

found that *L. emarginata* has larvae with osmoregulatory ability for much of the larval life before the megalopa reverts to the stenohaline pattern of adults. This could be a survival mechanism in large estuaries.

Allometric studies show that there is a 16-fold weight range for mature non-molting males, similar to that found for other male majids (Aldrich 1974). Some of the smallest of these males are capable of pursuing and mating with mature females. Mature females are ovigerous in two size categories, but the largest "old" mature females were never found with eggs. Their reproductive status is not understood. Within this great range of mature sizes, small crabs bearing many encrusting organisms appear to have lived for several years whereas larger crabs from muddy bottoms, seldom heavily encrusted, may not have lived as long. Two sets of crabs may be present, small ones that have reproduced for several years and larger ones with a shorter reproductive period. Aldrich discussed feeding strategies for these proposed groups.

Moreover, Aldrich (1976) maintained that predation of *Libinia emarginata* upon *Asterias* in absence of other food, the discovery of significant amounts of *Asterias* ossicles in newly molted crabs, and the finding together of *L. emarginata* with *Asterias* having many missing arms, suggest that under the right conditions this predation may be common. He noted that in captivity a crab eats only one arm of a starfish at a time, twisting open the dorsal side of an arm with the chelae. A starfish thus wounded autotomizes the arm and the crab eats at the open end of the detached arm. The spider crabs prefer prey of mean weight 12% of their own weight regardless of crab size; crabs fed ad libitum in 12°–13°C water ate little more than enough to sustain metabolism, but this may have been a seasonal phenomenon. In the same experiment, *Callinectes sapidus* and *Cancer irroratus* held with *L. emarginata* did not attack starfish even though starved for several weeks.

The eyes of *L. emarginata* show light-dark adaptation analogous in some respects to rods and cones of the vertebrate eye, i.e., are differentiated not for color vision but for use in dim and bright light as are the vertebrate rods and cones (Wald 1968).

Gray (1957) compared gill area in this sluggish species with that of other common littoral crabs in the Carolinas and found that it had the smallest gill area per gram body weight of any studied.

#### Genus *Nibilia* A. Milne Edwards 1878

Rathbun 1925:289.

#### *Nibilia antilocapra* (Stimpson)

Figs. 254, 259f

*Pisa antilocapra* Stimpson 1871a:110.

*Nibilia antilocapra*.—Rathbun 1925:290, text-fig. 97, pls. 102, 103, and 239.—Williams 1965:251, figs. 230, 233F.—Powers 1977:65.

*Recognition characters*.—Carapace pyriform, conspicuously spinose, much swollen, longer than wide; gastric and cardiac regions with about 18 spines of moderate size and smaller ones interspersed, largest spines surmounting summit of regions and somewhat surrounded by circle of smaller spines; other regions also well spined. Rostrum horizontal, undivided at base but moderately bifurcate for greater part of length, horns varying from  $\frac{3}{5}$  to  $\frac{4}{5}$  total length of rostrum. Preorbital spine ascending, slightly curved, not so advanced as base of horns; behind this a small spine on supraoculr eave and a triangular (intercalated) spine or tooth on supraocular border; postocular cup terminating in a spine. Basal antennal article with strong distolateral spine, short spine just outside posterior end, and tubercle behind this in line with prominent angle of buccal cavity. Maxilliped and sternum smooth. Pterygostomian region armed with 2 rows of spines.

Chelipeds of adult male longer and stouter than walking legs; merus and carpus rough with spines above and below; chelae almost cylindrical; hand nearly as long as merus, nearly smooth, few spines near articulation with carpus; fingers agape for half of length in large males, with well-developed tooth on dactyl in gaping part. Walking legs long, slender; merus and carpus with few spines longitudinally arranged; dactyls long, stout, unarmed.

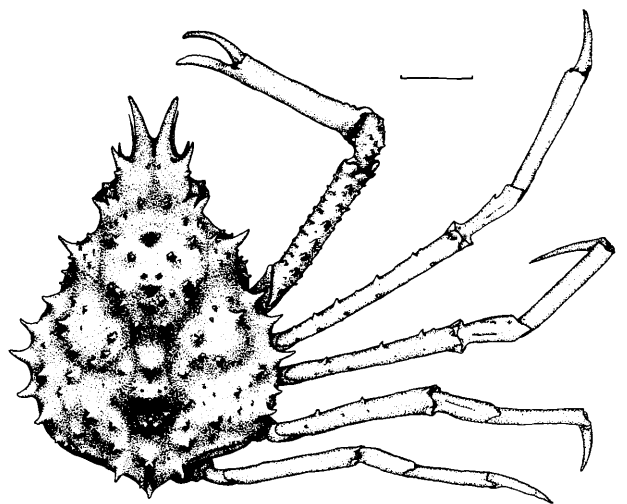


Fig. 254. *Nibilia antilocapra* (Stimpson). Male in dorsal view, legs of left side not shown, 10 mm indicated (from Williams 1965).

*Measurements in mm.*—Carapace: large male, length 120, width 82; female, length 60, width 43.

*Variation.*—The young and half-grown are covered with short hair, but adults are nearly bare except for hairy dactyls on the walking legs.

*Habitat.*—The species has been reported from gray and coarse sand, broken-shell, and coral bottoms (Rathbun 1925); 66 to 256 m (Wenner and Read 1982).

*Type-locality.*—Florida, off Carysfort Reef, 95 and 109.7 m; and off Alligator Reef, 251.8 m.

*Known range.*—Off Cape Hatteras, N. C., to Gulf of Mexico just east of Mississippi River Delta and Gulf of Campeche; Windward Islands, West Indies, off Guyana.

*Remarks.*—Ovigerous females are known from St. Vincent in February, Barbados in March, and North Carolina in July and October (Rathbun 1925; USNM).

Individuals collected from a reef SE of Cape Lookout, N. C., did not survive 48-h exposure to 10°C (F. J. and W. B. Vernberg 1970).

### Genus *Pelia* Bell 1835

Garth 1958:268.

#### *Pelia mutica* (Gibbes)

Figs. 255, 259a

*Pisa mutica* Gibbes 1850:171.

*Pelia mutica.*—Hay and Shore 1918:455, pl. 38, fig.

7.—Rathbun 1925:278, text-fig. 94, pl. 98, figs.

2–3.—Williams 1965:250, figs. 229, 233E.—

Felder 1973:53, pl. 7, fig. 13.—Powers 1977:65.

*Recognition characters.*—Small species. Carapace pyriform, greatest width approximately  $\frac{2}{3}$  greatest length; swollen, devoid of tubercles, covered with sparse pubescence, gastric and cardiac regions elevated. Rostrum well developed,  $\frac{2}{5}$  as long as remainder of carapace, formed of 2 more or less distally divergent horns with outer margins often parallel, furrow on basal portion. Eyes retractile. Basal antennal article long, slender, forming incomplete floor to orbit and jutting out beyond orbital margin, usually with small tooth or spine at anteroexternal angle; antennal flagellum greatly developed.

Chelipeds of mature male as long as first walking legs but stouter and almost bare, weaker in females and young males; upper and inner margin of merus dentate; carpus with longitudinal denticulate ridge; upper and lower margins of hand slightly arcuate; basal half of fingers widely agape,

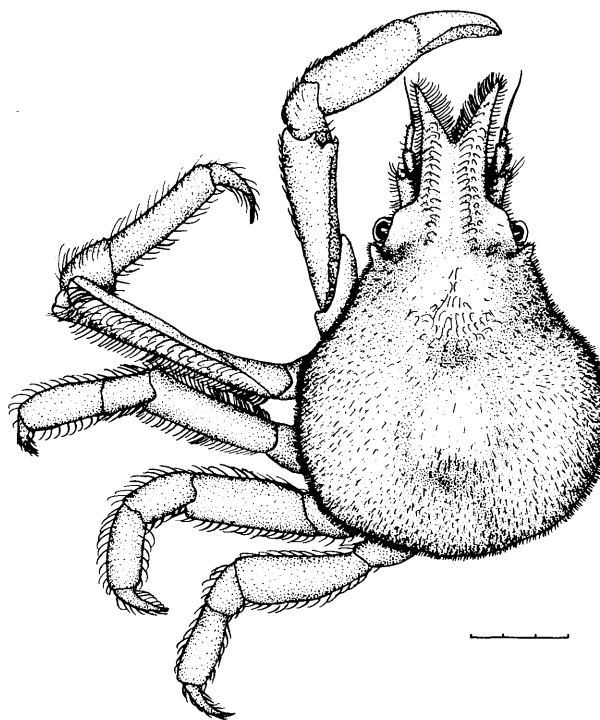


Fig. 255. *Pelia mutica* (Gibbes). Animal in dorsal view, legs of right side not shown, 3 mm indicated (from Williams 1965).

with denticulate margins on occludent parts and broad basal tooth of dactyl; fingers weaker and not agape in females and young males. Walking legs with marginal rows of stiff setae, meri much compressed, dactyls strongly curved.

Abdomen of both sexes with 7 free segments.

*Measurements in mm.*—Carapace: male, length 13, width 9; ovigerous females, length 5–10 (Wass 1955).

*Color.*—Bright red in patches on carapace and in bands on legs, spots of light red on chelipeds (Rathbun 1925).

*Habitat.*—This species has been found on gravelly and shelly bottoms of bays and sounds, among hydroids, ascidians, and sponges on wharf piles, and also on shelly reefs (Felder 1973; Pearse and Williams 1951). Individuals are often so covered with sponge that they are difficult to recognize. Gray (1961) reported the species from *Chaetopterus* tubes. Low-water mark to 51 m.

*Type-locality.*—Charleston Harbor, off White Point Battery, S. C.

*Known range.*—Buzzards Bay and Vineyard Sound, Mass., to off Port Mansfield, Willacy Co., Tex. (Felder 1973); Cuba, Puerto Rico, and St. Thomas, West Indies.

*Remarks.*—Ovigerous females are known in most months of the year in Florida (Rouse 1970), through the summer in the Carolinas, and July in Massa-

chusetts (Rathbun 1925). Hartnoll (1965) concluded that breeding was year round in Jamaica.

**Genus *Rochinia* A. Milne Edwards 1875**

Garth 1958:282.—China 1966:257.

Carapace pyriform or elongate-triangular; armed either with tubercles or long spines, hepatic and

branchial spines always prominent and very conspicuous. Rostrum consisting of 2 spines, usually long and slender. Eyes small, retractile against sharp postocular process commonly but little cupped; supraocular eave terminating either in forwardly directed tooth or upturned spine. Basal antennal article not very broad, sharply truncate; mobile portion of antennae freely exposed on either side of rostrum.

**Key to Species**

(Modified from Rathbun 1925)

1. Six spines on gastric region . . . . . *R. crassa*  
Less than 6 spines on gastric region . . . . . 2
2. Dorsal spines or tubercles acute . . . . . *R. tanneri*  
Dorsal spines or tubercles mostly large and flat topped . . . . . *R. umbonata*

***Rochinia crassa* (A. Milne Edwards)**

Figs. 256, 260a

*Amanthia crassa* A. Milne Edwards 1879:203, pl. 28.  
*Rochinia crassa*.—Rathbun 1925:210, text-figs. 83–84, pls. 68–69, 226.—Boone 1938:216, pls. 77–78.—Williams, McCloskey, and Gray 1968:60.—W. E. Pequegnat 1970:183.—Powers 1977:66.

*Recognition characters*.—Carapace convex with tendency to median carination; surface pubescent; median spines 6 (5 in juveniles), 2 anterior spines (gastric) in row, each flanked by remote spine on each side; anteriormost median spine forming first of an oblique row extending backward to spine at lateral angle of branchial region, scattered spines

mesial to row; prominent marginal hepatic spine; small spine on each side of middle above posterior margin (lacking in juveniles) and row of about 6 spines over bases of last 2 legs; from above anterior of legs (third walking leg) an irregular row of spines extending forward to anterior angle of buccal cavity. Rostrum divided into 2 stout, gradually tapering, acuminate spines, diminishing in relative length with age. Eyes small and retractile against well-developed postorbital lobe; supraocular eave bearing tubercle and ending in preocular spine. Basal antennal article with 2 spines on lateral margin pointing downward, forward and outward.

Chelipeds long, slender, tuberculate, becoming quite stout and elongate in adults; merus with distal spine and 1 or more spinules near proximal end; hand slightly compressed and distally enlarged; fingers gaping at base, tooth on dactyl in gape of males, prehensile edges with stout, close fitting teeth. Walking legs slender, diminishing noticeably in size from first to fourth, surpassing chelipeds in medium sized individuals; merus with short distal groove.

*Measurements in mm*.—Carapace: male, length to base of rostral horns 95, width 79.5 (Rathbun 1925); female, length to base of rostral horns 77, including horns 87, width 65.

*Color*.—Carapace on dorsal side diffusely mottled with light rust-orange; remainder dirty white. Merus, carpus and propodus with darker rust-orange blotches, particularly on distal parts (Williams, et al. 1968).

*Habitat*.—Mud and sand substrates; 66 to 860–1216 m (Wenner and Read 1982).

*Type-locality*.—Between Cuba and Florida, 24°15'N, 82°13'W.

*Known range*.—Nantucket Shoals, Mass., to Gulf

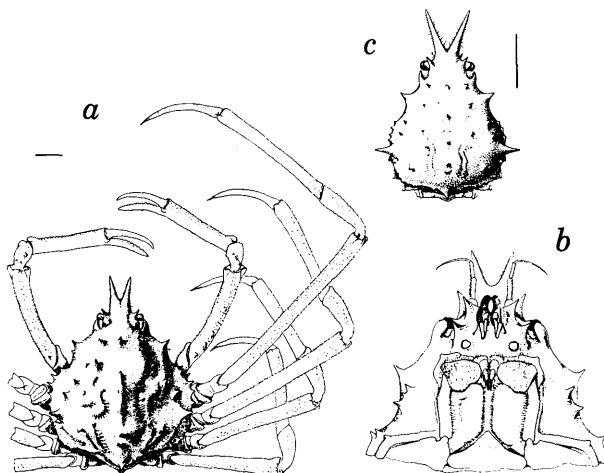


Fig. 256. *Rochinia crassa* (A. Milne Edwards). a, Female in dorsal view, walking legs of left side not shown completely; b, anterior part of same, enlarged ventral view; c, body of male in dorsal view. a, USNM 5693, c, 1 cm indicated (from Rathbun 1925 after Smith).

of Mexico off southern Texas; northern Cuba; W of Cabo de la Vela, Colombia; off French Guiana.

*Remarks.*—This species is the largest of the three species of *Rochinia* treated here. Ovigerous females are known from the northern Gulf of Mexico in February, August and November, and off southern Florida in June and August.

Menzies, et al. (1973) considered *R. crassa* an archibenthal species which ranges upward.

### *Rochinia tanneri* (Smith)

Figs. 257, 260b

?*Amathia modesta* Stimpson 1871a:124.

*Amathia tanneri* Smith 1883:4.

*Rochinia tanneri.*—Rathbun 1925:216, pl. 227, fig.

1.—Williams, McCloskey, and Gray 1968:60, fig. 15.—Powers 1977:66.

*Recognition characters.*—Small species. Carapace with fewer but relatively more prominent spines than *R. crassa*; 4 median spines of good size, 2 anterior gastrics flanked on each side by much smaller tuberculiform spine to form diamond-shaped pattern; 1 cardiac and 1 intestinal; moderate hepatic spine on each side, and branchial region with triangular arrangement of strong spine at posterolateral corner flanked mesially by 2 smaller spines. Rostral horns prominent, divergent, straight and slender. Orbit moderately open, preorbital spine

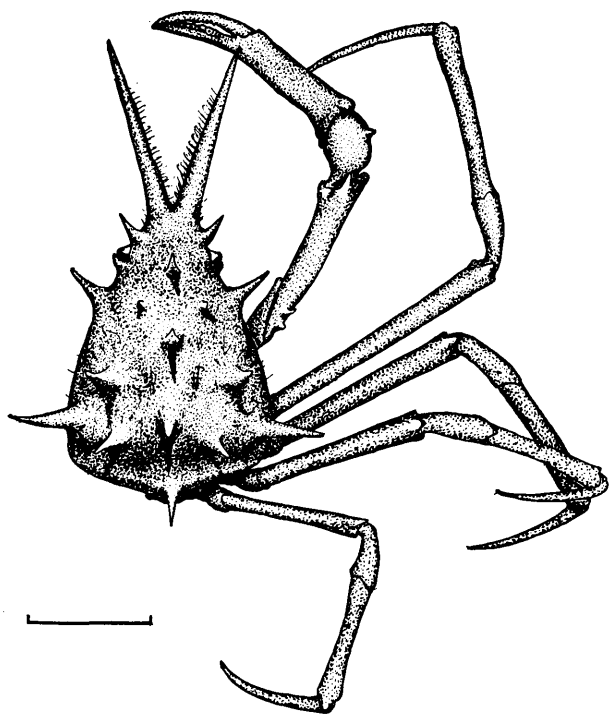


Fig. 257. *Rochinia tanneri* (Smith). Male in dorsal view, legs of left side not shown, 1 cm indicated (from Williams, et al. 1968).

moderately developed, postorbital spine blunter. Basal antennal article with terminal anterolateral spine. Anterior angles of buccal cavity prominent, broad triangular tooth followed by 3 or 4 blunt, conical projections on pterygostomial region.

Chelipeds somewhat stouter than walking legs, similar to those of small *R. crassa*. Walking legs with short distal spine on merus of first leg, those of remaining legs reduced to tuberculiform protuberances.

*Measurements in mm.*—Carapace: male, length to base of rostral horns 21.6, width including spines 23.1 (Rathbun 1925); female, length to base of rostral horns 14.8, including horns 22.5, width including spines 14.8.

*Habitat.*—Sand, shells; 128 to 708 m.

*Type-locality.*—Off Delaware Bay.

*Known range.*—Off Martha's Vineyard, Mass., to Straits of Florida.

*Remarks.*—Juvenile *R. crassa* and *R. tanneri* are similar.

### *Rochinia umbonata* (Stimpson)

Figs. 258, 260c

*Scyra umbonata* Stimpson 1871a:115.

*Rochinia umbonata.*—Rathbun 1925:222, text-fig. 85, pl. 72; pl. 73, fig. 1.—Chace 1940:63.—Williams, McCloskey, and Gray 1968:61, fig. 16.—W. E. Pequegnat 1970:183.—Powers 1977:67.

*Recognition characters.*—Surface covered with close tuberculiform pubescence, longer club-shaped se-

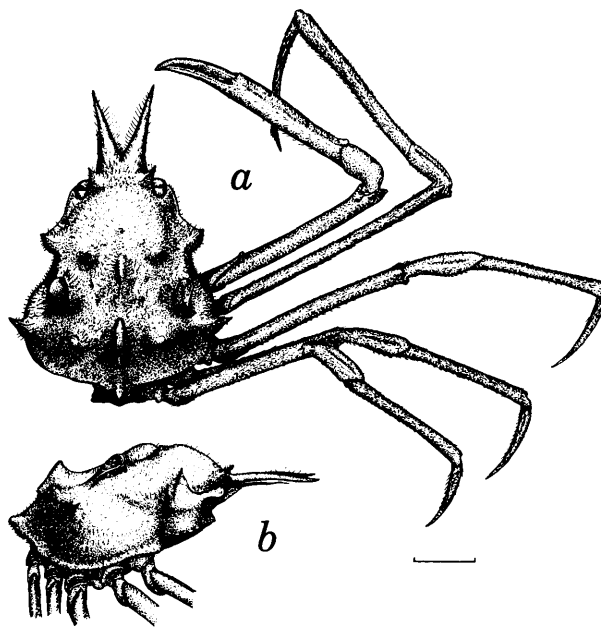


Fig. 258. *Rochinia umbonata* (Stimpson). Male: a, dorsal view, legs of left side not shown; b, lateral view of body, 1 cm indicated (from Williams, et al. 1968).



Fig. 259. Subfamilies Tychinae, Epialtinae and Pisinae, tips of right first pleopods of males: *a*, *Pithe therminieri* (Schramm), abdominal view; *b*, *Tyche emarginata* White, lateral view; *c*, *Spencarcinus corrosus* A. Milne Edwards, sternal view; *d*, *Epialtus dilatatus* A. Milne Edwards, sternal view; *e*, *Pelia mutica* (Gibbes), sternal view; *f*, *Nibilia antilocapra* (Stimpson), abdominal view; *g*, *Libinia dubia* H. Milne Edwards, lateral view; *h*, *L. emarginata* Leach, lateral view; *i*, *Coelocerus spinosus* A. Milne Edwards, lateral view, USNM 57842; (*a-h* from Williams 1965); 0.33 mm indicated.

tae on margins of legs, and slender curved setae on rostrum, gastric region, and laterally on branchial region. Carapace with 9 tubercles on dorsal surface; 6 of these often large, flattened and irregular in shape, 1 posterior gastric, 1 cardiac, 2 on each branchial region; 3 smaller tubercles all gastric, 11 anterior, others lateral. Lateral margin with hepatic and branchial spine either triangular, flattened and somewhat appressed, or conical and projecting outward. Small tubercle on middle of posterior margin or on raised ridge parallel to posterior margin. Rostral horns divergent and varying in length. Orbits either narrow with supraocular eave somewhat convex in outline and preocular spine directed outward, or wider with eave concave and preocular spine directed outward. Basal antennal article unarmed or with inconspicuous tooth at distolateral angle. Angles of buccal cavity projecting, lobiform; subbranchial and pterygostomian regions tuberculate.

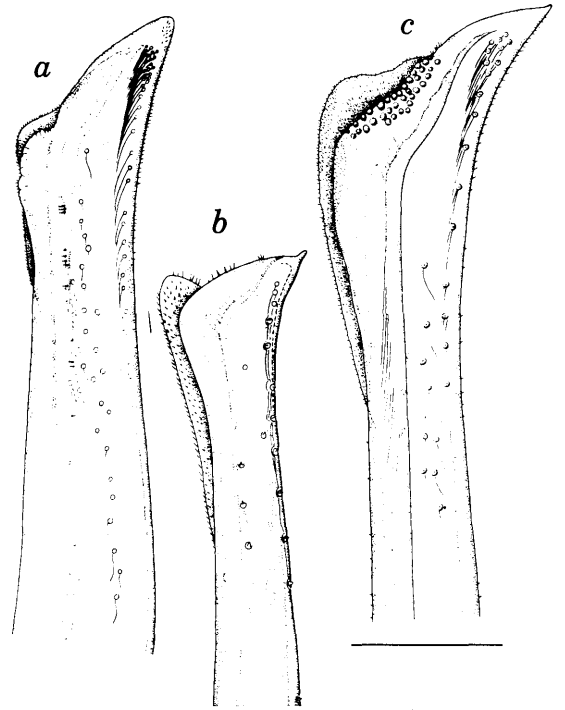


Fig. 260. Subfamily Pisinae, tips of right first pleopods of males, sternal view: *a*, *Rochinia crassa* (A. Milne Edwards), USNM 1169539; *b*, *R. tanneri* (Smith), USNM 46773; *c*, *R. umbonata* (Stimpson), USNM 11377; 0.33 mm indicated.

Chelipeds of male nearly as long as first walking legs, slightly enlarged; merus somewhat angled, upper margin tuberculate and with distal spine; carpus uneven, inner margin with thin lobe near merus; palm compressed, narrow, elongate, margins thin; fingers much shorter than palm, large tooth at base of gape in large males, prehensile edges of fingers denticulate. Walking legs slender, spine at distal extremity of merus on first pair, tubercle or spine on remaining legs.

*Measurements in mm.*—Carapace: male, length to base of rostral horns 54, including horns 62, width including spines 44; ovigerous female, length to base of rostral horns 57, including horns 73, width including spines 47.

*Variation.*—Extremely variable in ornamentation. The slender legs become extremely so in large individuals.

*Habitat.*—161 to 900 m.

*Type-locality.*—Off Sand Key, Florida.

*Known range.*—SE Cape Lookout, N. C., through eastern and northern Gulf of Mexico to NE of Nicaragua; through West Indies to St. Vincent.

*Remarks.*—Ovigerous females are known from April through June off Florida, in August off Georgia, and September off Nicaragua. Yang (1967), from an ovigerous female taken off Florida in June maintained at 10°C, hatched several prezoae and two well-developed zoeae. These were transferred

to 15°C but failed to develop further. He described the first stage, which was larger than that of other majids studied.

### Subfamily Mithracinae

Carapace broadened anteriorly by outstanding, often tubular orbits; orbits formed by (1) an arched

supraocular hood, or semitubular horn, (2) hollowed postocular process, and (3) remarkable broadening or prolongation of anterior part of basal antennal article affording complete concealment to retracted eye. Rostrum often more or less deflexed (Alcock 1895). First pleopod like that in Pisinae; second pleopod short (Stephensen 1945).

### Key to Genera and One Species

(Adapted from Garth 1958)

1. Intercalated orbital spine present (between supraorbital and postorbital spine); orbits not tubular . . . . . 2  
Intercalated orbital spine absent; orbits tubular . . . . . 4
2. Legs cristate; orbits not projecting laterally beyond general outline of carapace (poor character) . . . . . *Hemus cristulipes*  
Legs not cristate; orbits projecting laterally somewhat beyond general outline of carapace (poor character) . . . . . 3
3. Carapace ovate, usually broader than long; rostrum small (except *M. acuticornis*) . . . . . *Mithrax*  
Carapace broadly pyriform, longer than broad; rostrum large, usually with 2 strong divergent horns; basal antennal article armed with prominent spine at anteroexternal angle . . . . . *Microphrys*
4. Lateral margin of carapace not armed with series of strong spines, but with 1 spine, usually strong, at lateral angle . . . . . *Macrocoeloma*  
Lateral margin of carapace armed with series of strong spines; basal antennal article very broad . . . . . *Stenocionops*

### Genus *Hemus* A. Milne Edwards 1895

Rathbun 1925:345.

#### *Hemus cristulipes* A. Milne Edwards

Fig. 261

*Hemus cristulipes* A. Milne Edwards 1875:88, pl. 16, figs. 1–1f.—Rathbun 1925:345, text-fig. 110, pl. 124, fig. 1; pl. 248, figs. 9–15.—Coelho and Ramos 1972:213.—Powers 1977:50.

*Recognition characters*.—Body and legs covered with depressed granules. Carapace longer than wide, thick and swollen, especially in prominent cardiac region; postorbital portion wide; gastric region high; branchial regions elliptical, each bearing 2 subacute prominences directed outward, first stronger than second. Subhepatic region deeply grooved. Rostrum small, short and wide, bicarinate dorsally, bent downward and bifurcated. Orbit with upper border unarmed but with narrow fissure; lower border incomplete; postorbital cavity receiving retracted eye; no preorbital spines. First and second movable articles of antennae wide and

flat, flagellum inserted at external angle of second. Merus of third maxillipeds long and somewhat dilated anterolaterally, exognath broad through midlength, narrowed distally.

Chelipeds small, fingers slightly gaping, strongly bent inward distally, scarcely spoon shaped. Walking legs short but strong, first longest and strongest, last pair very small; each merus wide, ornamented dorsally with thin straight crest and ventrally with lamellar prolongation bearing crenulate and arcuate border; remaining articles smaller but dactyls strong, much curved.

Abdomen of both sexes with 7 free segments.

*Measurements in mm*.—Carapace: female, length 7.6, width 6 (Rathbun 1925).

*Habitat*.—Sand, rock, and coral bottoms; in horn sponges and the coral *Porites porites*, 15 to 69 m (Powers 1977, summary).

*Type-locality*.—Near Contoy [Yucatan], at the entrance to the Gulf of Mexico, 21.9 to 32.9 m.

*Known range*.—Off Cape Lookout, N. C., and South Carolina; northwest of Gulf of Mexico and Yucatan, through West Indies to Pernambuco, Brazil (Powers 1977; Herbst, et al. 1979).

*Remarks*.—The dilated legs, antennal peduncle,

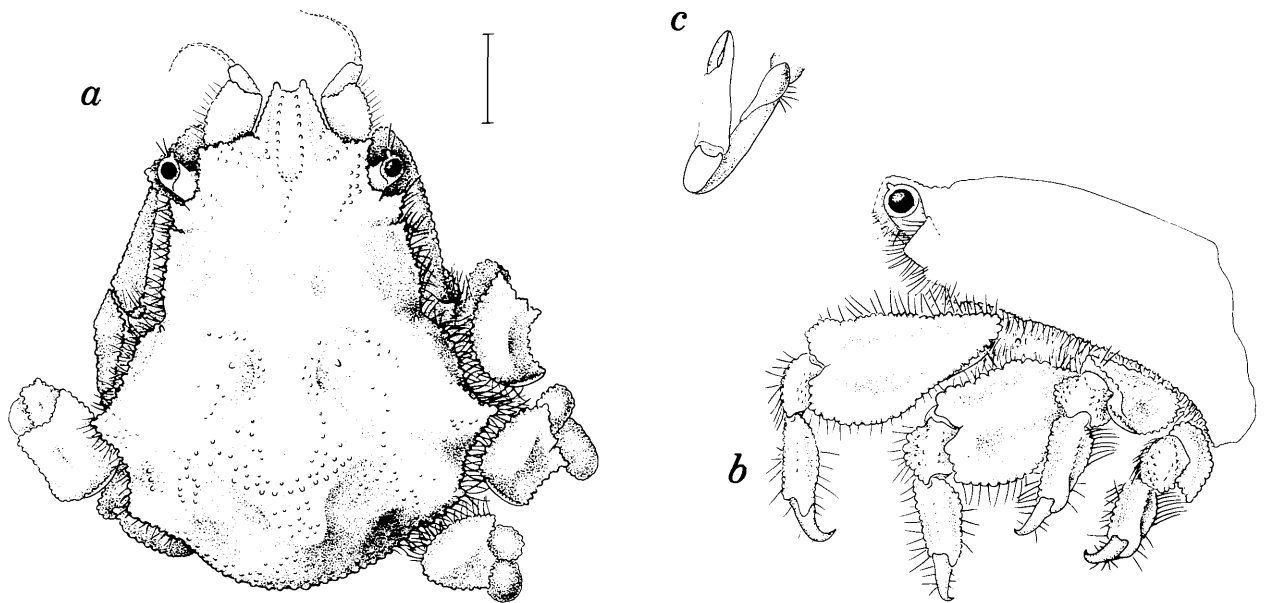


Fig. 261. *Hemus cristulipes* A. Milne Edwards. Female: *a*, dorsal view, some legs deleted; *b*, lateral view showing legs 2–5 in situ; *c*, right cheliped; 1 mm indicated (USNM 94050).

and deflexed rostrum cluster to surround a large cavity beneath the body (Rathbun 1925).

#### Genus *Macrocoeloma* Miers 1879

Garth 1958:412.

Carapace subpyriform or suboblong, but broadened anteriorly by projecting orbits; dorsal surface unarmed, tuberculate, or with few long spines;

margins without series of elongate lateral spines, but often with strongly developed lateral epibranchial spine preceded by smaller spines. Rostral spines well developed. Eyes retractile within roomy tubular orbits. Antennae with basal article considerably enlarged and armed distally with 1 or 2 spines; mobile part sometimes concealed by rostrum. Abdomen with 7 separate segments in both sexes. (Modified after Garth 1958.)

#### Key to Species

1. Carapace with fewer than 7 spines on posterior half, or if 7 some small. . 2  
Carapace with 7 strong spines on posterior half . . . . . *M. camptocerum*
2. Basal (fixed) antennal article armed with 2 ventral spines; rostral horns separated by U-shaped space . . . . . *M. eutheca*  
Basal (fixed) antennal article armed with 1 spine or sharp tubercle; rostral horns separated by space narrow or pointed at its base. *M. trispinosum*

#### *Macrocoeloma camptocerum* (Stimpson)

Figs. 262, 275m

*Pericera camptocera* Stimpson 1871a:112.

*Macrocoeloma camptocerum*.—Hay and Shore 1918:457, pl. 38, fig. 12.—Rathbun 1925:469, pl. 174, fig. 4; pl. 270, fig. 2.—Williams 1965:264, figs. 244, 245K.—Powers 1977:50.

*Recognition characters*.—Carapace irregularly triangular; surface covered with short, close pubescence, and, in addition, long, stiff, curled hairs on

front, gastric region, and lateral parts of branchial regions; wide at level of orbits, narrowing distinctly in hepatic portion, widening again posteriorly; 4 strong spines on dorsal region, 1 on gastric, 1 on cardiac, and 1 on each epibranchial region. Posterolateral spines subconical, regularly tapering, acute, and directed slightly backward; posterior median spine shorter, acute, obliquely erect. Rostral horns acute, rather regularly divergent from base. Distolateral spine on basal article of antenna rather slender, divergent. Orbital tubes, pre- and

postorbital spines protuberant laterally, preorbital spine curving a little forward.

Chelipeds of male strong, longer than carapace; merus with few short spinules above; carpus somewhat nodose with tubercle at inner angle; palm widest near articulation; fingers tipped with black or dark brown. Walking legs nearly smooth.

*Measurements in mm.*—Carapace including spines: male, length 40, width 36; ovigerous female, length 31, width 25.

*Variation.*—The rostral horns may be straight or slightly curved outward at tips, and range in length from  $\frac{1}{6}$  to  $\frac{1}{3}$  the total length of the carapace. The interspace between horns may vary from a narrow V-shape to almost a right angle. The posterolateral spine may be straight in frontal section, curved upward and nearly transverse, or directed strongly backward.

*Color.*—A dirty brown.

*Habitat.*—The species has been taken on a variety of bottoms ranging from sand with grass, or a hard smooth substrate, to rocky or coral bottoms; Rathbun (1925) reported it from predominantly coarse bottoms. About 3.7 to 24 m.

*Type-locality.*—Near Key West [Fla.], 3.7 to 9.2 m.

*Known range.*—Beaufort Harbor, N. C., around southern Florida to Alligator Harbor, Fla.

*Remarks.*—Encrusting organisms on the dorsal surface of the carapace are often as large a mass as the crab itself—including the sponges *Dysidea* sp.,

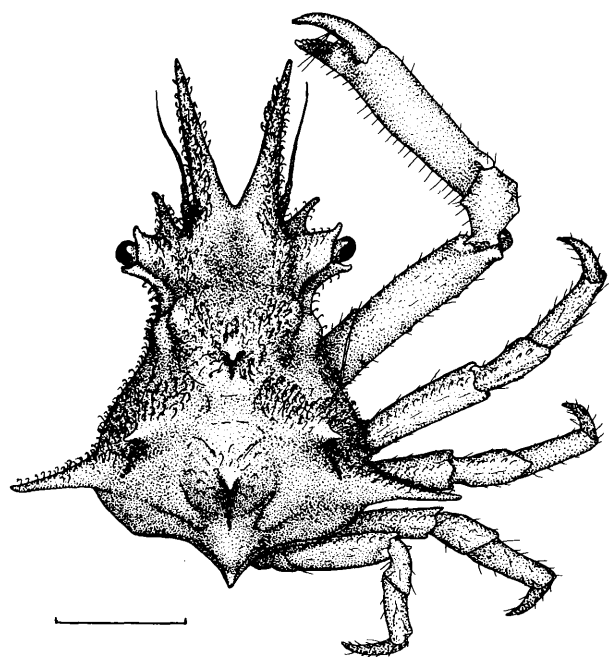


Fig. 262. *Macrocoeloma camptocerum* (Stimpson). Male in dorsal view, legs of left side not shown, 10 mm indicated (from Williams 1965).

*Haliclona* sp., *Lissodendoryx isodictyalis*, and unidentified ascidians (Rouse 1970).

Ovigerous females are known in Florida from January to April (USNM); Hartnoll (1965) considered breeding to be continuous in Jamaica. He observed hatching of eggs in 13–14 days at 22°–25° C. From a single brood hatched in March, Yang (1967) reared the larvae singly in 50 ml plastic compartments in the laboratory. He described the stages, finding that at 25°C zoea I lived 2 days ( $\bar{x}$ ) before molting, zoea II 3 days ( $\bar{x}$ ), the megalopa 7–8 days, and the first and second crab stages 6 days each.

Individuals collected from a reef SE of Cape Lookout, N. C., in September and October withstood experimental exposure to temperature of 4°C for 7 h but died after 17-h exposure (F. J. and W. B. Vernberg (1970).

### *Macrocoeloma eutheca* (Stimpson)

Figs. 263, 275k

*Pericera eutheca* Stimpson 1871a:112.

*Macrocoeloma eutheca.*—Rathbun 1925:485, pls. 170, fig. 1; 171, fig. 1.—Powers 1977:51.

*Recognition characters.*—Carapace subtrapezoidal, narrow behind orbits; median spine on gastric, cardiac and intestinal prominences, spinule on gastric region behind each orbit in line with gastric spine and at summit of each branchial region; 1 strong spine at lateral angle directed outward and backward. Rostrum small, horns slender, nearly parallel in proximal half of length with interspace U-shaped, but tips slightly divergent. Tubular orbits directed forward, upward and outward, prolonged well beyond ventral face of basal antennal article and having 4 spines, 1 pre-, 1 post-, 1 supra-ocular, and 1 ventral belonging to antennal article. Latter article in addition bearing 2 ventral spines; pterygostomian region with 4 tubercles.

Merus of rather slender cheliped with 3 marginal rows of tubercles, hand with partial row above and below as well as scattered proximally. Walking legs seem short and slight for size of body, diminishing markedly in length from first to last pair.

*Measurements in mm.*—Carapace: male, length without horns 32, including horns 41, width including spines 35; ovigerous female, length without horns 28, including horns 30, width including spines 26.

*Habitat.*—55 to 214 m.

*Type-locality.*—Off French Reef [Fla.], 27.4 m, and west of Tortugas, 67.7 m.

*Known range.*—SE of Cape Lookout, N. C.; off



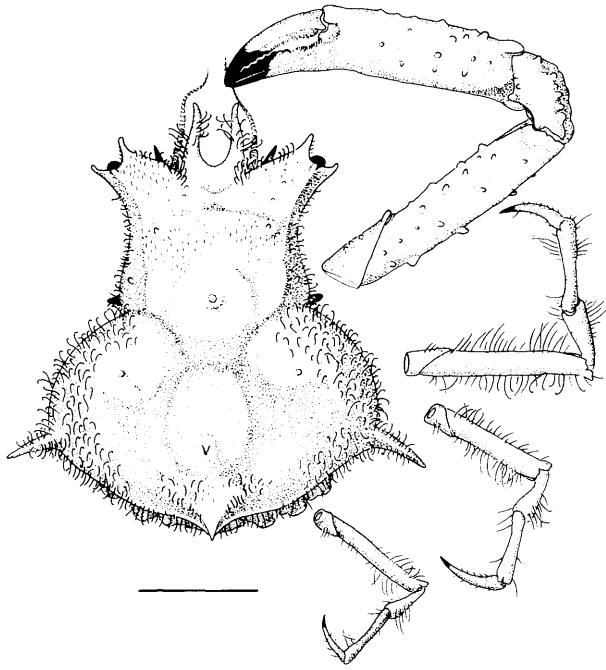


Fig. 263. *Macrocoeloma eutheca* (Stimpson). Male in dorsal view, dissociated cheliped and 3 legs of right side shown; 10 mm indicated (USNM 173637).

NW Florida through Bahama Banks and West Indies; Panama.

*Remarks.*—Ovigerous females are known from NW Florida in December and St. Croix in January.

Individuals collected from a reef SE of Cape Lookout, N. C., in September and October withstood experimental exposure to temperature of 4°C for 7 h but died after 17-h exposure (F. J. and W. B. Vernberg 1970).

***Macrocoeloma trispinosum* (Latreille)**

***Macrocoeloma trispinosum*, variety**

***Macrocoeloma trispinosum nodipes* (Desbonne)**

(Grass crab, sponge crab, decorator crab)

Figs. 264, 275l

*Pisa trispinosa* Latreille 1825:142.

*Pericera nodipes* Desbonne 1867:15, pl. 5, fig. 13.

*Macrocoeloma trispinosum*.—Hay and Shore 1918:457, pl. 38, fig. 11.—Rathbun 1925:466, text-fig. 132, pl. 166, fig. 1; pl. 167.—Boone 1927:40.—Williams 1965:263, figs. 243, 245J.—Coelho and Ramos 1972:217.—Felder 1973:53, pl. 7, fig. 9.—Powers 1977:52.

*Macrocoeloma trispinosum*, variety.—Rathbun 1925:468, pl. 168, fig. 1.

*Macrocoeloma trispinosum nodipes*.—Rathbun 1925:468, pl. 166, fig. 2; pl. 168, fig. 2.

*Recognition characters.*—Carapace irregularly tri-

angular, body and legs with velvety covering of short brown hairs, thick and swollen, wide at level of orbits, narrowing distinctly in hepatic portion, widening again posteriorly. Middorsal region much elevated and bearing 4 low, rounded tubercles or bosses, 1 on gastric, 1 on cardiac, and 1 on each epibranchial region. Posterolateral angle prolonged into long flattened spine directed obliquely outward and backward, sometimes curved upward; posterior margin with broad, median, triangular projection with tip sometimes slightly recurved. Rostrum formed of 2 somewhat flattened horns adjacent and subparallel at base, divergent distally. Upper margin of orbit deeply emarginate, pre- and postocular teeth prominent, preocular teeth curved forward. Basal article of antenna with distolateral angle produced, exceeding frontal margin, and forming broad spine directed obliquely outward at each side of rostrum.

Chelipeds of male narrow, approximately as long as carapace; merus nodose; palm with subparallel sides; dactyl approximately half as long as upper margin of palm and lightly furrowed above. Walking legs rather slender, slightly nodose.

*Measurements in mm.*—Carapace including spines: male, length 47, width 41; ovigerous female, length 37, width 31.

*Variation.*—Rathbun (1925) discussed variation in this species throughout its known range. Body shapes falling into three general series are distinguishable. In the typical form, the posterolateral prominences are narrow, with regularly tapering spines projecting beyond the general outline of the carapace, directed more or less backward, and sometimes strongly curved from base to tip with the concavity forward. The carapace is considerably constricted behind the orbits. The orbits are prominent owing to this constriction, and the pre- and postocular teeth are strong, the former directed forward and curved. The upper edge of the orbit is deeply emarginate. The four large tubercles or bosses are prominent, some or all with an acute tip, that on the gastric region sometimes nearly a spine.

In the second series, treated by Rathbun as an unnamed variety, the posterolateral prominences are wider than in the first series, less spinelike and more laminate, their posterior margins nearly transverse. The carapace is less narrowed behind the orbits, the orbital teeth less marked, though the preocular tooth is directed forward and a little curved, and the superior emargination less deep. The four large dorsal bosses are lower than in series one, but the gastric boss tends to be surmounted by a sharp tubercle or granule.

In series three, called *M. t. nodipes*, the posterolateral prominences are broader and more obtuse

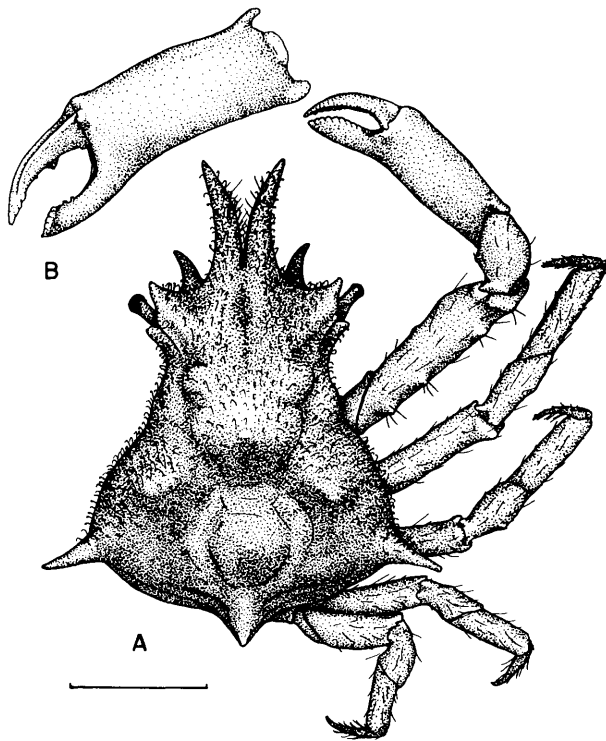


Fig. 264. *Macrocoeloma trispinosum* (Latreille). *a*, Small male in dorsal view, legs of left side not shown, 10 mm indicated; *b*, right chela of adult male in external view (from Williams 1965).

than in series two with their margins almost continuing the margin of the carapace. The carapace is constricted little or not at all behind the orbits; the preocular tooth is acute but not prominent, and the postocular tooth is blunt or subacute with both teeth somewhat more prominent in young individuals than in old ones. The orbit has a slight emargination in the upper border. The dorsal bosses are lower than in the other series, smoothly rounded and blunt.

In the three series the posterior median spine varies in a manner similar to the lateral spines, and the rostrum shows great variability in length, direction, and curvature of horns.

#### Key to Species

1. Carapace with 2 lateral laminiform processes, 2 strong branchial spines. . . . . *M. antillensis*
- Carapace without lateral laminiform processes, 1 strong branchial spine. . . . . *M. bicornutus*

#### *Microphrys antillensis* Rathbun

Figs. 265, 275*h*

*Microphrys platysoma*.—Hay and Shore 1918:459, pl. 38, fig 9.

*Microphrys antillensis* Rathbun 1920:24.—1925:498, text-fig. 141, pl. 176, figs. 3–4.—Williams

*Color*.—Hairs yellowish or reddish brown (various authors); scarlet vermilion (W. L. Schmitt, notes).

*Habitat*.—In North Carolina, this species has been found in seaweed in Beaufort Harbor, in the ocean on floating masses of *Sargassum*, and dredged from offshore reefs. Elsewhere it has been found in a variety of situations, from pilings, and mangrove roots to weedy rocks, coarse coral-sand, sand-shell, and broken-shell bottoms. The species is often concealed by a covering of sponge. Shallow water to 82 m.

*Type-locality*.—"Nouvelle Holland" (?) [error].

*Known range*.—Beaufort, N. C., to Alligator Harbor, Fla.; Yucatan; through West Indies to Bahia, Brazil.

*Remarks*.—Ovigerous females of the varieties together are known from March to December in Florida, April in Bermuda and Cuba, July in Jamaica and St. Thomas, and September east of the Mississippi River delta. Structure of the sperm was described by Hinsch (1973).

Boone (1927) reviewed an early description of decoration in the species. Randall (1967) reported *M. trispinosum* in stomach contents of the squirrel-fish, *Holocentrus ascensionis*.

#### Genus *Microphrys* H. Milne Edwards 1851

Garth 1958:385.

Carapace broadly pyriform, somewhat depressed, dorsally uneven and tuberculate or nodose, small marginal spine or tubercle at lateral angle of branchial region; preocular spine usually developed. Orbits small, circular, with closed fissures; eyes small. Rostral horns moderate or small, divergent. Basal article of antenna considerably dilated, armed with sizeable spine at anteroexternal angle visible in dorsal view; movable antennal parts visible dorsally. Abdomen of both sexes with 7 separate segments. (Modified after Garth 1958.)

1965:260, figs. 240, 245G.—Coelho and Ramos 1972:217.—Powers 1977:53.

*Recognition characters*.—Carapace depressed, tuberculate, and granulate, area at inner angle of branchial region finely granulate; intestinal region with 4 or more large, equal tubercles. Anterolateral wall with 2 laminiform processes, 1 on hepatic,

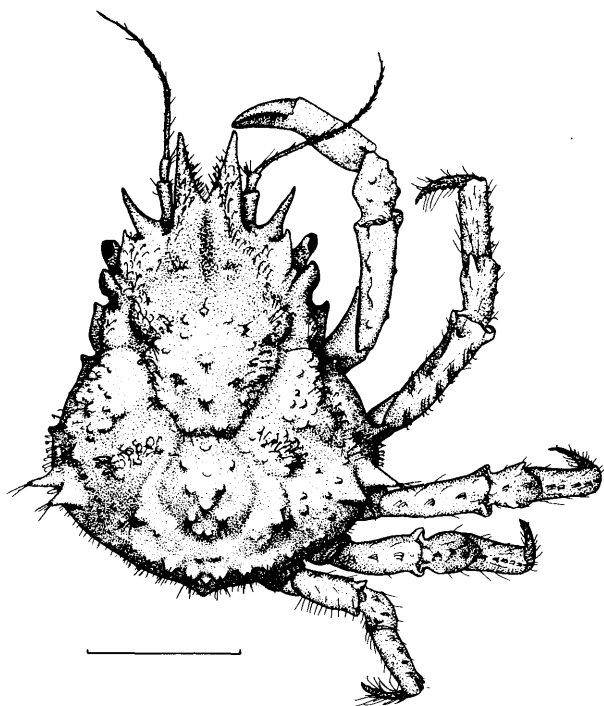


Fig. 265. *Microphrys antillensis* Rathbun. Male in dorsal view, legs of left side not shown, 5 mm indicated (from Williams 1965).

1 ill-defined on branchial region; hepatic process with anterior end acute, projecting outward and occasionally forward in large individuals, sometimes with outward-projecting tubercle at middle of upper edge; spine between and below level of hepatic and branchial processes. Branchial region with 3 spines, 1 forming posterolateral angle occasionally doubled. Posterior margin with row of tubercles increasing in size mesially. Rostral horns slender, rather short, directed forward. Basal article of antenna with spine at outer angle about half length of rostral spines. Preocular spines acute, about half as long as antennal spines.

Merus of chelipeds with dentate and laminate dorsal crest; carpus tuberculate; palm less than twice as long as broad; fingers widely gaping, fixed finger curved downward. Walking legs sparsely hairy and with few spines and tubercles; propodi with prominent distal laminiform process for articulation of dactyls.

*Measurements in mm.*—Carapace: male, length to base rostral horns 15.6, including horns 18, width 15.6; female, length to base rostral horns 14.2, including horns 16.2, width 14.6.

*Habitat.*—3.7 to 27 m.

*Type-locality.*—Off Montego Bay Point, Jamaica.

*Known range.*—Near capes Hatteras and Lookout, N. C., to Cape Fear, N. C.; Cuba; Jamaica; Puerto Rico; Pernambuco, Brazil.

*Remarks.*—Ovigerous females are known from

June to September off North Carolina, July off Florida, and November at Bimini (Rathbun 1925, and USNM).

Cain (1970) reported occurrence of the species on an offshore reef near capes Lookout and Hatteras, N. C. F. J. and W. B. Vernberg (1970) found that zoeae collected in this reef region died within three to four h at 4°C. At 10°C the zoeae were inactive but recovered if returned to room temperature after 24 h.

### *Microphrys bicornutus* (Latreille)

Figs. 266, 275g

*Pisa bicornuta* Latreille 1825:141.

*Microphrys bicornutus.*—Hay and Shore 1918:459, pl. 38, fig. 10.—Rathbun 1925:489, text-fig. 139, pl. 175.—Williams 1965:259, figs. 239, 245F.—Coelho and Ramos 1972:216.—Powers 1977:54.

*Recognition characters.*—Carapace subtriangular, moderately hairy, all raised parts covered with rounded tubercles; line of 4 tubercles arching upward on intestinal region, branchial region with 2 or 3 short spines and another spine at lateral angle. Rostrum composed of 2 stout horns, divergent throughout or at base with extremities curving inward,  $\frac{1}{2}$  to  $\frac{1}{3}$  length of remainder of carapace. Basal article of antenna with conspicuous, flat, obtuse spine at anterior angle and marginal tubercle behind this or short, stout spine in large individuals. Preorbital angle rectangular.

Chelipeds spotted, spots persisting for many years in alcohol; merus with 3 or 4 tubercles or short, blunt spines above; carpus somewhat nodose; hand smooth; fingers gaping, hollowed out at tips. Walking legs diminishing noticeably in length from first to fourth pair, hairy, margins somewhat rough.

*Measurements in mm.*—Carapace: male, length 36, width 26; female, length 24, width 20.

*Color.*—Variable; carapace often dull yellowish brown or bright purplish rose; chelipeds grayish white, covered with small, round, purplish spots.

*Habitat.*—The species is common on coral reefs. It is often disguised by foreign objects such as sponges, anemones, hydroids, algae, etc., which became attached to it. Shallow water to 30 m.

*Type-locality.*—“Nouvelle Hollande.”

*Known range.*—Near Beaufort, N. C., through Gulf of Mexico (Ray 1974) to Florianopolis, Santa Catarina, Brazil; Bermuda.

*Remarks.*—This species is represented by a large collection in the USNM, and has been the subject of a number of studies. Hartnoll (1965) showed that the species in Jamaica has a recognizable molt of

puberty in which male chelipeds increase relatively in size, the female abdomen becomes broadened and male gonopods remain unaltered from prepubertal condition. He concluded that breeding was continuous. Other records show ovigerous females from March to August in the Caribbean area and November to January in the West Indies and northern South America (Rathbun 1925; USNM). The female mates in the hard condition. Hartnoll observed as many as four sets of fertile eggs to be laid following a single mating which probably supplies enough sperm to last through the reproductive life. A female with carapace length of 25 mm can lay 3000 eggs in a clutch. There is little delay in laying a new clutch of eggs following the hatching of a previous one. Hatching, usually nocturnal, is facilitated by the female standing on the tips of the dactyls, extending the abdomen and waving the pleopods while repeatedly thrusting the chelae into the egg mass.

From laboratory rearings, Hartnoll (1965a) described the prezoa and two zoeal stages. Yang (1967) described the first and second zoea, megalopa and first crab stage, and from several broods reared at 25°C he found the following duration of stages in days: zoea II, 3; megalopa, 5; crab 1, 4–6; crab 2, 4–8; crab 3, 9; crab 4, 5–9; crab 5, 7–11; crab 6, 11. Greatest mortality was in the first zoeal stage and the megalopa.

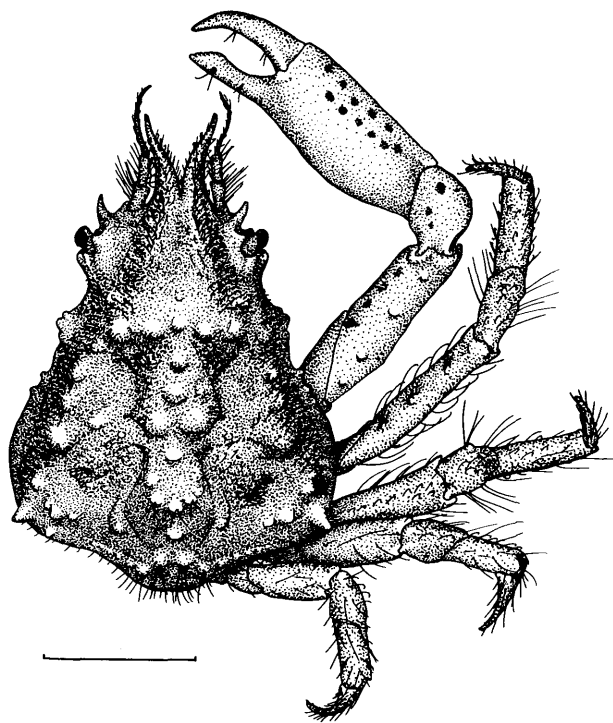


Fig. 266. *Microphrys bicornutus* (Latreille). Male in dorsal view, legs of left side not shown, 10 mm indicated (from Williams 1965).

In the majids (Hartnoll 1965) there are two kinds of breeding season, continuous under essentially uniform temperature conditions (*M. bicornutus* as a model), or fixed in which one set of eggs is laid per year (*Hyas coarctatus* in cold northern water as a model). In neither of these types is the molt of puberty at a fixed point in life, i.e., at a uniform size as in some Brachyura, but this terminal feature, whether in a large or a relatively small individual, marks the group as among the most specialized of the Brachyura. There is tremendous change in this one molt.

Hartnoll (1967) also studied the effects of parasitism on this species by *Sacculina biscuspidata* in Jamaica, giving an excellent general review of sacculinid host-parasite relationships. He found 15% of the crabs infected, and multiple infections rare. Effects of parasitism on the male crabs are: relative length of the chelar propodus becomes smaller than in prepubertal males; abdomen is broadened; fringing abdominal setae are elongate, the locking mechanism is lost, but genital openings and papillae are not affected; first pleopods remain unaltered but second and succeeding pleopods may become biramous, typically with an antero-posterior gradient in masculinity; sperm ducts may remain large and filled with spermatophores containing spermatozoa, but spermatogenesis usually is stopped or reduced. Parasitized females appear as normal adults but the ovaries are small and pale; 1/3 of such females observed did not copulate. As noted by others, the externa of the parasites act as substitute egg masses, effecting hormonal changes to induce this. Parasitized males can be distinguished from females by absence of female genital openings.

Pearse (1932b), working at Dry Tortugas, listed the copepod *Anthiacus intermedius* from the gill lamellae (accidental guest) and a tapeworm plerocercoid, *Rhynchobothrus*, from the viscera, and (in Wilson 1935) reported a few specimens of *Cantrincola jamaicensis* Wilson from the branchial cavity of this crab. Hartnoll (1966) described a new entoniscid (*Achelion occidentalis*) from specimens of *M. bicornutus* taken in Kingston Harbor, Jamaica.

Hazlett (1972a) presented models to *M. bicornutus* to test the importance of postures of walking legs, chelae, and body during agonistic interactions. The double first ambulatory raise and spread chelipeds both elicited a significant number of responses, but multiple leg raises or lowered body posture did not. Size and sex of test animals seem to have little effect on their responses, although small crabs may retreat and slightly larger ones may respond by "freezing." Hazlett (1972b) concluded that agonistic display movements are more stereotyped than nondisplays, feeding or walking move-

ments from which they may have evolved in this species. Hazlett and Estabrook (1974) showed that a set of postures characterize the agonistic behavior patterns among individuals that meet while feeding on detritus and algae. Static factors (sex, size, color phase, hunger state) have less influence on behavior patterns shown by one animal in a fight than behavior of the other animal. The first crab to move won 70% of interactions, regardless of static factors. Camouflage of these crabs may tend to hide size.

The species lacks a tendency to match its own decorated covering with that of the background (Getty and Hazlett 1978). Lack of any tendency actively to match background may be associated with low mobility of the crabs. Animals were often found in the same habitat patch for several weeks. The authors suggest that since these crabs appear to have a moderately high rate of replacing algal decoration on their dorsal surface (every two or three

days), this tendency may be sufficient to maintain an acceptable degree of camouflage.

Randall (1967) reported *M. bicornutus* from stomach contents of the bandtail puffer, *Sphaeroides spengleri*.

### Genus *Mithrax* Desmarest 1823

Carapace convex, ovate or oblong-ovate, narrowing noticeably in front. Front formed of 2 small, often pointed rostral horns, other preorbital or antennary spines or projections laterally. Orbital margins generally more or less spinous or tuberculate. Basal article of antenna wide, bearing 2 or 3 strong spines in front; second article inserted outside of orbit at base of rostrum. Merus of external maxillipeds broad, dilated on outside; exognath broad. Sternal plastron nearly circular. Abdomen of male formed of 7 free segments. (Modified after Garth 1958).

### Key to Species

1. Carapace roughened to greater or lesser extent by tubercles or spinules, branchial grooves absent; spine lateral to movable articles of antenna conspicuous, pointed, or subtruncate. . . . . [Subgenus *Mithrax*] 2  
Carapace smooth and bearing oblique branchial grooves, either strongly or weakly indicated; spine lateral to movable articles of antenna inconspicuous, tuberculiform . . . . . [Subgenus *Mithraculus*, 1 species] *M. forceps*
2. Acute rostral horns definitely overreaching spines lateral to movable articles of antennae . . . . . 3  
Obtuse rostral horns only slightly overreaching spines lateral to movable articles of antennae. . . . . 4
3. In lateral view, spine at lateral angle (fourth or fifth) situated noticeably below level of preceding spines . . . . . *M. acuticornis*  
In lateral view, spine at lateral angle in line with preceding spines . . . . . *M. spinosissimus*
4. Carapace paved with close-set, tessellate granules (concealed by short hair in young) . . . . . *M. verrucosus*  
Carapace not paved with such granules . . . . . 5
5. Spine on or just above posterolateral margin close behind spine at lateral angle; rostral sinus U-shaped; attains large size . . . . . *M. hispidus*  
Tubercle on or just above posterolateral margin close behind spine at lateral angle; rostral sinus V-shaped except in old adults; never attains large size . . . . . *M. pleuracanthus*

#### *Mithrax (Mithrax) acuticornis* Stimpson

Figs. 267, 275a

*Mithrax acuticornis* Stimpson 1870:116.—Jones 1969:381.

*Mithrax (Mithrax) acuticornis*.—Rathbun 1925:388, pl. 136, figs. 1–2; pl. 257, fig. 1.—Coelho and Ramos 1972:214.—Felder 1973:52, pl. 7, fig. 10.—Powers 1977:56.

*Recognition characters*.—Carapace distinctly longer than broad; cervical and cardiac sutures distinct; dorsal surface ornamented with spines, short and scanty on gastric region, longer and more numerous elsewhere; 5 large anterolateral spines, first or hepatic spine tending to be doubled, next 3 often with small spine in front of each, last spine in this row at lateral angle longest and below others, behind it 1 shorter posterolateral spine. Rostral horns

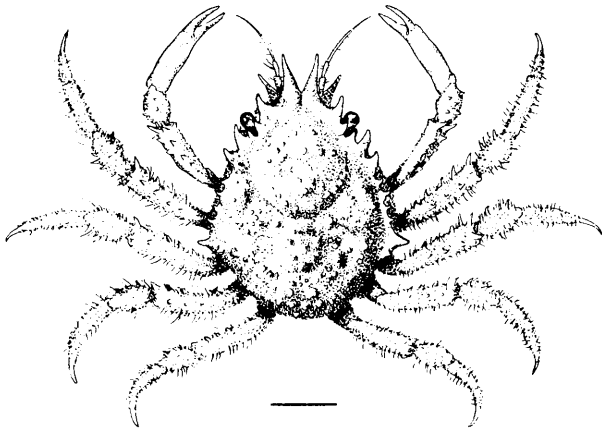


Fig. 267. *Mithrax (M.) acuticornis* Stimpson. Male in dorsal view, USNM 15817, 5 mm indicated (from Rathbun 1892).

straight with slight inward curve at tip, divergent, regularly tapering. Distolateral spine of basal (fixed) antennal article half as long as rostrum, straight or slightly curved; 2 other spines on article, 1 forming part of orbital border, other tiny spine (sometimes obsolete) at base of first movable article. Orbit armed with 1 strong ventral spine outside antennal article and 1 at outer angle, 3 above including prominent preorbital, second of these with more or less developed accessory lateral spine.

Chelipeds of male about as long and stout as first walking legs; merus with 2 rows of long spines above; carpus covered with short spines or tubercles, 3 on inner margin; palm with 1 or few dorsal spinules proximally in individuals over 18 mm long; fingers with short, narrow gape, opposed edges denticulate, larger denticle in middle of gape on dactyl. Walking legs with spines in 2 rows above on merus and carpus, especially long in first 2 pairs.

*Measurements in mm.*—Carapace: male, total length 24.2, without rostral horns 21.2, width including spines 22.2; ovigerous female, total length 18.5, without rostral horns 16.5, width including spines 15.0.

*Variation.*—Spinination is positively correlated with size.

*Color.*—Deep red orange, fingers somewhat purplish red with narrow white bands near bases (Henderson in Rathbun 1925).

*Habitat.*—Mainly calcareous bottom, occasionally sand or mud; 22 to 103 m, rarely 298 m.

*Type-localities.*—Off the Quicksands [Fla.], 62.6 m; west of the Tortugas, 67.7 and 76.8 m.

*Known range.*—Off Cape Lookout, N. C.; W Florida and Yucatan Channel through West Indies to Espírito Santo, Brazil.

*Remarks.*—Rathbun (1925) emphasized the ease

with which *M. acuticornis* may be confused with young *M. spinosissimus* and *M. cornutus*.

Ovigerous females are known from April to July in Florida, January in Bahia, Brazil, and May, June, and October in North Carolina.

Individuals collected from a reef southeast of Cape Lookout, N. C., did not survive 48-h exposure to 10°C (F. J. and W. B. Vernberg 1970).

### *Mithrax (Mithrax) hispidus* (Herbst)

(Coral crab)

Figs. 268, 275d

*Cancer hispidus* Herbst 1790:245 (247 by error), pl. 18, fig. 100.

*Mithrax (Mithrax) hispidus.*—Rathbun 1925:406, text-fig. 124, pls. 145–146; pl. 147, fig. 3.—Boone 1927:38.—Williams 1965:256, figs. 236, 245C.—Coelho and Ramos 1972:215.—Powers 1977:56.

*Mithrax hispidus.*—Jones 1969:381.—Pequegnat and Ray 1974:236, figs. 5–10.

*Recognition characters.*—Carapace swollen, considerably wider than long, smooth except for some low, rounded prominences chiefly toward outer margin of branchial region, gastric tubercles faint; front wide. Rostral horns short, obtuse, separated by U-shaped notch (sometimes narrow). Preorbital angle blunt, slightly produced. Basal article of antenna with 2 teeth, inner tooth nearly as advanced as rostrum, outer smaller tooth on orbital border. Orbit with 4 tubercles on margin, 2 superior much smaller than external or inferior ones. Anterolateral margin with 4 spiniform teeth, first tooth obtuse, often bifid at tip; second longer, sharp, double, and curving forward; third and fourth slender. Posterolateral border with smaller spiniform tooth situated higher on carapace in line with 2 obliquely located tubercles, or low spine and tubercle. Subhepatic region with 2 tubercles; a few other tubercles on subbranchial and pterygostomial regions.

Chelipeds large, unequal in males, equal in females; merus with 4 or 5 spines and few tubercles on upper surface, spine on inner margin; carpus smooth; hand smooth; fingers spooned at tips, gaping, with broad low crenulated tooth near base of dactyl. Walking legs moderately stout; dactyls slender, somewhat hooked and pointed.

*Measurements in mm.*—Carapace: large male, length 102, width 146; ovigerous female, length 52, width 62.

*Variation.*—Young individuals have tubercles on the carapace more protuberant than in the old.

*Color.*—Nearly uniform deep brownish-red or terra cotta color above, brighter on chelipeds and

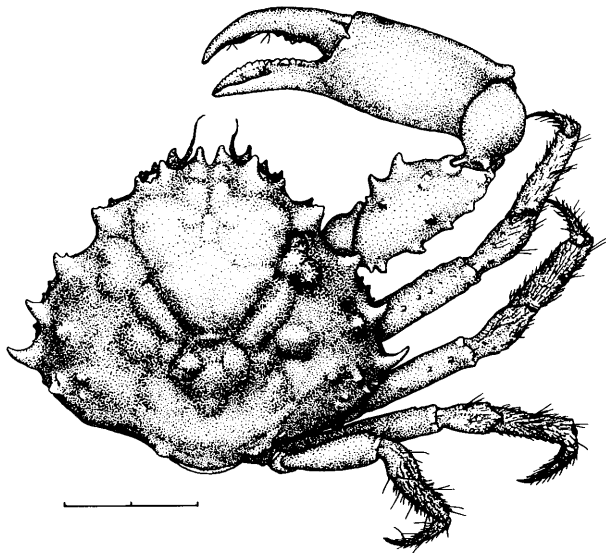


Fig. 268. *Mithrax (M.) hispidus* (Herbst). Male in dorsal view, legs of left side not shown, 20 mm indicated (from Williams 1965).

darker on legs (due to brown hairs); legs often with brighter red bands at joints; underparts of body mostly white or bluish white; legs red, speckled with pale yellow (Verrill 1908a). Body deep tan but lighter on raised areas, especially gastric and cardiac regions. Major cheliped (minor missing) with tan hand but obsolete cross rugae on inner surface lighter giving somewhat striped appearance; spines of merus lighter tan; fingers purplish near spooned tips except lighter and bluish at very edge of fine teeth along spoon. Walking legs dull reddish brown or dull maroon with cross bands of yellowish tubercles, 2 on meri (1 subproximal, 1 subdistal), indistinct band but scattered yellowish tubercles on carpi, 1 on propodi; slender dactyls with black band at base of reddish orange tips (specimen from North Carolina).

*Habitat*.—Commonly on rough bottom, also sand, shell, *Halodule* beds, and in sponges; shallow water to 64 m (Coelho and Ramos 1972).

*Type-locality*.—Unknown.

*Known range*.—Recorded in literature from as far north as Delaware Bay (Say 1818), off Charleston Harbor, S. C., and Georgia (Gibbes 1850). Northwestern Gulf of Mexico; Bahamas and Florida Keys through West Indies to São Paulo, Brazil; Bermuda.

*Remarks*.—*Mithrax hispidus* has a reported fossil record dating from Pliocene coral rock deposits in Barbados (Collins and Morris 1976).

Ovigerous females are known from off French Guiana in May, Florida in June, July and December, and St. Croix in December (USNM).

Individuals collected from a reef SE of Cape

Lookout, N. C., in September and October withstood experimental exposure to temperature of 4°C for 7 h but died after 17-h exposure (F. J. and W. B. Vernberg 1970).

### *Mithrax (Mithrax) pleuracanthus* Stimpson

Figs. 269, 275e

*Mithrax pleuracanthus* Stimpson 1871a:116.—Hay and Shore 1918:458, pl. 38, fig. 3.—Jones 1969:382.

*Mithrax depressus* Milne Edwards 1875 (in part):96, pl. 20, figs. 4–4c.—Rathbun 1901:68.—Verrill 1908a:407, pl. 23, fig. 1.—Hay and Shore 1918:458, pl. 38, fig. 2.

*Mithrax hispidus* Rathbun 1892(in part):265.

*Mithrax (Mithrax) pleuracanthus* Rathbun 1925:411, pl. 150.—Boone 1927:39.—Williams 1965:257, figs. 2376, 245D.—Powers 1977:57.

*Recognition characters*.—Carapace not much wider than long, conspicuously tuberculate; front wide. Rostral horns shorter and wider than in *M. hispidus*, notch between horns narrower and nearly triangular, always triangular in young individuals. Preorbital angle blunt, slightly produced; orbit with 2 superior tubercles; small postorbital angle and suborbital tubercle. Basal article of antenna with 2 teeth, inner one nearly as advanced as rostrum, outer smaller one on orbital border. Spines of anterolateral border well developed, first or second inclined to be double, posterior 2 more acute and

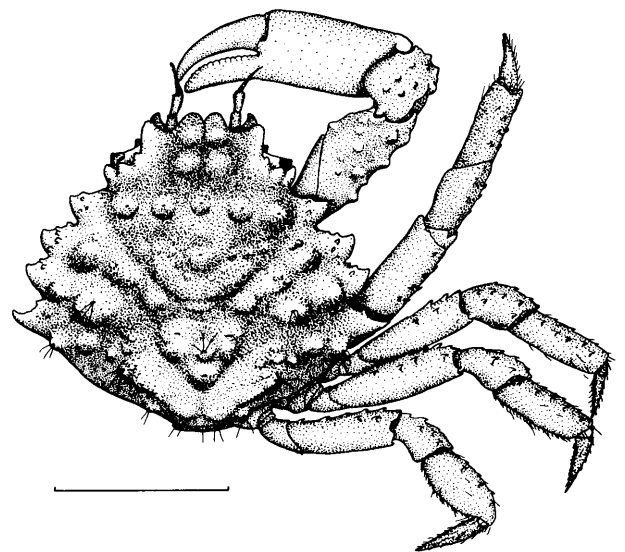


Fig. 269. *Mithrax (M.) pleuracanthus* Stimpson. Animal in dorsal view, legs of left side not shown, 10 mm indicated (from Williams 1965).

pointed forward, small tubercles about base of spines. Gastric region with transverse row of 5 tubercles; in front of these, 2 pairs of tubercles, anterior pair at base of rostral horns. Mesogastric region with 2 tubercles on each side in transverse line. Cardiac region with 3 poorly defined tubercles. Branchial area with 4 rather strong tubercles and several smaller ones arranged more or less in 3 oblique rows radiating from cardiac region to anterolateral border.

Chelipeds large; merus with scattered low spines on upper margin, simple spine, spine and tubercle, or rounded eminence on inner margin and 5 small spines on posterior border; carpus smooth or with few low tubercles on upper surface; hands smooth; fingers slightly gaping, dentate for nearly entire length, spoon shaped at tips. Walking legs dentate and hairy.

*Measurements in mm.*—Carapace: large male, length 36, width 44; ovigerous female, length 16, width 19.

*Variation.*—In young individuals the rostral horns are wider behind and flatter than in adults; the notch between the rostral horns in extremely large individuals may be U-shaped; the large tubercle above the posterolateral margin may be spiniform but is located higher on the carapace than the similarly formed tubercle in *M. hispidus*.

*Color.*—Carapace yellowish white, with blotches of bright red; 2 largest red spots over branchial areas, median spot on cardiac area, pair situated farther back, small pair behind orbits, and another beneath orbits; legs yellowish white, blotched or barred with red; chelae light red with pale tips (Verrill 1908, for *M. depressus*).

*Habitat.*—The species, which is often encrusted with bryozoans and other organisms, is found predominantly on coarse or rocky substrates but occasionally on muddy or sandy bottom. In North Carolina it is a common species on the offshore banks and is associated with *M. forceps*. Pearse (1934) found the species in canals of the sponge *Stematumenia strobilinia* at Tortugas, Fla. Shallow water to 51 m.

*Type-localities.*—Key West, 3.6–9.1 m, Tortugas [Fla.] 9.1–11 m; St. Thomas.

*Known range.*—Beaufort, N. C., to Pensacola, Fla., western Gulf of Mexico to Yucatan Channel off Cape Catoche, Mexico; West Indies to Venezuela; Bermuda.

*Remarks.*—Ovigerous females are known in Florida from December to August; North Carolina in April and September; St. Thomas in July, and Venezuela in April and September (Rathbun 1925; USNM).

Yang (1967) described first stage zoeae reared

from an ovigerous female collected from Biscayne Bay, Fla.

***Mithrax (Mithrax) spinosissimus* (Lamarck)**

Figs. 270, 275b

*Maia spinosissima* Lamarck 1818:241.

*Mithrax (Mithrax) spinosissimus.*—Rathbun 1925:383, pl. 135.—Chace 1940:67.—Williams 1965:254, figs. 234, 245A.—Collins and Morris 1976:118, pl. 17, fig. 1; pl. 18, figs. 2,3.—Powers 1977:58.

*Mithrax spinosissimus.*—Jones 1969:380.

*Recognition characters.*—Large. Carapace nearly naked, subcircular, approximately as broad as long; surface rough with short spines, those in center blunt, elsewhere sharp; cervical suture deep; hepatic and cardiac regions distinctly delimited. Rostral horns narrow, obliquely truncate and granulate at extremity, separated by U-shaped notch of equal length and breadth; 2 stout spines at base of horns and 2 more behind these but farther apart; preorbital spine stouter, truncate, and less advanced than rostrum. Orbital border with 3 small teeth exclusive of postorbital spine; suborbital margin with 1 acute spine outside antennal segment and larger truncate spine lateral to this. Antennal segment with outer small acute spine and inner spine more or less advanced than rostrum bearing small secondary lateral spine near end. Lateral margin with 6 spines, first 2 double, last and smallest one on posterolateral margin. Other spines present on suborbital, subhepatic, subbran-

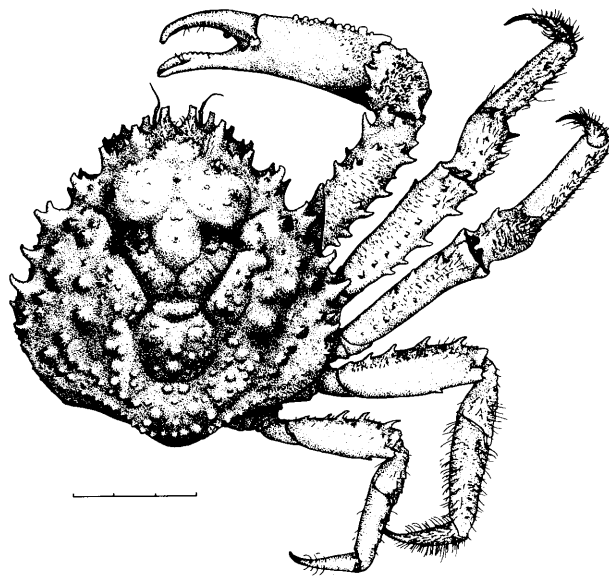


Fig. 270. *Mithrax (M.) spinosissimus* (Lamarck). Male in dorsal view, legs of left side not shown, 30 mm indicated (from Williams 1965).



chial, pterygostomian regions, and at angle of buccal cavity.

Chelipeds of adult male massive, longer than walking legs; merus armed with 8 or 9 stout spines on outer margin, others irregularly placed; carpus armed with unequal spines, about 5 on inner margin; hand deep, compressed, armed above with more or less double row of spines and on inner surface with 2 to 4 spines proximally; fingers curved leaving wide gape, strong tooth near middle of dactyl, tips spooned with edges crenate preceded by few low tubercles. Adult female with chelipeds no longer and not much stouter than first pair of walking legs; hand tapering somewhat distally; fingers narrowly gaping with numerous denticles on cutting edges. Walking legs of both sexes spinose and coarsely hairy; propodi elongate and compressed.

*Measurements in mm.*—The largest species of *Mithrax* in the region. Carapace: male, length 170, width 184; female, length 77, width 80.

*Variation.*—In large males, spines on the chelipeds tend to become blunt and tuberculiform. In medium-sized individuals, the carapace is relatively longer than in the largest, spines are sharper, rostral horns curve inward at the sharp tips, the carapace is covered with short hair, chelipeds of both sexes are small, and the gape extends only half the length of the fingers. In small individuals, the spines are even more accentuated, rostral horns are  $\frac{1}{3}$  as long as the carapace, there are two spines on the suborbital margin outside the antennal segment, chelipeds are no longer or stouter than the first walking legs, and gape of the fingers is less than in large individuals.

*Color.*—Bright carmine; vinous red with yellowish tints; or cephalothorax dark red; walking legs brick red and chelipeds rose red with yellow fingers (various authors including Rathbun 1925).

*Habitat.*—The species is often covered with encrusting organisms and found among rocks; shallow water to 179 m.

*Type-locality.*—"Ile-de-France." Locality erroneous.

*Known range.*—North (?) and South Carolina to Nicaragua, and through West Indies to Barbados and Venezuela.

*Remarks.*—Collins and Morris (1976) reported *M. spinosissimus* from Pliocene and Pleistocene coral rock in Barbados. Ovigerous females are known possibly year-round in southern Florida (Hazlett and Rittschof 1975; Bohnsack 1976), and are reported in March, May and June from Cuba (Rathbun 1925; Chace 1940) and January in Venezuela (Provenzano and Brownell 1977).

The latter worked out larval development from

captured females under primitive laboratory conditions, finding that at 24–28°C in seawater of 34–36‰ salinity the larvae developed from hatching to first crab in about six days. Stages include a non-swimming prezoaea, two zoeae, and a megalopa.

Hazlett and Rittschoff (1975) and Bohnsack (1976) found from study of a population in a canal in the Florida Keys that the crabs are herbivorous, living primarily on algae scraped from rocks at night. Population density there was highly correlated with crevice density, clusters of 2–11 crabs often living together, but females often exclude other females from crevices and presence of many females in an area restricts their movements. The nocturnal animals usually forage within 4 to 6 m of a crevice, but if they do not return to this shelter they will move an average of 12.9 m to another crevice by dawn. The extent of daily movement is inversely correlated with spider crab density, especially for females, with no correlation between animal size and measure of movement; males relocate more than females. Presence of spiny lobsters usually excludes crabs from crevices.

Claw meat in the large crabs is a limited food resource. The crabs cannot be trapped, removal of a claw from a living crab is often fatal, and slow growth of an estimated 18 months between molts precludes quick regeneration after removal.

### *Mithrax (Mithrax) verrucosus* H. Milne Edwards

Figs. 271, 275c

*Mithrax verrucosus* H. Milne Edwards 1832:cl. 7, pl. 4 (col.) [+ unpaginated description].—Jones 1969:119.

*Mithrax (Mithrax) verrucosus.*—Rathbun 1925:400, pl. 144.—Boone 1927:39.—Williams 1965:255, figs. 235, 245B.—Coelho and Ramos 1972:215.—Collins and Morris 1976:119, pl. 17, fig. 7, pl. 18, figs. 5–6.—Powers 1977:58.

*Recognition characters.*—Mature males, large to medium-sized. Carapace covered with flattened, closely crowded granules, nearly naked, granules covered with small pits, cervical suture deep; branchial region with few dorsal spines on outer part, front and orbit with truncate spines. Rostral horns short, separated by deep notch. Preorbital spine directed somewhat outward, 4 other spines on orbital margin aside from 3 on broad basal antennal article. Anterolateral margin with 8 spines, first 6 in pairs, anterior spines of each pair smaller, spines in first 2 pairs more or less united at base; single posterolateral spine, and below lateral margin a row of about 9 spines.

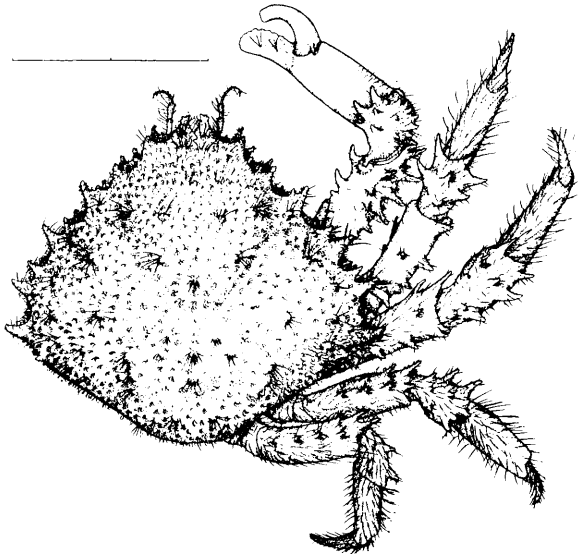


Fig. 271. *Mithrax (M.) verrucosus* H. Milne Edwards. Male in dorsal view, legs of left side not shown, 20 mm indicated (from Williams 1965).

Chelipeds stout; outer margin of merus with 6 sharp spines, approximately 6 spines on upper surface; inner margin of whole cheliped armed with blunt spines or lobes, 11 on ischium, 4 on merus, 2 or 3 on carpus; carpus with dorsal surface smooth or slightly tuberculate proximally; palm unarmed, elongate, somewhat swollen, fingers gaping with large tooth near middle of dactyl, edges of spoon-shaped tips slightly crenulate, 2 bunches of hair inside spoon. Walking legs covered with coarse hair, meri and carpi spiny.

*Measurements in mm.*—Carapace: male, length 51, width 65; ovigerous female, length 35, width 43.

*Variation.*—Females, juveniles, and most immature males differ from mature males in that the carapace is covered densely with hair; rostral horns of females and immature males are shorter and farther apart but horns of the young are sharper; spines on the inner margin of the chelipeds are sharper, the carpus is more or less spiny dorsally, and the palm is spinulose and hairy above proximally. The degree of spination on the chelipeds also varies individually.

*Color.*—Dark red; color largely concealed by hairiness, carapace dark dull red, pincers olive above and lighter olive below, tips claret, teeth white, underparts maroon flecked with white and yellow (various authors and Rathbun 1925).

*Habitat.*—This species lives near shore among rocks, where it hides in holes. It is nocturnal, and has been caught with the aid of a light while feeding.

*Type-locality.*—Robert Bay, Martinique.

*Known range.*—Charleston, S. C.; Campeche

Banks; through West Indies to Fernando Noronha Island, Brazil.

*Remarks.*—Collins and Morris (1976) reported *M. verrucosus* from Pliocene and Pleistocene coral rocks in Barbados.

Ovigerous females are known from Cuba in April and Florida in July and August.

Randall (1967) reported *M. verrucosus* from stomach contents of the Nassau grouper, *Epinephelus striatus*.

### *Mithrax (Mithraculus) forceps* (Milne Edwards)

Figs. 272, 275f

*Mithraculus forceps* A. Milne Edwards 1875:109, pl. 23, fig. 1.

*Mithrax forceps.*—Hay and Shore 1918:457, pl. 38, fig. 1.—Jones 1969:382.

*Mithrax (Mithraculus) forceps.*—Rathbun 1925:431, pl. 156.—Chace 1940:67.—Williams 1965:258, figs. 238, 245E.—Türkyay 1968:254.—Coelho and Ramos 1972:216.—Pequegnat and Ray 1974:236, fig. 1–4.—Powers 1977:55.

*Recognition characters.*—Carapace about  $\frac{1}{5}$  wider than long, deeply sculptured in young individuals but smoother with age. Anterolateral margin with 4 tubercles or simple teeth exclusive of postorbital angle, separated by broad rounded sinuses, first tooth usually shortest, remainder usually acute and turned forward at tip. Three grooves running diagonally backward over branchial area from near first, second, and fourth sinuses of anterolateral margin, between these grooves 2 well-defined, unbroken ridges and broken ridge behind third groove. Cardiac and gastric regions crossed by less sharply defined ridges somewhat broken up into low rounded tubercles. Notch between rounded rostral horns broadly V-shaped, 2 pairs of tubercles on frontal region behind lobes of rostrum. Preorbital angle prominent, not exceeding rostrum. Orbital margin with dorsal and ventral tubercle near postorbital angle. Outer spine of fused antennal article nearly equaling rostrum.

Chelipeds strong. Merus with 2 strong spines or tubercles in front, 5 much smaller ones on posterior margin, and usually 2 on upper surface near posterior margin. Carpus smooth or with small spine or tubercle on inner margin near inner distal angle. Hand smooth, polished, somewhat tumid. Fingers widely gaping in male, with expanded hollowed-out tips; dactyl with single large tooth  $\frac{1}{3}$  distance from proximal end, or with few minute teeth; fixed finger with from 1 to 3 small teeth or tubercles in

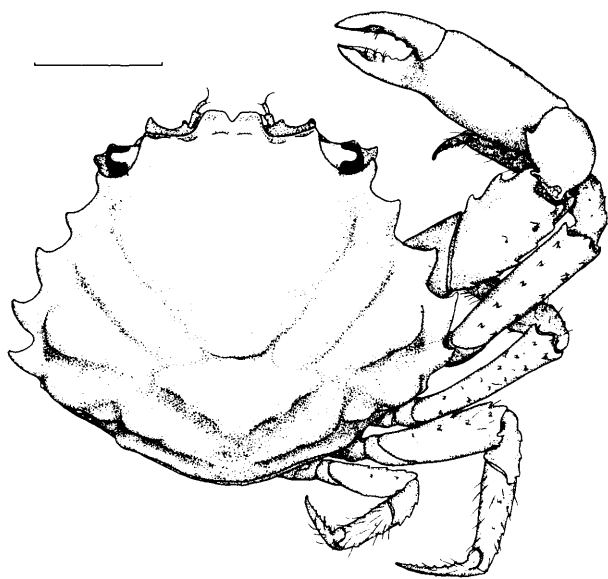


Fig. 272. *Mithrax (Mithraculus) forceps* A. Milne Edwards. Male in dorsal view, legs of left side not shown, 5 mm indicated (from Williams 1965).

middle. Walking legs spiny or denticulate with many fine hairs.

*Measurements in mm.*—Carapace: male, length 31, width 38; ovigerous female, length 20.7, width 23.3.

*Color.*—Red, approaching vermilion, with occasional trace of purple. Terra cotta, or uniform yellowish brown, varying to greenish brown; often with wide, pale yellow, median dorsal stripe, and legs often banded, especially in young individuals (various authors).

*Habitat.*—The species lives on rocky shores and reefs in crevices, under stones and dead coral; also exposed between tides and in shallow water in certain areas (Verrill 1908a; Coelho and Ramos 1972; Pequegnat and Ray 1974). In North Carolina this form is found on offshore reefs and has been found in the sponge *Stematomenia strobilinia* at Dry Tortugas, Fla. (Pearse 1934). Intertidal to 90 m.

*Type-locality.*—Guiana.

*Known range.*—From Cape Hatteras, N. C., through Gulf of Mexico to Rio de Janeiro, Brazil; Bermuda.

*Remarks.*—Ovigerous females have been taken virtually the year round in Florida, and from the northern Gulf of Mexico in February (Pequegnat and Ray 1974), Cuba in March (Chace 1940), Curacao in April, Barbados and Aruba in midsummer, Venezuela in September and November, North Carolina in September, and Trinidad in November (Rathbun 1925; USNM). Lebour (1944) and Yang (1967) described some of the larval stages, but Wilson, et al. (1979) reared, described and illustrated the full larval development. From ovigerous females taken in 6-m depths off St. Lucie County, Fla., in September, eggs were maintained in 36‰ salinity at 20°, 25°, and 20°–25°C on a diet of *Artemia* nauplii. They passed through a prezoal and two zoal stages plus a megalopa, developing to first crab in 14 days at 25°C and 16 days at 20°C.

Randall (1967) reported *M. forceps* in stomach contents of the squirrelfish, *Holocentrus ascensionis*, and longspined squirrelfish, *H. rufus*.

#### Genus *Stenocionops* Desmarest 1823

Garth 1958:401.

Carapace subpyriform, rather convex, dorsal surface uneven, tuberculated or spinous; lateral margins armed with series of long spines; preocular spine well developed. Rostrum composed of 2 strong, deflexed spines divergent from base. Orbits tubular, not strongly projecting; eyes small, retractile within orbits. Basal antennal article considerably enlarged, armed with 1 or 2 small distal spines or tubercles not visible in dorsal view. Abdomen in male distinctly 7-segmented. (Modified after Garth 1958.)

#### Key to Species

1. Hepatic region neither enlarged nor produced beyond general outline of carapace, armed with not more than 1 large spine . . . . . 2  
    Hepatic region enlarged and produced separately from curve of branchial region, 3 marginal hepatic spines; carapace with 12 or 13 median spines . . . . . *S. spinimana* (adult)
2. Four marginal spines behind orbit; carapace with about 4 median spines or spiniform tubercles. . . . . *S. furcata coelata*  
    Three marginal spines behind orbit; carapace with about 8 median spines . . . . . *S. spinimana* (young)

#### *Stenocionops furcata coelata* (A. Milne Edwards)

Figs. 273, 275i

*Pericera coelata* A. Milne Edwards 1878:224.

*Stenocionops furcata coelata.*—Hay and Shore 1918:460, pl. 39, fig. 3.—Rathbun 1925:450, pl. 164.—Williams 1965:261, figs. 241, 245H.—Felder 1973:53(?).—Powers 1977:59.

*Recognition characters.*—Carapace oblong-ovate, approximately  $\frac{3}{4}$  as wide as long, uneven, with strong spines and dense covering of short setae and many scattered, longer, hooked hairs. Rostrum consisting of 2 nearly straight diverging horns with rows of hooked setae. Orbital region broad, eyes small, retractile within tubular orbits; preorbital spine strong, suborbital and postorbital spines much smaller. Basal antennal article enlarged, armed with 1 or 2 small distal spines or tubercles not visible dorsally. Middorsal line with 4 strong spines or spiniform tubercles, 1 on gastric region, remainder on cardiac and intestinal regions, fourth spine with tip curved forward. Lateral border with 4 stout spines, 1 on hepatic, remainder on branchial region; in addition, 2 other rather stout spines on branchial region and various smaller spines toward front. Ventral surface of body, except distal articles of chelipeds, closely covered with bulbous setae hiding carapace.

Chelipeds in adult males fairly large and nodose; hand long, cylindrical, and granulate; fingers approximately half as long as palm, gaping in basal half, tooth on dactyl near base. In other individuals chelipeds weak; fingers less than half as long as palm; merus with strong spines above near distal end preceded by several smaller spines. Walking legs moderately elongate, more or less rough with clusters of hooked hairs, articles subcylindrical.

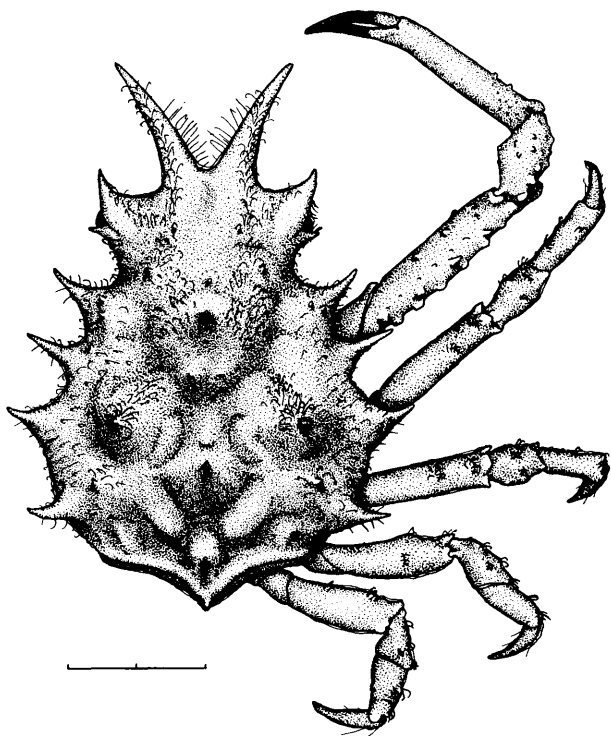


Fig. 273. *Stenocionops furcata coelata* (A. Milne Edwards). Male in dorsal view, legs of right side in part (from Rathbun 1925), legs of left side not shown, 20 mm indicated (from Williams 1965).

Abdomen in male and female with 7 distinct segments.

*Measurements in mm.*—Carapace: large male, length including rostrum 137, length rostral horn 26, width including spines 111; smaller male, same measurements 91, 25, 64; ovigerous female 91, 18, 68.

*Variation.*—Large individuals have relatively shorter rostral horns than smaller ones; juveniles are smoother than adults.

*Color.*—Dark red or orange red, distal half of fingers dark purplish to black.

*Habitat.*—Found on a variety of bottoms, including fine white sand, yellow sand, coarse gray sand, sand with algae, sandy shell, broken shell, and coral; it has been reported most often from coarse bottom (Rathbun 1925). Shallow water near shore to 110 m, rarely to 509 m.

*Type-localities.*—Ten miles from Jolbos Islands [Yucatan], and near Havana [Cuba], 320 m.

*Known range.*—Shelly reefs off Beaufort, N. C., to northwest Florida and Alabama; Yucatan Channel; West Indies to Barbados.

*Remarks.*—This subspecies is similar to the typical subspecies *S. f. furcata* which ranges from Georgia to Bahia, Brazil, in shallow water near shore to 64 m depth. The typical subspecies has the carapace more evenly sculptured and is less spinose than *S. f. coelata* (Rathbun 1925:449).

*Stenocionops furcata* may carry as many as 20–30 *Calliactis tricolor* on its carapace and legs (Cutress, et al. 1970). When it encounters *C. tricolor* attached to another surface, the crab uses chelipeds and walking legs in stroking, scratching, and pinching movements, at first gently, then more actively, until the anemone is freed. After a period of manipulation, the crab seizes the anemone firmly in one claw and hoists it overhead to place it on the carapace. Both chelipeds usually test the carapace beforehand for free areas. The anemone relaxes completely when stimulated and manipulated in these ways, apparently in a state of general inhibition.

Ovigerous females are known in Florida from March to August (USNM).

Individuals collected from a reef SE of Cape Lookout, N. C., in September and October withstood experimental exposure to temperature of 4°C for 7 h but were dead after 17-h exposure (F. J. and W. B. Vernberg 1970).

#### *Stenocionops spinimana* (Rathbun)

Figs. 274, 275j

*Libinia spinimana* Rathbun 1892:240, pl. 30.

*Stenocionops spinosissima.*—Hay and Shore 1918:460, pl. 39, fig. 2.

*Stenocionops spinimana*.—Rathbun 1925:457, pl. 267.—Williams 1965:262, figs. 242, 245I.—W. E. Pequegnat 1970:182.—Powers 1977:59.

*Recognition characters*.—Carapace subpyriform, convex, covered with sparse growth of short, fine, curled hairs; 8 to 13 median dorsal spines (occasionally doubled), and numerous other spines on gastric and branchial regions; 3 anterior marginal hepatic spines, anteriormost small and occasionally absent in large individuals. Rostral horns widely divergent, straight, tapering gradually to slender tip. Orbits tubular, not strongly projecting, eyes small, retractile within orbits; preorbital spine similar in size to spine near anterolateral angle of basal article of antenna.

Merus and carpus of chelipeds with numerous spines, hand with 2 rows of spines above, 1 below, spines becoming progressively smaller distally. Walking legs with few spines; each merus with terminal spine above, and on first leg a longitudinal inner-upper row of 5 or 6 and ring of about 4 spines near distal end; on second leg a ring of 3 or 4; on third and fourth only 1 or 2 spines besides terminal spine. Carpus of first leg with 3 or 4 spines, second with 3 spinules or tubercles, third and fourth with 1.

Abdomen in male and female with 7 segments, 6 free in females.

*Measurements in mm*.—Carapace: large male,

length including rostral horns 130, length horns 11, width including spines 118; smaller male (holotype), same measurements 89, 10, 76; ovigerous female, length to base of broken rostrum 103, width including spines 94.

*Variation*.—This species exhibits great change in shape and spination with increasing size, as has been pointed out by Rathbun (1925), and Garth (1958) for related forms. Young individuals differ much in shape from adults, having a width considerably less than length (width about 70% of length including spines and rostrum), whereas the mature animals are more rounded in contour (large adult male, width about 90% of length). Adults have a thicker coating of hair than juveniles, especially on the chelipeds. Chelipeds in large adults become quite large and stout with the palm compressed (length more than twice that of carapace). The young have fewer spines than adults; the hepatic region is not expanded and bears only 1 marginal spine as opposed to 3 spines in adults.

*Habitat*.—Found on a variety of bottoms, from gray mud, through various grades of sand, to sandshell, coral, and rock (Rathbun 1925); 37 to 227 m.

*Type-locality*.—Off Cape Lookout, N. C., 227 m.

*Known range*.—Off Cape Hatteras, N. C., to Florida Straits and Gulf of Mexico off Mobile Bay, Ala., and E of Chandeleur Is., off Miss. (Franks, et al. 1972).

*Remarks*.—Ovigerous females have been re-

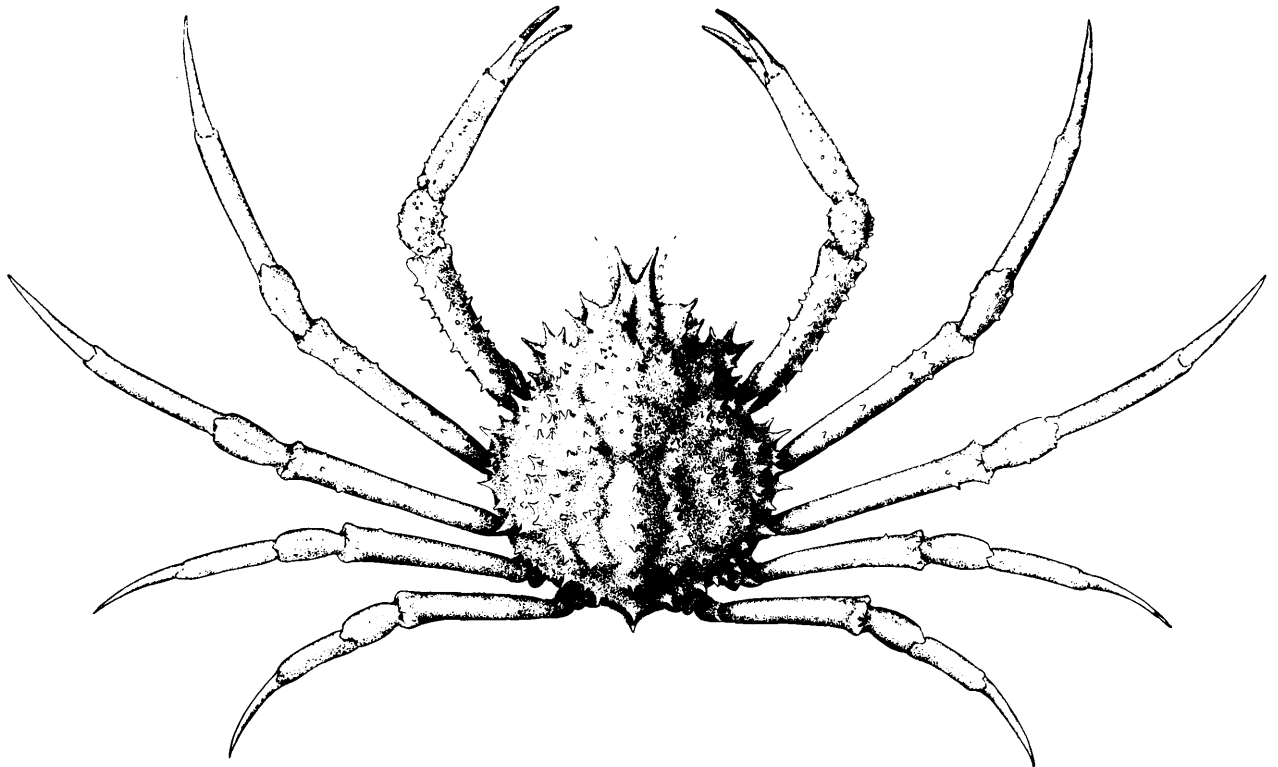


Fig. 274. *Stenocionops spinimana* (Rathbun). Holotypic male in dorsal view (from Rathbun 1892).

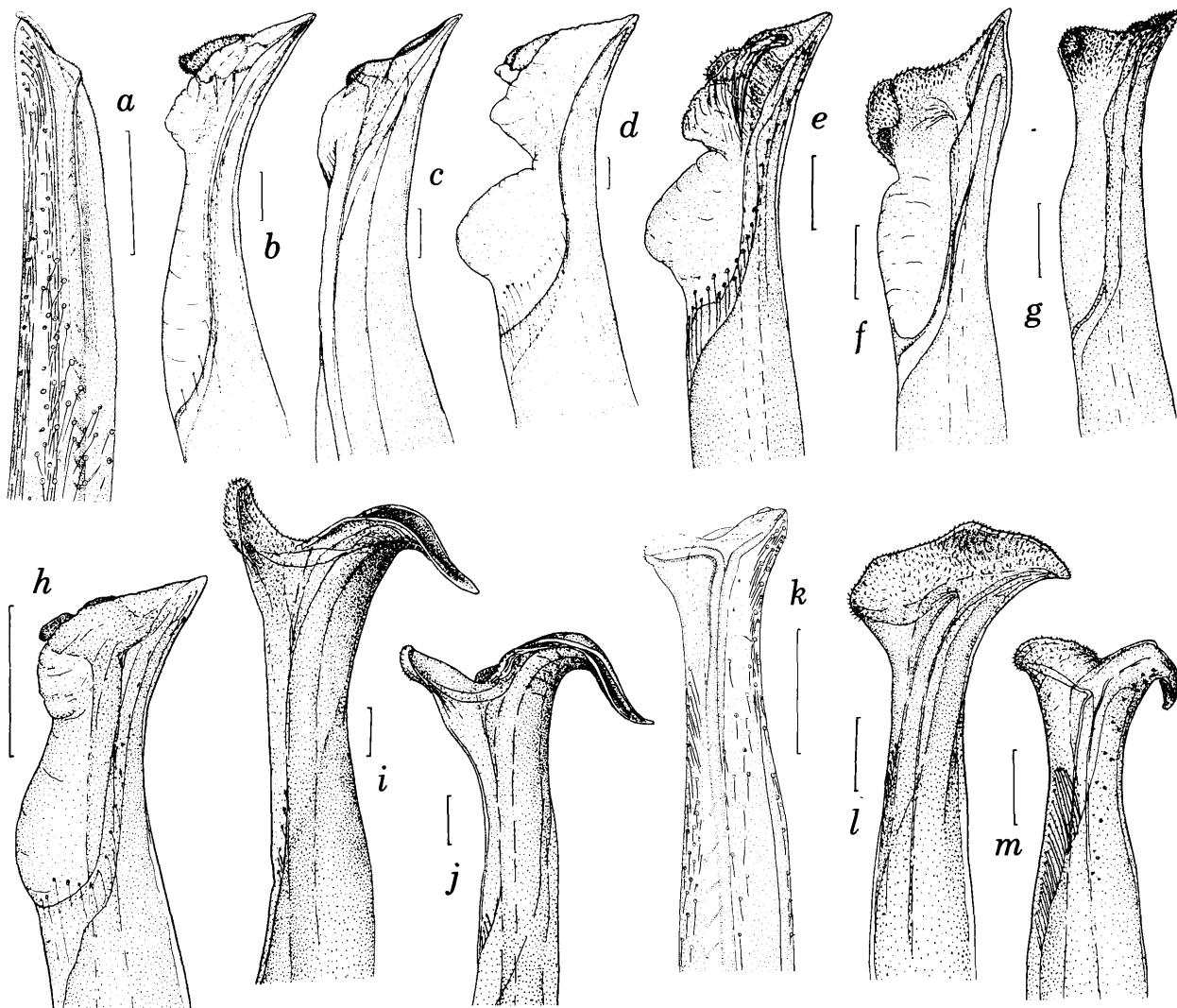


Fig. 275. Subfamily Mithracinae, tips of right first pleopods of males: *a*, *Mithrax* (*M.*) *acuticornis* Stimpson, UNC-IMS 2210; *b*, *M. (M.) spinosissimus* (Lamarck); *c*, *M. (M.) verrucosus* H. Milne Edwards; *d*, *M. (M.) hispidus* (Herbst); *e*, *M. (M.) pleuracanthus* Stimpson; *f*, *M. (Mithraculus) forceps* A. Milne Edwards; *g*, *Microphrys bicornutus* (Latreille); *h*, *Microphrys antillensis* Rathbun; *i*, *Stenocionops furcata coelata* (A. Milne Edwards); *j*, *S. spinimana* (Rathbun); *k*, *Macrocoeloma eultheca* (Stimpson), USNM 46932; *l*, *Macrocoeloma trispinosum* (Latreille); *m*, *Macrocoeloma camptocerum* (Stimpson); *a-j*, sternal view; *k-m*, lateral view; all except *a* and *k* from Williams 1965; 0.33 mm indicated.

ported from Florida in late summer, and from South Carolina in December (Rathbun 1925).

### Superfamily Parthenopoidea

#### Family Parthenopidae

Eyes usually retractile within small, circular, well-defined orbits, floor of orbit nearly continued to front, leaving hiatus usually filled by second [article] of antennary peduncle. Basal antennal [article] small, deeply imbedded between inner angle of orbit and antennular fossae. Antennules folding somewhat obliquely (Alcock 1895).

#### Subfamily Parthenopinae

Carapace commonly equilaterally triangular, sometimes subpentagonal or ovate-pentagonal, and sometimes almost semicircular or semi-elliptical in outline. Cardiac and gastric regions usually deeply marked off from branchial regions on either side, making dorsal surface of carapace trilobed. Rostrum simple or obscurely trilobed. Chelipeds vastly longer and more massive than walking legs (Alcock 1895). First pleopod varying, more or less stout, apically tapering or not tapering; second pleopod usually short and of usual shape (Stephensen 1945).

## Key to Genera

(Modified after Rathbun 1925)

1. Carapace not laterally expanded over walking legs . . . . . 2  
Carapace more or less expanded to form vault concealing walking legs from dorsal view . . . . . 4
2. Carapace tuberculate or eroded . . . . . *Parthenope*  
Carapace smooth except for few strong spines . . . . . 3
3. Efferent branchial channels opening at sides of endostome as usual in *Oxyrhynga* . . . . . *Solenolambrus*  
Efferent branchial channels opening at middle of projecting, triangular endostome as usual in *Oxystomata* . . . . . *Mesorhoea*
4. Carapace greatly expanded both laterally and posteriorly; pterygostomial region smooth, not ridged . . . . . *Cryptopodia*  
Carapace expanded laterally but not posteriorly; pterygostomial and subhepatic regions transversed by granulate or crenulate ridge . . . . . *Heterocrypta*

Genus *Parthenope* Weber 1795

Garth 1958:434.—China 1966:249.

Carapace either broadly triangular or ovate-pentagonal, front pointed but short. Surface granular, tubercular or spiny. Eyes enclosed in distinct orbits, a suture above, hiatus below occupied by second article of antennal peduncle. Antennules

folding obliquely; antennae small, basal article extremely short and not reaching front, wedged between antennular fossa and large lobe constituting floor of orbit. Chelipeds usually of immense size and length, out of all proportion to short, slender walking legs; usually prismatic with borders strongly dentate; fingers shorter than palm and abruptly curved inward and a little downward. (Modified after Garth 1958.)

## Key to Species

1. Carapace ovate-pentagonal, surface scarcely carinate in adult . . . . .  
. . . . . [Subgenus *Parthenope*] *P. agona*  
Carapace broadly triangular, carinate or tuberculate with more or less rounded sides . . . . . [Subgenus *Platylambrus*] 2
2. Carapace and chelipeds very flat; spine at end of main dorsal branchial ridge small . . . . . *P. granulata*  
Carapace convex, chelipeds not flat; spine at end of main dorsal branchial ridge large . . . . . 3
3. Carapace much broader than long; hand with 8–12 teeth on inner, 10–12 on outer margin . . . . . *P. pourtalesii*  
Carapace not much, if any, broader than long; hand with few good-sized marginal teeth, 6–8 on inner, 3–5 on outer margin . . . . . *P. fraterculus*

*Parthenope (Parthenope) agona* (Stimpson)

Figs. 276, 280a

*Lambrus agonus* Stimpson 1871a:131.*Parthenope agona*.—Hay and Shore 1918:462, pl. 39, fig. 5.—Gore and Scotto 1979:35, figs. 16, 17E–H, h, 18.*Parthenope (Parthenope) agonus*.—Rathbun 1925:513, text-figs. 146, 178–179; pl. 275, figs. 1–3.—Türkay 1968:254.—Powers 1977:68.*Parthenope (Parthenope) agona*.—Williams 1965:266, figs. 246, 252A.—W. E. Pequegnat 1970:183.

*Recognition characters*.—Carapace ovate pentagonal or subcircular, somewhat broader than long, sides rounded without angles. Postorbital constrictions light, not involving pterygostomial ridge continuing from lower side of orbit to point above cheliped. Depressions between regions of carapace not markedly deep; surface coarsely punctate or eroded and with numerous granules and tubercles, larger tubercles more or less spiniform and arranged as follows: 5 on gastric region, 3 on cardiac, 1 on each side of urocardiac lobe, 5 on branchial, and 1 on each hepatic region. Anterolateral

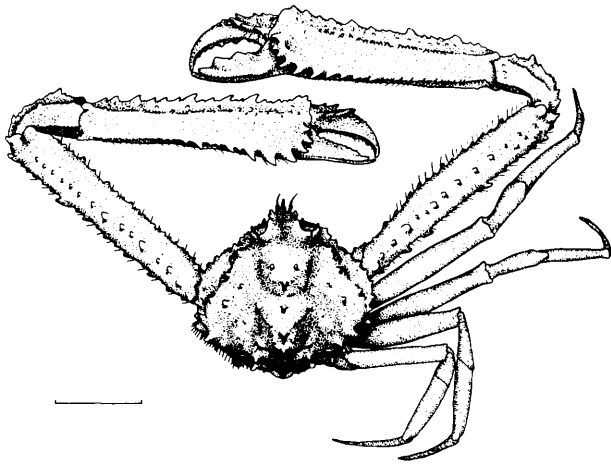


Fig. 276. *Parthenope (Parthenope) agona* (Stimpson). Male in dorsal view, position of legs reconstructed, walking legs of left side not shown, 10 mm indicated (from Williams 1965).

margin of branchial region with 6 small teeth, broad triangular tooth below and behind last tooth, and still lower on ventral surface a spine visible between ischia of cheliped and first leg. Median rostral tooth narrow, produced, denticulate at base, an acute forward-pointing tooth over each antennular cavity. Orbit with several spines on outer margin, suture above, open below; eye with small spine on upper surface. Conical spine or tubercle on each side of sternum near base of chelipeds.

Chelipeds long, slender (length of merus approximately 1.3 times width of carapace), prismatic, upper surface finely rugose. Merus and carpus with irregular row of dentiform tubercles near middle of upper surface, on inner and outer margins, and near outer margin of hand. Upper margin of hand with row of 18–20 irregular teeth, largest near base of fingers but decreasing in size both proximally and distally; outer margin with 4–6 larger teeth and many intermediate smaller ones. Walking legs long, slender, bare, and almost smooth.

Second segment of abdomen with sharp transverse crest.

*Measurements in mm.*—Carapace: male, length 20, width 21, length of merus 30; ovigerous female, width 16.5 (Gore and Scotto 1979).

*Variation.*—The rostrum may be broadly triangular or subentire instead of tridentate with denticulate margins. In young individuals it is less produced, the pterygostomial ridge is less developed anteriorly and the postorbital constriction more evident than in adults.

*Color.*—Light buff, somewhat marbled with purple, chelipeds and legs with broad bands of purple.

*Habitat.*—Reported from predominantly sandy or broken-shell bottom (Rathbun 1925); 46 to 391 m.

*Type-localities.*—Off the Marquesas, Carysfort Reef, and Conch Reef, 73 and 89.6 m [southern Fla.].

*Known range.*—Off Capes Hatteras and Lookout, N. C., and central eastern Florida; Gulf of Mexico and Pensacola, Fla., to near Ft. Myers; through Florida Straits, West Indies and Caribbean Sea to Surinam.

*Remarks.*—Ovigerous females have been taken from Florida in January, March, April and August–November, and off the Guianas in September (USNM).

Individuals collected from a reef SE of Cape Lookout, N. C., in September and October withstood experimental exposure to temperature of 4°C for 7 h but were dead after 17-h exposure (F. J. and W. B. Vernberg 1970).

### *Parthenope (Platylambrus) fraterculus* (Stimpson)

Figs. 277, 280b

*Lambrus fraterculus* Stimpson 1871a:130.

*Parthenope (Platylambrus) fraterculus.*—Rathbun 1925:525, pls. 186–187; pl. 190, fig. 2.—Williams 1965:269, figs. 249, 252D.—Powers 1977:68.

*Parthenope fraterculus.*—Gore and Scotto 1979:41, figs. 19–21.

*Recognition characters.*—Carapace subtriangular, approximately 4-sided, posterolateral margins continuous with sides of posterior margin, and long anterolateral margins in line with rostral borders. Depressions separating branchial from cardiac and hepatic regions deep; cardiac and gastric regions connected by narrow ridge, hepatic and branchial regions by wider ridge bounded below by deep hollow visible in side view; hepatic region with large submarginal tubercle visible in dorsal view. Margin of branchial region cut into 11–13 small teeth; posterior margin with 3 equal teeth. Prominences of carapace ornamented with few large tubercles and spines as follows: 3 gastric in triangle, 1 genital, 2 cardiac, and 3 on branchial ridge. Front inclined about 45°, ending in narrow blunt tooth, blunt tooth on each side above antennules, and outside below these a small slender spine. Tubercle on preorbital lobe; orbit with small blunt tooth on inner lower angle and large tubercle between this and angle of buccal cavity. Endognath with row of 5 tubercles near outer margin.

Chelipeds of male approximately 2.5 times as long as carapace; inner, outer, and upper margins of merus with few unequal stout spines; inner and outer margin of hand armed with triangular, denticulate, unequal teeth, 6 or 7 larger ones on inner, 3 or 4 on outer margin; largest tubercle on upper



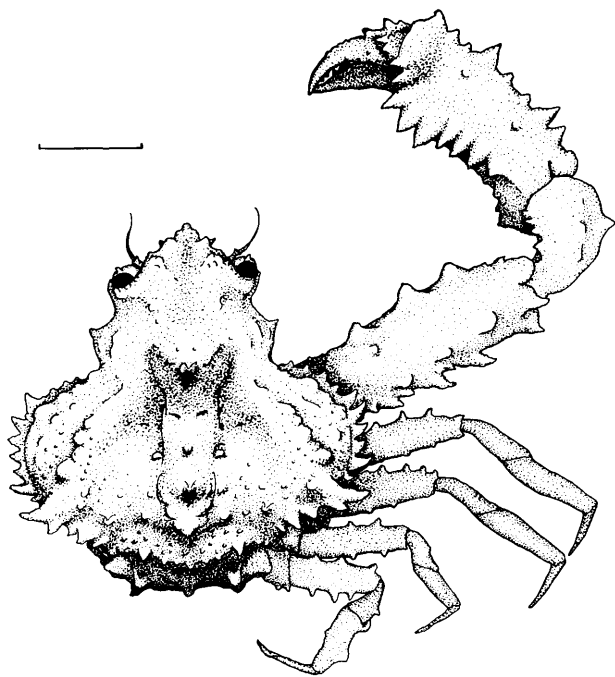


Fig. 277. *Parthenope (Platylambrus) fraterculus* (Stimpson). Male in dorsal view, position of legs reconstructed, legs of left side not shown, 5 mm indicated (from Williams 1965).

surface at proximal third conical. Walking legs with meri denticulate; dactyls furred except at tip; carpus and propodus of last pair with 2 or 3 lobes above and 5 denticles below.

Sternum and abdomen tuberculate, second to sixth abdominal segment each with large transverse tubercle.

*Measurements in mm.*—Carapace: male, length 16, width 17; female, length 16, width 18.

*Variation.*—There is great individual variation in the nature of tubercles and spines. In some individuals the prominences are low and blunt, in others high and sharp. The front varies in degree of inclination, and margins of the frontal lobes and orbits may be denticulate, entire or subentire. Gore and Scotto (1979) gave an analysis of variation.

*Color.*—Uniform red, eggs bright red (various authors).

*Habitat.*—Has been taken predominantly on rocky or shelly bottoms (Rathbun 1925; Holthuis 1959); 7.3 to 201 m.

*Type-localities.*—Off Sand Key, Caryfort and Conch reefs, west of Tortugas, 47.6 to 124.4 m [southern Fla.].

*Known range.*—Off Cape Fear, N. C.; central eastern Florida southward; Gulf of Mexico, off Cape San Blas, Fla., to Florida Straits; off Cape Catoche, Yucatan, Mexico; through West Indies to mouth of Amazon River (USNM).

*Remarks.*—Ovigerous females have been re-

ported in May, July, August, September, and December (Rathbun 1925; Gore and Scotto 1979; USNM).

Individuals collected from a reef southeast of Cape Lookout, N. C., did not survive 48-h exposure to 10°C (F. J. and W. B. Vernberg 1970).

***Parthenope (Platylambrus) granulata* (Kingsley)**

Figs. 278, 280c

*Lambrus granulatus* Kingsley 1879:150.

*Parthenope serratus.*—Hay and Shore 1918:463, pl. 39, fig. 7.

*Parthenope (Platylambrus) serrata.*—Rathbun 1925:516 (part, not pls. 180, 181, and 275, figs. 7–10 [= *P. serrata* H.M.E. restr.]).—Williams 1965:267, figs. 247, 252B.

*Parthenope (Platylambrus) punctata* Chace 1942a:85, pl. 26.

*Parthenope (Platylambrus) granulata.*—Gore 1977a: 505–523 (passim), pls. 3, fig. A; 4, figs. C, D; 5, figs. C, D; text-figs. 1A–D, 2A.

*Parthenope granulata.*—Gore and Scotto 1979:52, figs. 23, 24A–D, d, 25A.

*Recognition characters.*—Carapace depressed, convex anterolateral margin with about 11 irregularly triangular teeth in front of longer lateral spine curved obliquely backward. Posterolateral margin concave; posterior margin convex, wide, both margins together with about 7 tubercles noticeably larger than others, each terminating in indefinite longitudinal or oblique line of tubercles. Elevations of carapace ornamented with numerous unequal granulated tubercles trending in concentric rows; depression between gastric and branchial regions deep; intestinal and posterior spines protuberant, surrounded by granules. Rostrum short,

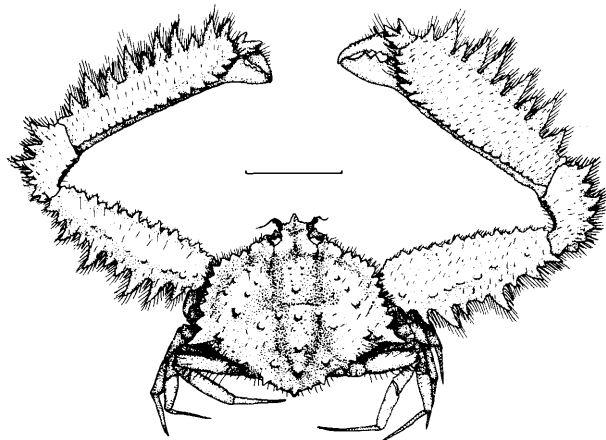


Fig. 278. *Parthenope (Platylambrus) granulata* (Kingsley). Male in dorsal view, 10 mm indicated (from Williams 1965).

tridentate, narrow at tip, and with raised margin continuous with superior wall of orbits. Pterygostomian and subhepatic regions with excavation reaching margin of orbit and, with chelipeds retracted, forming covered efferent passages.

Chelipeds, when extended, approximately 2 to 2.5 times as long as carapace, trigonal, smooth beneath, more or less tuberculate on upper surface, and with margins cut into lanceolate or acutely triangular teeth constricted at bases and fringed with fine hairs, much stronger on outer than on inner side of articles; hand with about 10 teeth alternately large and small, projecting outward or obliquely forward; fingers stout, oblique. Walking legs of moderate size, longest not exceeding merus of cheliped.

Abdomen of male with segments 3 to 5 fused, sixth segment with median spine.

*Measurements in mm.*—Carapace: male, length 18.2, width 25; ovigerous female, length 20, width 26.

*Color.*—Red somewhat mottled with gray; fingers carmine, shading to black.

*Habitat.*—The species has been reported from a variety of bottoms; 9.6 to 55 m, rarely 677–824 m.

*Type-locality.*—Tortugas, Florida.

*Known range.*—Off the three North Carolina capes southward around Florida to Louisiana; Bermuda; Bahia Honda, Cuba (?); St. Thomas, Virgin Is. (Gore 1977a).

*Remarks.*—Gore (1977a) in studying *Parthenope* species from the southeastern United States found that the species long known as *P. serrata* consisted of two forms, that listed above under its oldest name, and “true” *P. serrata* which is seemingly more tropical in distribution, ranging from the western Gulf of Mexico to Brazil.

Ovigerous females are known from North Carolina in June, from Florida in March, April, summer, and September–November, and Cuba in October (USNM; Gore and Scotto 1979).

### *Parthenope (Platylambrus) pourtalesii* (Stimpson)

Figs. 279, 280d

*Lambrus pourtalesii* Stimpson 1871a:129.

*Parthenope pourtalesii.*—Hay and Shore 1918:462, pl. 39, fig. 6.—Gore and Scotto 1979:49, figs. 17A–D, 22.

*Parthenope (Platylambrus) pourtalesii.*—Rathbun 1925:521, pls. 182, 183, and 276.—Chace 1940:53.—Williams 1965:268, figs. 248, 252C.—W. E. Pequegnat 1970:183.—Powers 1977:69.

*Recognition characters.*—Carapace broadly ovate-

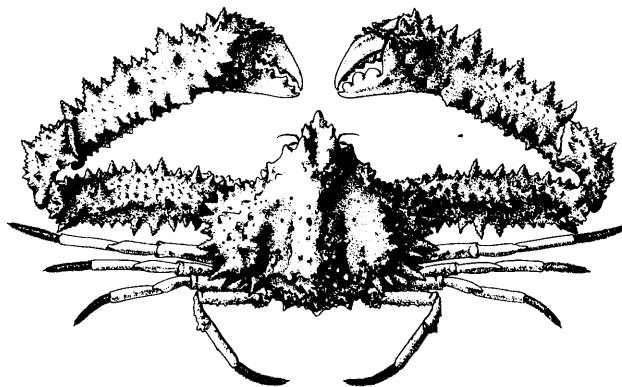


Fig. 279. *Parthenope (Platylambrus) pourtalesii* (Stimpson). Female in dorsal view, approx.  $\times 0.8$  (from Smith 1887).

triangular, convex; branchial regions rather deeply separated from gastric, cardiac, and hepatic regions. Posterolateral angle marked by conspicuous lacinated spine located behind bulging curve of anterolateral margin; hepatic margin armed with small but prominent spine. Anterolateral margin behind cervical suture armed with 8 or 9 teeth and spines, first 3 or 4 shorter than remainder. Posterolateral margin with 3 or 4 unequal spines. General surface of carapace pitted and eroded, with granulated tubercles disposed as follows: 1 gastric, 1 genital, 2 cardiac, 2 on branchial ridge in line with lateral spine, and tendency to rows of tubercles on branchial regions. Rostrum tipped with long, narrow, obtuse tooth with denticle on each side, subacute basal tooth with short spine below and outside it. Supraorbital spine blunt, postorbital spine smaller but somewhat sharper; upper side of emargination on eye spined.

Chelipeds long, rough, armed with lacinated teeth and spine on both margins; merus with additional median row of spiniform tubercles on upper surface with largest spine at inner angle; hand with obsolete median row beneath. Meri of walking legs spinulose, also carpus and propodus of last pair; dactyls furred; tubercle on sternum at base of cheliped and each of first 3 walking legs.

Abdomen with large tubercle in middle of second to sixth abdominal segments and conical tubercle at extremity of segments 2 and 3; segments 3 to 5 fused in male. Lower surface of body granulate and tuberculate.

*Measurements in mm.*—Carapace: male, length 40, width 53; ovigerous female, length 35, width 47.

*Variation.*—Varies greatly in number and prominence of tubercles and teeth, and in constriction and ornamentation of the rostrum. Elevations of the carapace may bear spines or tubercles.

*Color.*—Purplish red with cross bands of buff on chelipeds and walking legs; palms pinkish brown (various authors).

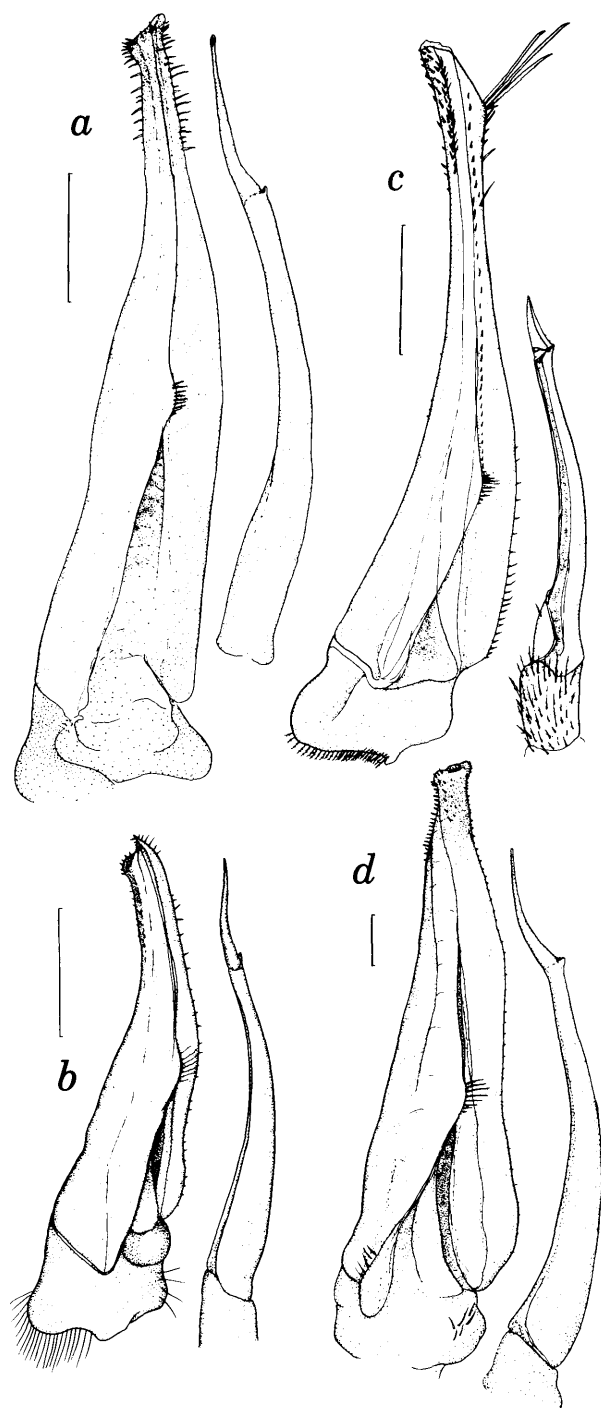


Fig. 280. Family Parthenopidae, first and second right pleopods of males in mesial view: a, *Parthenope (Parthenope) agona* (Stimpson); b, *P. (Platylambrus) fraterculus* (Stimpson); c, *P. (Platylambrus) granulata* (Kingsley); d, *P. (Platylambrus) pourtalesii* (Stimpson); 1 mm indicated (from Williams 1965).

*Habitat*.—Predominantly on sand or sandy mud bottoms (Rathbun 1925); 18 to 440 m.

*Type-localities*.—Off Conch Reef, French Reef, and American Shoal [southern Fla.], 73–214 m.

*Known range*.—Off Martha's Vineyard, Mass.; latitude of New Jersey southward; Gulf of Mexico through West Indies to Grenada.

*Remarks*.—Ovigerous females are known from Florida in July, North Carolina in December, and South Carolina in January (USNM).

Individuals collected from a reef SE of Cape Lookout, N. C., in September and October withstood experimental exposure to temperature of 4°C for 7 h but were dead after 17-h exposure (F. J. and W. B. Vernberg 1970).

### Genus *Cryptopodia* H. Milne Edwards 1834

Garth 1958:470.

#### *Cryptopodia concava* Stimpson

Figs. 281, 286a

*Cryptopodia concava* Stimpson 1871a:137.—Rathbun 1925:553, pl. 202, figs. 3, 4; pl. 282, figs. 6–11.—Williams, McCloskey, and Gray 1968:64.—Coelho and Ramos 1972:206.—Powers 1977:67. *Cryptopodia concava* Gore and Scotto 1979:13, figs. 4, 5H-P (erroneous spelling).

*Recognition characters*.—Surface smooth and shining. Carapace broadly triangular, dorsally presenting 3 concave faces sloping away from rounded gastric region, large lateral vaulted expansions scarcely concealing walking legs and projecting beyond base of abdomen. Anterolateral margin twice length of posterolateral, meeting at obtuse lateral angle; posterolateral margins slightly converging posteriorly; posterior margin straight in female, slightly emarginate in male; all margins cut into small teeth with denticulate distal edges, separated by closed fissures. Ridge from gastric region toward posterolateral margin granulate. Rostrum triangular and flattened; pterygostomial region smooth. Orbits small, nearly circular, with suture in superior margin; eyes small and retractile. Epistome well developed. Merus of third maxillipeds triangular, internal angle slightly truncate.

Cheliped with upper surface of merus and hand dilated toward middle; margins with few teeth analogous to those on carapace. Crests of walking legs denticulate.

Sternum very concave anteriorly; deep hollow fitting terminal segment of abdomen, strong dentate crest on each side.

*Measurements in mm*.—Carapace: male, length 8.1, width 10.9; female, length 8.6, width 11.6.

*Variation*.—A few larger individuals tend to have more denticulate distal edges on teeth of the carapace and chelipeds than smaller crabs in which the distal edges of these teeth are truncate.

*Color*.—Female with body and chelipeds translucent dirty white dorsally, few scattered small red-

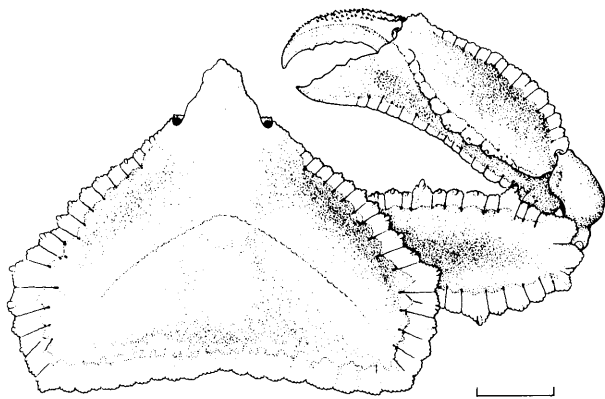


Fig. 281. *Cryptopodia concava* Stimpson. Male in dorsal view, walking legs hidden and left cheliped not shown, 2 mm indicated (UNC-IMS 2659).

dish spots ventrally at base of chelipeds and elsewhere on chelipeds and other limbs ventrally; faint suggestion of transverse pink band at midlength of fingers. Eggs bright orange (Williams, et al. 1968).

*Habitat*.—Sand and broken shell or coral, also mud; 7.3 to 73 m.

*Type-locality*.—Off Conch Reef [Fla.], 62.2 m.

*Known range*.—SE Cape Lookout, N. C.; central east Florida; S Cape San Blas, Fla., to St. Thomas; Ceará to Bahia, Brazil.

*Remarks*.—Ovigerous females are known from Florida in June, October and December.

Gore and Scotto (1979) gave a comprehensive review of the species along with details of its distribution in Florida.

### Genus *Heterocrypta* Stimpson 1871

Garth 1958:473.—China 1966:255.

#### *Heterocrypta granulata* (Gibbes)

(Pentagon crab)

Figs. 282, 286b

*Cryptopodia granulata* Gibbes 1850:173.

*Heterocrypta granulata*.—Hay and Shore 1918:464, pl. 39, fig. 9.—Rathbun 1925:555, text-fig. 152, pl. 203, figs. 1–2; pl. 282, figs. 1–3.—Williams 1965:270, figs. 251–252E.—Coelho and Ramos 1972:206.—Felder 1973:45, pl. 6, fig. 6.—Powers 1977:67.—Gore and Scotto 1979:15, figs. 5A–D, 6, 7.

*Recognition characters*.—Carapace subtriangular, with wide clypeiform vaulted expansions, length  $\frac{2}{3}$  width; general surface smooth, punctate; margins crenulate. Anterolateral margin nearly straight, with dorsal surface sloping upward from margin to

prominent, granulate branchial ridge running parallel with each side, these connected by short transverse ridge on gastric region and joined behind to posterior marginal ridge. Rostrum broad, blunt, deflexed, with rounded margins connected to gastric ridge by pair of granulate crests. Orbits small, nearly circular; eyes small, retractile. Cardiac region with large domelike elevation granulated at summit.

Chelipeds unequal, rather heavy, longer than width of carapace; margins of upper surface of merus, carpus, and hand expanded into irregular granulate or dentate crests; fingers short, agape in larger cheliped. Walking legs short, almost completely hidden beneath carapace.

Sternum and lower surface of abdomen coarsely granulate; male abdomen with third, fourth, and fifth segments fused, sixth segment with sharp proximal appressed spine with tip lying between 2 tubercles on fifth segment.

*Measurements in mm*.—Carapace: male, length 13, width 19; female, length 15, width 21.

*Color*.—Varying from light gray to nearly black, usually commingled so as to produce an irregular mottling or marbling (various authors).

*Habitat*.—This species is found on shingly bottoms, sometimes on oyster beds (Felder 1973). Its angular form and coloration bear so close a resemblance to fragments of shell among which it lives that it is extremely difficult to detect; 3.7 to 137 m.

*Type-localities*.—Near Kiawah Island, Sullivan Island, and White Point Shoal, Charleston Harbor, S. C.

*Known range*.—Nantucket Sound, Mass., around peninsular Florida to southern Texas; through West Indies to Trinidad; Ceará to Bahia, Brazil.

*Remarks*.—Ovigerous females are found in the Beaufort, N. C., area throughout the summer, and are known from Florida in February (USNM), March, April, June, July, and October (Gore and

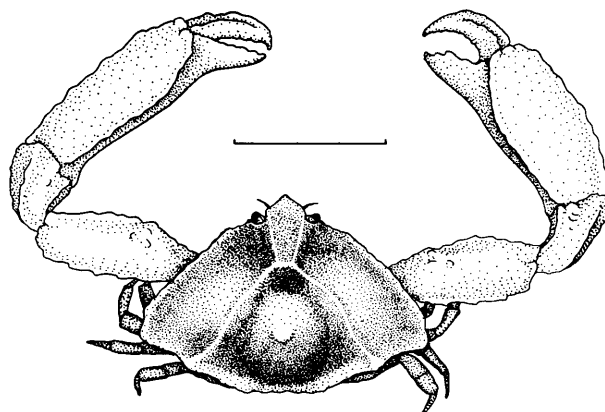


Fig. 282. *Heterocrypta granulata* (Gibbes). Male in dorsal view, 10 mm indicated (from Williams 1965).

Scotto 1979). These authors discussed the possible identity of *H. granulata* and *H. lapidea* Rathbun.

### Genus *Mesorhoea* Stimpson 1871

Garth 1958:465.

#### *Mesorhoea sexspinosa* Stimpson

Figs. 283, 286c

*Mesorhoea sexspinosa* Stimpson 1871a:136 (spelling error, *sexspinosa*).—Rathbun 1925:547, pl. 200, text-fig. 150.—Williams, McCloskey, and Gray 1968:64, fig. 17.—Powers 1977:68.—Gore and Scotto 1979:30, figs. 5E-G, 13.

**Recognition characters.**—Carapace about equally produced in front of and behind lateral angles; surface punctate and inconspicuously pubescent. Protuberances of gastric, cardiac and branchial regions strongly angular, 3-sided, branchials forming projection on posterolateral margin; angles or ridges more or less crenulate. Lateral edges of gastric protuberance continued anteriorly toward front; cardiac protuberance more slender than others; surface between ridges more or less regularly concave. Rostrum short. Eyes small and retractile into deep sockets. Margins of carapace sublaminiform and almost entire, normal crenulation indicated only by faint impressed lines and microscopic notches; anterolateral margin slightly convex at middle, terminating in tooth on either side (sometimes obtuse). Afferent channels deep, separated from subhepatic channels by prominent, thin, sharp, ciliated lamina and defined on inner side by ciliated outer edge of third maxillipeds.

Chelipeds short, somewhat pubescent along ridges and on inner surface; merus with margins crenulated with 6 or 7 small teeth on either edge; carpus flattened above with 2 strong crenulated

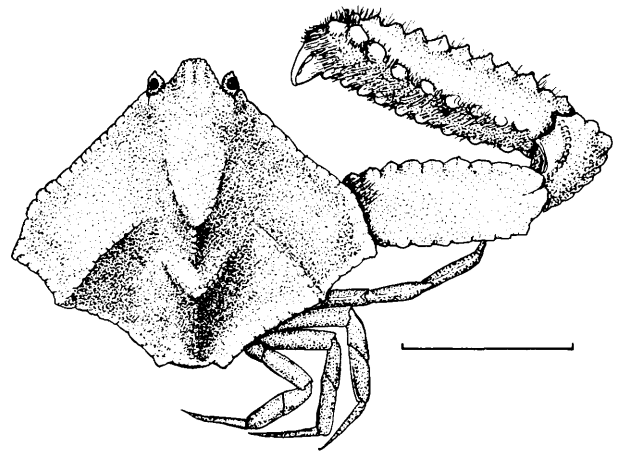


Fig. 283. *Mesorhoea sexspinosa* Stimpson. Female in dorsal view, legs of left side not shown, 5 mm indicated (from Williams, et al. 1968).

crests; hand with 9-toothed superior crest and 11-toothed outer margin; fingers small, dactyls at right angle to palm. Walking legs much compressed, carpus and propodus crested above, merus and propodus of last pair crested below.

**Measurements in mm.**—Carapace: male, length 10, width 12.5; female, length 9.5, width 12.5.

**Variation.**—Young individuals show a tendency to relatively more slender tipped protuberances than adults.

**Habitat.**—8 to 100 m.

**Type-locality.**—4 miles southwest of Loggerhead Key, Florida, 20 m.

**Known range.**—SE Cape Lookout, N. C.; off NW Florida, to Flanagan Passage, Virgin Islands.

**Remarks.**—Ovigerous females are known from Florida in January, August (USNM), and June (Gore and Scotto 1979).

### Genus *Solenolambrus* Stimpson 1871

Garth 1958:458.

#### Key to Species

(Modified from Rathbun 1925)

1. Carapace with no teeth on posterior or posterolateral margins; dorsal protuberances rounded (except short branchial crests in some specimens). . . . . *S. tenellus*
- Carapace with 4 teeth on posterior and posterolateral margins; dorsal protuberances angular. . . . . *S. typicus*

#### *Solenolambrus tenellus* Stimpson

Figs. 284, 286d

*Solenolambrus tenellus* Stimpson 1871a:134.—Hay

and Shore 1918:463, pl. 39, fig. 8.—Rathbun 1925:541, pl. 194, figs. 3–4; pl. 279, figs. 5–9.—Chace 1940:54.—Williams 1965:270, fig. 250.—Powers 1977:70.—Gore and Scotto 1979:21, figs. 8, 9D-F, 10A.

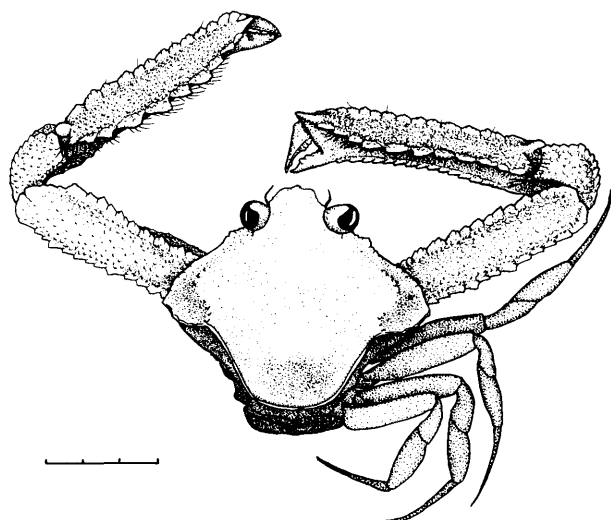


Fig. 284. *Solenolambrus tenellus* Stimpson. Female in dorsal view, walking legs of left side not shown, 3 mm indicated (from Williams 1965).

**Recognition characters.**—Small delicate species. Carapace but little broader than long and about equally produced in front of and behind line of lateral angles; surface punctate; protuberances of gastric and cardiac regions fairly well marked and often surmounted by tubercle near posterolateral margin but almost obsolete anteriorly. Anterolateral margins of carapace crenulated, 5 or 6 teeth on expanded and broadly rounded lateral angle being most prominent and defined chiefly by impressed lines on marginal shelf; hepatic region with 2 or 3 denticulate teeth. Posterolateral margin concave; branchial region often with short crest extending forward from margin broken into tubercles or ending in anterior tubercle, isolated tubercle on anterior slope; posterior margin convex, its lateral angles obtuse. Rostrum rather prominent, faintly tridentate at extremity, median tooth most prominent. External angle of orbit not prominent; eyes large with extremely minute tubercle at summit. Basal article of antenna approximately as long as next article. External maxilliped with ischium somewhat tuberculate near outer margin and extremity.

Chelipeds long, slender, general surface smooth, polished; edges denticulate. Merus with about 13 teeth on either edge, third tooth from distal end larger than others. Hand with 12 sharp forward-curving teeth on superior edge, terminal tooth above finger spiniform and considerably longer than others; outer margin with about 11 small teeth, inner with 19 or 20 minute teeth. Walking legs naked, compressed, without laminiform crests; merus of last pair slightly expanded below near base.

Abdomen and sternum of male coarsely pitted, otherwise smooth and glabrous.

**Measurements in mm.**—Carapace: male, length 6, width 6. Length of cheliped 16. Carapace: ovigerous female, length 5, width 6 (width 6.9, Gore and Scotto 1979).

**Habitat.**—5.5 to 366 m.

**Type-localities.**—Off Carysfort, Conch, and French reefs, 64 to 89.6 m [southern Fla.].

**Known range.**—Off Cape Lookout, N. C.; central east Florida southward; Gulf of Mexico, near Cape St. George, Fla., to Florida Keys; Bahamas; Barbados.

**Remarks.**—Ovigerous females have been reported in April from Cuba (Chace 1940), May from Barbados, May, June and August–November from Florida (Rathbun 1925; Gore and Scotto 1979), and questionably in August from North Carolina (an incompletely labeled specimen from Hay and Shore's material in UNC-IMS collection, and *Fish Hawk* records for 1902).

### *Solenolambrus typicus* Stimpson

Figs. 285, 286e

*Solenolambrus typicus* Stimpson 1871a:133.—Rathbun 1925:537, text-fig. 148, pl. 192–193, pl. 279, figs. 1–4.—Chace 1940:53.—Williams, McCloskey, and Gray 1968:63.—W. E. Pequegnat 1970:184.—Powers 1977:70.—Gore and Scotto 1979:24, figs. 9A–C, 10B, 11, 12.

**Recognition characters.**—Small species. Carapace slightly broader than long; surface punctate; protuberances of gastric and cardiac regions triangularly pyramidal and acute with ridges at angles crenulated. Cardiac pyramid symmetrical, equal sided; gastric pyramid asymmetrical, its posterior ridge short and nearly vertical but with long, curved

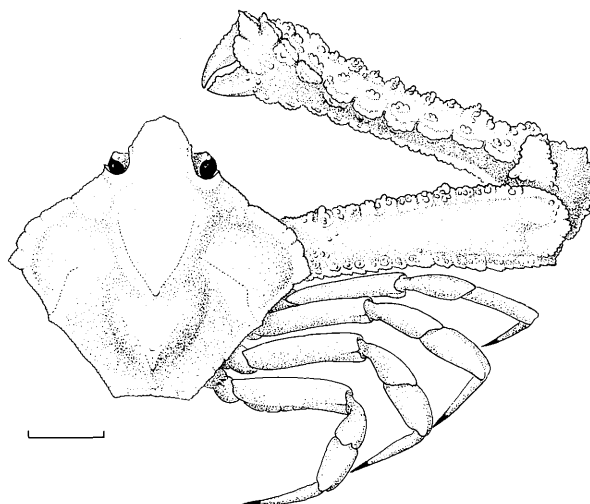


Fig. 285. *Solenolambrus typicus* Stimpson. Male in dorsal view, legs of left side not shown, 3 mm indicated (USNM 48885).

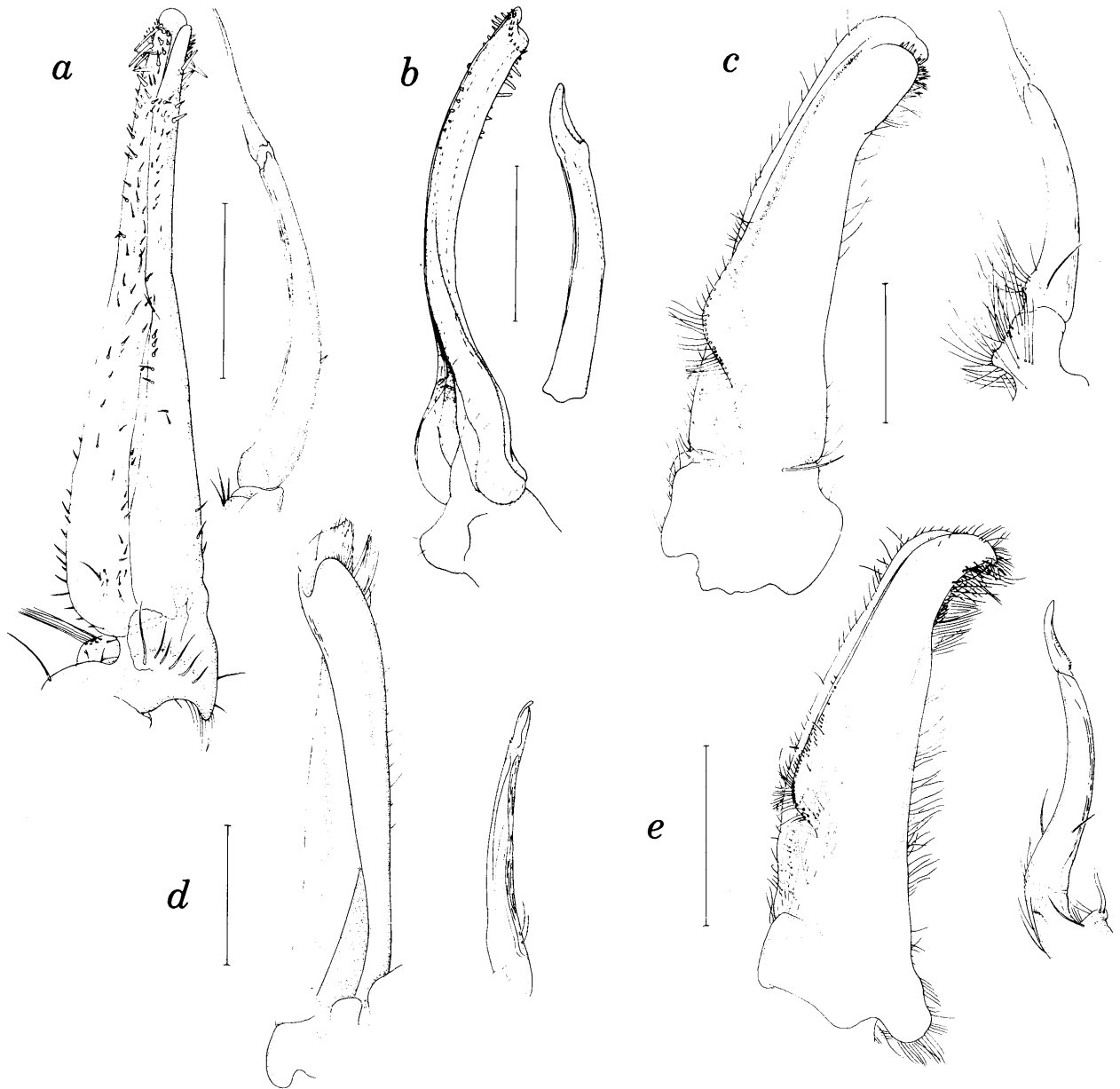


Fig. 286. Family Parthenopidae, first and second pleopods of males: *a*, *Cryptopodia concava* Stimpson, sternal view, UNC-IMS 659; *b*, *Heterocrypta granulata* (Gibbes), mesiosternal view (from Williams 1965); *c*, *Mesorhea sexspinosa* Stimpson, sternal view, USNM 72556; *d*, *Solenolambrus tenellus* Stimpson, mesiosternal view, USNM 18678; *e*, *S. typicus* Stimpson, sternal view, USNM 18677; 1 mm indicated.

anterior ridges enclosing somewhat convex anterior side gradually sloping toward front. Branchial ridges crenulated and bent at nearly right angle in middle. Each protuberance of carapace tending to be surmounted by small spine in male, more rounded in female. Margins more or less distinctly crenulated; anterolateral margin concave anteriorly, convex posteriorly and bearing suggestion of 3 weak teeth near often dentiform lateral angle; no more than 4 teeth on posterolateral and posterior margins; posterior margin straight. Rostrum rather prominent and faintly tridentate, median

tooth most prominent. Basal article of antenna somewhat longer than next article. Epistome of moderate length. External maxilliped tuberculate near outer margin and extremity.

Chelipeds long, slender, naked except for inconspicuous setae on crest of hand; merus with denticulate margins, surface smooth and glossy except for few tubercles near margin; carpus with 5 denticulate crests; hand trigonal, 10 strong teeth on inner crest, 12–14 small granulate teeth on outer margin, upper surface with 2 rows of tubercles, inner surface with 2 rows, outer with 3 rows and all

tubercles ornamented with 2–5 granules. Fingers very short, closed dactyl at right angle to palm. Walking legs compressed, smooth, crested above and merus of last pair crested below with proximal expansion.

Abdomen tuberculate at sides; sternum with few tubercles between bases of chelipeds.

*Measurements in mm.*—Carapace: male, length 10.8, width 11.6 (Rathbun 1925); ovigerous female, length 10.4, width 11.1.

*Variation.*—The two projections at ends of the posterior margin vary from prominent to inconspicuous teeth or spines. Chelipeds vary in roughness, those of some specimens having a merus with nearly smooth upper surface and a line of granules near the posterior edge, but on others the posterior half is quite granulate; rougher specimens have longer marginal teeth on the hand, especially on the upper crest.

*Habitat.*—Sand, shell, and coral fragments; 14.6 (?), 91 to 618 m.

*Type-localities.*—Off the Samboes and off Alligator Reef [southern Fla.], 146.3 to 201.2 m.

*Known range.*—SE Cape Lookout; western Gulf of Mexico off Corpus Christi, Tex., and N of Yucatan; Swan Island and Nicaragua Shelf; southern Florida through West Indies to Surinam and Brazil (Gore and Scotto 1979).

*Remarks.*—An ovigerous female from Florida (USNM) bears no collection date.

## Section Cancridea

### Superfamily Cancroidea

#### Family Cancridae

Carapace broadly oval or hexagonal. Last pair of legs not adapted for swimming. Antennules folding lengthwise. Antenna with flagellum more or less hairy.

#### Genus *Cancer* Linnaeus 1758

Rathbun 1930a:176.—Hemming 1958b:51.—Glaessner 1969:R509.—Nations 1975:30.—1979:153–187 (passim).—Bigford 1979:1.

Nations (1975; 1979) revised the genus *Cancer*, dividing it into 4 subgenera based primarily on shape of the carapace and the chelae, and reviewed its modern distribution as well as its geologic record which dates from the Miocene Epoch. The modern distribution is limited to waters ranging in temperature from about 1.3° to 25°C (Williams and Wigley 1977), i.e., to the temperate zones except along the northwestern coast of South America in the cold Humboldt Current, and regions of limited tropical submergence (Nations 1975; 1979).

#### Key to Species

1. Anterolateral teeth of carapace with denticulate margins; upper margin of palm denticulate; outer orbital tooth with pointed tip, not coalesced with adjacent anterolateral tooth in small juveniles . . . . . *C. (Metacarcinus) borealis*  
Anterolateral teeth of carapace with margins granulate; chelipeds granulate, not denticulate; outer orbital tooth with rounded tip, coalesced with adjacent anterolateral tooth in small juveniles . . . . . *C. (Cancer) irroratus*

#### *Cancer (Metacarcinus) borealis* Stimpson

(Jonah crab; northern crab)

Fig. 287

*Cancer borealis* Stimpson 1859:50.—Hay and Shore 1918:434, pl. 35, fig. 2.—Rathbun 1930a:182, text-fig. 30.—Williams 1965:175, fig. 156.—Powers 1977:71.

*Cancer (Metacarcinus) borealis.*—Nations 1975:45, figs. 4, 38-2, 38-3.—1979:184 (by implication).

*Recognition characters.*—Carapace transversely oblong, approximately  $\frac{2}{3}$  as long as wide, surface

granulate. Anterolateral margins divided into 9 quadrangular, crenate lobes or teeth, with margins minutely denticulate and with notches between teeth continued on carapace as short closed fissures. Front produced beyond inner orbital teeth and provided with 3 teeth, center one longest and depressed. Orbits circular, with 2 narrow fissures above and 2 below; suborbital lobe strongly produced.

Chelipeds nearly as long as second pair of legs, stout; carpus and hand with strong, granulose rugae; carpus with sharp spine at inner angle; hand smooth on inner face, heavily rugose on outer face, 2 rugae continued from hand on slightly deflexed



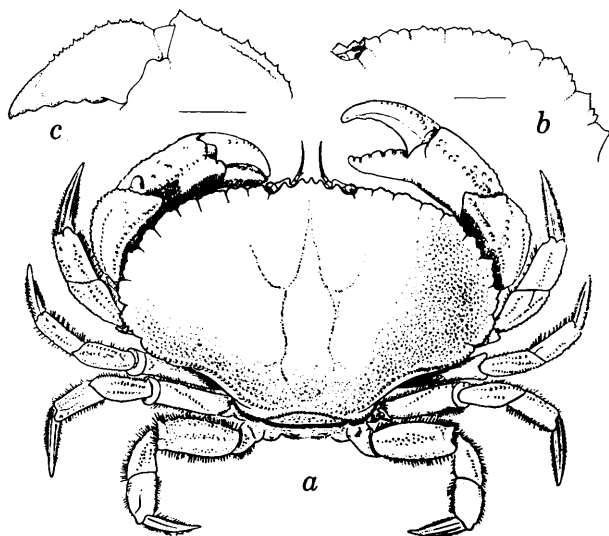


Fig. 287. *Cancer (Metacarcinus) borealis* Stimpson. *a*, Male in dorsal view, reduced (from Smith 1879); *b*, right anterolateral border; *c*, dactyl and upper border of chela (USNM 9446, from Williams 1974c); *b-c*, 1 cm indicated.

fixed finger; dactyl with rough upper surface, both fingers slaty black at tip. Walking legs short, fringed beneath, dactyls dark tipped.

*Measurements in mm.*—Carapace: male, length 90, width 143; ovigerous female, length 80, width 124.

*Color.*—Red above, yellowish beneath; carapace with 2 curved lines of yellowish spots and, behind middle, a figure somewhat resembling letter H; legs mottled and reticulated with yellow and red, more or less purplish.

*Habitat.*—See discussion under "Remarks." Small to medium-sized individuals found near shore seasonally (especially in the south), whereas larger ones occur in deeper water; between tides among rocks to 800 m.

*Type-locality.*—Nova Scotia to Cape Cod.

*Known range.*—Nova Scotia to south of Tortugas, Fla.; Verrill (1908a) judged that a Bermuda record was probably mislabelled.

*Remarks.*—Recent studies treat aspects of the biology and ecology of *C. borealis*. Haefner (1977) showed, from samples trawled in March, April, June and October in the mid-Atlantic Bight, that gonad development in June is related to size. Gonads of most crabs  $\leq 80$  mm in carapace width were undeveloped or slightly developed. Mature gonads were seen only in crabs  $\geq 100$  mm in width. Testes and vasa deferentia of most males  $\geq 150$  mm in width were well developed, but no females were ripe. Reilly and Saila (1978), studying samples from commercial trawls in southern New England waters as well as stomach contents of predacious fishes and observations of SCUBA divers, found that growth

of the two sexes is similar up to 30–40 mm carapace width, but the rate then diverges, females showing less increment per molt than males. Growth does not exceed 15 mm during the first year. Females were judged to attain a maximum of 100 mm width in 8 years after 14 molts, and males were judged to attain a little under 130 mm width after 13–14 molts in 6–7 years. They found that females mature at carapace widths as low as 14–30 mm. Ovigerous females of 21 mm width were calculated to carry 4430 eggs, and 88-mm females to carry 330,400 eggs. Females with unripe, red-orange eggs were found from November to May, and those with ripe brown eggs from March to June; they thought the eggs may be carried for up to five months. The largest females molted in December, the largest males from January to March, and an additional smaller group of males 40–60 mm wide molted in May. Growth curves and age and mortality estimates were calculated. Jeffries (1966), working with both *C. borealis* and *irroratus* in Narragansett Bay, observed a major shedding period in May and June. Since *Cancer* mates when the female is in the soft condition (Snow and Nielsen 1966; Hartnoll 1969), the season from June to December would seem to be an active breeding period.

Sastry (1977b) worked out the larval development in laboratory culture, but did not record the times at which parent females from Narragansett Bay were taken by SCUBA divers. Larvae were reared from eggs isolated in compartmented plastic boxes in sea water of 30‰ salinity and held at constant temperatures between 10° and 25°C. First stage zoeae released at 20°C were segregated after hatching and reared at that temperature on a diet of *Artemia salina* nauplii. Five zoeal stages and a megalopa were described and illustrated. The larvae are identical to those of *C. irroratus* except for minor variation in number of setae on some appendages, but the physiological requirements differ. Under the above conditions, early stage eggs of *C. borealis* deteriorated, but the late-stage eggs hatched to release mostly prezoae and first zoeae. Fish (1925) recorded larvae attributed to *C. borealis* in plankton of the Woods Hole region in September and October. Hillman (1964) found *Cancer* larvae in Narragansett Bay from May through July.

Jeffries (1966) found *C. borealis* on rocky areas in association with *Homarus americanus* whereas *C. irroratus* was found on sandy bottom, with little mixing of the two populations. *Cancer borealis* has proportionately heavier chelae than *C. irroratus*, is less prone to burying in sand when disturbed, and in experiments generally showed a lower walking and activity rate which Jeffries correlated with differences in serum phosphate concentrations possibly

related to level of energy metabolism. Comparison of walking ability in an experimental treadmill showed *C. irroratus* to react optimally at 14°–18°C, *borealis* at 6°–14°C, but endurance of the former was far above the latter. Jeffries correlated the experimental results with distribution records, concluding that spatial partitioning of the bottom prevents competition. However, Musick and McEachren (1972) found the species not to be mutually exclusive on the Continental Shelf from Cape Henlopen, Del., to Cape Hatteras, N. C., over an area where sand is predominant, with occasional patches of gravel, and slope sediments are mostly silt and clay. Both species were most abundant along the shelf edge, but probability of catching *C. borealis* was highest over silt clay or coarse canyon sediments. Scarratt and Lowe (1972) found *C. irroratus* also on rocky areas, but larger individuals often on sand, and fishermen in the same area found commercial-sized crabs on mud. Musick and McEachren (1972) judged *C. borealis* to be more stenothermal than *C. irroratus*, supporting Sastry's finding (see below). They also suggested that there may be inshore and offshore populations of *C. borealis*.

In that same area of sampling, males in Haefner's (1977) samples ranged from 12 to 175 mm in carapace width, females from 13 to 152 mm. He recognized four modal-size groups, with tendency for sizes to correlate positively with depth. The population had a contagious distribution within a depth range of 20 to 400 m, and was maximally abundant within 150 to 400 m at 8°–13.9°C.

Haefner (1977) recorded incidence of fouling organisms, predominant among which was the barnacle, *Poecilasma inaequilaterale*, attached to gills in the branchial chamber.

### *Cancer (Cancer) irroratus* Say

(Rock crab)

Fig. 288

*Cancer irroratus* Say (in part) 1817:59, pl. 4, fig. 2.—Hay and Shore 1918:435, pl. 35, fig. 1.—Rathbun 1930a:180, text-fig. 29, pl. 85, fig. 1.—Williams 1965:175, fig. 155.—Bigford 1979a:1, fig. 1.

*Cancer (Cancer) irroratus*.—Nations 1975:45, figs. 4, 42–3, 42–4.—1979:185 (by implication).

**Recognition characters.**—Carapace approximately  $\frac{2}{3}$  as long as wide, convex, granulated. Anterolateral border divided into 9 teeth with margins granulate, not denticulate as in *C. borealis*, and with

notches between teeth continued on carapace as short, closed fissures giving teeth a pentagonal character. Posterolateral border a granulated ridge with 1 tooth at outer end similar to those of anterolateral border but smaller. Front with 3 teeth, middle one exceeding others and depressed.

Chelipeds of moderate size, not so long as second pair of legs; carpus with granulated ridges and sharp spine at inner distal angle; hand nearly smooth on inner face, outer face with 4 or 5 granulated lines, 2 lower ones continued on slightly deflexed fixed finger, superior one cristate. Walking legs rather long and slender; merus of first and second pairs extending far beyond carapace. Abdomen of male broad, first, second, and third segments with transverse granulated ridge.

**Measurements in mm.**—Carapace: male, length 78, width 119; length 62, width 91; ovigerous female, length 44, width 67.

**Color.**—Yellowish, closely dotted with dark purplish brown, becoming reddish brown after death. Squires (1965a) noted that it is reddish to pale purple on a light yellow background.

**Habitat.**—See discussion under "Remarks." Small to medium-sized individuals found near shore seasonally, whereas larger ones occur in deeper water. This species, and the preceding one, have ranges extending south of the Carolinas only in deep water. Low water mark to 575 m.

**Type-locality.**—"Inhabits the ocean" [Atlantic coast of the United States].

**Known range.**—Labrador to off Miami, Fla.

**Remarks.**—*Cancer irroratus* has a fossil record ex-

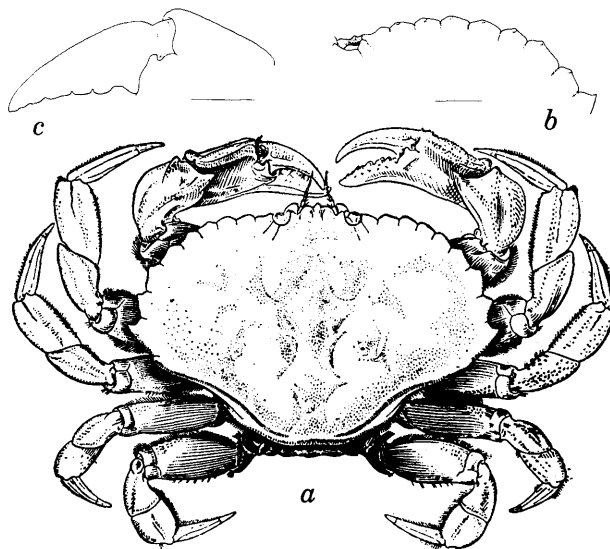


Fig. 288. *Cancer (Cancer) irroratus* Say. a, Male in dorsal view, reduced (from Rathbun 1884); b, right anterolateral border; c, dactyl and upper border of chela (USNM 13023, from Williams 1974c); b-c, 1 cm indicated.

tending from the Plio-Pleistocene to the present in North America (Nations 1975).

Bigford (1979a) summarized biological data more completely than can be done in space available here. Information on reproduction and development of *C. irroratus* is more extensive than that for *C. borealis*. Scarrett and Lowe (1972) reported mating in Northumberland Strait, near Prince Edward Island, from July to October, noting that males always mate with females 30–40 mm narrower than themselves, carrying them in a courtship embrace before, during and after molting, and copulating when the female is in the postmolt soft condition (also Hartnoll 1969, Elner and Staski 1978). Turner (1953, 1954) implied an earlier mating season in April–May for the Boston Harbor, Mass., area. Haefner (1976) gave detail from studies along the Middle Atlantic States, finding the species actively molting in April and June. Gonad development in June was related to size, that of males > 101 mm wide being well developed but that of males < 50 mm being undeveloped or in a very early stage of maturation; most females < 70 mm wide were in an early stage of ovarian development, but none with ripe ovaries were observed. Ovigerous females have been reported year round in Maine, peaking in August (Krouse 1972), but spawning there was judged to occur in late fall and early winter. Otherwise ovigerous females are known in January, February, April, and June in Virginia (Van Engel and Sandifer 1972; Haefner 1976), in March off Miami, Fla. (USNM), and August in Massachusetts (Rathbun 1930a). Musick and McEachren (1972) found ovigerous females only at depths < 30 m.

Sastry (1977a) described and figured five zoeal stages and a megalopa reared under laboratory conditions on a diet of *Artemia salina* nauplii. Eggs were removed from ovigerous females collected in Narragansett Bay (date not given), washed with sea water treated with Streptomycin and held in compartmented plastic boxes in 30‰ salinity seawater at 10°, 15°, and 20°C under a 14 h light–10 h dark regime. Eggs hatched directly into stage I zoeae, never into prezoaeae as did *C. borealis* from the same locality. The 15°C group survived best and they were described. Connolly (1923), reporting only four zoeal stages, may have missed an intermediate stage in plankton, and described a megalopa that does not agree with the reared one. Recent experiments (Sastry 1978) show that larvae cultured under daily cyclic temperatures (10°–20°, 15°–25°, 12.5°–17.5° and 17.5°–22.5°C) complete development to first crab stage at 10°–20°, 15°–25° and 12.5°–17.5°C and to megalopa at 17.5°–22.5°C, and that survival of all stages is enhanced at 10°–20°C cyclic tempera-

tures when compared with other constant and cyclic temperatures. Bigford (1979) found that the zoeal stages have positive phototaxis, but the extent of such movement decreases slightly as metamorphosis approaches; conversely, responses to gravity appear to change significantly as development proceeds from geonegative to rather abruptly geopositive behavior in zoeal stage V. This strong change results in a shift from planktonic to benthic habit.

Larvae from plankton were reported by: Fish (1925) from May to August at Woods Hole; Frost (1936) during summer around Newfoundland; Deevey (1960) from April to June in Delaware Bay; Hillman (1964) from late May to mid-July in Narragansett Bay near its mouth (*Cancer* sp.); Sage and Herman (1972) near Sandy Hook, N. J., in late spring; Scarrett and Lowe (1972) from June to September in Northumberland Strait with a peak in August and September; and Sandifer (1973d) occasionally at lower Chesapeake Bay stations in low concentrations, most abundantly off the mouth of the Bay in 23.3–32.3‰ salinity (mainly > 25‰) from May to July and September to October, with a peak in May and a smaller one in October, mainly in the temperature range 13°–21°C. There was little difference between surface and bottom densities. He (1975) felt that larvae of this species showed no distributional adaptations for retention in bays as do some other species more or less restricted to estuarine habitats.

Although *C. irroratus* is essentially a marine species as are other species of the genus, it does occur in lower reaches of estuaries, the movements being mainly seasonal (inshore during fall–winter–spring) among the younger segment of the population (Winget, et al. 1974; Ferreira, et al. 1979). Haefner and Van Engel (1975) found that male *C. irroratus* migrate into lower Chesapeake Bay in late fall, molt extensively in January, remain in papershell condition until late March and April, and leave the Bay in May. Crabs held in the laboratory confirmed the molting pattern observed in the field, which seems related to decreasing seawater temperatures, although rate of progression through the intermolt cycle is positively related to temperature. Crabs larger than 100 mm wide did not molt. Turner (1953, 1954) found that males in Massachusetts molt in November and March. The spring molters are soft in April and show a great growth increase in May. Haefner and Van Engel (1975) confirmed this, showing that most water uptake occurred between peeler and soft crab stages when progressive growth in length, width and weight resulted in increases of 18%–23%, 19%–27%, and 52%–82% respectively. In tank experiments, crabs

acclimated at 7°C approached isosmoticity near 28–30‰ salinity; crabs acclimated at 17.5°C were isosmotic near 24–26‰, but showed hyperregulation in salinity less than 20‰. Beers (1958), studying structure of the green gland in related *C. borealis*, concluded that its function is inefficient in salinities below 50‰ seawater, and hence limits the estuarine tolerance of the species.

In temperature tolerance experiments, F. J. and W. B. Vernberg (1970) found that animals collected from the Cape Hatteras area in February died after 1 h in water of 30°C, May animals died after 2 h at 32°C, but animals were unaffected by 48-h exposure to 10°C. Zoeae exposed to 4°C in 30‰ seawater survived for long periods with no harm, but zoeae at 20°C in 10‰ seawater were inactive after 1½ hr.

Distribution on the Continental Shelf is discussed in "Remarks" for *C. borealis*. Musick and McEachren (1972) suggested a continuous population of *C. irroratus* from southern New England to the Chesapeake Bight. Haefner (1976), in samples taken on the Continental Shelf in October, April, and June, found the species contagiously distributed in depths from 18 to 390 m with maximum density at 40–60 m in water of 6° to 9.9°C.

Mann (1973) showed that rock crabs are active predators on sea urchins but eat smaller sizes and less than the American lobster. Predatory fishes and crabs attracted to sclop dredge tracks within one hour of fishing have been observed at densities 3–30 times those observed outside the tracks (Caddy 1973); a photograph shows *C. irroratus* eating a lethally damaged scallop. Squires (1965a), noting its attraction to baited lobster traps, as have others, listed the food of *C. irroratus* as small *Littorina*, amphipods, *Crangon*, polychaetes and small pelecypods. He wrote that "dominated by the lobster, it

occupies fringe areas of the lobster grounds and makes forays into these grounds in search of food. Lobsters eat them and when stranded they are preyed upon by crows and gulls." *C. irroratus* is also preyed upon by fishes such as hake (Sikora, et al. 1972).

These and other aspects of the species' biology were reviewed by Saila and Pratt (1973), and parasites were reviewed by Sinderman and Rosenfield (1967). Haefner (1976) recorded incidence of fouling ectoparasites, *Alcyonidium* sp., and barnacles, *Octolasmis lowei*. *Gaffkya homari* is the causative agent of the fatal septicemic disease of lobsters. Cornick and Stewart (1968) showed that experimental infections with this agent from lobsters could cause significant numbers of crab deaths in a prolonged period at 15°C but that mean time to death is doubled at 10°C and is even longer at still lower temperatures. They postulated that at the latitude of Halifax, Nova Scotia, *C. irroratus* could serve as a reservoir of infection for lobsters, being relatively unaffected by it themselves during the prolonged cold season.

## Section Brachyrhyncha

### Superfamily Portunoidea

#### Family Portunidae

Carapace broad and flat, greatest width commonly marked by lateral spine; front dentate or lobate, orbits and eyestalks moderately large or elongate, anterolateral margin dentate; antennules folding obliquely or transversely, fifth legs mostly flattened, with leaf-shaped dactyl (Glaesner 1969).

#### Key to Subfamilies, Genera, and Some Species

1. Carapace with 5 teeth on anterolateral margin; lateral tooth equal to or not much larger than others . . . . . 2  
     Carapace with 9 anterolateral teeth, lateral tooth often much larger than others . . . . . [Subfamily Portuninae] 3
2. Distal articles of fifth legs not paddlelike. . . . . [Subfamily Carcininae] *Carcinus maenas*  
     Distal articles of fifth legs paddlelike . . . . [Subfamily Polybiinae] *Ovalipes*
3. Movable part of antenna not excluded from orbit. . . . . 4  
     Movable part of antenna excluded from orbit by prolongation of basal article; anterolateral teeth alternately large and small . . . . *Cronius ruber*
4. Carpus of cheliped with mesiodistal spine; abdomen of male triangular . . 5  
     Carpus of cheliped without mesiodistal spine; abdomen of male T-shaped . . . . . *Callinectes*
5. Front with 2 bifurcated teeth between inner orbitals; fissures on orbital margin broadly open; color light brown, thickly covered over dorsal surface

with small white spots, reticulate pattern persisting in alcohol. . . . .  
 . . . . . *Arenaeus cribrarius*  
 Front with 4 separate teeth between inner orbitals (latter sometimes bifurcate);  
 fissures on orbital margin closed except for shallow notch; color varied  
 but never as above . . . . . *Portunus*

### Subfamily Carcininae

Carapace not very broad, anterolateral margins with 5 teeth (3–5 in extraterritorial species). Basal antennal article longer than broad. Legs 2–5 similarly constructed, though dactyl of fifth leg broadened and flattened. (After Christiansen 1969.)

### Genus *Carcinus* Leach 1814

Christiansen 1969:49.—Hemming 1958b:107.—Manning and Holthuis 1981:75.

### *Carcinus maenas* (Linnaeus)

(Shore crab; green crab)

Fig. 289

*Cancer maenas* Linnaeus 1758:627.

*Carcinides maenas*.—Rathbun 1930a:15, fig. 4.

*Carcinus maenas*.—Zariquey Alvarez 1968:354, fig. 115a, c.—Christiansen 1969:49, fig. 18.—Manning and Holthuis 1981: 75.

*Recognition characters*.—Carapace about  $\frac{3}{4}$  as long as broad, regions well defined, surface finely and unevenly granular, especially in anterior half. Front with 3 broad, rounded teeth or lobes projecting moderately beyond orbits, middle one most advanced. Anterolateral border slightly arched and shorter than posterolateral, its 5 strong teeth directed forward. Superior orbital margin with single

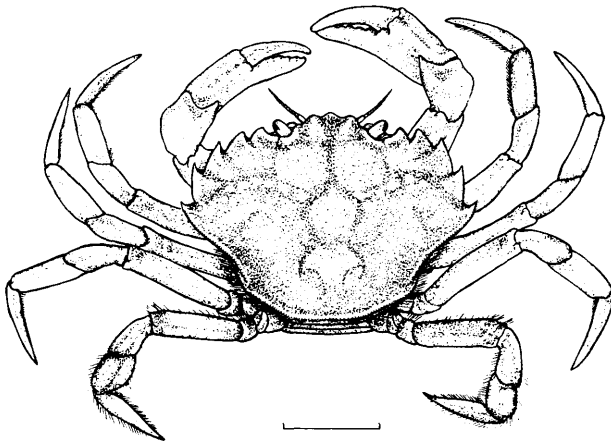


Fig. 289. *Carcinus maenas* (Linnaeus). Male in dorsal view from Oslofjord, Norway, 2 cm indicated (from Christiansen 1969).

notch about in middle, another in lower border near outer orbital tooth.

Chelipeds slightly unequal, nearly smooth except for 2 ridges (slightly granular in large individuals) on upper surface of hand; merus short; carpus with broad internal tooth or angle. Walking legs smooth and unarmed, second and third pairs longest, last pair shortest and more flattened than remaining legs with fringe of hairs on last 3 articles and dactyl acutely lanceolate. Rather broadly triangular abdomen of male with segments 3–5 fused, broad abdomen of mature female with segments free.

*Measurements in mm*.—Carapace: male, length 60, width 79 (Rathbun 1930a); female, length 60, width 77 (Christiansen 1969). Larger crabs are known in nature, one specimen from the Scilly Islands measured 92 mm, and widths of 132 mm have been induced experimentally (Carlisle 1957).

*Color*.—Usually multicolored with dorsal surface dark green, bluish green, grayish green or reddish, sometimes clear light sky blue, often mottled with white in juveniles; a row of lighter colored spots following cervical groove on each side and curving backward to posterolateral margins; yellowish white to darker (tile) color ventrally; legs varying from yellowish white to “tile” color or violet (Christiansen 1969; Crothers 1968; Rasmussen 1973). Provenzano (1960) noted 3% total or partial albinism in an adult population in Massachusetts. Larvae of albino adults also lacked pigment except for the eyes. Provenzano suggested that more than one gene may be responsible for the wide variation in degree of albinism. Hogarth (1975a) contrasted the highly polymorphic color pattern of juveniles with the typically drab adults, suggesting that among crabs in general a bold small pattern appears less conspicuous against a natural textured background but becomes conspicuous when the crab grows. He (1978) found loss of pattern with growth. Wald (1968) showed that the green crab has a visual system composed of at least two types of receptor with red and blue sensitivities presumably serving the function of color discrimination.

*Habitat*.—Usually in shallows less than 5 or 6 m but rarely to 200 m (Christiansen 1969). The species lives on a variety of bottoms. Naylor (1962) found small crabs (35 mm wide) present at low tide in all months; larger crabs tended to move up-

shore with high tides in summer to remain stranded beneath stones at intervening low tides, but no such movements occurred in winter. Crothers (1969, 1970) found variation in population density associated with habitat, lower densities occurring on wave beaten, exposed shores and higher levels prevailing in protected bays with lower salinity. Muus (1967) described a peculiar construction of shallow hollows in sand. The salinity range usually tolerated is about 10–33‰, although in intertidal zones regularly flooded by fresh runoff the crabs may reside between tides in 1.4–3.2‰ salinity (Perkins, et al. 1969).

*Type-locality*.—Marstrand N of Goteborg, west coast of Sweden (Holthuis and Gottlieb 1958).

*Known range*.—Northumberland Strait near Pugwash and Merigomish, Nova Scotia, and St. Patrick's Channel, South Bay in central Cape Breton Island (Bousfield and Laubitz 1972) to Virginia; Iceland; Kvaenangen, Norway, just beyond 70°N, southward, including southwestern and rarely southern Baltic Sea, through North Sea and British Isles to Mauritania; Australia (Almaça 1960, 1962, 1963; Christiansen 1969; Manning and Holthuis' 1981). According to these authors, both the North American and Australian populations are probably the result of introductions, and reported occurrences other than the above represent either temporary introductions or misidentifications, but Boschma (1972) noted introductions, probably by transport on ships, in Maungmagan, Burma, also the Red Sea, Madagascar, India and Ceylon.

*Remarks*.—The literature on *C. maenas* and its close relative *C. aestuarii* (= *C. mediterraneus*, see Manning and Holthuis 1981) is probably even more extensive than that on the American blue crab, *Callinectes sapidus*. Broekhuysen's (1936) comprehensive work on the species in the Netherlands consolidated a great deal of earlier investigation and served as a baseline for elaborative studies. That together with Crothers's (1967, 1968, 1969, 1970) masterful interpretive summary and Clay's (1965) exhaustive review of literature of the species make further summary redundant. For convenience and recognition of a few additional papers, the following notes are included.

The green crab is an omnivore whose feeding is influenced by abundance, size, and kinds of food available (Ropes 1968). Pelecypods formed a dominant part of the diet of crabs 30 to 59 mm wide in Plum Island Sound, Mass.; crabs there opened and ate clams equal to their own width, only the largest clams resisting attack. Greater amounts of food in crabs caught during low tide and just after sunrise suggested that feeding is heaviest at night at high tide. Activity and feeding seemed reduced at water

temperatures below 7°C; low salinity apparently did not influence feeding. Ovigerous females were relatively inactive, thus less destructive of clams than non-ovigerous females; feeding was reduced among males during mating and in crabs preparing for molting or assuming a new hardened integument.

Animals hatched in spring from winter eggs may attain a carapace width of about 20 or more mm by fall of the first season; those developed from summer eggs will be much smaller but by the next spring will catch up to the first group because the young crabs molt frequently until reaching about 30-mm width after which they molt infrequently. Early estimates of mean increase in size per molt were  $\frac{1}{3}$ – $\frac{1}{5}$  regardless of age and sex, but Hogarth (1975b) formulated instar number and growth for juveniles from observation and results of other research. Females are judged to live about 3 years attaining average widths of 36, 42 and 50 mm in yearly intervals while males are judged to attain ages of 3 or more years (some even 5) at slightly larger sizes with increasing age, 36, 42, 48, 56 mm annually, with a few even larger. Mature males tend to molt during May-June, females in July-September. Females may reach sexual maturity at 19–20 mm width (in one case an ovigerous dwarf measured 12.1 mm [Williams and Needham 1937]), and males at 25–30 mm may have spermatophores, but ability to copulate at this size is not proved.

Early molting of the males may be correlated with the fact that hard males mate with females that are in the soft condition (Hartnoll 1969), hence would molt before the latter. Mating resembles that described for *Callinectes sapidus*; it may last for hours and be repeated if the pair is separated (Cheung 1966a, and others). Reaction of males to a displaying female may vary from pairing to rejection with injury to the female, probably depending on physiological state of the male. A single mating can fertilize more than one batch of eggs but few soft females fail to mate. Spalding (1942) described functional morphology of the male and female reproductive systems. He considered the seemingly useless internal spermatophore of *Carcinus* to represent a holdover from affixed external spermatophores of *Macrura* and *Anomura*.

In Holland, the number of females ovigerous declines to near zero during the later summer-early fall molting period but abruptly thereafter rises to a level of 50%–60%. This number persists through winter until June when another brief drop occurs followed by some new egg production in July. These fluctuations correspond to phasing of maturity among females. Those that spawned in fall drop hatching eggs in the spring, molt, and then may cast a second clutch of eggs in summer. Overwin-

tering juveniles may attain maturity in spring and spawn after that in early summer, but in other geographic areas spawning varies. In the Baltic, berried females hide in deeper (8–10 m) more saline water until the larvae are hatched (Rasmussen 1959). The egg mass often contains a nemertine, probably *Carcinonemertes carcinophila*.

A debate has set forth alternate possibilities for the mechanism of attachment of eggs to the abdominal pleopods of ovigerous decapod crustaceans. Cheung (1966b) reviewed the evidence and partly on basis of experiments with *C. maenas* contended that in decapods no externally deposited membranes are formed around the egg at any stage. The outermost membrane really consists of 3 layers which are histochemically distinct from one another and cannot be equated with epicuticle. The outermost layer is derived from the vitelline membrane, the middle layer through solidification of a fluid exuded from the egg at spawning, and the inner layer formed by a highly PAS-positive substance (a histochemical test) from the egg. It is suggested that formation of this trichromatic membrane is initiated by fertilization. The funiculus (stalk) for attachment is formed of the outermost layer of the trichromatic membrane. The glue appears to be derived from the same substance which solidifies to form the middle layer. This is assumed to be liberated from the egg by being squeezed through layer 1 under pressure when the latter is being stretched and twisted during formation of the stalk. "Cement" glands are lacking in *Carcinus*, the mucuslike substance of *Macrura* is absent in *Brachyura*; hence the only conceivable source of the glue for the eggs, and perhaps also of the appropriate enzymes which Burkenroad (1947a) suggested, must be the egg itself. In any case, for eggs to be successfully attached to pleopods a female must bury herself in sand to form an enclosed cavity beneath her body in order that the extruded eggs can be forced against the pleopods.

A large female (46 mm wide) is estimated to have 185,000–200,000 eggs in a clutch. During the incubatory period females carry on characteristic preening and aerating movements about the egg mass. It was for this species that Bethe (1897) described the "Eierschutzreflex" for berried females which when intensely stimulated freeze into a huddled protective posture with the legs cradled around the egg mass. Ovigerous females of many *Brachyura* show this reflex. *Carcinus maenas* infested with *Sacculina carcini* also will show cleaning-aerating and migrating movements, feminized males reacting as if even a small-sized externa were an egg mass (Rasmussen 1959) and demonstrating the "Eierschutzreflex." Rasmussen found that ovigerous crabs in Danish waters leave littoral areas to hide in

deeper, more saline water until larvae are hatched, after which they return to molt and copulate with males that stay all summer in shallows of 0–1.5 m at a salinity of 19.54‰ ( $\bar{x}$ ). Behavior of the parasitized crabs is similar and highly influenced by oxygen tension, low tension accelerating the movements in a conspicuous way. In aquaria, when *Sacculina externa* had stopped producing sexual products and a slight decaying commenced, the crabs stopped this behavior and in some cases tore and even ate the externa. This suggests that only a living externa can induce the behavior and that hormonal feminizing influences it.

Experimentally, eggs will develop in a salinity range of 25.8–26 to 40.3–50.4‰ at 10°C, or 41–53.1‰ at  $\bar{x}$  16.3°C, and 20‰ at 15.7–17°C. Cold of 1.4°C in low salinity areas kills eggs; the animals usually migrate to avoid such extremes. Wear (1974), using *C. maenas* along with other species, showed that increasing egg size slows down rate of development and increases a constant factor ( $a$ ) which reflects change in incubation period due to changes in temperature, thereby defining shifts along a development axis. Hence, among closely related forms increasing egg size (yolkiness) slows down rate of development and increases value of  $a$ . Moreover, the increasing temperatures of spring (March–June) can effect a 3-fold decrease in natural incubation time of a single species in one locality, depending on when eggs are incubated.

Upon hatching, development of *C. maenas* passes through a perhaps abnormal prezoal stage, 4 zoeal stages and a megalopa that were described from rearing and plankton by Williamson (1903, 1915) and Lebour (1928). Williams (1968) was the first to complete rearing of larvae in the laboratory with the aid of a variety of diets, but Rice and Ingle (1975) are the only recent workers to give detailed description of reared larval stages (at 15°C). Average duration of the zoeal stages in days was I 14.8, II 7.9, III 9.6, IV 10.0, and megalopa 15.4. Dries and Adelung (1976) found that food and temperature are the most important exogenous factors for larval rearing success. On a diet of *Artemia* nauplii, success of zoeae was best at 15°C, megalopae at 17.5°C. Larvae hatched in darkness.

In the western Atlantic, Deevey (1960) found larvae in Delaware Bay from June to August, and Hillman (1964) reported them in July–August and December in Narragansett Bay. Kurian (1956) reviewed records of larval occurrence in Europe showing variation with latitude. Larvae of *C. maenas* are present year round at Plymouth, England, but most abundant in spring and summer, while in the Sound off Norway they are present in summer with megalopae persisting until fall. Rasmussen (1973) found that eggs spawned later than May–July may

never develop to first crab off Denmark and that annual fluctuation in salinity-temperature governs success or failure of a year class in those waters. Experimentally, *C. maenas* zoeae show higher mortality in diluted sea water than megalopae, and molting of the latter into crabs is delayed or prevented by water of low salinity.

In the United States, the green crab has had an economic impact on the fishery for the soft clam, *Mya arenaria*. Decreases in the fishery, especially from clam farming, have been correlated with predation by the crab (Glude 1955). Marked increase in the soft clam fishery of New England has been linked to mortalities and declining abundance of the green crab associated with cold winters and a general cooling trend (Welch 1968).

A vast literature on physiology, genetics, growth, etc., resting disproportionately on studies of *C. maenas*, is beyond the scope of this account and more fittingly found in reviews such as Waterman (1960, 1961).

### Subfamily Polybiinae

Carapace not broad, anterolateral margin with 3 to 5 teeth, some legs as long as chelipeds, fifth legs

paddle-shaped. (After Glaessner 1969.)

Holthuis (1968) reviewed the synonymy of this subfamily and gave notes on related subfamilies.

### Genus *Ovalipes* Rathbun 1898

Rathbun 1898b:597.—Stephenson and Rees 1968:215.

Carapace relatively narrow but somewhat broader than long, deep dorsoventrally; anterolateral borders curved, bearing 5 teeth approximately equal in size and spacing; stridulating ridges on under surface of pterygostomian region. Front rather narrow, 3 teeth on margin between orbits; basal article of antennules dorsally visible. Chelipeds subequal, merus with boss on anterodistal margin; carpus with well-developed internal spine; palm with conspicuous inner and outer dorsal carina continued on dactyl, inner surface dorsally with dense row of hairs. Second, third, and fourth legs with long, sharp dactyl with grooved surfaces and carinate edges; propodus and carpus grooved and carinate on outer border. (Adapted from Stephenson and Rees 1968.)

### Key to Species

1. Carapace yellowish gray, closely set with small annular spots of reddish purple; iridescent spots between each pair of anterolateral spines approximately alike in size and shape . . . . . *O. ocellatus*  
Carapace yellowish gray, without ocellated spots; iridescent spot between fourth and fifth anterolateral spines large and nearly semicircular in shape . . . . . *O. stephensoni*

### *Ovalipes ocellatus* (Herbst)

Fig. 290

*Cancer ocellatus* Herbst 1799:61, pl. 49, fig. 1.

*Ovalipes ocellatus*.—Williams 1965:160, fig. 143.—Stephenson and Rees 1968:241, pls. 37B, 40D, 41C, 42I, figs. 1I, 2H, 3H, 4H.—Williams 1974c:29, fig. 81.—Felder 1973:54.

**Recognition characters.**—Carapace about  $\frac{1}{4}$  wider than long, convex, finely granulate except for longitudinal band of slightly enlarged granules in median line, and smooth area on posterior central part of adults. Median frontal tooth about twice as long as lateral ones. Orbit with shallow fissures above, often nearly closed in adults, open in young. Anterolateral teeth strong, acute, directed forward; inner suborbital angle projecting at least as far as median frontal tooth. Pterygostomian region with long, curved, stridulating ridge made up of ap-

proximately 50 close-set striae narrowing into tubercles at inner end of ridge, short complementary ridge on proximal end of inner margin of cheliped merus. Lobe at distal inner angle of merus of outer maxilliped longer than broad.

Chelipeds rather large; distal  $\frac{3}{5}$  of anterior margin of merus with several small, blunt spines and dense fringe of hair; carpus finely but irregularly granular, with 2 spines, inner one very long; hand triangular in cross section, external border ridged and covered with fairly uniform small tubercles; fingers about as long as palm, tapering gradually, tips turned abruptly toward each other.

Abdomen of male narrow, sides nearly parallel; sixth segment nearly twice as long as seventh in midline, seventh segment subcircular; first pleopod of male broad and stout in proximal  $\frac{2}{3}$ , narrowing abruptly distally and with terminal part bent ventrolaterally in sinuous curve. Abdomen of adult female suboval and small compared to sternum.



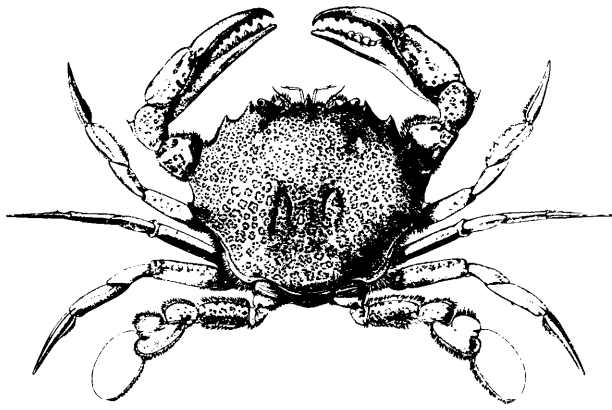


Fig. 290. *Ovalipes ocellatus* (Herbst). Male in dorsal view, approximately  $\times 0.8$  (from Rathbun 1884).

*Measurements in mm.*—Width of carapace: male 87; female 60.

*Variation.*—Spines are more acute on young than old individuals; on some old adults the anterolateral spines are worn away leaving only rounded humps. The orbital fissure is nearly closed in adults but often open in juveniles. The width between the suborbital angles tends to increase relatively with age.

*Color.*—“Yellowish gray, closely set with small annular spots of reddish purple; carapace and chelipeds with a silvery or brassy iridescence; ground color of chelipeds and legs light brownish tending to orange and bluish; large irregular bluish purple spots on upper surface of chelipeds; large part of carpus including spine bluish; similar but lighter spots on proximal half of other legs; paddles greenish yellow, with deep yellow rim” (Rathbun 1930a, and others). An iridescent spot between each pair of anterolateral spines.

*Habitat.*—Common on a variety of bottoms, especially sand; surface to 95 m (Williams and Wigley 1977).

*Type-locality.*—Long Island near New York.

*Known range.*—Northumberland Strait, Prince Edward Island, Canada (Bousfield and Laubitz 1972), to Georgia. Records from Mississippi (Franks, et al. 1972) and the Texas coast (Whitten, et al. 1950) should be referred to *O. floridanus* Hay and Shore (Leary 1946 and 1967; Williams 1976; Park 1978).

*Remarks.*—The distinction between this species and *O. stephensoni* (= *guadulpensis*) was discussed by both Williams (1962) and, in detail, by Stephenson and Rees (1968) in their revision of the genus (see also Powers 1977). There is a distinct difference in color, and an apparent difference in habitat among the adults. Adults of *O. ocellatus* are usually found near shore (Musick and McEachren 1972) and in the Carolinas the young of both species are found

there, as pointed out by a number of authors. Occasional specimens are carried well into estuaries by currents (Mansueti 1962). Assessing lethal limits, F. J. and W. B. Vernberg (1970) found that animals from the Cape Hatteras region in October became inactivated after 1 h exposure to 35° water, recovered when returned to 25°C, but at the other extreme tolerated 4°C for prolonged periods without harm. Physiologically, *O. ocellatus* is a species with northern affinities (W. B. and F. J. Vernberg 1970). Ferreira, et al. (1979) found that the species enters New Haven, and Stamford, Conn., harbors during summer, reaches a peak in numbers in early fall, then leaves before the onset of winter.

Females mate in the soft stage (Bliss 1968; Hartnoll 1969). Ovigerous females have been noted in North Carolina with orange eggs in October and February and with black eggs in October and December (Dudley and Judy 1971). Costlow and Bookhout (1966a) reared larval stages in the laboratory, finding five zoeal stages and a megalopa. At 30°C larvae completed development to first crab in salinities of 25, 30 and 35‰. At 25°C larvae survived in 25 and 30‰ salinity, but did not develop beyond the megalopa at 35‰. Extra larval stages were not observed. Development required 26.1 to 27 days at 20°C, and approximately 18 days at 25°C. Rate of development was not affected by the limited range of salinities employed. Hillman (1964) found larvae in plankton on 27 June and 18 July in Narragansett Bay and Fish (1925) took them from late July until late October at Woods Hole. Sandifer (1973d; 1975) found them common around Cape Hatteras in November, but in an extensive plankton survey in the lower Chesapeake Bay region took only 39 zoeae, mostly late stages, in 25.26–32.34‰ salinity at 20°–26.2°C from June to October, most commonly in September and usually at the surface.

Pearse, et al. (1942) pointed out that *O. ocellatus* can bury itself completely in sand and respire by passing water into the gill cavity from anterior or lateral openings, then out through two posterior openings. An evidence for this is presence of the parasitic barnacle *Octolasmis mulleri* on the afferent side of the gills whereas in most hosts it is on the efferent side (Walker 1974). Gray (1957) correlated great activity of the species with large gill area and compared this with gill areas of other strictly aquatic crabs.

Stephenson and Rees (1968) suggested that the ancestral *Ovalipes* had a predisposition towards stridulation leading to the remarkable development of stridulatory apparatus in the genus. Stephenson (1969) expanded analysis of these functions by study of museum specimens, suggesting

that since both sexes possess the mechanisms, sound communication may be a method for attracting individuals into aggregations.

***Ovalipes stephensoni* Williams**

Fig. 291

*Platyonichus ocellatus* (var.).—Smith 1887:632.

*Ovalipes ocellatus guadulpensis*.—Rathbun 1930a:23 (part, the North Carolina and Georgia specimens).

*Ovalipes guadulpensis*.—Williams 1962:39–41.—1965:161.

*Ovalipes guadulpensis* (Form a).—Stephenson and Rees 1968:243, pls. 37C, 40E, 41D, 42J; figs. 1J, 2I, 4I.

*Ovalipes stephensoni* Williams 1976:208, figs. 1e, f, 2.

*Recognition characters*.—Closely resembling *O. ocellatus*, but differing in the following characters: dorsal aspect of carapace not covered with ocellated spots; body flatter; outer orbital and frontal teeth more acute, median frontal tooth acuminate; iridescent spot between fourth and fifth anterolateral spine larger than spots between first to fourth teeth and nearly semicircular in shape; dorsal sur-

face of palm and external ridge of palm with tubercles not uniform in size, giving a roughened appearance in individuals larger than 30 mm wide.

*Measurements in mm*.—Carapace: male, length 68, width 82; female, length 63, width 78.

*Variation*.—The distance between the suborbital angles tends to increase relatively with age.

*Color*.—General color of carapace light lavender-gray underlaid with dull yellow, some specimens darker or lighter, with regular pattern of lighter spots dull yellow, off-white, or bluish yellow to lavender yellow, rear border of carapace light blue; spine of carapace purplish red at base to red or purple subdistally, white at tips; carpus and merus of chelipeds somewhat same color as carapace except pink flesh colored at merocarpal joint and on hand; fingers white on inner surface, and with white teeth; large spine at internal angle of carpus and a few small but distinct spots on superoexternal surface of hand purple, large spine grading to lighter purple on body of carpus; anterior border of chela and first 3 pair of walking legs with longitudinal band of brownish purple, band extending to lower border of dactyl on chela; dactyls of first 3 walking legs and outer border of hand immediately below external ridge same color, sometimes darker on dactyl with teeth same color, distal tip of fixed fin-

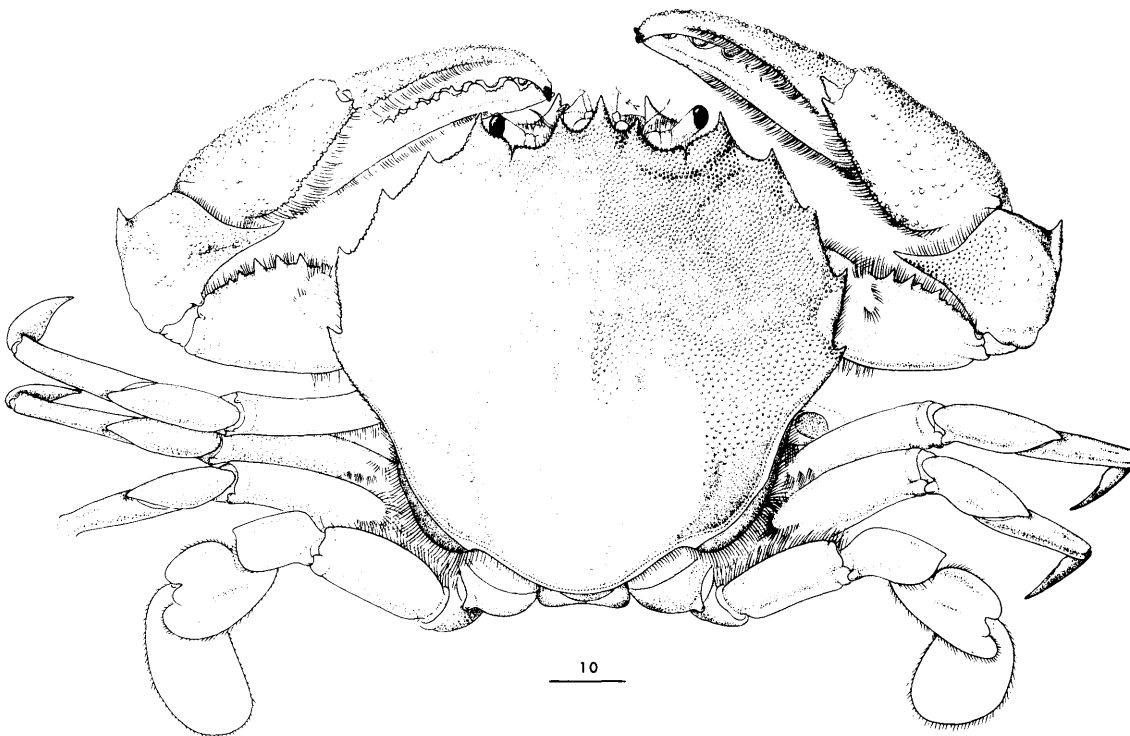


Fig. 291. *Ovalipes stephensoni* Williams. Male in dorsal view, 10 mm indicated (from Williams 1976).

ger similarly colored; blade of swimming leg yellowish; underparts light.

Iridescent spots between anterolateral teeth, on distal or dorsal surface of external carpal spine and along upper edge of hand, at superodistal corner of merus on first 3 walking legs and along dorsal edge of these legs distally, on dorsal surface of second abdominal segment; spot between fourth and fifth anterolateral spines nearly semicircular (Williams 1962; 1965).

*Habitat*.—On or over sandy bottom, surface to 227 m (Wenner and Read 1982).

*Type-locality*.—South of Beaufort Inlet, N. C., 31°11'N, 76°42'W, 35 m.

*Known range*.—Off Accomack County, Va., 37°31'N, to near Biscayne Bay, Fla.

*Remarks*.—This species and its twin, *O. floridanus* Hay and Shore (= *guadulpensis* [Saussure] of various authors [Williams 1976]), are among the relatively few described examples of divergence of a marine Carolinian stock into two recognizable entities. The Gulf of Mexico species is much smoother than the Atlantic Carolinian one, but coloration and habitat seem similar.

Adults of *O. stephensoni* are found farther from shore than adults of *O. ocellatus* in the Carolinas, but the young of both species occur near shore as pointed out by a number of authors. Musick and McEachren (1972) thought that the difference may be related to temperature preferences; they captured *O. ocellatus* from 8° to 12°C and 11 to 22 m and *O. stephensoni* from 11° to 19°C and 18 to 49 m in the southern Chesapeake Bight. F. J. and W. B. Vernberg (1970) found that both of these species have similar tolerance to elevated temperature, but did not compare low temperature tolerance of *O. stephensoni* with the sustained low of 4°C survived by *O. ocellatus*.

Ovigerous females are reported from North Carolina in January and Florida in March.

Adaptations of *O. floridanus* (= *guadulpensis*) for feeding and burrowing in sandy bottoms (Caine 1974) are parallel to those of *O. stephensoni*. The crabs are nocturnally active, walking with dactyls of walking legs penetrating the substrate, and are extremely aggressive with conspecifics or other portunids but not with other crabs. Burrowing by alternate thrusts, flexures and sweepings of several pairs of legs, the crabs squat at rest in sand at an angle of 60° where they breathe by reversed circulation, thus avoiding oxygen-deficient water from the substrate. Caine discussed the opportunistic carnivorous feeding habits and described the gastric armature.

### Subfamily Portuninae

Carapace broad, anterolateral margin with up to 9 teeth, chelipeds very long; fifth legs flattened, paddle-shaped. (After Glaessner 1969.)

### Genus *Arenaeus* Dana 1851

Rathbun 1930a:134.—Hemming 1958b:13.

### *Arenaeus cribrarius* (Lamarck)

(Speckled crab, siri-capote (Brazil))

Fig. 292

*Portunus cribrarius* Lamarck 1818:259.

*Arenaeus cribrarius*.—Hay and Shore 1918:434, pl. 34, fig. 3.—Rathbun 1930a:134, pl. 58, figs. 2–3; pls. 59–60.—Williams 1965:173, fig. 153.—1974c:30, fig. 86 (key).—Coelho and Ramos 1972:188.—Taisoun 1973:52, photo 9, figs. 8A, 9A.—Felder 1973:55, pl. 8, fig. 4.—Powers 1977:74.

?*Arenaeus websteri* Jones 1968a:156, photograph p. 155.

*Recognition characters*.—Carapace more than twice as wide as long, finely granulate, produced on each side into strong spine. Front not so far advanced as outer orbital angles, with 6 teeth including inner orbitals, submesial pair of teeth at either side of central notch coalesced. Anterolateral teeth strong, somewhat acuminate, heavily ciliate beneath. Superior margin of orbit with 2 deep fissures divid-

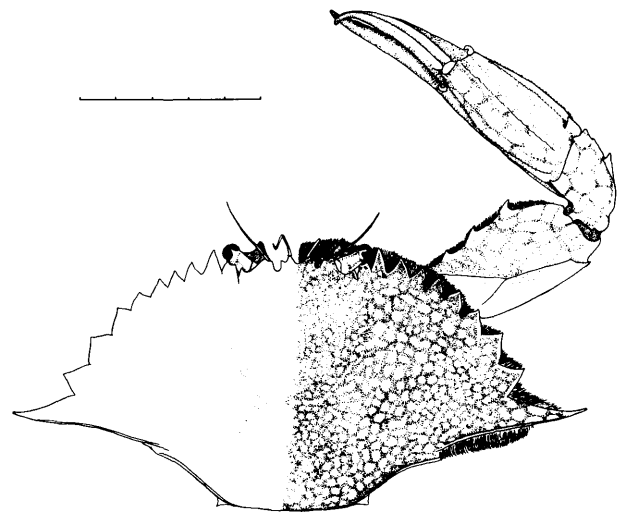


Fig. 292. *Arenaeus cribrarius* (Lamarck). Male in dorsal view, legs not shown except for right cheliped, color pattern of right side indicated, 5 cm indicated (from Williams 1965).

ing it into 3 lobes; inferior margin of orbit with wide external fissure, inner angle much advanced. Lower surface of carapace hairy.

Chelipeds of moderate size; merus with 3 spines on anterior border and short tuberculiform one near distal end of posterior border; carpus with inner and outer spine and lower lateral ridge flanked mesially by obsolescent row of tubercles; hand with 5 longitudinal granulose ridges and 2 spines, one at articulation with carpus and another above base of dactyl. Walking legs rather short and broad, densely fringed with short hairs. Swimming legs stout. Basal segment of abdomen produced on each side into strong, sharp, slightly upcurved spine.

*Measurements in mm.*—Carapace: male, length 65, width including lateral spines 142; mature female, length 54, width 116. Both males and females reach width of 153 (Camp, et al. 1977).

*Color.*—Light brown, light maroon, gray or olive brown thickly covered over dorsal surface with small, rounded, white to yellow spots; spots on dorsal surface of chelipeds somewhat larger; tips of walking legs yellow. Color pattern persisting in alcohol (various authors). Occasionally white with pinkish-brown reticulations (Jones 1968a).

*Habitat.*—This crab lives in rather shallow water along ocean beaches from the water line to 68 m and is well adapted to life in the waves and shifting sand (Dragovich and Kelly 1964; Dudley and Judy 1971; Fausto-Filho 1966a; Hoese 1972; Wass 1955). Hildebrand (1954) reported it as preferring the relatively shallow water of the white shrimp grounds in Texas, and Siebenaler (1952) regarded it as a "trash" form on the Florida east coast shrimp grounds. Pearse, et al. (1942) stated that where waves roll at the low-tide mark *A. cribrarius* may scurry across sand and burrow backward. In doing this, the crab flips sand forward away from the body with the chelipeds, waves the second to fourth legs rapidly from the median line laterally, and the fifth legs posteriorly and dorsally, thus sinking vertically into the sand. Often the crabs bury themselves completely. The heavy coat of hairlike setae on each side of the mouthparts keeps out sand, and with the chelipeds held close to the body a clear channel is left for currents from the branchial chamber. Ability to maintain strenuous activity in the breaker zone near shore may be partly explained also by the relatively large respiratory surface in this species (Gray 1957).

*Type-locality.*—Brazil.

*Known range.*—Vineyard Sound, Mass., to Santa Catarina, Brazil.

*Remarks.*—At a beach-seine sampling station in

the surf zone and an associated tidal pool in South Carolina, Anderson, et al. (1977) took 422 specimens of *A. cribrarius* over a two-year period. In water temperature of 11°–28.6°C at 27.5–35‰ salinity, the specimens taken measured 7 to 141 mm in carapace width. One of the most abundant organisms taken in the samples, the number of crabs was directly correlated with water temperature. Ovigerous females occurred as early as mid-June, and recently spawned ones as late as mid-September (see also Park 1978). Small individuals occurred from May through October.

Elsewhere, ovigerous females are known in May, July and August from Florida (Camp, et al. 1977), in August from North Carolina, and in September from Venezuela and Brazil. Many ovigerous females have been collected at night on sand shoals near Beaufort Inlet, N. C., at the edge of the surf zone in very shallow water (J. Costlow, personal communication).

Old crabs may bear the barnacle *Octolasmis mulleri* on the gills (Camp, et al. 1977).

The case of *Arenaeus websteri* Jones probably parallels that of *Callinectes humphreyi* Jones for which positive determination cannot be achieved because the dry holotype was destroyed by a bloodhound pup (see Williams 1974b:741). Differences between the eastern Pacific *A. mexicanus* and western Atlantic *A. cribrarius* are slight, and the possibility of a population of the latter becoming genetically isolated in Barbados seems remote. Light-colored crabs living on light-colored bottoms are common, and *A. websteri* is probably an albinistic phase of *A. cribrarius*. Limits of morphometric variation in *A. Cribrarius* probably encompass the dimensions of *A. websteri*.

Randall (1967) reported *A. cribrarius* from stomach contents of the porcupinefish, *Diodon hystrix*.

### Genus *Callinectes* Stimpson 1860

Williams 1974b:719.

Portunid crabs lacking internal spine on carpus of chelipeds. Abdomen of male broad proximally, narrow distally, roughly T-shaped; third to fifth segments fused and tapering from broad third to distally narrow fifth; sixth narrow, elongate, telson ovate with acute tip. Abdomen of female exhibiting two forms: immature with abdomen triangular from fourth segment to tip of telson, segments fused; mature with abdomen broadly ovate, segments freely articulated, telson narrow, triangular. (After Williams 1974b.)

### Key to Species Based on Carapace

(Excluding juveniles)

1. Front with 2 prominent, broad-based, triangular teeth between inner orbitals; each with or without rudimentary submesial tooth on mesial slope. . . . . *C. sapidus*  
 Front with 4 teeth between inner orbitals, or 2 prominent teeth separated by space often bearing pair of rudimentary submesial teeth . . . . . 2
2. Submesial pair of frontal teeth well developed and more than half as long as lateral pair (measuring from base of lateral notch between teeth). . . . . *C. bocourti*  
 Frontal teeth decidedly unequal in size, submesial pair no more than half as long as lateral pair (measuring from base of lateral notch between teeth) . . . . . 3
3. Carapace very smoothly granulate, lines of granules visible but barely perceptible to touch (except epibranchial line variably prominent). . . . . *C. similis*  
 Carapace coarsely granulate, scattered granules and lines of granules quite evident to sight and touch . . . . . 4
4. Anterolateral teeth (exclusive of outer orbital and lateral spine) lacking shoulders and swept forward . . . . . 5  
 Anterolateral teeth (exclusive of outer orbital and lateral spine) lacking shoulders, not swept forward . . . . . 6
5. Anterolateral teeth well separated, all except first 3 and lateral spine with anterior margins concave; chelipeds with ridges finely granulated . . . . . *C. larvatus*  
 Anterolateral teeth adjacent, stout, anterior margins not noticeably concave, fifth tooth often largest; chelipeds with ridges coarsely granulated . . . . . *C. exasperatus*
6. Submesial pair of frontal teeth absent or vestigial . . . . . *C. ornatus*  
 Submesial pair of frontal teeth never vestigial, but no more than half length of lateral pair . . . . . *C. danae*

### Key to Mature or Nearly Mature Males

(Based primarily on first pleopods)

1. Tips of first pleopods falling well short of suture between thoracic sternite VI and mesially expanded sternite VII . . . . . 2  
 First pleopods reaching to, almost to, or beyond suture between thoracic sternite VI and mesially expanded sternite VII . . . . . 4
2. First pleopods well separated from each other, almost never touching or crossing; tips not lanceolate . . . . . 3  
 First pleopods overlapping each other, often crossing; tips lanceolate . . . . . *C. ornatus*
3. First pleopods slender distally, nearly straight, tips bent slightly mesad . . . . . *C. similis*  
 First pleopods fairly stout distally, angled toward midline, then abruptly bent forward in a short slender terminal extension . . . . . *C. larvatus*
4. Tips of first pleopods curved abruptly mesad. . . . . *C. exasperatus*  
 Tips of first pleopods not curved abruptly mesad . . . . . 5
5. First pleopods with tips never extending beyond abdominal locking tubercle on thoracic sternite V, slender distal part almost straight, minutely spined, tips almost always bent ventrolaterally. . . . . *C. danae*  
 First pleopods with tips extending beyond abdominal locking tubercle on thoracic sternite V, slender part definitely curved or sinuous, variously

- spined, never bent ventrolaterally at tip. . . . . 6
6. Front with 2 prominent, broad based, triangular teeth between inner orbitals; each with or without rudimentary submesial tooth on mesial slope . . . . . *C. sapidus*
- Front with 4 teeth between inner orbitals reaching nearly common level. . . . . *C. bocourti*

***Callinectes bocourti* A. Milne Edwards**

(Siri (Brazil))

Figs. 293f, 294

*Cancer pelagicus*.—De Geer 1778:427, pl. 26, figs. 8–11.

*Callinectes Bocourti* A. Milne Edwards 1879:226.

*Callinectes bocourti*.—Williams 1974b:766, figs. 12, 18j, 20m, 22j, 27.—Powers 1977:75.

**Recognition characters.**—Carapace bearing 4 frontal teeth with tips reaching nearly common level, lateral triangular pair obtuse with mesial side having flatter angle than lateral side, submesial pair narrower than laterals. Metagastric area with length and posterior width about equal, anterior width 2 times length. Anterolateral margins moderately arcuate, anterolateral teeth exclusive of outer orbital and lateral spine swept forward, anterior margin of teeth shorter than posterior margin, teeth in lateral half of row always acuminate. Surface of carapace dorsally smooth and glistening around perimeter (when wet) and on epibranchial surfaces; central part granulate, coarsest granules over mesobranchial and rear half of cardiac areas and lateral half of branchial lobes. Epibranchial line prominent and nearly continuous, sulci on central part of carapace deeply etched.

Chelipeds remarkably smooth except for usual spines and obsolescent granules on ridges; fingers of major chela heavily toothed, lower margin of fixed finger often decurved near base in adults.

Male abdomen and telson long, extending nearly to juncture between thoracic sternites III and IV; telson lanceolate, much longer than broad; sixth segment of abdomen broadened distally. Mature female abdomen and telson reaching as far forward as in male, sixth segment nearly as long as fifth, its distal edge uniformly arched, telson elongate-triangular with inflated sides. First pleopods of male very long, often exceeding telson and crossed near tips; sinuously curved and overlapping in 2 places proximally, diverging distally, twisting mesioventrally on axis lateral to abdominal locking tubercle and recurving gradually to termination near midline; armed distally with dorso-lateral band of large and small recurved spi-

nules. Gonopores of female asymmetrically ovate in outline with apex on long axis directed antero-mesad; aperture of each sloping from surface on mesial side under rounded, sinuous anterolateral border superior to low rounded eminence on posterior border.

**Measurements in mm.**—Largest male: carapace length 76, width at base of lateral spines 132, including lateral spines 156. Largest female: length 70, width at base of lateral spines 121, including lateral spines 146. The species characteristically reaches fairly large size.

**Variation.**—Williams (1974b) discussed variation in this species.

**Color.**—Complete color descriptions (Chace and Hobbs 1969; Taissoun 1969, 1972) and notes (Rathbun 1896a, 1930; Holthuis 1959) give a range of color variations. These can be broadly summarized as: Overall cast olive green with prominent reddish markings. Carapace olive, grayish green, greenish chestnut or forest green with variable purplish to red markings, especially on branchial, hepatic, cardiac, and gastric areas, individuals of large size sometimes being dark chestnut tinted blackish brown on gastric and metagastric areas, with an oblique spot on subbranchial region; anterolateral teeth olive green with brown to red tints and yellowish white tips. Chelipeds red to dark reddish brown above and whitish below with bluish tints, main colors being sharply separated on outer surface of palm; fingers red to reddish brown, a purplish cast on internal articulation of merus with carpus and this member with chela; tubercles, tips of fingers and spines on articles cream. Remaining legs reddish above with shades of maroon, yellow and olive green ventrally except distal articles scarlet to red or dark red distally; hairs olive-tan. Underparts of body mainly dirty white to purplish red with suffusion of blue marginally, first abdominal segment mainly reddish tan. Males tend to be reddish, females greenish.

**Habitat.**—Usually in shallow brackish waters ranging in salinity from nearly fresh (Norse 1978; 1978a) to nearly full marine concentrations over mud to sandy bottoms; mature females tend to move to saltier water after mating. Associated with *Callinectes sapidus* in many estuaries but seems more tolerant of stagnant, polluted situations (Chace and

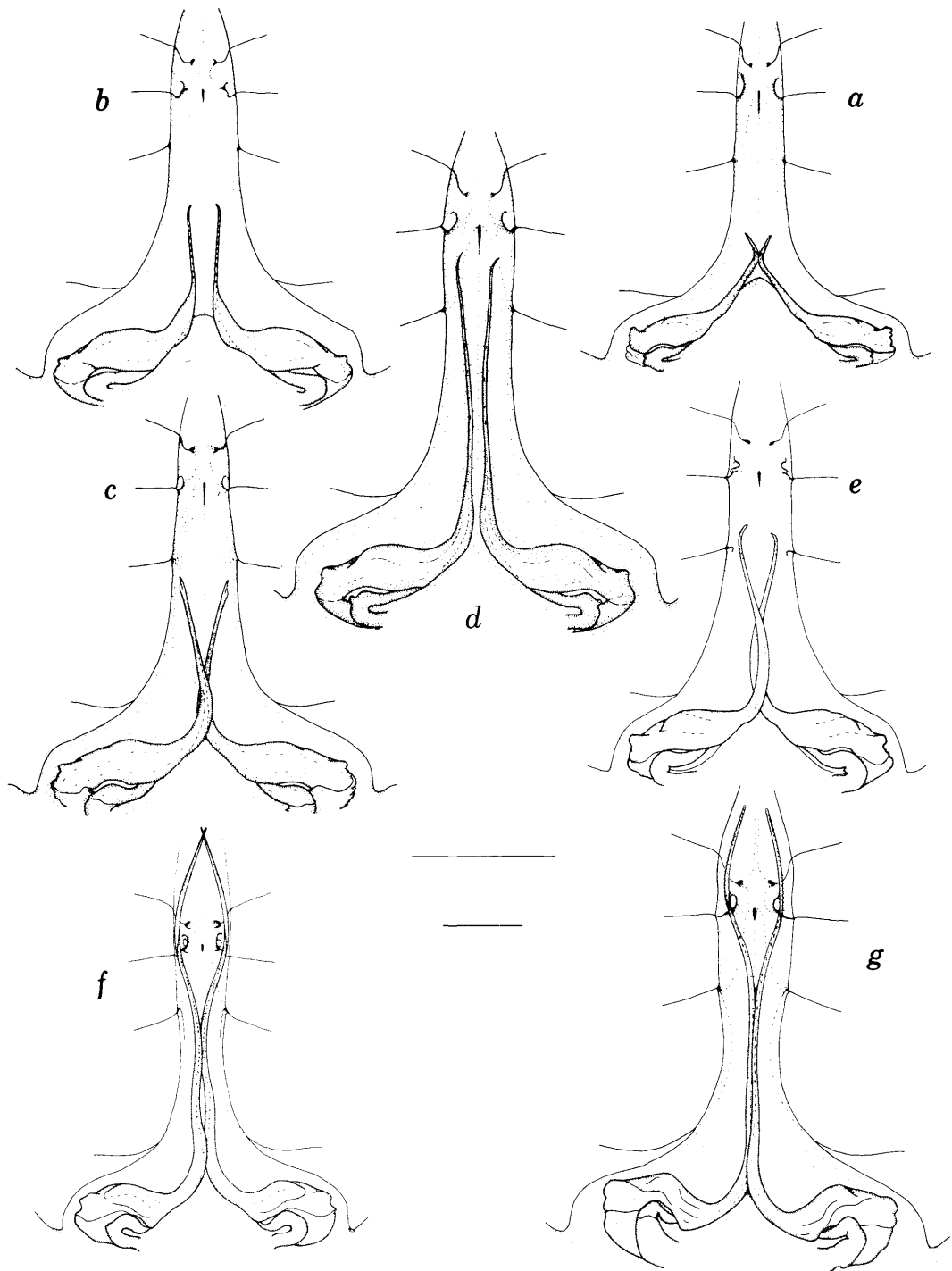


Fig. 293. *Callinectes*, male first pleopods in situ with abdomen removed; portions of sternites IV-VIII; a, *C. larvatus* Ordway; b, *C. similis* Williams; c, *C. ornatus* Ordway; d, *C. danae* Smith; e, *C. exasperatus* (Gerstaecker); f, *C. bocourti* A. Milne Edwards; g, *C. sapidus* Rathbun. Scales = 1 cm, g has lower magnification (from Williams 1974b).

Hobbs 1969; Taissoun 1969, 1972; Williams 1974b).

*Type-locality*.—Mullins River, 20 miles south of Belize, [British] Honduras.

*Known range*.—Jamaica and Belize to Santa Catarina, Brazil; occasional occurrences in Florida, Mississippi and North Carolina, USA (Williams

1974b; Perschbacher and Schwartz 1979; Williams and Williams 1981).

*Remarks*.—North American records may be explained by drift from the Caribbean, possible routes being suggested by drift bottles (Brucks 1971) and debris (Williams and Williams 1981).

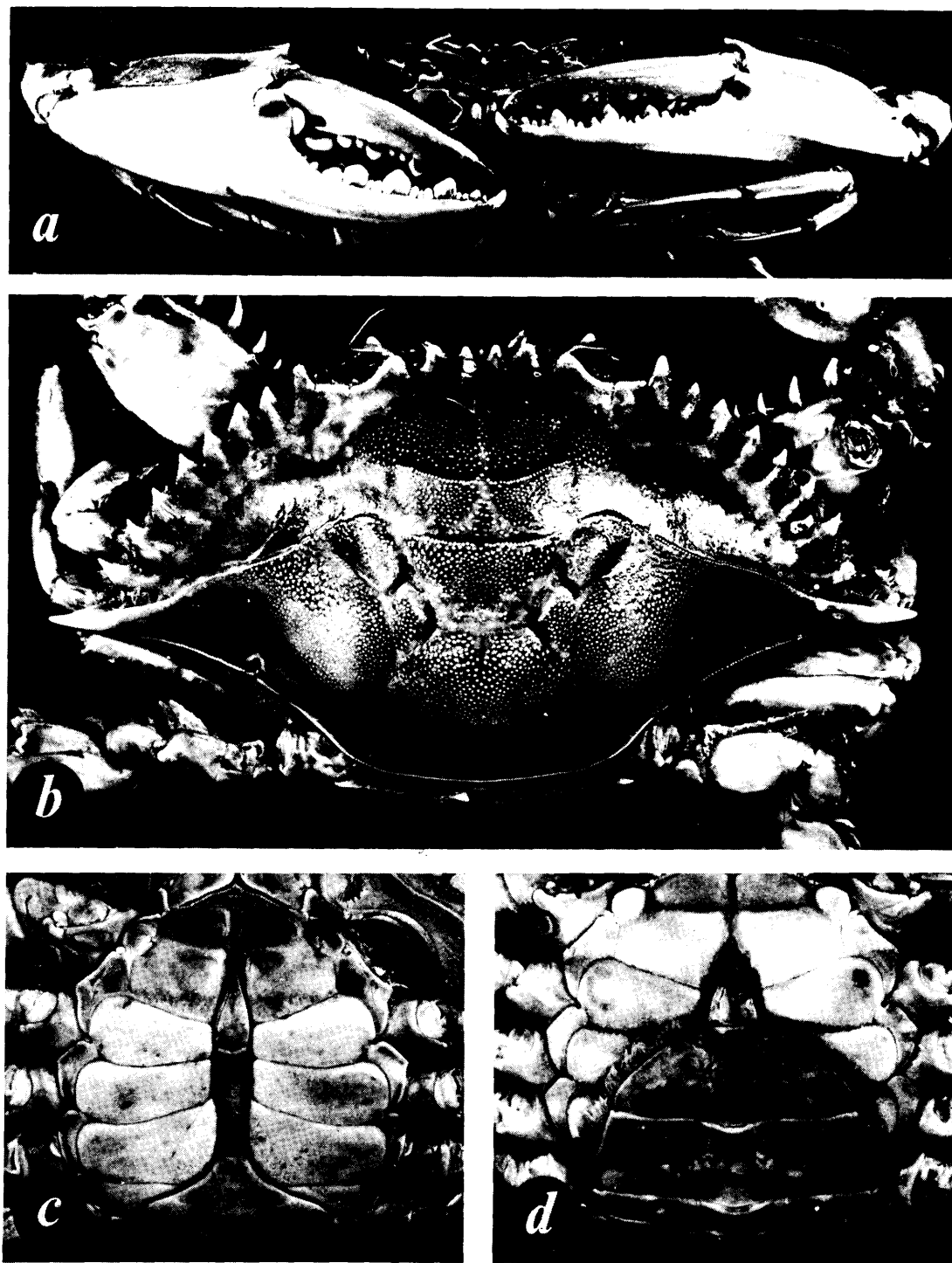


Fig. 294. *Callinectes bocourti* A. Milne Edwards. *a*, Male chelae in frontal view; *b*, carapace; abdomen and sternal area, *c*, male, *d*, female; *a*, *c*  $\times$  1; *b*  $\times$  1.2; *d*  $\times$  1.4 (from Williams 1974b).

Ovigerous females are known nearly the year round in one part or another of the range, perhaps with seasonal peaks in abundance associated with latitude (Williams 1974b).

Though not so important economically as *C. sapidus*, fisheries for *C. bocourti* exist along the northern coast of South America (Williams 1974b).

#### *Callinectes danae* Smith 1869

Figs. 293*d*, 295

*Callinectes Danae* Smith 1869:7.

*Callinectes danae*.—Williams 1974b:746, figs. 7, 18*e*, 20*e-f*, 22*e*, 24.



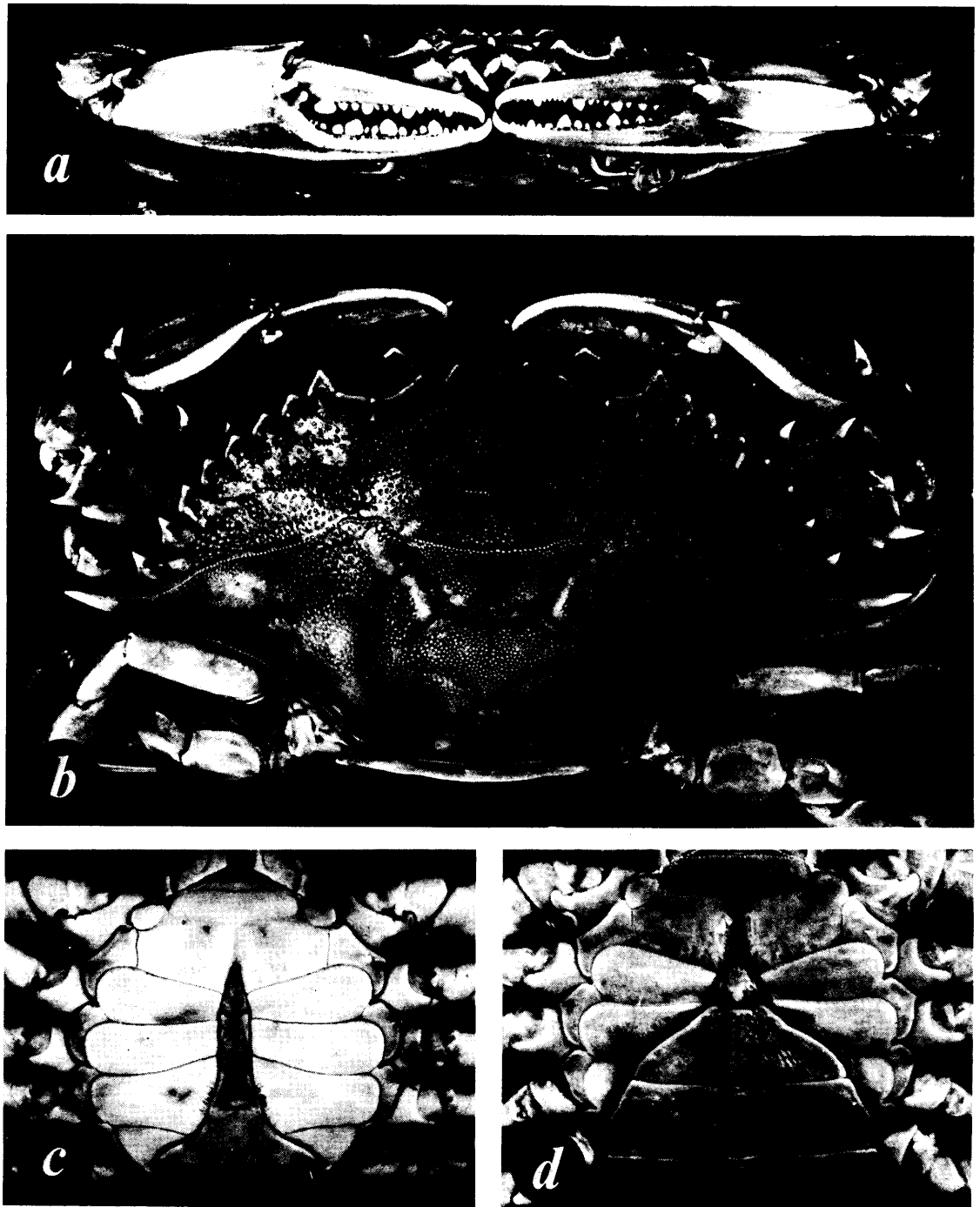


Fig. 295. *Callinectes danae* Smith. a, Male chelae in frontal view; b, carapace; abdomen and sternal area; c, male, d, female; a,  $c \times 1$ ;  $b \times 1.4$ ;  $d \times 1.5$  (from Williams 1974b).

*Recognition characters.*—Carapace bearing 4 frontal teeth, submesial pair no more than half length of lateral pair. Metagastric area of adults with anterior width about 2–2.5 times length, posterior width about 1.5 times length. Anterolateral margins somewhat arched, teeth exclusive of outer orbital and lateral spine varying from often convex sided with subacute tips at orbital end of row to sharper

and more spiniform laterally, each with anterior margin shorter than posterior and separated from contiguous ones by narrow based rounded notches. Surface of carapace rather evenly and smoothly granulate, except granules more widely spaced on epibranchial region and near anterolateral border, most crowded on gastric, mesobranchial and cardiac regions; nearly smooth along frontoorbital,

posterolateral and posterior borders.

Chelipeds with granulate ridges, upper surface of carpus bearing slightly developed interrupted ridges trending longitudinally with axis of limb, ridges bearing obsolescent granules often better developed in males than in females, inferior lateral ridge terminating in strong lateral spine or teeth often followed by strong eminence. Male abdomen and telson reaching beyond suture between thoracic sternites IV and V; telson triangular, longer than broad with somewhat inflated sides; sixth segment of abdomen with sides nearly straight, diverging proximally, poorly calcified proximally except for variably indurated basal portion often connected to distal part by narrow central column. Mature female abdomen and telson reaching as far as in male, sixth segment shorter than fifth, telson triangular with slightly inflated sides. First pleopods of male reaching beyond midpoint of thoracic sternite VI, overlapping each other near base, or adjacent, and tapering to narrow membranous tips usually bent ventrolaterally; armed with scattered but mainly dorsal minute spinules and 2 to 4 subterminal, sternomesial, exceedingly slender elongate spinules. Gonopores of females broadly and irregularly ovate with apex on long axis directed anteromesad, aperture of each broadly open mesially, narrowing laterally, and sloping from superior border and rounded prominence on posterolateral border.

*Measurements in mm.*—Largest male: carapace length 58, width at base of lateral spines 104, including lateral spines 139. Largest female: length 48, width at base of lateral spines 84, including lateral spines 108.

*Variation.*—Williams (1974b) discussed variation in this species.

*Color.*—Live males from Cubatão River near Santos, São Paulo, Brazil: Carapace olive, becoming indigo on edges of lateral spines and outer anterolateral teeth in some individuals, more uniformly olive in others; teeth and spines on chela white tipped; a white patch in deepest part of depression above third walking leg. Cheliped with upper surface of palm, dactyl, part of carpus and spined edge of merus indigo to purple, and same color in splashes on inside of fingers, distally on merus and laterally on carpus. Flat outer dorsal surface of palm and upper surface of merus reticulate blue and olive (but many crabs predominantly olive on this part). Walking and swimming legs predominantly china to azure blue, grading to greenish and olive in darker parts. Lower edge of chelae grading from purple to china blue or azure individually. Chelipeds with inner face of palm,

outer face of palm and fingers, lower face of merus, as well as meri of remaining legs and ventral surface of cephalothorax, white.

Described above is a colorful male which should be called the "purple crab" if *C. sapidus* is called a "blue crab." Some individuals are duller and some have a reticulate pinkish-blue cast on the upper surface of chelipeds.

Color notes by Kretz and Bucherl (1940) and Taissoun (1969) emphasized the distal intense purple coloration of legs and grayish-blue carapace on adult males.

*Habitat.*—A common species in Brazil where it occurs from muddy estuaries in mangroves and algae-covered broken shell bottoms, to beaches and open ocean depths of 75 m. Specific limits of salinity tolerated are not well documented, but ranges indicated are from fresh to full sea water, and perhaps to hypersaline lagoons. Norse (1978; 1978a) regarded the species as more marine than estuarine. Kretz and Bucherl (1940) indicated that *C. danae* is the most abundant member of the genus along beaches from Santos to Rio de Janeiro where they worked. Park (1969) found the species only on or adjacent to the ocean side of islands in Biscayne Bay, usually on wave-beaten shores. He reported it absent from the Florida Keys.

*Type-locality.*—Recife [= Pernambuco, Estado de Pernambuco], Brazil.

*Known range.*—Bermuda; New Hanover County, N. C., near Cape Fear, rare (Perschbacher and Schwartz 1979); southern Florida and eastern side of Yucatan Peninsula to Estado de Santa Catarina, Brazil.

*Remarks.*—Records north of Florida may be explained by drift from the Caribbean (Williams and Williams 1981). A probable Pleistocene occurrence in Maryland is reported by Williams (1974b).

The spawning season probably extends the year round over the range as a whole (Williams 1974b).

Incidental reports of purchase in markets and capture on fishing vessels imply fairly general utilization of this species where it is abundant (Williams 1974b).

### *Callinectes exasperatus* (Gerstaecker)

Figs. 293e, 296

*Lupea exasperata* Gerstaecker 1856:129.

*Callinectes exasperatus.*—Williams 1974b:757, figs. 9, 18g, 20i, 22g, 26.

*Recognition characters.*—Carapace bearing 4 well-developed frontal teeth, submesial pair narrower and slightly shorter than lateral pair. Metagastric

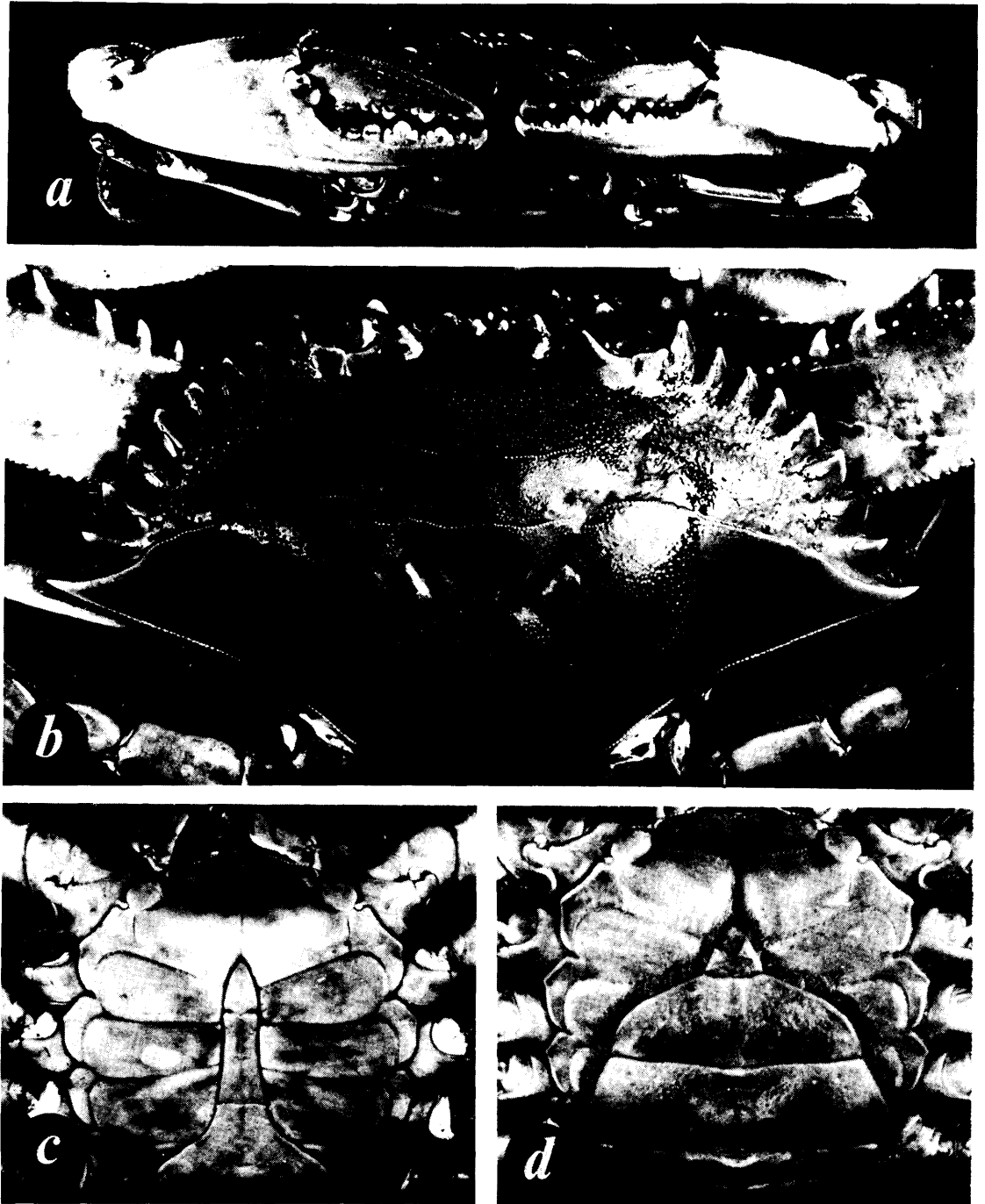


Fig. 296. *Callinectes exasperatus* (Gerstaecker). *a*, Male chelae in frontal view; *b*, carapace; abdomen and sternal area, *c*, male, *d*, female; *a*  $\times$  0.8, *b*  $\times$  1.1, *c*  $\times$  1, *d*  $\times$  1.4 (from Williams 1974b).

area with posterior width 1.2–1.3 times length, anterior width 2.3–2.5 times length. Anterolateral margins strongly arched with anterolateral teeth exclusive of outer orbital and lateral spine usually but not always curved forward; teeth progressively broader laterally with fifth tooth often largest. Lateral spine stout, usually less than twice length of preceding tooth. Surface of carapace conspicuously granulate with densest concentrations on central eminences, coarsest and most widely spaced

granules in front of epibranchial line separated by smooth surfaces. Central sulci on carapace definite but not deep; epibranchial line rather flatly arched, slightly sinuous.

Chelipeds robust, ridges and crests of all articles coarsely granulate; fingers of major chela strong but not markedly gaping.

Male abdomen and telson reaching along posterior quarter of thoracic sternite IV; telson lanceolate with sinuous inflated sides, length 1.5 times

basal width; basal portion of fused segments 3–4–5 truncate laterally. Mature female abdomen and telson reaching about same level as in male; telson triangular with inflated sides, length 1.2 times basal width; fifth segment longer than sixth. First pleopods of male reaching slightly beyond suture between thoracic sternites VI and VII, sinuously curved, overlapping in proximal half along midline then diverging distally, twisting on axis near tip and bending abruptly mesad; armed distally with scattered minute spinules, tip slightly broadened and opening posteromesially. Gonopores of female broadly and somewhat asymmetrically ovate in outline with orientation of long axis mainly in frontal plane but with apex directed anteromesad; aperture of each laterally elongate and sinuous, sloping from broadest area at surface on mesial side to narrower and deeper portion under rounded overhanging anterior border with prominent central projection and posterior border with elongate posterolateral eminence.

*Measurements in mm.*—Largest male: carapace length 67, width at base of lateral spines 114, including lateral spines 129. Largest female: length 59, width at base of lateral spines 101, including lateral spines 124.

*Variation.*—Williams (1974b) discussed variation in this species.

*Color.*—Carapace of adult male purplish red, more accented on proto-, meso-, and metagastric areas and at base of lateral spines and anterolateral teeth; branchial region and anterolateral teeth obscure maroon. Dorsal surface of all legs purplish red with intense orange red on articulations; inferior portion of merus, carpus, and fingers of chelipeds intense violet; internal and external portion of chelae as well as remaining ventral aspect of animal white with tints of soft purple (Taissoun 1969).

*Habitat.*—Primarily in shoal marine, estuarine, and perhaps fresh water, especially in association with mangroves and around river mouths from water's edge to recorded depths of about 7.5 m (Rankin 1900; Coelho 1967, 1970; Chace and Hobbs 1969; Taissoun 1979).

*Type-locality.*—Puerto Cabello, Venezuela.

*Known range.*—Duval County, E of Jacksonville, Fla. (rarely) (USNM), to Santa Catarina, Brazil; Veracruz, Mexico; Bermuda; also reported from extreme southern Texas.

*Remarks.*—*Callinectes exasperatus* has a number of distinctive features. It has the roughest appearing carapace and chelipeds of any species in the genus because the granulations are coarser and sharper than in others. The median epistomial tooth is more widely separated from the front than among the

congeners, perhaps a function of the vaulted carapace which contributes to the deep bodied form. Similar to *C. bocourti* in structure of frontal teeth, *C. exasperatus* has less prominent cardiac lobes and sulci bounding the metagastric area. The lateral spines are relatively shorter than among other species of the genus. A blunt anteromesial eminence on the carpus is pronounced. Narrowest width of the male abdomen is in the distal third of the sixth segment, the narrowed portion becoming increasingly distal with age together with progressive crossing of the pleopods.

Few dated collections contain ovigerous females: March, Puerto Rico and Guadeloupe; April, Barbuda and Panama; May, Jamaica; June, West Indies; August, Santa Catarina, Brazil. Other undated collections in museums are from Bermuda, southern Florida, Pernambuco and São Paulo, Brazil.

### *Callinectes larvatus* Ordway

Figs. 293a, 297

*Callinectes larvatus* Ordway 1863:573 [8].—Manning and Holthuis 1981:93, fig. 20c, d.

*Callinectes marginatus.*—Williams 1974b:722 (part), figs. 3, 18b, 20a, 22b.—Felder 1973:59, pl. 8, fig. 9.—Powers 1977:77.

*Recognition characters.*—Carapace bearing 4 frontal teeth, submesial pair no more than half length of lateral pair. Central trapezoidal (metagastric) area short, anterior width about 2.4 times, posterior width about 1.5 times length. Anterolateral margins arched slightly; anterolateral teeth exclusive of outer orbital and lateral spine without shoulders, usually trending forward and anterior margins of all except first 2 concave, last 2 teeth spiniform. Lateral spine moderately long and slender. Surface coarsely granulate anterior to prominent epibranchial line and over mesobranchial regions, more finely and closely granulate on proto- and mesogastric areas, prominent branchial lobes, and especially on cardiac lobes; posterior and posterolateral margins smooth.

Chelipeds with smoothly granulate prominent ridges on propodi and reduced ones on carpi; fingers compressed but broadened dorsoventrally producing a pointed spatulate shape; major chela with usual enlarged proximal tooth on dactyl opposing molariform complex on fixed finger often with decurved lower margin.

Male abdomen and telson narrow, reaching slightly beyond suture between sternites IV and V; telson about 1.8 times longer than wide; sixth seg-

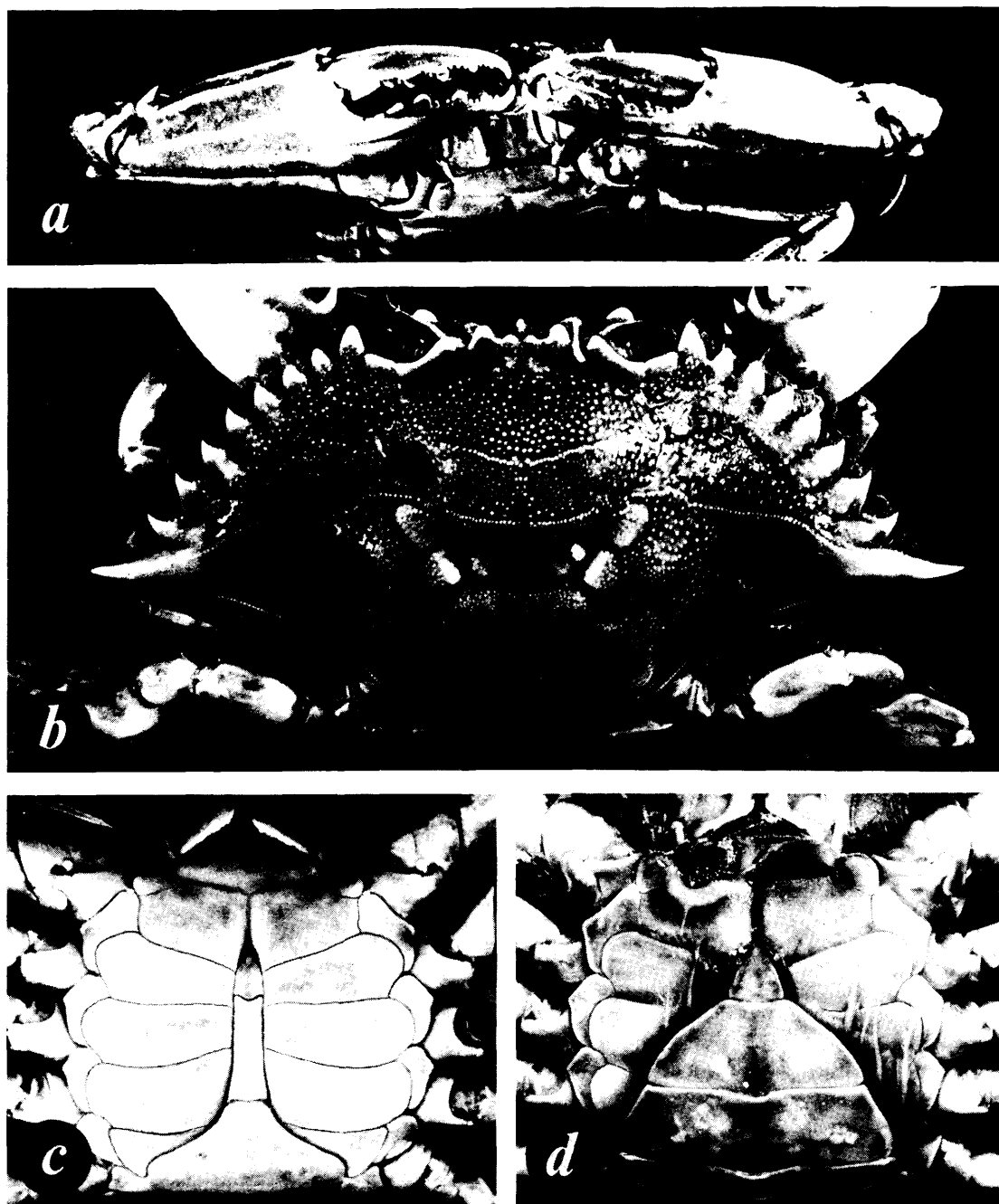


Fig. 297. *Callinectes larvatus* Ordway. a, Male chelae in frontal view; b, carapace; abdomen and sternal area, c, male, d, female; a  $\times$  1, b  $\times$  1.5, c  $\times$  1.4, d  $\times$  1.7 (from Williams 1974b).

ment nearly parallel-sided but somewhat broadened proximally. Mature female abdomen and telson reaching same level as in male, length slightly exceeding width (1.05 times); sixth segment longer than fifth. First pleopods of male short, reaching about midlength of sternite VII, approximating each other or occasionally overlapping at level of sharp distal curve, distal portion abruptly curved laterad, tapered to a rather sharp point, twisted  $\frac{1}{4}$

turn on axis and, except for membranous spout-like tip, armed with minute scattered reflexed spinules tending to arrangement in rows, a few spinules proximal to flexure. Gonopores of female ovate with apex on long axis directed anteromesad, aperture of each with margin irregularly rounded and sinuous except on mesial side where it slopes from surface laterad under superior anterior border.

*Measurements in mm.*—Largest male: carapace length 67, width at base of lateral spines 118, including lateral spines 142. Largest female: length 59, width at base of lateral spines 82, including lateral spines 95. Mature size of females varies considerably, the smallest examined having a carapace length of 33 and width including lateral spines of 70.

*Variation.*—Williams (1974b) discussed variation in western Atlantic members of *C. larvatus* (= *C. marginatus*).

*Color.*—Carapace brown with areas of bluish black. Chelae brown above; fingers dark on external face except for tips and proximal portion, internal face dark in distal  $\frac{2}{3}$ ; dark color of fingers retained in preservation.

A juvenile male collected by Elliott Norse at Pigeon Key, Fla., 6 August 1974, frozen and observed by me a few days later: mottled grayish tan over carapace and dorsal side of chelipeds. Fingers of chelae white tipped; central band of blue on both fingers running onto palm and becoming lighter as it grades into white; teeth maroon in center of row or white rimmed with maroon along "gum line"; distal and proximal teeth white, large proximal crushing tooth off-white.

Tiny male with essentially white chelae except for mottled dorsal side.

*Habitat.*—The species lives in a variety of shallow environments probably seldom exceeding 15 m but usually in depths of 5 m or less and often in intertidal pools. Most specimens have been collected by hand, seine, dip net, etc., from sand and mud flats, algae and grass flats, sandy beaches, rocky pools, eroded coral bases, oyster bars, shallows at edge of mangroves, and at the surface under lights at night (Williams 1974b)

*Type-localities.*—Key West, Florida; Tortugas; Bahama Islands; Haiti.

*Known range.*—Beaufort, N. C., through Caribbean Sea to south central Brazil off São Paulo; Bermuda. North Carolina records are rare (Williams 1974b; Perschbacher and Schwartz 1979).

*Remarks.*—The populations of *C. larvatus* and *C. marginatus* on each side of the Atlantic were judged indistinguishable by means of external morphological characters until Manning and Holthuis (1981) studied a large series of specimens and found differences in granulation of the carapace, depth of cervical groove behind the orbits, ventral inner orbital angle, and minute differences in the male pleopods.

Ovigerous females are recorded from December to July in various parts of the geographic range on both sides of the Atlantic. Specifically the records

are: St. Thomas, December and January; Grenadines and Cuba, March; Haiti, April; Jamaica, May; Colombia and Curaçao, June; Florida and Puerto Rico, July.

### *Callinectes ornatus* Ordway

Figs. 293c, 298

*Callinectes ornatus* Ordway 1863:571.—Williams 1974b:739, figs. 6, 18d, 20d, 22d.—Felder 1973:58.—Powers 1977:77.

*Recognition characters.*—Carapace with lateral pair of frontal teeth prominent but submesial pair small, often almost completely rudimentary. Metagastric area of adults not deeply sculptured, anterior width about 2.8–2.9 times length, posterior width about 1.75 times length. Anterolateral margins broadly arched, teeth exclusive of outer orbital and lateral spine progressively more acuminate laterad; first 5 teeth with posterior margins longer than anterior margins, shouldered, distinctly separated by narrow based, rounded notches; last 2 teeth with margins approximately equal in length, separating notches broad, next to last tooth distinctly more acuminate than spiniform last one. Lateral spine trending forward. Surface of carapace with granulations most prominent on anterior half and on mesobranchial regions, granulations smaller and more closely crowded on meso-metagastric and cardiac regions, nearly smooth along posterolateral and posterior borders.

Chelipeds with smoothly granulated ridges on chelae, carpus almost smooth dorsally, inferior lateral ridge terminating in a low tooth occasionally followed by an inconspicuous eminence. Major chela usually with strong basal tooth on dactyl and, especially in adult males, lower margin of propodal finger often decurved near base.

Male abdomen and telson reaching beyond suture between thoracic sternites IV and V, usually with distal portions recessed below plane of sternum in retracted position; telson slightly longer than broad with somewhat inflated sides; sixth segment of abdomen relatively narrow, sides slightly constricted, not parallel. Mature female abdomen and telson reaching as far forward as in male, telson as broad as long. First pleopods of male reaching almost to suture between thoracic sternites VI and VII, overlapping each other completely near base but diverging distally and tapering to usually lanceolate membranous tip; armed subterminally with short reflexed spinules quite visible at low magnification, somewhat more numerous and longer

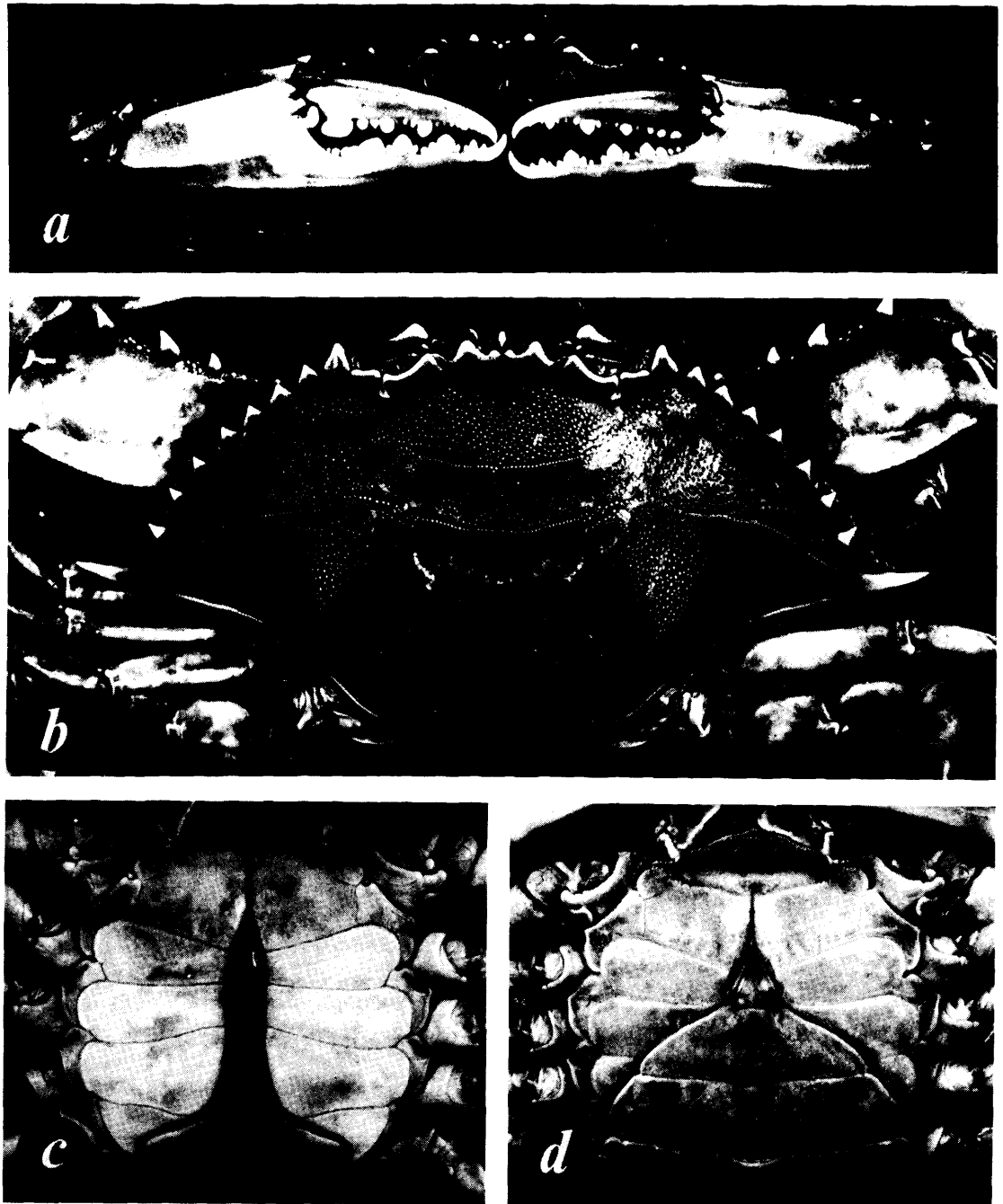


Fig. 298. *Callinectes ornatus* Ordway. *a*, Male chelae in frontal view; *b*, carapace; abdomen and sternal area, *c*, male, *d*, female; *a*  $\times$  1; *b*, *d*  $\times$  1.3; *c*  $\times$  1.5 (from Williams 1974b).

distally than proximally with tendency to arrangement in rows near tip on ventral and mesial margin. Gonopores of females irregularly ovate with apex on long axis directed anteromesad; aperture of each irregularly and broadly lunate, sloping from surface on mesial side under rounded crenate anterior border and rounded eminence on posterior border.

*Measurements in mm.*—Largest male: carapace length 60, width at base of lateral spine 105, in-

cluding lateral spines 130. Two largest females: length 58, width at base of lateral spines 84, including lateral spines 107—length 69, width at base of lateral spines 83, including lateral spines 99. These two females demonstrate variability in mature form that is characteristic of all species in the genus.

*Variation.*—Williams (1974b) discussed variation in this species.

*Color.*—Color of this species varies. Three de-

scriptions follow:

(1) Adult males with carapace dull olive to dark brown, usually with a large, ill-defined, roundish spot of orange or orange red on each side posteriorly; lateral spines and anterolateral teeth maroon, light blue or whitish, white tipped. Eystalks purple. Chelipeds proximally similar to carapace, spotted with blue or soft purple and with spines paler, joints red; inner surface of palm white but with a large bright red patch bordered with purple; fingers mostly purple, tipped with red. Walking legs bright blue above, with a band of scarlet at each joint and a patch of paler blue or green on posterior and lower side of each article; dactyls red or violet. Swimming legs similar in color but with red articular bands wider, a patch of orange or yellow on each article; dactyl with proximal blue band separated from distal scarlet band by an orange band. Abdomen light blue posteriorly. Females similar to males except upper surface of chela more violet; fingers with white or fuchsia colored teeth.

Many individuals less brilliantly colored, juveniles often dull or plain olive-yellow to greenish above. Some males more melanistic, exhibiting shades of dark brown and purple with accents of yellow and brownish red. Albinistic (or light hued) forms not uncommon (Verrill 1908a as condensed in Williams 1966; Taissoun 1969).

(2) Mature male with dorsal side of carapace a uniform light grayish green; anterolateral teeth and lateral spine white tipped. Chelipeds generally same color dorsally to somewhat grayer on upper surface of palm and dactyl, dorsal lateral ridge of palm darker gray; outer face of chelae white; inner surface of fingers dark blue with color running onto carpus, outlining mesiodorsal margin of palm (under shelflike ridge) and along anterior margin of merus; spines and teeth white. Tints of blue on legs. Swimming legs barred with alternate cross bands of light in central parts of articles and a tendency to light slate blue to gray at ends of articles, pale orange at articulations. Sternum white, and legs white to grayish distally. Some specimens more tan than grayish green, some tending toward pinkish gray. (Described a few days later from specimens brought to me frozen from Pigeon Key, Fla., 6 August 1974, by Elliott Norse.)

(3) Carapace almost uniformly light olive to suffused shades of flesh to pale orange or pale rust. Chelipeds light olive dorsally as on carapace, spines white, mesial margins dorsally rimmed with purple that spreads to spines and continues to tip of dactyl in males but ends at proximal half of dactyl in females; purple grading in tints of blue also along lower inner margin of hand and propodal finger of male, fading to white in center of palm; female

with no such lower border, but inner surface of palm with two longitudinal lines of blue separated by reticulate blue pattern on white background. Fingers white distally in females and teeth white. In males, fingers colored as outlined above, and teeth on inner surface blue and purple to magenta. Externally, hands of both sexes are light olive above but white below (a gradual change) with fingers white distally. Dactyls of walking legs rust to olive dorsally; propodus, carpus and merus slightly greenish to tannish blue. Fifth legs tannish to buff, barred with a broad transverse lighter band on proximal half of propodus and dactyl; these articles (especially the last) rust distally; propodus with a tinge of bluish near distal articulation. Venter white in males; females same with some transverse buff to magenta barring on segments of abdomen in adults. (Described 24 June 1975 from specimens taken at *Oregon II* Stn. 17696 off mouth of Amazon River, Brazil, and frozen by Bruce B. Collette, 12 May 1975.)

Gore (1977b) pointed out that dactyls of the swimming legs are a uniform golden brown or light tan, and the propodus is banded with translucent yellow proximally and dark bluish green distally.

*Habitat*.—Essentially a tropical species found mainly on sandy or muddy bottom from shore to about 75 m; the young have also been collected on shell and sponge bottoms. Occurrence in bays and river mouths (Holthuis 1959; Park 1969; Rouse 1970; in addition to collection data presented here), as well as entrapment in fresh water (Brues 1927), indicates tolerance of a broad range of salinity (recordings of 0–50‰ in temperatures ranging from 18°–31°C); nevertheless, most collections have come from waters of relatively high salinity (Norse 1978; 1978a). Taissoun (1969) reported occurrence in a temperature of 9°C, but this is perhaps a reference to *C. similis* which occurs in colder water.

*Type-localities*.—Charleston, South Carolina; Gonaives, Haiti; Cumana, Venezuela; Tortugas and Bahamas also listed in original description.

*Known range*.—Bermuda; Virginia, North and South Carolina through southern Florida; northwestern Yucatan to Estado de São Paulo, Brazil.

*Remarks*.—It is difficult to distinguish some juveniles, immature males, and adult females of *C. ornatus* from *C. danae* and *C. similis*. Width of the metagastric area approaches that of *C. similis* in some individuals. Borders of this area are more prominently defined than in *C. similis*, but become indistinct with age; in that condition they approach the smoothness of young *C. similis*.

The anterolateral teeth are more acuminate, forward pointing, and longer than in *C. similis*. The abdomen of males usually is recessed, but may be



flush with the sternum as in immature male *C. similis*, though never so broad as in *C. similis*.

Williams (1966), in restricting *C. ornatus*, noted that syntypes from Charleston, S. C., were from a locality representing an apparent extreme northern limit of geographic range. At that time no other specimens of *C. ornatus* were known from the Carolinas, but now material from the Cape Fear River estuary (Perschbacher and Schwartz 1979) and the Beaufort Inlet area of North Carolina has been taken on a number of occasions, as well as a few immature specimens from the mouth of the Chesapeake Bay in late summer (USNM). The records for *C. ornatus* from New Jersey represented by museum specimens all refer to *C. similis* (Williams 1974b). Large collections of this species from Bermuda were the basis for Verrill's (1908b) postulation that drifting larvae in currents could serve as colonizers for the islands.

The spawning season probably extends year round. Museum collections studied include ovigerous females as follows: January, Puerto Rico; April, Guyana, Rio de Janeiro, Brazil; May, São Paulo, Brazil; July, Rio de Janeiro, Brazil; August, Trinidad, Guyana, Surinam; September, Venezuela, the Guianas; October, North Carolina; December, St. Thomas, Rio de Janeiro, Brazil. Taisoun (1969) reported ovigerous females from the Golfo de Venezuela in January and May. Undated collections are recorded from southern Florida, Margarita I., Venezuela, and São Paulo, Brazil.

### *Callinectes sapidus* Rathbun

(Blue crab)

Figs. 293g, 299

*Callinectes sapidus* Rathbun 1896a:352, pl. 12; pl. 24, fig. 1; pl. 25, fig. 1; pl. 27, fig. 1.—Fowler 1912:416, pls. 128–130.—Williams 1974b:778, figs. 1, 16, 17, 19d, 21, 23b-c.—Felder 1973:55, pl. 8, fig. 7.—Powers 1977:78.

*Recognition characters*.—Carapace bearing 2 broad either obtuse or acuminate, triangular frontal teeth with mesial slopes (incorporating pair of rudimentary submesial teeth) longer than lateral slopes. Metagastric area with posterior width approximately 1.2 times length, anterior width about 2 times length. Anterolateral margins slightly arched; anterolateral teeth exclusive of outer orbital and lateral spine obtuse to acuminate and directed outward more than forward. Much of surface smooth, with scattered granules, but granules concentrated locally on mesobranchial, posterior slope of car-

diac, and anterior portion of mesogastric areas; tendency to crowding of granules into transverse ridge at summit of cardiac and mesobranchial area in some individuals. Sculpturing of surface varying individually from low to raised relief. Lateral spines varying from rather stout, blunt and forward trending to slender, elongate and slightly backward trending. Epibranchial line nearly straight over branchial region, otherwise sinuously curved.

Propodus and carpus of cheliped with moderate finely granulate ridges, width of chelae similar, propodal finger of major hand occasionally with lower margin decurved proximally.

Male abdomen and telson reaching about midlength of thoracic sternite IV; telson lanceolate, much longer than broad; sixth segment of abdomen broadened distally. Mature female abdomen and telson reaching about midlength of thoracic sternite IV; telson with inflated sides almost equilaterally triangular, fifth and sixth abdominal segments equal in length. First pleopods of male very long, reaching beyond suture between thoracic sternites IV and V but not exceeding telson; sinuously curved and overlapping proximally, diverging distally, twisting mesioventrally on axis lateral to abdominal locking tubercle and recurving to termination near midline; armed distally with row of large and small reflexed spinules following ventral and lateral borders with twist of axis; tip membranous, flared portion suggesting an elongate quadrilateral in outline. Gonopores of female paraboloid in outline with apex on long axis directed anteromesad, aperture of each sloping from surface on mesial side under irregularly rounded and linearly wrinkled anterior border superior to bulbous posterolateral border.

Much of the following discussion is taken almost verbatim from Williams (1974b).

*Measurements in mm.*—Largest male: carapace length 91, width at base of lateral spines 168, including lateral spines 209. A male measuring 9 inches (227 mm) across the carapace was reported from Ingram Bay, mouth of Great Wicomico River, Northumberland Co., Va. (Anonymous 1975a). Largest female: length 75, width at base of lateral spines 143, including lateral spines 204. Mature size of females varies considerably, the smallest examined having a carapace length of 21, width at base of lateral spines 41, including lateral spines 55.

Pretzmann (1966) discussed a large immature female with acute spines: length 65, width 132.5. The largest immature female I have seen, also with fairly acute spines, reached a carapace length of 60, width at base of lateral spines 109, including lateral spines 135. Some others in material studied approached this size. All such specimens seen by

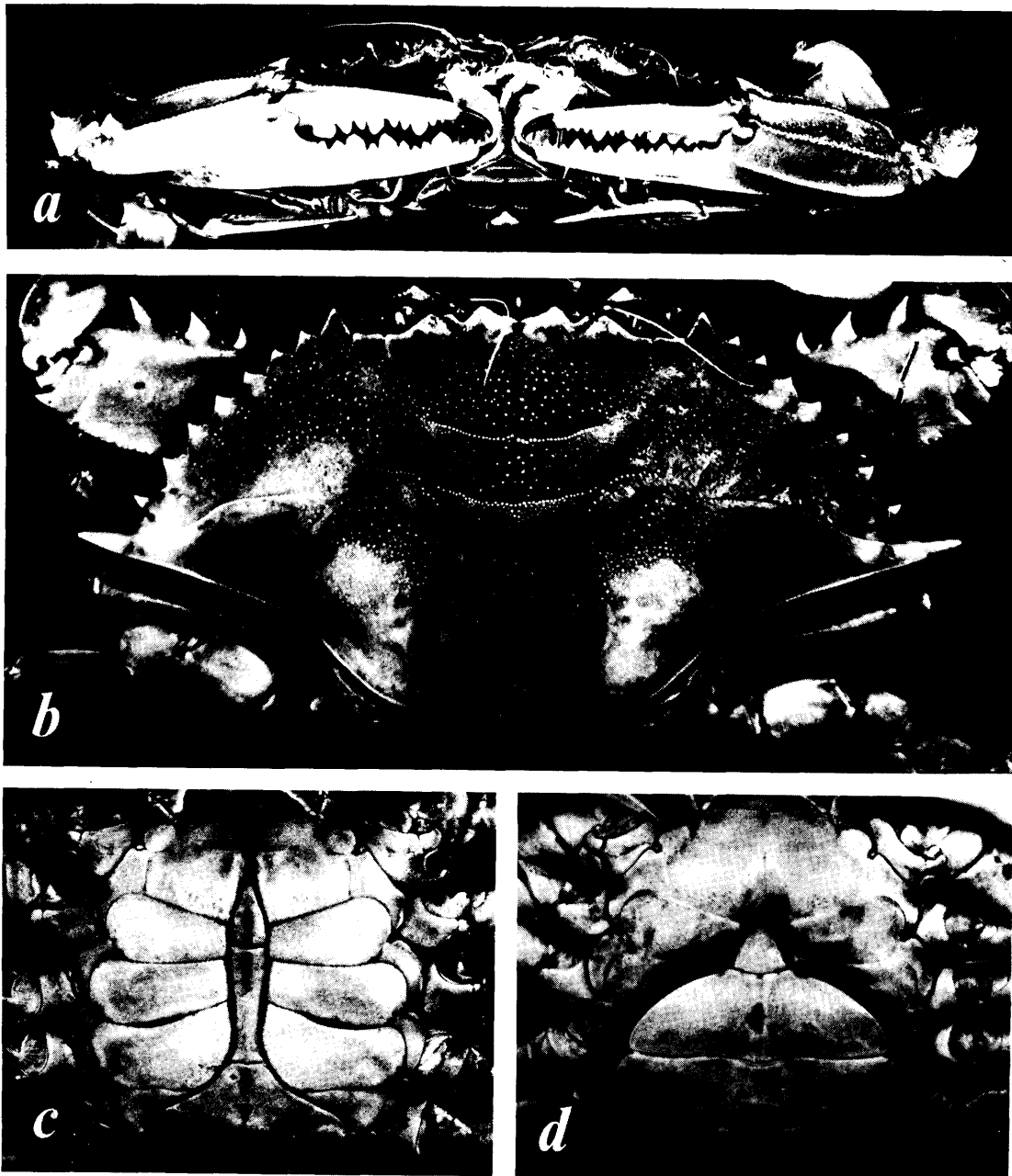


Fig. 299. *Callinectes sapidus* Rathbun. a, Male chelae in frontal view; b, carapace; abdomen and sternal area, c, male, d, female; a  $\times 0.8$ , b  $\times 1.3$ , c  $\times 0.6$ ; d  $\times 0.85$  (from Williams 1974b).

me are from the Gulf of Mexico and may represent parasitized individuals in which the maturation process has been altered.

Pullen and Trent (1970) developed regression equations for total weight and carapace width of *C. sapidus* from Galveston Bay, Tex. Male crabs were significantly heavier than females for a given carapace width.

*Variation.*—There are morphological variations in this species having far greater systematic interest than size and color. Study of many specimens from throughout the range of the species bears out

the conclusion of Chace and Hobbs (1969) that extreme variants “are so different from each other that they could easily be interpreted as distinct species,” but there is “no point of demarcation”—morphological, geographic, bathymetric—between the “typical” rather blunt-spined form predominating along the east coast of the United States and the acute-spined form named *C. sapidus acutidens* by Rathbun predominating from Florida southward.

Rathbun (1896a) characterized the “acutidens” form (paraphrasing) as being wider than the “typ-

ical" with all prominences more strongly marked, areolations separated by deeper depressions, granules more raised, gastric ridges stronger and more sinuous, a transverse granulate ridge on each cardiac lobe, frontal teeth narrower and more acute and bearing two small intervening teeth, anterolateral teeth broad at base and narrowing abruptly to long acuminate tips with margins granulate, lateral spines longer than in "typical" specimens of equal size, and ridges of chelipeds quite prominent and strongly granulate.

I thought for a time that a species distributed through approximately 85 degrees of latitude from North Temperate through Tropic to South Temperate zones might reflect responses to temperature in spination or other characters, "typical" structure being prevalent in the temperate zones and sharp spination in the tropics, the differences thereby justifying nomenclatural recognition. There is weak but inconsistent evidence for this pattern. Though "acutidens" individuals are uncommon outside the tropics, intermediates occur everywhere to some degree, and some "typical" individuals occur in the tropics. Genetic pooling or environmental response reflected in morphology seems poorly structured. I consider the whole *C. sapidus* complex to be a single species which has diverged into ill-defined populations in certain parts of its range. The "acutidens" form predominates over most of the latitudinal range, but there are variations. Among these are "typical" features that reach their most pronounced expression in the population along the east coast of the United States. Taxonomic thinking of biologists has been influenced by the form originally described, the North American variant which became the standard against which all comparisons were made. The variations are discussed in more detail by Williams (1974b).

*Color.*—Grayish, bluish, or brownish green of varying shades and tints dorsally on carapace and chelipeds; spines may have reddish tints, tubercles at articulations of legs orange, and legs varying blue and white with traces of red or brownish green. Males with propodi of chelae blue on inner and outer surfaces, fingers blue on inner and white on outer surfaces and tipped with red. Mature females with orange fingers on chelae tipped with purple. Underparts off-white with tints of yellow and pink.

Color variations other than those associated with sexual dimorphism and molt cycle are known. Albinos or partial albinos are in museum collections and have been reported both in systematic literature and elsewhere (Gowanloch 1952; Sims and Joyce 1965). Haefner (1961) reported an adult male lacking dorsal green coloration and bright blue and

scarlet markings on legs. Instead, the upper surface of the carapace was "robin egg blue" and the appendages were paler than usual, but the abdomen and underparts had normal color. A similar blue specimen was reported elsewhere (Anonymous 1950). Haefner also pictured a bilateral gray and brown colored specimen from the collection of L. Eugene Cronin. Williams (1974b) summarized important literature on coloration.

*Habitat.*—The blue crab is a coastal creature occurring on a variety of bottoms in freshwater, estuaries, and shallow ocean from the water's edge to approximately 90 m (Franks, et al. 1972) but mainly in the shallows to depths of 35 m. Biology of the species is better known than that of any other in the genus. Hatching in mouths of estuaries and shallow ocean, development of larvae progresses in the ocean (studied both in nature and the laboratory), followed by migration of megalopae and young crabs back into estuaries to mature into adults (summarized in Williams 1965, 1971; Tagatz 1968; Taissoun 1969; literature compilation, Tagatz and Hall 1971; Williams 1974b). It is probable that all species in the genus carry out their life histories on this model.

Tolerant of extremes, the species has been found from freshwater to hypersaline lagoons such as Laguna Madre de Tamaulipas, Mexico, where collections have been made in salinities ranging from 44 to 48‰ and unproductive portions of the lagoon range up to 117‰ (Hildebrand 1957), in temperatures ranging from 3° to 35°C, and in tertiary sewage treatment ponds in which mean daily O<sub>2</sub> tension dropped as low as . . . 08 mg/l in summer (Smith 1971). In Lebanon (eastern Mediterranean) it has been collected in winter in 39‰ salinity water at 17.5°C where there is no good place for estuarine development because streams are small, seasonal, and exceedingly foul in dry weather (George and Athanassiou 1965). In Marion Co., Fla., large males have been taken from salt springs in the St. Johns River over 180 miles from the sea. Invasion of fresh water is governed by adaptation to chlorinity. On the basis of experiment and observation Odum (1953) concluded that oligohaline (100–1000 p.p.m. Cl) and nearly oligohaline waters (25–1000 p.p.m. Cl) can be invaded to a considerable extent if the crabs are able to adjust slowly to the reduced chlorinity, as in natural invasions. Tagatz (1971) found that osmoregulatory ability of adult males and females is essentially the same, showing good hyperosmotic regulation in 5 and 50% sea water, but hyposmotic regulation in 100% sea water.

*Type-locality.*—East coast of United States.

*Known range.*—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 (T. Sakai, in litt.).

The extreme southern record by Ringuet (1963) is substantiated by the figure in his paper. Records north of Cape Cod occur only during favorable warm periods (Scattergood 1960).

Holthuis (1961a, 1969), Holthuis and Gottlieb (1955, 1958), and Christiansen (1969) summarized the introduction of *C. sapidus* into Europe, and Bulgurkov (1968) extended the known range, recording an adult female taken in the western part of Varna Bay in Oct., 1967; Froglija (1972) and Maury (1975) added still other European records, and introduction to Japan was first noted in July, 1975 (T. Sakai, in litt.). From these accounts it seems that introduction over the world has resulted from transport of individuals (op. cit., and Wolff 1954a, 1954b). Banoub (1963) noted that presence in Egypt does not seem to have been recorded before 1940. When *C. sapidus* was first noticed there in Lake Manzilah, it was confused with *Portunus pelagicus* (Linnaeus), itself an immigrant to the area from the Indian Ocean via the Suez Canal, and this confusion has persisted in literature concerning both species. Banoub thought that *C. sapidus* may have migrated from Greece around the eastern Mediterranean to flourish in the brackish lakes of Egypt, reproducing the life pattern it exhibits in the Western Hemisphere.

*Remarks.*—The vast, growing literature on species such as *Callinectes sapidus* cannot be fully reviewed in a short digest such as this; therefore, the discussion is selective.

The fossil record for the genus *Callinectes* extends through the Eocene-Miocene of Brazil, Central America and the West Indies, and the Pleistocene of North America (Glaessner 1969), but in material seen by Rathbun and recently by Williams (1974b) only two specimens from the Pleistocene are certainly identifiable as *C. sapidus*, although some published records of Pleistocene occurrence are valid.

Though all species of *Callinectes* are consumed as human food, there is no doubt that *C. sapidus* is the most valuable in commercial fisheries, providing a highly acceptable, nutritious product worth several million dollars annually. Traditionally, the seat of this fishery in the United States has been Chesapeake Bay where records on the fishery have been kept for about a century. Pearson (1948), summarizing annual catch for this area from 1880 to 1942,

showed the annual catch to have increased from 9.5 million pounds in 1890 to a peak of 68.7 million pounds in 1930, but catch fluctuated before and after 1930 declining to 35.8 million by 1942 during World War II. Van Engel (1962) provided a history of the types of gear used in this fishery, and evolution from hand-dip trotline to the baited crab pot (trap) and dredge. Adoption of the baited pot and its spread to the Carolinas and elsewhere during the late 1950's, along with other methods of capture including incidental harvest of crabs from shrimp trawls, greatly expanded the catch. By the 1970's, the United States fishery had expanded to over 140 million pounds of hard crabs with a landed value of over 20 million dollars annually (5 year average 1971–75, Robinson 1977).

The species is harvested throughout its range either commercially or for home use. It is caught locally in Belize with hand nets (B. Kensley, personal communication), and Taissoun (1969, and personal communication) reported a growing industry in Venezuela. Banoub (1963) reported growth of an Egyptian fishery in lakes (poor flavor) and sea (good flavor), but remarked on losses from damage to nets and on the myriads of crabs having no local commercial value because Egyptians consider the meat unpalatable (Anonymous 1965). A developing fishery in northern Greece (Kinzelbach 1965) declined because of overfishing (Boschma 1972).

Because the blue crab supports such a large crab fishery, fluctuations in abundance (especially in the Chesapeake area) have been the subject of a number of investigations. Pearson (1948) concluded that the fluctuations appear to be associated with variable rates of survival in the first year of life. No correlation was found between relative abundance of female crabs and their progeny. Examination of data from 13 generations indicated that size of spawning stock did not determine size of population surviving to commercial age at the rate of fishing prevailing during the years studied. Pearson found evidence that excessively cold weather may reduce availability of immature and adult crabs either by direct mortality or by making crabs less available to the fishery immediately after the periods of cold weather. Heavy runoff in some wet years may lower salinity in the spawning areas enough to have an adverse effect on survival of young, but such limits are poorly understood.

During its life the blue crab leads a migratory existence. The migratory patterns have been studied in greatest detail in Chesapeake Bay but the pattern seen there appears to be true of other areas as well. Mating usually takes place in water of reduced salinity well up in estuaries. After this, the