A New Burrowing Barnacle from the Western Atlantic

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In the course of an ecological study of sessile marine invertebrates of the northeastern Gulf of Mexico, numerous specimens of an undescribed species of burrowing barnacle have been collected by the senior author. These specimens were found embedded in characteristic, easily recognized burrows in dredged shell material, especially in shells of the turkey wing ark, *Arca zebra* Swainson, and the mossy ark, *Arca imbricata* Bruguière (= *Arca umbonata* Lamarck), and in masses formed of calcareous red algae (*Lithothamnium* and *Goniolithon* species). Independently, the junior author had found this species in shells from North Carolina and Florida and in dead coral from Puerto Rico.

These barnacles are members of the suborder Acrothoracica, which are recognized by their having a soft mantle without calcareous plates, reduced cirri, no abdomen (except appendages in cyprid stages), and dwarf males. Under the system of classification of the Acrothoracica proposed by Berndt (1907), they would be placed in the genus *Kochlorine*, which was established by Noll (1875) for a species he described from Cadiz, on the Atlantic coast of Spain. Later Noll (1883) described another species of *Kochlorine* from the Cape of Good Hope, South Africa; and Tomlinson (1963) has recently described a species from Japan. The description of a fourth species follows.

Genus *Kochlorine* Noll 1875

Diagnosis (emended). Mouth cirri biramous, may be weakly segmented; 3 pairs of terminal cirri; 1 pair of 2-segmented caudal appendages; lateral bar often present.

Kochlorine floridana, new species

Diagnosis. *Kochlorine* with 1 pair of short conical spines and rows of tack-shaped teeth on mantle aperture, and with lateral bar; attachment process moderately developed.

Type locality. At 8-10 meters depth in the Gulf of Mexico off Dog Island, Florida, approximately 8 miles southeast of Carrabelle, Franklin Co., Florida.

Type material. Female holotype (USNM cat. no. 113221) with one attached male, collected 16 May 1963, and some paratypes (USNM cat. nos. 113222, 113223, 113224, and 113225), deposited in the Division of Crustacea, U. S. National Museum. Other paratypes and additional material in the author's collections.

Additional material. FLORIDA: SE of Pensacola, from the bryozoan *Hippoporidra edax* (Busk), California Academy of Sciences, R. Kiwala, coll.; St. Andrews Bay entrance, near Panama City, from *Murex fulvescens* Sowerby, G. Bertrand, coll.; off Cape St. George (Gulf of Mexico) from *Aequipecten gibbus* (Linné), H. W. and M. J. Wells, colls.; Fernandina Beach from *Arca imbricata,* A. Ross, coll.; off St. Augustine, from *Murex fulvescens* and other shell material, H. W. and M. J. Wells, colls. GEORGIA: off Sapelo Island, from *Arca imbricata* and other shell material, J. Kraeuter, coll. SOUTH CAROLINA: off Charleston, M/V *Silver Bay* Sta. 1389, from *Arca imbricata* and calcareous algae; off Georgetown, M/V *Silver Bay* Stas. 1360, 1392, from *Arca zebra.* NORTH CAROLINA: Shackleford Banks, from *Murex fulvescens,* H. W. and M. J. Wells, colls., V. Zullo, coll.; Back Sound, from shelly bottom, H. W. Wells, coll.; Cape Lookout jetty, A. Ross, coll.; Diamond Shoals, from *Murex fulvescens* and *Cassis madagascariensis* Lamarck, H. W. Wells, coll. In addition, the "*Alcippe lampas*" recorded for the Beaufort area by Wells (1961) is in reality *K. floridana.* PUERTO RICO: from dead coral fragments, W. A. Newman, coll. Other material found in *Murex microphyllus* Lamarck from Tuléar, Madagascar (by courtesy of the Institut Royal des Sciences Naturelles de Belgique), is regarded by the junior author as being identical.

Description

Female. Body compressed, sac-shaped in lateral view (Fig. 1), and slightly asymmetrical with the posterior end twisted slightly to the side. Holotype length, 2.10 mm; width, 1.25 mm; thickness, about 0.75 mm. In a series of 18 additional females, 0.53 to 3.33 mm long, body width 0.518 to 0.702 times body length, with the smallest specimens proportionately narrowest.

Mantle surface with irregularly scattered small bi- or tricuspate hooks, slightly more numerous in lateral patches near site of attachment of males; a series of larger tack-shaped teeth around aperture margin. Mantle containing superficial longitudinal muscle bands and deeper circular bands; suffused with red pigment

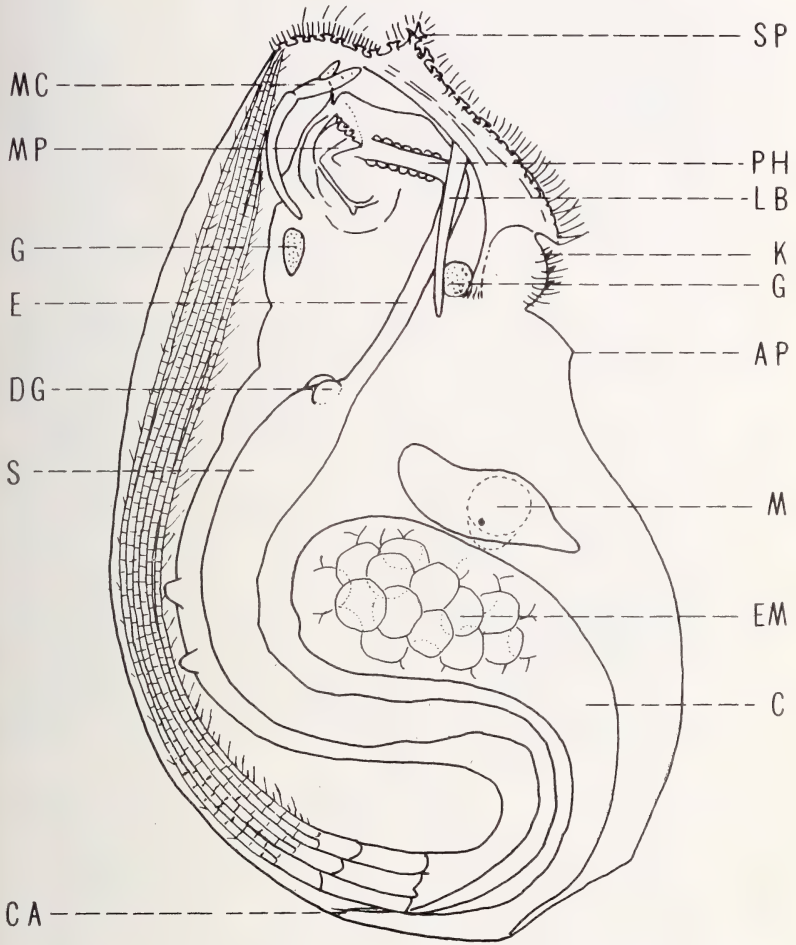

Fig. 1. *Kochlorine floridana*, n. sp., female, lateral view, with attached male. Abbreviations: AP - attachment process, C - mantale cavity, CA - caudal appendage, DG - digestive glands, E - esophagus, EM - embryos, G - ganglion, K - knob, LB - lateral bar, M - male, MC - mouth cirrus, MP - mouth parts, PH - pharynx, S - stomach, SP - spine.

near aperture. Aperture gently arched, bearing a pair of short, blunt spines, usually studded with strong teeth. Apertural length 0.484 to 0.767 times body width, proportionately longer in smallest specimens. Apertural rim and spines ornamented in a characteristic pattern of three rows of heavy teeth. Teeth in outer row bifid, in inner two rows broad and tack-shaped, with single acute dorsal and ventral spines and lobate lateral margins to the crown, thus resembling a flower. Comb-like row of spinules guarding apertural inner edge at ventral end; rounded spinous knob at dorsal end. Knob of large specimens prominent, bearing up to ten ventrally curved spines; spines and knob reduced or absent in juvenile specimens.

Attachment process moderately developed, more or less protruding, mid-dorsal and posterior to knob. Body normally lodged in surrounding shell by projection of attachment process into a small depression in burrow wall, disk posterior to attachment process, attached to walls of burrows in mollusk shells. Pads of shed cuticle often retained in the form of a cone at disk site in specimens removed from calcareous algae (Fig. 3a). One or two pairs of dissociated antennules occasionally attached to this cuticle, from former attachment of males at this site. A lateral bar, finely reticulated, on each side extending posteriorly from apertural margin. Distinct muscle bands extending from attachment process along dorsal body wall to posterior end, from attachment process to point posterior to stomach, and from attachment process to mouth region. Another muscle band extending from mouth region to point posterior to stomach.

Body enclosed within mantle, tapering and, in the contracted state, curving dorsally; posterior end bending sharply ventrally; two pairs of small, fleshy ventral protuberances in midregion. Head rounded, studded with one or more rows of fine hairs. Digestive tract: muscular pharynx extending dorsally from mouth; long esophagus extending posteriorly; broad stomach; pair of small, round digestive glands attached to stomach at juncture with esophagus; anus situated at end of short intestine, between terminal cirri.

Paired mouthparts of mandibles with palps and two pairs of maxillae. Mandible (Fig. 2a) with three simple teeth of decreasing size, a small bifid tooth at the tip of its cutting edge, numerous spines, and numerous rows of bristles; apodeme extension short,

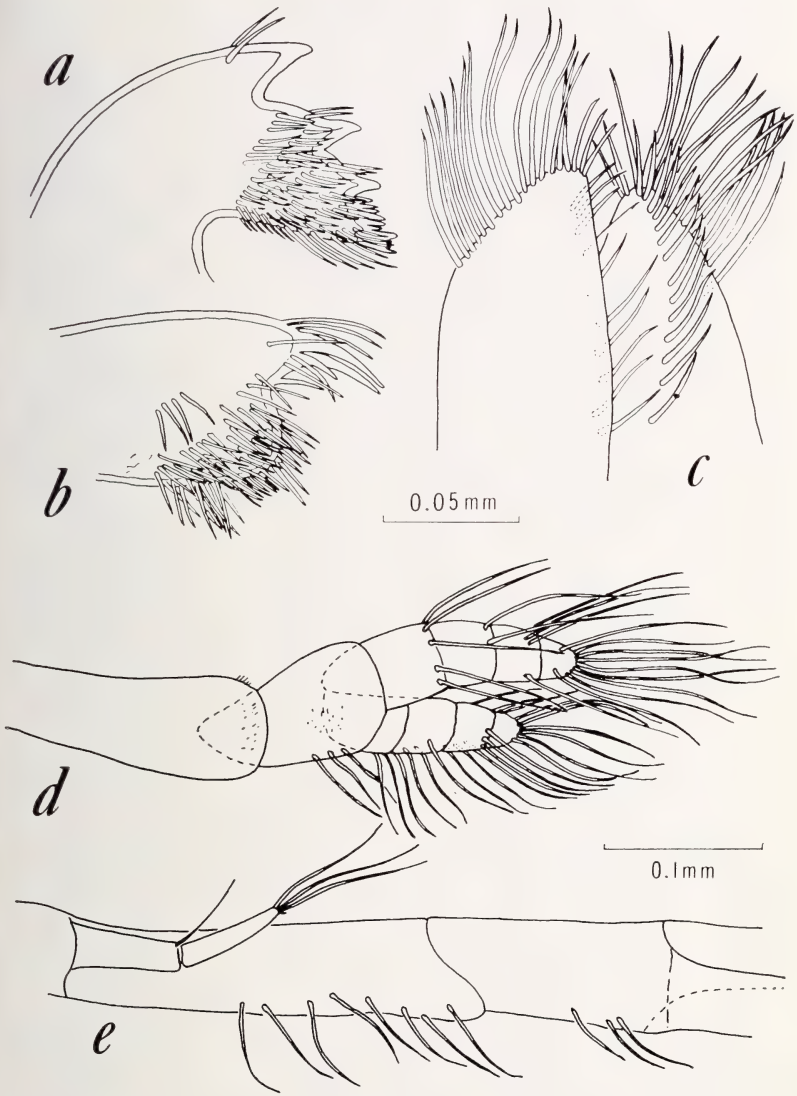

Fig. 2. *Kochlorine floridana*, n. sp., female: a. mandible, b. first maxilla, c. second maxillae, d. mouth cirrus, e. caudal appendage and basal segments of third terminal cirrus. (a-c to same scale; d-e to same scale.)

not hooked. Palp edged by row of hairs, with a tapering end extending beyond mandible tip, closely appressed to labrum. First maxilla (Fig. 2b) bilobate, with many bristles; two strong, curved teeth at tip of superior lobe; long curved or hooked apodeme attached at base. Second maxilla (Fig. 2c) relatively large and soft, with long flexible bristles at tip and along edges.

Mouth cirri (Fig. 2d) posterior to second maxillae, capable of extending anteriorly well beyond apertural margin; with two short rami attached to a long 2-segmented pedicle. Anterior ramus longer, 4-segmented; posterior ramus indistinctly 3- or 4-segmented; both provided with numerous flexible, usually feathery bristles.

Three pairs of biramous terminal cirri and one pair of uniramous caudal appendages attached to posterior end of body. Rami of terminal cirri subequal, with numerous, distinctly segmented articles with long setae along the inner side of their curvature. Setal arrangement (Fig. 3d) characteristic: a distal pair of long setae (usually with a minute median seta) and a middle pair of short setae on the inner side of each segment, with one or two setae of intermediate size situated at intervals on opposite (outer) face of cirrus. Intermediate sized outer setae spaced from 1 to 5 segments apart, with mean number of intervening segments being 1.69 in cirrus 2 (for 1 specimen), 2.90 in cirrus 3, and 2.97 in cirrus 4. Mean number of segments (for 5 specimens) in the anterior and posterior rami respectively: 27.0 and 37.0 for cirrus 2, 40.5 and 45.6 for cirrus 3, and 42.0 and 44.8 for cirrus 4. Pedicles edged with bristles, 2-segmented with proximal segment much the longer, and with oblique sutures between segments. Caudal appendages (Fig. 2e) 2-segmented, their tips not reaching the first articulation of cirral pedicles; terminal segment with three feathery setae and a minute spine at tip; proximal segment minutely ridged ventrally, with one dorsal seta.

Although all specimens 0.962 mm or more in length show the cirral complement described above, specimens smaller than 0.8 mm exhibit an incomplete cirral complement. Two specimens, 0.611 and 0.767 mm long, bear two pairs of cirri and a pair of short, stout cirral buds anterior to the cirri, as well as caudal appendages. Two other specimens, 0.572 and 0.598 mm long, possess only two pairs of cirri and the caudal appendages. The smallest specimen, 0.533 mm long, bears only a single pair of well devel-

oped cirri and a pair of short cirral buds, as well as the more slender caudal appendages.

The excavation produced in shell material is smooth-walled and somewhat variable, corresponding to the shape and size of the inhabitant's body. The excavation slants obliquely in a dorsal direction and expands to its greatest width in the lower half. This lower part of the burrow is usually twisted slightly to one side. Typically, a small depression occurs immediately below the dorsal lip, in a position corresponding to the attachment process of the barnacle. The orifice (Fig. 3e) is a narrow slit in surface view, broader at the ventral end, and is considerably shorter than the maximum height of the burrow. Particularly at the narrow, dorsal end, a delicate ridge composed of opaque calcium carbonate may be built up around the orifice edge. In certain mollusk shells (e.g. *Atrina* species), these deposits around the orifice and the similar opaque lining of the excavation stand out in marked contrast to the translucent crystalline structure of the surrounding shell.

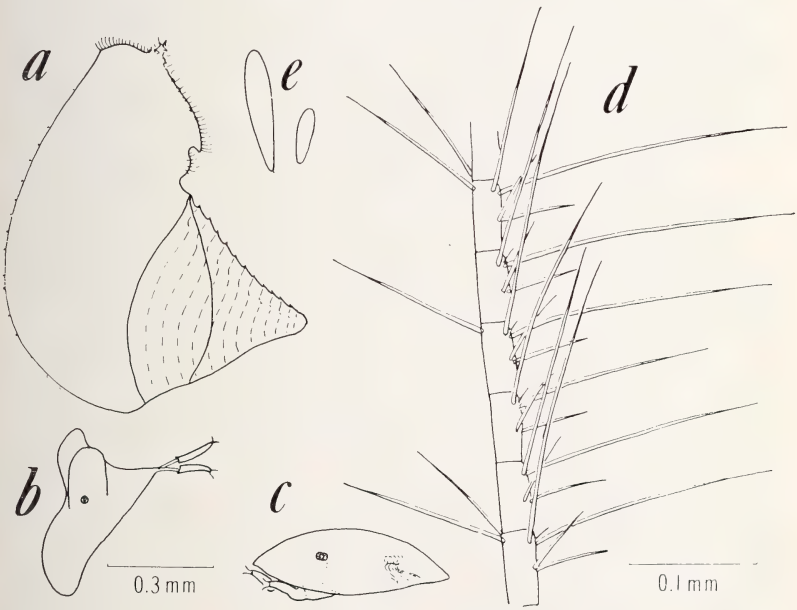

Fig. 3. *Kochlorine floridana*, n. sp.: a. lateral view of female removed from calcareous algae by acid treatment, showing cone of shed cuticle, b. male, c. cyprid larva, d. setation of segments of terminal cirrus, e. orifices of burrows produced by large and small individuals. (b-c to same scale.)

Male. Body lobate (Fig. 3b), 0.41 to 0.46 mm long, 0.11 to 0.14 mm wide. One lobe more cylindrical and bluntly rounded than the others, with a small pigment spot, projecting into a depression in mantle of female. Attachment by a pair of stout antennules approximately 0.11 mm long connected to body by a slender neck region 0.07 to 0.10 mm long (Fig. 3b). Penis tapering, 0.985 mm long by 0.020 to 0.015 mm wide, extending from posterior end of one male.

These dwarf males attach to the wall of a burrow occupied by a female or to the mantle of the female on one or both sides. Supernumerary males are common, with as many as five males associated with a single female. Additional pairs of male antennules occasionally remain attached to the cuticular material. Thus, each female may be served by a number of relatively short-lived males.

Cyprid larva. Body elongate, tapered at both ends (Fig. 3c), 0.55 mm long and 0.19 mm wide, with a pair of prominent antennules near middle of body, and a pair of pigmented eyespots.

Remarks. This species is placed in the genus *Kochlorine* Noll because it possesses three pairs of terminal cirri and a pair of caudal appendages in the adult female. These characters distinguish *Kochlorine* from *Balanodytes* Utinomi, *Lithoglyptes* Aurivillius, and *Berndtia* Utinomi, related acrothoracican genera known to burrow into calcareous shells and coral. *Balanodytes* has four pairs of terminal cirri (Utinomi, 1949b); *Lithoglyptes* has four pairs of terminal cirri and caudal appendages (Tomlinson and Newman, 1960); and *Berndtia* has five pairs of terminal cirri (Utinomi, 1949a). From other species described in the genus *Kochlorine, K. floridana* differs in the shape or number of projections on the aperture of the female, having a single pair of short conical spines. *Kochlorine bihamata* Noll (1883) from the Cape of Good Hope, South Africa, and *K. habei* Tomlinson (1963) from Japan bear a pair of hook-like projections on the apertural margin. *Kochlorine hamata* Noll (1875) from Spain bears a single hook-like projection on the aperture as well as a pair of stout conical projections similar to those found on *K. floridana. Kochlorine floridana* also differs from *K. habei* in possessing many large tack-shaped teeth around the aperture, and from *K. hamata* and *bihamata* in possessing a more or less prominent attachment process, corresponding to the attach-

ment process described for *Balanodytes taiwanus* Utinomi (1949b) from Formosa.

The burrows produced by *Kochlorine floridana* show some resemblance to acrothoracican barnacle burrows described by Ross (1965) from Florida Miocene material. The discovery of *Kochlorine floridana* in western Atlantic waters adds this species to the Recent Caribbean and western Atlantic fauna considered by Ross. However, an attempt to relate the excavations in Miocene material to this species does not seem justified by the evidence at hand.

Kochlorine floridana is named in allusion to the collection of the type specimens from Florida waters.

DISCUSSION

At the type locality, *K. floridana* is an abundant inhabitant of shell material. Its burrows occur chiefly in shells of the turkey wing ark, *Arca zebra*, whether or not the mollusk is alive. The burrows are most common in the oldest part of the shell, i.e. in the umbonal region. At the type locality, *Kochlorine floridana* also occurs in masses of calcareous algae, calcareous serpulid polychaete tubes, compartments of the acorn barnacle (*Balanus calidus* Pilsbry), dead coral, and shells of the mossy ark (*Arca imbricata*), the wing oyster (*Pteria colymbus* Röding), the rock oyster (*Chama macerophylla* Gmelin), and pen shells of the genus *Atrina*.

By its burrowing activity, *K. floridana* contributes to the erosion and destruction of shells that accumulate in nearshore waters. In these waters, it shares its ecological role with boring sponges (*Cliona* species) and several species of burrowing pelecypods and polychaetes, which are also abundant in calcareous material at the type locality.

The classical interpretation of the boring mechanism in boring barnacles relates their penetrating ability solely to mechanical erosion by teeth and hooks of the mantle as the mantle is moved by muscular contraction (for *Trypetesa*, Darwin, 1854; for *Balanodytes*, Utinomi, 1949b; for *Lithotrya*, Darwin, 1854, and Yonge, 1963). The deposits of calcareous material found at the narrow, dorsal end of *Kochlorine* burrows fit the description of similar deposits in the burrow of *Trypetesa lampas* (Hancock) by Darwin (1854), who attributed this deposition to a chemical phenomenon rather than to biological secretion. An opaque calcium carbonate

layer lines the dorsal wall of the *Kochlorine* burrow and forms a ridge at the dorsal end of the orifice. To what degree the barnacle participates in shaping these deposits is not known.

Acknowledgments

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