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Revision of genera *Gaza* and *Callogaza* (Vetigastropoda, Trochidae), with description of a new Brazilian species

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Abstract

A revision of the trochid genera *Gaza* and *Callogaza*, inhabiting the deep waters of western Atlantic Ocean and eastern Pacific Ocean, is here provided. Species are separated mainly by shell characters, but anatomical features are also used in some species. The species considered in this study are: *Gaza compta* **n. sp.** (SE Brazil), *G. daedala* Watson, 1879 (Central Pacific), *G. rathbuni* Dall, 1890 (tropical W Pacific), *G. fischeri* Dall, 1889 (E Caribbean), *G. superba* (Dall, 1881) (Gulf of Mexico and Caribbean), *G. cubana* Clench & Aguayo, 1940 (N Caribbean), *G. olivacea* Quinn, 1991 (NE South America and SE Brazil), *Callogaza watsoni* Dall, 1881 (Gulf of Mexico), *C. sericata* (Kira, 1959) (NW Pacific) and *C. frederici* (Smith, 1906) (S India). Anatomical data are provided for: *Gaza compta*, *G. olivacea*, *G. fischeri*, *G. superba* and *G. cubana*. Both *Gaza* and *Callogaza* are characterized by having iridescent, thin-walled shell, with the outer lip deflected (determined growth), and a flat callus partially or completely covering the wide umbilicus, making it a hollow chamber. Anatomically, the examined *Gaza* spp. have long epipodial tentacles and two series of holes between the propodium and the base of the head. The number of these structures can assist in the differentiation of species. Based on similarities of the shell and comparison with species of other trochid genera, we conclude that *Gaza* and *Callogaza* have some characters in common, which most probably constitute synapomorphies that support a monophyletic branch of the family. *Microgaza* is not regarded as part of this trochid branch, but may rather belong to Solariellinae.

Key words: Trochidae, *Gaza*, *Callogaza*, *Gaza compta* new species, Anatomy, Brazil, revision

Introduction

Gaza Watson, 1879 (type species *Gaza daedala* Watson, 1879: 601, OD), in the trochid subfamily Margaritinae, encompasses, at present, six species, two of them occurring in the Pacific Ocean (*G. daedala* and *G. rathbuni* Dall, 1890), and four in the Atlantic Ocean (*G. fischeri* Dall, 1889; *G. superba* Dall, 1881; *G. cubana* Clench & Aguayo, 1940, and *G. olivacea* Quinn, 1991). Furthermore, *Gaza* has also been considered by some authors (e.g., Abbott 1974; Rios 1994) as possessing two additional nominal subgenera: *Callogaza* Dall, 1881 (type species *C. watsoni* Dall, 1881, OD, from Caribbean) and *Microgaza* Dall, 1881 (type species *M. rotella* Dall, 1881, OD, from Caribbean). *Gaza* (*s.s.*) is characterized by having an iridescent, thin walled shell, a deflected outer lip (determined growth), and the development of a flat callus partially or completely covering a wide umbilicus, making it a hollow chamber. Most *Gaza* species occur in deep waters and have shells of about 3-4 cm. *Callogaza* has similar characters to *Gaza*, but is normally smaller (about 2 cm) and has more colorful shells.

A study of the Brazilian deep waters mollusks found some specimens of *Gaza*. The analysis of this material revealed a new species formally described herein. The investigated data and worldwide material is sufficient to perform a revision of *Gaza* and *Callogaza*, a subgroup of trochids that share some conchological characters. These two

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taxa are considered here as distinct genera. *Microgaza* is not part of this subgroup, but is placed in the trochid subfamily Solariellinae (see discussion), and consequently the species referred to this genus were not included in the present study.

Material and methods

The list of all material examined follows the species description. Specimens preserved in 70% alcohol were extracted from their shells and dissected under a stereomicroscope, with the specimen immersed in preservative. All drawings were made with a camera lucida. SEM examination of radulae and jaws were made in the Laboratório de Microscopia Eletrônica do Museu de Zoologia da Universidade de São Paulo.

In the list of material examined, 'shells' means empty specimens, used to state only the conchological attributes of each species; while 'specimens' means a complete individual (with soft parts) additionally used for anatomical investigation.

Anatomical abbreviations: **af**, afferent gill vessel; **an**, anus; **bg**, buccal ganglion; **bm**, buccal mass; **br**, subradular membrane; **cc**, cerebral commissure; **ce**, cerebral ganglion; **cm**, columellar muscle; **cf**, cephalic lappet; **cp**, columellar muscle projections; **cv**, ctenidial vein or efferent gill vessel; **dc**, dorsal chamber of buccal mass; **dd**, duct to digestive gland; **ef**, esophageal folds; **eg**, esophageal gland or crop; **el**, esophageal papillae; **ep**, epipodium; **es**, esophagus; **et**, epipodial tentacle; **fo**, foot anterior orifices**; fs**, foot sole (mesopodium); **ft**, foot; **ga**, gill's anterior projection or suspensory membrane; **gi**, gill; **gm**, gill muscle; **he**, haemocoel; **in**, intestine or intestinal loop in haemocoel; **is** insertion of m5 in radular sac; **jw**, jaws; **ki**, kidney; **m1-m12**, odontophore muscles; **ma**, mantle; **mb**, mantle border; **mc**, mouth sphincter; **mj**, jaw and peribuccal muscles; **mo**, mouth; **mt**, transversal muscle of buccal mass; **ne**, nephrostome; **oc**, anterior odontophore cartilage; **od**, odontophore; **of**, ophthalmic nerve; **om**, ommatophore; **on**, osphradial nerve; **op**, opercular pad; **os**, osphradium; **pc**, pericardium; **pe**, pedal ganglion; **pg**, anterior furrow of pedal glands; **pl**, pleural ganglion; **pn**, pedal nerve; **po**, posterior odontophore cartilage; **ps**, pedal medial sinus; **ra**, radula; **rn**, radular nucleus; **rs**, radular sac; **rt**, rectum; **sa**, salivary gland aperture; **sc**, subradular cartilage; **sd**, salivary duct; **se**, septum between odontophore and esophagus; **sg**, salivary gland; **sn**, snout; **sp**, snout papilla; **st**, stomach; **su**, suprabranchial chamber; **te**, cephalic tentacle; **tg**, integument.

Institutional abbreviations: **AMNH**, American Museum of Natural History, New York, USA; **ANSP**, Academy of Natural Sciences of Philadelphia, USA; **BMNH**, The Natural History Museum, London, Great Britain; **UFMNH**, Florida Museum of Natural History, University of Florida, Gainesville, USA; **FMNH**, Field Museum of Natural History, Chicago, USA; **FSBCI**, Florida Marine Research Institute, Department of Natural Resources, St. Petersburg, USA; **IBUFRJ**, Instituto de Biologia, Universidade Federal do Rio de Janeiro, Brazil; **MCZ**, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA; **MNRJ**, Museu Nacional da Universidade Federal do

Rio de Janeiro, Brazil; **MZSP**, Museu de Zoologia da Universidade de São Paulo, Brazil; **OMNH**, Osaka Museum of Natural History, Japan; **UMML**, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida, USA; **USNM**, National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA; **ZSI**, Zoological Survey of India, Calcutta, India; **ZSM**, Zoologische Staatssammlung München (Munich), Germany.

Systematics

Genus Gaza Watson, 1879

Gaza Watson, 1879: 601-602. Dall 1889: 354. Dall 1908: 347. Thiele 1929: 78. Wenz 1938: 295-296. Clench & Abbott 1943: 2. Abbott 1974: 49. Hickman & McLean 1990: 90.
T**ype species**: *Gaza daedala* Watson, 1879, OD.

Diagnosis: Shell of medium size (about 30 mm), white-iridescent with green tinge, turbiform. Iridescence given by transparence of thin shell layers. Periostracum very thin, translucent. Aperture rounded, prosocline. Outer lip well-formed, deflected. Umbilicus wide, partially or completely covered by thin-walled, flap-like callus (only in mature specimens), producing a hollow chamber.

List of included taxa: *G. compta* **n. sp.**, *G. cubana*, *G. daedala*, *G. fischeri*, *G. olivacea*, *G. rathbuni*, *G. superba*.

Gaza compta new species
(Figs. 1–10, 49–52, 67–77, 92)

Types: **Holotype** MZSP 40324; **Paratypes**: MZSP 40325, 5 specimens; ANSP 413312, 1 shell; MNRJ 10531, 1 shell; ZSM 20060173, 1 shell, all from type locality.

Type locality*:* BRAZIL: off Cabo Frio, Rio de Janeiro, 22º53'S 42º01'W, 700–800 m depth (otter trawl, i/2004. C.M. Cunha leg.).

Diagnosis: Shell color pale-beige iridescent, first 2 whorls of teleoconch with purple color, strong axial undulations; spire low with about five whorls. Protoconch without hole in adult. Body whorl with about 55 very narrow spiral lines. Height/width 1.45 on average. Weak carina at middle level of body whorl. Umbilicus completely covered by callus. Orifices in anterior part of mesopodium: 10 on left, 8 on right side. Number of epipodial tentacles: 4 on left, 5 on right side. Rachidian tooth with square base, about 1/6 of total radular width, about 20 tall and slender marginal teeth.

Description

Shell (Figs. 1–4): up to 26 mm in diameter; about five whorls, first 2 whorls purple,

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remainder pale-beige iridescent. Protoconch (Figs. 2, 4) cream in color, low, of about one whorl, surface smooth, transition with teleoconch unclear. First two teleoconch whorls sculptured only with axial lines (Fig. 4), narrow, spaced by distance equivalent to their width; on third whorl, spiral lines of equal strength of axial lines gradually appearing, producing reticulate shell surface; spiral lines gradually becoming predominant, about 30 on penultimate whorl, about 55 on body whorl; spiral lines very narrow low, close to each other. Tip of spire blunt (Fig. 1), about as high as body whorl, about half of its volume; profile of whorls rounded; suture somewhat shallow, but well marked. Umbilicus only visible in young specimens, wide, deep, width about 1/4 of shell diameter. Peristome preceded by portion of body whorl weakly projecting downwards, amount of deflection equal to 3–4 spiral lines of sculpture (Fig. 1). Outer lip of determinate growth, marked by short, thick projection towards exterior. Inner lip lower (siphonal) region as continuation of outer lip; upper 2/3 of inner lip as part of columella, upper half marked by a very thin, semi-transparent callus (Fig. 3); lower half marked by large callus, with somewhat thin walls, covering entire ventral opening of umbilicus, attached to umbilicus at its edges.

Head-foot (Figs. 9, 67, 68, 92): Total length slightly less than half whorl when contracted. Head bulging, located approximately in middle region of head-foot. Snout wide, cylindrical; distal end wider than base; distal surface plane, papillated, with papillae larger at edge, smaller close to mouth (Fig. 9). Papillae long, cylindrical, with rounded tips, separated from each other by about half width of papillae. Mouth located in middle of snout's ventral surface. Pair of cephalic lappets on dorsal surface of snout, uniting median region of snout with middle region of tentacles' base (Figs. 67, 68: cf); both cephalic lappets separated from each other in median line by distance equivalent to half of cephalic lappets' width. Cephalic tentacles about 1/3 longer than snout; narrowing gradually up to somewhat pointed tip; tentacles covered by small, microscopic papillae, large cilia seen at high magnifications. Ommatophores located on outer base of cephalic tentacles, about 1/5 of tentacles' length, almost as wide as their base. Eyes relatively large, dark, occupying most of ommatophores. Foot thick, occupying about half of total head-foot length; divided into mesopodium and epipodium; epipodium (Figs. 67, 68: ep) surrounding lateral-dorsal region of mesopodium, equidistant from sole and snout tip. Foot's anterior orifices located along lateral-dorsal region of foot, on both sides, forming arch from anterior region of anterior edge of foot, at some distance from median line, up to middle region of lateral surface of mesopodium, covered by epipodium (Fig. 92); 10 orifices on left, 8 on right side. Anterior pedal margin wider than remainder of foot, pointed laterally, projecting slightly beyond. Furrow of pedal glands present along entire anterior edge of foot; relatively deep, wide; single aperture of pedal glands relatively broad, located in median region of this furrow. Anterior third of epipodium forming one pair of wide horizontal flaps, anterior end close to ommatophores' base, abruptly widening near its posterior end. Remaining 2/3 of epipodium relatively low, thick; 5 right, 4 left long, slender epipodial tentacles inserted at its distal edge. Epipodial tentacles located somewhat equidistantly,

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well spaced from each other, symmetrical on both sides (except in number), becoming shorter from anterior to posterior; anterior epipodial tentacle about half as long as foot; tip pointed. Pair of columellar muscles thick, of about 1/4 whorl, broadly fused with each other in median line (Fig. 68: cm). Posterior end of mesopodium with longitudinal, shallow furrow separating it into two halves (Fig. 67). Haemocoel antero-posteriorly elongated, about 2/3 of head-foot width.

Operculum (Figs. 5, 6): Rounded, horny, multispiral, yellow. Nucleus central. Inner edge sigmoid, as inner mold of inner apertural lip.

Mantle organs (Figs. 71, 73): Mantle border relatively thick, simple, white. Pallial cavity of about 3/4 whorl. Osphradium forming node located at base of gill suspensory stalk, weakly dislocated to left (Fig. 71: os). Osphradium possessing two nerves inserted at opposite sides; on left side, large nerve coming from nerve ring; on right side, nerve going to distal section of gill suspensory stalk. Gill located on left side of pallial cavity; of about 3/4 of its length; projecting anteriorly by wide, tall suspensory stalk. Anterior end of gill narrow, rounded, projecting outside cavity; gradually increasing towards posterior; posterior end abrupt. Left gill filaments about twice size of right filaments (Fig. 73), possessing ventral-left, pointed projection; right filaments simple. Afferent gill vessel coming from left region of kidney, lying obliquely about 1/4 of its length free from gill filaments; running after in gill distal region of central axis, just distal to gill muscle. Ctenidial vein or efferent gill vessel about three times wider than afferent vessel, running in basal region of gill central axis; its posterior 1/4 free from gill filaments, lying parallel, at left from afferent vessel up to pericardium. Gill muscle running along distal region of gill central axis. Between gill and rectum an area on average of about 1/3 width of pallial cavity roof. No clear hypobranchial gland. Rectum about 1/4 as wide as pallial cavity, sigmoid, posterior region with loop turned to left surrounding kidney (Fig. 71: rt), close to median line abruptly curving anteriorly, gradually towards right up to anus. Anus wide, short free end, located on anterior right side of pallial cavity, close to mantle border.

Visceral mass: Not studied.

Circulatory and excretory systems (Fig. 71): Not seen in details because of preservation problems. Pericardium located between pallial cavity and visceral mass, just posterior to kidney, close to median line, slightly to right; its left side receiving ctenidial vein; inner structures (auricles, ventricle) not seen. Single kidney examined, wide, dorso-ventrally flattened, pale brown, located in posterior-right region pallial cavity posterior end. Inner renal cavity filled by solid glandular tissue. Nephrostome located at anterior-right region of kidney, preceded by tall, hollow stalk.

Digestive system (Figs. 8–10, 69–72, 74–77): Oral tube length about half of odontophore length and width, walls with circular muscles (Fig. 69: mc). Distal region of oral tube with circular fibers; basal region with oblique fibers (Fig. 69: **mj**), originating gradually from dorsal surface, close to median line, running divergently towards posterior and sides, inserting in ventral surface of odontophore. Remaining oral tube walls thin (Fig.

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8). **Jaw** plates (Figs. 10, 70, 74) thick, rounded; cutting edge anterior, occupying most of buccal cavity's dorsal surface; separated from each other by narrow space. Pair of dorsal folds starting at half of jaws length posterior to jaws, at level of separation between esophagus and odontophore, becoming gradually tall, narrow. Odontophore about 10% longer than snout. Odontophore muscles (Figs. 69, 75–77): **m1**, series of small muscles connecting buccal mass with adjacent inner surface of snout and haemocoel; **m1a**, 2–3 pairs of dilators of oral tube, narrow, thin, originating on lateral surface of haemocoel, in posterior position of snout, running anteriorly, covering ventral surface of mj, inserting in ventral region of oral tube, on side of m1v; **m1b**, pair of small retractors of buccal mass, originating on lateral surface of haemocoel on side of m1a, running shortly anteriorly, inserting on lateral-posterior surface of odontophore, dorsal most pair of m1a connected to m1b; **m1v**, pair of small ventral protractors of odontophore, originating on surface ventral surface of oral tube, running posteriorly away from each other, inserting in ventral-posterior region of odontophore, in median surface of posterior cartilages; **m2**, pair of retractors of buccal mass, originating on lateral surface of haemocoel, just posterior to buccal mass level, running anteriorly, inserting in two bundles, ventral branch about half as long as dorsal branch, but spreading on lateral surface of odontophore; **m4**, broad pair of dorsal tensor muscles of radula, subradular membrane; originating part in anterior cartilages, along their ventral surfaces at some distance from median line, part in posterior cartilages, in their posterior, lateral surfaces, surrounding anterior cartilages lateral, ventral surfaces, inserting along subradular membrane, in its dorsal region exposed inside buccal cavity, with portion in radular ribbon in its region preceding buccal cavity; **m5**, pair of large ventral tensor muscles of radula, originating in ventral surface of posterior cartilages, running towards dorsal, median, subsequently running anterior, inserting in radular ribbon in its region preceding buccal cavity; **m6**, horizontal muscle, uniting both anterior cartilages almost along entire ventral edge (except short posterior region), in their external surface; **m7**, very small, thin pair of muscles, originating in inner ventral surface of radular sac, in its middle region, running anterior, covering m6, separating from each other at their middle level, inserting in terminal edge of subradular membrane; **m7a**, very small, thin pair of muscles, originating in haemocoelic ventral surface, running dorsally, separating from one another surrounding m7, inserting in radular sac, anterior to insertion of m7; **m8**, pair of broad approximator muscles of cartilages, originating in anterior cartilages, in a small area of their lateral surface, posterior to insertion of mj, running posterior, decreasing gradually, inserting in middle region of anterior surface of posterior cartilages; **m8a**, pair of accessories of m8, shorter, originating posteriorly on same side of anterior cartilages as m8, running parallel, posterior to m8 pair, covered by them, inserting in posterior cartilages just dorsal to m8 insertion; **m11**, two pairs of narrow, thin ventral tensor muscles of radula, originating in middle region of ventral surface of posterior cartilage, one separated from other by distance equivalent to their width, running anteriorly covering m6, anterior cartilage's ventral surface, inserting in subradular

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membrane distal edge, some distance beyond it towards radular ribbon, along its inner surface. Odontophore non-muscular structures (Figs. 76, 77): **oc**, pair of anterior odontophore cartilages, antero-posteriorly elongated, flat, anterior and posterior ends rounded (anterior end smaller and weakly turned medially), with about same length of odontophore; **po**, small pair of posterior odontophore cartilages, about 1/10 of anterior cartilages length, about half of their width; located in posterior, slightly lateral side of anterior cartilages; **br**, subradular membrane, covering most of odontophore exposed in buccal cavity, where most of intrinsic odontophore muscles inserts; **sc**, subradular cartilage, maintaining radular ribbon, expanding in buccal cavity beyond radula, covering about half of exposed portion of subradular membrane. Radular sac wide, projecting beyond posterior side of odontophore, with approximately same as length. Radular nucleus bifid, divided in middle by a furrow. **Radula** (Figs. 49–52) symmetrical, arched. **Rachidian** (Figs. 50, 52) with square base, about 1/6 of total radula width; cutting edge with projection turned posterior (almost 90º) covering posterior end of preceding tooth, this projection triangular, tip blunt, almost as wide as base, preceded by narrower, thickened region; interlock sub-terminal, at base of cutting projection. Six **lateral** teeth somewhat similar to rachidian, except for being asymmetrical, greatly curved towards medial; lateral teeth gradually becoming narrower and more elongated; lateral teeth forming curve with concave side towards radular sac, sixth lateral positioned at about same level as rachidian tooth of preceding row; tip sharply pointed; 2–3 small cusps separated from each other along both edges. About 20 **marginal** teeth (Figs. 49, 51), tall, slender, curved inwards; teeth gradually becoming narrower towards periphery; tip sharp pointed, preceded by wider, flattened region, having about 15 small, narrow, sharply pointed, well-separated cusps on both sides; non-functional lateromarginal plate as reduced innermost marginal tooth (Fig. 50). **Salivary glands** (Figs. 8, 69, 74: **sg**) small, close to origin of esophagus . Salivary ducts very short, opening almost immediately after penetration in dorsal wall of buccal cavity; salivary apertures small pores located in middle region of each dorsal fold, slightly posterior to their origin (Fig. 74: **sa**). Conspicuous series of transversal muscles separating esophageal and odontophoral branches of buccal mass (Fig. 69: **mt**). Anterior esophagus (Figs. 8, 69, 74: **es**) very wide, inner surface with four tall, narrow folds (Fig. 74: **ef**); two of them as continuation of dorsal folds, producing wide dorsal furrow; central region of this dorsal furrow smooth, remaining regions, including folds, completely covered by small papillae (Fig. 74: **el**); papillae low, separated by space equivalent to their size, with rounded tips. Another pair of folds running along left side, close to each other, producing narrow left furrow; ventral fold of this pair disappearing gradually in posterior level of haemocoel; dorsal fold uniting with left dorsal fold, forming small chamber, at posterior end of haemocoel. Right dorsal fold running beyond posterior end of haemocoel, becoming gradually lower. Posterior esophagus, stomach not seen in details. Intestine very wide (Fig. 71: **in**), originating in anterior-dorsal region of visceral mass, running anteriorly along haemocoel up to region

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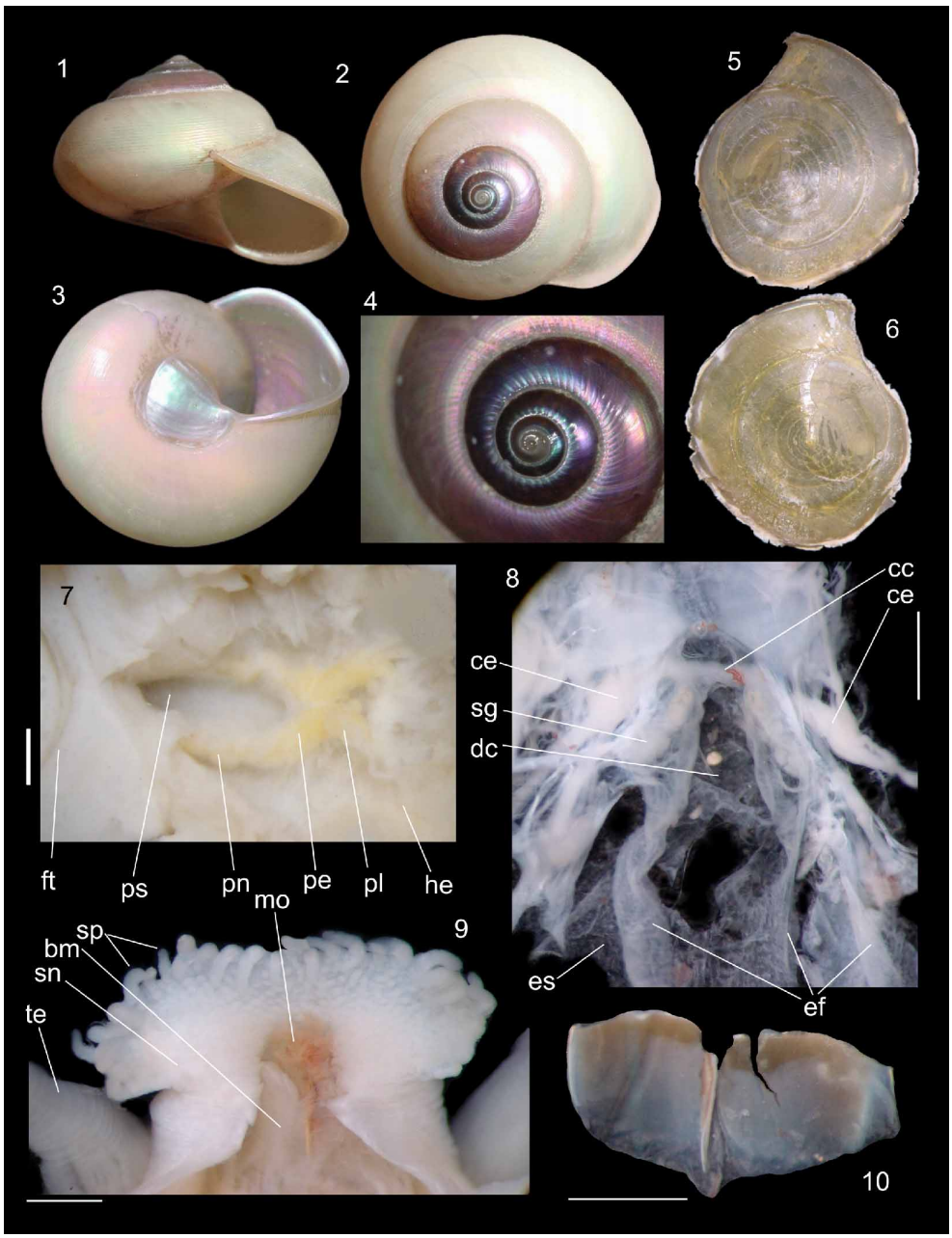

FIGURES 1–10. *Gaza compta*. Figs. 1–4, Shell of Holotype MZSP 40324 (diameter = 26 mm). Fig. 1: Apertural view. Fig. 2: Apical view. Fig. 3: Umbilical view. Fig. 4: Detail of spire. Fig. 5–6: Operculum, outer and inner views (length = 10 mm). Fig. 7: Pedal ganglia and adjacent region, dorsal view, dorsal structures into haemocoel removed, pedal medial sinus (ps) opened longitudinally. Fig. 8: Foregut, ventral view, odontophore removed, esophagus (es) opened longitudinally, some structures, such as nerve ring (cc, ce) and salivary gland (sg) seen by transparency. Fig. 9: Snout, ventral view, opened longitudinally along its ventral median line. Fig. 10: jaw plates, ventral view. Scale bars: 7–10 = 1 mm.

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close to buccal mass (Figs. 69, 71), bending abruptly, running posteriorly; in visceral mass anterior region possessing wide loop surrounding kidney, pericardium, exiting to pallial cavity in its right-posterior corner. Rectum, anus described above (pallial organs). Fecal material solid, hard, filling entirely intestine, having a middle, ventral, longitudinal furrow (Fig. 72).

Genital system: Not studied.

Central nervous system (Figs. 7, 69): Nerve ring located surrounding anterior half of buccal mass. Cerebral ganglia broad, long, located on lateral region of buccal mass. Cerebral commissure thick, long. Pleural, pedal ganglia close to each other, located inside pedal musculature just below ventral surface of haemocoel. Pedal commissure very short, with both ganglia practically touching one another. Very large pedal nerve running forward from each pedal ganglion (Fig. 7: pn), surrounding median pedal blood sinus. Statocysts located very close to posterior side of pedal ganglion.

Etymology: The specific epithet refers to the ornamentation of the first teleoconch whorls, from the Latin *comptus*, meaning ornamented.

Measurements of shells (larger diameter and width in mm): Holotype. MZSP 40234: 26.0 x 19.0; MZSP 40235, #1: 25 x 18; #2: 24 x 17; #4: 25 x 17.

Distribution: Know only from the type locality.

Habitat: Rocky, 700 to 800 m depth.

Material examined: Types.

***Gaza superba* (Dall, 1881)**
(Figs. 11–15, 64–66, 78–82)

Synonymy see Clench & Abbott (1943: 2). Complement:
Callogaza superba Dall, 1881: 49.
Gaza superba: Dall 1889: 354 (pl. 22, figs. 4, 4a). Clench & Abbott 1943: 2 (figs. 1–2, Holotype). Abbott 1974: 49 (fig. 375). Abbott & Dance 1983: 40 (unnumbered text-fig.). Hickman & McLean 1990: 91 (figs. 51b–c, 52, 53b, f, g).
Gaza (Callogaza) superba: Thiele 1929: 78.
Gaza watsoni: Rios 1985: 20 (pl. 9; fig. 79). 1994: 35 (pl. 10, fig. 104) (*non* Dall, 1881).

Types: **Lectotype** MCZ 7541 (not examined) (explicitly designated by Clench & Abbott 1943); **Paralectotypes** USNM 94992, 6 shells, 3 opercula, 1 dry soft parts (examined).

Type locality: off Montserrat, Caribbean.

Diagnosis: Color of shell pale-beige iridescent; surface smooth, glossy, spire height about 2/3 of body whorl width; about five whorls. Apex open in adult. Body whorl with very low, weak, spiral lines, almost smooth. Height/width ratio 1.52 on average. Carina at lower region of body whorl. Umbilicus about 75% covered by callus. Orifices in anterior part of mesopodium: 12 on left, 8 on right side. Number of epipodial tentacles: 5 on right, 6 on left side. Rachidian tooth with elongated base, about 1/10 of total radular width; about

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18 tall, slender marginal teeth.

Distinctive description

Shell (Figs. 11–15): Size, about 40 mm in diameter; color pale-beige iridescent, about five whorls. Protoconch eroded (Fig. 12), forming small whole communicating with umbilicus. Teleoconch with almost glossy surface, iridescent by transparency of external shell layer. Shell surface with weak axial lines, more evident on last whorls. Spire relatively low, height about 2/3 of that of body whorl. Body whorl with weak spiral carina between middle, interior thirds. Umbilicus wide, deep, 75% covered by callus (Figs. 13, 14). Peristome preceded by portion of body whorl weakly projected downwards, amount of deflection equal to 2 spiral lines of sculpture. Outer lip marked by short, thick deflection. Lower half of inner lip with flap-like callus covering about half of umbilicus.

Head-foot (Figs. 78, 79, 81): Distal end of snout somewhat concave, papillated. Papillae at edge 8–10 times longer than those close to mouth, decreasing abruptly in size towards mouth. Cephalic tentacles about twice as long as length of snout. Ommatophores located at outer dorsal base of cephalic tentacles, about 1/10 of tentacles length. Foot's anterior orifices: 12 orifices on left, 8 on right side (Fig. 81: **fo**). Epipodium with long, slender epipodial tentacles inserted sub-terminally at distal edge, on ventral surface, 5 on right, 6 on left side. Anterior tentacle about 1/4 of foot length, about twice as large as remainder; tip pointed; remaining tentacles similar in size. Posterior end of mesopodium with longitudinal, shallow furrow separating it into two halves.

Operculum (Fig. 15): As in preceding species, except brown color.

Mantle organs (Figs. 80, 82): Gill of about same length as pallial cavity; extended anteriorly by wide, tall suspensory stalk. Anterior end of gill pointed; extended region detached from mantle for about 1/3 of gill length (supported by suspensory stalk). Left gill filaments three times smaller than right filaments, both filaments possessing ventral, pointed projection. Rectum about 1/4 of pallial cavity width, nearly straight (Fig. 80: rt).

Digestive system: Foregut, terminal digestive duct parameters similar to those of *G. compta*. **Radula** (Figs. 64–66). **Rachidian** with antero-posteriorly elongated base (about 50% longer than wider), narrowing gradually, about 1/10 of total radular width (Figs. 64, 65); cutting edge with projection turned inwards (almost 90º) covering base of preceding tooth, cutting edge triangular, tip blunt, almost half as wide as base, preceded by narrower, thickened region; cutting edge smooth or with sparse, small pointed cusps. Six **lateral** teeth with similar features of preceding species; 3–4 small cusps located separated from each other along proximal edge. About 15 tall, slender **marginal** teeth, of similar shape of those of preceding species; about 18 small, narrow, sharp pointed, well separated cusps on outer side, about 3–4 sub-terminal cusps on inner side.

Measurements of shells (in mm): UFMNH 323758, #1: 32.5 x 21.7; #2: 30.3 x 19.6.

Distribution: Caribbean and Gulf of Mexico.

Habitat: Muddy sand bottom; from 380 to 925 m depth, mostly around 600 m depth, with 1 lot of dead shells at 47 m (Surinam).

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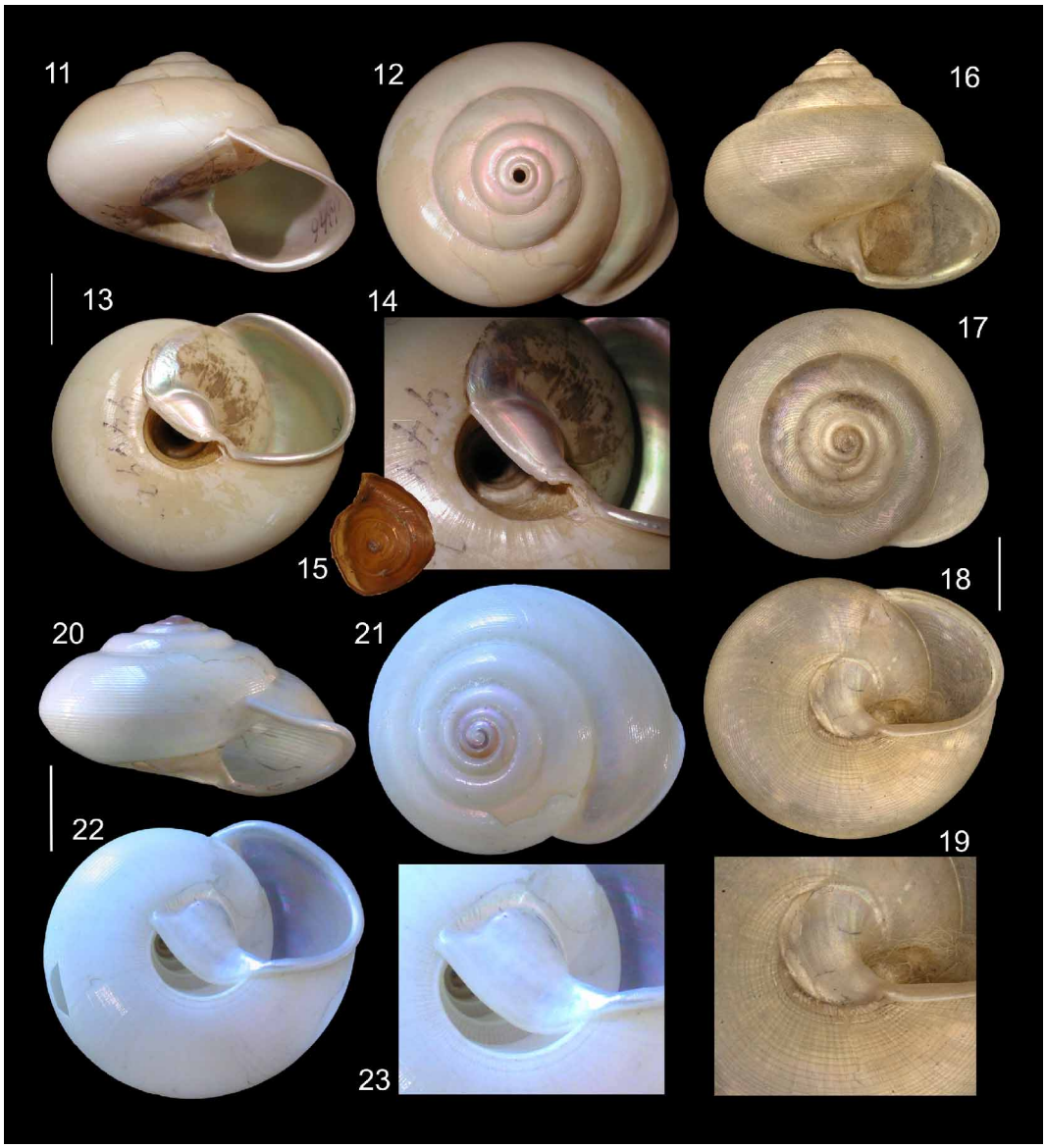

FIGURES 11–23. *Gaza* spp. Figs. 11–15: *G. superba* Paralectotype USNM 94992. Figs. 11–13: Shell in apertural, apical and umbilical views. Fig. 14: Detail of umbilical area. Fig. 15: Operculum, outer view. Scale bar = 10 mm. Figs. 16–19: *G. daedala* Holotype BMNH. Figs. 16–18: Shell in apertural, apical and umbilical views. Fig. 19: Detail of umbilical area. Scale bar = 5 mm. Figs. 20–23: *G. cubana* Holotype MCZ 135151. Figs. 20–22: Shell in apertural, apical and umbilical views. Fig. 23: Detail of umbilical area. Scale bar = 5 mm.

Material examined: Paralectotypes. GULF OF MEXICO. 29º13'N 87º54'W, 380 m, 16 shells, FMNH 57047 (22/vi/1956, H.R.Bullis Jr. leg.), 29º11'N 88º03'W, 417 m, 3 shells, FMNH 66399 (24/ix/1957, H.R. Bullis Jr leg.). UNITED STATES OF AMERICA. **Mississippi** (R.V. Oregon, o.t.); South of Pascogoula, 29º09'N 88º12'W, 417–463 m

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depth, FMNH 187423, 6 shells (sta. 3684, 8/viii/1962), 29º09'N 88º11'W, 472 m depth, FMNH 187436, 6 shells (sta. 3221, 4/iii/1961), 29º13'N 87º54'W, 444–454 m depth, 6 shells, FMNH 187425 (sta. 2825, 17/vii/1960), 1 shell, FMNH 187437 (sta. 3678, 7/viii/1962); South of Mississippi, Silver Bay, 29º07'N 88º11'W, 555 m depth, FMNH 187430, 6 shells (sta. 1180, 3/vi/1959); Delt Louisiana, 28º16'N 89º02'W, 925 m depth, FMNH 187443, 2 shells (sta. 1179, 28/viii/1954); South of the Mississippi delta, FMNH 69025, 2 shells (ex. Ted Dranga, 1955). MEXICO. Cape Catoche, 24º22'N 87º47'W, 546 m, FMNH 187429, 2 shells (R.V. Oregon, sta. 11134, 9/viii/1970, o.t.). **Florida**; Florida straits, 24º19.521'N 83º14.953'W, FMNH 323758, 3 specimens (Sta. GHB-03-05; Bell, T. & Olaivar, B. col. 23/iv/2003). LESSER ANTILLES (R.V. Oregon II, o.t.). DOMINICA, 15º39'N, 61º10'W, 657 m depth, FMNH 187422, 5 shells (sta. 5929, 5/iii/1966), 15º40'N 61º09'W, 629 m depth, FMNH 187426, 6 shells (sta. 10827, 1/xii/1969), 15º42'N 61º18'W, 685 m depth, FMNH 187444, 1 shell (sta. 10282, 2/xii/1969); North of Christopher, 18º28'N 63º23'W, 690 m depth, FMNH 187446, 5 shells (sta. 10835, 6/xii/1969); St. Christopher, 17º46'N 62º59'W, 657–676 m depth, FMNH 187432, 4 shells (sta. 6696, 18/v/1967), 17º38'N, 62º48'W, 629–703 m depth, FMNH 187448, 2 shells (sta. 6721), 17º34'N 63º42'W, 620–707 m depth, FMNH 187441, 2 shells (sta. 6722, 5/vi/1967). SURINAM. North off Paramaribo, 6º48'N 55º12'W, 47 m depth, FMNH 187447, 4 shells (R.V. Oregon, sta. 2284, 8/ix/1958, o.t.).

Remarks: Rios (1975: 25) reported *Callogaza watsoni* (under *Gaza*) as occurring off Pará, north Brazilian coast, 750 m, on the basis of the material collected by the R.V. Albatross; the illustration provided by the author (pl. 6, fig. 71) was a copy of the original figure by Dall (1889, pl. 22, figs. 7, 7a). In the subsequent editions (Rios 1985, 1994), the author repeated the record of *C. watsoni* from Brazil, but illustrating a specimen of *Gaza superba*; for this reason, the citations of Rios (1985, 1994) are here transferred to the synonymy of *G. superba*. However, the reexamination of the material collected by the R.V. Albatross (USNM 97116) revealed that this material actually correspond to *C. watsoni* (see additional comments in *C. watsoni*).

Gaza daedala Watson, 1879
(Figs. 16–19)

Gaza daedala Watson, 1879: 602–603. Thiele 1929: 78. Clench & Abbott 1943: 2.

Types: Holotype BMNH 8729346 (examined).

Type locality: FIJI, Kandavu, 19º10'S 178º10'E, 1128 m depth.

Diagnosis: Color of entire shell pale-beige iridescent; surface opaque, spire about as high as body whorl; about six whorls. Protoconch without hole in adult. Spire profile slightly convex straight. Body whorl with evident spiral lines, spire diameter about 80% of total shell diameter. Carina in lower region of body whorl. Umbilicus completely covered

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by callus.

Distinctive description

Shell (Figs. 16–19): Large, spire height about same as body whorl, about 3/4 its volume. Spire profile almost straight; very weakly convex, suture shallow. Sculpture similar to that of *G. compta*, with about 25 spiral lines in penultimate whorl. Spire with first 3.5 whorls smooth (Fig. 17), gradually axial lines appearing closer to upper suture; then spiral, axial lines becoming equally developed, except near aperture with spiral lines predominating. Body whorl with weak spiral carina between middle and lower thirds. Callus covering entirely umbilical opening (Figs. 18, 19).

Measurements (in mm): Holotype = 20.6 x 17.0.

Distribution: Fiji Islands.

Habitat: About 1100 m depth.

Material examined: Holotype.

Gaza cubana Clench & Aguayo, 1940

(Figs. 20–23, 53, 54, 83–88)

Gaza superba cubana Clench & Aguayo, 1940: 81–82 (pl. 15, fig. 3). Clench & Abbott 1943: 3 (pl. 3, fig. 1–2).
Gaza cubana: Abbott 1974: 49 (fig. 375a).

Types*:* Holotype MCZ 135151 (examined).

Type locality: CUBA, Santa Ciara, off Sagua la Grande 23º21'N 79º56'W.

Diagnosis: Shell color white iridescent, pale purple on first whorls; surface smooth, glossy, spire about 2/3 of body whorl high; about five whorls. Protoconch without hole in adult. Body whorl with very low, weak spiral lines, almost smooth. Height/width 1.59 on average. Umbilicus about 3/4 covered by callus. Orifices in anterior part of mesopodium: 7 on left, 6 on right side. Number of epipodial tentacles: 5 on right, 6 on left side. Rachidian tooth with squared base, about 1/10 of total radular width; about 20 tall, slender marginal teeth.

Distinctive description

Shell (Figs. 20–23): Shell discoidal; spire low, its height about a half of body whorl height and about half its volume. Protoconch dome-shaped, smooth, glossy, of two whorls (Figs. 20, 21). Spire profile forming flat dome; whorls convex, suture well marked. Body whorl possessing low, blunt carina at periphery. Sculpture similar to that of *G. compta*, with about 20 spiral lines on penultimate whorl. Spire with first four whorls smooth, gradually spiral lines appearing, becoming more developed on last two whorls; axial sculpture weak, almost absent, more developed in peri-umbilical area. Callus covering about 3/4 of umbilicus (Figs. 22, 23); thin connection with beginning of last whorl; callus edge thicker.

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Head-foot (Figs. 83–85, 88): Snout about 1/3 of head-foot width; distal end flat, with numerous almost uniformly sized papillae, slightly larger (50%) at edge, smaller close to mouth. Foot's anterior orifices: 7 on left, 6 on right side (Fig. 88). Posterior half of epipodium with long, slender epipodial tentacles, 5 on right, 6 on left side (Fig. 84); anterior epipodial tentacle larger, inserted in distal edge; remaining epipodial tentacles up to 3 times shorter, inserted in ventral surface of epipodium. Posterior part of epipodium, surrounding opercular pad, with series of small, papillae rounded at tip (Fig. 83: **op**), separated from each other by distance equivalent to their width, somewhat irregularly sized.

Operculum: Similar to *Gaza compta*.

Mantle organs (Figs. 86, 87): Gill about same length as pallial cavity. Anterior end of gill pointed. Left gill filaments with about same area as right filaments, both possessing pointed projection oriented towards opposite sides (Fig. 87). Rectum about 1/6 of pallial cavity width, sigmoid, posterior region with loop turned to left surrounding kidney, close to median line abruptly curving anteriorly, gradually towards right up to anus. Anus located about 1/6 of mantle cavity length posterior from mantle border.

Digestive system (Figs. 85, 86): Foregut characters similar to those of *G. compta*. **Radula** (Figs. 53, 54) similar to that of *G. compta*, except by marginal teeth with about 50% wider cutting edge, each marginal tooth with about 12 sub-terminal cusps. Transverse muscles separating anterior region of esophagus from odontophore about 50% shorter, more concentrated in anterior half of esophagus. Internal folds of esophagus possessing similar distributed folds, but taller, more glandular. Rectum about 1/6 of pallial cavity width, weakly looped, with a "U"-shaped loop in its posterior 2/3 into pallial cavity (concavity right).

Measurements of shells (in mm): Holotype = 23.5 x 15.0; UMML 308136, #1, 27.6 x 17.3; #2, 27.2 x 18.7.

Distribution: Gulf of Mexico.

Habitat: About 400 m depth.

Material examined: Holotype. MEXICO; **Yucatan**; 20º22'N 87º11'W, 434 m depth, UMML 308136, 2 specimens (Pillsbury 602 col., 16/iii/1967; J.F. Quinn Jr. det.).

***Gaza olivacea* Quinn, 1991**
(Figs. 24–27, 61–63, 89–91)

Synonymy: see Quinn (1991:166). Complement:
Gaza sp: Hickman & McLean 1990: 91 (fig. 51a).
Gaza olivacea: Quinn 1991:166–168, figs. 1–3. Merlano & Hegedus 1994:117, fig. 366.

Types*:* Holotype USNM 752369; Paratypes USNM 859424, 22 shells; USNM 752390, 17 shells; UMML 308365, 1 shell; FSBCI 39513, 1 shell. (All examined).

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FIGURES 24–36. *Gaza* spp. Figs. 24–27: *G. olivacea* FMNH 223560 (from Surinam). Figs. 24–26: Shell, apertural, apical and umbilical views. Fig. 27: Detail of umbilical area. Scale bar = 10 mm. Figs. 28–32: *G. fischeri* Paralectotype USNM 94989. Figs. 28–30: Shell in apertural, apical and umbilical views. Fig. 31: Detail of umbilical area. 32. Operculum, outer view. Scale bar = 5 mm. 33–36. *G. rathbuni* AMNH 254993 (off Cape Mala, Panama) shell. Figs. 33–35: Apertural, apical and umbilical views. Fig. 36: Detail of umbilical region. Diameter = 32.5 mm.

Type locality: COLOMBIA; off Península de la Guajire, 12º30'N 72º08'W, 475 m depth.

Diagnosis: Color of entire shell beige iridescent; surface smooth, spire low with about five whorls. Protoconch with hole in adult. Body whorl with very low spiral lines, glossy. Height/width 1.47 on average. Weak carina in lower level of body whorl. Umbilicus

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almost completely covered by callus, except by narrow lower opening. Orifices in anterior part of mesopodium: 7 on left, 8 on right side. Number of epipodial tentacles: 6 on right side. Rachidian tooth with elongated base, about 1/10 of total radular width, six lateral teeth somewhat similar to rachidian, about 10–12 tall, slender marginal teeth.

Distinctive description

Shell (Figs. 24–27): Size about 35 mm. Color beige with green tinge. Outline turbiniform; spire height, volume approximately same as body whorl. Protoconch eroded forming small hole communicated with umbilicus (Fig. 25). Spire profile forming hemisphere; whorls weakly convex, suture shallow. Sculpture similar to that of *G. superba*; shell surface somewhat glossy; spiral lines weakly visible, about 15 spiral lines on penultimate whorl; axial sculpture almost absent, except some very weak lines in periumbilical area. Callus covering umbilicus almost completely, except for short, narrow lower region (Figs. 26, 27), surrounded by inner lip, forming tube communicating with umbilical chamber.

The following anatomical description is based on a re-hydrated specimen.

Head-foot (Figs. 89, 91): Snout papillae broad (about 1/20 of shout width and length), touching each other. Tentacles having two clearly separated regions: basal half broader, with long cilia; distal half slender, smooth. Epipodial tentacles slightly short, uniform in size, stubby, 7 on left, 8 on right side (Fig. 89), inserting on ventral surface of epipodium (instead of its border). Foot's anterior orifices 6 on right (Fig. 91) side, not seen on left side.

Operculum: similar to that of *Gaza compta*.

Mantle organs: Details not seen because of problematic preservation.

Digestive system (Fig. 90): Foregut with similar characters to *G. compta*. Radular (Figs. 61–63) characters similar to those of *G. compta*, with following differences: rachidian and lateral teeth about 50% longer antero-posteriorly than their width (Figs. 61, 62); rachidian about 1/10 of total radular width; fewer marginal teeth (about 10–12 pairs per row), slender, with marginal cusps along almost entire length (about 30 pairs). Intestinal loops in anterior region of visceral mass, posterior region of pallial cavity very wide (Fig. 90), having two long antero-posterior loops preceding rectum.

Measurements of shell (in mm): Holotype = 32.9 x 27.0.

Distribution: Caribbean Sea to Rio de Janeiro, Brazil.

Habitat: Muddy bottom with coral aggregations; from 370 to 606 m depth, mostly at 400 m depth; with a record of a dead shell in 28 m depth (FMNH 187421).

Material examined: (R.V. Oregon, o.t.; S.Walker det.). COLOMBIA. Off Riohacha (R.V. Oregon II): 11º25'N 73º56'W, 440 m depth, FMNH 187431, 4 shells (sta. 11252, 10/xi/1970); off Península de la Guajire, 444–454 m depth, FMNH 187445, 2 shells, (sta. 4923, 2/vi/1964), 12º31'N 71º58'W, 380 m depth, FMNH 187435, 2 shells (sta. 5692, 10/x/1965); 12º30'N 72º08'W, 475 m depth, FMNH 187434, 12 shells (**Topotype**, sta. 5690, 10/x/1965); off Santa Marta, 11º03'N 75º10'W, 370 m depth, FMNH 187440, 12 shells (sta. 10260, 2/xii/1968), 11º18'N 74º44'W, 606 m, FMNH 187424, 3 shells (sta. 11248, 9/

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ix/1970), 11º04'N 74º25'W, 28 m depth, FMNH 187421, 1 shell (sta. 10266, 2/xii/1968). TRINIDAD. Northwest, 11º33'N 62º30'W, 370 m, FMNH 187442, 2 shells (sta. 2782, 20/iv/1960), 11º37'N 62º47'W, 370–444 m depth, FMNH 187428, 3 shells (sta. 5037, 24/ix/1964), 11º31'N, 62º24'W 343–370 m depth, FMNH 187427, 6 shells (sta. 2351, 23/ix/1958); off west side on Penin, 12º29'N 72º19'W, 490 m, FMNH 187439, 3 shells (sta. 5689, 9/x/1965). SURINAM. North off Paramaribo, 7º34'N 54º13'W, 370 m depth, FMNH 187433, 6 shells (sta. 4301, 24/iii/1963), 7º34'N 54º50'W, 370 m depth, FMNH 223560, 49 shells (sta. 2005, 6/xi/1957). FRENCH GUIANA. North of Cayenne, 7º10'N 53º07'W, 370 m depth, 6 shells, FMNH 187438 (sta. 2026, 9/xi/1957), 370 m, 20 shells, FMNH 223558 (sta. 2026, 9/xi/1957). BRAZIL; **Rio de Janeiro**; 23º40'S 41º00'W, 545 m depth, IBUFRJ 10050, 1 shell and part of dry specimen (Revizee central II, RV Astrogaroupa, sta. #5C, 25/x/1997).

Remarks: The single lot examined from Brazil (IBUFRJ 10050), contains one complete dry specimen and soft parts of another specimen. This material differs from the remaining lots of *G. olivacea* examined by having a lower spire and a more discoidal shell outline. However, the remaining shell characters, such as sculpture, color and umbilical flap, are very similar. As the *G. olivacea* lots from the north Atlantic lack soft parts for a more comprehensive analysis, and taking into account the remaining shell similarities of both materials, a conservative approach is given here: the specimens from Brazil are referred to *G. olivacea*, until addition material becomes available.

Gaza fischeri Dall, 1889

(Figs. 28–32, 55–57, 93–98)

Gaza fischeri Dall, 1889: 355–356 (pl. 37, fig. 6). Clench & Abbott 1943: 4 (pl. 3, fig. 3–5: lectotype). Abbott 1974: 49 (fig. 376). Abbott & Dance 1983: 40 (unnumbered text-fig. of holotype).

Types: **Lectotype** MCZ 7543 (examined) (explicitly designed by Clench & Abbott 1943). **Paralectotype** USNM 94989 (examined).

Type locality: Caribbean Sea, off St. Lucia Island, 13º54'55"N 61º06'05"W, 229 m depth, (A. Agassiz col., 16/ii/1879).

Diagnosis: Color of entire shell pale-beige iridescent, smooth, spire very low with about five whorls. Protoconch without hole in adult. Body whorl with very narrow spiral lines, spire diameter about 60% of total shell diameter. Weak carina at middle level of body whorl. Umbilicus completely covered by callus. Orifices in anterior part of mesopodium: 5 on left, 6 on right side. Number of epipodial tentacles: 6 on right, 5 on left side. Rachidian tooth with trapezoidal base, about 1/6 of total radular width, about 20 tall, slender marginal teeth.

Distinctive description

Shell (Figs. 28–31): Size about 30 mm. Color beige with orange tinge. General form

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discoid; spire low, height nearly one half of body whorl, about half its volume. Spire profile forming flat dome; whorls highly convex, suture well marked. Protoconch smooth, glossy, with about 2 whorls (Fig. 29). Sculpture similar to that of *G. compta*, with about 25 spiral lines in penultimate whorl. Teleoconch with first 4 whorls possessing axial lines weakly broader than local spiral lines, well spaced from each other, stronger close to upper suture smooth, gradually disappearing towards lower suture; gradually axial lines disappearing before penultimate whorl; peri-umbilical area with weak axial sculpture. Callus sealing entire lower region of umbilical opening (Figs. 30, 31).

Head-foot (Figs. 93, 94, 96, 98): Snout papillae three-times larger at edge than close to mouth (Fig. 98). Foot's anterior orifices; 5 orifices on left, 6 at right side; each orifice located at tip of rounded, low stalk (Fig. 96: fo). Flap of anterior third of epipodium as long as snout (Fig. 93: ep). Remaining epipodium with very long, slender tentacles of similar size, middle one about half as long, 6 on right, 5 on left side.

Operculum (Fig. 32): similar to that of *G. compta*.

Mantle organs (Fig. 95): Anterior end of gill pointed. Left gill filaments with about twice surface area of right filaments, possessing one ventral-left, pointed projection; right filaments simpler, weakly pointed. Rectum about 1/4 length of pallial cavity width, sigmoid, posterior region as undulating line up to region posterior to anus.

Digestive system (Figs. 95, 97, 98): Foregut similar to that of *G. compta*, including intrinsic and extrinsic musculature of odontophore; **m1v** about 50% broader. **Radula** (Figs. 55–57): Cutting edges of rachidian, lateral teeth with triangular fashion; their bases having wider proximal edge than distal edge (trapezoidal); their projected region about 50% narrower (Figs. 55, 56). About 20 marginal teeth, narrow, with 3 pairs of very small marginal cusps, along most of tooth shaft. Salivary glands small, attached to esophageal origin region, on lateral sides (Fig. 97: sg). Fecal material solid, hard, filling entirely intestine, possessing three middle, ventral, longitudinal furrows (Fig. 95).

Central nervous system (Fig. 97): Nerve ring similar to that of *G. compta*, except for about 30% more slender cerebral ganglia.

Measurements (in mm): Lectotype = 32.5 x 21.0; AMNH 269826: #1 23.0 x 15.0; #2, 20.9 x 14.3.

Distribution: Caribbean Sea.

Habitat: Muddy sand bottom; about 230 m depth.

Material examined: Lectotype, Paralectotype. BAHAMAS; off Long Island, AMNH 269826, 2 specimens (RV Columbus, deep trawl, 21/xi/1981).

Gaza rathbuni Dall, 1890

(Figs. 33–40)

Gaza rathbuni Dall, 1890: 394. 1890: 342 (pl. 7, fig. 4). Abbott & Dance 1983: 40 (unnumbered text-fig. of holotype). Keen 1971: 342. Finet 1995: 23.

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Types: Holotype USNM 97054 (examined).

Type locality: Ventana Bay, near Galapagos Islands, 24°11'30"N 109°55'00"W, 717 m depth (R/V Albatross, Sta. 2828, United States Fish Commission, 30/iv/1888).

Diagnosis: Color of entire shell pale-beige iridescent, smooth, spire low with about five whorls. Protoconch without hole in adult. Body whorl with very low spiral lines. Height/width 1.40 on average. Weak carina at middle level of body whorl. Umbilicus completely covered by callus. Epipodial tentacles: 7 on right side.

Distinctive description

Shell (Figs. 33–40): Size about 35 mm. Color beige with green tinge. Outline discoid (Figs. 33, 37); spire low, height 10% more than half of body whorl, about half its volume. Spire profile forming flat dome; whorls weakly convex, suture almost plane, weakly marked. Protoconch smooth, dome-shaped, of two whorls (Figs. 34, 38). Sculpture of only weak spiral, about 25 spiral lines in penultimate whorl. Teleoconch up to 4.5 whorls. Peristome, umbilical regions similar to those of *G. compta*, including umbilical chamber completely sealed by callus (Figs. 35, 36).

Measurement of shells (in mm): Holotype = 38.0 x 27.0; AMNH 254993: 32.5 x 22.0.

Distribution. From Galapagos Island to western coast of Panama.

Habitat: In sand, from 200 to 717 m depth.

Material examined: Holotype: USNM 97054. PANAMA, off Cape Mala (Pacific Ocean), 200 m depth, AMNH 254993, 1 shell (Helen DuShane collection, sta. KN 113, ix/1975).

Remarks: Although the specimen AMNH 254993 (Figs. 33–36) was not found close to Galapagos, the collection locality is sufficiently close, and the shell attributes are very similar to the *G. rathbuni* holotype (Figs. 37–40), which confirm its identification. This AMNH specimen is important in having the peristome and umbilical flap completely developed. It provides the basis for a complete description of all shell characters, which is not possible from the immature holotype (Figs. 37, 39, 40). However, AMNH specimen is not a topotype; additionally, the immature holotype is larger than the fully grown AMNH specimen.

Some anatomical data of this species were given by Dall (1890), who reported the presence of seven epipodial tentacles on the right side.

Genus *Callogaza* Dall, 1881

Gaza (Callogaza) Dall, 1881: 49 [type species, OD, *C. watsoni* Dall, 1881]; Dall 1889: 366. Thiele 1929: 78. Wenz 1938: 296. Clench & Abbott 1943: 5. Hickman & McLean 1990: 90.

Diagnosis: Similar to *Gaza*, but smaller (about to 20 mm), flat shaped, discoid to trochiform, stronger spiral and axial sculpture. Pigmentation mosaic of brown spots on pale beige background. Shell walls thicker, making shell less iridescent. Whorls somewhat

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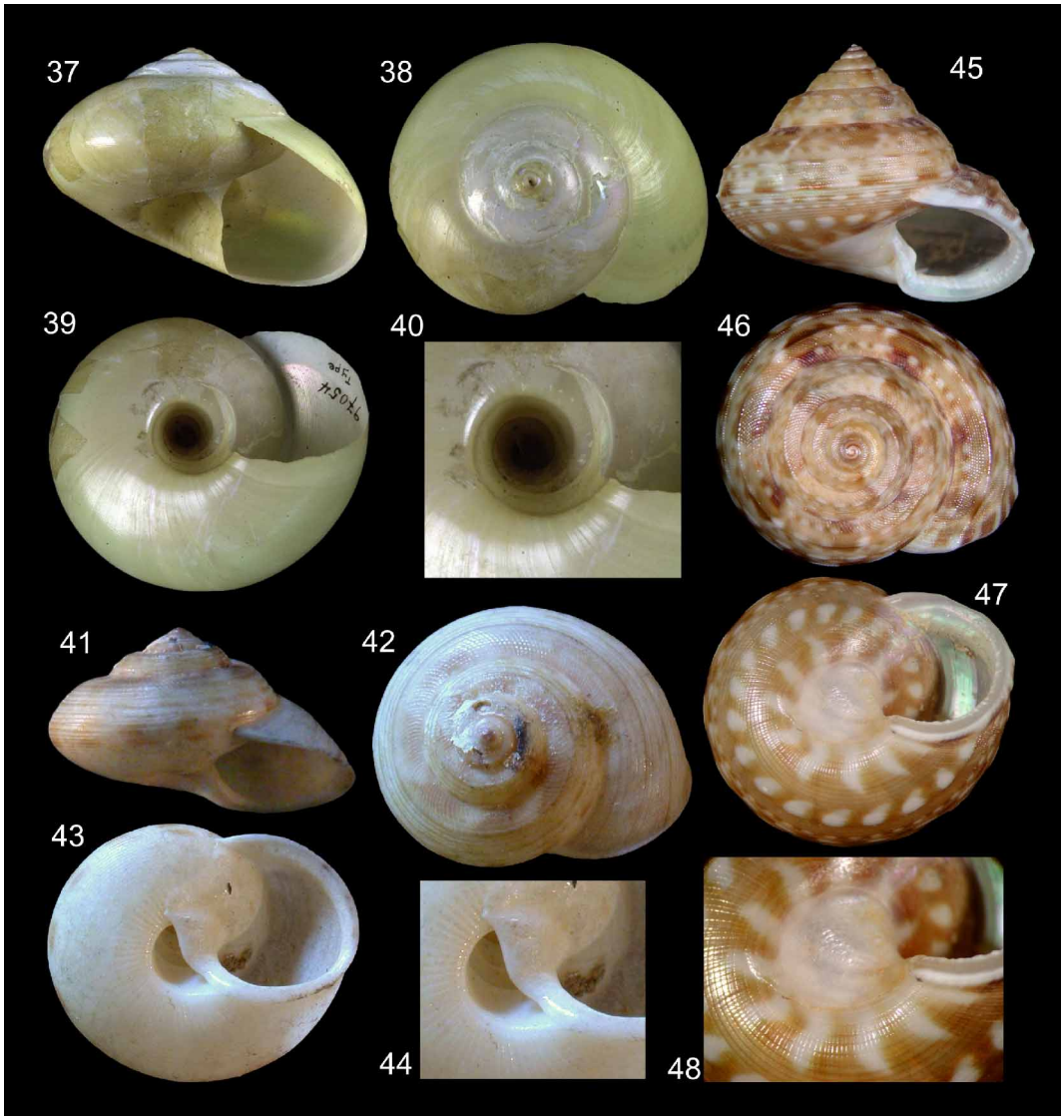
shouldered. Umbilicus partially or totally covered by flap-like callus on lower region of inner lip in adult specimens. Peristome deflected (determinate growth) preceded by region weakly dislocated downwards.

List of included taxa: *C. watsoni*, *C. sericata* and *C. frederici.*



FIGURES 37–48. Shells. Figs. 37–40: *Gaza rathbuni* Holotype USNM 97054. Figs. 37–39: Shell in apertural, apical and umbilical views. Fig. 40: Detail of umbilical area; Diameter: 38 mm. Figs. 41–44: *Callogaza watsoni* Holotype MCZ 7544, a specimen with peristome not formed. Figs. 41–43: Shell in apertural, apical and umbilical views. Fig. 44: Detail of umbilical area; Diameter = 11 mm. Figs. 45–48: *C. sericata* MZSP 48530 from Aliguay, Philippines. Figs. 45–47: Shell in apertural, apical and umbilical views. Fig. 48: Detail of umbilical area. Diameter = 15 mm.

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***Callogaza watsoni* Dall, 1881**
(Figs. 41–44, 58–60)

Callogaza watsoni Dall, 1881: 50. Dall 1889: 356–357 (pl. 22, figs. 7, 7a; pl. 23, figs. 1, 1a; pl. 24, figs. 2, 2a). Dall 1890: 342.
Margarita filogyra Dall, 1881: 42.
Gaza (Callogaza) watsoni: Clench & Abbott 1943: 5 (pl. 2, figs. 3–4). Abbott 1974: 49 (fig. 377). Rios 1975: 25 (pl. 6, fig. 71).
Gaza watsoni: Clench & Aguayo 1940: 381.

Types: Holotype MCZ 7544 (examined).

Type locality: CUBA, off Havana, 24º34'N 83º16'W, 324 m depth, (Blake Expedition, 1877).

Diagnosis: Shell color pale beige with brown spots, spire low with about five whorls. Protoconch without hole in adult. Height/width 1.44 on average. Spire 0.60 of body whorl high. Umbilicus half covered by callus.

Distinctive description

Shell (Figs. 41–44, 58–60): discoid; spire low, height about 0.60 of body whorl height and about half its volume. Spire profile slightly concave, triangular dome-shaped; whorls convex, suture well marked; weak sub-sutural carina about 1/3 from upper suture in relation to total whorl width; surface between upper suture and carina horizontal, flat; between carina and lower suture a slope of minimally concave (almost straight) profile. Protoconch smooth, glossy, with about 2 whorls (Figs. 42, 60). Sculpture between upper suture, carina uniform reticulate; with spiral, curved axial lines equally developed, spaced; about 10 spiral lines. Sculpture between carina, lower suture composed almost exclusively of about 6 spiral cords, space between cords about 2–3 times their width. Sculpture between carina and umbilicus in body whorl with 18 spiral lines of uniform size, close to each other, axial lines well-marked in peri-umbilical area (Figs. 43, 44, 59), disappearing gradually from about 1/4 of lower body whorl surface; these axial lines having small notch at short distance from umbilicus, producing shallow spiral furrow surrounding umbilicus. Callus covering half of lower region of umbilical opening (Figs. 43, 44), about 3 times broader in upper region than its lower region.

Measurement of shells (in mm): Holotype = 22.0 x 13.0.

Distribution: Caribbean Sea to north Brazil (off Pará).

Habitat: From 320 to 716 m depth.

Material examined: Holotype MCZ 7544. BRAZIL; **Ceará**; off Fortaleza, 03° 22'00"S 37°49'00"W, 716 m depth, USNM 97116, 1 shell (R/V Albatross Sta. 2756, trawl, United States Fish Commission, 14/xii/1887, reported as "off Pará river").

Remarks: The specimen referred by Dall (1890: 342) from off Brazilian coast (off Fortaleza, Ceará) was re-examined (Figs. 58–60). This material corresponds to a young (lacking callus), eroded and broken specimen. It has a taller profile than the holotype, but the remaining features including the shell sculpture do not differ from those of *C. watsoni*.

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Callogaza sericata (Kira, 1959)

(Figs. 45–48)

Gaza sericata Kira 1959: 17 (pl. 8, fig. 13). Kira 1962: 14 (pl; 9, fig. 12). Bieler & Petit 1990: 135; Hardy, 2005 (unnumbered text-fig.), Yamada, 2005(unnumbered text-fig.).
Callogaza sericata: Okutani 2000: 60–61 (fig. 36).

Types: 5 syntypes OMNH 1390 (Kira collection) (examined).

Type locality: Japan.

Diagnosis: Shell color pale beige with dark brown spots, spire as tall as body whorl, with about six whorls. Protoconch without hole in adult. Height/width 1.18 on average. Umbilicus completely covered by callus.

Distinctive description

Shell (Figs. 45–48): size about 15 mm. Color pale beige with dark brown spots spread almost uniformly (about 6–7 on last whorl) as irregular axial bands; pale cream small spots organized as successive axial, interrupted bands (about 12 on body whorl: Figs. 47, 48) profile turbiform; spire height nearly as tall as body whorl, about same volume. Spire profile triangular; whorls slightly convex, suture well marked. Protoconch smooth, glossy, with about 2 whorls (Fig. 46). Sculpture composed of 5–6 relatively large spiral cords at periphery, well separated from each other, slightly elevated from surface; area between upper of these cords and adjacent upper suture, 5–6 narrow spiral lines, close to each other; about 70 weak, narrow axial lines. Sculpture inside body whorl composed of equally developed axial and spiral lines forming reticulation, up to peri-umbilical area. Callus sealing entire lower region of umbilical opening (Figs. 47, 48).

Measurements (in mm): OMNH (figured syntype): 16.3 x 12.5; MZSP 48530: 15.0 x 13.5 mm.

Distribution: From Japan to Philippines.

Habitat: 50 to 300 m depth.

Material examined: Syntypes. PHILIPPINES; Alliguay, 50–80 m depth, 1 shell, MZSP 48530 (Michel Jourdan leg., dredged). JAPAN; West Amami Island, near Jokoate-shima, 160–250 m depth, MZSP 67143, 2 shells (fishermen col. by nets, vi/2005; Femorale). Photos of Japanese specimen in Hardy (2005) (6 shells) and Yamada (2005) (3 shells).

Callogaza frederici (Smith, 1906)

Gaza (Callogaza ?) frederici Smith, 1906: 246 (no fig.).

Types: Holotype ZSI M3779/1 (not examined).

Type locality: Gulf of Manar, 228 m depth (Sta. 333).

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FIGURES 49–57. Radulae in SEM. Figs. 49–52: *Gaza compta*. Fig. 49–51: Holotype. Figure 49: entire shell; scale bar = 100 µm. Fig. 50: Detail of central and lateral teeth; scale bar = 50 µm. Fig. 51: Same, detail of marginal region; scale bar = 50 µm. Fig. 52: Paratype, central region; scale bar = 50 µm. Figs. 53–54: *G. cubana*. Fig. 53: Entire shell; scale bar = 100 µm. Fig. 54: Lateral teeth, scale bar = 100 µm. Figs. 55–57: *G. fischeri*. Fig. 55: Entire shell, scale bar = 100 µm. Fig. 56: Detail of central and lateral teeth; scale bar = 100 µm. Fig. 57: Detail of lateral region; scale bar = 50 µm.

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Description

Shell: See description given by Smith (1906: 246).

Measurements (in mm): Holotype: 25 x 23.

Discussion: The holotype, the only known specimen of this species, is up to date not accessible. The species was never figured, and all efforts for obtaining the type were not successful. Consequently, no additional information beyond the original description is available. Based on the original description, it appears to be a *Callogaza*.

Discussion

The analysis of the species of *Gaza* and *Callogaza*, when compared with other trochid genera, revealed that they possess some characters in common, which most probably constitute synapomorphies that diagnose a clade. However, a better assessment will only be possible when the anatomy of all the species will be known in detail. Of course, the same is true for the remaining species of the family. Nevertheless, the conchological attributes show some particularities that allow this interpretation.

The shell characters of *Gaza* and *Callogaza*, that probably represent synapomorphies, are:

1) The thin shells, making them light and fragile, so that they are usually collected damaged (Figs. 58–60). This is more evident in *Gaza* spp., which is much lighter than *Callogaza* spp.

2) The thin outer shell layers (ostracum, periostracum) are almost transparent. This feature keeps the inner iridescent nacre visible, producing the external iridescence. This character is also more developed in *Gaza*.

3) The callus of the inner lip forms a flap covering the umbilical chamber. This cover can be partial (*Gaza superba*, *G. cubana*, *Callogaza watsoni*) (Figs. 14, 23, 44), almost complete (*G. olivacea*) (Fig. 27), or complete (*G. compta*, *G. daedala*, *G. fischeri*, *G. rathbuni*, *C. sericata*), sealing the ventral aperture of the umbilical chamber (Figs. 3, 19, 31, 35, 48). This feature is only present in fully grown specimens, while the younger specimens have an entirely open umbilicus (Figs. 39, 59). The original description of the genus (Watson 1879) described this conspicuous feature as nacreous umbilical pad.

An open umbilicus is present in a few groups within Trochoidea including some species of *Calliotropis* Seguenza, 1903, *Clanculus* Montfort, 1810, *Margarites* Gray, 1847, some Umboniinae and most Solariellinae (Hickmann & McLean 1990), etc. In all these taxa, there are representatives with and without umbilicus. However, all species of *Gaza* and *Callogaza* possess it. Additionally, there is the development of a covering callus. The combination of characters (umbilicus always present, and a flat callus partially or completely covering it) may be regarded as a synapomorphy for *Gaza-Callogaza*. Umbilical chambers are also found in other non-vetigastropod taxa, such as Xenophoridae (Simone 2005). In xenophorids, the presence of a polychaete worm, living inside this

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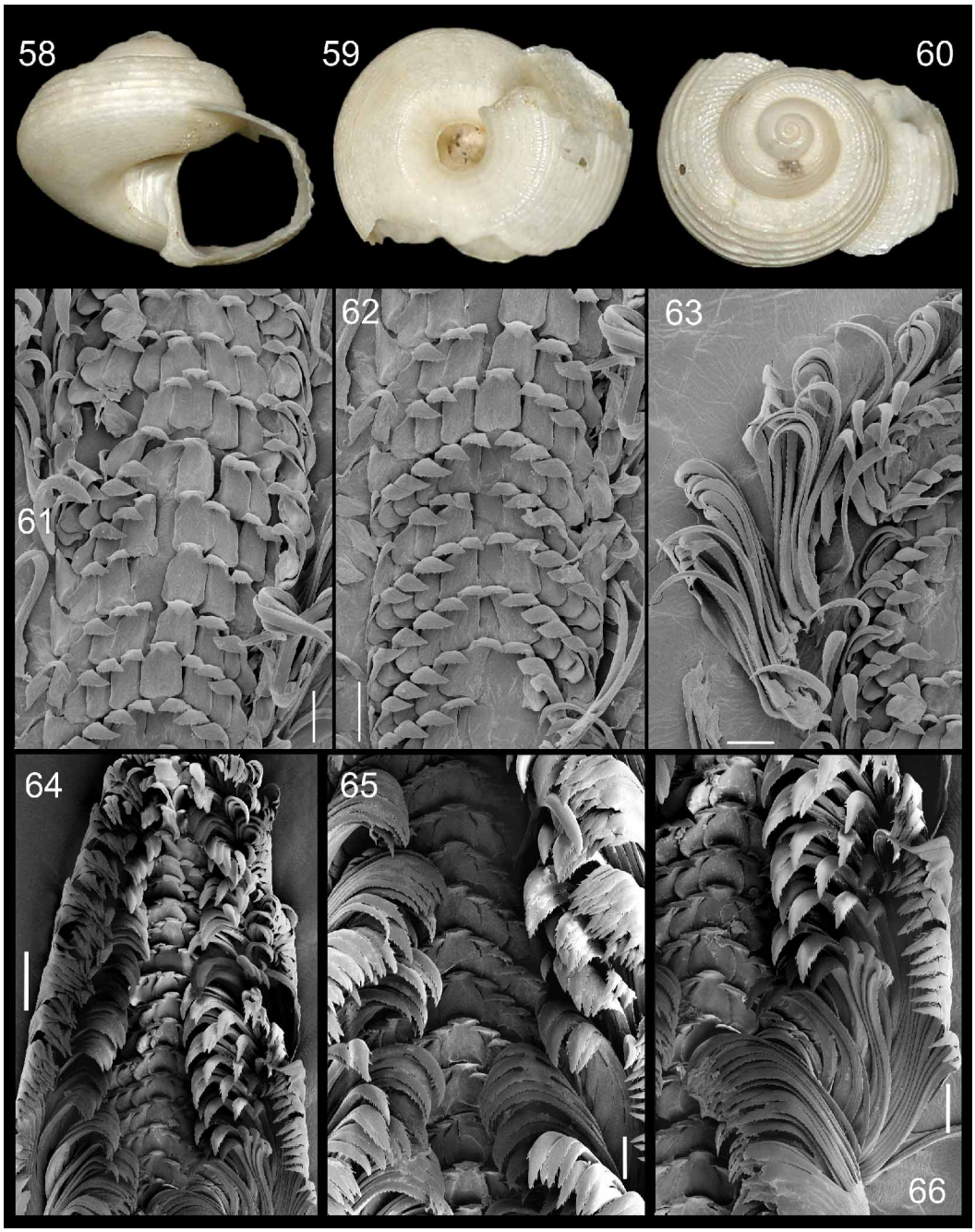

FIGURES 58–66. Shell and radulae in SEM. Figs. 58–60: *Callogaza watsoni* from off Pará, Brazil (specimen mentioned by Dall, 1889, USNM 97116): apertural, umbilical and apical views; diameter = 7.1 mm. Figs. 61–63: *Gaza olivacea*. Figs. 61–62: Central and lateral teeth. Fig. 63: Detail of lateral teeth; scale bars = 100 µm. Figs. 64–66: *Gaza superba*. Fig. 64: Entire shell; scale bar= 200 µm. Fig. 65: Detail of central and lateral teeth; scale bar = 100 mµ. Fig. 66: detail of lateral teeth; scale-bar = 100 µm.

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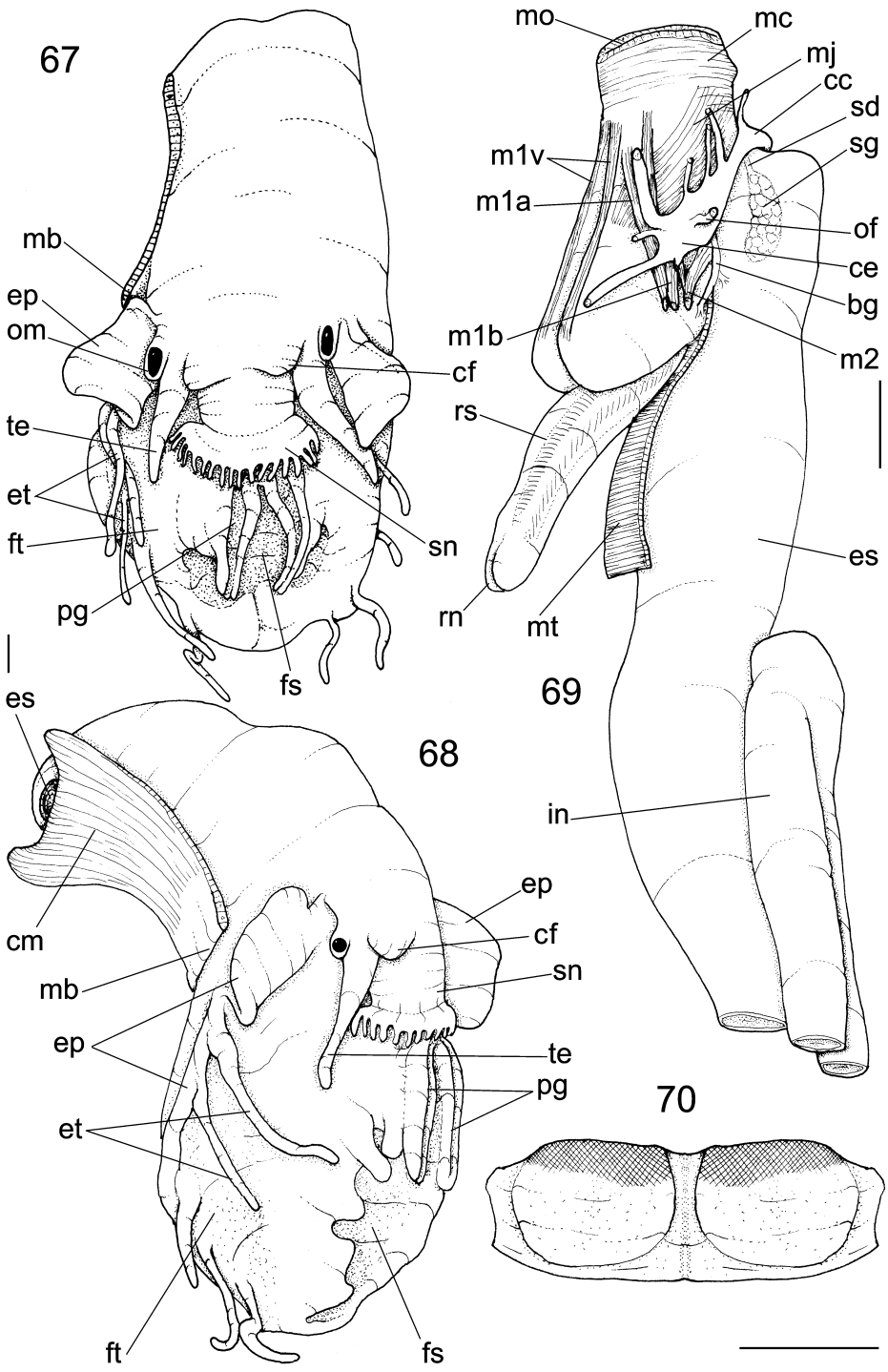

FIGURES 67–70. *Gaza compta* anatomy. Fig. 67: Head-foot, apertural view. Fig. 68: Same, right view. Fig. 69: Foregut, left view, some adjacent structures of haemocoel also shown. Fig. 70: Jaws, ventral view. Scale bars = 1 mm.

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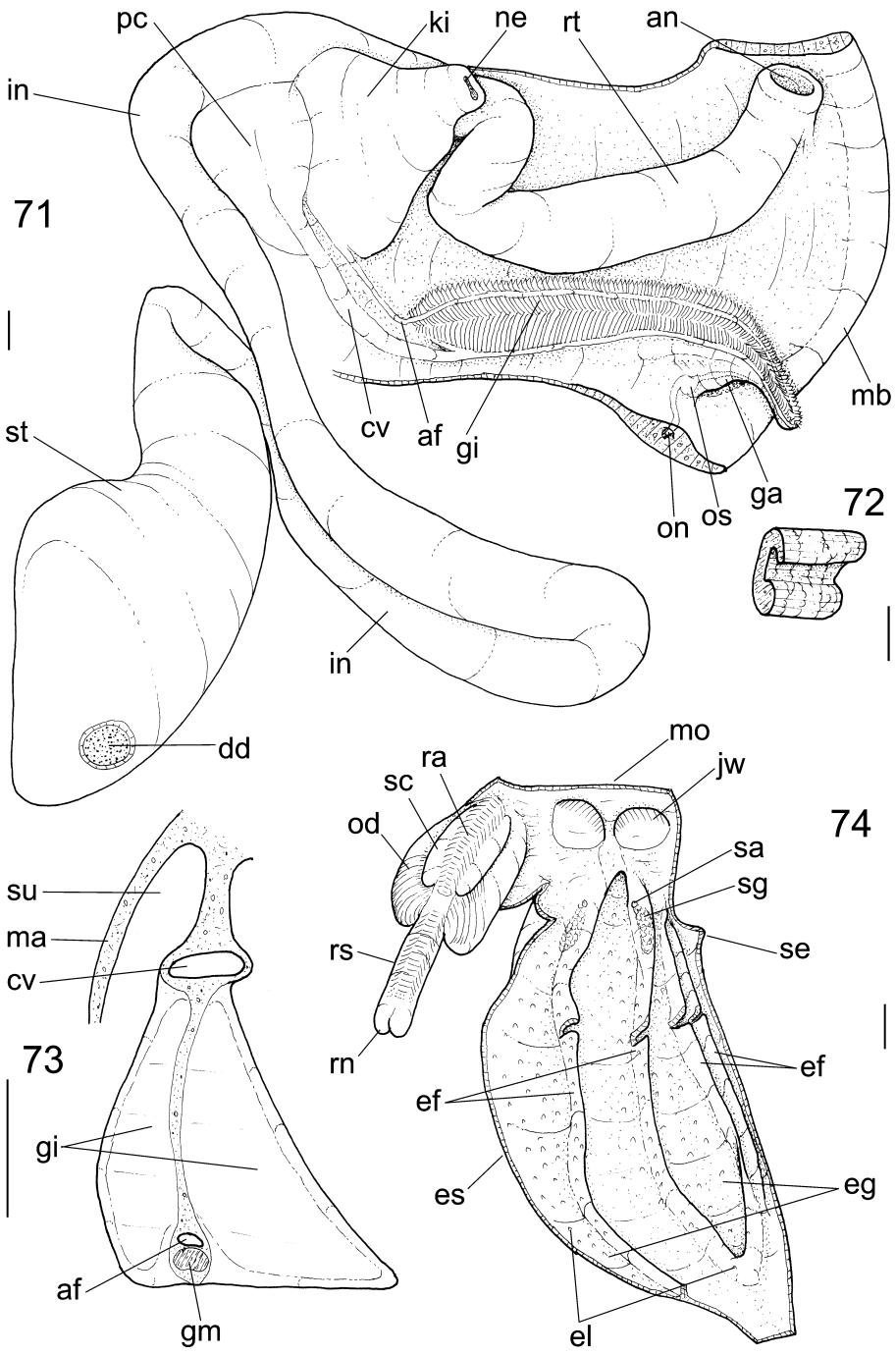

FIGURES 71–74. *Gaza compta* anatomy. Fig. 71: Pallial cavity, mid and hindgut, ventral view, digestive tubes somewhat deflected. Fig. 72: Transversal piece of fecal bundle. Fig. 73: Transversal section of gill, showing filaments and adjacent region of mantle. Fig. 74: foregut, ventral view, esophagus (es) opened longitudinally, odontophore (of) deflected to left, in dorsal view. Scale bars = 1 mm.

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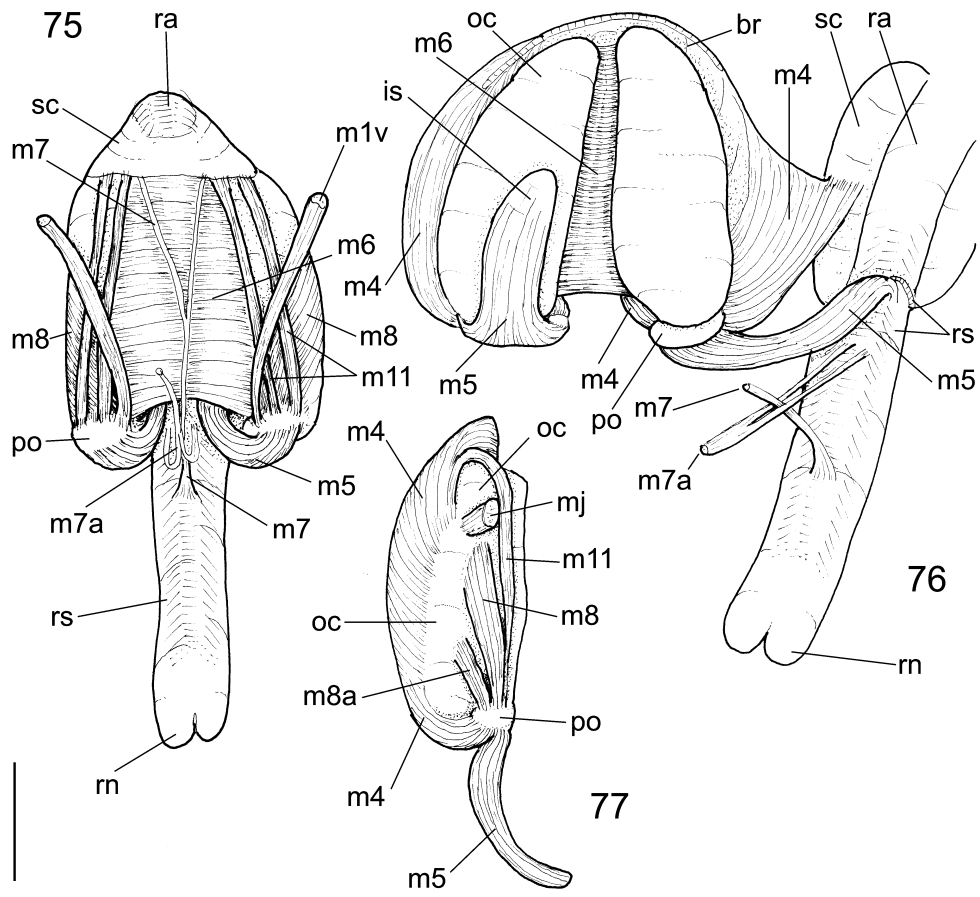

FIGURES 75–77. *Gaza compta* odontophore. Fig. 75: General, ventral view, superficial membrane removed. Fig. 76: Dorsal view, both anterior cartilages (oc) deflected, most muscles also deflected, left m4 and m5 (right in Fig.) shown still inserted in subradular cartilage (sc), buccal cavity portion of radula and adjacent structures only partially shown. Fig. 77: Right half, dorsal-slightly lateral view, showing muscular insertions, m5 deflected. Scale bar = 1 mm.

chamber is common. Some indication of this organism is present in *G. olivacea* specimens (Figs. 26, 27, the dirt inside umbilical aperture). These data suggest a possible relation between the presence of these worms and the development of a callus flap covering the umbilical chamber in *Gaza* and *Callogaza*. Possibly something related to this is the presence of an orifice in the shell apex in the fully growth specimens of some species (*G. olivacea, G. superba*) (Figs. 12, 25). This orifice communicates between the umbilical chamber and the external environment dorsal to the animal. This orifice was never observed in species with the umbilicus completely covered by the callus.

4) The determinate growth, i.e., the development of a differentiated peristome (e.g., deflection, callus; see Vermeij & Signor 1992) is another uncommon feature in Trochidae, which normally groups species with indeterminate growth (peristome simple).

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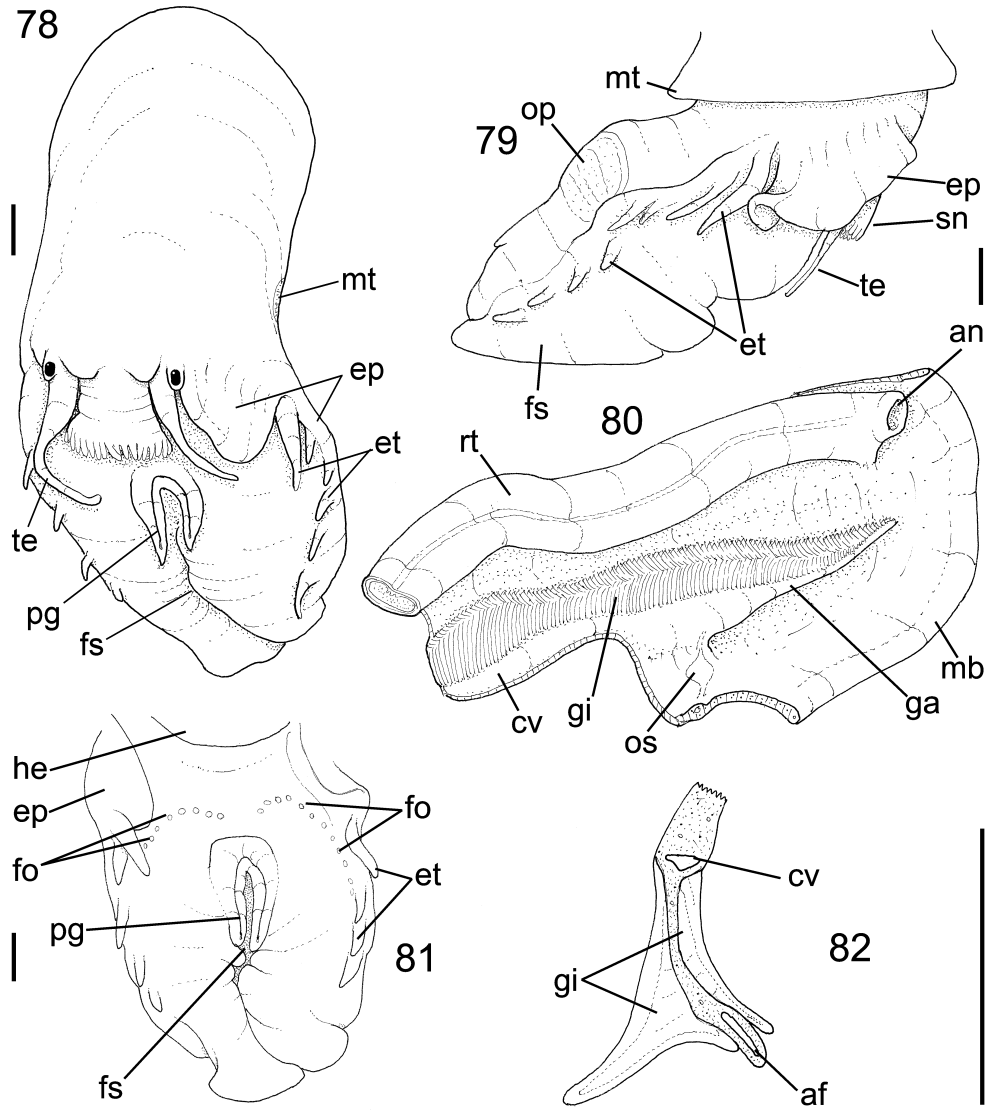

FIGURES 78–82. *Gaza superba* anatomy. Fig. 78: Head-foot, apertural view. Fig. 79: Same, lateral-right view, mantle also shown. Fig. 80: Pallial cavity hoof, ventral view. Fig. 81: Foot, head removed, foot anterior orifices (fo) shown. Fig. 82: Gill, transversal section in its middle region. Scale bars = 2 mm.

5) The region preceding the peristome is slightly projected downwards. This is clearer by the examination of the sculpture of the penultimate whorl. It is possible to see that the region preceding the peristome has a portion of body whorl weakly projecting downwards, the amount of the deflection is normally equal to 3–4 spiral lines of sculpture (Figs. 1, 11, 20, 24, 33, 41, 45). However, this character appears in other vetigastropods, such as the trochid *Clanculus* Montfort, 1810, and certain Scissurellinae and Anatomidae (Geiger 2006a, b).

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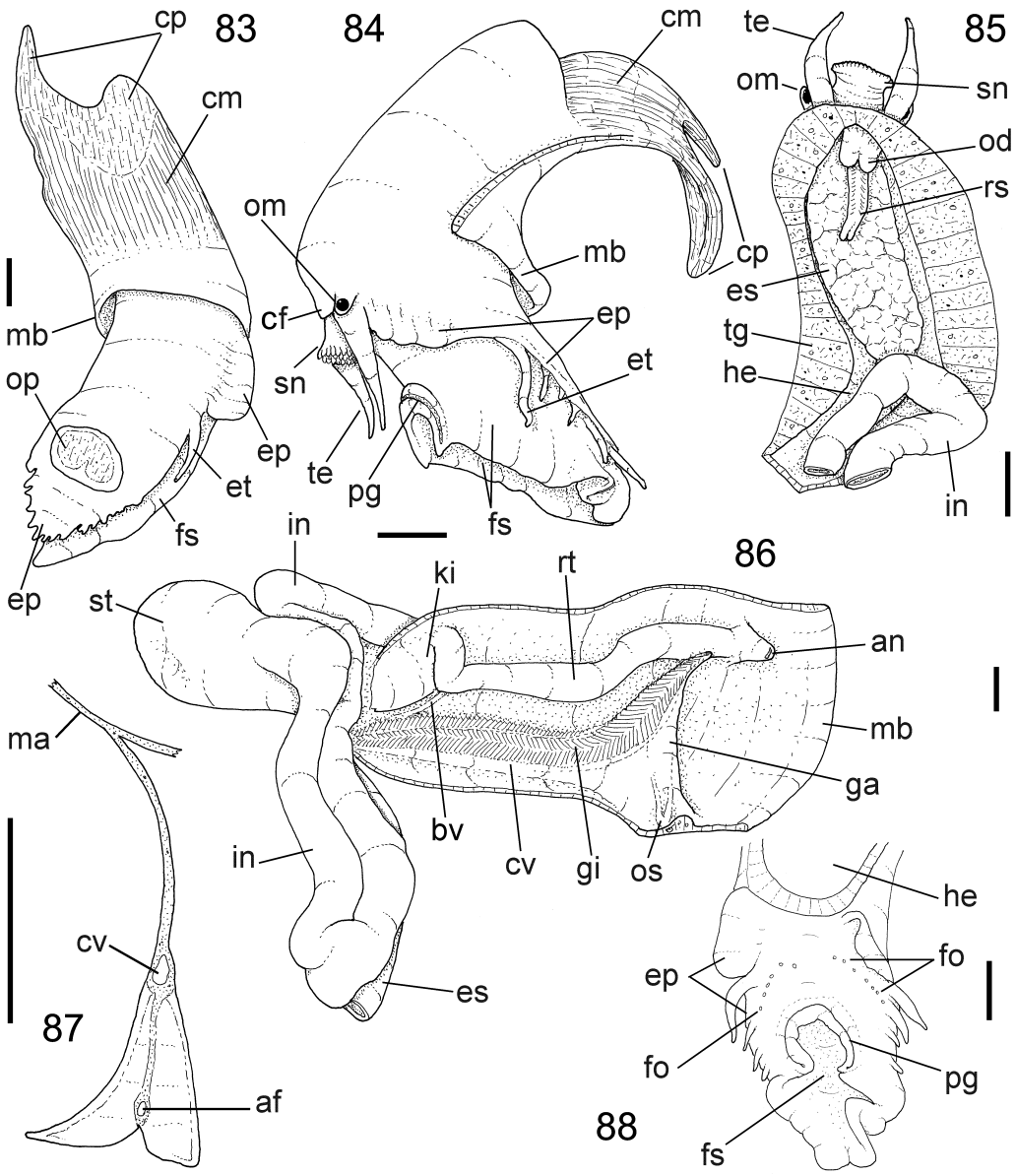
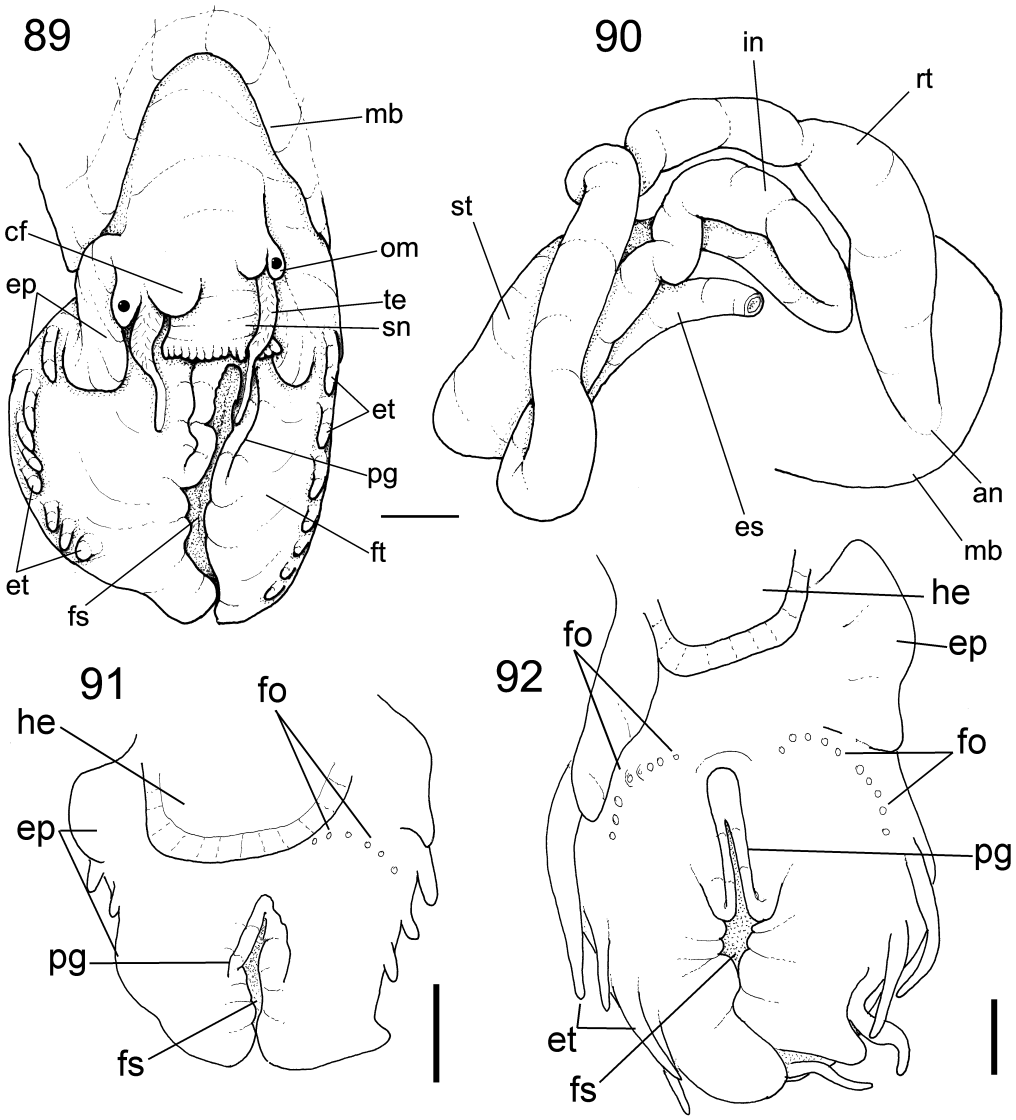


FIGURES 83–88. *Gaza cubana* anatomy. Fig. 83: Head-foot, dorsal-slightly right view, operculum removed. Fig. 84: Same, left view. Fig. 85: Head and haemocoel, ventral view, foot and columellar muscle removed. Fig. 86: Pallial cavity hoof and part of mid gut as in situ, ventral view, some adjacent visceral structures also shown. Fig. 87: Gill, transversal section in its middle region. Fig. 88: Foot, head removed, foot anterior orifices (fo) shown. Scale bars = 2 mm.

Both genera, *Gaza* and *Callogaza*, were separated from the other trochids, in the systematic treatment of the family given by Hickman & McLean (1990: 90), in their own tribe Gazini within Margaritinae. The main conchological differences given by those authors are the thickened and reflected outer lip, and the nacre visible through the thin

outer shell layers. Some particularities (see below) of the radula and anatomy were also reported as diagnostic. On the other hand, it is difficult to attribute additional characters to the branch uniting *Gaza* and *Callogaza* beyond those of the shell, as no anatomical information is available for *Callogaza*.



FIGURES 89–92. *Gaza* spp. anatomy. Figs. 89–91: *G. olivacea*, Brazilian re-hydrated specimens. Fig. 89: Head-foot, frontal view. Fig. 90: Mid and hindgut as in situ, dorsal-slightly right view. Fig. 91: Foot (re-hydrated and partially damaged), head removed, foot anterior orifices (fo) shown. Fig. 92: *G. compta*, foot, head removed, foot anterior orifices (fo) shown. Scale bars = 2 mm.

The genus *Callogaza* differs from *Gaza* by in shell sculpture. While *Gaza* mainly has weak spiral sculpture, *Callogaza* has both stronger axial and spiral lines, forming a

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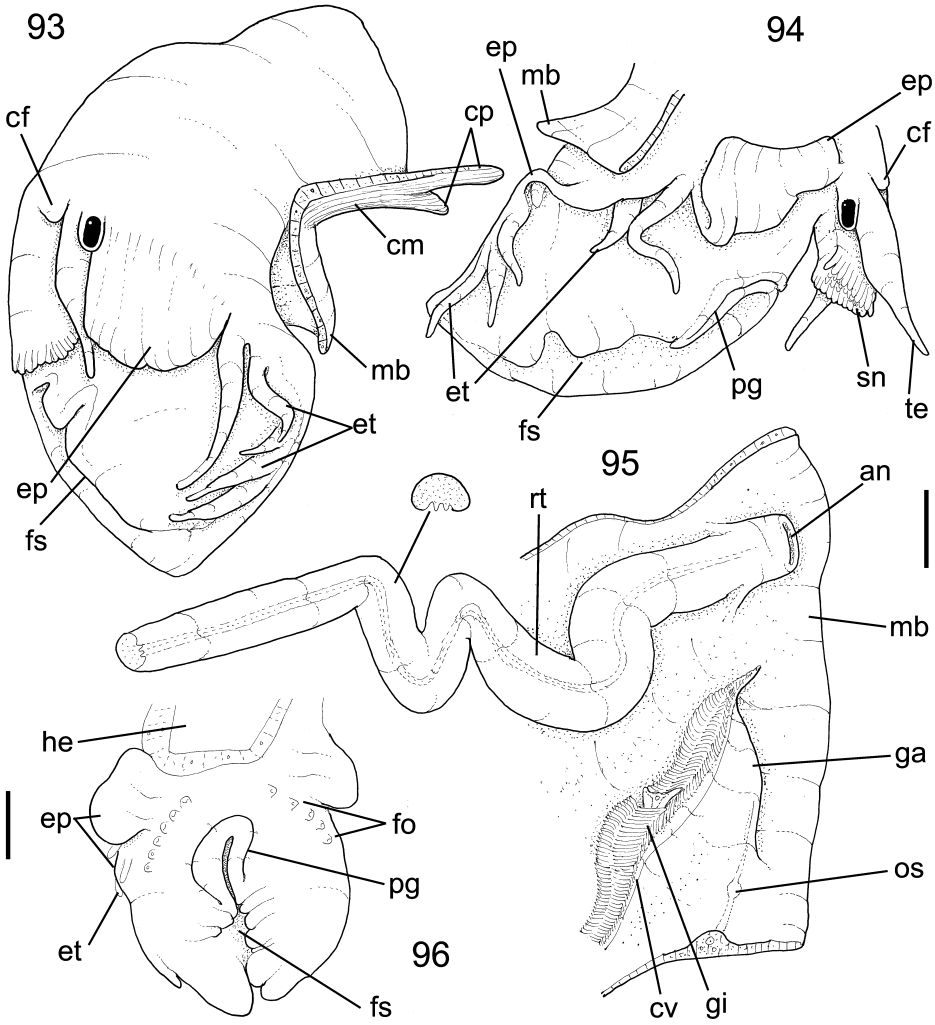
reticulate pattern (Figs. 42, 46). Besides, *Callogaza* possesses some elevated spiral cords in the upper region of each whorl (Figs. 41, 45), which are absent in *Gaza*. *Callogaza* also bears distinct color patterns, having brown and beige spots, contrasting with the uniformly pale beige or cream *Gaza* species. The single species of *Gaza* that possess some distinction in the shell color is *G. compta*, which has a purple apical region (Figs. 2, 4), which gradually disappears in the penultimate whorl.



FIGURES 93–96. *Gaza fischeri* anatomy. Fig. 93: Head-foot, lateral-left view. Fig. 94: Same, lateral-right view, partially shown. Fig. 95: Pallial cavity hoof, ventral view, rectum (rt) seen as in situ, a transversal section of the fecal thread, in indicated region, also shown. Fig. 96: Foot, head removed, foot anterior orifices (fo) shown. Scale bars = 2 mm.

Microgaza was originally described (Dall 1881) and has sometimes been used (e.g., Smith 1906; Rios 1994) as a subgenus of *Gaza*. On the other hand, some authors consider both genera as separated entities, even placed in different trochids subfamilies, *Microgaza*

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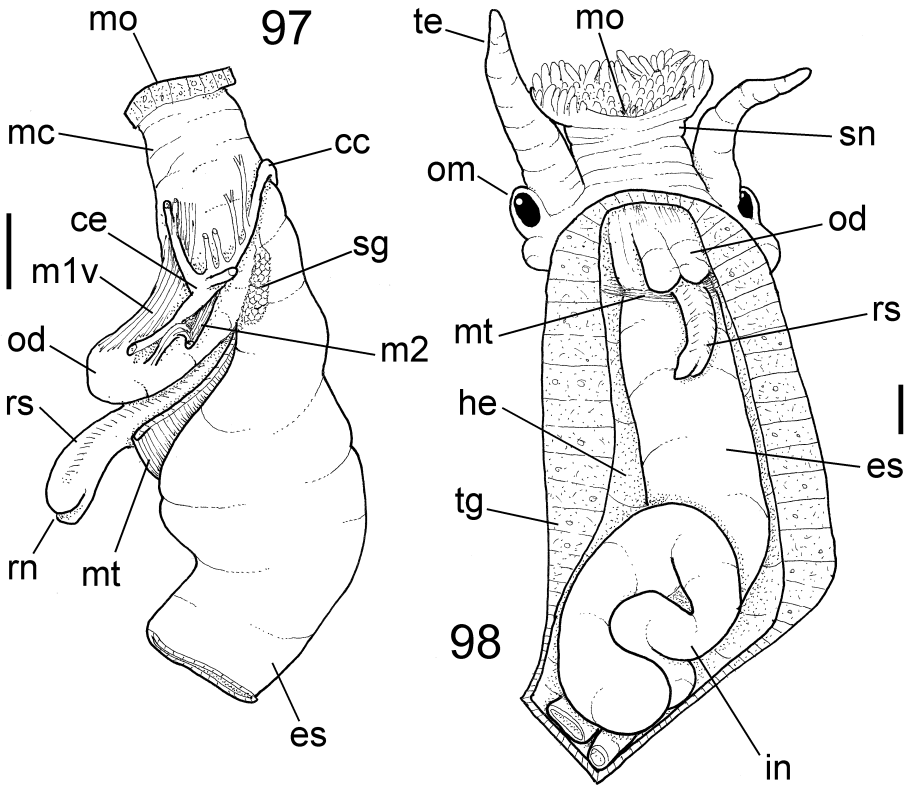
in Solariellinae, and *Gaza-Callogaza* in Margaritinae (Hickman & McLean 1990). The characters that *Microgaza* shares with the other two genera include the thin shell that shows iridescence, the wide umbilicus and the deep water habitat. However, all remaining characters that unite both genera are absent in *Microgaza* including determinate growth and the callus covering the umbilicus. For this reason, the statement of Hickman & McLean (1990) is followed here, in such *Microgaza* is regarded as not belonging to the group that unites *Gaza* and *Callogaza*.



FIGURES 97–98. *Gaza fischeri* anatomy. Fig. 97: Foregut, left view, some adjacent structures, like part of nerve ring, also shown as in situ. Fig. 98: Head and haemocoel, ventral view, foot and columellar muscle removed. Scale bars = 1 mm.

The shell outline is an important character for species distinction. *Gaza daedala* and *Callogaza sericata* have a tall spire, keeping the shell almost as high as wide (Figs. 16, 45); additionally, the spire is pointed, with only slightly convex profile. *Gaza olivacea* also has a tall shell, but the spire profile is dome-shaped and rounded (Fig. 24). *Gaza cubana* and *G. compta* are more discoid species, with a low, flat spire (Figs. 1, 20). The remaining species have an intermediate shape of the shell outline.

The profile of each whorl is also a useful distinctive character. Each whorl in *Gaza fischeri* and *Callogaza watsoni* are highly convex and have a deeper suture (Figs. 28, 41). While in *G. olivacea* and *G. rathbuni* the whorls are weakly convex, with a shallow suture

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(Figs. 24, 33, 37), the remaining species have a somewhat intermediate condition.

The first whorls of the shell sometimes possess axial undulations, that disappear after 2–3 teleoconch whorls, as in *Gaza compta* and *G. fischeri* (Figs. 4, 29), although it is stronger in the former species. The remaining species are almost smooth.

As noted above, the apex of some species has a hole, communicating with the umbilical chamber, such as *Gaza superba* and *G. olivacea*. In these species, the protoconch is lost (Figs. 12, 25).

The sculpture of all *Gaza* species, has almost only uniform, low and narrow spiral lines, except for weak undulations in the peri-umbilical region of some species. This sculpture is well marked in *G. daedala* and *G. cubana* (Figs. 16, 20), while the sculpture is almost absent, forming an almost smooth, glossy surface in *G. superba, G. olivacea* and *G. rathbuni* (Figs. 11, 24, 33, 37).

The body whorl of some species forms a weak carina. It is noted in the lower region of *Gaza superba* and *G. daedala* (Figs. 11, 16), and in the middle region of *G. cubana* and *Callogaza watsoni* (Figs. 20, 41). No carina is found in *G. compta, G. olivacea, G. fischeri, G. rathbuni* and *C. sericata*, which have a rounded profile.

The radulae of the species examined showed little interspecific variability except those referred in the diagnoses. The non-functional lateromarginal plate (Hickman & McLean, 1990: fig. 53), a reduced innermost marginal tooth, can be observed in the species studied here (Figs. 50, 57). It can be seen as inner marginals that are smaller than further out, which then decrease in size again.

The anatomy of the examined species reveals the normal organization for the family Trochidae, including the single pallial organs (osphradium and gill). The distinctive features are: the larger papillae at the snouts edge (Figs. 7, 67, 78, 84, 89, 94), and the smaller papillae covering the ventral surface of snout up to the mouth; the shape and arrangement of the epipodial tentacles, and having a larger flap (cephalic lappets) on both sides of the head (Figs. 68, 79, 84, 89, 93: ep); the broad furrow of the pedal glands, extending over almost entire anterior edge of the foot (Figs. 67, 78, 84, 89, 94: pg). In the odontophore, some features are so far unique for *Gaza*, such as the small muscles inserted in middle ventral region of the radular sac, called m7 and m7a (Figs. 75, 76). The double nature of the approximator muscle of the odontophore cartilages, divided into m8 and m8a, is also exclusive of *Gaza* (Fig. 77). Currently, it is impossible to determine the taxonomic rank at which these characters are useful. The terminally expanded snout and the foot with lateral tips are the anatomical diagnostic characters for the tribe Gazini given by Hickman & McLean (1990: 90). Those authors showed in their figure 52 additional unique combination of features: the pair of short flaps on the dorsal side of the shout's base, a smooth flap just posterior to the head, occupying about 1/3 of the epipodial length, and the remaining posterior 2/3 having long and separated tentacles. This set of head-foot characters was also found in all species examined here. The expansion of the snout was emphasizing by Dall (1889: 355), being nearly three times as wide as its stem.

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There are some additional differences in the species examined anatomically. The epipodial tentacles of *Gaza compta*, *G. cubana* and *G. fischeri* originate from the edge of the epipodium (Figs. 68, 84, 94), while in *G. superba* and *G. olivacea* they originate from its ventral surface (Figs. 78, 89). Although the morphology of the epipodial tentacles can be greatly influenced by the degree of contraction during the fixation, which apparently diminishes the importance of this character, their site of origin is unambiguous. Additionally, this feature is consistent in all specimens of each species. The cephalic tentacles are uniform in most species, but are clearly divided into two different regions in *G. olivacea* and *G. fischeri* (Figs. 89, 94). The pattern of intestinal looping is somewhat variable among all the species (compare Figs. 71, 80, 86, 90, 95).

The papillae on the anterior surface of the snout are apparently a unique feature of *Gaza*. Depending on the species, the papillae at the edge are proportionally more or less enlarged compared to those towards the mouth. This differentiation is most pronounced in *G. superba* and *G. fischeri*.

The presence of small orifices in two series, approximately equidistant from the base of the propodium and base of the head, is another distinction of *Gaza*. These orifices are aligned, in an arched manner, starting a short distance from the median line, towards the posterior (Figs. 81, 88, 91, 92, 96). The number of orifices is different on both sides and among the species, as shown by the examined soft parts of 17 specimens of six species treated here (Table 1). This number can be used for species identification, taking into account the limited number of specimens available for study. A shallow incision was done in these orifices, but no distinct gland or structure was found below. However, histological serial section could certainly illuminate their structure and suggest a function. *Gaza fischeri* was the only species that possesses these orifices on short stalks (Fig. 96).

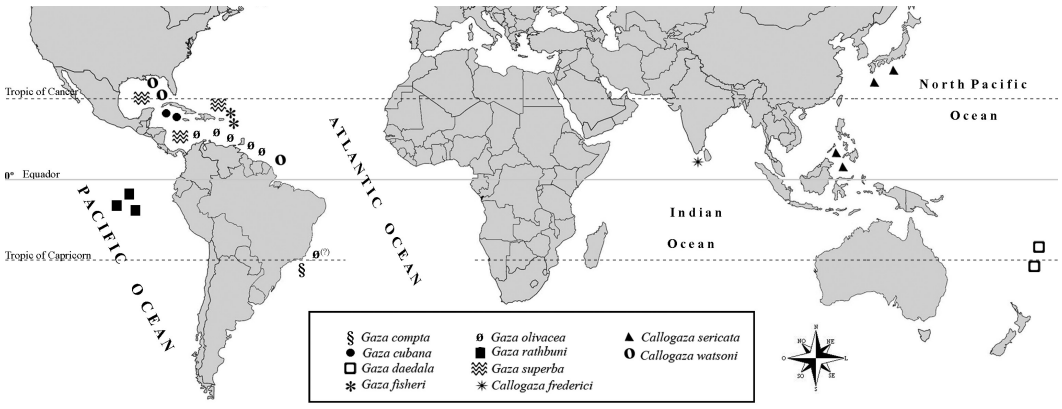

FIGURE 99. World map showing the distribution of *Gaza* and *Callogaza* species.

There is a terminological problems related to the vessels of the gill. The term preferred here is those that I have applied in my papers (e.g., Simone 2005), in calling the sinus that precedes the gill as afferent gill vessel, while the one placed after the gill as ctenidial vein

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or efferent gill vein. Some authors are also using this terminology (e.g., Haszprunar, 1985), while others prefer to use afferent gill vein (e.g., Ambron *et al.* 2004). I apply the term "vein" to the vessels that immediately are connected to the auricle, as do the ctenidial vein. I apply the more generic term "vessel" to those located in places farer from the auricle. Those vessels connected to the ventricle are properly called artery or aortas. On the other hand, textbooks (e.g., Ruppert & Barnes 1994) use more generic epithets like "sinus" for all those vessels.

The gut contents are uncharacteristic for trochids (which usually have algal matter in their guts or amorphous organic matter). It was impossible to either distinguish between sand and mud, hence, no inference can be made about either diet or mode of feeding.

The main anatomical differences of the *Gaza* and *Callogaza* species are summarized in Table 1.

TABLE 1. Main anatomical differences among the species of *Gaza* and *Callogaza* considered in this study (except *C. frederici*).

Species	Ocean	Callus covering umbilicus	% height / width	Foot anterior orifices left	Foot anterior orifices right	Epipodium tentacles left	Epipodium tentacles right	N*
G. compta	Atlantic	100%	1.24–*1.45*–1.51	10	8	4	5	6
G. superba	Atlantic	75%:	1.45–*1.52*–1.57	12	8	5	8	4
G. daedala	Pacific	100%	1.24					
G. cubana	Atlantic	75%	1.53–*1.59*–1.67	7	6	6	5	2
G. olivacea	Atlantic	95%	1.47		6	7	8	2
G. fischeri	Atlantic	100%	1.43–*1.50*–1.57	5	6	5	6	2
G. rathbuni	Pacific	100%	1.40				7 **	
C. watsoni	Pacific	50%	1.44					
C. sericata	Pacific	100%	1.18					

* Only specimens with soft parts included. ** From Dall (1890). N: Number of specimens examined.

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Key for identification of fully growth *Gaza* and *Callogaza* specimens based on shell characters (except *C. frederici*)

Umbilical cover connected to inner lip of lower callus. (P) Pacific Ocean occurrence, (A) Atlantic Ocean occurrence.

1) Shell with strong and not uniform spiral cords, colored with brown spots..... ..... *Callogaza* (P) ... 2
   Shell with uniform and weak spiral sculpture, uniformly colored with pale beige .... *Gaza* ... 3
2) Shell as high as wide, umbilicus entirely sealed ..... *C. sericata*
   Shell twice as wide as high, umbilicus only about half covered ..... *C. watsoni*
3) Umbilicus completely sealed 4
   Umbilicus only partially sealed 7
4) Shell height/width = 1.24, somewhat trochiform, spiral sculpture well marked (P) .... *G. daedala*
   Shell height/width 1.40–1.50 5
5) Surface almost glossy (sculpture very weak), suture shallow, spire dome-shaped (P) .. .. *G. rathbuni*
   Surface opaque, suture well marked (deeper), spire stairs-shaped 6
6) First whorls of teleoconch with purple color and strong axial undulations, spire diameter about 60% of total shell diameter (A)..... *G. compta*
   First whorls of teleoconch pale beige (as remaining of shell) and with very weak axial undulations, spire diameter about 65% of total shell diameter (A)..... *G. fischeri*
7) Shell as high as wide, lower region of umbilicus communicating by a narrow tubular aperture (A) ..... *G. olivacea*
   About twice as wide as high, umbilicus open 8
8) Apex eroded and opened, spire width about 70% of height of body whorl, umbilicus covered less than a half (A) ..... *G. superba*
   Apex preserved, spire with about 50% high relative to body whorl height, umbilicus covered more than a half (A) ..... *G. cubana*

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