

ANATOMY AND SYSTEMATICS OF *BUCCINANOPS GRADATUS* (DESHAYES, 1844) AND *BUCCINANOPS MONILIFERUS* (KIENER, 1834) (NEOGASTROPODA, MURICOIDEA) FROM THE SOUTHEASTERN COAST OF BRAZIL

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ABSTRACT

A morphological revision of species of the genus *Buccinanops*, endemic to South America, begins with the description of *B. gradatus* and *B. moniliferus*. In an attempt to obtain data to resolve systematic problems from the family to the specific level in this group, a detailed anatomical description of the head-foot, pallial organs, digestive system, including odontophoral muscles, and genital system are given. These animals are blind, have a vestigial valve of Leiblein and, in the case of *B. moniliferus*, there is sexual dimorphism, males being about half of the size of females.

INTRODUCTION

The systematic concepts on the South American neogastropod species *Buccinanops gradatus* (Deshayes, 1844) and *B. moniliferus* (Kiener, 1834) are confused at almost every level.

There a controversy about their at the family-level placement; some authors (e.g., Abbott & Dance, 1983; Rios, 1994) have considered these species to be Nassariidae, whereas others (e.g., Rios, 1985) have included the genus in the Buccinidae. Meanwhile, Ponder (1973: 325) noted that anatomical characters for the separation of these two families have not been established.

At the generic level, *B. moniliferus* was considered to belong to *Dorsanum* Gray, 1847, by several authors (e.g., Carcelles & Parodiz, 1939; Rios, 1994) and *Buccinanops* Orbigny, 1841, by Calvo (1987) and Rios (1985), based on radular characters, and by Pastorino (1993) because of differences from the type species of the genus *Dorsanum*, *D. miran* (Bruguère). Both species—*B. moniliferus* and *B. gradatus*—were included in the South African genus *Bullia* Gray, 1834, in early literature (e.g., Reeve, 1846) and by Abbott & Dance (1983) and Allmon (1990).

At the species level, *B. moniliferus* in contrast, is well established, due its distinctive conchological characters. *Buccinanops gradatus*, on the other hand, is a variable species with several synonyms according to some authors (e.g., Rios, 1975), whereas oth-

ers consider these synonyms to be valid species. No convincing arguments have been given to support either position. The available species-group names are: *B. lamarckii* (Kiener, 1834), *B. cochlioides* (Dillwyn, 1817), *B. uruguayensis* (Pilsbry, 1897), and *B. deformis* (King & Broderip, 1832). Aggravating these problems is the fact that neither *B. gradatus* or *B. moniliferus* were described with a specific type locality.

A step in solving these systematic problems may be an anatomical analysis of well localized and identified specimens. This paper includes anatomical descriptions of *Buccinanops moniliferus* and *B. gradatus*, which will serve as the basis for future comparisons.

The specific names are changed to masculine gender herein, following Art. 30(a)ii of the ICZN Code for generic names ending in *-ops*.

MATERIAL AND METHODS

Part of the studied material belonged to Museu de Zoologia da Universidade de São Paulo (MZUSP) and part was collected by otter trawl by fishermen in Praia Grande, São Paulo, Brazil, and has been deposited in MZUSP, fixed in 70% ethanol.

The anatomical dissections were made using standard techniques. Some anatomical parts, such as the genital organs and anterior region of the digestive system, were dehy-

drated in ethanol series, stained in carmine, cleared and fixed in creosote. Radulae and protoconch were also examined using SEM in the Laboratório de Microscopia Eletrônica do Instituto de Biociências da USP. All drawings were made with the aid of a camera lucida.

The musculature of the odontophore was studied by means of dissection of three specimens of each species preserved with an extended proboscis. The jugal muscles and peroral muscles are not described in detail. For the most part, the muscles are named according to the terminology of Wils-mann (1942).

The synonymic list of *B. gradatus* is not given here, because studies on possible syn-onymy are continuing.

#### Abbreviations

aa	anterior aorta
af	anterior furrow of the foot
ag	albumen gland
an	siphoned anus
ao	anterior oesophagus
au	auricle
bm	mantle border
cg	capsule gland
cm	columellar muscle
cv	ctenidial vein
da	duct to anterior digestive gland
dl	duct of the gland of Leiblein
dp	duct to posterior digestive gland
ft	foot
ga	inner gland near anus
gd	gonopericardial duct
gi	gill
gk	glandular part of the kidney
gl	gland of Leiblein
go	gonad
gp	female genital pore
in	intestine
lc	left cartilage
m1 to	
m14	odontophoral muscles
me	mid oesophagus
mf	muscular fibers
mo	mouth
ne	nephrostome
ng	nephridial gland
nn	nuchal node
nr	nerve ring
nv	nephridial vessel
nw	nephridial wall
od	odontophore

oe	posterior oesophagus
os	osphradium
pa	posterior aorta
pc	pericardic walls
pe	penis
pn	proboscis nerve
pp	penial papilla
ps	penial sinuses
pv	proximal vertex of the cartilages
pw	proboscis wall
ra	radula
rc	right cartilage
rm	radular membrane
rn	radular nucleus
rt	rectum
sd	salivary gland duct
sg	salivary gland
si	siphon
st	stomach
sv	seminal vesicle
te	tentacles
ty	gastric typhlosoles
uc	union between both cartilages
va	vas deferens aperture to pallial cavity
vd	vas deferens
ve	ventricle
vl	valve of Leiblein
vm	visceral mass
vp	villous part of the kidney

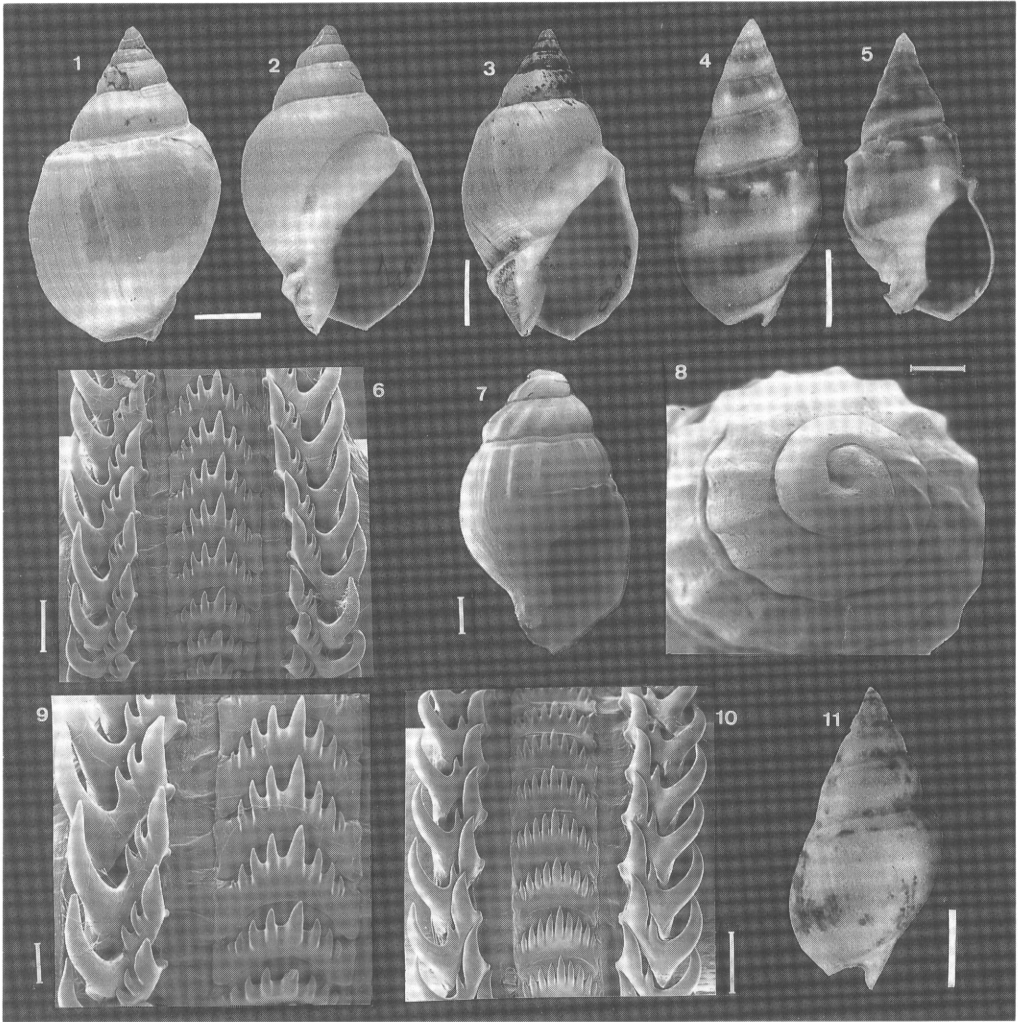
*Buccinanops gradatus* (Deshayes, 1844)  
(Figs. 1–3, 6, 9, 12–30)

#### Diagnosis

Shell generally homogeneous beige in color; subsutural carina generally present, without spines. Osphradium about 2/3 of gill length. Radular rachidian teeth with eight well-spaced cusps that are heterogeneous in size; two well-developed median cusps on lateral teeth. Odontophore with only one pair of "m9" muscles; and with double radular protractor muscle (m14). Both stomach typhlosoles longitudinal. Penis long, with a well-developed papilla. Female genital pore papillate, surrounded by two folds.

#### Description

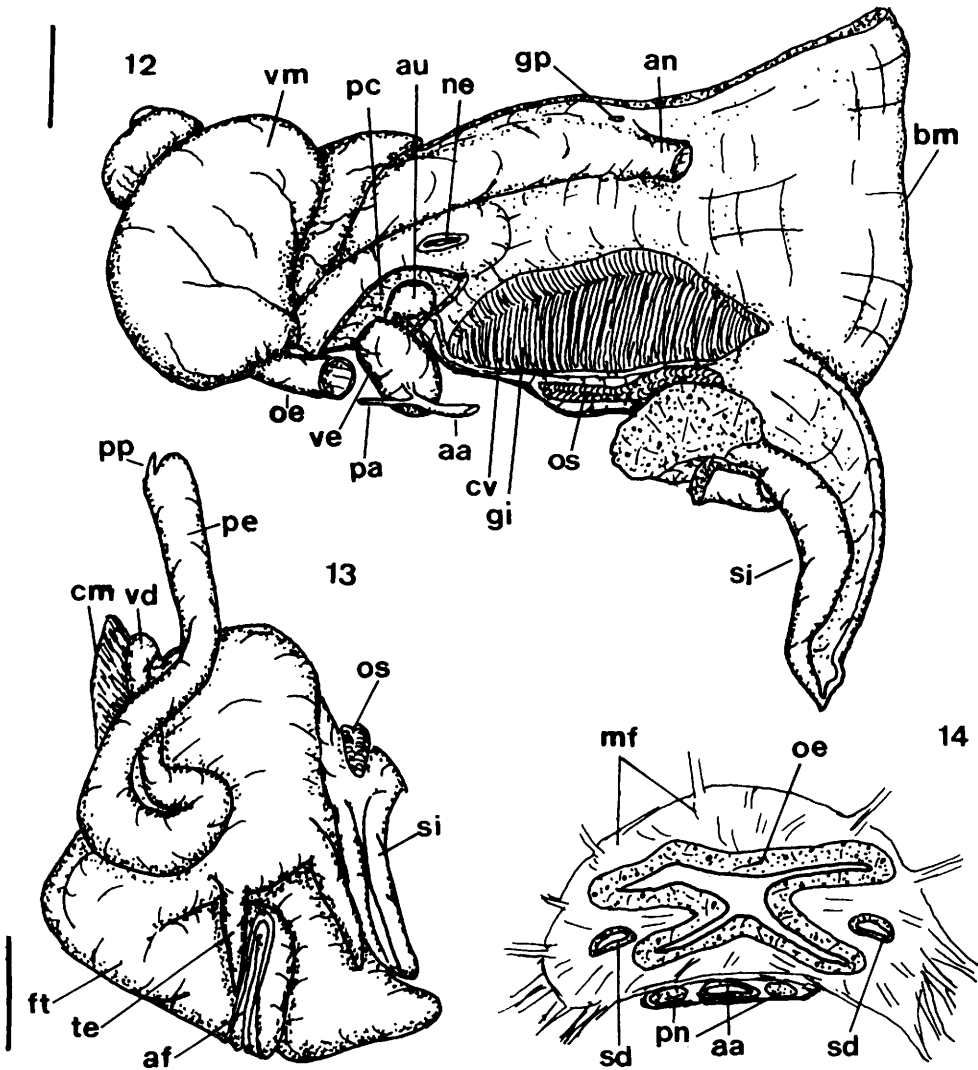
*Shell*: Up to 60 mm in length, homogeneous beige, with up to 8 convex whorls (Figs. 1–3). Protoconch of about 2.5 whorls; first whorl glassy-smooth, semi-spherical; others with strong axial ridges. Limit between protoconch and teleoconch not conspicuous. Teleoconch to 5 whorls; two first whorls with



FIGS. 1–11. Shells and radulae: 1, 2, dorsal and frontal view of female of *Buccinanops gradatus* (MZUSP 28079), scale = 10 mm; 3, frontal view of a male of *B. gradatus* (MZUSP 28078), scale = 10 mm; 4, 5, dorsal and frontal view of two specimens of *B. moniliferus* (MZUSP 28191), scale = 10 mm; 6, radula of *B. gradatus*, SEM, scale = 0.2 mm; 7, profile of the protoconch and first teleoconch whorl of *B. moniliferus*, SEM, scale = 1 mm; 8, the same in apical view, scale = 0.5 mm; 9, detail of Fig. 6, scale = 0.1 mm; 10, radula of *B. moniliferus*, SEM, scale = 0.2 mm; 11, dorsal view of a specimen of *B. moniliferus* without developed spines on the subsutural carina (MZUSP 28181), scale = 10 mm.

axial ridges, similar to those of protoconch, gradually disappearing on subsequent whorls. Subsutural carina generally present, low, rounded (Fig. 3). Periostracum very thin, dark-brown, lost on body whorl. Aperture elliptic; outer lip arched, sometimes notched by carina; inner lip concave, covered by thin callus. Canal short, broad, bordered externally by well-developed carina.

There is considerable shell variation; the most common form is shown in Figures 1–3, but specimens with a shorter or taller spire are common. The subsutural carina is lacking in some specimens, resembling *B. cochlidius* and *B. uruguayensis*, whereas others have a well-developed carina and resemble *B. deformis*. The lot MZUSP 28080 has specimens showing both conditions. Several specimens



FIGS. 12–14. *Buccinanops gradatus* anatomy: 12, visceral mass and pallial cavity organs of a female, scale = 5 mm; 13, frontal view of a male head-foot, mantle removed, scale = 5 mm; 14, transversal section of the mid region of the anterior oesophagus, scale = 1 mm.

have the spire without a carina and a well-developed carina on the last whorl. No notable shell differences between males and females were found.

**Operculum:** Corneous, ovate-unguiculate, with terminal nucleus, partially sealing shell aperture. Muscle scar elliptic, near inner border. Operculum deformation very common.

**Head-Foot:** Homogeneous pale-beige in color. Head somewhat projecting. Tentacles long, lateral, without eyes (Figs. 13, 15). Foot

large, with furrow along anterior edge for anterior pedal glands (Fig. 13: af). Males with large penis, behind right tentacle (Fig. 13). Small posterior metapodial tentacle present.

**Mantle Border:** Simple, slightly thick. Siphon developed, with smooth borders (Figs. 12, 13). Without pigment or with scanty dark spots.

**Mantle Cavity:** About one whorl in length (Fig. 12). Osphradium bipectinate, narrow, long (about 2/3 of the total gill length), with

several leaflets on both sides. Gill monopectinate, somewhat elliptic, with numerous triangular, low leaflets. Hypobranchial gland a thin glandular mass covering mantle between gill and rectum.

*Circulatory and Excretory Systems:* Heart at posterior-right side of pallial cavity (Fig. 12); auricle fusiform; ventricle spherical, very-large. Anterior and posterior aorta as normal for caenogastropods (Fig. 12). Kidney large, behind posterior-left side of pallial cavity (Fig. 12). Internally, kidney with villous and glandular parts (Fig. 28); nephridial gland covering pericardial wall of kidney lumen (Fig. 28: ng). Nephrostome a slit surrounded by muscle fibers, in mid region of kidney wall at posterior end of pallial cavity (Figs. 12, 28: ne).

*Digestive System:* Proboscis pleurembolic, thick-muscular (Fig. 15), very-long (about same length as shell when extended). Buccal mass about half length of proboscis. Proboscis opening surrounded by thick muscular sphincter. Mouth a vertical slit at distal end of proboscis. Proboscis structure (Fig. 15): odontophore in anterior half attached to inner ventral wall; muscles at posterior odontophore edge running posteriorly and attaching to ventral half of inner proboscis surface up to ventral face of rhynchodeal cavity (Fig. 15: mf). Aorta, paralleled in both sides by a pair of nerves, runs in mid line of ventral surface covering these muscles; oesophagus lies above all these structures, connected to proboscis by tridimensional net of thin muscle fibers.

Odontophore muscles (Figs. 20–26): (m1) dorsal jugal muscles—origin: outer-proximal dorsal wall of odontophore; insertion: inner-dorsal peribuccal wall; (m2) transversal muscle—uniting dorsally outer edge of both cartilages, involving dorsally other muscles of odontophore; (m3) pair of lateral retractor muscles of radula (retractor of pharynx)—origin: in dorsal region of foot, running attached to inner-ventral wall of proboscis; insertion: proximal vertex of each cartilage (pv); (m4) medial retractor muscle of radula—origin: partly in dorsal region of foot, between m3 muscles, running attached to inner-ventral wall of proboscis also between the m3, and partly in ventral face of proximal vertex of each cartilage (mid tensor); insertion: mainly on ventral edge of radula; (m5) dorsal protractor muscle of radula—origin: joined with

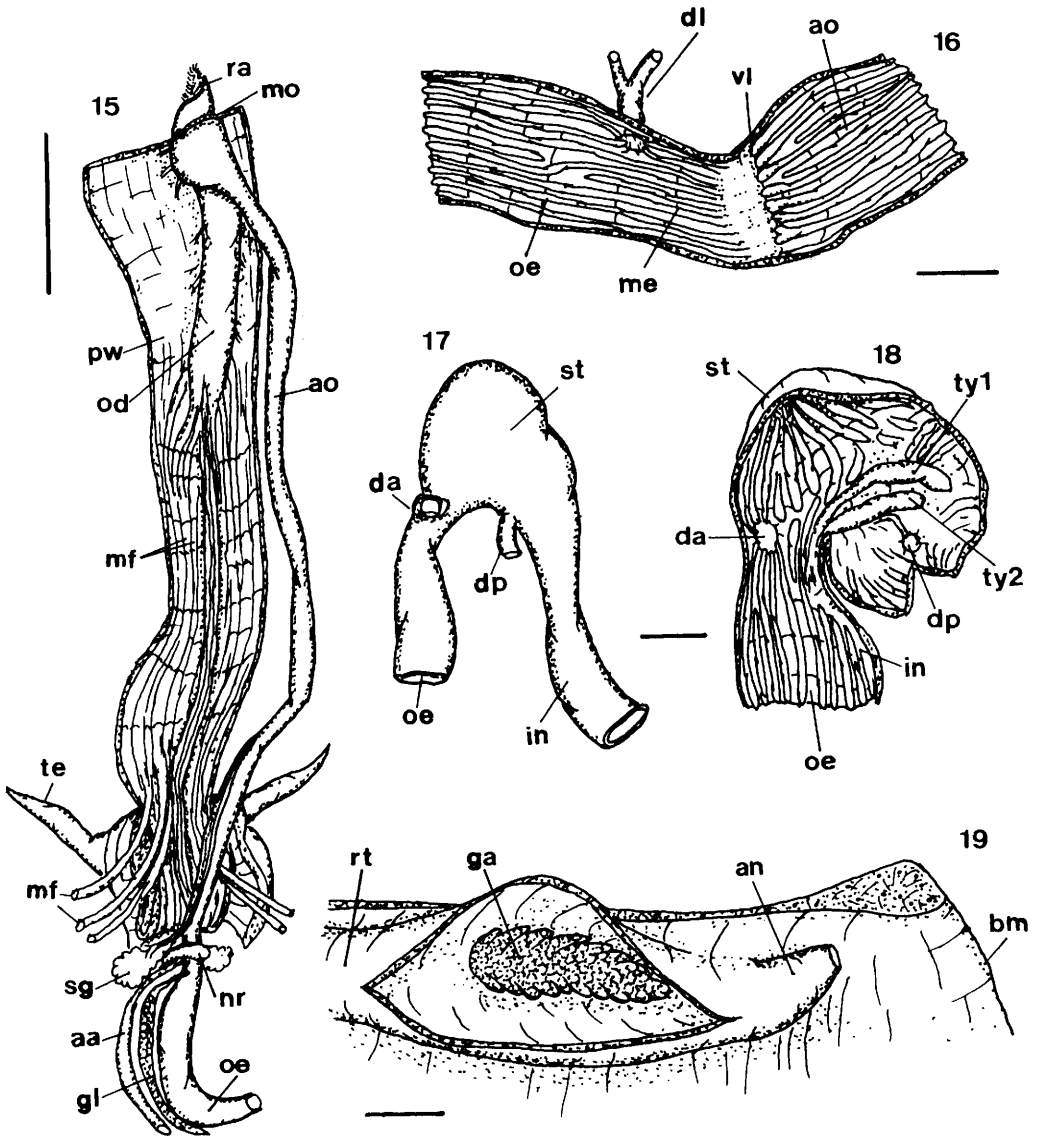
medial retractor muscle (m4), bifurcating in mid region of odontophore; insertion: dorsally on both sides of peroral wall; (m6) pair of tensor lateral muscles—lying on anterior half of the outer edge of both cartilages; (m7) pair of small muscles—origin: on outer edge of cartilages just proximal to m6 origin; insertion: on peribuccal wall just proximal to m5 insertion; (m8) small muscle—origin: on outer edges of both cartilages just proximal to m7 origin; near mid region of muscle both branches unite for a short distance and after they separate inserting on ventral region of peribuccal wall near mid line; (m9) pair of small muscles—origin: outer edge of cartilages just proximal to the m8 origin; insertion: dorsal edge of radula; (m10) pair of large lateral tensor muscles of radula—origin: dorsal face of proximal vertex of cartilages; insertion: mainly lateral-dorsal margin of radula, uniting with medial retractor muscle (m4) for about 2/3 of their length (Fig. 22); (m11) horizontal muscle—uniting ventrally inner edge of both cartilages; (m12) ventral jugal muscles—origin: outer-proximal-dorsal wall of odontophore; insertion: inner-ventral peribuccal wall, some muscular fibers more developed (Fig. 24); (m13) pair of large tensor ventral muscles—origin: ventral face of posterior vertex of each cartilage just at medial retractor muscle (m4) origin; insertion: ventral edge of radula; (m14) pair of small protractor muscles of radula—origin: mixed with medial retractor muscle (m4), distinguishable only near horizontal muscle (m11); insertion: ventral edge of radula between tensor ventral muscle (m13) insertion.

Radula (Figs. 6, 9)—Rachidian flattened, arched, with eight well-spaced cusps that are smaller towards outer edges; lateral teeth oblique, each with four cusps, marginal cusp largest, middle two cusps smallest.

Anterior oesophagus lumen "X" in section (Fig. 14), covered by net of radial and oblique muscles uniting oesophagus with inner surface of proboscis wall; salivary gland ducts running on either side of oesophagus (Fig. 14: sd) and discharging into peroral chamber.

Valve of Leiblein vestigial, anterior to nerve ring, poorly visible on outer surface of oesophagus (Fig. 15), marked internally by sudden change of inner longitudinal folds, forming a low valve (Fig. 16: vl).

Two salivary glands clustered around nerve ring (Fig. 15: sg), their ducts on outer side of nerve ring, running to posterior half of anterior oesophagus and within muscular net



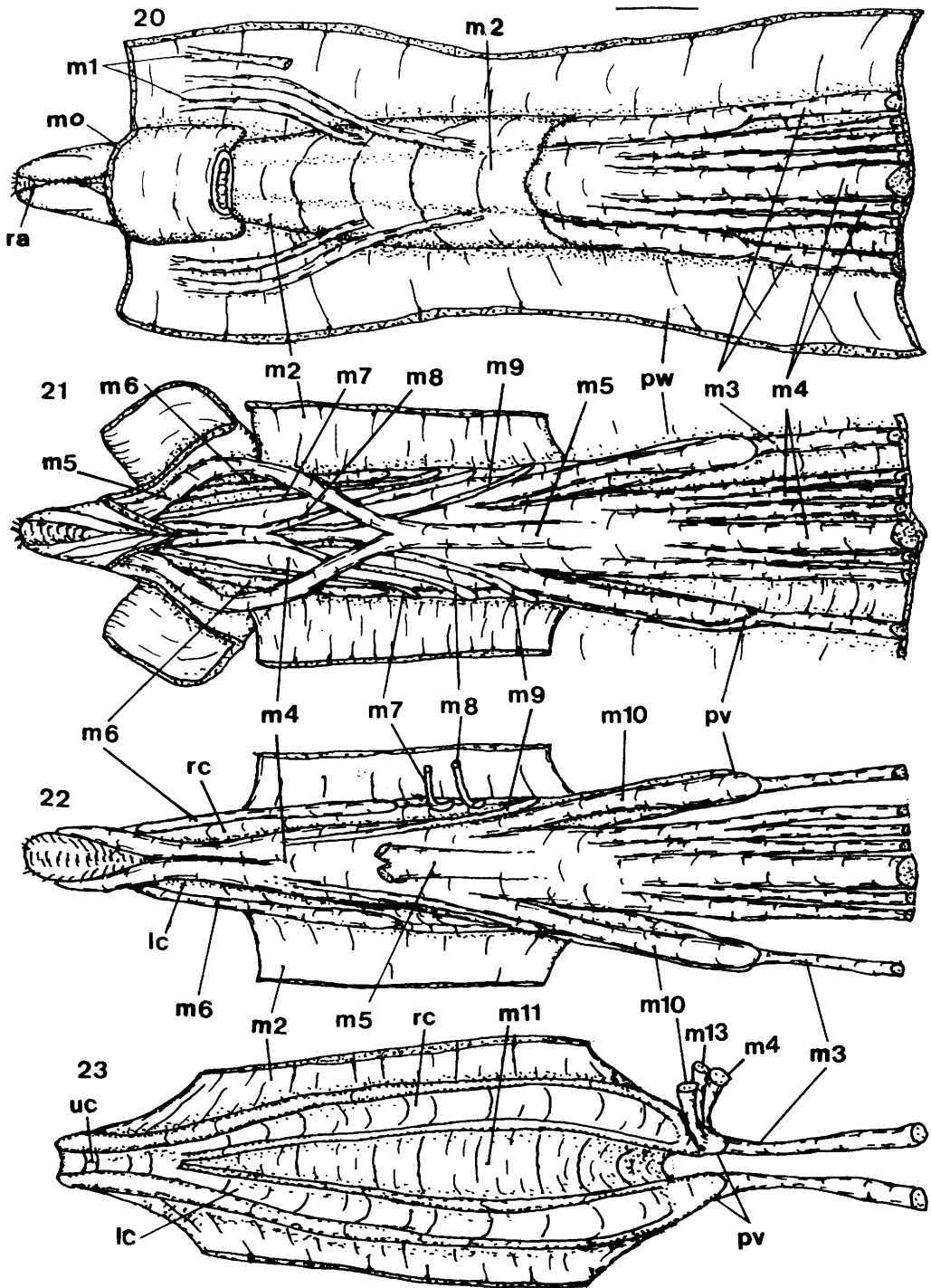
FIGS. 15–19. *Buccinanops gradatus* anatomy: 15, anterior region of the digestive system and proboscis opened longitudinally along dorsal mid line and head mid line, scale = 10 mm; 16, detail of the region of mid oesophagus opened longitudinally, scale = 2 mm; 17, stomach in ventral view, scale = 2 mm; 18, the same opened longitudinally, scale = 2 mm; 19, detail of the anal region, terminal region of the rectum partially opened longitudinally to expose an inner gland, scale = 1 mm.

of anterior half of anterior oesophagus (Fig. 14). No accessory salivary glands present.

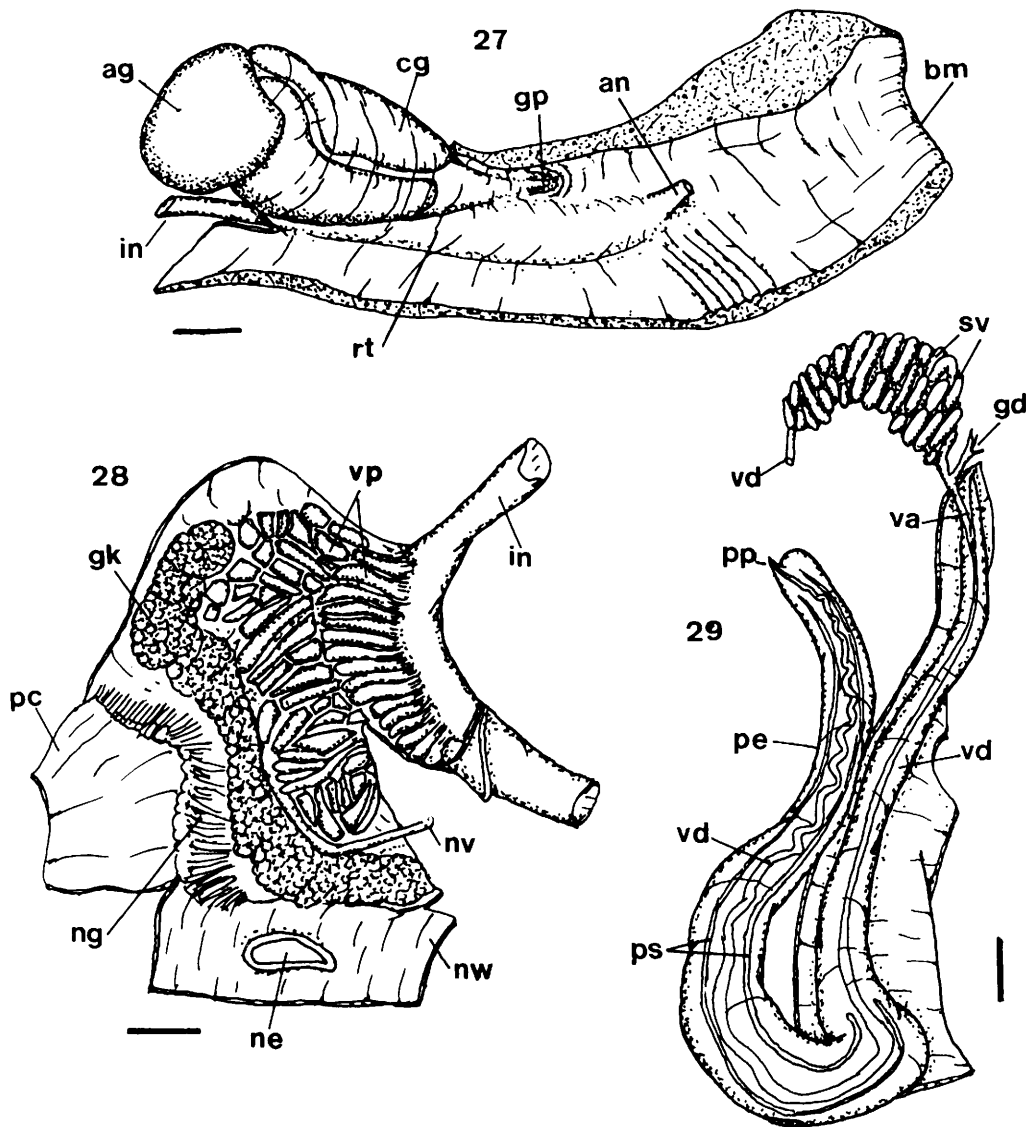
Entire oesophagus a long, somewhat uniform, thick muscular walled tube without crop (Figs. 15–17); internally with several longitudinal folds (Fig. 16). Mid-oesophagus very short (Fig. 16: me). Gland of Leiblein

long, thin, with short duct, running posteriorly close to posterior oesophagus (Figs. 15, 16), yellowish-brown in color.

Stomach well developed; walls somewhat thick; two ducts to digestive glands, one dorsal near insertion of oesophagus, the other ventral near opening to intestine (Fig. 17). In-



FIGS. 20–23. Odontophore of *Buccinanops gradatus*: 20–23, successive dissection in dorsal view. 20, only proboscis wall opened and oesophagus removed. 21, the outer layer of muscles removed. 22, second layer of muscles removed exposing the inner muscles. 23, most muscles removed to show the cartilages.



FIGS. 27–29. *Buccinanops gradatus* anatomy: 27, detail of the right side of the pallial cavity in inner view to show the pallial oviduct; 28, kidney chamber opened ventrally; 29, detail of a cleared penis and right side of the pallial cavity floor showing the mid and anterior regions of the male reproductive system. Scales = 2 mm.

by two folds, right fold thin, left fold larger broad (Fig. 30), sited in the posterior-right side of anus (Figs. 12, 27, 30).

Habitat. Sandy-mud bottoms, from 5 to 25 m depth. For data on posture and capsules, see Penchaszadeh (1973).

Range. With certainty from Rio de Janeiro to São Paulo coast; specimens from other regions still under study.

Examined specimens. BRAZIL, otter trawl. Rio de Janeiro: MZUSP 28184, 1 specimen, Cabo de São Thomé (11/ii/1969); MZUSP 15295, 1 specimen, Atafona, São João da Barra. São Paulo: Ubatuba: MZUSP 28080, 8 specimens, Itaquá Beach (i/1971, Montouchet col.); MZUSP 28185, 2 specimens, Cabras Is., Anchieta Is. (28/vi/1978); MZUSP 28186, 2 specimens, Anchieta Is. (4/viii/1960,



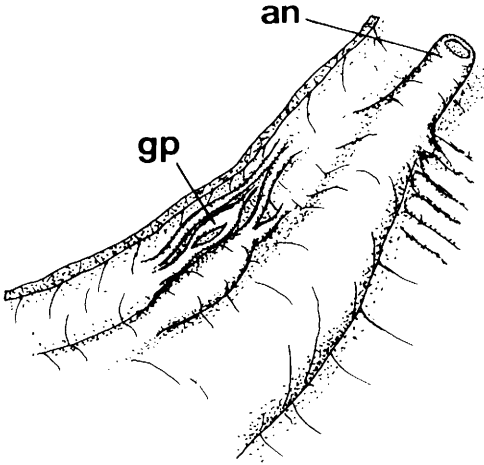


FIG. 30. *Buccinanops gradatus* anatomy: detail of Fig. 27, showing the female genital pore, scale = 1 mm.

Clarimundo col.); MZUSP 28081, 1 specimen, same (21/v/1979). Baixada Santista: MZUSP 28183, 5 specimens, from Barra de Santos to Guarujá (vii/1969, Instituto de Pesca col.); MZUSP 28192, 20 specimens, Perequê Beach, Guarujá (6/vi/1985); MZUSP 28193, 8 specimens, Santos Bay (2/ix/1970); MZUSP 28187, 2 specimens, from Moela Is. to Ponta Perequê (17/v/1962, Clarimundo col.); MZUSP 28188, 5 specimens, Goes Beach, Guarujá (17/viii/1970, Colella col.); MZUSP 28189, 2 specimens, from Barra de Santos to Farol da Moela (vii/1969, Instituto de Pesca col.); MZUSP 28078, 28079, 28082, 25 specimens, Barra de Santos (21/ix/1970, Colella col.); MZUSP 28183, 14 specimens, Moela Is., 15 m deep (17/v/1962, Clarimundo col.). Praia Grande, off Boqueirão Beach: MZUSP 28190, 12 specimens (i/1994, Simone col.); MZUSP 27319, 12 specimens (10/i/1990, Simone col.). Total: 117 specimens.

*Buccinanops moniliferus* (Kiener, 1834)

(Figs. 4, 5, 7, 8, 10, 11, 31–42)

*Buccinum moniliferum* Kiener, 1834: 2, pl. 3, fig. 8; Reeve, 1842: 234, pl. 268, fig. 4; Deshayes, in Lamarck, 1844: 191.

*Bullia armata* Gray, 1854: 26; Reeve, 1846: pl. 1, fig. 2 [Hab. ?]; Adams & Adams, 1858: 113; Kobelt, 1877: 290; Tryon, 1882: 14,

pl. 6, figs. 82, 83; Paetel, 1888: 116; Morretes, 1949: 98.

*Buccinanops moniliferum*: Orbigny, 1845: 199; Rios, 1985: 103, pl. 35, fig. 456; Calvo, 1987: 143, fig. 122 (radula); Pastorino, 1993: 160–165, figs. 1–3 (radula).

*Buccinum (Buccinanops) maniliferum*: (err.) Orbigny, 1846: 434.

*Buccinanops cochlidium*: Gray, 1854: 40 (non Dillwyn, 1817).

*Buccinum armatum*: Küster, 1858: 90, pl. 15, fig. 20.

*Bullia (Buccinanops) moniliferum*: Chenu, 1859: 160, fig. 750; Abbott & Dance, 1983: 117 (fig.).

*Dorsanum armatum*: Cossmann, 1901: 218.

*Dorsanum moniliferum*: Carcelles & Parodiz, 1939: 747, figs. 1, 2; Carcelles, 1944: 249; Rios, 1970: 92, pl. 28; Rios, 1975: 95, pl. 27, fig. 398; Penchaszadeh, 1971a (posture and capsules); Penchaszadeh, 1971b: 480; Figueiras & Siccardi, 1972: 179, pl. 13, fig. 176; Martorelli, 1991 (parasite); Castellanos, 1994: 89, 96, fig. 31–4 (capsule); Rios, 1994: 130, pl. 41, fig. 557.

#### Diagnosis

Shell generally with two spiral purple bands on each whorl; subsutural carina with regular-spaced spines. Osphradium about half of gill length. Radular rachidian teeth with nine cusps of homogeneous size; generally only one mid cusp on lateral teeth. Odontophore with two or three pairs of m9 muscles; and with single radular protractor muscle (m14). Typhlosoles of stomach perpendicular one another. Male about half of female size. Penis somewhat long, with a small node in tip. Female genital pore single, bordered by bulged thick muscular walls.

#### Description

*Shell*: Up to 50 mm in length, with up to seven convex whorls, generally pale-cream, with two broad spiral bands brown-purple on each whorl (Figs 4, 5). Protoconch of about 2.5 whorls; first whorl smooth, others with strong axial ridges and subsutural furrow (Figs. 7, 8). Limit between protoconch and teleoconch not conspicuous. First two whorls of teleoconch with axial ridges, similar to those of protoconch, disappearing on subsequent whorls. Subsutural carina present, with short, uniform, somewhat spaced, triangular

spines turned distally and dorsally (Figs. 4, 5). Periostracum very thin, black, lost on body whorl. Aperture elliptic; outer lip arched, notched by carina, with a low anal sinus; inner lip concave, covered by a thin white callus. Canal short, broad, bordered externally by well-developed carina.

Shell variation is low compared with the preceding species, as shown in Figure 42. In rare specimens, absence of spines in sub-sutural carina were observed (e.g., MZUSP 28181; Fig. 11). In other specimens, there is a homogeneous purple color, in contrast to the common two spiral bands per whorl. Albino and sinistral specimens are also known.

*Operculum:* Corneous, ovate-unguiculate, with terminal nucleus, partially sealing shell aperture; muscle scar elliptic near inner border. Operculum deformation very common, rarely lost. One female (MZUSP 28151) has two well-developed opercula side by side, in the normal position.

*Head-Foot:* Homogeneous pale-beige in color. Head somewhat projecting; tentacles long, lateral, without eyes. Foot large, with furrow along anterior edge for anterior pedal glands (Figs. 31, 32: af). Small posterior metapodial tentacle present.

*Mantle Border:* Simple, slightly thick (Fig. 33). Siphon developed, with smooth borders (Figs. 31, 33), pigmented by dark-brown irregular spots. Siphon with well-developed muscular root.

*Mantle Cavity:* About 1.5 whorls in length (Fig. 33). Osphradium bipectinate, narrow, long, with several short leaflets in both sides, lying along about half of gill length. Gill monopectinate, elliptic, long, with numerous triangular, low leaflets. Hypobranchial gland thin, poorly developed, near and anterior to anal region.

*Circulatory and Excretory Systems:* As described for preceding species (Fig. 33).

*Digestive System:* Radular rachidian teeth with nine cusps that are somewhat uniform in size and close one-another (Fig. 10); marginal teeth with only one mid cusp (Fig. 10) or rarely with two smaller cusps, the inner cusp longer.

In odontophore, most part of muscles and other structures very similar to that of *B. gradatus*, except that in *B. moniliferus* the small

muscles originating on the outer edge of cartilages and inserting on the dorsal edge of radula (called "m9" in preceding species) are multiple and vary from 2 to 3 successive similar-sized pairs. The small muscle that originates with medial retractor muscle of radula (m14) and inserts on ventral edge of radula near mid line is single (Fig. 34: m14a) and has a part of its fibers inserting ventrally in beribuccal wall also near mid line (Fig. 34: m14b).

Stomach (Fig. 37) similar to that of preceding species, except one typhlosole is longitudinal, from the oesophagus to the intestine (fig. 38: ty1), whereas the other is transversal, lying duct to posterior digestive gland (Fig. 38: ty2).

All other studied characters of the digestive system of *B. moniliferus* are closely similar to preceding species (Figs. 35, 36), including characters of valve and gland of Leiblein (Fig. 35) and anus (Fig. 33).

*Genital System:* Male. Testis in visceral mass near columella. Seminal vesicles greatly convoluted (Fig. 39) just posterior to pallial cavity. A small aperture where vas deferens enters floor of pallial cavity (Fig. 39: va); remainder closed, thickened by prostate gland (Fig. 40). Penis narrow, long (Fig. 32), internally a convoluted vas deferens and two well-developed sinuses in both sides (Fig. 40: ps); rounded tip with a very small vesicle on right side in which vas deferens opens (Fig. 40).

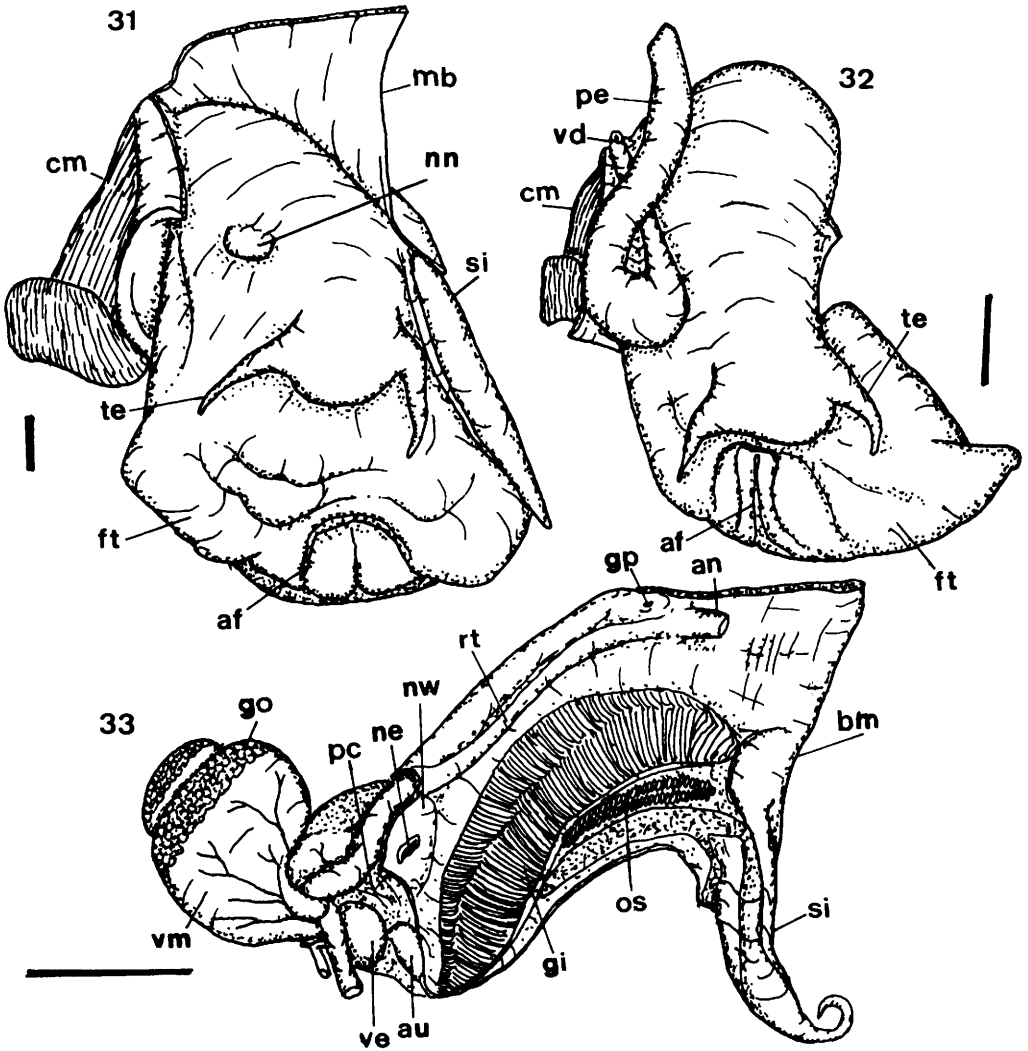
Female. Ovary in columellar side of visceral mass not mixed with digestive gland (Fig. 33). Oviduct very narrow. Albumen and capsule glands well developed, difficult to distinguish from one another, occupying about half of pallial cavity length (Fig. 41); vestibule thin-walled, very short. Female genital aperture small, bordered by bulged thick muscular walls (Fig. 41). Two specimens (39.8 mm and 33.0 mm length, MZUSP 28176) have a small node where penis occurs in males (Fig. 31).

Sexual dimorphism. Mature males notably smaller than mature females. Mature male length: 20.3–27.8–36.8 mm. Mature female length: 31.0–43.5–49.5.

Habitat. Sandy-mud bottoms, from 5 to 25 m depth.

Range. From Rio de Janeiro, Brazil, to San Matias Gulf, Argentina.

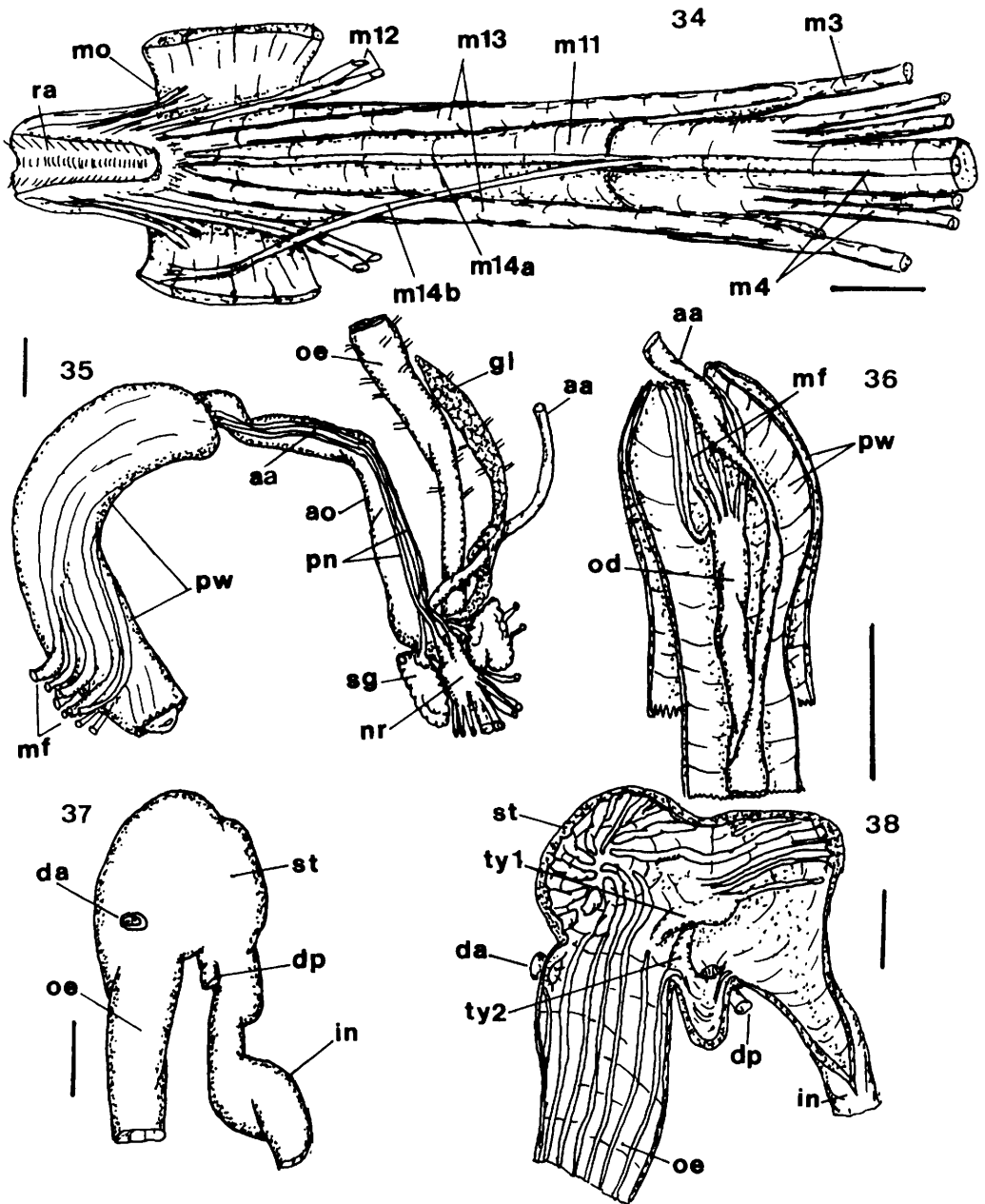
Examined specimens. BRAZIL, otter trawl. Rio de Janeiro: MZUSP 19591, 1 specimen, sta. IV, 22°06'S, 41°04'W, off Cabo de São



FIGS. 31–33. *Buccinanops moniliferus* anatomy: 31, frontal view of a female (MZUSP 28176) with nuchal node, mantle partially opened, scale = 2 mm; 32, frontal view of the head-foot of a male, mantle and siphon removed, scale = 2 mm; 33, visceral mass and pallial cavity organs of a female in inner view, scale = 10 mm.

Thomé, 16 m (11/ii/1969, "W. Besnard" col.). São Paulo: off Ubatuba: MZUSP 28124, 17 specimens, 22°05'50"S, 41°04'12"W, 10 m (vii/1991); MZUSP 28125, 19 specimens, 22°06'07"S, 41°04'08"W, 13 m (3/1992). Baixada Santista: MZUSP 28179, 1 specimen, from Barra de Santos to Guarujá (vii/1969, Instituto de Pesca col.); MZUSP 28181, 2 specimens, Goes Beach, Guarujá (17/viii/1970, Colella col.); MZUSP 28084, 10 specimens, Perequê Beach, Guarujá (6/vi/

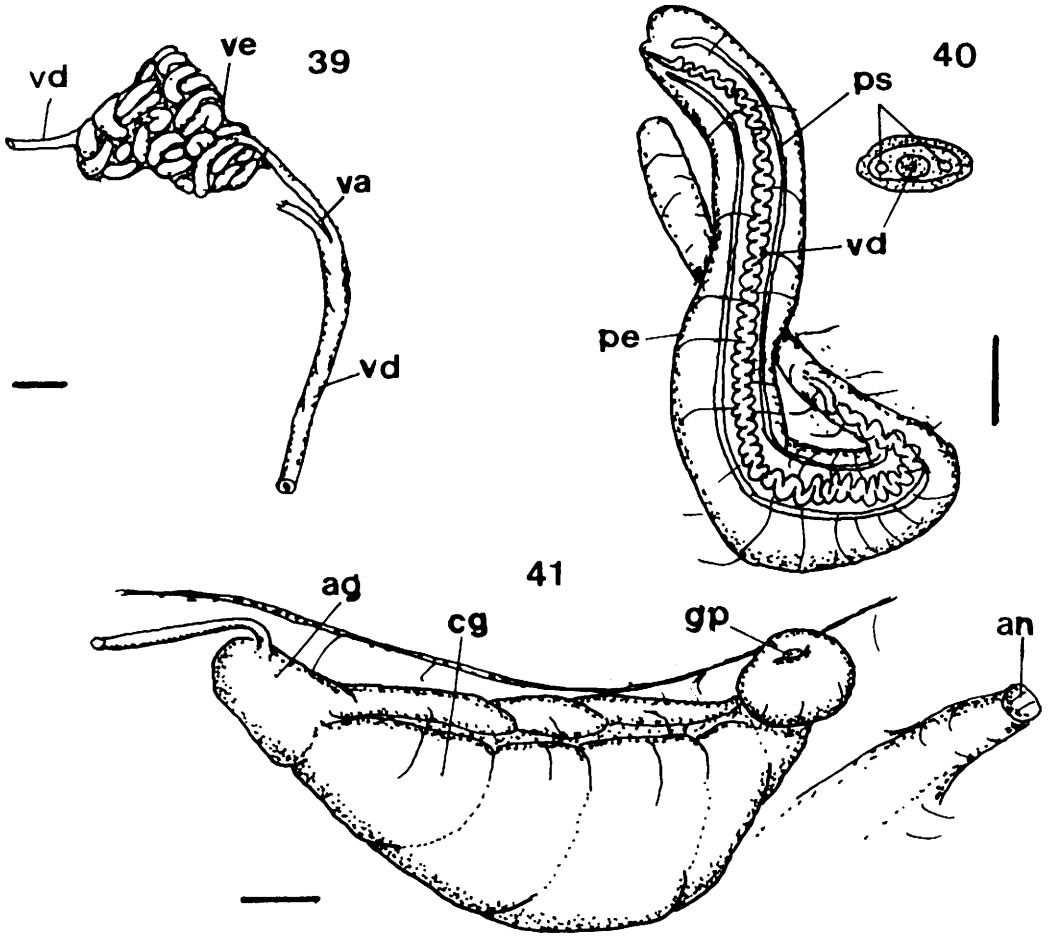
1985). Praia Grande, off Boqueirão Beach: MZUSP 28191, 11 specimens (i/1994, Simone col.); MZUSP 26865, 2 specimens (10/xi/1970, Ribas col.); MZUSP 28175, 20 specimens (i/1994, Simone col.); MZUSP 28176, 46 specimens (i/1990, Simone col.); MZUSP 27320, 2 specimens (10/i/1990, Simone col.); MZUSP 28177, 5 specimens (summer, 1994, Simone col.); MZUSP 28151, 86 specimens (xii, 1991, Simone col.); MZUSP 28152, 17 specimens (summer, 1987, Simone col.);



FIGS. 34-38. *Buccinanops moniliferus* anatomy: 34, odontophoral muscles exposed by dissection (compare with the fig. 25), scale = 2 mm; 35, left view of the anterior region of the digestive system, scale = 8 mm; 36, region of the proboscis opened longitudinally in dorsal mid line, scale = 2 mm; 37, stomach in ventral view, scale = 2 mm; 38, the same opened longitudinally, scale = 2 mm.

MZUSP 28153, 18 specimens (i/1987, Simone col.). Itanhaém: MZUSP 28180, 1 specimen, Prainha Beach (18/ii/1970, Vaz col.);

MZUSP 28178, 13 specimens, Prainha Beach (18/ii/1970, Vaz col.). Total: 271 specimens.



FIGS. 39–41. *Buccinanops moniliferus* anatomy: 39, mid region of the male genital duct in ventral view; 40, dorsal view of a cleared penis and right side of the pallial floor with a detail of a section in mid region of the penis; 41, detail of the right side of the pallial cavity showing the pallial oviduct, scales: 1 mm.

## DISCUSSION

*Buccinanops gradatus* differs anatomically from *B. moniliferus* in having: (1) the osphradium proportionally longer; (2) the rachidian teeth of the radula with fewer, more widely spaced cusp that are less uniform in size; (3) the lateral teeth with two well-developed intermediate cusps (*B. moniliferus* generally has only one or two smaller cusps, see fig. 1 of Pastorino, 1993); (4) only one pair of odontophoral “m9” muscles; (5) double “m14” muscle; (6) stomach with the typhlosoles parallel one another; (7) absence of sexual dimorphism—in *B. moniliferus*, the mature male is smaller than the mature female; (8)

penis proportionally longer, and with the papilla more developed; (9) the female genital pore in form of a small papilla surrounded by two folds, whereas in *B. moniliferus*, it bulges, has thick walls, and is without papilla.

Analysis of the anatomical characters of other species of *Buccinanops* is necessary for any systematic interpretation of the above-cited differences. Probably, based on number and degree of differences, both studied species may belong to close, but different genera. *Buccinanops moniliferus* is maintained in the genus *Buccinanops*, but the generic attribution may change in future. Pastorino (1993) gave a strong argument in favor to the separation of this species from

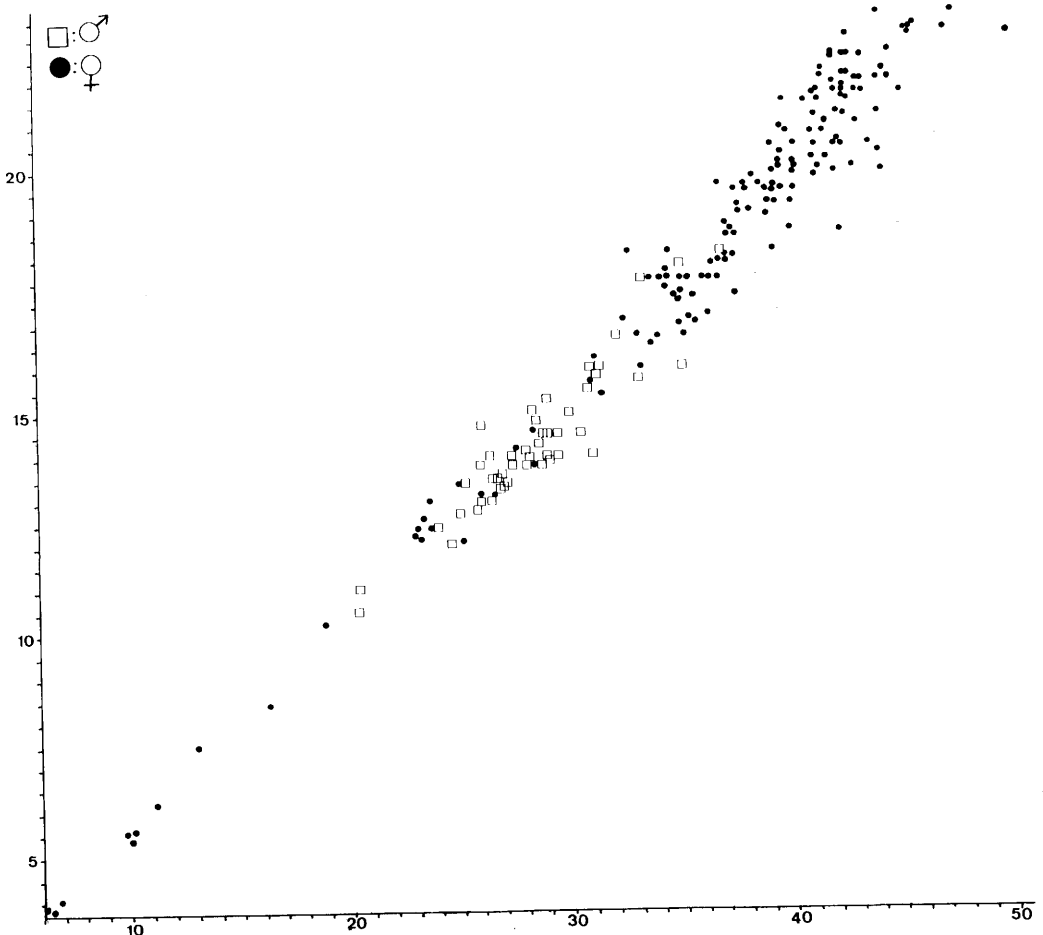


FIG. 42. Graph length  $\times$  width based on 203 specimens of *Buccinanops moniliferus*, 156 females (dark circles) and 48 males (squares).

the genus *Dorsanum*, based on differences from its type species, *D. miran* from Africa (Allmon, 1990).

The radula of *B. moniliferus* is similar to that of *B. cochlidius* (see Pastorino, 1993: 162, figs. 4–6), but differs in having more cusps on the rachidian, and its largest cusp on the right, not the left side.

Both studied species have some morphological similarity to the European *Buccinum undatum* (Buccinidae) and *Nassarius reticulata* (Nassariidae) (Fretter & Graham, 1962: 214–5, figs. 115–116), differing mainly in hav-

ing tentacles without eyes and by reduction of the valve of Leiblein. The odontophoral muscles of both studied species are similar to those of *Buccinum undatum* (see Wilsmann, 1942), differing mainly in having: (1) the horizontal muscle (m11) shorter, (2) the dorsal protractor of the radula (m5) thinner, (3) the lateral tensor muscle (m10) stronger, and (4) the minor dorsal muscles (m7, 8 and 9) differently arranged. No studies with this level of detail of the *Nassarius* odontophore exists. The ongoing comparative study on the arrangement of the odontophoral muscles of

other *Buccinanops* and *Nassarius* species may add data useful in family-level distinctions.

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