

The Peristerniinae (Mollusca: Gastropoda, Buccinoidea, Fasciolariidae) from the Neogene of Venezuela

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The *Latirus*-group of Peristerniinae Tryon, 1881 present in the early Miocene, late Burdigalian, Cantaure Formation assemblage of Venezuela, and other less well-known Venezuelan Miocene assemblages, is described and discussed. Seven species taxa representing three genera are present in the northern Venezuelan Miocene assemblages, six are new to science; *Hemipolygona snyderi* nov. sp., *Hemipolygona carrizalensis* nov. sp., *Polygona praeanaletes* nov. sp., *Polygona barbascoensis* nov. sp., *Polygona sepulcralis* nov. sp. and *Polygona buenevaraensis* nov. sp. The presence of *Pustulatirus tumbeziensis* (Olsson, 1932) in the Cantaure Formation of Venezuela is confirmed. For all three genera, *Pustulatirus*, *Hemipolygona* and *Polygona* these represent the earliest records in the Caribbean portion of the Tropical American Neogene Gatunian biogeographical province.

KEY WORDS: Peristerniinae, Mollusca, Miocene, Cantaure Formation, Venezuela, new species

Introduction

In this paper we continue with the description of the molluscan assemblage found in the early Miocene, late Burdigalian, Cantaure Formation of Venezuela, describing the *Latirus*-group (sensu Vermeij & Snyder, 2006) of Peristerniinae Tryon, 1881 found in these deposits. We have widened the area of study to include specimens from other less well-known Venezuelan Miocene assemblages. The molluscs found in this assemblage were first monographed by Jung (1965). Landau & Vermeij (in print) gave a summary of all gastropod taxa described or recorded from the Cantaure assemblage. This is the first contribution subsequent to the listing given by Landau & Vermeij (in print, table 1).

Material and methods

The material described here is from the Panama Paleontology Project (PPP) collection and the Gibson-Smith collection, both housed in the Naturhistorisches Museum Basel (NMB coll.), Switzerland, and the Bernard Landau collection (BL coll.), now deposited in the Naturhistorisches Museum Wien (NHMW coll.), Vienna, Austria. We follow the systematics and descriptive framework for the teleoconch suggested by Vermeij & Snyder (2006).

Systematic palaeontology

Superfamily Buccinoidea Rafinesque, 1815
Family Fasciolariidae Gray, 1853
Subfamily Peristerniinae Tryon, 1881
Genus *Pustulatirus* Vermeij & Snyder, 2006

Type species – *Latirus mediamericus* Hertlein & Strong, 1951, by original designation. Recent, Eastern Pacific.

Pustulatirus tumbeziensis (Olsson, 1932)

Figs 1-9

*1932 *Pseudolatirus tumbeziensis* Olsson, p. 167, pl. 18, figs 3, 5, 6.

1965 *Latirus* (subgenus?) cf. *tumbeziensis* (Olsson) – Jung, p. 538, pl. 73, figs 8-10.

2006 *Pustulatirus tumbeziensis* (Olsson, 1932) – Vermeij & Snyder, p. 421.

Dimensions and type material – Holotype PRI 2285, height 33.9 mm (Fig. 8), paratype PRI 2288, height 25.0 mm (Fig. 9), paratype PRI 2287, height 26.6 mm. Quebrada La Cruz, Tumbez Department, Peru (early Miocene, Burdigalian).

Other material – NMB H18427, height 52.8 mm, width

20.0 mm (Figs 1-3); NMB H18428, height 55.1 mm, width 21.9 mm; NMB H18429, height 61.3 mm, width 24.0; NMB H18430, height 52.2 mm, width 21.6; NMB H18431, height 50.2 mm, width 18.2 (Figs. 4-6); NMB H18432, height 34.6 mm, width 13.1; all type material from lot NMB 17516, 'lower shell bed'; NHMW 2010/0103/0004, height 49.1 mm, 'lower shell bed'; 86 specimens NMB17519, maximum height 46.3 mm, 'upper shell bed', Casa Cantaure; 26 specimens NMB 17516, maximum height 55.5 mm, 'lower shell bed', Casa Cantaure; 2 specimens lot DS 6340, NMB locality 17245; 3 specimens lot DS 6341, NMB locality 17246; 3 specimens lot DS 6343/1, NMB locality 12842; 4 specimens lot DS 6343/2, NMB locality 12842; 3 specimens lot DS 6344, NMB locality 17241, all Cantaure.

Type locality – Quebrada La Cruz, Tumbes Department, Peru.

Type stratum – Zorritos Formation, early Miocene, Burdigalian.

Description – Shell medium-sized, elongated fusiform, with a tall spire and very long siphonal protuberance; protoconch multispiral, low dome-shaped, consisting of 3.75 smooth, strongly convex whorls with a small nucleus, two strongly sinuous riblets present on last quarter of protoconch, protoconch boundary sharply delimited by a prosocline scar; teleoconch consists of six angular whorls; suture impressed, undulating; spiral sculpture on the first teleoconch whorl consists of two close-set rounded cords placed mid-whorl, from the second whorl a narrow subsutural collar is present, below which is a relatively steep, straight subsutural sector, delimited by the adapical primary cord, whorl profile straight in the central sector to the abapical primary cord, which forms the whorl periphery, below which the whorl profile tapers inwards to the abapical suture; secondary cords, slightly weaker than the primary cords develop on the subsutural sector, spiral treads appear in the interspaces from the third or fourth teleoconch whorl; axial sculpture consists of 6-7 broad rounded ribs starting below the subsutural collar, weaker in the subsutural sector, somewhat knob-like and in some specimens pointed at the shoulder; last whorl slightly inflated, subsutural sector concave, shoulder angled, central sector weakly convex, central cord hardly developed, base weakly constricted; aperture small, ovate, outer lip sinuous in profile, with a beveled edge, lirate within, the lirae, non-beaded, extending a variable distance within the aperture; adapical sinus well-developed, forming a narrow groove in the labral callus; siphonal protuberance open, narrow, very long, curving to the left, weakly posteriorly recurved at the tip; columella shallowly excavated, bearing a well-developed parietal rib; 2-4 weak folds at the base of the columella and a few tubercles on the initial portion of the siphonal protuberance of variable development; columellar callus sharply delimited, adherent, moderately thickened, weakly expanded over the ventral side of the last whorl, the spiral sculpture embossed onto the callus in the parietal portion; siphonal fasciole flattened, bearing close-set spiral cords.

Discussion – Olsson (1932) described *Pseudolaticus tumbeziensis* from the Zorritos Formation (early Miocene) of northern Peru. In his monograph of molluscs from the Cantaure Formation (early Miocene) of Venezuela, Jung (1965) assigned specimens to what he called *Latirus* sp. cf. *L. tumbeziensis* (Olsson), and noted that he was uncertain to which genus this species should belong. We have examined Olsson's specimens (PRI 2285, 2287 and 2288; the former and the latter illustrated here Figs 8-9). The Peruvian shells are much smaller (maximum height 35 mm) than the Venezuelan material, but in other ways they are indistinguishable. We therefore assign the Cantaure specimens to Olsson's species.

Vermeij & Snyder (2006) assigned *Pseudolaticus tumbeziensis* Olsson, 1932, to their new genus *Pustulaticus* (type species *Latirus mediamericus* Hertlein & Strong, 1951; tropical eastern Pacific). Species in this genus have high-spired shells with a long, straight siphonal protuberance and low, rounded spiral cords overriding but not nodulating the broad axial ribs. The surface of the shell has a glossy texture. Most living species of *Pustulaticus* have distinctly beaded lirae on the inner side of the outer lip (hence the name), whereas *P. tumbeziensis* has weakly developed smooth lirae. The parietal rib of *P. tumbeziensis* is well expressed in adult specimens, as in Recent species of *Pustulaticus*.

Pustulaticus tumbeziensis belongs to a group of species that have swollen, node-like axial ribs. These species include the Recent Brazilian *Latirus ogum* Petuch, 1979, and the eastern Caribbean *Latirus virginensis* Abbott, 1958. Vermeij & Snyder (2003) included *L. ogum* Petuch, 1979 with some hesitation in the otherwise Indo-West Pacific genus *Benimakia* Habe, 1958, because of similarities in shell shape, external sculpture and the presence of a labral tooth, but they noted that the Brazilian species has beaded lirae on the inner side of the outer lip, whereas species of *Benimakia* have smooth lirae. M.A. Snyder and we now assign *L. ogum* to the genus *Pustulaticus*. *Pustulaticus tumbeziensis* is much larger than the two Recent species. All three species differ from more typical species of *Pustulaticus* by having swollen axial ribs instead of low, broad, long ribs. The node-like ribs make the whorls of *P. tumbeziensis*, *P. ogum*, and *P. virginensis* (Abbott, 1958) appear more-inflated than in other species of the genus.

The early Miocene *P. tumbeziensis* from Venezuela and Peru is the geologically oldest tropical American member of the genus as currently understood. An even older species that has been assigned to *Pustulaticus* is *P. zuschini* Harzhauser, 2009, from the early Miocene (Aquitanian) of Tanzania. This small species (maximum height 25 mm) resembles *P. tumbeziensis* in having knob-like axial ribs. Harzhauser (2009) assigns several other fossil Indo-West Pacific species to *Pustulaticus*, including *P. fasciolariaeformis* (Martin, 1883) and *P. tjilonganensis* (Martin, 1906) from the late Miocene of Indonesia, and perhaps *Latirus indicus* Vredenburg 1924 from the Oligocene of Burma (= Myanmar). In describing *Latirus madiunensis*, Martin (1895) compared his species to his earlier *Latirus fasciolariaeformis* Martin, 1883. The Pliocene *L. madiunensis*, however, has a planar outer lip, not a strongly medially convex one as in *Pustulaticus*, and there is a small

pseudoumbilicus, a feature that is absent in *Pustulaturus*. *L. madiunensis* therefore should not be considered a member of *Pustulaturus*.

Distribution Atlantic – Early Miocene; Cantaure Formation, Falcón State, Venezuela.

Distribution Pacific – Early Miocene; Zorritos Formation, Tumbes Department, Peru.

Genus *Hemipolygona* Rovereto, 1899

Type species – *Chascax maderensis* Watson, 1973 (= *Latirus armatus* A. Adams, 1855), by monotypy. Recent, West Africa.

***Hemipolygona snyderi* nov. sp.**

Figs 10-14

Dimensions and type material – Holotype NMB H18409, height 60.9 mm, width 24.9 mm (Figs 10-12); paratype 1 NMB H18410, height 68.3 mm, width 33.4 mm (Figs 13-14); paratype 2 NHMW 2010/0103/0001, height 70.3 mm, width 29.2 mm (NHMW coll., ex BL coll.).

Other material – Two specimens lot GS-33-PGNA, NMB 17521, larger specimen NMB H18406 only last whorl preserved, height 58.5 mm, smaller specimen NMB H18407 last whorl damaged, height 56.3 mm, La Candelaria Beds, La Candelaria, Paraguaná Peninsula, Falcón State, Venezuela.

Etymology – In honour of Martin Avery Snyder, in recognition of his work on the group.

Type locality – 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS-12-PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum – Lower shell bed, Cantaure Formation (early Miocene: late Burdigalian).

Diagnosis – A *Hemipolygona* species with a large shell, well-developed sharp shoulder angulation, poorly developed central cord, nodes only developed on the shoulder cord, outer lip lirae non-beaded and columella with a very weak parietal rib and no folds on the abapical portion.

Description – Shell large, elongated fusiform, with a tall angular spire and a long siphonal protuberance; protoconch missing; seven teleoconch whorls preserved; suture deeply impressed, undulating; spiral sculpture on the first preserved teleoconch whorl consists of five rounded cords with secondary cords in some of the interspaces, early teleoconch whorls weakly convex; from the second whorl a narrow subsutural collar develops formed by two flattened cords derived from division of the adapical primary cord, below which is a steep, straight subsutural sector, delimited by the second primary cord, whorl profile weakly convex

below in the central sector to the abapical suture, with the periphery just below mid-whorl; on later teleoconch whorls the subsutural sector widens, becomes shallower and less concave, the shoulder sharply angled, the periphery mid-whorl, whorl profile below convex, with secondary and tertiary spiral sculpture on the subsutural sector and interspaces between the primary cords; axial sculpture consists of elevated rounded ribs, five on the first teleoconch whorl, increasing in number to 8-10 on the last whorl, narrower than their interspaces; on early whorls ribs well-developed over the entire whorl height between the sutures, winding around the shell in an anticlockwise direction on apical view; on later whorls ribs weakly-developed on the subsutural sector, swollen at the shoulder, extending well-developed to the abapical suture; spiral sculpture overrides the axial ribs, the shoulder cord forming a small blunt spine where it crosses the axial ribs; last whorl subsutural collar with three secondary cords, subsutural sector shallow, broad, flat to weakly concave, shoulder sharply angled, central sector convex, central cord weakly developed, strongly constricted at the base; aperture ovate, outer lip thin, finely and deeply lirate within, lirae non-beaded; anal canal poorly developed, represented by a small notch; siphonal protuberance open, narrow, long, straight, curving to the left; columella shallowly excavated, with three weak columellar folds placed deeply within, palpable with a needle, but not on visual inspection from the apertural view; columellar callus very thin, sharply delimited, adherent, weakly expanded over the ventral side of the last whorl, parietal rib poorly developed, columellar folds absent; siphonal fasciole relatively broad, flattened, bearing close-set spiral cords, bordering a deep, well-developed pseudoumbilicus.

Discussion – *Hemipolygona snyderi* nov. sp. is placed in the genus *Hemipolygona* Rovereto, 1899, although it does not fit precisely with the revised generic description given by Vermeij & Snyder (2006), *Hemipolygona snyderi* deviates from typical *Hemipolygona* species in having only shoulder angulation noded where the shoulder cord crosses the axial ribs (the central cord is hardly developed on the last whorl), and the lirae are non-beaded, whereas they are typically beaded in *Hemipolygona* species. Vermeij & Snyder (2006) noted that *Hemipolygona beckyae* (Snyder, 2000) and an undescribed species from the Dominican Republic also had only the shoulder angulation noded.

The genus is well represented in the Neogene and Recent Tropical Atlantic. Of the Recent Tropical American species, the shells of *H. snyderi* differ from those of *H. carinifera* (Lamarck, 1816), *H. centrifuga* (Dall, 1915), *H. mcgintyi* (Pilsbry, 1939) and *H. cuna* (Petuch, 1990) in having the central cord hardly developed, and non-beaded lirae within the outer lip. *Hemipolygona distincta* (A. Adams, 1855) has a very squat shell, whilst *H. beckyae* has a more slender shell than *H. snyderi*, with the shoulder far less pronounced.

In the fossils assemblages, *Hemipolygona taurus* (Olsson, 1922) from the late Miocene Nancy Point Formation, Toro Cays of Bocas del Toro area, Panama, has a shell typical for the genus, differing from *H. snyderi* in having the whorls less strongly shouldered and the central cord more

strongly developed, as well as beaded lirae. *Hemipolygona nosali* (Lyons, 1991) and *H. stephensae* (Lyons, 1991) from the Plio-Pleistocene of Florida are somewhat unlike the typical Recent species in having rather short siphonal protuberance, very broad siphonal fascioles and the last whorl tends to be rounded rather than angular, quite unlike our new Venezuelan taxon.

This record for *Hemipolygona* for the early Miocene Burdigalian is now the earliest record for the genus, slightly earlier than that of *H. erinaceus* (Peyrot, 1928) from the Middle Miocene of France (Vermeij & Snyder, 2006). This casts doubts on the Mediterranean origin of the genus suggested by Vermeij & Snyder (2006).

Distribution – Early Miocene, Cantaure Formation, Falcón State, Venezuela.

***Hemipolygona carrizalensis* nov. sp.**

Figs 15-18

Dimensions and type material – Holotype NMB H18411, height 26.6 mm, width 11.9 mm (Figs 15-16); paratype 1 NMB H18412, height 25.3 mm, width 13.5 mm (Figs 17-18); paratype 2 NMB H18413, height 28.3 mm, width 13.6; paratype 3 NMB H18414, height 28.7 mm, width (incomplete 12.8 mm); paratype 4 NHMW 2010/0103/0002 (NHMW coll., ex BL coll.), height 27.5 mm, width 14.5; holotype and paratypes 1-3 material from lot NMB 17530, Cementerio de Carrizal.

Other material – Four specimens NMB 17530, maximum height 32.6 mm, Cementerio de Carrizal.

Etymology – From the locality of Cementerio de Carrizal, Falcón State, where this species is found.

Type locality – Cemetery at Carrizal, Falcón State, Venezuela.

Type stratum: Mataruca Member, Caujarao Formation (late Miocene).

Diagnosis – A small, stocky *Hemipolygona* species, with a paucispiral protoconch, the teleoconch with strong axial sculpture, forming prominent, somewhat spiny shoulder tubercles and a relatively short siphonal protuberance.

Description – Shell small, broadly fusiform, with an elevated angular spire and a relatively short siphonal protuberance; protoconch paucispiral, consists of 1.5 smooth convex whorls with a large nucleus; teleoconch consists of seven rather squat whorls; suture impressed and deeply undulating; spiral sculpture on the first teleoconch whorl consists of two rounded cords placed mid-whorl; on the second teleoconch whorl a narrow subsutural collar develops, subsutural sector steep and strongly concave, delimited by the adapical primary spiral cord, second primary cord forms the whorl periphery, whorl profile between the cords and between cords and sutures weakly concave; irregular secondary cords appear on the subsutural ramp and

in the interspaces; axial sculpture consists of five elevated rounded ribs, equal in width to their interspaces, winding around the shell in an anticlockwise direction on apical view; weakly developed on the subsutural sector, swollen at the shoulder, extending well-developed to the abapical suture; spiral sculpture overrides and slightly swollen on the axial ribs; last whorl subsutural collar with three secondary cords, subsutural sector concave, shoulder angled, central sector convex, central cord weakly-moderately developed and noded, strongly constricted at the base, bearing eight primary cords below the shoulder, with secondary and tertiary spiral sculpture in the interspaces; aperture ovate, outer lip damaged in all specimens, bearing four lirae within, one placed adapically, the remaining three equally spaced below the periphery; adapical sinus not preserved; siphonal protuberance relatively short, narrow, straight; columella deeply excavated adapically, straight below, bearing a small blunt parietal tubercle and three stout, oblique columellar folds in the mid-portion; columellar callus moderately thickened, sharply delimited, erect abapically, weakly expanded over the ventral side of the last whorl; siphonal fasciole rounded; small pseudumbilicus present.

Discussion – The character of the strong ornament, pronounced shoulder angulation, and nodes at the shoulder angulation suggest placement in the genus *Hemipolygona*, although, as in the previous species, *H. carrizalensis* nov. sp. does not fit exactly in the generic description given by Vermeij & Snyder (2006) in having the siphonal protuberance rather short for the genus.

Hemipolygona carrizalensis has a small, stocky, very solid shell, with a short siphonal protuberance, which clearly distinguishes it from most of its congeners. *Hemipolygona distincta* (A. Adams, 1855), found in the Recent waters of southeastern Florida, the Gulf of Mexico and western Caribbean as well as the Early Pleistocene of Florida (Vermeij & Snyder, 2006) is the only Tropical American congener with a similar stocky shell and short siphonal protuberance. It differs from the Venezuelan taxon in having slightly more numerous axial ribs, the central cord is more strongly developed, separating the central and basal sectors more clearly, and the siphonal fasciole seems to be wider, although it is difficult to be certain of this with our imperfect specimens.

Distribution – Late Miocene, Caujarao Formation, Falcón State, Venezuela.

Genus *Polygona* Schumacher, 1817

Type species – *Polygona fusiformis* Schumacher, 1817 (= *Murex infundibulum* Gmelin, 1791), by monotypy. Recent, Caribbean.

***Polygona praeanapetes* nov. sp.**

Figs 19-24

1965 *Latirus* (*Polygona*) aff. *anapetes* Woodring – Jung, p. 539, pl. 73, fig. 1.

Dimensions and type material – Holotype NMB H18415, height 33.5 mm, width 12.8 mm (Figs 19-21); paratype 1 NMB H18416, height 39.2 mm, width 15.3 mm (Figs 22-23); paratype 2 NMB H18417, height 32.6 mm, width 13.0; paratype 3 NMB H18418, height 36.2 mm, width 14.2; paratype 4 NMB H18419, height 37.4 mm, width 15.5; paratype 5 NMB H18420, height 16.8 mm, width 17.2 (Fig. 24); all type material from lot NMB 17520, ‘upper shell bed’.

Other material – Sixty seven specimens NMB17520, maximum height 44.4 mm, ‘upper shell bed’, 2 specimens lot DS 6345, NMB locality 17241, 5 specimens lot DS 6346, NMB locality 17240, 3 specimens lot DS 6347, NMB locality 17248, 1 specimen H 13743, no locality data, illustrated by Jung (1965, pl. 73, fig. 1), Casa Cantaure; 12 specimens lot GS-33-PGNA, NMB 17521, maximum height 44.5 mm, La Candelaria Beds, La Candelaria, Paraguaná Peninsula, Falcón State, Venezuela; 17 specimens BL coll., maximum height 48.6 mm.

Etymology – Reflecting the similarity to *P. anapetes* (Woodring, 1964), but occurring in geologically older sediments.

Type locality – 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS-6-PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum – Upper shell bed, Cantaure Formation (early Miocene; early Burdigalian).

Diagnosis – A *Polygona* species with a small to medium sized shell, stepped spire, long narrow siphonal protuberance, a distinct shoulder angulation, weakly nodose where the cords cross the axial ribs, a distinct adapical sinus present on the outer lip, a convex outer lip in the central sector and non-beaded lirae within the outer lip.

Description – Shell medium-sized to small, elongated fusiform, with a tall spire and a long siphonal protuberance; protoconch multispiral, high dome-shaped, consisting of 3.75-4 smooth, convex whorls with a small nucleus, up to five strongly prosocline, sinuous riblets present on last half of protoconch, protoconch boundary sharply delimited by a prosocline scar; teleoconch consists of six whorls; suture impressed, undulating; spiral sculpture on the first teleoconch whorl consists of four narrow cords; on spire whorls the adapical cord is placed just below the suture and weakens, giving the impression of only three primary cords present on later spire whorls, the space between the adapical cord and the next slightly wider than the interspace between the remaining cords, forming a steep, concave subsutural sector, next two cords placed either side of the central sector, most prominent, the abapical cord abuts the suture, whorl periphery at the third cord; numerous fine secondary cords and threads of irregular strength and disposition develop in the interspaces; axial sculpture consists of broad rounded ribs, 5-6 on the first teleoconch whorl, 8-9 on the last whorl, equal in width to their interspaces, weaker on the subsutural sector; the spiral sculpture over-

rides the axial ribs; last whorl slightly inflated, subsutural sector weakly concave, shoulder roundly angled, central sector convex, central cord hardly developed, constricted at the base; aperture small, ovate, outer lip sinuous in profile, with a beveled edge, bearing 6-8 fine, widely spaced lirae within; adapical sinus well-developed, forming a narrow groove in the labral callus; siphonal protuberance open, narrow, very long, curving to the left initially, tip curved to the right; columella excavated, bearing a well-developed parietal rib and four moderately to strongly developed columellar folds placed in the abapical half of the columella; columellar callus sharply delimited, adherent, moderately thickened, weakly expanded over the ventral side of the last whorl; siphonal fasciole flattened, bearing close-set spiral cords; in some fully adult specimens a small pseudoumbilicus is present.

Discussion – Vermeij & Snyder (2006) described and discussed the characters of the genus *Polygona* Schumacher, 1817, and recognized two distinct lineages within the genus. *Polygona praeaanapetes* nov. sp. belongs within the *Polygona angulata*-group, their shells characterized by having a stepped spire, a distinct shoulder angulation, nodose where the cords cross the axial ribs, a distinct adapical sinus present on the outer lip and the central sector of the outer lip is convex. The lirae, usually beaded, are smooth in some species.

This species was discussed and illustrated by Jung (1965, p. 539, pl. 73, fig. 1) as *Latirus cf. anapetes* from the late Miocene Chagres Limestone of Panama. As Jung pointed out the Chagres Formation species is larger (50.7 mm height), has four prominent cords on the spire whorls, whereas in *Polygona praeaanapetes* only three of the four primary cords present on the first teleoconch whorl continue as prominent primary cords on later spire whorls and *P. anapetes* has slightly fewer axial ribs (7 vs. 8-9). The most important difference between the two taxa is in the character of the siphonal fasciole or pillar, broad, strongly sculptured and with a wide pseudoumbilicus in *P. anapetes*; narrow, weakly sculptured and without pseudoumbilicus in *P. praeaanapetes*. Jung (1965, p. 539) was incorrect in describing three folds on the columella of the Cantaure shell, as our specimens all show four, but less prominent than in *P. anapetes*. Jung (1965) suggested these differences might be caused by the immature stage of his shell from Paraguaná, however, in our series, which includes fully adult specimens, these differences are consistent.

Polygona praeaanapetes has numerous relatives in the Recent Caribbean faunas with a closely similar shell. *Polygona abbotti* (Snyder, 2003) is easily distinguished by its much finer spiral sculpture; *P. angulata* (Röding, 1798) is a much larger shelled species; *P. bayeri* (Petuch, 2001) is somewhat squatter-shelled with fewer axial ribs; *P. brevicaudata* (Reeve, 1847) has a shorter siphonal protuberance, as the name would suggest; *P. jucunda* (McGinty, 1940) has a shorter spire, the shoulder is placed higher and the base is more constricted; *P. lactea* (Matthews-Cascon, Matthews & Rocha, 1991) has a more fusiform shell with a longer, straighter siphonal protuberance; *P. martini* (Snyder, 1988) has a broader shell with a much wider aperture;

P. nemata (Woodring, 1928) has a shorter siphonal protuberance and finer spiral sculpture; *P. vermeiji* (Petuch, 1986) has a smaller, stockier shell, with broader axial ribs. From the Recent Tropical American Pacific *P. concentrica* (Reeve, 1847) is very similar to our fossil Venezuelan taxon, but differs in having fewer axial ribs, weaker secondary spiral sculpture and being slightly more constricted at the base; *P. socorroensis* (Hertlein & Strong, 1951) has a more fusiform shell and is less constricted at the base; *P. tumens* (Carpenter, 1856) is quite different, very much larger than the other species, with a broader shell and very broad axial ribs. Almost all Recent members of the genus *Polygona* have beaded, not smooth lirae as in *P. praeanaletes* and *P. analetes*.

In the fossil Caribbean assemblages, *P. analetes* has been discussed and compared above. *Polygona irazu* (Olsson, 1922) from the early Pleistocene Moin Formation of Costa Rica is very similar to *P. angulatus*, but thinner shelled, with finer spiral sculpture and with a larger aperture, quite unlike *P. praeanaletes*. In the Plio-Pleistocene of Florida *P. hypsipettus* (Dall, 1890) has a tall-spined shell with a short siphonal protuberance and prominent, wide-spaced spiral cords; *P. maxwelli* (Pilsbry, 1939) is larger-shelled with more numerous axial ribs.

Distribution – Early Miocene; Cantaure Formation, Falcón State, Venezuela.

***Polygona barbascoensis* nov. sp.**
Figs 25-34

Dimensions and type material – Holotype NMB H18421, height 38.6 mm, width 15.8 mm (Figs 25-27); paratype 1 NMB H18422, height 32.2 mm, width 14.2 mm (Figs 28-31); paratype 2 NMB H18423, height, 34.5 mm, width 13.7; paratype 3 NMB H18424, height 30.3 mm, width 12.0; paratype 4 NMB H18425, height 27.6 mm, width 11.7; paratype 5 NMB H18426, height 43.9 mm, width 16.2; all type material from lot NMB 17516, 'lower shell bed'; paratype 6 NHMW 2010/0103/0003 (NHMW coll., ex BL coll.), height 43.9 mm, width 16.2 (Figs 32-34).

Other material – Twenty four specimens NMB 17516, maximum height 35.0 mm, 'lower shell bed', Casa Cantaure; 11 specimens BL coll., maximum height 48.6 mm.

Etymology – This name was suggested by Jack Gibson-Smith for this taxon, as a manuscript name included in the type lot. This is a reference to Loma Barbasco and Quebrada Barbasco, which are geographic features within the Cantaure area.

Type locality – 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS-12-PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum – Lower shell bed, Cantaure Formation (early Miocene, late Burdigalian).

Diagnosis – A *Polygona* species with a small to medium sized shell, stepped spire, short siphonal protuberance, bent to the left, a distinct shoulder angulation, weakly nodose where the cords cross the axial ribs, a distinct adapical sinus present on the outer lip, a convex outer lip in the central sector and non-beaded lirae within the outer lip.

Description – Shell medium-sized to small, elongated fusiform, with a tall spire and a relatively short siphonal protuberance; protoconch multispiral, low dome-shaped, consisting of 3.5 smooth, convex whorls with a small nucleus, one or two sinuous riblets present on last quarter of protoconch, protoconch boundary sharply delimited by a procline scar; teleoconch consists of seven weakly convex whorls; suture impressed, weakly undulating; spiral sculpture on the first teleoconch whorl consists of four close-set rounded cords; on the second whorl the adapical cord is placed just below the suture, the second cord weakens, the fourth cord, placed just below mid-whorl, forming the whorl periphery, secondary cords appear in the interspaces; on the fifth teleoconch whorl a fifth primary spiral cord appears at the abapical suture; axial sculpture consists of 8-9 broad rounded ribs, equal in width to their interspaces, weaker on the subsutural ramp, somewhat swollen mid-whorl; the spiral sculpture overrides the axial ribs; last whorl slightly inflated, subsutural sector concave, shoulder roundly angled, central sector strongly convex, central cord weakly to moderately developed, constricted at the base, bearing about ten primary spiral cords with secondary and sometimes tertiary spiral sculpture in the interspaces; aperture small, ovate, outer lip sinuous in profile, with a beveled edge, finely crenulated by the spiral cords, bearing seven fine lirae within, the labral end of the lirae stopping some distance within the aperture and slightly swollen into a denticle, most apparent on the abapical lira; adapical sinus well-developed, forming a deep, narrow groove in the labral callus; siphonal protuberance open, narrow, relatively short, slightly curved posteriorly and to the left; columella excavated, bearing a well-developed parietal denticle and four strong, oblique, elongated columellar folds placed in the abapical half of the columella; columellar callus sharply delimited, thickened, weakly expanded over the ventral side of the last whorl, erect abapically; siphonal fasciole rounded, bearing close-set spiral cords, a small pseudumbilicus present.

Discussion – *Polygona barbascoensis* nov. sp. with its very solid shell and relatively short siphonal protuberance is a very characteristic species. There is some degree of variability seen in the Cantaure shells, with some specimens more slender (Figs 25-27) and others squatter (Figs 28-31), and some having a relatively longer siphonal protuberance (Figs 25-27), whilst others have a very short protuberance indeed (Figs 32-34).

The character of the short siphonal protuberance, siphonal fasciole bearing to the left with a small pseudumbilicus similar to members of the genus *Bullockus* Lyons & Snyder, 2007, but the spiral sculpture is denser and less sharp than in living members of the genus and most importantly the columellar folds are well-developed in *Polygona barbascoensis*, whereas in the genus *Bullockus* they are ab-

sent. *Polygona barbascoensis* belongs within a subgroup of the *Polygona angulata*-group characterized by having a short siphonal protuberance. These include the Recent Caribbean *P. brevicaudata* (Reeve, 1847), which is very similar indeed, but has a less pronounced shoulder and the siphonal protuberance is less strongly bent to the left, and *P. nemata* (Woodring, 1928), which is immediately distinguished by its much finer sculpture. *Polygona hypsipettus* (Dall, 1890) from the Plio-Pleistocene of Florida also has a short siphonal protuberance, but is distinguished by its sharp, widely spaced spiral cords.

Distribution – Early Miocene; Cantaure Formation, Falcón State, Venezuela.

***Polygona sepulcralis* nov. sp.**

Figs 35-38

Dimensions and type material – Holotype NMB H18433, height 26.6 mm, width 11.9 mm (Figs 35-36); paratype 1 NMB H18434, height 25.3 mm, width 13.5 mm (Figs 37-38); paratype 2 NMB (unnumbered), height 28.3 mm, (incomplete); paratype 3 NMB (unnumbered), height 28.7 mm (incomplete).

Etymology – From ‘of a tomb’ (Latin: *sepulcralis*), as it is found at the cemetery at Carrizal.

Type locality – Cemetery at Carrizal, Falcón State, Venezuela.

Type stratum – Mataruca Member, Caujarao Formation (late Miocene).

Diagnosis – A medium-sized *Polygona* species, bearing six broad rounded axial ribs on later whorls, a rounded shoulder, a weakly inflated last whorl, a medium-sized aperture and a long, straight siphonal protuberance.

Description – Shell medium-sized, elongated fusiform, with a tall spire and a relatively short siphonal protuberance; protoconch missing; teleoconch consists of ten whorls; suture impressed, undulating; sculpture on first two teleoconch whorls worn; spiral sculpture on the third whorl consists of four narrow cords, the second adapical cord weaker, a fifth primary cord placed at the abapical suture and secondary cords appear in the interspaces from the fifth whorl; spire whorls with poorly developed subsutural collar bearing the adapical primary cord, subsutural sector flat, delimited by the third primary spiral cord, whorl profile convex below, with the periphery at the fourth primary cord; axial sculpture consists of six broad rounded ribs, seven on the last teleoconch whorl, equal in width to their interspaces, weaker on the subsutural sector, the spiral sculpture overrides the axial ribs, whole surface covered in close-set fine growth lines giving the surface a finely reticulate appearance under magnification; last whorl slightly inflated, subsutural sector weakly concave, shoulder rounded, central sector convex, central cord weakly developed, constricted at the base; aperture small, ovate, outer

lip straight in profile, with a beveled edge, bearing six fine, widely spaced lirae within (paratype; in the holotype obscured by matrix); adapical sinus forming a small groove in the labral callus; siphonal protuberance open, narrow, relatively short, curved to the left; columella excavated, bearing a weak parietal rib and five columellar folds, the adapical fold weak, strengthening abapically; columellar callus sharply delimited, not expanded, bordering the aperture, erect, moderately thickened; siphonal fasciole flattened, bearing close-set spiral cords; small pseudoumbilicus present.

Discussion – *Polygona sepulcralis* nov. sp. belongs within the *Polygona infundibulum*-group (see Vermeij & Snyder, 2006), characterized by shells with a cylindrical to weakly inflated last whorl, shoulder angulation weak or absent, axial ribs extending onto the long, straight siphonal protuberance, outer lip planar, with six to nine smooth lirae within and with a pseudoumbilicus usually present. *Polygona sepulcralis*, however, is easily distinguished from *P. infundibulum* (Gmelin, 1791) in having a somewhat broader shell, fewer, broader axial ribs, a larger aperture, which is very small in *P. infundibulum*, and a shorter siphonal protuberance. The shells of *P. sepulcralis* are closer to another Recent Caribbean taxon, *P. bernadensis* (Bullock, 1974), the holotype of which also has seven axial ribs (Bullock, 1974, p. 76), but they are even broader in our fossil taxon and the siphonal protuberance is shorter than that of *P. bernadensis*.

Distribution – Late Miocene; Caujarao Formation, Falcón State, Venezuela.

***Polygona buenevaraensis* nov. sp.**

Figs 39-41

Dimensions and type material – Holotype NMB H18408, height 50.5 mm (incomplete), width 22.3 mm (Figs 39-41).

Etymology – From the locality of Buenevara, Paraguaná Peninsula, where this species is found.

Type locality – 100 m from the foot of the north scarp of the igneous/metamorphic massif of the Mesa de Cocodite, 50 to 100 m west of a reservoir (tanque) to the SSE of Buenevara, Paraguaná Peninsula, Falcón, Venezuela (= locality GS-113-PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum – Buenevara Adentro Beds, Middle/late Miocene? (Gibson-Smith & Gibson-Smith, 1979, pp. 13, 22).

Diagnosis – A medium-sized *Polygona* species, with strongly convex whorls, bearing seven broad rounded axial ribs, with a last whorl strongly constricted at the base, a small, rounded aperture strongly sculptured within, a broad, straight siphonal protuberance, and a relatively wide pseudoumbilicus.

Description – Shell medium-sized, fusiform, with an ele-

vated spire composed of convex whorls and a long, broad siphonal protuberance; protoconch and early teleoconch whorls missing; four squat, convex teleoconch whorls preserved, with a narrow, convex subsutural sector delimited by the adapical primary spiral cord, whorls strongly convex below; suture impressed, undulating; spiral sculpture on the first teleoconch whorl preserved consists of four narrow rounded cords, with two secondary cords on the subsutural sector and faint secondary sculpture in the interspaces; axial sculpture consists of seven elevated rounded ribs, equal in width to their interspaces, winding around the shell in an anticlockwise direction on apical view; strongly developed the whole whorl height; last whorl strongly convex, subsutural and central sectors not clearly delimited, central cord equal in strength to other primary spiral cords, strongly constricted at the base, bearing seven primary cords, with a single secondary thread in the interspaces; aperture small, ovate, outer lip beveled, bearing eight lirae within, the labral end of the lirae beaded; adapical sinus marked by a shallow groove in the labral callus; siphonal protuberance relatively long, narrow, straight, curved to the left; columella deeply excavated adapically, bearing a stout parietal rib and two weaker parietal denticles abapical to it, seven oblique irregular or interrupted columellar folds placed below mid-aperture; columellar callus moderately thickened, sharply delimited, erect, weakly expanded over the ventral side of the last whorl; siphonal fasciole broad, rounded, bearing spiral cords; relatively wide pseudoumbilicus present.

Discussion – *Polygona buenevaraensis* nov. sp. is superficially similar to *P. infundibulum*, but differs in having more convex whorls, the last whorl is more constricted at the base and the aperture is shorter and rounder. *Polygona infundibulum* has four regular oblique columellar folds placed in the abapical portion, whereas *P. buenevaraensis* has seven interrupted columellar folds. More importantly, the axial ribs, strongly developed on the subsutural and central sectors of the shell, weaken on the base, and do not continue onto the siphonal protuberance. The siphonal fasciole in *P. buenevaraensis* is very broad with a relatively wide pseudoumbilicus. *Polygona infundibulum* can also have a well-developed, broad siphonal fasciole, but in all such specimens seen, the axial ribs are prominent, winding gently around the fasciole. Despite these differences, this

new species is provisionally placed in the genus *Polygona* on the grounds of its general similarity to the type species *P. infundibulum*.

Distribution – Late Miocene; Caujarao Formation, Falcón State, Venezuela.

Implications

This is the first taxonomic study concentrating on the Caribbean Neogene Peristerniinae of the *Latirus*-group (sensu Vermeij & Snyder, 2006). In this work, in which we have restricted ourselves to the Neogene assemblages of northern Venezuela, we describe seven species representing three peristernine genera within this group. This is a marked increase in our knowledge of the group in the southern Caribbean Neogene, which previous to this work, consisted of a single representative from the Cantaure Formation (Jung, 1965). Further undescribed *Latirus*-group species occur in the assemblages of the early Miocene Baitoa Formation of the Dominican Republic and the Neogene Bocas del Toro area, Panama, which will be dealt with in subsequent papers.

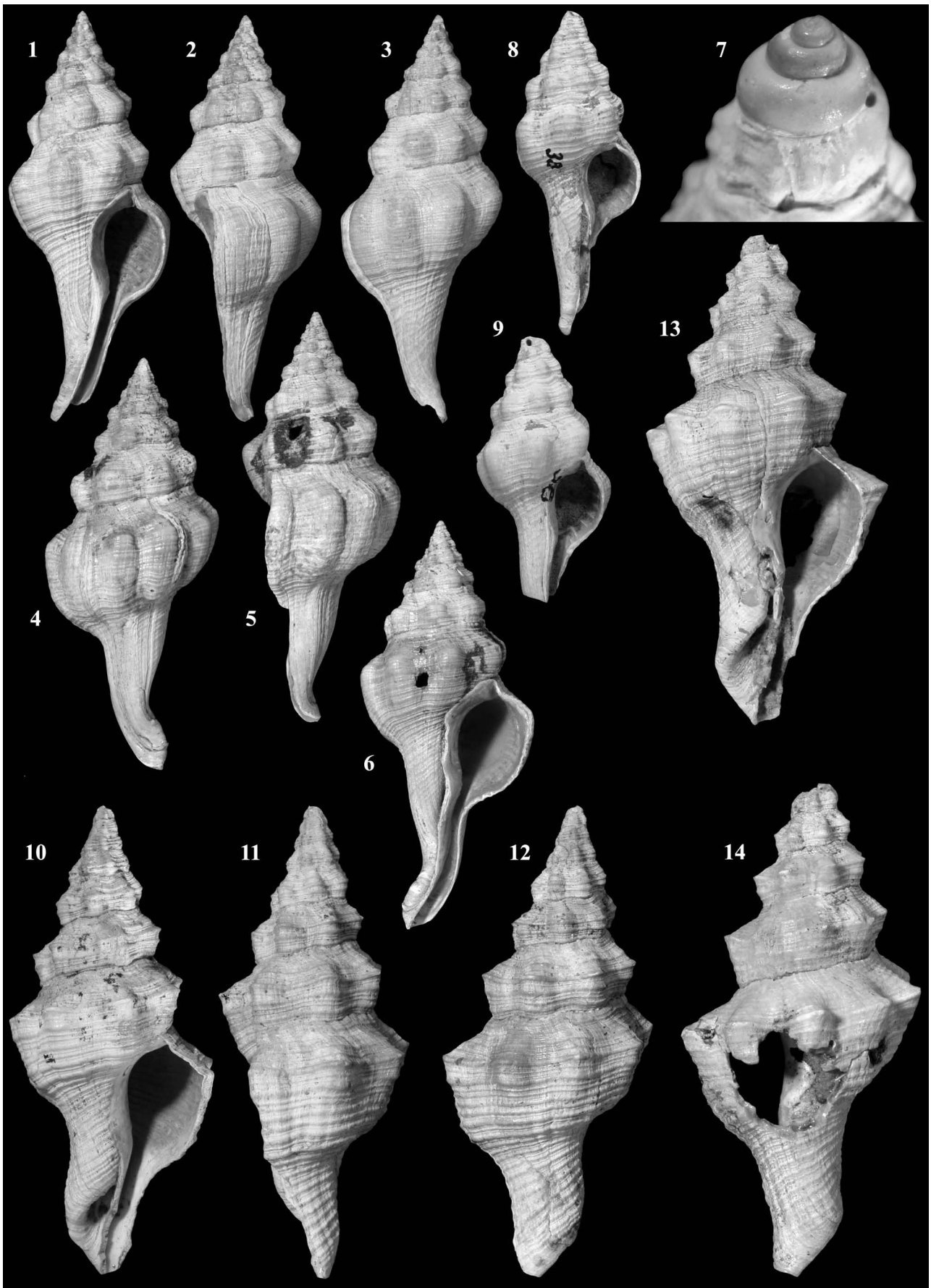
The generic classification of the Recent *Latirus*-group was reviewed by Vermeij & Snyder (2006), who considered the Recent Caribbean species to represent three genera; *Hemipolygona*, *Polygona* and *Pustulatirus*. All three of these genera were already in place in the Atlantic portion of the Gatunian palaeobiogeographic province by the end of the early Miocene.

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We would like to thank Walter Etter and Olivier Schmidt of the Naturhistorisches Museum Basel (NMB), Switzerland, for access to the Gibson-Smith collection and the loan of type specimens from the NMB collection. Our thanks also to Gregory Dietl (Paleontological Research Institution, Ithaca, New York, USA) for permission to reproduce some images of type material from their database. We also want to thank two unknown reviewers for their comments.

Figures 1-14.

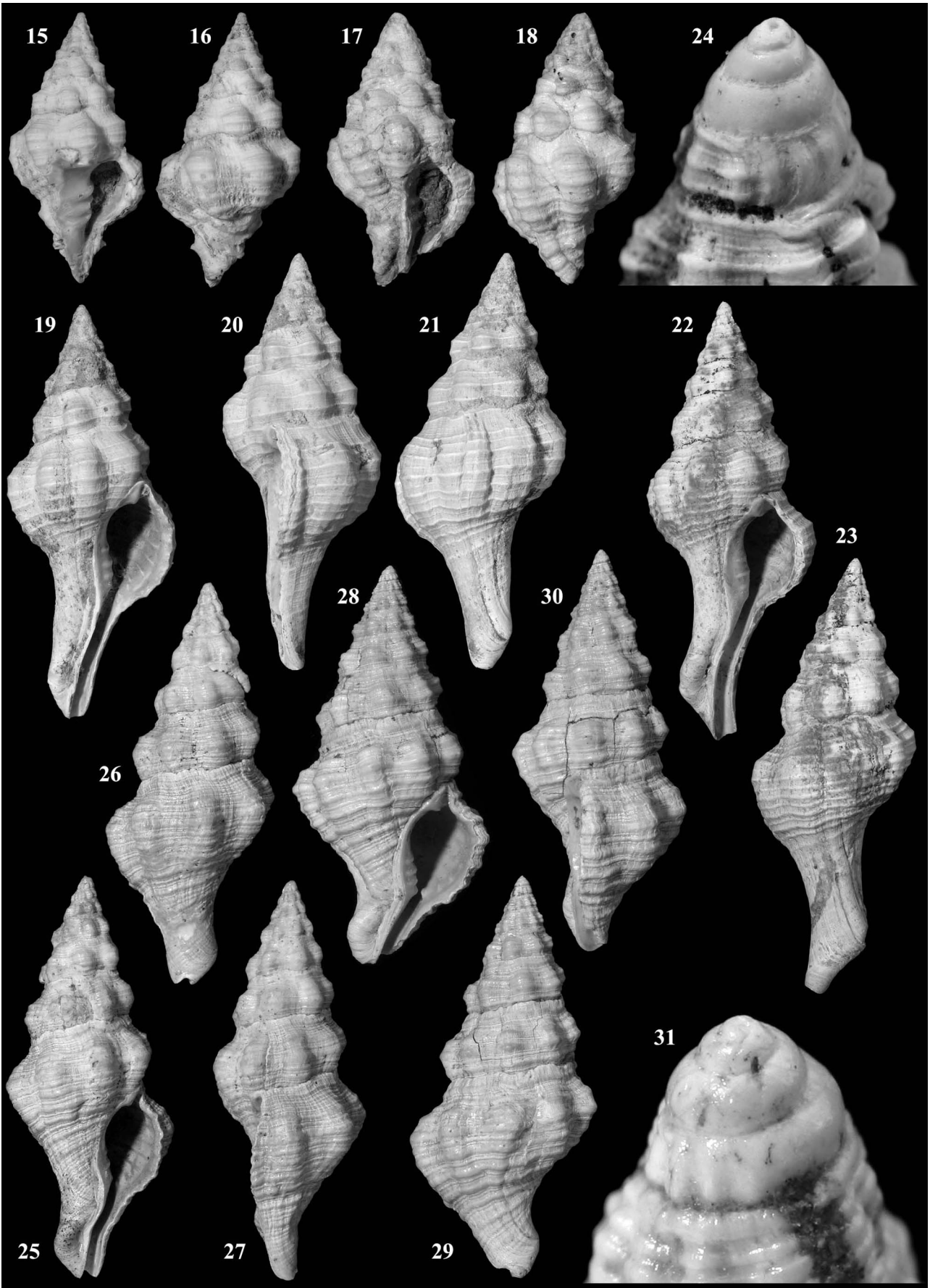
- 1-3. *Pustulatirus tumbeziensis* (Olsson, 1932). NMB H18427, height 52.8 mm, width 20.0 mm. Lower shell bed, 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Paraguaná Peninsula, Falcón State, Venezuela; Cantaure Formation (early Miocene; late Burdigalian).
- 4-6. *Pustulatirus tumbeziensis* (Olsson, 1932). NMB H18431, height 50.2 mm, width 18.2 mm. Data as in figs 1-3.
7. *Pustulatirus tumbeziensis* (Olsson, 1932). NHMW 2010/0103/0004, height 49.1 mm. Detail of protoconch. Data as in figs 1-3.
8. *Pustulatirus tumbeziensis* (Olsson, 1932). **Holotype** PRI 2285, height 33.9 mm, Quebrada La Cruz, Tumbes Department, Peru (early Miocene; Burdigalian) (Photo PRI).
9. *Pustulatirus tumbeziensis* (Olsson, 1932). **Paratype** PRI 2288, height 25.0 mm. Data as in fig. 8 (Photo PRI).
- 10-12. *Hemipolygona snyderi* nov. sp. **Holotype** NMB H18409, height 60.9 mm, width 24.9 mm. Data as in figs 1-3.
- 13-14. *Hemipolygona snyderi* nov. sp. **Paratype** 1 NMB H18410, height 68.3 mm, width 33.4 mm. Data as in figs 1-3.



Figures 1-14.

Figures 15-31.

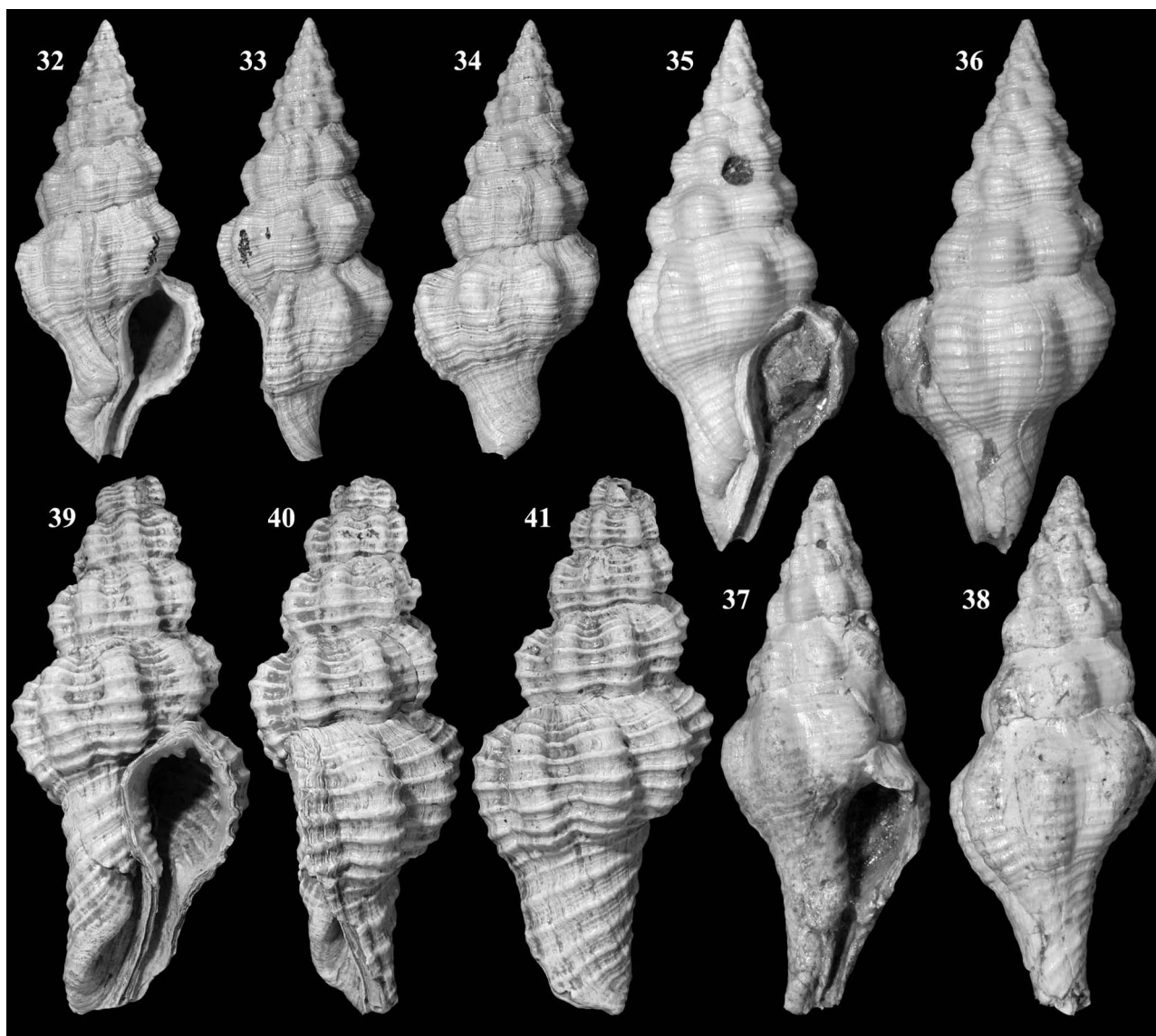
- 15-16. *Hemipolygona carrizalensis* nov. sp. **Holotype** NMB H18411, height 26.6 mm, width 11.9 mm. Cementerio de Carrizal, Falcón State, Venezuela.
- 17-18. *Hemipolygona carrizalensis* nov. sp. **Paratype** 1 NMB H18412, height 25.3 mm, width 13.5 mm. Data as in figs 15-16.
- 19-21. *Polygona praeanaletes* nov. sp. **Holotype** NMB H18415, height 33.5 mm, width 12.8 mm. Lower shell bed, 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Paraguaná Peninsula, Falcón State, Venezuela; Cantaure Formation (early Miocene; late Burdigalian).
- 22-23. *Polygona praeanaletes* nov. sp. **Paratype** 1 NMB H18416, height 39.2 mm, width 15.3 mm. Data as in figs 19-21.
24. *Polygona praeanaletes* nov. sp. **Paratype** 5 NMB H18420, height 16.8 mm, width 17.2 mm. Detail of protoconch. Data as in figs 19-21.
- 25-27. *Polygona barbascoensis* nov. sp. **Holotype** NMB H18421, height 38.6 mm, width 15.8 mm. Data as in figs 19-21.
- 28-31. *Polygona barbascoensis* nov. sp. **Paratype** 1 NMB H18422, height 32.2 mm, width 14.2 mm. Detail of protoconch. Data as in figs 19-21.



Figures 15-31.

Figures 32-38.

- 32-34. *Polygona barbascoensis* nov. sp. **Paratype** 6 NHMW 2010/0103/0003 (NHMW coll., ex BL coll.), height 43.9 mm, width 16.2 mm. Lower shell bed, 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Paraguaná Peninsula, Falcón State, Venezuela; Cantaure Formation (early Miocene; late Burdigalian).
- 35-36. *Polygona sepulcralis* nov. sp. **Holotype** NMB H18433, height 26.6 mm, width 11.9 mm. Cementerio de Carrizal, Falcón State, Venezuela.
- 37-38. *Polygona sepulcralis* nov. sp. **Paratype** 1 NMB H18434, height 25.3 mm, width 13.5 mm. Data as in figs 35-36.
- 39-41. *Polygona buenevaraensis* nov. sp. **Holotype** NMB H18408, height 50.5 mm (incomplete), width 22.3 mm. Buenevara, Paraguaná Peninsula, Falcón State, Venezuela; Buenevara Adentro Beds, middle/late Miocene?



Figures 32-38.

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