

New Late Cretaceous (Santonian and Campanian) gastropods from California and Baja California, Mexico

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ABSTRACT

Three new genera and six new species of shallow-marine Late Cretaceous gastropods are reported from various formations in California and from one formation in Baja California, Mexico. *Tegula jeanae* new species, of early Campanian age, is the earliest known species of this trochid genus. *Nerita* (subgenus?) *orovillensis* new species is the second known Early Campanian neritid from California. The cerithioid *Bullamirifica* new genus is represented by three species: *Bullamirifica verruca* new species of Coniacian age; *Bullamirifica elegans* new species of early Campanian age; and *Bullamirifica ainiktos* (Dailey and Popenoe, 1966) of middle to late Campanian age. The latter species has the most widespread distribution, with occurrences in southern California and northern Baja California. *Minytropis melilota* new genus and species of Santonian age, and *Paxitropis dicriota* new genus and species of Late Santonian to early Campanian age are high-spined trichotropids. As presently known, *Bullamirifica*, *Minytropis*, and *Paxitropis* were endemic to the study area.

INTRODUCTION

This study is based largely on specimens collected by Eric Göhre of Oroville, California. Over the years, he has amassed a sizeable collection of shallow-marine mollusks from the lower Campanian Pentz Road member of the Chico Formation near Pentz, Butte County, northern California (Figure 1). His collection has yielded several new species of gastropods, and some of these were described by Groves (2004) and Squires and Saul (2004). In part, this present study concerns three additional new species and a new genus of gastropods found in his collection. They are the trochid *Tegula jeanae* new species, the neritid *Nerita* (subgenus?) *orovillensis* new species, and the cerithioid *Bullamirifica elegans* new genus and species.

Inspection of the literature, as well as examination of the collections at the Natural History Museum of Los

Angeles County, allowed us to incorporate two additional species into *Bullamirifica*. These are *Bullamirifica verruca* new genus and species from the Coniacian Member IV of the Redding Formation in the Oak Run area, northern California, and *Bullamirifica ainiktos* Dailey and Popenoe (1966) new combination from the middle Campanian Pigeon Point Formation southwest of San Francisco, northern California; the middle upper Campanian Punta Baja Formation, Baja California, Mexico; and the upper Campanian Jalama Formation, southern California (Figure 1). "*Cimolithium miya-koense*" (Nagao, 1934) and "*Vicarya* (*Shoshiroia*) *yabei*" Kamada, 1960, reported by Perrilliat-Montoya (1968) from Baja California, Mexico (see Figure 1, formation 6), are judged by us to be synonyms of *Bullamirifica ainiktos*.

Also included in this present study are new trichotropid gastropods found in the collections at the Natural History Museum of Los Angeles County. They are *Minytropis melilota* new genus and species from the Santonian part of the Redding and Chico formations of northern California, and *Paxitropis dicriota*, new genus and species from the of upper Santonian part of the Redding Formation, northern California; the lower Campanian part of the Chico Formation; and the lower Campanian part of the upper Holz Member of the Ladd Formation, southern California (Figure 1).

The geologic age of each new species described in this paper is shown in Figure 2. The entire interval of time that encompasses all these species is Coniacian to late Campanian, or about 19 million years. The new species are locally common, except for *Tegula jeanae*, *Nerita* (subgenus?) *orovillensis*, and *B. verruca*.

The classification system used here generally follows that of Hickman and McLean (1990) for the tegulines, Ponder (1988) for the trichotropids, and Ponder and Warén (1988) for the other taxa.

Study localities are listed in Appendix 1. Abbreviations used in the text are: CAS: California Academy of Sciences,

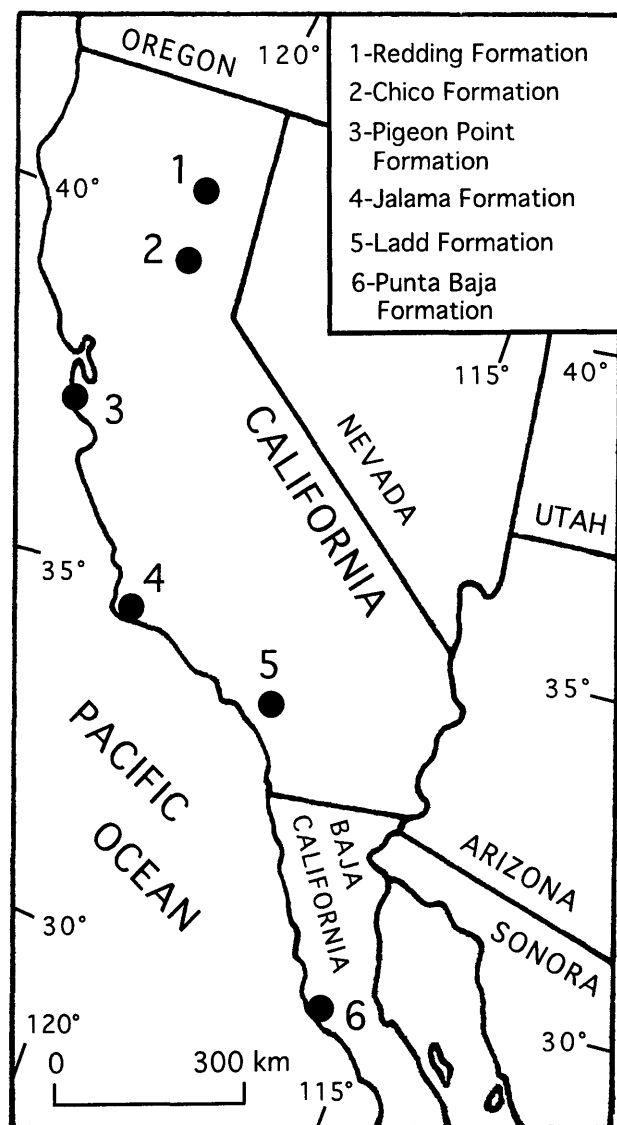


Figure 1. Location of formations bearing the new taxa.

San Francisco; IGM: México Museo del Paleontología del Instituto de Geología; LACMIP: Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCLA: University of California, Los Angeles (collections now housed at LACMIP); UCMP: University of California Museum of Paleontology (Berkeley); USGS: United States Geological Survey.

STRATIGRAPHY

Except for the Punta Baja Formation, which is discussed below, the ages and depositional environments of all the formations and members containing the new taxa discussed in this paper can be found in the following papers: Member IV of the Redding Formation, Squires and Saul (2003a); Musty Buck Member of the Chico Formation, Saul and Squires (2003); Pentz Road member (informal) of the Chico Formation, Squires

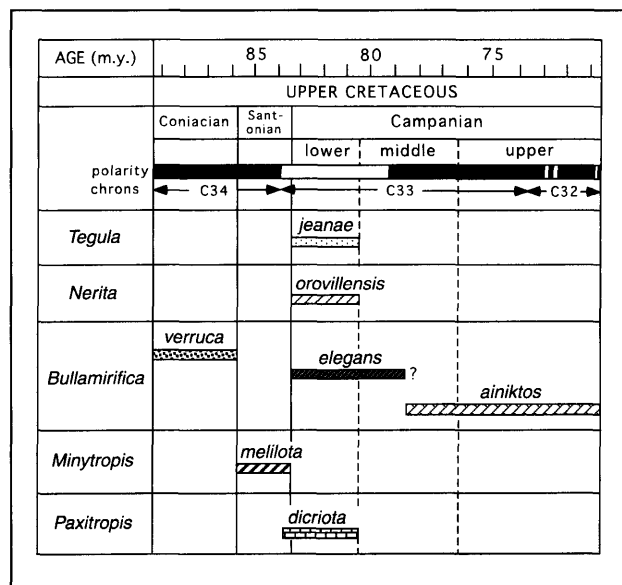


Figure 2. Chronostratigraphic positions of the new taxa. Ages of stage boundaries and magnetostratigraphy from Gradstein et al. (2004, fig. 19.1).

and Saul (1997); Ten Mile Member of the Chico Formation, Squires and Saul (2003b); upper Holz Shale of the Ladd Formation, Squires and Saul (2001); Pigeon Point Formation, Elder and Saul (1993) and Squires and Saul (2003b); and Jalama Formation, Squires and Saul (2003b). The locales of these formations are shown in Figure 1. Stratigraphic information mentioned below concerns additional pertinent biostratigraphic details. The age of the Jalama Formation used here is slightly younger than used in our previous papers because we had to adjust its chronostratigraphic position based on the latest published (Gradstein et al., 2004) absolute-time and global-paleomagnetic data correlations.

PUNTA BAJA FORMATION

Perrilliat-Montoya (1968) reported specimens of gastropods, herein assigned to *Bullamirifica ainiktos*, from the "Rosario Formation" at Punta Baja, near El Rosario, northern Baja California, Mexico. The 5–140 m thick Punta Baja Formation (Figure 1) overlies fluvial deposits of the La Bocana Roja Formation, and the angular unconformity between these two formations is canyon-shaped (Boehlke and Abbott, 1986). This canyon is filled with conglomerate, sandstone, and siltstone reported by Kilmer (1963) to have been deposited in shallow-marine depths not exceeding 60 meters. Boehlke and Abbott (1986) have a differing viewpoint and reported that the deposits represent turbidites that accumulated in bathyal depths. They reported, furthermore, that shallow-marine mollusks are common, but Kilmer's collection at UCMP does not contain very many specimens. The Punta Baja Formation is unconformably overlain by terrestrial deposits of the La Escarpa Member of the El Gallo

Formation, which, in turn, is overlain by the Rosario Formation.

Based on molluscan fossils collected by F. H. Kilmer, Saul (1983: 21–22, fig. 9) reported the ammonite *Metaplacenticeras* cf. *pacificum* (Smith, 1900) and the gastropod *Turritella chicoensis pescaderoensis* Arnold, 1908, from the siltstone in the Punta Baja Formation. Although these two mollusks were reported by Saul (1983: 65–66) to be of late Campanian age, more recent biostratigraphic studies (Elder and Saul, 1996: fig. 1) depicted both of these taxa as ranging in age from late middle Campanian to earliest late Campanian. Adjustments for the most recently published (Gradstein et al., 2004) absolute-time and global-paleomagnetic data correlations place these ammonite and turritellid zones in the middle late Campanian. Recent examination by the junior author of additional Punta Baja Formation mollusks revealed three specimens of the bivalve *Calva*. The best preserved specimen is from LACMIP loc. 12582 and is *Calva* (*Egelicalva*) *crassa* Saul and Popenoe, 1992, whose geologic range is early late Campanian to early Maastrichtian elsewhere on the Pacific slope of North America (Saul and Popenoe, 1992). The other two *Calva* specimens are worn and broken, from UCMP loc. B-3388. These two specimens are similar to *Calva* (*Calva*) *peninsularis* (Anderson and Hanna, 1935), whose geologic range is latest Campanian to early Maastrichtian elsewhere on the Pacific slope of North America (Saul and Popenoe, 1992).

Boehlke and Abbott (1986: fig. 4) assigned the age of the Punta Baja Formation to the early Campanian based entirely on calcareous nannofossils. They also reported that the benthic foraminifera in this formation correspond to the F2-lower E foraminifera zones of Goudkoff (1945), but they did not rely on the foraminifera for their age call. Almgren (1986: table 2) reported that the F2-lower E foraminifera zones are essentially correlative to the early Campanian to late Campanian. It is important to mention that the Alcalde Shale in the Coalinga area along the west side of the San Joaquin Valley, central California, is correlative to the E zone (Almgren, 1986: table 3). As depicted in Saul (1983: fig. 10), the Alcalde Shale contains *Metaplacenticeras* cf. *M. pacificum*, and Almgren (1986) assigned the Alcalde Shale to the early late Campanian.

In summary, the *Metaplacenticeras*, *Turritella*, *Calva*, and benthic foraminifera data strongly support a middle late Campanian age for the Punta Baja Formation. The calcareous nannofossils, however, support an early Campanian age. It seems probable that the older calcareous nannofossils are reworked, and this would be consistent with the depositional environment of the formation.

SYSTEMATIC PALEONTOLOGY

Superfamily Trochoidea Rafinesque, 1815
Family Trochidae Rafinesque, 1815

Subfamily Tegulinae Kuroda, Habe and Oyama, 1971
Genus *Tegula* Lesson, 1835

Type Species: *Tegula elegans* Lesson, 1835, by monotypy; Recent, west coast of Central America to the Gulf of California, Mexico.

Discussion: Although Wenz (1938), Keen (1960), and Davies (1971) reported the geologic range of *Tegula* to be Miocene to Recent, Bandel and Stinnesbeck (2000) reported a species of *Tegula* of Late Cretaceous (Maastrichtian) age from central Chile. Kiel and Bandel (2001) reported a tentatively identified *Tegula* from upper Campanian strata in northern Spain. The early Campanian new species described below represents the confirmed earliest record we know of for *Tegula*. For the Pacific slope of North America, the previous earliest record of *Tegula* was given by Addicott (1973: 17, pl. 8, figs. 2, 4), who reported it from the Wygal Sandstone Member of the Temblor Formation, southwestern margin of the San Joaquin Valley, Kern County, central California. Squires (2003: table 2.1, fig. 2.1) placed this member in the lower Oligocene Matlockian Stage.

Tegula jeanae new species
(Figures 3–5)

Diagnosis: A *Tegula* with low to moderate spire. Whorls convex, smooth, and bearing one spiral groove on posterior third of last whorl. Anomphalous. Last whorl with raised lip along basal edge, base sunken between this lip and columellar lip, which bears at least one denticle and one much smaller denticle adapically.

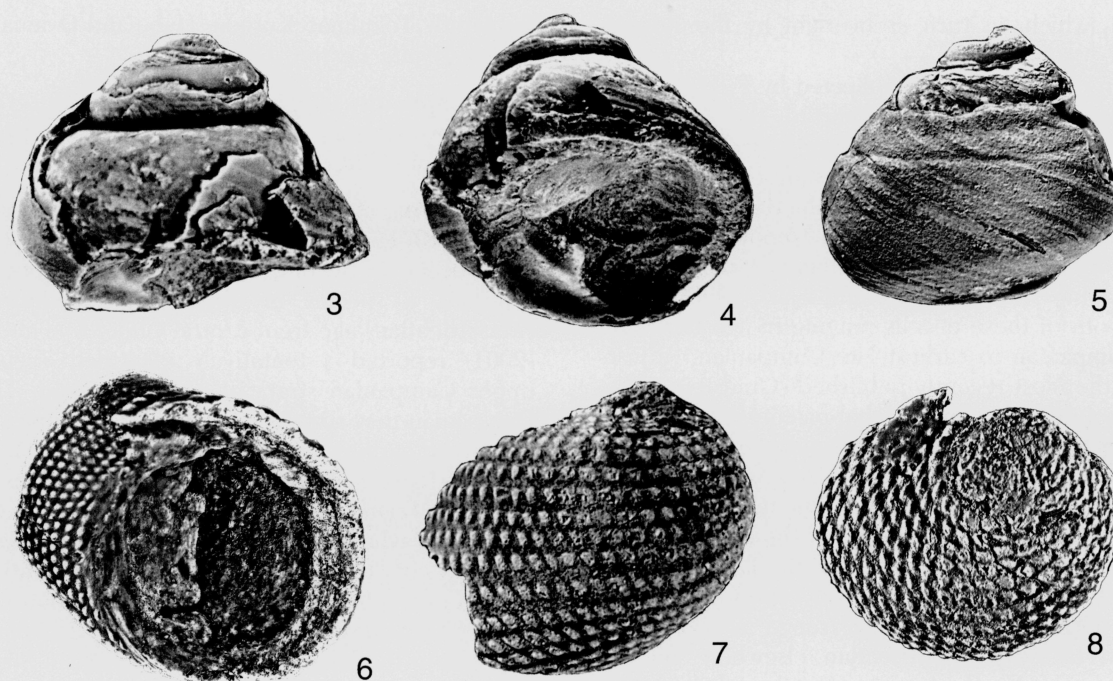
Description: Shell medium (up to 16.6 mm height and 21.7 mm diameter, same specimen). Turbiniform with spire low to moderately elevated. Protoconch unknown. Teleoconch consisting of three whorls. Suture impressed, slightly channeled. Whorls convex, sometimes slightly concave short distance anterior of suture; blunt angulation anterior of medial part of last whorl. Whorls smooth; spiral groove posterior of medial part of last whorl. Aperture oblique, peristome discontinuous. Anomphalous, umbilical area covered by broad callus. Base wide and smooth, peripheral (abaxial) margin coincident with raised lip along edge of last whorl; area depressed between this lip and columella. Outer lip strongly prosocline. Columellar lip with at least one oblique denticle; much weaker second denticle sometimes present immediately posterior of main denticle. Growth lines strongly prosocline, forming wide bands.

Holotype: LACMIP 13322, 18.7 mm in height, 22 mm in diameter.

Paratype: LACMIP 13323.

Type Locality: LACMIP loc. 24337.

Geologic Age: Early Campanian.



Figures 3–8. New tegulid and neritid gastropods. Specimens coated with ammonium chloride. **3–5.** *Tegula jeanae* new species, LACMIP loc. 24337. **3.** Paratype LACMIP 13323, apertural view, height 13.9 mm, diameter 17.9 mm. **4–5.** Holotype 13322, height 18.7 mm, diameter 22 mm. **6–7.** *Nerita* (subgenus?) *orovillensis* new species. **6.** Holotype LACMIP 13324, apertural view, height 11.6 mm, diameter 16.8 mm. **7–8.** Paratype LACMIP 13325, total shell height 10 mm, diameter 13.7 mm. **7.** Abapertural view. **8.** Apical view.

Distribution: Chico Formation, Pentz Road member (informal), near Pentz, Butte County, northern California.

Etymology: Named for Jean Göhre, mother of Eric Göhre, who collected and donated the type material to LACMIP.

Discussion: This new species is known from two specimens, both showing good preservation. The new species is remarkably similar to *Tegula* (*Chlorostoma*) *funnebralis* (Adams, 1855), from Pliocene and Pleistocene strata of southern California (Grant and Gale, 1931) and from the Recent of Vancouver Island, British Columbia, to central Baja California, Mexico (McLean, 1978). The new species differs from *T. (C.) funnebralis* by having a smooth shell rather than being ornamented by weak spiral ribs. The similarity between the new species and *T. (C.) funnebralis* is even stronger if the specimens of the latter are worn.

Tegula ovallei (Philippi, 1887: pl. 12, fig. 4; Bandel and Stinnesbeck, 2000: 761, pl. 1, B), the only other positively identified Cretaceous *Tegula* that we know of, is from Maastrichtian strata in central Chile. The new species differs from *T. ovallei* by having a smooth shell rather than being ornamented by granulated spiral ridges.

Kiel and Bandel (2001: 139, pl. 1, fig. 1) reported a tentatively identified *Tegula?* *simplex* (Quintero and Revilla, 1966: 49, pl. 8, fig. 3) from upper Campanian

strata in northern Spain. The new species differs greatly from *T.?* *simplex* by having a less elevated spire, smooth shell, blunt rather than a sharp angulation anterior of the medial part of the last whorl, broad callus covering the umbilical region, wider aperture, very much stronger denticles on the columella, raised lip along the basal edge of the last whorl, and sunken base between this raised lip and the columellar lip.

Family Neritidae Rafinesque, 1815
Genus *Nerita* Linnaeus, 1758

Type Species: *Nerita peloronta* Linnaeus, 1758, by subsequent designation (Montfort, 1810); Recent, south Florida, West Indies, and Bermuda.

Discussion: *Nerita* sensu lato ranges from Early Cretaceous (Hauterivian), and the earliest record is from the Ono Member of the Budden Canyon Formation, Trinity County, northern California (Saul and Squires, 1997). The new species described below represents the first record of an early Campanian *Nerita* from the study area.

Subgenus?
Nerita (subgenus?) *orovillensis* new species
(Figures 6–8)

Diagnosis: A *Nerita* with approximately 18 to 19 beaded spiral ribs. Columellar lip with four or five obscure teeth.

Description: Shell medium small (up to 11.6 mm in height and 16.3 mm in diameter, same specimen), broader than high, globose. Last whorl rapidly expanding. Protoconch unknown. Teleoconch consisting of 2.5 to 2.75 whorls. Uppermost spire very low. Suture obscure. Earliest 1.5 teleoconch whorls apparently smooth, rest of teleoconch covered with approximately 18 narrow spiral ribs bearing small beads; interspaces between ribs approximately as wide as interspaces. Beads on ribs becoming smaller and slightly elongate on base of last whorl, especially in parietal region. Spiral rib adjacent to suture can be slightly stronger than other ribs. Aperture large, nearly circular. Outer lip flared, interior smooth. Columellar lip with five somewhat obscure teeth, most posterior tooth widest and longest. Deck area broad, sloping, and sharply demarcated from base of last whorl. Growth lines prosocline.

Holotype: LACMIP 13324, 11.6 mm in height, 16.8 mm in diameter.

Paratype: LACMIP 13325.

Type Locality: LACMIP loc. 24337.

Geologic Age: Early Campanian.

Distribution: Chico Formation, Pentz Road member (informal), near Pentz, Butte County, northern California.

Etymology: Named for Oroville, California.

Discussion: The new species is based on two specimens. The external surfaces are moderately well preserved, but the columellar lip and especially the deck area are poorly preserved.

The new species is remarkably similar to *Nerita* (*Theliostyla*) *crooki* Clark (1938: 700, pl. 4, figs. 1, 2) from the Markley Formation east of San Francisco, Solano County, northern California. Squires (2003: table 2.1, fig. 2.1) assigned this formation to the middle Eocene ("Tejon Stage"). The new species differs from *N. (T.) crooki* by having fewer and wider teeth on the columellar lip, fewer ribs on the last whorl with relatively wider interspaces, and ribs near the middle of the last whorl not noticeably broader than adjacent ribs.

The new species is also very similar to *Nerita umzambiensis* Woods (1906: 311, pl. 37, figs. 14–15; Bandel and Kiel, 2003: 51–52, pl. 1, figs. 4–5) from the Santonian/Campanian Umzamba Formation in southeastern South Africa. The new species differs from *N. umzambiensis* by having fewer teeth on the columella lip, ribs on the base of the last whorl, and a deck area sharply demarcated from the base of the last whorl.

The new species somewhat resembles *Nerita* (*Theliostyla*?) *kennedyi* Squires and Saul (2002: 185–187, figs. 31–34) from the upper lower to lower middle Eocene ("Domengine Stage") Santiago Formation, northern San Diego County, southern California. The new species differs from *N. (T.?) kennedyi* by having

beads that are not elongate, wider interspaces between the ribs, and fewer, stronger, and wider teeth on the columellar lip.

The only other early Campanian neritid known from the Pacific slope of North America is *Neritina* (*Dostia*) *cuneata* (Gabb, 1864: 137, pl. 21, fig. 97) from lower Campanian strata at Tuscan Springs on Little Salt Creek, Tehama County, northern California. Gabb's species might also be present in 1) upper Campanian and/or lower Maastrichtian strata in the Pozo area, San Luis Obispo County (Vedder, 1977) and 2) Maastrichtian strata along the western edge of the San Joaquin Valley, California (Woods and Saul, 1986). The new species is vastly different from *Neritina* (*Dostia*) and does not have its patelliform shape nor its distinctive collabral sculpture.

Superfamily Cerithioidea Férussac, 1819
Family Indeterminate

Discussion: The new genus described below is most likely a cerithioid, on the basis of its sigmoidal growth lines, high spire, sculpture, short siphonal canal (slightly twisted), smooth columella, and smooth interior of the outer lip. Some specimens of the new genus have a narrow spire, like that found in cerithioids, but other specimens of the new genus have a buccinid-like shell. The strongly sigmoidal growth lines of the new genus, however, are unlike that found on buccinid shells. It is possible that the new genus belongs to a new cerithioid family.

Genus *Bullamirifica* new genus

Type Species: *Bullamirifica elegans*, new species; Early Campanian, Pentz area, Butte County, northern California.

Description: Shell medium (up to 83 mm height and 37 mm diameter, same specimen), fusiform to turreted. Height to diameter ratio 2 to 2.7. Spire high, comprising 41 to 55% of total shell height. Pleural angle 33 to 42°. Protoconch unknown. Teleoconch whorls six to eight. Spire whorls with shoulder angulate; last whorl with periphery angulate. Ramp short to moderately long, concave to rarely straight-sloped. Suture slightly undulatory, weakly impressed. Collabral sculpture consisting of many narrow ribs, closely to moderately widely spaced; interspaces smooth. Collabral ribs slightly opisthocline to opisthocyrt, usually extending from suture to suture. Collabral ribs present on base or obsolete; if present, swollen and elongate. Spiral sculpture consisting of several spiral ribs with variable width and spacing, especially on last whorl. Spire whorls with strongest spiral rib on whorl shoulder, several weak or moderately strong spiral ribs occasionally near anterior suture, and suture coincident with weak spiral rib either bearing weak nodes or without nodes. Last whorl sculpture with three to four widely spaced, strong spiral ribs on periphery and one or two weaker spiral ribs