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LATEST CRETACEOUS AND EARLY TERTIARY TUDICLIDAE AND MELONGENIDAE (GASTROPODA) FROM THE PACIFIC SLOPE OF NORTH AMERICA

LOUELLA R. SAUL
Earth Sciences Division, Natural History Museum of Los Angeles County,
900 Exposition Boulevard, Los Angeles, California 90007

ABSTRACT—Four species belonging in Tudiclidae and one in Melongenidae have been confused with perissityids. The new genus *Rapopsis* is proposed for a tudiclid species, *R. joseana* n. sp. of early Maastrichtian age. Three other tudiclid species may belong in the Tethyan genus *Pyropsis, P. fantozzii* n. sp. of early to middle Paleocene age, *P. striata* (Stanton, 1896) of later Paleocene age, and ?*P. gabbi* (Stanton, 1896) probably of early to middle Paleocene age. The melongenid genus *Protobusycon,* represented by *P. judithae* n. sp. of late Paleocene age, has not previously been recognized in eastern Pacific faunas.

INTRODUCTION

A STUDY of Late Cretaceous and early Tertiary Perissityidae (Popenoe and Saul, 1987; Saul, in press) has revealed several species that are allocable to the families Tudiclidae and Melongenidae, but which have been confused with Perissityidae. These comprise the tudiclids *Rapopsis joseana* n. gen. and sp., *Heteroterma gabbi* Stanton, 1896, *H. striata* Stanton, 1896, *Pyropsis fantozzii* n. sp., and the melongenid *Protobusycon judithae* n. sp. The paper describes these incorrectly assigned species.

Incomplete and partially cleaned specimens of *Rapopsis joseana* n. sp. were misidentified as *Perissitys colocara* Popenoe and Saul, 1987. Cleaned apertures display the sharp basal fold of a tudiclid, and additional, recently collected specimens, having the distinctively bent anterior siphonal canal intact, indicate the need for a new genus, *Rapopsis.* The closest known relatives of *R. joseana* are from the Upper Cretaceous of India.

Two species described by Stanton (1896), *Heteroterma gabbi* and *H. striata,* have been particularly susceptible to misunderstanding, and the extended biogeographic range of *Heteroterma* Gabb, 1869, to South America and New Zealand has been largely based upon similarity of austral species to *H. gabbi.* Neither *H. gabbi* nor *H. striata* is a *Heteroterma;* both resemble species of the tudiclid genus *Pyropsis. Pyropsis* is a Tethyan genus (Erickson, 1974, p. 211), and its recognition in lower Tertiary deposits of middle California adds to the tropical aspect of these faunas. The genus is best known from the Cretaceous of the Western Interior and the Gulf Coast regions (Sohl, 1964, p. 235), and three West Coast species, *P. fantozzii, P. striata,* and especially ?*P. gabbi,* are assigned to it with reservations. Specimens of *Pyropsis fantozzii* n. sp. were referred to the perissityids *Heteroterma trochoidea* Gabb, 1864, and *Cophocara stewarti* Zinsmeister, 1983b, but *Pyropsis fantozzii* resembles *P. striata* (Stanton, 1896).

Specimens of *Protobusycon judithae* n. sp. have been misidentified as "*Heteroterma*" *gabbi* Stanton or "*Heteroterma*" *striata* Stanton. *Protobusycon* has previously been recognized only in the Late Cretaceous of the Gulf Coast (Sohl, 1964); its inclusion in the Melongenidae suggests that it has tropical affinities.

Reassignment of these gastropods involves the families Perissityidae (Popenoe and Saul, 1987; Saul, in press), Tudiclidae, and Melongenidae. Perissityidae comprises bucciniform, fusiform, and pyriform gastropods having an elliptical aperture that is expanded anteriorly and a moderate to long anterior canal. Their growth lines have a shallow posterior sinus. When present, columellar folds or pseudofolds have a medial to anterior position. Tudiclidae includes fusiform to rapiform gastropods having a rounded aperture and a moderate to long anterior canal. When present, the single columellar fold is at the base of the columella immediately adjacent to the anterior canal and the inner lip is wrapped over the fold. Melongenidae comprises fusiform to pyriform gastropods having a large aperture that is expanded posteriorly and tapers anteriorly into the anterior canal. Melongenids lack columellar folds and have growth lines that are opisthocline across the ramp.

Geographic areas for fossil localities are numbered on Figure 1 and are referred to throughout this paper by these numbers in parentheses. Abbreviations used with locality and catalog numbers are: CAS = California Academy of Sciences; LACMIP = Natural History Museum of Los Angeles County, Invertebrate Paleontology; LSJU = Stanford University; SDSNH = San Diego Society of Natural History; UCB = University of California, Berkeley; UCBMP = University of California, Berkelev, Museum of Paleontology; UCLA = University of California, Los Angeles; UCR = University of California, Riverside; USGS = United States Geological Survey; USNM = United States National Museum. UCLA collections are at the Natural History Museum of Los Angeles County. LSJU collections are at the California Academy of Sciences.

Pacific slope Paleocene mollusks are customarily referred to the "Martinez" stage, but Saul (1983) has tentatively assigned some mollusks to standard European stages. These assignments are largely based on stratigraphic juxtaposition of the P4 Zone foraminifer *Planorotalites pseudomenardii* and the mollusks. This zone falls largely within the recognized late Paleocene stage, the Thanetian, but, in part because the stratotype of the Thanetian is so limited. Berggren et al. (1985, p. 150) suggested replacing the Thanetian with the Selandian which has a more inclusive stratotype, or subdividing the Selandian and utilizing the Thanetian as the upper substage. Both terms are used in this paper in accordance with this latter suggestion. "Martinez" may be roughly equivalent to Selandian, and "Martinez" mollusks from below the P4 Zone are assigned an early Selandian age.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Linnaeus, 1758
Class GASTROPODA Cuvier, 1797
Order NEOGASTROPODA Wenz, 1938
Superfamily MURICACEA Rafinesque, 1815
Family TUDICLIDAE Cossmann, 1901,
emend. Finlay and Marwick, 1937

Discussion.—Finlay and Marwick (1937, p. 69) suggested that Cossmann's (1901) four turbinellid (=Xancidae or Vasidae)

subfamilies, Turbinellinae, Tudiculinae, Fulgurinae, and Melongeninae, be promoted to family rank. Cossmann's (1901, p. 60) use of the spelling Tudiculinae was based upon his unjustified emendation of Röding's (1798) genus to *Tudicula* (Cossmann, 1901, p. 68). *Tudicla* Röding, 1798, *Pyropsis* Conrad, 1860, *Pseudoperissolax* Clark, 1918, *Napulus* Stephenson, 1941, *Tudiclana* Finlay and Marwick, 1937, *Perissolax* Gabb, 1861, and *Rapopsis* n. gen. comprise the Tudiclidae. The family has been well characterized by Finlay and Marwick (1937) and by Zinsmeister (1983b). Tudiclids characteristically have a short to moderately elevated spire and whorls that are broad shouldered and have nodes, tubercles, or axial nodes on the angulations. The body whorl contracts into a siphonal neck that in some genera is quite long. In *Tudicla* and *Rapopsis* there is a sharp fold on the columella at the base of the siphonal canal; in *Pyropsis* there is a swelling; but in *Napulus* and *Pseudoperissolax* the columella is smooth and straight. Fully mature *Pseudoperissolax* develop a pseudofold in this position. Thus, tudiclids have one or no fold at the base of the columella. The fold of *Tudicla* and *Rapopsis* and the swelling of *Pyropsis* are partly a reflection of the separation of the inner lip from the columellar wall proper.

Most workers have succumbed to the confusingly similar names of *Tudicla* and *Tudicula,* and even when correctly recognizing generic relationships, as does Sohl (1964), have confounded Tudiclidae with Vasidae (=Xancidae, Turbinellidae); or when clearly distinguishing the family Tudiclidae, as did Zinsmeister (1983b), have confused *Tudicla* and *Tudicula.* Cossmann (1901, p. 68–70) included representatives of at least three families in his discussion of the unjustifiably emended *Tudicla.* Davies (1971, p. 382) spelled Tudiclinae correctly but then inappropriately characterized the subfamily as having one or two oblique columellar folds rather than one or none. Abbott (1959) recognized the relationship of living *Tudicula* to *Vasum,* on both anatomical and conchological similarities, and that *Tudicla* is not closely related; but he indicated that *Tudicla krenkeli* Cox, 1925, described as having three columellar folds, is the earliest true *Tudicla* (Abbott, 1959, p. 31). These confusions make chronologic and paleobiogeographic distributions of Tudiclidae difficult to compile. The family was certainly more diverse and widespread in the Late Cretaceous and early Tertiary than at present.

Tudicula H. and A. Adams, 1863 (type species, *T. armigera* A. Adams, designated by Wenz, 1943), is represented by several Holocene species, and its anatomy is known. *Tudicula* has three or four folds on the columella and is closely related to *Vasum* (Abbott, 1959). The Vasidae have been included in the Volutacea (Abbott, 1959; Taylor and Sohl, 1962), the Buccinacea (Sohl, 1964), and the Muricacea (Pondor, 1973).

But *Tudicla* Röding, 1798 (type species, *Tudicla carinata* Röding, 1798 = *Murex spirillus* Linnaeus, 1767, designated by Fischer, 1884), has only a single fold at the base of the columella. The anatomy of the only living tudiclid, *Tudicla spirilla* (Linnaeus), which inhabits the Bay of Bengal in the Indian Ocean, is unknown (Abbott, 1959, p. 31). The inclusion of this species in the Vasidae has apparently been based upon its rapiform shell shape, but it lacks the multiple columellar folds of the Vasidae and has a rounder aperture. The shell morphology has been considered in the past to indicate inclusion elsewhere; Stoliczka (1867, p. 150) placed *Tudicla* in the subfamily Rapaninae of the Muricidae, doubtless being influenced by the Cretaceous forms that have an aperture similar to *Tudicla* but a shorter anterior canal and an umbilicus similar to that of *Rapana* Schumacher, 1817. Muricids, including Rapaninae, are listed as lacking columellar folds (Ponder, 1973, p. 326), but Sohl (1964) included *Sargana* Stephenson, 1923, which has a basal columellar fold, in the subfamily Rapaninae of the Muricidae (a placement accepted by Radwin and D'Attilio, 1976). He also included in the Muricidae the subfamily Moreinae Stephenson, 1941, which has a similar fold. Stephenson (1923) had erected a family Sarganidae for *Sargana* because of this strong columellar fold, and Keen (1971) recognized both of the families Sarganidae and Moreidae and included them in the Muricacea. The strong columellar fold possessed by some tudiclids does not, therefore, exclude them from the Muricacea (sensu Taylor and Sohl, 1962; Sohl, 1964; Keen, 1971; Radwin and D'Attilio, 1971).

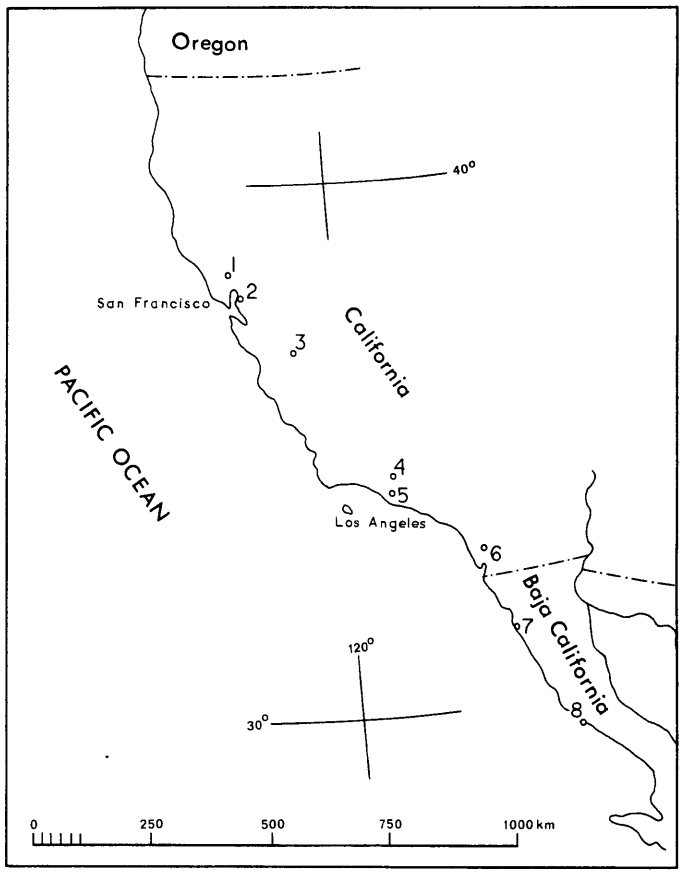

FIGURE 1—Index map to geographical areas of localities cited in this paper. Areas are listed from north to south. Places within each area are listed alphabetically. (1) Herndon Creek, south of Lower Lake, Lake County, California. (2) Vicinity of Martinez, includes Gum Tree Hill, Pacheco, Stewartville, Contra Costa County, California. (3) Panoche Creek at junction with Silver Creek, Tumey Hills, Fresno County, California. (4) Warm Springs Mountain, Los Angeles County, California. (5) Simi Hills, Ventura County, California. (6) Carlsbad Research Park, north of Palomar Airport, San Diego County, California. (7) Punta San Jose, Baja California, Mexico. (8) Arroyo Santa Catarina, Baja California, Mexico.

Genus RAPOPSIS n. gen.

Type-species.—*Rapopsis joseana* n. sp.

Diagnosis.—Tudiclid gastropods with low-spired, rapiform shells; whorls shouldered, peripherally expanded, strongly constricted anteriorly; siphonal neck moderately long, umbilicate, bent; columella with a single, strong fold at anterior end of aperture; aperture rounded with well-developed posterior sinus

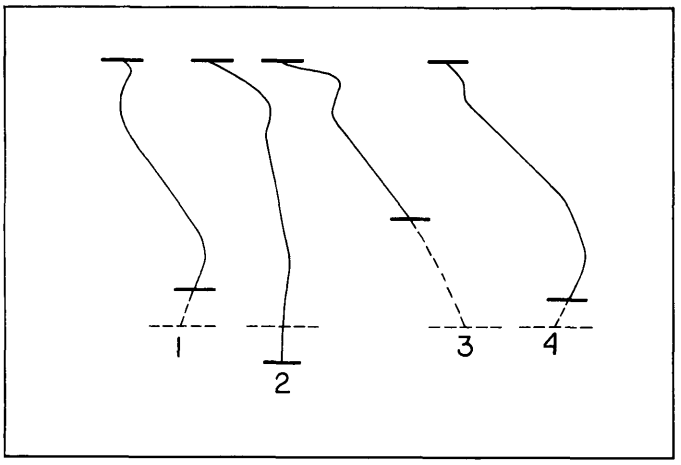

FIGURE 2—Comparison of posterior portion of growth lines of *Rapopsis joseana* and three species of *Pyropsis* from camera lucida tracings adjusted to uniform distance between posterior suture and periphery. Chosen growth line is on last whorl as near the aperture as possible and the anterior suture is projected. Heavy lines indicate posterior and anterior sutures, and dashed line indicates periphery or, for those having a broad periphery, the posterior side of the periphery. *1, Rapopsis joseana* n. sp. *2, Pyropsis fantozzii* n. sp. *3, ?P. gabbi* (Stanton). *4, P. striata* (Stanton). The periphery is anterior to the suture in *R. joseana, ?P. gabbi,* and *P. striata.*

at suture producing a strong welt externally; outer lip thickened, beveled, inconspicuously dentate within; inner portion of inner lip delicately wrinkled; sculpture predominately spiral, consisting of strong, broad, carina-forming ribs overridden by finer spiral ribs and riblets; subsutural welt, carina, and stronger ribs made nodose by collabral undulations.

Discussion.—As in the tudiclids *Tudicla* and *Pyropsis,* the inner lip wraps over the columellar fold and leaves an umbilical opening below, the aperture is well rounded, and the anterior canal is of at least moderate length. *Rapopsis* differs from *Pyropsis* in its more open umbilicus, shorter, more bent anterior canal, obscurely wrinkled inner lip, stronger and sharper columellar fold, and lack of spines. It differs from *Tudicla* in having a much shorter, more bent anterior canal with a strong siphonal fasciole and a narrow umbilical opening.

The aperture is similar to that of *Sargana* Stephenson, 1923, placed by Sohl (1964, p. 173, Pl. 19, figs. 12, 16, 22, 25) in the muricid subfamily Rapaninae, but the anterior canal is much longer. *Rapopsis* lacks the spines of *Sargana,* has a more angulate whorl profile, and a narrower umbilicus. Rapaninae are stoutly bucciniform to rapiform in shape, except for *Sargana,* have a smooth columella, are generally strongly sculptured, have a large aperture that tends to be nearly simicircular in shape, and have a basal spiral grove ending in a blunt labial tooth (Radwin and D'Attilio, 1971).

Rapopsis differs from perissityids in its well-rounded rather than elliptical aperture, in having an umbilicus, and in its *Tudicla*-like columellar fold and wrapped over inner lip.

Tudicla exima Stoliczka, 1867, of probable Maastrichtian age from the Ariyalur Group of Karapadi, India, is also a *Rapopsis.* In addition, three species tentatively included by Sohl (1964) in *Pyropsis, Rapa andoorensis* Stoliczka, 1867, *Rapa nodifera* Stoliczka, 1867, and *Rapa cancellata* (Sowerby) of Stoliczka, 1867, may belong to *Rapopsis;* these are from the Trichinopoly Group and are older than *Rapopsis exima;* they have the shorter, more bent anterior canal of *Rapopsis,* but the weaker collumellar fold of *Pyropsis* and their sculpture appears to be more nodular than spinose.

Etymology.—The generic name, a combination of *Rapana* and *Pyropsis,* is descriptive of its turnip-like shape and reflects the intermediate form and sculpture of *Rapopsis,* which partake of genera assigned to the families Rapanidae and Tudiclidae.

RAPOPSIS JOSEANA n. sp.
Figures 2.1, 3.1–3.8, 3.10

Diagnosis.—Biangulate *Rapopsis* with concave whorl profile both on ramp and anterior to broad periphery; anterior and posterior angulations bearing wide spiral rib, each with about 15 low nodes per whorl.

Description.—Shell pyriform, low spired; protoconch large, consisting of 1–1.5 whorls; profile of last whorl concave on ramp, juvenile whorls slightly convex; anterior and posterior angulations nearly equal, marked by about 15 nodes on each; whorl narrowing abruptly and concavely to anterior siphonal neck; siphonal neck about 40 percent of shell height, bent backward and abaperturally, having strong siphonal fasciole surrounding deep, narrow umbilicus; suture covering noded posterior angulation, developing a strong welt; growth line concave across ramp to anterior angulation, then slightly opisthocline.

Overall sculpture of fine spiral ribs, slightly narrower than interspaces and of nearly equal strength, slightly stronger on angulations and superposed on wide spiral rib that marks each angulation; nodes of posterior angulation somewhat better developed than those of anterior angulation.

Aperture rounded with well-defined posterior sinus at inner–outer lip junction; outer lip with slight flare; inner lip clearly demarked, of moderate thickness, with slight parietal thickening just anterior to posterior sinus; columella with strong plait at base of anterior siphon.

Types.—Holotype, SDSNH 32676; paratypes, SDSNH 32677 from SDSNH loc. 3405 near Palomar Airport (6), San Diego Co., California; LACMIP 7613 from UCLA loc. 5431, Punta San Jose (7); LACMIP 7614 from UCLA loc. 6534, Arroyo Santa Catarina (8), Baja California, Mexico.

Type locality.—SDSNH loc. 3392, near Palomar Airport (6), San Diego Co., California.

Dimensions.—Holotype, height 27.8 mm, diameter 22.0 mm, height of spire 2.8 mm, length of siphonal neck 11.0 mm; paratype LACMIP 7613, height 16.0 mm (anterior canal missing), diameter 17.0 mm, height of spire 3.7 mm.

Distribution.—Apparently rare in the Point Loma Formation at Carlsbad (6), San Diego Co., California; and the Rosario Formation at Punta San Jose (7) and Arroyo Santa Catarina (8), Baja California, Mexico.

Geologic age.—Cretaceous, early Maastrichtian.

Remarks.—The above description is based on four specimens. The holotype and paratype SDSNH 32677 are well preserved. The paratype from Punta San Jose, LACMIP 7613, is an immature individual; its outer lip is chipped about the periphery and the anterior canal is broken off. The most mature shell, LACMIP 7614, from Arroyo Santa Catarina, is less complete but gives some indication of the adult shape. Youthful *R. joseana* may easily be confused with youthful *Perissitys colocara* Popenoe and Saul, 1987; both are rapiform with noded periphery and similar spiral sculpture. *Rapopsis joseana* does not develop the callus coating over the outside of the whorl typical of *P. colocara,* has the two noded angulations slightly farther apart, and has a strong plait on the columella at the beginning of the anterior siphonal canal. *Rapopsis joseana* is very similar to *Pyropsis fantozzii;* it differs in being lower spired and in having smaller peripheral nodes, stronger spiral sculpture, and a round-

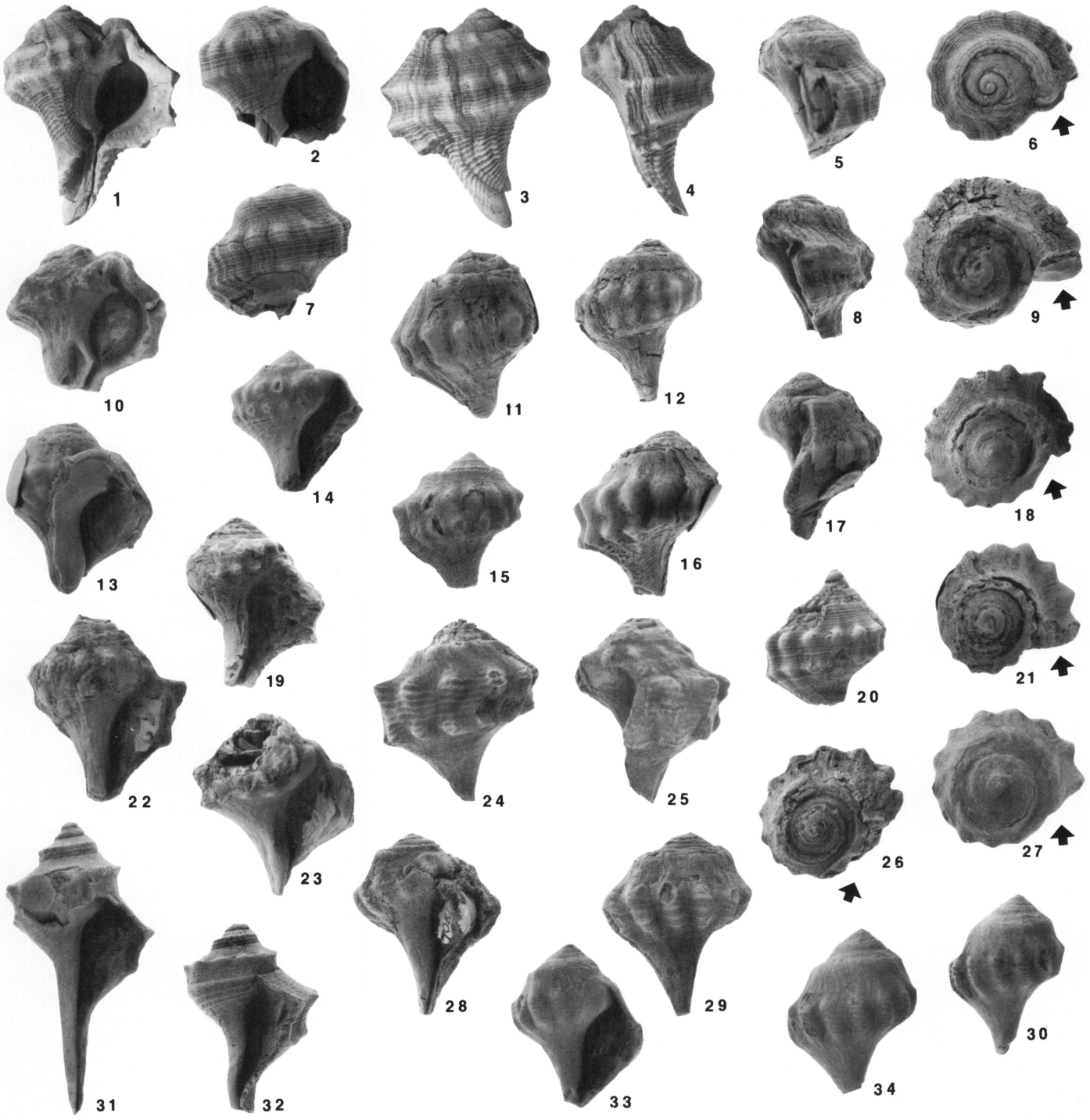

FIGURE 3—Five species of tudiclid gastropods: *Rapopsis joseana* n. sp., *Pyropsis fantozzi* n. sp., *P. striata* (Stanton, 1896), ?*P. gabbi* (Stanton, 1896), and *Pseudoperissolax blakei* (Conrad, 1855). All figures × 1 unless otherwise noted. Arrows on apical views point at position of aperture. *1–8, 10, Rapopsis joseana* n. sp.; *1, 3, 4,* SDSNH cat. no. 32676 from SDSNH loc. 3392, holotype ×1.5; *2, 5–7,* LACMIP cat. no. 7613 from UCLA loc. 5431, paratype, ×1.5; *8, 10,* LACMIP cat. no. 7614 from UCLA loc. 6534, paratype. *9, 11–21, Pyropsis fantozzii* n. sp.; *9, 12, 17,* UCR cat no. 6670/901 from UCR loc. 6670, paratype, *9* ×1.5, *12* ×1.25, *17* ×1.25; *11, 13,* LACMIP cat no. 7615 from UCLA loc. 2330, holotype ×1.5; *14, 15, 18,* UCBMP cat. no. 30574 from UCB loc. 3760, paratype, *14–15* ×1.25, *18* ×1.5; *16, 19, 21,* LACMIP cat. no. 7616 from UCLA loc. 3111, paratype, ×1.5; *20,* UCBMP cat no. 30575 from UCB loc. 3776, paratype, juvenile, ×2. *22–25, Pyropsis striata* (Stanton, 1896); *22, 25,* LACMIP cat. no. 7618 from LACMIP loc. 10488, hypotype; *23, 24,* LACMIP cat. no. 7619 from LACMIP loc. 10488, hypotype. *26–30, 33, 34,* ?*Pyropsis gabbi* (Stanton, 1896); *26, 28–29,* LACMIP cat. no. 7620 from LACMIP loc. 7051, hypotype; *27, 30, 33, 34,* LACMIP cat. no. 7599 from UCLA loc. 2307, hypotype, *25* ×1.5, *30, 33, 34* ×1.25. *31, 32, Pseudoperissolax blakei* (Conrad, 1855); *31,* LACMIP cat. no. 7647 from UCLA loc. 2340, hypotype; *32,* LACMIP cat. no. 7648 from UCLA loc. 2340, hypotype, aperture cut away to show low, oblique pseudofold on columella.

er aperture. *Rapopsis joseana* is more strongly noded than *R. exima* (Stoliczka) and has more and stronger spiral riblets. *Rapopsis andoorensis* (Stoliczka) has a much weaker columellar fold than *R. exima* and *R. joseana,* but a similar whorl profile. It further differs from *R. joseana* in lacking nodes on the angulations and in having a moderately strong spiral rib below the anterior angulation. Both *R. cancellata* (Sowerby of Stoliczka) and *R. nodifera* (Stoliczka) have a weaker columellar fold and stronger spiral sculpture than *R. joseana.* Additionally, *R. cancellata* has a rounder whorl profile, and *R. nodifera* has the posterior angulation so strong and the anterior so weak that the shell is more obconic than pyriform.

Etymology.—The specific name is derived from Punta San Jose, Baja California, Mexico.

Genus PYROPSIS Conrad, 1860

Type-species.—By monotypy, *Tudicla (Pyropsis) perlata* Conrad, 1860, p. 288.

Discussion.—Both Abbott (1959) and Sohl (1964) emphasized the relationship of *Pyropsis* to *Tudicla.* Sohl (1964, p. 234) reviewed the history of *Pyropsis* and its classification. He considered it generically distinct from, but closely related to, *Tudicla* Röding, 1798, and placed it with *Tudicla* in the family Xancidae, subfamily Vasinae. This close relationship to *Tudicla,* however, places *Pyropsis* in the Tudiclidae. *Pyropsis* is pyriform to rapiform, has a short spire, swollen, shouldered whorls, with strong spiral sculpture and a tendency to form nodes and spines on the spirals, an abruptly contracted base, a long anterior canal, and a broad weak to strong swelling at the base of the columella about which the inner lip wraps. Typically, the wrapping of the inner lip leaves an umbilical chink, but in those species assigned to *Medionapus* by Stevenson (1941) the umbilical fissure is sealed or nearly so. Sohl (1964) considered the size of the umbilical chink to be of specific importance and included these species in *Pyropsis.*

West Coast species herein assigned to *Pyropsis* differ from Western Interior and Gulf Coast *Pyropsis* in having spiral ribbing that is finer and less rough and a stronger axial component to the sculpture; the length of the canal is undetermined on all of them. *Pyropsis fantozzii* and *P. striata* from California have two rows of nodes, the stronger one at the shoulder and a subequal row at the anterior angulation. Both species resemble *Rapopsis* in their biangulate whorl profile, but do not appear to have had a bent anterior siphonal canal. They resemble *Pseudoperissolax* Clark, 1918, in having a strongly bicarinate periphery and a whorl profile that is concave both on the ramp and anterior to the periphery, but they differ in having a lower spire and more rapidly increasing whorl diameter than do *Pseudoperissolax tricarinata* (Weaver, 1905), *P. praeblakei* Vokes, 1939, or *P. blakei* (Conrad, 1855) (Figure 3.31–3.32). *Pseudoperissolax blakei* has an oblique pseudofold well within the aperture at the beginning of the anterior siphonal canal, and an aperture resembling that of *Pyropsis* and *Tudicla.*

PYROPSIS FANTOZZII N. SP.
FIGURES 2.2, 3.9, 3.11–3.21

Heteroterma trochoidea Gabb. NELSON, 1925, p. 427, in part, Pl. 58, figs. 3, 5 only (not fig. 4 = *Heteroterma trochoidea* Gabb, 1869).

Cophocara stewarti ZINSMEISTER, 1983b, p. 1298, in part, fig. 3K only (not fig. 3J = *Perissitys stewarti* (Zinsmeister)).

Diagnosis.—Biangulate *Pyropsis* with concave whorl profile on ramp; two spiral rows of about 15 strong nodes on each angulation.

Description.—Shell small for genus, pyriform, low spired; profile of last whorls concave on ramp, prior whorls slightly convex; anterior and posterior angulations nearly equal, marked by about 15 nodes on each; whorl narrowing abruptly to anterior siphonal neck; suture just anterior to noded posterior angulation; growth line slightly concave on ramp.

Overall sculpture of fine spiral ribs narrower than interspaces anterior to posterior angulation and on siphonal neck.

Aperture roundish with posterior sinus at inner–outer lip junction; inner lip clearly demarked, thickened, with parietal thickening just anterior to posterior sinus; columella with plait at base of anterior siphon.

Types.—Holotype, LACMIP 7615; paratypes, UCR 6670/901 (Zinsmeister, 1983b, fig. 3K); UCBMP 30574 from UCB loc. 3760 (Nelson, 1925, Pl. 58, fig. 3); UCBMP 30575 from UCB loc. 3776 (Nelson, 1925, Pl. 58, fig. 5); LACMIP 7616 from UCLA loc. 3111, and 7617 from UCLA loc. 2330.

Type locality.—UCLA loc. 2330, Simi Hills, Ventura Co., California (5).

Dimensions.—Holotype LACMIP 7615, height 18.7 mm (incomplete), diameter 16.5 mm (incomplete), spire height 4.8 mm (incomplete); paratypes UCR 6670/901, height 22.0 mm (incomplete), diameter 6.0 mm, spire height 3.7 mm; LACMIP 7616, height 18.8 mm (incomplete), diameter 6 mm, spire height 4.1 mm; LACMIP 7617, height 20.7 mm (incomplete), diameter 23.7 mm, spire height 6.5 mm (incomplete).

Distribution.—Lower Santa Susana Formation of the Simi Hills (5), Ventura Co., California.

Geologic age.—Paleocene, early Selandian, zone of *Turritella peninsularis.*

Remarks.—Eight specimens are at hand; all are incomplete; the largest (LACMIP 7617) lacks most of its shell. These specimens show considerable variation in strength of nodes, thickness of the inner lip, and whorl profile anterior to the anterior angulation. One specimen (LACMIP 7616) is distinctly more similar to *P. striata* (Stanton, 1896) in shape and size of nodes than are the other specimens. But even this specimen of *P. fantozzii* differs from *P. striata* (Stanton, 1896) in having more nodes per whorl and finer spiral riblets. *Pyropsis fantozzii* additionally differs from *P. striata* in having a slightly lower spire and a thicker inner lip with a posterior welt and low plication at the base of the columella. Most of the specimens have a somewhat stronger spiral riblet just anterior to the anterior angulation, causing the anterior angulation to be more rounded and the whorl base to resemble that of youthful *Pseudoperissolax* (Figure 3.32). These resemble *P. gabbi* (Stanton, 1896) in shape but differ from that species in their distinctly binoded periphery. The holotype of *P. fantozzii* combines elements of these two variants but resembles *Rapopsis joseana* in having a much thickened inner lip with a posterior parietal welt and basal columellar fold. All specimens have the anterior siphon broken, but there is no indication of an umbilicus. With the specimens at hand, the possibility remains that more than one species may be included among the specimens assigned to this taxon; but the possibility that *P. fantozzii* is the precursor of *P. striata* is supported by morphologic similarity and the earlier geologic occurrence of *P. fantozzii.*

Specimens of *Pyropsis fantozzii* have been identified as *Heteroterma trochoidea* Gabb, 1869, and *Perissitys stewarti* (Zinsmeister, 1983b) because of similar shape and sculpture. *Pyropsis fantozzii* differs from these two in having the two spiral rows of nodes farther apart, a rounder aperture, and a plait at the base of the columella. The ramp of *P. fantozzii* is concave, but slopes less than that of *Perissitys stewarti,* producing a whorl that is broader posteriorly. The spire of *P. fantozzii* is slightly higher than that of *Perissitys stewarti* and lower than that of *H. trochoidea. Pyropsis fantozzii* has a thicker inner lip, a rounder aperture, and a broader periphery than does *H. trochoidea,* and

it differs from *Rapopsis joseana* in its finer spiral sculpture, stronger nodes on anterior and posterior angulations, angulations that are more widely spaced, slightly more angulate aperture, less enveloped spire, weaker fold at the base of the columella, and probable lack of the bent siphonal neck and umbilicus of *Rapopsis*. It differs from *Pseudoperissolax blakei* (Figure 3.31–3.32) in having a lower spire and well-developed nodes on the anterior angulation.

Etymology.—The species is named for J. H. Fantozzi, whose collections from the lower Santa Susana Formation have been very useful.

PYROPSIS STRIATA (STANTON, 1896)
FIGURES 2.4, 3.22–3.25

Heteroterma striata STANTON, 1896, p. 1046, Pl. 67, fig. 5.
not *Heteroterma striata* Stanton. SMITH, 1975, p. 479, Pl. II, fig. 19–20; ZINSMEISTER, 1983a, p. 70, Pl. 4, fig. 8; ZINSMEISTER, 1983b, p. 1299, fig. 3L–N; all = *Protobusycon judithae* n. sp.

Diagnosis.—Biangulate *Pyropsis* with concave whorl profile both on ramp and anterior to broad periphery; about 12–13 strong nodes on each angulation.

Description.—Shell small for genus, pyriform, low spired; profile of last whorls concave on ramp; posterior angulation stronger than anterior, each with about 12–13 strong nodes; whorl narrowing abruptly and concavely to anterior siphonal neck; suture on noded posterior angulation bounded anteriorly by waved welt; growth line concave on ramp, slanting aperturally across periphery.

Overall sculpture of fine spiral ribs narrower than interspaces, very fine and faint on ramp, strongest on periphery and siphonal neck.

Aperture subangulately equant with posterior sinus at inner–outer lip junction; inner lip demarked, moderately thickened; columella abruptly bent at base of anterior siphon.

Types.—Holotype, USNM 157845; hypotypes, LACMIP 7618–7619 from LACMIP loc. 10488 (=Weaver loc. 2080) (2).

Type locality.—USGS loc. 4189, 1 mile north of Pacheco, Contra Costa Co., California (2).

Dimensions.—Hypotype LACMIP 7618, height 30.0 mm (incomplete), diameter 26.5 mm.

Distribution.—Upper Vine Hill Sandstone of the Martinez area, Contra Costa Co. (2); basal Lodo Formation of Panoche Creek, Fresno Co. (3), California.

Geological age.—Late Paleocene, Thanetian, zones of *Turritella infragrantulata* and *T. i. pachecoensis*.

Remarks.—This species was included in a list of "common Martinez species" by Dickerson (1914, p. 113), but it seems to be rare and is not present in collections from several of the localities at which it is listed by Dickerson. The two hypotypes are from near the type locality; they and the holotype are all incomplete. Two fragments from the basal Lodo Formation on Panoche Creek, Fresno County (3), may also be this species. The inner lip of *P. striata* is not as thickened as is usual in *Pyropsis*, and, although there is a slight swelling on the columella at the beginning of the siphonal canal, none of the available specimens has a strong, sharp plait like that of *Rapopsis joseana*. *Pyropsis striata* differs from *R. joseana* and *P. fantozzii* in having fewer and larger nodes on its angulations and a somewhat higher spire. The species has been confused with the melongenid *Protobusycon judithae* n. sp. from which it differs in having a biangulate whorl with a row of nodes on each angulation of the body whorl and much finer spiral sculpture on the ramp. The biangulate body whorl resembles that of *Tudicla rusticula* Basterot, 1825, of Miocene age, but the whorl is less expanded and the columellar swelling is less well developed.

?PYROPSIS GABBI (Stanton, 1896)
Figures 2.3, 3.26–3.30, 3.33–3.34

Heteroterma gabbi STANTON, 1896, p. 1046, Pl. 67, fig. 3; ZINSMEISTER 1983a, p. 70, Pl. 4, figs. 6, 7; ZINSMEISTER, 1983b, p. 1299, in part, fig. 3O–P only.
not *Heteroterma gabbi* Stanton. DICKERSON, 1914, p. 151, Pl. 17, fig. 1; CLARK, 1929, Pl. 2, fig. 2, = *Protobusycon judithae* n. sp.; nor ZINSMEISTER, 1983b, p. 1299, in part, fig. 3Q, = *?Heteroterma acrita* SAUL, in press.

Diagnosis.—*Pyropsis* with strong, short axial ribs about periphery overridden by four narrow spiral ribs; inner lip relatively narrow and appressed; columella with bend at base of anterior siphon.

Description.—Shell of moderate size, pyriform, low spired; profile concave on ramp, abruptly angled on adapical side of periphery and roundly angled on anterior side of periphery, flatly sloped for length of axial ribs, contracting abruptly and concavely to form narrow siphonal neck; suture covering or nearly covering nodes of posterior angulation, with strong subsutural welt; growth line with small antispiral sinus on welt, shallow antispiral sinus across ramp, and spiral antisinus at base of whorl.

Periphery with about 14 strong, rounded, axial ribs, appearing abruptly at posterior angulation and dying out on base, overridden by four moderate spiral ribs narrower than interspaces; interspaces, base of whorl, and posterior half of neck with finer spiral riblets; ramp and anterior half of neck nearly smooth.

Aperture lenticular, with small posterior sinus at welt, constricted by bend to columella and produced anteriorly; outer lip unknown; inner lip clearly demarked, of moderate width and extending adapically onto body whorl almost to previous suture.

Types.—Holotype, USNM 157831; hypotypes, LACMIP 7620 from LACMIP loc. 7051, Lower Lake, Lake Co. (1); LACMIP 7599 from UCLA loc. 2307, Simi Hills, Ventura Co. (5), California.

Dimensions.—Holotype, height 42.5 mm, diameter 35.7 mm, height of spire (incomplete) 6.4 mm; hypotype LACMIP 7620, height 30.0 mm, diameter 25.0 mm, height of spire 6.0 mm.

Type locality.—USGS loc. 4192, Lower Lake, Lake Co. (1), California.

Distribution.—"*Heteroterma gabbi* Stanton" is a common entry on molluscan check lists from most Pacific slope Paleocene localities. *?Pyropsis gabbi* has, however, been much confused with *Protobusycon judithae* n. sp. and *?Heteroterma acrita* Saul (in press). *?Pyropsis gabbi* certainly occurs in the "Martinez" Formation along Herndon Creek, southeast of Lower Lake (1), and in the lower Santa Susana Formation, *Turritella peninsularis* Zone, Simi Hills (5). A partial specimen from UCLA loc. 1595, San Francisquito Formation on Warm Springs Mountain (4), may also be this species.

Geologic age.—Paleocene, ?late Danian, zone of *Turritella peninsularis quaylei*, and early Selandian, zone of *Turritella peninsularis*. Identifications of *Heteroterma gabbi* from rocks of later Paleocene age should be rechecked.

Remarks.—*?Pyropsis gabbi* is apparently not rare in the vicinity of its type locality, but most specimens are crushed or incomplete. All available Simi Hills specimens are smaller than are topotypes, have a less strongly developed subsutural welt, are less widely expanded at the posterior angulation, and appear to have a higher spire.

The species differs notably from other *Pyropsis* in having the axial sculpture much stronger than the spiral sculpture, the aperture more elongate and less expanded posteriorly, and the columellar bend weak for a *Pyropsis*. The strong subsutural welt suggests *Perissitys*, but the columellar bend is stronger than that of *Perissitys*, and the aperture is less expanded anteriorly. The

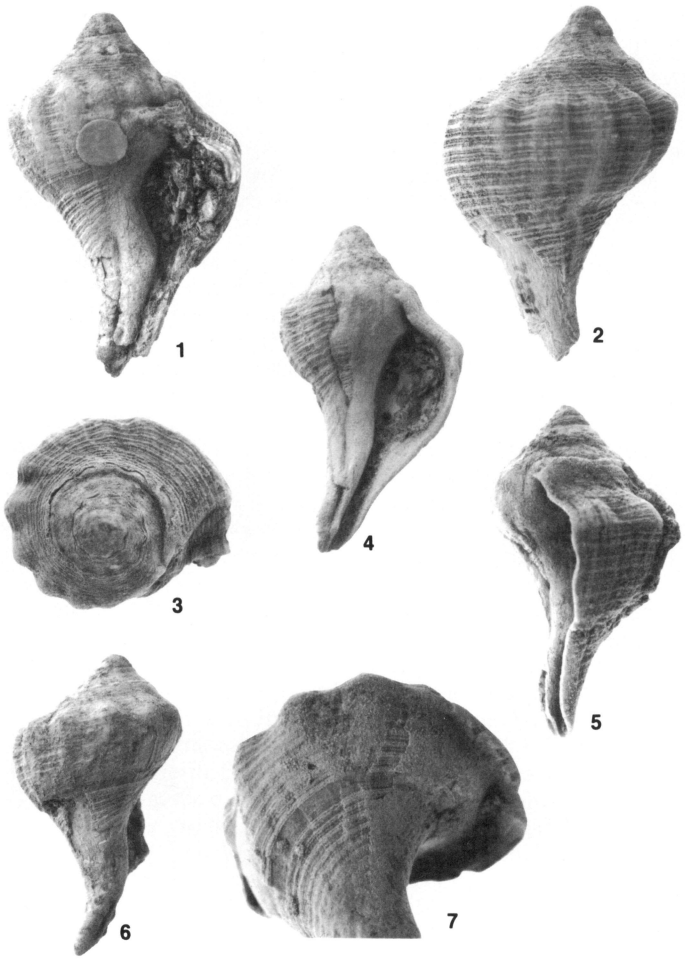

FIGURE 4—*Protobusycon judithae* n. sp., all ×1 unless otherwise indicated. *1–3,* LACMIP cat. no. 7621 from UCLA loc. 6456, holotype; *4, 5,* LACMIP cat. no. 7623 from LACMIP loc. 7044, paratype with body whorl somewhat compressed but apparently complete anterior canal; *6,* LACMIP cat. no. 7622 from UCLA loc. 6456, paratype; *7,* LACMIP cat. no. 7624 from LACMIP loc. 7044, paratype, spiral band on base of whorl near inner lip, ×2.

whorl profile of ?*Pyropsis gabbi* (Stanton, 1896) bears some resemblance to the Northeast Pacific genus *Perse* Clark, 1918, but the fold on the columella of *Perse* is very oblique. ?*Pyropsis gabbi* is remarkably similar in shape and sculpture to *Lupira pyriformis* Stephenson, 1941, and *L. varibilis* (Wade, 1926), of Maastrichtian age from the Gulf Coast Ripley Formation (Sohl, 1964), but *Lupira* has folds on the columella near the mid-point of the inner lip whereas the columellar bend of ?*P. gabbi* is adjacent to the anterior siphon. ?*Pyropsis gabbi* also resembles the melongenid *Pyrifusus crassus* Sohl, 1964, of Maastrichtian age (Sohl, 1964) from the Ripley Formation, but ?*Pyropsis gabbi* has a more widely expanded whorl that is narrower about the periphery, a narrower anterior canal, and a rounder aperture.

?*Pyropsis gabbi* differs from *Protobusycon judithae* n. sp. in having a very strong subsutural welt, stronger axial ribs that arise more abruptly about the periphery, no spiral band about the base of the whorl, and apparently no fasciole on the anterior siphonal neck. It differs from ?*Heteroterma acrita* in having a lower spire, stronger spiral ribbing on the periphery but a smoother siphonal neck, and a slightly stronger bend to the columella. Both ?*Pyropsis gabbi* and ?*Heteroterma acrita* resemble "*Heteroterma*" *zelandica* Marshall, 1917 (p. 453, Pl. 35, figs. 20, 21; Finlay and Marwick, 1937, p. 84, Pl. X, figs. 8–10), from the Wangaloan of New Zealand and "*H.*" *praecursor* (Wilckens, 1907, p. 21, Pl. 3, figs. 14, 15) from the Maastrichtian of Chile. ?*Pyropsis gabbi* has a lower spire, a smaller aperture that is more abruptly constricted anteriorly, a heavier inner lip, and a somewhat stronger swelling or angulation to the columella. ?*Pyropsis gabbi* differs from *Tudiclana simulator* Finlay and Marwick, 1937 (p. 70, Pl. IX, figs. 4–6), in lacking an obvious plait on the columella, in probably having a shorter canal, in having the whorls more enveloping and a strong subsutural welt, a thicker inner lip, a more biangulate whorl profile, and stronger axial ribs and weaker spiral ribs.

Family MELONGENIDAE Fischer, 1884
Genus PROTOBUSYCON Wade, 1917

Type-species.—By original designation, *Busycon (Protobusycon) cretaceum* Wade, 1917, p. 295.

PROTOBUSYCON JUDITHAE n. sp.
Figure 4.1–4.7

?*Heteroterma gabbi* Stanton. DICKERSON, 1914, p. 151, Pl. 17, fig. 1; CLARK, 1929, Pl. 2, fig. 2.

Heteroterma striata Stanton. SMITH, 1975, p. 479, Pl. II, figs. 19, 20; ?ZINSMEISTER, 1983a, p. 70, Pl. 4, fig. 8; ?ZINSMEISTER, 1983b, p. 1299, fig. 3L–N; not *Heteroterma striata* Stanton, 1896.

Diagnosis.—A *Protobusycon* with low, evenly tapered spire, low rounded nodes on shoulder; spiral band broad and shallow.

Description.—Shell of moderate size, pyriform, low spired, strongly shouldered; spire profile concave, flank broadly convexly rounded from shoulder to whorl base, shallowly concave from base to anterior siphon; base of whorl with shallow spiral band; suture lapping over shoulder; anterior siphon of moderate length, with well-developed fasciole, bent at angle of about 30° to columella; growth line strongly opisthocline across ramp, broadly sinused across flank, antisinused on spiral band, and thence nearly straight to siphonal fasciole.

Overall sculpture graded sets of fine spiral ribs crossing growth lines to produce finely but roughly textured surface; shoulder with broad collabral swellings dying out both anteriorly and posteriorly.

Aperture ovoid, with small posterior notch at inner–outer lip juncture; inner lip clearly demarked, thickened, of moderate width.

Types.—Holotype, LACMIP 7612; paratypes, LACMIP 7622 from UCLA loc. 6456, 7623, 7624 from LACMIP loc. 7044, LSJU 10245 from CAS loc. 61666 (Smith, 1975, Pl. II, fig. 19), and UCBMP 14209 from UCB loc. A-6717 (Smith, 1975, Pl. II, fig. 20); hypotypes, UCBMP 11733 from UCB loc. 1540 (Dickerson, 1914, Pl. 17, fig. 1; Clark 1929, Pl. 2, fig. 2), UCLA 59294 from UCLA loc. 3117 (Zinsmeister, 1983a, Pl. 4, fig. 8; 1983b, fig. 3L), and 59295 from UCLA loc. 3114 (Zinsmeister, 1983b, fig. 3M, N).

Type locality.—UCLA 6456, at the confluence of Silver and Panoche Creek, Fresno Co. (3), California.

Dimensions.—Holotype, height 47 mm, diameter 31.9 mm, height of spire 10 mm.

Distribution.—"Martinez" 1.6 km (1 mi) south of Stewartville, Contra Costa Co. (2); basal Lodo Formation on Panoche Creek, Fresno Co. (3); lower Santa Susana Formation, Simi Hills, Ventura Co. (5), California.

Geologic age.—Paleocene, Thanetian, zones of *Turritella infragranulata* and *T. i. pachecoensis.*

Remarks.—The species is common in the basal Lodo Formation along Panoche Creek east of Silver Creek, Tumey Hills,

Fresno County (3). Compared to the larger specimens from the vicinity of the type locality, the smaller specimens have a relatively higher spire, more prominent collabral ribs, and the strongest rib of the graded sets of spiral ribs stronger. From youth to maturity the suture progressively overlaps more of the posterior angulation so that the posterior ends of the collabral ribs show clearly on the early whorls but on some large specimens those of the penultimate whorl are completely overlapped. Specimens from the "Martinez" south of Stewartville (2) (*Heteroterma gabbi* Stanton of Dickerson, 1914), the Santa Susana Formation in the Simi Hills (5) (*Heteroterma striata* Stanton of Zinsmeister, 1983a, 1983b), and the Coal Canyon Formation in the Santa Monica Mountains, Los Angeles County, California, are smaller than the largest of the Panoche Creek specimens and are higher spired and more strongly sculptured than most Panoche Creek specimens. These differences may ultimately prove to be indicative of more than intraspecific variation.

Protobusycon judithae differs from *Pyropsis striata* (Stanton, 1896), with which it has been confused, in lacking the two rows of strong nodes, having a spiral band about the body whorl, having a growth line that is prosocline but not sinused on the ramp, and in its overall sculpture of strongly textured sets of spiral riblets rather than more distant subequal riblets. ?*Pyropsis gabbi* (Stanton, 1896) has a lower spire, stronger posterior and anterior angulations, and lacks the spiral band about the body whorl.

Protobusycon judithae differs from the two Maastrichtian Gulf Coast species of the Ripley Formation, *P. cretaceum* (Wade, 1917) and the slightly younger *P. binodosum* Sohl, 1964, in having a concavely sloped spire, lower more rounded nodes on the shoulder, a broader, shallower spiral band, and a more strongly bent anterior siphonal canal. *Protobusycon judithae* additionally differs from *P. binodosum* Sohl in lacking the second row of nodes.

Etymology.—The species is named for Judith Terry Smith in recognition of her work on the molluscan fauna of the Lodo Formation.

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APPENDIX

LOCALITIES CITED

With the exception of type localities, for which complete descriptions are given, previously published localities are abbreviated and referenced. Numbers in parentheses key the localities to Figure 1.

(2) 1540 UCB: S of Stewartville 1–2 km (1 mi), Mt. Diablo quad., Contra Costa Co., Calif. "Martinez" Formation. Paleocene, early Selandian. (Dickerson, 1914, p. 153.)

(4) 1595 UCLA: North side of Warm Springs Mountain, Warm Springs Mtn. quad., Los Angeles Co., Calif. San Francisquito Fm. Paleocene, ?Danian. (Saul, 1983, p. 113.)

(5) 2307 UCLA: E side near crest of spur W of W branch of Meier Canyon, 2.9 km (1.8 mi) SW of 961 B.M., Santa Susana, 1,061 m (3,500 ft) SE of hill 1480 in sec. 13, T2N, R17W, Santa Susana quad., Simi Hills, Calabasas quad., Ventura Co., Calif. Coll: W. P. Popenoe, 1/9/1946. Lower Santa Susana Fm. Paleocene, ?late Danian or early Selandian.

(5) 2330 UCLA: Nose of spur on NW side Meier Canyon, approx. 1,136 m (3,750 ft) S50°E of 1473 hill, SE¼, SE¼, sec. 12, T2N, R18W, Santa Susana quad., Ventura Co., Calif. Coll: W. P. Popenoe, 4/3/1946. Lower Santa Susana Fm. Early Selandian.

(5) 3111 UCLA: Head of Las Virgenes Canyon, Calabasas quad., Simi Hills, Ventura Co., Calif. Las Virgenes Sandstone, upper part. Paleocene, ?late Danian. (Saul, 1983, p. 119.)

(5) 3114 UCLA: 152 m (500 ft) S. of hill 2150, on crest of gently sloping ridge in very coarse to medium-grained, brown sandstone, 23 m (75 ft) below overlying shale and south of the road, 3,760 m (12,408 ft) S25°E of NW corner of Calabasas (1929) quad., Simi Hills, Ventura Co., Calif. Coll: J. H. Fantozzi, 6/23/1953. Lower Santa Susana Fm. Paleocene, early Selandian.

(5) 3117 UCLA: E (0.4″) of hill 2150 on small hill S of the road 4,000 m (13,200 ft) S34.5°E of NW cor. Calabasas (1929) quad., Simi Hills, Ventura Co., Calif. Coll: J. H. Fantozzi, 8/29/1953. Lower Santa Susana Fm. Paleocene, early Thanetian.

(6) 3392 SDSNH: Carlsbad area, N of Palomar Airport, roadcut along W side of College Blvd. at survey station 86 + 50, elevation 163′, approx. 424 m (1,400 ft) S of intersection with El Camino Real. Fossils collected from single 0.3 m (1 ft) thick horizon approximately 2.4 m (8 ft) below road level. Invertebrate fossils associated with a partial dinosaur skeleton; oyster and *Spondylus* sp. shells attached to dinosaur bones. Lat. 33°08′21″N; long. 117°17′02″W. San Luis Rey quad., San Diego Co., Calif. Coll: SDSNH field party, May 1987. Point Loma Formation. Cretaceous, early Maastrichtian.

(6) 3405 SDSNH: Carlsbad area, N of Palomar Airport, excavation for College Blvd. road bed between survey stations 84 and 92, approx. 242–485 m (800–1,600 ft) S of intersection with El Camino Real, between elevations 150–240 ft. Section consists of gently dipping (3–5°SW) sequence of blue-gray, massive to crudely bedded, bioturbated, fossiliferous mudstone. Fossils collected through an 18.2 m (60 ft) section of unweathered strata. This is a general locality for the entire cut which extended laterally for some 182 m (600 ft) and vertically for 27.3 m (90 ft). Several stratigraphic horizons were sampled separately and given individual locality numbers (e.g., SDSNH 3392). Lat. 33°08′21″N; long. 117°17′02″W. San Luis Rey quad., San Diego Co., Calif. Coll: B. O. Riney, M. A. Roeder, R. Q. Gutzler, April–May 1987. Point Loma Formation. Cretaceous, early Maastrichtian.

(5) 3760 UCB: Simi Hills, Ventura Co., Calif. Santa Susana Fm. Paleocene, ?late Danian–early Selandian. (Nelson, 1925, p. 438).

(5) 3776 UCB: Simi Hills, Ventura Co., Calif. Santa Susana Fm., Paleocene, ?late Danian–early Selandian. (Nelson, 1925, p. 440).

(2) 4189 USGS: 1–2 km (1 mi) north of Pacheco, Concord quad., Contra Costa Co., Calif. Coll: T. W. Stanton, Sept. 1894. Upper Vine Hill Sandstone. Paleocene, Thanetian, *Turritella infragranulata* Zone.

(1) 4192 USGS: Herndon Creek, about 1–2 km (1 mi) SE of Lower Lake, Lake Co., Calif. Coll: T. W. Stanton, Sept. 1894. "Martinez" Fm. Paleocene, early Selandian, *Turritella peninsularis* Zone.

(7) 5431 UCLA: S side Punta San Jose, Baja California, Mexico. Rosario Fm. Cretaceous, early Maastrichtian. (Popenoe and Saul, 1987, p. 36.)

(3) 6456 UCLA: Sandstone and some interbedded shale abrupt hill slope S side road, S side Panoche Creek about 1.2 km (0.75 mi) E of Silver Creek, 1,045 m (3,450 ft) S, 152 m (500 ft) E of NW cor. sec. 21, T15S, R12E, Tumey Hills quad., Tumey Hills, Fresno Co., Calif. Coll: L. R. Saul, 6/10/77. Basal Lodo Fm. Paleocene, early Thanetian.

(8) 6534 UCLA: NW side Arroyo Santa Catarina, Baja California, Mexico. Rosario Fm., buff silts below gritty sands with fossils, cobble cgl. above. Cretaceous, early Maastrichtian. (Popenoe and Saul, 1987, p. 37.)

(5) 6670 UCR: E side Meier Canyon, Calabasas quad., Simi Hills, Ventura Co., Calif. Santa Susana Fm. Paleocene, early "Martinez," probably = early Selandian. (Popenoe and Saul, 1987, p. 37.)

(3) 7044 LACMIP: Fresh roadcut E bank of Silver Creek 0.4 km (0.25

mi) S of junction with Panoche Creek, Tumey Hills quad., Fresno Co., Calif. Coll: C. E. Weaver, 1949. Basal Lodo Fm. Paleocene, early Thanetian.

(1) 7051 LACMIP: 61 m (200 ft) S of west bank Herndon Creek along gully tributary to Herndon Creek about 364 m (1,200 ft) S of Lower Lake–Monticello Hwy, 1.2 km (0.75 mi) E of Lower Lake, Lake Co., Calif. Coll: W. P. Popenoe, 5/12/44. "Martinez" Formation. Paleocene, ?Early Selandian.

(3) A-9717 UCB: E side Panoche Pass Road about 0.4 km (0.25 mi) S of confluence Panoche and Silver Creeks, Tumey Hills quad., Fresno Co., California. Basal Lodo Formation. Paleocene, early Thanetian. (Smith, 1975, p. 480.)

(2) 10488 LACMIP (=Weaver 2080): Pasture land E of Pacheco Road and S of Gum Tree Hill, 848 m (2,800 ft) S60°E from intersection of Pacheco Rd and Santa Fe Railway at overpass in E limb of Pacheco syncline, Contra Costa Co., Calif. Upper Vine Hill Sandstone. Paleocene, Thanetian. (Weaver, 1953, p. 93.)

(3) 61666 CAS (=LSJU 2073): Juncture of Panoche and Silver Creeks, Tumey Hills Quad., Fresno Co., Calif. Basal 9.1 m (30 ft) of Lodo Fm. Paleocene, early Thanetian. (Smith, 1975, p. 465.)