J. Paleont., 75(1), 2001, pp. 46–65

0022-3360/01/0075-46$03.00

NEW LATE CRETACEOUS GASTROPODS FROM THE PACIFIC SLOPE OF NORTH AMERICA

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ABSTRACT—Two new genera and ten new species of shallow-marine, warm-water gastropods are reported from several Upper Cretaceous formations found between British Columbia and southern California. The buccinid *Zaglenum* new genus is represented by two new species and the turbinellid *Fimbrivasum* new genus is represented by three new species. The nododelphinulid *Trochacanthus pacificus* new species is the first record of this genus in the Western Hemisphere, and the procerthiid *Nudivagus? califus* new species could be the first record of this genus on the Pacific slope of North America. The xenophorid *Xenophora* (*Endoptygma*) *hermax* new species is only the second known Cretaceous species of this genus on the Pacific slope of North America, and this species establishes that *Endoptygma* Gabb, 1877, is a valid taxon. The neritid *Otostoma sharonae* new species is only the fourth known Cretaceous species of this genus on the Pacific slope of North America. The ringiculid *Ringicula*? (*Ringiculopsis*?) *hesperiae* new species is the first Campanian record of this genus on the Pacific slope of North America and the first recognition of this subgenus in this area.

INTRODUCTION

THIS PAPER concerns new taxa of shallow-marine gastropods found in Upper Cretaceous rocks in northern Baja California, Mexico; southern and northern California; Sucia Island, Washington; and Vancouver Island and the associated Gulf Islands, British Columbia (Fig. 1). Many of the taxa are found in the Point Loma Formation just southeast of Carlsbad, northern San Diego County, southern California. Mollusks from these beds are arguably the best preserved fossils of Late Cretaceous age found on the Pacific slope of North America. Most of the Carlsbad area specimens used in this report were collected in "salvage operations" during grading activities associated with development projects.

The classification system used here generally follows that of Ponder and Warén (1988), Ponder and Lindberg (1997), and Mikkelsen (1996). Abbreviations used for catalog and locality numbers are: CIT, California Institute of Technology (collections now stored at LACMIP); GSC, Geological Survey of Canada, Ottawa; IGM, Instituto de Geología, Universidad Nacional Autónoma de México, Mexico City; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section, Los Angeles; NRM, Swedish Museum of Natural History, Stockholm; SDSNH, San Diego Society of Natural History, San Diego; SDSU, San Diego State University, San Diego; UCLA, University of California, Los Angeles (collections now stored at LACMIP); UCMP, University of California, Museum of Paleontology, Berkeley.

STRATIGRAPHY

The following stratigraphic units are listed from oldest to youngest in geologic age.

Haslam Formation.—The Haslam Formation was named by Clapp (1912) for outcrops on southeastern Vancouver Island, British Columbia. Muller and Jeletzky (1970) reviewed the stratigraphy and depositional environment of this formation and reported it to consist of megafossil-rich nearshore marine shale, siltstone, and minor sandstone. Using ammonites, they reported the age of the formation to range from late Santonian to early Campanian. On the basis of further ammonite studies, which resulted in the placement of the lower *Sphenoceramus schmidti* Zone within the Santonian Stage, Haggart (1989) reported the age of the Haslam Formation to be Santonian. Magnetostratigraphic work could place the stage boundary more precisely because the base of the Campanian Stage is known to be associated with a polarity reversal (Fig. 2). The portion of the Haslam Formation that is normal in polarity is of Santonian age.

Holz Shale of the Ladd Formation.—Popenoe (1942) designated the Holz Shale as the upper member of the Ladd Formation of the Santa Ana Mountains, Orange County, southern California. The fossils included in this present report are from the upper part of the Holz Shale. Saul (1982) reported that localities yielding megafossils in the upper part of the Holz Shale are predominantly thin sandstone beds deposited in a relatively deep-shelfal environment and of early Campanian age.

Pentz Road Member of Chico Formation.—The informal Pentz Road member of the Chico Formation was named by Russell et al. (1986) for outcrops in the vicinity of the hamlet of Pentz, Butte County, northern California. Squires and Saul (1997) reviewed the stratigraphy of the Pentz Road member and reported it to consist of deposits of early Campanian age and that most of these are of shallow-marine origin.

Cedar District Formation.—The Cedar District Formation was named by Clapp and Cooke (1917) for outcrops on southeastern Vancouver Island and on some neighboring much smaller islands near Vancouver, British Columbia. The exposures on two of these smaller islands that concern this present report are on Sucia Island, Washington, and Texada Island, British Columbia (Fig. 1). Muller and Jeletzky (1970) reviewed the stratigraphy and depositional environment of this formation and reported it to consist of megafossil-poor turbidites consisting of marine muds subject to the influx of material from the nearshore area. Jeletzky (*in* Muller and Jeletzky, 1970) reported the age of the Cedar District Formation to range from the *Hoplitoplacenticeras vancouverense* Zone on Sucia Island (uppermost fossiliferous beds) to the *Metaplacenticeras* cf. *M. pacificium* Zone in the upper part of the formation on both Denman Island and north of Trent River on Vancouver Island. Texada Island is east of Denman Island and north of Trent River, and Jeletzky identified *Baculites occidentalis* Meek, 1862, from there in outcrops assigned to the Cedar District Formation. *Baculites occidentalis* has a long range (Fig. 2) but occurs commonly in the *Metaplacenticeras* cf. *M. pacificum* Zone, and the Cedar District Formation on Texada Island might be somewhat younger than that on Sucia Island. Elder and Saul (1996, fig. 1) considered this ammonite zone to be of middle middle through late middle Campanian age.

Pleasants Sandstone Member of the Williams Formation.—Both the Williams Formation and the Pleasants Sandstone Member were named by Popenoe (1942) for outcrops along the

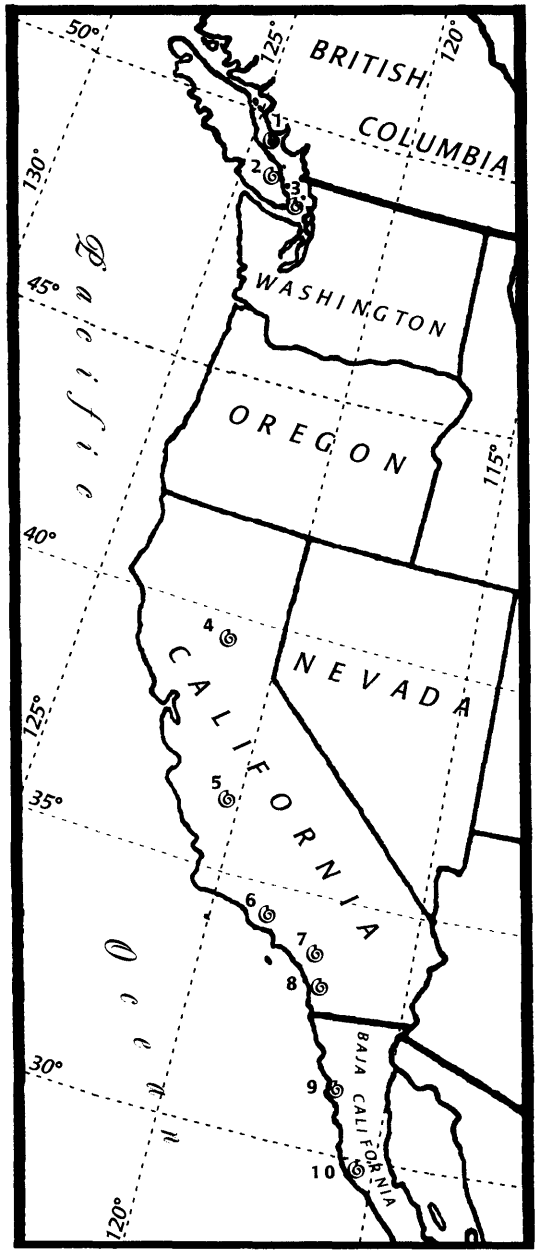


FIGURE 1—Index map showing geographic areas mentioned in the text. 1 = Texada Island; 2 = Vancouver Island; 3 = Sucia Island; 4 = Pentz; 5 = Anticline Ridge, north of Coalinga; 6 = Simi Hills; 7 = Santa Ana Mountains; 8 = Carlsbad; 9 = San Antonio del Mar; 10 = Arroyo Santa Catarina.

west side of the Santa Ana Mountains, Orange County, southern California. Saul (1982) reported that the Pleasants Sandstone Member is of Late Campanian age and that the mollusks contained therein lived in a shallow-shelf to moderate-depth-shelf environment.

Point Loma Formation.—The Point Loma Formation was named by Kennedy and Moore (1971, p. 711–713), who referred the Rosario Formation in San Diego County to group status, subdivided it into a middle unit (Point Loma Formation) and an upper unit (Cabrillo Formation), and added the nonmarine Lusardi Formation as the basal unit of the group. The Point Loma Formation crops out in San Diego County, southern California along the west side of Point Loma, as well as at La Jolla and in the city of Carlsbad. The Point Loma Formation is underlain by the Lusardi Formation and, in the area of the Carlsbad airport, is overlain by Eocene strata. The Carlsbad area in northern San Diego County concerns this present report. In this area, the Point Loma Formation has yielded several ammonites including the zonal indicators *Baculites lomaensis* Anderson, 1958; *Pachydiscus* (*Neodesmoceras*) *catarinae* (Anderson and Hanna, 1935); and *Didymoceras hornbyense* (Whiteaves, 1896) (Fig. 2). Of these, the pachydiscid is rarest. A specimen of *Baculites lomaensis* was extracted from within the aperture of a specimen of *Xenophora* (*Endoptygma*) *hermax* n. sp. from SDSNH locality 3402. A magnetic reversal, 32R, has been correlated (Elder and Saul, 1996, fig. 1) with the zone of *Didymoceras hornbyense*. On Point Loma this reversal encompasses 30 to 50 m of section (Bannon et al., 1989), and most of the Carlsbad collections might be from within the *D. hornbyense* Zone and thus of middle late Campanian age. This age is in agreement with that of other recent workers who have studied mollusks from this formation (Loch, 1989; Groves, 1990), and of Coombs and Deméré (1996) who used coccolith correlations of D. Bukry to date a dinosaur. However, as the ranges of both *P.* (*N.*) *catarinae* and *B. lomaensis* are considered to include the Campanian–Maastrichtian boundary, and both are identified from the Point Loma Formation in Carlsbad, the possibility remains that some strata near Carlsbad are of early Maastrichtian age.

The section of the Point Loma Formation in Carlsbad consists mostly of mudstone interbedded with sandstone. Paleobathymetric interpretations based upon foraminifers indicate inner shelf (less than 140 m deep) deposition for most of the Point Loma beds in the Carlsbad region. Locally, there are diverse, shallow-marine molluscan fossils (Bartling and Abbott, 1984; Loch, 1989). Most of these fossils are scattered through the mudstones, which are of shallow-marine origin but deposited below storm-wave base. Sundberg and Riney (1984) reported that megafossils have also been found in conglomerates and conglomeratic sandstones of the underlying Lusardi Formation, but these gravelly deposits represent the basal part of the Point Loma Formation (Kennedy et al., in press).

Along Palmer Way near the Madonna Hill Guest Home area in Carlsbad, recent grading uncovered new exposures of the Point Loma Formation (Kennedy et al., in press) that yielded several of the new taxa. They are in the coarse-grained matrix material of a basal conglomerate containing well-rounded metavolcanic pebbles and boulders derived from the nearby Santiago Peak Volcanics of Jurassic age. In addition, there are some granitic clasts, apparently derived from local exposures of the Green Valley Tonalite. The specimens of the new species of *Xenophora* utilized the metavolcanic pebbles as camouflage on their shells. The presence of such coarse-grained sedimentary material, along with shoreline-dwelling gastropods, including the new species of *Otostoma,* oyster valves, rudistids, and rarer pieces of driftwood, algal-encrusted pebbles, and echinoid spines indicate that this particular conglomerate was deposited at or near the shoreline. Some of these same invertebrates, especially the oysters, are also found in poorly sorted sandstone immediately overlying the conglomerate.

At SDSNH locality 3392, where specimens of the new species of *Ringicula*? (*Ringiculopsis*?) were collected, the various invertebrate fossils were found in association with a partial dinosaur skeleton of the nodosaurid ankylosaur *Nodosaurus*. Some oysters and also the bivalve *Spondylus* were found attached to the dinosaur bones (Coombs and Deméré, 1996).

Rosario Formation.—Upper Cretaceous marine deposits in Baja California are assigned to the Rosario Formation (Beal, 1948). The Rosario Formation in northwest Baja California, including the San Antonio del Mar section and Arroyo Santa Catarina, about 100 km and 300 km south of Ensenada, respectively,

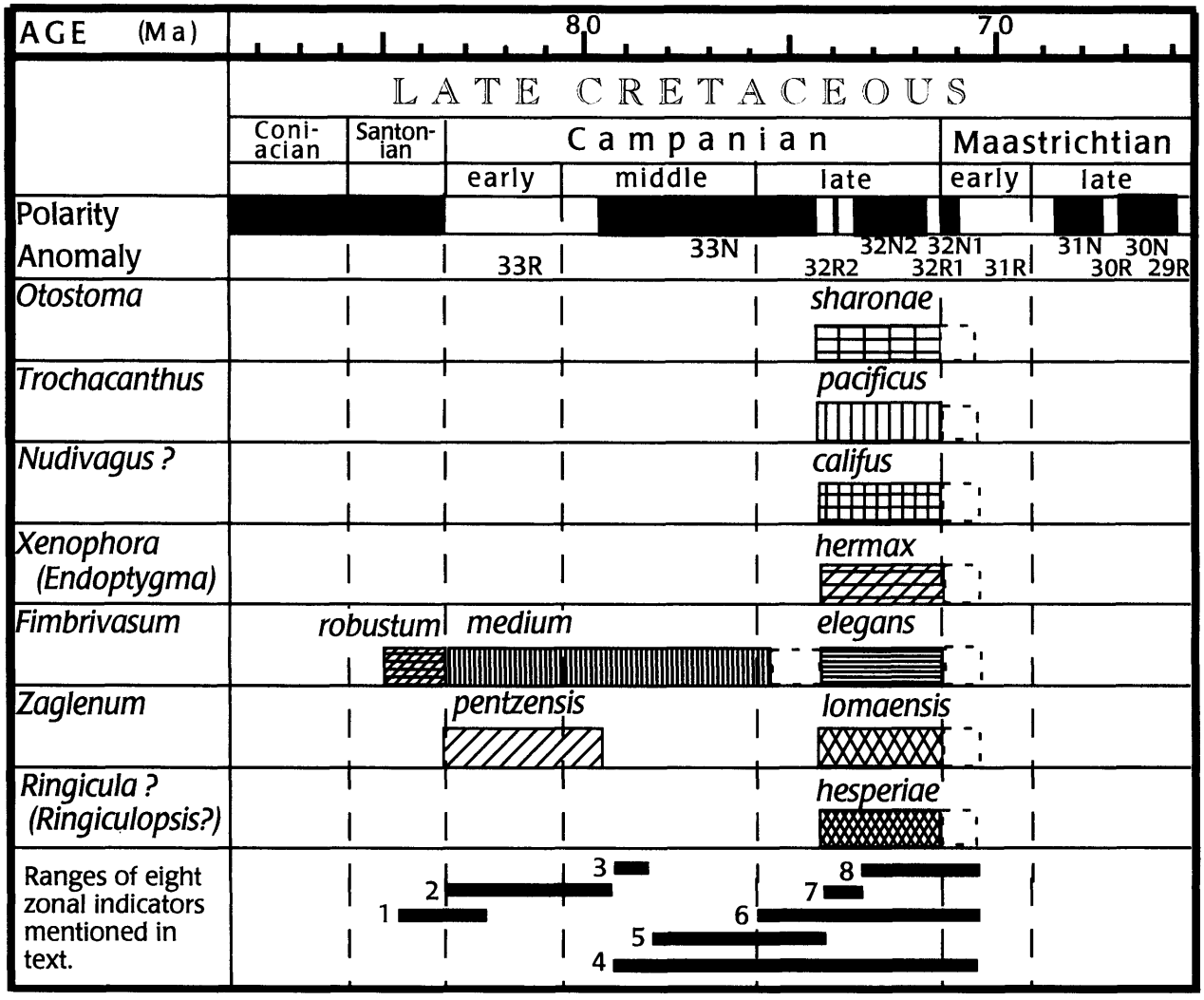


FIGURE 2—Chronostratigraphic positions of the new Cretaceous gastropods from the Pacific slope of North America. Geologic ages, polarity, and ammonite zones after Elder and Saul (1996, fig. 1); Coniacian/Santonian boundary modified to agree with Palmer and Geissman (1999). Zonal indicators referred to in text are 1) the inoceramid *Sphenoceramus schmidti*; and seven ammonites 2) *Submortoniceras chicoense,* 3) *Hoplitoplacienticeras vancouverense,* 4) *Baculites occidentalis,* 5) *Metaplacenticeras* cf. *M. pacificum,* 6) *Baculites lomaensis,* 7) *Didymoceras hornbyense,* 8) *Pachydiscus (Neodesmoceras) catarinae.*

is stratigraphically equivalent to the Point Loma and Cabrillo formations of the San Diego area (Yeo, 1984). In their reviews of the stratigraphy of the Rosario Formation in Baja California, Yeo (1984) and Cunningham and Abbott (1986) reported it to be of late Campanian to early Maastrichtian age, and that the deposits grade from shallow-marine facies to deep-basin turbidite facies. Webster (1983) tentatively assigned the age of the Rosario Formation in the Arroyo Santa Catarina area to be late Campanian to early Maastrichtian age.

Chatsworth Formation.—The Chatsworth Formation was named by Colburn et al. (1981) for exposures in the Simi Hills, Simi Valley, Los Angeles and Ventura counties, California. The formation consists of slope and deep-sea fan deposits, and the age of the formation is late middle Campanian to early Maastrichtian. Outcrops of the formation in the Lang Ranch area at the west end of the Simi Hills are relevant to this present paper. There, the formation is of early Maastrichtian age, based on the presence of the zonal ammonites *Baculites lomaensis* Anderson, 1958, and *Pachydiscus (Neodesmoceras) catarinae* (Anderson and Hanna, 1935).

Panoche Formation.—The Panoche Formation was named by Anderson and Pack (1915) for exposures in the Panoche Hills, Fresno County, California. The formation accumulated as deep-sea turbidites in a forearc basin and has an enormous thickness (up to 6,100 m) and variable lithology (Dibblee, 1981). In the Panoche Hills, the formation was divided into several formations by Payne (1962), in order to accommodate the lithologic variability. Dibblee (1981), who mapped the Panoche Formation in the Diablo Range north of the Panoche Hills, reported that few, if any, of Payne's units are recognizable in exposures outside of the Panoche Hills. Dibblee retained the name Panoche Formation as did Anderson (1972), who mapped the Panoche Formation near Coalinga, Fresno County, south of the Panoche Hills. Anderson designated informal members, and it is his "Ragged Valley Shale member" in the upper part of the Panoche Formation that is relevant to this present report. This member is approximately 366 m thick, consists of silty dark mudstone intercalated with numerous thin lenses of sandstone, and Trumbly (1983) suggested that the depositional environment of the member was the outer fan or the basin-plain of a submarine fan. Ammonite assemblages from

the "Ragged Valley Shale member" were dated by Matsumoto (1960) as late Campanian or early Maastrichtian, and *Baculites lomaensis* is abundant.

SYSTEMATIC PALEONTOLOGY

Class GASTROPODA Cuvier, 1797
"Order" NERITOMORPHA Golikov and Starobogatov, 1975
Family NERITIDAE Rafinesque, 1815
Genus OTOSTOMA d'Archiac, 1859

Type species.—*Nerita rugosa* Hoeninghaus, 1830, by indication (Douvillé, 1904); Late Cretaceous (Maastrichtian), Netherlands. The type species designation for *Otostoma* has a complicated nomenclatural history, which was discussed fully by Squires and Saul (1993).

OTOSTOMA SHARONAE new species
Figure 3.1–3.5

Diagnosis.—Medium-small shell, flat spire, smooth shell, seven moderately strong squarish teeth on inner lip, and internally dentate outer lip.

Description.—Shell medium small (up to 19 mm in height), subquadrate to globose, broader than high, moderately thick shelled, consisting of about two whorls; spire flat; body whorl smooth and rapidly expanding with rounded shoulder; aperture moderately large; deck wide, smooth and callused, with callus thickest on more mature specimens; inner lip with seven moderately strong squarish teeth; teeth equidistant, except for more closely spaced anteriormost one; teeth approximately same strength, except for anteriormost small one; outer lip thick and broad, and internally with about six roundish teeeth.

Etymology.—The new species is named for Sharon A. Rhodes, of Encinitas, California, who first discovered specimens of *Otostoma* at the type locality.

Types.—Holotype LACMIP 12810. Paratypes LACMIP 12811. CAS 68403 and 68404; IGM 4123 and 4124; NRM Mo 160493 and Mo 160494; UCMP 39940 and 39941. All types are of late Campanian age to possibly early Maastrichtian age and from the basal Point Loma Formation, Carlsbad, San Diego County, California, SDSU loc. 3871.

Measurements.—LACMIP 12810, height 15 mm, width 19 mm. LACMIP 12811, height 19 mm, width 23.5 mm; the other types are within these height and width ranges.

Other material examined.—Thirty-two specimens: one from SDSNH loc. 3162, three from SDSNH loc. 3672, one from SDSNH loc. 3869; 23 (in 2 lots?) 20 from SDSU loc. 3871, three from SDSU loc. 3871, and one each from SDSU locs. 346, 3870, 3877, and 3879.

Occurrence.—Upper Campanian to possibly lower Maastrichtian, Point Loma Formation, Carlsbad, San Diego County, California; and Rosario Formation, San Antonio del Mar, Baja California, Mexico.

Discussion.—A total of 42 specimens were found. Nearly all are well preserved although their apertures are usually plugged with hard matrix.

Otostoma is a Tethyan genus and most species are from the Old World. The geologic range of this genus is Early Cretaceous (Albian) to middle Eocene, with the youngest occurrences being from southern California (Squires, 1995; Saul and Squires, 1997).

Three other Cretaceous species of *Otostoma* have been described from the Pacific slope of California. *Otostoma*? *atopos* Saul and Squires (1997, p. 138–139, figs. 19–21) is found in reworked clasts of late Albian to early Cenomanian age in the Turonian Venado Formation, Colusa County, California. *Otostoma lucanus* Saul and Squires (1997, p. 138, figs. 15–18) is from the Turonian Baker Canyon Member of the Ladd Formation, Orange County, California. *Otostoma aethes* Squires and Saul (1993, p. 261–263, figs. 2–4) is from uppermost Cretaceous or possibly lowermost Paleocene strata on the south side of Lake Nacimiento, San Luis Obispo County, California.

The new species is most similar to *O.*? *atopos* in terms of the smooth shell, size, and thickened outer lip. The new species differs from *O.*? *atopos* by having a flat spire, teeth on the outer lip, and seven rather than six teeth on the inner lip. The new species differs from both *O. aethes* and *O. lucanus* by being smaller in size and having no sculpture on the shell.

The new species also resembles *Nerita* (*Odontostoma*) *bruni* Roman and Mazeran (1920, p. 38–39, pl. 4, fig. 20, 20a) from Turonian strata in southeastern France. The new species differs from *N.* (*O.*) *bruni* by having a flat spire, equal-sized teeth on the inner lip, and teeth on the outer lip.

"Order" VETIGASTROPODA Salvini-Plawén, 1980
Family NODODELPHINULIDAE Cox, 1960
Genus TROCHACANTHUS Dacqué, 1936

Type species.—*Trochus tuberculatocinctus* Münster *in* Goldfuss, 1844, by subsequent designation (Wenz, 1938); Late Cretaceous, Europe (Poland and Germany).

Discussion.—*Trochacanthus* was proposed by Dacqué (1936) for three species of German Late Cretaceous turbiniform gastropods that had, in the past, been assigned to *Turbo, Trochus,* or *Delphinula.* All are phaneromphalus and have an orbicular aperture and two strong, nodose cords exposed on later spire whorls. The last whorl develops a deviant coiling that brings the aperture in under the penultimate whorl. Shell structure for the family Nododelphinulidae has been unknown (Cox, 1960), but the inner shell layer of one Carlsbad specimen (SDSNH 67156) appears to have been nacerous.

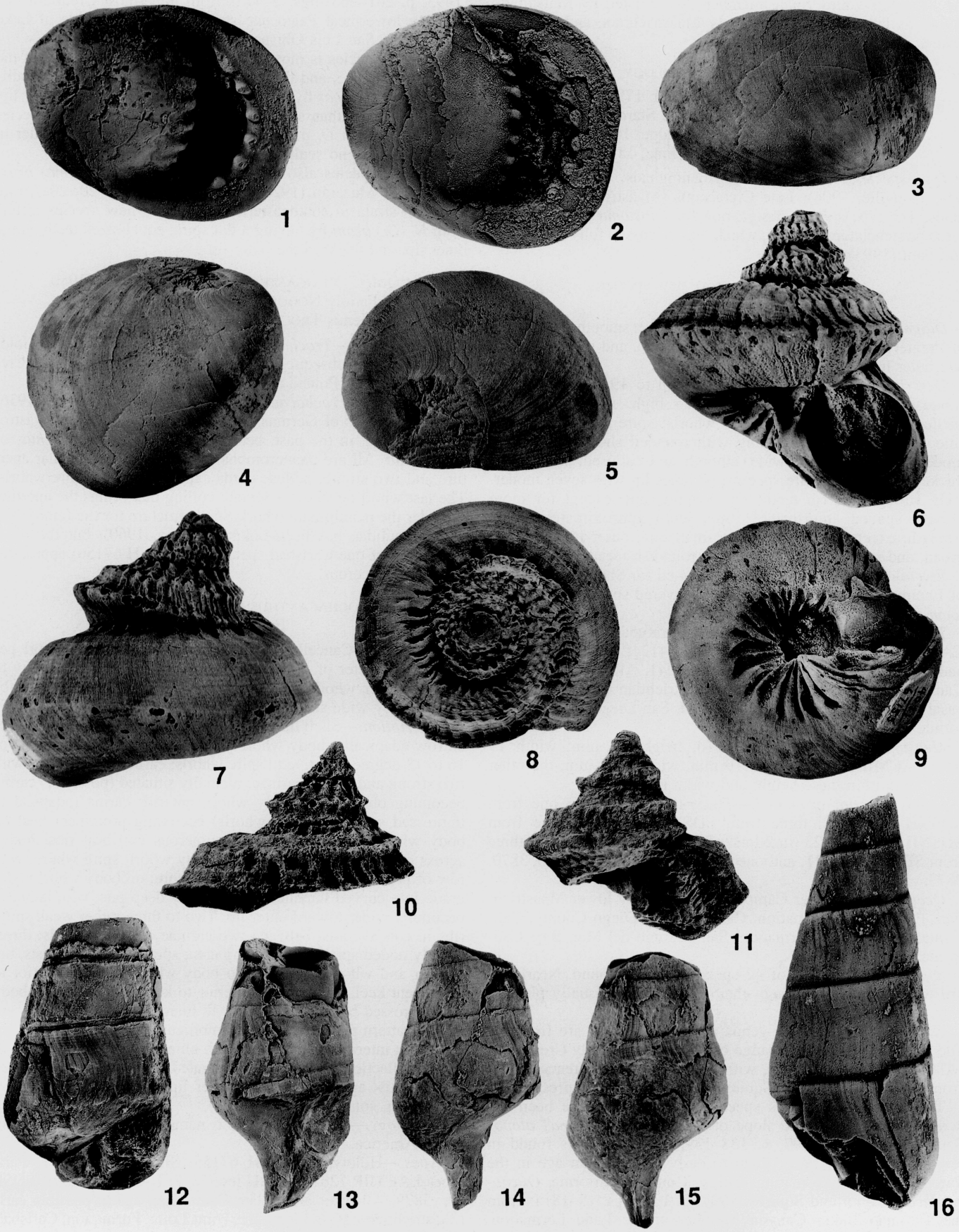
TROCHACANTHUS PACIFICUS new species
Figure 3.6–3.11

Diagnosis.—Cancellate spire, single keel on body whorl periphery, diameter of body whorl increased disproportionately to that of earlier whorls, and umbilicus bearing thin radiating ribs separated by wide sunken areas.

Description.—Shell turbinate, of five and one-half whorls, spire narrow adapically, body whorl wide, deviantly coiled at angle of 16 to 18 degrees relative to spire whorls; earlier spire whorls with two strong and noded carinae; medially situated (posterior) carina becoming obsolete on body whorl; anterior carina (adapical to impressed suture on spire whorls) becoming prominent keel on body whorl; spire whorls with numerous collabral ribs, noded across carinae; nodes obsolete on body whorl; spire whorls with row of protruding nodes abapical to suture; on body whorl nodes grade into curved lamellae separated by deep pits, with lamellae becoming wider toward outer lip. Two to three rather weak spiral ribs in concave area between two carinae on spire whorls; three, weakly noded spiral ribs in ramp area; spiral ribbing persists, but weaker and without nodes, onto body whorl region posterior to prominent keel; body whorl anterior to keel smooth, entire body whorl crossed by prosocline growth lines, forming a minute cancellate pattern posterior to keel; umbilicus deep, rimmed by a low spiral rib; interior of umbilicus with numerous radiating bladelike ribs (=reflections of outer lip) separated by deep slots, narrowing toward axis; aperture circular; inner lip smooth, callused; outer lip smooth, somewhat projecting.

Etymology.—The new species is named for the Pacific coast of North America.

Types.—Holotype SDSNH 67155, SDSNH loc. 4071. Paratypes LACMIP 12812, SDSU loc. 3872; LACMIP 11281, SDSU loc. 3879. All types are of late Campanian age to possibly early Maastrichtian age and from the Point Loma Formation, Carlsbad, San Diego County, California.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Measurements.—SDSNH 67155, total height 47.5 mm, height of spire 26 mm, maximum diameter 49.1 mm. LACMIP 11281, height of upper spire 15 mm, diameter of upper spire 30 mm (this specimen has an external mold consisting of two pieces: the upper spire and the rest of the teleoconch). LACMIP 12812, height 35.5 mm, width 37 mm (partial specimen).

Other material examined.—One specimen (spire only) from SDSU loc. 3870.

Occurrence.—Upper Campanian to possiby lower Maastrichtian, Point Loma Formation, Carlsbad, San Diego County, California.

Discussion.—The new species is the first record of genus *Trochacanthus* in the Western Hemisphere. The only other occurrence of this genus is from Santonian to Maastrichtian rocks of western Germany and lower Campanian to upper Maastrichtian rocks of central Poland (Abdel-Gawad, 1986).

Cox (1960) characterized *Trochacanthus* as having the body whorl flattened peripherally between two spiral angulations, but this flattening in *T. pacificus* seems to be related to the size of the specimen. The juvenile stage has a flattened periphery, whereas the adult stage has a single keel. Dacqué (1936) indicated that *Trochacanthus* has an overall ornament of fine spiral threads, but spiral riblets and threads are weak to obsolete anterior to the carina on the body whorl of *T. pacificus*. Additionally, *Trochacanthus pacificus* differs from the type species, *T. tuberculatocinctus* in having stronger sculpture on the spire, a more deviantly coiled body whorl, and a concave ramp on most whorls of the spire.

Superorder CAENOGASTROPODA Cox, 1959
Order NEOTAENIOGLOSSA Haller, 1882
Superfamily CERITHOIDEA Férussac, 1819
Family PROCERITHIIDAE Cossmann, 1905
Genus NUDIVAGUS Wade, 1917

Type species.—*Nudivagus simplicus* Wade, 1917, by original designation; Late Cretaceous (Maastrichtian), southeastern United States.

NUDIVAGUS? CALIFUS new species
Figure 3.12–3.15

Diagnosis.—Fusiform-smooth, with flat-sided spire whorls and slightly rounded body whorl, moderately long anterior canal, and opisthocyrt growth lines.

Description.—Shell medium, fusiform, flat-sided spire whorls, spire high, apical angle approximately 26 degrees; suture impressed; very closely spaced minute spiral threads on whorls; body whorl slightly rounded; inner lip smooth with moderately light callus; interior of outer lip with two denticulations; growth lines opisthocyrt.

Etymology.—The new species is named for the state of California.

Types.—Holotype LACMIP 12813, SDSU loc. 3875. Paratype LACMIP 12814, SDSU loc. 3870. Both types are of late Campanian age to possibly early Maastrichtian age and from the Point Loma Formation, Carlsbad, San Diego County, California.

Measurements.—LACMIP 12813, height 38 mm (incomplete), width 20.8 mm. LACMIP 12814, height 21 mm (incomplete), width 13.2 mm.

Occurrence.—Upper Campanian to possibly lower Maastrichtian, Point Loma Formation, Carlsbad, San Diego County, California.

Discussion.—The two specimens are difficult to assign to a genus because neither one has its outer lip intact. However, impressions on the internal mold of the holotype show at least two denticulations at intervals on the inside of the outer lip. Externally these places of denticulation formation are marked by, at most, a thickened shell producing a slight swelling. The Carlsbad specimens are very similar to specimens belonging to genus *Nudivagus* Wade, 1917, which is known from only two species: *Nudivagus morrisi* Abbass (1973, p. 122–123, pl. 2, figs. 11, 12) from mid-Cretaceous (Aptian), Ferruginous Sands, Isle of Wight, England (Abbass, 1973) and *Nudivagus simplicus* Wade (1917, p. 287, pl. 19, figs. 4, 5; Elder, 1990, p. 295, fig. 2) from the Upper Cretaceous Maastrichtian, Ripley Formation of the southeastern United States (Wade, 1917, 1926; Sohl, 1960). The new species differs from *N. morrisi* by having more rounded whorls and differs from *N. simplicus* by having much stronger spiral threads, and no tabulate shoulder. According to Sohl (1960), *N. simplicus* has slightly prosocline growth lines, but an examination of a specimen of this species (Fig. 3.16) revealed that it has opisthocyrt growth lines.

The new species also resembles *Cerithium* (*Fibula*?) *detectum* Stoliczka (1868, p. 192–193, pl. 15, fig. 1) from the Arrialoor Group of southern India. These strata are of Campanian to middle Maastrichtian age (Acharyya and Lahiri, 1991). Stoliczka's species was originally included in *Nudivagus* by Wade, but Abbass (1973) commented that further investigation is required before that assignment can be made with certainty. The new species differs from Stoliczka's species by having fine spiral ribbing and an absence of slight varices preceded by a deep furrow.

?*Nudivagus cooperensis* Stephenson (1941, p. 294–295, pl. 54, figs. 11, 12; Elder, 1990, p. 296, figs. 1, 3, 6–9; Akers and Akers, 1997, p. 117, figs. 103–104), from Upper Cretaceous (lower Maastrichtian) rocks in the Navarro Group of Texas, was reassigned to the aporrhaid genus *Tibiaporrhais* Elder, 1990, based on specimens that were better preserved than the ones Stephenson had available for study. The outer lip of these new specimens revealed two, moderately long, spinelike processes on the slightly expanded outer lip which conclusively prove that Stephenson's species is an aporrhaid (Elder, 1990). Moderately preserved specimens (i.e., those lacking the outer lip) of *Tibiaporrhais cooperensis* (Stephenson) closely resemble the new species, which differs by having opisthocyrt rather than essentially prosocline growth lines, flatter spire whorls, and more pervasive spiral ribbing.

The new species is also similar to *Tibiaporrhais japonica* (Nagao, 1932, p. 44–45, pl. 7, figs. 1–3, 5, 6; Hayami and Kase, 1977, p. 59, pl. 7, fig. 4) from Campanian strata of Sakhalin Island, Far Eastern Russia. As in the case of *T. cooperensis*, a

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FIGURE 3—New Cretaceous gastropods from the Pacific slope of North America and one Gulf Coast species. Specimens coated with ammonium chloride. *1–5, Otostoma sharonae* n. sp., SDSU loc. 3871; *1,* paratype LACMIP 12811, apertural view, height 19.2 mm, ×2.1; *2–5,* holotype LACMIP 12810, height 15 mm, ×3.1; *2,* apertural view; *3,* abapertural view; *4,* oblique abapertural view; *5,* apical view. *6–11, Trochacanthus pacificus* n. sp.; *6–9,* holotype SDSNH 67155, SDSNH loc. 4071, height 47.5 mm, ×1.2; *6,* apertural view; *7,* abapertural view; *8,* apical view; *9,* umbilical view; *10,* paratype LACMIP 11281, SDSU loc. 3879, lateral view of rubber peel of external mold of upper spire, height 15 mm, ×2; *11,* paratype LACMIP 12812, SDSU loc. 3872, apertural view, height 35.5 mm, ×1.4;. *12–15, Nudivagus*? *califus* n. sp.; *12,* apertural view, paratype LACMIP 12814, SDSU loc. 3870, height 21 mm, ×2.5; *13–15,* holotype LACMIP 12813, SDSU loc. 3875, height 38 mm, ×1.3; *13,* apertural view; *14,* left-lateral view, *15,* abapertural view. *16, Nudivagus simplicus* Wade, 1917, hypotype LACMIP 12815, LACMIP loc. 8063, right-lateral view, height 44.7 mm, ×1.7.

few exceptional specimens of *T. japonica* show an outer lip possessing two processes, and Elder (1990) interpreted them to be digitations like those found on other aporrhaids. The new species differs from *T. japonica* by having opisthocyrt rather than mostly prosocline growth lines and by having weaker spiral ribbing.

Elder (1990, p. 296–297, fig. 4) also reported a single specimen of moderately preserved *Tibiaporrhais* sp. from Campanian strata in the Forbes Formation in the Rumsey Hills, Yolo County, northern California. *Nudivagus*? *califus* n. sp. closely resembles this specimen but differs by having more pervasive spiral ribbing, flatter spire whorls, and a less impressed suture.

In spite of the very close resemblance of *Nudivagus* and *Tibiaporrhais,* Elder (1990) rightfully did not reassign *Nudivagus* to the Aporrhaidae because evidence for an expanded aperture and apertural digitations is lacking in the type species of *Nudivagus.* It should also be noted that *Nudivagus* commonly has opisthocyrt growth lines, whereas *Tibiaporrhais* has predominantly prosocline growth lines. Future work might possibly reveal that the two genera are synonymous, but for now, *Nudivagus* appears to be a valid taxon. Until better preserved specimens of the new species are found, it seems best to tentatively assign the Carlsbad species to genus *Nudivagus.*

Nudivagus? *califus* represents the first record (albeit tentative) of this genus on the Pacific slope of North America.

Superfamily XENOPHOROIDEA Troschel, 1852
Family XENOPHORIDAE Philippi, 1853
Genus XENOPHORA Fischer von Waldheim, 1807

Type species.—*Xenophora laevigata* Fischer von Waldheim, 1807, by subsequent designation (Harris, 1897) (=*Trochus conchyliophorus* Born, 1780); Recent, North Carolina, United States and south to Brazil (Clench and Aguayo, 1943). The type species designation of *Xenophora* has a complicated nomenclatural history, and a listing of the relevant publications is given by Ponder (1983).

Subgenus ENDOPTYGMA Gabb, 1877

Type species.—*Phorus umbilicatus* Toumey, 1854, by monotypy; Late Cretaceous (Senonian), Alabama.

Discussion.—Gabb (1877) provided the name *Endoptygma* for *Xenophora* spp. possessing a strong revolving rib in the inner surface of the base of the shell. A number of species, in addition to *X. umbilicata, X. plicata* (Zekeli, 1852), and *X. leprosa* (Morton, 1834), exhibit this inner rib, but no modern *Xenophora* do so. The feature has been considered to be a gerontic characteristic and of no systematic importance (Stephenson, 1941; Sohl, 1960; Kollmann, 1980; Ponder, 1983). The specimens of *X. hermax, n. sp.*, however, do not support this conclusion because they show that the rib is not restricted to a late stage of individual development.

XENOPHORA (ENDOPTYGMA) HERMAX new species
Figure 4.1–4.10

Diagnosis.—Medium-large shell, high spire, angulate whorl profile, greatly depressed base with internal spiral ridge, keeled inner lip, and entire shell covered with closely spaced, small to very large pebbles.

Description.—Shell medium large (up to 95 mm in diameter), trochiform, about five whorls, whorl profile shouldered with blunt periphery; spire high, apical angle about 71 degrees; whorls angulate with a lowly sloping ramp, whorls apparently straight-sided (flat) anterior to ramp; suture distinct and impressed; entire teleoconch covered by closely spaced pebbles, attachment scars deeply embedded on anterior half of each whorl; shell surface (sans pebbles) smooth?; body whorl wide; base broad, greatly depressed, area near anterior end of inner lip with coarse growth lines, remainder of base smoothly coated by callus; base internally with a spiral ridge; aperture circular, inner lip bordered by a keel with a narrow peripheral flange; no umbilicus.

Etymology.—The species is named *hermax,* Greek, meaning a heap of stones.

Types.—Holotype SDSNH 50707, SDSNH loc. 3673. Paratypes SDSNH 34018, SDSNH loc. 3402; LACMIP 12816, SDSU loc. 3871; LACMIP 12817, SDSU loc. 3875. All types are of late Campanian age to possibly early Maastrichtian age and from the Point Loma Formation, Carlsbad, San Diego County, California.

Measurements.—SDSNH 50707, height 50 mm, maximum diameter 95 mm (sans pebbles). SDSNH 34018, height 45 mm, maximum diameter 50 mm (specimen incomplete, spire only). LACMIP 12816, height 33 mm, maximum diameter 40 mm (specimen incomplete, spire only). LACMIP 12817, height 15.7 mm, maximum diameter 36 mm (specimen incomplete, one whorl only).

Other material examined.—Sixty-five specimens: 63 from SDSNH loc. 3673, one from SDSNH loc. 3762, and one from SDSU loc. 3870.

Occurrence.—Upper Campanian to possibly lower Maastrichtian Point Loma Formation, Carlsbad, northern San Diego County, southern California.

Discussion.—The new species is rather remarkable in that, of the 68 specimens examined, all but three of the shells retained their original lithic armament, which consists of heavy and rounded pebbles of metavolcanic rock. The pebbles are closely packed and nearly always touching one another. Rarely, the pebbles are subangular. The largest pebbles are 42 mm in length and correspond to very large pebbles on the Wentworth (1922) clast scale. When viewed from above, the shells appear to represent small piles of pebbles, with the smallest ones on the upper spire and the largest ones on the body whorl. The pebbles, therefore, must have provided camouflage. In addition, the pebbles are positioned so that they act as stilts which lift the entire base and the aperture up off the substrate. These two functional uses of the foreign implanted material (in this case, pebbles) correspond with the report of Linsley and Yochelson (1973) upon other shells of Xenophoridae. In addition, the heavy weight of the pebbles might have allowed the shells to be resistant to being overturned by strong currents or waves.

Some of the shells of the new species have been bored by endobionts, as well as encrusted by the bivalve *Spondylus subrugosus* (Packard, 1922), or by bryozoans. A few of the specimens of the new species have a rather low profile, and the implanted pebbles are slightly larger than on the other specimens. It is not clear if this flattened shape is due to post-burial compaction or is due to the large pebbles interfering with normal growth.

In some specimens of *Xenophora hermax* (Fig. 4.3), the base of the preceding whorl has been detached or caved-in to create a falsely umbilicate appearance.

Comparison of the new species with other Cretaceous species of *Xenophora* is greatly hindered by the poor preservation of these other species. This observation is underscored by the comment of Darragh and Kendrick (1994) who reported that figured specimens of Cretaceous *Xenophora* species from Europe, Africa, Australia, and North America are not well preserved. The same is true for Cretaceous *Xenophora* from southern India (Stoliczka, 1867–1868). Some Cretaceous southeastern United States specimens of *Xenophora leprosa* (Morton, 1943) illustrated by Dockery (1993, p. 71–72, pl. 20, figs. 1–4), however, are well preserved with the smallest specimen showing the larval shell. The new species generally resembles most species of *Xenophora* sensu stricto that have a high spire and an unornamented shell surface,

but, in terms of the internal spiral ridge on the base, the new species is very similar to *Xenophora* (*Xenophora*) sp. Darragh and Kendrick (1994, p. 34–38, figs. 6C–F, 7A–C) from the Upper Maastrichtian Miria Formation, Carnarvon basin, northwestern Australia. The new species differs from this Australian species by having a more depressed shell base, no umbilicus, a more thickened inner lip, much more pebble armor, and a lack of ornamentation on the body whorl and on the shell base.

The only other Cretaceous species of *Xenophora* from the Pacific slope of North America is *Xenophora willisi* Webster (1983, p. 1092, 1095, figs. 2A–F, 3A) from the Upper Cretaceous (upper? Campanian to early? Maastrichtian) Rosario Formation at Arroyo Santa Catarina and near San Antonio del Mar in the northern part of the state of Baja California, Mexico. Other than being covered by pebble armor, the new species differs from *X. willisi* by having a smaller size, higher spire, smoother shell surface without a trace of axial ribs, narrower diameter, much narrower apical angle, blunter periphery, more shouldered whorl profile, fewer but much larger and deeper attachment scars, a keel along the border of the inner lip, an internal spiral ridge on the base, and a more concave base.

The only other Cretaceous species of *Xenophora* known from North America are *Xenophora* sp. Stephenson (1952; unfigured) from the Upper Cretaceous (Cenomanian) Woodbine Formation of Texas, and *Xenophora leprosa* (Morton) from Campanian and Maastrichtian rocks of Mississippi, Tennessee, and Texas (Sohl, 1960; Dockery, 1993). The latter species is widespread and is common as steinkerns in the Maastrichtian Prairie Bluff Formation of Mississippi and Alabama (Dockery, 1993). *Xenophora umbilicata* (Toumey, 1854) has been considered by Sohl (1960) to be possibly distinct from *X. leprosa* (Morton). The new species differs from *Xenophora* sp. Stephenson by having a much larger size and a higher spire, and the new species differs from *X. leprosa* by having a larger size, a much more concave base, a peripheral flange, an internal spiral ridge on the base, a keel bordering the inner lip, no umbilicus, and being armored by pebbles.

Xenophora grasi Matheron (1842–1843; Roman and Mazeran, 1920, p. 42–43, pl. 4, fig. 28, 28a; pl. 5, figs. 15, 15a,b) from Turonian rocks of southeastern France has a peripheral flange like that on the new species, but *Xenophora* (*E.*) *hermax* differs by having a higher spire, an internal spiral ridge on the base, no umbilicus, and no dorsal and ventral spiral sculpture.

Xenophora simpsoni Stanton (1893, p. 133, pl. 29, figs. 4–6) was reported from the Upper Cretaceous (Turonian) Codell Sandstone in Colorado, but if the illustrations are correct, this species is not a *Xenophora* because the anterior half of the body whorl is convex. This species appears to be a trochid.

At SDSNH localities 3672 and 3673, the new species was found mostly in massive siltstone/mudstone with scattered metavolcanic clasts, some of which have encrusting specimens of the rudist bivalve *Coralliochama orcutti* White, 1885, and the rock-scallop *Spondylus subrugosus* (Packard, 1922). Associated with the new species at SDSNH locality 3673, where most of the specimens of the new species were found, was a diverse assemblage of warm-water, shallow-marine (inner shelf) gastropods and bivalves, as well as ammonites, nautiloids, brachiopods, crabs, and many spines and body plates of sea urchins. The new species is the most common gastropod at this locality, and oysters are the most common bivalve. There are also articulated specimens of the above-mentioned bivalves, as well as those of *Crassatella* sp. and *Glycymeris* sp., and a small colony of *Coralliochama orcutti*. Most of the same species found at SDSNH locality 3673 are also found at SDSNH locality 3672, but *Xenophora* (*E.*) *hermax* is a rare component at this latter locality.

At SDSU locality 3871, the new species is found rarely in the matrix of a boulder conglomerate consisting of metavolcanic clasts and associated with *Otostoma sharonae* new species.

Genus *Xenophora* ranges from the Late Cretaceous (Cenomanian) to Recent (Ponder, 1983; Dockery, 1993). On the Pacific slope of North America, *Xenophora* is represented by six species. Two are of Late Cretaceous age and include *X. willisi* and the new species. The other four are of Tertiary age. *Xenophora zitteli* Weaver (1905, p. 118–119, pl. 12, fig. 8) and *Xenophora simiensis* Nelson (1925, p. 422, pl. 55, figs. 7a–c) are of late Paleocene age and are found in California (Zinsmeister, 1983). *Xenophora stocki* Dickerson (1916, p. 502–503, pl. 37, figs. 4a,b) is of early to middle Eocene age and is found in Baja California Sur, Mexico; California; and Oregon (Squires and Demetrion, 1992; Squires, 1994). *Xenophora hawleyi* Loel and Corey (1932, p. 269–270, pl. 63, fig. 12) is of early Miocene age and is found in California. Unlike the new species, these four Tertiary species have flat bases, and none has pebble armor like the new species.

Order NEOGASTROPODA Thiele, 1929
Superfamily MURICOIDEA Rafinesque, 1815
Family TURBINELLIDAE Swainson, 1840
Genus FIMBRIVASUM new genus

Type species.—*Fimbrivasum elegans* n. sp., Late Cretaceous, Campanian to possibly Maastrichtian, California.

Diagnosis.—Fusiform turbinellid with two to three inner lip folds and sub-cancellate fimbriate sculpture.

Description.—Shell medium large, fusiform to ovate biconical, about four varicate whorls; spire moderately high to high (40 to 54 percent of total shell height), apical angle 50 to 74 degrees; broadly cancellate sculpture with spiral ribbing stronger, especially on tabulate shoulder and medial part of body whorl where spiral ribs protrude; columella with or without callus and with two to three, thin or stout columellar folds; siphonal canal slightly twisted and bent to the left; growth lines slightly prosocline but sigmoidal near impressed suture.

Etymology.—The genus is derived from *fimbria* (Latin, frilled) and *vasum* (Latin, vessel).

Occurrence.—Upper Santonian to upper Campanian (or possibly Maastrichtian), British Columbia, Washington, and southern California.

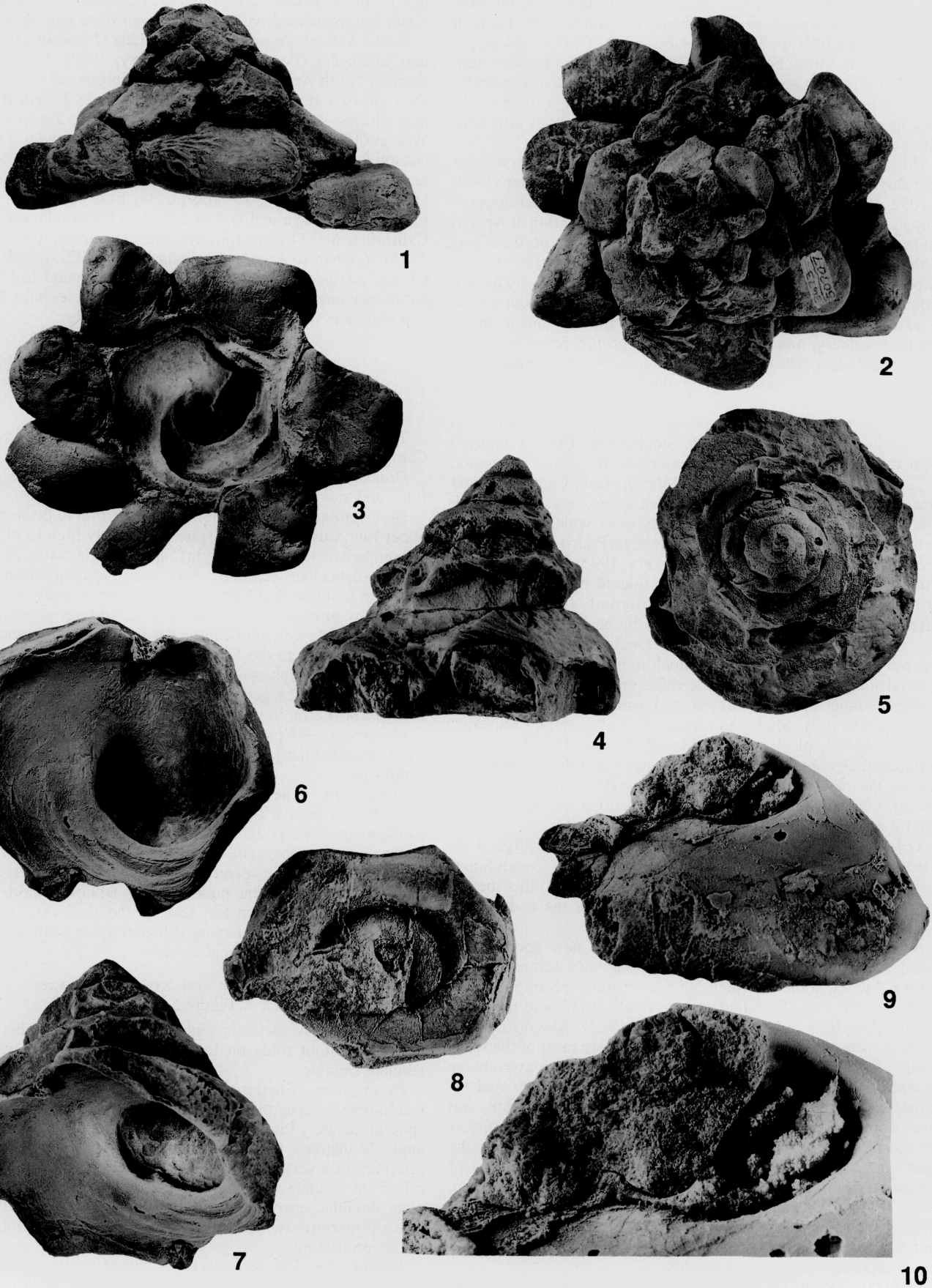
Discussion.—The new genus has the main morphologic characteristics of family Turbinellidae. These are a medium to large, fusiform to ovate-conic shell; prominent spiral cords and axial nodes or blunt spines; and columellar folds. In particular, the new genus most resembles genus *Vasum* Röding, 1798, especially in terms of both the blunt nodes on the tabulate whorls and the prominent spiral ribs on the neck of the shell. The new genus differs from *Vasum* by having a higher spire, stronger inner lip folds, and a weaker siphonal fasciole.

FIMBRIVASUM ROBUSTUM new species
Figure 5.1, 5.2

Diagnosis.—Moderately high spire, very inflated body whorl, three very stout folds on inner lip, and ramp concave next to tabulate shoulder.

Description.—Shell medium large (up to 72 mm in height, but incomplete), ovate biconical with a very inflated body whorl, spire moderately low, about 40 percent of total shell height; apical angle 74 degrees; protoconch not preserved; whorls about three, sculpture of a very bluntly noded and very protruding strong spiral rib on tabulate shoulder; ramp wide and concave next to tabulate shoulder; aperture very wide, inner lip with three very stout folds, posteriormost two about same length but anteriormost one not as protruding.

Etymology.—The new species is named for its robust size and shape.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Types.—Holotype GSC 118672, GSC loc. 15667. Paratype GSC 118673 (unfigured), GSC loc. 15667. Both types are of late Santonian age and from the lower Haslam Formation, Vancouver Island, British Columbia.

Measurements.—GSC 118672, height 71.6 mm, width 54.5 mm. GSC 118673, height 44.4 mm, width of penultimate whorl 25.5 mm.

Occurrence.—Upper Santonian (lower *Sphenoceramus schmidti* Zone), lower Haslam Formation, Vancouver Island, British Columbia, Canada.

Discussion.—Of the two known specimens, the paratype is mostly an internal mold and consists of about two whorls, including most of the body whorl. The holotype has a partly decorticated shell. The shell remaining on the holotype, however, is mostly concealed by extremely well indurated siltstone. The type locality of the new species has yielded the inoceramid *Sphenoceramus schmidti,* which is considered to be of late Santonian age (Haggart, 1989).

Fimbrivasum robustum differs from *F. medium* n. sp. and *F. elegans* n. sp. by having a much wider ramp, a stronger tabulate shoulder, a wider apical angle, and a wider aperture.

FIMBRIVASUM MEDIUM new species
Figure 5.3–5.9

Diagnosis.—High spire, moderately wide body whorl, well developed spiral ribs, and three prominent folds on columella.

Description.—Shell medium large (up to 51 mm in height, but incomplete), fusiform with tabulate whorls, spire high, about 54 percent of total shell height; apical angle 50 to 60 degrees, protoconch not preserved; whorls four to five, suture impressed, with a moderately strong spiral rib immediately posterior to it; sculpture of widely spaced strong spiral ribs (protruding on body whorl) and widely spaced weaker axial ribs, the latter rather ill-defined except on body whorl; intersections of spiral and axial ribs form cancellate pattern on spire and periphery, but neck area with only spiral ribs; smaller specimens with at least one somewhat poorly defined varix; whorls with a bluntly noded strong spiral rib on tabulate shoulder; ramp with one to two widely spaced ribs, posterior one strongest; spire whorls crossed by 10 to 12 axial ribs, ill-defined except where they cross stronger spiral ribs and on neck of smaller specimens; body whorl with greatest inflation at tabulate shoulder; swollen posterior part of body whorl with three strong spiral ribs, rib on shoulder the strongest, anteriorly the spiral ribs (usually noded where crossed by weaker axial ribs) gradually decrease in strength; aperture moderately wide; on smaller specimens inner lip calloused and projecting, on larger specimens inner lip not calloused; inner lip with three prominent folds, posteriormost strongest and anteriormost weakest; on largest specimen posteriormost two folds pass into moderately strong spiral ribs on dorsum of shell; siphonal canal twisted and bent to left; growth lines slightly prosocline but opisthocline near suture.

Etymology.—The new species is named *medium* because it is morphologically transitional between *F. elegans* n. sp. and *F. robustum* n. sp.

Types.—Holotype CAS 228.01, type locality CAS loc. 228, middle Campanian, Cedar District Formation, Sucia Island, Washington. Paratypes LACMIP 12818, LACMIP loc. 10093, early Campanian Ladd Formation, upper Holz Shale Member, Orange County, California; GSC 118674, GCS loc. 85009, middle Campanian, Cedar District Formation, Texada Island, British Columbia; GSC 118675, GCS loc. 16461, middle Campanian, Cedar District Formation, Sucia Island, Washington.

Measurements.—CAS 228.01, height 37 mm, width 20.2 mm. LACMIP 12818, height 24 mm, width 14 mm. GSC 118674, height 30. 5 mm, width 22.1 mm (incomplete specimen). GSC 118675, height 51.3 mm, width 37.7 mm.

Occurrence.—Lower to middle Campanian. Lower Campanian: Ladd Formation, upper Holz Shale Member, Santa Ana Mountains, Orange County, California. Middle Campanian: Cedar District Formation, Sucia Island, Washington, and Texada Island, British Columbia.

Discussion.—A total of four specimens of *Fimbrivasum medium* n. sp. is known. The new species is morphologically transitional between *F. robustum* n. sp. and *F. elegans* n. sp. in terms of the width of the body whorl, the strength of the cancellate sculpture, and the strength of the inner lip folds. In addition, the whorl profile on *F. medium* is more rounded anterior to the shoulder than is that of *F. elegans.*

FIMBRIVASUM ELEGANS new species
Figure 5.10–5.16

Diagnosis.—Moderately high spire, moderately wide body whorl, well developed spiral ribs, and two narrow folds on the inner lip.

Description.—Shell medium large (up to 77 mm in height), fusiform with tabulate whorls, spire moderately high, about 40 percent of total shell height, apical angle 50 to 60 degrees; protoconch not preserved; whorls four to five; suture somewhat impressed, with a moderately strong spiral rib immediately posterior to it; sculpture of widely spaced strong spiral ribs (protruding on body whorl) and widely spaced, weaker axial ribs, intersections of ribs form broad-cancellate pattern, interspaces smooth and concave, producing an overall frilled appearance; all whorls with three somewhat poorly defined varix regions, each set at about every 120 degrees; whorls with bluntly noded strong spiral rib on tabulate shoulder, ramp with two widely spaced and moderately strong spiral ribs, posteriormost one tends to be slightly stronger and with very weak spiral rib between it and suture; spire whorls crossed by about 10 axial ribs, ill-defined except where they cross stronger spiral ribs; body whorl elongate, with greatest inflation at tabulate shoulder; swollen posterior part of body whorl with four strong spiral ribs, rib on shoulder strongest; anteriorly spiral ribs (noded where crossed by weaker axial ribs) gradually decrease in strength except on posterior part of narrow siphonal canal where posteriormost columellar fold passes into moderately strong spiral rib on dorsal side of shell; spiral ribs near anterior end of shell with two spiral interribs; aperture very narrow (possibly somewhat compressed); inner lip with two narrow folds, posteriormost one strongest; outer lip crenulate; growth lines

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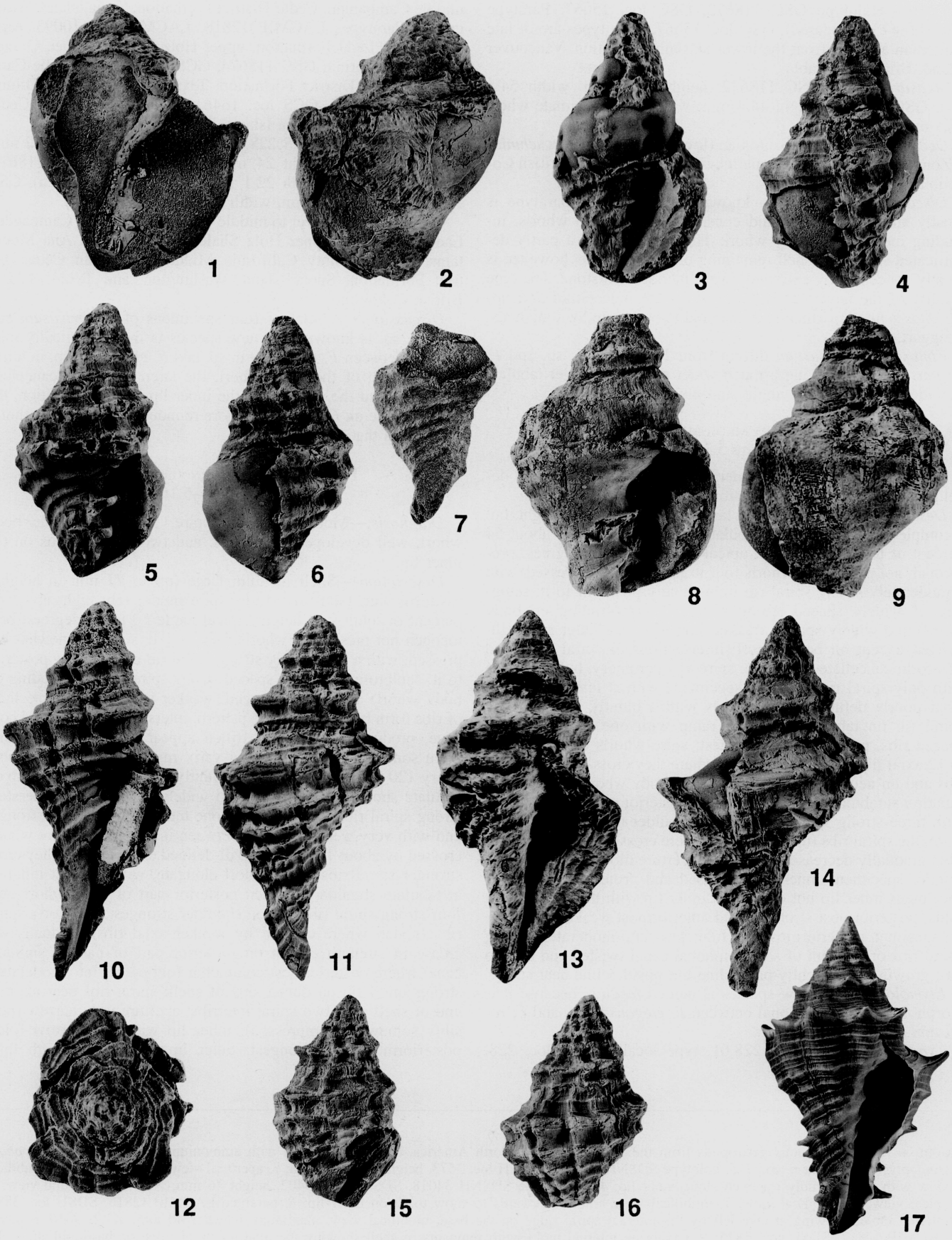
FIGURE 4—New Cretaceous gastropods from the Pacific slope of North America. Specimens coated with ammonium chloride. *1–10, Xenophora (Endoptygma) hermax* n. sp.; *1–3,* holotype SDSNH 50707, SDSNH loc. 3673, height 50 mm, ×0.8; *1,* apertural view; *2,* apical view; *3,* umbilical view with base partially removed along inner lip; *4–7,* paratype SDSNH 34018, SDSNH loc. 3402, height 46 mm, ×1; *4,* abapertural view; *5,* apical view; *6,* umbilical view; *7,* umbilical view, tilted backwards to show tooth on inner lip; *8,* paratype LACMIP 12816, SDSU loc. 3871, internal mold, showing groove left by the internal spiral ridge on the base, umbilical view, maximum diameter 40 mm, ×1.2; *9–10,* paratype LACMIP 12817, SDSU loc. 3875; *9,* mostly an internal mold, with remnants of shell showing the internal spiral ridge on base, oblique right-lateral view, maximum diameter 36 mm, ×2; *10,* enlargement of a portion of Figure 4.9, ×4.6.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slightly proscocline but sigmoidal near suture; anterior canal twisted and bent slightly to left.

Types.—Holotype SDSNH 67158, SDSNH loc. 4071. Paratypes SDSNH 11146, SDSNH loc. 2928 and SDSNH 34067, SDSNH loc. 3392. All types are of late Campanian to possibly early Maastricthian age and from the Point Loma Formation, Carlsbad, California.

Measurements.—SDSNH 67158, height 57 mm, width 27.7 mm. Paratype SDSNH 11146, height 77 mm, width 40 mm. Paratype SDSNH 34067, height 18.3 mm, width 11.4 mm (an incomplete specimen).

Other material examined.—A latex pull from an external mold (hypotype LACMIP 12882) from LACMIP loc. 17198 (Santa Ana Mountains).

Occurrence.—Upper Campanian to possibly lower Maastrichtian. Upper Campanian: Pleasants Sandstone Member of the Williams Formation, Santa Ana Mountains, Orange County, southern California. Upper Campanian to possibly lower Maastrichtian: Point Loma Formation, Carlsbad, northern San Diego County, southern California.

Discussion.—The three known specimens of *Fimbrivasum elegans* n. sp. resemble *Vasum ceramicum* Linnaeus, 1758, a modern-day species from the Philippines and Polynesia (Fig. 5.17). The new species differs from *V. ceramicum* by having smaller nodes on the tabulate whorls, much more prominent cancellate ornamentation, and fewer inner lip folds.

Fimbrivascum elegans n. sp. differs from *F. robustum* n. sp. by having a narrower ramp, a less projecting tabulate shoulder, a narrower apical angle, well developed spiral ribs, weak axial ribs, a narrower aperture, and fewer and weaker folds on the inner lip. *Fimbrivasum elegans* n. sp. differs from *F. medium* n. sp. by having a more projecting tabulate shoulder, a more elongate siphonal canal, and fewer and weaker folds on the inner lip.

Family BUCCINIDAE Rafinesque, 1815
Genus ZAGLENUM new genus

Type species.—*Zaglenum lomaensis* n. sp., Late Cretaceous (Campanian to possibly Maastrichtian), California.

Diagnosis.—Buccinid-like shells with whorls flat-sided and sloping anteriorly to prominent spiral carina located just posterior of suture; sculpture of many closely spaced primary and secondary spiral ribs with a weaker cancellate pattern caused by growth lines; inner lip with several small folds and wrinkles; thickened outer lip with teeth; and short, narrow, and twisted siphonal canal.

Description.—Shell medium small (up to 34 mm in height, but incomplete), fusiform to somewhat inflated fusiform, usually flat-sided whorls, spire high and about 50 percent of total shell height, apical angle 52 to 58 degrees; whorls five to six, suture deeply impressed to canaliculate with projecting spiral carina just posterior to it; carina similarly conspicuous on body whorl and situated approximately in middle of whorl; sculpture of fine to coarse primary spirals with faint to moderately strong cancellate (minutely beaded) pattern caused by arched opisthocyrt growth lines; interspaces between spiral ribs with variable number (one to three) secondary spiral ribs of variable strength; spiral rib anterior to carina on body whorl nearly as strong as the carina and imparting a bicarinate appearance to body whorl; aperture oval, inner lip callused with several small folds and wrinkles (pustules); outer lip internally thickened and lirate; siphonal canal short, narrow, and twisted; siphonal fasciole very weak; opisthocyrt growth lines.

Etymology.—The genus name is derived from *za* (Greek, exceedingly) and *glenos* (Greek, thing to stare at, show wonder).

Occurrence.—Lower Campanian to upper Campanian and possibly lower Maastrichtian; California.

Discussion.—It is difficult to assign, with certainty, *Zaglenum* n. gen. to a family, and likewise difficult to make comparisons to other genera, because the new genus has the general shape of a buccinid; the apertural features of possibly a nassariid, or to a lesser degree, a thaidid; and the growth-line pattern of a trichotropid. The new genus seems to be more like a *Cantharus*-like buccinid in having a short anterior notch and a weak siphonal fasciole. The new genus differs from *Cantharus* s.s. Röding, 1798, by having a weaker siphonal fasciole and by lacking both axial ribs and an apertural posterior gutter.

ZAGLENUM PENTZENSIS new species
Figure 6.1–6.3

Diagnosis.—Apical angle of about 52 degrees, coarse spiral ribbing, and moderately coarse cancellate sculpture.

Description.—Shell medium small (up to 34 mm in height, but incomplete), fusiform with flat-sided whorls, spire high and about 50 percent of total shell height; apical angle about 52 degrees, protoconch not preserved; whorls five to six, suture canaliculate with projecting spiral carina short distance posterior to it; carina similarly conspicuous on body whorl and situated approximately in middle of whorl; sculpture of primary spiral ribs with distinct cancellate pattern (commonly beaded) caused by growth-line intersections; interspaces between primary spiral ribs on spire and posterior half of body whorl with nearly equal secondary spiral ribs; interspaces between spiral ribs on anterior half of body whorl with two weaker spiral ribs, decreasing to one near anterior end of shell; prominent spiral rib immediately anterior to carina on body whorl approximately same strength, producing a bicarinate look; inner lip callused, apparently smooth, interior of inner lip and outer lip not seen; siphonal canal short, narrowly notched, and slightly twisted.

Etymology.—The species is named for Pentz, Butte County, California.

Types.—Holotype LACMIP 12819, LACMIP loc. 24340. Paratype LACMIP 12820, LACMIP loc. 24340. Both types are of early Campanian age and from the Chico Formation, Pentz Road Member, near Pentz, California.

Measurements.—LACMIP 12819, height 29.6 mm, width 18 mm wide. LACMIP 12820, height 33.4 mm, width 18.2 mm (estimated, due to shell missing).

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FIGURE 5—New Cretaceous gastropods from the Pacific slope of North America and one modern species. Specimens coated with ammonium chloride. *1, 2, Fimbrivasum* robustum n. sp., holotype GSC 118672, GSC loc. 15667, height 71.6 mm, ×0.7; *1,* apertural view; *2,* abapertural view. *3–9, Fimbrivasum medium* n. sp.; *3, 4,* paratype LACMIP 12818, LACMIP loc. 10093, height 24 mm, ×2.1; *3,* apertural view; *4,* abapertural view; *5, 6,* holotype CAS 228.01, CAS loc. 228, height 37 mm, ×1.4; *5,* apertural view; *6,* abapertural view; *7,* paratype GSC 118674, GSC loc. 85009, incomplete specimen, left-lateral view of neck area, height 30.5, ×1.2; *8, 9,* paratype GSC 118675, GSC loc. 16461, height 51.3 mm, ×1; *8,* apertural view; *9,* abapertural view. *10–16, Fimbrivasum elegans* n. sp.; *10–12,* holotype SDSNH 67158, SDSNH loc. 4071, height 57 mm, ×1.2; *10,* apertural view; *11,* abapertural view; *12,* apical view. *13, 14,* paratype SDSNH 11146, SDSNH loc. 2928, height 77 mm, ×0.9; *13,* apertural view; *14,* abapertural view; *15, 16,* paratype SDSNH 34067, SDSNH loc. 3392, incomplete specimen, height 18.3 mm, ×2.2; *15,* apertural view; *16,* abapertural view. *17, Vasum* ceramicum Linnaeus, 1758, hypotype LACM 87861, Quezon Province, Philippine Islands, apertural view, height 72.8 mm, ×0.8.

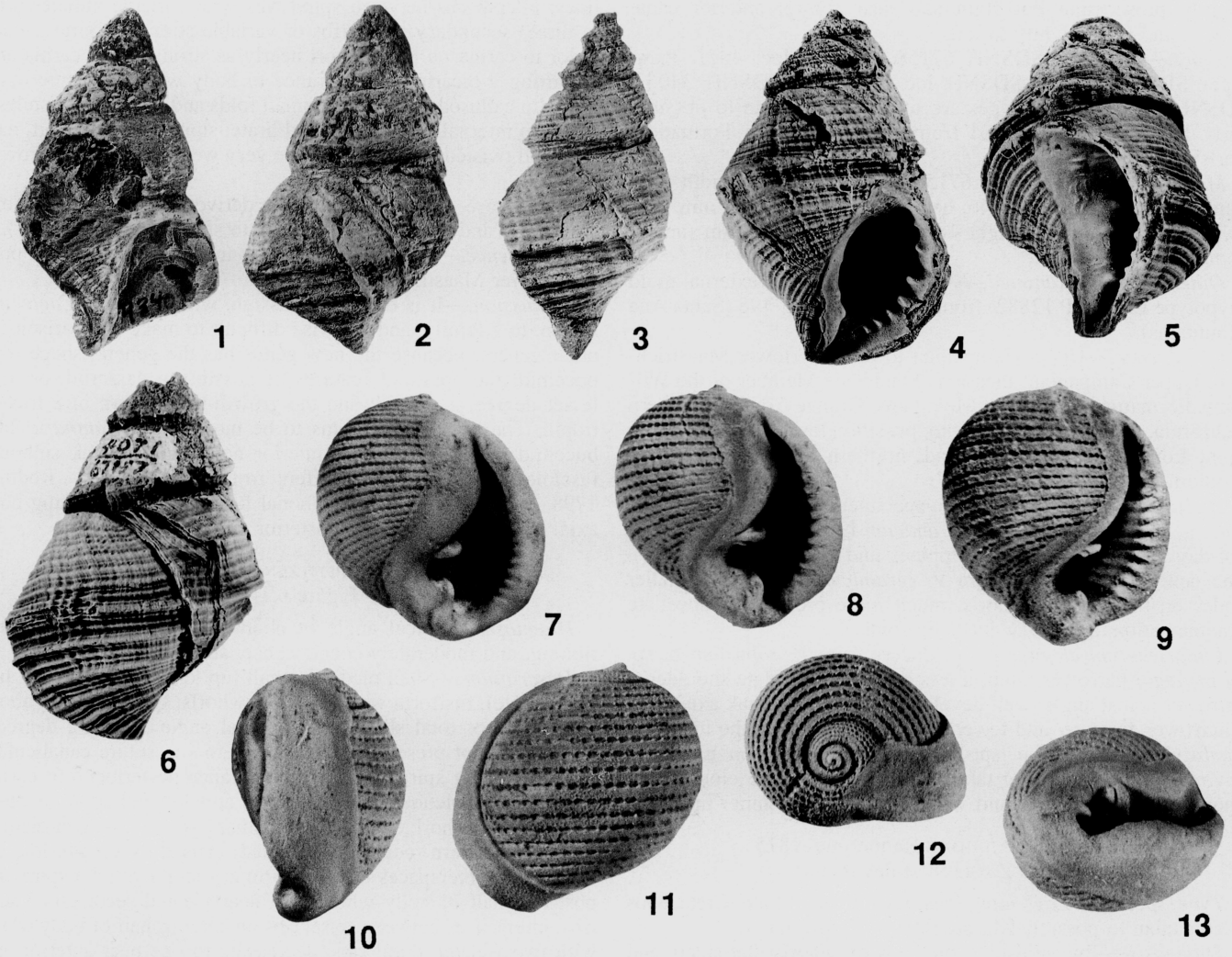

FIGURE 6—New Cretaceous gastropods from the Pacific slope of North America. Specimens coated with ammonium chloride. *1–3, Zaglenum pentzensis* n. sp.; *1, 2,* holotype LACMIP 12819, LACMIP loc. 24340, height 29.6 mm, ×1.7; *1,* apertural view; *2,* abapertural view; *3,* paratype LACMIP 12820, LACMIP loc. 24340, abapertural view, height 33.4 mm, ×1.5. *4–6, Zaglenum lomaensis* n. sp., holotype SDSNH 67157, SDSNH loc. 4071, height 33 mm, ×1.5; *4,* apertural view; *5,* oblique view showing teeth on inner lip; *6,* abapertural view. *7–13, Ringicula*? (*Ringiculopsis*?) *hesperiae* n. sp.; *7,* paratype SDSNH 26188, SDSHN loc. 3162, apertural view, height 5 mm, ×7; *8–13,* holotype SDSNH 70976, SDSNH loc. 3392, height 5.5 mm, ×6.4; *8,* apertural view; *9,* apertural view showing interior of outer lip; *10,* right-lateral view; *11,* abapertural view; *12,* apical view; *13,* anterior view.

Occurrence.—Lower Campanian (*Submortoniceras chicoense* Zone) Chico Formation, Pentz Road Member, near Pentz, Butte County, California.

Discussion.—Both specimens show moderately good preservation, but the details of the inner lip and, especially, those of the outer lip are wanting. *Zaglenum pentzensis* n. sp. differs from *Z. lomaensis* n. sp. by having a narrower apical angle, coarser spiral ribbing, coarser cancellate sculpture, and a more canaliculate suture.

ZAGLENUM LOMAENSIS new species
Figure 6.4–6.6

Diagnosis.—Apical angle of about 58 degrees, fine spiral ribbing, and faint cancellate sculpture.

Description.—Shell medium small (up to 33 mm high, but incomplete), somewhat inflated-fusiform with sloping generally flat-sided whorls; spire high and about 50 percent of total shell height; apical angle about 58 degrees; protoconch not seen; whorls five to six, suture deeply impressed (canaliculate near outer lip), with projecting spiral carina just posterior to it; carina similarly conspicuous on body whorl and situated approximately in middle of whorl; sculpture of primary sprial ribs with a very faint cancellate pattern (locally beaded) caused by growth-line intersections, interspaces between primary spiral ribs on spire and posterior half of body whorl with single secondary spiral rib; interspaces between spiral ribs on anterior half of body whorl with three weaker spiral ribs, decreasing to one near anterior end of shell; prominent spiral rib immediately anterior to carina on body whorl approximately same strength as carina, separated from carina by somewhat groove-like interspace; aperture moderately wide, oval shaped; inner lip callus lowly concave, with prominent tooth near anterior end, faint wrinkle (pustule-like feature) just posteriorly, two nearly equal, small teeth on posterior end, and several (two to three) small, spirally elongate pustules in parietal area; outer lip internally thickened, lirate with seven elongate teeth, strongest near mid point of lip; outer lip teeth decrease in strength both

posteriorly and anteriorly; siphonal canal short, narrowly notched, and slightly twisted; siphonal fasciole very poorly developed; growth lines with backward-arching sigmoidal curve (opisthocyrt).

Etymology.—The species is named for the Point Loma Formation.

Type.—Holotype SDSNH 67157, SDSNH loc. 4071, late Campanian to possibly early Maastrichtian in age, Point Loma Formation, Carlsbad, California.

Measurements.—SDSNH 67157, height 33 mm (incomplete spire), width 22 mm.

Occurrence.—Upper Campanian to possibly lower Maastrichtian; Point Loma Formation, southeast of Carlsbad, San Diego County, California.

Discussion.—The single specimen is, except for its missing spire tip, very well preserved. *Zaglenum lomaensis* n. sp. differs from *Z. pentzensis* n. sp. by having a wider apical angle, finer spiral ribbing, much finer cancellate sculpture, and a less well developed canaliculate suture.

Superorder HETEROBRANCHIA Gray, 1840
Order OPISTHOBRANCHIA Milne Edwards, 1848
Family RINGICULIDAE Meek, 1863
Genus RINGICULA Deshayes, 1838

Type species.—*Auricula ringens* Lamarck, 1804, by subsequent designation (Gray, 1847); Eocene, Paris Basin, France.

Discussion.—*Ringicula* includes small to very small, globose to subglobose shells with a moderately short spire, and a moderately deep siphonal emargination on the outer lip adjacent to the columellar tip. Sculpture is commonly present and consists of incised spirals crossed by raised growth lines. The outer lip is thickened externally, and in typical *Ringicula,* is thickened and dentate within (Sohl, 1964). At the base of the columella is a strong, upward slanting fold.

The new species described below is similar to *Ringicula* in terms of the following apertural features: strong posteriorward slanting fold at the base of the columella, more or less horizontal fold at the base of the whorl, an angulate posterior parietal welt, and an internally dentate outer lip. The new species has a lower spire than does a typical *Ringicula.* The new species has the low spire and very globular shape of *Avellana* d'Orbigny, 1843, *Oligoptycha* Meek, 1876, and *Biplica* Popenoe, 1957. *Avellana,* however, has one columellar fold and generally two parietal folds and a dentate outer lip. Its columellar fold is said to be horizontal (Sohl, 1964). *Oligoptycha* has a very strong columellar fold, well developed exteriorly and said to have a trend down toward the anterior margin (Sohl, 1964). North American Cretaceous ringiculids of globular shape from the east coast, Gulf coast, and western interior have mainly been described as *Oligotpycha,* or reassigned to this genus (Sohl, 1964; Erickson, 1974). *Biplica* has an externally thickened but internally edentate outer lip. Its anterior siphonal notch is shallow and not adjacent to the columella, and its two nearly parallel folds strengthen within the aperture and are less visible exteriorly.

Two other ringiculid genera whose globose shape is somewhat similar to that of specimens of the new species from the Point Loma Formation are *Gilbertina* Morelet, 1888, and *Eriptycha* Meek, 1876. *Gilbertina* has a less blunt spire than the other globose ringiculids, and the outer lip has two dentiform tubercles on its inner side. *Eriptycha* has a very narrow aperture with a swollen, dentate parietal callus and a bipartite fold at the base of the columella.

In summary, based mainly on its apertural features, the following new species is questionably assigned to genus *Ringicula.* The geologic range of *Ringicula* is Late Cretaceous (Cenomanian) to Recent, and it has a cosmopolitan distribution in the fossil record (Cossmann, 1895; Zilch, 1959–1960).

Subgenus RINGICULOPSIS Chavan, 1947

Type species.—*Ringicula (Ringiculopsis) larteti* Chavan, 1947, by original designation; Campanian, Mount of Olives, Palestine.

Discussion.—According to Chavan (1947), subgenus *Ringiculopsis* Chavan, 1947 differs from *Ringicula* in having a less horizontal fold at the base of the columella, a bifid posterior columellar fold, and an elongate, angular welt posterior to the bifid fold. His word for this type of welt is "arête." Chavan claimed that in *Ringicula* s.s. the posterior parietal "welt" is a more toothlike structure which penetrates the aperture rather than bordering it. *Ringiculopsis* has a very thick lirate outer lip that is reflected exteriorly to form a broad callus band extending onto the penultimate whorl. The type species of *Ringiculopsis* is more globose than most *Ringicula* s.s., but is higher spired than the Point Loma species, and has a more constricted aperture.

The geologic range of *Ringiculopsis* is Santonian to Maastrichtian, and species are known from France, Palestine, Iran [=Persia], and the Texas Gulf Coast (Chavan, 1947). Chavan's distribution gives a somewhat Tethyan aspect to the group.

RINGICULA? (RINGICULOPSIS?) HESPERIAE new species
Figure 6.7–6.13

Biplica obliqua (Gabb). SUNDBERG AND RINEY, 1984, p. 105–106, fig. 3.2

Diagnosis.—Very small shell, very low spire, marked fold at base of columella, angled posteriorward; a second, almost horizontal, strong fold, and posteriorly an elongate angular welt. Interior of outer lip dentate. Sculpture of 21 incised spirals crossed by raised lines.

Description.—Shell small (up to 10.5 mm in height); subspheroidal, spire only slightly projecting, of three whorls; body whorl forming about 90 percent of height of shell; protoconch one and one-half whorls, smooth, at slight angle to coiling of shell; suture impressed; sculpture of numerous (21 on body whorl of holotype) incised spaced spiral ribs crossed by raised growth lines producing series of chain-like links, grooves one-third width of ribs, ribs wider and flatter than those on spire; spiral ribs on spire with minutely beaded pattern caused by growth lines; aperture ovate, posteriorly pointed, maximum breadth between inner lip folds; inner lip strongly callused with an elongate parietal welt, a strong almost horizontal fold (rarely slightly bifid) at base of whorl and a strong, posteriorly directed columellar fold at base of columella; outer lip thick with callus extending out as a wide band onto body whorl (partially concealing the penultimate whorl and intervening suture) and connecting with inner lip callus posteriorly; outer lip internally lirate with about 10 lirae present on callus and extending into the aperture; anterior notch shallow but very distinct.

Etymology.—Named for *Hesperia,* one of the Hesperides or Nymphs of the Setting Sun who lived in the extreme west (i.e., Spain and Italy) near the ocean.

Types.—Holotype SDSNH 70976, SDSNH loc. 3392. Paratype SDSNH 26188, SDSNH loc. 3162. Both types are of late Campanian to possibly early Maastrichtian in age and from the Point Loma Formation, Carlsbad, California.

Measurements.—DSNH 70976, height 5.5 mm, width 5 mm. SDSNH 26188, height 5 mm, width 4.5 mm.

Other material examined.—One hundred and thirty-seven specimens: 87 from LACMIP loc. 2852 and immediate vicinity (Arroyo Santa Catarina); 27 from LACMIP loc. 23792 and immediate vicinity (San Antonio del Mar); 12 from SDSNH loc. 3162; five from LACMIP loc. 23814 (Lang Ranch); three from SDSNH loc. 3392; and one each from LACMIP locs. 4898 (Madonna Hill Guest Home) and 25902 (Coalinga).

Occurrence.—Upper Campanian to possibly lower Maastrichtian; Rosario Formation at Arroyo Santa Catarina and San Antonio del Mar, Baja California, Mexico; Point Loma Formation, Carlsbad, San Diego County, California; Chatsworth Formation, Lang Ranch area, Simi Hills, Ventura County, California; and upper Panoche Formation ("Ragged Valley Shale member") north of Coalinga, Fresno County, California.

Discussion.—Nearly all specimens of the new species are well preserved.

Ringicula? (*Ringiculopsis*?) *hesperiae* resembles illustrations of a rather ovoid *Oligoptycha corrugata* Sohl (1964, p.(297) pl. 48, figs. 36, 37). The anterior columellar fold of *R.*? (*R.*?) *hesperiae* differs from that of *O. corrugata* by trending in a strongly posteriorward direction.

Ringicula? (*Ringiculopsis*?) *hesperiae* resembles *Biplica obliqua* (Gabb, 1864, p. 111, pl. 19, figs. 64, 64a–c; Popenoe, 1957, p. 435–436, pl. 51, figs. 4–12) but differs from Gabb's species by being much smaller, having fewer spiral ribs (21 rather than 24 to 30), having two strong folds that are not parallel and that extend outward enough to be readily seen without peeling back the outer lip, and in having a dentate and less oblique outer lip. *Ringicula*? (*R.*?) *hesperiae* is younger than *B. obliqua,* which is of early and middle Campanian age and known from Vancouver, British Columbia, Canada to the Santa Ana Mountains, Orange County, California. *Biplica miniplicata* Popenoe, 1957, with which *R.*? (*R.*?) *hesperiae* was in part contemporaneous, is larger, has more spiral ribs (30), a non-dentate outer lip, and only one weak fold.

Ringicula? (*Ringiculopsis*?) *hesperiae* resembles "*Cinulia*" *pusilla* Whiteaves, 1884, which, according to him, is known from South [=Sandilands] Island, Skidegate Inlet, Queen Charlotte Islands, British Columbia. McLearn (1972) recognized the *Brewericeras hulenense* Zone of early Albian age in sandstones of the Haida Formation on Sandilands Island, and Bolton (1965) listed "*C.*" *pusilla* as from the Haida Formation. Erickson (1974) considered this species to be close to *Oligoptycha,* although its apertural characteristics are as yet not described. "*Cinulia*" *pusilla* is similar in size to *R.*? (*R.*?) *hesperiae,* but has fewer (15–16) and broader ribs. The somewhat older *Oligoptycha*? *popenoei* Allison, 1955, of late Aptian age from the Alisitios Formation of Baja California, Mexico, is also of similar size, but it has 25 spirals. Another similar ringiculid, *Biplica michaeli* Popenoe, 1957, from the early Albian *Leconites lecontei* Zone in the Budden Canyon Formation, Shasta County, California, has 18 to 20 spirals and two strong parallel folds.

In addition to the species of *Biplica* discussed by Popenoe (1957), Pacific slope Cretaceous species commonly assigned to ringiculid taxa include: *Cinulia mathewsonii* Gabb, 1864, *Ringicula varia* Gabb, 1864, and *Ringinella polita* Gabb, 1869. Of these, *Cinulia mathewsonii* Gabb, 1864, has a form most simlar to that of *R.*? (*R.*?) *hesperiae,* but it is more ovate than *R.*? (*R.*?) *hesperiae.* Stewart (1927) assigned "*C.*" *mathewsonii* to *Avellana,* which seems an appropriate placement. It has three folds, as suspected by Stewart, and a dentate outer lip, and it also appears to have had a thick inner lip callus which expanded over much of the apertural face of the body whorl. Gabb's specimen came from Bull's Head Point, Contra Costa County, California, and although Stewart (1927) considered this species to be of Cretaceous age, most of Gabb's other species from Bull's Head Point are of Paleocene age. The eastern part of Bull's Head Point has been mapped as Upper Cretaceous and the western as the Vine Hill Formation of Paleocene age (Weaver, 1953). Gabb referred *Avellana mathewsonii* to his Cretaceous "Division B." Most of Gabb's "Division B" fossils have subsequently been found to be of Tertiary age, but no species similar to *Avellana mathewsonii* has yet been found in the Tertiary. Nor as yet, has it been recognized elsewhere in Pacific slope Cretaceous deposits; although the age of this species remains problematic, its resemblance to *Avellana* suggests a Cretaceous age.

Both *Ringicula varia* and *Ringinella polita* are elongate ovate in shape with a higher spire than *R.*? (*R.*)? *hesperiae* and much weaker sculpture. *Ringicula varia* is from the Redding Formation, Cow Creek, Shasta County, California, and was indicated by Stewart (1927) to "belong to an unnamed group" within the Ringiculidae. Excellently preserved specimens of Santonian age from the Hooten Gulch Mudstone Member of the Redding Formation have been collected on Clover Creek, Shasta County. The spiral grooves of the early whorls fade to faint striae on the polished body whorl. Although the outer lip is externally thickened with a broad collar, it is edentate within. *Ringinella polita* Gabb, 1869, is from the Great Valley Series, south of the road from Colusa to the Hot Sulphur Springs in the first range of foothills, Colusa County, California, but has also been collected from Turonian-age strata of the Redding Formation, Shasta County. It was assigned by Stewart (1927) to *Acteon* of the family Acteonidae and figured as *Acteon politus* (Gabb) (Stewart, 1927, p. 431, pl. 24, fig. 18; Jones et al., 1978, p. 11, pl. 1, fig. 1).

On the Pacific slope of North America, the Cretaceous record of *Ringicula* is poorly known, but *Ringicula* (*Ringicula*) *pinguis* (Gabb, 1864) is known from strata of late Paleocene ("Martinez Stage") to earliest Eocene ("Meganos Stage) age (Zinsmeister, 1983; Squires, in press). If the generic assignment of *Ringicula*? (*Ringiculopsis*?) *hesperiae* is correct, then this gastropod represents the first Campanian record of *Ringicula* on the Pacific slope of North America and the first record of *Ringiculopsis* in this area.

The Gulf coast species that Chavan (1947) included in *Ringiculopsis* are *Ringicula pulchella* Shumard (1861, p. 192; Stephenson, 1941, p. 387–388, pl. 73, figs. 3–5) and *Ringicula sufflata* Stephenson (1941, p. 389–390, pl. 73, figs. 8, 9), and both are Maastrichtian in age. Both species generally resemble *Ringicula*? (*Ringiculopsis*?) *hesperiae* n. sp., with *R. pulchella* having apertural features more as in the new species and *R. sufflata* having a shape more as in the new species. *Ringicula*? (*Ringiculopsis*?) *hesperiae* differs from *R. pulchella* in having a less globose shape, a much lower spire, and fewer spiral ribs on the body whorl. In addition, the new species has an inner lip tooth that is only rarely bifid and much more weakly bifid. *Ringicula*? (*Ringiculopsis*?) *hesperiae* differs from *R. sufflata* in having a much lower spire, a much weaker and much less projecting inner lip tooth, absence of a vertical bifid ridge of callus running upward high on the spire, and fewer spiral ribs on the body whorl.

BIOGEOGRAPHIC AND EVOLUTIONARY SIGNIFICANCE OF THE NEW TAXA

Late Cretaceous molluscan faunas commonly show a strong North Pacific component (e.g., Elder and Saul, 1993). It is, therefore, of interest to find that of the genera herein discussed, more than half have been associated with the warm waters of the Tethys Sea of the Old World (i.e., *Otostoma, Trochacanthus, Nudivagus*?, *Xenophora,* and *Ringicula*? (*Ringiculopsis*?). In part, the presence of warm-water species in the Carlsbad area fauna may be ascribed to the southern location of Carlsbad, San Diego County. However, the somewhat earlier and more southern fauna from Punta Abreojos, Vizcaino Peninsula, Baja California Sur, Mexico, also has more temperate and North Pacific species than Tethyan species (Elder and Saul, 1993).

Otostoma has been reported intermittently in Pacific slope faunas from Albian to middle Eocene, with a noteably long hiatus between Turonian and latest Maastrichtian/earliest Paleocene age (a span of about 25 m.y.). *Otostoma sharonae* n. sp. shortens this

hiatus to Turonian to latest Campanian/earliest Maastrichtian (a span of about 18 m.y.).

Trochacanthus pacificus n. sp. provides the first and only record thus far of this very distinctive, otherwise European genus in the Western Hemisphere. It is recorded from rocks of Santonian age in Europe, but has not been found in California earlier than late Campanian to possibly earliest Maastricthian. This geographic disjunctness of similar forms suggests unfound specimens in the early Campanian.

Although *Nudivagus*? *califus* n. sp. can only questionably be assigned to the genus, it does represent the first probable record of this genus from the Pacific slope of North America, and, if correctly assigned, is the oldest known species of the genus.

Xenophora, which has a geological range of Cenomanian to Recent, was well established in the Tethyan area by Campanian time. On the Pacific slope of North America, it did not appear until the end of the Campanian (Webster, 1983). *Xenophora* (*Endoptygma*) *hermax* n. sp. indicates that *Xenophora* sensu lato had, at least on the Pacific slope of North America, diversified and given rise to a species able to inhabit a rubble substrate and use heavy pebbles for camouflage in a nearshore environment. The new species has also established that the strong revolving internal rib of *Endoptygma* is not a gerontic character.

Chavan (1947) assigned species to *Ringicula* (*Ringiculopsis*) that give the subgenus a Santonian to Maastricthian geologic range and a marginally Tethyan geographic range from Asia Minor to the Texas Gulf coast. *Ringicula*? (*Ringiculopsis*?) *hesperiae* n. sp. of latest Campanian to possibly earliest Maastrichtian age provides the first record of this subgenus from the Pacific slope of North America.

The two new genera described each have a longer geologic and wider geographic record in the Pacific slope Late Cretaceous faunas than do the five Tethyan genera. *Fimbrivasum* n. gen., which ranges from late Santonian to late Campanian/earliest Maastrichtian, comprises three new species. The youngest of these, *F. elegans,* is morphologically remarkably similar to species of the modern genus *Vasum* Röding, 1798. Although *Fimbrivasum* is here considered a North Pacific genus, the British Columbia and Washington deposits in which *F. robusta* n. sp. and *F. medium* n. sp. occur are considered by some to have been transported northward (Champion et al., 1984), but the northernmost occurrences of *Zaglenum* n. gen. that are considered to have been deposited on the North America craton are from Chico Formation outcrops in the vicinity of Pentz, Butte County, California. Elder and Saul (1993, p. 177, table 1, column 2) recorded a very low-Tethyan component in the fauna from the vicinity of Chico, Butte County. This was, however, not a cold-water fauna. Fragments of an undescribed cypraeid gastropod from Pentz suggest that the fauna inhabited a warm-temperate sea with temperatures comparable to those found in the modern Californian province. To the south near Carlsbad, in southern California, during the time of deposition of the Point Loma Formation, the mix of North Pacific and Tethyan elements suggest a province more equatable with the modern Surian province (see Elder and Saul, 1993, p. 178, fig. 4).

ACKNOWLEDGMENTS

T. Deméré (SDSNH) allowed access to collections and alerted us about the existence of many of the specimens of new taxa. G. L. Kennedy (SDSU) collected many specimens from the vicinity of the Madonna Hill Guest Home and took us in the field to collect more. He also provided locality data. L. T. Groves (LACMIP) allowed access to collections and obtained some hard-to-find literature. The late J. A. Jeletzky of the Geological Survey of Canada assisted in finding specimens in the collections and arranged for their loans. E. B. Lander and M. A. Roder (Palaeo Environmental Associates, Inc., Altadena, California) kindly provided locality information. The manuscript benefited from reviews by D. T. Dockery III (Mississippi Department of Environmental Quality Office of Geology) and J. W. Haggart (GSC).

REFERENCES

ABBASS, H. L. 1973. Some British Cretaceous gastropods belonging to the families Procerithiidae, Cerithiidae and Cerithiopsidae (Cerithiacea). Bulletin of The British Museum (Natural History) Geology, 23: 107–175.

ABDEL-GAWAD, G. I. 1986. Maastrichtian non-cephalopod mollusks (Scaphopoda, Gastropoda and Bivalvia) of the middle Vistula Valley, cental Poland. Acta Geologica Polonica, 36:69–224.

ACHARYYA, S. K., AND T. C. LAHIRI. 1991. Cretaceous paleogeography of the Indian subcontinent; a review. Cretaceous Research, 12:3–26.

AKERS, R. E., AND T. J. AKERS. 1997. Texas Cretaceous gastropods. Texas Paleontology Series, Publication No. 6, Houston Gem and Mineral Society, Houston, Texas, 340 p.

ALLISON, E. C. 1955. Middle Cretaceous Gastropoda from Punta China, Baja California, Mexico. Journal of Paleontology, 29:400–432.

ANDERSON, F. M. 1958. Upper Cretaceous of the Pacific coast. Geological Society of America Memoir, 71, 378 p.

ANDERSON, F. M., AND G. D. HANNA. 1935. Cretaceous geology of lower California. Proceedings of the California Academy of Sciences, Series 4, 23:1–34.

ANDERSON, J. Q. 1972. Cretaceous subdivisions of the Coalinga district, Fresno County, California, p. 11–18. *In* R. E. Steinert (ed.), Cretaceous of the Coalinga Area. Pacific Section, SEPM, Guidebook Fall Field Trip, Los Angeles, California.

ANDERSON, R., AND R. W. PACK. 1915. Geology and oil resources of the west border of the San Joaquin Valley north of Coalinga, California. U.S. Geological Survey Bulletin, 603:1–220.

ARCHIAC, E. J. A. D'. 1859. Note sur le genre *Otostoma.* Bulletin de la Société Géologique de France, Série 2, 16:871–879.

BANNON, J. L., D. J. BOTTJER, S. P. LUND, AND L. R. SAUL. 1989. Campanian/Maastrichtian stage boundary in southern California. Resolution and implications for large-scale depositional patterns. Geology, 17:80–83.

BARTLING, W. A., AND P. L. ABBOTT. 1984. Upper Cretaceous sedimentation and tectonics with reference to the Eocene, San Miguel Island, and San Diego area, California, p. 85–102. *In* P. L. Abbott (ed.), Upper Cretaceous Depositional Systems-Southern California-Northern Baja California. Pacific Section, SEPM, Book 36, Los Angeles, California.

BEAL, C. H. 1948. Reconnaissance of the geology and oil possibilities of Baja California, Mexico. Geological Society of America Memoir, 31, 138 p.

BOLTON, T. E. 1965. Catalogue of type invertebrate fossils of the Geological Survey of Canada. Volume 2. Geological Survey of Canada, 344 p.

BORN, I. 1780. Testacea musei caesarei vindobonensis. Joannis Pauli Kraus, Vienna, 442 p.

CHAMPION, D.E., D. G. HOWELL, AND C. S. GROMME. 1984. Paleomagnetic and geologic data indicating 2500 km of northward displacement for the Salininan and related terranes, Calilfornia. Journal of Geophysical Research, 89:7736–7752.

CHAVAN, A. 1947. La faune Campanienne de Mont des Oliviers d'apres les matériaux Vignal-Massé. Journal de Conchyliologie, 87:125–197.

CLAPP, C. H. 1912. Geology of the Nanaimo sheet, Nanaimo coal field, Vancouver Island, Bristish Columbia. Geological Survey of Canada, Summary Report for 1911:91–105.

CLAPP, C. H., AND H. C. COOKE. 1917. Sooke and Duncan map-areas, Vancouver Island. Geological Survey of Canada Memoirs, 96, 445 p.

CLENCH, W. J., AND C. G. AGUAYO. 1943. The genera *Xenophora* and *Tugurium* in the western Atlantic. Johnsonia, 1:1–6.

COLBURN, I. P., L. R. SAUL, AND A. A. ALMGREN. 1981. The Chatsworth Formation: a new formation name for the Upper Cretaceous strata of the Simi Hills, California, p. 9–16. *In* M. H. Link, R. L. Squires, and I. P. Colburn (eds.), Simi Hills Cretaceous Turbidites, Southern California. Pacific Section, SEPM Volume and Guidebook, Los Angeles, California.

COOMBS, W. P., JR., AND T. A. DEMÉRÉ. 1996. A Late Cretaceous nodosaurid ankylosaur (Dinosauria: Ornithischia) from marine sediments of coastal California. Journal of Paleontology, 70:311–326.

COSSMANN, M. 1895. Essais de Paléoconchologie Comparée. Volume 1. Privately published, Paris, 159 p.

COSSMANN, M. 1905. Sur un gisement de fossiles bathoniens près de Courmes. Bulletin de la Société Géologique de France, 2:829–846.

COX, L. R. 1959. Thoughts on the classification of the Gastropoda. Proceedings of the Malacological Society of London, 33:239–261.

COX, L. R. 1960. Family Nododelphinulidae Cox, n. fam., p. 308. *In* R. C. Moore (ed.), Treatise on Invertebrate Paleontology, Part I, Mollusca 1. Geological Society of America and University of Kansas Press, Lawrence.

CUNNINGHAM, A. B., AND P. L. ABBOTT. 1986. Sedimentology and provenance of the Upper Cretaceous Rosario Formation south of Ensenada, Baja California, Mexico, p. 103–118. *In* P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, SEPM, Book 46, Los Angeles, California.

CUVIER, G. L. C. F. D. 1797. Tableau élémentaire de l'histoire naturelle des animaux [des Mollusques]. Paris, 710 p.

DACQUÉ, E. 1936. Über homöogenetische Gastropodenformen. Zentralblatt für Mineralogie, Geologie und Paläontologie, 12(B):533–546.

DARRAGH, T. A., AND G. W. KENDRICK. 1994. Maastrichtian Scaphopoda and Gastropoda. Records of the Western Australian Museum, Supplement, 48:1–76.

DESHAYES, G. P. 1838. *In* G. P. Deshayes and H. Milne-Edwards (eds.), J. B. P. Lamarck's Histoire des Animaux Sans Vertèbres (second edition). Volume 8. Paris.

DIBBLEE, T. W., JR. 1981. Upper Mesozoic rock units in the central Diablo Range between Hollister and New Idria and their depositional environments, p. 13–20. *In* V. Frizzell (ed.), Geology of the Central and Northern Diablo Range, California. Pacific Section, SEPM, Los Angeles, California.

DICKERSON, R. E. 1916. Stratigraphy and fauna of the Tejon Eocene of California. University of California Publications, Bulletin of the Department of Geology, 9:363–524.

DOCKERY, D. T. 1993. The streptoneuran gastropods, exclusive of the Stenoglossa, of the Coffee Sand (Campanian) of northeastern Mississippi. Mississippi Department of Environmental Quality, Office of Geology Bulletin, 129:1–191.

DOUVILLÉ, H. 1904. Paléontologie, mollusques fossiles, p. 191–380. *In* J. De Morgan (eds.), Mission Scientifique en Perse. Volume 3. Part 4. E. Leroux, Paris.

ELDER, W. P. 1990. *Tibiaporrhais,* a new Late Cretacous genus of Aporrhaidae resembling *Tibia* Röding. The Veliger, 33:293–298.

ELDER, W. P., AND L. R. SAUL. 1993. Paleogeographic implications of molluscan assemblages in the Upper Cretaceous (Campanian) Pigeon Point Formation, California, p. 171–186. In G. C. Dunne and K. A. McDougall (eds.), Mesozoic Paleogeography of the Western United States-II. Pacific Section, SEPM Book 71.

ELDER, W. P., AND L. R. SAUL. 1996. Taxonomy and biostratigraphy of Coniacian through Maastrichtian *Anchura* (Gastropoda: Aporrhaidae) of the North American Pacific slope. Journal of Paleontology, 70:381–399.

ERICKSON, J. M. 1974. Revision of the Gastropoda of the Fox Hills Formation, Upper Cretaceous (Maestrichtian) of North Dakota. Bulletins of American Paleontology, 66(284):131–253.

FÉRUSSAC, J. B. L. 1819. Histoire naturelle générale et particulière des mollusques terrestres et fluviateles. Volume 1. Paris, 128 p.

FISCHER VON WALDHEIM, G. 1807. Muséum Demidoff, ou Catalogue Systématique et Raisonné des Curiosités de la Nature et de l'art. Volume 3. Moscow, 330 p.

GABB, W. M. 1864. Description of the Cretaceous fossils. California Geological Survey, Palaeontology. Volume 1, p. 57–243.

GABB, W. M. 1869. Cretaceous and Tertiary fossils. California Geological Survey, Palaeontology, Volume 2, 299 p.

GABB, W. M. 1877. Notes on American Cretaceous fossils, with descriptions of some new species. Proceedings of the Philadelphia Academy of Natural Sciences, 28:276–324.

GOLDFUSS, A. 1826–1844. Petrefacta Germaniae. Abbildungen und Beschreibungen der Petrefacten Deutschlands und der angrenzenden Länder. A. Goldfuss, Düsseldorf, Volume 3, 128 p.

GOLIKOV, A. N., AND Y. I. STAROBOGATOV. 1975. Systematics of prosobranch gastropods. Malacologia, 15:185–232.

GRAY, J. E. 1840. Synopsis of the contents of the British Museum. Edition 42. Woodfall & Son, London, 370 p.

GRAY, J. E. 1847. A list of the genera of Recent Mollusca, their synonyma and types. Proceedings of the Zoological Record of London, 15: 129–219.

GROVES, L. T. 1990. New species of Late Cretaceous Cypraeacea (Mollusca: Gastropoda) from California and Mississippi, and a review of Cretaceous cypraeaceans of North America. The Veliger, 33:272–285.

HAGGART, J. W. 1989. New and revised ammonites from the Upper Cretaceous Nanaimo Group of British Columbia and Washington State. Geological Survey of Canada, Contributions to Canadian Paleontology Bulletin, 396:181–221.

HALLER, B. 1882. Die Morphologie der Prosobranchia. Morphologisches Jährbucher, 14:54–169.

HARRIS, G. F. 1897. Catalogue of Tertiary Mollusca in the Department of Geology, British Museum (Natural History). Part 1. The Australasian Tertiary Mollusca. British Museum (Natural History), London, 407 p.

HAYAMI, I., AND T. KASE. 1977. A systematic survey of the Paleozoic and Mesozoic Gastropoda and Paleozoic Bivalvia from Japan. The University Museum, University of Tokyo Bulletin, 13:1–155.

HOENINGHAUS, F. W. 1830. Versuch einer geognostischen Eintheilung seiner Versteinerung-Sammlung (Zweiter Theil). [Neues] Jahrbuch für Mineralogie, Geognoise, Geologie und Petrefaktenkunde [Universität zu Heidelberg], 1:446–476.

JONES, D. L., W. V. SLITER, AND W. P. POPENOE. 1978. Mid-Cretaceous (Albian to Turonian) biostratigraphy of northern California. Annales du Muséum l'Histoire Naturelle de Nice, 4:1–13.

KENNEDY, G. L., L. R. SAUL, AND M. L. BELLOWS. In press. Geology and paleontology of the basal Upper Cretaceous in San Diego County, southern California. Western Society of Malacology Annual Report for 1999 (Abstracts), San Diego.

KENNEDY, M. P., AND G. W. MOORE. 1971. Stratigraphic relations of Upper Cretaceous and Eocene formations, San Diego, California. Bulletin of the American Association of Petroleum Geologists, 55:709–722.

KOLLMANN, H. A. 1980. Gastropoden aus der Sandkalkbank (Hochmoosschichten, Obersanton) des Beckens von Gosau (Oö). Annalen des Naturhistorischen Museums in Wien, 83:107–213.

LAMARCK, J.-B., 1804. Mémoires sur les fossiles des environs de Paris (suite 3). Annales du Muséum d'Histoire Naturelle, 4:429–436.

LINNAEUS, C. 1758. Systema Naturae per Regna Tria Naturae. Regnum Animale. Editio decima Reformata. Volume 1. Laurentius Salvius, Holmiae, 824 p.

LINSLEY, R. M., AND E. L. YOCHELSON. 1973. Devonian carrier shells (Euomphalidae) from North America and Germany. U.S. Geological Survey Professional Paper, 824:1–23.

LOCH, J. D. 1989. A new genus of aporrhaid gastropod from southern California. Journal of Paleontology, 63:574–577.

LOEL, W., AND W. H. COREY. 1932. The Vaqueros Formation, lower Miocene of California. I. Paleontology. University of California Publications, Bulletin of the Department of Geological Sciences, 22:31–410.

MATSUMOTO, T. 1960. Upper Cretaceous ammonites of California. Part 3. Memoirs of the Faculty of Science, Kyushu University, Series D, Geology, Special Volume 2:1–204.

MATHERON, P. 1842–1843. Catalogue Méthodique et Descriptif des Corps Organisés Fossiles du Département des Bouches-du-Rhóne et Lieux Circonvoisinus. Marseille, 269 p.

MCLEARN, F. H. 1972. Ammonoids of the Lower Cretaceous Sandstone Member of the Haida Formation, Skidegate Inlet, Queen Charlotte Islands, western British Columbia. Geological Survey of Canada Bulletin, 188:1–78.

MEEK, F. B. 1862. Descriptions of new Cretaceous fossils collected by the North-Western Boundary Commission, on Vancouver and Sucia islands. Proceedings of the Academy of Natural Sciences of Philadelphia (for 1861), 13:314–318.

MEEK, F. B. 1863. Remarks on the family Actaeonidae with descriptions of some new genera and subgenera. American Journal of Science, Series 2, 35:84–94.

MEEK, F. B. 1876. A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country. U.S. Geological Survey of the Territories, Hayden Survey, Volume 9, 629 p.

MIKKELSEN, P. M. 1996. The evolutionary relationships of Cephalaspidea s.l. (Gastropoda: Opisthobranchia): a phylogenetic analysis. Malacologia, 37:375–442.

MILNE-EDWARDS, H. 1848. Note sur la classification naturelle des mollusques gastéropodes. Annales des Sciences Naturelles Zoologiques, 9: 102–112.

MORELET, A. 1888. Diagnosis generis novi molluscorum fossilum. Journal de Conchyliologie, 36:220–221.

MORTON, S. G. 1834. Synopsis of the Organic Remains of the Cretaceous Group of the United States. Philadelphia, Pennsylvania, 84 p.

MULLER, J. E., AND J. A. JELETZKY. 1970. Geology of the Upper Cretaceous Nanaimo Group, Vancouver Island and Gulf Islands, British Columbia. Geological Survey of Canada Paper, 69–25:1–77.

NAGAO, T. 1932. Some Cretaceous Mollusca from Japanese Saghalin and Hokkaido (Lamellibranchiata and Gastropoda). Journal of the Faculty of Science, the Hokkaido Imperial University, Series 4, 2:23–50.

NELSON, R. N. 1925. A contribution to the paleontology of the Martinez Eocene of California. University of California Publications Bulletin of the Department of Geological Sciences, 15:397–466.

ORBIGNY, A. D'. 1843. Paléontologie Française, Terrains Crétacés. Volume 3, Mollusques. Atlas, pls. 237–489. G. Masson, Paris, 807 p.

PACKARD, E. L. 1922. New species from the Cretaceous of the Santa Ana Mountans, California. University of California Publications Bulletin of the Department of Geological Sciences, 13:413–462.

PALMER, A. R., AND J. GEISSMAN. 1999. Geological Society of America 1999 Geologic Time Scale. <http://www.geosociety.org/publs/timescl.htm>

PAYNE, M. B. 1962. Type Panoche group (Upper Cretaceous and overlying Moreno and Tertiary strata on the west side of the San Joaquin Valley). California Division of Mines and Geology Bulletin, 181:165–175.

PHILIPPI, R. A. 1853. Handbuch der Conchyliologie und Malakozoologie. Halle, 547 p.

PONDER, W. F. 1983. A revision of the Recent Xenophoridae of the world and of the Australian fossil species. Australian Museum Memoir, 17: 1–126.

PONDER, W. F., AND D. R. LINDBERG. 1997. Towards a phylogeny of gastropod molluscs: an analysis using morphological characters. Zoological Journal of the Linnean Society, 119:83–265.

PONDER, W. F., AND A. WARÉN. 1988. Classification of the Caenogastropoda and Heterostropha—a list of the family-group names and higher taxa. Malacological Review, Supplement, 4:288–326.

POPENOE, W. P. 1942. Upper Cretaceous formations and faunas of southern California. Bulletin of the American Association of Petroleum Geologists, 26:162–187.

POPENOE, W. P. 1957. The Cretaceous gastropod genus *Biplica,* its evolution and biostratigraphic significance. University of California Publications in Geological Sciences, 30:425–454.

RAFINESQUE, C. S. 1815. Analyse de la Nature, ou Tableau de l'Universe des Corps Organisées. Palermo, 224 p.

RÖDING, P. F. 1798. Museum Boltenianum. Johan Christi Trappii, Hamburg, 199 p.

ROMAN, F., AND P. MAZERAN. 1920. Monographie paléontologique de la faune du Turonien du bassin d'Uchaux et de ses dépendances. Archives du Muséum d'Histoire Naturelle de Lyon, 12:1–137.

RUSSELL, J. S., S. L. BAUM, AND R. WATKINS. 1986. Late Coniacian to early Campanian clastic shelf deposits and molluscan assemblages of the northeastern Sacramento Valley, California, p. 179–196. *In* P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, SEPM, Book 46, Los Angeles, California.

SALVINI-PLAWÉN, L. 1980. A reconsideration of systematics in the Mollusca (phylogeny and higher classification). Malacologia, 19:249–278.

SAUL, L. R. 1982. Water depth indications from Late Cretaceous mollusks, Santa Ana Mountains, California, p. 69–76. *In* D. J. Bottjer, I. P. Colburn, and J. D. Cooper (eds.), Late Cretaceous Depositional Environments and Paleogeography, Santa Ana Mountains, Southern California. Pacific Section, SEPM, Field Trip Volume and Guidebook, Los Angeles, California.

SAUL, L. R., AND R. L. SQUIRES. 1997. New species of neritid gastropods from Cretaceous and lower Cenozoic strata of the Pacific slope of North America. The Veliger, 40:131–147.

SHUMARD, B. F. 1861. Description of new Cretaceous fossils from Texas. Proceedings of the Boston Society of Natural History, 8:188–205.

SOHL, N. F. 1960. Archeogastropoda, Mesogastropoda and stratigraphy of the Ripley, Owl Creek, and Prairie Bluff formations. U.S. Geological Survey Professional Paper, 331-A:1–151.

SOHL, N. F. 1964. Neogastropoda, Opisthobranchia and Basommatophora from the Ripley, Owl Creek, and Prairie Bluff formations. U.S. Geological Survey Professional Paper 331-B:1–344.

SQUIRES, R. L. 1994. Macropaleontology of Eocene marine rocks, upper Sespe Creek area, Ventura County, southern California, p. 39–56. *In* A. E. Fritsche (ed.), Sedimentology and Paleontology of Eocene Rocks in the Sespe Creek Area, Ventura County, California. Pacific Section, SEPM (Society for Sedimentary Geology), Book 74, Los Angeles, California.

SQUIRES, R. L. 1995. The gastropod *Philine bisculptata* Hanna, 1927, from the Eocene of southern California, belongs in the neritid genus *Otostoma* d'Archiac, 1859. The Veliger, 38:188–192.

SQUIRES, R. L. In press. Upper Paleocene to lower Eocene ("Meganos Stage") marine megafossils in the uppermost Santa Susana Formation, Simi Valley, southern California. Natural History Museum of Los Angeles County Contributions in Science.

SQUIRES, R. L., AND R. DEMETRION. 1992. Paleontology of the Eocene Bateque Formation, Baja California Sur, Mexico. Natural History Museum of Los Angeles County Contributions in Science, 434:1–55.

SQUIRES, R. L., AND L. R. SAUL. 1993. A new species of *Otostoma* (Gastropoda: Neritidae) from near the Cretaceous/Tertiary boundary at Dip Creek, Lake Nacimiento, California. The Veliger, 36:259–264.

SQUIRES, R. L., AND L. R. SAUL. 1997. Late Cretaceous occurrence on the Pacific slope of North America of the melanopsid gastropod genus *Boggsia* Olsson, 1929. The Veliger, 40:193–202.

STANTON, T. W. 1893. The Colorado Formation and its invertebrate fauna. U.S. Geological Survey Bulletin, 106:1–189.

STEPHENSON, L. W. 1941. The larger invertebrate fossils of the Navarro Group of Texas. The University of Texas Publication, 4101:1–641.

STEPHENSON, L. W. 1952. Larger invertebrate fossils of the Woodbine Formation (Cenomanian) of Texas. U.S. Geological Survey Professional Paper, 242:1–226.

STEWART, R. B. 1927. Gabb's California fossil type gastropods. Proceedings of the Academy of Natural Sciences of Philadelphia, 78:287–447.

STOLICZKA, F. 1867–1868. Cretaceous fauna of south India. Volume 2. The Gastropoda. Memoirs of the Geological Survey of India, Palaeontologica Indica, Series 5, 2:1–497.

SUNDBERG, F., AND B. RINEY. 1984. Preliminary report on the Upper Cretaceous macro-invertebrate faunas near Carlsbad, California, p. 103–107. *In* P. L. Abbott (ed.), Upper Cretaceous Depositional Systems-Southern California-Northern Baja California. Pacific Section, SEPM, Book 36, Los Angeles, California.

SWAINSON, W. 1840. A Treatise on Malacology; or the Natural Classification of Shells and Shell-fish. Longman et al., London, 419 p.

THIELE, J. 1929–1935. Handbuch der systematischen Weichtierkunde. Gustav Fisher Verlag, Jena, Germany, 1154 p.

TOUMEY, M. 1854. Description of some new fossils from the Cretaceous rocks of the southern states. Proceedings of the Philadelphia Academy of Natural Sciences, 7:167–172.

TROSCHEL, F. H. 1852. Verzeichnis der durch Herrn Dr. von Tschudi in Peru gesammelten Conchylien. Archives Naturgesellschaft, 18:151–208.

TRUMBLY, P. N. 1983. Stratigraphy and sedimentation of the Cretaceous Brown Mountain Sandstone near Coalinga, California. Unpublished M.S. thesis, San Diego State University, San Diego, 154 p.

WADE, B. 1917. New and little known Gastropoda from the Upper Cretaceous of Tennessee. Proceedings of the Philadelphia Academy of Natural Sciences, 69:280–304.

WADE, B. 1926. The fauna of the Ripley Formation on Coon Creek, Tennessee. U.S. Geological Survey Professional Paper, 137:1–192.

WEAVER, C. E. 1905. Contributions to the palaeontology of the Martinez Group. University of California Publications Bulletin of the Department of Geology, 4:101–123.

WEAVER, C. E. 1953. Eocene and Paleocene deposits at Martinez, California. University of Washington Publications in Geology, 7:1–102.

WEBSTER, M. L. 1983. New species of *Xenophora* and *Anchura* (Mollusca: Gastropoda) from the Cretaceous of Baja California Norte, Mexico. Journal of Paleontology, 57:1090–1097.

WENTWORTH, C. K. 1922. A scale of grade and class terms for clastic sediments. Journal of Geology, 30:377–392.

WENZ, W. 1938. Familia Amberleyidae (Eucyclidae), p. 262–268. *In* O.

H. Schindewolf (ed.), Handbuch der Paläozoologie, Band 6, Gastropoda. Allgemeiner Teil und Prosobranchia, Teil 4. Gebrüder Borntraeger, Berlin.

WHITE, C. A. 1885. On new Cretaceous fossils from California. U.S. Geological Survey Bulletin, 22:7–14.

WHITEAVES, J. F. 1884. On the fossils of the coal-bearing deposits of the Queen Charlotte Islands, British Columbia. Geological Survey of Canada, Mesozoic Fossils, 1(3):191–262.

WHITEAVES, J. F. 1896. On some fossils of the Nanaimo Group of the Vancouver Cretaceous. Royal Society of Canada Transactions and Proceedings for 1895, Series 2, 1:119–133.

YEO, R. K. 1984. Sedimentology of Upper Cretaceous strata, northern Baja California, Mexico, p. 109–120. *In* P. L. Abbott (ed.), Upper Cretaceous Depositional Systems-Southern California-Northern Baja California. Pacific Section, SEPM, Book 36, Los Angeles, California.

ZEKELI, L. F. 1852. Die Gastropoden der Gosaugebilde in den nordöstlichen Alpen. Kaiserlich-koeniglichen Geologischen Reichsanstalt Abhandlungen, 1:1–124.

ZILCH, A. 1959–1960. Handbuch der Paläozoologie. Gastropoda Teil 2: Euthyneura. Gebrüder Borntraeger, Berlin-Nikolasse, 834 p.

ZINSMEISTER, W. J. 1983. Late Paleocene ("Martinez provincial stage") molluscan fauna from the Simi Hills, Ventura County, California, p. 61–70. *In* R. L. Squires and M. V. Filewicz (eds.), Cenozoic Geology of the Simi Valley area, southern California. Pacific Section, SEPM, Field Trip Volume and Guidebook, Book 35, Los Angeles, California.

ACCEPTED 3 JULY 2000

APPENDIX

Localities Cited

CAS 228.—No detailed information available. Sucia Island, Washington. Cedar District Formation. Age: Middle Campanian.

GSC 15667.—At foot of first large falls (7 to 10 m high) on north bank of Brannan Creek [old name for Benson Creek], just west of Nanaimo, southeastern Vancouver Island, British Columbia. Lower Haslam Formation. Age: Late Santonian (lower *Sphenoceramus schmidti* Zone). Collector: J. L. Usher, 1945.

GSC 16461.—No detailed information available. Sucia Island, Washington. Cedar District Formation. Age: Middle Campanian. Collector: J. Usher, 1948.

GSC 85009.—No detailed information available. Texada Island, British Columbia. Cedar District Formation. Age: Middle Campanian. Collector: W. Harvey, 1901.

LACMIP 2852.—Elevation 55 m, in prominent exposures of conglomerate near mouth of small embayment about 1,128 m north of Ammonite Ravine, approximately 6.5 km from coast, west side Arroyo Santa Catarina (south, north, and west walls), Baja California, Mexico. Rosario Formation. Age: Late Campanian? (*Didymoceras hornbyense* Zone). Collector: M. Webster, 1966.

LACMIP 4898.—Dark gray mudstone at base of cliff of east-facing roadcut on El Camino Real, opposite and south of drive to Madonna Hill Guest Home (5392 El Camino Real); U.S. Geological Survey, 7.5-minute San Luis Rey Quadrangle, 1968 (photorevised 1975), southeast corner of Carlsbad, northern San Diego County, California. Point Loma Formation. Age: Late Campanian to possibly early Maastrichtian. Collectors: G. L. Kennedy, C. B. and L. M. Kennedy, and Whitney and L. Hinds, June 10, 1973; G. L. Kennedy and R. M. McCall, January, 1975; G. L. Kennedy and P. G. Owen, March 18, 1975; and G. L. Kennedy and B. O. Riney, April, 25, 1975.

LACMIP 8063.—Dave Week's place on Coon Creek, 5.6 km south of Enville, 12 km north of Adamsville, McNairy County, Tennessee. Age: Maastrichtian. Collector: W. P. Popenoe, 1935.

LACMIP 10093.—[=CIT 1053; UCLA 4191]. First prominent northeast-southwest spur north of Santiago Creek near junction with Modjeska Creek; pebbly lens near top of shale series just below crest of ridge, 61 m north, 869 m east of southwest corner of sec. 20, T 5 S, R 7 W, U.S. Geological Survey, El Toro Quadrangle, 1949, Santa Ana Mountains, Orange County, California. Ladd Formation, upper Holz Shale Member. Age: Early Campanian. Collector: W. P. Popenoe, April 19, 1934.

LACMIP 17198.—Unsorted very indurated conglomerate lens with pebble and cobble-sized rocks and a sandstone matrix; at elevation 207 m, on west side of divide on west side of Bee Canyon, 4,496 m south and 3,117 m east of northwest corner of U.S. Geological Survey, El Toro Quadrangle, 1949, Santa Ana Mountains, Orange County, California. Williams Formation, Pleasants Sandstone Member. Age: Late Campanian. Collector: D. A. Alexander, May 27, 1997. [Locality now covered by the Eastern Transportation Corridor].

LACMIP 23792.—Concretionary sandstone beds below oyster reefs on north side of Arroyo San Antonio, N10°E of Johnson's Ranch house and about 1.6 km from the arroyo mouth. Baja California, Mexico. Rosario Formation. Age: Late Campanian. Collector: W. P. Popenoe, February 10, 1948.

LACMIP 23814.—Dark gray calcareous sandstone stringers in brown sandstone in gully channel 76 m north of private road on Lang Ranch, 854 m north and 53 m west of southeast corner of sec. 26, T 2 N, R 19 W, U.S. Geological Survey, 7.5-minute Thousand Oaks Quadrangle, 1950 (revised 1967), northwest end of Simi Hills, Ventura County, California. Chatsworth Formation. Age: Late Campanian/early Maastrichtian. Collector: D. H. Dailey, April, 1958.

LACMIP 24340.—Conglomerate beds cropping out just below a drainage canal, southeast side of Oroville Highway, about 1.2 km northeast of intersection of the highway and Pentz-Magalia-Oroville Road, and 427 m south and 183 m west of northeast corner of sec. 36, T 21 N, R 3 E, U.S. Geological Survey, 7.5-minute, Cherokee Quadrangle, 1949, Butte County, California. Chico Formation, Pentz Road member (informal) of Russell et al. (1986). Age: Early Campanian. Collector: W. P. Popenoe, May 13, 1960.

LACMIP 25902.—About 30 m above contact with Joaquin Rocks Member, just west of center of sec. 7, T 19 S, R 15 E, in gullies tributary to Oil Canyon at its source, U.S. Geological Survey, 7.5-minute, Joaquin Rocks Quadrangle, 1969, Fresno County, California. Upper Panoche Formation ("Ragged Valley Shale member"). Age: Late Campanian/early Maastrichtian. Collector: W. P. Popenoe, April 27, 1949.

SDSNH AND SDSU

U.S. Geological Survey, 7.5-minute San Luis Rey Quadrangle, 1968 (photorevised 1975), southeast corner of Carlsbad, northern San Diego County, California. Point Loma Formation. Age: Late Campanian to possibly early Maastrichtian.

SDSNH

2928.—Letterbox Canyon [="Ammonite Valley"]. Collector: F. Stephens, 1925.

3162.—Elevation 85 m, at Carlsbad Research Center, in blue-gray sandy mudstone with interbedded well cemented sandstones, in a sewerline trench now covered by Faraday Avenue. Collector: B. O. Riney, November 1, 1983.

3392.—Elevation 50 m, in unweathered blue-gray fossiliferous mudstone in a roadcut along west side of College Boulevard, approximately 427 m south of intersection with El Camino Real. Collector: SDSNH field party, May 19, 1987.

3402.—Elevation 49 m, at Carlsbad Research Center, in unweathered blue-gray siltstone in a temporary exposure (the locality has since been graded away) made during grading for the College Boulevard extension. Collector: B. O. Riney, April 23, 1987.

3672.—Elevation 75 m, at Carlsbad Research Center, on north side of Faraday Ave., approximately 305 m west of intersection with College Boulevard, 1349 m north and 3450 m west of southeast corner of San Luis Rey Quadrangle. Collector: B. O. Riney, May 11, 1993.

3673.—At Carlsbad Research Center, in trench within the road bed of Faraday Ave, approximately 366 m west of intersection with College Boulevard, 1326 m north and 3520 m west of southeast corner of San Luis Rey Quadrangle. Collector: B. O. Riney, May 20, 1993.

3869.—Concretionary cobble bed near base of Point Loma Formation, now covered by a building on south side of Rutherford Road near culde-sac of Farnsworth Courth, north of Palomar Airport and southwest of El Camino Real. Collector: B. O. Riney, 1987.

4071.—Elevation 47 m, at the Taylor Made Golf facility on west side of Letterbox Canyon, 1676 m north and 2987 m west of southeast corner of San Luis Rey Quadrangle. Collector: B. O. Riney, April 15, 1997.

SDSU

346.—Detailed information not available. Rosario Formation, San Antonio del Mar, Baja California, Mexico. Age: Campanian.

3870.—In sandstone immediately overlying basal conglomerate, and from spoil piles along south side of commercial property at 5607 Palmer Way, Carlsbad. Collectors: G. L. Kennedy, M. L. Bellows, and S. A. Rhodes, various dates between September, 1998 to June, 1999; G. Davis, L. T. Groves, L. R. Saul, and R. L. Squires, January, 1999.

3871.—In upper part of basal conglomerate, about 1 m stratigraphically below SDSU locality 3870, and from spoil pile of pebbles and cobbles derived from excavation of building pad for commercial property at 5607 Palmer Way, Carlsbad. Collectors: G. L. Kennedy, M. L. Bellows, and S. A. Rhodes, various dates between September, 1998 to June, 1999.

3872.—From small spoil pile of pebbles and cobbles from basal conglomerate exposed in foundation trench along center of north side of building pad for commerical building at 5607 Palmer Way, Carlsbad. Collectors: M. L. Bellows, G. L. Kennedy, and S. A. Rhodes, various dates between September, 1998 and February, 1999.

3875.—Spoil piles for shallow utility trench parallel to curb along east side of property at 5601 Palmer Way, Carlsbad. Collectors: M. L. Bellows and S. A. Rhodes, December, 1998 and February, 1999.

3877.—An approximately 3-m deep utility trench and associated spoil piles at southeast side of footing wall for parking places at 5601 Palmer Way, Carlsbad. Collectors: G. L. Kennedy, January and February, 1999; and M. L. Bellows, April, 1999.

3879.—Displaced indurated fossiliferous sandstone boulder (with internal and external molds) found between roadway and northeast side of building at 5607 Palmer Way, Carlsbad. Collector: G. L. Kennedy, January, 1999.