



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, $\times 1.7$; 1, apertural view; 2, abapertural view; 3, paratype LACMIP 12820, LACMIP loc. 24340, abapertural view, height 33.4 mm, $\times 1.5$. 4–6, *Zaglenum lomaensis* n. sp., holotype SDSNH 67157, SDSNH loc. 4071, height 33 mm, $\times 1.5$; 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, SDSNH loc. 3162, apertural view, height 5 mm, $\times 7$; 8–13, holotype SDSNH 70976, SDSNH loc. 3392, height 5.5 mm, $\times 6.4$; 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 (*Submortonicer* *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 spiral 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 OPISTHOBANCHIA 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 *Oligoptycha*, 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 tooth-like 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.—SDSNH 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 *Breweriaceras 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 Alisities 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 similar 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 notably 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 Maastrichtian. 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 Maastrichtian 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. *Fimbrivusum* 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 *Fimbrivusum* 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 cypræid 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 (LAC-MIP) 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).

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