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PACIFIC SLOPE CRETACEOUS BIVALVES: EIGHT VENERID SPECIES

L. R. SAUL

Natural History Museum of Los Angeles County, 900 Exposition Blvd.,
Los Angeles, California 90007

ABSTRACT—Four new venerid species from the Cretaceous of the North American Pacific Slope are described and four previously described species are reassigned. Of the new species, two are allotted to new genera: *Rhaiphiale* based upon *Rhaiphiale pharota* n. sp. and *Egrona* based upon *Egrona fallax* n. sp., both Turonian in age and from southern California. The other new species are *Loxo quintense* n. sp., of late Maastrichtian age from California, and *Paraesa cedrina* n. sp., late Albian in age from Baja California, Mexico. The previously described species “*Meretrix*” *arata* Gabb, 1864, Turonian, and “*Meretrix*” *fragilis* Gabb, 1869, late Maastrichtian, are placed in the new genus *Callistalox*; “*Meretrix*” *lens* (Gabb, 1864), Campanian age, and *Flaventia zeta* Popenoe, 1937, Turonian, are provisionally assigned to *Paraesa* Casey, 1952. This is the first identification of *Paraesa* from the Pacific Slope of North America. No species of *Flaventia* Jukes-Brown, 1908, is now known in Pacific Slope faunas.

INTRODUCTION

THE VENERIDAE is one of the largest and most advanced of bivalve families. Its early evolution and increasing diversity in the Cretaceous remain too little known. Descriptions of new species and new genera and generic reallocations of Cretaceous venerid bivalve species discussed here result from a study of the Pacific Slope genus *Calva* Popenoe, 1937 (Saul and Popenoe, 1992). Specimens of these reassigned taxa had been misidentified as species now included in *Calva*, or, as in the case of *Callistalox arata*, specimens of a species of *Calva* were misidentified as, for instance, *Meretrix arata*, a species not assignable to *Calva*. Their allocation to taxa not previously recorded from Pacific Slope Cretaceous deposits increases the recognized diversity within the Veneridae. Of the five genera discussed, four have anterior lateral teeth and are included in the Pitarinae. The remaining genus, *Paraesa*, may belong in the Clementiinae. If so, the geologic range of this subfamily is extended back to the Early Cretaceous.

Reallocation of the taxa has resulted mainly from careful cleaning of the specimens, especially of the hinge areas, so that generic and specific characters could be seen. Some morphological characteristics useful in discriminating between these five Pacific Slope genera and *Calva* are shown in Table 1.

Specimens of *Loxo quintense* n. sp., late Maastrichtian in age, have been confounded with *Calva varians* (Gabb, 1864), but *L. quintense* has the angled anterior lateral tooth of *Loxo* and a better demarked escutcheon than *C. varians*. Specimens of *Egrona fallax* n. gen. and sp., of Turonian age, have been confounded with *Calva regina* Popenoe, 1937, but these specimens lack the posterior lateral teeth of *Calva* and have a better defined escutcheon. “*Meretrix*” *fragilis* Gabb, 1869, late Maastrichtian

in age, was referred to *Loxo* by Saul (1983), but this species lacks the posterior lateral teeth present in *Loxo* and it is here placed in the new genus *Callistalox*, as is *Meretrix arata* Gabb, 1864. Popenoe (1937) questionably assigned Turonian age *M. arata* to *Aphrodina* Conrad, 1869, but *M. arata* does not have the bifid cardinal tooth 2a of *Aphrodina*. *Callistalox arata* and *C. fragilis* retain a groove on cardinal 4b that suggests derivation of *Callistalox* from *Resatrix* Casey, 1952. Except for this grooved 4b, their hinges resemble that of *Microcallista* Stewart, 1930, a widespread early Tertiary subgenus. Specimens of *Rhaiphiale pharota* n. gen. and sp. have been confused with *Callistalox arata* (Gabb, 1864), but *R. pharota* has an abruptly margined and depressed escutcheon. Specimens of *Paraesa cedrina* n. sp. have been mistaken for *Calva (Egelicalva) nitida* (Gabb, 1864), but *P. cedrina* lacks lateral teeth. Neither *Flaventia lens* (Gabb, 1864) nor *F. zeta* Popenoe, 1937, the two North American Pacific Slope species previously assigned to *Flaventia* Jukes-Brown, 1908, have the inscribed lunule and demarked escutcheon of *Flaventia*. They do have the excavated hinge areas in front of the anterior cardinals that are characteristic of *Paraesa* Casey, 1952, but these two species are more lenticular than other species of *Paraesa* and are placed in this genus with reservation.

Figure 1 is an index map to areas mentioned in the text, from which Cretaceous venerids have been reported. Localities and place names are keyed to the map by bracketed numbers.

Institutional acronyms used in this paper are: ANSP = Academy of Natural Sciences of Philadelphia; CIT = California Institute of Technology, collections now housed at LACMIP; GSC = Geological Survey of Canada; LACMIP = Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCMBP = University of California, Berkeley, Museum

TABLE 1—Some features characteristic of genera discussed.

Characteristics	<i>Calva</i>	<i>Loxo</i>	<i>Callistalox</i>	<i>Egrona</i>	<i>Rhaphiale</i>	<i>Paraesa</i>
Posterior laterals	X	X				
Anterior laterals	X	X	X	X	X	
Grooved cardinal 4b			X			
Demarcated escutcheon				X	X	
Inscribed lunule	X	X	X	X	X	
Anterior lateral AII hooked	X					
Anterior lateral AII not parallel to lunular margin		X	X			
Anterior hinge area excavated						X
Shell surface smooth	X†			X		X
Shell surface ribbed	X‡				X	
Shell surface grooved		X	X			

† Subgenera *Calva*, *Egelicalva*, and *Penecallista*.

‡ Subgenus *Microcalva*.

of Paleontology; UCLA = University of California, Los Angeles, collections now housed at LACMIP; USGS = United States Geological Survey; USNM = United States National Museum.

Abbreviations used for measurements of specimens are: H = height, L = length, I = inflation of one valve, B = distance from beak to anterior end of valve, LL = length of lunule, LW = width of lunule, LTA = angle formed by a line through laterals AII and PII or through their sockets.

In the following descriptions a small shell is less than 10 mm long. Medium-sized shells range between 10 mm and 59 mm in length. No species described in this paper is large.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Linnaeus, 1758

Class BIVALVIA Linnaeus, 1758

Order VENEROIDA H. and A. Adams, 1856

Superfamily VENERACEA Rafinesque, 1815

Family VENERIDAE Rafinesque, 1815

Subfamily PITARINAE Stewart, 1930

Genus LOXO Dailey and Popenoe, 1966

Type species.—By original designation *Loxo decore* Dailey and Popenoe, 1966, from the late Campanian and early Maastrichtian of California and Baja California.

Discussion.—*Loxo* and *Calva* Popenoe, 1937, have very similar hinges. In *Loxo* the anterior lateral AII is not hooked, does not parallel the lunular margin but is at an angle to it, and is relatively shorter than the anterior lateral of *Calva*. *Loxo* is less inflated than *Calva*, has lower umbos, a less depressed lunule, and a more elongate oval, rather than trigonal shape. It resembles the subgenus *Calva* (*Microcalva*) Saul and Popenoe, 1992, in having concentric sculpture and may be derived from *Microcalva*.

Tashiro (1976) placed *Callistina* (*Larma*) *japonica* Amano, 1957, in *Loxo* and suggested that *Cytherea* (*Callista*) *sculpturata* Stoliczka, 1870, from the Arrialoor Group of India belonged to the same genus. Stoliczka did not mention the presence of posterior lateral teeth nor did Tashiro; but as Stoliczka did not describe the hinge of the right valve, in which posterior laterals

are apparent, he may have had only a left valve hinge and been unaware that laterals were present. Thus, whether or not *C. (C.) sculpturata* is a *Loxo* remains uncertain. *Loxo japonicum* is late Campanian to early Maastrichtian in age; *C. (C.) sculpturata* is apparently of Senonian age; thus, both are more nearly contemporaneous with *Loxo decore* than with *L. quintense* n. sp. *Loxo japonicum* is much smaller and more roundly inflated than *L. quintense*; *C. (C.) sculpturata* is more elongate and has coarser sculpture than *L. quintense*.

LOXO QUINTENSE n. sp.

Figure 2.1–2.13

Calva varians (Gabb). SAUL, 1986, p. 26, figs. 7–9. Not *Calva varians* (Gabb, 1864).

Diagnosis.—A relatively large, inflated *Loxo* with rather broad hinge plate.

Description.—Shell medium-sized, ovoid, flatly inflated medially; beaks low, near anterior quarter-length of shell, prosogyrous; lunular margin slightly concave to straight; anterior end well-rounded; ventral border broadly arched; posterior end roundly truncated; posterior dorsal slope long, barely arched; lunule narrowly lanceolate, moderately depressed, circumscribed by a line; shell surface ornamented by closely and evenly spaced concentric grooves and irregularly spaced, impressed growth checks.

Ligament groove long, arched, behind long, narrow, smooth nymphae. Hinge of right valve with cardinals 3a and 1 slightly divergent, beneath beak, 1 longer than 3a; cardinal 3b twice as long as 1, bifid; anterior laterals obscure, enclosing a moderately deep, oblique socket for AII; posterior lateral PI low, bordering an elongate, narrow socket. Hinge of left valve with cardinals 2a and 2b nearly equal in length, divergent; 2a slender; 2b stout, trigonal, posteriorly directed; cardinal 4b long, slender, separated from nymph by a groove; anterior lateral AII short, oblique to lunular and lower hinge plate margins; posterior lateral PII a barely projecting salient of valve edge. Pallial sinus broadly linguiform, extending nearly one-third of shell length across valve. Adductor muscle scars lightly impressed.

TABLE 2—Measurements (in mm) of *Loxo quintense* n. sp.

Museum no.	H	L	I	B	LL	LW	LTA	L/H	H/I	L/B	LL/LW
LACMIP 8254	44.8	—	17.7	—	15.0	3.4	100°	—	2.5	—	4.4
LACMIP 8255	41.3	49.5	15.6	21.4	12.5	3.0	108°	1.2	2.6	2.3	4.2
LACMIP 8256	42.5	—	19.5	25.0	11.3	4.0	103°	—	2.2	—	2.8
LACMIP 8257	43.0	52.3	15.1	23.0	12.3	2.7	106°	1.2	2.8	2.3	4.6
UCBMP 38029*	45.0	—	18.8	12.4	11.6	3.2	101°	—	2.4	—	3.6
UCBMP 38030*	—	—	—	—	—	—	107°	—	—	—	—

* Measurements made on LACMIP plaster casts 7567, 7568.

Holotype.—LACMIP 8254.

Paratypes.—LACMIP 8169 from LACMIP loc. 10664 (=CIT loc. 1576), south of Laguna Seca [10], Merced County; 8255–8256 from UCLA loc. 6501, Garza Creek [9], Stanislaus County; 8257 from UCLA loc. 7174, Orestimba Creek [9], Stanislaus County; 8258–8260 from LACMIP loc. 9196, Cantinas Creek [11], San Luis Obispo County, California. UCBMP 38029–38030 from UCBMP loc. A-3369, Cantinas Creek [11], San Luis Obispo County, California.

Type locality.—UCLA 6501, Garzas Creek [9], Stanislaus County, California.

Geologic age.—Late Maastrichtian.

Distribution.—Moreno Formation, Quinto silt, east side Diablo Range [9 and 10], Stanislaus and Merced Counties, El Piojo Formation, near Lake Nacimiento [11], San Luis Obispo County, California.

Measured specimens.—See Table 2.

Remarks.—The shell surface is not adequately preserved in any available specimen. *Loxo decore* has a polished surface with inscribed concentric lines, and *L. quintense* may have had a similar surface, but all examined specimens are etched rough, and the best preserved specimens of *L. quintense* retain only a suggestion of concentric sculpture, which may have been inscribed lines. *Loxo quintense* differs from *L. decore* Dailey and Popenoe, 1966, of early Maastrichtian age, in being larger and more inflated. Because of its inflation, it is more readily confused with *Calva varians* than is *L. decore*. It differs from *Calva varians* (Gabb, 1864) in being more elongate, less inflated, and having lower, less prominent beaks.

Etymology.—The species name is given with reference to Quinto Creek and the Quinto silt.

Genus CALLISTALOX n. gen.

Type species.—*Meretrix arata* Gabb, 1864.

Diagnosis.—Concentrically grooved pitarine venerids with an inscribed lunule; three cardinals in each valve; right posterior cardinal 3b bifid; left posterior cardinal 4b with a longitudinal groove; posterior laterals lacking.

Discussion.—Two Late Cretaceous venerids described by Gabb, *Meretrix arata* and ?*M. fragilis*, resemble in sculpture and hinge the type species of *Microcallista*, *Cytherea proxima* Deshayes, 1860, from the Eocene (Ypresian), of France (Figure 3.1–3.5). Compared to *Callista* (*Microcallista*) *proxima* (Deshayes), both Cretaceous species are shorter, and have a shorter and less linguiform pallial sinus than *Callista* (*Microcallista*) *proxima*. However, other Early Tertiary species, *Callista* (*Microcallista*) *conradiana meganosensis* (Clark and Woodford, 1927) for instance, are nearly as short as these Cretaceous species, suggesting that in shape and pallial sinus length “*M.*” *arata* and “*M.*” *fragilis* may fall within the bounds of *Microcallista*. Like “*M.*” *arata* and “*M.*” *fragilis*, species of *Microcallista* are small to medium in size. Among the largest venerids are species belonging to three other genera with similar hinges: *Callista* Poli, 1791 (type species *Venus chione* Linnaeus, 1758, Holocene, Mediterranean); *Macrocallista* Meek, 1876 (type species *Venus nimbosa* Lightfoot, 1786, Holocene, Caribbean); and *Megapitaria* Grant and Gale, 1931 (type species *Cytherea aurantica* Sowerby, 1831, Holocene, Pacific Panamic fauna). The hinges of *Microcallista*, *Callista* and *Macrocallista* are essentially similar. *Microcallista* differs from *Callista* and *Macrocallista* only in being of smaller size and in having concentric sculpture rather than being smooth. The type species of these three supraspecific taxa all have right valve hinges with 3a slender, 1 high and moderately slender, 3b narrow, elongate and grooved, AIII and AI shorter than the socket for AII, and the shell margin grooved posterior to the ligament groove. They all have left valve hinges

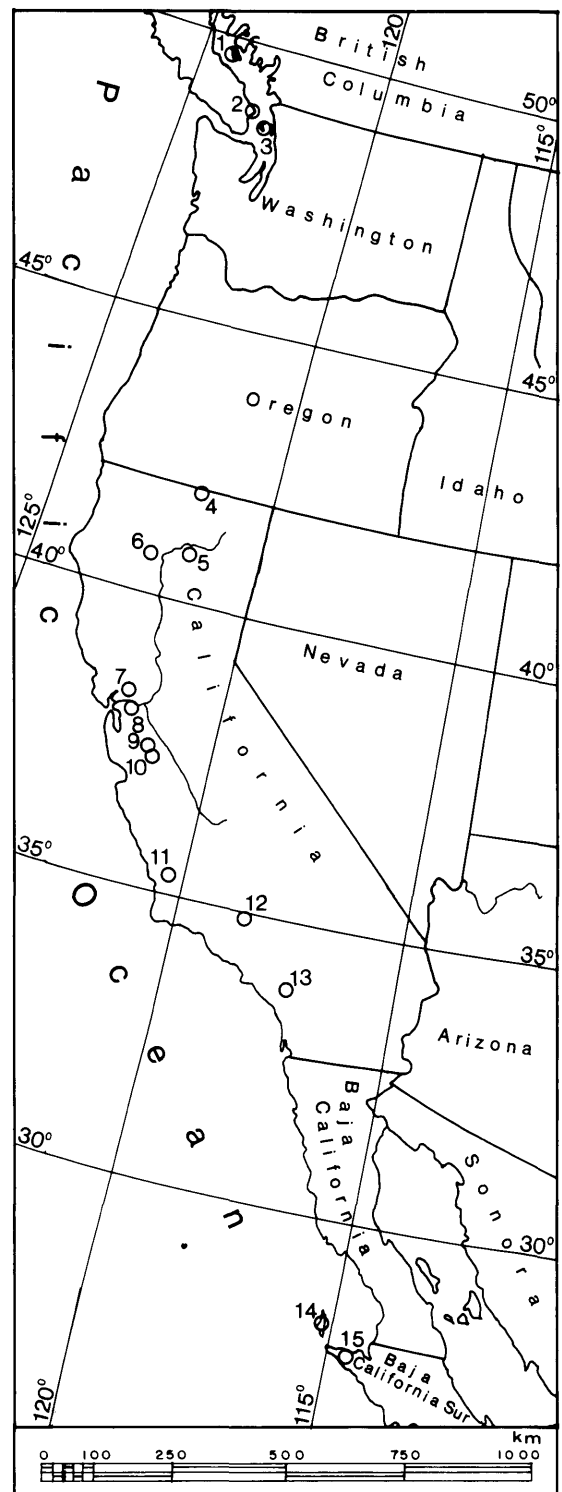


FIGURE 1—Index map to areas mentioned in text. 1, Hornby and Denman Islands; 2, vicinity of Nanaimo; 3, Sucia Island; 4, Siskiyou Mountains; 5, Redding area, Shasta County; 6, Ono area, Shasta County; 7, Thompson Creek, Yolo County; 8, Martinez, Contra Costa County; 9, eastern Diablo Range, Stanislaus County; 10, eastern Diablo Range, Merced County; 11, Nacimiento area, San Luis Obispo County; 12, Warm Springs Mountain, Los Angeles County; 13, Santa Ana Mountains, Orange and Riverside Counties; 14, Cedros Island; 15, Vizcaino Peninsula.

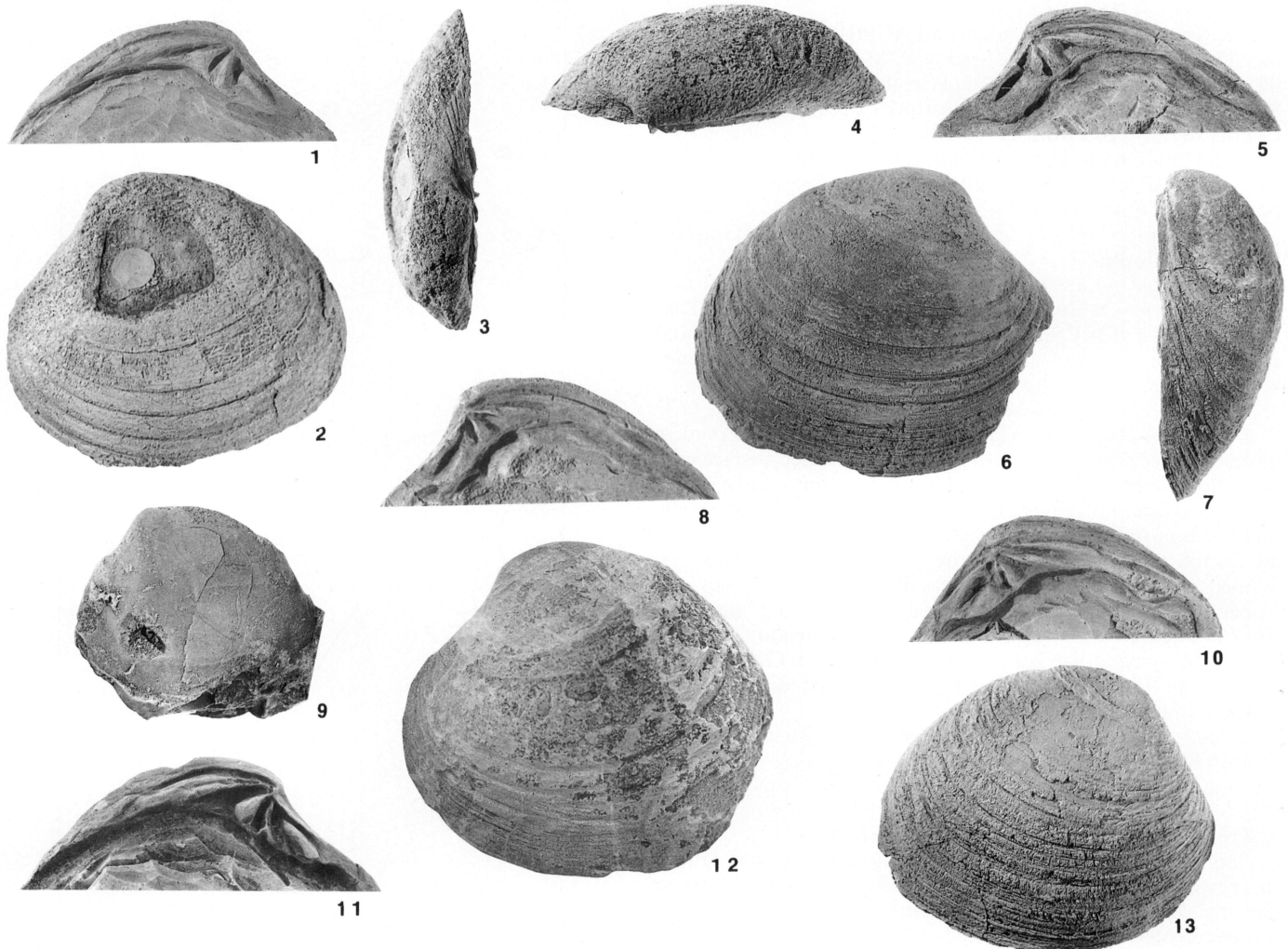


FIGURE 2—*Loxo quintense* n. sp., late Maastrichtian, all $\times 1$, all except 9 coated with ammonium chloride, photos by De Leon except as otherwise noted. 1–3, LACMIP 8257, paratype, from UCLA loc. 7174, left valve. 1, hinge; 2, exterior; 3, anterior view. 4, 8, LACMIP 8256, paratype, from UCLA loc. 6501, right valve. 4, dorsal view; 8, hinge. 5–7, LACMIP 8254, holotype, from UCLA loc. 6501, right valve. 5, hinge; 6, exterior; 7, posterior view. 9, LACMIP 8169, paratype, from LACMIP loc. 10664, left valve, pallial sinus. 10, 13, LACMIP 8255, paratype, from UCLA loc. 6501, right valve. 10, hinge; 13, exterior. 11, 12, UCBMP 38029, paratype, from UCB loc. A-3369, left valve, photos by Saul. 11, hinge; 12, exterior.

with 2a slender, joined to 2b, 2b narrowly triangular, 4b slender and high on the nymph, AII elongate and subparallel to lunular margin. *Macrocallista nimbosa* has a delicate hinge with 3b narrow, perhaps misleading Keen (1969) into characterizing *Macrocallista* as having 3b not grooved. This tooth is actually just a narrower version of the 3b in *Callista chione* and is similarly grooved but on a more delicate scale.

Keen (1969) characterized *Megapitaria* as being like *Pitar* Römer, 1857 (type species *Venus tumens* Gmelin, 1791, Holocene, Senegal); but *Megapitaria* does not have 2a and 2b looped into an inverted ∇ as does *Pitar*, nor 3a and 3b joined into an arch dorsal to 1; its hinge and shape are actually more similar to *Callista*, from which it differs in having a heavier hinge with the dorsal ends of 2a and 2b tucked under the subumbonal margin, having 4b longer, sturdier, and further from the nymph, and the anterior laterals shorter and sturdier. In the type species of *Callista*, *Macrocallista*, *Microcallista*, and *Megapitaria* the lunular margin of the right valve is a little thickened and raised so that it just overlaps the left valve margin. The right valve lunule is slightly wider than that of the left valve. Along the

thickened margin of the right valve is a low welt extending from the beak to the anterior end of the lunule. This welt fits into a corresponding shallow groove in the left valve margin. Only its elongate shape separates *Macrocallista* from *Callista*, and were it not present in the Eocene and thus possessed of considerable geological range, *Callista* and *Macrocallista* should be synonymized as morphologic reasons to separate these taxa are fewer than commonly considered necessary for a supraspecific division. *Microcallista*, because of its concentric sculpture, and *Megapitaria*, because of its heavier hinge with 4b more distant from the nymph, can also be retained as subgenera although the morphological differences are slighter than are commonly used to differentiate subgenera.

Although “*Meretrix*” *arata* and “*Meretrix*” *fragilis* are similar to *Callista* (*Microcallista*) *proxima*, the grooved 4b and shorter valve length constitute greater differences than those separating the four taxa discussed above, and *Callistalox* is proposed as a genus despite its similarity to *Microcallista*.

The groove along cardinal 4b recalls that of *Resatrix* Casey, 1952 (type species, *R. dolabra* Casey, 1952, Aptian, England),

but *Resatrix* has posterior lateral teeth. *Resatrix* is a genus of wide distribution in the Early Cretaceous (Casey, 1952); these Late Cretaceous Pacific Slope species may be derived from it by loss of the posterior laterals, the retention of the groove on 4b being evidence of this derivation.

Etymology.—The name is compounded of *Callista* and *alox*, Greek, a furrow, with reference to the groove on 4b, and is of feminine gender.

CALLISTALOX ARATA (Gabb, 1864)

Figure 3.6–3.19

Meretrix arata GABB, 1864, p. 166, Pl. 30, fig. 250; STEWART, 1930, p. 247, Pl. 1, fig. 4. Not *Cytherea arata* (Gabb). WHITEAVES, 1896, p. 125; nor *Meretrix arata* Gabb. WHITEAVES, 1903, p. 378 = *Calva* (*Microcalva*) *haggarti* Saul and Popenoe, 1992. Probably not *Callista* (?) cf. *arata* (Gabb). NAGAO, 1932, p. 39, Pl. 6, fig. 6, 6a = *Callista*? sp. HAYAMI, 1975, p. 145.

Aphrodina? arata (Gabb, 1864). POPENOE, 1937, p. 397, Pl. 48, figs. 15, 16. STADUM, 1973, Pl. I, fig. 4.

Diagnosis.—An oval *Callistalox* ornamented with well-impressed concentric grooves.

Description.—Shell small, oval, roundly inflated medially; beaks prosogyrous, not prominent, at anterior third-length of shell; lunular margin concave; anterior end well rounded; ventral border broadly arched; posterior end rounded; posterior dorsal slope long, barely arched; lunule plumply lanceolate, moderately depressed, circumscribed by a line; shell surface ornamented by closely and evenly spaced, concentric grooves and irregularly spaced, impressed growth checks.

Ligament groove long, barely arched, behind long, narrow, smooth nymphae; nymphae slightly salient posteriorly. Hinge of right valve with cardinals 3a and 1 divergent, beneath beak, 1 longer than 3a; cardinal 3b twice as long as 1, bifid; anterior laterals short, obscure, enclosing moderately deep socket for AII; posterior valve margin grooved. Hinge of left valve with cardinals 2a and 2b sturdily, nearly equal, divergent; cardinal 4b longer, slender, longitudinally grooved, separated from nymph by deep groove; anterior lateral AII short, at slight angle to lunular margin. Pallial line distant from shell margin; pallial sinus broad, angulate, short, extending nearly one-third of shell length across valve; dorsal arm convex, slightly ascending; ventral arm steeply ascending at nearly 70° to pallial line. Muscle scars lightly impressed.

Lectotype.—Herein designated, ANSP 4388. Stewart (1930) found only this one of Gabb's specimens, which is from Orestimba Canyon [9], and figured it. Because he was unable to find the specimen figured by Gabb (1864, Pl. 30, fig. 250), which Stewart suggested was probably from Cottonwood Creek [6], Shasta County, he did not designate ANSP 4388 as lectotype in the hope that Gabb's figured specimen might be found. Richards (1968, p. 33) lists ANSP 4388 as Cotype of *Meretrix arata* Gabb, 1864; it is the only California Geological Survey specimen of *Meretrix arata* at the Academy (Elana Benamy, personal commun.).

Hypotypes.—UCLA 40662 from LACMIP loc. 8197 (=CIT loc. 1068), Santa Ana Mts. [13]; 40663 and 49501 from LACMIP loc. 10079 (=CIT loc. 1164), Santa Ana Mts. [13], Orange County, California. LACMIP 8189 from LACMIP loc. 10744 (=CIT loc. 1442), Swede Basin [5], Shasta County; 8190 from LACMIP loc. 8198 (=CIT loc. 1069), Santa Ana Mts. [13], Orange County; 8191 from LACMIP loc. 8195 (=CIT loc. 82), Santa Ana Mts. [13], Orange County; 8236 from LACMIP loc. 10079 (=CIT loc. 1164), Santa Ana Mts. [13], Orange County; 8237 from LACMIP loc. 8197 (=CIT loc. 1068), Santa Ana Mts. [13], Orange County, California.

Type locality.—"Orestimba Cañon" [9], Stanislaus County, California.

Geologic age.—Turonian.

Distribution.—Redding Formation, Bellavista Sandstone Member, Little Cow Creek area [5], Shasta County; Panoche Formation, Orestimba Canyon [9], Stanislaus County; near base of Yolo Shale, Thompson Creek [7], Yolo County; Ladd Formation, top of the Baker Canyon Conglomerate Member and lowermost Holz Shale Member, Santa Ana Mountains [13], Orange County, California. Whiteaves (1903, p. 378) said that Stanton had sent him a specimen of *Meretrix arata* from the Chico Group of Tehama County, California, identical to specimens from Sucia Island [3], San Juan County, Washington. Whiteaves' specimens from Sucia Island are undoubtedly *Calva* (*Microcalva*) *haggarti* Saul and Popenoe, 1992, but during this study no specimen similar to either species has been found in collections from Tehama County, and the identity of Stanton's specimen remains unknown as does its horizon and more precise locality.

Measured specimens.—See Table 3.

Remarks.—Gabb (1864) listed three localities for "*Meretrix*" *arata*, Cottonwood Creek [6], Shasta County, Siskiyou Mountains [4], and Orestimba Canyon [9], Stanislaus County, California. Popenoe (1937, p. 397) followed Stewart (1930) in suggesting that the species was originally described from Cottonwood Creek [6], Shasta County. The upper member of the Budden Canyon Formation along Cottonwood Creek, the Gas Point Member, ranges in age from Cenomanian to late Turonian (Murphy et al., 1969) and would be, therefore, the most likely source for "*M.*" *arata*. However, no specimens have been relocated from there, and Rodda (1959) did not list it from that area. Additionally, he characterized the sediments as having been deposited in moderately deep water, an unlikely environment for this otherwise apparently relatively nearshore taxon. If *Callistalox arata* occurs on Cottonwood Creek, Shasta County, it is rare. Cottonwood Creek [4], Siskiyou County, also flows across rocks of Turonian age. These, the lower beds of the Hornbrook Formation, have yielded specimens of *C. arata*.

The designated lectotype is a small specimen, and its size and fragility unfortunately argue against attempting to expose the hinge. The ventral and posterior margins appear to be a little broken, and the concentric ribs are wider than on many of the other specimens inferred to be conspecific. It resembles *Calva* (*Microcalva*) *elderi* Saul and Popenoe, 1992, in rib width, but the ribs are more flat-topped than those of *C. (M.) elderi*, and they are more arcuate ventrally. In *C. (M.) elderi* the ribs are straightened ventrally and bent subangulately along the posterior flexure. Nonetheless, the small size of the lectotype makes difficult the unequivocal identification of other specimens with it.

Popenoe (1937) questionably assigned *Meretrix arata* to *Aphrodina*, but *M. arata* lacks two hinge characteristics of *Aphrodina* Conrad, 1869: its laterals are not striated, and cardinal tooth 2a is not bifid. Externally *Callistalox arata* resembles *Calva* (*Microcalva*) *elderi* Saul and Popenoe, 1992, of Coniacian age, but lacks the posterior laterals, its anterior laterals are shorter, and AII on the left valve is not hooked. The concentric sculpture differs in that *Calva (M.) elderi* has round-topped ribs, but the surface of *Callistalox arata* is grooved. *Callistalox arata* resembles *Loxo decore* Dailey and Popenoe, 1966, in its shape and sculpture, but differs from *L. decore* in being smaller, more roundly inflated, slightly shorter, and lacking posterior lateral teeth. *Callistalox arata* is much more common than *Rhaiphiale pharota* n. sp., which is also a small, concentrically ribbed venerid of Turonian age that also occurs in the northern Santa Ana Mountains [13]. *Callistalox arata* is more elongate than

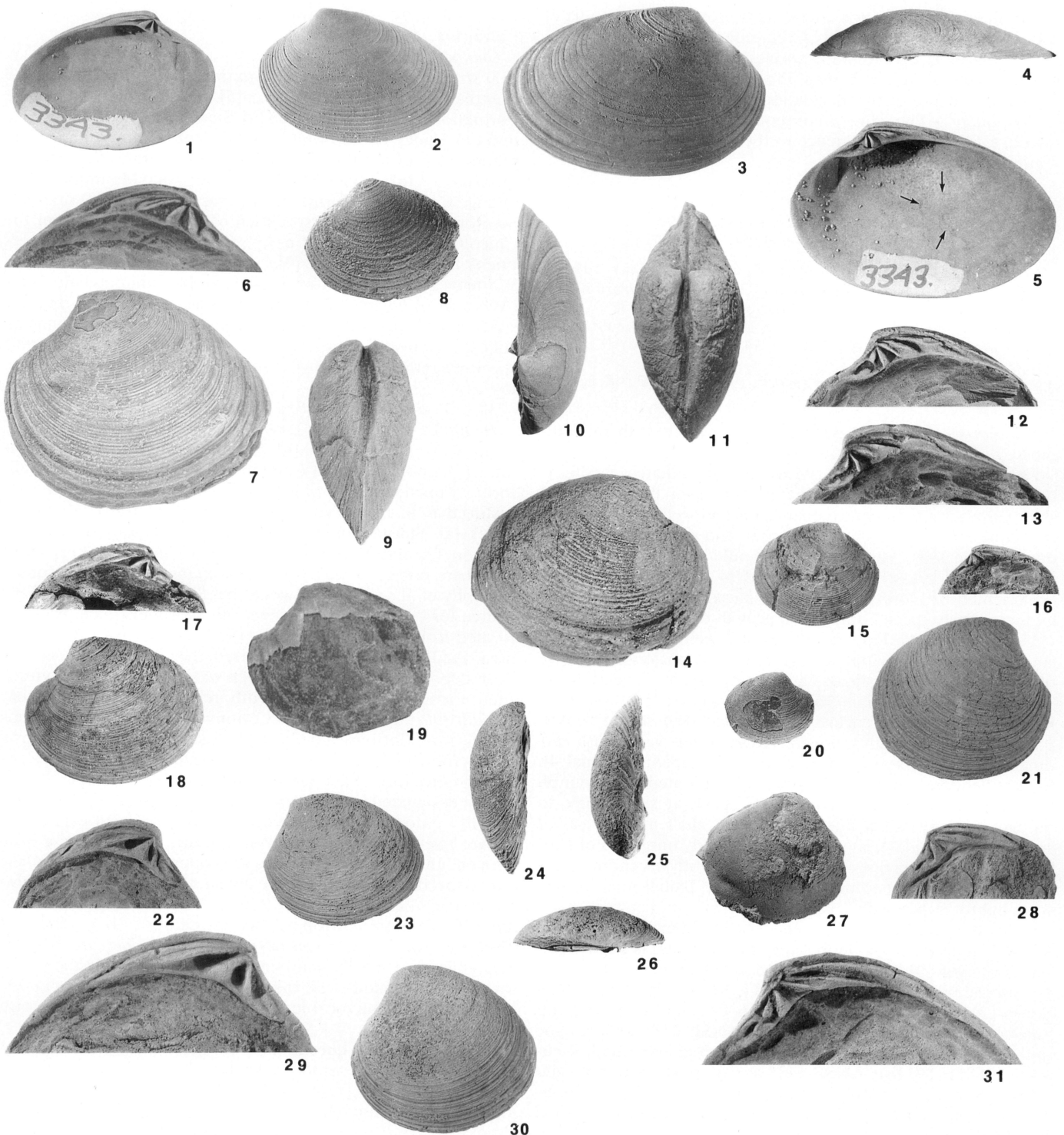


FIGURE 3—*Callista (Microcallista) proxima* (Deshayes) and *Callistalox* spp. All except 8, 19, and 20 coated with ammonium chloride, all photos by De Leon except as otherwise indicated. 1–5, *C. (M.) proxima* (Deshayes, 1860). 1, 2, LACMIP 11299, hypotype, $\times 2$, Eocene, Ypresian, Sables de Cuise, Cuise, Oise, France, left valve; 1, hinge; 2, exterior; 3–5, LACMIP 11298, hypotype, $\times 2$, Eocene, Ypresian, Sables de Cuise, Cuise, Oise, France, right valve; 3, exterior; 4, dorsal view; 5, hinge. 6–19, *Callistalox arata* (Gabb, 1864). 6, 7, LACMIP 8236, hypotype, $\times 2$, Turonian, from LACMIP loc. 10079, left valve; 6, hinge; 7, exterior; 8, ANSP 4388, lectotype, $\times 2$, Turonian, from “Orestimba Cañon,” left valve, exterior, photo by Susuki; 9, 11, LACMIP 8186, hypotype, $\times 2$, Turonian, from UCLA loc. 2323; 9, posterior view; 11, dorsal view; 10, 13, LACMIP 8191, hypotype, $\times 2$, Turonian, from LACMIP loc. 8195, right valve; 10, anterior view; 13, hinge; 12, 14, LACMIP 8237, hypotype, $\times 2$, Turonian, from UCLA loc. 4208, right valve; 12, hinge; 14, exterior; 15, 16, LACMIP 8189, hypotype, $\times 2$, Turonian, from LACMIP loc. 10766, right valve; 15, exterior; 16, hinge; 17, 18, LACMIP 8175, hypotype, $\times 2$, Turonian, from LACMIP loc. 10766, left valve; 17, hinge; 18, exterior; 19, LACMIP 8190, hypotype, $\times 2$, Turonian, from LACMIP loc. 8198, left valve, pallial line. 20–31, *Callistalox fragilis* (Gabb, 1869). 20, ANSP 4385, lectotype, $\times 1$, late Maastrichtian, from Martinez, right valve, exterior, photo by Susuki; 21, 31, LACMIP 8264,

TABLE 3—Measurements (in mm) of *Callistalox arata*.

Museum no.	H	L	I	B	LL	LW	L/H	H/I	L/B	LL/LW
ANSP 4388	10.0	12.8	3.4	5.5	—	—	1.3	2.9	2.3	—
LACMIP 8175	13.2	16.6	5.6	6.4	4.2	1.6	1.2	2.4	2.6	2.6
LACMIP 8189	9.5	11.4	3.5	4.5	3.6	1.0	1.2	2.7	2.5	3.6
LACMIP 8191	19.3	—	7.7	8.0	4.8	1.9	—	2.5	—	2.5
LACMIP 8236	19.0	23.5	5.2	11.5	6.0	1.4	1.2	3.6	2.0	4.3
LACMIP 8237	16.7	21.0	6.2	9.4	4.0	1.5	1.3	2.7	2.2	2.7
UCLA 40662	17.0	21.7	6.0	8.8	4.2	1.8	1.3	2.8	2.5	2.3
UCLA 49501	20.4	25.4	6.8	11.7	4.6	2.0	1.2	3.0	2.2	2.3

Rhaiphiale pharota and its sculpture consists of impressed concentric lines rather than fine to moderately wide ribs, as in *R. pharota*. *Callistalox arata* is smaller and more elongate than *Callistalox fragilis* (Gabb, 1869).

Specimens of *Callistalox arata* have been confused with *Calva* (*Microcalva*) *haggarti*, but *C. arata* lacks posterior laterals, has a more widely bifid cardinal 3b and a longitudinally grooved cardinal 4b, and is sculptured by concentric grooves rather than round-topped ribs.

Nagao (1932, p. 39, Pl. 6, fig. 6, 6a) figured a specimen from the Upper Ammonite bed (=Coniacian-Santonian, upper Yezu Group) of Hokkaido as *Callista* (?) cf. *arata* (Gabb), but its hinge is unknown, and it appears too inflated to be *Callistalox arata* (Gabb). Although Nagao indicated that its sculpture was similar to Whiteaves' description of the Sucia Island specimens, which are *Calva* (*Microcalva*) *haggarti*, it cannot be assigned to *Microcalva* on the basis of sculpture alone.

Callistalox arata is rare in the Redding area [5], Shasta County, but common in the Santa Ana Mts. [13], Orange County, California. Collections from the Diablo Range [9 and 10], including Orestimba Canyon, are too few, too sparse, and of insufficient volume to indicate abundance of the species.

CALLISTALOX FRAGILIS (Gabb, 1869)

Figure 3.20–3.31

?*Meretrix fragilis* GABB, 1869, p. 185, Pl. 30, fig. 77.

“?Meretrix” *fragilis* Gabb, 1869. STEWART, 1930, p. 246, Pl. 4, fig. 4.

Diagnosis.—A relatively short, subtrigonal *Callistalox* ornamented with closely spaced concentric grooves.

Description.—Shell small, rounded subtrigonal, roundly moderately inflated medially; beaks prominent, at anterior third-length of shell, prosogyrous; lunular margin slightly concave; anterior end well rounded; ventral border arched; posterior end rounded; posterior dorsal slope long, barely arched; lunule lanceolate, moderately depressed, circumscribed by a line; shell

surface ornamented by closely and evenly spaced concentric grooves and irregularly spaced impressed growth checks.

Ligament groove long and arched, behind long, narrow, smooth nymphae. Hinge of right valve with cardinals 3a and 1 anteriorly directed, divergent, beneath beak, 1 longer than 3a; cardinal 3b twice as long as 1, bifid; anterior laterals obscure enclosing moderately deep socket for AII; no posterior lateral but posterior valve margin grooved. Hinge of left valve with cardinals 2a and 2b sturdy, nearly equal, divergent; cardinal 4b longer, slender, separated from nymph by shallow groove; anterior lateral AII short, at an angle to lunular and hinge plate margin. Pallial line distant from shell margin; pallial sinus broad, angulate, extending nearly one-third of shell length across valve; dorsal arm convex, slightly ascending; ventral arm steeply ascending at nearly 70° to pallial line. Muscle scars lightly impressed.

Lectotype.—ANSP 4385.

Paralectotypes.—ANSP 76909. Stewart (1930) indicated that the syntype lot consisted of three specimens. The two (incomplete) paralectotypes have been newly catalogued (Elana Benamy, personal commun.).

Hypotypes.—LACMIP 8261, 8262 from CIT loc. 1573, Los Baños Creek [10], Merced County; 8264 from CIT loc. 1572, canyon south of Laguna Seca [10], Merced County, California. UCBMP 38657, from UCBMP loc. A-3371, north side Lake Nacimiento [11], San Luis Obispo County, California.

Type locality.—Martinez [8], Contra Costa County, California.

Geologic age.—Late Maastrichtian.

Distribution.—Great Valley Series near Martinez [8], Contra Costa County; Moreno Formation, Tierra Loma Shale Member, east side Diablo Range [10], Merced County; El Piojo Formation near Lake Nacimiento [11], San Luis Obispo County; San Francisco Formation, Warm Springs Mountain [12], Los Angeles County, California.

Measured specimens.—See Table 4.

Remarks.—Gabb's figure shows an ascending, linguiform si-

TABLE 4—Measurements (in mm) of *Callistalox fragilis*.

Museum no.	H	L	I	B	LL	LW	L/H	H/I	L/B	LL/LW
ANSP 4385†	11.0	13.8	4.4	6.2	—	—	1.2	2.5	2.2	—
LACMIP 7549	27.2	31.2	9.5	12.3	7.0	1.8	1.1	2.9	2.5	3.9
LACMIP 8261	21.0	—	8.0	11.5	5.1	1.7	—	2.6	—	3.0
LACMIP 8262	23.4	28.3	8.5	13.2	—	—	1.2	2.8	2.1	—
LACMIP 8264	27.4	31.0	9.0	13.0	6.7	1.8	1.1	3.0	2.4	3.7
UCBMP 38657	28.7	32.5	10.8	15.0	7.0	1.8	1.1	2.7	2.2	3.9

† Measured on UCLA plaster cast 28772.

hypotype, late Maastrichtian, from LACMIP loc. 10663, right valve; 21, ×1, exterior; 31, ×2, hinge; 22, 24, 25, 30, UCBMP 38657, hypotype, ×1, late Maastrichtian, from UCB loc. A-3371, left valve; 22, hinge; 24, posterior view; 25, anterior view; 30, exterior; 23, 26, 29, LACMIP 8262, hypotype, late Maastrichtian, from LACMIP loc. 10685, left valve; 23, ×1, exterior; 26, ×1, dorsal view; 29, ×2, hinge; 27, LACMIP 8184, hypotype, ×1, late Maastrichtian, from UCLA loc. 2661, right valve, pallial sinus; 28, LACMIP 8261, hypotype, ×1, late Maastrichtian, from LACMIP loc. 10685, left valve, hinge.

nus. The lectotype is small and its hinge is not exposed. In its shape and sculpture it resembles the above hypotypes. The species was referred to as *Loxo fragilis* (Gabb, 1869) by Saul (1983), and its oblique anterior lateral is suggestive of *Loxo*, but the absence of posterior lateral teeth excludes it from *Loxo*. *Callistalox fragilis* has a linguiform pallial sinus suggestive of *Microcalva*, but the absence of posterior lateral teeth excludes it from *Microcalva*. *Callistalox arata* is more coarsely sculptured, more elongate, and smaller than *C. fragilis*. In both *C. arata* and *C. fragilis* the posterior margin of the right valve is grooved and the posterior margin of the left valve fits into this groove.

Genus EGRONA n. gen.

Type species. — *Egrona fallax* n. sp., Turonian, Orange County, California.

Diagnosis. — Veneriform bivalves having smooth exterior except for growth lines; lunule depressed, set off by incised line; escutcheon of left valve obscurely delimited by angulation; three cardinals in each valve; right posterior cardinal bifid; an elongate, smooth sided anterior lateral tooth in left valve; shell margin of right valve grooved parallel to margin posterior to ligament; nymphs smooth; pallial sinus moderately deep and angular.

Discussion. — *Egrona* is a pitarine venerid externally similar enough in shape to *Calva* Popenoe, 1937, to have long been confounded with it, but *Egrona* lacks posterior laterals, has a better defined escutcheon, and has weak growth checks. *Egrona* has a better developed escutcheon than *Callistina* Jukes-Brown, 1908, and smooth rather than rugose laterals. Stewart (1930), Cox (1952), and Keen (1969, p. N676) synonymized *Aphrodina* Conrad, 1869, and *Callistina* Jukes-Brown, 1908. Although the type species of *Callistina*, *Venus plana* J. Sowerby, 1812 (late Albian, Upper Greensand, Blackdown, Devon, England), was reported to have cardinal 2a not bifid, David Jablonsky and Noel Morris have just shown, on the basis of hinges of type specimens cleaned by Morris, that *Callistina plana* has a slightly grooved 2a; and *Aphrodina* and *Callistina* cannot be separated on that basis. Apparently, Stephenson (1952) considered a bifid 2a to be of only specific importance as he included in *Callistina* two species having weakly bifid 2a, *C. lamarensis* (Shumard, 1860) and *C. (L.) munda* Stephenson, 1952, as well as *C. (L.) taffi* (Cragin, 1893) and *C. (L.) alta* Stephenson, 1952, in neither of which is 2a bifid. He differentiated the two genera on the basis of the alignment of cardinal and lateral teeth and the submergence of *Callistina* in *Aphrodina* is perhaps premature.

Egrona resembles three supraspecific taxa that have the left anterior cardinal 2a bifid: *Aphrodina* Conrad, 1869 (type species *Meretrix tippiana* Conrad, 1858, from the Gulf and Atlantic Coast Maastrichtian), *Larma* Stephenson, 1952 (type species *Callistina (Larma) munda* Stephenson, 1952, Cenomanian, Woodbine Formation, Lamar County, Texas), and *Mesocallista* Cox, 1952 (type species, *Meretrix andersoni* Newton, 1909, ?Albian or Campanian of South Africa). In addition to having an entire 2a, *Egrona* lacks the striate anterior lateral AII of *Aphrodina*. Compared to *Larma*, it has a longer 4b that is more distant from 2b, a more linguiform pallial sinus, and a smooth rather than ribbed exterior. Keen (1969) placed *Larma* as a subgenus of *Mesocallista* presumably because both have smooth laterals and because the type species of *Larma*, *Callistina (Larma) munda*, has a weakly bifid 2a, although Stephenson (1952) had included two species with entire cardinals 2a in *Larma*. *Mesocallista* was described as a relatively small, ovate *Aphrodina* by Cox (1952), who ranked it as a subgenus of *Aphrodina*. *Egrona* is relatively large compared to both *Aphrodina tippiana* and *Mesocallista andersoni*.

The hinge of *Microcallista* Stewart, 1930, is similar to that of

Egrona, but *Microcallista* is concentrically ribbed, does not have as distinct an escutcheon, and is of small size.

Etymology. — The generic name *Egrona* is by anagram from orange, for Orange County, California, and is feminine in gender.

EGRONA FALLAX n. sp.

Figure 4.1–4.12

Diagnosis. — As given for the genus.

Description. — Shell thick, of moderate size, subtrigonal, nearly as high as long, evenly inflated; beaks prominent, anterior to mid-length of shell, prosogyrous; anterior dorsal border strongly concave; anterior end sharply rounded; ventral border broadly arched; posterior end roundly truncate; posterior dorsal border moderately long, slightly arched; lunule heart-shaped, moderately large, depressed, delimited by inscribed line; escutcheon moderately wide, smooth, demarked by angulation in left valve.

Ligament groove arched behind moderate nymphs. Hinge of right valve with anterior tooth 3a and median cardinal tooth 1 short, narrowly triangular, diverging ventrally, situated directly beneath beaks; posterior cardinal 3b elongate, straight, shallowly bifid subparallel to nymph; socket for lateral AII elongate, narrow, moderately deep, smooth sided, parallel to lunular border of the shell. Hinge of left valve with anterior cardinal 2a prominent, very slender, aligned almost vertically beneath beak; cardinal 2b thicker than 2a, trigonal, directed posteriorly; posterior cardinal 4b slightly longer than anterior teeth, slender, very close to nymph and separated from it only by shallow groove; anterior lateral AII elongate, parallel to lunular valve margin, smooth sided. Pallial sinus sharply angulate, of moderate depth; dorsal arm nearly straight, horizontal; ventral arm arcuate, ascending.

Holotype. — LACMIP 8193.

Paratypes. — LACMIP 8194, 8195, 11273, 11274 from UCLA loc. 3449, Mabey Canyon, Santa Ana Mts. [13], Riverside County; 8265–8268 from LACMIP loc. 8167 (=CIT loc. 1305), east side Santa Ana Mts. [13], Orange County, California. USNM 456076 from USGS loc. 2184, Santa Ana Mts. [13], Orange County, California.

Type locality. — UCLA loc. 3449, Mabey Canyon, Santa Ana Mts. [13], Riverside County, California.

Geologic age. — Turonian.

Distribution. — Ladd Formation, upper Baker Canyon Conglomerate Member and lower Holz Shale Member, Santa Ana Mountains [13], Orange County, California.

Measured specimens. — See Table 5.

Remarks. — Specimens of *Egrona fallax* have long been confounded with *Calva (Calva) regina* Popenoe, 1937. They are more flatly inflated, have a more angulate escutcheonal margin, and are not as abruptly truncated posteriorly as those of *C. regina*. *Egrona fallax* usually has obscure growth checks. Internally, *E. fallax* has no posterior laterals, but the right valve does have a long shallow groove in the dorsal shell margin posterior to the ligament. Anterior lateral AII is relatively shorter in *E. fallax* than in *C. (C.) regina*. The portion of the hinge plate that supports the anterior lateral or its socket widens dorsally, unlike that of *C. (C.) regina*, which remains of nearly the same width for the length of the tooth or socket.

Egrona fallax differs from *Callistina plana* (J. Sowerby, 1812) (Woods, 1908, Pl. 30, figs. 1–6) in having a smaller lunule, narrower nymphs, 3b narrowly rather than widely bifid, and smooth laterals. Of the three species assigned by Stephenson (1952) to the subgenus *Larma* from the Woodbine, *Egrona fallax* is most similar in shape to *C. (L.) munda* Stephenson, 1952, which has 2a weakly bifid, but *E. fallax* has a stronger

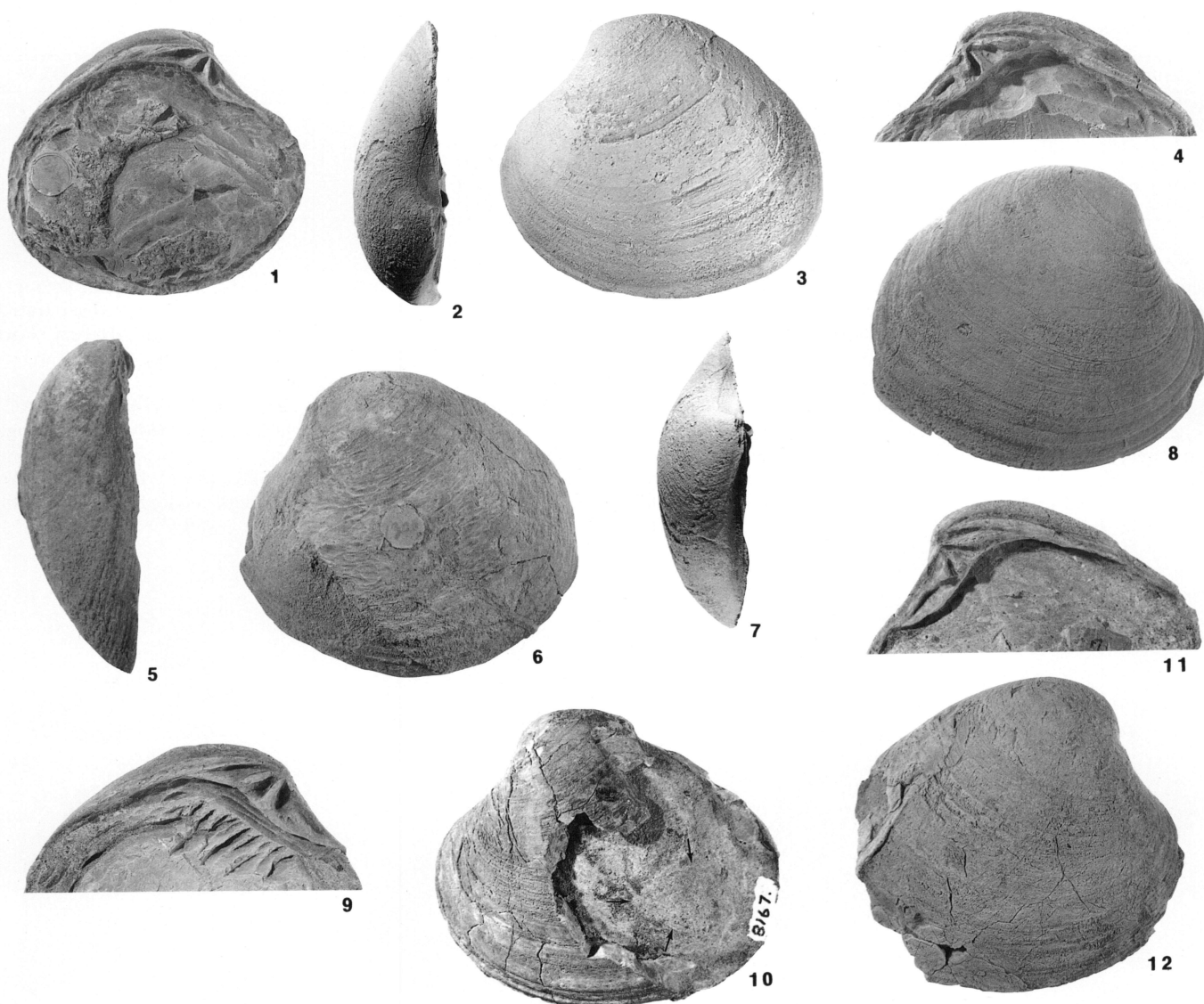


FIGURE 4—*Egrona fallax* n. sp., Turonian, $\times 1$; all except 10 coated with ammonium chloride; all photos by De Leon. 1–3, 7, LACMIP 8193, holotype, from UCLA loc. 3449, left valve. 1, hinge; 2, anterior view; 3, exterior; 7, dorsal view. 4, 8, LACMIP 8194, paratype, from UCLA loc. 3449, right valve. 4, hinge; 8, exterior. 5, 6, 9, LACMIP 8265, paratype, from LACMIP loc. 8167, left valve. 5, posterior view; 6, exterior; 9, hinge. 10, LACMIP 8268, paratype, from LACMIP loc. 8167, left valve, pallial sinus. 11, 12, LACMIP 8266, paratype, from LACMIP loc. 8167, right valve. 11, hinge; 12, exterior.

posterior truncation, lacks concentric ribs, and has a less trigonal more linguiform pallial sinus; *C. (L.) taffi* (Cragin, 1893) is less concave in front of the beak and less produced anteriorly; and *C. (L.) alta* Stephenson, 1952, is higher and has a heavier hinge.

Etymology.—The specific name *fallax* is from Latin, deceitful, false.

RHAIPHIALE n. gen.

Type species.—*Rhaiphiale pharota* n. sp., Turonian, Santa Ana Mountains, Orange County, California.

Diagnosis.—Discoidal veneriform bivalves with concentric ribbing, small outlined lunule and narrow, abruptly depressed escutcheon. Hinge with three cardinals in each valve; 3b only narrowly bifid; anterior laterals very close to cardinals; nymphs smooth, low and long.

Remarks.—In shape the shell resembles a small *Dosinia*, but its concentric sculpture is strong for *Dosinia* and its abruptly depressed escutcheon excludes it from *Dosinia*.

Etymology.—The generic name is a combination of *rhaïs*, Greek, break or smash, and *phiale*, Greek, saucer or bowl, and is of feminine gender.

RHAIPHIALE PHAROTA n. sp.

Figure 5.1–5.16

Aphrodina? arata (Gabb, 1864). POPENOE, 1937, p. 397, in part.

Diagnosis.—As for the genus.

Description.—Shell small, rather discoidal, flatly inflated medially; beaks prominent, at anterior third-length of shell, prosogyrous; lunular margin concave; anterior end well rounded; ventral border rounded; posterior end rounded, subtruncated;

TABLE 5—Measurements (in mm) of *Egrona fallax* n. sp.

Museum no.	H	L	I	B	LL	LW	L/H	H/I	L/B	LL/LW
LACMIP 8193	41.4	47.5	16.0	21.0	12.5	3.5	1.1	2.6	2.3	3.6
LACMIP 8194	45.8	—	19.2	22.5	15.0	4.6	—	2.4	—	3.3
LACMIP 8195	42.5	54.7	18.7	21.7	15.0	4.0	1.3	2.3	2.5	3.8
LACMIP 8265	45.5	50.8	16.5	18.0	17.0	5.0	1.1	2.8	2.8	3.4
LACMIP 8266	47.0	—	17.0	19.2	15.0	5.4	—	2.8	—	2.8
LACMIP 8268	45.0	52.0	12.5	22.5	15.0	4.4	1.2	3.6	2.3	3.4

posterior dorsal slope long, arched; lunule short, plumply lanceolate, depressed, circumscribed by a line; escutcheon narrow, but clearly demarked by abrupt angulation; shell surface ornamented by closely spaced, round-topped, concentric ribs abruptly tripling in width near valve height of 10 mm, and becoming irregularly spaced; growth checks impressed.

Ligament groove long, barely arched behind long, low, smooth nymphae. Hinge of right valve with cardinals 3a and 1 divergent, beneath beak, 1 longer and stouter than 3a; cardinal 3b twice as long as 1, bifid; anterior laterals short, close to cardinals enclosing a short moderately deep socket for AII. Hinge of left

valve with cardinals 2a and 2b sturdy, nearly equal, strongly divergent; cardinal 4b longer, slender, very near and separated from nymph by shallow groove; anterior lateral AII very short but strong, close to 2a. Pallial sinus unknown.

Holotype.—LACMIP 8238.

Paratypes.—LACMIP 8166, 8167, 8239–8241 from LACMIP loc. 10888 (=CIT loc. 981), Santa Ana Mts. [13], Orange County, California.

Type locality.—LACMIP loc. 10881 (=CIT loc. 981) SW¼, sec. 21, T5S, R7W, Santiago Peak quadrangle, Santa Ana Mts. [13], Orange County, California.

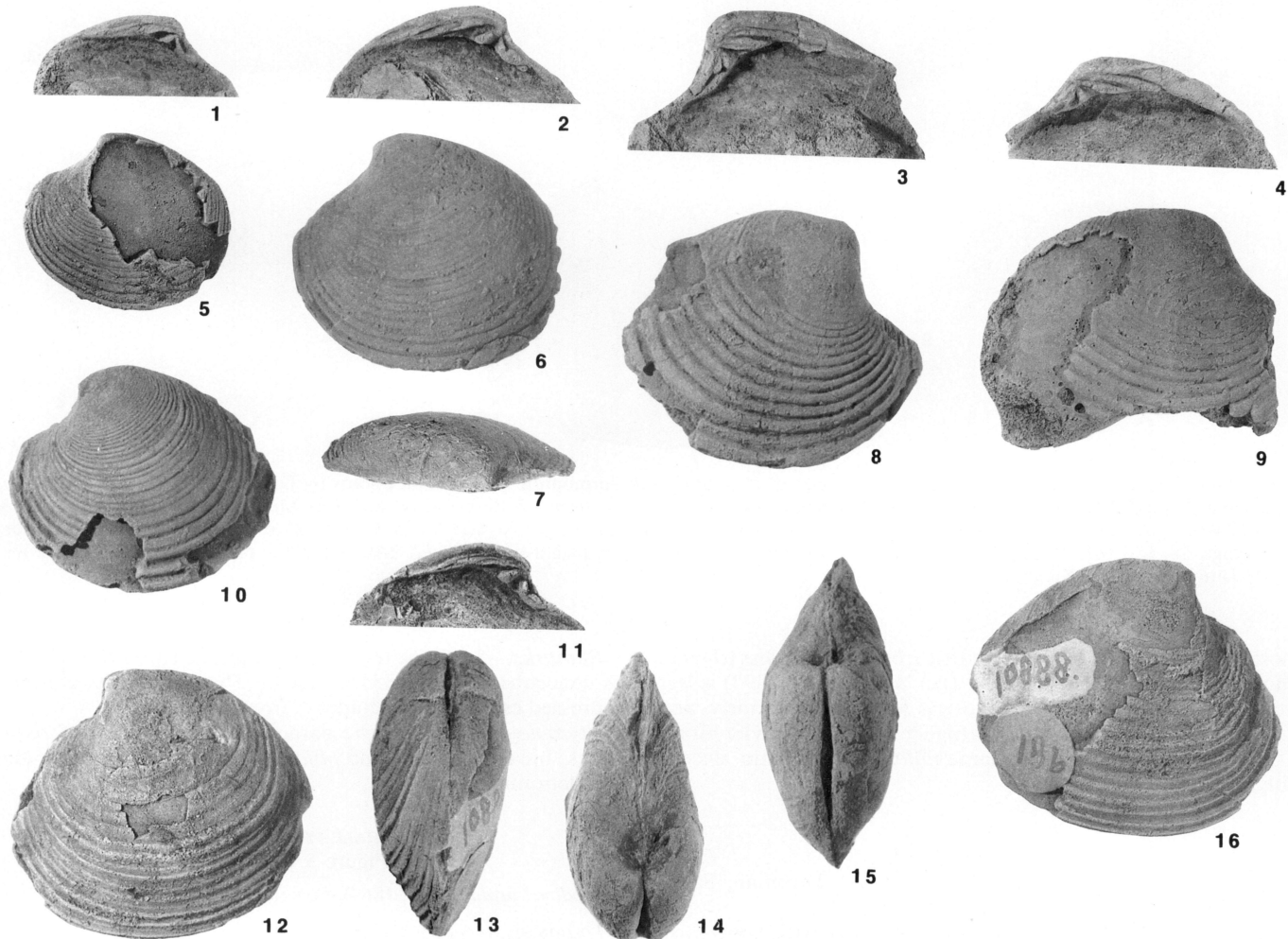


FIGURE 5—*Rhaiphiale pharota* n. sp., $\times 2$, Turonian, from LACMIP loc. 10888, all coated with ammonium chloride, photos by De Leon. 1, 5, LACMIP 8167, paratype, left valve. 1, hinge; 5, exterior. 2, 6, 7, LACMIP 8238, holotype, left valve. 2, hinge; 6, exterior; 7, dorsal view. 3, 8, LACMIP 8239, paratype, right valve. 3, hinge; 8, exterior. 4, 9, LACMIP 8166, paratype, right valve. 4, hinge; 9, exterior, smooth portion of shell marked by grinder used to remove matrix. 10, 11, LACMIP 8141, paratype, left valve. 10, exterior; 11, hinge. 12–16, LACMIP 8240, paratype, left valve. 12, exterior; 13, posterior view; 14, anterior view; 15, dorsal view; 16, exterior.

TABLE 6—Measurements (in mm) of *Rhaiphiale pharota* n. sp.

Museum no.	H	L	I	B	LL	LW	L/H	H/I	L/B	LL/LW
LACMIP 8167	12.3	14.5	4.0	5.5	2.1	1.0	1.2	3.1	2.6	2.1
LACMIP 8238	16.0	19.0	5.4	8.3	4.5	1.8	1.2	3.0	2.3	2.5
LACMIP 8239	17.7	—	6.0	9.0	4.0	1.4	—	3.0	—	2.9
LACMIP 8240	19.2	21.0	4.8	11.3	3.3	2.0	1.1	4.0	1.9	1.6
LACMIP 8241	15.5	18.5	5.7	6.0	2.0	1.2	1.2	2.7	3.1	1.7

Geologic age.—Turonian.

Distribution.—Ladd Formation, Baker Canyon Conglomerate Member, Santa Ana Mountains [13], Orange County, California.

Measured specimens.—See Table 6.

Remarks.—*Rhaiphiale pharota* was included in *Aphrodina? arata* (Gabb, 1864) by Popenoe (1937, 1942). It is much less common than *Callistalox arata* (Gabb, 1864), however, and LACMIP has specimens from only two localities, in a moderately coarse sand matrix. It differs from *C. arata* in being shorter, having more prominent beaks, and round-topped, concentric ribs rather than incised grooves. This ribbing is fine on the beak area but becomes much coarser at a shell height of about 10 mm. On these coarser ribs the profile is asymmetric, being oversteepened on the beakward side. The ribbing of *R. pharota* is coarser than that of *C. (M.) haggarti* Saul and Popenoe (1992) and resembles that of *Amiantis callosa* (Conrad, 1837).

Etymology.—The specific name is derived from Greek *pharos*, plow, and refers to the furrowed aspect of the ribbing.

Subfamily CLEMENTIINAE Frizzell, 1936
PARAESA Casey, 1952

Type species by original designation.—*Venus faba* J. de C. Sowerby, 1827, late Albian of England.

Diagnosis.—An oval venerid with lunule defined by faint line. Hinge of right valve with 3b widely bifid; left valve with 4b well separated from nymph; no anterior or posterior laterals in either valve. Both valves with deeply concave area in hinge plate below lunule, anterior to cardinals; concave area bounded ventrally by raised, ridge-forming, ventral edge of hinge plate.

Discussion.—Casey (1952) suggested that *Paraesa* evolved from *Resatrix* (*Vectorbis*), a subgenus in which the laterals typical of *Resatrix* are present only in the young and disappear before maturity. *Resatrix* was classed in the subfamily Pitarinae by Keen (1969), but *Paraesa* was placed in the Tapetinae because it lacks laterals. It has, however, the excavated hinge plate in front of the cardinals that is typical of Clementiinae. Inclusion of *Paraesa* in the Clementiinae extends the geologic range of this subfamily back to the Early Cretaceous.

PARAESA CEDRINA n. sp.
Figure 6.1–6.6

Diagnosis.—A plump *Paraesa* with 4b moderately distant from and subparallel to nymph, 3b strongly bifid consisting of one lamella on each side of a broad, round-bottomed rather than flat-bottomed depression.

Description.—Shell thick, ovoid, roundly inflated, longer than high; beaks broad, anterior to mid-length of shell, prosogyrous; anterior dorsal border concave; anterior end well rounded; ventral border broadly arched; posterior end roundly truncated; posterior dorsal border long, arched; lunule slightly depressed, broadly heart shaped, delimited by incised line; posterior slope with slight flexure from beak to posterior margin.

Ligament groove arched behind moderate nymphs. Hinge of right valve with anterior tooth 3a and median cardinal 1 narrowly triangular, diverging ventrally, directly beneath beaks,

posterior cardinal 3b more than twice as long as anterior cardinals, strongly bifid with two lamellae separated by broad round-bottomed depression. Hinge of left valve with anterior cardinals 2a, 2b nearly equal, narrowly triangular, forming an inverted V beneath beak; posterior cardinal 4b with groove along its top, about twice as long as anterior cardinals, slender, subparallel to but well separated from the nymph.

Holotype.—LACMIP 8141.

Paratype.—LACMIP 8142, from UCLA loc. 6973, Vizcaino Peninsula [15], Baja California Sur, Mexico.

Type locality.—LACMIP loc. 11936, Arroyo Vargas, Cedros Island [14], Baja California, Mexico.

Geologic age.—Late Albian (associated with *Mariella* sp., *Turrilitoides* sp., and *Mortonicerus* sp.)—?Cenomanian, probably early (associated with *Calva (C.) heliaca* Saul and Popenoe, 1992, and *Anthonya cultriformis* Gabb, 1864).

Distribution.—Middle Member of the Valle Formation, Vizcaino Peninsula [15], Baja California Sur, and Cedros Island [14], Baja California, Mexico.

Measured specimen.—Holotype: H = 30.8 mm, L = 36.6 mm, I = 14.5 mm, B = 12.3 mm.

Remarks.—Both *Paraesa cedrina* and *P. faba* have the dorsal ends of 2a and 2b looped together, and in the right valve 3a and 3b connected dorsally above the dorsal end of 1. *Paraesa cedrina* differs from the type species exteriorly in being more

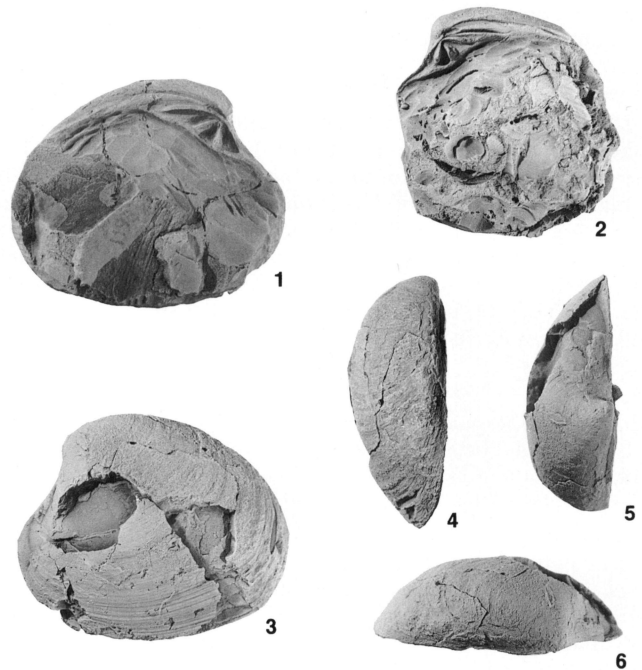


FIGURE 6—*Paraesa cedrina* n. sp., $\times 1$, all coated with ammonium chloride, photos by De Leon. 1, 3–6, LACMIP 8141, holotype, ?late Albian, from LACMIP loc. 11936, left valve. 1, hinge; 3, exterior; 4, posterior view; 5, anterior view; 6, dorsal view. 2, LACMIP 8142, paratype, early Cenomanian, from UCLA loc. 6973, right valve, hinge.

roundly inflated, having a higher more prominent beak, and having the posterior slope more inflated. The inflated posterior slope gives *P. cedrina* a ligamental area that is roundly margined rather than being bounded exteriorly by the obtusely carinated edges of the disk as in *P. faba*. In the right hinge, *P. cedrina* has anterior cardinal 3a much shorter and not reaching the hinge plate edge, 1 more divergent and ventrally rather than anteriorly directed, and 3b less widely bifid; in the left 4b is not as widely separated from the nymph, and has a groove along the top. The flexure along the posterior slope of *P. cedrina* resembles that of the clementine, *Compsomyax subdiaphana* (Carpenter, 1864) (type species of *Compsomyax* Stewart, 1930), which *P. cedrina* resembles in shape and sculpture. But in *C. subdiaphana* the ligament area is bounded exteriorly by the sharply angular valve margin, and *C. subdiaphana* has a more submerged ligament than does either *P. cedrina* or *P. faba*. Casey (1952) described *Paraesa* as having a pallial sinus and muscle scars like those of *Resatrix*. An exfoliated specimen from UCLA loc. 6972 that may be *P. cedrina* has an obscure pallial line with an angulate pallial sinus similar to that of *Resatrix* Casey, 1952. *Paraesa cedrina* resembles *Flaventia ovalis* (J. Sowerby, 1827), of Albian age from England, but *P. cedrina* is more inflated and it lacks the groove in cardinal 2a. It is also more inflated than *Flaventia ludana* Stephenson, 1952, of Cenomanian age from the Woodbine of Texas. The specimens of *P. cedrina* are from small lots of fossils collected by students doing geologic mapping on Cedros Island [14], Baja California, and the Vizcaino Peninsula [15], Baja California Sur, Mexico. These specimens were originally identified for the students as *Calva nitida* (Gabb, 1864), but they differ from *C. nitida* in lacking both anterior and posterior lateral teeth and in being slightly more elongate with a somewhat more anteriorly placed beak. The shell surface is imperfectly preserved, but fine, inscribed concentric lines appear to cover the beak area. At a height of about 10 mm this regular concentric sculpture dies out, and the more ventral portion of the valves is marked only by growth lines and indistinct growth checks.

Etymology.—The name is from Latin, *cedrina*, of cedar, and refers to the occurrence of the species on Cedros Island.

PARAESA s.l.

Discussion.—The West Coast species assigned to *Flaventia* Jukes-Brown, 1908, by Stewart (1930) and Popenoe (1937) lack the groove in cardinal tooth 2a, the inscribed lunule, and the demarked escutcheon of *Flaventia*. They are similar in shape to *Cyclorisma* Dall, 1902, and have more in common with *Cyclorisma* than with *Flaventia*, but they have the excavated area on the hinge anterior to the cardinal teeth that is found in *Paraesa*. They are more lenticular than most species of *Paraesa* and lack an inscribed lunule.

PARAESA? ZETA (Popenoe, 1937)

Flaventia zeta POPENOE, 1937, p. 393, Pl. 48, figs. 9–11; ANDERSON, 1958, p. 134; POPENOE, 1973, p. 18, Pl. 1, fig. 7.
Not *Flaventia zeta* Popenoe. SUNDBERG, 1979, p. 176, Pl. 1, fig. 8 = *Calva (Penecallista) marina* Saul and Popenoe, 1992.

Remarks.—*Paraesa? zeta* is less inflated than most other species assigned to this genus; it is more elongate than species of *Cyclorisma* Dall and has concavities on the hinge plate anterior to the cardinal teeth not present in *Cyclorisma*. Casey (1952, p. 163) has shown that none of the European Early Cretaceous species assigned to *Cyclorisma* belong there, and the Turonian age of *P.? zeta* places it for consideration as an ancestor of *Cyclorisma*. Casey has suggested that *Cyclorisma* descended from *Calva* by loss of the lateral teeth, but the hinge of *P.? zeta* is more similar to that of *Cyclorisma carolinensis* (Conrad, 1875),

Atlantic Coast, Maastrichtian, than is the hinge of any species of *Calva*. The hinge of *P.? zeta* differs from that of *C. carolinensis* mainly in having the anterior concavities that *C. carolinensis* lacks. *Paraesa? zeta* is also very similar to *Paraesa cedrina*, from which it differs in being less inflated and in lacking an inscribed lunule.

PARAESA? LENS (Gabb, 1864)

Meretrix lens GABB, 1864, p. 23, fig. 143.
Tellina meekiana WHITEAVES, 1874, p. 268, fig. 6.
Cyprimeria lens (Gabb, 1864). WHITEAVES, 1879, p. 152, Pl. 17, fig. 15, 15a.
Cyprimeria lens WHITEAVES, 1896, p. 125; WHITEAVES, 1903, p. 379.
Cyprina? anthracicola WHITEAVES, 1903, p. 382, fig. 26.
?Macrocallista cordata WARING, 1917, p. 62, Pl. 8, fig. 1.
Flaventia? lens (Gabb, 1864). STEWART, 1930, p. 247, Pl. 4, fig. 6.
Flaventia lens (Gabb, 1864). POPENOE, 1937, p. 392, Pl. 48, fig. 4; POPENOE, 1973, p. 20, Pl. 2, fig. 21.
Flaventia hornbyensis ANDERSON, 1958, p. 134.

Remarks.—*Paraesa? lens* is a common shallow-water component of Campanian age faunas from the Nanaimo Basin, southern British Columbia and northern Washington, southward to southern California. It is less elongate than *Paraesa? zeta*.

Whiteaves provided several names for *Paraesa? lens* (Gabb). The holotype of *Cyprina? anthracicola*, GSC 5903, is a very badly crushed specimen from the Newcastle Formation in the No. 1 shaft, Nanaimo [2], Vancouver Island, British Columbia. The holotype of *Tellina meekiana*, GSC 5730, is from the Northumberland Formation of Gabriola Island [2]. Whiteaves incorrectly decided that the specimens he assigned to *Cyprimeria lens* (Gabb) in 1879 did not belong to Gabb's species and renamed his specimens *Cyprimeria lens* Whiteaves, 1896. As he selected no type specimens for his species, his hypotypes of *C. lens* (Gabb) GSC 5723, 5724, 5724a, 5724c, became his syntypes of *Cyprimeria lens* Whiteaves. GSC 5723 is from the northwest side of Hornby Island [1], possibly from the Northumberland or lower Spray Formation; the other three specimens are from the Cedar District Formation on Sucia Island [3], Washington. Whiteaves said he had four specimens from Sucia Island, but GSC cat. no. 5724b is apparently not one of the original specimens as it was collected by Newcombe in 1891 (Bolten, personal commun.). Although GSC 5724c is the best specimen, GSC 5724 is here designated as lectotype of *Cyprimeria lens* Whiteaves, 1896, because Whiteaves considered his sole specimen from Hornby Island atypical of *C. lens* and because Whiteaves gave as a major reason for considering his specimens distinct from Gabb's species the dentition of this specimen, which proved that it did not belong to the genus *Meretrix*. Whiteaves (1896, 1903), who had only the hinge of a left valve of *P.? lens*, interpreted the anterior hinge concavity as a possible socket for a lateral tooth. Stewart (1930) suggested that if *C. lens* Whiteaves were distinct from *Flaventia? lens* (Gabb), *C. lens* Whiteaves should have a new name. This name, *Flaventia hornbyensis* Anderson, 1958, was provided without designation of type specimen(s) or type locality. Although Anderson's specific name and his mention of the age of the fauna from the northwest side of Hornby Island suggest that he was basing *F. hornbyensis* on the specimen from Hornby, he included Whiteaves' specimens from Sucia Island. He stated that Stewart "suggests new name for Whiteaves' species," and *Flaventia hornbyensis* Anderson is given as a "n. name" and not as "n. sp." The lectotype of Anderson's species is thus that of *C. lens* Whiteaves, and its type locality is Sucia Island. All of these Nanaimo Basin occurrences fall within the time range of *Paraesa? lens* (Gabb) in California.

Paraesa? lens differs considerably from other species assigned to *Paraesa* in its more discoidal shape. It is not as discoidal as *Cyclorisma carolinensis* (Conrad), in which the lunule and escutcheon are ill defined. In *Cyclorisma alta* (Conrad, 1875) neither lunule nor escutcheon is defined, and Stephenson (1923) suggested that *C. carolinensis* and *C. alta* might be conspecific. As the states of lunule and escutcheon in *Cyclorisma* are unclear, they cannot be used to support placement of *P. lens*. *Paraesa? lens* does have the excavated anterior hinge areas of *Paraesa*, but *Cyclorisma* lacks these concavities.

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APPENDIX
LOCALITIES CITED

Previously published localities are briefly characterized and referenced except for type localities of species described in this paper which are fully described. Bracketed numbers refer to the numbered areas of Figure 1.

- [13] 1068 CIT: See LACMIP loc. 8197 (Matsumoto, 1960, p. 103).
- [13] 1069 CIT: See LACMIP loc. 8198 (Matsumoto, 1960, p. 103).
- [10] 1572 CIT: See LACMIP loc. 10663 (Saul, 1983, p. 111).
- [10] 1576 CIT: See LACMIP loc. 10664 (Saul, 1983, p. 111).
- [13] 2184 USGS: About 4 mi SW of Corona, in northern foothills of Temescal Range, 2nd canyon N of McKnight's Ranch, Orange County, California. Coll: Stanton and Bowers, Sept. 26, 1900. Ladd Formation, Baker Canyon Member. Turonian.
- [13] 2323 UCLA: Sandstone at top of Baker Canyon Member exposed on S end of low hill N of gully, about 2,600 ft N of Holz Ranch house, Silverado Canyon, 2,100 ft S, 390 ft W of NE cor. sec. 7, T5S, R7W, Black Star Canyon quad., Santa Ana Mts., Orange County, California. Coll: W. P. Popenoe, 1946. Ladd Formation, Baker Canyon Member. Turonian.
- [10] 2661 UCLA: Conglomerate reef bed cropping out on NW slope of Los Baños Creek, about 3,200 ft N and 1,800 ft W of SE cor. sec. 12, T11S, R9E, Ortigalita Peak NW quad., Merced County, California. Coll: Popenoe, Lian, McLain, and Susuki, April 28, 1950. Moreno Formation, "Quinto Reef." Maastrichtian.
- [11] A-3369 UCBMP: Cantinas Creek, Bradley quad., San Luis Obispo County, California. El Piojo Formation. Mid-Maastrichtian. (Saul, 1983, p. 121.)
- [11] A-3371 UCBMP: North side of Lake Nacimiento, Tierra Redonda Mountain quad., San Luis Obispo County, California. El Piojo Formation. Maastrichtian. (Saul, 1983, p. 121.)
- [13] 3449 UCLA: Tillotson Ranch, S side of Mabey Canyon marked by Clay Pit, approx. 1,200 ft N, 1,500 ft W of SE cor. sec. 4, T4S, R7W, Corona South quad. (1954), E side Santa Ana Mts., Riverside County, California. Coll: D. Lamar, L. Magnolia, and T. Susuki, Dec. 20, 1955. Ladd Formation, Baker Canyon Sandstone. Turonian.
- [13] 4208 UCLA: In fault block S of Silverado Canyon and E of White Canyon, 2,000 ft N, 1,000 ft E of SW cor. sec. 16, T5S, R7W, Santiago Peak quad. (1954), Santa Ana Mts., Orange County, California. Coll: W. P. Popenoe. Ladd Formation, top of Baker Canyon Sandstone. Late Turonian.

- [9] 6501 UCLA: N side of Garza Creek, gully to E of Oat Gulch, 1,775 ft N, 475 ft W of SE cor. sec. 13, T8S, R7E, Pacheco Pass quad., Stanislaus County, California. Coll: F. A. Schilling, Jr. Moreno Formation, Quinto silt, 550 ft above base. Maastrichtian.
- [15] 6972 UCLA: A coquina? near base of upper Valle Formation, about 3.7 km S 21°W of Campitos, NW end of Vizcaino Peninsula, about 22 km E of Punta Eugenia, Baja California Sur, Mexico. Coll: David Bernal, 1979–1980. Upper Valle Formation. Cenomanian.
- [15] 6973 UCLA: Approx. 3.3 km S 13°W of Campitos, NW end of Vizcaino Peninsula, about 21 km E of Punta Eugenia, Baja California Sur, Mexico. Coll: David Bernal, 1979–1980. Basal upper Valle Formation. Cenomanian.
- [9] 7174 UCLA: Orestimba Creek, T7S, R7E, Orestimba quad., Diablo Range, Stanislaus County, California. Coll: W. P. Popenoe, August, 1944. Moreno Formation, Quinto silt. Late Maastrichtian.
- [13] 8167 LACMIP: (=CIT loc. 1305) east side Santa Ana Mts., about 1 mi N of Skyline Drive and ¼ mi W of Martinez contact, Corona quad., Santa Ana Mts., Orange County, California. Coll: W. P. Popenoe, April 24, 1936. Ladd Formation, Baker Canyon Member. Turonian.
- [13] 8195 LACMIP: (=CIT loc. 82) limy sandstone bed near base of shale, S of roadcut at Holz Ranch (locality may become obscured by slides), Silverado Canyon, E edge SE¼, SE¼, sec. 7, T5S, R7W, El Toro quad., Santa Ana Mts., Orange County, California. Coll: Bernard N. Moore, 1927. Ladd Formation, Holz–Baker transition. Turonian.
- [13] 8197 LACMIP: (=CIT loc. 1068) faulted area on S side of Silverado Canyon between Wildcat and White Canyons; from small gully E of abandoned farm and just above a spring, about 3.5 mi S 72°E of mouth of Silverado Canyon, 2,000 ft N, 1,000 ft E of SW cor. sec. 16, T5S, R7W, Santiago Peak quad., Santa Ana Mts., Orange County, California. Coll: W. P. Popenoe and Anderson, March 14, 1934. Ladd Formation, top of Baker Canyon Sandstone. Late Turonian.
- [13] 8198 LACMIP: (=CIT loc. 1069) faulted area on S side of Silverado Canyon between Wildcat and White Canyons, about 400 ft N of CIT loc. 1068 along banks of next small gully to north, 2,300 ft N, 110 ft E of SW cor. sec. 16, T5S, R7W, Santiago Peak quad., Santa Ana Mts., Orange County, California. Coll: W. P. Popenoe and Anderson, March 14, 1934. Ladd Formation, top of Baker Canyon Sandstone. Late Turonian.
- [11] 9196 LACMIP: Cantinas Creek, San Luis Obispo County, California. El Piojo Formation. Late Maastrichtian (Saul, 1988, p. 24).
- [13] 10079 LACMIP: (=CIT loc. 1164) South side of Silverado Canyon near mouth of small N-flowing gully, and at top of lower fossiliferous sandstone series, about 400 ft SE of Holz Ranch house, 1,025 ft N, 150 ft E of SW cor. sec. 8, T5S, R7W, El Toro quad., Santa Ana Mts., Orange County, California. Coll: W. P. Popenoe, May 15, 1935. Ladd Formation, Baker Canyon Member. Turonian.
- [10] 10663 LACMIP: (=CIT loc. 1572) Canyon S of Laguna Seca, Ortigalita Peak quad., Merced County, California. Moreno Formation, Tierra Loma Sandstone Member. Maastrichtian (Saul, 1983, p. 111.)
- [10] 10664 LACMIP: (=CIT loc. 1576) Canyon S of Laguna Seca, Ortigalita Peak quad., Merced County, California. Moreno Formation, Tierra Loma Sandstone Member. Maastrichtian (Saul, 1983, p. 111.)
- [10] 10685 LACMIP: (=CIT loc. 1573; UCLA loc. 2661) conglomerate reef cropping out on NW slope of Los Baños Creek, about 3,200 ft N, 1,800 ft W of SE cor. sec. 12, T11S, R9E, Ortigalita Peak NW quad., Merced County, California. Coll: B. C. Adams and W. P. Popenoe, June, 1942. Moreno Formation, "Quinto B" Member. Maastrichtian.
- [5] 10744 LACMIP: (=CIT loc. 1255) hard concretions in soft, massive brown sandstone; W bank of French Creek about ½ mi north of Swede Basin, 600 ft N, 600 ft E of SW cor. sec. 33, T33N, R2W, Millville quad., Shasta County, California. Coll: W. P. Popenoe, April 12, 1937. Redding Formation, Bellavista Sandstone. Turonian.
- [5] 10766 LACMIP: (=CIT loc. 1442) soft sandstone on left bank of main branch of French Creek at 1st fork upstream from line fence between N and S halves sec. 4, N end Swede Basin, 1,800 ft S, 300 ft E of NW cor. sec. 4, T32N, R2W, Millville quad., Shasta County, California. Coll: W. P. Popenoe, March 21, 1940. Redding Formation, ?Melton Sandstone. Turonian.
- [13] 10888 LACMIP: (=CIT loc. 981) fossiliferous sandstone overlying gray basal cgl. from 2,250 ft–3,000 ft N 5°W of dam just above mouth of Harding Canyon, NW¼, SW¼, sec. 21, T5S, R7W, Santiago Peak quad., Santa Ana Mts., Orange County, California. Coll: W. P. Popenoe, March 26, 1932. Ladd Formation, Baker Canyon Member. Turonian.
- [14] 11936 LACMIP: Arroyo Vargas, ammonites in conglomerate clast near top of conglomeratic unit, approx. 3 km SE of coast, west side Cedros Island, Baja California, Mexico. Coll: D. P. Smith, 1988. Valle Formation, lower member. Albian.

Errata for Saul, 1993, Pacific Slope Cretaceous bivalves: eight venerid species. *Journal of Paleontology*, v. 67

Hypotype LACMIP 8186 of *Callistalox arata* from UCLA loc. 2323 not cited under *Hypotypes* p. 969. In figure caption p. 970 - figs. 3.9, 3.11

Hypotype LACMIP 8175 of *Callistalox arata* from LACMIP loc. 10766 not cited under *Hypotypes* p. 969. In figure caption p. 970 - figs. 3.17-3.18

p. 971, beginning of penultimate line of fig. caption - "8184, hypotype" should be **8148**, hypotype

p. 974, middle of penultimate line of fig. caption - "LACMIP 8141, paratype" should be LACMIP **8241**.