

PROPEAMUSSIUM SPECIES (BIVALVIA: PROPEAMUSSIIDAE) FROM THE UPPER CRETACEOUS OF SOUTHERN CALIFORNIA

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ABSTRACT—*Propeamussium* (*Parvamussium*) *holzense* n. sp. and *Propeamussium* (*Parvamussium*) *robinsonense* n. sp. are described from the Upper Cretaceous Holz Shale Member of the Ladd Formation, Santa Ana Mountains, southern California. These species occur with *Bostrychoceras elongatum* (Whiteaves), *Glyptoxoceras subcompressum* (Forbes), and *Inoceramus orientalis* (Sokolow), which are indicative of a late medial Santonian age (*Bostrychoceras elongatum* Biochron). *Propeamussium* (*Parvamussium*) *cowperi* (Waring), from the Campanian Chatsworth Formation of the Simi Hills, southern California, is also redescribed and reillustrated for comparative purposes.

INTRODUCTION

THIN SHELLED “mud pectens” belonging to the family Propeamussiidae are relatively common from deeper water mudstones of Cretaceous age in the circum-Pacific area (Waring, 1917; Yabe and Nagao, 1928; Nagao, 1932; Ichikawa and Maeda, 1958; Hayami, 1965; Tamura, 1973, 1976; Tashiro, 1976; Sundberg, 1980, 1982, 1983; Tashiro and Matsuda, 1986). Because of their relative abundance and widespread distribution in this deeper water lithofacies, the Propeamussiidae may have biostratigraphic and paleoecological value. However, there are few adequate descriptions of this group from the Cretaceous of the circum-Pacific area.

Two new species of *Propeamussium* (*Parvamussium*) from southern California are described and the previously named species *Propeamussium* (*Parvamussium*) *cowperi* (Waring, 1917) is redescribed and reillustrated. *Propeamussium* (*Parvamussium*) *holzense* n. sp. and *Propeamussium* (*Parvamussium*) *robinsonense* n. sp. occur in the Upper Cretaceous Holz Shale Member of the Ladd Formation, Santa Ana Mountains, southern California (Figure 1). Sundberg (1980, 1982, 1983) has previously reported the two species as a single taxon, *Propeamussium* (*Propeamussium*) sp. A or *Propeamussium* sp. For comparison purposes, *Propeamussium* (*Parvamussium*) *cowperi*, also found in the Upper Cretaceous of southern California, is redescribed and reillustrated because its original description and illustrations (Waring, 1917) are inadequate.

Measurements for the three taxa are explained in Figure 2 and presented in Tables 1, 2, and 3. The following institutional abbreviations are used: CAS, Department of Geology, California Academy of Sciences, Golden Gate Park, San Francisco, California; CSUF, Department of Geological Sciences, California State University, Fullerton, California; LACMIP, Section of Invertebrate Paleontology, Los Angeles County Museum of Natural History, Los Angeles, California; UCLA, Department of Earth and Space Sciences, University of California, Los Angeles, California (collections presently housed at LACMIP).

AGE

Propeamussium (*Parvamussium*) *holzense* and *Propeamussium* (*Parvamussium*) *robinsonense* occur with *Bostrychoceras elongatum* (Whiteaves), *Glyptoxoceras subcompressum* (Forbes), and/or *Inoceramus orientalis* (Sokolow) in the Plano Trabuco area (UCLA locs. 7057, 7058, 7059, and 7061) and in Silverado Canyon (LACMIP loc. 8087 and CSUF loc. 68), Santa Ana Mountains, southern California. In northern California, these associated taxa are indicative of the *Bostrychoceras elongatum* Biozone of late medial Santonian age (Haggart, 1984), thus in-

dicating a late medial Santonian age for *P.* (*P.*) *holzense* and *P.* (*P.*) *robinsonense*.

Propeamussium (*Parvamussium*) *cowperi* occurs at Stanford University locality 2 (Waring, 1917; =CAS 61644). This locality is in the basal portion of the Chatsworth Formation (Waring, 1917; Saul and Anderson, 1981) and is probably late medial Campanian age (Colburn et al., 1981).

SYSTEMATIC PALEONTOLOGY

Superfamily PECTINACEA Rafinesque, 1815
 Family PROPEAMUSSIIDAE Abbott, 1954
 Genus PROPEAMUSSIUM de Gregorio, 1884
 Subgenus PARVAMUSSIUM Sacco, 1897

Type species.—*Pecten duodecim-lamellatus* Bronn, 1831.

Diagnosis.—*Propeamussium* with a byssal notch present throughout ontogeny.

Description.—Valves small, thin, nearly equally convex; exterior of right valve covered with submarginal lirae; exterior of left valve commonly covered with radial costae; anterior auricle of right valve with byssal notch present throughout ontogeny and, in some shells, with radial costellae; lacks lateral gape; maximum internal rib height (RH) on left valve approximately 50–100 percent of shell height. (Modified from Hertlein, 1969, p. N350–N351.)

Discussion.—*Propeamussium* (sensu stricto) and *Parvamussium* have been considered subgenera of *Propeamussium* (Hertlein, 1969) or as separate genera (Tamura, 1973; Moore, 1984). *Propeamussium* (sensu lato) species from the Upper Cretaceous of southern California illustrate a mixture of morphological characteristics used by Hertlein, Tamura, and Moore to differentiate *Propeamussium* from *Parvamussium*. Modern species of *Parvamussium* are presently recognized based on the persistence of a byssal notch throughout ontogeny, whereas in *Propeamussium* (sensu stricto) the byssal notch disappears in later growth stages (Waller, personal commun.). This single character difference between *Propeamussium* (sensu stricto) and *Parvamussium* is here considered minor. Thus, the two taxa are here considered subgenera of *Propeamussium*.

Tamura (1973) considered all Mesozoic species of *Propeamussium* (sensu lato) as belonging to the genus (subgenus) *Parvamussium*. The species from southern California support Tamura's hypothesis. Other reported Mesozoic species of *Propeamussium* (sensu lato) are assumed to belong to the subgenus *Parvamussium*, although published illustrations of some species are not adequate for determining if the byssal notch is present throughout ontogeny.

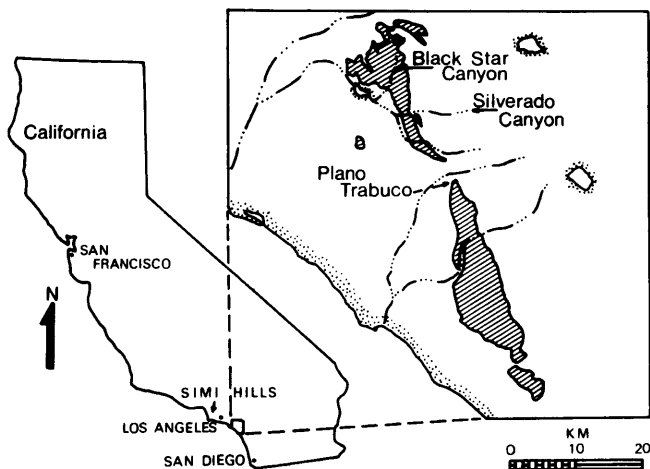


FIGURE 1—Location map showing the Simi Hills and (in the enlarged area) the Upper Cretaceous outcrop belt in the Santa Ana Mountains.

Right valves of *Propeamussium* (sensu lato) have an outer shell layer composed of columnar prismatic calcite and inner layers of foliated calcite and crossed lamellar aragonite (Waller, 1972, 1984). In the right valve, the stronger foliated calcite and crossed lamellar aragonite shell layer terminate at the same location as the internal ribs (which are foliated calcite) (Waller, 1972). This termination leaves the weaker, more fragile, prismatic calcite layer unsupported along the ventral margin of the right valve. As a result, the fragile ventral margin of the right valve is commonly broken off and/or not preserved. A few of the fossil specimens described here show this thin prismatic calcite layer (Figure 3.10). Left valves do not have the outer shell layer composed of columnar prismatic calcite. In these valves, the inner layer of foliated calcite extends to the valve edge (Waller, 1972, 1984).

The internal ribs in *Propeamussium* have different relative lengths in right and left valves (Waller, personal commun.). All rib height/height ratios (RH/H) mentioned in the following descriptions refer to left valves only. The height of the internal ribs in the right valve is not discussed due to the fragile ventral margin as discussed above. The internal ribs are considered primary if they begin in the umbonal region and secondary if they begin at some distance away from the umbonal region.

PROPEAMUSSIUM (PARVAMUSSIUM) HOLZENSE n. sp.
Figures 3, 4

Diagnosis.—*Propeamussium* (*Parvamussium*) with a posteriorly ovate to subcircular valve outline; well-developed to moderately well-developed byssal notch on right anterior auricle; 6–9 radial costellae on right anterior auricle; 11–15 internal ribs on right valve (10–15 primary and 0–3 secondary); 9–15 on left valve (9–15 primary and 0–3 secondary); hinge line straight.

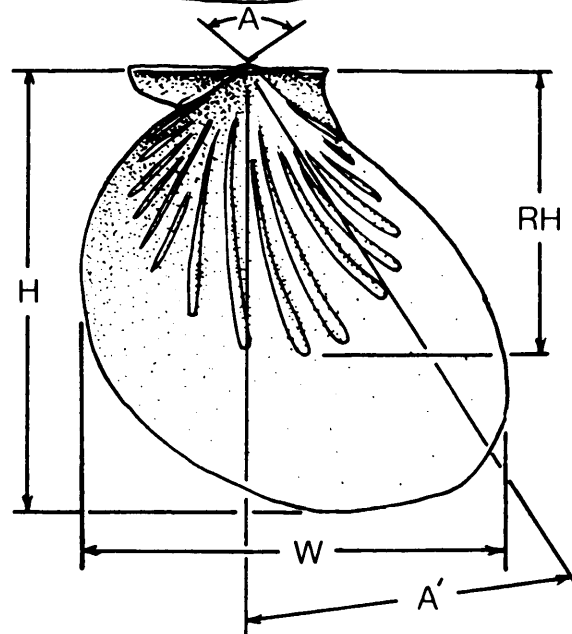
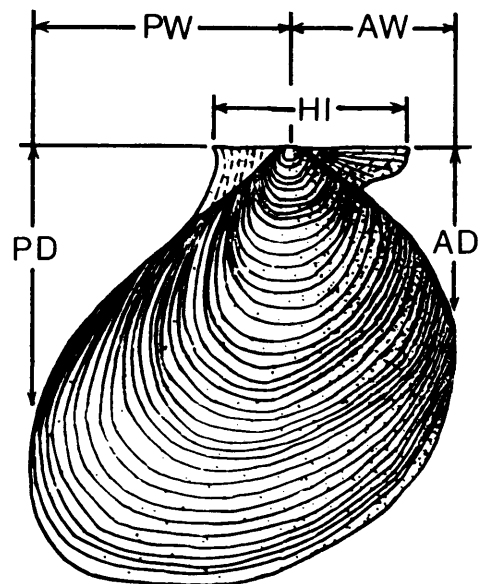
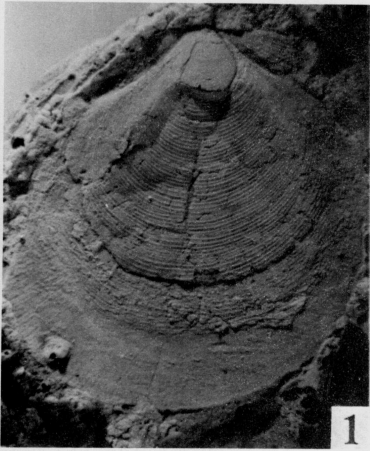
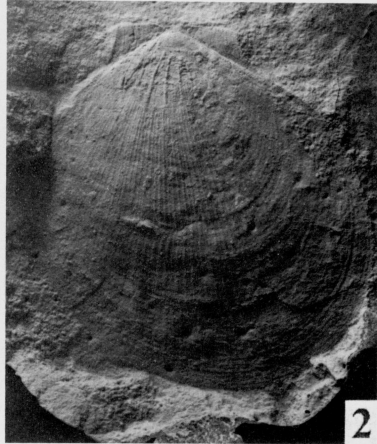


FIGURE 2—Measurements used for *Propeamussium* (*Parvamussium*) *holzense* n. sp., *Propeamussium* (*Parvamussium*) *robinsonense* n. sp., and *Propeamussium* (*Parvamussium*) *cowperi* (Waring). External right valve at top; internal right valve at bottom. A, umbonal angle; A', angle of maximum distance from umbo; H, height; HI, hinge line length; RH, maximum height of ribs; W, width; AD, anterior distance from umbo to maximum anterior width; AW, maximum anterior width from umbo; PD, posterior distance from umbo to maximum posterior width; PW, posterior width from umbo.

FIGURE 3—*Propeamussium* (*Parvamussium*) *holzense* n. sp. from the Santa Ana Mountains. All specimens coated with ammonium chloride sublimate or magnesium ribbon smoke. 1, 4, latex cast of holotype (LACMIP 7231); 1, right valve exterior, posterior auricle broken, $\times 2.9$; 4, close-up of holotype anterior auricle, $\times 12.9$; 2, 3, 5, latex cast of paratype (LACMIP 7219); 2, left valve exterior, $\times 1.6$; 3, left valve interior, $\times 1.6$; 5, close up of hinge line, $\times 5.6$; 6, paratype (LACMIP 7238), latex cast of left valve interior, $\times 1.5$; 7, 8, latex cast of paratype (LACMIP 7228); 7, exterior right valve with posterior auricle missing and left valve interior, $\times 1.5$; 8, left valve exterior with auricles missing and right valve interior, $\times 1.5$; 9, paratype (LACMIP 7232), articulated specimen, right valve up with prismatic calcite fringe missing, posteriorly ovate specimen, $\times 1.8$; 10, latex cast of paratype (LACMIP 7241), right valve exterior with prismatic calcite fringe preserved, $\times 3.0$; 11, 12, latex cast of paratype (LACMIP 7220); 11, left valve exterior with hinge area missing, $\times 1.5$; 12, left valve interior, short rib section near ventral margin probably broken off from posterior side of umbonal region, $\times 1.5$; 13, paratype (LACMIP 7216), left valve exterior with auricles missing, $\times 1.8$. 14, latex cast of paratype (LACMIP 7221), left valve exterior, $\times 3.8$.



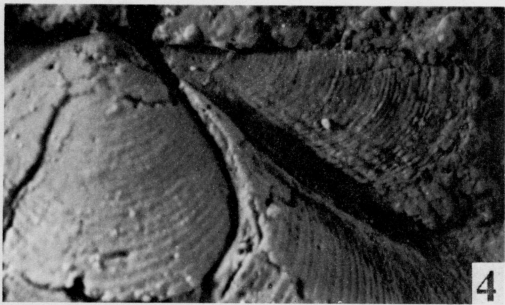
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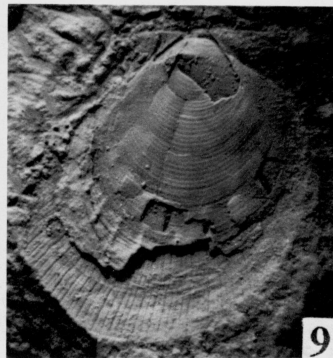
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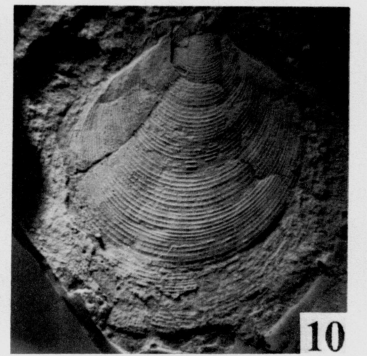
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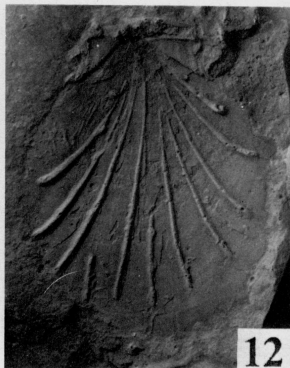
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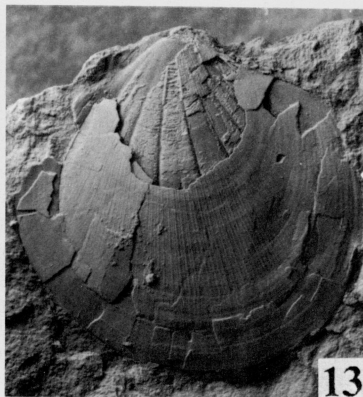
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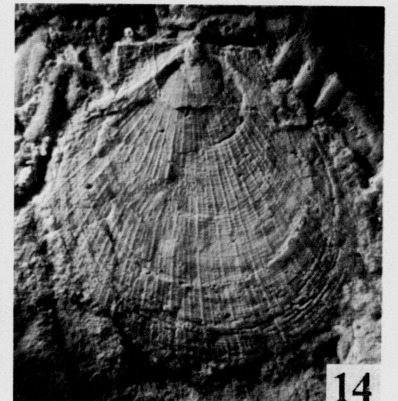
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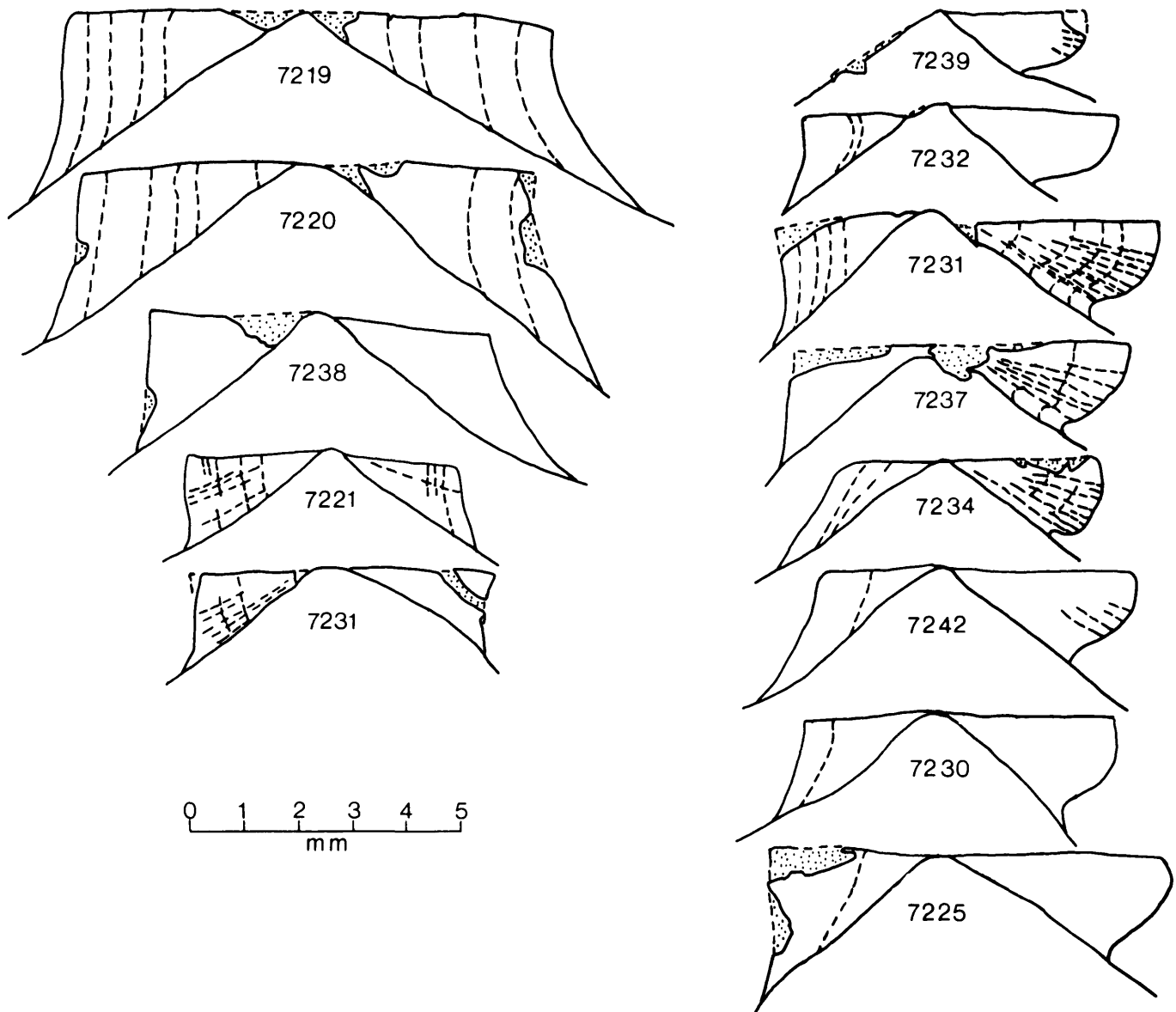


FIGURE 4—Auricles of right and left valves of *Propeamussium (Parvamussium) holzense* n. sp. Numbers in umbo region are LACMIP type numbers.

Description.—Valves posteriorly ovate to subcircular in outline, approximately as wide as high (height/width = 1.07); auricles relatively large, equal; average umbonal angle 111° ; average maximum internal rib height 75 percent of the left valve height; secondary internal ribs present in some right and left valves.

Exterior of right valves covered with several fine submarginal lirae of moderate relief; ventral margin fragile beyond distal ends of internal ribs typically not preserved; posterior auricles with fine growth lines acute to obtuse auricle angles; anterior auricles with fine growth lines, 6–9 radial costellae, well-developed to moderately well-developed byssal notches, acute to 90° auricle angles; interior of right valves with 12–15 ribs (10–15 primary and 0–3 secondary); internal ribs straight anteriorly and curved towards margin posteriorly, lateral internal ribs slightly swollen at termination.

Exterior of left valves covered with several fine radial costae;

radial costae variable in height, typically with one or two weaker costae between two stronger costae; radial costae sharp in cross section in valves less than 20 mm in height, rounded and less pronounced at shell heights greater than 20 mm; growth lines faint to raised, fine submarginal lirae; grid pattern formed by radial costae and submarginal lirae; posterior auricles with faint growth lines, rare radial costellae (1–5 when present), slightly acute to obtuse auricle angles; anterior auricles with faint growth lines, common radial costellae (5–8 when present), 90° to slightly obtuse auricle angles; interior of left valves with 9–15 ribs (9–15 primary and 0–3 secondary); central internal ribs straight, lateral internal ribs curved toward margin anteriorly and posteriorly; lateral internal ribs swollen at termination.

Measurements.—See Table 1.

Discussion.—*Propeamussium (Parvamussium) holzense* n. sp. is variable in the development of the auricles and valve outline. The byssal notch on the right valve ranges from relatively deep

TABLE 1—Measurements (in mm) and ratios of *Propeamussium* (*Parvamussium*) *holzense* n. sp. Spec = LACMIP specimen number, Val = valve, L = left valve, R = right valve, PR = primary internal rib count, SR = secondary internal rib count. See Figure 2 for other abbreviations.

Spec	Val	HI	H	W	A	A'	RH	PR	SR	H/W	RH/H	AD	AW	PD	PW	Locality
7207	L	—	15.0	—	—	—	11.6	—	—	—	77%	—	—	—	—	UCLA 7062
7212	L	7.1	13.8	14.9	114	25	9.3	11	*	0.93	67%	5.8	6.7	8.3	8.3	UCLA 7057
7214	L	3.9	9.6	9.4	—	—	6.5	—	—	1.02	68%	4.0	5.1	5.1	4.3	UCLA 7058
7216	L	—	24.3	24.1	119	12	—	—	—	1.01	—	13.5	9.7	12.8	15.4	UCLA 7061
7217	L	—	8.6	8.1	111	27	6.4	12	2	1.06	74%	4.5	4.2	5.1	3.9	UCLA 7061
7219	L	9.0	29.5	28.0	121	24	22.0	9	0	1.05	74%	12.6	11.7	19.0	16.3	UCLA 7059
7220	L	10.2	25.5	21.2	104	19	23.3	11	1	1.20	91%	9.8	9.2	9.7	12.0	UCLA 7059
7221	L	5.2	11.7	11.6	112	30	—	—	—	1.01	—	5.8	5.1	7.1	6.5	UCLA 7059
7223	L	—	16.5	—	—	—	10.8	—	—	—	65%	—	—	—	—	UCLA 7057
7225	L	6.0	19.0	—	103	—	—	—	—	—	—	—	—	—	—	UCLA 7057
7228	L	—	10.7	—	—	—	7.8	9*	3	—	73%	—	—	—	—	UCLA 7058
7229	L	—	14.1	—	107	14	10.1	12	3*	—	72%	—	—	—	—	UCLA 7058
7232	L	6.0	12.5	12.3	—	—	9.7	—	—	1.02	78%	7.2	4.6	6.4	7.7	UCLA 7059
7236	L	—	15.3	15.6	108	26	11.0	15	—	0.98	72%	—	—	8.3	8.3	UCLA 7059
7238	L	6.1	24.0	21.5	111	21	19.0	12	3	1.12	79%	13.0	9.9	—	—	LACMIP 8087
7214	R	3.9	7.5	6.9	100	13	7.5	11	—	1.09	100%	4.0	5.1	5.1	4.3	UCLA 7058
7215	R	4.5	7.8	7.7	109	10	7.8	10	1	1.01	100%	2.9	4.1	4.2	3.6	UCLA 7058
7218	R	5.2	11.8	12.1	111	24	8.8	10*	—	0.98	75%	7.3	5.4	7.8	6.7	UCLA 7059
7221	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	UCLA 7059
7223	R	—	—	—	113	16	—	—	—	—	—	—	—	—	—	UCLA 7057
7224	R	—	8.4	8.5	109	7	—	—	—	0.99	—	4.6	4.3	4.8	4.2	UCLA 7057
7225	R	—	11.8	12.2	—	—	11.8	—	—	0.97	100%	5.1	6.8	5.8	6.4	UCLA 7057
7226	R	4.8	10.8	11.8	105	20	—	—	—	0.92	—	6.1	5.6	6.4	6.2	UCLA 7058
7227	R	4.9	7.2	6.8	110	28	7.2	—	—	1.06	100%	—	—	—	—	UCLA 7058
7228	R	5.2	—	—	110	—	—	9*	3	—	—	—	—	—	—	UCLA 7058
7230	R	5.5	11.1	—	110	15	11.1	10	2*	—	100%	—	—	—	—	UCLA 7058
7231	R	7.1	17.3	16.4	120	21	13.9	—	—	1.05	80%	7.4	8.7	6.2	7.7	UCLA 7059
7232	R	6.0	12.5	12.3	108	15	9.7	—	—	1.07	78%	7.2	4.6	6.4	7.7	UCLA 7059
7233	R	—	10.9	12.2	113	27	10.3	13	0	0.89	98%	6.1	5.1	5.1	7.1	UCLA 7059
7234	R	5.2	9.9	10.7	114	27	9.9	15	0	0.93	100%	4.7	5.2	6.1	5.5	UCLA 7059
7235	R	6.9	16.0	—	102	—	10.9	—	—	—	68%	—	—	6.1	6.7	UCLA 7059
7237	R	7.1	13.0	14.0	112	22	10.0	—	—	0.93	77%	6.4	5.0	10.0	8.5	UCLA 7059
7239	R	—	7.1	6.5	114	15	5.0	11*	0*	1.09	70%	—	—	—	—	LACMIP 8087
7240	R	—	24.5	22.0	115	—	19.5	11	2*	1.11	80%	—	—	—	—	LACMIP 8087
7241	R	5.8	14.1	14.7	123	16	—	—	—	1.10	96%	7.1	6.3	7.7	8.4	UCLA 7074
7242	R	6.1	14+	—	112	19	—	—	—	—	—	—	—	9.3	7.8	UCLA 7074
7243	R	—	—	16.0	107	—	—	—	—	—	—	—	—	—	—	UCLA 7074
7244	R	4.5	14.4	14.7	105	—	10.6	—	—	0.98	74%	6.4	4.5	9.0	10.2	UCLA 7074
Average		5.9	14.1	13.8	111	20	11.2	—	—	1.02	73%**	—	—	—	—	—
SD		1.5	5.7	5.6	5.4	6.2	4.6	—	—	0.07	4.3%	—	—	—	—	—

* All internal ribs may not be visible.

** Exclusive of right valves and left valves with RH/H of 90% or greater.

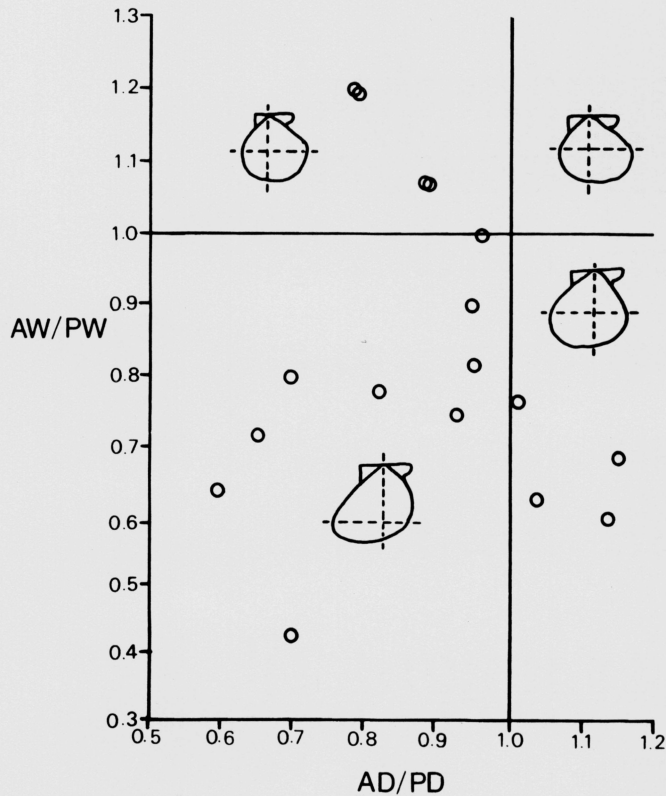


FIGURE 5—Graph of anterior (AW) and posterior (PW) width ratios vs. anterior (AD) and posterior (PD) distance ratios for *Propeamussium* (*Parvamussium*) *holzense* n. sp.

to only moderately well-developed (Figure 4). Posterior auricle angles of right valves range from acute to obtuse (Figure 4). Valve outlines (Figure 5) range from posteriorly ovate ($AW/PW < 1.00$) to slightly anteriorly ovate ($AW/PW > 1.00$). The distribution of data points in the scatter plot (Figure 5) shows that the posteriorly ovate specimens are part of a continuum of forms ranging from posteriorly ovate to subcircular to slightly anteriorly ovate. Some valves may have been compressed through compaction, thus changing their outlines, but the predominance of posteriorly ovate forms suggests that it was originally present.

Specimens of *Propeamussium* (*Parvamussium*) *holzense* with posteriorly ovate outlines are unlike other Mesozoic species of *Parvamussium* from the circum-Pacific area. Tamura (1973) referred to *P. (Parvamussium) hinagense* as circular, although some of his figured specimens appear to be posteriorly ovate. The variability in the outline of *P. (Parvamussium) hinagense* may be the result of structural deformation. If this outline variation is not the result of deformation, then the two species still can be separated on the basis of *P. (Parvamussium) hinagense* having more internal ribs, radial costae on the right valve exterior, and coarser radial costae on the left valve exterior.

Specimens of *P. (Parvamussium) holzense* with semicircular outlines are similar to other Cretaceous *Parvamussium* species from Japan and Borneo. *Propeamussium* (*Parvamussium*) *hinagense* (Tamura, 1973) and *P. (P.)* sp. cf. *hinagense* (Tamura, 1973) are similar to *P. (P.) holzense* but differ in having fewer and stronger radial costae on the exterior of the left valve, 17 internal ribs (*P. hinagense*), and radial costae on lateral and ventral areas on the right valve. *Propeamussium* (*Parvamussium*) *yubarensis* (Yabe and Nagao, 1928) differs from *P. (P.) holzense* in having faint radial costae on the right valve, absence

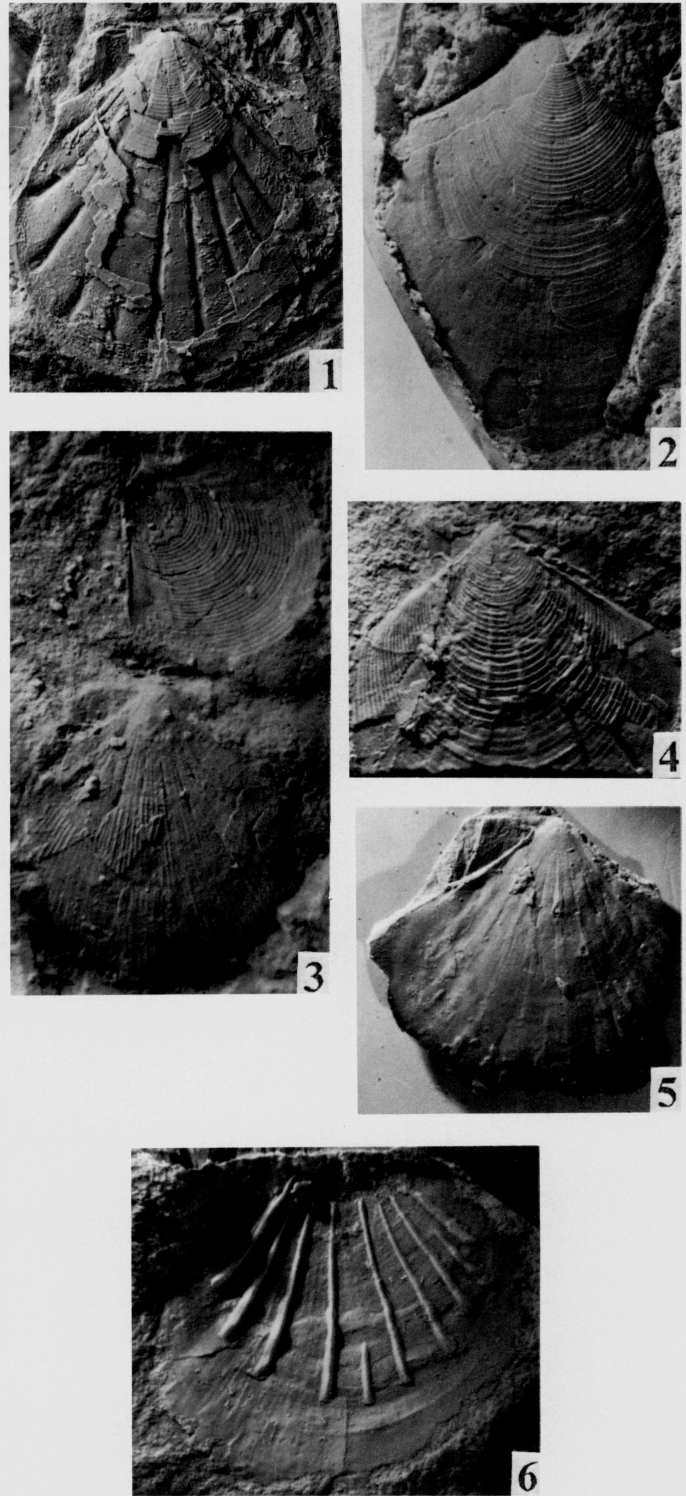


FIGURE 6—*Propeamussium* (*Parvamussium*) *robinsonense* n. sp. from the Santa Ana Mountains. All specimens coated with ammonium chloride sublimate or magnesium ribbon smoke. 1, 2, holotype (LACMIP 7222); 1, right valve exterior, posterior auricle broken, $\times 2.4$; 2, latex cast of right valve exterior showing posterior auricle, $\times 2.8$; 3, 4, paratype (LACMIP 7209); 3, counter part of LACMIP 7209, right valve exterior, and left valve exterior of LACMIP 7209, $\times 3.7$; 4, part (LACMIP 7209), with ventral margin broken, $\times 6.0$; 5, paratype (LACMIP 7211) left valve interior, posterior auricle, and ventral margin missing, $\times 2.7$; 6, latex cast of paratype (LACMIP 7210), left valve interior, auricle area missing, $\times 3.5$.

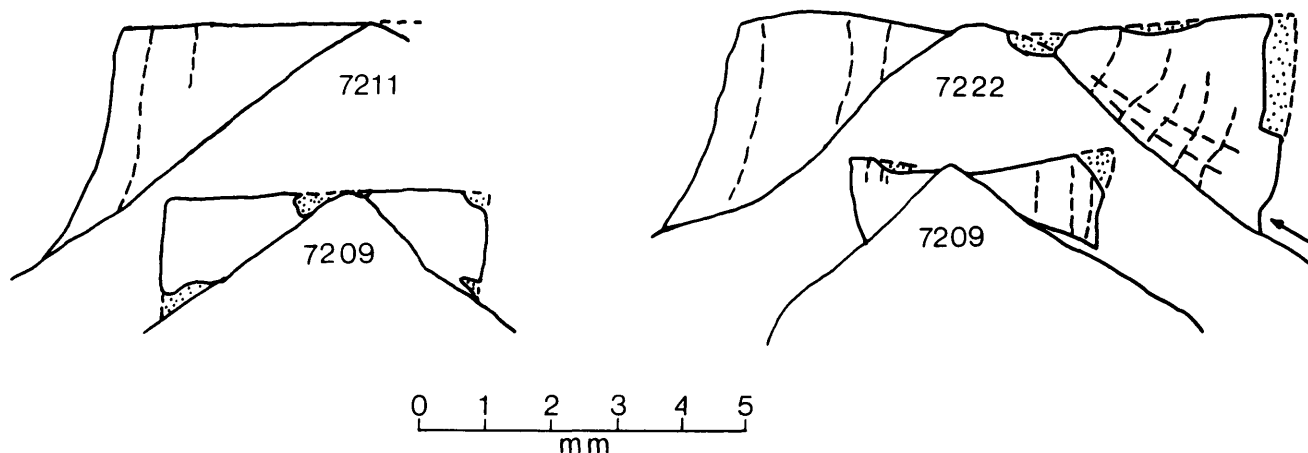


FIGURE 7—Auricles of right and left valves of *Propeamussium* (*Parvamussium*) *robinsonense* n. sp. Numbers in umbo region are LACMIP type numbers. Arrow points to slight byssal notch.

of a well-developed byssal notch (except for a specimen figured by Tamura (1976, Pl. 1, figs. 10, 11) that has a well-developed byssal notch and is probably a new species), fewer internal ribs (typically 8–9), unequal auricles, and different auricle angles (Yabe and Nagao, 1928; Tashiro, 1976). *Propeamussium* (*Parvamussium*?) *awajense* Ichikawa and Maeda (1958) differs from *P. (P.) holzense* in having coarse submarginal lirae and fine radial costae on the left valve (if Ichikawa and Maeda are correct in identifying the valves as left valves, no right valves are known) and a smaller umbonal angle (90°). *Propeamussium* (*Parvamussium*) *kimurai* (Hayami, 1965) differs from *P. (P.) holzense* in having unequal auricles, smaller umbonal angle (100°), fewer ribs (8–9), different auricle angles, absence of radial costellae on right valve auricles, and coarser radial costae on left valve. *Propeamussium* (*Parvamussium*) *tosaense* (Tashiro and Matsuda, 1986) differs from *P. (P.) holzense* in having unequal auricles, posterior auricle on right valve with a strongly acute angle, and smaller umbonal angle (90°).

Etymology.—The species is named after the Holz Shale, Ladd Formation, in which it is found.

Material.—Holotype, LACMIP 7242, right valve from UCLA loc. 7074; paratypes, LACMIP 7212, 7223–7226 from UCLA loc. 7057; LACMIP 7214, 7215, 7227–7230 from UCLA loc. 7058; LACMIP 7218–7221, 7231–7236 from UCLA loc. 7059; LACMIP 7216 and 7217 from UCLA loc. 7061; LACMIP 7207 from UCLA loc. 7062; LACMIP 7241–7244 from UCLA loc. 7074; LACMIP 7238–7240 from LACMIP loc. 8087.

Age.—Late medial Santonian, *Bostrychoceras elongatum* Biozone.

Occurrence.—Holz Shale Member of the Ladd Formation at the Robinson Ranch, on Plano Trabuco (UCLA locs. 7057, 7058, 7059, 7061, and 7074); and in Silverado Canyon (LACMIP loc. 8087), Santa Ana Mountains, Orange County, California.

PROPEAMUSSIUM (PARVAMUSSIUM) ROBINSONENSE n. sp.

Figures 6, 7

Diagnosis.—*Propeamussium* (*Parvamussium*) with subcircular valve outline; slight byssal notch in right anterior auricle in later growth stages; 0–2 riblets on right anterior auricle; 9–11 internal ribs on right valve (9–11 primary); 9–12 internal ribs on left valves (8–12 primary and 0–2 secondary); dorsal lateral margins of auricles projecting above umbo on right valve.

Description.—Valves subcircular in outline, approximately as wide as high (height/width = 1.13); auricles relatively large,

equal; average umbonal angle 107°; average maximum internal rib height 66 percent of left valve height; secondary internal ribs present in some left valves.

Exterior of right valves covered with several fine submarginal lirae of moderate relief; ventral margins fragile beyond distal ends of internal ribs, ventral margins not preserved on specimens; posterior auricles with fine growth lines and acute to obtuse auricle angles; anterior auricles with fine growth lines, 0–2 radial costellae, slight byssal notches, acute to 90° auricle angles; dorsal lateral margin of auricles projecting above umbo; interior of right valve with 9–11 ribs, all primary; internal ribs straight; lateral internal ribs swollen slightly at termination.

Exterior of left valves covered with several fine radial costae; radial costae variable in height, typically with one or two weaker costae between two stronger costae; radial costae sharp in cross section; growth lines faint to raised, fine submarginal lirae; grid pattern formed with radial costae and submarginal lirae; posterior auricles with faint growth lines, slightly acute auricle angles; anterior auricles with faint growth lines, 90° to slightly obtuse auricle angles; interior of left valves with 9–12 ribs (8–12 primary and 0–2 secondary); internal ribs straight, with no terminal swelling.

Measurements.—See Table 2.

Discussion.—*Propeamussium cowperi* (Waring, 1917) differs from *P. (P.) robinsonense* in having 4–8 internal ribs on the left valve, only nine internal ribs on the right valve, the internal ribs extending a maximum 80 percent of the left valve height, radial costellae on the posterior auricle of the right valve, and the lack of terminal swelling on the internal ribs. *Propeamussium* (*Parvamussium*) *yubareense* (Yabe and Nagao, 1928) differs from *P. (P.) robinsonense* in having faint radial costae on the right valve, a pronounced byssal notch in some specimens (Tamura, 1976, Pl. 1, figs. 10, 11; probably a new species), fewer internal ribs (typically 8–9), unequal auricles, and different auricle angles (Yabe and Nagao, 1928; Tashiro, 1976). *Propeamussium* (*Parvamussium*?) *awajense* Ichikawa and Maeda (1958) differs from *P. (P.) robinsonense* in having coarse submarginal lirae and fine radial costae on the left valve (if Ichikawa and Maeda are correct in identifying the valves as left valves, no right valves are known) and a smaller umbonal angle (90°). *Propeamussium* (*Parvamussium*) *kimurai* (Hayami, 1965) differs from *P. (P.) robinsonense* in having unequal auricles, well-developed byssal notch, smaller umbonal angle (100°), fewer ribs (8–9), radial costellae on left valve auricles, and coarser radial costae on left valve. *Propeamussium* (*Parvamussium*?)

TABLE 2.—Measurements (in mm) and ratios of *Propeamussium (Parvamussium) robinsonense* n. sp. Spec = LACMIP specimen number, Val = valve, L = left valve, R = right valve, PR = primary internal rib count, SR = secondary internal rib count. See Figure 2 for other abbreviations.

Spec	Val	HI	H	W	A	A'	RH	PR	SR	H/W	RH/H	AD	AW	PD	PW	Locality
7209	L	4.1	10.6	10.4	100	3	7.7	9*	0*	1.02	73%	4.4	4.7	6.2	5.7	CSUF 68
7210	L	—	—	—	—	—	—	8	2	—	—	—	—	—	—	CSUF 68
7211	L	—	—	—	—	—	—	12*	0*	—	—	—	—	—	—	CSUF 68
7209	R	3.9	7.9	7.6	110	—	7.1	9	0*	1.04	90%	3.5	3.9	4.5	3.7	CSUF 68
7222	R	8.4	19.9	18.6	111	24	19.2	11*	0*	1.11	96%	12.2	9.8	7.1	10.1	UCLA 7074

* All internal ribs may not be visible.

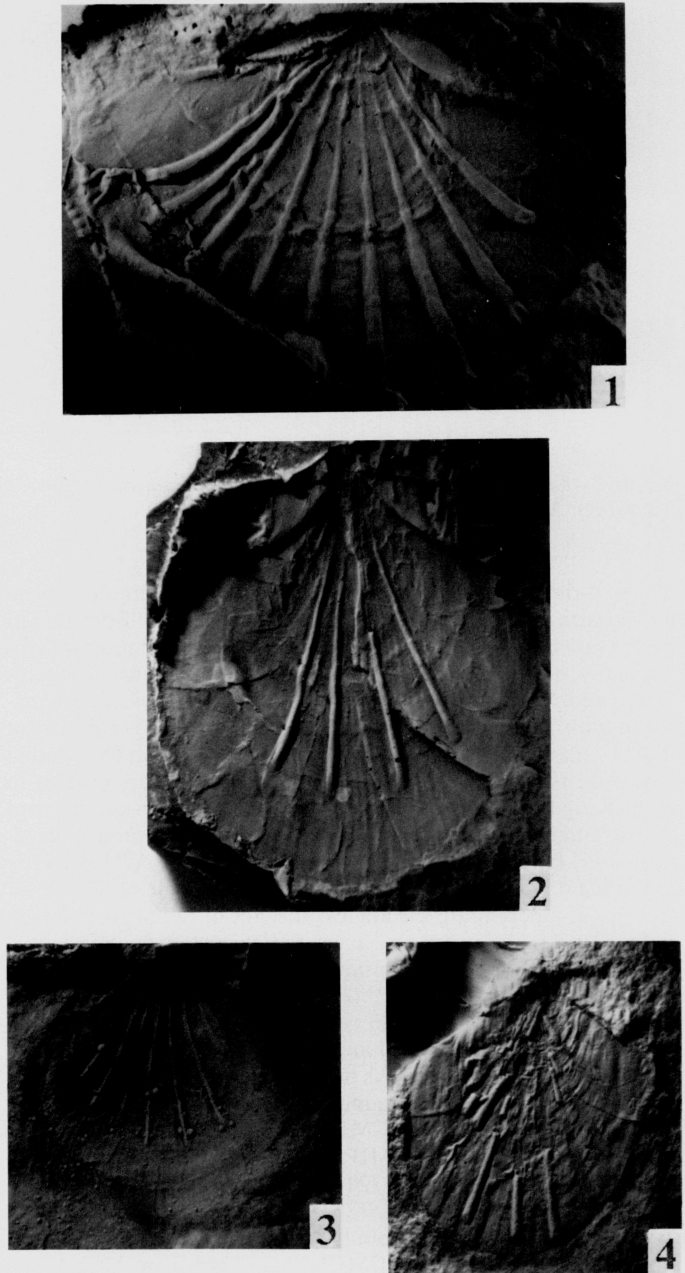


FIGURE 8—*Propeamussium (Parvamussium) cowperi* (Waring) from the Simi Hills. All specimens coated with magnesium ribbon smoke. 1, latex cast of paralectotype (CAS 61644.01), right valve interior, auricles broken and ventral margin missing, $\times 2.9$; 2, latex cast of lectotype (CAS 61644.02), left valve interior, $\times 2.9$; 3, latex cast of paralectotype (CAS 61644.04), left valve interior, auricles broken, $\times 3.3$; 4, latex cast of paralectotype (CAS 61644.03), right valve interior with anterior auricle broken, $\times 2.9$.

kattoi (Tashiro and Matsuda, 1986) differs from *P. (P.) robinsonense* in having coarser concentric costae on right valve, 8–9 internal ribs, straight hinge line, small umbonal angle (85°), and coarser radial costae on left valve.

Etymology.—The species is named after its type locality at Robinson Ranch.

Material.—Holotype, LACMIP 7222, right valve from UCLA loc. 7074; paratypes, LACMIP 7209–7211 from CSUF loc. 68.

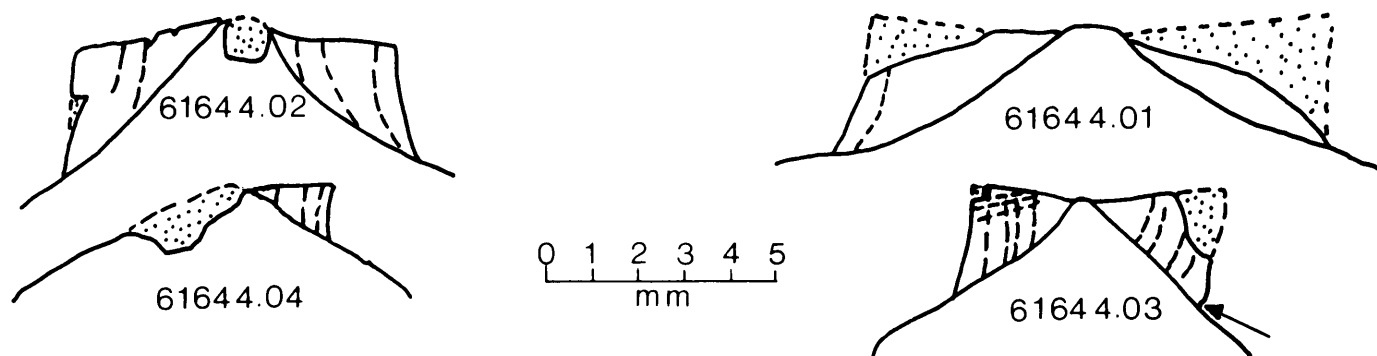


FIGURE 9—Auricles of right and left valves of *Propeamussium (Parvamussium) cowperi* (Waring). Numbers in umbo region are CAS type numbers. Arrow points to slight byssal notch.

Age.—Late medial Santonian, *Bostrychoceras elongatum* Biozone.

Occurrence.—Holz Shale Member of the Ladd Formation at the Robinson Ranch, Plano Trabuco (UCLA loc. 7074); Silverado Canyon (CSUF loc. 68), Santa Ana Mountains, Orange County, California.

PROPEAMUSSIUM (PARVAMUSSIUM) COWPERI Waring, 1917
Figures 8, 9

Pecten (Propeamussium) cowperi WARING, 1917, p. 63–64, Pl. 7, figs. 1, 2.

Diagnosis.—*Propeamussium (Parvamussium)* with subcircular valve outline; very slight byssal notch; 0–3 radial costellae on right posterior auricle; nine primary internal ribs on right valve and 4–8 primary internal ribs on left valve; no secondary internal ribs; dorsal lateral margin of right valve auricles projecting above umbo.

Description.—Valves subcircular in outline, approximately as wide as high (height/width = 1.06); auricles relatively large, equal; average umbonal angle 125°; average maximum internal rib height 80 percent of shell height; secondary internal ribs absent.

Exterior of right valves covered with several fine submarginal lirae of moderate relief that do not extend to lateral margins; ventral margin fragile beyond distal ends of internal ribs; posterior auricles with fine growth lines, 0–3 faint radial costellae, and 90° to obtuse auricle angles; anterior auricle with fine growth lines, very slight byssal notches, acute to 90° auricle angles; dorsal lateral margin of auricles projecting above umbo; interior of right valve with nine primary ribs; lateral internal ribs slightly curved or straight; internal ribs not swollen at termination.

Exterior of left valves covered with several fine radial costae; radial costae variable in height; growth lines not preserved; exterior surface of auricles not preserved; posterior auricle with 90° auricle angles; anterior auricle with slightly obtuse auricle angles; interior of left valve with 4–8 primary ribs; lateral internal ribs straight or slightly curved, internal ribs not swollen at termination.

Measurements.—See Table 3.

Discussion.—Waring (1917) named *Propeamussium (Parvamussium) cowperi* without establishing a type specimen. The original? label that indicated “type spec.” was housed with specimens CAS 61644.01 and CAS 61644.02, which are the two figured specimens of Waring (M. G. Kellogg, personal commun.). Stanford University cataloged these specimens as syntypes and an additional specimen (CAS 61644.03) as a topotype, which CAS later catalogued as a paratype. Specimens CAS

61644.04 and CAS 61644.05 (counterpart of CAS 61644.01) are plaster casts; the location of the original specimens is unknown. Although the author prefers to designate right valves as holotypes, the fragmentary nature of Waring’s figured right valve (CAS 61644.01; Pl. 7, fig. 2) makes a poor candidate for a lectotype. The left valve figured by Waring (1917, Pl. 7, fig. 1; CAS 61644.02) is more complete and is designated here as the lectotype. The specimens CAS 61644.01 and CAS 61644.03 are designated as paralectotypes.

Propeamussium (Parvamussium) cowperi is known from four specimens. Two of these specimens are probably deformed. Specimen CAS 61644.01 and counterpart CAS 61644.05 have expansion cracks and may be flattened, and specimen CAS 61644.03 has structural lineations and may be tectonically elongated. As a result, the measured variables for these specimens are probably unreliable (although ratios of distances taken in the same axis are probably reliable (i.e., RH/H)), and valve outline of the species cannot be determined. In addition, some morphological features are not preserved or poorly preserved on the specimens, thus preventing a complete description of the species.

Propeamussium (Parvamussium) robinsonense differs from *P. (P.) cowperi* in having 9–12 internal ribs on the left and right valves, an average maximum internal rib height 66 percent of the left valve height, radial costellae on the anterior auricle of the right valve, and terminal swellings on the internal ribs. *Propeamussium (Parvamussium) yubareense* (Yabe and Nagao, 1928) differs from *P. (P.) cowperi* in having faint radial costae on the right valve, a pronounced byssal notch in some specimens (Tamura, 1976, Pl. 1, figs. 10, 11; probably a new species), and unequal auricles (Yabe and Nagao, 1928; Tashiro, 1976). *Propeamussium (Parvamussium?) awajense* Ichikawa and Maeda (1958) differs from *P. (P.) cowperi* in having coarse submarginal lirae and fine radial costae on the left valve (if Ichikawa and Maeda are correct in identifying the valves as left valves, no right valves are known), straight hinge line, and a smaller umbonal angle (90°). *Propeamussium (Parvamussium) kimurai* (Hayami, 1965) differs from *P. (P.) cowperi* in having unequal auricles, smaller umbonal angle (100°), different auricle angles on right valve, radial costellae on left valve auricles, and coarser radial costae on left valve. *Propeamussium (Parvamussium?) kattoi* (Tashiro and Matsuda, 1986) differs from *P. (P.) cowperi* in having coarser concentric costae on right valve, straight hinge line, small umbonal angle (85°), and coarser radial costae on left valve.

Material.—Lectotype, herein designated, CAS 61644.02, left valve from CAS loc. 61644; paralectotypes, CAS 61644.01 (counter part = CAS 61644.05) and 61644.03 from CAS loc.

TABLE 3.—Measurements (in mm) and ratios of *Propeamussium (Parvamussium) covperi* Waring. Spec = CAS specimen number, Val = valve, L = left valve, R = right valve, PR = primary internal rib count, SR = secondary internal rib count. See Figure 2 for other abbreviations.

Spec	Val	HI	H	W	A	A'	RH	PR	SR	H/W	RH/H	AD	AW	PD	PW	Locality
61644.02	L	7.1	18.7	16.7	110	8	14.5	4	0	1.19	78%	7.8	6.7	10.0	10.4	CAS 61644
61644.04	L	—	9.1	9.8	131	25	7.3	8	0	0.93	80%	5.3	4.6	4.6	4.4	CAS 61644
61644.01	R	9.8	18.1	24.6	143	—	17.2	9	0	0.76	95%	5.8	12.4	7.5	11.9	CAS 61644
61644.03	R	5.4	12.8	11.0	115	10	12.2	9	0	1.16	95%	7.7	6.1	4.8	5.2	CAS 61644

61644; other specimens (plaster casts), CAS 61644.04 and 61644.05 from CAS loc. 61644.

Age.—Late medial Campanian.

Occurrence.—Lower Chatsworth Formation, Bell Canyon (CAS loc. 61644), Simi Hills, Ventura County, California.

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APPENDIX

LOCALITIES

- 68 CSUF, Silverado Canyon, El Toro 7.5' quadrangle (1949), Santa Ana Mountains, Orange County, California. Dark to medium-gray mudstone at southwestward bend in Silverado Creek south of the Holz Ranch (=loc. 8 of Sundberg, 1980), elevation 354 m, NE $\frac{1}{4}$, SE $\frac{1}{4}$, SE $\frac{1}{4}$, sec. 7, T5S, R7W SBBM. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.
- 61644 CAS, Bell Canyon, Calabasas 7.5' quadrangle (1957), Simi Hills, Ventura County, California. Medium-gray mudstone in lower portion of Bell Canyon, T2N, R17W SBBM. Exact location unknown. Chatsworth Formation. Late medial Campanian (Colburn et al., 1981; Saul and Anderson 1981).
- 8087 LACMIP, Silverado Canyon, El Toro 7.5' quadrangle (1949), Santa Ana Mountains, Orange County, California. From moderately well indurated, sandy mudstone float blocks from Silverado Creek near CSUF loc. 68 and downstream. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.
- *7057 UCLA, Plano Trabuco, Santiago Peak 7.5' quadrangle (1954), Santa Ana Mountains, Orange County, California. Medium to light-brown to grayish-brown mudstone with minor siltstone, sandstone, and limestone beds in the south side of "Y" in northeast trending canyon on east fork, south-southeast of UCLA loc. 7059, NW $\frac{1}{4}$, SW $\frac{1}{4}$, NW $\frac{1}{4}$, NE $\frac{1}{4}$, sec. 13, T6S, R7W SBBM. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.
- *7058 UCLA, Plano Trabuco, Santiago Peak 7.5' quadrangle (1954), Santa Ana Mountains, Orange County, California. Medium to light-brown to grayish-brown mudstone with minor sandstone and limestone lenses in the southeast side of northeast trending canyon south of canyon's "Y," W $\frac{1}{2}$, SW $\frac{1}{4}$, NW $\frac{1}{4}$, NE $\frac{1}{4}$, NE $\frac{1}{4}$, sec. 13, T6S, R7W SBBM. Area of UCLA loc. 7057 after construction grading. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.
- *7059 UCLA, Plano Trabuco, Santiago Peak 7.5' quadrangle (1954), Santa Ana Mountains, Orange County, California. Medium to light-brown to grayish-brown mudstone with minor beds of friable siltstone and sandstone, 1 to 2 m level in measured section, in "Y" of northeast trending canyon, SW $\frac{1}{4}$, NW $\frac{1}{4}$, NE $\frac{1}{4}$, sec. 13, T6S, R7W SBBM. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.
- *7061 UCLA, Plano Trabuco, Santiago Peak 7.5' quadrangle (1954), Santa Ana Mountains, Orange County, California. Light to medium-gray to brownish-gray mudstone with minor sandstone beds, 18 to 19 m level in measured section, west side of northeast trending canyon, NE $\frac{1}{4}$, SE $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, NE $\frac{1}{4}$, sec. 13, T6S, R7W SBBM. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.
- *7062 UCLA, Plano Trabuco, Santiago Peak 7.5' quadrangle (1954), Santa Ana Mountains, Orange County, California. Light to medium-gray to brownish-gray mudstone with minor sandstone beds, 21 to 22 m level in measured section, west side of northeast trending canyon, NE $\frac{1}{4}$, SE $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, NE $\frac{1}{4}$, sec. 13, T6S, R7W SBBM. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.
- *7074 UCLA, Plano Trabuco, Santiago Peak 7.5' quadrangle (1954), Santa Ana Mountains, Orange County, California. Locality includes material collected from the northeast trending canyon that has no specific locality or known stratigraphic position (area encompassing UCLA locs. 7057, 7058, 7059, 7061, and 7062), on dividing line between NW $\frac{1}{4}$ and NE $\frac{1}{4}$, N $\frac{1}{2}$, NE $\frac{1}{4}$, sec. 13, T6S, R7W SBBM. Holz Shale, Ladd Formation. Santonian, *Bostrychoceras elongatum* Biozone.

* Locality destroyed by construction activities.