

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.

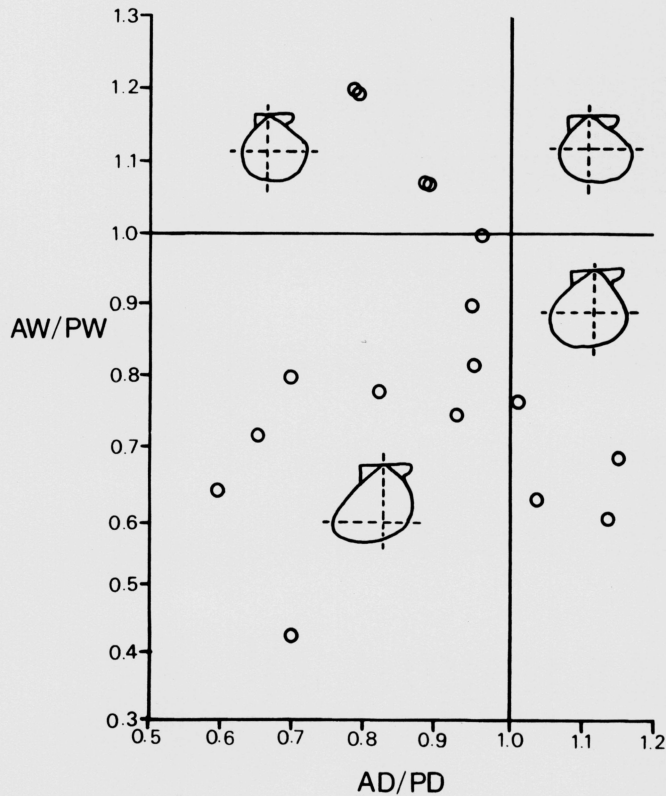


FIGURE 5—Graph of anterior (AW) and posterior (PW) width ratios vs. anterior (AD) and posterior (PD) distance ratios for *Propeamussium* (*Parvamussium*) *holzense* n. sp.

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

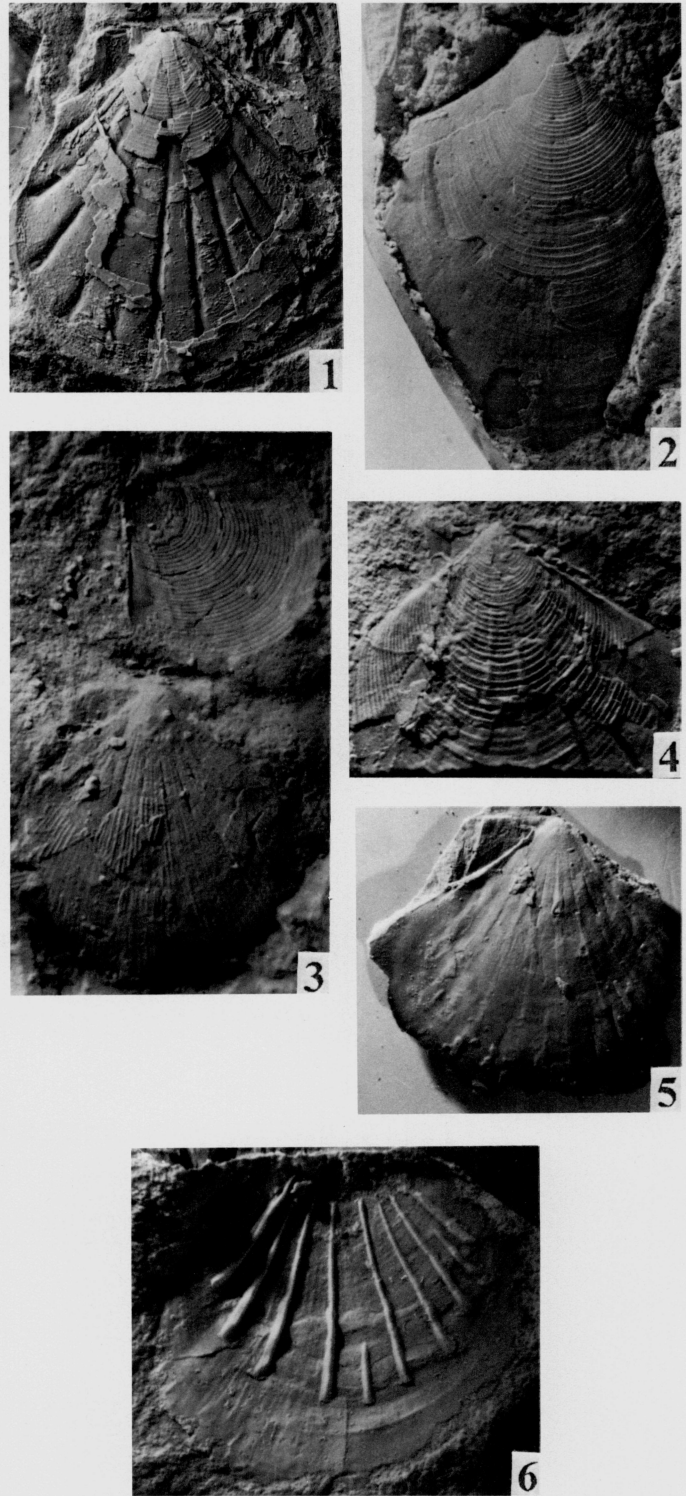


FIGURE 6—*Propeamussium* (*Parvamussium*) *robinsonense* n. sp. from the Santa Ana Mountains. All specimens coated with ammonium chloride sublimate or magnesium ribbon smoke. 1, 2, holotype (LACMIP 7222); 1, right valve exterior, posterior auricle broken, $\times 2.4$; 2, latex cast of right valve exterior 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, $\times 3.5$.

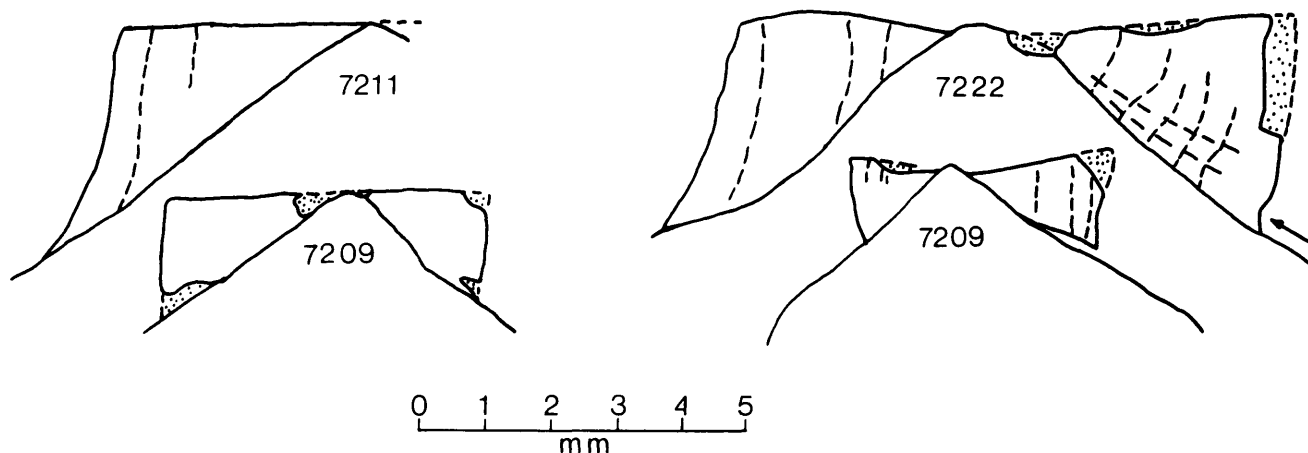


FIGURE 7—Auricles of right and left valves of *Propeamussium* (*Parvamussium*) *robinsonense* n. sp. Numbers in umbo region are LACMIP type numbers. Arrow points to slight byssal notch.

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*?)