TABLE 5—Measurements in mm of *Cymbophora gabbiana* (Anderson)

Cat. no.	H	L	T	H/L	T/L	S	S/L	RH	RW	RW/RH	Remarks
5267	32	43	11	.74	.26			3.5	2	.57	length incomplete
6852	20	25	6	.8	.24	10	.4				
6853	21	27	8	.78	.3	11	.41	2	1.2	.6	
48490	35	42	10	.83	.24			4	2	.5	

H=height of valve; L=length of valve; T=thickness of valve; S=length of pallial sinus; RH=height of resilifer; RW=width of resilifer.

across approximately ¾ths of posterior portion of shell.

Holotype.—CAS cat. no. 1 (plaster cast UCLA cat. no. 5267).

Hypotypes.—UCLA cat. no. 6852, CIT loc. 1440, Redding area; UCLA cat. no. 6853, CIT loc. 1268, Redding area; UCLA cat. no. 48490, UCLA loc. 4249, Young Ranch, SE of Henley.

Type locality.—"Lower Chico beds near Henley, and on Willow Creek, Siskiyou County, California."

Age.—Middle to late Turonian.

Remarks.—The age of *C. gabbiana* can now be established with reasonable surety, but a definite type locality can not. Anderson (1902, p. 75) originally stated that *C. gabbiana* occurred at "Henley and Willow Creek, in Siskiyou County, and in the Santa Ana and Temescal Mountains of Los Angeles and Riverside counties," but did not indicate which of the four localities was the type locality. Packard (1916, p. 299) stated that the type locality was Henley Creek. Anderson, in 1958 (p. 144) indicated Henley and Willow Creek and revised Packard's "Henley Creek" to Rancheria Creek (U.S.G.S. Hornbrook Quadrangle, 1955 edition, shows Rancheria Gulch near Henley). The holotype of *C. gabbiana* was recovered by Anderson from the ashes of the California Academy of Sciences following the San Francisco earthquake and fire of 1906. No original labels remain, and Henley and Willow Creek which are roughly 20 miles apart can hardly both be the type locality. UCLA loc. 4249 lies roughly 7 miles south and 3 miles east of Henley. The specimens of *C. gabbiana* at this locality are of similar size and preservation to the holotype and the matrix is also similar (due allowance being made for the holotype having gone through a fire). The Hornbrook Formation conglomerate containing these *C. gabbiana* also contains *Gymnarus manubriatus* (Gabb) and underlies sandstone containing *Meekia radiata* Gabb. *Gymnarus manubriatus* (Gabb) (Popenoe et al., 1960, chart 10e as *"Pugnellus" manubriatus*) and *Meekia radiata* Gabb are known elsewhere from beds of Turonian age. Jones (1959, p. 1726) has stated that the "lower member" of the "lower unit" of the Hornbrook Formation contains an Upper Turonian fauna. Specimens of probable *C. gabbiana*, smaller than those from the Henley-Hornbrook vicinity, Siskiyou Co., California are present in Members I and III (middle to late Turonian) of the Redding area, Shasta Co., California.

Anderson's records of *C. gabbiana* from the "Santa Ana and Temescal Mountains of Los Angeles and Riverside counties" probably refer to the Late Campanian *C. popenoei.* The western slope of the Santa Ana Mountains is now in Orange Co., Orange County having been carved out of Los Angeles County in 1889. Although the Baker Canyon Member and lower Holz Member of this area contain a Turonian fauna (Popenoe, 1954, p. 17), *C. gabbiana* has not been found. "Temescal Mountains" occurs on U. S. Geological Survey and University of California, Berkeley museum labels of material collected in the early 1900's from the east slope of the Santa Ana Mountains, Riverside County. The Temescal Range, however, was defined by the Whitney Survey (see Engel, 1959) as the hills lying on the northeast side of the Elsinore Valley, and Cretaceous marine sediments are not known from the area that could properly be called Temescal Mountains. Turonian age fossils have been collected from the Baker Canyon Member cropping out on the east slope of the north end of the Santa Ana Mountains, but I have not seen *C. gabbiana* among these fossils.

Packard's (1916, p. 299) discussion of the hinge of *C. gabbiana* from Chico Creek was based on specimens of *C. bella* of Early Campanian age.

Waring's (1917, p. 63) *Mactra gabbiana* from the Santa Monica Mts. and Popenoe's (1937, p. 398; 1942, fig. 4; 1954, p. 18) *C. gabbiana* from the Santa Ana Mountains are *C. popenoei.*

Differences between *C. gabbiana, C. popenoei,* and *C. bella* are discussed under *C.*

TABLE 6—Measurements in mm of *Cymbophora popenoei* n. sp.

Cat. no.	H	L	T	H/L	T/L	S	S/L	RH	RW	RW/RH	Remarks
375	20	27	6	.74	.22						deformed
28712	27	32	8	.84	.25						
40665	30	35	9	.86	.26			3.3	2	.61	
48492	22	28	7	.79	.25			2	1.4	.7	
48493	29	36	9	.81	.25	19	.53				
48495	24	30	7	.8	.23			2	1.4	.7	
48496	22	28	6	.78	.21	12	.43				
48497	44	56	12	.79	.21						large specimen

H=height of valve; L=length of valve; T=thickness of valve; S=length of pallial sinus; RH=height of resilifer; RW=width of resilifer.

popenoei and *C. bella*. *C. gabbiana* resembles *C. popenoei* in its tripartite sculpture, clearly marked selenis and heavy shell. A mactrid of similar sculpture pattern, *Mactra* (*Schizodesma*) *tripartita* Forbes is reported from the Turonian Trichinopoly group of India (Stoliczka, 1870, p. 57, Pl. 5, fig. 8–11). The indistinctly drawn hinges (Pl. 5, fig. 10–11) of *M.* (*S.*) *tripartita* can be interpreted as resembling those of *C. gabbiana*. Until specimens or clearer illustrations are available, however, these resemblances must remain speculative and not, at present, indicative of a close relationship.

C. gabbiana is most commonly found in coarse-grained sandstone associated with conglomerate or pebble beds.

CYMBOPHORA POPENOEI n. sp.

Pl. 1, fig. 13; Pl. 2, fig. 9; Pl. 3, figs. 13–15; Table 6

Cymbophora Ashburnerii (Gabb) WHITEAVES, 1879, p. 141 (at least in part), Pl. 17, fig. 8.
Cymbophora Ashburneri (Gabb) large ribbed variety, WHITEAVES, 1903, p. 373 (at least in part).
Mactra gabbiana Anderson, WARING, 1917, p. 63, Pl. 8, fig. 11.
Cymbophora gabbiana (Anderson) POPENOE, 1937, p. 398, Pl. 49, fig. 2; Popenoe, 1954, p. 18, fig. 3 (4).

Description.—Shell of average size for the genus, thick, of average inflation, an isoceles triangle in outline with the ventral side longest. Beaks moderately prominent; anterior margin nearly straight then curving abruptly at the anterior angulation to the ventral margin; ventral margin smoothly curved, angled at the posterior angulation; posterior margin barely curved, meeting the short, sloping posterodorsal margin at a slight angle; posterior angulation well-marked by sharp ridge near the beak becoming more broadly rounded and welt-like near the ventral margin. Surface of flank ornamented by well-developed, flattish-topped concentric ribs which are wider than their interspaces; selenis ornamented with regular concentric ribs fanning from beneath the beak, ribs continuing across slightly impressed line bounding the selenis, increased somewhat irregularly at the line by bifurcation or intercalation usually two ribs on the flank for each one on the selenis; marginward area of corcelet ornamented with coarser regular concentric ribs fanning from the beak to the posterior side of the broad welt-like, roughened posterior angulation.

Resilifer with a slightly raised ventral margin, not extending to the edge of the hinge plate. Hinge of right valve with 3a close to and nearly parallel to valve margin, 3b as long as the width of the hinge plate and equal in length to 3a, laterals sturdy, AI and PI ornamented by granulations which tend to coalesce into squiggly lineations, AI long, with strong beakward slanting groove on dorsal side, AIII half as long as AI and paralleling the anterior end of AI. Hinge of left valve with inverted V of 2b nearly filled, 4b thin, AII short and stout with steep nubbined posterior end, PII twice as long as AII. Pallial sinus ascending, extending across approximately three-fourths of posterior portion of shell.

Holotype.—UCLA cat. no. 40665 = CIT cat. no. 3451.

Paratypes.—UCLA cat. nos. 28712, 48492–48494, CIT loc. 974, Santa Ana Mts.; UCLA cat. nos. 48495–48496, CIT loc. 976, Santa Ana Mts.; UCLA cat. no. 48497, CIT loc. 86, Santa Ana Mts.; LSJU cat. no. 375, Waring's loc. 3, Santa Monica Mts.

Type locality.—CIT loc. 974, SW slope of ridge between Aliso and Santiago Creeks, El Toro quad., Santa Ana Mts., Orange Co., Calif.

Age.—Late Campanian, *Hoplitoplacenticeras vancouverense* and *Metaplacenticeras pacificum* zones.

Remarks.—*C. popenoei* differs from *C. gabbiana* in having a more shouldered dorsal outline, coarser ribs on the flank especially toward the ventral margin where commonly ribs will appear to have coalesced and formed broad ribs two to four times the width of the normal ones, and less regular increase in number of concentric ribs at the border of the selenis. The hinge of *C. popenoei* has the laterals slightly curved rather than straight and the cardinals shifted to a more anterior position.

C. popenoei differs from *C. bella* in having the interspaces no wider than the concentric ribs on the more juvenile portions of the shell and becoming narrower than the ribs on the more mature portions of the shell, in the irregular increase in the width of the concentric ribs especially toward the ventral margin, in having the selenis bounded by an impressed line, and a more ascending, shorter pallial sinus than does *C. bella*. *C. popenoei* also has slightly colaminar AI and AII; *C. bella* does not.

C. popenoei is common to abundant in the *Metaplacenticeras pacificum* zone in the Santa Ana Mts., Santa Monica Mts., and the Simi Hills of southern California. It has also been found, but less ubiquitously, in the older *Turritella chicoensis perrini* division of Popenoe (1942, fig. 4) in the Santa Ana Mountains. Whiteaves (1879, p. 141; 1903, p. 373) listed ribbed *Cymbophora* from seven localities in the vicinity of Vancouver Island, British Columbia. Correlation charts of Usher (1952) and Muller and Jeletzky (1970) suggest Whiteaves' specimens may have come from beds of early Campanian through early Maestrichtian age. It is very possible that he was confounding more than one species. His figured specimen (1879, Pl. 17, fig. 8) is lost, but according to the catalogue of the Geological Survey of Canada, it was from Sucia Island (T. E. Bolten, 1972, letter). Specimens from Sucia Island in the UCLA collections resemble *C. popenoei* in their sculpture. Whiteaves (1879, p. 142) compared his specimens to *Mactra tripartita* Sowerby MSS of Forbes but did not recognize tripartite sculpture on his specimens. The tripartite aspect of the sculpture on the UCLA specimens from Sucia Island is not readily recognized because the specimens are usually somewhat crushed or partially exfoliated. The ribbed *Cymbophora* from Sucia Island is included in *C. popenoei* even though some of the northern specimens are more inflated than typical southern specimens. Jeletzky's (*in* Muller and Jeletzky, 1970, p. 54) interpretation of the Cedar District Formation on Sucia Island as older than the *Metaplacenticeras pacificum* zone and younger than the *Submortoniceras chicoense* zone implies a correlation between those beds and the *Turritella chicoensis perrini* assemblage which is also sandwiched between the same two ammonite zones (Popenoe, Imlay and Murphy, 1960, p. 1514).

The less common occurrence of *C. popenoei* in the Holz Shale, in contrast to its abundance in the Pleasants Sandstone, is probably related to grain size of the sediments as it, like *C. gabbiana*, seems to have preferred a coarse sand rather than fine sand bottom.

The species is named in honor of W. P. Popenoe for his many contributions to this study.

CYMBOPHORA BUTTENSIS Anderson

Pl. 1, figs. 8–9; Pl. 2, figs. 5–6; Pl. 3, figs. 7–8; Table 7

Crassatellites triangulatus Waring, REAGAN, 1924, p. 185, Pl. 20, fig. 2. Not *C. triangulatus* Waring.
Cymbophora buttensis Anderson, 1958, p. 145, Pl. 61, fig. 3, 5a (5a is erroneously identified as *Cucullaea* (*Idonearca*) *buttensis* Anderson).

Description.—Shell large, moderately thick, trigonal with obvious posterior gape. Beaks prominent; anterior margin slightly curved, well-rounded at the anterior angulation; ventral margin smoothly curved; posterior margin doubly angled by the double fold of the posterior angulation; posterior angulation moderately high, with two folds and a slight sulcus between. Surface of flank not ribbed but somewhat roughened by growth lines and growth checks; anterior slope ornamented with slightly irregular, moderate, concentric ribs fanning from beneath the beak, dying out across the anterior angulation; selenis obscurely defined by shallow groove, slight bend in growth lines and increase in number of ribs which rapidly die out flankward; marginward area of corcelet with similar ribs very near the beak only, dying out before reaching the posterior fold of the posterior angulation.

Resilifer with a barely raised ventral margin, extending nearly to the margin of the hinge plate, occupying the widest part of the hinge plate. Hinge of right valve with 3a short, at an angle to the valve margin, 3b nearly twice as long as 3a, extending to the hinge plate margin, shorter than the resilifer; laterals moderately sturdy, AI and PI ornamented with very fine granulations on the

TABLE 7—Measurements in mm of *Cymbophora buttensis* Anderson

Cat. no.	H	L	T	H/L	T/L	S	S/L	RH	RW	RW/RH	Remarks
823	80	91	21	.88	.23						battered
187735	68	78	18	.87	.22			8	4.5	.56	
187736	50	58	14	.86	.24	26	.45				
48541	51	65	15	.78	.23			5.4	3.7	.68	
48543	42	52	13	.81	.25	24	.46				length incomplete

H=height of valve; L=length of valve; T=thickness of valve; S=length of pallial sinus; RH=height of resilifer; RW=width of resilifer.

upper edge only of their dorsal surfaces, AI longer than AIII with broad shallow slanted groove on dorsal side and slight colaminar profile giving AI two nearly equal low humps. Hinge of left valve with narrow inverted V of 2b filled, 4b very thin, shorter than the resilifer, AII with two very shallow slanted grooves on ventral side and hint of colaminar profile. Pallial sinus ascending, extending across approximately ¾ths of posterior portion of shell.

Holotype.—CAS cat. no. 10643.

Paratype.—CAS cat. no. 10644.

Hypotypes.—UCLA cat. no. 48541, UCLA loc. 4340, near Pentz; UCLA cat. no. 48543, CIT loc. 1328, Butte Creek; USNM cat. nos. 187735–187736 (plaster casts UCLA cat. nos. 48539–48540) USGS loc. 1240, near Pentz; LSJU cat. no. 823, "Pence's Ranch."

Type locality.—CAS loc. 1125, 1 mi. W. of Pentz, on the S. side of the road, in the ravines leading to the SW, Butte Co., Calif.

Age.—Early Campanian, *Submortoniceras chicoense* zone.

Remarks.—*C. buttensis* is the largest *Cymbophora* known. Individual differences in the prominence of the beaks and their relatively more anterior or median position result in a variable outline for the species. Specimens with the shell broken from the beak area are of such different configuration as to suggest that such rock casts are not of *C. buttensis*; however, the joint occurrence of two similarly sized species, one of which has always lost its shell, seems unlikely.

The large battered specimen identified by Reagan (1924, p. 185, Pl. 20, fig. 2) as *Crassatellites triangulatus* Waring has pallial sinus and muscle scar impressions corresponding to those of *C. buttensis*; and it is from "Pence's Ranch, Butte Co., California," the type locality of *C. buttensis.*

In outline, *C. buttensis* somewhat resembles *C. stantoni* and *C. ashburnerii.* It differs from *C. stantoni* in its finer lower ribs on the posterior slope and selenis and in having 3a at a greater angle to the valve margin. It differs from *C. ashburnerii* in having a double fold with sulcus between on the corcelet and in lacking the broad welt on the posterior angulation.

C. buttensis is most abundant in the coarse-grained to conglomeratic sandstone in the vicinity of Pentz. It is rare and of smaller size in finer-grained sediments. Large mactrids that appear to be this species also occur in conglomeratic sandstone at CAS loc. 2365 near Big Tar Canyon, Garza Peak quad., Kings Co., Calif. The stratigraphic and geographic position of this locality is commented upon under *Cymbophora suciensis* (Whiteaves).

CYMBOPHORA BELLA n. sp.

Pl. 1, figs. 10–11; Pl. 2, fig. 11; Pl. 3, figs. 9–10; Table 8

Cymbophora Ashburnerii (Gabb) GABB, 1869, Pl. 29, fig. 69, 69a.

Spisula (Cymbophora) ashburnerii (Gabb) PACKARD, 1916, Pl. 26, fig. 4–5 (repeat of Gabb, fig. 69, 69a).

Spisula (Cymbophora) gabbiana (Anderson) PACKARD, 1916, p. 299 (in part: specimen from Chico Creek). Not Pl. 27, fig. 2.

Description.—Shell of average size for the genus, resembling an isosceles triangle in outline with the strongly curved ventral margin the longest side. Beaks prominent; anterior margin nearly straight, sloping abruptly, curved at the broad anterior angulation; ventral margin more strongly convexly curved on the anterior side, often with a small concave bend just before the strong, sharp, high posterior angulation; posterior margin curved into the curved posterodorsal margin. Flank ornamented with well-developed, round-topped concentric ribs which increase regularly in size from the beak toward the ventral margin and which are a little narrower than the interspaces; anterior slope ornamented by similar concentric ribs fanning from beneath the beak, the ribs continuing uninterrupted across the anterior angulation, number of ribs irregularly increased

TABLE 8—Measurements in mm of *Cymbophora bella* n. sp.

Cat. no.	H	L	T	H/L	T/L	S	S/L	RH	RW	RW/RH	Remarks
48533	36	45	12	.8	.27			3.6	2.5	.7	
48535								3.6	2.3	.64	
48536	39		11			21					
48538	32	39	10	.82	.26	16	.41				

H=height of valve; L=length of valve; T=thickness of valve; S=length of pallial sinus; RH=height of resilifer; RW=width of resilifer.

at the angulation by intercalation or rarely bifurcation; selenis not defined; posterior slope with broad, usually slightly concave unribbed but roughened area next to the sharp angulation, marginward area of corcelet ornamented with coarse concentric ribs fanning from the beak.

Resilifer with a slightly raised ventral margin, not extending to the edge of the hinge plate. Hinge of right valve with 3a close to and paralleling the valve margin, 3b slightly longer than 3a, as long as the width of the hinge plate and longer than the resilifer; laterals sturdy, AI and PI ornamented by granulations which tend to coalesce into squiggly lineations, short, AI and AII nearly equal, PI and PII slightly more elongate. Hinge of left valve with wide inverted V of 2b partially filled, 4b very thin, anterior and posterior laterals of nearly equal length. Pallial sinus nearly horizontal, extending across the posterior portion of the shell.

Holotype.—UCLA cat. no. 48533.

Paratypes.—UCBMP cat. nos. 14925–14926, probably near Pentz; UCLA cat. nos. 48534, 48536, UCLA loc. 4081, near Pentz; UCLA cat. nos. 48535, 48537–8, UCLA loc. 4340, near Pentz.

Type locality.—UCLA loc. 4081, 1½ mi. S. of Pentz, in gully tributary to Dry Creek, near middle sec. 36, T. 21 N., R. 3 E. Cherokee Quad., Butte Co., California.

Age.—Early Campanian, *Submortoniceras chicoense* zone.

Etymology.—Latin; pretty, lovely, fine.

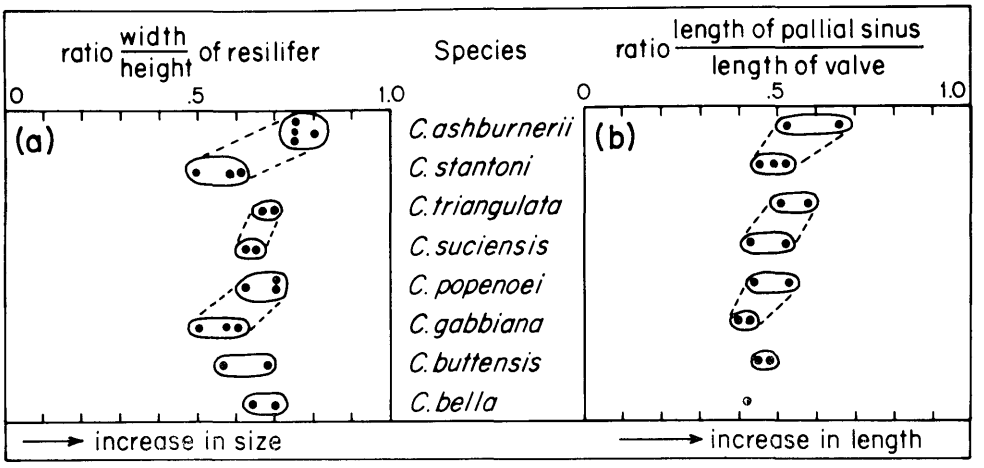
Remarks.—This species has been commonly confused with *C. gabbiana* from which it differs in having coarser, higher concentric ribs with wider interspaces, no line bounding the selenis, and usually a high, sharp posterior angulation bordered by a slight concavity of the posterior slope. The anterior laterals show no differentiation and the granulations are coarser than those on the slightly colaminar laterals of *C. gabbiana.*

No species considered in this paper has a hinge which is identical to Gabb's illustration for the genus *Cymbophora. C. bella* is closest, although there are several discrepancies. The right hinge (Gabb, 1869, fig. 69) differs mainly in the greater angle of the resilifer to the dorsal valve margin and the omission of laterals AIII and PIII. Gabb did not realize that the structures bordering the anterior side of the resilifer were cardinal teeth and 3b (fig. 69) and 4b (fig. 69a) are drawn as though they were part of the resilifer. Gabb's 2b (fig. 69a) is a narrow, unfilled inverted V which is set back from the hinge plate margin. However, if Gabb had exposed only the upper part of the tooth, he would have seen only the slender upper edges and the narrowest part of the inverted V, and the tooth would not extend to the edge of the hinge plate. Another reason for believing Gabb figured the hinge of *C. bella* is its abundance at Pentz in a friable sandstone matrix, one which he would have found easier to remove from the delicate hinge structures than the harder, better cemented matrices of other localities. Also, although Gabb commonly gives size marks when he has enlarged or reduced a drawing, he gives no such marks for his hinges of *C. ashburnerii.* Specimens of *C. bella* similar in size to figures 69 and 69a are common in the vicinity of Pentz.

C. bella occurs in both coarse- and fine-grained sandstone, but it is more abundant at localities where the matrix is coarse- to medium-grained.

RELATIONSHIPS BETWEEN EIGHT SPECIES OF *CYMBOPHORA*

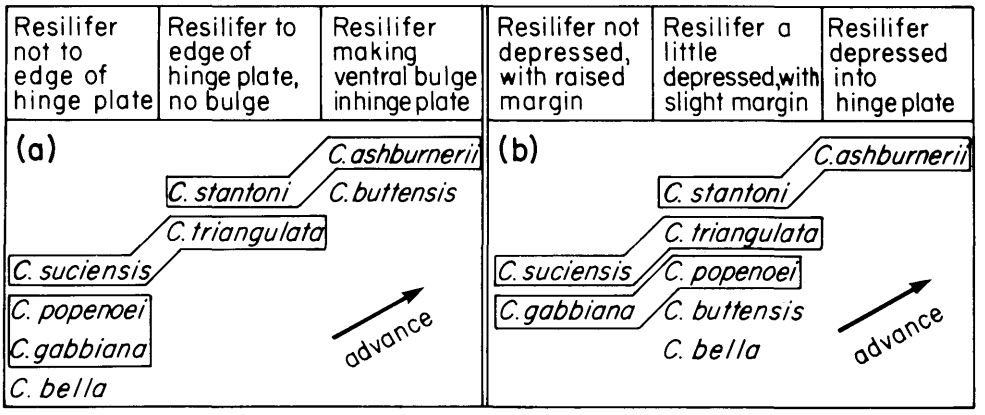
Five relatively stable morphologic characteristics were chosen for Text-figure 4. The five characteristics are 1) the relative thinness of the lateral teeth; 2) the coarseness of the granulations on the dorsal surface of the lateral teeth; 3) presence of well-developed concentric ribbing on the flank of the valve; 4) presence of a clearly marked selenis; and 5) inclination of the pallial sinus. Tabulation of the occurrence of these characteristics in



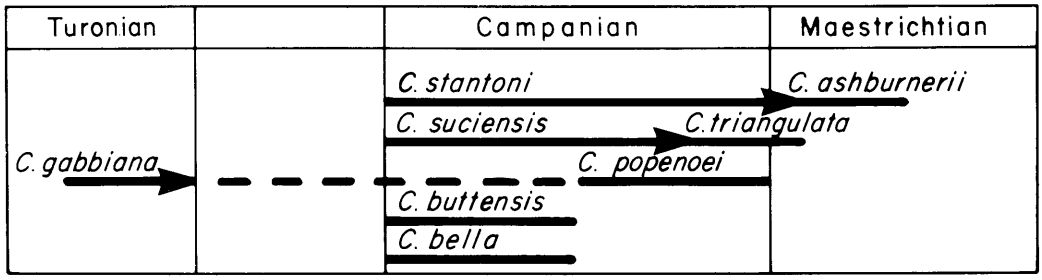
TEXT-FIG. 5—Plots of ratios of width/height of resilifer and ratios of length of pallial sinus/length of valve. A dot represents a measured specimen. Lineage-pairs are connected by dashed lines. The geologically younger member (Text-fig. 7) of each lineage-pair is more advanced than the older.

eight species of *Cymbophora* paired six of the eight species: *C. stantoni* and *C. ashburnerii* (= *Cymbophora* s.s.), *C. triangulata* and *C. suciensis*, and *C. gabbiana* and *C. popenoei*.

All *Cymbophora* typically are found in sandy sediment, and each species is found in sediments having considerable range in grain size, but each species is also more abundant in a limited range of grain size. Both members of each of the above pairs are characteristically found in sediments having similar grain size. *C. suciensis-C. triangulata* are typically found in fine-grained sandstone, *C. stantoni-C. ashburnerii* are more common in medium-grained sandstone. *C. gabiana-C. popenoei, C. buttensis,* and *C. bella* are more often associated with pebble beds and conglomerates. Only the pair, *C. suciensis-C. triangulata* is not commonly found associated with abundant *Meekia* spp. These groupings suggest lineages especially since the two species of each pair are not contemporaneous (Text-fig. 7). Four species are found in the early Campanian *Submortoniceras chicoense* zone near Pentz, but *C. buttensis* and *C. bella* are most abundant in the coarse grained pebbly sandstone east of Pentz; *C. stantoni* is abundant in medium-grained sandstone west of Pentz from which specimens of *C. bella* and *C. suciensis* can also be obtained; thirteen miles to the north along Chico Creek, *C. suciensis* is very abundant in fine-grained sandstone of this zone.



TEXT-FIG. 6—Tabulation of depth and length of the resilifer. Deepening and lengthening develops discrepantly between lineage-pairs and between unpaired species See Text-figure 7 for geologic age of species.



TEXT-FIG. 7—Geologic age of eight species of *Cymbophora*. Lineage-pairs are connected by arrows. Known range of each species is indicated by a bar beneath the name.

The lineage-pairs derived from the data in Text-figure 4 show a lengthening of the pallial sinus from earlier to later geologic age (Text-fig. 5b), the difference is slight between *C. gabbiana* and *C. popenoei*, a little greater between the others. Holocene species are usually as consistent in length of pallial sinus as in any other structure, but for these Cretaceous species many inaccuracies of measurement may be caused by vagaries of preservation. Accuracy of the measurement being uncertain makes the apparent trend of lengthened pallial sinus suspect, and changes in hinge structures are considered to be more definitive.

Hinge features of Cretaceous mactrids become "advanced" with increased similarity of Holocene mactrids. Size and position of the resilifer are plotted in Text-figures 5a and 6. The earliest species, *C. gabbiana* (Text-fig. 7), is the least advanced and the latest, *C. ashburnerii*, is the most advanced. But for the other species, a pattern of change toward more advanced characteristics can only be seen if the comparisons are made within the lineage-pairs. Each lineage-pair then shows from earlier to later geologic age a comparative enlargement of the resilifer which becomes deeper-set into the hinge plate. As previously suggested (Saul, 1973, p. 36), such resilifer enlargement is probably related to increase in efficiency of the ligament.

Although not all Holocene mactrids have colaminar laterals, colaminar laterals are considered to be advanced because the most extreme cases in the Mactridae of the division of laterals AI and AII into laterals and cardinals are found in Holocene species (e.g. *Simomactra dolabriformis* (Conrad)). Development of colaminar teeth AI and AII is shown by these Cretaceous species of *Cymbophora* in three ways: 1) bimodally curved profile especially in tooth AI, 2) thickening of the posterior end of the tooth to form a nubbin, and 3) broad grooves or cusps along the dorsal side of AI and the ventral side of AII. Only *C. bella* is without such embellishments having laterals which are short, thick, thinned at both ends, and evenly rounded in profile. The other seven species have broad grooves or cusps on the dorsal side of AI and the ventral side of AII. In the lineage-pair *C. suciensis-C. triangulata* the cusps are nearly vertical, but in the other five species the grooves or cusps slant from the tooth edge toward the beaks. Two lineage-pairs *C. gabbiana-C. popenoei* and *C. suciensis-C. triangulata* have nubbins on the posterior ends of the laterals. A bimodal profile is most clearly shown on lateral AI in the species *C. ashburnerii* and *C. buttensis*. For the lineage-pairs, the colaminar aspect of the tooth is increased – deeper cusps, stronger nubbins, etc. – on the geologically younger species of the pair.

The geologic ages of these eight species are given in Text-figure 7 so that the development at a similar time of these evolving structures may more easily be compared. It can be seen from Text-figures 5 and 6 that at the same geologic time, these species and lineage-pairs do not all advance nor develop the same features equally.

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CITED FOSSIL LOCALITIES

Text-fig. 1

Descriptions for nearly half of the cited numbered localities have been previously published. These are listed briefly with a reference.

3 [Arnold's loc. 3] Los Gatos Creek, Joaquin Rocks quad., Fresno Co., Calif. Panoche Fm., "Joaquin Ridge" sandstone member [late Campanian] (Arnold, 1909, p. 11).

3 [Waring's loc. 3] (Waring, 1917, p. 58 and text fig. 3) probably near UCLA loc. 4439.

86 CIT Santiago-Aliso Creek divide ½ mile E. of county road. Corona quad., Santa Ana Mts., Orange Co., Calif. Coll: B. N. Moore, 1927. Williams Fm., Pleasants sandstone member [late Campanian].

974 CIT Santa Ana Mts., El Toro quad., Orange Co., Calif. Williams Fm., Pleasants sandstone member [late Campanian] (Matsumoto, 1960, p. 99).

976 CIT [=UCLA 4207] Santa Ana Mts., El Toro quad., Orange Co., Calif. Williams Fm., Pleasants sandstone member [late Campanian] (Matsumoto, 1960, p. 99).

1012 CIT Pentz vicinity, both sides of Durham-Pentz Rd., approx. 850′S, 350′E of NW cor. sec. 25, T.21N., R.3E., Cherokee quad., Butte Co., Calif. Coll: Popenoe and Scharf, Aug. 15, 1931. Chico Fm. [early Campanian, *Submortoniceras chicoense* zone].

1168 CIT Baker Canyon, Corona quad., Santa Ana Mts., Calif. calcareous beds just below sandstone-conglomerate beds forming crest of ridge, west wall Baker Canyon, N.85°W. of Peterson ranch house, 6740′N.60°E. of mouth of Baker Canyon, Orange Co. Coll: W. P. Popenoe, May 16, 1935. Ladd Fm., Holz Shale Member [Campanian, *Turritella chicoensis* assemblage].

1183 CIT [=UCLA 3648] Chico Creek, Paradise quad., Butte Co., Calif. Chico Fm. [early Campanian] (Matsumoto, 1960, p. 15, 103).

1240 USGS 1½ miles south of Pence's [Pentz] Ranch, Butte Co., Calif. Coll: Stanton, Storrs, and Oliver, 1894. Chico Fm. [early Campanian, *Submortoniceras chicoense* zone].

1268 CIT see UCLA 3293.

1328 CIT Butte Creek, Paradise quad., Butte Co., Calif. Chico Fm. [early Campanian] (Saul, 1973, p. 39).

1396 CIT bluffs along south side of Fossil Bay, south side and east end of Sucia Island, Orcas Island quad., San Juan Co., Washington. Coll: R. Durbin, H. L. Popenoe, and W. P. Popenoe, July 23, 1935. Cedar District Fm. [middle or early late Campanian].

1400 CIT Sucia Island, Orcas Island quad., San Juan Co., Wash. Cedar District Fm. [middle or early late Campanian, *Hoplitoplacenticeras vanconverense* zone] (Matsumoto, 1960, p. 107).

1440 CIT Redding area, 1.5 miles by road from Salt Creek bridge, 200′N, 2000′W of SE cor. sec. 26, T.33N., R.3W., Millville quad., Shasta Co., Calif. Coll: W. P. Popenoe, March 19, 1940. Member I [Turonian].

2609 UCB probably loc. 1. of Merrian, 1897, p. 768. Hills SW of Martinez, Contra Costa Co., Calif. [Maestrichtian].

3923 UCLA [=CIT 1268] Little Cow Creek, Redding area, Millville quad., Shasta Co., Calif. Member III [Turonian] (Popenoe, 1957, p. 448; Matsumoto, 1960, p. 105; Saul & Popenoe, 1962, p. 328).

3312 UCLA near Martinez, Concord Quad., Contra Costa Co., Calif. [Maestrichtian] (Saul and Popenoe, 1962, p. 328).

3313 UCLA W slope of gully about 2100′S. 28°W. of NE cor. sec. 24, T.1N., R.1E., S side Deer Valley, Mt. Diablo quad., Contra Costa Co., Calif. Coll: W. P. Popenoe, 1944. Deer Valley Fm. [Maestrichtian].

3637 UCLA Chico Creek, Paradise quad., Butte Co., Calif. Chico Fm. [early Campanian, *Submortoniceras chicoense* zone] (Matsumoto, 1960, p. 15, 156).

3641 UCLA E side Chico Creek county rd., 1400′S., 400′W. of NE cor. sec. 23, T.23N., R.2E., Paradise quad., Butte Co., Calif. Coll: L. R. and R. B. Saul, August 20, 1952. Chico Fm. [early Campanian].

3643 UCLA W bank Chico Creek, 1500′S., 2500′W. of NE cor. sec. 26, T.23N., R.2E., Paradise quad., Butte Co., Calif. Coll: L. R. and R. B. Saul, August 22, 1952. Chico Fm. [early Campanian].

3648 UCLA [=CIT 1183] Chico Creek, Paradise quad., Butte Co., Calif. Chico Fm. [early Campanian] (Matsumoto, 1960, p. 15, p. 157).

3815 UCLA Loose boulders of gray calcareous sandstone in gully channel, 200′N of private road on Lang Ranch, 2350′N., 100′E. of SW cor. sec. 31, T.2N., R.18W., NW end Simi Hills, Thousand Oaks quad., Ventura Co., Calif. Coll: D. H. Dailey, April, 1958 [early Maestrichtian].

4081 UCLA near Pentz, Cherokee quad., Butte Co., Calif. Chico Fm. [early Campanian] (Saul and Popenoe, 1962, p. 328).

4140 UCLA fine grained, dark gray sandstone, 900′N. of Jalama Creek, elev. 500′, 1.85 miles E., .36 mile S. of Jalama Ranch Headquarters, 2.9 miles W., .73 mile N., of SE corner Lompoc Hills quad., Santa Barbara Co., Calif. Coll: W. P. Popenoe, Sept. 1938. Jalama Fm. [early Maestrichtian].

4207 UCLA [=CIT 976] Santa Ana Mts., El Toro quad., Orange Co., Calif. Williams Fm., Pleasants sandstone member [late Campanian, *Metaplacenticeras pacificum* zone] (Matsumoto, 1960, p. 99).

4249 UCLA Young Ranch, Yreka quad., Siskiyou Co., Calif. Hornbrook Fm. [late Turonian] (Saul, 1973, p. 40).

4337 UCLA Pentz vicinity, roadcuts both sides new Oroville Hiwy., 2600′N., 1000′W., of SE cor. sec. 36, T.21N., R.3E., Cherokee quad., Butte Co., Calif. Coll: Popenoe and Dailey, Aug. 28, 1959. Chico Fm. [early Campanian].

4340 UCLA Pentz vicinity, Cherokee quad., Butte Co., Calif. Chico Fm. [early Campanian] (Saul and Popenoe, 1962, p. 329).

4347 UCLA sandstone exposed at low tide about ½ mile N. of Bolsa Pt. and just S. of Spring Bridge Gulch, Pigeon Point quad., San Mateo Co., Calif. Coll: L. R. and R. B. Saul, 1960. Pigeon Point Fm. [middle Campanian].

4439 UCLA Temescal fireroad near top of ridge S side Temescal Cr., 3 miles 5080′E. and 2300′N. of

SW cor. sec. 19, T.1S., R.16W., Topanga quad., Santa Monica Mts., Los Angeles Co., Calif. Coll: J. D. Champeny, 1961, T. Richards, 1971. [late Campanian, *Metaplacenticeras pacificum* zone].

4863 UCLA N side valley of Arroyo San Antonio del Mar about 1 mile from coast and N. 12°W. from "Johnson's Ranch" house, Baja California, Mexico. Coll: Popenoe, Lusk, and Helms, February 3, 1949. Rosario Fm. [late Campanian].

6001 UCLA hilltop 3600′ N.78°W. of Grove triangulation point, 8400′N. 69°W. of Martinez City Hall, Benicia quad., Contra Costa Co., Calif. Coll: W. P. Popenoe, April 22, 1968 [Maestrichtian].

6019 UCLA Rivas Canyon, approx. 3500′N. of Sunset Blvd., 1350′S. of Boca de Santa Monica grant line, Topanga quad., Santa Monica Mts., Los Angeles Co., Calif. Coll: Saul, et al, 1970 [late Campanian, *Metaplacenticeras pacificum* zone].

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FIGS. 3-6 — Cymbophora stantoni (Arnold). 3, Right valve, pallial sinus, hypotype (UCLA 48507); 4, Right valve, hypotype (UCLA 48502); 5, Right valve, selenis and posterior slope, hypotype (UCLA 48505); 6, Right valve, hypotype (UCLA 48505).