# *ACILA PRINCEPS*, A NEW UPPER CRETACEOUS PELECYPOD FROM CALIFORNIA

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# ACILA PRINCEPS, A NEW UPPER CRETACEOUS PELECYPOD FROM CALIFORNIA

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ABSTRACT—The new species occurs in a sand lentil in the Moreno formation in sec. 12, T. 12 S., R. 10 E., M.D.M., Merced County, California. It is related to *Acila* (*Truncacila*) *demessa* Finlay from the Chico formation of Butte County, California, but differs chiefly in its larger size and coarser ornamentation. Also illustrated are the following Upper Cretaceous specimens: a topotype of *A. demessa; Acila* (*Truncacila*) sp. D from near Martinez; two specimens of *Acila* (*Truncacila*) sp. E from the Marca shale member of the Moreno formation; two specimens of *A. demessa* from the Pleasants sandstone; one specimen of *A. demessa* from the upper Holz shale; and *Acila* (*Truncacila*) sp. F from the Cretaceous of Baja California.

## INTRODUCTION

DETAILED geologic mapping on the west side of the San Joaquin Valley, California, by Max B. Payne resulted in the discovery of a large number of fossils in strata of late Cretaceous age. Among the specimens sent to Stanford University in 1941 is a new species of nuculid pelecypod, here described as *Acila* (*Truncacila*) *princeps*. Acknowledgment is due the Chief Geologist, Richfield Oil Corporation, and Messrs. Mason Hill and Payne of that company, for the generous donation of specimens, stratigraphic data, helpful suggestions, and for permission to publish this new record.

W. P. Popenoe, California Institute of Technology, identified some of the pelecypods associated with the new species and lent many specimens of *Acila demessa* from several localities. G. Dallas Hanna and Leo G. Hertlein, California Academy of Sciences, and Bruce L. Clark, University of California, also provided comparative material. Gary Ellis, R. A. C. Brown, and Ivan F. Wilson aided the writer in 1941 in the collection of specimens of *Acila princeps* at the type locality. Allan P. Bennison supplied data regarding fossils collected by him. Joseph A. Cushman, Sharon, Mass., and Helen Jeanne Plummer, Austin, Texas, sent specimens of foraminiferal species for comparison with those in the local California section. At Stanford University, Lois T. Martin identified critical foraminiferal faunules; Konrad B. Krauskopf prepared a report on the matrix; Siemon Wm. Muller and A. Myra Keen criticized an early draft of the typescript; Mrs. Carl F. Janish and Alexander Tihonravov aided in the preparation of the illustrations; P. W. Reinhart, Donald C. Birch, and Elizabeth A. Watson collected well-allocated specimens from the Marca member of the Moreno formation and from Cretaceous beds in Contra Costa County; C. F. Green, who has made a detailed geologic map of the Charleston School quadrangle, generously permitted the use of much stratigraphic information; and finally, the Research Committee supplied funds for the investigation. It is a privilege to acknowledge all of this assistance and cooperation.

## GEOLOGIC OCCURRENCE

The new species is from Stanford University locality 2372, in a sandstone lentil in the Moreno formation, as shown on the accompanying geologic sketch map, figure 1.

Stratigraphically above the Moreno formation in the Charleston School quadrangle are beds of Paleocene age overlain by Eocene strata. These formations are not differentiated on the sketch map.

Immediately below the Paleocene strata is a brown shale, approximately 330 feet in thickness, which is thought by Payne to be the correlative of the upper part of the Tierra Loma shale member of the type Moreno formation. Payne believes that a disconformity here separates the Cretaceous shale and the Tertiary sandstone. At locality M-261 (NE ¼ sec. 13, T. 12 S., R. 10 E.) near the base of the Cretaceous shale member, C. F. Green collected a foraminiferal

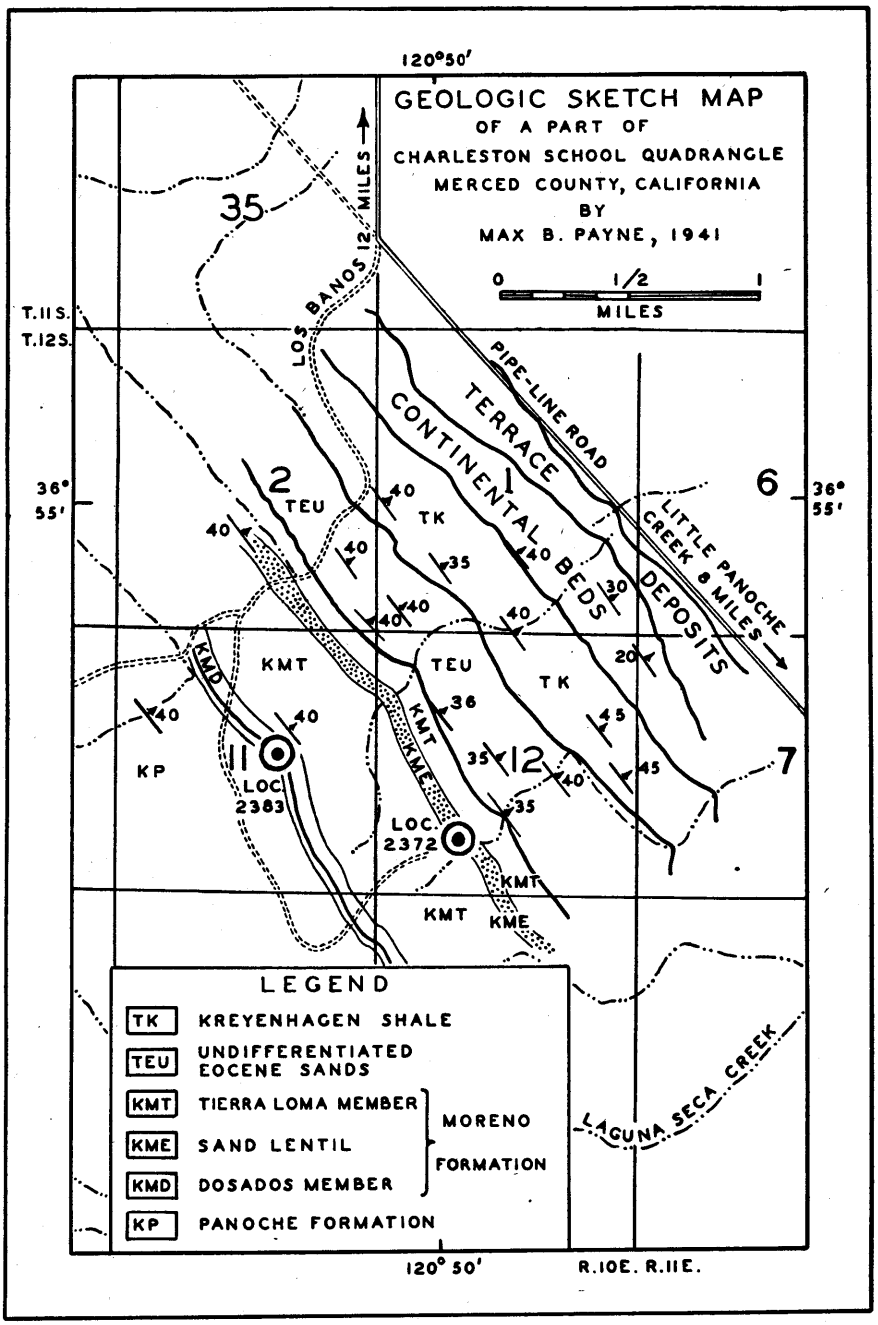


FIG. 1.—Geologic sketch map of a part of Charleston School quadrangle, Merced County, Calif. Type locality of *Acila princeps* is No. 2372.

faunule with abundant specimens of *Bulimina prolixa* Cushman and Parker, *Siphogenerinoides whitei* Church, and other species, which he has recorded in his report (1942).

Conformably below the upper shale member is a sandstone lentil totalling 200± feet in thickness at this locality. It is in this member at locality 2372 that the new species of *Acila* was found. The matrix of the specimens is described by Konrad B. Krauskopf (report dated June 14, 1941) as follows:

> The rock has so much calcite cement that it might be described as a sandy limestone almost as well as a calcareous sandstone. The quartz and feldspar grains range up to 0.2 mm., and the mica flakes up to 1.0 mm. There is little material in the finer silt grades, the majority of grains being over 0.02 mm. The grains are extremely angular; some of the quartzes show reentrant curves, and some are so elongated as to resemble glass shards.
>
> The most abundant mineral is quartz, which aggregates about 50 percent of the light minerals. Feldspar (orthoclase 25 percent, plagioclase 25 percent) and a little muscovite make up the remaining light minerals. All varieties of feldspar are relatively fresh. Heavy minerals are abundant, their relative proportions being approximately as follows:

| | Percent |
|---|---|
| Green hornblende | 71 |
| Colorless zircon | 9 |
| Ilmenite | 9 |
| Epidote and clinozoisite | 5 |
| Garnet | 3 |
| Sphene | 2 |
| Biotite | 1 |
| Blue tourmaline | >1 |
| Andalusite | >1 |

> By way of a guess, I would suggest that the good sorting points to marine deposition, the freshness of the material suggests rapid deposition without a great deal of weathering, and the general mineral assemblage indicates a dominant metamorphic or basic igneous provenance.

The conformably subjacent lower Tierra Loma shale member consists of 1310± feet of brown shale. No diagnostic molluscan fossils have as yet been discovered from this member of the Moreno in this area.

Conformably underlying the thick brown shale member is a sequence of beds which has been differently correlated and named by several workers. Along a line of section through locality 2372, one finds a thickness of about 120 feet of alternating sandstone and shale below the lower Tierra Loma shale member. Where the outcrops are satisfactory, one can see that the upper 70–80 feet of the alternating sandstone and shale correspond lithologically to the Dosados member of the type Moreno formation, whereas the lower 40–50 feet consist chiefly of massive, fossiliferous, concretionary sandstone and conglomerate. It is this sandstone and conglomerate which Payne takes to be the uppermost member of the Panoche formation, as shown in figure 1. Green's treatment is somewhat different. He believes (oral communication) that because the strata are difficult to differentiate northwestwards along the strike it is more satisfactory to recognize only a single cartographic unit (about 550 feet thick) below the lower Tierra Loma shale member: a unit composed of the Dosados sandstone and shale, the upper member of the Panoche (as mapped by Payne), a subjacent shale member, and a lower massive sandstone. Some workers have placed the top of the Panoche formation still lower in the section. The disputed part of the column (that is, whether Moreno or Panoche) is more than 750 feet in thickness.

Among the Upper Cretaceous mollusks in the Panoche formation as mapped by Payne (fig. 1) at locality 2383 are the following: *Acila* (*Truncacila*) sp., *Cophocara* sp., *Glycymeris veatchii* (Gabb), *Hamites* cf. *ellipticus* Anderson, *Parallelodon* sp., and *Tenea inflata* (Gabb). At the nearby locality 2489 (1250 feet E., 2800 feet N. of SW cor. sec. 13, T. 12 S., R. 10 E.) on the north side of Laguna Seca Creek and only a few feet lower stratigraphically, *Acila* (*Truncacila demessa* Finlay occurs in some abundance, associated with other fossils listed by Green (1942). These molluscan fossils at localities 2383 and 2489 aid in defining the Panoche formation in the Charleston School quadrangle.

Further evidence bearing on the placement of the boundary between the Moreno and Panoche formations in this area is a faunule with *Globotruncana arca* (Cushman) found by Green at locality M-260 (2350 feet N., 300 feet E. of the SW corner sec. 13, T. 12 S., R. 10 E.). The foraminiferal shale at this locality is approximately 850 feet stratigraphically below the lower Tierra Loma shale member, as here mapped. Some geologists believe that the beds carrying these fossils should be allocated to the

Panoche formation, whereas others place them in the lower Moreno.

Whatever the interpretation of the uppermost limit of the Panoche formation, no geologist familiar with the stratigraphy of the district denies the fact that the sandstone member containing the new species of *Acila* is well above the top of that formation. Attention is further directed to the fact that *Acila princeps* at its type locality occurs 1440± feet stratigraphically above a sandstone carrying *Acila demessa*. It is significant that *Acila princeps* is a Moreno species and is geologicaly younger than *A. demessa*.

## SYSTEMATIC PALEONTOLOGY

### ACILA (TRUNCACILA) PRINCEPS Schenck, n. sp.

Plate 8, figures 1–4, 6–8

*Type material.*—Holotype no. 6960, figured paratypes nos. 6961, 6962. Stanford University Paleontological Type Collection.

*Type locality and age.*—Stanford University Locality No. 2372, Merced County, California, Charleston School quadrangle, 1200 feet north, 1650 feet east of the SW cor. sec. 12, T. 12 S., R. 10 E., M.D.B. & M. Sand lentil in the Moreno formation, Upper Cretaceous. The specimens are abundant.

*Associated fossils.*—*Glycymeris veatchii* (Gabb), *Parallelodon* (*Nanovavis*) cf. *brewerianus* (Gabb), *Tenea inflata* (Gabb), and other mollusks.

*Description.*—Adult shells large for subgenus, quadrangular, inflated; anterior dorsal margin straight to slightly convex; anterior end evenly rounded, with a relatively marked change of slope to meet the dorsal margin; ventral margin convex; posterior end straight, making a sharp angle with ventral margin; ratio of height to length varies from 69 to 82 percent, the median of 26 specimens falling at 79 percent; beaks small, strongly inturned, appressed; lunule and escutcheon not sharply set off; faint rostral sinus extending from near umbones to ventral margin slightly anterior to posterior end; surface of holotype sculptured by about 83 straplike radial ribs (pl. 8, fig. 8)—counted at midheight—which attain a maximum width of 0.5± mm., separated by interspaces up to 0.2 mm. wide but generally narrower; secondary bifurcation present on some specimens, anterior to primary bifurcation, which is anterior to center of shell; nature of ornamentation on escutcheonal area not determined; concentric lines form about six marked growth rings; area of obsolete radial ribbing present on holotype; interior smooth, nacreous; adductor muscle scars and simple pallial line impressed; central, median, and punctiform muscle scars (Schenck, 1934, p. 21) visible on some of the internal casts; marginal plications faint (pl. 8, fig. 3) owing to imperfect preservation of specimens; chrondrophore inclined anteriorly; about 22 anterior, 11 posterior teeth (pl. 8, fig. 2).

*Dimensions.*—The measurements of the better-preserved specimens of *Acila* (*Truncacila*) *princeps* in the original lot from locality 2372 are given in the table. The graph reproduced as text figure 2 is based upon measurements of these and additional specimens preserved as molds and casts.

## COMPARISONS

*Introduction.*—A survey of the pelecypods of the genus *Acila* has been published by the writer in the several papers cited in the

| Specimen | Length in mm. | Height in mm. | Thickness in mm. (2 valves) | Umbonal angle (degrees) | Angle of bifurcation (degrees) | Ratio of height to length (percent) |
|---|---|---|---|---|---|---|
| Holotype No. 6960 | 32.7 | 25.1 | 19.0 | 104 | 67 | 77 |
| Paratype No. 6962 | 29.4 | 23.3 | 14.6 | 102 | 60 | 79 |
| Paratype No. 6961 | 31.6 | 22.7 | | | | 72 |
| Paratype No. 6963 | 30.0 | 23.3 | 15.0 | 109 | 60 | 78 |

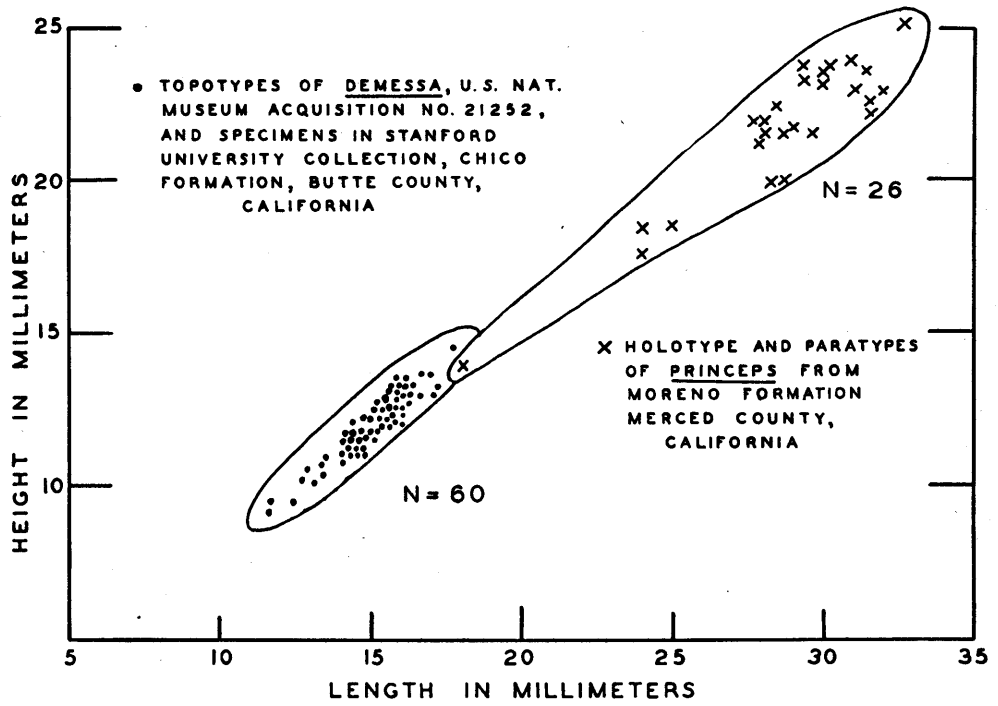


FIG. 2.—Height-length relations of *Acila princeps* compared with *Acila demessa*.

accompanying bibliography. Of the species there considered, only two Cretaceous species need to be discussed in comparison with the new species: *Acila* (*Truncacila*) *demessa* Finlay and *Acila* (*Truncacila*) *hokkaidoensis* (Nagao), 1932. The present discovery has necessitated a reexamination of a large number of Cretaceous specimens and a measurement of several hundred specimens, including Recent species. This study proved that some reliance may be placed upon dimensions for the separation of species.

*Comparison with Acila demessa Finlay.*—The new species, *Acila princeps*, is most nearly related to *Acila demessa* Finlay, a representative topotype of which is shown on plate 8, figure 5. Dimensions of topotypes are given in text figure 2; on the same graph are the dimensions of *princeps*. Measurements of more than one hundred additional specimens from Butte County, California, support the belief that the true *demessa* does not exceed a length of 20 mm.

Representative examples of *A. demessa* from Orange County, California, are illustrated on plate 9, figures 1, 3, and 7. The specimen shown in figure 1 from the upper Holz shale is 14 mm. long and 11.2 mm.

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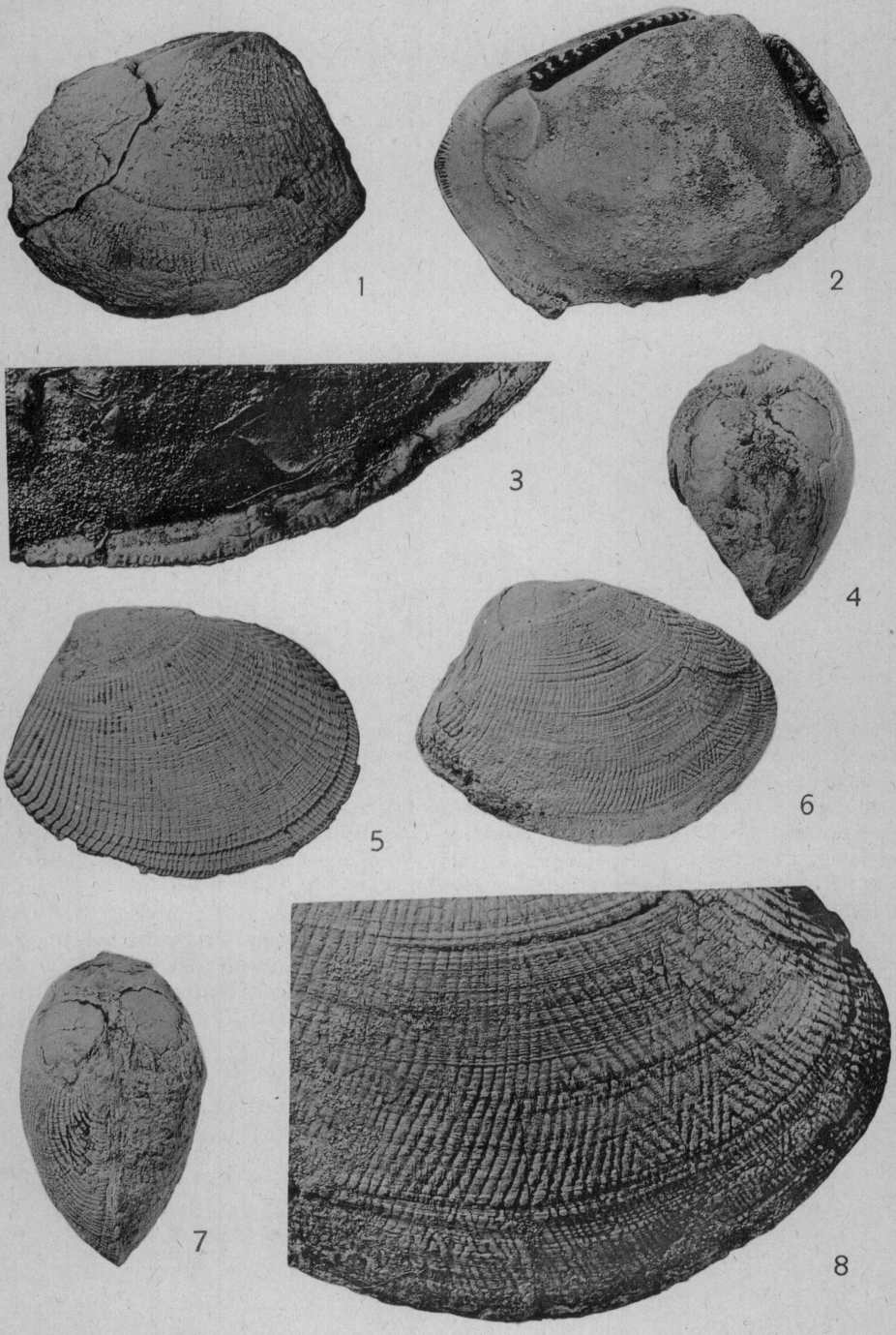
EXPLANATION OF PLATE 8

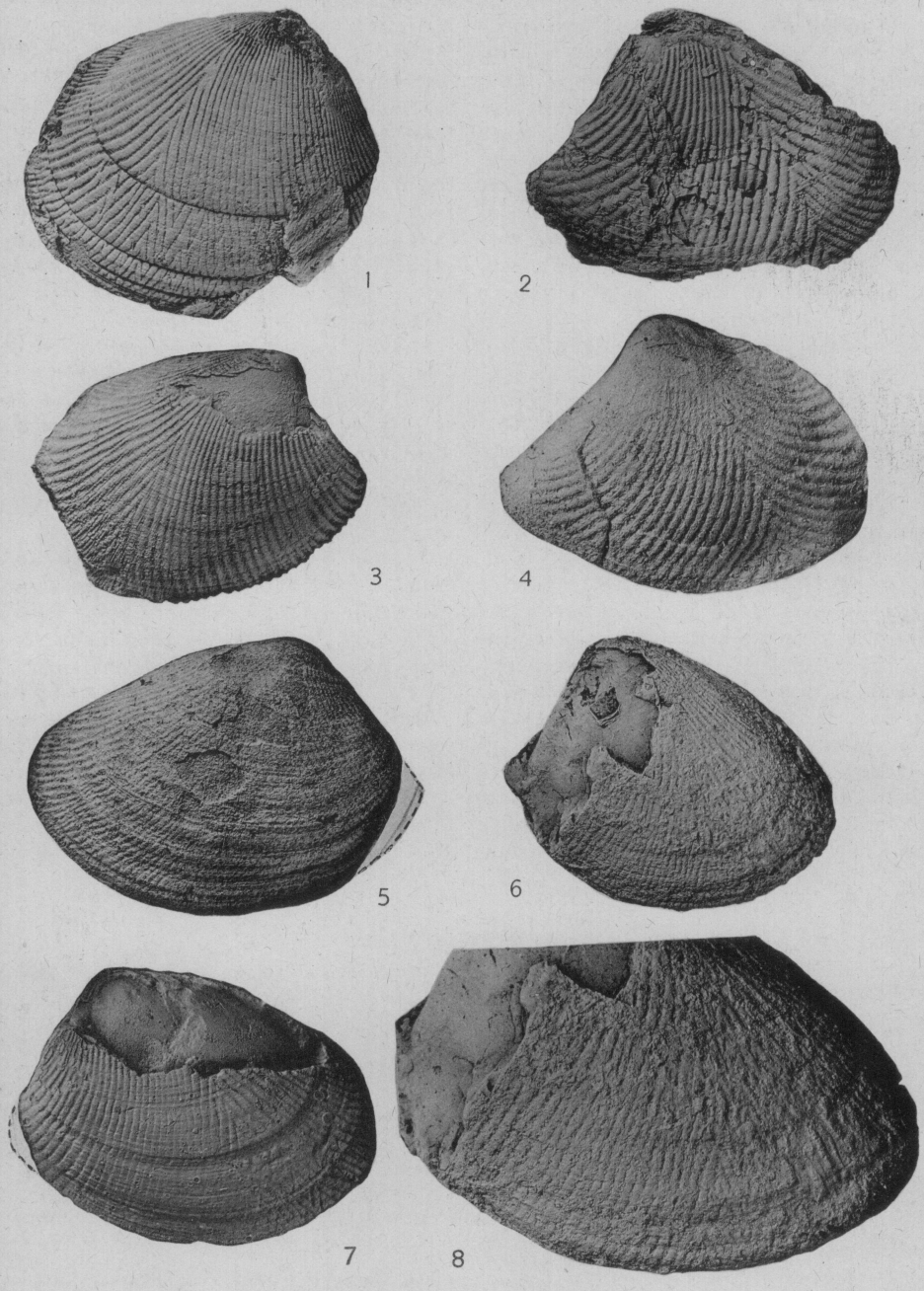
All specimens in Stanford University Paleontological Type Collection

FIGS. *1–4, 6–8*—*Acila* (*Truncacila*) *princeps* Schenck, n. sp. Sand lentil, Moreno formation (Upper Cretaceous), Merced County, California; L.S.J.U. loc. 2372, sec. 12, T. 12 S., R. 10 E., M.D.B.&M. *1*, Left valve, ×1.5; *3*, inner ventral margin, ×4; paratype 6962. *2*, Left valve, ×1.9; paratype 6961. *4*, Posterior view, ×1.3, *6*, right valve, ×1.3, *7*, dorsal view, ×1.3, *8*, anterior ventral portion, ×2.6; holotype 6960. (p. 63)

*5*—*Acila* (*Truncacila*) *demessa* Finlay. Chico formation, (Upper Cretaceous), L.S.J.U. loc. 361, near Pentz, Butte County, California. Right valve, ×3; hypotype 6959. This specimen is 15.5 mm. long, hence slightly less than one-half the size of the shell shown in figure 6. (p. 64)




Schenck, Upper Cretaceous Acilas




Schenck, Upper Cretaceous Acilas

high. As it was tilted when photographed in order to accentuate the details of the ribbing, the characteristic profile of the species cannot be judged from this figure. The Pleasants sandstone specimen shown in figure 7 measures 15.2 mm. in length, 12.3 mm. in height; this figure was designed to illustrate the nature of the ribbing on the posterior part of the shell; the exact profile of this valve is indeterminate owing to the matrix. Another Pleasants sandstone specimen, figure 3, is 13.5 mm. long, 10.6 mm. high.

The sculpturing of the two species is similar in proportions, but the ribs are wider in *A. princeps*. On the new species there are about 1.6 to 1.8 radial ribs per millimeter, in contrast to 2.2 to 2.4 ribs per millimeter on *A. demessa*. No distinct area of obsolete radial ribbing has been noted on topotypes of *A. demessa*, whereas this feature is present on the holotype of *A. princeps*.

In general, the umbonal angle of *A. demessa* appears to be greater than in *A. princeps*, the median of the former being 110°. The median of the ratio of height to length in *A. demessa is* 80 percent, whereas in *A. princeps* (N = 26) the median falls in the 79 percent class interval.

*Comparison with Acila (Truncacila) sp. D.* —On plate 9, fig. 5, is figured a specimen (type no. 7368, Stanford Univ. Paleont. Type Coll.) from the "Chico" formation exposed along the Santa Fe railroad near Martinez, Contra Costa County, California, at locality 2180 (75 mm. west, 20 mm. south of intersection of Lat. 38°00′ and Long. 122°05′, on the map of the Concord quadrangle). A description of the section through this locality is contained in a report by Watson (1941). According to current views on correlation based on foraminiferal faunules, the sandstone with this specimen is not only older than the Moreno formation but is also older than the lowest known occurrence of *Acila demessa*.

*Acila (Truncacila)* sp. D is about 21 mm. long, 14.6 mm. in height, thus falling into the general size category of *A. princeps*, but the largest radial rib is about 350 microns wide, in contrast to the coarser ornamentation of *A. princeps*. In sculpturing but not in proportions, therefore, *Acila* sp. D resembles *A. demessa*.

*Comparison with Acila (Truncacila) sp. E.* —On plate 9, figure 4, is illustrated a specimen (type no. 7369, Stanford Univ. Paleont. Type Coll.) from the Moreno formation in the NE corner of the SE¼ sec. 23, T. 16 S., R. 12 E., M.D.M., Fresno County, California, collector Donald C. Birch. This single specimen is a mold in a white-weathering limestone concretion in brown shale. This is the same species as that which the writer (1936-b, p. 50) has called "*Acila (Truncacila)* cf. *demessa*," as based on hypotype no.

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EXPLANATION OF PLATE 9

Specimens illustrated in Figs. *1, 3, 7* at California Institute of Technology; others in Stanford University Paleontological Type Collection.

FIGS. *1, 3, 7—Acila (Truncacila) demessa* Finlay. Upper Cretaceous, Corona Quad., Santa Ana Mts., Orange Co., California. *1*, Left valve, ×3.5, from Upper Holz shale, C. I. T. loc. 1059, ¼ mi. above mouth of Harding Canyon. *3*, Left valve, ×3, from Pleasants sandstone, C. I. T. loc. 975, 300 feet NW of middle of S line of sec. 29, T. 5 S., R. 7 W., S.B.M. *7*, Right valve, ×3, Pleasants sandstone, C. I. T. loc. 974, middle of S line of sec. 29, T. 5 S., R. 7 W., S.B.M. Hypotypes, C. I. T. nos. 4650–4652. (p. 64)

*2, 4—Acila (Truncacila)* sp. E. Marca shale member, Moreno formation (Upper Cretaceous) *2*, Right valve, from L.S.J.U. loc. 2574, 1000 feet. NE of center of sec. 17, T. 19 S., R. 15 E., M. D. B. & M., Fresno County, California; a crushed specimen, ×2.2, details of profile uncertain; hypotype 5906, *4*, Right valve, ×2.8, rubber cast from mold in limestone concretion, L.S.J.U. loc. 2575, NE cor. SE ¼, sec. 23, T. 16 S., R. 12 E., M. D. B. & M., Fresno County, California; hypotype 7369. (p. 65)

*5—Acila (Truncacila)* sp. D. Upper Cretaceous near Martinez, Contra Costa County, California; L.S.J.U. loc. 2180, in railroad cut 500 feet west of Santa Fe Railroad tunnel above Franklin Canyon Inn. Rubber cast from mold of left valve, ×2.5; details of profile uncertain; hypotype 7368. (p. 65)

*6, 8—Acila (Truncacila)* sp. F. Upper Cretaceous. Calif. Acad. Sci. loc. 950, San Antonio del Mar, Baja California, Mexico. *6*, Right valve, ×1.7, of specimen 26 mm. long; *8*, enlarged view of anterior portion, ×2.8, to show ribbing; hypotype 6023, Calif. Acad. Sci. (p. 66)

5906, Stanford Univ. Paleont. Type Coll., a crushed specimen about 19 mm. long, 16 mm. high, illustrated on plate 9, figure 2.

The specimen collected by Birch came from 500 feet stratigraphically below the top of the Moreno formation. This would be the Marca shale member of the Moreno formation of this area, which according to Payne (written communication) is overlain by the Dos Pálos shale member and is underlain by the Tierra Loma shale member, below which, in turn, is the Mercy sand lentil. Payne believes that this *Acila* from the Marca member is geologically younger than *Acila princeps*.

*Acila* (*Truncacila*) sp. E (pl. 9, fig. 4) is 17 mm. long, 12 mm. high, thus falling into the general size category of *Acila demessa*. Viewed posteriorly, however, the Marca specimen has radial ribs (450 ± microns wide) continuing to the margin of the valve, whereas in *demessa* the ribless area in the "escutcheonal" region is a striking morphologic feature. Finally, the sculpturing of *Acila* sp. E is coarser than that of *demessa*. Compared with *A. princeps*, the smaller size and comparatively coarser ornamentation will separate the species.

Other specimens referred to *Acila* sp. E were generously donated by Arthur S. Huey from the Superior Oil Company well "Ciervo Unit Plan" No. 1, 330 feet north, 2156 feet west of the SE corner sec. 20, T. 16 S., R. 13 E., M.D.B.&M., depth (approximate) 5220 feet, associated with numerous specimens of *Siphogenerinoides*. The stratigraphic position is estimated to be 810 feet below the top of the Moreno formation.

*Comparison with Acila* (*Truncacila*) *sp. F.*—The specimen figured on plate 9, figures 6, 8, from Baja California, Mexico,[1] is the one which Schenck (1936-b, pp. 49–50) had identified as *A. demessa*. According to F. M. Anderson (as transmitted by L. G. Hertlein) the strata at the locality are upper Campanian in age. Measurements are as follows: length, 26 mm.; height, 20 mm.; radial ribs near middle of the ventral margin, 430 microns in width. Compared with *A. princeps* this specimen differs in profile and ornamentation. Its large size, shape and ornamentation are the reasons for now excluding it from *A. demessa*.

*Comparison with Acila hokkaidoensis* (*Nagao*).—The new species approaches the Japanese species in size. The holotype of *hokkaidoensis* is 30 mm. long and 22 mm. in height; the largest paratype measures 30 mm. in length, 20 mm. in height, and 10 mm. in thickness (two valves). Thus, *princeps* differs in height-length relations and is more inflated than *hokkaidoensis*. The two species differ somewhat in profile and ornamentation.

### AGE AND ORIGIN OF THE SANDSTONE AT LOCALITY 2372

The precise dating of the sand lentil with *Acila princeps* at locality 2372 in terms of the European standard of the Cretaceous is not possible with the limited data now in hand, although certain inferences may be offered for testing. The "*Acila*-scale" would date the sandstone as Aptian or younger, as the oldest known *Acila* is Aptian. The fossiliferous beds of the upper Panoche formation, stratigraphically below the sandstone carrying the new species, are believed to be Campanian in age. *Siphogenerinoides whitei* Church from the shale 260 ± feet stratigraphically above the locality of the new species is closely related to *Siphogenerinoides cretacea* Cushman from the lower Colon shale (possibly Campanian) of Venezuela. The foraminiferal faunule from this superjacent shale contains enough species to warrant a correlation with at least a part of the type Tierra Loma shale member of the Moreno formation, where late Cretaceous reptiles have been collected and reported upon by Stock (1941). The mollusks associated with *Acila princeps* are thought to be restricted to the Upper Cretaceous. Although available evidence proves that the sand lentil with this new nuculid pelecypod is late Cretaceous in age, only indirect reasoning permits the surmise that it is Maestrichtian.

Refined correlations of finely-spun lithogenetic units such as the sand lentil with *Acila princeps* with others of the Cretaceous

[1] California Academy of Sciences Locality 950: Hard lens about 1 foot thick outcropping behind old distillery on Johnson Ranch at San Antonio del Mar, Lower California, Mexico. Upper Cretaceous mollusks collected by E. K. Jordan and L. G. Hertlein, January, 1926.

in California are inconclusive at this time. Perhaps, however, a few of the occurrences of *Acila demessa* will be suggestive of synchronizations.

The uppermost sandstone member of the Panoche formation at its type area, as defined by Anderson and Pack (1915), carries abundant specimens of *Acila demessa* in association with *Baculites, Glycymeris veatchii, Hamites ellipticus, Parallelodon* cf. *vancouverensis,* and *Turritella chicoensis* var., at L.S.J.U. locality 2251 (600 feet south, 700 feet west of the NE cor. sec. 12, T. 15 S., R. 11 E., M.D.M., Fresno Co.). This is the assemblage that occurs in the upper member of the Panoche formation, as mapped by Payne, in the Charleston School quadrangle.

G. D. Hanna and J. H. Show collected *A. demessa* from California Academy of Sciences locality 1552, sec. 28, T. 26 S., R. 18 E., M.D.M., 500 feet west of center of section 28, in the Panoche formation. This is in the area of "Knoxville-Chico" rocks mapped by Arnold and Johnson (1910) at the north end of Shale Hills.

*Acila demessa* occurs in the type Chico formation about 1250 feet above its base, as measured by Taff, Hanna, and Cross (1940). The specimens are from C. A. S. locality 27838 (sec. 23, T. 23 N., R. 2 E.) on Big Chico Creek. From the same locality those authors figure specimens of "*Ammonites*" *chicoensis, Baculites chicoensis, Oligoptycha obliqua, Anchura falciformis, Tenea inflata,* and *Trigonocallista varians.* The "*Ammonites*" is *Submortoniceras*, according to Siemon Wm. Muller (personal communication), and is Campanian in age.

In Shasta County, Redding region, Popenoe has collected numerous specimens of *Acila,* some of which are certainly *demessa.* He has stated (written communication) that the total stratigraphic range of *Acila demessa* in that area is about 1100 feet.

In the Santa Ana mountains, Corona quadrangle, Orange County, Popenoe has collected *Acila demessa* (pl. 9, figs. 3, 7) from C. I. T. locality 974 (middle south line sec. 29, T. 5 S., R. 7 W.), locality 975 (300 feet northwest of loc. 974), and locality 976 (NE¼ NE¼ sec. 19, T. 5 S., R. 7 W.), about 50–75 feet above the Pleasants member of the Williams formation. The range of the species, its occurrences at other localities, and associated fossils are given by Popenoe (1942). Among the many species found with *A. demessa* in the Pleasants member are *Baculites, Clisocolus cordatus, Cymbophora ashburnerii, "Fulgur" hilgardi, Glycymeris veatchii, Gyrodes expansus, Legumen ooides, Metaplacenticeras pacificum, Oligoptycha obliqua, Perissitys brevirostris,* and *Turritella chicoensis* (flat-whorled variety).

The subjacent upper Holz shale carries *Acila demessa* (p. 9, fig. 1) at C. I. T. locality 1059, between Santiago and Williams canyons, about 4650 feet N. 62° W. of the dam one-fourth mile upstream from the mouth of Harding canyon, Corona quadrangle. The molluscan fauna of the upper Holz shale, according to Popenoe, includes *Clisocolus cordatus, Cymbophora ashburnerii, Flaventia lens, Glycymeris veatchii, Tenea inflata, Turritella chicoensis perrini,* and many other species. No specimens of *Acila* were recorded from the middle and lower Holz shale nor from the subjacent Baker Canyon sandstone member of the Ladd formation. The recorded stratigraphic range of *Acila demessa* in the Santa Ana mountains is thus provisionally estimated to be approximately 300 feet.

The careful work by Popenoe seems to have established the Teilzone of *Acila demessa* in the Santa Ana mountains and in Shasta County. The writer is struck by the fact that the fauna of the Pleasants sandstone is closely comparable with that recorded by Schenck (1936-b, p. 49) from the type locality of *A. demessa* in Butte County. He is also impressed by the similarity of these two faunas with the assemblages from the upper sandstone member of the Panoche formation at its type area and from the upper Panoche, as mapped by Payne, in the Charleston School quadrangle, well below the sandstone with *A. princeps.* Hence, the conclusion is reached that *Acila princeps* is geologically younger than *Acila demessa.*

If such correlations as have been drawn in this paper are correct, then it would seem possible to propose a sequence of species of *Acila* in California. The oldest known *Acila* is the one from Contra Costa County here described as *Acila* (*Truncacila*) sp. D. Next in chronological order is *Acila* (*Truncacila*) *demessa* Finlay. Still younger is *Acila* (*Trun-*

*cacila*) *princeps* Schenck. The youngest Cretaceous species so far collected is the one described as *Acila* (*Truncacila*) sp. E from the Marca shale member of the Moreno formation.

Finally, a possible origin of the sandstone at locality 2372 may be inferred from the distribution of Recent specimens of *Acila* and from the petrographic study of Krauskopf. The hypothesis is that the sand was deposited rapidly without much weathering in the late Cretaceous sea between 8 and 800 fathoms, in water temperatures probably lower than 72° Fahrenheit and higher than 34° F. The sand may have been laid down in the lower neritic or upper bathyal zone in temperate waters.

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