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Cretaceous *Acila* (*Truncacila*) (Bivalvia: Nuculidae) from the Pacific Slope of North America

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Abstract. The Cretaceous record of the nuculid bivalve *Acila* (*Truncacila*) Grant & Gale, 1931, is established for the first time in the region extending from the Queen Charlotte Islands, British Columbia, southward to Baja California, Mexico. Its record is represented by three previously named species, three new species, and one possible new species. The previously named species are reviewed and refined. The cumulative geologic range of all these species is Early Cretaceous (late Aptian) to Late Cretaceous (early late Maastrichtian), with the highest diversity (four species) occurring in the latest Campanian to early Maastrichtian. *Acila* (*T.*) ***allisoni***, sp. nov., known only from upper Aptian strata of northern Baja California, Mexico, is one of the earliest confirmed records of this subgenus. "Aptian" reports of *Truncacila* in Tunisia, Morocco, and possibly eastern Venzeula need confirmation.

Specimens of the study area *Acila* are most abundant in sandy, shallow-marine deposits that accumulated under warm-water conditions. Possible deeper water occurrences need critical evaluation.

INTRODUCTION

This is the first detailed study of the Cretaceous record of the nuculid bivalve *Acila* H. Adams & A. Adams, 1858, in the region extending from the Queen Charlotte Islands, British Columbia, Canada southward to the northern part of Baja California, Mexico (Figure 1). Schenck (1936) did a detailed study of Cretaceous to Recent specimens of *Acila* from the Pacific slope of North America, but his emphasis was on Cenozoic species because they had been better collected, both as to number of specimens and stratotype placement. Schenck (1943) added more information about some Cretaceous species. In the last 60 years, knowledge of Pacific slope of North America Cretaceous stratigraphy has increased significantly, and much more collecting has been done. This present investigation, which greatly expands on Schenck's work, is based on collections borrowed from all the major museums having extensive collections of Cretaceous fossils from the study area. We detected 122 lots (72 = LACMIP, 26 = CAS, 15 = UCMP, 9 = other), containing a total of 868 specimens of *Acila*. Our work establishes a documentable paleontologic record of *Truncacila* from late Aptian to early late Maastrichtian on the Pacific slope of North America (Figure 2), with the highest diversity (four species) occurring during the latest Campanian to early Maastrichtian.

Acila lives today in the marine waters of the Pacific and Indo-Pacific regions and is a shallow-burrowing deposit feeder. Like other nuculids, it lacks siphons but has an anterior-to-posterior water current (Coan et al., 2000). It is unusual among nuculids, however, in that it commonly inhabits sandy bottoms. Although is does not have a streamlined shell, it is a moderately rapid burrower because of its relatively large foot (Stanley, 1970). *Acila* has a very distinctive divaricate ornamentation, and, although this type of ornamentation is uncommon among bivalves, it "shows widespread taxonomic distribution, brought about through adaptive convergence" (Stanley, 1970:65).

Recent *Acila* has a considerable tolerance for temperature ranges, from cold to tropical waters, but the greatest number of specimens comes from temperate waters (Schenck, 1936). One example of having this eurythermal adaptability is *Acila* (*Truncacila*) *castrensis* (Hinds, 1843), known to range from the cold waters of Kamchatka and the northeastern Bering Sea into the tropical waters of the Golfo de California, Baja California Sur, Mexico (Coan et al., 2000). Cretaceous *Acila* in the study area lived mostly during warm-ocean periods. The Aptian fauna of the Alisitos Formation of northern Baja California is wholly tropical in aspect. Warm-temperate water conditions existed during the Albian to Turonian in the study area. Some cooling took place from the Coniacian to early Maastrichtian, but the faunas that lived during

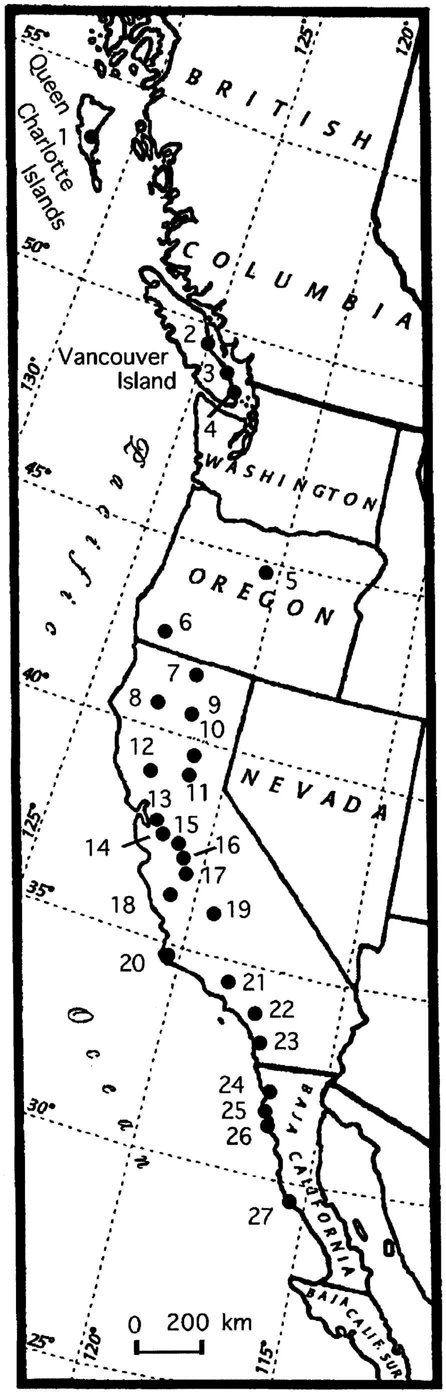

Figure 1. Index map showing locales mentioned in text. 1 = Skidegate Inlet, Queen Charlotte Islands. 2 = Hornby and Denman islands. 3 = Nanaimo area. 4 = Chemainus River and Saltspring Island areas. 5 = Mitchell and Antone areas. 6 = Phoenix. 7 = Yreka. 8 = Ono. 9 = Redding area. 10 = Chico Creek. 11 = Pentz. 12 = Sites. 13 = Franklin Canyon. 14 = ← Mount Diablo and Corral Hollow Creek. 15 = Garzas Creek. 16 = Charleston School Quadrangle area. 17 = Panoche. 18 = Lake Nacimiento. 19 = North Shale Hills. 20 = Jalama Creek. 21 = Simi Hills. 22 = Santa Ana Mountains. 23 = Carlsbad. 24 = Punta Banda. 25 = Punta China and Punta San Jose. 26 = San Antonio del Mar. 27 = Arroyo Santa Catarina.

this time also contain warm-water elements. There was a warming trend during the late Maastrichtian (Saul, 1986a).

Recent *Acila* also has a considerable depth range, from below the intertidal zone (5 m) into the bathyal zone (400 m) (Schenck, 1936:34, fig. 10; Coan et al., 2000). There are many shallow-water marine occurrences of Cretaceous *Acila* in the study area (e.g., Alisitos Formation, Pentz Road member of the Chico Formation, and Jalama Formation), but deeper water occurrences are equivocal, largely because of lack of detailed depositional-environment studies on beds containing *Acila* specimens. Based on a survey of the literature, it seems that the Moreno Formation (see Stratigraphy) has the best potential of containing relatively deep-water occurrences of *Acila,* but detailed studies are needed to confirm this assertion.

Sundberg (1980, 1982) defined an *Inoceramus-Acila* paleocommunity, which included the bivalves *Propeamussium* and "*Parallelodon,*" as well as the scaphopod *Dentalium,* that occupied most of the Holz Shale Member of the Ladd Formation, Santa Ana Mountains, Orange County, southern California. He believed that this paleocommunity probably existed in restricted lagoonal waters, at depths between 0 and 100 m. Almgren (1973), on the basis of benthic foraminifera, however, reported that the major part of the Holz was deposited in slope depths. Saul (1982), on the basis of gastropods and bivalves, reported that the lower Holz was deposited in middle to outer shelf depths and that the upper Holz was deposited in outer to shallow shelf depths.

The earliest documented records of *Acila* are *Acila* (*Truncacila*) *schencki* Stoyanow, 1949 [not *Acila schencki* Kuroda in Kira, 1954:83, 155–156, pl. 41, fig. 6], from the upper Aptian Pacheta Member of the Lowell Formation, southeastern Arizona and *Acila* (*Truncacila*) ***allisoni***, sp. nov. from the upper Aptian, lower part of the Alisitos Formation, Baja California, Mexico.

Acila (*T.*) *bivirgata* (J. de C. Sowerby, 1836) is the name that has been most commonly applied to Aptian-Albian specimens of *Acila* found anywhere in the world. The type locality of Sowerby's species is in southeastern England, in rocks correlative to the lower Albian ammonite *Douvilleiceras mammilatum* Zone (Casey, 1961: 605). Schenck's (1936:35, 47) reports of *Acila* (*T.*) *bivirgata* in the Aptian of Tunisia and Morocco, the Aptian-Albian of eastern Venezuela (also see Schenck, 1935a), and the Albian of France and Morocco all need confir-

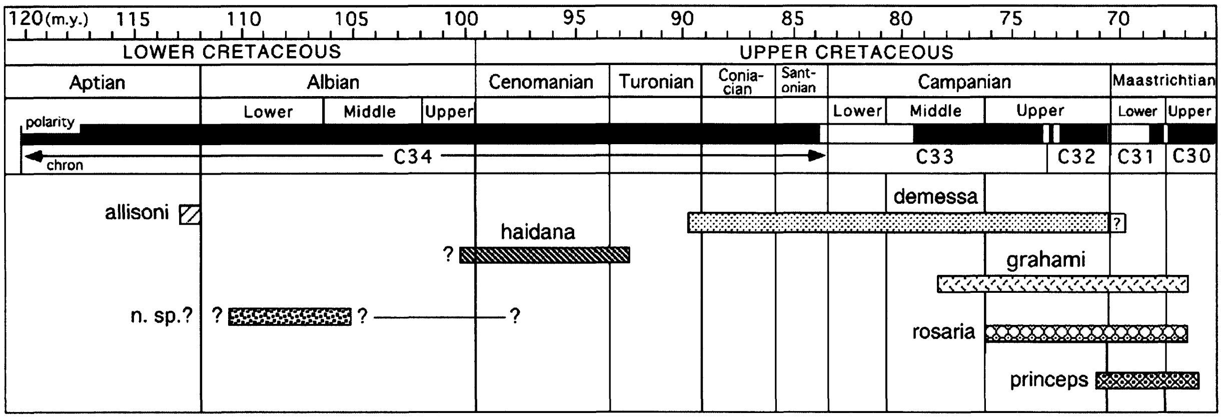

Figure 2. Chronostratigraphic positions of the new and restudied *Acila* (*Truncacila*) species. Geologic ages, geomagnetic polarities (black = normal, white = reversed), and chrons from Gradstein & Ogg (2004:fig. 2).

mation as to geologic age. Until this verification is done, global-migration routes of the earliest *Acila* (*Truncacila*) cannot be worked out.

Most of the study area specimens that have been mentioned in faunal lists or found in major museums have been identified as *Acila* (*Truncacila*) *demessa* Finlay, 1927, even though some of them belong to other species. Our study revealed that *A.* (*T.*) *demessa* ranges from late Turonian to late late Campanian and possibly early Maastrichtian, an interval of approximately 18 million years, thereby making it the longest ranging of the Cretaceous *Acila* (*Truncacila*) species in the study area. Such long ranges are not unusual for *Acila*; for example, *Acila* (*Truncacila*) *hokkaidoensis* (Nagao, 1932) from the Cretaceous Himenoura Group in Kyushu, Japan, ranges from Coniacian to Maastrichtian (Tashiro, 1976), an interval of approximately 19 million years.

Our study has refined also the geographic and stratigraphic ranges of the other two previously named study area species: *Acila* (*Truncacila*) *haidana* Packard in Schenck, 1936 and *Acila* (*Truncacila*) *princeps* Schenck, 1943. In addition, we discovered three new species and one possible new species.

Umbonal angle refers to the angle of divergence of the antero-umbonal and postero-umbonal surfaces, with the sides of the angle drawn to obtain maxiumum tangentiality with the valve surfaces. The umbonal-angle measurements were made from photographs of specimens. Although drawing the postero-umbonal part of the angle is easy because this surface is usually fairly straight, drawing the antero-umbonal part of the angle was usually subject to variation because this surface is usually convex. Chevron-angle measurements were also made using photographs of specimens, and measurements were taken near the point of divarication of the ribs, on approximately the medial part of the disk. It makes a significant difference where one measures this angle, because the sides of the chevron angle becomes increasingly wider ventrally. In this study, the imaginary line bisecting the chevron angle is used as a reference point and referred to as a bisecting line.

In this study, shell size, rib width, and rib interspace width are all denoted by relative terms pertaining to subgenus *Truncacila* Grant & Gale, 1931. Rib width and rib interspace information, furthermore, pertain only to the area posterior to the line bisecting the chevrons on the disk area of adult specimens. Umbo and ventral margin areas posterior of the bisecting line are excluded. In the case of multiple chevrons, the rib-width and rib-interspace information pertain to the area posterior of the line bisecting the posteriormost chevron.

The suprageneric classification system used here follows that of Coan et al. (2000). Abbreviations used for catalog and locality numbers are: ANSP, Academy of Natural Sciences, Philadelphia; CAS, California Academy of Sciences, San Francisco; GSC, Geological Society of Canada, Ottawa; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; LSJU, Stanford University, California (collections now housed at CAS); RBCM, Royal British Columbia Museum, Victoria; UCMP, University of California Museum of Paleontology, Berkeley; UO, University of Oregon, Eugene.

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS

The geologic ages and depositional environments of most of the formations and members cited in this paper have been summarized by Squires & Saul (2001, 2003a, b, c, d, 2004a, b). Stratigraphic and depositional-environment information mentioned below concerns those rock units not discussed in recent literature. The stratigraphic units are listed from oldest to youngest.

Hudspeth Formation

This formation crops out in the Mitchell area, Wheeler County, northeast-central Oregon (Figure 1, locale 5) and consists mainly of marine mudstone (Wilkinson & Oles, 1968). The type locality of *Acila* (*T.*) sp. nov.? plots on the geologic map of Wilkinson & Oles (1968:fig. 1) in the lower part of the "Main Mudstone member" of the Hudspeth Formation. Based on ammonites, Wilkinson & Oles (1968) reported the age of this part of the formation to be early or early middle Albian. There have been no detailed studies of the depositional environments of this formation.

Haida Formation

This formation crops out in the central part of the Queen Charlotte Islands, northern British Columbia (Figure 1, locale 1) and consists of two members, which accumulated as part of the same transgression event. The two members, a nearshore sandstone member and an overlying mostly outer shelf shale member, are laterally equivalent and interfinger. Storm deposits, which characterize the sandstone member, are also found in the shale member and are represented by fine- to medium-grained sandstone with associated shell lags (McLearn, 1972; Haggart, 1991a). The type locality of *Acila* (*Trunacila*) *haidana* Packard in Schenck, 1936, was reported to be a beach-cliff exposure of the Haida Formation, and utilizing the geologic map of Haggart (1991a:fig. 3), this exposure would seem to plot in the shale member. Schenck's (1936:51) description of the type locality "about 1 mile east of Queen Charlotte City," however, is not precise and could refer to outcrops in either the shale member or the sandstone member, depending on if one uses as a starting point the old hotel or the current post office in Queen Charlotte City, respectively (J. Haggart, personal communication). No *Acila* has been found by recent collecting in the sandstone member, and, consequently, Schenck's material probably came from the lower part of the shale member (J. Haggart, personal communication). The type specimens of *A.* (*T.*) *haidana* occur in fine-grained sandstone, and the holotype consists of conjoined valves. If these type specimens are part of a storm lag, then the amount of post-mortem transport was not great. All indications are that these specimens probably lived in a transitional nearshore to slightly deeper environment. This would be in keeping with the shallow-water environments of localities in the study area at which additional specimens of this species are found.

The sandstone member of the Haida Formation is Albian in age, based on a rich assemblage of ammonites (McLearn, 1972), and the shale member ranges from latest Albian to Cenomanian to early Turonian in age, based on scarce remains of inoceramid bivalves (McLearn, 1972; Haggart, 1987, 1991a). The exposures at the type locality of *A.* (*T.*) *haidana,* however, are probably latest Albian to Cenomanian (J. Haggart, personal communication).

The Queen Charlotte Islands and Vancouver Island, which is mentioned later in this paper, are parts of an amalgamated sequence of tectonic terranes, collectively called the Insular Superterrane, whose accretional history is currently in dispute. Two mutually contradictory hypotheses deal with this accretionary history, and both have been summarized by Cowan et al. (1997) and Ward et al. (1997). One hypothesis suggests that the Insular Superterrane was already in place in its current position (more or less) relative to western North America by the Cretaceous and perhaps earlier. The second hypothesis, known as the "Baja BC hypotheses," suggests that the superterrane was situated 3000 km south of its present position. Kodama & Ward (2001), using paleomagnetic paleolatitudinal distribution of bivalve rudists, suggested that Baja BC was no farther south than 40°N (i.e., northern California) in the Late Cretaceous. The distribution of *Acila* (*T.*) *haidana* supports the contention that the Insular Superterrane was not any farther south than northern California during the Cretaceous, because besides being found in the Haida Formation, this species is only known elsewhere from southern Oregon and northern California.

Upper Cedar District Formation, West Shoreline of Denman Island

Both *A.* (*T.*) *demessa* and *A.* (*Truncacila*) ***grahami,*** sp. nov., occur in mudstone exposed in an intertidal bench at Locality 4 on the west-central shoreline of Denman Island, off the east coast of Vancouver Island, British Columbia (Figure 1, locale 2). The latest geologic map of this island shows these exposures to be part of the Cedar District Formation of the Nanaimo Group (Katnick & Mustard, 2001). Mustard et al. (2003) reported that this formation along the west side of Denman Island consists of proximal-turbidite deposits in lower and middle submarine-fan complexes. Mustard (1994:table A6) reported that megafossils found in these turbidite deposits include resedimented shallow-water taxa. All the acilid specimens collected from Locality 4 are single valves, and although this suggests that they might have been resedimented, taphonomic studies are needed.

Mustard et al. (2003:127) reported that molluscan fossils found locally in the Cedar District Formation on the west side of Denman Island indicate a late Campanian age. Mollusks found at Locality 4 include the ammonites *Metaplacenticeras* cf. *pacificum* (Smith, 1900) and *Desmophyllites diphylloides* (Forbes, 1846). The *Metaplacenticeras pacificum* biozone is of late middle to early late Campanian age (Elder & Saul, 1996:fig. 1), and the geologic range of *D. diphylloides* is "relatively long, covering most of the Campanian" (Matsumoto, 1959:10). The Cedar District Formation ranges in age from early to middle late Campanian (Jeletzky, 1970; Ward, 1978;

Haggart, 1991b), therefore, the strata at Locality 4 belong to the upper part of this formation. Enkin et al. (2001: figs. 3, 4) took paleomagnetic samples from the immediate vicinity of Locality 4 and determined that these samples represent sediments deposited sometime during the 33 N (normal) polarity interval, which is equivalent to the middle to early late Campanian (see Figure 2). Based on the molluscan and paleomagnetic data, therefore, the age of the fossils at Locality 4 can be assigned a late middle to early late Campanian age.

Moonlight Formation?

A few specimens of *Acila* spp. were detected in two collections made from muddy siltstones exposed in a small area on the north side of Shale Hills, southwest side of Antelope Valley, eastern Temblor Range, Kern County, south-central California (Figure 1, locale 19). CAS loc. 1552 yielded a specimen of *Acila* (*Truncacila*) ***rosaria***, sp. nov., and a specimen of *A.* (*T.*) ***grahami***. CAS loc. 69095 yielded another specimen of *Acila* (*T.*) ***rosaria***. These muddy siltstones were mapped by English (1921: pl. 1), who described them as being a soft clay shale. They are most likely correlative to the shallow-marine siltstone facies of the Moonlight Formation, which crops out on the other side of Antelope Valley (Marsh, 1960: pl. 1). This facies, which is soft and clayey, closely resembles the rocks described by English. Matsumoto (1959:11; 1960:63) noted that the ammonite *Baculites rex* Anderson, 1958, is found at CAS loc. 1552, and this biozone is early late Campanian in age (Elder & Saul, 1996: fig. 1).

Northumberland Formation at Collishaw Point, North End of Hornby Island

The type locality of *Acila* (*T.*) ***grahami*** occurs in mudstone exposed in an intertidal bench at Locality 3 at Collishaw Point, north end of Hornby Island, off the east coast of Vancouver Island, British Columbia (Figure 1, locale 2). The latest geologic work done on the Collishaw Point outcrops is that of Katnick & Mustard (2001, 2003) and Mustard et al. (2003). These workers assigned the mudstone in question to the Northumberland Formation of the Nanaimo Group. In Mustard et al. (2003:figs. 23, 24), Collishaw Point is also mentioned as a field-trip stop, and reports dealing with the fossils (including ammonites, inoceramids, and shark teeth) from this locale have been summarized by these authors. The beds there consist of silty mudstones intercalated with less common sandstone beds of turbidite origin. The *A.* (*T.*) ***grahami*** material is from a "thin lens of what appears to be a debris flow containing abundant shell fragments, numerous and diverse shark teeth, and rare bird bones" (R. Graham, personal commun.). No studies have been done yet on the depositional environment or of the taphonomy of the fossils found in this particular lens. All the specimens of *A.* (*T.*) ***grahami*** are single valves, and they appear to be unabraded.

In spite of the presence of ammonites and inoceramids in the beds at Collishaw Point, there is no consensus on the age of these beds. As summarized by Mustard et al. (2003), the age has been variously reported as either latest Campanian or early Maastrichtian, and further work is needed to resolve this age disagreement.

As mentioned under the discussion of the Haida Formation, the amount of tectonic displacement that Vancouver Island (which is part of the Insular Superterrane) has undergone is controversial. As summarized by Enkin et al. (2001), sedimentologic and paleontological evidence, as well as some paleomagnetic studies (Kodama & Ward, 2001), indicate that the Nanaimo Group of Vancouver Island was deposited near its present northern position, whereas other paleomagnetic studies indicate that these sediments were deposited near the modern-day location of Baja California (Enkin et al., 2001).

Moreno Formation

This formation crops out along the western side of the San Joaquin Valley, central California (Figure 1, locales 15 and 16) and is a clastic sedimentary sequence that records the shoaling of the central San Joaquin basin from deep water to shelf depths. The formation, which is time-transgressive (Saul, 1983), consists of four members that span an interval from the Maastrichtian through early Danian (Paleocene) (McGuire, 1988). Members revelant to this report are the Tierra Loma and the supradjacent Marca Shale; both are discussed below.

Tierra Loma Member

This member, which crops out south of Los Banos, southwestern Merced County, California, consists mainly of muddy siltstones and turbidites containing irregularly interbedded, channelized sandstones (McGuire, 1988). One of these channelized sandstones, approximately in the middle of the Tierra Loma Member, was referred to by Schenck (1943) and Payne (1951) as the Mercy sandstone lentil. The type locality of *A.* (*T.*) *princeps* occurs within this lentil, and this locality was plotted on geologic maps by Schenck (1943:fig. 1) and by Payne (1951:fig. 2).

Acila (*T.*) ***rosaria*** also occurs in the Tierra Loma Member, and deposition of this member took place in an oxygen-deficient, lower to upper slope environment (McGuire, 1988). Specimens of this bivalve occur as a few single valves. Detailed work is needed to determine if these specimens are in situ or have undergone post-mortem transport from a shallower water environment.

Saul (1983) and Squires & Saul (2003a) discussed the geologic age of the Tierra Loma Member, which is late early to early late Maastrichtian age, based on turritellas, bivalves, and ammonites.

Marca Shale Member

This member crops out for a distance of approximately 20 km (in northwestern Fresno County) southward of where the Mercy sandstone lentil (see above) lenses out. The Marca Shale Member gradationally overlies the Tierra Loma Member and consists of 80 to 95 m of finely laminated siliceous shale and diatomaceous shale that accumulated in a gently inclined, upper slope environment under intense anoxic conditions associated with an upwelling system (McGuire, 1988). According to Payne (1951), at the top and bottom of this member, there are white, hard, calcareous concretions containing a few poorly preserved megafossils. A few specimens of *Acila* (*T.*) ***grahami*** have been collected from the Marca Shale Member. Only one specimen (Figure 32) is conjoined, and it is in a matrix of diatomaceous shale. It is unlikely that this specimen underwent any post-mortem transport by means of a turbidity current, because, according to McGuire (1988), there is a complete absence of any sandstone or other coarse terrigenous sediment in the Marca lentil. This absence indicates that the slope environment on which this unit accumulated was isolated from the source(s) of sands found in all other members of the Moreno Formation.

According to Saul (1983:fig. 10), the Marca Shale contains the ammonite *Trachybaculites columna* (Morton, 1834). This ammonite, which is an intracontinental zonal indicator of late early to early late Maastrichtian age (Cobban & Kennedy, 1995), also occurs in the underlying Tierra Loma Shale (see Squires & Saul, 2003b). Although the age of the Marca Shale is approximately the same age as that of the Tierra Loma Member, the Marca Shale is slightly younger because of its stratigraphic position.

Panoche Formation at Franklin Canyon

This formation crops out in Franklin Canyon in the Franklin Ridge area (Dibblee, 1980) just west of Martinez, Contra Costa County, northern California (Figure 1, locale 13). Weaver (1953) provided a faunal list of mollusks found in these rocks, and at a few localities he listed "*Acila* (*T.*) *demessa*" in association with the bivalve *Meekia sella* Gabb, 1864. Saul (1983:fig. 4) showed *Meekia sella* to range from early to late Maastrichtian (67 Ma), but not into the latest Maastrichtian. The only specimen of *Acila* we were able to find in any museum collection that was derived from this area was Schenck's (1943) specimen (hypotype CAS 69086.02) of *Acila* sp. D. This specimen is identified herein as *A.* (*T.*) *princeps* and is illustrated in Figure 46.

El Piojo Formation

This formation crops out in the vicinity of Lake Nacimiento, San Luis Obispo County, west-central California (Figure 1, locale 18) and consists mainly of sandstone (Seiders, 1989). No detailed depositional-environment studies have been done on this formation. Although molluscan fossils are uncommon in this formation, Saul (1986b) studied the mollusks from LACMIP loc. 30141 and reported them to be of early late Maastrichtian age, including a single specimen of *Acila* sp. Additional cleaning of this specimen revealed it to be *Acila* (*Truncacila*) *princeps*.

Deer Valley Formation

Two specimens of *Acila* (*Truncacila*) *princeps* were detected in the LACMIP collection from very fine-grained sandstone in Deer Valley on the north flank of Mount Diablo, Contra Costa County, northern California (Figure 1, locale 14). This sandstone is in Colburn's (1964) informal Deer Valley formation, which, according to him, was deposited in a nearshore, above wave base, open-ocean environment. Colburn (1964) also mentioned the presence of *A.* (*T.*) *princeps* in this formation. Based on the presence of the bivalves *Meekia sella* Gabb, 1864, and *Calva* (*Calva*) *varians* (Gabb, 1864), this sandstone can be assigned to the upper Maastrichtian (Saul & Popenoe, 1962, 1992).

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Linnaeus, 1758

Class BIVALVIA Linnaeus, 1758

Order NUCULOIDEA Dall, 1889

Superfamily NUCULOIDEA J. E. Gray, 1824

Family NUCULIDAE J. E. Gray, 1824

Genus *Acila* H. Adams & A. Adams, 1858

Type species: *Nucula divaricata* Hinds, 1843, by subsequent designation (Stolickza, 1871); Recent, China.

Discussion: Like other nuculids, *Acila* has a posteriorly truncate, nacreous shell with opisthogyrate beaks, and an internal ligament in a resilifer. Three subgenera have been named: *Acila* sensu stricto, which ranges from Oligocene to Recent (Keen, 1969); *Lacia* Slodkevich, 1967, which ranges from late Eocene to late Pliocene (Slodkevich, 1967); and *Truncacila* Grant & Gale, 1931, which ranges from Early Cretaceous (late Aptian) to Recent (Schenck, 1936). *Acila* s.s. is characterized by large size, well-defined rostral sinus, a rostrate (protruding) posterior end, and strong divaricate ornamentation (Schenck, 1935b; Keen, 1969; Slodkevich, 1967; Addicott, 1976; Coan et al., 2000). *Lacia* is characterized by a very poorly defined rostral sinus. The characteristics of *Truncacila* are mentioned below.

Table 1

Check list of key morphologic characters used in differentiating the studied species.

Species	Shell size	#Ribs/ valve (approx.)	Divarication on venter	Other*
allisoni	small	55	central	roundly subquadrate; ribs very narrow, interspaces approximately ⅓ as wide; escutcheonal ribs continuous with ribs on disk
n. sp.?	medium	55	anterior	quadrate; ribs narrow, interspaces approximately ⅓ as wide
haidana	medium	40	usually central	usually subquadrate; ribs very narrow to narrow, interspaces ⅓ approximately ⅓ as wide to same width as ribs
demessa	medium	70	anterior	ribs flat and very narrow to moderately wide, interspaces approximately ⅕ to ⅓ as wide; escutcheonal area bounded by smooth groove
grahami	small	50	usually anterior	can be trigonal; ribs narrow to moderately wide, interspaces approximately ⅓ to ½ as wide; escutcheonal ribs continuous with ribs on disk
rosaria	medium	80	anterior	shell weakly rostrate postero-ventrally; ribs very narrow to narrow, interspaces approximately ¼ as wide to same width as ribs; escutcheon bounded by flattish to shallowly grooved area usually crossed by ribs not continuous with ribs on disk
princeps	large	85	anterior	subquadrate, rarely trigonal; ribs flat and narrow to wide, interspaces approximately ⅕ to ¼ as wide

* Rib and interspace information pertains only to the area posterior to chevron-bisecting line on adult specimens; umbo and ventral-margin regions are excluded.

Subgenus *Truncacila* Grant & Gale, 1931

Type species: *Nucula castrensis* Hinds, 1843, by original designation; Pliocene to Recent, northeastern Pacific.

Discussion: *Truncacila* is characterized by small size, relative to other acilids, and an absence of a rostral sinus (Slodkevich, 1967; Coan et al., 2000). Although *Truncacila* has been reported as lacking a rostrate posterior end (Slodkevich, 1967; Coan et al., 2000), it can have a small rostration at the point of meeting of the ventral and posterior margins (Stoyanow, 1949:62). *Acila (T.)* ***rosaria*** has such a rostration. So do some of the subquadrate forms of *A. (T.) demessa* and *A. (T.)* ***grahami***, as well as the best preserved specimens of *A. (T.) princeps*.

The key characters of the studied species are given in Table 1.

Acila (Truncacila) ***allisoni*** Squires & Saul, sp. nov.

(Figures 3–8)

Acila (Truncacila) bivirgata (Sowerby). Allison, 1974:tables 4, 6, 7.

Not *Acila (Truncacila) bivirgata* (J. de C. Sowerby, 1836: 335, pl. 11, fig. 8).

Diagnosis: Shell small, roundly subquadrate. Chevrons bisected by line meeting center of ventral margin. Total number of ribs on disk of each valve approximately 55; ribs (posterior of chevron-bisecting line) very narrow, with interspaces approximately ⅓ as wide. Escutcheonal ribs continuous with ribs on disk.

Description: Shell small for subgenus (up to 12.1 mm in height and 15.5 mm in length), longer than high, height/length ratio = 0.78. Roundly subquadrate, inequilateral, equivalved, valves moderately inflated. Anterior end broadly rounded. Antero-dorsal margin long and straight. Posterior margin truncate and set off from escutcheon by moderately strong rostration. Ventral margin convex. Umbones low, located posteriorly; umbonal angle 98 to 116°. Beaks pointed, incurved, opisthogyrate. Disk broad, ornamented with abundant ribs diverging from umbo area and forming chevron-shaped (divaricate) pattern. Chevron angle 38 to 47°. Chevrons bisected by line extending from slightly anterior of umbo to center of ventral margin; ribs anterior to bisecting line 23 to 34; ribs posterior to bisecting line 24 to 33 (excluding occasional short bifurcations near ventral margin). Total number of ribs on disk of each valve usually approximately 55; ribs very narrow with interspaces approximately ⅓ as wide, except anterior of chevron-bisecting line, where ribs become slightly wider, occasionally wavy, and more widely spaced. Growth checks irregularly spaced from medial part of disk to ventral margin. Escutcheon moderately prominent, slightly sunken, and bounded by shallow groove crossed by very narrow ribs continuous with ribs on disk; ribs stronger (approximately same strength as those on disk) on elevated central part of escutcheonal area. Hinge with at least 14 anterior taxodont teeth and 11 posterior taxodont teeth. Resilifer opisthocline, narrow.

Dimensions of holotype: Conjoined valves (partial right