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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

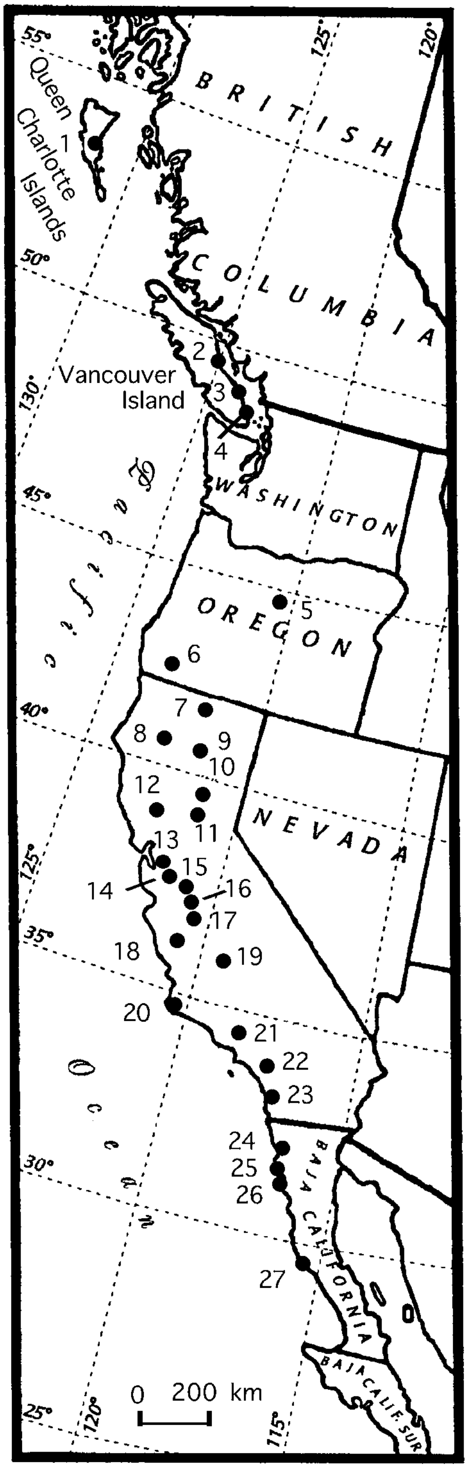


Figure 1. Index map showing locales mentioned in text. 1 = Skidegate Inlet, Queen Charlotte Islands. 2 = Hornby and Denman islands. 3 = Nanaimo area. 4 = Chemainus River and Saltspring Island areas. 5 = Mitchell and Antone areas. 6 = Phoenix. 7 = Yreka. 8 = Ono. 9 = Redding area. 10 = Chico Creek. 11 = 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-

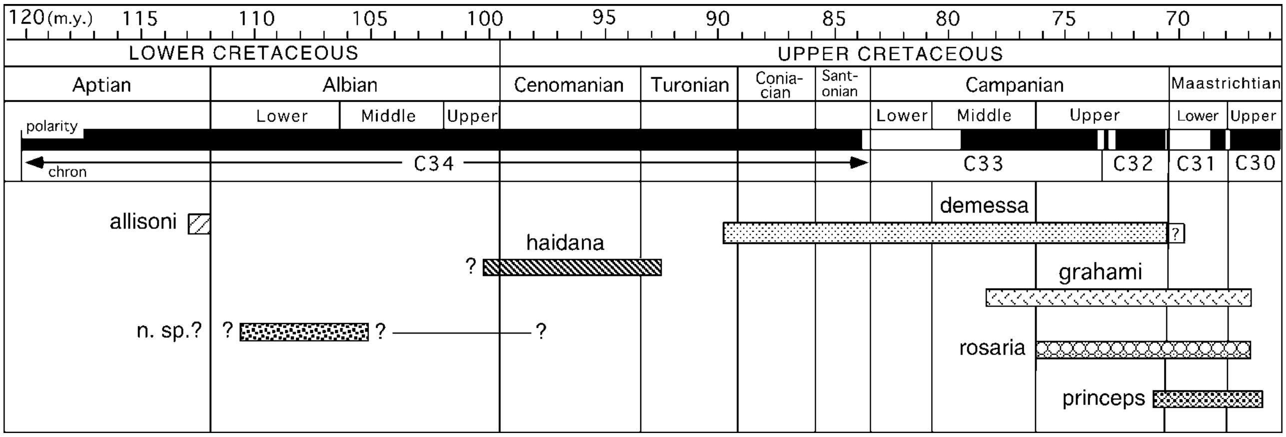


Figure 2. Chronostratigraphic positions of the new and restudied *Acila* (*Truncacila*) species. Geologic ages, geomagnetic polarities (black = normal, white = reversed), and chrons from Gradstein & Ogg (2004:fig. 2).

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 1/3 as wide; escutcheonal ribs continuous with ribs on disk
n. sp.?	medium	55	anterior	quadrate; ribs narrow, interspaces approximately 1/3 as wide
haidana	medium	40	usually central	usually subquadrate; ribs very narrow to narrow, interspaces 1/3 approximately 1/3 as wide to same width as ribs
demessa	medium	70	anterior	ribs flat and very narrow to moderately wide, interspaces approximately 1/5 to 1/3 as wide; escutcheonal area bounded by smooth groove
grahami	small	50	usually anterior	can be trigonal; ribs narrow to moderately wide, interspaces approximately 1/3 to 1/2 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 1/4 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 1/5 to 1/4 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)

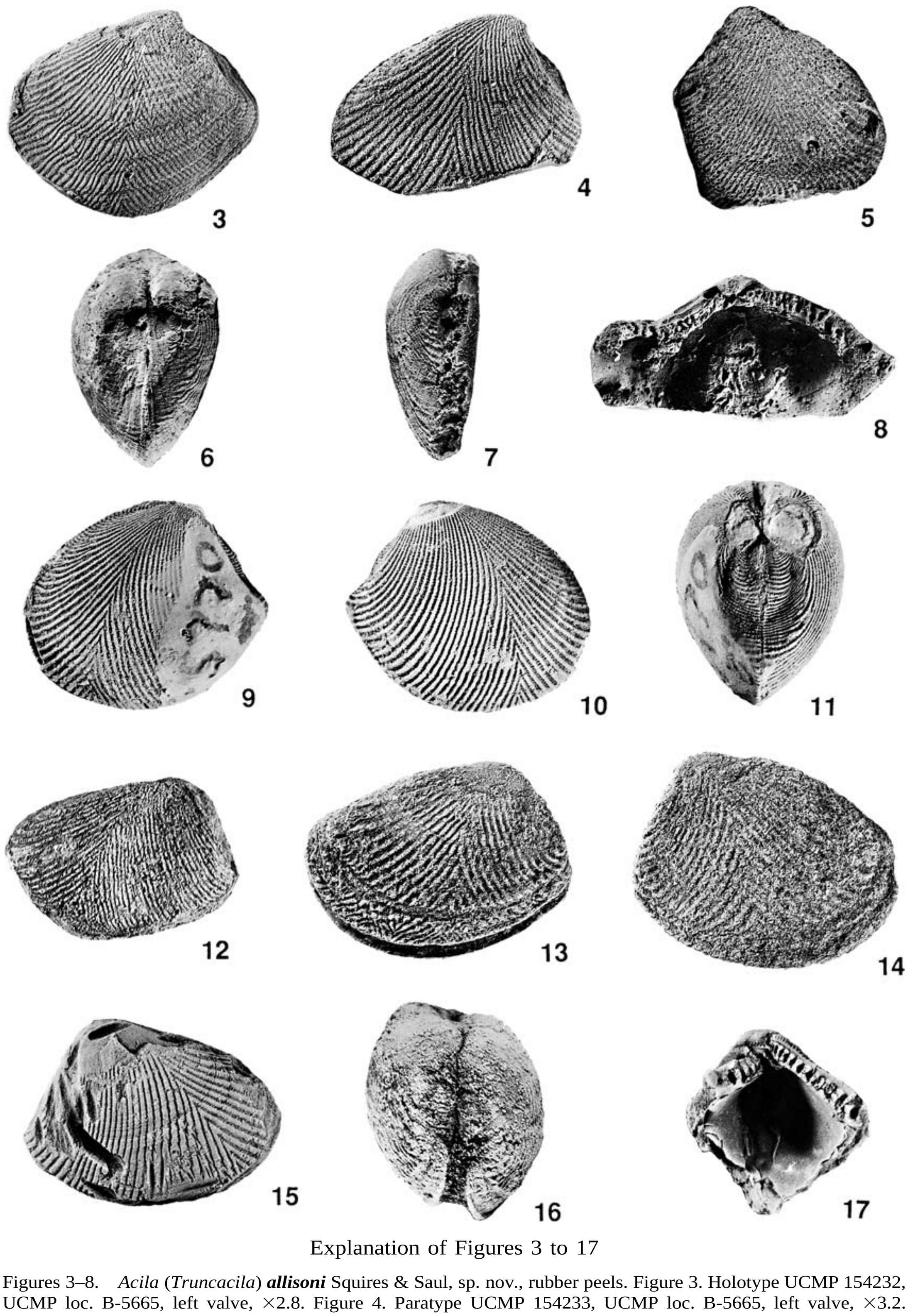
Acila (*Truncacila*) *bivirgata* (Sowerby). Allison, 1974:tables 4, 6, 7.

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



Explanation of Figures 3 to 17

Figures 3–8. *Acila* (*Truncacila*) ***allisoni*** Squires & Saul, sp. nov., rubber peels. Figure 3. Holotype UCMP 154232, UCMP loc. B-5665, left valve, ×2.8. Figure 4. Paratype UCMP 154233, UCMP loc. B-5665, left valve, ×3.2. Figure 5. Paratype UCMP 154234, UCMP loc. A-6275, right valve, ×2.8. Figure 6. Holotype UCMP 154232, UCMP loc. B-5665, posterior view, ×3. Figure 7. Paratype UCMP 154233, UCMP loc. B-5665, posterior view of valve), height 12.1 mm, length 15.5 mm (incomplete), thickness 7.8 mm (approximate).

Holotype: UCMP 154232.

Type locality: UCMP B-5665, near Punta China, Baja California, Mexico, 31°30′N, 116°40′W.

Paratypes: UCMP 154233, 154234, 154235.

Geologic age: Late Aptian.

Distribution: Alisitos Formation, Baja California, Mexico.

Discussion: The above description of the new species is based on eight rubber peels: one left valve, three right valves, two with conjoined valves, and two partial hinges.

The new species is most similar to *Acila* (*Truncacila*) *bivirgata* (J. de C. Sowerby, 1836:335, pl. 11, fig. 8) from upper Aptian strata of England. The similarity is close enough for Allison (1974) to have identified as Sowerby's species specimens from the Alisitos Formation. Illustrations (Figures 9–11) of *A.* (*T.*) *bivirgata* are herein provided for comparison, and this is the same specimen used in Schenck (1936:47, pl. 2, figs. 1, 2). The new species differs from *A.* (*T.*) *bivirgata* by having the line bisecting the chevrons located nearer the center of the ventral margin, slightly wider ribs, narrower interspaces, and a less sunken escutcheon.

The new species differs from *Acila* (*T.*) *schencki* Stoyanow (1949:61–63, pl. 8, figs. 1–8), the only other Aptian acilid known from western North America, by having more numerous and narrower ribs (especially on the anterior half of the disk), no tendency for the line bisecting the chevrons to be slightly anterior of the center of the ventral margin, and an absence of strong curvature dorsally of the ribs near the anterior edge of the disk.

Etymology: Named for the late E. C. Allison, in recognition of his extensive collecting of mollusks from the Alisitos Formation.

Acila (*Truncacila*), sp. nov.?

(Figure 12)

Acila (*Truncacila*) sp. A. Schenck, 1936:51, pl. 2, fig. 13.

Diagnosis: Shell medium, quadrate. Chevrons bisected by line meeting ventral margin near meeting of anterior end and ventral margin. Total number of ribs on disk of left valve approximately 55; ribs (posterior of chevron-bisecting line) narrow, with interspaces approximately ⅓ as wide.

Description: Shell medium for subgenus (14.2 mm in height and 21.2 mm in length), longer than high, height/length ratio = 0.67. Quadrate, inequilateral, equivalved, valves moderately inflated. Anterior end broadly rounded. Antero-dorsal margin long and straight, generally parallel to ventral margin. Posterior end straight, truncate. Umbones low, located posteriorly; umbonal angle 100°. Disk broad, ornamented with abundant ribs diverging from umbo area and forming chevron-shaped (divaricate) pattern. Chevron angle 55°. Chevrons bisected by line extending from slightly anterior of umbo to point located near where anterior end and ventral margins meet; ribs anterior to bisecting line about 21; ribs posterior to bisecting line about 34 (excluding occasional short bifurcations near ventral margin). Total number of ribs on disk usually approximately 55; ribs narrow with interspaces approximately ⅓ as wide, except anterior of chevron-bisecting line, where ribs become more widely spaced.

Geologic age: Early Albian or early middle Albian, possibly Cenomanian.

Distribution: POSSIBLY LOWER ALBIAN: Budden Canyon Formation, upper lower Chickabally Mudstone Member, Ono area, Shasta County, northern California. LOWER ALBIAN OR LOWER MIDDLE ALBIAN: Hudspeth Formation, lower part of ''Main Mudstone member,'' near Mitchell, Wheeler County, northeast-central Oregon. POSSIBLY CENOMANIAN: Unnamed strata, near Antone, Wheeler County, northeast-central Oregon.

Discussion: The possible new species is known only from a single specimen (hypotype CAS 69097 = UO 6000), a left valve (height 14.2 mm, length 21.2 mm), the posterior end of which is not preserved. This hypotype is the only moderately well preserved specimen of *Acila* of Albian age known from the study area. It is likely that this species is new, but until more specimens are discovered, we are reluctant to name it.

A possible record of *A.* (*T.*) sp. nov.? is a latex peel of a fragment from CAS loc. 69110 in the upper lower Chickabally Mudstone Member of the Budden Canyon

←

left valve, ×4. Figure 8. Paratype UCMP 154235, UCMP loc. A-6275, right-valve hinge, ×3.7. Figures 9–11. *Acila* (*Truncacila*) *bivirgata* (J. de C. Sowerby, 1836), CAS hypotype 5770, Gault Formation, Folkestone, England, ×3.7. Figure 9. Left valve. Figure 10. Right valve. Figure 11. Posterior view. Figure 12. *Acila* (*Truncacila*) sp. nov.?, hypotype CAS 69087, UO loc. 461, left valve, ×1.8. Figures 13–17. *Acila* (*Truncacila*) *haidana* Packard in Schenck, 1936, CAS loc. 69080. Figure 13. Holotype CAS 69081, left valve, ×3. Figure 14. Paratype CAS 69080.01, left valve, ×2.8. Figure 15. Hypotype LACMIP 13227, LACMIP loc. 24365, right valve, ×3.4. Figure 16. Holotype CAS 69081, posterior view, ×3. Figure 17. Hypotype CAS 69106.03, LACMIP loc. 23950, partial right-valve hinge, ×4.8.

Formation in the Huling Creek area, southwest of Redding, Shasta County, northern California. Jones et al. (1965) assigned these rocks to the early Albian. Another possible record of *A.* (*T.*) sp. nov.? is a plastic replica of a partial specimen from unnamed strata at UCMP loc. 814 south of Antone, between Rock Creek and Spanish Gulch, Wheeler County, northeast-central Oregon. Popenoe et al., (1960:column 54 of chart 10e) assigned rocks from this area to the Cenomanian.

Acila (*T.*) sp. nov.? is similar to *A.* (*T.*) ***rosaria*** but differs by having a truncate posterior end, usually slightly wider ribs, and slightly wider spaced ribs. *Acila* (*T.*) sp. nov.? is somewhat similar to *A.* (*T.*) ***allisoni*** but differs by having a larger size, more widely spaced ribs that are never wavy, uniform-rib strength over the entire disk, and chevrons bisected by a line located anterior of center of ventral margin.

Acila (*Truncacila*) *haidana* Packard in Schenck, 1936

(Figures 13–17)

Acila (*Truncacila*) *demessa* Finlay, var. *haidana* Packard in Schenck, 1936:50–51, pl. 2, figs. 3, 4, 6, 10.
?*Nucula* (*Acila*) *truncata* Gabb. Whiteaves, 1884:232.

Diagnosis: Shell small, subquadrate (usually) to elliptical. Chevrons bisected by line usually meeting center of ventral margin (rarely to anterior of center). Total number of ribs on disk of each valve approximately 40; ribs (posterior of chevron-bisecting line) very narrow to narrow, with interspaces ⅓ as wide to same width as ribs.

Description: Shell small for subgenus (up 14.4 mm in height and 16.7 mm in length), longer than high, height/length ratio = 0.73 to 0.86. Subquadrate (usually) to elliptical, inequilateral, equivalved, valves moderately inflated. Antero-dorsal margin long, straight to lowly convex. Posterior end truncate and set off from escutcheon by weak rostration. Ventral margin convex. Umbones low, located posteriorly; umbonal angle 101 to 116°. Beaks pointed, opisthogryate. Disk broad, ornamented with abundant ribs diverging from umbo area and forming chevron-shaped (divaricate) pattern. Chevron angle 46 to 59°. Chevrons bisected by line extending from slightly anterior of umbo to center (rarely anterior) of ventral margin; ribs anterior to bisecting line 18 to 20, ribs posterior to bisecting line about 20 to 28. Secondary divarication rare, only on specimens with anteriorly located divarication. Total number of ribs on disk of each valve usually approximately 40; ribs very narrow to narrow, with interspaces approximately ⅓ as wide to same width as ribs, except anterior of chevron-bisecting line, where ribs become wider and more widely spaced. Growth checks near ventral margin or absent. Escutcheon moderately prominent, slightly sunken, and crossed by narrow ribs. Hinge with at least 18 anterior taxodont teeth and, at least, six posterior taxodont teeth. Resilifer opisthocline, narrow.

Dimensions of holotype: Conjoined valves (partially open), height 11.5 mm, length 15.7 mm, thickness 9 mm (taking into account the partial opening).

Holotype: CAS 69081 [= CAS 5090].

Type locality: CAS 69080, just east of Queen Charlotte City, Bearskin Bay, Skidegate Inlet region, Queen Charlotte Islands, British Columbia.

Paratypes: CAS 69080.01 [= CAS 5091] and CAS 69080.02 [= CAS 5092].

Geologic age: Latest Albian (probably) to early Turonian.

Distribution: UPPERMOST ALBIAN (PROBABLY) TO CENOMANIAN: Haida Formation, just east of Queen Charlotte City, Bearskin Bay, Skidegate Inlet region, Queen Charlotte Islands, northern British Columbia. LOWER TURONIAN: Hornbrook Formation, Osburger Gulch Member, Jackson County, southern Oregon; Redding Formation, Frazier Siltstone, Shasta County, northern California; Cortina formation (informal), Venado Sandstone Member, near Sites, Colusa County, northern California; Panoche Formation, Garzas Creek, Stanislaus County, north-central California.

Discussion: The above description of this species is based on eight specimens: one left valve, six right valves, and one with conjoined valves. The escutcheonal area is poorly preserved on all of these specimens.

Whiteaves (1884:232) reported one specimen of *Nucula* (*Acila*) *truncata* Gabb, 1864, from the type locality area of *A.* (*T.*) *haidana* and one specimen from the vicinity of Alliford Bay, also in the Skidegate Inlet region, Queen Charlotte Islands. Whiteaves, unfortunately, did not figure these specimens, nor could they be located by us in any museum collection. Based on their geographic occurrence, however, it is most likely that they are *A.* (*T.*) *haidana.*

Schenck (1936:50) included tentatively ''?*Nucula* (*Acila*) *truncata* Gabb. Whiteaves, 1879:162; 1903:389–390,'' in his synonymy of *A.* (*T.*) *haidana*, but Whiteaves reported that these specimens were collected at localities on 1) the northwest side of Hornby Island, 2) the southwest side of Denman Island, Vancouver Island, and 3) Sucia Island, Washington. All of these localities occur in the Nanaimo Group. Both *A.* (*T.*) *demessa* and *A.* (*T.*) ***grahami*** are herein recognized from this group, but *A.* (*T.*) *haidana* is not. It does not seem likely, therefore, that these Nanaimo Group specimens of Whiteaves (1879, 1903) should be identified as *A.* (*T.*) *haidana.* Whiteaves, furthermore, provided no type numbers and no illustrations of these specimens. In addition, Bolton (1965) did not list type numbers from them. Additionally, none of them is part of the GSC collection.

One specimen of *Acila* (*T.*) *haidana* is from USGS loc. M-175 near Sites, Colusa County, northern California. Although this locality is usually reported as being in the upper part of the Cenomanian Antelope Shale, Popenoe et al. (1987:79) reported that some of the fossils at this particular locality probably slumped from the overlying basal Venado Formation of early Turonian age. We concur, based on the presence of the following Turonian gastropods found with the *Acila* (*T.*) *haidana* specimen: *Gyrodes* (?*Sohlella*) *yolensis* Popenoe et al., 1987 and *Gyrodes* (*Gyrodes*) *dowelli* White, 1889.

Acila (*Truncacila*) *demessa* Finlay, 1927

(Figures 18–26)

Nucula truncata Gabb, 1864:198, pl. 26, figs. 184, 184a, 184b.
not *Nucula truncata* Nilsson, 1827:16, pl. 5, fig. 6.
Acila demessa Finlay, 1927:522 (new name for *Nucula truncata* Gabb, not Nilsson); Stewart, 1930:45, pl. 3, fig. 6.
Acila (*Trunacila*) *demessa* Finlay. Schenck, 1936:48–50, pl. 2, figs. 5, 7, 8, 9, text-fig. 7; 1943:pl. 8, fig. 5; pl. 9, figs. 1, 3, 7.
Acila shumardi Dall. Ludvigsen & Beard, 1994:90, fig. 54 (in part); 1997:110, fig. 65 (in part).
?*Nucula* (*Acila*) *truncata* Gabb. Whiteaves, 1879:162 (in part); 1903:389–390 (in part).

Diagnosis: Shell medium, subtrigonal to subquadrate. Chevrons bisected by line meeting ventral-margin anterior. Total number of ribs on disk of each valve approximately 70; ribs (posterior of chevron-bisecting line) flat and very narrow to moderately wide, with interspaces approximately ⅕ to ⅓ as wide. Escutcheon bounded by smooth area not crossed by ribs.

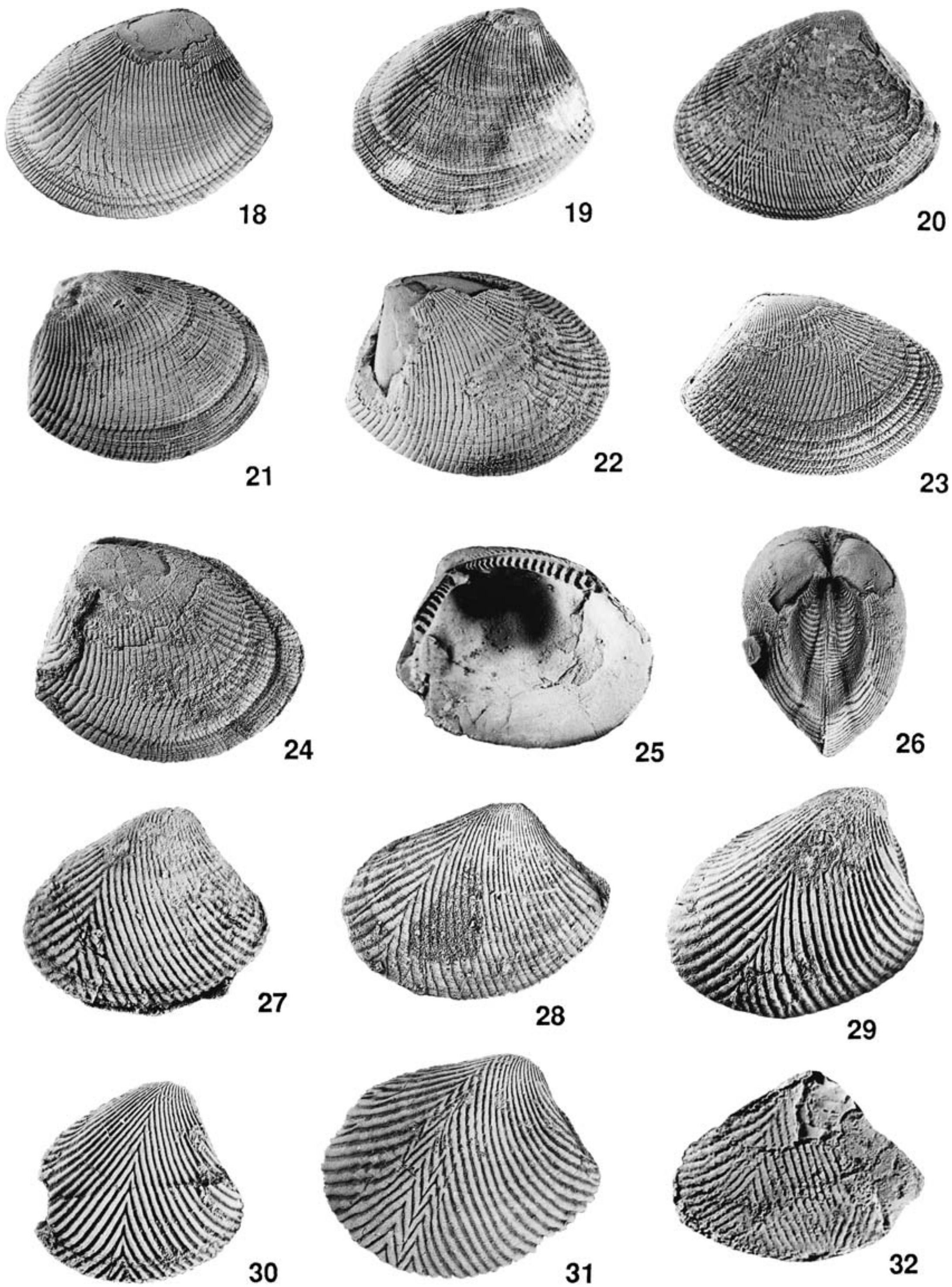
Description: Shell medium for subgenus (up to 20.4 mm in height and 26.5 mm in length, most specimens approximately 13 mm in height and 16 mm in length), longer than high, height/length ratio = 0.72 to 0.89. Subtrigonal to subquadrate; inequilateral, equivalved, valves moderately inflated. Anterior end broadly rounded. Antero-dorsal margin long, straight to convex. Posterior end straight, abruptly truncate and set off from escutcheon by weak rostration. Ventral margin convex. Umbones low, located posteriorly; umbonal angle 103 to 117°. Beaks pointed, incurved, opisthogyrate. Disk very broad, ornamented with abundant ribs diverging from umbo area and forming chevron-shaped (divaricate) pattern. Chevron angle approximately 30 to 34°. Secondary development of chevrons on few specimens. Chevrons bisected by line extending from slightly anterior of umbo to center of ventral margin; ribs anterior to bisecting line 22 to 39 (excluding occasional bifurcations near where anterior and ventral margins meet), ribs posterior to bisecting line 26 to 47. Total number of ribs on disk of each valve usually approximately 70; ribs flat and very narrow to moderately wide, with interspaces approximately ⅕ to ⅓ as wide, except anterior of chevron-bisecting line, where ribs become wider and more widely spaced. Growth checks near ventral margin common on some specimens and associated, from about ⅓ of distance from posterior end to where anterior end meets ventral margin, with bifurcation of ribs into riblets and riblet insertion. Prominent growth checks, corresponding to same position on each valve, occasionally continue across escutcheon area to beaks. Ventral-margin edge and inner margin (for short distance) finely crenulate. Escutcheon prominent, sunken, and bounded by shallow groove not crossed by ribs; narrow ribs present on slightly inflated central part of escutcheonal area. Interior nacreous. Adductor scars well delineated. Left-valve hinge with approximately 11 posterior taxodont teeth, similar in form, becoming stronger posteriorly; approximately 23 anterior taxodont teeth, similar in form, becoming stronger anteriorly. Resilifer narrow, opisthocline; bordered posteriorly by strong, high tooth.

Lectotype: ANSP 4417 (designated by Stewart, 1930: 46).

Type locality: Pentz, Butte County, northern California.

Geologic age: Late Turonian to late late Campanian and possibly early Maastrichtian.

Distribution: UPPER TURONIAN: Budden Canyon Formation, Gas Point Member, Shasta County, northern California; Ladd Formation, Baker Canyon Member to Holz Shale Member transition, Santa Ana Mountains, Orange County, southern California. CONIACIAN: Redding Formation, Member V, upper part, Shasta County, northern California. LOWER SANTONIAN: Redding Formation, Member V, Shasta County, northern California. UPPER SANTONIAN: Haslam Formation, lower part, Chemanius River, near Nanaimo, Vancouver Island, British Columbia; Haslam Formation, lower part, Saltspring Island, British Columbia; Redding Formation, Member VI?, Shasta County, northern California; Chico Formation, Musty Buck Member, Butte County, northern California. SANTONIAN UNDIFFERENTIATED: Panoche Formation, Merced County, north-central California. UPPER SANTONIAN/LOWERMOST CAMPANIAN: Haslam Formation, upper part, Brannen Lake, near Nanaimo, Vancouver Island, British Columbia. LOWER CAMPANIAN: Chico Formation, Ten Mile Member, Butte County, northern California; Chico Formation, Pentz Road member (informal), Butte County, northern California; Ladd Formation, upper Holz Shale member, Santa Ana Mountains, Orange County, southern California. LOWER MIDDLE CAMPANIAN: Ladd Formation, upper Holz Shale Member, Santa Ana Mountains, Orange County, southern California. UPPER MIDDLE TO LOWER UPPER CAMPANIAN: Cedar District Formation, upper part, west shoreline of Denman Island off east coast of Vancouver Island, British Columbia. Chatsworth Formation, Dayton and Bell canyons, Simi Hills, Ventura



Explanation of Figures 18 to 32

Figures 18–26. *Acila* (*Truncacila*) *demessa* Finlay, 1927. Figure 18. Hypotype LACMIP 13228, LACMIP loc. 10835, left valve, ×2.6. Figure 19. Hypotype LACMIP 13229, LACMIP loc. 17611, left valve, ×2.6. Figure 20. Hypotype RBCM.EH2003.009.0001, Locality 1, left valve, ×1.7. Figure 21. Hypotype LACMIP 13229, LACMIP loc. 17611, right valve, ×2.6. Figure 22. Hypotype LACMIP 13230, LACMIP loc. 10832, right valve, ×2.7.

County, southern California; Williams Formation, Pleasants Sandstone Member, Santa Ana Mountains, Orange County, southern California. LOWER UPPER CAMPANIAN: Jalama Formation, Santa Barbara County, southern California. UPPER UPPER CAMPANIAN TO POSSIBLY LOWER MAASTRICHITAN: Rosario Formation at Punta San Jose and San Antonio del Mar, Baja California, Mexico.

Discussion: The above description is based on 847 specimens: 320 left valves, 356 right valves, and 171 with conjoined valves.

Our study revealed, for the first time, that on *A.* (*T.*) *demessa*, ribs commonly bifurcate into riblets near the ventral margin, the left-valve hinge has approximately 11 posterior teeth, and the right-valve hinge has approximately 18 anterior teeth.

Schenck (1936:48–50) reported *A.* (*T.*) *demessa* (from strata now referred to as the Rosario Formation) at Punta Banda and San Antonio del Mar, Baja California (Figure 1, locales 25 and 26, respectively). Only his San Antonio del Mar specimen is *A.* (*T.*) *demessa.* His Punta Banda specimen (hypotype CAS 6205) is *A.* (*T.*) ***grahami***.

Whiteaves (1879, 1903) reported *Nucula* (*Acila*) *truncata* Gabb, 1864, from various localities, including the Nanaimo area, Vancouver Island, British Columbia, and Sucia Island, Washington. He provided no type numbers nor any illustrations of these specimens, and none is part of any known museum collection. Based on their geographic occurrences, however, it is possible that the Nanaimo area and Sucia Island specimens are *A.* (*T.*) *demessa.*

Page et al. (1951:1738–1739) mentioned that *Acila demessa* was found at four LSJU localities in beds in the Santa Ynez Mountains northeast of Santa Barbara, Santa Barbara County, southern California. These beds were later placed in the Espada Formation by Dibblee (1966: 17), which ranges in range from latest Jurassic or Early Cretaceous to Late Cretaceous age (Dibblee, 1966). He also mentioned that these *Acila* specimens were found associated with the rudist *Coralliochama orcutti* White, 1885. This rudist is known to be of late Campanian to early Maastrichtian age (Marincovich, 1975). An attempt to find these *Acila* and rudist fossils in the CAS collection was unsuccessful. If the identification of the rudist is accurate, these *Acila* specimens could be *A.* (*T.*) *demessa*, *A.* (*T.*) ***grahami***, sp. nov., or *A.* (*T.*) ***rosaria***, sp. nov.

Haggart & Higgs (1989) reported *Acila* (*Truncacila*) sp. from the upper Santonian in marine shales apparently overlying the Honna Formation in the area of Skidegate Inlet, Queen Charlotte Islands, British Columbia. Although the geologic age of this bivalve is within the range of *A.* (*T.*) *demessa*, closer investigation of this Queen Charlotte bivalve revealed that its preservation is too poor to even allow generic identification (J. Haggart, personal communication).

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

(Figures 27–38)

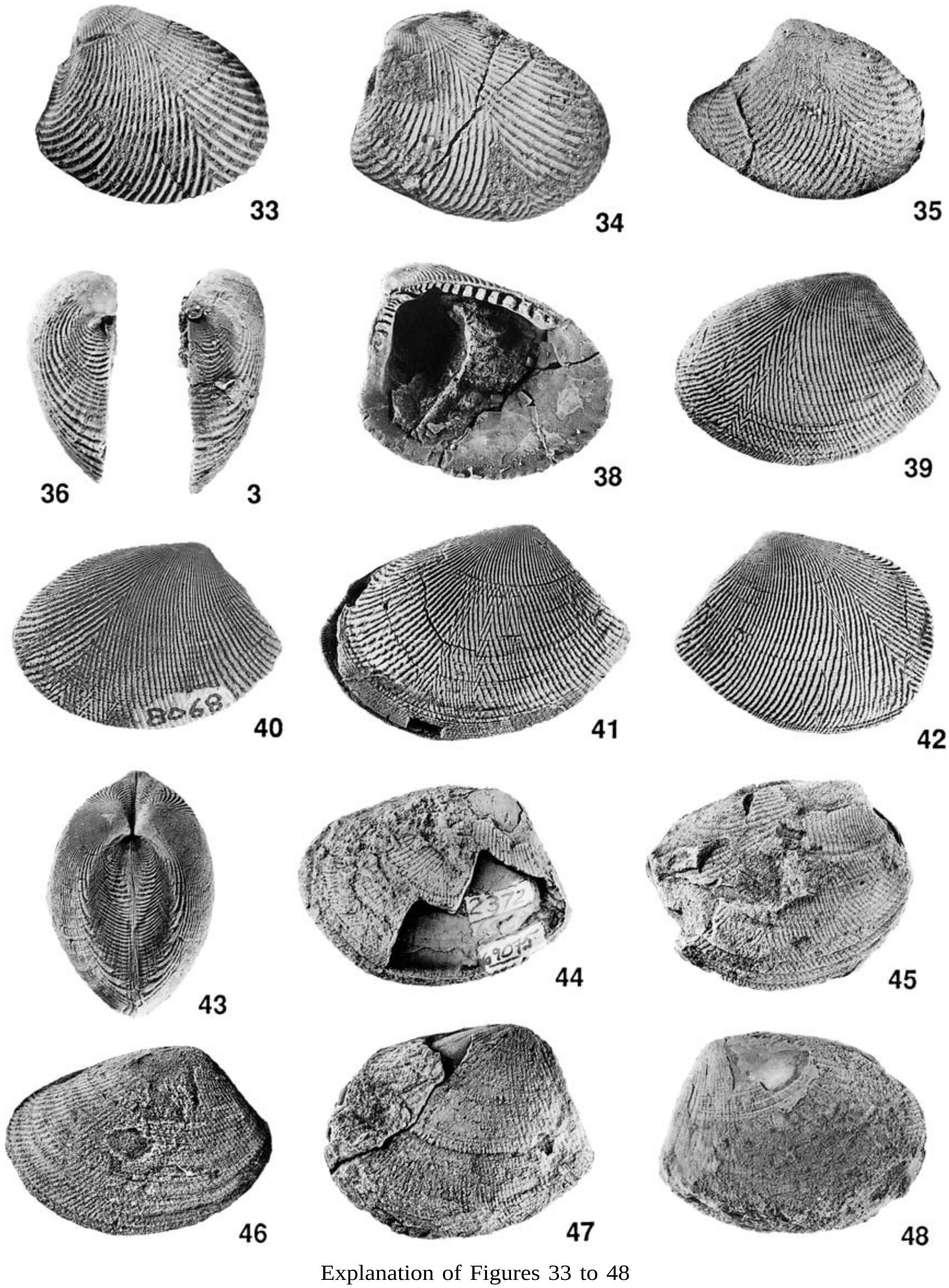
Acila (*Truncacila*) cf. *demessa* Finlay, 1927. Schenck, 1936: 50.
Acila (*Truncacila*) sp. E. Schenck, 1943:65–66, pl. 9, figs. 2, 4.
?*Nucula* (*Acila*) *truncata* Gabb. Whiteaves, 1879:162 (in part).

Diagnosis: Shell small, trigonal to subquadrate. Chevrons bisected by line usually meeting ventral-margin anterior (rarely center). Total number of ribs on disk of each valve approximately 50; ribs (posterior of chevron-bisecting line) narrow to moderately wide, with interspaces approximately ⅓ to ½ as wide. Escutcheonal ribs continuous with ribs on disk.

Description: Shell small for subgenus (up to 13.1 mm in height and 16.5 mm in length, most specimens approximately 8 mm in height and 9 mm in length), longer than high, height/length ratio = 0.75 to 0.92. Trigonal to subquadrate, inequilateral, equivalved, valves moderately inflated. Anterior end broadly rounded. Antero-dorsal margin long and straight. Posterior end truncate and set off from escutcheon by weak rostration. Ventral margin convex. Umbones moderately low, located posteriorly; umbonal angle varying from 86° (most trigonal shells) to 114° (most subquadrate shells). Beaks pointed, incurved, opisthogyrate. Disk very broad, ornamented with abundant ribs diverging from umbo area and forming chevron-shaped (divaricate) pattern. Chevron angle varying from 38° (most trigonal shells) to 56° (most subquadrate

←

Figure 23. Hypotype RBCM.EH2003.010.0001, Locality 2, right valve, ×1.8. Figure 24. Hypotype LACMIP 13231, LACMIP loc. 22406, right valve, ×2.7. Figure 25. Hypotype LACMIP 13232, LACMIP loc. 28780, left-valve hinge, ×3. Figure 26. Hypotype LACMIP 13233, LACMIP loc. 10832, posterior view, ×1.4. Figures 27–32. *Acila* (*Truncacila*) ***grahami*** Squires & Saul, sp. nov. Figure 27. Paratype RBCM.EH2003.012.0002, Locality 3, left valve, ×4.4. Figure 28. Paratype RBCM.EH2003.014.0001, Locality 4, left valve, ×2.8. Figure 29. Holotype RBCM.EH2003.011.0002, Locality 3, left valve, ×3.8. Figure 30. Paratype RBCM.EH2003.012.0001, Locality 3, left valve, ×3.9. Figure 31. Paratype RBCM.EH2003.013.0001, Locality 4, left valve, ×2.8. Figure 32. Paratype CAS 69079, CAS loc. 69079, crushed specimen of left valve, ×2.4.



Explanation of Figures 33 to 48

Figures 33–38. *Acila* (*Truncacila*) ***grahami*** Squires & Saul, sp. nov. Figure 33. Paratype RBCM.EH2003.012.0003, Locality 3, right valve, ×4.4. Figure 34. Paratype RBCM.EH2003.011.0001, Locality 3, right valve, ×3.2. Figure 35. Paratype CAS 69082.01, CAS loc. 69082, rubber peel of right valve, ×2.4. Figure 36. Holotype RBCM.EH2003.011.0002, Locality 3, posterior view of left valve, ×4.2. Figure 37. Paratype RBCM.EH2003.011.0003, Locality 3, posterior view of right valve, ×4. Figure 38. Holotype RBCM.EH2003.011.0002, Locality 3, shells). Chevrons bisected by line extending from slightly anterior of umbo to anterior part of ventral margin (rarely center); ribs anterior to bisecting line 12 to 30, ribs posterior to bisecting line 22 to 33. Total number of ribs on disk of each valve usually approximately 50; ribs narrow to moderately wide, with interspaces approximately ⅓ to ½ as wide, except anterior of chevron-bisecting line, where ribs become slightly wider and more widely spaced. Escutcheon moderately prominent, slightly sunken, and bounded by shallow groove crossed by ribs continuous with ribs on disk; ribs slightly stronger on inflated central part of escutcheonal area. Anterior hinge with 16 teeth, posterior hinge with 9 teeth.

Dimensions of holotype: Left valve, height 9 mm, length 10.8 mm.

Holotype: RBCM.EH2003.011.0002.

Type locality: Loc. 3, north end of Hornby Island, British Columbia, 49°32′57″N, 124°41′40″W.

Paratypes: RBCM.EH2003.011.0001, RBCM.EH2003.011.0003, RBCM.EH2003.012.0001 to RBCM.EH2003.012.0003, RBCM.EH2003.013.0001, RBCM.EH2003.014.0001, and CAS 69082.01.

Geologic age: Late middle Campanian to early late Maastrichtian.

Distribution: UPPER MIDDLE TO LOWER UPPER CAMPANIAN: Cedar District Formation, upper part, west shoreline of Denman Island off east coast of Vancouver Island, British Columbia. LOWER UPPER CAMPANIAN: Jalama Formation, Santa Barbara County, southern California. UPPERMOST MIDDLE CAMPANIAN TO LOWERMOST UPPER CAMPANIAN: Moonlight Formation?, north end of Shale Hills, southwest side of Antelope Valley, eastern Temblor Range, Kern County, south-central California. UPPERMOST CAMPANIAN OR LOWER MAASTRICHTIAN: Northumberland Formation, Collishaw Point, north end of Hornby Island, east coast of Vancouver, British Columbia. UPPER UPPER CAMPANIAN TO POSSIBLY LOWER MAASTRICHTIAN: Rosario Formation at Punta Banda, near Ensenada, Baja California. UPPER LOWER TO LOWER UPPER MAASTRICHTIAN: Moreno Formation, Ortigalita Creek, Merced County and Ciervo Hills, Fresno County, central California; Moreno Formation, Marca Shale Member, Fresno County, central California.

Discussion: This new species is based on 18 specimens: five left valves, 10 right valves, and three with conjoined valves. The best preserved ones are from the Northumberland Formation.

The new species is most similar to *Acila* (*Truncacila*) *haidana*, but the new species differs by having a more variable shape, narrower interspaces between the ribs, and having the line bisecting the chevrons located more anteriorly on the ventral margin.

Acila (*Truncacila*) ***grahami*** is similar to *Acila piura* Olsson (1931:35, pl. 2, figs. 9, 10, 14) from the upper Oligocene Heath Formation of northern Peru. The new species differs from *A. piura* by having a narrower chevron angle, more variability in the width of the interspaces between the ribs, and more ribs (22 to 33 versus 17) posterior to the bisecting line.

Whiteaves (1879:162) reported *Nucula* (*Acila*) *truncata* Gabb, 1864, from the northwest side of Hornby Island. He provided no type numbers nor any illustrations of any specimens, and none is part of any known museum collection. It is most likely, however, than any acilids found there would be *A.* (*T.*) ***grahami***, because the type locality of this species is at the north end of Hornby Island.

Etymology: The species is named for Raymond Graham who collected many of the specimens and who informed the authors about them.

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

(Figures 39–43)

Diagnosis: Shell medium, elliptical-subquadrate. Chevrons bisected by line meeting ventral-margin anterior. Total number of ribs on disk of each valve approximately 80; ribs (posterior of chevron-bisecting line), very narrow to narrow, with interspaces approximately ¼ as wide to same width as ribs. Escutcheon bounded by flattish to grooved area usually crossed by ribs not continuous with ribs on disk.

Description: Shell medium for subgenus (up to 19.6 mm in height and 25.5 mm in length), longer than high, height/length ratio = 0.68 to 0.78. Elliptical-subquadrate,

←

left-valve hinge, ×3.8. Figures 39–43. *Acila* (*Truncacila*) ***rosaria*** Squires & Saul, sp. nov. Figure 39. Holotype LACMIP 13234, LACMIP loc. 25431, left valve, ×1.8. Figure 40. Paratype LACMIP 13235, LACMIP loc. 8068, left valve, ×2. Figure 41. Paratype UCMP 155631, UCMP loc. B-5320, left valve, ×2. Figure 42. Paratype LACMIP 13236, LACMIP loc. 25431, right valve, ×1.8. Figure 43. Hypotype LACMIP 13234, LACMIP loc. 25431, oblique posterior view, ×2.3. Figures 44–48. *Acila* (*Truncacila*) *princeps* Schenck, 1943. Figure 44. Holotype CAS 69075, CAS loc. 69075, left valve, ×1.3. Figure 45. Hypotype LACMIP 13130, LACMIP loc. 23314, left valve, ×1.5. Figure 46. Hypotype CAS 69086.02, CAS loc. 69086, rubber peel of left valve, ×2.1. Figure 47. Paratype CAS 69078, CAS loc. 69075, left valve, ×1.5. Figure 48. Paratype CAS 69076, CAS loc. 69075, right valve, ×1.5.

inequilateral, equivalved, valves moderately inflated. Anterior end broadly rounded. Antero-dorsal margin long and straight. Posterior end straight, truncate and set off from escutcheon by weak rostration. Ventral margin convex. Lunule small, not very distinct, very slightly depressed, and crossed by ribs. Umbones low, located posteriorly; umbonal angle varying from 113 to 125°. Beaks pointed, incurved, opisthogyrate. Disk very broad, ornamented with abundant ribs diverging from umbo area and forming chevron-shaped (divaricate) pattern. Chevron angle 34 to 44°. Chevrons bisected by line extending from slightly anterior of umbo to anterior of ventral margin (rarely near center); ribs anterior to bisecting line 30 to 44 (excluding occasional bifurcations), ribs posterior to bisecting line 42 to 49. Secondary divarication common; tertiary divarication rare and only on those specimens where divarication is near center. Total number of ribs on disk of each valve usually approximately 80; ribs very narrow to narrow, with interspaces approximately ¼ as wide to same width as ribs, except anterior of chevron-bisecting line, where ribs become slightly wider, more widely spaced, and occasionally of irregular width. Ribs on juvenile specimens minutely tuberculate. Growth check(s) prominent on some adult specimens near ventral margin; growth check(s) commonly associated with riblet insertion near ventral-margin center and anterior of ventral-margin center. Ventral-margin edge and, for short distance, interior finely crenulate. Escutcheon prominent, sunken, bounded by flattish to shallowly grooved area usually crossed by ribs not continuous with ribs on disk, except on ventral part of escutcheon; flattish to shallowly grooved area occasionally smooth. Escutcheonal area elevated centrally and with riblets more widely spaced than elsewhere on this area. Interior nacreous. Adductor scars well delineated. Right-valve hinge with at least 18 anterior teeth, similar in form, becoming stronger posteriorly. Resilifer narrow, oblique.

Dimensions of holotype: Conjoined valves, height 18.0 mm, length 25.4 mm, thickness 14.9 mm.

Holotype: LACMIP 13234.

Type locality: LACMIP loc. 25431, Punta San Jose, Baja California, Mexico, 31°265′30″N, 116°38′45″W.

Paratypes: LACMIP 13235 and 13236, and UCMP 155631.

Geologic age: Early late Campanian to early late Maastrichtian.

Distribution: LOWER UPPER CAMPANIAN: Moonlight Formation?, north end of Shale Hills, southwest side of Antelope Valley, eastern Temblor Range, Kern County, south-central California. UPPER UPPER CAMPANIAN TO POSSIBLY LOWER MAASTRICHTIAN: Point Loma Formation, near Carlsbad, San Diego County, southern California; Rosario Formation at Punta San Jose, San Antonio del Mar, and Arroyo Santa Catarina, Baja California, Mexico. UPPER LOWER TO LOWER UPPER MAASTRICHTIAN: Moreno Formation, Tierra Loma Member, Merced County, north-central California.

Discussion: This species is based on 40 specimens: 10 left valves, 11 right valves, and 19 with conjoined valves. Most show excellent preservation, although a few shells are partially decorticated. Most specimens are from the Rosario Formation, and most of these are from or near the vicinity of Punta San Jose.

The new species is most similar to *A.* (*T.*) *demessa,* but the new species differs by having a more oval shape, more projected anterior and posterior ends, generally more uniform sculpture over the entire valve surface, and usually a larger shell size. On the posterior part of the disk of the new species, the ribs have more prominent interspaces than those of *A.* (*T.*) *demessa.* In addition, large specimens of the new species have narrower ribs than large specimens of *A.* (*T.*) *demessa.* In addition, the ribs on the anterior part of the valves of the new species can be elevated and minutely tuberculate, whereas correspondingly, on *A.* (*T.*) *demessa* these ribs are flat-topped and smooth. The escutcheonal area of the new species can be very similar to that of *A.* (*T.*) *demessa,* if the bounding shallow groove is smooth or smoothish, but most specimens of the new species have ribs across the entire escutcheon.

Acila (*T.*) *rosaria* is similar to *A.* (*T.*) sp. nov.? but differs by having a more elliptical shape, usually narrower ribs, and slightly narrower spaced ribs.

Etymology: The new species is named for the Rosario Formation, Baja California, Mexico.

Acila (*Truncacila*) *princeps* Schenck, 1943

(Figures 45–51)

Acila (*Truncacila*) *princeps* Schenck, 1943:63–66, pl. 8, figs. 1–4, 6–8.
Acila (*Truncacila*) sp. D. Schenck, 1943:65, pl. 9, fig. 5.
Acila (*Truncacila*) sp. F. Schenck, 1943:66, pl. 9, figs. 6, 8.
Acila sp. Saul, 1986b:26.

Diagnosis: Shell large, subquadrate, rarely trigonal. Chevrons bisected by line meeting ventral-margin anterior. Total number of ribs on disk of each valve approximately 85; ribs (posterior of chevron-bisecting line), flat and narrow to wide, with interspaces approximately $\frac{1}{5}$ to $\frac{1}{4}$ as wide.

Description: Shell large for subgenus (up to 25.8 mm in height and 34.4 mm in length), longer than high, height/length ratio = 0.71 to 0.85. Subquadrate, rarely trigonal; inequilateral, equivalved, and valves inflated. Anterior end broadly rounded. Antero-dorsal margin long and lowly convex. Posterior end straight, abruptly truncate and set off from escutcheon by weak rostration. Ventral mar-


49


50


51

Explanation of Figures 49 to 51

Figures 49–51. *Acila* (*Truncacila*) *princeps* Schenck, 1943. Figure 49. Holotype CAS 69075, CAS loc. 69075, right valve, ×1.3. Figure 50. Hypotype CAS 950.01, CAS loc. 950, right valve, ×1.7. Figure 51. Holotype CAS 69075, CAS loc. 69075, posterior view, ×1.3.

gin convex. Lunule poorly developed, slightly depressed. Umbones low, located posteriorly; umbonal angle varying from 94 to 119°. Beaks pointed, incurved, opisthogyrate. Disk very broad, ornamented with abundant ribs diverging from umbo area and forming chevron-shaped (divaricate) pattern. Chevron angle 30 to 39°. Chevrons bisected by line extending from slightly anterior of umbo to anterior of ventral margin; ribs anterior to bisecting line 30 to 39, ribs posterior to bisecting line 45 to 54. Secondary divarication uncommon. Total number of ribs on disk of each valve usually approximately 85; ribs flat and narrow to wide, with interspaces approximately $\frac{1}{5}$ to $\frac{1}{4}$ as wide, except anterior of chevron-bisecting line, and to a lesser extent on extreme posterior part of disk, where ribs become round and slightly wider. Each rib commonly bifurcates into two riblets along ventral margin between approximately $\frac{1}{3}$ of distance from posterior end to meeting of anterior end and ventral margin. Growth check(s) near ventral margin often associated with appearance of these bifurcated riblets. Ventral-margin edge and interior, for short distance, finely crenulate. Escutcheon slightly? sunken, bounded by smooth? region; middle part of area crossed by numerous oblique ribs, becoming stronger ventrally. Interior nacreous. Simple pallial line. Adductor muscle scars well delineated. Approximately 21 anterior teeth and 11 posterior teeth.

Dimensions of holotype: Conjoined valves, height 26 mm, length 34.5 mm, thickness 18.7 mm.

Holotype: CAS 69075 [= LSJU 6960].

Type locality: CAS 69075 [= LSJU 2372], west side San Joaquin Valley, northern California.

Paratypes: CAS 69076 [= LSJU 6963]; CAS 69077 [= LSJU 6961], and CAS 69078 [= LSJU 6962].

Geologic age: Late late Campanian to early late Maastrichtian.

Distribution: UPPER UPPER CAMPANIAN TO POSSIBLY LOWER MAASTRICHTIAN: Point Loma Formation, La Jolla, San Diego County, southern California; Rosario Formation, San Antonio del Mar, Baja California, Mexico. UPPER LOWER TO LOWER UPPER MAASTRICHTIAN: Tesla Formation, Alameda and San Joaquin counties, northern California; Moreno Formation, ''Garzas Sand'' member and also Mercy sandstone lentil, within middle part of Tierra Loma Member, Merced County, north-central California. LOWER UPPER MAASTRICHTIAN: El Piojo Formation, Lake Nacimiento, San Luis Obispo County, west-central California. UPPER MAASTRICHTIAN UNDIFFERENTIATED: Panoche Formation, Franklin Canyon, west of Martinez, Contra Costa County, northern California; Deer Valley formation (informal), north flank of Mount Diablo, Contra Costa County, northern California.

Discussion: The above description of this species is based on nine specimens: two left valves, one partial left valve, two right valves, three with conjoined valves, and one internal mold of a left valve. The lunule and escutcheon are both poorly preserved on every examined specimen.

Acila (*T.*) *princeps* is very closely similar to *A.* (*T.*) *demessa* in having, on some specimens, ribs that are flat-topped and very closely spaced. *Acila* (*T.*) *princeps* differs from *A.* (*T.*) *demessa* by having larger size, more uniform sculpture, and more numerous ribs. Schenck (1943:63) mentioned an area of obsolete radial ribbing on the holotype, but that is not the case (see Figures 44 and 49).

Schenck (1943:63) reported that the chevron angle, which he referred to as the angle of bifurcation, of *A.* (*T.*) *princeps* is 60 to 67°. In this present study, we measured the chevron angle of *A.* (*T.*) *princeps* near where the divarication begins, in the same manner as we measured this feature for all the other studied species. The only way we could obtain measurements of 60 to 67° is if we measured the along the ventral margin of the valve, where the ribs usually curve significantly.

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APPENDIX

LOCALITIES CITED

Locality 1. Private shale quarry at 340 Blackburn Road, 6 km NW of Fulford Harbor, Saltspring Island, off southeast coast of Vancouver Island, British Columbia. Haslam Formation, lower part. Age: Late Santonian. Collector: Raymond Graham, September 29, 2000.

Locality 2. Cliff on left bank of Chemainus River, 500 m downstream from the confluence with Banon Creek, 3.3 km SW of town of Chemainus, southeastern Vancouver Island, British Columbia. Haslam Formation, lower part. Age: Late Santonian. Collectors: Lois Walker and Raymond Graham, August 25, 2002.

Locality 3. SE ¼ of an intertidal bench, 300 m seaward from the high-water mark at Collishaw Point, N end of Hornby Island, off east coast of Vancouver Island, British Columbia. Northumberland Formation. Age: Latest Campanian or early Maastrichtian. Collector: Raymond Graham, June 21, 1997.

Locality 4. Intertidal bench 400 m N of Buckley Bay/ Denman Island ferry terminal, west-central shoreline of Denman Island, off east coast of Vancouver Island, British Columbia. Cedar District Formation, upper part. Age: Late middle to early late Campanian. Collector: Raymond Graham, June 21, 2001.

CAS 950. Hard lens about 0.3 m thick outcropping behind old distillery on Johnson Ranch at San Antonio del Mar, Baja California, Mexico. Rosario Formation. Age: Late Campanian to early Maastrichtian. Collectors: E. K. Jordan and L. G. Hertlein, January, 1926.

CAS 1552. 152 m W of center of section 28, T. 26 S, R. 18 E., Sawtooth Ridge Quadrangle (7.5 minute, 1961), N end of Shale Hills, SW side of Antelope Valley, eastern Temblor Range, Kern County, south-central California. Moonlight Formation? Age: Latest middle Campanian to earliest late Campanian. Collector: G. D. Hanna and J. H. Snow, April, 1929.

CAS 69075. [= SU 2372]. In second valley (with right turns), about 1.6 km N of Laguna Seca, on brow of hill on N side of valley, 366 m N and 503 m E of SW corner of section 12, T. 12 S, R. 10 E, Charleston School Quadrangle (7.5 minute, 1956), Merced County, north-central California. Moreno Formation, Mercy sand lentil within Tierra Loma Shale Member. Age: Late early to early late Maastrichtian. Collector: M. B. Payne, 1941.

CAS 69079. [= LSJU 1274]. White concretionary limestone bed embedded in shale, just NE of town of Oil City, 305 m NE of center of section 17, T. 19 S, R. 15 E, Domengine Ranch Quadrangle (7.5 minute, 1956) Fresno County, north-central California. Moreno Formation, about 91 to 122 m below top of formation. Age: Late early to early late Maastrichtian. Collector: P. W. Reinhart, January 27, 1934.

CAS 69080. About 1.6 km E of Queen Charlotte City, above beach, Bearskin Bay, Skidegate Inlet region, southern Graham Island, Queen Charlotte Islands, British Columbia, Canada. Haida Formation, probably Shale member. Age: Probably latest Albian to Cenomanian. Collector: unknown.

CAS 69082. [= LSJU 2575]. Limestone concretion embedded in purple shale, NE corner of SE ¼ of section 23, T. 16 S, R. 12 E, Monocline Ridge Quadrangle (7.5 minute, 1955), Fresno County, northern California. Moreno Formation, Marca Shale Member. Age: Late early to early late Maastrichtian. Collector: D. C. Birch.

CAS 69086. In railroad cut near Santa Fe Railroad tunnel above Franklin Canyon Inn, W of Martinez, Briones Valley Quadrangle (7.5 minute, 1959), Contra Costa County, northern California. Panoche Formation. Age: Late Maastrichtian. Collector: E. A. Watson.

CAS 69095. In small area of Cretaceous siltstone in SW ¼ of section 21, T. 26 S, R. 18 E, Sawtooth Ridge Quadrangle (7.5 minute, 1961), N end of Shale Hills, W side of Antelope Valley, eastern Temblor Range, Kern County, south-central California. Moonlight Formation? Age: Latest middle Campanian or earliest late Campanian. Collector: G. Henny.

CAS 69110. [= LACMIP 22874]. On E fork of Huling Creek, at edge of streambed in limestone bed, on S limb of hairpin meander, 1457 m N 25.5°E of confluence of Huling Creek and North Fork of Cottonwood Creek, Ono Quadrangle (15 minute, 1952), Shasta County, northern California. Budden Canyon Formation, Chickabally Mudstone Member. Age: Early Albian (*Leconteites lecontei* Zone). Collector: M. A. Murphy, summers 1951–1953.

LACMIP 8068. Approximately 2.4 km S of Punta San Jose, Baja California, Mexico. Rosario Formation. Age: Late late Campanian to possibly early Maastrichtian. Collector: unknown.

LACMIP 10832. In the field on both sides of the E-W highway connecting Pentz and Chico, about 1.3 km N86°W of Pentz, Cherokee Quadrangle (7.5 minute, 1949), Butte County, northern California. Chico Formation, Pentz Road member (informal). Age: Early Campanian. Collectors: W. P. Popenoe and D. W. Scharf, August 15, 1931.

LACMIP 10835. Loose blocks in landslide, SW ¼ of SW ¼ of section 8, T. 22 N, R. 3 E, Paradise Quadrangle (15 minute, 1953), Butte Creek, Butte County, northern California. Chico Formation, Ten Mile Member. Age: Early Campanian. Collectors: W. P. Popenoe and W. Findlay, September 3, 1933.

LACMIP 17611. Outcrop in streambed of Dry Creek, 472 m south and 152 m east of northwest corner of sec. 36, T. 21 N, R. 3 E, Cherokee Quadrangle (7.5 minute, 1970), Pentz area, Butte County, northern California. Chico Formation, Pentz Road member (informal). Age: Early Campanian. Collector: E. Göhre, 2000–2002.

LACMIP 22406. Gullies on both sides of highway approximately 0.8 km straight W of Pentz, Cherokee Quadrangle (7.5 minute, 1970), Butte County, northern California. Chico Formation, Pentz Road member (informal). Age: Early Campanian. Collector: W. P. Popenoe, July 18, 1946.

LACMIP 23314. On W slope of gully near gully bed, about 640 m S28°W of NE corner of section 24, T. 1 N, R. 1 E, of S side of Deer Valley, Antioch South Quadrangle (7.5 minute, 1973), Contra Costa County, northern Californa. Deer Valley formation (informal). Age: Late Maastrichtian Collector: W. P. Popenoe, August, 1944.

LACMIP 23950 [= CAS 69106]. Gray mudstone in the

N bank, 732 m W and 610 m N of SE corner of section 4, T. 29 N, R. 6 W, Ono Quadrangle (15 minute, 1952), Shasta County, northern California. Budden Canyon Formation, Gas Point Member. Age: Late Turonian. Collectors: W. P. Popenoe and W. A. Findley, 1933.

LACMIP 24365. In fine-grained sandstone on left bank of French Creek [= Swede Creek], approximately 152 m N and W of SE corner of section 5, T. 32 N, R. 2 W, Millville Quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation, Frazier Siltstone Member. Age: Turonian. Collector: W. P. Popenoe, August 25, 1957.

LACMIP 25431. Exposed in littoral zone and 3 to 6 m above high tide, S side of Punta San Jose, about 0.8 km E of the point and 48 km airline S of Ensenada, Pacific coast of Baja California, Mexico. Rosario Formation. Age: Late late Campanian to possibly early Maastrichtian. Collectors: W. P. Popenoe and W. Sliter, October, 1965.

LACMIP 28780. Pentz, Butte County, northern California. Chico Formation, Pentz Road member (informal). Age: Early Campanian. Collector: P. W. Reinhart, year unknown.

LACMIP 30141. Fossils in pebbly sandstone, about 1.6 km N of Nacimiento River on E side of road (?Bee Rock Road) near middle of northern-section line of section 18, T. 25 S, R. 10 E, Tierra Redonda Mountain Quadrangle (7.5 minute, 1949), San Luis Obispo County, west-central California. El Piojo Formation. Age: Early late Maastrichtian. Collector: unknown.

UCMP 814. South of Antone, between Rock Creek and Spanish Gulch, in sections 12 and 13 and SE ¼ of section 11, T. 13 S, R. 24 E, Antone Quadrangle (7.5 minute, 1985), Wheeler County, Oregon. Unnamed Cretaceous strata. Age: Cenomanian. Collector: unknown.

UCMP A-6275. Rio de Santo Tomás, Punta China area, northwest Baja California, Mexico. Alisitos Formation. Age: Late Aptian. Collector: E. C. Allison.

UCMP B-5320. Sea cliff on S side of Punta San Jose, Baja California, Mexico. Rosario Formation. Age: Late late Campanian to possibly early Maastrichtian. Collectors: E. C. Allison and F. H. Kilmer, June 27, 1957.

UCMP B-5665. In arenaceous bed 35 m stratigraphically below base of major volcanic-pyroclastic part of formation, upper Arroyo Ink, approximately 2 km due E of Punta China, Santo Tomás map (1:50,000, 1964), northwest Baja California, Mexico. Alisitos Formation. Age: Late Aptian. Collector: E. C. Allison.

UO 461. Soft sandstone about 61 m above valley floor, NE side of Bridge Creek Valley, 0.8 km from and NW from Mitchell Rock, SE ¼, SW ¼ of section 26 and NE ¼, NW ¼ of section 35, T. 11 S, R. 21 E, Mitchell Quadrangle, Wheeler County, northeast-central Oregon. Hudspeth Formation, lower part of ''Main Mudstone member.'' Age: Early Albian or early middle Albian. Collector: unknown.

USGS M-175. 61 m E of the SW corner of sec. 33, T. 18 N, R. 4 W, 2012 m S of point ''1009 ft'' on Logan Ridge, Lodoga Quadrangle (15 minute, 1943), Colusa County, northern California. Probably float from lower Turonian Venado Sandstone Member of Cortina formation (informal). Collectors: R. D. Brown, Jr., and E. I. Rich, 1958.