Hills, near Olympia in southwestern Washington (Squires & Goedert, 1994b).

Superorder CAENOGASTROPODA Cox, 1959

Order NEOTAENIOGLOSSA Haller, 1882

Superfamily CERITHIOIDEA Férussac, 1819

Family POTAMIDIDAE Adams & Adams, 1854

Genus *Terebralia* Swainson, 1840

Type species: *Strombus palustris* Linnaeus, 1758, by subsequent designation (Sacco, 1895); Recent, tropical waters, eastern Africa to western Pacific Ocean.

*Terebralia **susana*** Squires & Kennedy, sp. nov.

(Figures 6–10)

Diagnosis: *Terebralia* whose adult whorls have numerous weak, very closely spaced spiral threads and about 11 axial ribs.

Description: Shell large in size, 6.5 cm high (incomplete, upper spire missing; projected height about 9.5 cm), thick-shelled; turreted-conical, consisting of at least five whorls. Upper spire unknown. Whorls convex, suture distinct and slightly inset into each successive whorl. Last five whorls with numerous weak, very closely spaced spiral threads; body whorl near outer lip with widely spaced, coarse spiral ribs, about seven in number, decreasing in strength anteriorly and with three spiral ribs in interspaces. Last three whorls with axial ribs (indeterminate in number, estimated to be about 11 per whorl), most strongly developed on posterior half of whorl. Last three whorls with aligned varices on both sides of shell. Base of body whorl rounded. Aperture large, ovate, with a posterior groove; anterior siphonal canal short and nearly closed at junction with outer lip. Inner lip smooth, concave. Outer lip flared, with varix; interior of outer lip smooth.

Holotype: LACMIP 7942.

Type locality: LACMIP loc. 26814, upper part of Santa Susana Formation, upper Quarry Canyon, east-central Santa Monica Mountains, latitude 34°05′24″N, longitude 118°33′30″W.

Dimensions: Height 65 mm (incomplete), width 31.7 mm.

Distribution: Known only from the type locality (LACMIP loc. 26814).

Geologic age: Late Paleocene (Thanetian).

Discussion: Only a single specimen was found at LACMIP loc. 26814, in sandstone immediately below the algal limestone. The specimen is somewhat worn and the upper spire is missing. No other megafossils were found in association with the holotype at the type locality.

*Terebralia **susana*** is very similar to *T. pathani* Iqbal (1969:20, pl. 12, figs. 11–12) from littoral to sublittoral mudstone of the lower Eocene Ghazij Formation east of Quetta in Pakistan, but *T. **susana*** differs by having a larger shell, weak and closely spaced spiral threads on adult whorls, and fewer, weaker, and more widely spaced spiral ribs near the outer lip.

A tentatively identified terebralid, *Terebralia? juliana* Dailey & Popenoe (1966:22, pl. 6, figs. 7, 8) from the Upper Cretaceous (upper Campanian Stage to lower Maastrichtian Stage) Jalama Formation in Santa Barbara County of southern California, represents what may be the only other report of this genus from the Pacific Coast of North America. *Terebralia **susana*** differs from *T. juliana* by having a much larger and thicker shell, poorly developed spiral ribbing rather than four well-developed spiral ribs bearing numerous prominent nodes, and axial ribbing.

According to Houbrick (1991), the geologic range of *Terebralia* is early Miocene to Recent. Cossmann (1906) and Wenz (1940), however, cited the genus from rocks as old as Late Cretaceous (Maastrichtian Stage). Pervinquière (1912:pl. 1, figs. 26–28) reported specimens of *Cerithium* (*Terebralia*) *sanctiarromani* Thomas et Peron, 1889, from slightly older, Turonian (Upper Cretaceous) rocks in Tunisia, northern Africa. Positive generic assignment of that particular species cannot be made because the aperture is unknown. The shell does resemble that of *Terebralia*. *Terebralia **susana*** differs from the Tunisian species by having many fewer axial ribs.

Etymology: The species is named for the Santa Susana Formation.

Class BIVALVIA Linnaeus, 1758

Order VENEROIDA Adams & Adams, 1856

Family SOLENIDAE Lamarck, 1809

Genus *Solena* Mörch, 1853

Type species: *Solen obliquus* Spengler, 1794, by subsequent designation (Stoliczka, 1871); Recent, Caribbean Sea.

Subgenus *Eosolen* Stewart, 1930

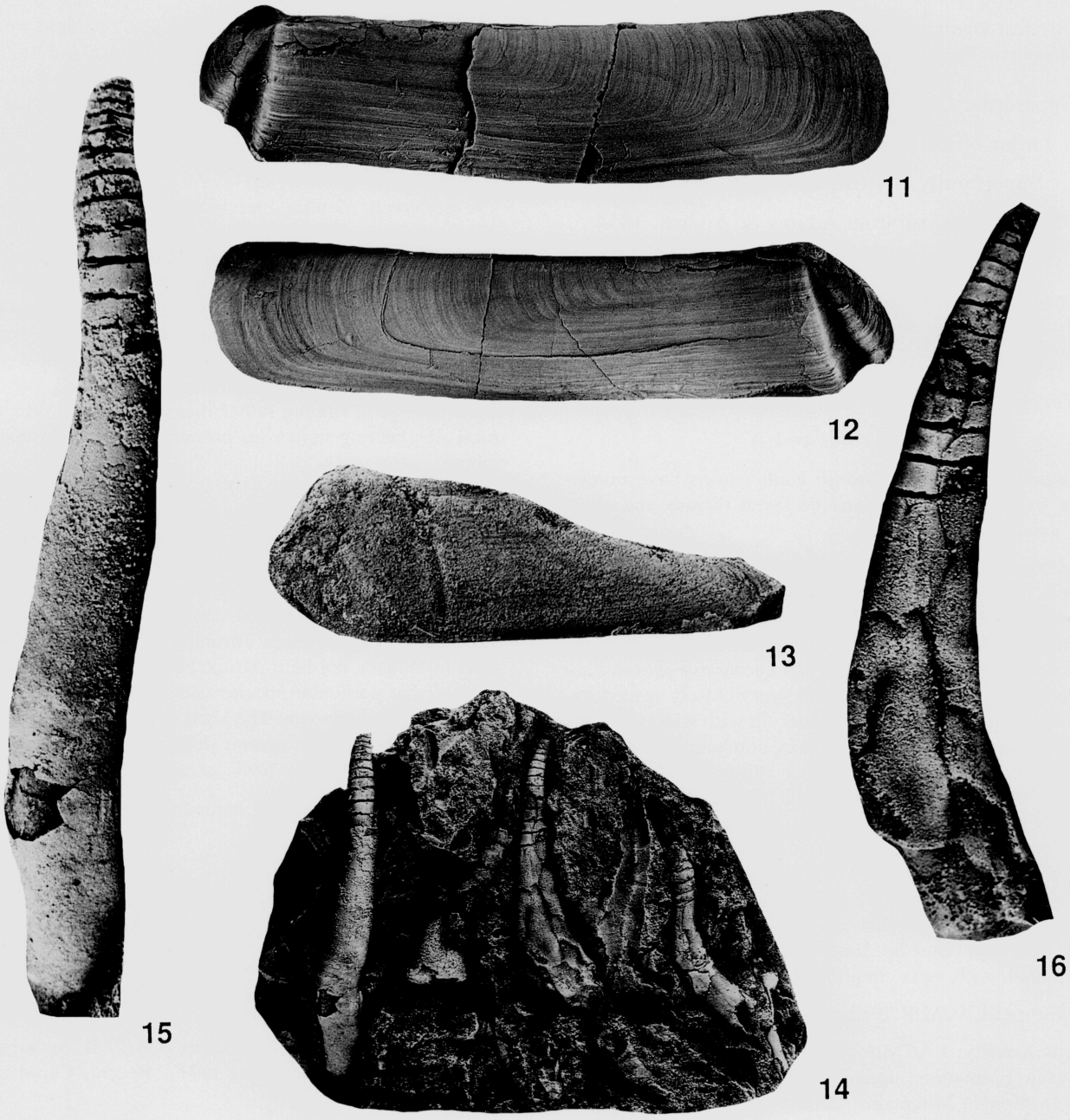
Type species: *Solen plagiaulax* Cossmann, 1906, by original designation; middle to upper Eocene (Lutetian to Bartonian Stages), Paris Basin, France.

Solena (*Eosolen*) *stantoni* (Weaver, 1905)

(Figures 11–12)

Solen stantoni Weaver, 1905:116, pl. 12, fig. 1. Dickerson, 1914:151 (table), pl. 12, fig. 3. Keen & Bentson, 1944: 108.

Solena (*Eosolen*) *stantoni* (Weaver). Zinsmeister, 1983a:63 (table), pl. 1, fig. 18.



Explanation of Figures 11 to 16

Figures 11–12. *Solena* (*Eosolen*) *stantoni* (Weaver, 1905), LACMIP hypotype 7943, LACMIP loc. 16897, closed-valve specimen, length 65 mm, height 15 mm, ×1.6. Figure 11. left valve. Figure 12. right valve. Figure 13. *Martesia* sp., LACMIP hypotype 7944, LACMIP loc. 16869, internal mold of left valve, length 33.8 mm, height 11.4 mm, ×2.4. Figures 14–16. *Nototeredo*(?) sp., LACMIP hypotype 7945, LACMIP loc. 16869. Figure 14. hand specimen of a cluster of individuals, two of which are shown in the following figures, ×1.3. Figure 15. side view of individual on left side of hand specimen, height 45 mm, maximum width 4.9 mm, ×3.2. Figure 16. side view of individual in center of hand specimen, height 32 mm, maximum width 6 mm, ×3.5

Not *Solen* (*Plectosolen*) *stantoni* Weaver. Clark & Woodford, 1927:103–104, pl. 18, fig. 10.

Not *Solen* cf. *parallelus* Gabb. Clark & Woodford, 1927: 104, pl. 18, fig. 9 [=*Solen* (*Plectosolen*) *stantoni* (Weaver), *in errata* fide Keen & Bentson, 1944].

Original description: "The shell is thin, elongated and moderately convex. The cardinal and basal margins are nearly parallel. The beaks are anterior. The base is straight and the ends somewhat rounded. The posterior end is more abruptly truncated than the anterior. The surface is marked by faint concentric lines of growth. Passing down from the beak to the base of the anterior margin there is on each side a deep, sharp constriction which is nearly at right angles to the hinge line. The maximum length of the type specimen was found to be 50 mm. The greatest width is 7 mm" (Weaver, 1905:p. 116).

Supplementary description: Shell moderately large in size, up to 6.6 cm in length, shell thin, elongate, ornamented by concentric growth lines; dorsal and ventral margins nearly parallel, dorsal margin slightly concave; beaks anterior; posterior end somewhat truncate; anterior area on both valves separated from remainder of shell by a deep and wide umbonal groove, widest at the ventral margin, set at an angle of about 105 to 110° to the dorsal margin; a distinct ridge and a second weaker, groove lie parallel and immediately anterior to the primary umbonal groove; anterior end produced, gaping, and bent posteriorly. Dentition unknown.

Holotype: UCMP 11941.

Type locality: UCMP loc. 532, upper Vine Hill Sandstone between Martinez and Walnut Creek at mouth of Vaca Canyon, Contra Costa County, northern California.

Geographic distribution: Contra Costa County, northern California to Santa Monica Mountains, Los Angeles County, southern California.

Geologic age: Late Paleocene (Thanetian).

Stratigraphic distribution: Upper Vine Hill Sandstone, near Pacheco, Contra Costa County (Weaver, 1953); middle part of Santa Susana Formation, south side of Simi Valley, Ventura County (Zinsmeister, 1974, 1983a); upper part of Santa Susana Formation, Santa Ynez Canyon area (LACMIP loc. 16869), east-central Santa Monica Mountains; upper part of Santa Susana Formation in Pulga Canyon (LACMIP loc. 16897), east–central Santa Monica Mountains.

Discussion: The subgenus *Eosolen* is characterized by having an oblique umbonal groove on the anterior end.

Two small specimens of *S.* (*E.*) *stantoni* were found at LACMIP loc. 16869 in the Santa Ynez Canyon area. One is an external mold of a complete late-juvenile specimen (20 mm long and 6 mm high) that consists of an open pair of valves, arranged in parallel fashion immediately next to each other ("butterflied"). The second specimen is a fragment of a slightly larger individual. Three large specimens were also found at LACMIP loc. 16897 in the upper Pulga Canyon area. These are complete, early to late adult, ranging from 5.5 to 6.6 cm in length and 13 to 15.5 mm in height, and they represent the largest known specimens of this species. Each consists of an open and "butterflied" pair of valves. Only the exteriors are visible. The specimens are essentially internal molds, but have impressions of the exterior sculpture, and thus are functional casts. Tiny remnants of the original shell material remain in a few places.

Both juvenile and adult specimens of *Solena* (*Eosolen*) *stantoni* are alike in their morphologic features in that they all have a slightly curved dorsal margin and a produced anterior end with two grooves. Morphologically they resemble the holotype but are better preserved. The holotype is a closed-valved early adult (length 5 cm) whose shell is mostly decorticated.

Clark & Woodford (1927:103–104, pl. 18, fig. 10 = UCMP hypotype 31324) illustrated a specimen of *Solen* (*Plectosolen*) *stantoni* (Weaver) from "division D strata of the Meganos Formation" in Deer Valley, Contra Costa County, northern California. Almgren et al. (1988:fig. 4) assigned "division D strata of the Meganos Formation," as used by Clark & Woodford (1927), to the CP9 Zone (lowest Eocene) of the standard calcareous nannofossil zonation. These shallow-marine strata are now referred to the Margaret Hamilton Sand (Edmondson, 1984). Clark & Woodford (1927:104, pl. 18, fig. 9 = UCMP hypotype 31325) also illustrated another specimen from the same formation as *Solen* sp. cf. *parallelus* Gabb. According to Stewart (1930) and Keen & Bentson (1944), Clark & Woodford noted *in errata* that UCMP hypotype 31325 should have been identified as *S.* (*Plectosolen*) *stantoni*. Examination of the two hypotypes reveals that they are unlike *S.* (*E.*) *stantoni* because the dorsal margin of each is straight rather than slightly curved and the anterior end of each is too rounded. The hypotypes of Clark & Woodford (1927) are herein tentatively identified as *Solena* (*E.*) *subverticala* Vokes (1939:96–97, pl. 15, fig. 8), which is known from the middle lower Eocene ("Capay Stage") to middle Eocene ("Domengine Stage") rocks in southern California (Givens, 1974), and from "Domengine" rocks in central California (Vokes, 1939).

Keen (1969) and Davies & Eames (1971) reported that *Eosolen* was restricted to the Eocene of Europe and North America. The lower limit of the geologic range is revised to late Paleocene by the presence of *Solena* (*Eosolen*) *stantoni* in upper Paleocene rocks in California.

The only other Paleocene solenid of which we are aware is "*Solen*" *parallelus* Gabb (1864:146–147, pl. 22, fig. 117), the lectotype of which is not well preserved, especially anteriorly. "*Solen*" *parallelus* was also figured by Stewart (1930:291–292, pl. 7, fig. 1), who reported that there is a faint suggestion of a diagonal groove on the anterior end. The type locality of "*S.*" *parallelus* is

controversial, and the species has been confused with Eocene solenids from the Pacific coast of North America. The type locality of "*S.*" *parallelus* is most likely from the Martinez area in Contra Costa County of northern California and is from upper Paleocene rocks (Stewart, 1930; Keen & Bentson, 1944). Due to poor preservation of existing material, this species is not assignable to a subgenus. *Solena* (*Eosolen*) *stantoni*, therefore, is the only confirmed representative of *Eosolen* in the Paleocene.

"*Solen*" *cuneatus* Gabb (1869:175–176, pl. 29, fig. 61), possibly from Cretaceous rocks near the Martinez area, is very poorly preserved (Stewart, 1930:292, pl. 5, fig. 12), and the confirmation of its solenid status (which seems doubtful) awaits better preserved material.

Dailey & Popenoe (1966) reported a late Campanian or possibly early Maastrichtian *Leptosolen* sp. from the Jalama Formation in Santa Barbara County of southern California. *Leptosolen* Conrad, 1867, resembles *Eosolen* but is characterized by wider valves, less terminal beaks, and the presence of a strong internal rib, and, in some species, with concentric imbricating sculpture (Conrad, 1867; Stephenson, 1941; Dailey & Popenoe, 1966). *Leptosolen*, which is known only from the Cretaceous and is widely distributed, belongs to the family Cultellidae, which is closely related to family Solenidae (Keen, 1969). *Leptosolen* sp. from the Jalama Formation is represented by a few internal molds, and examination of the best specimens (LACMIP hypotypes 40425 and 40426) reveals that they might belong to *Eosolen*. They are similar to *Eosolen* in narrow valves, and the beaks are more anterior than on *Leptosolen*. In addition, the internal molds show a sulcus on each valve that resembles the anterior umbonal groove of *Eosolen* in that it is nearly vertical and close to the end of the shell. If the sulcus had been formed by the diagnostic internal rib of *Leptosolen*, it would be nearer the center of the shell. Better preserved specimens of *Eosolen*-like shells from the Jalama Formation are needed to confirm their generic assignment. If they do prove to belong to *Eosolen*, they would represent its earliest record.

Order MYOIDA Stoliczka, 1870

Family PHOLADIDAE Lamarck, 1809

Subfamily MARTESIINAE Grant & Gale, 1931

Genus *Martesia* Sowerby, 1824

Type species: *Pholas clavata* Lamarck, 1818 [= *Martesia striata* (Linnaeus, 1758)], by original monotypy; Recent, "seas of Western Europe and America" (Turner, 1955).

Martesia sp.

(Figure 13)

Description: Small to medium in size, reaching approximately 3.4 cm in length and 1.5 cm in height, elongate, pear-shaped and tapering posteriorly. Umbones near anterior end. Shell divided by umbonal-ventral sulcus extending obliquely and posteroventrally from umbo to ventral margin. Anterior slope broad, rounded, with broad V-shaped notch on growth margin, about one-third of entire shell length; anterior slope sculptured by fine, concentric ridges, too finely denticulated to express radial sculpture. Disc and posteror slope with numerous, closely spaced, fine concentric ridges. Callum smooth, entire, without ellipsoidal notch on margin. Funnel-shape pit below umbonal reflection present on one specimen. Umbonal regions on all specimens too poorly preserved for description. Accessory plates lacking.

Distribution: Upper part of Santa Susana Formation, Santa Ynez Canyon area (LACMIP loc. 16869), east-central Santa Monica Mountains.

Geologic age: Late Paleocene (Thanetian).

Discussion: Fossil specimens of the wood-boring genus *Martesia* are rare in Paleogene deposits of the Pacific Coast of North America (Kennedy, 1974:58). The six specimens recovered from the upper part of the Santa Susana Formation in the Santa Ynez Canyon area (LACMIP loc. 16869) represent only the fifth confirmed record of typical *Martesia* from the Pacific Coast region and, more significantly, they represent the earliest record for the genus in this region. Although the genus has been reported in Jurassic and Cretaceous rocks, all Mesozoic specimens thus far examined (by the junior author) are assignable to *Opertochasma* Stephenson, 1952, another wood-boring genus similar in some respects to *Martesia* (Kennedy, 1974).

The six specimens from the Santa Susana Formation in the Santa Monica Mountains are all isolated single valves of adults preserved in sandstone. Associated carbonaceous material and one small piece of wood suggest proximity to peaty, vegetative, or wood debris. It is probable that the isolated valves separated and dispersed following disintegration of their original water-logged woody substrate. The umbonal regions of all specimens are poorly preserved, and most of the original shell material is missing on the specimens. The posterior-dorsal margin of the figured specimen (Figure 13, LACMIP hypotype 7944) is crushed and folded out of view. Accessory plates, such as the mesoplax, metaplax, and hypoplax, that fit around the margins of the paired valves, and which are useful in species identification, were not preserved or recovered.

Species of *Martesia* all have similar elongate, pear-shaped valves, an anterior margin with a broad V-shaped notch, a funnel-shaped pit below the umbonal reflection, and a wood-boring habit that makes them readily identifiable at the generic level. Kennedy (1974) recognized three subgenera of *Martesia*. Two of these, *Martesia* sensu stricto and *Particoma* Bartsch & Rehder, 1945, are

distinguished by differences in their mesoplax (the dorsal accessory plate that fits above the umbones), in addition to characteristics of their umbonal regions. The posterior-dorsal margins of *Martesia* and *Particoma* are not reflected, as they are in the third subgenus, *Paramartesia* Kennedy, 1974, whose posterior-dorsal margin is folded over upon itself, forming an elongae enclosure similar to that found in the modern rock-boring genus *Parapholas* Conrad, 1848. The type species of *Paramartesia*, namely *Martesia* (*Paramartesia*) *tolkieni* Kennedy (1974:59–60, figs. 67–70, frontispiece), is from the Lodo Formation on the west side of the San Joaquin Valley in central California. The Lodo Formation ranges from upper Paleocene to lower Eocene, but the type locality of *M.* (*P.*) *tolkieni* plots in the upper part of the formation (Payne, 1974:pl. 1), thus placing it in the lower Eocene part of the formation. The Santa Ynez Canyon specimens of *Martesia* sp. differ from *M.* (*P.*) *tolkieni* by not having a reflected posterior-dorsal margin.

Martesia meganosensis Clark & Woodford (1927:103, pl. 18, figs. 7, 8; Kennedy, 1974:58–59, figs. 65, 66) from the Margaret Hamilton Sand [= division D of Meganos Formation as used by Clark & Woodford (1927)] in Contra Costa County of northern California, is the only described California Paleogene Martesia that actually belongs to "typical" *Martesia*. The type specimens (Kennedy, 1974:58–59, figs. 65, 66) of *M. meganosensis*, however, do not have any characters distinctive below the generic level, and thus the name should be considered a *nomen dubium*. Almgren et al. (1988:fig. 4) assigned "division D strata of the Meganos Formation," as used by Clark & Woodford (1927), to the CP9 Zone (lowest Eocene) of the standard calcareous nannofossil zonation.

Forty-two specimens of *Martesia* sp. cited by Hickman (1969:69, pl. 8, figs. 4, 6) from the Eugene Formation near Eugene, Oregon, belong to *Martesia* sensu stricto based on the mesoplax of several specimens preserved in a single piece of fossil wood. Kennedy (1974:58) also reported one small, poorly preserved specimen of *Martesia* sp. from the Keasey Formation at Rock Creek, near Keasey, northwestern Oregon. Armentrout et al. (1983) assigned both the Eugene Formation and the Keasey Formation to the upper Eocene.

Other Paleogene records of *Martesia* from the Pacific coast lower Tertiary are more properly assigned to other genera. As reported by Kennedy (1974:61), Nelson's (1925:facing p. 402) record of "*Martesia* (?) species" from the "Martinez marine member" on the south side of Simi Valley in Ventura County, southern California, was based on a single poorly preserved specimen that is probably assignable to *Opertochasma*. Zinsmeister (1983a, 1983b) and Saul (1983:94) assigned the "Martinez marine member" to the Paleocene (Thanetian).

Martesia turnerae Hickman (1969:68, pl. 8, figs. 10–11, 13–14, 16), from the upper Eocene Eugene Formation in Oregon is also an *Opertochasma*, as demonstrated by Kennedy (1974:61, figs. 71–72).

"*Martesia*(?) sp." of Dickerson (1914:96, 140; see Kennedy, 1974:72, fig. 99), from the Paleocene Martinez Formation at Little Lake in Lake County of northern California, can be assigned to *Teredina* Lamarck, 1818, (Kennedy, 1974; S. R. A. Kelley, personal communication). *Teredina* is well represented and best known from the Eocene of the Paris Basin, France.

Family TEREDINIDAE Rafinesque, 1815

Subfamily BANKIINAE Turner, 1966

Genus *Nototeredo* Bartsch, 1923

Type species: *Teredo edax* Hedley, 1895, by original designation; Recent, Australia and New Zealand.

Nototeredo(?) sp.

(Figures 14–16)

Description: A cluster of seven calcareous tubes, either separate or touching, up to 4.5 cm in length and 6 mm in diameter; gently to moderately curved, tapered posteriorly. Tubes without constrictions, except at the concamerate posterior (siphonal) end. Concamerate part about 25 to 40 percent of length of tubes (incomplete); consisting of 10 to 12 concentrically arranged, internal restrictions (concamerations) that are spaced up to 1.5 mm apart.

Distribution: Upper part of Santa Susana Formation, Santa Ynez Canyon area (LACMIP loc. 16869), east-central Santa Monica Mountains.

Geologic age: Late Paleocene (Thanetian).

Discussion: A single hand specimen (Figure 14) containing a cluster of concamerate tubes was found at LACMIP loc. 16869. The specimens in Figure 14 are tubes that have been filled with sediment and subsequently leached (dissolved) away, leaving a cavity where the original shell once was. All the tubes in the cluster are oriented with the posterior ends (siphonal openings) in the same direction, indicative of their original aligned position within the enclosing substrate. Although teredinids are typically wood borers, the absence of preserved wood suggests they might have been colonizing an organic-rich, peaty substratum rather than wood.

The concamerate tubes at LACMIP loc. 16869 resemble those belonging to genus *Nototeredo* Bartsch, 1923, and as far as we know, this is the only genus to have tubes similar to those from the Santa Susana Formation. Nevertheless, a positive identification cannot be made because the valves of the shell are missing, as are the pallets, which are used for generic and species identification, at least among modern teredinids (Turner, 1966). On the basis of figure 13D of Turner (1966:39), one could infer

that the concamerations are designed to fit closely around the extended siphons in wider, down-hole parts of the tube that accommodate other organs or structures, but which are otherwise too cavernous for the slender siphons.

The tubes closely resemble those of *Nototeredo globosa* (Meek & Hayden, 1858:53; Meek, 1876:264–265, figs. 31, 32 and pl. 30, fig. 13), a wood-boring teredinid from the upper Paleocene (Danian) Cannonball Formation from North Dakota. Cvancara (1970:620–621, pl. 121, fig. 12) illustrated the pallets and concamerate tubes of this species and noted that the tubes are present both in well-preserved petrified wood as well as in very fine-grained detrital rocks in which little, if any, original organic material remains. The Santa Susana Formation specimens differ by being more curved and more tapered, but this is probably related to the original substratum rather than being of taxonomic significance. The calcareous tubes of most wood-boring teredinids are of very little taxonomic use, and generic and specific determinations are typically based on the periostracal parts of the pallets, which are rarely preserved in the fossil record (Turner, 1966).

Similar concamerated tubes of "*Gastrochaena amphisbaena*" Goldfuss, 1837, have been illustrated by Geinitz (1874:pl. 52, figs. 8–12). Goldfuss' species is from the Pläner beds in southeastern Germany, which Gignoux (1950:421) assigned to the Upper Cretaceous (Cenomanian Stage to Turonian Stage). The Santa Susana Formation specimens differ from Goldfuss's specimens by their greater consistency in the spacing of the concamerate segments. In addition, none of the Santa Susana Formation specimens has the close spacing found in some of the German specimens, although the taxonomic significance, if any, of this spacing has not been evaluated.

Nototeredo(?) sp. from the Santa Susana Formation in the Santa Ynez Canyon area represents the first record of fossil concamerate tubes from the Pacific Coast of North America. If the species is correctly assigned, it would be one of the earliest known records for this genus.

Two additional hand specimens from LACMIP loc. 16869 also contain aligned teredinid tubes, but none shows the concamerations of the tubes shown in Figure 14. They might represent another, unidentified (genus and) species of teredinid, or they might be tubes of juvenile animals that had yet to develop the concamerations. They might also simply represent differences in preservation. The shell material of the tubes on the additional hand specimens is still present.

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