J. Paleont., 71(5), 1997, pp. 847–861

0022-3360/97/0071-0847$03.00

TAXONOMY AND DISTRIBUTION OF THE BUCCINID GASTROPOD *BRACHYSPHINGUS* FROM UPPERMOST CRETACEOUS AND LOWER CENOZOIC MARINE STRATA OF THE PACIFIC SLOPE OF NORTH AMERICA

RICHARD L. SQUIRES
Department of Geological Sciences, California State University, Northridge 91330-8266
⟨richard.squires@csun.edu⟩

ABSTRACT—*Brachysphingus* is a low-spired bucciniform neogastropod known only from the fossil record of California and northern Baja California. The earliest species, *Brachysphingus gibbosus* Nelson, 1925, ranges in age from latest Cretaceous or possibly earliest Paleocene to the late Paleocene. During the early Paleocene, the smoothish *B. gibbosus* evolved into the axially ribbed *B. sinuatus* Gabb, 1869, which is the senior primary synonym of *B. gabbi* Stewart, 1927. During the late Paleocene, *B. sinuatus* evolved into *B. mammilatus* Clark and Woodford, 1927, which is the youngest species of *Brachysphingus* and which lasted into the early Eocene.

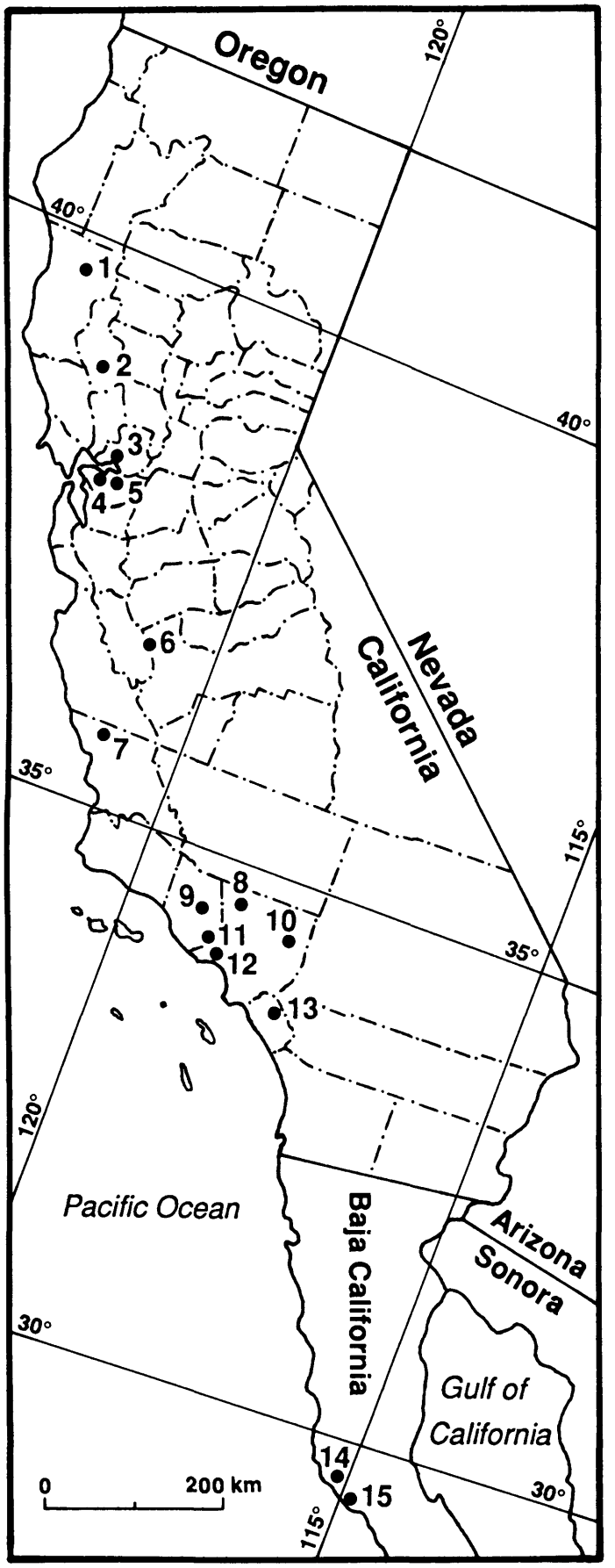
All three species of *Brachysphingus* were shallow-marine dwellers subject to transport into deeper waters via turbidity currents.

INTRODUCTION

THE GASTROPOD genus *Brachysphingus* has long been used as an indicator of Paleocene marine rocks on the Pacific slope of North America. Although rocks of this age are not that common in this region, *Brachysphingus* is present in nearly every area of outcrops (Figure 1). At nearly every *Brachysphingus* locality there is at least one species of associated *Turritella.* This is a fortunate circumstance because *Turritella* species are crucial in determining geologic age, and the zonation used in this report follows that of Saul (1983a).

Four species of *Brachysphingus* were previously described: *B. liratum* Gabb, 1864, *B. gibbosus* Nelson, 1925; *B. sinuatus* Gabb, 1869, and *B. mammilatus* Clark and Woodford, 1927. *Brachysphingus liratum* is a homonym, and in 1927, Stewart substituted the name *B. gabbi* Stewart, 1927. All the species were originally regarded as restricted to the Paleocene, except for *B. mammilatus,* which was reported by Clark and Woodford (1927) and Givens (1974) as restricted to the Eocene. The stratigraphic and geographic distributions of these taxa have never been tabulated, and the phylogenetic relationships among them have never been determined. These are the primary objectives of this report.

Previous workers had few problems in recognizing *B. gabbi* because its robust axial ribs make it very distinctive. Recogni-



tion of the other species of *Brachysphingus,* however, proved troublesome because they are smoothish and, generally, similar in shape. It is not uncommon while observing museum collections to come across labels with two or three different identifications for the same specimen. This confusion has greatly hindered any potential biostratigraphic utility that might be associated with the evolution of *Brachysphingus.* Initially, in my own work, I had the same kind of difficulty when I tried to identify just a few lots of specimens of smoothish *Brachysphingus.* It was only after I had observed a large number of specimens that I finally understood how one smoothish species is morphologically distinguishable from another. Using museum collections at several institutions, I found a total of 562 specimens. While doing so, I also came across 14 new stratigraphic occurrences of *Brachysphingus.* These are indicated in the "Occurrence" sections later in this paper.

By careful comparative studies of all the known specimens of *Brachysphingus,* I was able to determine that only three of the previously named species are valid; namely, *B. gibbosus, B. sinuatus,* and *B. mammilatus. Brachysphingus sinuatus* and *B. gabbi* are synonyms, and the name *Brachysphingus sinuatus* has priority. Figure 2 illustrates the stratigraphic ranges of the valid species of *Brachysphingus.* All the species of *Brachysphingus* are found in California, and all except *B. mammilatus* are found in northern Baja California. This investigation is important because it establishes the evolutionary sequence of species in the genus and when these evolutionary steps took place. Even rare transitional specimens between species are recognizable. Information like this is uncommon for the early Tertiary fossil record of the Pacific slope.

Detailed paleoenvironmental analyses are wanting for most formations where *Brachysphingus* is present. For those formations that have been studied (Table 1), the associated mollusks are always shallow-marine forms. Specimens of *Brachysphingus gibbosus,* however, are commonly found as transported material in lenses of sandy siltstone contained within deep-water turbidites. The distance of transport from their shallower water habitats into deeper waters was not great because the amount of shell abrasion is low. The other two species, although also subject to displacement via turbidity currents, are usually found in shallow-marine rocks. *Brachysphingus sinuatus* is usually in medium-grained sandstone, whereas *B. mammilatus* is usually in fine-grained sandstone. Evidently, the axial ribs of *B. sinuatus* strengthened the shell and allowed for living in agitated waters where coarser grained sediment accumulated.

Brachysphingus is unusual in that it is one of the few latest Cretaceous to early Tertiary, shallow-marine gastropod genera seemingly indigenous to the Pacific slope of North America. As far as I am aware, there are no confirmed ancestors or successors to *Brachysphingus* in the fossil record. It is present only in California and northern Baja California, Mexico. As will be dis-

←

FIGURE *1*—Index map showing geographic locations of species of *Brachysphingus.* Localities are grouped into 15 areas that are numbered from north to south: 1—Middle Fork Eel River. 2—Lower Lake. 3—Potrero Hills. 4—Martinez-Pacheco area. 5—Deer Valley. 6—Junction of Silver and Panoche Creeks. 7—Dip Creek (Lake Nacimiento area). 8—East Fork Fish Creek and Warm Springs Mountain. 9—Sespe Hot Springs. 10—Big Rock Creek (Valymero area). 11—East side of Browns Canyon, north side Simi Valley, south side Simi Valley (Bus and Meier Canyons), and Simi Hills (Las Virgenes Canyon and summit area). 12—Stokes Canyon, Encino Reservoir, Stone Canyon Reservoir, Garapito Creek, Temescal Canyon, and Pulga Canyon. 13—North of Lake Irvine. 14—Mesa San Carlos. 15—Santa Catarina Landing.

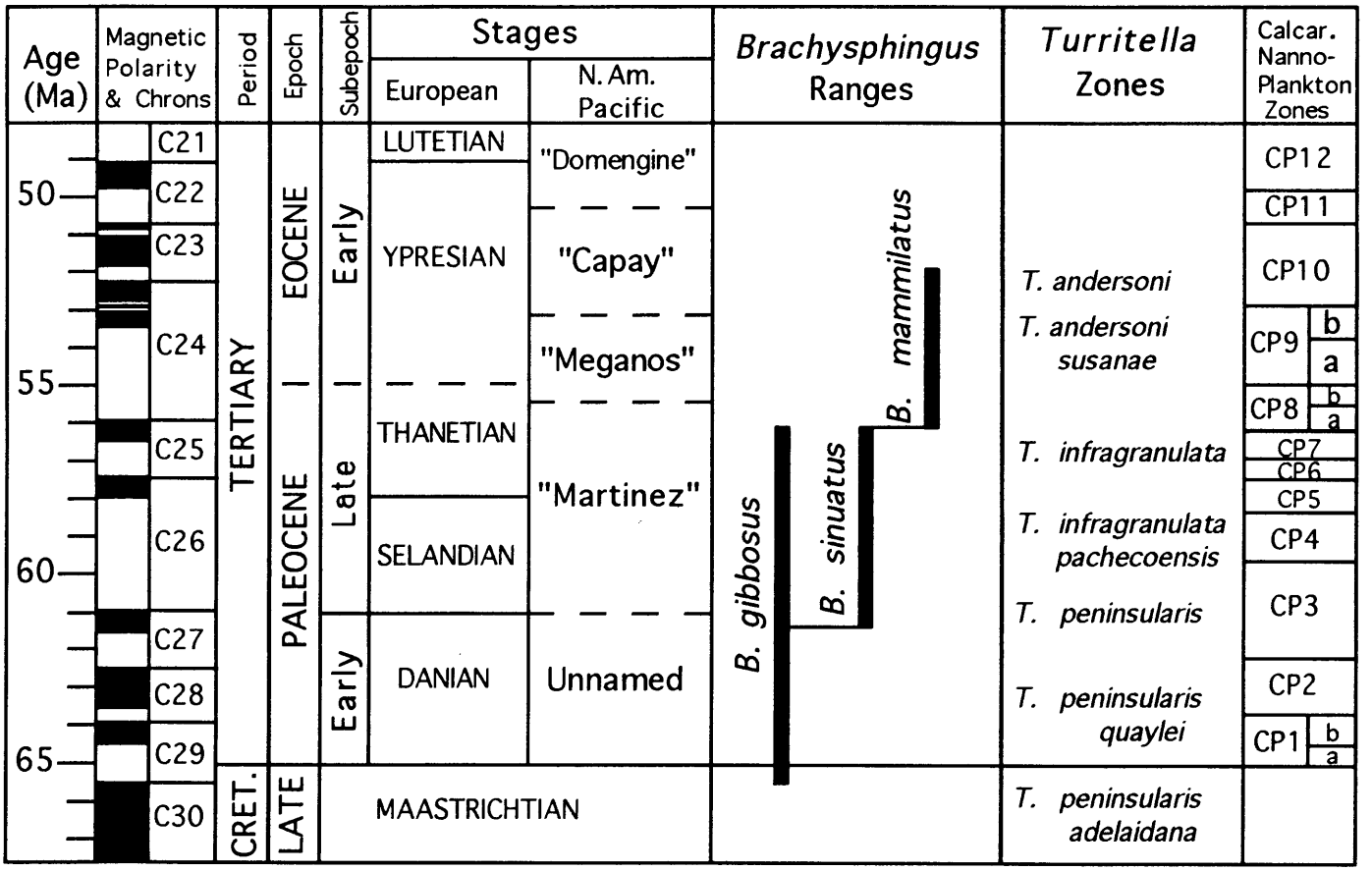


FIGURE 2—Geologic ranges of species of *Brachysphingus* plotted against geochronologic time scale, magnetic polarity and chrons, European stages, and calcareous nannofossil zones (from Berggren et al., 1995), North American Pacific stages (from Saul, 1983a, 1983b; Squires, 1988), and selected *Turritella* zones (from Saul, 1983a).

cussed more thoroughly later in this paper, Cossmann's (1901) report of *Brachysphingus* from the Eocene of Paris Basin, France, proves to be false. Stewart (1927) noted that possibly "*Fusus*" *luciani* Briart and Cornet (1871, page 24, plate 2, figures 3a–c), from the Calcaire Grossier de Mons in Belgium, is related to *Brachysphingus*. The Calcaire Grossier de Mons is of Danian age (Schuler et al., 1992). "*Fusus*" *luciani*, however, has a long anterior canal, very strong spiral ribs, and no siphonal fasciole. The species does not belong in genus *Brachysphingus*.

Abbreviations used are: ANSP = Academy of Natural Sciences of Philadelphia; CASG = California Academy of Sciences, Geology; CSUN = California State University, Northridge; IGM = México Museo del Paleontologia del Instituto de Geología; LACMIP = Natural History Museum of Los Angeles County, Invertebrate Paleontology; UCMP = University of California Museum of Paleontology, Berkeley; UCR = University of California, Riverside; UWBM = Thomas Burke Memorial Washington State Museum (=UW in older literature).

SYSTEMATIC PALEONTOLOGY

Superfamily MURICOIDEA Rafinesque, 1815
Family BUCCINIDAE Rafinesque, 1815

Remarks.—Bucciniform neogastropods started to diversify during the late Mesozoic and early Tertiary, but little is known about their branching order relative to each other. In the study of these gastropods, there has been a tendency to place them in the living families Buccinidae or Nassariidae. The choice of which family has been controversial because they are closely related with no known characters to unambiguously define either group (Allmon, 1990). Ponder (1973) and Cernohorsky (1984) suggested that the differences between the two groups could be treated as subfamilial, and Ponder and Warén (1988) combined both groups in the family Buccinidae. Their classification scheme is used in this paper. I agree with Allmon (1990) that the placing of all late Mesozoic and early Tertiary bucciniform neogastropods into a few traditionally recognized living families has led to obscuring of family-level phylogeny and an underestimating of family-level diversity during this time interval. It is likely that with further study, new families will be erected in order to accommodate early bucciniform neogastropods, like *Brachysphingus*.

Most early workers in the first half of this century followed the usage of Cossmann (1901) and assigned *Brachysphingus* to the nassariids. He based his determination, in large part, on the similarity of *Brachysphingus* to *Buccinum patulum* Deshayes (1835, page 646, plate 88, figures 5, 6), a species known from Eocene rocks in the Anglo-Paris Basin, western Europe. Cossmann (1901) referred to Deshayes' species as *Buccinanops* (*Brachysphingus*) *patulum* and considered it to be a nassariid and the only known Eocene species of *Brachysphingus*. This species was illustrated by Cossmann and Pissarro (1904–1913, pl. 36, fig. 175-1). Allmon (1990, p. 86, pl. 9, figure 12) referred to the same species as "*Ancillopsis*" *patula* (Deshayes) and reported it to be of late Eocene (Auversian-Bartonian) age. He excluded it from his nassariid *Bullia* group and considered that it had independently achieved a shell form somewhat similar to that of some living species of *Bullia*.

TABLE 1—Reported depositional environments of formations containing *Brachysphingus*.

Formation; location	Literature source	Depositional environment
	Brachysphingus gibbosus	
Unnamed; Dip Creek, San Luis Obispo Co.	Grove, 1986	Deep-water turbidities with displaced shallow-marine mollusks
San Francisquito; Warm Springs Mtn., Los Angeles Co.	Kirby, 1991	Transition zone between shoreface and offshore with accumulations of shallow-marine mollusks
San Francisquito; Big Rock Creek, Los Angeles Co.	Kooser, 1980	Deep muddy water with displaced shallow-marine mollusks
Lower and middle Santa Susana; South side Simi Valley, Ventura Co.	Parker, 1983	Middle bathyal turbidities with displaced shallow-marine mollusks
Sepultura; Mesa San Carlos, Baja Calif., Mexico	Zinsmeister and Paredes, 1988	Shallow-shelf with storm accumulations of mollusks
Basal Lodo; Silver Creek and Panoche Creek junction, Fresno Co.	Smith, 1975	Submarine canyon? with localized displaced shallow neritic to sublittoral mollusks
	Brachysphingus sinuatus	
Uppermost Las Virgenes; South side Simi Hills, Ventura Co.	Parker, 1983	Nearshore marine along a low-energy coast; fossils in storm lags
Lower and middle Santa Susana; South side Simi Valley, Ventura Co.	Parker, 1983	Transition zone between nearshore and offshore
Sepultura; Mesa San Carlos, Baja Calif., Mexico	Zinsmeister and Paredes, 1988	Shallow-shelf with storm accumulations of mollusks
San Francisquito; Warm Springs Mtn., Los Angeles Co.	Kooser, 1982	Deep-sea fan turbidites with displaced shallow-marine mollusks
Basal Lodo; Silver Creek and Panoche Creek junction, Fresno Co.	Smith, 1975	Submarine canyon? with localized displaced shallow neritic to sublittoral mollusks
	Brachysphingus mammilatus	
Margaret Hamilton Sand; Deer Valley, Contra Costa Co.	Almgren, 1978	Probable mid-neritic
Basal Lodo; Silver Creek and Panoche Creek junction, Fresno Co.	Smith, 1975	Submarine canyon? with localized displaced shallow neritic to sublittoral mollusks
Uppermost Santa Susana; North side Simi Valley, Ventura Co.	Heitman, 1983	Outer shelf
Lower Juncal; Sespe Hot Springs, Ventura Co.	Givens, 1974	Nearshore shallow-marine

In my private collection, I have specimens of "*Ancillopsis*" *patula* from the middle Eocene Bracklesham Group, Bracklesham Bay, Sussex, England. Although "*A.*" *patula* does bear close resemblance to *Brachysphingus sinuatus,* there are important differences. "*Ancillopsis*" *patula* is characterized by a dorsoventrally flattened shape, minute spire, and expanded callus in the parietal area, and a non-projecting siphonal fasciole that extends a considerable distance posteriorly. None of these features is present in *B. sinuatus*; therefore, "*A.*" *patula* should not be considered as a member of genus *Brachysphingus.* Thus, the basis for Cossmann (1901) placing *Brachysphingus* in the nassariids is removed.

Modern workers have been reluctant to classify *Brachysphingus* as a nassariid. Nuttall and Cooper (1973) doubted that it is nassariid as it lacks the terminal plait found in all definite nassariids. They also stated that the siphonal-fasciole ridge and growth lines suggest that *Brachysphingus* might belong in the very broadly construed Buccinidae. Cernohorsky (1984) considered *Brachysphingus* to be a buccinid genus. To Allmon (1990) it did not appear to belong to the nassariids, and he considered its placement uncertain.

Cossmann (1901, page 221, plate 9, figure 14) reported that *Ancilla subglobosa* (Conrad, 1832, page 25, plate 10, figure 13), a species from Eocene strata of the southeastern United States and northeastern Mexico (Allmon, 1990), belongs in *Buccinanops* (*Brachysphingus*). According to Allmon (1990), this species is a junior synonym of "*Bullia*" *altilis* (Conrad, 1832), which is a problematic taxon allied to genus *Bullia.* "*Bullia*" *altilis* is characterized by a dorsoventrally flattened shape, very expanded parietal callus that can cover the entire ventral surface of the shell, a siphonal fasciole that is weak or absent, and no external sculpture. None of these features is present in *Brachysphingus*; therefore, "*Bullia*" *altilis* is not a member of *Brachysphingus.*

Genus BRACHYSPHINGUS Gabb, 1869

Remarks.—Nuttall and Cooper (1973) suggested that the lectotype of *Molopophorus striatus* (Gabb, 1869, pages 157, 219, plate 26, figure 36), which is the type species of genus *Molopophorus* Gabb, 1869, is actually a juvenile specimen of *Brachysphingus* sp. If their suggestion is correct, which has not been proven, then genus *Molopophorus* becomes a junior synonym of *Brachysphingus. Molopophorus striatus,* however, differs significantly from any *Brachysphingus* by being much smaller (only up to 6 mm high) and by having the suture bordered by a rib on the top of the succeeding whorl. I do not consider *M. striatus* as belonging to genus *Brachysphingus. Molopophorus striatus* is known from upper Eocene rocks of California (Allmon, 1990).

Allmon (1990) reported that *Molopophorus* is probably a nassariid but that the genus has an uncertain status and should be used in an informal sense (denoted by quote marks).

Brachysphingus gibbosus, and to a lesser degree *B. mammilatus,* bear close resemblance to "*Molopophorus*" *clarki* (Weaver, 1912, page 48, plate 4, figure 38; plate 6, figure 57) from the Cowlitz Formation (Weaver, 1942) of late middle Eocene age (Nesbitt, 1995) in southwestern Washington. Although "*Molopophorus*" *clarki* resembles the smooth forms of *Brachysphingus,* "*M.*" *clarki* has a slight terminal fold, which is usually a nassariid character (Allmon, 1990).

The upper spire of nearly every specimen of *Brachysphingus* is preferentially decorticated, whereas the body whorl has all or

most of its shell material intact. The upper spire, therefore, is almost always preserved as an internal mold. On a few specimens, remnants of shell give the upper spire the appearance of having a sutural cord or cords. Rare specimens that have shell material present, on at least the penultimate whorl, do not have any sutural cords.

The suture on every specimen of *Brachysphingus* has been adversely affected by weathering. It seems to be very shallowly grooved, but that might just be an artifact of weathering. Nuttall and Cooper (1973) reported that the suture appeared to be canaliculate (grooved) on at least one specimen of *B. gibbosus* that they had available for study.

The illustrations (Figures 3, 4) of representative specimens of each of the species of *Brachysphingus* are arranged in a growth-series pattern, from juvenile to adult. Where appropriate, unusual specimens are included after the growth-series of the normal specimens. Measurements of these specimens, as well as non-illustrated paratypes, are given in Table 2.

Type species.—*Brachysphingus sinuatus* Gabb, 1869, by subsequent designation (Cossmann, 1901).

Brachysphingus gibbosus Nelson, 1925
Figure 3.1–3.16

Brachysphingus gibbosus Nelson, 1925, table opposite p. 402, p. 426, pl. 57, figs. 5a, 5b, 6; Clark and Woodford, 1927, p. 117; Keen and Bentson, 1944, p. 133–134; Nuttall and Cooper, 1973, pl. 8, figs. 3, 4; Allmon, 1990, table on p. 23.

Brachysphingus sinuatus Gabb. Zinsmeister and Paredes-Mejia, 1988, pl. 1, figs. 12, 13.

Brachysphingus gabbi Stewart. Zinsmeister, 1983, pl. 4, figs. 13, 14

Brachysphingus cf. *B. gibbosus* Nelson. Kirby, 1991, p. 67–68, pl. 1, fig. 8.

Brachysphingus n. sp. Saul, 1986, figs. 52–53.

Original description.—"Shell short, thick, subovate; spire low; whorls 5; suture linear, slightly appressed; body whorl swollen, in most specimens roughly con-shaped in upper portion, curving rather abruptly inward below. Main portion of body whorl smooth except for more or less prominent sinuous growth lines; portion of body whorl just above canal marked by 6 or 7 fine revolving ribs. Aperture roughly oval-shaped with maximum width just anterior to center, pointed behind, notched anteriorly. Outer lip simple; inner lip moderately calloused; canal short" (Nelson, 1925, p. 426).

Supplemental description.—Shell medium size (up to 35.1 mm high), consisting of approximately six convex whorls. Suture shallowly grooved?; protoconch unknown. Spire low to moderately elevated; very rarely projected, never concave-looking. Juveniles globose, uncommonly with projected anterior area; adults (greater than approximately 27 mm high) cylindrical-ovoid. Penultimate whorl with approximately seven to eight closely spaced, fine spiral ribs, usually without a finer spiral rib in the interspaces. Body whorl usually smooth, rare specimens (never more than 22 mm high) with fine spiral ribbing on posterior half of ventral surface of body whorl; rarer specimens (never more than 21 mm high) with fine spirals on entire ventral surface of body whorl. A few coarse growth rugae near outer lip moderately common. Neck area with 8 to 12, fine spiral ribs, becoming fainter posteriorly; spiral ribs on neck stronger than elsewhere on the shell; necl-area spiral sculpture usually obsolete on large adults. Siphonal fasciole distinct but usually not strongly developed. Anterior notch short. Inner lip callus light to moderate. Growth line sigmoidal with strongest deflection between the rounded shoulder and the suture.

Type specimens.—Holotype UCMP 30526 and paratype UCMP 30527.

Type locality.—UCMP 3776, upper lower Santa Susana Formation, Runkle Canyon, south side of Simi Valley, Ventura County, southern California.

Remarks.—A total of 237 specimens were found in museum collections. Early juvenile specimens are scarce and poorly preserved. None was less than 13 mm high. Late-stage adults are not that common; only 15 were detected in the museum collections. Specimens of *B. gibbosus* generally show good preservation, but they are usually weathered and missing the uppermost spire, the anterior end of the shell, and the outer lip. The aperture on most specimens is plugged with hard matrix.

The area with the most specimens and localities of *B. gibbosus* is on the south side of Simi Valley in the Meier Canyon area, Ventura County, southern California, where there are numerous float boulders from the almost completely covered, so-called "Martinez marine member" of the lower Santa Susana Formation. This is area where Nelson (1925) collected his type specimens of *B. gibbosus*. Every museum collection studied has an appreciable number of specimens from this area. Inspection of the specimens revealed that nearly all are globose juveniles. Only a few are adults.

The change in shape of the body whorl of *B. gibbosus* from globose juveniles to ovoid adults is new information, as is the observation that juveniles can have spiral ribs on the ventral surface of the body whorl. On the globose juveniles, the maximum diameter is on the medial part of the body whorl and perpendicular to the axis of coiling. On the ovoid adults, the maximum diameter is very oblique to this axis and extends from near the shoulder to the anterior third of the body whorl.

Nelson's (1925, plate 57, figures 5a, 5b, 6) illustrations of the two primary type specimens of *B. gibbosus* have drawbacks in that they do not show complete specimens and both are late juveniles. The spire is missing on the holotype, and the base is missing on the paratype. These specimens are illustrated (Figure 3.3, 3.7, 3.8), and a comparable size, but more complete specimen, is also illustrated (Figure 3.5, 3.6).

Nuttall and Cooper (1973, plate 8, figures 3, 4) illustrated two specimens of *B. gibbosus* from Ventura County. One illustration is of a sectioned specimen, and it shows that there is no columellar plait. The other illustration is an oblique view of the spire, and it shows how the growth lines are reversed at the suture.

The earliest known specimens of *B. gibbosus* are from unnamed strata at LACMIP locs. 26525 and 26526 in the Dip Creek area, along the south shore of Lake Nacimiento, San Luis Obispo County, central California. Saul (1983a, 1986) and Squires and Saul (1993) assigned these strata to an age of latest Cretaceous (or possibly earliest Paleocene). Four specimens of *B. gibossus* were found in the Dip Creek area. They range in morphology from globose to narrow with a projecting spire (Figure 3.13, 3.14). The narrow form is unusual and may give a clue as to the progenitor of the *Brachysphingus* lineage.

A few of the late-stage juveniles (approximately 19 to 20 mm high) of *B. gibbosus* are unusual in that, in addition to the globose body whorl, they have a narrow and elongate neck area. This anterior elongation is present only on the geologically older specimens. It is present on one of the geologically oldest specimens of *B. gibbosus* from the Dip Creek area. It is also present on a specimen (Figure 3.11, 3.12) from LACMIP loc. 1581 in upper Danian strata in East Fork Canyon near Warm Springs Mountain, Los Angeles County, southern California.

Specimens of *B. gibbosus* are uncommon in Thanetian-age rocks. Only six specimens were detected in the museum collections.

The most obvious way of distinguishing *Brachysphingus gibbosus* from *B. sinuatus* is that *B. gibbosus* has no axial ribs. There are, however, certain specimens that are intermediate between *B. gibbosus* and *B. sinuatus*. These specimens, which are known

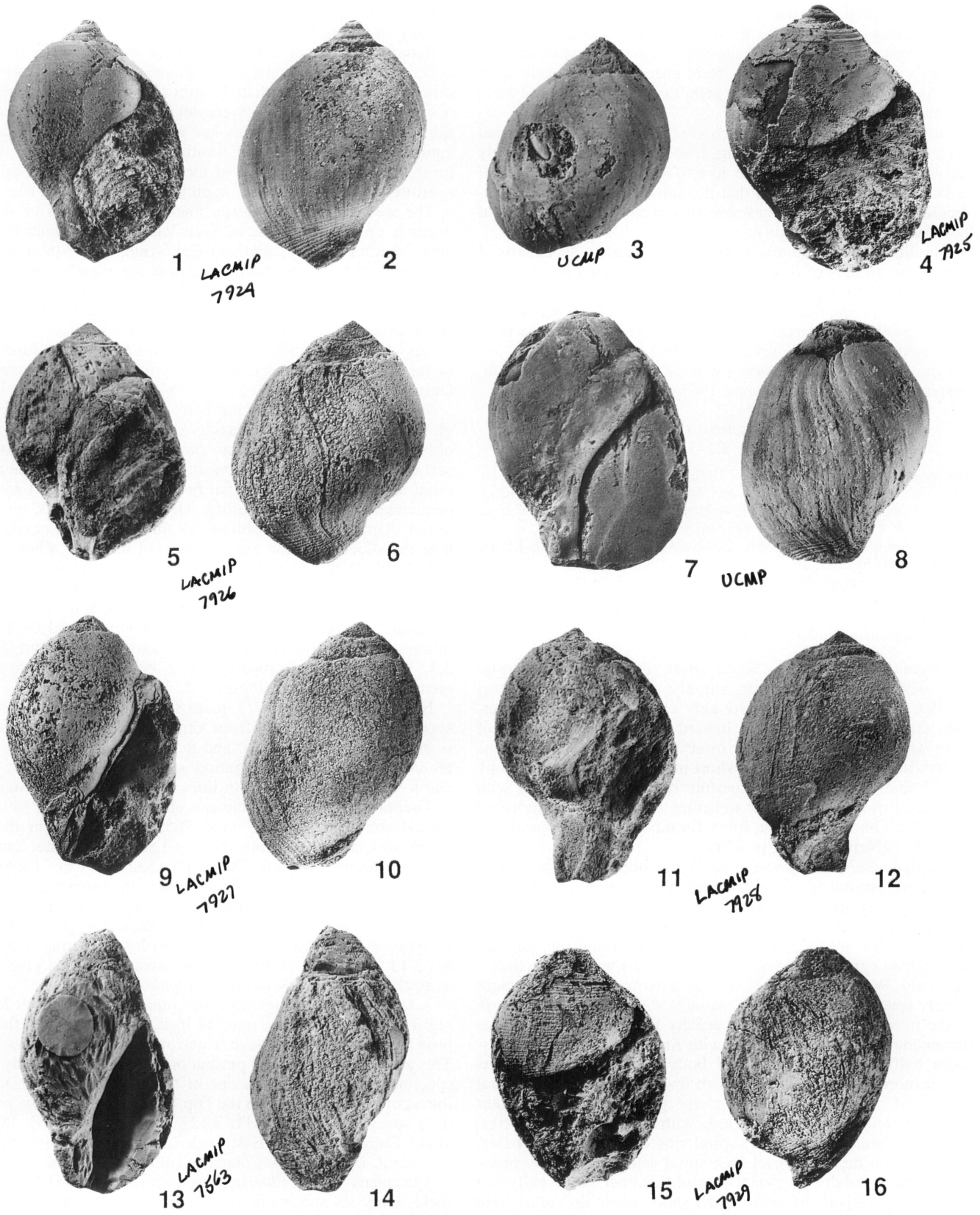


FIGURE *3—1–16, Brachysphingus gibbosus* Nelson, 1925. *1, 2,* hypotype, LACMIP 7924, LACMIP loc. 22330, apertural and abapertural views, ×2.7. *3,* paratype, UCMP 30527, UCMP loc. 3776, abapertural view, ×2. *4,* hypotype, LACMIP 7925, LACMIP loc. 22330, apertural view, ×2.3. *5, 6,* hypotype, LACMIP 7926, CSUN loc. 123c, apertural and abapertural views, ×2. *7, 8,* holotype, UCMP 30526, UCMP loc. 3776, apertural and abapertural views, ×2.1. *9, 10,* hypotype, LACMIP 7927, LACMIP loc. 22702, apertural and abapertural views, ×1.4. *11, 12,* hypotype, LACMIP 7928, LACMIP loc. 21581, apertural and abapertural views, ×2.4 *13, 14,* hypotype, LACMIP 7563, LACMIP loc. 26526, apertural and abapertural views, ×1.7. *15, 16,* hypotype, LACMIP 7929, LACMIP loc. 23110, apertural and abapertural views, ×2.2.

CSUN 123c = LACMIP 17086