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Source: Journal of Paleontology, 80(sp66) : 1-42

Published By: The Paleontological Society

URL: https://doi.org/10.1666/0022-3360(2006)80[1:SFTRTM]2.0.CO;2

SPONGES FROM THE REEF TRAIL MEMBER OF THE UPPER GUADALUPIAN (PERMIAN) BELL CANYON FORMATION, GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

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ABSTRACT—An extensive faunule of silicified calcareous sponges has been recovered from the Upper Guadalupian Reef Trail Member of the Bell Canyon Formation, from the Patterson Hills, in the southwestern part of the Guadalupe Mountains National Park in western Texas. This is the youngest silicified faunule of Permian sponges known from that area, and possibly the youngest from North America. It includes the hypercalcified ceractinomorph ''sphinctozoans'' *Amblysiphonella* sp., *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby, 1988, *Colospongiella permiana* n. gen. and sp., *Exaulipora permica* (Senowbari-Daryan, 1990), *Parauvanella minima* Senowbari-Daryan, 1990, and the ''sphinctozoans'' *Girtyocoelia beedei* (Girty, 1909), *Sollasia ostiolata* Steinmann, 1882, *Sollasiella reticulata* n. gen. and sp., *Ramosothalamiella divaricata* n. gen. and sp., and *Spica texana* n. sp. Also present are *Guadalupia zitteliana* Girty, 1909, *Guadalupia minuta* n. sp., *Lemonea cylindrica* (Girty, 1909), and *Lemonea micra* Rigby, Senowbari-Daryan, and Liu, 1998. Aspiculate calcareous sponges include the ''inozoids'' *Preperonidella rigbyi* (Senowbari-Daryan, 1991), ?*Djemelia* sp., *Radiotrabeculopora virga* n. sp., *Daharella ramosa* Rigby and Senowbari-Daryan, 1996, *Daharella pattersonia* n. sp., *Daharella crassa* n. sp., and *Newellospongia perforata* n. gen. and sp. The problematic *Lercaritubus problematicus* Flügel et al., 1990 is tentatively included with the ''inozoids.''

The new siliceous protomonaxonid demosponge *Monaxoradiata lamina* n. gen. and sp., is a moderately common sponge from the member. The new siliceous lithistid demosponges *Chiastocolumnia cylindrica* n. gen. and sp., *Dactylites obconica* n. sp., and *Dactylites magna* n. sp., the large hexactinellid sponge *Toomeyospongia gigantia* Rigby and Bell, 2005, and the new lyssacinosid *Flexuospiculata hexactina* n. gen. and sp., along with isolated large hexactines, are associated with these silicified calcareous sponges from the Reef Trail Member. *Toomeyospongia gigantia* Rigby and Bell, 2005, described earlier, is the only large complete hexactinellid sponge that is part of the Reef Trail Member assemblage.

The problematical *Pulsatospongia obconica* n. gen. and sp., whose taxonomic position is uncertain, along with an encrusting possible inozoid sponge, and spicule-lined ?burrows are also described as part of the fossil assemblage.

Significant faunal similarity occurs between this assemblage and those from several areas within the Paleo-Tethys Sea, especially with those from the Djebel Tebaga area of Tunisia. This suggests significant faunal exchange between the two regions, possibly resulting from strong trans-Panthalassan equatorial currents and a significant anti-cyclonic gyre within the Paleo-Tethys basin.

INTRODUCTION

An extensive diverse assemblage of Upper Guadalupian silicified calcareous sponges has been recovered from the eastern Patterson Hills, south of Guadalupe Peak, in the southern part of Guadalupe Mountains National Park, in western Texas (Fig. 1). These are among the youngest silicified Permian sponges known from the region, and possibly from North America. They are from a locality in the Reef Trail Member, the uppermost member of the Upper Guadalupian Bell Canyon Formation (Fig. 2).

Permian sponges have been known from western Texas for nearly a century, beginning with the early pioneer work by Girty (1909), who documented their occurrence in his broad study of the Guadalupian fauna. Later publications by R. H. King (1933, 1943), Finks (1960, 1983, 1995), and Rigby, Senowbari-Daryan, and Liu (1998) added to the region's then known poriferan record. The sponges described here add further to the assemblage and help document one of the most diverse reef-related Permian sponge faunas known.

P. B. King (1948) established a basic stratigraphic framework of formations and members for the reefs and shelf deposits, and the laterally equivalent backreef and basin units in the Guadalupe Mountains and nearby areas. Newell et al. (1953) presented discussions and paleoecological and sedimentological interpretations of those deposits, and their study, with that of King, has been the base for additional carbonate and systematic paleontological studies of the region.

Wilde et al. (1999) named the siliciclastic-bearing upper beds of the Bell Canyon Formation as the Reef Trail Member (Fig. 2). These beds overlie the Lamar Limestone Member of the Bell Canyon Formation (Fig. 2) and were termed the post-Lamar beds by P. B. King (1948). The type section of the Reef Trail Member is 0.5 km east-southeast of the Permian Geology Reef Trail, northeast of the mouth of McKittrick Canyon, on the front of the Guadalupe Mountains northeast of Guadalupe Peak. Lithologic criteria established by Wilde et al. (1999) allows confident identification of the member in upper Bell Canyon–pre-Castile Formation beds in the Patterson Hills, although P. B. King (1948) mapped these latest Guadalupian exposures as within the Lamar Member. Biostratigraphic correlations applying fusulinid zonations of Wilde et al. (1999, fig. 3, 3a) further substantiate that correlation, and indicate that these productive fossiliferous beds are from the latest Guadalupian *Paraboultonia splendens* Zone. This fusulinid is found in wackestones immediately above the basal siliciclastic unit on the same hillside as USGS Locality 7663, and above the stratigraphic level of the USB (Fig. 2). The stratigraphic section of the siliciclastic-bearing beds of the Reef Trail Member, from which the sponges described here were obtained, is shown in Figure 2.

These sponges were collected from very near, or at, P. B. King's (1948) *Strigogoniatites fountaini* locality (USGS Locality 7663, P. B. King, 1948, pl. 2), named by King for the ammonoids earlier reported from the locality by Miller and Furnish (1940, p. 12). Small specimens of *Strigogoniatites* Spath, 1934 were collected by Bell and associates from the scaphopod beds (Fig. 2), so this sponge fauna is equivalent in age with the youngest ammonoids known from the Permian Basin of Texas and New Mexico.

Lambert et al. (2002), using conodont correlations, placed the Guadalupian–Lopingian (Middle Permian–Late Permian) series boundary at the base of the Castile Formation, at the top of the Reef Trail Member. This placement differs somewhat from conclusions presented earlier by Wilde et al. (1999) that fusulinids from the member suggested a Lopingian age for the Reef Trail Member. In either case, the sponges described here are among the youngest Permian sponges known from North America.

Initiation of the present study was prompted by discovery of silicified fossils in a carbonate bed of the Reef Trail Member. Blocks containing the fossils were collected by G. Bell and associates. These blocks were then etched in laboratory facilities of the park, where the resulting residues were preliminarily sorted

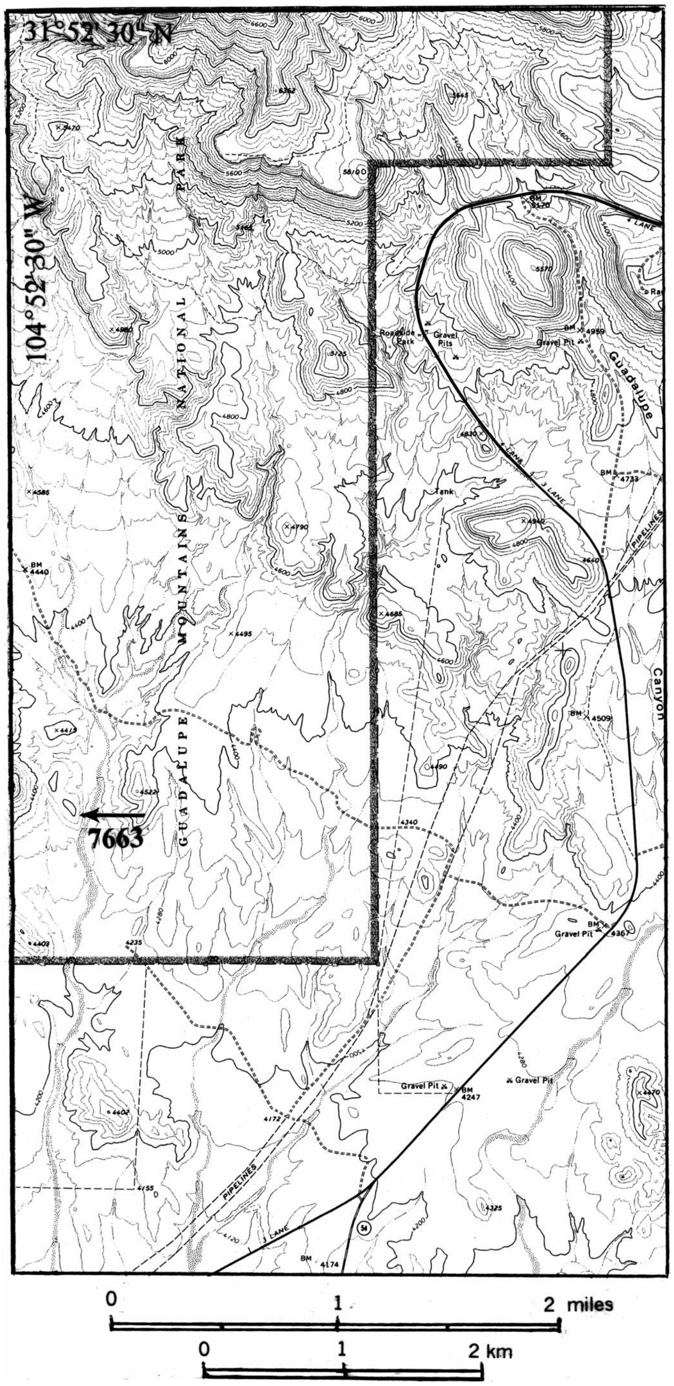


FIGURE *1*—Index map to USGS Locality 7663 (P. B. King, 1948, pl. 2), Guadalupe Pass 7.5-minute quadrangle, from which the suite of Upper Guadalupian silicified sponges were collected from the Reef Trail Member of the Bell Canyon Formation, from the southeastern Patterson Hills, Guadalupe Mountains National Park, Texas.

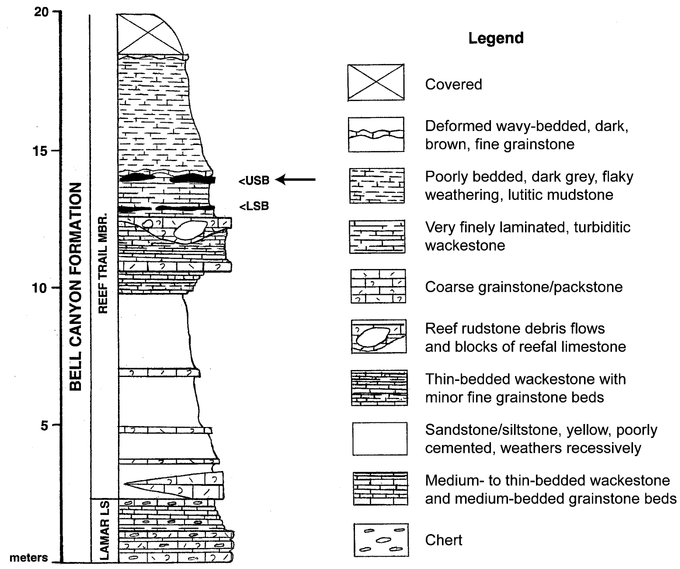


FIGURE *2*—Stratigraphic section of the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663 (=GUMO GEO 00006), showing position of the carbonate upper scaphopod bed (USB, arrow) from which the silicified sponge fauna described here was obtained. LSB, lower scaphopod bed.

by Bell and associates on the staff of Guadalupe Mountains National Park. Fossils from those residues thought to be sponges were sent to Rigby for systematic assignment, description, and illustration.

Seven species of the Guadalupe sponges documented here, including *Girtyocoelia beedei* (Girty, 1909), *Sollasia ostiolata* Steinmann, 1882, *Lemonea cylindrica* (Girty, 1909), *Cystauletes mammilosus* R. H. King, 1943, *Preperonidella rigbyi* (Senowbari-Daryan, 1991), *Daharella ramosa* Rigby and Senowbari-Daryan, 1996, and *Tristratocoelia rhythmica* Senowbari-Daryan and Rigby, 1988, have been reported from the Djebel Tebaga area in Tunisia, and some of them have also been reported from South China, Sicily, Oman, and Thailand, all of which formerly lay within Tethys. Four other genera reported here, *Spica* Termier and Termier, 1977a, *Radiotrabeculopora* Fan, Rigby, and Zhang, 1991, *Guadalupia* Girty, 1909, and ?*Djemelia* Rigby and Senowbari-Daryan, 1996, are also congeneric with taxa from that Tunisian fauna. Two other species from this Texas fauna, *Parauvanella minima* Senowbari-Daryan, 1990 and *Lercaritubus problematicus* Flügel et al., 1990, have also been reported from Oman. These occurrences represent an unexpected degree of faunal similarity between two areas on opposite sides of the terrestrial spine of Pangea (Fig. 3) and would seem to indicate a significant amount of faunal interchange across the Panthalassan

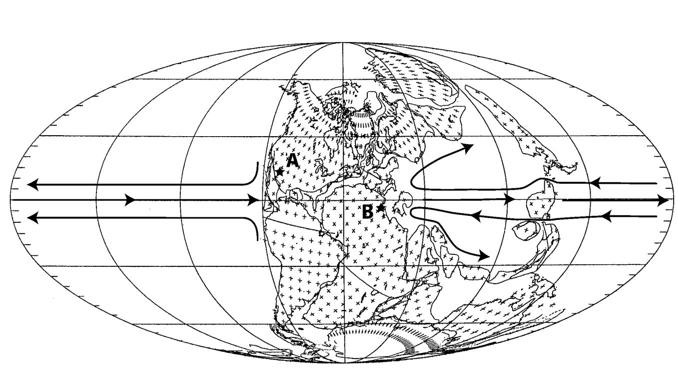


FIGURE *3*—Hypothetical oceanic currents based on sponge faunal data from this report and previously identified locations of Middle-Late Permian sponge reefs (shown as circles). A, Delaware Basin, Texas; B, Djebel Tebaga, Tunisia. (Base map adapted from Scotese and McKerrow, 1990).

Ocean near the end of the Guadalupian. Such close faunal similarity suggests that there was fairly rapid and unobstructed exchange of at least the larval stages of these sponges between the Delaware Basin of Texas and Tunisia. The most likely mechanism for this exchange would have been strong equatorial currents and countercurrents. At 5° North latitude, the Delaware Basin would have been at the eastern inception of the westbound North Equatorial Current and only a short distance north of the terminus of the eastbound Equatorial Countercurrent (Fig. 3).

Based on present concepts of paleogeographic reconstructions of lands surrounding the Tethys, South China sat directly astride the equator. Its position likely would have forced initially opposite excursions of the North and South Equatorial currents. These may have continued westward and reformed in a normal equatorial position that proceeded across the Tethys and arrived at the equatorial position of the Tunisian reefs. From this point, the two westbound currents likely turned in opposite directions and continued along the margins of their respective northern and southern portions of the Tethys. These currents may have been significant influences in building other Middle and Late Permian sponge reefs along the western, southern, and eastern margins of the Tethys. For a distribution map of these reefs see Ziegler et al. (2003, fig. 4b).

Locality.—The sponges were collected from the Reef Trail Member of the Bell Canyon Formation at, or near, USGS Locality 7663 (P. B. King, 1948, pl. 2), also listed as GUMO GEO 00006 by the Park. The locality is at latitude 30°49′45″ North, and longitude 104°52′18″ West, Guadalupe Pass 7.5-minute quadrangle. Beds from which the sponges were collected were included in the Lamar Limestone by P. B. King (1948, pl. 3), but are now considered in the Reef Trail Member of the Bell Canyon Formation (Fig. 2, USB). The locality is on the east promontory of a small hill approximately 1,300 ft west of spot height 4522, which is south of the Williams Ranch Road, and 2.15 mi west-northwest of the ranch road junction with U.S. highways 62 and 180. That junction is approximately 1.5 mi northeast of the junction of State Highway 54, the ''Van Horn Highway,'' with U.S. highways 62 and 180 (Fig. 1). The locality is within the national park and a valid research permit is required before any collecting is allowed.

Depositional environment.—The Reef Trail Member at Locality GUMO GEO 00006 was deposited within the Delaware Basin approximately 1–1.5 km or 1 mi from the shelf margin, as approximated from geologic mapping (P. B. King, 1948, pl. 3). The paleobathymetric depth along the northwest margin of this basin during latest Guadalupian time was estimated to have been approximately 1,700 ft (Newell et al., 1953, p. 190). The USB, or upper scaphopod bed, probably represents a small localized debris flow that originated at the shelf margin and terminated a short distance into the basin. It and the LSB (lower scaphopod bed) are contained within a 1.5 m thick sequence of finely laminated carbonate turbidites that indicate deepwater deposition within the basin. Quiet, deep-basin deposition of the sequence is further substantiated by the occurrence of a large, intact, globular hexactinellid sponge within this turbidite sequence, immediately below the LSB (Rigby and Bell, 2005).

The USB occurs as a discontinuous lens up to 0.2 m thick, with smaller, thinner outlying lenses to the north. Lithologically, the USB is a poorly sorted, highly bioclastic rudstone/packstone with a fine-grained carbonate matrix. Most of the bioclasts are silicified replacements, the largest of which consist of sponge fragments up to 7–8 cm long, and large scaphopods up to 11 cm long. The scaphopods appear to be in a nearly parallel orientation in many places. However, this relationship is difficult to quantify because most exposures of the beds are the dominantly vertical outcrop faces. However, the occurrences do suggest a fluid current-influenced or turbidity-influenced emplacement. The entire fauna contained within the USB is surprisingly diverse, including numerous types of gastropods and pelecypods; several types of brachiopods, bryozoans, and amphineurans; and less abundant nautiloids, ammonoids, corals, echinoderms and trilobites. Such a high diversity with a dominance of calcareous sponges and molluscs points to an allochthonous fauna derived from the vicinity of the shelf margin (Newell et al., 1953, fig. 69).

Depository.—All specimens are deposited in the paleontological research collections at Guadalupe Mountains National Park, Salt Flat, Texas.

SYSTEMATIC PALEONTOLOGY

HYPERCALCIFIED SPONGES
Class DEMOSPONGEA Sollas, 1875
Subclass CERACTINOMORPHA Lévi, 1953
Order AGELASIDA Verrill, 1907
Family SEBARGASIIDAE de Laubenfels, 1955

Diagnosis.—''Cylindroid; central cloaca (retrosiphonate); small, circular closely spaced exopores; wall microstructure spherulitic; no spicules known; vesicles may be present in chambers but not pillars or trabeculae'' (Finks and Rigby, 2004, p. 675).

Subfamily SEBARGASIINAE Senowbari-Daryan, 1990

Diagnosis.—''Catenulate arrangement of the segments with one or more central canals'' (Rigby et al., 1998, p. 41).

Genus AMBLYSIPHONELLA Steinmann, 1882

Type species.—*Amblysiphonella barroisi* Steinmann, 1882, p. 170.

Diagnosis.—''Single, rarely branched, porate sponges with one or more central tubes. Chambers are catenulate and ring-shaped. The endo- and exopores may be of the same size or different sizes. The pores may be simple or may branch dichotomously one or more times. Chambers lack filling structures but may contain vesiculae, particularly in early chambers. Skeleton consists of aragonite with a spherulitic microstructure. The retrosiphonate central tube may not always be recognizable'' (Senowbari-Daryan and Rigby, 1988, p. 179).

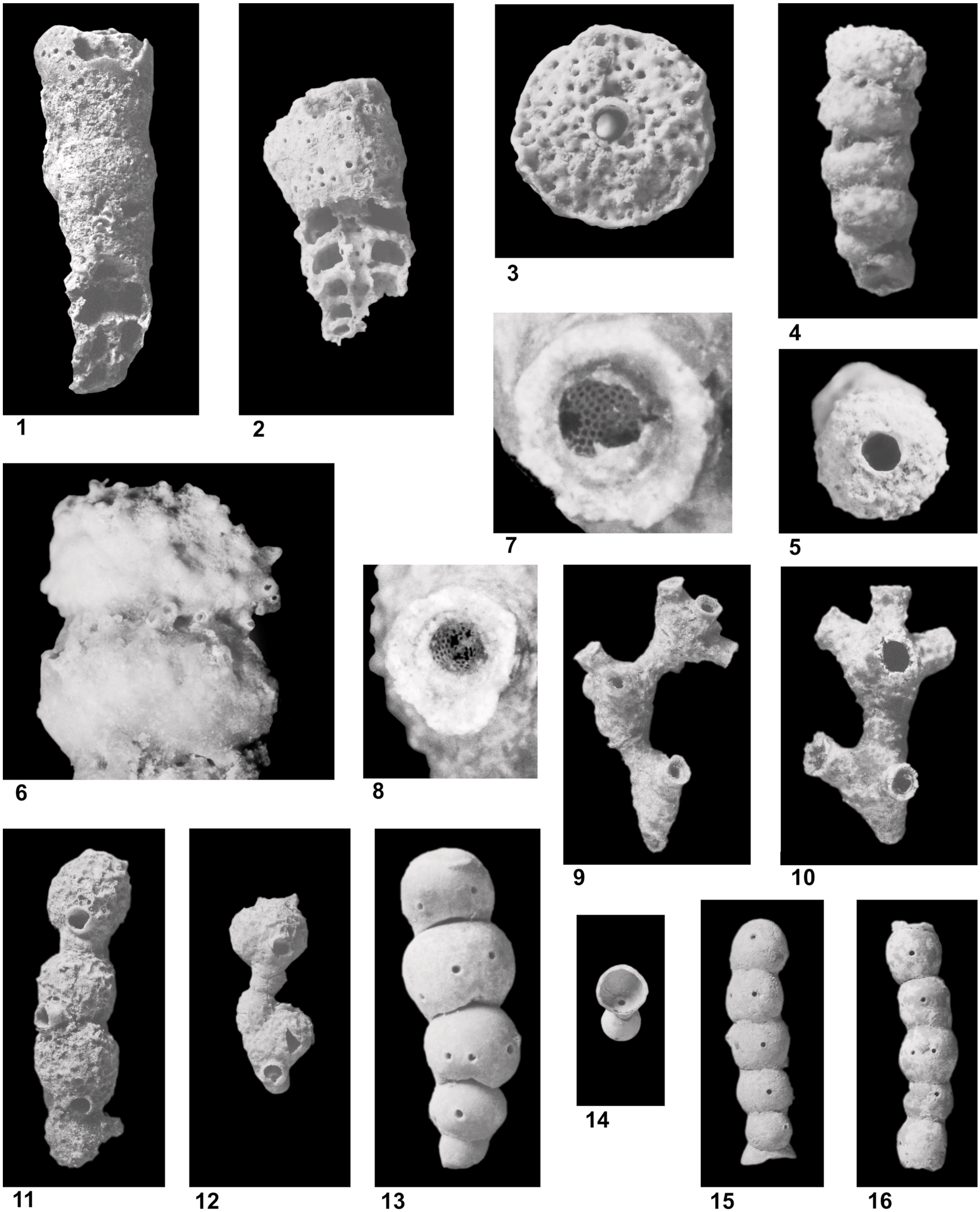
AMBLYSIPHONELLA sp.
Figure 4.1–4.3

Description.—Two small basal fragments of *Amblysiphonella* are steeply obconical chambered forms, each with a continuous axial tube that extends from the initial chamber base to the top of the fragment, and is surrounded by a catenulate ring-shaped chamber. The smaller one, GUMO 5250n, is 12 mm high and expands upward from a basal diameter of 0.7 mm to a maximum diameter of 7.5 mm at the broken top (Fig. 4.2). It has been fractured so the small lower chambers are seen in vertical section, but the upper chambers are covered by the relatively dense dermal layer.

The retrosiphonate central tube is 1.5 mm in diameter in the lower part and is 1.6 mm across at the top (Fig. 4.3). It has walls 0.2 mm thick, which are perforated by several endopores, 0.25–0.30 mm in diameter, per chamber.

Interwalls between chambers are upward-arched and thicken slightly upward from 0.3 mm to 0.5 mm thick. They are perforated by interpores approximately 0.2 mm in diameter occurring in concentric rings around the central tube. There are two such rings in lower interwalls and up to four rings in the upper exposed interwall at about midheight. There are five or six rings in the interwall exposed at the top of the fragment.

The dermal layer is perforated by several inhalant ostia at about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midheight on the chamber wall. These are 0.2–0.4 mm in diameter, with most 0.3–0.4 mm across, and most have a low rim, 0.2–0.3 mm high and 0.10–0.15 mm thick, on the exterior.

The larger specimen, GUMO 15089, is 24.5 mm tall and expands upward from a small broken chamber only 4 mm across and 2 mm tall, to an upper preserved chamber 7.5 mm in diameter and 4 mm tall (Fig. 4.1). Chambers generally increase in height upward, but somewhat irregularly. Lower chambers appear coated with a thin irregular layer of secondary spherulitic silica, so details are obscured. Exopores are best preserved in the outer wall of the uppermost chamber. They are 0.30–0.35 mm in diameter and are irregularly separated 0.7–1.0 mm apart over the entire outer chamber wall. Where the secondary coating is present on lower chambers, the exopores have low rounded rims or short tubular exaules up to 0.25 mm long. Most rims are only 0.10–0.15 mm high and 0.07–0.10 mm thick.

The central tube is well exposed in lower chambers and ranges from 1.5 mm in diameter, where thinnest at midheight, to 1.8 mm where it merges with the downward-curved upper interwall of the retrosiphonate structure. The central tube has a wall approximately 0.2 mm thick and is perforated by numerous circular to somewhat ovoid endopores that are 0.15–0.20 mm in diameter and irregularly spaced 0.1–0.3 mm apart.

Interwalls are 0.20–0.25 mm thick, but thicken toward the central tube where they are curved to form merged exowalls of the chambers. Interpores are 0.20–0.25 mm in diameter and are 0.2–0.3 mm apart in two or three irregular rings around the central tube, where exposed in lower chambers whose exowalls have been partially broken away.

Material examined.—The small fragment, GUMO 5250n, and the larger specimen, GUMO 15089, are the only specimens of *Amblysiphonella* in the collection. They were collected from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—Because only the two small, probably juvenile fragments of the genus are in the collection, specific identification is uncertain.

Family GIRTYOCOELIIDAE Finks and Rigby, 2004

Diagnosis.—''Spheroidal chambers; exowall generally imperforate, with well-developed exauli, that may contain internal cribibulla, in equatorial rings; cloaca present except in juveniles (protocysts), with endopores often concentrated in a ring; filling structures sparse to absent; but vesicles or trabeculae may occur'' (Finks and Rigby, 2004, p. 658).

Discussion.—Rigby et al. (1998, p. 55–56) included the subfamilies Thaumastocoeliinae and Enoplocoeliinae, and the genera *Sollasia* Steinmann, 1882 and *Girtyocoelia* Cossman, 1909 in the Thaumastocoeliidae. Those genera and several other genera were included in the new family Girtyocoeliidae, and the Thaumastocoelliidae was restricted by Finks and Rigby (2004, p. 658–667). In addition, the Amphorithalamiidae Senowbari-Daryan and Rigby (1988, p. 201) was included in the Girtyocoeliidae by Finks and Rigby (2004, p. 658).

Genus GIRTYOCOELIA Cossman, 1909
(pro *Heterocoelia* Girty, 1909 non Dahlbom, 1854)

Type species.—*Heterocoelia beedei* Girty, 1908, p. 284.

Emended diagnosis.—Linear to branched stems of spherical to barrel-shaped superposed chambers that overlap, are in contact, or are separated and connected by prominent central tube; chambers and central tube increase in diameter upward; exowalls thick, imperforate except for generally equatorial ring of large ostia that commonly extended to form exaules to several millimeters long; cribribulla may be preserved at inner end of each exaulos; axial tube prosiphonate with exowall pierced by small to large endopores that may be concentrated in rings near upper and lower interwalls of chambers, or irregularly distributed; interwalls imperforate.

GIRTYOCOELIA BEEDEI (Girty, 1909)
Figure 4.4–4.6

Heterocoelia beedei GIRTY, 1909 [1908], p. 248, pl. 14, figs. 1–8; R. H. KING, 1933, p. 78, pl. 14, figs. 1–8; non PARONA, 1933, p. 42, pl. 8, fig. 1.

Heterocoelia sphaerica R. H. KING, 1933, p. 79, pl. 7, figs. 7, 8.

Girtyocoelia beedei ZHURAVLEVA, 1962, p. 76, fig. 110; KÜGEL, 1987, p. 144, pl. 33, figs. 4–8; SENOWBARI-DARYAN AND DI STEFANO, 1988, p. 16–17, pl. 1, figs. 2, 3, 5b; pl. 3, figs. 1–4; pl. 7, fig. 7; SENOWBARI-DARYAN AND RIGBY, 1988, p. 200, pl. 39, figs. 14–17; SENOWBARI-DARYAN, 1990, p. 130–131, pl. 45, figs. 1–3, 5–7, text-fig. 48; SENOWBARI-DARYAN AND INGAVAT-HELMCKE, 1994, p. 24, pl. 7, fig. 1; pl. 8, fig 3?; pl. 9, fig. 2; WEIDLICH AND SENOWBARI-DARYAN, 1996, p. 42, fig. 9.6; RIGBY, SENOWBARI-DARYAN, AND LIU, 1998, p. 56–57, pl. 3, fig. 3; pl. 4, figs. 4–10, text-fig. 14.

Girtyocoelia cf. *G. beedei* TOOMEY, 1979, p. 248, fig. 4b.

Girtyocoelia dunbari R. H. KING, 1943, pl. 33–34, pl. 3, fig. 6; ZHURAVLEVA, 1962, p. 76, fig. 111; RIGBY, 1984, p. 1452, fig. 31.

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FIGURE 4—*Amblysiphonella* Steinmann, 1882, *Girtyocoelia* Cossman, 1909, *Ramosothalamiella* n. gen., *Sollasiella* n. gen., and *Sollasia* Steinmann, 1882 from the Reef Trail Member of the Bell Canyon Formation, USGS Locality 7633, Guadalupe Mountains National Park, Texas. *1–3, Amblysiphonella* sp., *1,* side view of larger specimen with inhalant ostia evident in upper dermal layer and internal structure in broken lower part, GUMO 15089, ×3. *2, 3,* GUMO 5250n, *2,* side view of small specimen showing inhalant ostia in mounds in the dense dermal layer of the upper part, and internal structure in the fractured lower part, with arcuate ring chambers around a porous retrosiphonate central tube, ×5; *3,* view from above of chamber interwall showing the numerous interpores arranged in concentric rings around the central tube, ×5; *4–6, Girtyocoelia beedei* (Girty, 1909), GUMO 15104, *4,* side view of nearly complete small moniliform sponge showing aligned, nodose, barrel-shaped chambers, with some nodes containing inhalant ostia ×4; *5,* view from above showing nodose upper wall and central axial tube, ×5; *6,* enlargement of upper two chambers showing nodose surface, with single inhalant ostia present in some nodes or short tubes, ×10. *7–10, Ramosothalamiella divaricatus* n. gen. and sp., *7,* photomicrograph of exaulos of paratype, with well-preserved screen in the opening, surrounded by a thick wall, GUMO 15118, ×20; *8,* photomicrograph of smaller screen in thick-walled exaulos of holotype, GUMO 15117, ×20; *9,* side view of branched holotype with three ovoid, nodose chambers, connected by short segments, and with short, divergent, thick-walled exaules, GUMO 15117, ×4; *10,* side view of branched paratype with two ovoid chambers that have short divergent exaules, GUMO 15118, ×4. *11, 12, Sollasiella reticulata*, n. gen. and sp., *11,* holotype, moniliform sponge of spheroidal chambers with reticulate sculpture and coarse inhalant exaulos in lower part of each chamber, with distinct ''neck'' between upper two chambers, GUMO 15113, ×4; *12,* paratype, with probable small initial chamber and two succeeding, sculptured, spheroidal chambers separated by a distinct ''neck'' and with lower exaulos in upper chamber, GUMO 15114, ×4; *13–16, Sollasia ostiolata* Steinmann, 1882, *13,* side view of nearly complete small moniliform sponge showing ontogenetic changes in early spheroidal chambers, GUMO 15108, ×4; *14,* view into lower part of fractured chamber, showing characteristic single cryptosiphonate interpore, GUMO 15109, ×2; *15,* side view of intermediate stage in moniliform sponge, with moderately aligned inhalant ostia, GUMO 15111, ×2; *16,* side view of moniliform series of chambers in fragment of adult stage, with irregular inhalant ostia, GUMO 15110, ×2.

Girtyocoelia sp. TERMIER AND TERMIER IN TERMIER ET AL., 1977a, p. 40, pl. 10, fig. 8; TERMIER AND TERMIER, 1977b, pl. 9l, figs. 1, 2; text-fig. 20.
Girtyocoelia sp. RIGBY, 1987, fig. 10.18e.

Diagnosis.—Straight or bent stems of spherical to barrel-shaped chambers overlapping in contact, or separated and connected by prominent, walled, central tube; chambers commonly 6–7 mm in diameter, ranging up to 10 mm in diameter. Exowalls and interwalls thick; exowalls pierced by distinct large ostia commonly extended to form exaules to several millimeters long. Prominent axial tube prosiphonate and one-quarter to one-third diameter of chambers. Endowall of spongocoel or central tube pierced by endopores smaller than ostia.

Description.—The most complete fragment of the species, GUMO 15104, is a stem of small, partially overlapping, subspherical chambers of the juvenile part of the sponge (Fig. 4.4). These chambers range from approximately 3.5 mm in diameter and 1.7 mm high, in the broken basal chamber, up to 4.8 mm in diameter and 3.0 mm high in the uppermost chamber. The chambers are pierced by a central axial tube that is 0.8 mm in diameter in the basal section and to 1.3–1.5 mm in diameter in the summit of the sponge (Fig. 4.5). The endowall of the tube is 0.2–0.3 mm thick in the basal chamber but is only 0.15 mm thick at the top of the sponge.

The dermal surface of the sponge is marked by numerous small low nodes that range up to 0.3 mm long or high and have bases approximately 0.5 mm and rounded summits that are approximately 0.3 mm in diameter. Some of these have central pores, possibly exaules, 0.10–0.13 mm in diameter (Fig. 4.6).

Other specimens from the same sample are essentially single chambers or fragments of single chambers. One such specimen is a chamber 3.1–3.4 mm in diameter and 3.2 mm high, which has a protruding segment of the central tube 1.2 mm long and 1.3 mm in diameter. That tube is double-layered and 0.3 mm thick, with an inner layer 0.1 mm thick, which is coated by an outer layer, 0.2 mm thick, and which was possibly part of the wall of a now-removed additional chamber. Neither the chamber wall nor the central tube are obviously porous. The chamber is nodose, however, like associated fragments, with nodes approximately 0.3 mm in diameter.

Two moderately well-preserved fragments of the species occur in collections from 030326-3-1. The more nearly complete of these, GUMO 15106, is 14 mm tall and consists of four complete chambers and a partial lower chamber. That lower fragment suggests a chamber 3.5 mm in diameter and they increase in size upward to the uppermost one that is 5.0 mm in diameter and 4.0 mm tall. A 1 mm long segment of the central tube is exposed between the upper two chambers, where it is 1.7 mm in diameter. Other chambers rest against each other. A section of the central tube is exposed in the lower broken chamber. There the tube is 1.0 mm in diameter, with a wall 0.10 mm thick that appears to lack pores. Much of the exterior is marked by a microporous structure, with micropores 0.02–0.04 mm in diameter and irregularly 0.02–0.06 mm apart. Cross sections of the wall suggest that these openings do not extend through the wall, but may be part of a thin coating, which may be foreign.

The exterior is marked by numerous nodular ostia or short exaules. The ostia are commonly 0.10–0.15 mm in diameter, but range up to 0.20 mm. They occur as terminal openings in nodes that are 0.4–0.6 mm in basal diameter and rise up to 0.6 mm above the wall surface.

The associated sponge, GUMO 15107, is only 12 mm tall and consists of four spheroidal chambers that are 4.5–5.0 mm in diameter and approximately 3 mm tall. The central tube forms a neck 2.0 mm in diameter and approximately 1 mm long between the two middle chambers, but the other chambers share interwalls. The central tube is exposed in the broken base where it is 1.3 mm in diameter and has a wall 0.2 mm thick. It expands to 1.5 mm in diameter in the uppermost chamber. The exterior is marked by numerous nodes, most of which do not have pores, as preserved, but the few that do have ostia 0.15–0.20 mm in diameter. Like the associated specimen, there are faint micropores irregularly preserved in the siliceous replacement.

Material examined.—The figured stem of six chambers, GUMO 15104, and five additional fragments of one or two chambers, from GUMO 5250d (010328-1-13d), and six fragments from GUMO-429 12510n (010328-1-11N), including GUMO 12510n and 15105, plus GUMO 15106 and 15107 and 13 examples, most of which are of one or two chambers or fragments, from 030326-3-1, represent the species in the collection, all of which are from the Reef Trail Member at USGS Locality 7663.

Discussion.—These specimens have the basic linear chambered structure with a continuous central tube typical of the genus. However, they are micronodose and do not have long exaules, although they do have moderately common rimmed to short tubular pores.

Genus SOLLASIA Steinmann, 1882

Type species.—*Sollasia ostiolata* Steinmann, 1882, p. 151.

Diagnosis.—''Aporate moniliform stems with a single large cryptosiphonate opening in the chamber interwalls, without a central tube. Chamber exowalls contain one or more ostia. Interwalls are normally two layered. Vesiculae may occur. The skeleton was composed of aragonite with spherulitic microstructure'' (Senowbari-Daryan and Rigby, 1988, p. 197).

SOLLASIA OSTIOLATA Steinmann, 1882
Figure 4.13–4.16

Sollasia ostiolata STEINMANN, 1882, p. 151–152, pl. 7, fig. 3.
Sollasia dussaulti MANSUY, 1914, p. 9, pl. 1, fig. 2a, b.
Heterocoelia beedei GIRTY, 1908, PARONA, 1933, p. 42, pl. 8, fig. 1.

An extensive partial synonymy of the species was presented by Rigby et al. (1998, p. 54). A complete listing of its synonymy to 1990 was given by Senowbari-Daryan (1990, p. 128), and later publications were listed by Senowbari-Daryan and Ingavat-Helmcke (1994, p. 19).

Diagnosis.—''Small to moderate size, moniliform sponges with spherical to barrel-shaped chambers generally 2–6 mm high, but rarely up to 10 mm. Chamber walls pierced laterally by ostia generally small in small specimens and larger in larger specimens, openings up to 1 mm in diameter. Interwalls with central cryptosiphonate openings up to 2.5 mm in diameter. Vesiculae rare. Lateral ostia up to 5 per chamber'' (Rigby et al., 1998, p. 55).

Description.—Many well-preserved silicified fragments of the small to moderate-sized species occur in the collections. They range from parts of single chambers to moniliform segments of six or seven chambers. Individual chambers are generally subspherical. Juvenile chambers are 1.5–2.0 mm in diameter and height, but enlarge upward within a few chambers to adult chambers that are 5.0–5.5 mm in diameter and 5 mm high, as in GUMO 15108 (Fig. 4.13). Chamber walls are generally 0.4–0.5 mm thick, but are somewhat thinner in earliest chambers.

Exowalls of chambers are generally smooth and pierced by relatively rare ostia, with only one or two ostia in juvenile chambers and up to eight ostia per chamber in adult stages. These openings are generally 0.4–0.5 mm in diameter in the preserved fragments. Some ostia have low rims to 0.2 mm high and 0.1 mm thick.

Interwalls between chambers are pierced by single central to somewhat offset interpores, like that in GUMO 15109 (Fig. 4.14), that are approximately 0.3 mm in diameter in small juvenile chambers but range up to 0.5–0.6 mm in diameter in most middle and upper chambers of the sponges. Most such interpores are circular, but a few are ovoid and to 0.8–0.9 mm in length. Chamber interiors are hollow in the preserved fragments in our collections, except where subsequently overgrown by other organisms.

Specimen GUMO 15177 has three spheroidal chambers, 2.2–2.5 mm in diameter and 4.0–5.5 mm high, that are partially encrusted with matrix and threads of the thalamid *Parauvanella* Senowbari-Daryan and Di Stefano, 1988. Chambers have two or three inhalant ostia, irregularly at midheight and on opposite walls, that are 0.25–0.30 mm in diameter. Some ostia with thick walls or rims 0.15–0.20 mm high, and rare ones with rims 0.4–0.5 mm high. Single exhalant central openings between chambers are 0.5–0.6 mm in diameter. Several fragments of small juvenile chambers and larger chamber bits are associated in the same collection.

An additional instructive sample, GUMO 15178, is a fragment 26 mm tall and has four egg-shaped chambers that have narrow bases, 3.5 mm in diameter, and expand upward into spheroidal chamber summits 4.5–5.0 mm in diameter, below junctions with the next younger chambers. Inhalant pores are 0.4–0.5 mm in diameter and occur two or three per chamber, irregularly in the middle half of the wall. Chamber walls are 0.2–0.35 mm thick. Subvertical diaphragms, but no central tube, occur in a chamber where the broken wall exposes the interior.

Material examined.—Figured specimens, GUMO 15108–15111, and cited GUMO 15112, and an additional 23 specimens were collected from Locality 010325-1-13dd. Also included in the species are three specimens from GUMO 5250cc, five fragments from GUMO 5250q, and many small fragments from both GUMO 5250bb and 5250d, plus several fragments from GUMO 12510c, including cited GUMO 15177, and a moderately well preserved, but broken, cited specimen GUMO 15178 from GEO 00006 (010327-3-1 k), and one specimen attached to *Guadalupia zitteliana* Girty, 1909 (GUMO 15125); 41 specimen fragments occur in 030326-3-1c, and one in 030326-3-1vv. All are from USGS Locality 7663.

Discussion.—*Sollasia ostiolata* is one of the most common and cosmopolitan sponges in the Carboniferous and Permian record. Rigby et al. (1998) documented it occurring at approximately 135 localities in the Guadalupe Mountains of Texas and New Mexico, to which can be added the occurrence reported here.

Genus SOLLASIELLA new genus

Type species.—*Sollasiella reticulata* n. sp.

Diagnosis.—Moniliform aporate sponges with central cryptosiphonate opening in interwalls, lacks central tube; chambers may be adnate with superposed chambers, or they may be slightly separated and connected by a tubular neck; inhalant exaules large, tubular, and generally one per chamber in lower chamber wall, exaules lack screens; dermal layer with reticulate outer surface.

Etymology.—*Sollas*, named for resemblance of these sponges to *Sollasia*; *ella*, L., small or diminutive, in reference to the small size of these sponges.

Discussion.—The genus is similar to *Sollasia* in some respects, but it has a single distinctive, coarse, tubular inhalant canal in the lower part of each chamber, and has some chambers connected by narrowed ''necks.'' *Colospongiella* n. gen. is also a somewhat similar moniliform sponge, but it has several large interpores in interwalls between chambers, and principal inhalant ostia are commonly near midwall of the chamber, or in the upper part of the wall, near the base of the overlapping younger chamber.

SOLLASIELLA RETICULATA new species
Figure 4.11, 4.12

Diagnosis.—Small to medium-sized moniliform sponges with spheroidal chambers generally 3–4 mm high and in diameter, with occasionally separating narrowed ''neck'' between chambers; single coarse tubular inhalant exaulos in lower part of each chamber wall and 0.8–1.0 mm in diameter; exterior with shallow depressions 0.2–0.4 mm across in reticulate network.

Description.—The holotype and largest, most complete, specimen of the species, GUMO 15113 is approximately 15 mm tall, and consists of four spheroidal chambers that are 3.3–3.8 mm in diameter and 3.7–4.0 mm tall (Fig. 4.11). The lower three are adnate, but the upper chamber is separated from the lower ones by a narrow skeletal ''neck'' 1.3 mm in diameter and 1.1 mm tall. A central tubular spongocoel is not developed, but adnate chambers are interconnected by a cryptosiphonate central opening 0.8–1.1 mm in diameter. Walls of the chambers are approximately 0.20 mm thick, and the dermal surface is marked by a distinct reticulation, with shallow depressions 0.2–0.4 mm across, or in diameter, that range from weakly polygonal to circular. They are surrounded by a slightly raised network of ridges that are approximately 0.10 mm wide and high.

A distinctive feature of the species is the coarse tubular inhalant openings that occur one per chamber. They open upward through the lower chamber wall, where chambers are adnate, and range to 1 mm long and 1.0–1.3 mm in diameter, with a slight distal taper. Pores in the tubular exaules are 0.7–1.0 mm in diameter. Exaulos walls are thin and range 0.1–0.2 mm thick. Where chambers are not adnate, the exaulos angles upward and opens into the upper end of the thinner ''neck'' where the wall of the overlying chamber was flexed slightly inward.

Four fragments of the species, including GUMO 15114–15116, consist of one or two spheroidal chambers and associated tubular ''necks.'' One of these, the paratype GUMO 15114, appears to be the basal part of a stem (Fig. 4.12), with an initial chamber approximately 1 mm tall and in diameter. The next chamber is 2.6 mm in diameter and 2.0 mm tall, and the succeeding fragment is of a chamber 2.9 mm in diameter and 3.0 mm tall. A tubular exaulos is present between the upper two chambers and is 1.0 mm in diameter and 0.5 mm long, with a pore 0.8 mm in diameter.

The other small fragments are of small chambers and associated tubular ''necks.'' They also show a single tubular exaulos per chamber, each piercing the reticulated outer wall.

Etymology.—*Reticulata*, L., in reference to the netlike reticulate dermal surface of the chambers.

Types.—Holotype, GUMO 15113, and paratypes, GUMO 15114–15116, from USGS Locality 7663.

Occurrence.—The type specimens, the only ones known of the species, are from the Reef Trail Member of the Bell Canyon Formation, from USGS Locality 7663.

Discussion.—Comparisons with similar sponges are treated in discussion of the genus, above.

Genus RAMOSOTHALAMIELLA new genus

Type species.—*Ramosothalamiella divaricata* n. sp.

Diagnosis.—Linear-branched sponges with ovoid chambers connected by narrowed short segments; ovoid chambers with one or more thick-walled tubular exaules that diverge at high angles from trend of stem; delicate screens present across exaules near outer ends of tubes; dermal surface of stems and chambers with low nodes and irregularly preserved ostia of small canals between nodes.

Etymology.—*Ramosus*, L., branchy; *thalamus,* chamber; *ella,* diminutive, named for the small, branched growth form of the chambered type species.

Discussion.—These branched sponges where ovate chambers are interconnected with narrowed segments are somewhat reminiscent of the aporate *Amphorithalamia* described by Senowbari-Daryan and Rigby (1988) from the upper Permian of Tunisia. That Tunisian sponge, however, is attached to the surface of an inozoan sponge and it consists of flasklike chambers that are connected by necklike tubes. In addition, its chambers are filled with reticular filling tissue and it has several starlike ostia per chamber situated on pustulelike elevations, rather than screened tubular exaules. In addition, no canals are evident in walls of the chambers or the interconnecting tubes, in contrast to the scattered small canals present in the sponges described here.

Olangocoelia Bechstädt and Brandner, 1970 has some tubes connecting chambers but it is a sponge with clusters of chambers rather than a linear form like the sponge described here.

RAMOSOTHALAMIELLA DIVARICATA new species
Figure 4.7–4.10

Diagnosis.—As for the genus.

Description.—Two small specimens of the species are in the collection. Both are linear-branched forms with ovoid chambers marked by strongly divergent, robust tubular exaules. The holotype, GUMO 15117, consists of three ovoid chambers, 3.0–3.3 mm tall and 2.5 mm in diameter (Fig. 4.9), separated by narrowed tapering parts of the ''stem'' that are approximately 1 mm long and 1.3 mm in diameter between the chambers. Each chamber has short, thick-walled, tubular exaules that are approximately 1 mm long and 1.3 mm in diameter, with pores 0.7–1.0 mm in diameter. Two such exaules occur in the early chamber, three in the second, and four in the upper terminal chamber, as the sponge is preserved. Exaules all diverge at high angles to the irregular trend of the stem and flare slightly distally.

The dermal surface of the sponge, particularly over the oblate chamber walls, is nodose, with sharp nodes to 0.20 mm high and with crests spaced 0.4–0.5 mm apart. Such nodes may occur in crude rings on the stems between the chambers. They also appear to occur with a somewhat polygonally reticulate pattern in parts of the sponges. Locally small pores, approximately 0.04 mm in diameter, occur 0.1–0.2 mm apart between the nodes, but they are not evident in many areas of the silicified skeleton.

Delicate screens are preserved in outer ends of a few exaules (Fig. 4.8). These screens are a regular uniform fine net of elements 0.01–0.02 mm in diameter, around openings that range from circular to ovoid and 0.03–0.04 mm across. Upper margins of the screens are attached at approximately 0.5 mm in from ostia of the tubes and the screens extend inward as rounded obconical to basin-shaped structures.

The paratype, GUMO 15118, consists of only two chambers, one is 3 mm in diameter and tall and the other one is 4 mm tall and 3.5 mm in diameter (Fig. 4.10). They are connected by a narrow stem segment 1.5 mm long and 1.8 mm in diameter. Exaulos tubes on these chambers range 1.5–1.7 mm long and with outer slightly flared diameters to 1.7 mm, around pores that are 0.8–1.3 mm in diameter. Walls of the tubes are 0.1–0.2 mm thick. The paratype is marked by a nodose surface like that of the holotype. A nearly complete screen is preserved in one exaulos (Fig. 4.7), and parts of screens are preserved in two others. These screens appear to be more nearly flat than those in the holotype, but with elements and openings of essentially the same dimensions as those in the holotype.

Etymology.—*Divaricatus*, L., spread apart, in reference to the branching form of the species.

Types.—The holotype and paratype, GUMO 15117 and 15118, the only known specimens of the species, are from USGS Locality 7663.

Occurrence.—The type specimens are from the Reef Trail Member of the Bell Canyon Formation.

Discussion.—Comparisons to related and similar forms have been presented in discussion of the genus above.

Family SPICIDAE Termier and Termier, 1977a

Diagnosis.—''Nous plaçons dans cette famille des Permosphincta don't l'ectosome aporeux compose un manchon de vésicules plus ou moins nombreuses autour d'un tube axial à paroi bien distincte constituant l'endosome et sans doute le choanosome''(Termier and Termier, 1977a, p. 41). (We place in this family the Permosphincta having an aporous ectosome composed in the main of more or less numerous vesicles around an axial tube with a very distinct wall as a constituent of the endosome and without doubt the choanosome.)

Discussion.—At least part of the Spicidae Termier and Termier (1977a, p. 41) and Fistulisponginidae Termier and Termier (1977a, p. 38) were included in the Aphrosalpingidae (Myagkova, 1955, p. 478) by Finks and Rigby (2004, p. 667), who also included the Spicidae within the Fistulisponginінae. Wood (1991) and Mastandrea and Russo (1995) concluded that the agelasid Ceratoporellidae have a chaetetid morphology and a spherulitic aragonite thalamidarium in the Guadalupiidae. Senowbari-Daryan and Rigby (1988, p. 201) concluded that the type specimens of *Fistulispongina elegans* Termier and Termier, 1977a are specimens of *Spica* that were overgrown by a chaetetid sponge, as documented by several specimens. Senowbari-Daryan and Rigby also observed that ''where the skeleton was not overgrown by chaetetids, or where the layer of chaetetids has been weathered away, the aporate chambers of *Spica spica*, each with only one circular or star-shaped ostium, are clearly visible.'' The well-preserved specimens of *Spica* in our material lack encrusting chaetetids, although early formed parts of these sponges may be secondarily coated by imperforate nontubular or noncellular material. Because nearly all of our specimens have uncoated skeletons, and all lack chaetetid layers, we have chosen to continue recognizing *Spica* as a valid genus, and the Spicidae as a valid family.

Genus SPICA Termier and Termier, 1977a

Type species.—*Spica spica* Termier and Termier, 1977a, p. 41.

Diagnosis.—''Single or rarely branched stems consist of glomerate chambers arranged only in one layer around the central tube. The exowall of the chambers is generally pierced by only one, rarely more, circular or star-shaped ostia with a low rim or short exaulos. Walls of the chambers, especially the endowall of the central tube, are porous and contain longitudinal and transverse canals. No vesiculae or other filling tissue are apparent. The skeleton was most probably composed of aragonite'' (Senowbari-Daryan and Rigby, 1988, p. 200).

SPICA TEXANA new species
Figures 5.3–5.7, 6.1

Diagnosis.—Slender-stemmed, commonly branched sponges with glomerate chambers arranged in one layer around a porous central tube; with rimmed ostia ranging to long tubular, regularly spaced, exaules, but not one for every chamber, on relatively smooth to gently domed dermal surface that is essentially secondarily imperforate, except for large ostia and exaules in all but last-formed chambers at branch tips; filling structures lacking.

Description.—The species is represented by slender stems that are commonly branched and approximately 3 mm in diameter, but which may be larger in the vicinity of branch initiation (Figs. 5.4, 6.1). The sponge is composed of subspherical to oblate chambers that occur in a single layer stacked around a tubular central spongocoel. Only fragments of the middle and upper parts of the sponge are preserved; the base is unknown. These fragments range up to 22 mm tall, and have from one to several branches, commonly at the upper end, but branches also occur elsewhere on some fragments.

Chambers are generally 1.1–1.3 mm high, measured at right angles to the tubular spongocoel, and up to 1.0 mm wide near the dermal surface of the stem, where their outer walls may be slightly domed (Fig. 5.6). Five or six chambers occur per ''whorl'' around the central tube, where they may have basal widths of attachment up to 0.4–0.5 mm. Chambers do not occur at regular levels, but are in crudely spiral series and are commonly diagonally offset from adjacent chambers, so that in some transverse sections this irregularity suggests more chambers per whorl. Walls of chambers are porous when first secreted, but dermal surfaces are secondarily covered and become nonporous in all but uppermost chambers of the stem. Chamber walls are 0.10–0.15 mm thick and have initial pores 0.08–0.12 mm in diameter that are spaced 0.3 mm apart, center to center, or are separated by skeletal tracts 0.10–0.15 mm wide.

Rimmed to tubular exaules are developed in lower dermal areas of all stems, and are spaced 1–2 mm apart. These openings range from low-rimmed ostia to tubular exaules that are to 1.5 mm long, with most 0.3–0.4 mm long (Fig. 5.3). Rimmed ostia are approximately 0.3 mm in diameter. Tubular exaules have canals 0.2–0.3 mm in diameter in lower parts of stems and up to 0.4 mm in diameter in upper parts. Tube walls generally range 0.15–0.20 mm thick, but some with widened bases up to 0.7–0.8 mm may have proximal thicknesses double that.

Central axial tubes are continuous through the stems and range 0.6–1.0 mm in diameter, where circular, and to 0.8×1 mm across, where oblate. Tubes have porous walls 0.10–0.30 mm thick, as silicified, with common endopores that are 0.08–0.12 mm in diameter and separated 0.10–0.15 mm apart.

One specimen, GUMO 15121, has unusually well-preserved microskeletal detail. Skeletal elements between pores are composed of siliceous microspherulites, 0.02–0.03 mm in diameter. These small spherulites are strongly reminiscent of initial spheroidal aragonite seen in related, nonsilicified, sponges from Tunisia.

Etymology.—*Texana*, in reference to western Texas, where the species has been found.

Types.—Holotype, GUMO 15119, and paratypes GUMO 15120–15123, and the associated 22 additional specimens, plus seven specimens from GUMO 5250t, 16 specimens from GUMO 5250d; and two specimens from GUMO 5250s are included in the species. The species also occurs as a single fragment in GUMO 5250b, and as three overgrown specimens in GUMO 5250g. One heavily silicified specimen from GUMO 5250p is questionably included in the species. In addition, seven well-preserved specimens occur in GUMO-429 12510e, and seven specimens from GUMO GEO 00006, one moderately well-preserved specimen from 010328-1b, three specimens from 010327-3-1d, including one well-preserved stem and two encrusted stems; and three specimens from 010327-3-1g, all of which are coated questionable specimens. The species is represented in collections from 030326-3-1 by 29 specimens.

Occurrence.—All of the known specimens of the species are from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7663.

Discussion.—This is the first recorded occurrence of *Spica* outside of the Djebel Tebaga area of northern Tunisia (Senowbari-Daryan and Rigby, 1988, p. 201), where it occurs in Upper Permian beds. The type species, *Spica spica*, includes much larger sponges that are rarely branched, and whose chambers have domed outer walls that are each pierced by one or more circular or star-shaped ostia or short exaulos. The type species has domed outer chamber walls, unlike the smooth, and apparently secondary, dermal layer present in this Guadalupe Mountain species, that also makes much of the outer skeleton aporous. The species described here has common, long exaules that are not distributed one per chamber, as are ostia in the Tunisian sponge.

Family GUADALUPIIDAE Girty, 1909

Diagnosis.—''Porate, bowl-like to mushroom-shaped, plate-like, dendroid or cylindrical sponge without filling structure. Segments are tube-like or extended egg-shaped. Spicules and skeletal mineralogy are not known'' (Rigby et al., 1998, p. 57).

Genus GUADALUPIA Girty, 1909

Type species.—*Guadalupia zitteliana* Girty, 1909, p. 80.

Diagnosis.—''Platter-like, bowl-like or dendroid sponges composed of tubular or oval segments that are arranged next to one another (stratiform, Finks, 1983). Upper surfaces of platters contain astrorhizae, which may be localized on elevations (mamelons) on the upper surface of the sponge (as in stromatoporoids and many sclerosponges). Lower sides of sponges, as well as walls between tubes, pierced by numerous pores. Spongocoel rarely developed. Vesiculae may occur. Primary skeletal mineralogy, as well as spicules are unknown. Finks (1983) concluded the microstructure was spherulitic'' (Rigby et al., 1998, p. 58).

GUADALUPIA ZITTELIANA Girty, 1909
Figure 6.2–6.7

Guadalupia zitteliana GIRTY, 1909, p. 80, pl. 6, figs. 1a–1d, 2a–2b; SENOWBARI-DARYAN, 1990, p. 149–150, pl. 53, figs. 1–10; pl. 54, figs. 1–6, text-fig. 50; RIGBY, SENOWBARI-DARYAN, AND LIU, 1998, p. 59–61, pl. 3, fig. 1; pl. 5, figs. 3–5, 7–9, text-fig. 15.
Guadalupia zitteliana var. GIRTY, 1909, p. 81.
Guadalupia williamsi R. H. KING, 1943, p. 23, pl. 2, fig. 10; pl. 3, figs. 7, 11 (not fig. 12 as indicated by R. H. KING, 1943, p. 14, 23).

Emended diagnosis.—Mushroom to irregularly bowl-shaped, broadly obconical or platelike sponges with principal chambered layer commonly 5–8 mm thick, composed of tubelike chambers 0.7–1.1 mm in diameter. Thinner gastral layer forms rough upper surface of the sponge which may have starlike exhalant canals (astrorhizae) or be relatively dense and micronodose above canalled layer. Lower dermal layer thin, with numerous pores, as in walls between the chambers. Vesiculae range from lacking or very rudimentary to prominent.

Description.—Most informative specimens of the species in the collection range from large, curved irregular fragments to smaller, nearly complete sponges that are broadly or moderately steeply obconical, but the collection also includes numerous small fragments.

The largest specimen of the species in the collection, GUMO 15127, is a gently folded fragment 66 mm tall, 36 mm wide, and up to 6.5 mm thick. It has a well-defined chambered layer, a thin irregularly preserved dermal layer, and an incomplete thin perforate gastral layer. Chambers are arcuate and approximately 5 mm high, with ovoid to circular cross sections that are 0.9–1.9 mm across, so that four to six chambers occur per 5 mm, measured transversely in the central part of the layer. Interwalls between chambers are 0.10–0.20 mm thick, and are perforated by numerous interpores that range 0.14–0.20 mm in diameter. These pores are separated by skeletal tracts 0.2–0.3 mm wide, in an irregular pattern, with two to four discontinuous irregular rows on interwalls between each of the adjacent chambers.

The thin dermal layer is so coarsely and irregularly silicified that the nature of its porous structure is uncertain. It ranges 0.2–0.5 mm thick as preserved. The gastral layer is up to 1.0 mm thick and is a finely porous structure, with several exhalant pores of essentially the same size as the interpores leading gastrally from each chamber into the meshwork of the gastral layer. The gastral layer consists of reticular fibers, 0.1–0.2 mm in diameter, around numerous interconnected pores 0.2–0.4 mm in diameter. Like most specimens of the species from the locality, this fragment has a microspherulitic siliceous preservation.

Another moderately large and thick specimen, GUMO 15126, is an arcuate elongate fragment 5.3 cm tall and 3 cm wide (Fig. 6.4). It is 6.5–9.5 mm thick and has an open, chambered layer that is 5.0–6.5 mm thick, a gastral layer that ranges 1.0–3.5 mm thick, and a dermal layer that is 0.3–0.5 mm thick. Chambers of the principal chamber layer are distinctly arcuate and approximately 1 mm in diameter at midheight. They contain variable numbers of flat to gently curved diaphragms that range 0.05–0.16 mm thick and 0.3–1.0 mm apart. Two or three vertical rows of interpores connect adjacent chambers, but are only locally preserved in the microidal silicification. They are 0.10–0.14 mm in diameter and 0.2–0.3 mm apart. Exopores are locally preserved in the rounded gastral ends of a few chambers, and range 0.20–0.25 mm in diameter and up to 0.15 mm apart.

The gastral layer is composed of an inner, more coarsely canalled part, and an outer, considerably finer, thick porous layer. Canals of the inner part are 0.3–0.5 mm in diameter and form a lateral network tangential to tips of overgrown chambers. They open to smaller canals that are 0.2–0.3 mm in diameter and generally perpendicular to the gastral surface. The outer or upper layer where these small canals are developed is dense and relatively thick, with variable thickness that produces a relatively even gastral surface. That surface is marked by numerous small hemispherical nodes, that are 0.2–0.3 mm in diameter and height, and a network of fine tangential grooves or depressions that surround them and that are 0.2–0.3 mm wide. Ostia of the fine exhalant canals open into these grooves and perforate the distinctive gastral surface.

One of the most complete specimens of the species, GUMO 15124, is stalked and broadly obconical with a shallow spongocoel (Fig. 6.5). It is 20 × 28 mm across at the top and is 10–11 mm tall, with a stalklike base that is 6 mm in diameter and 2–3 mm tall. The upper, saucerlike part is divided into two sections, with an older skeletal section and spongocoel that have been partially isolated by a younger, offset, secondary pulse of growth. The broad, platterlike part of the skeleton is composed of a single layer of cellular chambers, coated below with a thin, dense dermal layer, and above with a thin, more irregular gastral layer.

Chambers are cylindrical, 0.6–1.0 mm in diameter and 2.0–2.3 mm long or high, with a gently domed, lower, dermal end, and a smooth or flat, upper, gastral end, although the latter is commonly obscured by coarse reticulate trabeculae, spines, and nodes of the gastral layer. Chamber walls are 0.08–0.10 mm thick and are perforated by one or two rows of interpores that interconnect adjacent chambers. These pores are 0.08–0.10 mm in diameter and are approximately 0.20 mm apart within rows, which are commonly 0.3 mm apart. Inhalant prosopores are of the same general diameter, but flare to 0.12–0.16 mm in diameter at the indented dermal surface. Exhalant pores in the gastral layer are 0.2–0.3 mm in diameter, where circular, or 0.2–0.3 × 0.4 mm across where radially elongate. Generally two or three such openings occur per chamber, separated 0.3–0.4 mm apart.

Coarse nodes and spines extend upward from the gastral surface between exhalant pores and are up to 0.5 mm tall and 0.3–0.4 mm in diameter, although a few up to 1 mm tall occur locally. Their spacing is irregular, and their bases locally rise from a trabecular network near the gastral surface in the interior of the broad spongocoel. Low isolated nodes, 0.3–0.4 mm in diameter and height, are more common on upper or outer parts of the gastral surface.

The dense dermal layer is approximately 0.2 mm thick, with scattered inhalant ostia 0.10 mm in diameter that occur in shallow radial grooves, in upper parts, or in an interconnected network of grooves in older parts of the sponge. These grooves are 0.04–0.06 mm wide and deep and are separated by flat-topped ridges 0.1–0.2 mm wide.

Spherulitic microstructure is preserved in chamber wall interiors, but the microstructure appears netlike where spherules are not preserved in the dermal layer.

A more steeply obconical specimen, GUMO 4391, is also included in the species. It has an upward-flaring form, with an irregular, wrinkled oscular margin to an irregular, shallow spongocoel. Many coarse spines project into the spongocoel from the gastral skeletal surface. These spines are up to 1.5 mm long and 0.5–0.6 mm in diameter, and commonly rise from irregular triangular to polygonal bases up to 1.0 mm across. Some form fins or blades 0.2–0.3 mm thick, to 0.7–0.8 mm high and 1.5 mm long. All are irregularly spaced, so much of the spongocoel surface appears spinose.

Chambers of the main wall are upward arched, with distinct dermal and gastral skeletal layers. Chambers are 1.8–2.0 mm long, horizontally, and are approximately 1.0 mm wide and 0.5–0.6 mm high. They are offset diagonally from adjacent chambers and interconnected with interpores that are 0.10–0.12 mm in diameter and regularly 0.20–0.25 mm apart in rows, so two or three rows are shared with each subjacent/superjacent chamber. Interpores to diagonally lateral chambers are limited in number.

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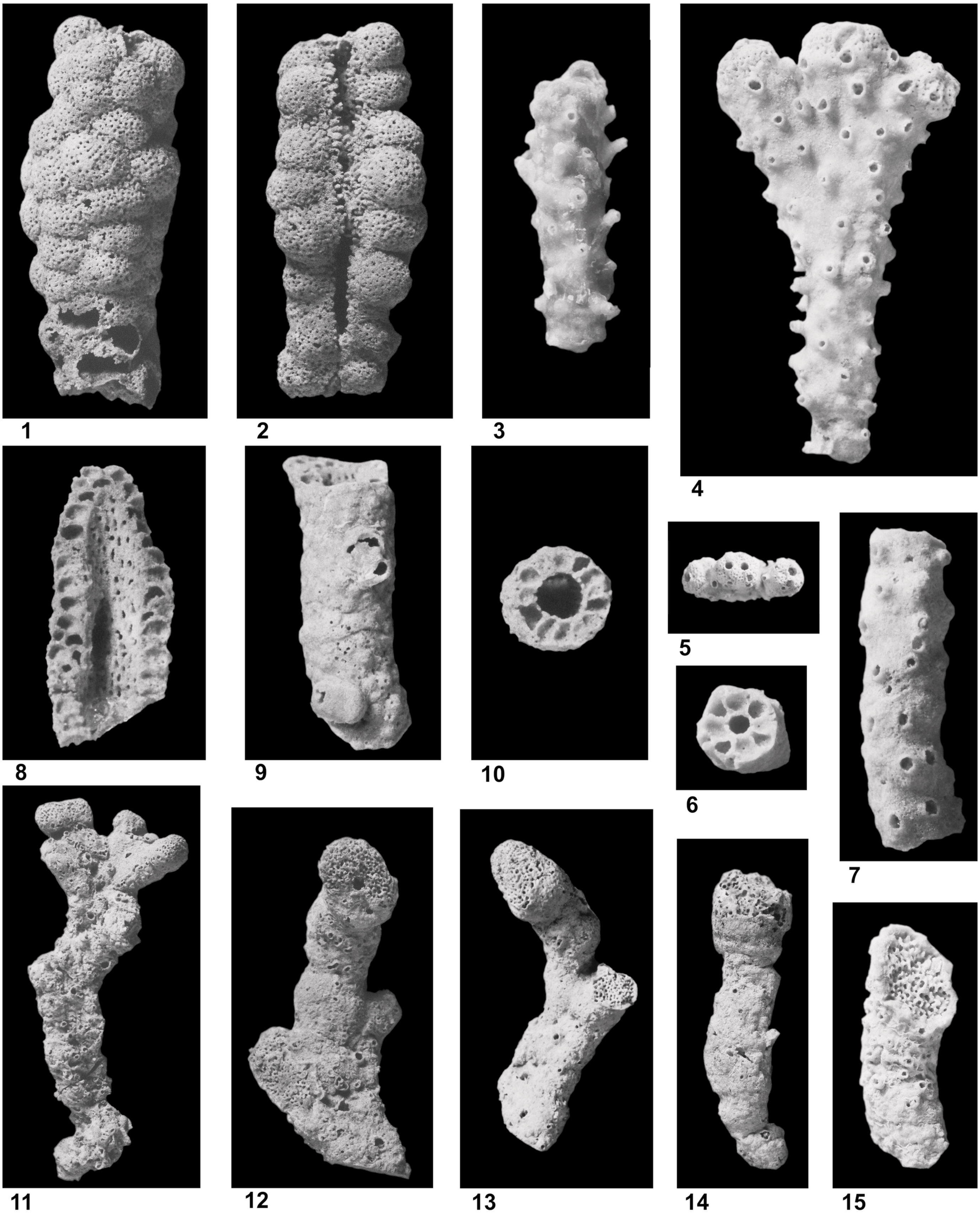
FIGURE 5—*Cystauletes* R. H. King, 1943, *Spica* Termier and Termier, 1977a, *Lemonea* Senowbari-Daryan, 1990, and *Daharella* Rigby and Senowbari-Daryan, 1996 from the Reef Trail Member of the Bell Canyon Formation, from USGS Locality 7663, Guadalupe Mountains National Park, Texas. *1, 2, Cystauletes mammilosus* R. H. King, 1943, figured specimen, GUMO 15174, *1,* side view of subcylindrical sponge with bulbous porous chambers, with incomplete base, broken chambers at base show upward-arcuate structure, ×2; *2,* reverse view shows slitlike spongocoel between rows of bulbous porous chambers, incompletely closed by irregular spines in central and upper part, ×2. *3–7, Spica texana* n. sp., *3,* small paratype with tubular exaules, GUMO 15121, ×4; *4, 5,* holotype, GUMO 15119, *4,* side view of branched holotype showing general form and characteristic rimmed to tubular exaules, ×4; *5,* view of holotype from above, showing oscula of central exhalant tubes, generally one per branch, ×2; *6,* cross section of small paratype stem from above, showing central axial tube or spongocoel surrounded by a single layer of porous-walled chambers, GUMO 15123, ×5; *7,* side view of small paratype with rimmed exaules, GUMO 15122, ×5. *8–10, Lemonea micra* Rigby, Senowbari-Daryan, and Liu, 1998, *8,* side view of diagonally broken small stem, showing prominent small chambers and porous gastral layer of spongocoel, which has circular to vertically elongate exhalant pores, GUMO 15137a, ×5; *9,* side view of small stem with chambered dermal surface and small pores in each chamber, GUMO 15136, ×5; *10,* transverse section of small stem showing outer chambered wall and central circular spongocoel, GUMO 15137b, ×5. *11–15, Daharella ramosa* Rigby and Senowbari-Daryan, 1996, *11,* tall, lobate-branched, figured specimen with several pulses of growth, shows effects of being overgrown in lower part, GUMO 15154, ×1; *12, 13,* branched figured specimen with mounded ostia in dense dermal layer, and skeletal structure exposed in complete upper end and in broken lower branch, GUMO 5250k, ×1.5; *14,* figured specimen with weakly annulate stem that has dense dermal layer perforated by scattered mounded ostia, and with reticulate internal skeleton exposed in incomplete upper end, GUMO 15152, ×2; *15,* small figured specimen with common mounded inhalant ostia of the dermal surface and internal reticulate skeleton well exposed in upper diagonal fracture across the stem, GUMO 15153, ×2.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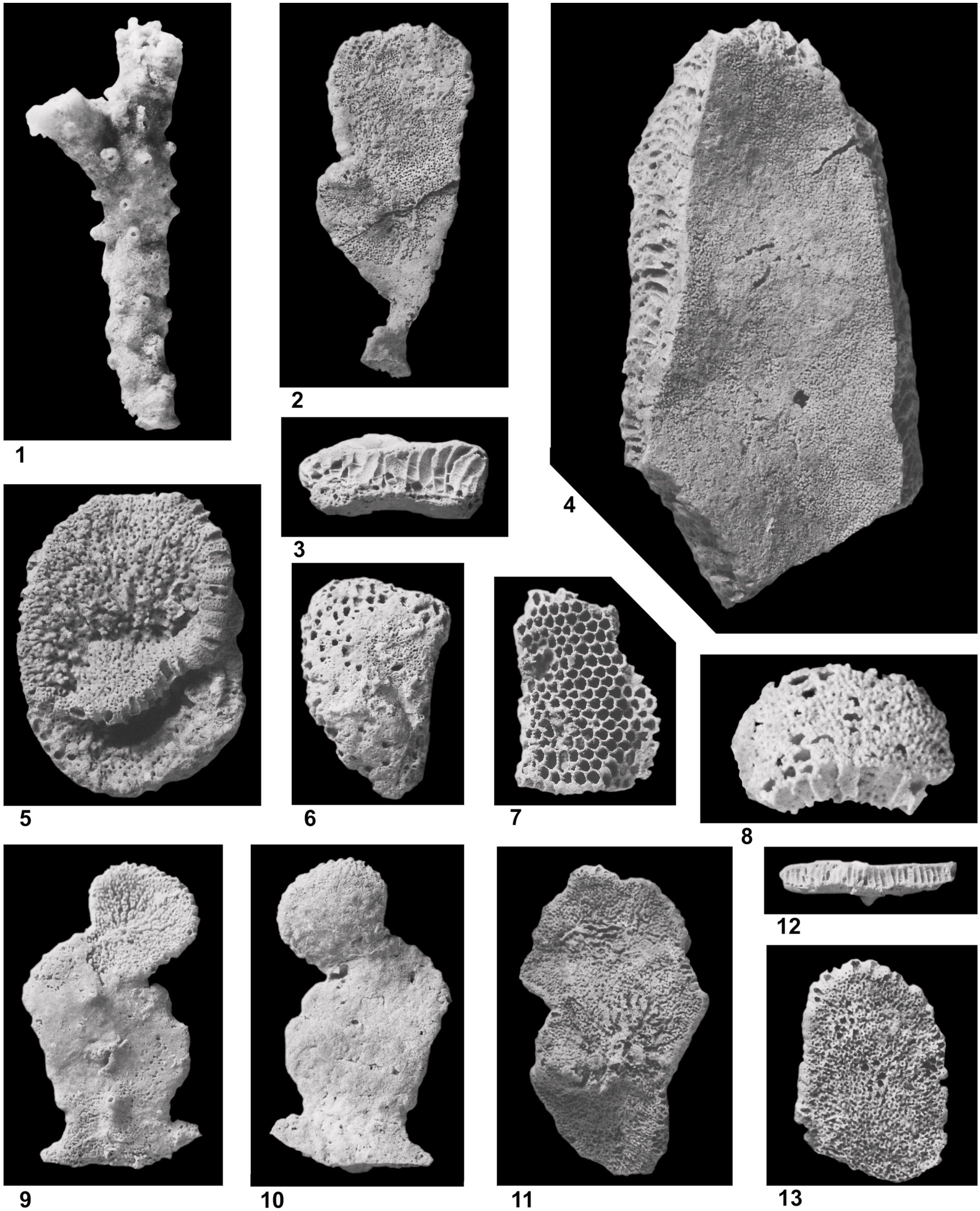
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Inhalant ostia in the dermal layer are 0.08 mm in diameter, and are regularly spaced 0.3–0.4 mm apart. These ostia are interconnected by grooves in the dermal surface that are 0.1–0.15 mm wide and deep, although some to 0.4 mm wide occur between low hemispherical nodes that are 0.20–0.35 in diameter and that rise up to 0.25 mm on the generally smooth dermal surface.

The skeletal structure is microspherulitic, with well-defined spherules 0.04–0.05 mm in diameter exposed in several areas.

Other fragments have chamber layers 2.5–3.5 mm thick, associated with dense dermal layers, 0.3–0.4 mm thick, and gastral layers, 1.0–2.0 mm thick, of reticulate trabeculae with superposed spines to 2 mm long. One of these, GUMO 15125, is a funnel-shaped remnant of an obconical sponge 16 mm high and 12 × 18 mm in diameter, at the oscular margin. It has chambers up to 3.0 mm long and 0.6–0.8 mm in diameter, in which three or four diaphragms occur in most chambers. Several flat or gently curved fragments of the same species, with thicknesses of 3–5 mm and the same general dimensions of chambers, ostia, and interpores, also occur in the collections.

Material examined.—The species is represented in the collections by a variety of sponges, ranging from the platelike GUMO 15126 and 15127, or the fanlike GUMO 15125, to the obconical GUMO 4391 and GUMO 15124. In addition the three curved to nearly flat fragments GUMO GEO 00006 (01327-3-1f, 1h, and 1i), GUMO 15179, and the attached and encrusting GUMO 5247e, GUMO 15166 and nine fragments from 030326-3-1 are included in the species.

Occurrence.—All the above listed specimens are from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—*Guadalupia zitteliana* is endemic to the Permian rocks of western Texas and New Mexico. It is intergrown with a variety of other sponges, including *Sollasia* and *Daharella* Rigby and Senowbari-Daryan, 1996, in our collections, and must have functioned as an important element of late Capitanian reef faunas of the region. Comparisons with other species of the genus have been treated in discussions of those taxa, but basically the species is characterized by its growth form and dimensions of chambers in the principal layer of its skeleton that are smaller than those in *Guadalupia explanata* Girty, 1909 and larger than those in *Guadalupia minuta* n. sp.

Guadalupia minuta new species
Figure 6.8–6.13

Diagnosis.—Thin, platelike to bladelike sponges, to 2.5 mm thick, composed of small tubular cylindrical chambers to 0.5 mm in diameter, in single layer, with distinct astrorhizal-bearing gastral layer capped by imperforate layer bearing widespread volcano-like mounds, each with single central oscular opening; chamber walls with common interpores.

Description.—The holotype and largest fragment of the thin sponge, GUMO 15128, is irregularly tabular or blade- to fanlike and 30 mm tall and up to 15 mm wide (Fig. 6.9, 6.10). It is 2.3–2.5 mm thick and consists of a lower dermal layer, an intermediate thicker chamber layer, and an upper, thin gastral layer. The dermal layer is generally imperforate, 0.2–0.3 mm thick, and with a smooth dense lower or outer surface. The major chamber layer is 1.3–1.6 mm thick, and composed of honeycomb-like tubular to slightly arcuate chambers 0.4–0.6 mm in diameter. On a broken edge, nine to ten chambers occur per 5 mm, measured parallel to the dermal surface (Fig. 6.12). Chambers have domed gastral and dermal ends, and upper gastral walls 0.15–0.20 mm thick. Chambers are separated by interwalls 0.08–0.10 mm thick, that are perforated by interpores, 0.04–0.08 mm in diameter, where up to four such vertically aligned pores may interconnect each adjacent chamber. A single exopore, 0.16–0.20 mm in diameter, perforates the upper domed summit of each chamber, and opens into convergent lateral canals of the astrorhizal system in the gastral layer.

The gastral layer is 0.4–0.6 mm thick and is marked by numerous irregularly placed pillars that are 0.2–0.4 mm in diameter. They are aligned along edges of transverse convergent canals of the astrorhizal system, and may converge upward to form discontinuous ''fins'' between canals below the imperforate ''roof'' of the layer, that may be to 0.1 mm thick. Astrorhizal canals are 0.2–0.4 mm in diameter and converge to central exhalant openings, 0.6–0.8 mm in diameter, that open to oscula 0.2–0.5 mm in diameter on the otherwise imperforate gastral surface of the sponge. These oscula are 7–10 mm apart and may be only rimmed to occurring in volcano-like mounds up to 1 mm tall.

A small, thin plate or bladed lobate paratype, GUMO 15129, is 11 mm tall, 7 mm wide, and 1.5–1.6 mm thick (Fig. 6.8). It includes an imperforate dermal layer, 0.08–0.10 mm thick, where the sponge has overgrown matrix that includes some allochthonous monaxial spicule fragments. The major chambered layer is

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FIGURE 6—*Spica* and *Guadalupia* Girty, 1909 from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7633, Guadalupe Mountains National Park, Texas. *1, Spica texana* n. sp., distinctly branched paratype with common tubular exaules, GUMO 15120, ×4. *2–7, Guadalupia zitteliana* Girty, 1909, *2,* rough gastral layer of fanlike sponge, with numerous inhalant ostia, and with transverse sections of a few chambers of the principal layer exposed on the upper left, GUMO 15125, ×1; *3, 6,* GUMO 15179, *3,* vertical section through the gently curved fragment shows the thick principal chambered layer, with horizontal diaphragms in several chambers, the thin upper gastral layer, and the thicker irregular dermal layer, below, ×2, *6,* view of the gastral surface; with a thin incomplete gastral layer that has numerous small exhalant pores, and transverse sections through some chambers of the principal layer, in the upper left, ×2; *4,* large fragment of the species with the porous thin gastral layer above the thick principal layer of arcuate chambers, some of which have diaphragms, GUMO 15126, ×2; *5,* upper gastral surface of broadly obconical specimen, with upper part divided into two sections where shallow spongocoel is subdivided by younger pulse of growth, porous chambers of the principal layer show around the right margin and the partially preserved gastral layer shows in the upper part, where it is perforated by numerous exhalant pores, 15124, ×2; *7,* transverse section through principal chambered layer of the skeleton of a small fragment shows general form of the chambers and growth direction toward the right, GUMO 15166, ×2. *8–13, Guadalupia minuta* n.sp.; *8,* small paratype fragment showing nature of the principal chambered layer and the gastral layer, GUMO 15129, ×5; *9, 10, 12,* holotype, GUMO 15128, *9,* gastral view of the holotype with short pillars along margins of the convergent canals of the astrorhizal system, particularly apparent in the upper and lower parts where they converge to volcano-like oscular mounds; such canals are obscured in the more nearly imperforate central part of the specimen, ×2; *10,* dermal view of the holotype with a generally imperforate dermal layer, as preserved, although a few ostia are evident in the upper margin where chamber outlines are also evident, ×2; *12,* transverse section across the base, showing the small chambers of the principal layer and the thin dermal and gastral layers of the skeleton, ×2; *11,* paratype, with rough gastral surface marked by exhalant pores and linear grooves that converge toward major exhalant opening, with some major chambers of principal layer exposed around the margin, GUMO 15130, ×2; *13,* paratype, gastral view of small plate with numerous irregularly placed exhalant pores, and with chambers of principal layer showing around margin, and in a few areas in the interior where the gastral layer has been removed, GUMO 15166A, ×2.

clearly developed, but the gastral layer shows only initial development. Chambers are 0.5 mm in diameter and to 1.5 mm tall, with walls 0.08–0.10 mm thick, that are perforated by three or four aligned interpores, which are 0.06–0.08 mm in diameter. Each chamber has a single major exopore, 0.18–0.30 mm in diameter, that opens into the canalled upper gastral layer. That layer is incompletely developed, or preserved, and ranges to 0.3–0.4 mm thick, where pillar bases are 0.15–0.20 mm in diameter, but irregularly developed and isolated. The tangential or horizontal canals of the astrorhizal system are only rudimentarily developed. An upper imperforate gastral layer is not developed.

A second paratype, GUMO 15130, is a weakly undulating elongate plate (Fig. 6.11) with a nearly complete growth margin, broken only along one small edge. The irregular plate is 29 × 15 mm across and mostly approximately 2 mm thick, although thicknesses of the margins range 1.5–2.2 mm. As is typical of the genus and species, most of the plate thickness is formed by the distinctly chambered layer. Those chambers are straight tubular structures 1.0–1.5 mm long and 0.3–0.5 mm in diameter. They have round to rounded prismatic cross sections and each shares parts of vertical interwalls with five to seven surrounding chambers. Those interwalls are 0.10–0.12 mm thick, although they thicken considerably toward junctions between three adjacent and parallel chambers. Interwalls between two adjacent chambers are perforated by one, and rarely two, vertical rows of interpores between each of the adjacent chambers. Those pores are commonly 0.08 mm in diameter and 0.15–0.20 mm apart within rows.

The lower or outer dermal layer is thin and dense, although locally marked by low hemispherical mounds at dermal ends of some of the outer chambers. Inhalant ostia, 0.10–0.12 mm in diameter, are locally evident in some of these apparently newly added chambers. Elsewhere, the ostia are commonly filled and not clearly defined where the skeletal layer is thicker.

The gastral layer is more porous-appearing and includes an irregular network of transverse canals associated with crude astrorhizal clusters (Fig. 6.11). One or two exopores are commonly evident per chamber, are 0.12–0.15 mm in diameter, where circular, and 0.12 × 0.20 mm across where elliptical. They feed up into the transverse canals that are approximately 0.2 mm across where first evident and expand up to 0.7 mm in diameter where they are major convergent structures near the two evident exhalant astrorhizal clusters. Irregular preservation suggests the canals were ''roofed'' rather than just linear depressions in the skeleton. The gastral layer, away from the astrorhizal centers, is distinctly finely nodose to almost spinose-appearing, with hemispherical nodes approximately 0.20 mm in diameter and up to 0.03 mm high, that grade to more elongate spinose structures between the convergent canals of the astrorhizae.

Newer collections include a small, ovoid, slightly curved plate-like fragment, GUMO 15131, that is 10 × 15 mm across and 2.5–3.0 mm thick, with both porous dermal and gastral layers. The cellular-appearing chambers of the main layer are slightly arched toward the sponge periphery and are approximately 0.5 mm in diameter, where circular, and 0.5 × 0.7 mm across, where ovoid. Chamber walls are 0.10–0.14 mm thick and perforated by interpores that are 0.10–0.12 mm in diameter and about that far apart in aligned perforations. Inhalant ostia are up to 0.16 mm in diameter in the dermal layer where they occur in short aligned grooves that produce a linear carved network in the layer, presumably with an upward or outward radiating pattern. Grooves are replaced by offset canals or grooves after two or three ostia are interconnected in one short groove segment.

Exhalant pores in the gastral surface are 0.10–0.30 mm in diameter, with most approximately 0.20 mm across, and up to four or five such openings occur per chamber, separated by skeletal tracts 0.10–0.20 mm in diameter. Some adjacent exhalant openings may merge to form short, canal-like openings to 0.4 mm in diameter at the gastral surface.

Both the dermal and gastral layers are porous and 0.3–0.4 mm thick. The gastral layer, in addition, has a few blunt spines that are up to 1 mm long and project into the shallow spongocoel. Astrorhizal structures are not evident in the gastral layer of the small specimen.

The dermal layer has low nodes 0.2 mm in diameter and high, centered between three or four inhalant ostia. These may produce low small ridges between grooves in the outer part, where the rounded edge of the wall suggests the original sponge margin.

Microstructure of skeletal elements of all specimens is spheroidal, with spherules 0.02–0.04 mm in diameter and appearing slightly angulated to smooth and spherical, or microcrystalline with the same general dimensions.

Etymology.—*Minutus*, L., little, small, in reference to the small chambers and other elements of the sponge.

Types.—The holotype, GUMO 15128, and the smaller paratype, GUMO 15129, plus two small fragments associated with the latter sponge, and a larger paratype, GUMO 15130, along with paratype GUMO 15131, document the morphological range of the species. Also included in the species are the single specimen 030328-1-13s, three small fragments from 010328-1-11L, and a collection of 15 specimens from 030326-3-1, plus one fragment GUMO 5250s, and one small fragment, GUMO 5250b-1, tentatively included in the species.

Occurrence.—All the above listed specimens are from the Reef Trail Member of the Bell Canyon Formation, at USGS Locality 7663.

Discussion.—The new species is similar in general structure to the associated *Guadalupia zitteliana*. That species has a layered skeletal structure, like the sponge described here, but is characterized by sheets that are 6–8 mm thick and composed of chambers 0.7–1.1 mm in diameter, with walls perforated by numerous interpores 0.2 mm in diameter. *Guadalupia explanata* n. sp. (R. H. King, 1943) forms sheets that are 9–11 mm thick, with chambers that are 2–5 mm in diameter and much larger than those of the small new species described here.

Genus Lemonea Senowbari-Daryan, 1990

Type species.—*Guadalupia cylindrica* Girty, 1909, p. 81.

Diagnosis.—''Porate, cylindrical, or conical sponges with one or several spongocoels passing essentially through the sponge. Around the spongocoel(s), the tube-like chambers are oriented radially. Astrorhizal system lacking. Vesiculae may occur but are not abundant. Solitary or colonial forms'' (Rigby et al., 1998, p. 62).

Lemonea cylindrica (Girty, 1909)
Figure 7.1–7.10

Guadalupia cylindrica Girty, 1909, p. 81, pl. 6, fig. 3, 3a–c; Parona, 1933, p. 47, pl. 9, figs. 10–12; Termier and Termier, 1977a, p. 45, pl. 10, fig. 10; 1977b, pl. 9, figs. 4, 5, text-fig. 16; Deng, 1982, p. 250, pl. 2, fig. 1; Flügel in Flügel et al., 1984, p. 202, pl. 37, figs. 2b, 3; Aleotti, Dieci, and Russo, 1986, p. 11, pl. 2, figs. 2–4; Senowbari-Daryan and Rigby, 1988, p. 203, pl. 34, figs. 10, 11; Senowbari-Daryan and di Stefano, 1988, p. 14, pl. 6, fig. 1.

Guadalupia neijiawaensis Deng, 1982, p. 250, pl. 2, fig. 2.

Lemonea cylindrica (Girty) Senowbari-Daryan, 1990, p. 151, pl. 54, figs. 7, 8; pl. 57, figs. 2, 4–6; Rigby, Senowbari-Daryan, and Liu, 1998, p. 52–63, pl. 3, fig. 1; pl. 7, figs. 1–4, 7; pl. 13, figs. 3, 6.

Diagnosis.—''Cylindrical sponges composed of numerous tube-like chambers which are arranged radially around the axial spongocoel of retrosiphonate type. The chamber walls are porate. Vesiculae rudimentary'' (Rigby et al., 1998, p. 62).

Description.—Specimens of the species in the collection range from relatively large, weakly annulate, subcylindrical to branched stems to small obconical or branched, near-basal, fragments. The largest well-preserved specimen, GUMO 5250y, is a Y-shaped, branched sponge 70–72 mm tall with an irregularly annulate structure (Fig. 7.3–7.5). It has an incomplete base, 8 × 9.5 mm in diameter, and expands upward to 11.5 × 16 mm across before subdividing into two smaller branches, 8 and 10 mm in diameter. These branches widen to 13 and 9 × 10 mm at their preserved summits. A throughgoing spongocoel extends from the base to summits of the branches, where these openings are 3.5 × 7 mm in one branch and 5.0 × 6.5 mm in the other.

Walls are 2.0–3.0 mm thick and are composed of a thin outer, dense dermal layer, 0.2–0.5 mm thick, a somewhat less well-defined gastral layer, and the major chamber-bearing layer. The latter is composed of a single layer of tubelike, horizontal, radial chambers, which have circular, oblate to weakly polygonal cross sections that are approximately 0.6–1.0 mm in diameter or wide. They occur five to six chambers per 5 mm, measured horizontally in tangential sections. Their shared chamber walls are 0.14–0.20 mm thick.

Abundant interpores connect adjacent chambers. These openings are 0.08–0.10 mm in diameter and are 0.15–0.20 mm apart, fairly regularly. They occur in linear series, parallel to the length of the tube, and two rows of diagonally offset openings appear to be shared between adjacent chambers.

The dermal layer has an outer reticulate-appearing surface marked by low nodes, 0.2–0.25 mm in diameter, that are separated, on weathered surfaces, by an indented canal-like reticulation with elements 0.06–0.10 mm wide around bases of each of the nodes. Where the surface has not been so weathered, clear matrix fills the reticulate spaces between the nodes. In this unusually well-preserved specimen, these nodes and much of the skeletal structure is composed of microspheroids, 0.015–0.02 mm in diameter, that are reminiscent of a spheroidal aragonite microstructure. Inhalant ostia are 0.06–0.12 mm in diameter, where circular, and 0.06–0.10 mm across where oblate. They occur several per chamber opening with moderately uniform spacing.

The gastral layer is 0.2–0.3 mm thick, and is marked by numerous nodes to spines, which are commonly 0.2–0.3 mm in diameter and high, although some nodes are spinelike and project out into the spongocoel up to 1 mm. They have the same microspherulitic texture as elements in the dermal layer. Nodes are separated by exhalant openings, 0.12–0.16 mm in diameter, in chamber inner walls.

The other silicified specimens of the species are less well preserved, but appear to have the same general chamber dimensions and pore sizes as the large form.

An intermediate-sized sponge, GUMO 15135, is steeply obconical with a broken, incipiently branched base and an upper obconical, thin-walled skeleton around a relatively large spongocoel. The sponge is 30 mm tall, with a basal incomplete diameter of 6 × 7 mm, and an ovate oscular margin 9 × 12 mm wide. The osculum is 5 × 8 mm wide, and is surrounded by walls 2.0 mm thick. These walls include one layer of radial tubular to slightly ovoid chambers that are 0.6–0.7 mm in diameter and are well exposed in the upper part of the sponge. The gastral layer is approximately 0.5 mm thick and has a vesicular or reticulate structure, beyond which extend scattered spines or bladelike fins up to 1.5 mm long and 0.3 mm in diameter or thick. Smaller spines, 0.8–0.9 mm long and 0.2 mm thick, occur in interspaces and project upward and outward into the spongocoel from the coarsely porous gastral layer. Exhalant pores occur three or four per chamber end, are 0.15–0.20 mm in diameter, and are separated by spinose tracts 0.10–0.15 mm in diameter or wide in the reticulate skeletal meshwork.

A dermal layer is clearly defined and is 0.2–0.3 mm thick. It is somewhat annulate and has small inhalant ostia that are best preserved in the middle and lower parts of the specimen. These openings are 0.10–0.14 mm in diameter and 0.2 mm apart, with regular spacing and linear arrangement. They occur three or four per dermal end of each chamber.

Interpores between chambers are 0.10–0.15 mm in diameter and commonly occur in radial rows 0.18–0.20 mm apart. However, some adjacent chambers are apparently not interconnected in this specimen.

A small, branched basal specimen of the species, GUMO 15132, has three short branches (Fig. 7.6, 7.7), each approximately 1 cm tall and with ovoid transverse sections 8 × 12 mm to 10 × 15 mm across. Each has a single spongocoel surrounded by characteristic chambered walls 2–3 mm thick that have a typical nodose, dense, dermal layer and a more coarsely perforate spinose gastral layer. Dermal layer nodes are 0.20–0.50 mm in diameter and 0.10–0.20 mm high. Inhalant ostia between the nodes are 0.08–0.12 mm in diameter, are commonly 0.2–0.3 mm apart, and interconnected by shallow surficial canals 0.08–0.15 mm across. The gastral layer has irregularly developed spines that range 0.5–1.0 mm apart and to 1 mm long. They have basal diameters of approximately 0.3 mm, that may expand distally to 0.5 mm in diameter, where they may be cross-connected at their tips into a crude net. Exhalant pores are 0.14–0.20 mm in diameter and 0.20–0.40 mm apart, and open into tangential canals that range to 0.4 mm wide and interconnect around the spines. All skeletal elements are composed of microspherulitic silica, as replaced, with spheroids that are consistently 0.015–0.020 mm in diameter.

That small, near-basal specimen, GUMO 15132, shows distinct pulses of growth in the upper part of the irregular steeply obconical form. This contrasts with the relatively smoothly expanding base in GUMO 15134 (Fig. 7.10), which has been broken diagonally and shows the chambered structure of the principal wall of the sponge and the spinose gastral layer.

Material examined.—Figured specimens include GUMO 5250y, 5247f, 15132, 15133, and 15134. Also included in the collections are 12 more specimens of the species from 03032603-1, and the three additional small fragments, GUMO 5250c and 5250e, and GUMO 15135. All were collected from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7663.

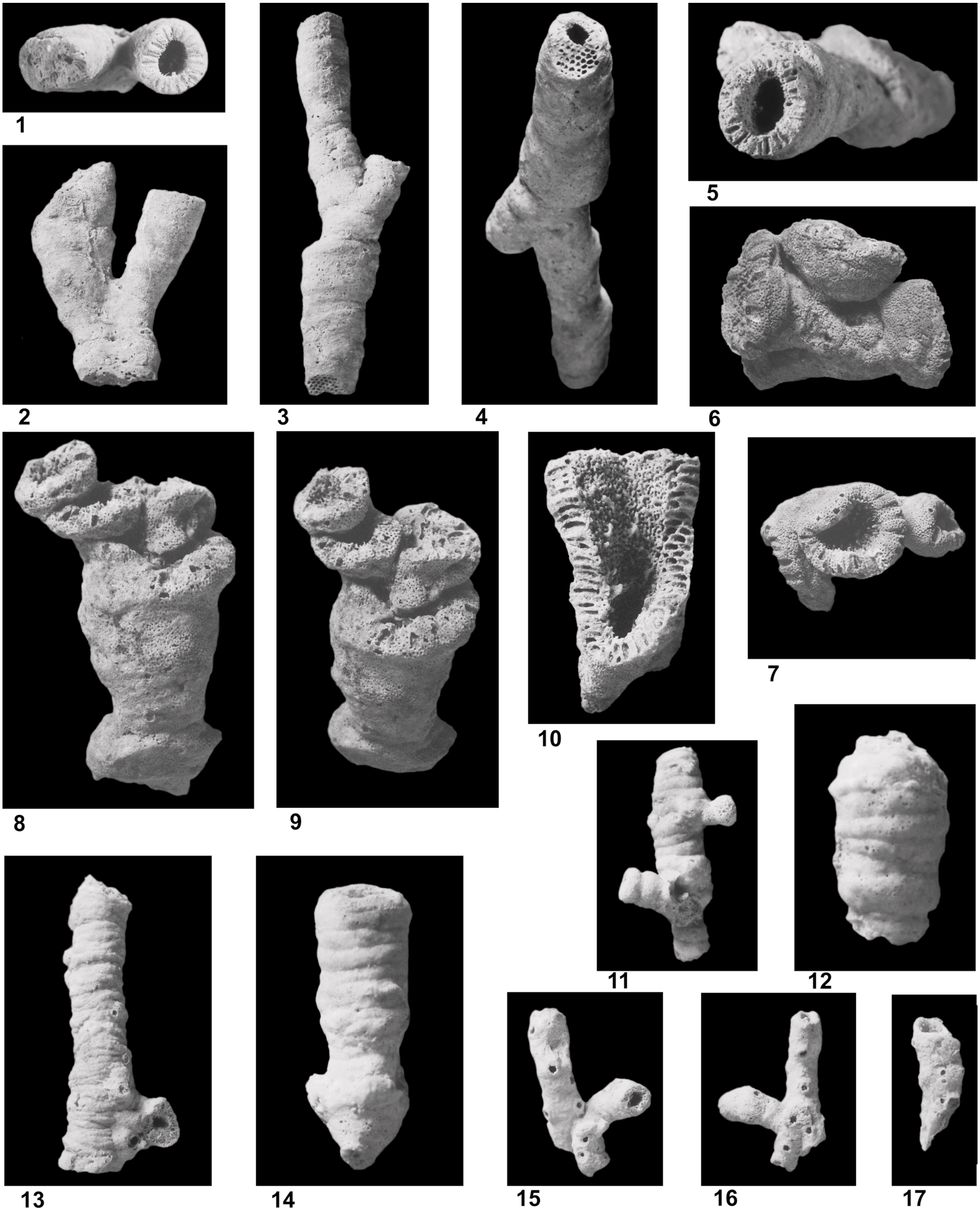
Discussion.—The generally cylindrical branched form, with a single axial spongocoel, characterizes the species, and differentiates it from several other species, such as *Lemonea conica* or *Lemonea siphonata*, described by Senowbari-Daryan (1990), that have multiple vertical exhalant tubes in the honeycomb-chambered structure. *Lemonea micra* and *Lemonea exaulifera*, described by Rigby, Senowbari-Daryan, and Liu (1998), are small-stemmed forms that occur in the upper Capitan Limestone in the Carlsbad Caverns area of the northern Guadalupe Mountains.

LEMONEA MICRA Rigby, Senowbari-Daryan, and Liu, 1998
Figure 5.8–5.10

Lemonea micra RIGBY, SENOWBARI-DARYAN, AND LIU, 1998, p. 66, pl. 1, figs. 3, 7; pl. 3, fig. 3; pl. 6, fig. 6; pl. 7, figs. 5, 7; pl. 8, figs. 1–6; pl. 9, figs, 4, 5.

Diagnosis.—"Small unbranched to occasionally branched species of *Lemonea* with broad axial spongocoel almost one-third to one-half diameter. Chambers relatively short, horizontally arranged around spongocoel, interior of spongocoel contains bubblelike vesicular structures, exaules absent" (Rigby et al., 1998, p. 66).

Description.—Four fragments of two stems of the species are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in the collection. Two of these are parts of a single stem, GUMO 15136 (Fig. 5.9), that is 17 mm long or tall, and 3.7–4.2 mm in diameter, with a central spongocoel 1.6 mm in diameter. Chambers are 0.4–0.5 mm in diameter and 1.0–1.2 mm tall, radially, with low, rounded dermal ends that usually have one central inhalant ostium per chamber. That opening is round and 0.10–0.40 mm in diameter. Chamber interwalls are 0.10 mm thick in the middle, but thicken gastrally and dermally to 0.20 mm thick, and appear similar to the dermal wall. Exaules are lacking.

Smooth gastral ends of the chambers have single exhalant openings that lead into the axial spongocoel. They are 0.12–0.14 mm in diameter, where circular, and 0.12–0.14 mm across and up to 0.20 mm high, where ovoid.

Two other fragments, GUMO 15137a and b (Fig. 5.8, 5.10), form a stem approximately 11 mm tall and 4.2 mm in diameter. It is broken at both ends, and a long diagonal fracture exposes the axial tube or spongocoel, which is approximately 1.7 mm in diameter, and also shows incipient branching of canals through the wall, too. Individual chambers are egg-shaped and horizontal-radial, and 0.9–1.2 mm tall and 0.5–0.6 mm in diameter. They have porous dermal ends that are 0.10–0.20 mm thick, where one to three, or locally four, inhalant ostia occur at midheight per chamber. Those circular ostia are 0.06–0.10 mm in diameter. Gastral ends have exhalant pores that are vertically elongate and 0.2 mm wide and 0.4 mm high through a wall that is 0.10–0.14 mm thick.

The microspherulitic skeletal structure is well preserved on gastral layers, with spherules 0.03–0.04 mm in diameter.

Material examined.—Two fragmental specimens, GUMO 15136 and 15137, occur in the collection from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7663.

Discussion.—Lack of exaules and small size are distinctive of the species, although *L. exaulifera* is of similar size, but has abundant prominent exaules. *L. exaulifera* is also a multibranched species, but *L. micra* has been observed to branch only occasionally. Both of these small species have been reported only from Upper Capitanian rocks of the Guadalupe Mountains (Rigby et al., 1998, p. 66).

Genus Cystauletes R. H. King, 1943

Type species.—*Cystauletes mammilosus* R. H. King, 1943, p. 32.

Diagnosis.—''Long cylinders with multiple branches; broad, central cloaca; chambers quincuncially arranged about cloaca, distally convex and proximally cuspate, forming slight bulges on exterior; no diaphragms observed; exopores, interpores, and endopores small, circular, and closely spaced, approximately equal in size, but endopores more closely spaced than other pores; thin trabecularium lining cloacal surface, consisting of narrow meandriform ridges separating similar grooves into which endopores open; microstructure small isodiametric spherulites; no spicules known'' (Finks and Rigby, 2004, p. 686–687).

Discussion.—Rigby et al. (1998, p. 45) discussed the taxonomic relationships of *Cystauletes* with possibly related genera. They noted that ''Senowbari-Daryan (1990, p. 56) placed the genera *Cystauletes* King, 1943, *Ascosymplegma* Rauff, 1938, and *Lichuanospongia* Zhang, 1983, into synonymy with *Discosiphonella* Inai, 1936.'' They also included those genera as synonyms of *Discosiphonella* and treated representatives of the relatively abundant type species of *Cystauletes* from the northeastern Guadalupe Mountains as *Discosiphonella mammilosa* (R. H. King, 1943). Rigby et al. (1995, p. 238) concluded, however, that type specimens of *Discosiphonella* appear to have a ''relatively simple perforate endowall'' that is much less complex than the canalled wall in *Cystauletes mammilosus*, and for that reason kept *Cystauletes* as a separate genus. Rigby et al. (1995) made attempts to examine the type specimens of *Discosiphonella manchuriensis* Inai, 1936, but the holotype and paratype were both reported to be lost. Finks *in* Finks and Rigby (2004, p. 687) concluded that although *Cystauletes* resembles *Discosiphonella*, the latter ''is poorly known and *Cystauletes* should be retained for tubular, branching forms.'' We have followed that recommendation. We have also included *Cystauletes* in the family Guadalupiidae, as was done by Finks and Rigby (2004, p. 687), although with some question.

Cystauletes mammilosus R. H. King, 1943
Figure 5.1, 5.2

Cystauletes mammilosus R. H. King, 1943, p. 32, pl. 1, figs. 3–5; Van de Graaff, 1969, p. 243, pl. 1, figs. 3, 4, 7; pl. 2, fig. 8; pl. 3, figs. 2, 5; pl. 4, figs. 2, 3, 5, 7, 8; pl. 5, figs. 1, 2; Toomey, 1979, p. 846, pl. 1, fig. 5; pl. 2, figs. 1–9; Senowbari-Daryan and Rigby, 1988, p. 191, pl. 33, figs. 1, 3, 5; pl. 35, fig. 19; Finks and Rigby, 2004, p. 686–688, fig. 454, 2a–2c.

Cystothalamia insolata Termier and Termier in Termier et al., 1977, p. 43, pl. 10, fig. 7; Termier and termier, 1977b, text-fig. 24.

Cystothalamia sp. Aleotti, Dieci, and Russo, 1986, p. 15, pl. 4, fig. 1a, 1b.

Cystothalamia sp. Rigby, 1987, text-fig. 10.18g.

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Figure 7—*Lemonea*, *Preperonidella* Finks and Rigby, 2004, and ?*Djemelia* Rigby and Senowbari-Daryan, 1996 from the Reef Trail Member of the Bell Canyon Formation, at USGS Locality 7633, Guadalupe Mountains National Park, Texas. *1–10, Lemonea cylindrica* (Girty, 1909), *1, 2,* figured specimen, GUMO 5247f, *1,* view from above showing large axial spongocoels and chambered walls with numerous pores, ×1; *2,* side view of branched specimen with three short branches, with finely nodose dense dermal layer, ×1; *3–5,* figured specimen, GUMO 5250y; *3,* side view of tall, Y-shaped sponge with irregularly annulate dense dermal layer with low separated nodes and small inhalant ostia, ×1; *4,* view of sponge from below with broken incomplete base, at top, showing regular small chambers and small axial spongocoel in broken diagonal surface, ×1; *5,* view of upper osculum and central spongocoel surrounded by chambered wall, ×2; *6, 7,* figured specimen, GUMO 15132, *6,* side view of small basal specimen with three broad branches; the dermal layer of each has distinct small nodes with common inhalant ostia and shallow surficial canals, ×1.5; *7,* view from above showing broad spongocoels surrounded by layer of porous-walled chambers, with spinose gastral layer exposed in the large central one, ×1.5; *8, 9,* figured specimen, GUMO 15133, *8,* side view of specimen with irregular growth form and short upper branches, ×2; *9,* diagonal view from above showing larger lower stem and short irregular upper branches with irregular spongocoels, ×2; *10,* side view of broken, smoothly expanding, sponge base, showing section through chambered wall, and rough, low spinose gastral layer of large open spongocoel, ×2, GUMO 15134. *11–14, Preperonidella rigbyi* (Senowbari-Daryan, 1991), *11,* side view of annulate, nearly complete, figured specimen with a short side branch, and an attached fragment, all perforated by numerous small inhalant pores, GUMO 15141, ×2.5; *12,* incomplete, small, figured specimen with characteristic annulate dermal layer with common inhalant ostia, GUMO 15139, ×8; *13,* side view of largest specimen, broken at both ends, with dense annulate dermal layer and short broken branches that show parts of throughgoing axial spongocoel, in fibrous skeleton, GUMO 15140, ×2.5; *14,* side view of nearly complete small sponge with essentially complete pointed base and rounded upper osculum, GUMO 15138, ×4. *15–17,* ?*Djemelia* sp., figured specimens, *15, 16,* branched, or merged, figured fragment of subcylindrical stems with axial spongocoels and with scattered coarse, rimmed ostia and numerous small inhalant pores in the dense dermal layer, GUMO 5250i, ×2; *17,* small, nearly complete, base of single stem with a few rimmed ostia and numerous small pores in the dermal layer below the oscular summit, GUMO 15142, ×5.

Discosiphonella mammilosa (King). Senowbari-Daryan, 1990, p. 57–58, pl. 20, figs. 4–6; pl. 59, figs. 4–6; Rigby, Senowbari-Daryan, and Liu, 1998, p. 45–47, pl. 1, figs. 9, 10; pl. 2, figs. 2, 3; pl. 3, figs. 2–4; pl. 7, fig. 8.

Diagnosis.—''Straight cylindrical to branching stems up to 20 mm in diameter, with chambers 3–8 mm high and wide, radially from central tubular spongocoel up to 6 mm in diameter and one-eighth to one-third total stem diameter. Chambers arranged in single cyst-like layer in monoglomerate arrangement around spongocoel. Pores in segment wall not usually numerous, but with common diameters of 0.1–0.2 mm and rarely up to 0.5 mm. Cyst-like chambers may be arranged in horizontal rings or in somewhat diagonally stacked patterns. Interwall and exowalls 0.2–0.4 mm thick, endowall to 0.5 mm thick with endopores to 0.25 mm in diameter. Vesiculae common in chambers'' (Rigby et al., 1998, p. 46).

Description.—One large, moderately complete sponge and two irregular fragments are in the collection. The large sponge, GUMO 15174, is a subcylindrical specimen composed of a single monoglomerate layer of bulbous or cystlike porous chambers that are arranged in somewhat diagonally stacked spirals (Fig. 5.1). An incompletely closed slitlike spongocoel extends full length on one side of the somewhat aberrant specimen (Fig. 5.2). The sponge is 25.4 mm tall and expands upward from a diameter of 7.5 mm at the broken base, to a maximum diameter, or width, of 11 mm 12–13 mm below the preserved summit, and then narrows to 9 mm in diameter at the essentially complete summit.

Upward-arcuate chambers range from small spheroidal elements 2 mm high and 3 mm wide near the base, to 3 mm high and 5 mm wide in the upper part. These have bulbous or lobate outer walls that arch radially 1–2 mm from their interwall junctions. Their exowalls are 0.10–0.14 mm thick where seen in the basal part of the sponge, but are up to 0.2 mm thick in summit chambers. Interwalls appear to be like the exowalls. Visible endowall sections are limited, but those exposed in the base are 0.2 mm thick, and are much thicker where curving gastral walls of chambers overlap.

Exopores are abundant and are mostly approximately 0.10 mm in diameter, although some range to 0.20 mm in diameter. These pores are moderately uniformly 0.2–0.3 mm apart, but they are not in distinct patterns, although some short linear rows of pores are recognizable in nearly all chambers. Interpores are essentially like the exopores in size and spacing, for they were initially exopores but became interpores when adjacent chambers were added. Endopores are circular to vertically elongate and range up to 0.2 mm wide and 0.3 mm high where best exposed in gastral parts of broken chambers, or where pores are visible in the incompletely enclosed spongocoel. Coarse endopores are 0.1–0.2 mm apart in bases of some chambers, and are associated with smaller pores, 0.10–0.20 mm across, that occur irregularly or in crude vertical rows that are separated by irregular low vertical ridges or smooth areas on the endowall of the spongocoel.

The spongocoel slit is 1×3 mm wide, is surrounded by the lower few chambers, and is nearly closed in the area of maximum diameter (Fig. 5.2), but is partially open above and below there. The dermal surface of the adjacent swollen chambers is relatively smooth, but irregular, small, stubby, fingerlike spines extend laterally from the chamber surfaces to enclose partially the spongocoel slit. These nodes or spines are 0.2–0.4 mm in diameter, above flared bases that range to 0.5 mm in diameter, and are irregularly 0.2–0.7 mm long.

Interiors of only a few chambers are exposed, but there is no significant evidence of diaphragms or vesiculae in any of them.

The original microspherulitic structure of the now silicified skeleton is locally well preserved and the small spherulitic masses average approximately 0.04 mm in diameter. In some areas, however, the spherulites were not preserved, but are evident by spheroidal openings in the spinose-appearing microstructure of the skeleton.

Material examined.—Figured specimen GUMO 15174 and two small fragments of the species from 030326-3-1 occur in the collection from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7663.

Discussion.—Relationships to possibly related forms and taxonomy of the species have been discussed in treatment of the genus, above. Arcuate chambers with abundantly porous outer walls in the specimens available here are like those in the holotype of the species (R. H. King, 1943, pl. 1, figs. 4, 5), but the nearly complete large specimen described here does not have a large spongocoel like that present in the type specimens from Kansas.

Family Preperonidellidae Finks and Rigby, 2004

Diagnosis.—''Sponges in which exhalant system consists of only spongocoel or cluster of several coarse canals in axial region of sponges; other differentiated canal systems may be absent or well developed; skeletal microstructure spherulitic'' (Finks and Rigby, 2004, p. 632).

Subfamily Preperonidellinae Finks and Rigby, 2004

Diagnosis.—''Sponges with axial spongocoel but without distinct inhalant and exhalant canals; skeletal microstructure spherulitic'' (Finks and Rigby, 2004, p. 632–633).

Genus Preperonidella Finks and Rigby, 2004

Type species.—*Peronidella magna* Rigby and Senowbari-Daryan, 1996, p. 58.

Diagnosis.—''Sponges smooth to annulate, columnar to branched, with exhalant canal system only tubular axial spongocoel, although endowall may be pierced by circular endopores in longitudinal rows, dermal layer pierced by small inhalant ostia; skeletal fibers thin and uniform to variable and thick, and commonly in irregular reticulate structure; fibers with spherulitic microstructure; dense dermal layer may be present'' (Finks and Rigby, 2004, p. 633).

Preperonidella rigbyi (Senowbari-Daryan, 1991)
Figure 7.11–7.14

Peronidella parva Rigby, Fan, and Zhang, 1989, p. 789–790, fig. 9.7, 9.8 (non *Peronidella parva* Nutzubidze, 1964).
Peronidella rigbyi Senowbari-Daryan, 1991, p. 405; Rigby and Senowbari-Daryan, 1996, p. 60–61, pl. 11, fig. 3; pl. 47, fig. 5.
Preperonidella rigbyi Finks and Rigby, 2004, p. 633.

Emended diagnosis.—Small, questionably branched, cylindrical *Preperonidella*, stems 4–6 mm in diameter with tubular spongocoel 1.2–2.0 mm across; skeletal fibers generally 0.2 mm across and skeletal canals of essentially the same dimensions; well-defined gastral layer and dermal armor; lacks distinct spicules (modified from Rigby, Fan, and Zhang, 1989, p. 789).

Description.—Specimens of the species in the collection range from small cylindrical fragments, 5 mm tall and 2.5 mm in diameter, to large specimens to 27 mm tall and 6 mm in diameter, all of which have rounded dermal annulations 0.3–1.0 mm tall. Few fragments show either the base or oscular ends, but one nearly complete small annulate sponge, GUMO 15138, is 13 mm tall and expands upward from an essentially complete base, 1.3–2.2 mm in diameter, to an upper diameter of 4.2×4.5 mm at the oscular margin (Fig. 7.14). It has an osculum 1.7×2.5 mm across, surrounded by the upper rounded walls, 1.0–1.2 mm thick, in which rounded openings between fibers in the skeletal net range 0.02–0.06 mm in diameter. The thin dermal layer is perforated by numerous small, circular, inhalant pores, 0.02–0.06 mm in diameter and less common ovoid pores 0.06 × 0.10 mm in diameter.

A small fragment, GUMO 15139, is only 5 mm tall and 2.5–3.2 mm in diameter (Fig. 7.12), and clearly shows the irregularly reticulate, porous, endosomal skeletal net. It has short tracts, 0.08–0.12 mm in diameter, that outline interconnected openings, 0.1–0.2 mm in diameter. It has a gastral layer, 0.08 mm thick, that locally shows two layers, 0.04 mm thick, which are perforated by gastral pores of dimensions like the endosomal openings. A thin dermal layer, 0.04–0.06 mm thick, has common inhalant ostia 0.02–0.06 mm in diameter.

The largest specimen, GUMO 15140, is 27 mm tall, but is broken at both ends (Fig. 7.13). It has an ovoid, throughgoing, central spongocoel 1.0 × 3.0 mm across, with a moderately defined perforated gastral layer 0.10–0.20 mm thick. The annulate dermal layer is 0.06–0.10 mm thick and is perforated by abundant, small, inhalant pores approximately 0.02 mm in diameter and other less common larger ones 0.06 mm in diameter. The irregularly reticulate endosomal skeleton has tracts 0.06–0.12 mm in diameter, with most approximately 0.10 mm in diameter, that outline interconnected circular openings 0.04–0.10 mm in diameter, with rare openings to 0.3 mm. No canals are clearly defined.

An additional instructive example, GUMO 15141 (Fig. 7.11), is a nearly complete annulate sponge 16 mm tall, which expands upward from a base 2.7 mm in diameter to an oscular diameter of 3.0 mm. It has a possible short branch 3.5 mm long that expands from a narrow base to an outer diameter of 2.4 mm. That branch lacks a central spongocoel, so is probably only the immediate base, which shows the characteristic irregular reticulate structure of the endosomal layer of the skeleton. An attached fragment, 6 mm long and 2.5 mm in diameter, has an osculum 1.0 × 1.3 mm across and is surrounded by a rounded rim. The lower part of the sponge has been diagonally fractured so that a section of skeleton is exposed. It has a perforate dermal layer, 0.05 mm thick, and a smooth gastral wall, approximately 0.10 mm thick, that is perforated by porelike openings in the endosome that range 0.2–0.6 mm in diameter.

A similar-sized specimen, GUMO 15149, is 16.5 mm tall and 4.0 mm in diameter and has the characteristic annulate form of the species. The spongocoel is 2.5 mm in diameter and is bordered at the osculum by rounded summits of walls 1.0 mm thick. Dermal annulations are irregular and may form rounded ridges only part way around the sponge. They range 0.5–1.5 mm high, with five to seven rings per 5 mm, and have ridges to 0.3 mm thick that are separated by shallow indentations where the dermal layer has arched inward several times over former rounded oscular margins.

The dense dermal layer is 0.2–0.3 mm thick and has abundant inhalant ostia that are commonly 0.02–0.04 mm in diameter and spaced 0.05–0.10 mm apart. A few rare ostia range up to 0.10 mm, and with the smaller pores connect to ‘‘canals’’ 0.2–0.3 mm in diameter in the endosomal part of the skeleton. Such ‘‘canals’’ extend irregularly through the wall and open into the spongocoel as exhalant pores of essentially the same diameter. These ‘‘canals’’ are outlined by reticulate cylindrical to flattened fibers 0.1–0.2 mm wide or in diameter.

Coarse spines and irregular vertical blades project into the spongocoel from the gastral margin and subdivide that axial opening into two oscular openings, one of which is approximately 1 × 2 mm across, and the other 1.2 mm in diameter. They extend several millimeters down into the spongocoel.

Associated curved to cylindrical specimens range to 8.5 mm tall and 2.7 mm in diameter, and show the same type of annulate dermal surfaces pierced by small inhalant ostia that open to canals in the reticulate interior skeletal net, and finally into the axial tubular spongocoel.

Material examined.—Figured specimens include GUMO 15138–15141. Also included in the species is a specimen from GUMO 5250z, six additional specimens from GUMO 5250j, eight specimens from GUMO 5250d, seven fragments, including GUMO 15149, from GUMO-429 12510g, and five moderately complete specimens and three fragments from 030326-3-1, all from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7663.

Discussion.—The subcylindrical, annulate, small stems of the sponge are of dimensions like those characteristic of *Preperonidella rigbyi*, and they are among the smallest known examples of *Preperonidella*. These unusually well-preserved specimens show that the species has a minutely perforate dermal layer, in contrast to what has been reported by earlier observers (Rigby, Fan, and Zhang, 1989, p. 789–790; Senowbari-Daryan, 1991, p. 405; Rigby and Senowbari-Daryan, 1996, p. 61).

Subfamily PERMOCORYNELLINAE Rigby and Senowbari-Daryan, 1996

Diagnosis.—‘‘Axial spongocoel extends virtually through sponge; inhalant and exhalant canals present as regular or irregular tubes’’ (Rigby and Senowbari-Daryan, 1996, p. 65).

Genus DJEMELIA Rigby and Senowbari-Daryan, 1996

Type species.—*Djemelia amplia* Rigby and Senowbari-Daryan, 1996, p. 71–72.

Diagnosis.—‘‘Single or branched, cylindrical to club-shaped sponge with axial spongocoel passing through whole sponge. Outer surface covered with numerous ostia, some of which occur on exaules. Ostia lead into branched tubes that pass into reticular fibrous skeleton of wall. Spongocoel with distinct wall with well-developed exhalant canals leading to spongocoel’’ (Rigby and Senowbari-Daryan, 1996, p. 71).

?DJEMELIA sp. Figure 7.15–7.17

Description.—The large figured specimen, GUMO 5250i, is a branched, or merged, fragment of subcylindrical stems that are 3.0–4.0 mm in diameter and up to 14 mm tall, with a broken base (Fig. 7.15, 7.16). Walls are 0.7–1.0 mm thick and surround continuous, cylindrical, axial spongocoels that extend through the branches. Spongocoels range 1.2 × 1.4 to 1.3 × 1.5 mm in diameter, or 0.9 × 1.8 mm across where flattened on one end.

The main skeletal net is of uniform reticulate fibers that are 0.08–0.12 mm in diameter and have junctions that are 0.12–0.14 mm across or thick. Individual fiber segments are 0.20–0.25 long, junction to junction, in the network and surround interconnected openings 0.08–0.14 mm in diameter. Fibers are discontinuous, but subvertical elements appear to diverge gently upward and outward from the gastral margin of the wall.

The moderately distinct, smooth, gastral layer is approximately 0.10 mm, or one skeletal fiber, thick. Pores in that layer range up to 0.08 mm in diameter, where they are circular, and to 0.20 mm long where they are elliptical. They are mostly vertically elongate and spaced 0.2–0.4 mm apart, without an obvious pattern.

A well-defined, dense, dermal layer is 0.10–0.20 mm thick and is interrupted by scattered coarse, rimmed or mounded, ostia. These circular to ovoid openings have dense tapered rims that are 0.3–0.8 mm high. They have basal diameters of 1.5–1.8 mm, and narrow distally to 1.2–1.3 mm in diameter at the ostia. They open into large canals, which lead directly to the spongocoel, and may be exhalant.

Numerous small, probably inhalant pores also open through the dermal layer, and range from circular and 0.04–0.06 mm in diameter to ovoid and up to 0.04 mm wide and 0.08–0.10 mm long. They occur uniformly over the entire smooth dermal layer between the mounded ostia, are 0.1–0.2 mm apart, and connect to interfiber openings in the main part of the reticulate skeleton.

The small single stem, GUMO 15142, is of the initial part of a sponge and is 7 mm tall (Fig. 7.17). It expands from a basal diameter of 0.9–1.0 mm to a maximum diameter of 1.9 mm a short distance below the oscular summit. There the sponge is 1.4 mm in diameter and the spongocoel is 0.6 mm in diameter. The dense dermal surface is pierced by numerous small circular pores approximately 0.05 mm in diameter that are spaced 0.05–0.08 mm apart.

More obvious are several rimmed coarse ostia to canals that may extend into the spongocoel. These ostia are approximately 0.3 mm in diameter in the lower part of the sponge, but increase to approximately 0.5 mm in diameter in upper openings. They have dense rims 0.06–0.08 mm thick in lower ostia, but an upper one has a rim 0.25 mm thick.

The dermal surface is weakly nodose, with nodes 0.3–0.4 mm in diameter in the middle part of the wall, where some discontinuous irregular low ridges or weak annulations also developed. Skeletal detail is not preserved in the fine crystalline siliceous replacement, although some aligned elements suggest an originally irregular fibrous structure.

Material examined.—The large figured specimen of the species, GUMO 5250i, and the small figured specimen, GUMO 15142, plus 11 additional fragments of the species from GUMO 5250d, and two small fragments from 010328-1-16, and one specimen attached to brachiopods on 010327-3-1r, represent the species in the collection from the Reef Trail Member of the Bell Canyon Formation, from USGS Locality 7663.

Discussion.—The three previously described species of the genus, described by Rigby and Senowbari-Daryan (1996, p. 71–73) from Tunisia, all have reticulate fibrous skeletons around axial spongocoels, that extend essentially through the entire sponge, and have dense dermal layers with numerous ostia. These openings range from simple ostia in *D. mediala* Rigby and Senowbari-Daryan, 1996, to rimmed openings in *D. nana* Rigby and Senowbari-Daryan, 1996, and tubular exaules in *D. amplia*. However, they all have branched inhalant and exhalant canals that do not extend as simple coarse tubular openings through the wall, as in the sponges described here, which are particularly well shown in the larger sponge.

Subfamily PRECORYNELLINAE Rigby and Senowbari-Daryan, 1996

Diagnosis.—"Sponges in which two or more axial spongocoels or clusters of coarse exhalant canals present; inhalant and exhalant canals present or absent" (Rigby and Senowbari-Daryan, 1996a, p. 74).

Genus LERCARITUBUS Flügel, Senowbari-Daryan, and Di Stefano, 1990

Type species.—*Lercaritubus problematicus* Flügel, Senowbari-Daryan, and Di Stefano, 1990, p. 361–362.

Emended diagnosis.—Linear tubelike to multiple branched sponges with a calcareous skeleton composed of superposed, thick-walled, segments or chambers; each characterized by a spongocoel and a distinct flared osculum, and separated internally by perforated interwall sieveplates. Dermal surface of skeleton marked by small, variably polygonal depressions outlined by irregular, reticulated, sharp ridges. Exaules locally present, each with sculptured dermal surfaces and occasionally preserved basal sieveplate. Small pores present in ectowall.

Discussion.—Taxonomic placement of the genus is somewhat problematic, because of differences in the early versus late appearance of its skeleton. The reticulate porous initial skeleton, preserved in at least one fragment and documented from other specimens from the Guadalupe Mountains by Senowbari-Daryan and Rigby (1996), suggests the sponge may be related to the Radiotrabeculoporiidae. However, the genus has a distinct spongocoel, a structure not present in the radiotrabeculoporiids. The genus may be related to other ceractinomorphid sponges. For now, the genus is questionably included in the Preperonidellidae, with the similar-appearing *Minispongia* Rigby and Senowbari-Daryan, 1996.

LERCARITUBUS PROBLEMATICUS Flügel, Senowbari-Daryan, and Di Stefano, 1990
Figure 8.1–8.7

Lercaritubus problematicus FLÜGEL, SENOWBARI-DARYAN, AND DI STEFANO, 1990, p. 361–363, pl. 1, figs. 1–16, text-figs. 2, 3l; WEIDLICH, 1992, p. 44–45, pl. 16, fig. 3; SENOWBARI-DARYAN AND RIGBY, 1996, p. 22–26, figs. 3, 4.

Diagnosis.—As for genus.

Description.—Specimens of the species in the collection include two moderately large stem fragments and several fragments of smaller stems. They range from relatively uniform small stems, 1–2 mm in diameter, to larger stems, 3–4 mm in diameter, that may show abrupt rejuvenation above earlier flared oscular margins. The two largest stems, GUMO 15147, are subparallel and intergrown with shared exaulos tubes (Fig. 8.1, 8.2), are approximately 15 mm tall, and are from approximately 3 mm in diameter, at their broken bases, up to 4–5 mm in diameter at the flared oscular summit of the taller branch. Both are marked with the characteristic irregularly reticulated, ridged, dermal surface. These sharp ridges are 0.1–0.3 mm wide at their bases and up to 0.3 mm high at their sharp summits, which may combine at junctions to form sharp, triangular-based spines up to 0.2–0.5 mm high, above crests of adjacent ridges. These ridges surround smooth-rounded to somewhat linear depressions that may be 0.4–1.0 mm across.

Walls range 0.3–0.5 mm thick between ridges and appear impervious. However, one well-preserved specimen, GUMO 15143, shows early stages in development with distinctly porous gastral walls, prior to those walls being secondarily coated or filled. The gastral layer is approximately 0.3 mm thick and has common circular exopores that are 0.04–0.08 mm in diameter, and spaced regularly 0.10–0.15 mm apart. The irregular, thinner, dermal layer, 0.1–0.3 mm thick, contains abundant smaller inhalant pores 0.04–0.06 mm in diameter, which are spaced 0.04–0.08 mm apart so that eight to ten pores occur in 0.2 mm, even on ridges of the dermal layer. Such fine pores and skeletal details are obscured on other available specimens of the species.

Fine-meshed interwalls and basal sieveplates are characteristic of the genus and species, but most specimens do not have these skeletal elements preserved. On GUMO 15144, an interwall and basal sieveplate are both well preserved (Fig. 8.3, 8.7). The interwall is a fine regular mesh, with remarkable uniform circular pores 0.04–0.05 mm in diameter, spaced so that five or six may occur in a distance of 0.5 mm in the locally aligned pores. Tracts between pores are 0.03–0.05 mm wide in the more or less hexagonally aligned structure. Several other associated specimens show interwalls or fragments of essentially the same dimensions.

Thin basal sieveplates to exaules are of the same general fine-textured appearance. They have circular to triangular or rounded rectangular pores that are commonly 0.04 mm in diameter or across. Tracts between them are 0.01–0.02 mm in diameter or thick, for some are finlike and 0.01–0.02 mm wide and up to 0.03

mm high. Pores in these elements are spaced such that four or five may occur in 0.4 mm, when they occur in a line.

Another well-preserved specimen, GUMO 15145 (Fig. 8.5), has somewhat coarser interwall screens where pores are up to 0.06 mm in diameter. This same specimen has chamber exowalls and a diaphragm composed in large part of microspherulitic elements 0.02–0.05 mm in diameter, with most approximately 0.04 mm in diameter. The smooth dense dermal layer is 0.1 mm thick, and the similarly smooth dense gastral layer is 0.04 mm thick, with the spheroidal layer between up to 0.5 mm thick in this small specimen.

Tubular to mounded exaules occur on most specimens, and may occur up to three or four per chamber, although some chambers lack them. These tubes are 0.7–0.8 mm in diameter and up to 2.2 mm long. They have walls 0.2–0.3 mm thick and are irregular because they also have the ridged reticulate dermal surface. Tubes have exaules pores 0.3–0.6 mm in diameter, but may be secondarily restricted to smaller openings where the skeletal layers are thickened.

Material examined.—Figured specimens GUMO 15144–15148, plus 15 additional fragments; described specimen GUMO 15143, plus four additional fragments from GUMO 5250bb; two specimens from GUMO 5250s; 10 small fragments from 030326-3-1, one of which has an intact transverse interwall screen; 47 specimens and small fragments from 030326-3-1f, and 20 small fragments from 010328-1-13a, all from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—The somewhat similar-appearing *Minispongia* has a ridged dermal ornamentation like that of the species described here, but that in the Tunisian species is more regularly ringlike than the irregular reticulate pattern seen in these Guadalupe Mountain sponges. Rigby and Senowbari-Daryan (1996, p. 78) noted that the exaggerated sharp-ridged sculpture, like that which characterizes these two genera, is not known in other sponges, and particularly in other small Permian sponges.

The Texas examples have only a single, broad spongocoel, rather than multiple parallel tubelike spongocoels, such as developed in the Tunisian *Minispongia*, and the single spongocoel is subdivided into chambers by porous, delicate screenlike interwalls. *Lercaritubus problematicus* has exowalls that may have begun as porous skeletal elements, but which were secondarily covered, both dermally and gastrally, by impervious skeletal layers, so that the sponge now appears to lack skeletal pores, other than the common prominent tubular exaules.

Family Virgolidae Termier and Termier, 1977a
Subfamily Preeudeinae Rigby and Senowbari-Daryan, 1996

Diagnosis.—"Virgulid sponges lacking large osculum or depression on summit" (Finks and Rigby, 2004, p. 601).

Discussion.—The subfamily was included initially in the Virgulidae by Rigby and Senowbari-Daryan (1996, p. 88), but was probably incorrectly moved to the Polysiphonellidae Wu, 1991 by Rigby et al. (1998, p. 78). That taxonomic shift was based on the questionable conclusion that definition of the Virgulidae by Termier and Termier (1977a) was unduly influenced by their interpretation of the structure of *Virgula osiensis* (de Gregorio, 1930). The subfamily was included in the revised Virgolidae Termier and Termier, 1977a, in the recently published Porifera volume of the *Treatise on Invertebrate Paleontology* (Finks and Rigby, 2004, p. 596), and that taxonomic position is utilized here.

Genus Newellospongia new genus

Type species.—*Newellospongia perforata* n. sp., by monotypy.

Diagnosis.—Cylindrical to branched stems with dense smooth to annular dermal layer over finely porous, trabecular endosomal skeletal net perforated by one to several, irregularly placed, vertical exhalant canals, which may be interconnected by narrow variable slots in the skeleton; fine trabecular skeletal structure irregularly upward divergent.

Etymology.—Named for Norman D. Newell, a major contributor to the understanding of Permian reefs of the Guadalupe Mountains area in western Texas and New Mexico, and to the paleontology of Paleozoic bivalves of North and South America.

Discussion.—The irregular development of multiple canals clearly differentiates this genus and species from the peronidellids and most other spongocoel-bearing sponges, such as *Heptatubispongia* Rigby and Senowbari-Daryan, 1996. *Cavusonella* Rigby, Fan, and Zhang, 1989 has a skeleton like the genus here, and a canal development that might also appear similar in some sections to that of *Newellospongia*, but that Chinese sponge has principally horizontal rather than distinctly vertical canals. *Preeudea* Termier and Termier, 1977a has numerous walled vertical canals throughout the sponge, and it also has numerous prominent tubular exaules in a dense dermal layer. *Medenina* Rigby and Senowbari-Daryan, 1996 is also an elongate form with numerous tubular longitudinal exhalant canals, but they are interconnected with horizontal canals in the outer part of the skeleton. Other genera in the subfamily include the small, spherical *Microsphaerispongia* Rigby and Senowbari-Daryan, 1996, and the mushroom-shaped *Polytubifungia* Rigby and Senowbari-Daryan, 1996, which has numerous parallel vertical exhalant canals and rimmed ostia in a dense dermal layer, in a structure different from that of *Newellospongia*.

Newellospongia perforata new species
Figure 9.5–9.9

Diagnosis.—As for the genus.

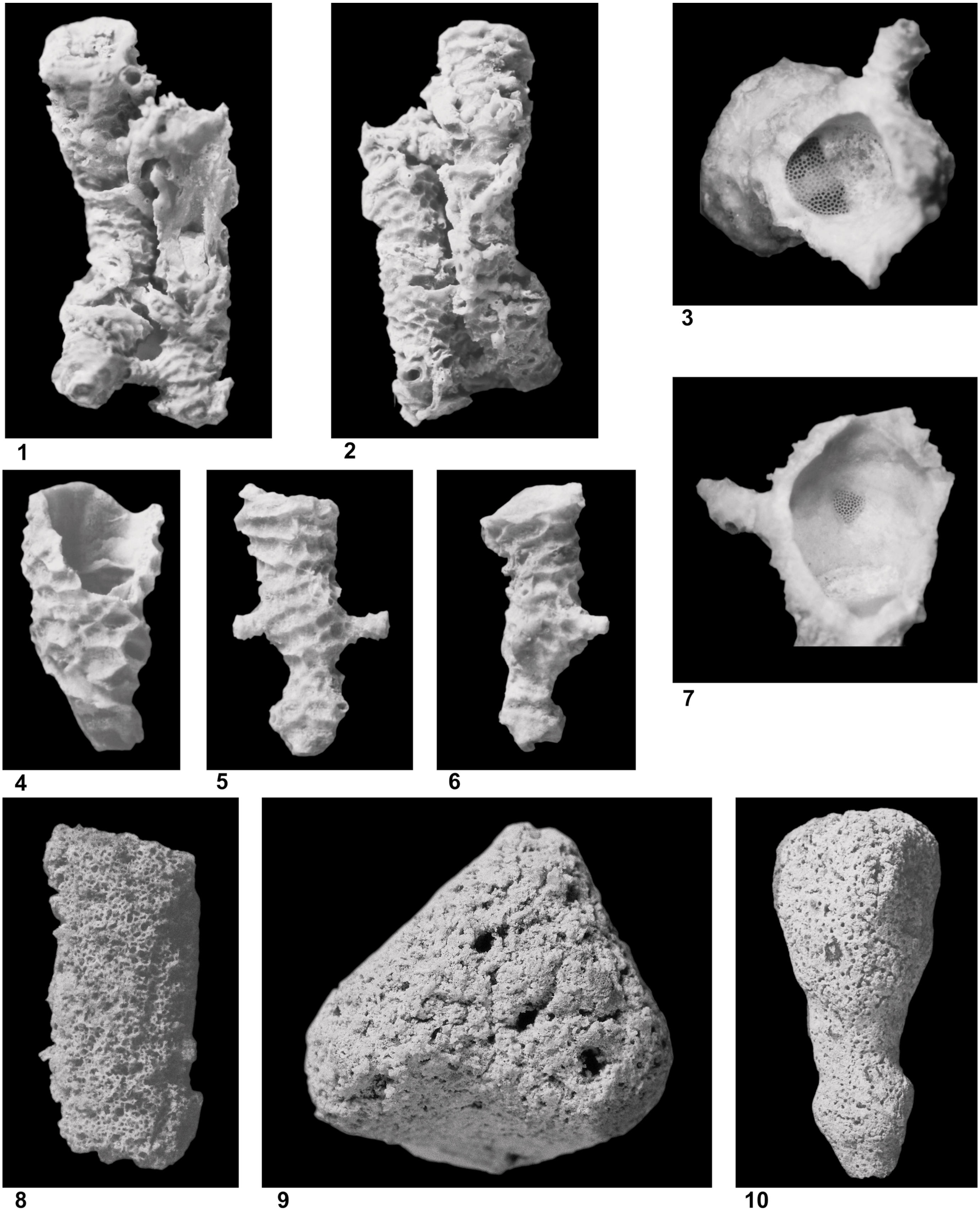
Description.—The holotype, GUMO 5250v, is a moderately large stem of the sponge 34 mm tall (Fig. 9.5, 9.9), which expands upward from a nearly complete base, 3.4 mm in diameter, to a diameter of 5–6 mm up to the irregularly annulate upper part of the sponge that is 8.5 mm in diameter. All but the uppermost 4 mm of the sponge is blanketed by a thin, imperforate, smooth to weakly annulate dermal layer that is 0.10–0.20 mm thick. That layer thins into the summit area where some probably inhalant circular pores are still unfilled and range up to 0.16 mm in diameter. Pores of the endosomal part of the skeleton are visible through the thin, transparent, uppermost few millimeters of the dermal layer.

The endosomal skeleton lacks an axial spongocoel, but is interrupted in the summit area by oscula of five vertical exhalant canals that range from 0.5 mm up to 1.3 mm in diameter or across. Upper ends of three of these canals are interconnected by a narrow irregular slot 0.2–0.3 mm wide (Fig. 9.9). Depth and continuity of these canals are unknown, but they are at least a few millimeters deep, and probably extend deep into the sponge.

The endosomal skeleton has somewhat finer openings in the trabecular net in the outer 1 mm, where pores are circular and commonly 0.10–0.16 mm in diameter, although some up to 0.20 mm in diameter were observed immediately inside the dermal layer. Similar openings in the inner parts of the skeleton range 0.06–0.28 mm in diameter, with most 0.10–0.20 mm in diameter, where circular, and up to 0.3 mm high, where ovoid and vertically elongate.

Fibers or tracts in the skeleton are 0.08–0.14 mm in diameter and up to 0.3 mm across where they join. They form a crude-layered, arched structure in the upper "dome" of the stem.

A branched fragment, GUMO 15150, has eight exhalant oscula in an elongate summit 6 × 9 mm across (Fig. 9.8). These openings range 0.6–1.2 mm in diameter and are separated 0.5–2.0 mm apart. They are somewhat aligned around the stem perimeter, 0.8–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1.0 mm in from the dermal surface. Some of them have distinctly smooth, thinly lined, and porous inner surfaces.

The internal skeletal structure exposed in that paratype (Fig. 9.7) consists of short, upward-divergent fiber segments up to 2–3 mm long. These separate at 40°–50° from one side of the stem to the other. These vertical fiber segments are 0.2–0.25 mm in diameter and are approximately 0.5 mm apart, center to center. Their cross-connecting, irregular, ladderlike ''rungs'' are short and form openings between fibers 0.18–0.40 mm wide and up to 0.5 mm high. They are smaller and more commonly circular and 0.14–0.20 mm in diameter between where new fibers are inserted in the upward-divergent structure.

The dermal layer in the fractured area is 0.3–0.5 mm thick and clearly shows a spheroidal structure. These spheroids are commonly 0.03–0.04 mm in diameter, but some up to 0.07 mm in diameter occur in the inner part of the impervious layer.

An additional reference specimen, GUMO 12510m, is a branched stem fragment 25 mm tall. It has an ovoid cross section, 6 × 7 mm in diameter, and a dense dermal layer is 0.5–0.8 mm thick. Well-defined inhalant ostia, 0.10–0.12 mm in diameter, are open only near possible oscular margins of the small branches, but are filled in and no regular pores or canals are evident elsewhere in the dermal layer, although some irregular, probably secondary, openings occur in the ''flaky'' silicification.

A midlength branch is 1.5 mm long and 4.5 × 5.0 mm in diameter, with an irregular dermal layer 0.5–1.0 mm thick. Three interconnected exhalant canals, 0.4–0.5 to 1.2 mm in diameter, interrupt the regular reticulate skeleton at the branch terminus, where trabeculae are approximately 0.10–0.14 mm in diameter, but merge to form compound dense junctions to 0.5 mm between canals. Endosomal pores or canals are round openings 0.10–0.16 mm in diameter and some are traceable as canals for up to 0.25–0.30 mm. They may connect to larger exhalant openings and major canals in the system.

Skeletal microstructure of these sponges is not well preserved, but some areas suggest a spherulitic structure, with spherules 0.02–0.03 mm in diameter.

Etymology.—*Perforata*, L., perforated, to bore through, in reference to the common vertical exhalant canals in the skeleton.

Types.—Specimens of the species in the collection include the holotype, GUMO 5250v, and two paratypes GUMO 15150 and 5250u, plus four additional specimens from GUMO 5252e, 12 fragments from GUMO 5250d, and reference specimen GUMO 12510m.

Occurrence.—All currently known specimens of the species are from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7663.

Discussion.—See under genus.

Family RADIOTRABECULOPORIDAE new family

Type genus.—*Radiotrabeculopora* Fan, Rigby, and Zhang, 1991.

Diagnosis.—Cylindrical, steeply obconical to branched or mushroomlike sponges with upward and outward divergent reticulate fibrous skeletons that lack an axial spongocoel or cluster of exhalant canals; inhalant ostia, short canals, and exhalant canals may be present or absent.

Discussion.—*Radiotrabeculopora* was initially described by Fan et al. (1991, p. 56) as a ''hydrozoan'' but Rigby and Senowbari-Daryan (1996, p. 29) concluded that several species of *Radiotrabeculopora* have canal systems and skeletal structures more like sponges and included the genus in the inozoid Porifera. They included *Radiotrabeculopora* in the family Auriculospongiidae Termier and Termier, 1977a, in the subfamily Auriculospongiinae with *Auriculospongia* Termier and Termier, 1977a. That taxonomic position is here reconsidered, for the auriculospongiids have a foliate or a thin palmate to sheetlike skeleton, with inhalant and exhalant openings on opposite sides of the palmate blade. This contrasts with the subcylindrical to steeply obconical form of species of *Radiotrabeculopora*, and also with sponges included in the subfamilies Daharellinae, Spinospongiinae, and Acoeliinae, proposed by Rigby and Senowbari-Daryan (1996). These latter sponges have more equally, transversely, and radiate skeletal and canal structures. Because of those differences, *Radiotrabeculopora* and these subfamilies are included here in a new family.

Subfamily RADIOTRABECULOPORINAE new subfamily

Type genus.—*Radiotrabeculopora* Fan, Rigby, and Zhang, 1991.

Diagnosis.—Steeply obconical to cylindrical or branched sponges lacking axial spongocoel; prominent exhalant canals upward and radially divergent; numerous inhalant ostia or short inhalant canals may or may not be present in reticulate fibrous skeleton.

Discussion.—Other subfamilies considered to be part of the family include the Daharellinae Rigby and Senowbari-Daryan, 1996, the Spinospongiinae Rigby and Senowbari-Daryan, 1996, and the Acoeliinae Wu, 1991. The Daharellinae have inhalant canals in their reticulate skeletons but lack exhalant canals and are, thus, clearly separable from the Radiotrabeculoporinae. The Acoeliinae and Spinospongiinae both lack exhalant and inhalant systems, and in addition the Spinospongiinae have prominent spinose skeletal elements in their dermal structure. Those differences set them apart from the Radiotrabeculoporiinae.

Genus RADIOTRABECULOPORA Fan, Rigby, and Zhang, 1991

Type species.—*Radiotrabeculopora xiangboensis* Fan, Rigby, and Zhang, 1991, p. 56–58.

Diagnosis.—''Coenosteum composed of many trabeculae, of various widths, that extend longitudinally and parallel to each other; trabeculae may merge into single coarse one, or a coarse one may split into two slender ones; skeletal openings between trabeculae have moderate range of diameters, many small pores irregularly interrupt trabeculae'' (Fan et al., 1991, p. 56).

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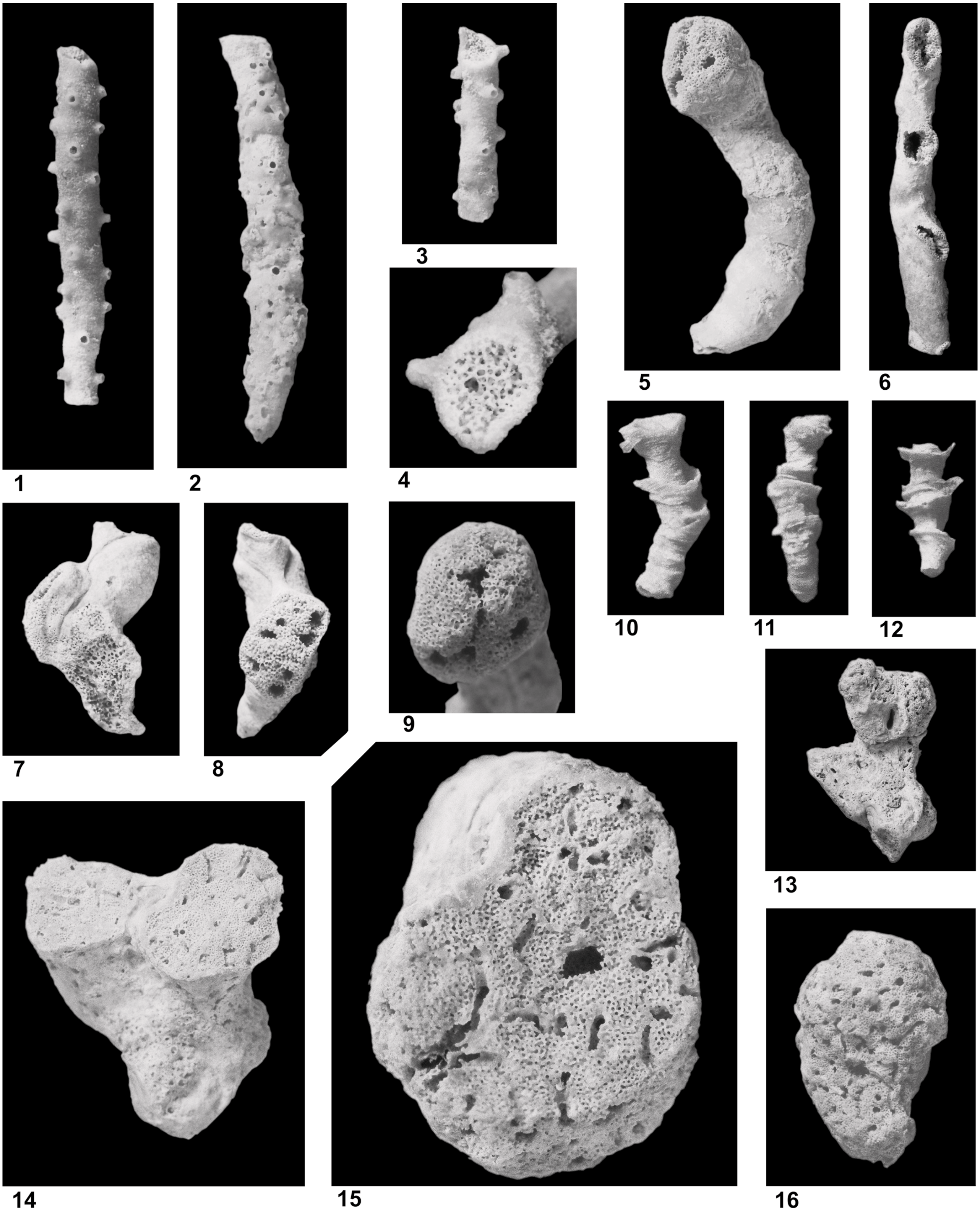
FIGURE 8—*Lercaritubus* Flügel, Senowbari-Daryan, and Di Stefano, 1990, *Chiastocolumnia* n. gen., and *Dactylites* Finks, 1960 from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7633, Guadalupe Mountains National Park, Texas. *1–7, Lercaritubus problematicus*, 1, 2, figured specimen, side views of two intergrown stems with shared tubular exaules and with distinctive reticulated ridged dermal surfaces, GUMO 15147, ×4; *3,* photomicrograph of interwall skeletal screen with pores 0.04–0.05 mm in diameter, GUMO 15144, ×10; *4,* side view of small basal section, with open spongocoel and reticulated thin walls, GUMO 15148, ×5; *5,* side view of smaller figured specimen showing reticulated surface and long exaulos tubes, GUMO 15145, ×5; *6,* side view of nearly complete small specimen with reticulated surface and extended exaules, GUMO 15146, ×5; *7,* photomicrograph of basal sieveplate at base of exaulos, with screen openings commonly 0.04 mm in diameter, GUMO 15144, ×10. *8, Chiastocolumnia cylindrica* n. gen. and sp., holotype, GUMO 15182; side view of small cylindrical holotype showing fine-textured skeletal structure with a few larger oscula, ×5; *9, 10, Dactylites magna* n. sp., holotype, GUMO 15162, *9,* view from above shows triangular form of the sponge, with a few irregularly spaced larger oscula on the summit, ×2; *10,* side view of large obconical holotype with abundant exhalant postica and small inhalant ostia in skeletal tracts between, a small brachiopod is attached to the middle part of the sponge, ×1.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RADIOTRABECULOPORA VIRGA new species
Figure 9.13–9.16

Diagnosis.—Branched, massive-appearing sponge with numerous, small, upward- and outward-directed exhalant canals and ostia, with scattered, somewhat larger irregular small oscular openings of short spongocoels, in uniform reticulate trabecular skeleton where inhalant openings are not present or are small inhalant ostia connected to short inhalant canals. Dense dermal layer on lower part, but dermal layer ill-defined on upper part.

Description.—The holotype, GUMO 15151, is a relatively massive-appearing, branched sponge 40 mm tall, with a broken base, and with short branches 10–13 mm in diameter with rounded upper hemispherical tips (Fig. 9.13). Numerous round to slightly irregular and ovoid oscula of moderately coarse exhalant canals, 0.4–0.5 mm in diameter, occur scattered moderately evenly 1–2 mm apart over the dermal surface, but without a regular pattern. These oscula open from short canals that are horizontal to slightly upward and outward inclined and 3–4 mm long in outer parts of the endosomal skeleton. The canals are uniform tubular openings and are partially lined with a moderately compact thin layer of trabeculae. These oscula are also locally and irregularly interconnected on the dermal surface by smooth shallow grooves 0.2–0.3 mm wide and deep.

Several larger oscula, 0.8–1.2 mm across, are scattered 7–11 mm apart over sides and rounded summits of branches (Fig. 9.13, 9.16), and are openings of convergent short irregular exhalant canals up to 0.5 mm in diameter. The oscular openings have spinose walls with tapering irregular projections that have basal diameters of 0.10–0.12 mm but distally become subcylindrical, 0.06–0.08 mm in diameter with round to pointed tips, and are up to 0.4 mm long.

A dermal layer is ill-defined over most of the upper part of the sponge, but is formed by slight thickening of individual trabeculae. However, the lower part of the sponge has a thick, dense dermal layer, 0.4–0.5 mm thick, in which both inhalant and exhalant pores are filled. Transitions between the two conditions are gradual.

The endosomal skeleton is uniform throughout the sponge (Fig. 9.14, 9.15), with pores 0.08–0.18 mm in diameter as round openings between trabeculae. Openings generally increase in size toward larger aligned pores that appear to be traces of canals. Trabecular segments between fused junctions are mostly approximately 0.20 mm long and 0.06–0.08 mm in diameter, but range 0.10–0.30 mm long and 0.06–0.14 mm in diameter, and are thicker at junctions where three or four segments merge in areas between three or four equally spaced spheroidal pores. Trabeculae generally have smooth surfaces, but locally appear granular and suggest an original spheroidal microstructure.

Etymology.—*Virga*, L., twig or branch, in reference to the branched form of the species.

Type.—The holotype and only known specimen is GUMO 15151.

Occurrence.—The holotype is from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—The genus and species are distinguished by the numerous, relatively small, upward-and-outward-directed exhalant canals in the outer part of the endosome, combined with the scattered larger, but small, oscular openings in the uniform trabecular skeleton. It lacks a central spongocoel or cluster of axial exhalant canals, and well-defined inhalant openings.

Subfamily DAHARELLINAE Rigby and Senowbari-Daryan, 1996

Emended diagnosis.—Sponges stemlike, with reticulate fibrous skeleton that lacks exhalant canals but with distinct inhalant canals; spaces between fibers served as exhalant openings.

Genus DAHARELLA Rigby and Senowbari-Daryan, 1996

Type species.—*Daharella ramosa* Rigby and Senowbari-Daryan, 1996, p. 35–36.

Diagnosis.—''Single or branched, cylindrical sponge without continuous central spongocoel or axial bundle of exhalant canals; outer surface with numerous circular or starlike ostia (inhalant pores) situated in elevated and tubelike elements. Sievelike plate may be developed in base of each ostium, which may continue as several small inhalant tubes into interior; skeleton reticulate fibrous'' (Rigby and Senowbari-Daryan, 1996, p. 34).

DAHARELLA RAMOSA Rigby and Senowbari-Daryan, 1996
Figure 5.11–5.15

Daharella ramosa RIGBY AND SENOWBARI-DARYAN, 1996, p. 35–36, pls. 4.9–4.11, 45.3, 72.1, 72.2, 73.3–73.6, 77.7, text-fig. 16a.

Diagnosis.—''Cylindrical and branched stems with numerous, circular or starlike ostia on exterior; base of each ostium with sievelike plate pierced by several small pores that continue as canals into interior; ostia usually situated on elevated or tubelike elements; internal skeleton of reticulate fibers'' (Rigby and Senowbari-Daryan, 1996, p. 35).

Description.—Two medium-sized specimens of the species occur in the collection from GUMO 5250c. The larger one, GUMO

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FIGURE 9—*Daharella*, *Newellospongia* n. gen., *Pulsatospongia* n. gen., and *Radiotrabeculopora* Fan, Rigby, and Zhang, 1991, from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7633, Guadalupe Mountains National Park, Texas. *1–4, Daharella pattersonia* n. sp.; *1,* holotype, single stem with dense dermal layer marked with numerous tubular ostia. GUMO 15155, ×4; *2,* paratype stem with dense dermal layer perforated by mounded to tubular ostia and with essentially complete base, GUMO 15156, ×4; *3, 4,* small paratype, GUMO 15157, *3,* side view of stem fragment with tubular ostia and with internal skeleton exposed on broken upper end, ×4; *4,* transverse section of upper end of stem showing open inner reticulate skeleton, with section of larger, discontinuous, inner exhalant canal, tubular ostia preserved in outer dense dermal layer, ×10. *5–9, Newellospongia perforata* n. gen. and sp.; *5, 9,* holotype, GUMO 5250v, *5,* side view of curved stem, with all but uppermost 4 mm coated by thin imperforate dermal layer; uppermost exposed part of the trabecular skeletal net has visible pores and skeletal fibers, with skeleton interrupted by several oscula, ×2; *9,* vertical view of summit of holotype with several oscula of interconnected exhalant canals in the trabecular skeleton, ×4; *6,* paratype with additional openings in the dense dermal layer of the stemlike sponge, GUMO 5250u, ×1.5; *7, 8,* paratype GUMO 15150, *7,* lower diagonal section of paratype with porous internal trabecular skeleton, surrounded by dense dermal part of skeleton, ×2; *8,* summit of paratype fragment with several isolated oscula in the trabecular skeleton, ×2. *10–12, Pulsatospongia obconica* n. gen. and sp., *10,* side view of paratype with curved, weakly digitate base and upper flared segments, GUMO 15168, ×5; *11,* side view of holotype, a small hollow stem with broken small base and upper end, with exterior marked by upward-flaring obconical, thin-walled segments marked by faint ridges or growth lines, GUMO 15167, ×5; *12,* small paratype with three distinct flared segments, GUMO 151269, ×5. *13–16, Radiotrabeculopora virga* n. sp., holotype, GUMO 15151, *13,* side view of holotype with fused branches and rounded upper ends perforated with numerous rounded ostia, ×1; *14,* transverse section through holotype, with radiating exhalant canals in outer part of reticulate skeletal net in two branches, ×2; *15,* photomicrograph of horizontal section of base of upper part, above fracture in *13,* with uniform reticulate skeletal net perforated by fine skeletal pores and coarser exhalant canals, ×5; *16,* rounded summit of holotype with numerous oscula in the reticulate skeleton, ×2.

15152, is an annulate stem 27 mm tall, with diameters of 3.5 mm at the base and 7.5 mm at the preserved summit (Fig. 5.14), where the internal skeletal structure is exposed. The dense dermal layer of the sponge is perforated by scattered mounded ostia, with volcano-like mounds to 1.0 mm in diameter and to 0.5 mm high. These have walls up to 0.2 mm thick around ostia commonly 0.3–0.4 mm in diameter.

The reticulate internal skeleton is composed of short tracts 0.08–0.12 mm in diameter, or wide where the tracts are somewhat bladelike around discontinuous canal segments. Two sizes of pores are evident in the reticulation, smaller ones are 0.14–0.20 mm in diameter, and larger ones are 0.3–0.4 mm in diameter, and both occur without a discernable pattern. Sections of larger discontinuous canals are 0.5–0.6 mm in diameter and are traceable vertically for only 2–3 mm in the exposed segment of skeleton. There is certainly no evidence of a central spongocoel.

A second, smaller specimen, GUMO 15153, is a curved stem 22 mm long, incomplete at both top and bottom (Fig. 5.15). It expands from 5 mm in diameter near the base to 6 mm in diameter at the top. It has a dense dermal layer, 0.2–0.5 mm thick, and common ostia of the same general size as those in the larger sponge. A diagonal fracture exposes the internal reticulate skeleton composed of short tracts, most commonly 0.12–0.22 mm in diameter, and some coarser units that are to 0.3 mm in diameter. These combine to surround irregularly placed pores that are 0.20–0.25 mm in diameter. A single section of a discontinuous internal canal, 0.3×0.6 mm across, occurs near the gastral margin of the reticular net. A matrix-filled canal, 0.8 mm in diameter, extends approximately 1 mm into the reticulate net from the base of one of the ostial tubes.

A somewhat larger branched specimen, GUMO 5250k, shows most characteristic features of the species (Fig. 5.12, 5.13). This sponge is a curved form 45 mm tall, with a fractured base 6×7 mm across, two broken branches, and a complete branch tip at the summit. A dense dermal layer covers all but the uppermost 5 mm of the stem, and is 0.2–0.3 mm thick. It is perforated by what are interpreted to be inhalant ostia, 1.0–1.2 mm in diameter, that are common on one flattened side of the lower part of the sponge and as scattered openings in middle and upper parts. These exaulos-like tubes have imperforate walls 0.2–0.3 mm thick and range up to 0.5 mm long. They appear to originate in the interior as upper ends of short discontinuous canals in the outer part of the skeletal net. They occur 5–6 mm apart, and are most common on the lower part of the sponge, without any predictable pattern.

Smaller, possibly inhalant pores, 0.3–0.5 mm in diameter, are common on the side opposite the larger dermal openings in the lower part of sponge, and are also common as scattered openings in the upper 2 cm of the stem as well. They have low rims to short tubes that have outside basal diameters of 0.7–0.8 mm and are up to 0.7 mm long. They are separated 0.5–1.0 mm apart by the dense dermal layer.

The upper 5 mm of the stem lacks a dermal layer so the porous endosomal reticulated net is well exposed. It is composed of curved short fibers, 0.12–0.20 mm in diameter, which thicken to nearly double that where they merge. They outline interconnected spherical to oblate pores that are 0.2–0.4 mm in diameter, with most 0.3–0.4 mm across. They are moderately uniformly developed throughout the interior, and may be joined to form short upward- and outward-curved canals around the outer part of the interior, inside the dense dermal layer. These probably lead upward and outward to the common large exaulos-like pores and tubes. One coarse cylindrical canal, 1.0×1.2 mm in diameter, interrupts the skeleton near the base of the ''dome.'' It is not a major spongocoel, but apparently formed where two of the other short canals merged.

A tall apically branched specimen of the species, GUMO 15154, shows several pulses of growth and the effects of being overgrown in the lower part (Fig. 5.11). It is approximately 7 cm tall and has a basal tip 4 mm in diameter. It widens upward into a narrow, bladelike lower part, which is 10–15 mm wide and 6–7 mm thick, and a branched lobate upper part, which is 5–6 mm thick and up to 3 cm wide. Pulses of growth are evident as weak, annulation-marked bulges, 5–7 mm tall, throughout the length of the specimen. Those pulses are particularly evident in the upper part of the sponge.

Prominent exaulos-like openings perforate the dense dermal layer and are particularly prominent on one side of the sponge where they range from side-by-side to separated 1 mm apart. They are short tubes up to 0.5 mm long and 0.5–0.7 mm in diameter, with walls up to 0.3 mm thick on both sides of the sponge. Their round pores are commonly 0.20–0.30 mm in diameter. A few scattered, coarser, walled openings, which may be exhalant, occur on both sides of the sponge and are 1.0–1.4 mm in diameter. They are most common on the side opposite the one where the smaller, probably inhalant, openings are most closely spaced.

The reticulate internal skeleton is well exposed on the rounded nodelike summits of the upper end. Here, interconnected pores or canals are 0.2–0.3 mm in diameter in the porous structure, and a few openings up to 0.4 mm also occur scattered in the relatively uniform-appearing structure. Skeletal tracts are 0.15–0.20 mm in diameter but may expand to 0.3–0.4 mm across at tract junctions. These tract junctions are uniformly 0.4–0.5 mm apart. Microstructure of the silicified skeletal elements is not well preserved, but suggests an altered, originally microspherulitic texture.

Material examined.—Figured specimens, GUMO 15152–15154 and GUMO 5250k, and the associated six fragments from GUMO 5250d, fragments from GUMO 5250a, along with GUMO-438 4413a (010328-1-8a), 010328-1-11H, 030326-3-1J, 030326-3-1P, and 24 specimens from 030326-3-1 are from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—This distinctly reticulate species of the genus has been reported previously only from the type area in Permian rocks of Djebel Tebaga, northern Tunisia (Rigby and Senowbari-Daryan, 1996, p. 35–36). The associated new species, *D. pattersonia* n. sp., described below, is characterized by a much finer reticulate skeleton and generally smaller sizes of stems and ostial openings. The new species, *D. crassa*, has a coarser textured skeleton.

DAHARELLA PATTERSONIA new species
Figure 9.1–9.4

Diagnosis.—Cylindrical, rarely branched, small stems with numerous, moderately uniformly spaced, although not aligned, circular ostia or exaules; interior skeleton of fine reticulate fibers, which may show in basal openings of ostia as a microreticulate sievelike structure pierced by small pores that may continue into interior as canals; ostia usually situated on elevated or tubelike elements.

Description.—Most complete specimens, the holotype, GUMO 15155 (Fig. 9.1), and a paratype, GUMO 15156 (Fig. 9.2), are single, or occasionally branched, unchambered stems with a dense outer wall and a fine reticulate interior skeleton that lacks a continuous central canal. Stems are commonly marked on the exterior with numerous tubular circular ostia or exaules. Stems range 1.0–3.1 mm in diameter, with most 2–2.5 mm in diameter, and all increase slightly in diameter upward. Fragments range to 19 mm tall, but the species could have been significantly taller than that, for neither the base nor osculum is clearly defined on any fragment. Dense walls are 0.2–0.25 mm thick and surround a central porous zone, 1.0–1.6 mm in diameter, in the fragments available. This central zone is filled with a reticulate microstructure (Fig. 9.4) where filaments 0.03–0.04 mm in diameter interconnect around circular openings that are 0.12–0.16 mm in diameter in the central part of the sponge and grade out to 0.08–0.10 mm in diameter near the outer wall. Some of the central openings may have been connected to form short subvertical canals, but an organized central canal section is not readily apparent.

The exterior is marked with numerous ostia that may occur as simple circular openings, rimmed openings or, more commonly, as tubular openings or exaules. They are 1.5–2.0 mm apart, around and along the stems, but are not aligned. Ostia range 0.3–0.5 mm in diameter and, where tubular, with slightly tapering tubes usually to 0.2–0.3 mm long, although a few to 0.5 mm long also occur. Ostial tubes or exaules have walls 0.15 mm thick at the base that taper distally to only 0.10 mm or less thick at the outer end. Tube walls are imperforate, but like the main walls of the sponge, may have initiated as fibrous reticulate structures that were subsequently filled by carbonates during ontogeny.

The exterior is marked in some well-silicified specimens with small micronodes up to 0.10 mm in diameter that rise 0.04–0.06 mm above the general surface, and which are spaced 0.2 mm apart. Some of these same specimens have small circular, possibly inhalant pores between the nodes. These small pores are 0.015–0.020 mm in diameter, and are not clearly preserved on many fragments in our collection.

Etymology.—*Pattersonia*, named for the Patterson Hills, where the fossils were collected, southwest of the southern end of the Guadalupe Mountains.

Types.—Holotype, GUMO 15155, and paratype specimens GUMO 15156 and 15157. In addition, a single specimen from GUMO 5247a, 17 specimens, or fragments, from GUMO 5250d; and 48 fragments, or specimens, from GUMO 5250b. Six small fragments from GUMO 5250bb are less certainly included in the species

Occurrence.—All the known specimens of the species are from the Reef Trail Member of the Bell Canyon Formation from USGS Locality 7663.

Discussion.—Two cylindrical species of the genus were named by Rigby and Senowbari-Daryan (1996, p. 35–37) from Permian material in Tunisia. The type species, *Daharella ramosa*, is a cylindrical to branched form with tubular ostia, but it is much larger than the species defined here, with stems up to 13 mm in diameter and ostia up to 1.5 mm in diameter. The smaller Tunisian species, *Daharella micella* Rigby and Senowbari-Daryan, 1996, includes stems with the general dimensions of this Texas species, but it has few ostia, and those present are linearly arranged on both sides of the holotype, although they are not aligned on all the other small stems of that species. *Daharella palmata* Rigby and Senowbari-Daryan, 1996 is commonly sheet- or handlike with digitations, rather than stemlike and subcylindrical, and is a larger sponge, even where cylindrical.

This and the co-occurring *Daharella ramosa* and *Daharella crassa* n. sp. are the first species of the genus reported from North America.

DAHARELLA CRASSA new species
Figure 12.3, 12.4

Diagnosis.—Irregular cylindrical to steeply obconical stems with coarse skeletal fibers 0.3–0.4 mm in diameter around skeletal pores to 0.5–0.6 mm in diameter in reticulate skeleton; lacks prominent tubular exaules but with scattered, rimmed ostia where dense dermal layer or encrustations developed.

Description.—The holotype is the upper part of a cylindrical stem, with complete hemispherical crest but a diagonally broken base, where the reticulate skeletal net is well exposed on both surfaces (Fig. 12.3). The stem fragment is 21 mm high and approximately 10 mm in diameter, with the upper 7–8 mm forming a complete rounded crest.

The dense dermal layer is incomplete, and ranges 0.1–0.25 mm thick. It is interrupted by two slightly mounded clusters or openings, 2–3 mm across, of ill-defined, upward-divergent, exhalant canals. These short canals are 0.5–0.6 mm in diameter where circular, or 0.5 × 1.0 mm across where the openings are elongate or ovoid. Such canals are also scattered, slightly larger openings in the rounded crest and diagonal basal fracture of the specimen.

The reticulate skeleton is composed of tracts 0.15–0.30 mm in diameter, with most 0.2–0.3 mm in diameter, or wide, between junctions that are 0.5–0.7 mm apart. They define skeletal openings commonly rimmed by five or six tangential fiber segments around regular skeletal pores that are 0.4–0.5 mm in diameter, where circular, or 0.4–0.5 × 0.6–0.7 mm across where ovate.

Fibers have a micronodose surface, with nodes 0.04–0.06 mm in diameter. These may record the original spherulitic microstructure of the calcareous skeleton or be a result of secondary silicification of the skeleton.

The paratype is a larger specimen, broken both top and bottom, that is 28 mm tall and with an ovate cross section that is 13 × 16 mm across at the diagonally fractured upper end (Fig. 12.4). The sponge is 9.5 mm in diameter at the base. It has a dense dermal layer, 0.1–0.3 mm thick, that has been extensively overgrown. Scattered low mounds around ostia in the dermal layer are up to 1 mm high and 2–3 mm across. They mark openings to isolated canals 0.5–0.7 mm in diameter. A few unmounded ostia of canals of the same size also perforate the dermal layer.

The internal skeleton has fibers or tracts of the same general dimensions as those in the holotype. Tracts are commonly 0.2–0.3 mm in diameter and have junctions 0.4–0.6 mm apart, around skeletal pores approximately 0.5 mm in diameter. Microstructure is less well preserved in this more densely silicified sponge than in the holotype.

Etymology.—*Crassus*, L., thick, fat, or stout; in reference to the thick skeletal fibers of the skeleton.

Types.—Holotype and paratype are GUMO 15180 and 15181.

Occurrence.—Specimens of the species are from collection 030326-3-1K and 1T, from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—*Daharella crassa* has a more coarsely fibrous reticulate skeleton than those in the associated *D. ramosa* and *D. pattersonia* n. sp. *Daharella micella* is a tiny sponge with simple exaules, and *D. palmata* is a cylindrical to sheet- or handlike-branched sponge. The latter two species are known only from Tunisia (Rigby and Senowbari-Daryan, 1996, p. 36–37), and have distinctly different growth forms and skeletal textures.

Order VACELETIDA Finks and Rigby, 2004

Diagnosis.—''Basal skeleton of microgranular aragonite organized in small, irregular units bounded by organic membrane and with organic center, the whole forming a cortex of sphinctozoan morphology, secreted at intervals over newly formed unit of soft tissue; no spicules in living *Vaceletia* Pickett, 1982, but some fossils contain imbedded monaxons, as well as dubious spicules of more elaborate form; exopores usually lobate or polygonal in outline'' (Finks and Rigby, 2004, p. 691).

Family COLOSPONGIIDAE Senowbari-Daryan, 1990

Diagnosis.—''In this family will be placed all porate representatives of the thalamid sponges without filling skeletons and without central tubes (spongocoels). The pores of the segment walls are either unbranched or dichotomously branched. Because of differences in arrangements of segments, two subfamilies are recognized'' (translation) (Senowbari-Daryan, 1990, p. 63).

Subfamily COLOSPONGIINAE Senowbari-Daryan, 1990

Diagnosis.—''Moniliform arrangement of segments.'' (Rigby et al., 1998, p. 47).

Genus TRISTRATOCOELIA Senowbari-Daryan and Rigby, 1988

Type species.—*Tristratocoelia rhythmica* Senowbari-Daryan and Rigby, 1988, p. 189–190.

Emended diagnosis.—Porate sponge composed of three types of skeletal sections or chambers that rhythmically repeat. Tallest major chambers barrel-shaped and about twice height of other sections or chambers. Second type of skeletal section dense ring-like elements between major sections; and third distinctive section of skeleton part of regular major chamber wall, below ringlike elements consistently more porous, with coarser pores. Internally, barrel-shaped chambers with thin, two-layered walls clearly set off from porous, thick-walled, ringlike sections. Interwall structures in ring segments or chambers include upper, coarse-textured, bifurcated grid above suspended rounded, netlike, tapering tubular meshworks that define several exhalant canals. Ostia may occur in chamber walls.

TRISTRATOCOELIA RHYTHMICA
Senowbari-Daryan and Rigby, 1988
Figure 10.1–10.3

Tristratocoelia rhythmica SENOWBARI-DARYAN AND RIGBY, 1988, p. 189–190, pl. 29, figs. 5, 6, 9, text-fig. 10; 1991, p. 625, fig. 3.6, 3.7; SENOWBARI-DARYAN AND INGAVAT-HELMCKE, 1993, fig. 5a; 1994, p. 13–14, pl. 10, figs. 1, 2, text-fig. 5; RIGBY, SENOWBARI-DARYAN, AND LIU, 1998, p. 47–48, pl. 4, figs.1–4, text-fig. 10.

Diagnosis.—Same as for genus.

Description.—Seven specimens and some small fragments of the species are in the collection and include two that have at least fragments of earliest chambers, and five that are only of upper chambers or fragments of chambers. The species and genus are characterized by relatively thin-walled, barrel-shaped, main chambers that are separated by distinct, thick-walled, less high, ringlike sections or segments.

One of the most complete sponges in the collection, GUMO 15090, has four barrel-shaped main chambers and is approximately 18 mm tall (Fig. 10.2). Its rounded, subspherical initial chamber is broken and only 1.7 mm tall and 2.5 mm in diameter. That chamber has walls 0.1–0.3 mm thick that are double-layered, with an outer, finely porous layer and a thin, inner, impervious layer, which appears to have been added secondarily. Thin curved vesiculae are present in the chamber. Main chambers, above the initial chamber, increase in size upward so that the uppermost preserved main chamber is 5.5 mm tall and has a maximum diameter at midheight of 4.5 mm. These chambers have thin walls, 0.8–0.09 mm thick, that are finely porous in the outer part, with pores or ostia generally 0.04–0.08 mm in diameter. These ostia are separated by branching fibers that are mostly 0.02–0.03 mm in diameter, and six to eight ostia occur per millimeter, but not in a predictable pattern.

Intervening ring segments or chambers range 1.0–1.3 mm high and 2.2–3.5 mm in maximum diameter. They have porous walls, with ostia commonly 0.8 mm in diameter, but ranging 0.04–0.14 mm across, and spaced six or seven per millimeter. Larger ostia may be compound openings. These openings are separated by an irregular fibrous net with fibers mostly 0.03–0.04 mm thick, but range 0.02–0.06 mm in diameter.

Each short ring chamber gradually increases in diameter upward, but narrows abruptly at the rounded segment or chamber summit, above which the next main chamber wall gradually expands to maximum diameter at chamber midheight, and then narrows somewhat to more or less grade into the wall of the overlying ring chamber, above a zone where relatively coarse inhalant ostia or pores are developed in the upper main chamber wall, in what Senowbari-Daryan and Rigby (1988, p. 189, fig. 10) differentiated as the ''bottom of the main chamber.''

The second well-preserved specimen, GUMO 15091, is 20 mm tall, and also appears to include part of the globular initial chamber (Fig. 10.1). The sponge has three barrel-shaped main chambers, which are separated by distinct ring segments or chambers. Main chambers range from 2.3 mm high, in the initial chamber, to 4.5 mm high, in the uppermost preserved one, and they range in maximum diameter from 2.8 mm in the small initial one to 4.2–4.4 mm in upper ones. These main chambers have smooth walls with an outer porous layer and an inner solid layer. Pores in the outer layers are 0.05–0.06 mm in diameter, or smaller, over most of the main barrel-shaped chamber walls. Pores in the upper, so-called BMC, parts of the chambers are coarser and range 0.12–0.15 mm across. These apparently open inward to inhalant canals that are 0.25 mm in diameter.

An osculum 1.5 mm in diameter is preserved at the top of the sponge, in the uppermost ring chamber. That exhalant opening (Fig. 10.3) is surrounded by finely porous walls approximately 1.5 mm thick. A moderately coarse, branched, transverse skeletal screen occurs low in the osculum and has several V-shaped openings separated by bifurcated rods or fibers that are up to 0.25 mm thick in the central part of the opening, but which thin radially to 0.15–0.20 mm in diameter where they merge with the inner surface of the chamber wall. One short secondary branch is only 0.10 mm in diameter. These V-shaped openings are the upper ends of circular exhalant canals that are 0.3–0.4 mm in diameter immediately below the transverse skeletal screen. These canals are defined by fine-textured skeletal mesh in which fibrous elements

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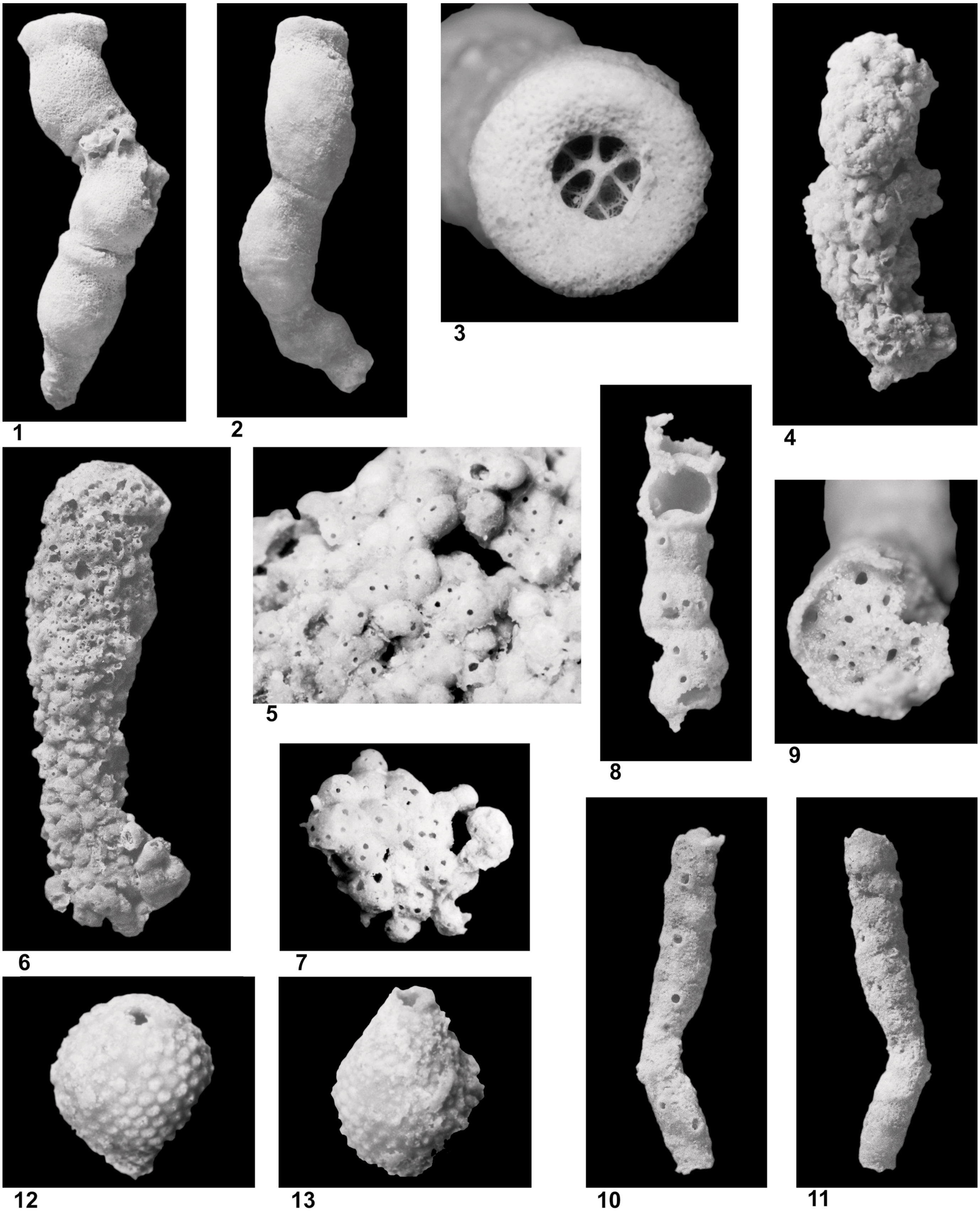
FIGURE 10—*Tristratocoelia* Senowbari-Daryan and Rigby, 1988, *Colospongiella* n. gen., *Parauvanella* Senowbari-Daryan and Di Stefano, 1988, and *Exaulipora* Rigby, Senowbari-Daryan, and Liu, 1998 from the Reef Trail Member of the Bell Canyon Formation, USGS Locality 7633, Guadalupe Mountains National Park, Texas. *1–3, Tristratocoelia rhythmica* Senowbari-Daryan and Rigby, 1988, *1,* side view of nearly complete sponge with three barrel-shaped main chambers and intervening ring segments above nearly complete initial globular chamber, GUMO 15091, ×4; *2,* side view of smaller sponge with less distinct ring segments and with incomplete initial chamber, GUMO 15090, ×4; *3,* detailed view of summit showing small pores in chamber wall of a ring segment, and microstructure of branched transverse screen in the osculum above finer mesh of upper parts of small exhalant canals, GUMO 15091, ×10. *4–7, Parauvanella minima* Senowbari-Daryan, 1990, *4,* characteristic irregular cluster of small spheroidal, adherent chambers, GUMO 15099, ×5; *5,* detail of chamber layer coating part of a heavily silicified ?*Djemelia*, GUMO 5250w-1, ×10; *6,* tall, club-shaped cluster of chambers, each with one to three circular pores in outer wall, GUMO 15103, ×4; *7,* detail of small cluster showing form of the chambers and ostia in chamber walls, GUMO 15101, ×10. *8–11, Colospongiella permiana* n. gen. and sp., *8,* side view of moniliform holotype with hollow spheroidal chambers and porous outer walls, GUMO 15096, ×4; *9,* basal-preserved interwall of holotype showing irregular large interpores near the outer wall and smaller ones in the interior, ×10, GUMO 15096; *10, 11,* side views of moniliform paratype with less prominent chambers and irregularly distributed, rimmed, inhalant ostia, GUMO 15097, ×4. *12, 13, Exaulipora permica* (Senowbari-Daryan, 1990), *12,* hemispherical base of flask-shaped chamber with a central ''spongiidae interwall'' opening in nodose and porous wall, ×15; *13,* upper end of chamber with tapered neck to exaulos, GUMO 15098, ×15.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are mainly 0.02–0.03 mm in diameter, although some up to 0.04 mm occur in the upper parts of the canal walls. They outline mesh spaces of variable shape that are 0.04–0.10 mm across or high. These canals taper downward, like the net of a basketball hoop, but have a rounded, closed, though porous base approximately 0.2 mm in diameter. These canals expand uniformly upward to a diameter of approximately 0.4 mm at 1.0–1.2 mm below the rounded oscular rim. The expanding canals are 0.5–0.7 mm deep below the coarse supporting grid. All the fine skeletal fibers or rods in the oscular screen are ornamented with scattered, fine, short spines.

The third, less complete, example of the species in the collection, GUMO 15092, has only one main chamber and upper and lower bordering ring chambers or segments. The fragment is only 11 mm tall. Both broken ends show the distinctive ''oscular'' screen structures like those in GUMO 15091, but here both are less completely preserved.

A fourth example, GUMO 15093, also shows the same internal screenlike structure in the central exhalant opening of ring chambers at both ends. This sponge fragment is approximately 12 mm tall and composed of two barrel-shaped main chambers and three ring chambers. The main chambers are 4 and 5 mm tall, with complete ring chambers 1.0 and 1.5 mm tall, so it probably represents a middle to upper part of the linear-chambered sponge.

Two additional specimens are included in a subsequent collection. The larger of these, GUMO 15094, is 30 mm tall and includes parts of three ring chambers and the two intervening barrel-shaped main chambers. The ring chambers are 2.5 mm tall and 5.5–6.7 mm in diameter, with pores 0.06–0.10 mm in diameter spaced 0.2 mm apart in the dense walls, in contrast to the indented porous upper part of the main chambers, below.

The somewhat barrel-shaped main chambers are 10–12 mm tall, 7.5 mm in maximum diameter, but narrow to 4.5–6.7 mm in diameter next to underlying and overlying ring chambers. These chamber walls have an upper, distinctly porous section, approximately 2.5 mm tall, where closely spaced pores occupy half the dermal surface. These pores are 0.18–0.20 mm in diameter and 0.10–0.20 mm part in the upper part, but narrow to 0.10 mm in diameter in transition zones to the ring chamber, above, and the main chamber below. They narrow to approximately 0.06 mm in the upper part of the main chamber walls, and to 0.02–0.04 mm in the lower half of the wall where they are mostly filled and obscure.

Porous screens are preserved in the central spongocoel opening of the ring chambers. These screens have central pores 0.5–0.6 mm in diameter that are defined by silicified fibrous elements, as in the other large specimens of the species documented here.

The smaller specimen, GUMO 15095, has the same general chamber pattern, with major chambers 7.0–7.5 mm high and up to 5.2–5.4 mm in diameter, with ring chambers 2.0–2.5 mm high and 5.0 mm in diameter. Chamber walls are 0.2–0.5 mm thick, with an irregular gastral surface and a smooth dermal surface. The lower barrel-chamber has two or three subvertical diaphragms or filling structures. Chamber walls have a coarse spherulitic microstructure, with spherules 0.10 mm in diameter.

Several additional specimens from 030326-3-1 show similar chambered structures and transverse skeletal screens like the larger, more complete GUMO 15090. Other smaller, less complete fragments are of likewise similar sponges.

Material examined.—Figured and cited specimens of the species include GUMO 15090–15095. Also included in the species are one fused pair of parallel sponges from 030326-3-1x, and 16 smaller sponges and fragments from 030326-3-1a, 10 of which include several chambers. All are from the Upper Guadalupian Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—Skeletal development in these juvenile parts of the sponge allows certain orientation so that exowalls of main chambers are distinctly indented above the thick-walled ring chambers, which more gradually expand to form a ring above the upper main chamber wall. In addition, these specimens clearly show the upper part of the main wall to be distinctly and more coarsely porous than the lower and main part of the chamber wall, converse to relations concluded by Senowbari-Daryan and Rigby (1988, p. 189). They described the type fragments from Tunisia as having a lower part of the main chamber wall as more porous.

Genus Colospongiella new genus

Type species.—*Colospongiella permiana* n. sp.

Diagnosis.—Moniliform, stemlike, chambered sponges with upward-arched interwalls that have numerous pores of various sizes; stem lacks spongocoel; with rimmed ostia common in otherwise only minutely perforate exowalls; chambers largely free of filling structures.

Etymology.—Named for similarity to the genus *Colospongia*.

Discussion.—The new genus is similar to *Sollasia* in general chambered stemlike form, but has interwalls that are coarsely perforate, rather than a single central cryptosiphonate opening. It is somewhat similar in general form to *Colospongia* Laube, 1865, but has minutely perforate exowalls, even though the up-arched endowalls are coarsely perforate, and has prominent coarse ostia and short exaules in exowalls of each chamber.

Colospongiella permiana new species
Figure 10.8–10.11

Diagnosis.—Small moniliform stem of hollow spheroidal chambers lacking central tube or spongocoel, but with porous interwalls and exowalls, which also have coarse, rimmed exaules in each chamber; chambers up to 3.2 mm in diameter and 2.5 mm high, with exaules up to 0.4 mm in diameter.

Description.—The holotype, GUMO 15096, is a small moniliform stem fragment 15 mm high, composed of stacked subspherical chambers, 2.7–3.2 mm in diameter and 2.0–2.5 mm high (Fig. 10.8). Each chamber exowall is perforated by two to five coarse ostia or exaules that occur commonly near the midwall of the chamber, or near the zone of overlap of the succeeding chamber's lower wall. These ostia are 0.3–0.4 mm in diameter, and, where exaules tubes are developed, these range up to 0.2–0.3 mm long, with walls approximately 0.10 mm thick, out to a rounded termination.

Exowalls are 0.3 mm thick and perforated by scattered micropores approximately 0.1 mm in diameter, in the somewhat crystalline silicification, where most pores have been lost.

Interwalls are 0.4–0.5 mm thick and are perforated by larger pores. The largest pores are round, 0.5 mm in diameter, and occur next to the exowall (Fig. 10.9). Intermediate pores are round to ovate and 0.2×0.35 mm across or in diameter, and smallest interpores are 0.2 mm in diameter and are the most common in the interwalls. These interpores are spaced approximately 1 mm or less apart, center to center, and separated by thick rounded tracts 0.5–0.7 mm wide.

Chambers are hollow and lack filling structures.

The paratype, GUMO 15097, is a slender, moniliform, chambered sponge fragment (Fig. 10.10, 10.11) that is 16 mm tall and ranges from 1.6 mm in diameter at the broken base up to 2.3 mm in diameter at the incomplete summit. It has the same general form and pore structure as the holotype, with chambers 1.5–2.0 mm high, and commonly with two exopores per chamber, with exaules to 0.2–0.3 mm long and 0.40 mm in diameter. Micropores in the outer chamber walls are mostly approximately 0.02 mm, but range up to 0.04 mm in diameter and 0.01–0.04 mm apart, fairly regularly, although not in an aligned pattern. Interpores are mostly 0.25–0.30 mm in diameter, although they range from 0.20 to 0.40 mm in diameter. They are somewhat more irregularly spaced than in the holotype.

Etymology.—*Permiana*, in reference to the Permian age of the species.

Types.—The holotype, GUMO 15096, and paratype, GUMO 15097, plus two additional reference specimens, 010328-1-13t and 030326-3-1, occur in the collection.

Occurrence.—The known specimens came from USGS Locality 7663, from the Upper Guadalupian Reef Trail Member of the Bell Canyon Formation.

Discussion.—Comparisons with related or similar genera have been presented in treatment of the genus, above.

Subfamily CORYMBOSPONGIINAE Senowbari-Daryan, 1990

Diagnosis.—''Glomerate to stratiform arrangement of segments'' (Rigby et al., 1998, p. 48).

Genus EXAULIPORA Rigby, Senowbari-Daryan, and Liu, 1998

Type species.—?*Corymbospongia*(?) *permica* Senowbari-Daryan, 1990, p. 69–70.

Diagnosis.—''Thalamid sponges composed of clusters of spherical to subspherical, occasionally egg-shaped chambers arranged glomerately in clusters or locally tending to grow with moniliform parts. Coarse exaules, tubular, perforate, only one, or rarely two, per chamber extend from porous chamber walls. All chamber walls, walls of exaules, and walls that form sieve-like plate at inner base of exaules perforated. Chamber interiors contain vesiculae'' (Rigby et al., 1998, p. 48–49).

EXAULIPORA PERMICA (Senowbari-Daryan, 1990)
Figure 10.12, 10.13

''Sheet-like and cateniform Sphinctozoa'' FAGERSTROM, 1987, pl. 48a. ?*Corymbospongia permica* SENOWBARI-DARYAN, 1990 p. 69–70, pl. 22, figs. 1–5.
Exaulipora permica (SENOWBARI-DARYAN). RIGBY, SENOWBARI-DARYAN, AND LIU, 1998, p. 49–51, pl. 2, figs. 4–7.

Diagnosis.—''Thalamid sponge composed of glomerate spherical to egg-shaped chambers, without an axial tube. Each chamber has one (rarely two) exaulos. The wall of the chambers and exaules possess numerous pores. A cribribulla (sieveplate) is developed at the base of each exaulos. Without filling structures, but with vesiculae'' (Rigby et al., 1998, p. 49).

Description.—A single perforate, necked, ovate or flask-shaped chamber of this sponge, GUMO 15098 occurs in the collection. It has a subspherical base 2.0 mm in diameter and 2.2 mm tall, with a tapering upper neck, or exaulos (Fig. 10.13), so that the entire chamber is 2.8 mm tall. The exaulos tube tapers to a terminal diameter of 0.6 mm, and is perforated at the tip by the exaulos that is 0.4 mm in diameter. The wall at the tip is 0.10 mm thick. The round base of the chamber is also perforated, with an ''interwall'' opening 0.3 mm in diameter (Fig. 10.12), and the exposed wall appears to be approximately 0.1 mm thick, but the wall may be thicker in the middle and upper parts of the chamber.

Walls of both the chamber and exaulos tube are perforated with pores that range 0.2–0.3 mm in diameter. Those in the lower part of the chamber are in regular horizontal rings that are spaced three rings per 0.5 mm, vertically, and two pores per 0.5 mm, horizontally, in the rings. Pores are smaller in the upper part of the chamber wall and in the exaulos, where they occur four or five rings per 0.5 mm, vertically, and where three pores occur per 0.5 mm, horizontally, within individual rings. Pores in the upper part of the chamber wall are ovoid and range to 0.10 mm high and 0.15 mm wide, and those in the middle and lower part of the chamber wall are circular and range up to approximately 0.20 mm in diameter. Pores in both the chamber wall and exaulos tube are separated by a skeletal net where fibers are approximately 0.05 mm thick. Skeletal elements are weathered somewhat, so matrix-fillings of pores rise nodelike on the dermal surface.

A sieveplate is not preserved, as best could be observed looking down into the small exaulos opening.

Material examined.—The single-necked chamber of the species, GUMO 15098, occurred with other sponges in etched residues from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—Because only a single chamber of this form occurs in the collection, its placement in the genus and species is somewhat questionable. However, the flasklike form of the chamber and exaulos, and measurements of their pores are like those of the type species. As a result we have included the small isolated chamber there.

Genus PARAUVANELLA Senowbari-Daryan and Di Stefano, 1988

Type species.—*Parauvanella paronai* Senowbari-Daryan and Di Stefano, 1988, p. 18.

Diagnosis.—''Nodular aggregates consist of numerous small and irregular chambers. The central channel (tube) is missing. The wall of chambers is sparitic to microsparitic (most probably aragonite?). The chamber walls are imperforate to coarsely perforate, without filling tissue and vesiculae'' (Senowbari-Daryan and Di Stefano, 1988, p. 18).

PARAUVANELLA MINIMA Senowbari-Daryan, 1990
Figure 10.4–10.7

Parauvanella sp. REINHARDT, 1988, p. 256, pl. 33, fig. 6; pl. 35, fig. 1 (non pl. 34, fig. 6).
Parauvanella minima SENOWBARI-DARYAN by FLÜGEL AND REINHARDT, 1989, p. 511, fig. 10a (nomen nudem); SENOWBARI-DARYAN, 1990, p. 70–71, pl. 22, figs. 1, 2, 6; pl. 57, fig. 3; pl. 58, figs. 5–8; pl. 59, figs. 2, 3; WEIDLICH AND SENOWBARI-DARYAN, 1996, p. 32, fig. 6.10; RIGBY, SENOWBARI-DARYAN, AND LIU, 1998, p. 51, pl. 4, fig. 5; pl. 9, fig. 7.

Diagnosis.—''Aggregate composed of small spherical chambers. Uviform arrangement of chambers. Chamber walls coarsely perforated. Vesiculae may occur'' (Senowbari-Daryan, 1990, p. 70).

Description.—Several examples in the collection range from small stems or nodular clusters to thin sheets or encrustations on other fossils. One of the largest specimens, GUMO 15103, is a tall club-shaped stem that is 22 mm tall (Fig. 10.6) and expands upward from 4.5 mm in diameter near the flared attachment base to a maximum diameter of 6.5 mm near the rounded summit. It is composed of hemispherical to ovoid chambers that are 0.5–0.9 mm in diameter and have micronodose walls, although that texture may be, in part, a response to the secondary silicification. The thin wall is commonly 0.02–0.04 mm thick, but ranges up to 0.6 mm thick. Each chamber has one to three circular pores in the outer exposed wall, but most have two such pores 0.10–0.16 mm in diameter, with those 0.12 mm in diameter most common. There are no small pores between the larger ostia. Interpores are of the same general diameters and open to adjacent or more interior chambers. Some tubular ''exhalant'' openings of approximate chamber size lead into the interior, perhaps to interior layers, or to the unknown overgrown coring organism.

One irregular nodular cluster, GUMO 15099, 13 mm tall and 3–5 mm in diameter (Fig. 10.4), shows the general form of the species, with small spheroidal, adherent, chambers commonly 0.5–0.6 mm in diameter, although a few range up to 1 mm in diameter. Their thin walls are perforated by isolated pores up to 0.1 mm in diameter, although the microstructure of the specimen is poorly preserved in the relatively dense silicification.

A smaller associated specimen, GUMO 15100, is more delicately silicified and has well-preserved spheroidal chambers, 0.6–0.8 mm in diameter, occurring in grapelike clusters. They have common circular pores, 0.15–0.20 mm in diameter, that may occur as many as four or five per chamber. Chamber walls are 0.04–0.06 mm thick in the silicified preservation.

One small fragment from GUMO 15101 (Fig. 10.7) shows the structure well in a delicately silicified part with porous spheroidal chambers in a layer, apparently from an encrusting occurrence. Another small fragment, GUMO 15102, shows similar well-preserved silicified porous chambers.

An encrusting occurrence of the species is associated with *Guadalupia explanata*, a bryozoan, and a small *Newellospongia perforata* n. gen. and sp. on a large ?*Virgola* de Laubenfels, 1955, on GUMO 5250w (Fig. 10.5). This specimen of *Parauvanella minima* forms an irregular sheet 4–5 mm wide and up to 25 mm long. Individual chambers in the encrusting sheet are 0.6–0.9 mm across and have pores like in the forms above. The sheet is locally multilayered and forms a mound 3 × 4 mm across and 1.7 cm high.

A similar specimen encrusts a limited part of the new species *Radiotrabeculopora virga*, on GUMO 15151, in a triangular area 12 × 8–9 mm across and 2 mm thick, where it is up to three chambers thick in the central part of the cluster. The sponge is composed of overlapping hemispherical to subspherical or arcuate chambers 0.6–0.8 mm in diameter, which have one or two circular ostia, 0.10–0.16 mm in diameter, in the outer wall of each chamber. Pores between chambers are commonly smaller and only 0.6–0.8 mm in diameter. Chamber walls are 0.08–0.12 mm thick, and their microstructure is obscure, with questionable impressions of spherulites in the crystalline-appearing siliceous replacement.

Variation in attachment bases are shown by GUMO 15175, which is attached to the interior of a pelecypod valve, and by GUMO 15176, which is attached to a fenestellid bryozoan fragment.

Material examined.—Figured specimens GUMO 15099, 15101, and 15103, and referred specimens GUMO 15100 and 15102, plus five additional specimens from GUMO 5250s, and three from GUMO 5250t, are characteristic of the isolated nodular clusters. A figured example of an encrusting occurrence of the species (GUMO 5250w) occurs in association with several other forms on *Guadalupia explanata*, and a similar encrusting cluster occurs on the new species *Radiotrabeculopora virga*, GUMO 15151. Variation in encrustation bases are documented by specimens GUMO 15103, 15175, and 15176. Additional specimens of the species include 30 fragments of various sizes from 030326-3-1, four from 010328-1-13x, and one specimen from 010328-1-13d. All these specimens are from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—Neither isolated nodular clusters nor encrusting sheets of the species are common in the collection. The species was reported by Rigby et al. (1998) to be common in the Upper Capitan Limestone in the northern Guadalupe Mountains.

Siliceous spiculate sponges
Class Demospongea Sollas, 1875
Subclass Clavaxinellida Lévi, 1956
Order Protomonaxonida Finks and Rigby, 2004

Diagnosis.—“Fibrous skeleton composed of oxeas alone” (Finks and Rigby, 2004, p. 9).

Family Sollasellidae von Lendenfeld, 1887

Type genus.—*Sollasella* von Lendenfeld, 1888.

Emended diagnosis.—Sponges with radiate architecture including dermal cortex; oxeas and strongyles are principal spicules and may have swollen shafts, skeletons lack tetraxons, microscleres, and spongin.

Genus Monaxoradiata new genus

Type species.—*Monaxoradiata lamina* n. sp.

Diagnosis.—Hemispherical to irregularly ramose or nodose sponges whose skeletons are composed of closely packed, parallel, radiating to divergent oxeas, with irregularly spaced small canals paralleling the spicules; lacks spongocoel.

Etymology.—*Monos*, Gr., one or single; *axon,* axis or pole, in reference to the monaxial spicules of the skeleton; *radiatus,* rayed or beaming, in reference to the upward and outward radially arranged spicules of the skeleton.

Discussion.—Of the genera included in the family (Finks and Rigby, 2004, p. 21–24), *Monaxoradiata* is probably most similar to *Opetionella* Zittel, 1878 [p. 4 (94)] in gross form. Like *Opetionella*, these Permian sponges range from moderately thinly hemispherical or irregular crustose-appearing to tuberous or elongate stems, whose spicules are closely spaced, parallel oxeas. However, limited canals of at least two sizes are evident in these Texas Permian sponges and canals, apparently lacking, or are very small, in the European Jurassic *Opetionella*. *Sphaeriella* Rigby and Pollard-Bryant, 1979 is a small spherical to subspherical or ovoid sponge with less compactly packed spicules than the new form described here. *Rhizopsis* Schrammen, 1910 is rootlike or ramose and may appear superficially similar to some of the specimens included here, but its skeleton is of thick filaments rather than uniform, closely spaced, parallel spicules like in the new genus described here. *Hamptonia* Walcott, 1920 may be globose or frondescent and appear somewhat similar to *Monaxoradiata*, but *Hamptonia* has a skeleton of subparallel, radially arranged, large monaxons that may be single or bundled and that are separated by tracts of small spicules that radiate from the center or central axis of the sponge (Finks and Rigby, 2004, p. 13).

Monaxoradiata lamina new species
Figure 11.1–11.5

Diagnosis.—Specimens of the species are relatively small, only a few millimeters across and high, and range from hemispherical to irregular lobate or bullet-shaped sponges that lack a spongocoel and have a relatively smooth dermal surface. In weathered cross sections they may appear laminated, with a distinct upward divergent spicule structure of closely spaced and parallel- uniform monaxial spicules. Most specimens show some irregularly distributed ostia of small canals on surfaces of the silicified sponges.

Description.—The holotype, GUMO 15158, is a partially hollow fragment of a fingertip-shaped sponge that is 12 mm high and up to 11.5 mm wide or in diameter (Fig. 11.1). It has a vertical section at approximately mid-diameter that clearly shows the internal structure of the sponge. It has an incomplete, upward-arched base that is 4 mm wide, from which the silicified spicule structure radiates upward and outward. A few irregularly placed larger canals that are approximately 0.1 mm in diameter show on the relatively smooth dermal surface. These canals are gaps between the parallel-aligned spicules of the skeleton.

Spicules are well preserved and range up to 0.04 mm in diameter, with most spicule segments 0.02–0.03 mm in diameter. Fragments of spicules up to 1.0 mm long are exposed in sections of the laminate-appearing skeleton (Fig. 11.4), and some show double tapers, but complete spicules were not observed, although rare sharp tips are locally evident on some section surfaces (Fig. 11.2). Parallel spicules are locally curved, in ropy fashion, but generally they are straight and spaced so that approximately five spicules occur per 0.20 mm, measured at right angles to the spicule axes.

Spicules are uniformly approximately 0.01 mm apart, although this varies where diameters of spicules undulate. Such variations in diameter occur at uniform positions in adjacent spicules and this produces a layered-appearing structure, even though individual spicules continue through several such laminae. Weathering has locally exaggerated this pseudolaminar structure on some specimens so that the upward-arcuate ''growth lines'' are more prominent than the long linear radiate structure of the skeleton.

A similar hemispherical-layered paratype, GUMO 15159, has spicules of the same general dimensions and two sizes of canals in the dermal layer (Fig. 11.5). The larger ones are 0.2–0.3 mm in diameter and smaller ones are 0.10–0.15 mm in diameter. The dermal surface of this sponge has a limited area where matrix between spicules has been silicified and the spicules dissolved. Most openings representing diameters of the spicules are 0.02 mm across, and they are separated by a uniform tubular net with elements 0.010–0.015 mm thick.

Several specimens have a bulletlike shape, as exemplified by paratype GUMO 15160, with a pointed tip and a rounded, concave, fractured base (Fig. 11.3). This paratype is 14.5 mm tall, with a rounded base 5 mm in diameter. The sponge expands upward to a maximum diameter of 7.2 mm at 7–8 mm above the base, above which it narrows to a rounded pointed tip at the summit. It has irregularly placed canals with ostia in the dermal surface that range 0.14–0.18 mm in diameter. These canals are parallel to the surrounding spicules.

The arcuate base exposes radially arranged spicules that are mostly 0.02 mm in diameter, although some are as small as 0.015 mm in diameter and show some taper. No complete spicules are evident in the exposed section.

Most other fragments of the species are less complete but show the same aligned, parallel, spicule structure as that evident in the type specimens.

Etymology.—*Lamina*, L., thin plate, blade, or sheet, in reference to the laminated structure of the sponge skeleton.

Types.—The holotype, GUMO 15158, and paratypes GUMO 15159–15161, plus over 150 other fragments of the species are from sample 03026-3-1aaa, and two are from sample 010328-1-13s.

Occurrence.—All known specimens are from USGS Locality 7663, from the Reef Trail Member of the Bell Canyon Formation, Guadalupe Mountains National Park, Texas.

Discussion.—Comparisons with similar genera in the family have been presented in discussion of the genus, above. Limits on species form are difficult to establish based on the very variable fragments in the collection.

Subclass CERACTINOMORPHA Lévi, 1953
Order LITHISTIDA Schmidt, 1870
Suborder ORCHOCLADINA Rauff, 1895
Family CHIASTOCLONELLIDAE Rauff, 1895

Type genus.—*Chiastoclonella* Rauff, 1894.

Diagnosis.—''Massive sponges with variably developed radial architecture; skeleton consists of chiastoclones, together with dendroclones and tetraclones, not strongly organized in linear series; no dermal specialization other than imperforate basal layer, which is often concentrically rugose'' (Finks, 1960, p. 63).

Genus CHIASTOCOLUMNIA new genus

Type species.—*Chiastocolumnia cylindrica* n. sp.

Diagnosis.—Small cylindrical or twiglike sponges lacking a distinct spongocoel or axial exhalant structures; skeletal net of small chiastoclones with common associated dendroclones and rhizoclones, in relatively uniform, fine-textured interior skeleton and a thin, somewhat coarser-spiculed dermal layer; inhalant openings small and numerous, with less common larger pores of irregularly distributed exhalant radial canals that are horizontal in outer part of skeleton.

Etymology.—*Chiasto*, in reference to the family, *columna,* L., pillar, in reference to the columnar or pillarlike form of the type species.

Discussion.—Most genera of the family are massive forms with prominent canals and well-defined large exhalant openings. The most similar genus is probably *Allasospongia* Rigby, 1986, from the Devonian of Western Australia. It is a cylindrical form, but it has a skeleton with distinct layering and an axial cluster of excurrent canals, structures that clearly differentiate it from the genus described here. *Actinocoelia* Finks, 1960, described initially from the Permian of Texas and New Mexico, is commonly a massive sponge, but it may be cylindrical and much larger, with a skeleton of tracts separated by coarse, upward-radiating canals. *Pseudovergulopsis* Deng, 1981, from the Permian of China, may be subcylindrical but it has a skeleton of thick, upward-divergent tracts and a well-defined, upward divergent canal system.

CHIASTOCOLUMNIA CYLINDRICA new species
Figures 8.8, 12.5, 12.6

Diagnosis.—Small cylindrical sponge with common inhalant openings approximately 0.10 mm in diameter and irregularly spaced oscula, to 0.35 mm in diameter; skeleton includes small irregularly oriented chiastoclones, 0.05–0.10 mm long or across in the interior and 0.2–0.4 mm long or across in the outer dermal layer, and associated common dendroclones and possible tetraclones, all fused at interdigitating clad tips to produce a uniform-appearing but unaligned skeleton in both dermal and internal areas.

Description.—The holotype is a cylindrical stem fragment 15 mm tall and approximately 5.0 mm in diameter (Fig. 8.5). It does not have a spongocoel nor any major throughgoing canals. Most obvious canals are relatively rare, short, horizontal, radial openings developed in the outer part of the sponge. These are irregularly spaced from side by side up to 0.5 mm apart and are up to 0.35 mm in diameter. Smaller ostia, approximately 0.20 mm in diameter, are somewhat more common but are less obviously connected to canals that open from the interior of the sponge. They may be inhalant openings associated with the numerous short, small canals that are approximately 0.10 mm in diameter and which occur between rays of adjacent fused spicules.

The endosomal skeleton is not internally layered but grades to an outer, somewhat more coarsely spiculed dermal layer in the relatively uniform structure. Principal spicules throughout the sponge are mostly irregularly X-, K-, and H-shaped chiastoclones (Fig. 12.5, 12.6) whose rays branch into irregular spinose clads with tips that interdigitate with those of adjacent spicules. As a result, clear separation of adjacent spicules is often difficult in the fused structure. Surfaces of rays may be smooth to minutely nodose or spinose in the silicified preservation. Characteristic outer spicules have irregular rays 0.1–0.2 mm long, so that spicules may be 0.2–0.4 mm across or long. Rays of these spicules may have basal diameters up to 0.04–0.06 mm that taper distally, to 0.03–0.04 mm in diameter before subdividing into clads. Clads are commonly 0.02–0.03 mm in diameter, proximal to where they subdivide into digitate spinose to arborescent tips. Interior spicules have rays that are commonly 0.02–0.10 mm long and have basal diameters of 0.02–0.05 that taper to sharp tips or to branched clads. These spicules range 0.1–0.3 mm long or across, and like spicules of the outer part of the skeleton are also irregularly fused.

Associated dendroclones are commonly I-shaped, with long shafts and branched clads, but some also grade to Y-shaped forms that appear to intergrade with chiastoclones. Shafts of dendroclones are generally smooth and enlarged at ends where they divide into the clads. Distal surfaces of clads branch and interfinger with tips of adjacent spicules, but proximal surfaces remain moderately smooth until near their outer tips. Characteristic dendroclones of the species have shafts 0.10–0.14 mm long and 0.03–0.06 mm in diameter, with thickest diameters immediately adjacent to separation of clads, that range 0.02–0.04 mm in diameter, proximally, but taper irregularly to spines in the interdigitating structures. Dendroclones occur irregularly so no ladderlike structures, such as characterize anthaspidellid sponges, are evident.

A larger paratype is a similar subcylindrical fragment, broken at both top and bottom. It is 14.5 mm tall and ranges from 4.5 to approximately 5.5 mm in diameter. It is locally encrusted, but shows the same general limited canal development and the same skeletal structure as the holotype, with a skeleton dominated by moderately uniformly distributed chiastoclones. A smaller, more delicately silicified paratype is a diagonally broken, subcylindrical, sponge fragment that is 7.5 mm long and 4.0–4.6 mm in diameter. It has an ill-defined, somewhat coarser spiculed dermal layer, which is approximately 0.5 mm thick, and an interior endosomal skeleton composed principally of finer chiastoclones, like those of the holotype.

Etymology.—*Cylinder*, L., in reference to the cylindrical form of the species.

Types.—The holotype and paratype, GUMO 15182 and 15183a, respectively, were collected at 010328-1-16, and the smaller paratype, GUMO 15183b, was collected at 010328-1-13.

Occurrence.—All the known specimens of the species are from USGS Locality 7663, from the Upper Guadalupian Reef Trail Member of the Bell Canyon Formation.

Discussion.—Comparisons to related or similar genera have been treated in discussion of the new genus, above.

Family ANTHRACOSYCONIDAE Finks, 1960

Type genus.—*Anthracosycon* Finks, 1960.

Diagnosis.—''Skeleton composed principally of tetraclones and dendroclones, oriented vertically and organized into horizontal, or concentric, layers. Rhizoclones also present in small numbers'' (Finks, 1960, p. 76).

Genus DACTYLITES Finks, 1960

Type species.—*Dactylites micropora* Finks, 1960, p. 84–85.

Diagnosis.—''Digitate to obconical sponges with spicule layers concentric and parallel to surfaces; circular oscules terminal; smaller ostia uniformly but irregularly distributed over whole sponge; few surface canals'' (Finks, 1960, p. 84).

Discussion.—Comparisons with related genera are discussed in treatment of *Dactylites obconica* n. sp., below.

DACTYLITES OBCONICA new species
Figure 11.12–11.15

Diagnosis.—Obconical sponge with one to several oscula in domed summit; smaller oscula and inhalant pores common over entire surface, but limited in lower part where dense dermal layer developed, thin parallel spicule layers concentric over entire surface and largely of unbundled dendroclones.

Description.—The holotype, GUMO 5250m, is a small, obconical sponge (Fig. 11.12), 10 mm tall, with an irregular base of attachment over a slit, 4 mm long and approximately 0.5 mm wide. The sponge expands upward so that approximately 3 mm below the domed summit it has a maximum diameter of 7 mm. The lower 5 mm is coated with a relatively smooth, dense, dermal layer 0.06 mm thick, which is perforated by restricted inhalant pores, 0.02–0.06 mm in diameter, but not by coarse ostia like those in the upper part of the skeleton.

A large osculum, 1.1 mm in diameter, is located on a flank of the summit (Fig. 11.14), and the canals associated with it and smaller oscula extend deep into the interior of the sponge. Oscula of exhalant canals, 0.2–0.6 mm in diameter and spaced 0.3–2 mm apart, are common on the summit and lateral slopes of the sponge (Fig. 11.15). Such openings are not restricted to pore fields like in some related species. A few of these oscula are interconnected with limited surficial canals that are 0.3–0.5 mm across, but most are isolated circular openings. Some of these oscula have surficial rims, 0.04–0.06 mm thick, of fused spicule tips, but these rims do not extend into the sponge as canal linings, for the canals are only perforations through the stacked concentric spicule layers of the skeleton. Some canal walls have projecting spines of spicule tips.

Concentric layers of the skeleton are all approximately 0.2 mm thick and are composed of thin, dense but porous, upper and lower layers, approximately 0.04 mm thick, separated by an open layer, 0.10–0.15 mm thick, of vertical pillarlike, isolated, unbundled shafts of dendroclones, and possibly some tetraclone spicules (Fig. 11.13). These shafts are spaced approximately 0.10 mm apart and are 0.010–0.015 mm in diameter, but thicken to perhaps double that diameter where the cladome rays branch, interdigitate, and fuse with those of adjacent spicules to form the laterally continuous upper and lower layers of segments or laminar units of the skeleton. Identification of individual spicule clads and ray tips in the fused silicified microfabric is virtually impossible. These fused rays outline circular to polygonal skeletal pores that are 0.04–0.10 mm in diameter. These are the openings that are evident as inhalant openings in the dense dermal layer.

Etymology.—*Obconica*, in reference to the general form of the holotype.

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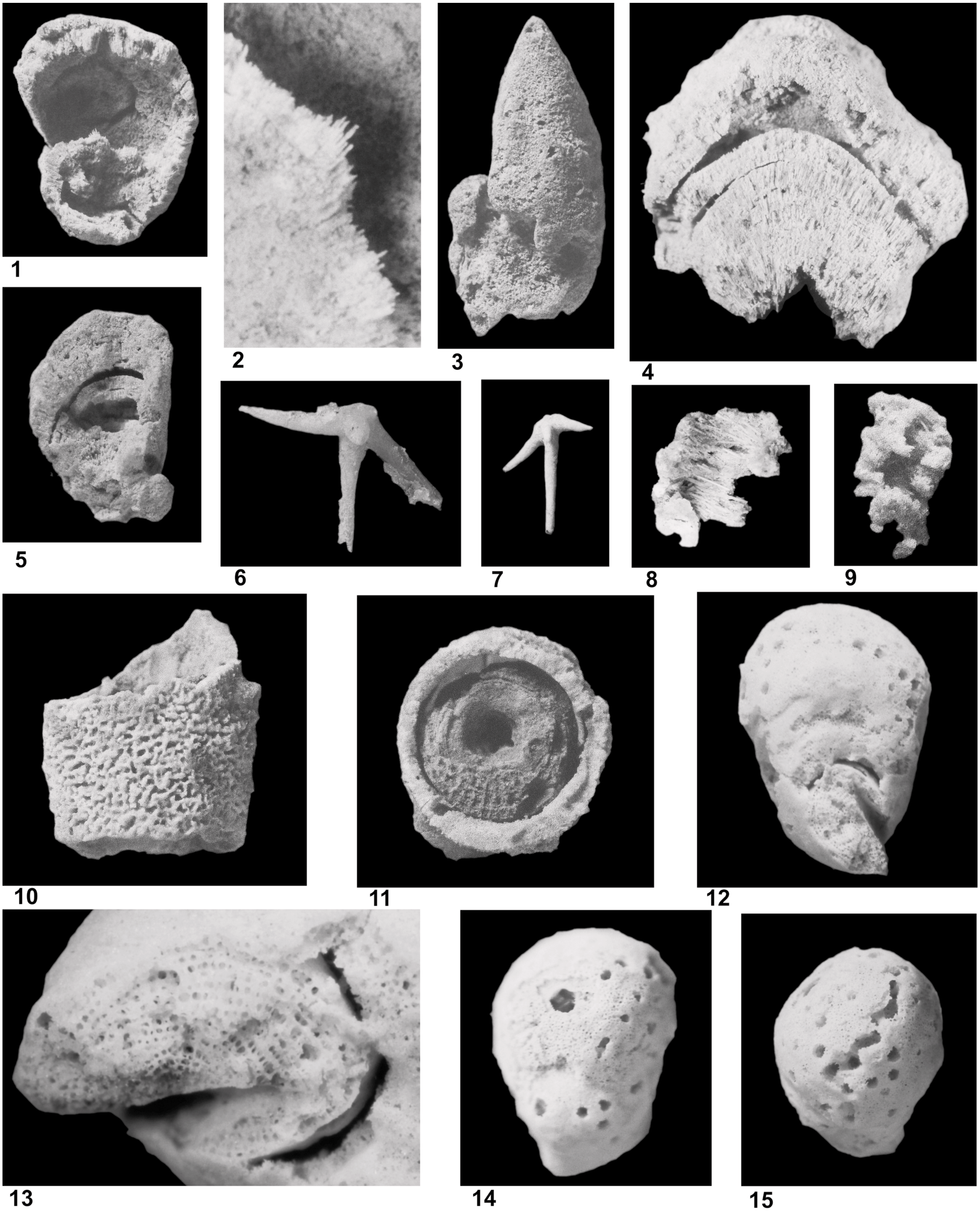
FIGURE *11*—Hexactinellid and lithistid sponges and trace fossils from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7633, Guadalupe Mountains National Park, Texas. *1–5, Monaxoradiata lamina* n. gen. and sp., type specimens, *1,* lower surface of domed holotype with arched incomplete base and section that shows skeleton of upward-radiating, parallel monaxons, GUMO 15158, ×4; *2,* photomicrograph of interior part of holotype with laminae of characteristic radiating monaxial spicules, GUMO 15158, ×20; *3,* side view of bullet-shaped paratype with spicular inner structure exposed in broken base, GUMO 15160, ×4; *4,* photomicrograph of paratype showing radiating monaxial spicules in several layers of the skeleton, GUMO 15161, ×10; *5,* lower surface of paratype showing concentric layers of outward-radiating monaxons, GUMO 15159, ×5. *6, 7,* Isolated large hexactine-based spicules, *6,* largest pentactine spicule in collection, 15163, ×2; *7,* smaller pentactine with weakly curved lateral rays, GUMO 15164, ×3. *8, 9,* Spicule-lined ?burrows, *8,* side view of largest preserved ?burrow segment, with tangential monaxial sponge spicules helping to define the cylindrical main opening, GUMO 15172, ×5; *9,* side view of small ?burrow segment partially defined by short segments of monaxial sponge spicules, GUMO 15173, ×10. *10, 11,* Encrusting inozoid(?) sponge on a crinoid columnal, GUMO 15171, *10,* side view of cylindrical tubular fragment of skeleton with ovoid to circular openings between irregular ridges and skeletal nodes, ×5; *11,* view from above of crinoid columnal encrusted by the light-colored probable sponge, ×5. *12–15, Dactylites obconica* n. sp., holotype, GUMO 5250m, *12,* side view showing concentric spicule layers of skeletal structure in the lower part, and the perforate upper part of obconical holotype with several oscula, ×5; *13,* photomicrograph of base of sponge with exposed concentric spicule layers formed of merged ray tips of dendroclones, with vertical shafts between layers, ×15; *14,* view of side opposite from that shown in *12,* with several small oscula and one larger osculum, ×5; *15,* view of domed summit with both isolated and interconnected oscula, ×5.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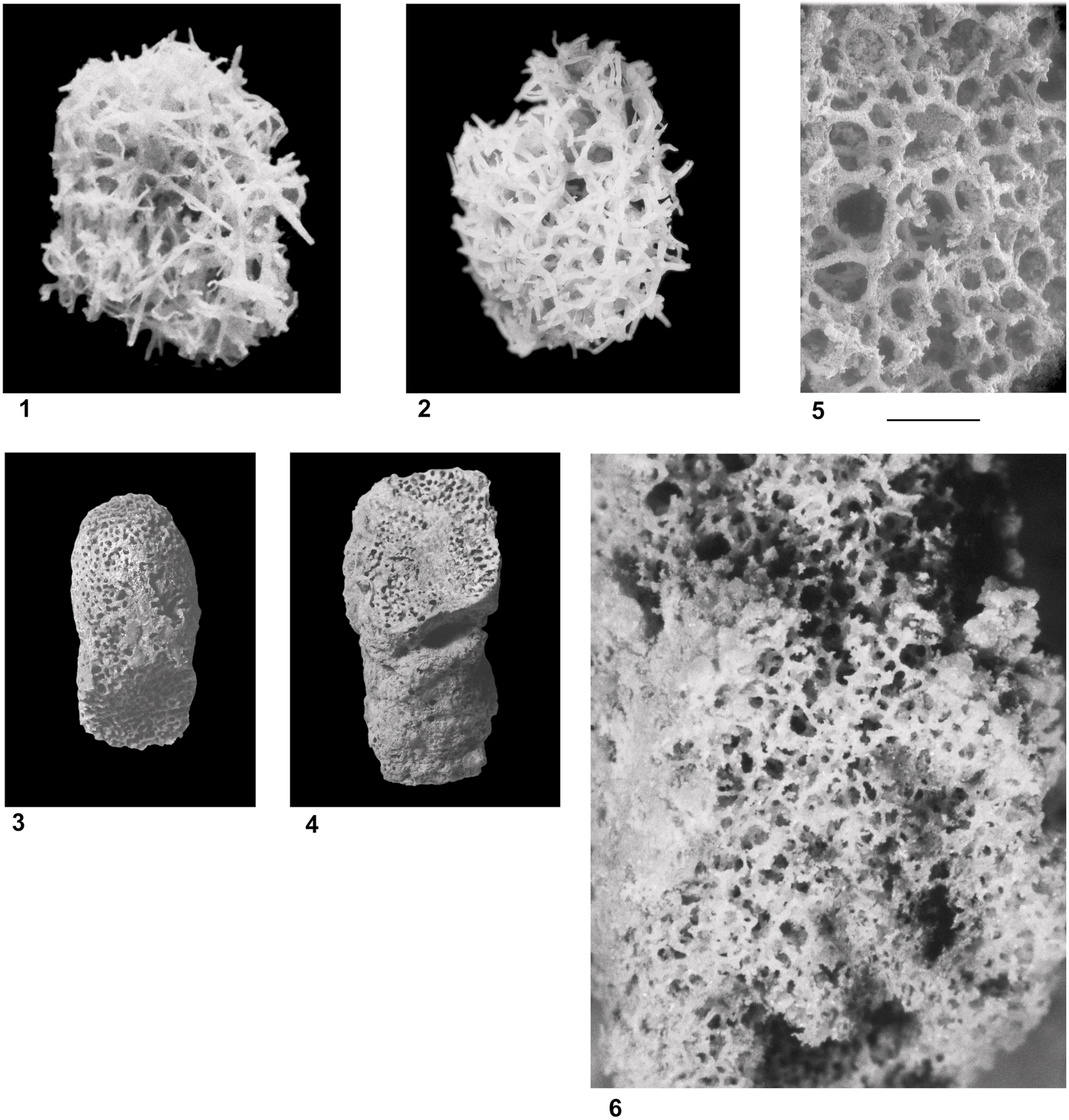

FIGURE 12—*Flexuospiculata* n. gen., *Daharella*, and *Chiastocolumnia* n. gen. from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7633, Guadalupe Mountain National Park, Texas. *1, 2, Flexuospiculata hexactina* n. gen. and sp., holotype, GUMO 15165, *1,* dermal surface of small holotype fragment, showing moderately uniform-sized, hexactine-based spicules with irregularly curved and interdigitating rays of dermal layer, ×10; *2,* lateral view of endodermal skeleton composed of irregularly oriented and spaced hexactine-based spicules of several sizes, ×10. *3, 4, Daharella crassa* n. sp.; *3,* side view of holotype, with reticulate skeletal structure evident in the diagonally fractured base and in the hemispherical summit; irregular exhalant opening shows on the right at midheight, GUMO 15180, ×2; *4,* side view of paratype with reticulate skeletal structure exposed in fractured upper surface, and with the lower part blanketed by a dense dermal layer that is perforated by a few large exhalant pores. GUMO 15181, ×2. *5, 6, Chiastocolumnia cylindrica* n. gen. and sp., GUMO 15183; *5,* SEM of dermal surface of paratype showing mix of branched chiastoclones and H- and X-shaped dendroclones. Bar scale is 500 microns; *6,* photomicrograph of basal area of paratype showing common chiastoclones and dendroclones in fused skeletal structure, ×10.

Type.—The holotype, GUMO 5250m, is the only known specimen of the species.

Occurrence.—The holotype was recovered from the Reef Trail Member of the Guadalupian Bell Canyon Formation at USGS Locality 7663.

Discussion.—Finks (1960, p. 76–77) proposed the lithistid family Anthracosyconidae and included there the genus *Anthracosycon*, and the new genera *Collatipora* Finks, 1960, and *Dactylites*. *Anthracosycon* includes forms that are conical to fungiform and which have the layers of spicules parallel to the upper surface, with edges exposed along the sides of the sponge, and that have numerous large oscula on the top surface, and ostia uniformly over the entire dermal surface. This contrasts to the small obconical form described here, which has spicule layers concentric over the entire surface and has relatively small oscula.

Collatipora includes smaller sponges that are hemispherical to spheroidal, have spicule layers concentric over the whole surface, and have one to several oscula. Ostia are mostly limited to restricted areas that lack surficial canals, but sponge surfaces around these areas are marked by abundant surficial canals. In contrast, the new *Dactylites obconica* has isolated ostia scattered over the entire dermal surface of the sponge and lacks the well-defined surficial canal system that characterizes species of *Collatipora*. The new species of *Dactylites* has concentric spicule layers of dendroclones and tetraclones, like the structure in *Collatipora*, but has isolated shafts of dendroclones extending vertically between fused layers of spicule rays, rather than the commonly bundled shafts like those in species of *Collatipora*.

Dactylites includes sponges with concentric spicule layers, where spicule shafts are unbundled to probably unbundled, and with ostia uniformly developed over the whole sponge surface, which is marked by few surface canals. In these respects the new species described here fits well within the genus. However, Finks (1960, p. 84) noted that the two species included by him, at least tentatively, in the genus are digitate, but he did observe that ?*D. subdigitatus* Finks, 1960 is conical and later becomes digitate. The new species, which has an obconical form, is included here in *Dactylites*.

DACTYLITES MAGNA new species
Figure 8.9, 8.10

Diagnosis.—Moderately large, steeply obconical sponge with compact dermal layer; several irregularly distributed oscula 2–3 mm in diameter, on rounded summit, some with shallow radiate grooves; rare oscula on sides below summit; exhalant postica 0.6–1.2 mm in diameter on sponge sides and locally vertically aligned, with coarser ones on upper part; ostia concentrated irregularly on one side of sponge and 0.4–0.6 mm in diameter and 5–6 mm apart in lower sponge, and 1–3 mm apart in upper part; upward-curved, concentric, skeletal layers approximately 0.2 mm apart and parallel dermal surface, layers composed of horizontal interfused dendroclones, with less common tetraclones and spinose rhizoclones; layers supported or separated by unbundled vertical shafts of dendroclones.

Description.—The holotype, GUMO 15162, is a relatively large obconical sponge (Fig. 8.10) that is 70 mm tall, with a broken base, and expands upward from an ovoid cross section, 10 × 12 mm in diameter, to a triangular cross section 31 × 34 mm across near the summit. It has a relatively dense dermal layer with only scattered ostia on one of the three upper sides, and a less clearly differentiated dermal layer with abundant ostia on the other two sides. The gently arched summit contains several distinct oscula that are 2–3 mm in diameter and separated approximately 5 mm apart (Fig. 8.9). Irregular discontinuous shallow grooves radiate from some oscula, but not from others. Additional rare oscula of the same general size occur to 1–2 cm below the summit on sides of the sponge.

Ostia on the two distinctly porous sides of the sponge are mostly approximately 1.0 mm in diameter, but range 0.6–1.2 mm in diameter, with lower ones averaging 0.7 mm in diameter grading up to those that are approximately 1.0 mm in diameter near the summit of the sponge. These ostia are separated 0.4–3.0 mm apart, but are commonly 1.0–1.5 mm apart. They are generally irregularly distributed, but locally up to six or seven ostia occur in discontinuous vertical rows in 10 mm, but more commonly three to five aligned ostia occur in shorter stacks amid the irregularly scattered inhalant openings.

Inhalant ostia are smaller, more rare, and more irregularly scattered on the side with a more dense dermal layer. These openings are mostly 0.4–0.5 mm in diameter and irregularly 5–6 mm apart in the lower part of the sponge, but grade to only 1–3 mm apart in the upper part of the sponge.

Skeletal pores in the compact dermal layer between the larger ostia are irregularly defined in the silicified preservation as openings between the fused ray tips of dendroclones and tetraclone spicules. These circular openings are up to 0.10–0.16 mm in diameter, but most are approximately 0.08 mm in diameter, where most evident, but some smaller pores only 0.05–0.06 mm in diameter are traceable for 0.2–0.3 mm as radial canals in the dense dermal layer. Coarser pores open into cylindrical canals that are traceable 0.4–0.5 mm into the skeletal net from the dermal surface.

The skeletal net is reminiscent of a structural grid, like in a building under construction, but with incomplete floors. Concentric layers, or floors, that parallel the dermal surface are approximately 0.2 mm apart, where seen in a transverse section across the broken base of the sponge. Here the parallel layers are 0.02–0.06 mm thick and are supported or separated by unbundled perpendicular shafts of dendroclones 0.08–0.14 mm long and 0.02–0.03 mm in diameter. Their branched clad tips merge with ray tips of other dendroclones and tetraclones to form the concentric layers of the skeleton.

Typical individual dendroclones, visible in layers parallel to the dermal surface, have smooth to locally spinose shafts 0.10–0.14 mm long and 0.03–0.04 mm in diameter. Divergent clads of those spicules are up to 0.04 mm long and end in branched tips that are fused with those of adjacent spicules. Associated tetraclones have four divergent rays that are 0.06–0.08 mm long and 0.03–0.04 mm in diameter, where not tapered, and from 0.04 to 0.02 mm or less where tapered. These ray tips are branched and fuse with similar tips of adjacent spicules. Locally spinose rhizoclones of the same general size occur in the layered skeleton, but are only locally recognizable in canal or ostial margins.

Two small fragments that may be basal, narrow obconical parts of the species occur in the collection. Both are approximately 20 mm tall, are laterally flattened, and 10–12 mm across. Both have dense dermal layers and few ostia, and dendroclones and tetraclone spicules like those in the large holotype of the species. However, their possible layered skeletal structure is not well preserved in either. Because of their size differences and relatively obscure skeletal structure they are only questionably included in the species.

Etymology.—*Magnus*, L., large, in reference to the relatively large size of the holotype.

Type.—The holotype, GUMO 15162, is the only specimen certainly included in the species. Two associated specimens on sample GUMO GEO 010328-1-9b are less certainly included in the species.

Occurrence.—All three of the above specimens are from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—This species is the largest of those included in the genus *Dactylites*. The somewhat similar *Collatipora discreta* Finks, 1960 is a small spherical or ellipsoidal form in which spicules are grouped in bundles, in which ostia are large for the genus, and where the dermal surface is covered with branching canals. *Collatipora delicata* Finks, 1960 is an encrusting, small hemispherical species with small ostia and one or a few oscula, and thus contrasts in size and form with the new species described here.

Collatipora pyriformis Finks, 1960 is a rounded stalked form, with numerous oscula and ostia, with limited canals in the dermal surface, and with strongly bundled spicules in the layered skeletal net. Like the new species described here, it has inhalant ostia concentrated irregularly on one side and largely lacks similar openings on the other side.

Class HEXACTINELLIDA Schmidt, 1870
Subclass HEXASTEROPHORA Schulze, 1887
Order LYSSACINOSA Zittel, 1877
Family TOOMEYOSPONGIIDAE Finks and Rigby, 2004
Genus TOOMEYOSPONGIA Rigby, Horrocks, and Cys, 1982

Discussion.—The large species *Toomeyospongia gigantia* Rigby and Bell, 2005, a well-preserved goblet-shaped to globose sponge recovered from the same general locality as the other sponges reported here, was described earlier in a separate paper (Rigby and Bell, 2005, p. 201). It is the only moderately complete, large hexactinellid sponge collected to date from these beds.

Family UNCERTAIN
Genus FLEXUOSPICULATA new genus

Type species.—*Flexuospiculata hexactina* n. sp.

Diagnosis.—Small hexactinellid sponges in which most spicules irregularly oriented and spaced, with curved or recurved to serpentine rays; largest spicules with straight rays also irregularly oriented and spaced; hexactine and pentactine spicules of ill-defined dermal layer with curved rays commonly tangential to dermal surface but irregularly oriented; small endosomal spicules of various sizes also irregularly oriented; skeleton perforated by variously spaced short canals normal to dermal surface.

Etymology.—*Flexuosus*, L., full of bends; *spiculata,* spiculate, in reference to the bent or curved rays of the hexactine spicules of the skeleton.

Discussion.—Although many hexactinellid sponges included in the order have irregularly oriented and spaced spicules, none described to date have distinctive, consistently curved to serpentine rays like those in the small fragment documented here. That fragment is characterized by irregularly oriented and spaced, intermediate-sized and small spicules with rays that are irregularly curved to recurved, by scattered and irregularly oriented, larger straight-rayed hexactines, and by the moderately defined dermal layer of intermediate-sized spicules with curved rays tangent to the surface.

Carbonella rotunda Hurcewicz and Czarniecki, 1986, from the Carboniferous of Poland, has a few hexactine-based spicules that show curved rays, but they are relatively minor elements in the skeleton and they do not have the irregular curvature of spicules like those in *Flexuospiculata*. Similarly, some hexactine spicules in *Lumectospongia uncinata* Rigby and Chatterton, 1989, from the Silurian of northern Canada, show minor curvature but they are far from the irregular recurved to serpentine rays typical of *Flexuospiculata*, described here.

FLEXUOSPICULATA HEXACTINA new species
Figures 12.1, 12.2, 13

Diagnosis.—As for genus.

Description.—A single small fragment of the skeletal net, the holotype, is in the collection (Fig. 12.1, 12.2). It is approximately 4.0 mm wide, 5.5 mm high, and 2 mm thick, and consists of several sizes of hexactine-based spicules that are irregularly oriented and spaced. The fragment has slight curvature and possibly represents part of a cylindrical sponge, but the fragment is too small to be certain. Several small canals are evident as openings through the fragment. They are approximately 0.5 mm in diameter or long, where they are 0.3–0.4 mm wide. They are approximately 1 mm apart, where most clearly defined, although with considerable variation.

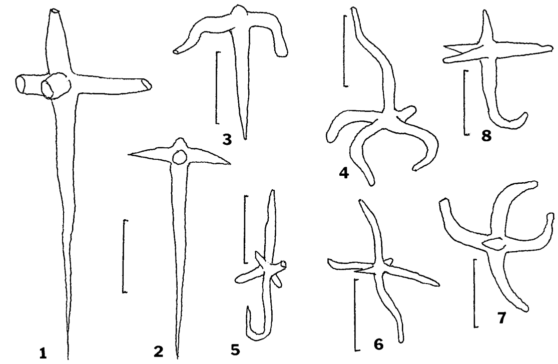

FIGURE *13*—Sketches of spicules of the holotype of *Flexuospiculata hexactina* n. gen. and sp., GUMO 15165, from USGS Locality 7663. Bar scales, 0.5 mm unless indicated otherwise. *1, 2,* Large straight-rayed hexactines of the endosomal part of the skeleton. *3, 4,* Intermediate-sized hexactines of the dermal layer, with irregularly curved rays. *5–7,* Intermediate-sized spicules of the endosomal part of the skeleton. *8,* Small spicule of the endosomal part of the skeleton, bar scale 0.25 mm.

Spicules are irregularly oriented and spaced. Only a poorly defined dermal layer is differentiated from the major part of the skeleton. That layer is approximately 0.5 mm thick and composed of intermediate-sized, moderately uniform spicules that have four principal rays roughly parallel to the dermal surface and with short distal rays represented as nodes or short spines. Proximal rays are commonly present, but some are difficult to differentiate in the confused structure of the fragment interior, and a few spicules appear to lack proximal rays. The tangential rays are nearly all irregularly curved so that no two spicules are alike, nor have the same orientation. Most of these spicules have basal ray diameters of 0.10–0.12 mm and ray lengths that range 0.5–1.0 mm, although total length is often difficult to determine because of irregular curvature and interdigitation of the rays.

Largest spicules are more or less regular, straight-rayed hexactines that are irregularly oriented. These have one major ray that ranges 1.4–1.9 mm long in the few such spicules that are preserved. Basal diameters of these long rays are 0.10–0.14 mm, although most flare abruptly near the ray junctions to diameters of up to 0.20 mm. Shorter rays of these hexactines that are normal to the long rays, or which extend beyond the junction, are up to 0.5 mm long and have basal ray diameters of 0.07–0.08 mm.

Smaller spicules are also irregularly oriented and all have irregularly undulate to curved or recurved rays and fill spaces between larger spicules. These smaller spicules commonly have rays 0.3–0.5 mm long and with basal ray diameters of approximately 0.05 mm.

Etymology.—*Hexactina*, in reference to the hexactine-based skeleton.

Type.—Only the holotype, GUMO 15165, represents the species in the collection.

Occurrence.—The holotype, the only known specimen of the species, was collected at USGS Locality 7663, from the Upper Guadalupian Reef Trail Member of the Bell Canyon Formation.

Discussion.—Characteristics of the species and genus and comparisons with similar or related forms are discussed in treatment of the genus, above.

Subclass and Order Uncertain
Isolated hexactine-based spicules
Figure 11.6, 11.7

Description.—Several isolated hexactine-based spicules and spicule fragments have been recovered from the etched residues. Most of these spicules are of ray fragments, but a few nearly complete coarse spicules showing hexactine or pentactine ray junctions have been recovered. A typical one of these, GUMO 15164, has coarse recurved rays with basal diameters of approximately 1.0 mm, and lengths of 3.5 mm or longer (Fig. 11.7). Some ray fragments of larger spicules are up to 7 mm long and 0.6 mm in diameter, with little taper. Most ray fragments are smaller and commonly 0.3–0.5 mm in diameter. These long-rayed spicules were probably root tuft or dermal elements.

The largest hexactine-based spicule in the present collection, GUMO 15163, is a pentactine (Fig. 11.6) with a rounded ray junction area from which the basal vertical ray extends 10 mm, to a broken tip. That ray has a basal diameter of 2.2 mm and tapers moderately uniformly to a diameter of 0.4 mm at the broken end. The reflexed rays have basal diameters of 2.4–2.5 mm and two of the nearly complete rays are 9 mm long. One of the associate reflexed rays is only a short, but complete element, 3.0 mm long.

Material examined.—Several isolated spicule fragments, including GUMO 15163 and 15164, were recovered from etched samples of the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—Large pentactine spicules, like those recovered here, have been reported as part of dermal spiculation in the globose to goblet-shaped *Toomeyospongia gigantia* from USGS Locality 7663. The large isolated spicules reported here could have come from that species.

Phylum, Class, Order, Family Uncertain
Genus Pulsatospongia new genus

Type species.—*Pulsatospongia obconica* n. sp.

Diagnosis.—Small stems of regularly added obconical, thin-walled chambers or segments with flared open upper ends; continuous central opening extends from short distance above base, through all segments, to summit; exterior of thin walls marked with prominent, moderately regular growth lines or annulations; interior surface of imperforate walls smooth; narrow bases of succeeding segments fused to lower interior of immediate earlier segments.

Etymology.—*Pulse*, an intermittent event, in reference to the irregular addition of the flared obconical segments that form the stem of the fossil; *spongia,* in reference to the spongelike stem of the holotype.

Discussion.—These are somewhat similar to the questionable tabulate coral *Salpingium* Smyth, 1928, from the Lower Carboniferous of Ireland, in having an irregularly pulsate growth form. That fossil, however, has distinct tabulae and faint radial ridges on the upper surfaces of the flaring expansions. It does not have the annulate growth lines such as are common in the fossils here, and these Texas fossils do not have tabulae. The fossil worm tube *Mercierella* Fauvel, 1923, from the Miocene of France, has a more regular pulsate growth form and is much larger, but it does have the weakly defined growth lines between flaring ridges or flanges and the tube is open. However, taxonomic relationships of these Texas fossils remain uncertain.

Pulsatospongia obconica new species
Figure 9.10–9.12

Diagnosis.—As for genus.

Description.—All fragments of the species in the collection show the same pulsating growth of the small stems by moderately regular addition of upward-flaring obconical, thin-walled segments. Stems fragments range to 10.5 mm tall. Individual flaring segments range to 2.5 mm tall and expand upward from short subcylindrical bases, which are commonly 0.9–1.4 mm in diameter, to irregular upper margins that are commonly 2.0–2.5 mm in diameter. Walls of the obconical structures are approximately 0.15 mm thick at their bases and thin to 0.10 mm thick at their upper, commonly broken margins. Walls of segments are imperforate and appear microcrystalline, as silicified.

All fragments show distinct annulate growth lines or faint ridges that are approximately 0.10 mm high and wide, trough to trough. On several specimens there are seven or eight such ridges per millimeter on both the subcylindrical narrow initial part of each segment, as well as on the upper flared walls.

A central tubular opening extends from near the juvenile base, in one stem where that part is preserved, through the full stem in all other specimens in the collection. That opening is only 0.3–0.4 mm in diameter in the nearly complete juvenile base, and expands to 0.8 mm in diameter in the first flared segment of that stem. The central opening is commonly 0.6–0.9 mm in diameter in other specimens of the species. In the narrowed cylindrical bases of the various flared segments, the pores are surrounded by walls 0.1–0.2 mm thick.

The holotype, GUMO 15167, is a stem segment 7.5 mm tall that consists of a lower subcylindrical part, 1.5–1.6 mm in diameter, that is approximately 3 mm tall, and an upper part, 4.5 mm tall, that consists of flared segments (Fig. 9.11). The base of the initial flared segment is 1.6 mm in diameter and it expands uniformly upward to an upper diameter of 2.7 mm. The uppermost flared segment has a base 1.4 mm in diameter, which is fused to the lower segment, and expands to 2.7 mm in diameter at the upper broken margin. A central longitudinal opening extends through the stem and is 0.9 mm in diameter, where best exposed at the base. Several minor pulses of surficial growth rings or annulations are apparent in the lower part of the stem, where clustered uniform ridges occur in sections 0.5–0.8 mm tall, that are separated by unmarked breaks. The holotype probably represents a juvenile and initial segmented part of the stem, but both the base and upper end are broken and incomplete.

The small paratype, GUMO 15168, is 5 mm tall and has a curved, weakly digitate nearly complete base (Fig. 9.10), which is approximately 3 mm tall and 1 mm in diameter, with short irregular ''roots'' to 0.5 mm in diameter. Above the base is the short cylindrical lower part of the stem, which is 1 mm tall and 1.1 mm in diameter. It grades up into the upper flared segment that is 1.5 mm tall and which expands upward from that cylindrical lower part to an upper margin 2.5 mm in diameter.

Another paratype, GUMO 15169, is also 5 mm tall and has three distinct segments that are approximately 1.5 mm tall and expand upward from basal diameters of 0.8–1.3 mm to flared upper margins 2.0–2.5 mm in diameter (Fig. 9.12). The basal exposed section is 0.9 mm in diameter, with walls approximately 0.1 mm thick around the central opening 0.7 mm in diameter. That opening is 0.7 mm in diameter in a tubular structure 1.1 mm in diameter at the top of the fragment, in the base of the next incomplete segment.

Etymology.—*Obconica*, in reference to the open, upward-flaring segments added to produce the stem of the structure.

Types.—The holotype, GUMO 15157, paratypes, GUMO 15158–15170, and 12 additional fragments of the species.

Occurrence.—The known specimens of the species are all from the Upper Guadalupian Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663.

Discussion.—Treatment of possible relationships of these fossils to associated fossils has been presented in discussion of the genus, above.

Phylum PORIFERA?
ENCRUSTING INOZOID SPONGE?
Figure 11.10, 11.11

Description.—A tubular encrustation around a crinoid columnal, GUMO 15171, is a possible inozoid sponge (Fig. 11.10). This tubular fragment is 10 mm tall and 8.5 mm in diameter, around a crinoid columnal that is 6.0 mm in diameter. The encrusting layer is 0.7–1.5 mm thick, including an inner massive layer 0.5–0.7 mm thick and an outer irregular netlike structure, and is partially separated by a narrow gap from the columnal (Fig. 11.11).

The silicified crust is not laminated nor does it have a regular structure or regular canals, as seen in transverse section, although traces of irregular radial pores occur here and there as discontinuous openings up to 0.04 mm in diameter. Some discontinuous tangential canals, to 0.20 mm in diameter, occur in the middle of the crustose film.

An irregular network of ridges and depressions mark the outer surface of the crust (Fig. 11.10), with moderately uniformly separated openings or depressions that are circular to ovoid and 0.2–0.4 mm in diameter. Skeletal nodes, which appear to be tips of radial elements, occur between the openings and are 0.3–0.4 mm in diameter. These are interconnected to form the network structure by rodlike or low-bladed elements that are 0.10–0.15 mm thick and 0.2–0.3 mm long, node to node. The nodes have pointed dermal tips that extend 0.1–0.2 mm beyond the general node and lateral rod levels of the skeleton.

Material examined.—A single specimen, GUMO 15171, that includes the encrusting fossil and the overgrown crinoid columnal occurs in the collection from USGS Locality 7663, from the Reef Trail Member of the Bell Canyon Formation.

Discussion.—Whether the encrusting structure is of inozoid origin or not is unknown, but it appears similar to the fabric in some possibly related inozoans.

?TRACE FOSSILS
SPICULE-LINED ?BURROWS
Figure 11.8, 11.9

Description.—The larger of the two preserved ?burrow fragments in the collection, GUMO 15172, is a section 6 mm tall, with a central opening approximately 2.6 mm in diameter. The ?burrow wall is irregular and ranges 0.6–1.0 mm thick. It is lined by transversely aligned and tangentially placed fragments of sponge spicules (Fig. 11.8). These fragments range to 2 mm long, although most are approximately 1 mm long or shorter, and are up to 0.14 mm in diameter, with most 0.08–0.10 mm in diameter, and some as small as 0.01–0.04 mm in diameter are inserted in the stacked, loglike structure. Some of these small spicules show gentle distal taper.

The smaller fragment, GUMO 15173, is 3 mm tall, with a central perforation approximately 0.7 mm in diameter, and with walls 0.3–0.5 mm thick (Fig. 11.9). Like the larger ?burrow fragment, spicules in the lining are transversely aligned and tangential to the inner surface of the ?burrow. Spicule fragments range to 0.06 mm in diameter, with most 0.03–0.04 mm, and some as small as 0.01 mm in diameter. The longest evident fragment is 1.0 mm long with most only 0.1–0.4 mm long in the tangential lining.

Material examined.—Two figured fragments of spicule-lined ?burrows, GUMO 15172 and 15173, are in the collection from the Reef Trail Member of the Bell Canyon Formation at USGS Locality 7663, Guadalupe Mountain National Park.

Discussion.—Origin of the ?burrows, or the identity of the organisms that lined them with the spicule fragments, are unknown. However, the consistent structure of the two ?burrows, even though of different diameters, suggests that they were produced by a single kind of organism.

ACKNOWLEDGMENTS

We appreciate the active support of the staff and faculty of the Department of Geology, Brigham Young University, in particular J. Keith, department chairman, and S. Ritter, paleontological colleague. K. Thompson, illustration specialist on the Geology Department staff, prepared digital images of the individual fossils and the photographic figures, from photographs taken by Rigby. Similarly, we appreciate the assistance of staff members at Guadalupe Mountains National Park, particularly J. Hearst, physical science technician, in the collection, acid preparation, and initial sorting of the fossils in facilities at the park headquarters. J. Botting and D. Janussen provided helpful reviews of the manuscript.

We wish to thank J. W. Adams, Midland, Texas, for many years of support and assistance to Guadalupe Mountains National Park historic and scientific projects, as well as his efforts to locate benefactors to support page costs for this memoir.

Most especially we want to recognize the contribution of M. S. Weeks, Miami, Florida, for her most generous donation to the Carlsbad Caverns–Guadalupe Mountains Association to cover the entire page costs associated with the publication of this memoir. Over the years, two generations of the Weeks family have provided much philanthropic support for Guadalupe Mountains National Park, various university foundations, the American Association of Petroleum Geologists, and research and publications of the geology of the Permian Basin and petroleum geology in general.

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ACCEPTED 15 DECEMBER 2005