

FORAMINIFERA OF THE GENERA SIPHOGENERINA AND PAVONINA

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Continued study of various collections of Foraminifera, largely brought together through governmental agencies, has rendered it both possible and advisable to present at this time a revision of two genera of Foraminifera and their component species, the Genus *Siphogenerina* Schlumberger, and *Pavonina* d'Orbigny.

GENUS SIPHOGENERINA SCHLUMBERGER

There seems to be some hesitation on the part of certain workers on the Foraminifera to make use of the generic name *Siphogenerina*. Instead of using it the generic name *Sagrina* is often used. A study of West Indian material has made possible the clearing up of the questions relating to these two generic names. A review of much of the literature, and of species so far as specimens are available, has given some very definite information as to distribution.

The type species of d'Orbigny's genus *Sagrina* is *S. pulchella* d'Orbigny.¹ The description and figure are very definite. The generic description freely translated is as follows: "Test free, regular, equilateral, conical, chambers globular, regularly alternating at all stages on each side of the longitudinal axis, partially overlapping; aperture rounded, above the last-formed chamber at the end of an elongate neck." The similarity to *Textularia* is also noted. The other species from the Chalk of the Paris Basin, *S. rugosa* d'Orbigny,² is of similar character.

Little further note is made of *Sagrina* until in 1865 Parker and Jones³ emended it, and used it in a subgeneric sense under *Uvigerina* to include *diaphanus*, *dimorpha*, and *nodosa*. Their work was followed by subsequent authors. The type of d'Orbigny is referred to as follows (p. 364): "D'Orbigny has figured under the name of *Sagrina pulchella* (Foram. Cuba, pl. 1, figs. 23, 24) a specimen which was either the young, or an arrested individual of such a bifurcated *Uvigerina*," and also: "Not only is our Nodosariform *Uvigerina*

¹ De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères," p. 150, pl. 1, figs. 23, 24.

² Mém. Soc. géol. France, vol. 4, 1840, p. 47, pl. 4, figs. 31, 32.

³ Philos. Trans., vol. 155, p. 363.

connected with the typical *U. pygmaea* (figs. 53-56) through *Sagrina pulchella*, D'Orb., but an intermediate condition between it and the feebler dimorphs of the Mediterranean area occurs in the mud brought up by the sounding lead from the Abrohlos Bank (*U. dimorpha*).⁴ "Altogether this latter group of forms shows how great the affinity is between the always hyaline *Uvigerina* and the porous sandy *Textularia*."

Brady in the *Challenger* Report notes the relationships of both *Sagrina pulchella* and *S. rugosa* to the Textulariidae.

A study of collections from the West Indies and the coast of Florida has shown conclusively that the *Sagrina pulchella* of d'Orbigny is in reality a *Bolivina* which is widely distributed in that general region. The peculiar apertural characters with the sides somewhat raised could have easily been mistaken for the sort of aperture in d'Orbigny's figure, if the specimen were not seen from the end. With *S. pulchella* really a species of *Bolivina*, and as Brady notes *S. rugosa* is related to *Gaudryina* it follows that *Sagrina*, if used at all, must be used for species belonging to the Textulariidae. As the type species is a *Bolivina* the name *Sagrina* can not be used unless for a part of that genus.

The first name that can be taken up for the generic characters of the species noted by Parker and Jones is *Siphogenerina* Schlumberger. Schlumberger called attention to the internal structure, and erected the genus *Siphogenerina* based on the tubular connecting interior.⁴ The genus is related to *Uvigerina* and *Trifarina* (*Triplasia* or *Rhabdogonium*) and to the group of the Lagenidae with apertures exserted, with a tubular neck and phialine lip.

Genus SIPHOGENERINA Schlumberger, 1883

Sagrina PARKER and JONES (not d'Orbigny), Philos. Trans., vol 155, 1865, p. 363.—H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 580.—CHAPMAN, The Foraminifera, 1902, p. 201.

Dimorphina SCHWAGER (not d'Orbigny), Novara-Exped., Geol. Theil., vol. 2, 1866, p. 251.

Siphogenerina SCHLUMBERGER (type, *S. raphanus* (Parker and Jones)), Feuille des Jeunes Naturalistes, ann. 13, 1883, p. 117.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 104; Bull. 104, pt. 4, 1923, p. 172.

Description.—Test elongate, composed at least in the microspheric form of a series of chambers arranged tri or bi serially, followed by a later uniserial development; walls hyaline and perforate; aperture in the uniserial portion central and terminal, usually with an elongated neck and flaring lip; interior of the chamber with a tubular connection running from the base of the apertural neck to the lip of the aperture below; wall smooth or ornamented by costae, pits, etc.

⁴ Feuille des Jeunes Naturalistes, ann. 13, 1883, p. 117.

Both microspheric and megalospheric forms occur in the various species of this genus. In the microspheric form the early chambers are biserial or triserial, and there is usually a considerable number of them before the adult uniserial development takes place. In the megalospheric form the uniserial condition is taken on much earlier, after only a few of the triserial or biserial chambers are developed.

In the present ocean the species are found in the Indo-Pacific most abundantly, but also in the Western Atlantic and the Mediterranean. In the fossil condition the genus occurs in the Tertiary as noted under the various species.

Halkyard in his paper edited by Heron-Allen and Earland⁵ places *Siphogenerina* as a subgenus of *Bigenerina*. The relationships, however, seen to be with *Uvigerina* and the Lagenidae. In microspheric specimens of *Siphogenerina bifrons* the early chambers sometimes show a decidedly coiled character, linking the early development of *Siphogenerina* with coiled forms like that of *Cristellaria*.

A rough key is given to the species of the genus treated here:

A KEY TO THE SPECIES OF SIPHOGENERINA

Test not compressed:

Costate—

Costae few and prominent—

Costae more prominent than suture lines—

Test large and fusiform..... *S. collomi*

Test tapering throughout—

Costae high, lamellate—

Costae 10 or less..... *S. raphanus*

Costae 15 or more..... *S. reedi*

Costae, low, not lamellate..... *S. kleinPELLI*

Costae less prominent than suture lines..... *S. branneri*

Costae numerous and prominent—

Neck short..... *S. striata*, var. *curta*

Neck long and slender..... *S. irregularis*

Costae very numerous, not prominent..... *S. striatula*

Lamellate—

Lamellae very prominent, not spinose..... *S. lamellata*

Lamellae less prominent, spinose near base..... *S. spinosa*

Smooth—

Test slender and elongate..... *S. columellaris*

Test short and stout..... *S. hughesi*

Coarsely punctate..... *S. dimorpha*

Spinose or hispid..... *S. virgula*

Slender, early portion costate, middle spinose, later part smooth..... *S. mexicana*

Test compressed:

Short, stout, sides deeply depressed..... *S. bifrons*

Elongate, slender, sides not depressed..... *S. advena*

⁵ Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, pt. 2, 1919, p. 37.

SIPHOGENERINA RAPHANUS (Parker and Jones)

Plate 1, figs. 1-4; plate 2, figs. 1-3, 10; plate 5, figs. 1, 2

Uvigerina (Sagrina) raphanus PARKER and JONES, Philos. Trans., vol. 155, 1865, p. 364, pl. 18, figs. 16, 17.

Sagrina raphanus H. B. BRADY, Rep. Voy. Challenger, Zoology, vol. 9, 1884, p. 585, pl. 75, figs. 21-24.—WOODWARD, The Observer, 1893, p. 144.—CHAPMAN, Journ. Linn. Soc., vol. 28, 1900, pp. 187, 208; 1902, p. 403.—MILLET, Journ. Roy. Micr. Soc., 1903, p. 272.—DAKIN, Rep. Ceylon Pearl Oyster Fish., vol. 5, 1906, p. 236, pl., fig. 11.—CHAPMAN, Journ. Linn. Soc. Zoology, vol. 30, 1910, p. 415.—SCHUBERT, Abhandl. geol. Reichs., vol. 20, pt. 4, 1911, p. 88.—HERON-ALLEN and EARLAND, Trans. Zool. Soc. London, vol. 20, 1915, p. 677.—SIDEBOTTOM, Journ. Roy. Micr. Soc., 1918, p. 148.—HERON-ALLEN and EARLAND, British Antarctic Exped., Zoology, vol. 6, 1922, p. 186; Journ. Linn. Soc. Zool., vol. 35, 1924, p. 627.

Siphogenerina (Sagrina) raphanus EGGER, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 317, pl. 9, fig. 36.

Siphogenerina raphanus CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 108, pl. 46, figs. 1-5; Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 280, pl. 56, fig. 7; Publ. 311, Carnegie Inst. Washington, 1922, p. 35, pl. 5, fig. 5; Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 174, pl. 42, fig. 14.—YABE and HANZAWA, Jap. Journ. Geol. Geog., vol. 2, No. 2, 1923, p. 32; vol. 2, No. 4, 1923, p. 103.—CUSHMAN, Publ. 342, Carnegie Inst. Washington, 1924, p. 28, pl. 8, figs. 1, 2.

Siphogenerina raphanus (PARKER and JONES), var. *costulata* CUSHMAN, Proc. U. S. Nat. Mus., vol. 51, 1917, p. 662; Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 281, pl. 56, fig. 6.

Siphogenerina costata SCHLUMBERGER, Feuille des Jeunes Naturalistes, ann. 13, 1883, p. 118, fig. 13.

Test elongate, cylindrical or tapering, chambers of the uniserial portion broader than long; surface marked by several rather widely separated, well-developed costae, each extending nearly the length of the test, independent of the sutures; aperture typically with a short tubular neck and well-developed flaring lip.

Length around 1 mm.

Distribution.—Parker and Jones when they described this species had specimens from the following localities: "West Indies, Panama, India (on clam-shell), Bombay Harbour (anchor-mud), Hong Kong (anchor-mud), Australian Coral-reefs (17 fathoms)." In the *Challenger* Report Brady gives the following records: "shore sands, Bermuda, West Indies, Panama, and Madagascar; anchor-mud, Port Louis, Mauritius; dredged sands, off Calpentyn, Ceylon, 2 fathoms, off Kerguelen Island, 12 fathoms, off the Philippines, 95 fathoms, off Honolulu, Sandwich Islands, 40 fathoms; and at fifteen stations amongst the islands of the South Pacific, at depths ranging from 2 fathoms to 260 fathoms." Egger records it also from off Mauritius. Chapman had it from numerous stations about Funafuti, some of which are in deep water, the greatest depth 2,728 fathoms. He also found it common from shallow depths in the lagoon to 300 fathoms

outside the reef. Millett records both microspheric and megalospheric specimens from the Malay region. Heron-Allen and Earland had it from five stations in their Kerimba Archipelago collections. Dakin records it as "sparingly," Gulf of Manaar. Sidebottom's specimens are from 465 fathoms off the East Coast of Australia. Heron-Allen and Earland record it from the Antarctic Expedition material dredged by the *Terra Nova* off Three Kings Island, New Zealand, 90-120 fathoms and from Lord Howe Island in the Pacific.

I have had it from the Pacific from off Japan in 44 and 361 fathoms, between Yokohama and Guam in 1,208 fathoms, and in 271 fathoms off the Hawaiian Islands. It occurred at several stations in the Samoan collections, most common at the deepest station, 50 fathoms, and at numerous stations in the Philippine region, 78-554 fathoms.

In the Atlantic it is rare, and the only records are from the western tropical portions. It occurred rarely but well developed in the shallow-water material from the Tortugas region, and at a single *Albatross* station off Central America in 382 fathoms.

There are very few records of its occurrence in the fossil state. Schubert records it from the "Neogene" of Sanaibas, in the Bismarek Archipelago, and from a "coral-sand" probably Pleistocene of Maria Island in the Paumotu group. Yabe and Hanzawa record it as rare from the Pliocene shell beds of Nojima, and as rare at Nagamura, Japan. Heron-Allen and Earland record a questionable specimen from New Zealand of sub-fossil character. Halkyard⁶ records the species from the Eocene Blue Marl of Biarritz. The editors of Halkyard's paper, Heron-Allen and Earland, make the following note as to these specimens. "They are much longer and narrower than any specimens of *S. raphanus* that we have ever seen, and there is no evidence of any uvigerine commencement. We should have ascribed them with little hesitation to *Nodosaria obliqua* (Linne)." This then removes from consideration this Eocene material which is so far out of the known range of the species.

The species is in its typical form one of characteristic distribution, mainly Indo-Polynesian, ranging from the Kerimba Archipelago across the Indian Ocean, extending northward to Japan, Guam, and the Hawaiian Islands, and southward to New Zealand. It also extends into the western tropical Atlantic, but seems to be rare. As a fossil it occurs in the late Tertiary of Japan and the Bismarek Archipelago.

⁶ Mem. Proc. Manchester Lit. Philos. Soc., 62, 1919, p. 38.

SIPHOGENERINA RAPHANUS (Parker and Jones), var. TROPICA, new variety

Plate 1, fig. 5; plate 5, figs. 7, 8

Description.—Variety differing from the typical in the shape of the test, which is tapering, wall thicker, the sutures less distinct, and the apertural end with a definite neck and flaring phialine lip.

This is the variety figured by Brady in the *Challenger Report*⁷ and which I have figured.⁸

This variety so far as known is confined to the Pacific in shallow water about coral reefs. Type specimens are from *Albatross* D 5178 in 78 fathoms near Romblon.

SIPHOGENERINA RAPHANUS (Parker and Jones), var. TRANSVERSUS Cushman

Plate 1, fig. 6

Siphogenerina raphanus (PARKER and JONES), var. *transversus* CUSHMAN, Bull. 103, U. S. Nat. Mus., 1918, p. 64, pl. 22, fig. 8.

Description.—Test subcylindrical, composed of comparatively few chambers, the earlier ones spirally arranged, later and greater portion of the test uniserial, sutures very prominently indented, between the longitudinal costae which are few in number; aperture with a short cylindrical neck, lip not evident.

Length of type specimen 1.25 mm.; breadth 0.54 mm.

This variety was originally described from the Culebra formation of the Panama Canal Zone in dark clay, north of Pedro Miguel Locks. I have material of this same variety from Brasso, Trinidad, British West Indies, collected by F. W. Penny.

This is related to *S. kleinPELLI* Cushman, but the costae are fewer and stronger, and the indented portions below the sutures deeper.

SIPHOGENERINA COLLOMI Cushman

Siphogenerina collomi CUSHMAN, Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 2, pl. 4, fig. 3.

Test large for the genus, fusiform, greatest width above the middle; early chambers irregularly spiral, later ones uniserial, distinct; sutures depressed, strongly curved, extending back on the costae to a considerable distance; test ornamented with very high, plate-like costae, usually ten in number, last-formed chamber smooth; aperture with a very short cylindrical neck and phialine lip.

Length up to 1.60 mm.; breadth 0.65 mm.

Type specimens (Cushman Coll. No. 4325) from Monterey shale, sec. 24, T. 28 S., R. 14 E., San Luis Obispo County, California, collected by W. D. KleinPELL.

This species is nearest related to *Siphogenerina spinosa* Bagg from the Miocene of Maryland and *S. lamellata* Cushman from the Miocene of Florida. The species is named for Roy E. Collom, well-known geologist of California.

⁷ Pl. 75, figs. 23, 24.

⁸ Bull. 100, U. S. Nat. Mus., vol. 4, 1900, pl. 56, fig. 7.

SIPHOGENERINA REEDI Cushman

Siphogenerina reedi CUSHMAN, Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 3, pl. 4, fig. 4.

Test about twice as long as broad, greatest breadth at the apertural end, thence gradually tapering to the initial end; chambers distinct; sutures somewhat depressed, strongly curved; wall ornamented with about fifteen lamellate costae which may continue onto the last-formed chamber; apertural characters obscure.

Length up to 1.10 mm.; breadth 0.50 mm.

Type specimens (Cushman Coll. No. 4326) from Monterey shale, sec. 24, T. 28 S., R. 14 E., San Luis Obispo County, California, collected by W. D. Kleinpell.

This may be distinguished from *S. collomi* by its smaller size and greater number of costae. It is nearest the form I have described from the Panama Canal Zone as *S. raphanus* (Parker and Jones), var. *transversus* Cushman.

It is named for Ralph D. Reed, geologist of California, under whose direction the material was collected.

SIPHOGENERINA KLEINPELLI Cushman

Siphogenerina kleinpelli CUSHMAN, Cushman Lab. Foram. Res., vol. 1, pt. 1, 1925, p. 3, pl. 4, fig. 5.

Test about twice as long as broad, greatest breadth at the apertural end, thence irregularly tapering to the initial end; chambers distinct; sutures depressed, very slightly if at all curved; wall ornamented with about fifteen very low costae, not at all lamellate, not continuing onto the last-formed chamber; aperture with a very short cylindrical neck and slight phialine lip.

Length up to 1 mm.; breadth 0.50 mm.

Type specimens (Cushman Coll. No. 4327) from Monterey shale, sec. 24, T. 28 S., R. 14 E., San Luis Obispo County, California, collected by W. D. Kleinpell.

This species may be distinguished from *S. reedi* by the much lower and less prominent costae, and the lack of curvature in the sutures.

It is named for W. D. Kleinpell who collected the material.

SIPHOGENERINA BRANNERI (Bagg)

Plate 1, figs. 7-9; plate 4, fig. 7

Sagrina branneri BAGG, Bull. 268, U. S. Geol. Surv., 1905, p. 40, pl. 7, fig. 4.

Sagrina californiensis BAGG, Bull. 268, U. S. Geol. Surv., 1905, p. 41, pl. 7, fig. 5.

Sagrina elongata BAGG, Bull. 268, U. S. Geol. Surv., 1905, p. 41, pl. 7, fig. 6

Description.—Test subcylindrical, the microspheric form tapering, the megalospheric fusiform; chambers numerous, inflated; sutures distinct, slightly depressed; surface ornamentation consisting of

numerous distinct, slightly raised, longitudinal costae, the chamber at the sutures continued backward along these costae giving a scalloped edge to the suture; aperture with a short, cylindrical neck and narrow phialine lip.

Length of microspheric form up to 2.6 mm.

Distribution.—This species is common in the Miocene of California. It was described from the Monterey shale, on the Ranchodel Encinal, 7,000 feet south of Asuncion station, San Luis Obispo County, California. The outcrop is on Graves Creek.

Three species were described by Bagg from this material. The first of these, *S. branneri*, is the microspheric form of the species, the other two, *S. californiensis* and *S. elongata*, represent the megalospheric form. I have material from the type locality.

SIPHOGENERINA STRIATA (Schwager), var. CURTA, new variety

Plate 2, fig. 5; plate 5, figs. 5, 6

Sagrina striata H. B. BRADY (not Schwager), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 584, pl. 75, figs. 25, 26.—MILLETT, Journ. Roy. Micr. Soc., 1903, p. 272.—DAKIN, Rep. Ceylon Pearl Oyster Fisheries, vol. 5, 1906, p. 236.

Siphogenerina (Sagrina) striata EGGER, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 316, pl. 9, figs. 32, 34, 35, 64, 65 [?].

Siphogenerina striata CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 107, pl. 47, figs. 4, 5; Bull. 100, vol. 4, 1921, p. 280, pl. 56, fig. 5.

Description.—Test elongate, cylindrical, chambers of the uniserial portion broader than long; sutures not deep but conspicuous; wall ornamented by longitudinal costae, not close together and not prominent; aperture circular with no neck but a prominent rounded lip.

Length up to 1 mm.

Distribution.—Schwager originally described this species from the Pliocene of Kar-Nicobar.⁹ His original figure shows a slender test with an elongate neck. Recent specimens have practically no neck and are stouter than the typical form. Whether they represent a new species or a variety of Schwager's species is a question. Brady's specimens were of this varietal form. His records are "off the coast of South America, south of Pernambuco, 350 fathoms; shore-sand, east coast of Madagascar; off Kandavu, Fiji Islands, 210 fathoms; off New Hebrides, 125 fathoms; Torres Strait, 3 to 11 fathoms; off Ki Islands, 129 fathoms; and off the Philippines, 95 fathoms." Millett's records are from the Malay Archipelago and Dakin's from Ceylon, both probably based on Brady's figures. Egger's records are dubious. I have had this varietal form from off Hawaii, 114 fathoms: off Guam, 234 fathoms: southeast of the Bonin Islands in

⁹ *Novara-Exped.*, Geol. Theil, vol. 2, 1866, p. 251, pl. 7, fig. 99.

1,618 fathoms, and from nine stations in the Philippine region, ranging in depths from 78 to 554 fathoms.

Heron-Allen and Earland record the species from the Kerimba Archipelago¹⁰ as follows:

At Stn. 10 the specimens are of a regular type, cylindrical in section, similar to Brady's figures. At Stn. 11 the specimens are large, oval in section, and characterized by a bifarine arrangement of the middle chambers, the septa, which are limbate, running in a zigzag direction. The shells thus appear to present a transition type between *S. striata* and *S. bifrons* Brady.

The figured specimens from the Kerimba region show specimens which seem to belong to *Bolivina* or *Bifarina* and not to *Siphogenerina*, nor do they suggest *S. bifrons*, which is a very well characterized species, even though it has a striate variety. The ornamentation of the figured specimens suggests *Bolivina* rather than *Siphogenerina*.

SIPHOGENERINA IRREGULARIS (Bagg)

Plate 1, figs. 11, 12

Sagrina irregularis BAGG, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 152, pl. 5, figs. 8-10.

Siphogenerina irregularis CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 109, pl. 47, figs. 6, 7.

Description.—Test elongate, subcylindrical; chambers somewhat irregular, but becoming uniserial in the last-formed portion; sutures distinct, depressed; wall thin, translucent, surface with numerous, slightly raised, longitudinal costae; apertural end of the chamber depressed, the aperture with a long slender cylindrical neck and slightly flaring lip.

Length, 0.75-1.50 mm.

Distribution.—Nothing is known of this species outside the region of the Hawaiian Islands. Bagg originally described it from *Albatross* collections off the Hawaiian Islands in 275-384 fathoms. I later had it from *Albatross* and *Nero* stations in the same region, in 268-392 fathoms.

The distinguishing characters of the species are the thin wall, numerous longitudinal costae, and especially the peculiar way in which the apertural neck is set down into a depression of the last-formed chamber.

Young specimens which have not yet developed the uniserial character very strongly resemble *Uvigerina nitidula* Schwager.¹¹ I have recorded it from the Lower Oligocene (Prof. Pap. 133, U. S. Geol. Surv., 1923, p. 35) but these specimens probably belong elsewhere.

¹⁰ Trans. Zool. Soc. London, vol. 20, 1915, p. 677.

¹¹ *Novara-Exped.*, Geol. Theil., vol. 2, 1867, pl. 7, fig. 93.

SIPHOGENERINA STRIATULA Cushman

Plate 1, fig. 10a, b

Siphogenerina striatula CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 108, pl. 47, fig. 1.—YABE and HANZAWA, Jap. Journ. Geol. Geog., vol. 2, No. 2, 1923, p. 32.

Description.—Test elongate, subcylindrical; chambers mostly broader than long, the last-formed one nearly as long as broad; sutures distinct, slightly depressed; surface ornamented with very fine, longitudinal striae; aperture narrowly elongated, without a definite neck but with a well-developed lip.

Length about 1 mm.

Distribution.—I originally found this species in material from numerous stations between Yokohama and Japan, at depths ranging from 859 to 1,660 fathoms. Yabe and Hanzawa record it as rare from the Pliocene shell beds of Nojima, Japan.

It would seem, therefore, that it is a species of the northwestern Pacific. The finely striate surface and elongate aperture are characteristic.

SIPHOGENERINA LAMELLATA Cushman

Plate 1, fig. 13

Siphogenerina lamellata CUSHMAN, Bull. 676, U. S. Geol. Surv., 1918, p. 55, pl. 12, fig. 3.

Description.—Test elongate, tapering gradually from the initial end, broadly rounded at the apertural end; chambers comparatively few, indistinct, surface ornamentations consisting of several equidistant, longitudinal lamellae extending from the initial end to the apertural end, where they fuse; aperture with a tubular neck and phialine lip.

Length 1 mm.

This species is known only from the Miocene of Florida, from the Choctawhatchee Marl, one mile south of Red Bay, Florida. Its nearest relative is *S. spinosa* Bagg from the Miocene of Maryland, but the Florida species has much stronger developed lamellae and no evidence of a spinose base.

SIPHOGENERINA SPINOSA (Bagg)

Plate 1, fig. 14

Sagrina spinosa BAGG, Maryland Geol. Surv. (Miocene), 1904, p. 480, pl. 133, fig. 11.

Siphogenerina spinosa CUSHMAN, Bull. 676, U. S. Geol. Surv., 1918, p. 55.

Description.—The original description of this species is as follows:

This peculiar and interesting species somewhat resembles *S. raphanus* Parker and Jones, but differs from the latter in several particulars. The surface ridges in our specimen end in a series of projecting points which at the distal end become definite spines, though these are short and stubby. Again there are arched

ridges between these costae which, while they may not indicate the internal structure of the chambers, serve to mark their location. The aperture ends in a neatly raised, phialine, everted lip with central rounded orifice.

Length about 1 mm.

The type specimen is from the Miocene, Choptank Formation, Jones Wharf, Maryland. I have had this specimen for study, and the sutures seem much more clearly marked than in the figure. It is a microspheric specimen.

It is related to *S. lamellata* Cushman, which is a more extremely lamellate species.

SIPHOGENERINA COLUMELLARIS (H. B. Brady)

Plate 2, figs. 4, 11; plate 3, figs. 1-4; plate 4, figs. 5, 6; plate 5, figs. 9-11

Sagrina columellaris H. B. BRADY, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 64; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 581 pl. 75, figs. 15-17.—CHAPMAN, Proc. Zool. Soc. London, 1895, p. 36.—FORNASINI, Rend. Accad. Sci. Bologna, vol. 1, (1896-97) 1897, p. 55, text figure; Mem. Accad. Sci. Ist. Bologna, ser. 5, vol. 8, 1900, p. 391, fig. 41.—CHAPMAN, Journ. Linn. Soc. Zool., vol. 28, 1902, p. 404.—MILLETT, Journ. Roy. Micr. Soc., 1903, p. 270, pl. 5, figs. 10, 11.—BAGG, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 151.—HERON-ALLEN and EARLAND, Trans. Zool. Soc. London, vol. 20, 1915, p. 676.—SIDEBOTTOM, Journ. Roy. Micr. Soc., 1918, p. 148, pl. 5, fig. 24.—HERON-ALLEN and EARLAND, British Antarctic Exped., Zoology, vol. 6, 1922, p. 185; Journ. Linn. Soc. Zool., vol. 35, 1924, p. 626.

Siphogenerina (Sagrina) columellaris EGGER, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 316, pl. 9, figs. 28, 31, 33.

Siphogenerina columellaris SILVESTRI, Atti Pont. Accad. Nuovi Lincei, ann. 55, 1902, p. 1, figs. 1, 2.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 104, pl. 47, figs. 2, 3; Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 276, pl. 56, fig. 1; Publ. 342, Carnegie Inst. Washington, 1924, p. 29, pl. 8, figs. 5, 6.

Siphogenerina glabra SCHLUMBERGER, Feuille des Jeunes Naturalistes, 1883, p. 118, pl. 3, fig. 1.

Description.—Test elongate, subcylindrical, somewhat tapering, straight or very slightly curved; chambers comparatively few, those of the uniserial portion well rounded, shorter than broad; sutures only slightly constricted; aperture large, terminal, with a very short tubular neck and broad flaring lip; wall smooth.

Length about 1 mm.

Distribution.—Brady's *Challenger* records for this species are as follows: "Off Gomera and off Palma, Canaries, at 600 fathoms and 1,125 fathoms, respectively; off the Azores, 450 fathoms; off Pernambuco, 350 fathoms; on the shore at Tamatave, Madagascar; at three stations on the southeast coast of Australia, 6 fathoms to 410 fathoms; and at five amongst the islands of the South Pacific, 125 to 620 fathoms." Chapman records it from the Arabian Sea and off Funafuti; Millett from the Malay Archipelago; Bagg from the region

of the Hawaiian Islands; Sidebottom from the east coast of Australia, and Heron-Allen and Earland, the Kerimba Archipelago, from Lord Howe Island, and from the Antarctic Expedition. Egger's specimens were from off western Australia and Mauritius.

I have recorded the species from numerous stations in the North Pacific from Hawaii to Japan; in the Philippine region, and from Samoa.

Unless more than one species is involved, this is much more widely distributed than other species of the genus.

Egger records it from the Cretaceous of central Europe, but his figure in end view certainly does not have the apertural characters of *S. columellaris*.

SIPHOGENERINA COLUMELLARIS (H. B. Brady), var. NODOSAROIDES Schubert

Sagrina raphanus PARKER and JONES, var. *nodosaroides* SCHUBERT, Abhandl. geol. Reichs., vol. 20, pt. 4, 1911, p. 88, text figures 8, 9a, b.

Under the above name Schubert figures a very long, slender form, with smooth surface and 14 chambers in the uniserial portion. There is no neck or lip, and the entire appearance is that of *S. columellaris* rather than *raphanus*, and it apparently should be placed as a variety of the former. It is more slender than the typical, and has a few more chambers. The type of the variety was from coral sand of Maria Island in the Paumotu Group.

SIPHOGENERINA COLUMELLARIS (H. B. Brady), var. SEMISTRIATA Schubert

Sagrina raphanus PARKER and JONES, var. *semistriata* SCHUBERT, Abhandl. geol. Reichs., vol. 20, pt. 4, 1911, p. 89, text figures 10a, b.

Schubert describes and figures a form which has the latter half of the test smooth, the earlier portion with numerous slight costae. The general form of the test and the apertural characters very strongly suggest *S. columellaris*. His specimen was from the Pteropod clays of Sainabas in the Bismarck Archipelago, late Tertiary in age.

SIPHOGENERINA HUGHESI Cushman

Siphogencrina hughesi CUSHMAN, Cushman Lab. Foram. Res., vol. 1, pt. 2, 1925, p. 36, pl. 7, figs. 4a, b.

Test elongate, fairly thick, two or three times as long as broad, circular in transverse section; chambers short and broad, the early chambers irregularly spiral, later ones uniserial; sutures distinct and depressed; wall thick, the exterior smooth throughout; aperture terminal, rounded, with a short neck and slight lip.

Length 1 mm. or slightly more; breadth 0.50 mm.

Holotype (Cushman Coll. No. 4364) from the Miocene Monterey shales near Chimney Rock, San Luis Obispo County, California.

The species is named for Donald D. Hughes, paleontologist of California.

SIPHOGENERINA DIMORPHA (Parker and Jones)

Plate 3, fig. 5

Uvigerina (Sagrina) dimorpha PARKER and JONES, Philos. Trans., vol. 55, 1865, p. 420, pl. 18, fig. 18.

Sagrina dimorpha H. B. BRADY, Journ. Roy. Micr. Soc., 1887, p. 915.—H. B. BRADY, PARKER and JONES, Trans. Zool. Soc. London, vol. 12, 1888, p. 225, pl. 45, fig. 6.—GOËS, Kongl. Svensk. Vet. Akad. Handl., vol. 25, No. 9, 1894, p. 52, pl. 9, figs. 510, 511.—KIAER, Rep't. Norwegian Fish. and Mar. Invest., vol. 1, No. 7, 1900, p. 37.—HERON-ALLEN and EARLAND, Trans. Linn. Soc. London, ser. 2, vol. 2, 1916, p. 266.

Siphogenerina dimorpha CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 175, pl. 42, figs. 16-18.

Description.—Test somewhat compressed, very slightly tapering, the greatest width usually near the apertural end; chambers comparatively few, rather broader than high, slightly inflated; sutures distinct, the basal portion in the last-formed chambers sometimes slightly excavated tending to bridge the sutures between the excavations at regular intervals; wall with a coarsely pitted surface; aperture circular, terminal, at the end of a short neck, usually with a distinctly phialine lip.

Length not over 0.60 mm.

Distribution.—This species should be distinguished from the following variety. Parker and Jones figured as their type a specimen from the Abrohlos Bank off Brazil. It must, therefore, be taken as the type, and the Pacific form made a variety.

Atlantic records include the Abrohlos Bank (Parker and Jones: H. B. Brady, Parker and Jones); Bukken and Oster Fiords, near Bergen, Norway (Norman) (Brady) (Goës) (Kiaer); Vest Fiord (Kiaer); low water, Howport, Girvan, Scotland (Robertson) (Brady); west of Scotland, rare (Heron-Allen and Earland); off Gomera, Canaries, and off Culebra Island, West Indies (Brady), and possibly in the South Atlantic, off Ascension Island (Brady).

I have had specimens from off the coast of Georgia, between Cuba and Yucatan, and from three stations in the Caribbean.

It has, therefore, a rather wide Atlantic distribution.

The Pacific form is the following variety:

SIPHOGENERINA DIMORPHA (Parker and Jones), var. PACIFICA, new variety

Plate 2, fig. 9; plate 3, figs. 6a, b

Uvigerina (Sagrina) dimorpha PARKER and JONES (part), Philos. Trans., vol. 155, 1865, p. 420.

Sagrina dimorpha H. B. BRADY (part), Rep. Voy. Challenger, Zoology, vol. 9, 1884, p. 582, pl. 76, figs. 1-3.—BAGG, Bull. 34, U. S. Nat. Mus., 1908, p. 152.—SCHUBERT, Abhandl. geol. Reichs., vol. 20, pt. 4, 1911, p. 86.—SIDEBOTTOM, Journ. Roy. Micr. Soc., 1918, p. 148.—HERON-ALLEN and EARLAND, British Antarctic "Terra Nova," Exped., Zoology, vol. 6, 1922, p. 186.

Siphogenerina dimorpha EGGER, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 317, pl. 9, fig. 30.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 106, pl. 45, figs. 3, 4; Bull. 100, pt. 4, 1921, p. 279, pl. 56, fig. 8.

Description.—Variety differing from the typical in the greater number of uniserial chambers, the cylindrical form of the test, and the much more prominent depressions at the base of the chambers along the sutures.

Distribution.—This variety is widely distributed in the Pacific. Parker and Jones had it from the Red Sea (near the Isle of Shadwan) and Australian coral reefs. Brady had it from off Tahiti, the Ki Islands, and off Kandavu, Fiji. It has occurred off the Hawaiian Islands (Bagg, Cushman), and I have had it from several stations in the western Pacific off Japan and the Bonin Islands, as well as a few stations in the Philippines. Sidebottom records it off the eastern coast of Australia, and Heron-Allen and Earland from several stations off New Zealand. Egger's only station is in the western part of the Indian Ocean.

The only fossil records for this area is that of Schubert, who recorded it in a *Globigerina* marl of late Tertiary age from Panaras in the Bismarck Archipelago and Koch, who records it from the late Tertiary of Kabu, Java.

It may be noted here that Halkyard records this species as occurring in the Blue Eocene Marl of Biarritz.¹² Heron-Allen and Earland note: "The specimens are longer, thinner in the shell wall, and the cusps between the chambers are much less pronounced than in recent types, but in other features they agree tolerably well with *Sagrina dimorpha* Parker and Jones." It would seem, then, as though these Eocene specimens may represent a varietal form more closely allied to the typical Atlantic form than to the Pacific variety.

SIPHOGENERINA VIRGULA (H. B. Brady)

Plate 2, figs. 7, 8; plate 4, figs. 8, 9

Sagrina virgula H. B. BRADY, Quart. Journ. Micr. Sci., vol. 19, 1879, p. 275, pl. 8, figs. 19-21; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 533, pl. 76, figs. 4-7 (not 8-10).—MILLETT, Journ. Roy. Micr. Soc., 1903, p. 271.—HERON-ALLEN and EARLAND, Trans. Zool. Soc. London, vol. 20, 1915, p. 676, pl. 51, figs. 4, 5.—SIDEBOTTOM, Journ. Roy. Micr. Soc., 1918, p. 148.—HERON-ALLEN and EARLAND, British Antarctic (*Terra Nova*) Exped., Zoology, vol. 6, 1922, p. 186.

Siphogenerina (Sagrina) virgula EGGER, Abh. kön. Bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 318, pl. 9, fig. 27.

Siphogenerina virgula CUSHMAN, Publ. 342, Carnegie Inst. Washington, 1924, p. 29, pl. 8, figs. 3, 4.

Description.—Test elongate, somewhat tapering, composed of a number of inflated chambers, the early ones in a uvigerine arrangement, later ones uniserial, the uniserial portion making up most of

¹² Mem. Proc. Manchester Lit. Philos. Soc., vol. 62, 1919, p. 39.

the test, surface hispid; aperture large, terminal, with a broad everted lip, the border of which often has a series of backwardly pointing, long, acicular spines.

Length up to 1 mm.

Distribution.—Except for one record by Brady from the South Atlantic, all other records are from the Indo-Pacific. Brady records it from several South Pacific stations in 12 to 2,075 fathoms. Millett notes it as common in his Malay Archipelago material, and Sidebottom from off the east coast of Australia. Heron-Allen and Earland record it from the Kerimba Archipelago off southeastern Africa and from the Antarctic expedition collections. Egger records it from off western South Africa and off western Australia. I have had abundant material from 50 fathoms at Samoa. Its Indo-Pacific distribution, even though wide, does not include the Philippines nor the islands in the Pacific north of the equator.

It is very distinct from other species of the genus in the development of spines from the edge of the lip.

SIPHOGENERINA MEXICANA, new species

Plate 5, figs. 4a, b

Description.—Test small, elongate, slender, the early portion triserial, tapering from a subacute initial end, the later portion cylindrical, composed of several chambers—up to eight—in a straight line; chambers distinct, those of the later portion inflated; sutures distinct, depressed, especially toward the apertural end; wall with numerous, rather coarse punctae, which are almost entirely confined to the basal half of each chamber, wall toward the early portion of the test with short, longitudinal costae, the later portion of the test smooth, thin, translucent; the apertural end truncate with a broad elliptical aperture connecting with the previous aperture by an internal tubular neck.

Length up to 1 mm.

Type specimens.—(Cat. No. 353174 U. S. N. M.) from Rio Buena Vista, 0.5 kms., 25°E. from Tumbadero Hacienda House, Vera Cruz, Mexico, T. Wayland Vaughan collector. Specimens also are in the United States National Museum collections from other localities in the Alazan clays in the same general region. The species also occurs in the Eocene of the Coastal Plain of the United States.

This species is undoubtedly the ancestor of *S. advena* Cushman, now living in the Gulf of Mexico, the Caribbean Sea, and adjacent regions of the western Atlantic. The living species has taken on a compressed character of the test; the ornamentation of the basal portion is somewhat different, having assumed a spinose condition, but the general characters of the two are very much alike. Both have the basal portion of the uniserial chambers punctate and the distal portion clear, although the relative amount of each is different in the two species.

SIPHOGENERINA ADVENA Cushman

Plate 5, figs. 3a, b

Siphogenerina advena CUSHMAN, Publ. 311, Carnegie Inst. Washington, 1922, p. 35, pl. 5, fig. 2; Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 173, pl. 42, fig. 15.

Description.—Test elongate, somewhat compressed, early portion either triserial or biserial, later portion, which makes up the larger portion of the test, uniserial; chambers numerous, distinct, inflated; sutures somewhat depressed, the early portion and a part of the uniserial portion with fine, longitudinal costae, more or less broken, followed by two or three chambers slightly spinose, after which the remaining chambers are smooth and very finely punctate; aperture elliptical, each one connecting with the preceding by an internal funnel-shaped tube.

Length up to 0.65 mm.

Distribution.—This species was originally described from the Tortugas region of southern Florida in comparatively shallow water. It has also occurred in the western part of the Caribbean off Central America in 382 fathoms, and off the Carolina coast in 168 fathoms. It seems therefore to be a species of the tropical western Atlantic.

A small species was figured by Goes as "*Textularia Pennatula*, var. *aculeata* forma *Bigenerina*",¹³ and he afterwards gave it a new name, *Sagrina pygmaea*.¹⁴ The specimen was from 300 fathoms in the Caribbean Sea. It may possibly be the same as our species, but the figure does not show any surface ornamentation, and his description is inadequate. I have not found his type specimen.

SIPHOGENERINA BIFRONS (H. B. Brady)

Plate 3, figs. 7-9; plate 4, fig. 4

Sagrina bifrons H. B. BRADY, Quart. Journ. Micr. Sci., vol. 21, 1881, p. 64; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 582, pl. 75, figs. 18-20.—MILLETT Journ. Roy. Micr. Soc., 1903, p. 270.—CHAPMAN, Journ. Linn. Soc. Zool., vol. 30, 1910, p. 415.—SCHUBERT, Abhandl. geol. Reichs., vol. 20, pt. 4, 1911, p. 86.—HERON-ALLEN and EARLAND, British Antarctic Exped., Zoology, vol. 6, 1922, p. 186.

Siphogenerina (Sagrina) bifrons EGGER, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, 1893, p. 317, pl. 9, figs. 25, 26, 29.

Siphogenerina bifrons CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 105, pl. 45, figs. 1, 2, 5-7; Bull. 100, vol. 4, 1921, p. 277, pl. 56, figs. 2, 3.

Description.—Test elongate, compressed, straight or very slightly curved, in end view elliptical, median portions of the broad faces somewhat concave, megalospheric form with the initial end broadly rounded and of about the same diameter as the rest of the test, microspheric form with the initial end much more attenuate, grow-

¹³ Kongl. Svensk. Vet. Akad. Handl., vol. 19, No. 4, 1882, p. 79, pl. 5, figs. 165, 166.

¹⁴ Bull. Mus. Comp. Zool., vol. 29, 1896, p. 51.

ing rapidly broader, then contracted where the uniserial portion begins; sutures hardly depressed, distinct, often of clear material, appearing darker than the rest of the test; aperture rounded or elliptical, without a distinct neck but with a slight rounded lip; microspheric form usually the larger.

Length, 0.75–1 mm.

Distribution.—The species was originally described by Brady from a dredging of the *Challenger* in 345 fathoms on the *Hyalonema* ground off southeastern Japan, and was apparently not obtained elsewhere by the *Challenger*. Egger records it from off western Australia but his figures are not at all characteristic, and may not represent the species. Millett's note on his Malay collections is as follows: "Of this rare form a few poor examples occur at several stations." He does not figure them. Chapman records a specimen from off Funafuti in 2,400 fathoms. I had excellent material from stations off southern Japan and the Philippines.

In the fossil state it is recorded by Schubert from the Bismarck Archipelago, and by Heron-Allen from the Antarctic. Egger records it from the Cretaceous of Central Europe, but an examination of the figures he gives shows little in common with the Pacific material, and the Cretaceous material is something else.

The very restricted records for this species seem to show that its main range is from southern Japan to the Philippines, and southward. Most of the records are in considerable depths, and it does not belong to the ordinary "coral-reef fauna," but probably is more widely distributed in the Indo-Pacific than the few records indicate.

SIPHOGENERINA BIFRONS (H. B. Brady), var. SYDNEYENSIS (Goddard and Jensen)

Plate 3, figs. 10a, b

Sagrina sydneyensis GODDARD and JENSEN, Proc. Linn. Soc. New South Wales, vol. 32, 1907, p. 304, pl. 6, figs. 4a, b.

The description given by the authors is as follows:

This species has a straight cylindrical test. The commencement is a large hemispherical chamber, which, however, contains one septum, indicating a uvigerine commencement. The subsequent chambers are short and cylindrical, and do not at first increase in diameter. Subsequently they increase slowly in diameter as well as in length (fig. 4a; pl. 3, fig. 10a). The surface of each chamber is ornamented with minute spines, and two or three extraordinarily large oval pores. The latter are irregularly distributed, but are chiefly found toward the proximal end of each segment. Size: Length, 0.57 mm.

From the figure given by the authors this seems very certainly a varietal form of *S. bifrons* (H. B. Brady).

The specimens were from 300 fathoms, 27.5 miles east of Sydney Heads, New South Wales, dredged by C. Hedley.

SIPHOGENERINA BIFRONS (H. B. Brady), var. STRIATULA Cushman

Plate 2, fig. 6; plate 4, figs. 1-3

Siphogenerina bifrons (H. B. BRADY), var. *striatula* CUSHMAN, Proc. U. S. Nat. Mus., vol. 51, 1917, p. 662; vol. 56, 1919, p. 620; Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 278, pl. 56, fig. 4.

Description.—Variety differing from the typical in having the surface with numerous longitudinal striations, rather more elongate, and the central indented portion deeper and more defined.

The only localities for this variety are in the Pacific. It was originally described from the Philippines, where it occurs at numerous stations in 135 to 554 fathoms with a single record at 1,262 fathoms. I have also had it from off New Zealand.

Heron-Allen and Earland¹⁵ mention feebly striate specimens of *S. bifrons* occurring as fossils.

SIPHOGENERINA AUSTRALIENSIS (Goddard and Jensen)

Sagrina australiensis GODDARD and JENSEN, Proc. Linn. Soc. New South Wales, vol. 32, 1907, p. 299, pl. 6, figs. 3a-c.

The authors describe this species as follows:

This species has a nviglerine commencement, after which it consists of a uniserial row of oval chambers cylindrical in section. The character of the shell is intermediate between *S. dimorpha* and *S. virgula*. The shell is thick and studded with large pits as in *S. dimorpha*. There are also tubercles externally approximating to the spines of *S. virgula*. The neck is as in *S. virgula*.

There is a distinct constriction at the junction of the chambers, and some of the chambers are proceoded outwards into small monticular prominences. (See fig. 3a.) The chambers increase gradually in size.

Under a high power the surface appears as in fig. 3b. On focussing down, canals are seen in the walls, extending from the interior and opening to the exterior in the small tubercles.

Size: Length, 0.7 mm.

Their specimens were from 15 fathoms, off Palm Island, near Townsville, Queensland, collected by C. Hedley.

From the rather poor figures and rather meagre description, it is difficult to discover much as to the relationships of this form.

There is a very slender species with numerous uniserial chambers and 10 to 12 costae, which occurs in the Navarro, Upper Cretaceous clays, one-half mile south of Kemp, Texas. This may be known as *Siphogenerina plummeri* Cushman, new species, and will be figured later.

There are numerous other species assigned by various authors to *Sagrina* which do not seem properly to belong to *Siphogenerina*.

¹⁵ British Antarctic Exped., Zoology, vol. 6, 1922, p. 186.

GENUS PAVONINA d'ORBIGNY

The genus *Pavonina* was originally described by d'Orbigny in 1826¹⁶ in a few words: "Plusiers ouvertures aux loges; test déprimé latéralement; loges concentriques." The type species *Pavonina flabelliformis* is given from Madagascar. There is no specific description, but a figure is given, and the species is illustrated also in the Modèles, No. 56. The early chambers of the Modèle show definitely alternating chambers in the ones I have seen, but neither the 1826 figure nor its modification in 1846¹⁷ show this character. Neither does the more elaborated description of 1846 make any mention of the textularian character of the early chambers. This lack of alternating chambers in the figures given by d'Orbigny so deceived Parker and Jones that in their review of d'Orbigny's 1826 work¹⁸ they conceive the idea that it may belong to the Miliolidae and be a form of either *Peneroplis* or *Orbitolites*. It was therefore not until Brady obtained good material first from the Seychelles¹⁹ and later from the *Challenger* Expedition,²⁰ that the true structure of this species and of the genus became known. Brady correctly placed *Pavonina* in the Textulariidae. Moebius in 1880²¹ described and figured specimens from Mauritius, and still further calls attention to the true structure. Since the excellent figures given by Brady also in the *Challenger* Report²² little further needs to be added to this particular species, but since that date other species have been distinguished. These will be noted later.

Genus PAVONINA d'Orbigny, 1826

Pavonina d'ORBIGNY (type, *P. flabelliformis* d'Orbigny), Ann. Sci. Nat., vol. 7, 1826, p. 260; Foram. Foss. Bass. Tert. Vienne, 1846, p. 72.—H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 274.—CHAPMAN, The Foraminifera, 1902, p. 169.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 30; Bull. 104, pt. 3, 1922, p. 51.

Description.—Test calcareous, hyaline, perforate, many-chambered, the early chambers biserial, alternating, the later ones uniserial, broad, curved, in the type species becoming embracing, this later series finally composed of one or more chambers; sutures limbate; wall usually thin and translucent, coarsely perforate; apertural wall with one or more rows of rounded apertural openings.

The genus is known both in the Tertiary and in the present ocean, represented by several species.

¹⁶ Ann. Sci. Nat., vol. 7, 1826, p. 260.

¹⁷ Foram. Foss. Vienne, 1846, pl. 21, figs. 9 and 10.

¹⁸ Ann. Mag. Nat. Hist., vol. 12, 1863, p. 440.

¹⁹ Ann. Mag. Nat. Hist., ser. 4, vol. 19, 1877, p. 41.

²⁰ Quart. Journ. Micr. Sci., vol. 19, 1879, p. 68, pl. 8, figs. 29, 30.

²¹ Beitr. Meeresfauna Insel Mauritius, 1880, p. 91, pl. 8, figs. 13-15

²² P. 374, pl. 45, figs. 17-21.

PAVONINA FLABELLIFORMIS d'Orbigny

Plate 6, figs. 1-4

- Pavonina flabelliformis* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 260, pl. 10, figs. 10, 11; For. Foss. Vienne, 1846, p. 72, pl. 21, figs. 9, 10.—PARKER, JONES, and H. B. BRADY, Ann. Mag. Nat. Hist., ser. 3, vol. 16, 1865, p. 27, pl. 1, fig. 22.—H. B. BRADY, Quart. Journ. Micr. Sci., vol. 19, 1879, p. 282, pl. 8, figs. 29, 30.—MÖBIUS, Beitr. Meeresfauna Insel Mauritius, 1880, p. 91, pl. 8, figs. 13-15.—H. B. BRADY, Rep. Voy. Challenger, Zoology, vol. 9, 1884, p. 374, pl. 45, figs. 17, 19-22 (not 18).—MILLETT, Journ. Roy. Micr. Soc., 1900, p. 7.—BAGG, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 132.—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 2, 1911, p. 30, figs. 51, 52 (in text).—HERON-ALLEN and EARLAND, Trans. Zool. Soc. London, vol. 20, 1915, p. 632, pl. 48, figs. 1-6; Journ. Linn. Soc. Zool., vol. 35, 1924, p. 619; Journ. Roy. Micr. Soc., 1924, p. 141, pl. 8, fig. 22.
- Pavonina flabelloides* BRONN, Klassen und Ordnungen Thier-Reichs, vol. 1, 1859, p. 72, pl. 6, figs. 13a, b.—BÜTSCHLI, in Bronn, Klassen und Ordnungen Thier-Reichs, vol. 1, 1880, p. 204, pl. 18, fig. 13.

Description.—Test free, many-chambered, much compressed, the early portion consisting of a few small chambers arranged biserially, the later chambers curved, spreading, uniserial or divided into more than one in each curve, in adults often with the chambers becoming almost annular; sutures somewhat limbate, depressed, distinct; wall thin and transparent, coarsely and irregularly punctate, the wall about these punctae often thickened and slightly raised; apertures in one or more linear rows about the periphery of the test, the peripheral face concave; color white.

The diameter of the test rarely exceeds 1 mm.

The species has an interesting distribution. The early specimens of d'Orbigny were from Madagascar. It is apparently most abundant in that general region as Heron-Allen and Earland record it very splendidly developed in the Kerimba Archipelago nearby. Brady's records of this species are "Madagascar, shore sand; Seychelle Islands, shallow water; Port Louis, Mauritius, harbor mud; off Calpenty, Ceylon, 2 fathoms; off Raine Island, Torres Strait, 155 fathoms; Nares Harbor, Admiralty Islands, 17 fathoms; and Honolulu Reefs, 40 fathoms." He records it also from Millett's collection from the coast of Korea. Moebius had material from Mauritius. Millett records a solitary specimen from his Malay Archipelago collections. Bagg had it from *Albatross* station D 4174, off the Hawaiian Islands, and I have had it from Nero station 2042 in 55 fathoms, also off Honolulu, Nero station 201, in 1,033 fathoms near Midway Island, and station 1310 in 518 fathoms, near the Bonin Islands. There is a single specimen in *Tanager* collections from 31 fathoms off Dowsett Reef, to the northwestward of the Hawaiian Islands. Heron-Allen and Earland record it from Lord Howe Island in the South Pacific.

Specimens are recorded from the Miocene (Filter Quarries) of Victoria by Heron-Allen and Earland.²³ I have had specimens from the same locality, but none of them show the embracing chambers of typical recent specimens, and the surface ornamentation seems different. Howchin²⁴ records the species from the Eocene of Muddy Creek, Victoria, but does not figure it.

The figures of this species given by Heron-Allen and Earland from the Kerimba region show very beautiful tests. The largest of their specimens figured is slightly more than a millimeter in diameter.

Pavonina flabelliformis is replaced in the Atlantic by the following species:

PAVONINA ATLANTICA Cushman

Plate 6, figs. 5, 6

Pavonina flabelliformis H. B. BRADY (in part) (not d'Orbigny), Rep. Voy. *Challenger*, vol. 9, 1884, p. 374, pl. 45, fig. 18 (not 17, 19–21).—WOODWARD, *The Observer*, vol. 4, 1893, p. 104.

Pavonina atlantica CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 3, 1922, p. 51, pl. 19, fig. 1.

Description.—Test subtriangular, slightly longer than broad, initial end with a short spine, very much compressed, the sides carinate; chambers comparatively few, the earliest ones alternating, biserial, those of the adult uniserial, broad, and low, extending across the width of the test, slightly curved backwards at the ends; sutures somewhat limbate, wall thin and translucent, finely perforate; apertures numerous on the terminal wall of the last-formed chamber.

Length up to 0.5 mm.

The type specimen of this species is from off Sand Key, Florida, in 92 fathoms. It was also found at stations off Florida and in the Tortugas lagoon. The specimens recorded by Brady as *P. flabelliformis* from off Culebra Island in 390 fathoms are this species. Plate 45, Figure 18, of the *Challenger* Report is from this station. Figures 19 and 20 are *P. flabelliformis* from shore sand of Tamatave, Madagascar, and Figure 21 is from off Calpentyn, Ceylon in 2 fathoms. I have no data for Figure 17, but it is probably from Madagascar.

Brady's figure (pl. 45, fig. 18), shows the traces of the lateral carinae characteristic of *P. atlantica*.

Pavonina atlantica in its very triangular form throughout instead of the circular form of *P. flabelliformis* is very distinctive. In this character *P. atlantica* is nearer to the following species:

²³ Journ. Roy. Micr. Soc., 1924, p. 141, pl. 8, fig. 22.

²⁴ Trans. Proc. Roy. Soc. So. Australia, vol. 12, 1889, p. 7.

PAVONINA MEXICANA new species

Plate 6, figs. 7-9

Description.—Test large, about as long as broad, roughly triangular, gradually tapering to the somewhat truncate base, much compressed; chambers numerous, the earlier ones biserial, the later ones very elongate, uniserial, apertural end rounded, sutures slightly limbate, sometimes beaded; wall slightly arenaceous, but smoothly finished; apertures about the peripheral face.

Length up to 1.25 mm.

Type specimens.—(Cat. No. 353173 U.S.N.M.) from the Tertiary of Mexico. This is in the Alazan Clay of Rio Buena Vista, 0.5 kms. 25° E. from Tumbadero Hacienda House, state of Vera Cruz, T. W. Vaughan, collector.

This is the only known locality for this species but it was in some numbers at this place. In the early development there is a spiral arrangement of the chambers before the alternating character is taken on showing the relation of *Spiroplecta* and *Textularia*, as in other genera of the Textulariidae. This coiling brings the proloculum and early chambers some distance in from the periphery. Often the proloculum is large, apparently megalospheric, and is thicker than the rest of the test, giving an umbonate appearance to the early portion.

This Tertiary species is apparently the largest of the genus.

PAVONINA ADVENA Cushman

Pavonina advena CUSHMAN, U. S. Geol. Survey Prof. Paper 133, 1923, p. 24, pl. 1, fig. 10.

Test of comparatively few chambers, only the very early ones showing a trace of the biserial arrangement; succeeding chambers rapidly increasing in width until an annular chamber is developed; wall thin, translucent, finely punctate, otherwise smooth.

Diameter slightly less than 0.50 mm.

This somewhat resembles *P. flabelliformis*, which is characteristic of certain parts of the Indo-Pacific region in shallow water but which has much coarser pores. It is less closely like *P. atlantica*, which I have described from material obtained off the Florida coast.

The types were from U. S. G. S. station 7376, from Byram marl, Lower Oligocene, Leaf River, Miss.

There are two other species described from the Tertiary of Europe, *Pavonina agglutinans* Schubert and *P. liburnica* Stache, but I have been unable to obtain specimens of these.

Pavonina liburnica Stache²⁵ does not from the figures seem to be a species of this genus, and it is difficult to place it without seeing type material.

²⁵A bhandl. k. k. geol. Reichs., vol. 13, 1889, p. 89, pl. 5a, figs. 1-10.

EXPLANATION OF PLATES

PLATE 1

- FIGS. 1, 2. *Siphogenerina raphanus*. Original figures. $\times 30$. Specimens from "East Indian Seas."
- 3, 4. *Siphogenerina raphanus*. $\times 40$. Specimens from the North Pacific. Figure 3, megalospheric; figure 4a microspheric; 4b, end view.
5. *Siphogenerina raphanus*, var. *tropica*. $\times 66$. Microspheric specimen.
6. *Siphogenerina raphanus*, var. *transversus*. $\times 35$.
- 7-9. *Siphogenerina branneri*. (After Bagg.) $\times 23$. From the Miocene-Monterey shale of California. Figure 7, microspheric form, type specimen; figures 8, 9, megalospheric forms. Figure 8, *Sagrina californiensis*; figure 9, *Sagrina elongata*.
- 10a, b. *Siphogenerina striatula*. $\times 75$. a, front view; b, apertural view. From the North Pacific.
- 11, 12. *Siphogenerina irregularis*. $\times 75$. Figure 11a, front view; b, apertural view; figure 12, median section of last two chambers. From off the Hawaiian Islands.
13. *Siphogenerina lamellata*. $\times 60$. Miocene, one mile south of Red Bay, Florida.
14. *Siphogenerina spinosa*. (After Bagg.) $\times 40$. From the Miocene, Jones Wharf, Maryland.

PLATE 2

- FIGS. 1, 2. *Siphogenerina raphanus*. $\times 65$. Figure 1, microspheric; figure 2, megalospheric. Specimens from Samoa.
3. *Siphogenerina raphanus*. $\times 50$. Megalospheric specimen from Tortugas region, Gulf of Mexico.
4. *Siphogenerina columellaris*. $\times 65$. Specimen from the Philippines.
5. *Siphogenerina striata*, var. *curta*. $\times 65$. Specimen from the Philippines.
6. *Siphogenerina bifrons*, var. *striatula*. $\times 65$. Specimen from the Philippines.
- 7,²8. *Siphogenerina virgula*. $\times 65$. Specimens from Samoa.
9. *Siphogenerina dimorpha*, var. *pacifica*. $\times 65$. Specimen from the Philippines.
10. *Siphogenerina raphanus*. $\times 75$. Later chambers by transmitted light, showing central tubes.
11. *Siphogenerina columellaris*. $\times 65$. Microspheric specimen from Samoa.

PLATE 3

- FIGS. 1,²2. *Siphogenerina columellaris*. $\times 100$. Sections. (After Silvestri.) Figure 1, megalospheric; figure 2, microspheric form.
3. *Siphogenerina columellaris*. $\times 75$. Specimen by transmitted light.
- 4a, b. *Siphogenerina columellaris*. $\times 75$. a, front view; b, apertural view. Specimens from the North Pacific.
5. *Siphogenerina dimorpha*. $\times 30$. Figure of type specimen. (After Parker and Jones.) From the Abrohlos Bank, Atlantic.
- 6a, b. *Siphogenerina dimorpha*, var. *pacifica*. $\times 65$. a, front view; b, apertural view. Specimen from the North Pacific.
- 7,²8. *Siphogenerina bifrons*. $\times 70$. Figure 7, megalospheric, figure 8a, microspheric form, figure 8b, apertural view. Specimens from off Japan.
9. *Siphogenerina bifrons*. $\times 65$. Specimen from the Philippines.
- 10a, b. *Siphogenerina bifrons*, var. *sydneyensis*. (After Goddard and Jensen.) a. $\times 90$; b, showing pores and structure of wall.

PLATE 4

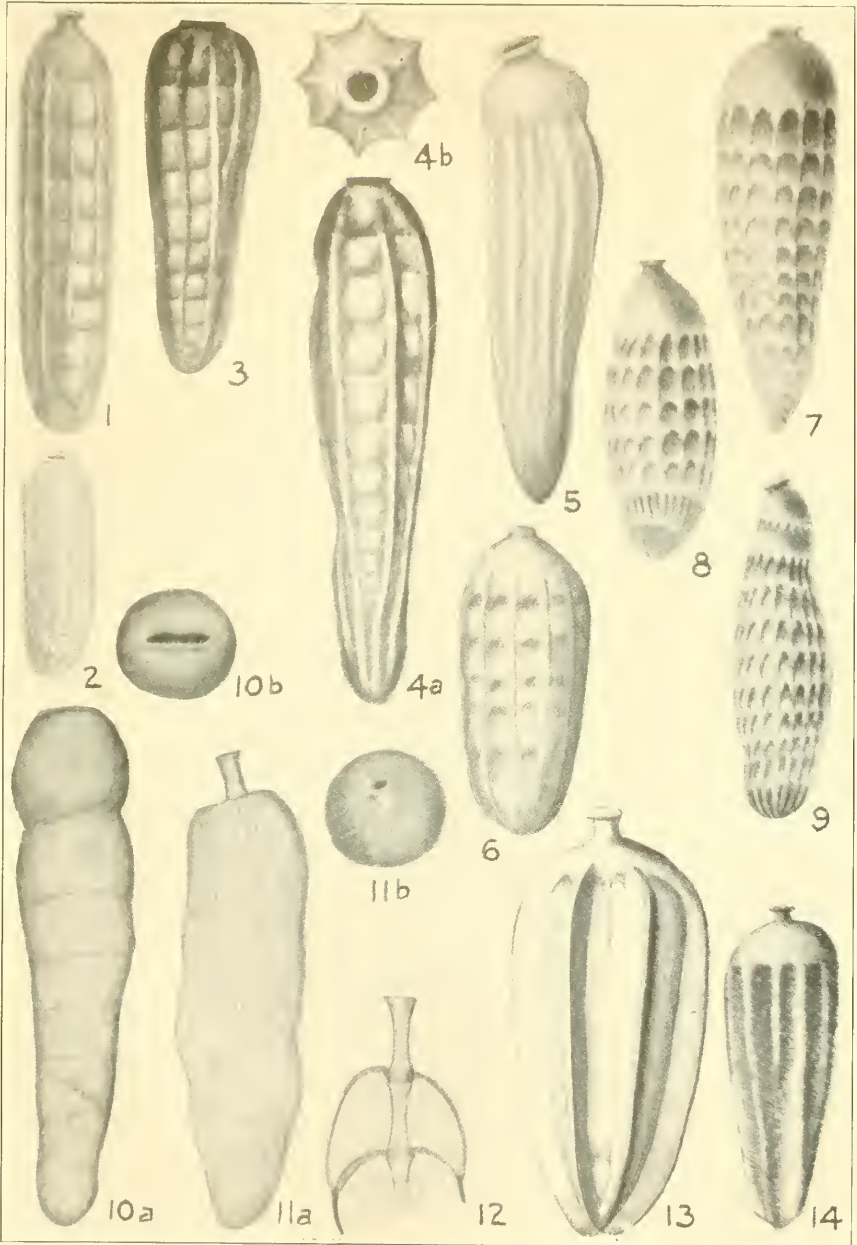
- FIGS. 1-3. *Siphogenerina bifrons*, var. *striatula*. $\times 75$. Specimen from the Philippines.
4. *Siphogenerina bifrons*. $\times 75$. Broken, microspheric specimen. From off Japan.
- 5, 6. *Siphogenerina columellaris*. (After Millett.) $\times 100$. Figure 5, microspheric specimen, showing the internal structure; figure 6, megalospheric form. Specimens from the Malay Archipelago.
7. *Siphogenerina branneri*. $\times 75$. Specimen from the type locality.
- 8, 9. *Siphogenerina virgula*. (After Heron-Allen and Earland.) $\times 100$. Specimens from the Kerimba Archipelago, Southeast Africa.

PLATE 5

- FIGS. 1, 2. *Siphogenerina raphanus*. $\times 75$. Specimens from Porto Rico.
- 3a, b. *Siphogenerina advena*. $\times 75$. a, front view; b, apertural view. Specimens from Tortugas region, Gulf of Mexico.
- 4a, b. *Siphogenerina mexicana*. $\times 75$. a, front view; b, side view. Specimens from the Upper Eocene, Alazan Clay, Mexico.
- 5, 6. *Siphogenerina striata*, var. *curta*. $\times 75$. Specimens from the Philippines.
- 7, 8. *Siphogenerina raphanus*, var. *tropica*. $\times 75$. Specimens from the Philippines.
- 9-11. *Siphogenerina columellaris*. $\times 75$. Figures 9, 10, megalospheric forms from the Philippines; figure 11, microspheric form from Samoa.

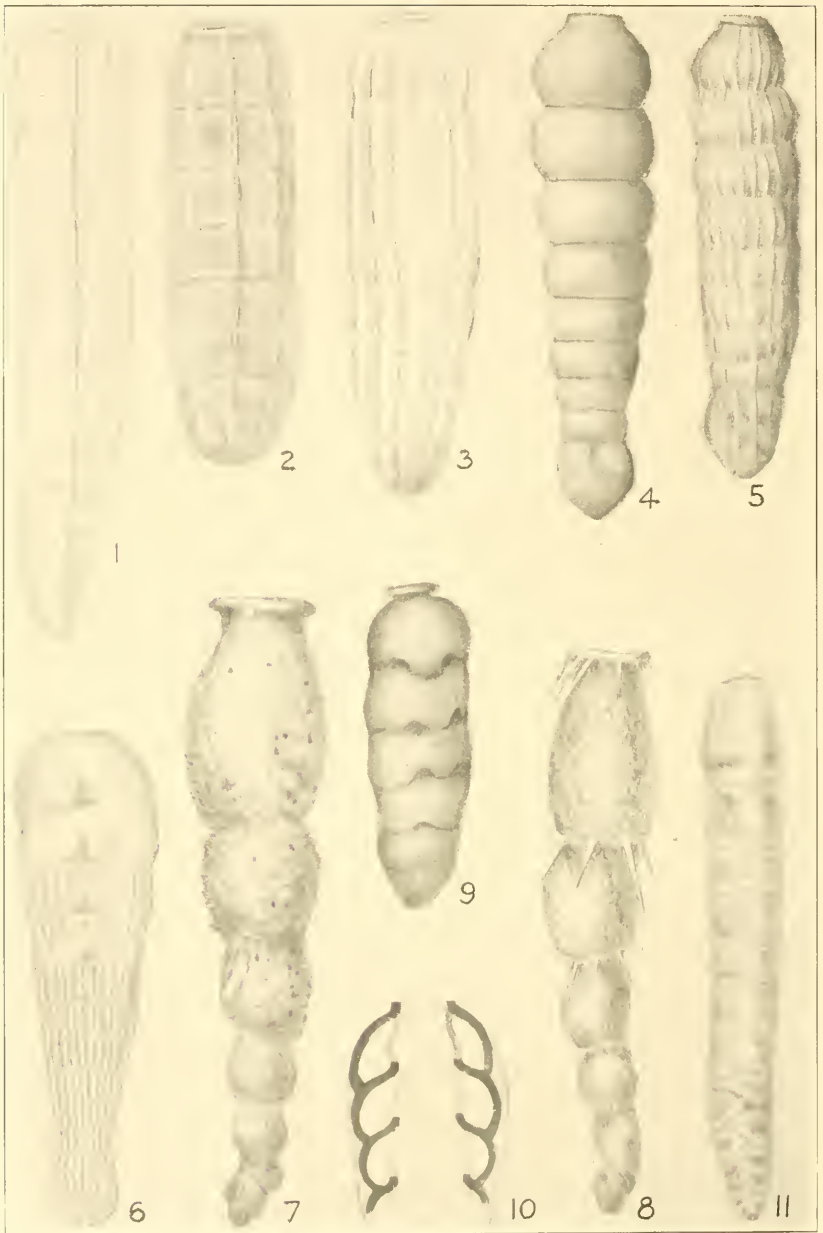
PLATE 6

- FIGS. 1-4. *Pavonina flabelliformis*. (After Heron-Allen and Earland.)
1. Young with the textularian stage just completed. $\times 50$.
 2. Early stage showing the semicircular chambers already developed. $\times 50$.
 3. Adult specimen with the chambers nearly annular. $\times 50$.
 4. Side view of specimen mounted in balsam, showing the arrangement of chambers in the development of the test. $\times 70$. (Specimens from the Kerimba Archipelago.)
- FIGS. 5, 6. *Pavonina atlantica*.
Young specimens from the coast of Florida, showing the textularian young, and the wedge-shaped test instead of the broadly curved chambers of the preceding species. The ornamentation of the biserial portion is much coarser than that of the later uniserial chambers. $\times 100$.
- FIGS. 7-9. *Pavonina mexicana*, new species.
7. Somewhat broken specimen, showing the truncate initial end, the proloculum and spiral chambers followed by a number of textularian chambers. The uniserial chambers show no tendency to become nearly annular. $\times 50$.
 8. A young specimen, showing the details of the early chambers. $\times 100$.
 9. A partially developed specimen. $\times 50$. (Specimens from the Alazan Clays of Mexico.)



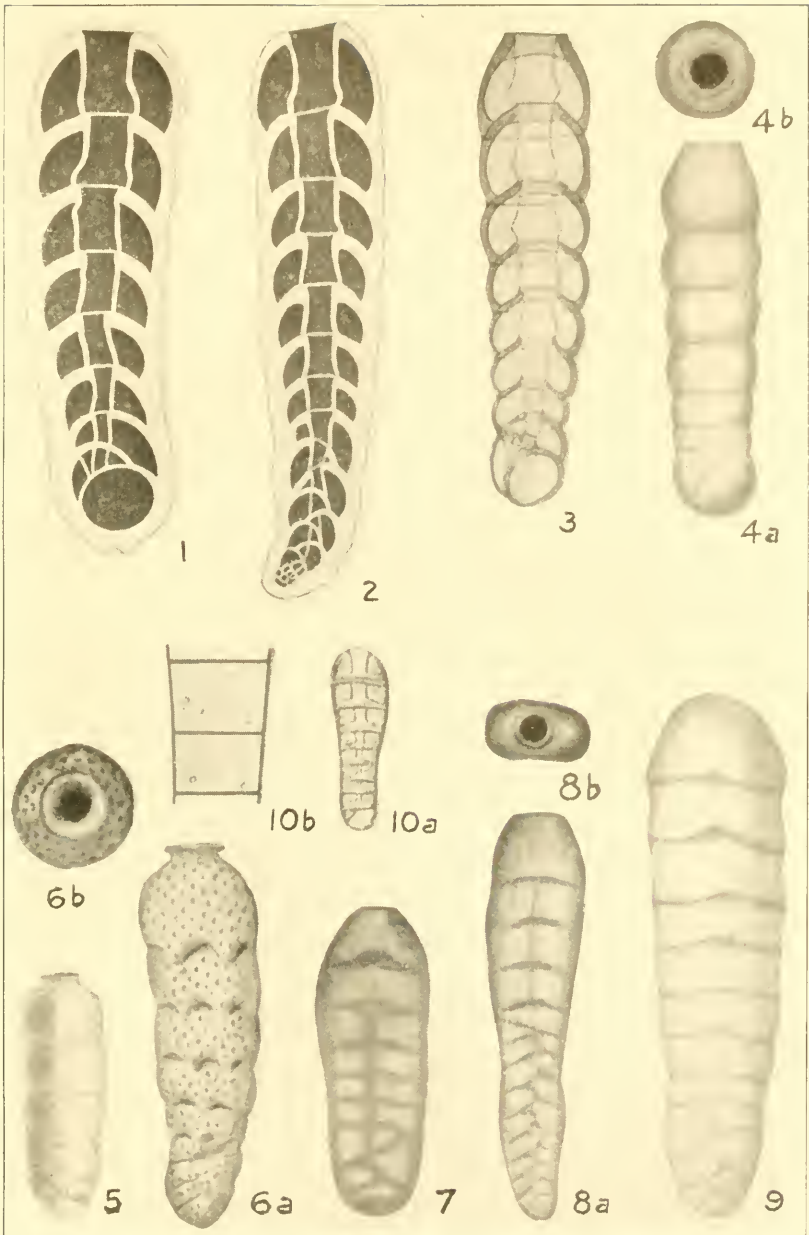
SPECIES OF SIPHOGENERINA

FOR EXPLANATION OF PLATE SEE PAGE 23



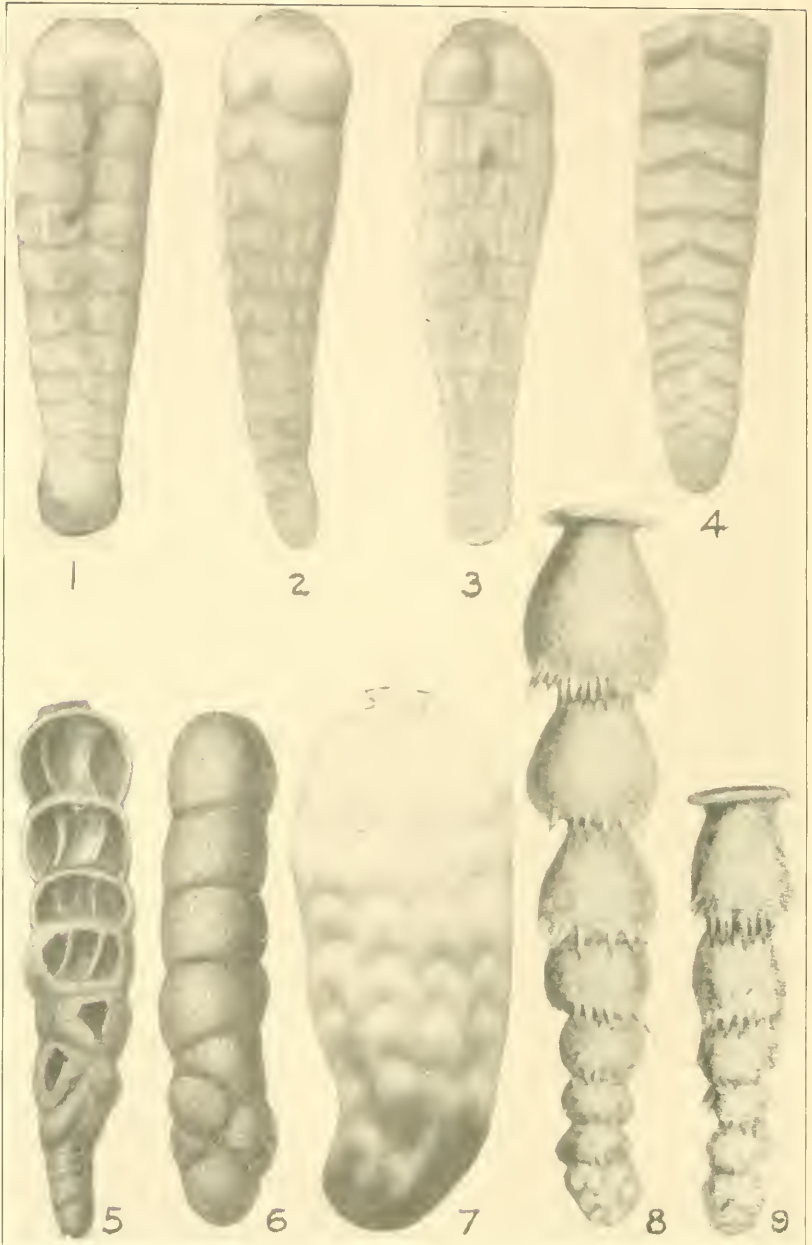
SPECIES OF SIPHOGENERINA

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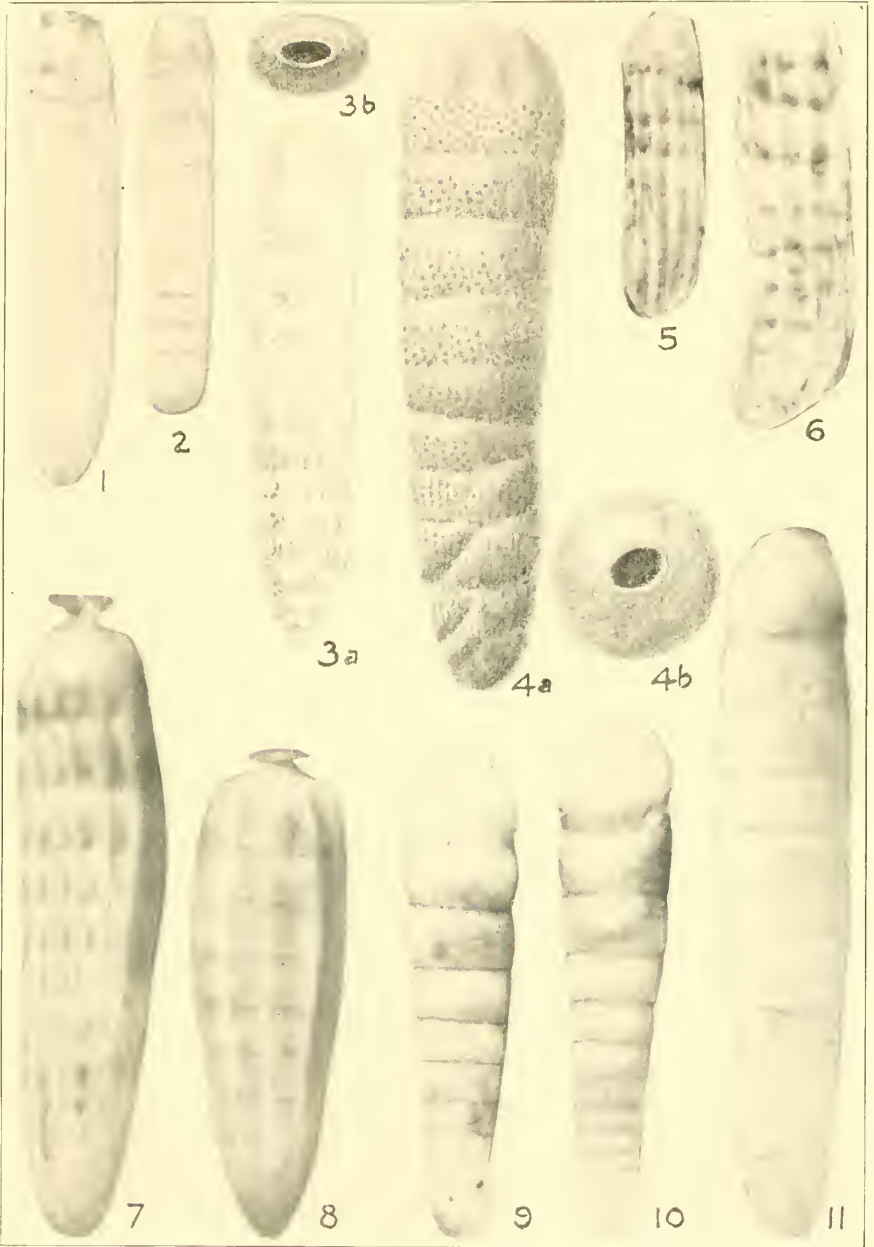
SPECIES OF SIPHOGENERINA

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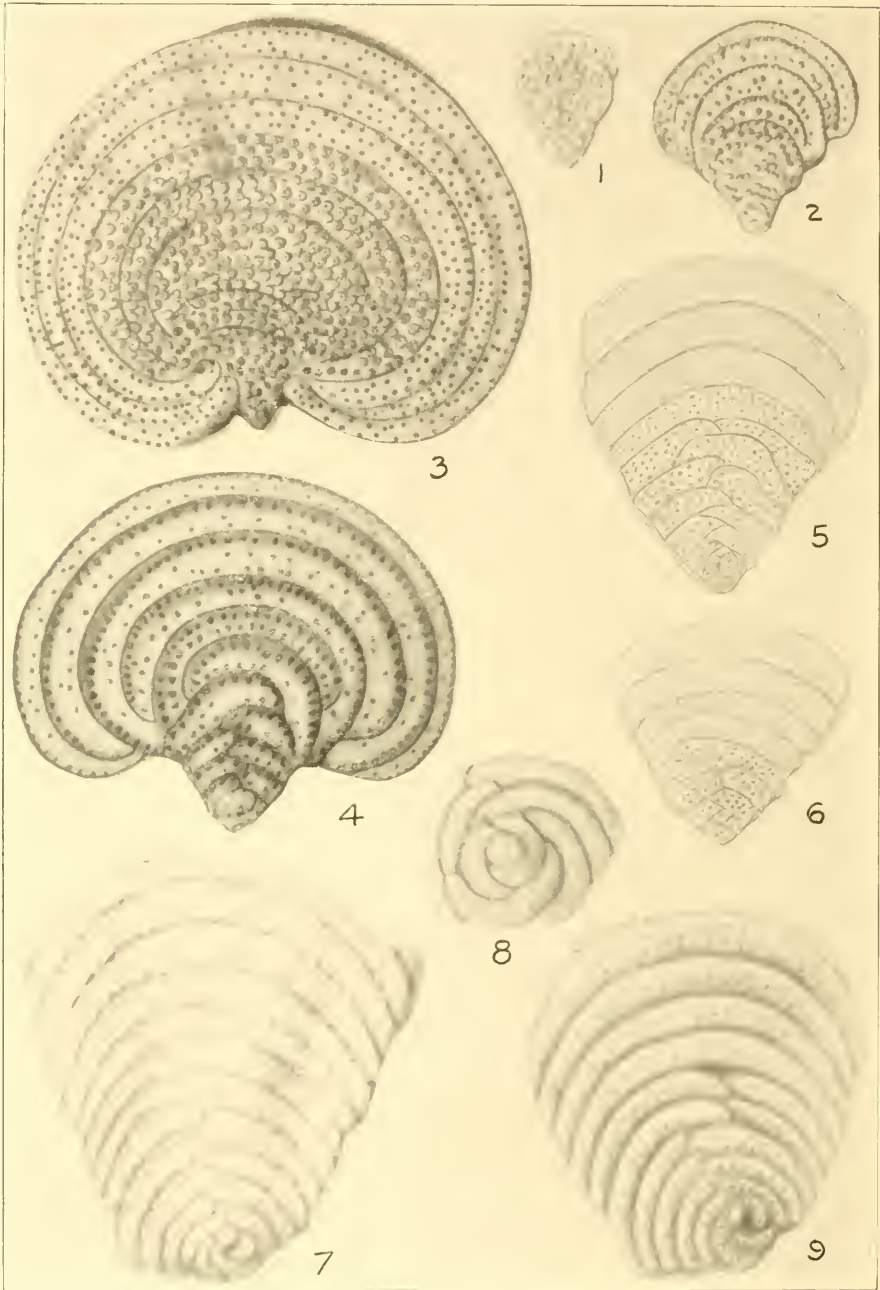
SPECIES OF SIPHOGENERINA

FOR EXPLANATION OF PLATE SEE PAGE 24



SPECIES OF SIPHOGENERINA

FOR EXPLANATION OF PLATE SEE PAGE 24



SPECIES OF PAVONINA

FOR EXPLANATION OF PLATE SEE PAGE 24