CONTRIBUTIONS FROM THE CUSHMAN LABORATORY FOR FORAMINIFERAL RESEARCH

149. NOTES ON THE GENUS TRETOMPHALUS, WITH DESCRIPTIONS OF SOME NEW SPECIES AND A NEW GENUS, PYROPILUS

By JOSEPH A. CUSHMAN

The genus *Tretomphalus* erected by Moebius in 1880 had, until 1915, contained only a single species, *T. bulloides* (d'Orbigny). In 1915, Heron-Allen and Earland gave the name *"Cymbalopora milletti"* to a species earlier figured by Millett from the Malay Archipelago, and referred by him to d'Orbigny's species. In 1924, I described the variety *plana* from Samoa, referring it to d'Orbigny's species as a variety. There are many records for *"bulloides"* from various parts of the world, mostly in the tropics. A review of the material at hand, together with a study of the young stages, has yielded some rather interesting results, not only from the point of view of the new species and distribution, but also of a wider significance in relation to the classification and relationships, not only of the Cymbaloporidae, but also of some of the other families as well.

It has been noted by several authors that two forms develop a final globular chamber, but in each case, the early stages are decidedly different. These two forms will be noted on our Plate 12:—figures 1, 2, 6, 8, and 9 showing the simple form which has a *Discorbis*-like early development, immediately after which a final globular chamber is developed. The other group, represented by the remaining figures, shows species in which, after an early *Discorbis*-like young stage, there are developed chambers in a more or less symmetrical manner about the periphery, somewhat similar to the development seen in *Cymbaloporetta*, after which a final globular chamber is developed. These two forms have sometimes been considered as the microspheric and megalospheric forms of one species, and with the exception of the two

forms mentioned above, have all been referred to d'Orbigny's species. As noted by Heron-Allen and Earland in their notes on *T. milletti*, no *Discorbis*-like form is found with that species, which is one of the most characteristic of the group. I have had numerous specimens of this species from different parts of the Pacific, showing various stages of development, but none of these have developed a globular chamber with a *Discorbis*-like stage. From this, it would seem that the stages developed where the two forms are concerned, should be considered distinct species, and they have been so considered here. It must be admitted however that the form figured by Earland from South Australia (Journ. Quekett Micr. Club, ser. 2, vol. 8, 1902, pl. 16, figs. 3, 5) shows somewhat similarly shaped chambers, although in one case they are all close coiled, and in the other there are no peripheral chambers, although figure 5 would seem to indicate that all the chambers were spiral. The early portion of figure 5 has a coiled development in which the sutures are apparently limbate, but no such stage is seen in figure 3. As drawn, there seems to be no particular difference in the size of the proloculum. These specimens therefore should be subjected to further study.

A study of our material has shown not only that the *Discorbis*-like forms have a different appearance, but have definite characters which, without the final globular chamber, would be considered as very different species. These include the number of chambers in the wall, differences in the sutures, and also in the character of the wall itself. In a similar way, the other group of species shows in the stages before the globular chamber is developed, characters which would separate them also into distinct species. It would seem therefore that we have here two groups of species, each of which develops in its later stages a final, more or less globular chamber, with coarse pores which serve as the apertures at this stage. One of these groups is very definitely connected with *Discorbis*, and without the globular chamber would be described as species of that genus. The other group in their early stages would probably be described as species of *Cymbaloporetta*.

The question therefore arises, whether we have here perhaps two distinct genera which in the final development assume similar structures, or whether these two groups are more closely related than their earlier stages of development would indicate.

The stages in the process of the development of the globular

chamber in the *Discorbis*-like forms are well shown in figure 8, and especially figure 9, where the last-formed chamber becomes more or less globular, and has the outer face with the large pores, but does not develop outside of the regular axis of coiling of the test. In the other group a very definite development to the *Cymbaloporetta*-like stage is evident before the globular chamber is formed on the ventral side, and as an added feature, rather than the development in the same manner as the previous chambers. I have not yet been able to demonstrate to my own satisfaction that there is a definite inner chamber in the simpler *Discorbis*-like forms.

In the development of the globular chamber, it is of interest, and perhaps of real significance, to note that in some of the species, especially the larger ones, of *Cymbaloporetta,* there is developed a peculiar structure on the ventral side. This consists of a convex plate over the somewhat concave umbilical area, and extends over the channels formed between the chambers. The central part of this plate is characterized by very large, circular openings. This structure is therefore somewhat comparable to the inner framework of the final globular chamber in *T. milletti,* as shown in our figure. The arched channels and the coarse perforations are here combined in one simple layer. It seems however that such a structure, developed in a closely related genus, should have some bearing on the development of the complex structures in the final stages of the more highly developed species of *Tretomphalus.* It would seem also to further suggest that the final globular chambers in the species with *Cymbaloporetta*-like early stages may be only a parallelism, and be developed independently of the subglobular chambers in those species with a *Discorbis*-like young.

Another character which also seems of some significance in this problem of relationships is that of the peculiar early stages in the more complex species. It has been noted that in the Cretaceous *Cymbalopora* there is a tendency for the early stages to be completely covered in later growth. Also a gradual change takes place from an arenaceous test with a chitinous inner wall to a purely calcareous test. In all the species here referred to *Tretomphalus,* which have a *Cymbaloporetta*-like young, the early chambers are yellowish-brown in color, due to the inner chitinous layer, which may be easily demonstrated by the use of weak acid which will dissolve the outer calcareous layer and leave

the thin, chitinous, inner layer intact. Also, in most of these species, there is the other character,—the covering of the early stages by a thick layer of calcareous, usually clear material. This same character is seen in the early stages of *Cymbaloporetta* and *Cymbaloporella*.

There is a progressive increase in the number of *Cymbaloporetta*-like chambers on the ventral side in the different species. In *T. milletti, T. planus,* and *T. atlanticus,* the number is typically four in each series. In *T. pacificus,* the number becomes reduced to three. In *T. grandis,* the number in the adult series is typically six. This is in each case the number of chambers in the series just preceding the development of the final globular chamber.

In the material from off Rangiroa in the Pacific, there is a bewildering array of forms which may be referred to *Cymbaloporetta* and *Cymbaloporella,* showing all stages in development,

---

EXPLANATION OF PLATE 11

FIGS. 1, 2. *Tretomphalus bulloides* (d'Orbigny). Fig. 1 (After d'Orbigny's type figures). Fig. 2, Specimen from Dry Tortugas, Florida. × 60. *a, a,* dorsal views; *b, b,* side views; *c, c,* ventral views.

FIGS. 3 *a–c.* *Tretomphalus atlanticus* Cushman, n. sp. × 60. Holotype. *a,* dorsal view; *b,* side view; *c,* ventral view.

FIGS. 4, 5. *Tretomphalus milletti* (Heron-Allen and Earland). Fig. 4, (After Heron-Allen and Earland), × 40. Fig. 5, From 12 fathoms off Levuka, Fiji, × 60. *a, a,* dorsal views; *b, b,* side views; *c, c,* ventral views.

FIGS. 6 *a–c.* *Tretomphalus clarus* Cushman, n. sp. × 80. Holotype. From 21 fathoms off Guam Anchorage, Ladrone Islands.

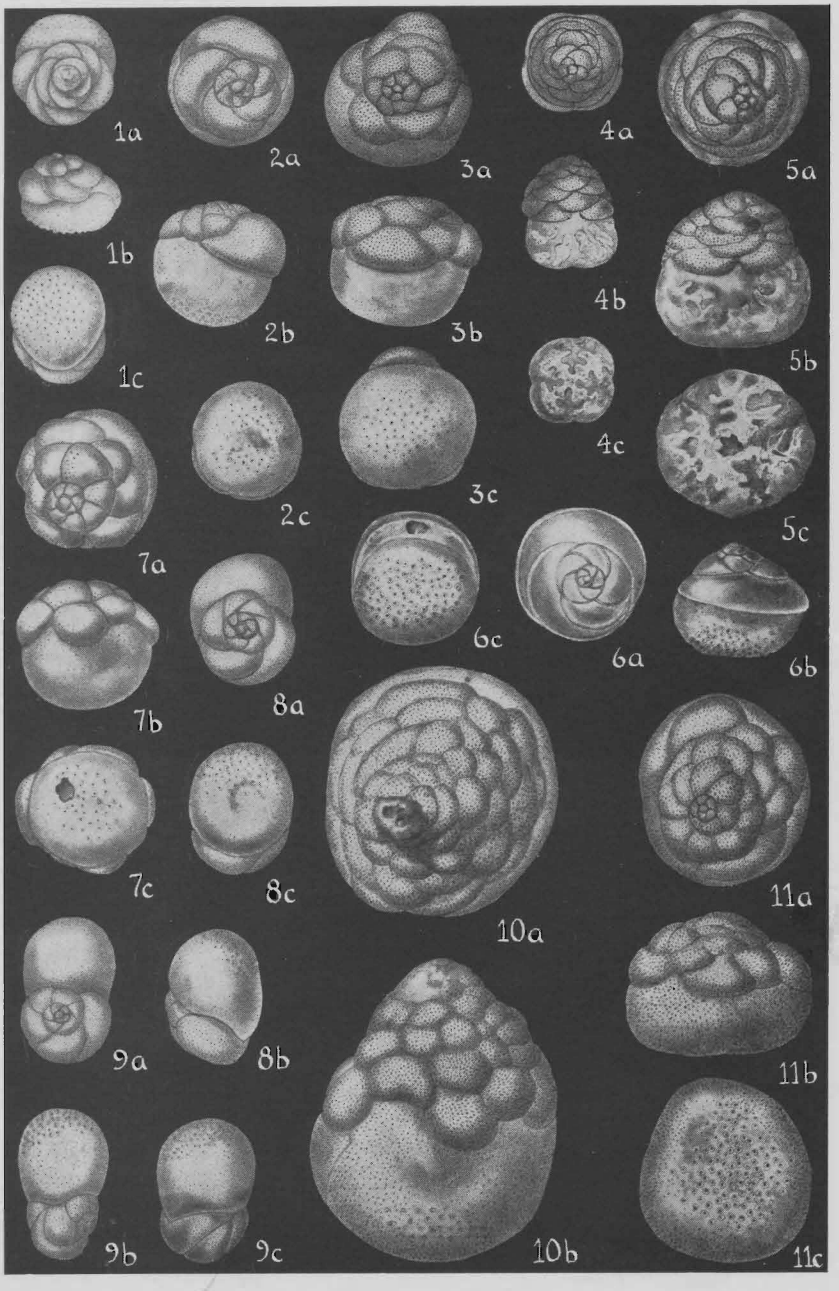
FIGS. 7 *a–c.* *Tretomphalus pacificus* Cushman, n. sp. × 60. Holotype. From Cumberland Bay, Juan Fernandez Island, Chile. *a,* dorsal view; *b,* side view; *c,* ventral view.

FIGS. 8, 9. *Tretomphalus concinnus* (H. B. Brady). × 60. Fig. 8, Surface specimen from off Midway Island. Fig. 9, In 40–50 fathoms off Fiji. *a, a,* dorsal views; *b, b,* side views; *c, c,* ventral views.

FIGS. 10 *a, b.* *Tretomphalus grandis* Cushman, n. sp. × 60. Holotype. From Rangiroa. *a,* dorsal view; *b,* side view; *c,* ventral view.

FIGS. 11 *a–c.* *Tretomphalus planus* Cushman. × 60. From Aua Reef, Pago Pago Harbor, Tutuila, Samoa. *a,* dorsal view; *b,* side view; *c,* ventral view.

Figures drawn by Margaret S. Moore.


1a
2a
3a
4a
5a
1b
2b
3b
4b
5b
1c
2c
3c
4c
5c
7a
6c
6a
6b
7b
8a
10a
11a
7c
8c
11b
9a
8b
9b
9c
10b
11c

the detailed study of which should be instructive in determining the specific limits and the relationships of those two genera.

With this series are specimens in various stages of development of the form here described as *Pyropilus rotundatus* Cushman, n. sp. This, while clearly related to *Cymbaloporella*, has developed further. Instead of stopping with a cyclical series of alternating chambers about a central, ventral, umbilical area, this form continues its development at one end only, with the chambers greatly enlarged, involute, and without definite apertures.

Instead of the apertures of the early stages, the outer face of the chamber develops larger pores which apparently serve as apertures. These are not as large as those of the final chamber of *Tretomphalus*, yet they strongly suggest the structure there developed.

Nothing is clearly known of the habits of life of *Tretomphalus* in its various stages. It has been suggested that it may lose its globular chamber, and settle down as a *Discorbis*. This is however probably the opposite of what actually occurs. From the fact that the surface specimens which were examined by Murray on the *Challenger* voyage, and those that I have examined from the surface tow nets at the Dry Tortugas, had no trace of the ordinary protoplasm, it would seem to indicate definitely that the production of the globular chamber is an end stage in the development of the test. It is probable that the forms are found on the bottom, and that they develop the globular chamber as a means of floating to the surface where the young stages are produced. Murray found actively moving, very small bodies in the globular chamber, and in the others as well. I found the same thing true in the Tortugas material. No sign of flagellae or cilia could be seen however. There is of course the possibility that these might have been spores of some parasitic form, but the fact that it occurs at this stage would seem to indicate that they are the gametes which conjugate and produce the microspheric proloculum. This is a stage which might well be carried through under definite control in some tropical laboratory.

From what is already known of the group, it is to be suspected that there are other species yet to be described, and that there is much to be learned as to the distribution of the species.

TRETOMPHALUS BULLOIDES (d'Orbigny) (Pl. 11, figs. 1, 2; pl. 12, fig. 6)

Rosalina bulloides D'ORBIGNY, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminifères," p. 104, pl. 3, figs. 2-5.

Cymbalopora bulloides CARPENTER, PARKER and JONES, Introd. Foram., 1862, p. 216.

Discorbina bulloides GOËS, Kong. Svensk. Vet. Akad. Handl., vol. 19, 1882, p. 106, pl. 8, figs. 262, 263.

Test in the earlier portion close coiled throughout, *Discorbis*-like, strongly convex, not involute, umbilical region open; chambers distinct, numerous, 4 or 5 in a whorl, elongate, increasing rather regularly in size as added; sutures distinct, very slightly depressed, strongly curved and oblique; wall smooth, finely and evenly perforate, clear, the earliest chambers often yellowish-brown, final chamber usually less than a hemisphere, evenly rounded, clear. Height 0.30 mm.; diameter 0.30 mm.

d'Orbigny gives a good description of this species, and figures it well. His specimens were from sands of Cuba and Haiti. The species has been referred to frequently in the literature, but it is doubtful if any of the records for it, except those given above, are really the same as d'Orbigny's species. I have had specimens for study which seem to show that it is discorbine until the final globular chamber is produced. The ventral side is not symmetrically radiate as in the following species. It is evidently a West Indian species, and is especially distinguished from the other species with *Discorbis*-like early stages:—for example, from *T. concinnus* by the more oblique sutures and longer chambers, and from *T. clarus* by the less oblique sutures and chambers, as well as the distinctly perforate wall instead of the hyaline one of *T. clarus*.

d'Orbigny's original figures are copied on our plate.

TRETOMPHALUS ATLANTICUS Cushman, n. sp. (Pl. 11, figs. 3 a-c; pl. 12, fig. 7)

Cymbalopora (*Tretomphalus*) *bulloides* (part) H. B. BRADY (not D'ORBIGNY), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 638, pl. 102, figs. 10, 11 (not 7-9, 12).—CUSHMAN, Publ. 311, Carnegie Instit. Washington, 1922, p. 42, text figs. 2, 3; Bull. 104, U. S. Nat. Mus., pt. 8, 1931, p. 86, pl. 16, figs. 5 *a-c*.

Test in the earliest portion close coiled, later with chambers becoming arranged radially in fours with deep channels between, earliest portion yellowish-brown, remainder colorless, moderately convex; chambers distinct, numerous, about six to a whorl in the early portion, later becoming radiate and generally triangular on the ventral side; sutures in the earliest portion limbate, later

depressed, curved, but only slightly oblique in the close coiled earliest portion; wall rather coarsely perforate, final chamber usually less than a hemisphere, evenly rounded, clear. Height 0.30 mm.; diameter 0.35 mm.

Holotype (Cushman Coll. No. 21542) from 12 fathoms, 1 mile N. E. of Loggerhead Key, Dry Tortugas, Florida. The species is well distributed in the general West Indian region, as far north as Bermuda, and fairly common about the Tortugas and Jamaica. It occurs at a few *Albatross* stations in the same general region.

Apparently the species is more abundant than *T. bulloides*. The shape of the chambers in the two species is distinctly different, and there is no evidence that the two are forms of the same species, as there is no consistent size in the proloculum of the two. The relative coarseness of the perforations in the two species is very different, giving a peculiar granular, opaque appearance in *T. atlanticus*, while in *T. bulloides* it is less distinctly perforate and much more clear.

The ventral side in *T. bulloides* is like that of *Discorbis*, while in *T. atlanticus* the chambers appear much as in *Cymbaloporetta*, but with four chambers in well developed specimens showing on the ventral side, and definite radiating channels between them. In the earlier description of this form in the Tortugas material taken in tow nets at the surface, the inclusion of what seemed to be swarms of zoospores was noticed, having a rapid movement, but showing no flagellae or cilia. It was supposed that these were a definite stage in the life history of this form, but there is the possibility that they may be merely some sort of parasitic organisms. The early chambers have a distinct, thin lining of a chitinous character, giving a yellowish-brown color to this part of the test. This same character occurs in most of the larger, more complex species.

TRETOMPHALUS MILLETTI (Heron-Allen and Earland) (Pl. 11, figs. 4, 5; pl. 12, figs. 1-5)

Cymbalopora bulloides MILLETT (not D'ORBIGNY), Journ. Roy. Micr. Soc., 1903, p. 697, pl. 7, fig. 4.

Cymbalopora milletti HERON-ALLEN and EARLAND, Trans. Zool. Soc. London, vol. 20, 1915, p. 689, pl. 51, figs. 32-35; Journ. Linn. Soc. Zool., vol. 35, 1924, p. 63.

Tretomphalus milletti CUSHMAN, Publ. 342, Carnegie Instit. Washington, 1924, p. 36, pl. 11, fig. 4; Bernice P. Bishop Museum Bull. No. 27, 1925 (1926), p. 132.

Cymbalopora (*Tretomphalus*) *bulloides* H. B. BRADY (part) (not D'ORBIGNY), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 638, pl. 102, fig. 9 (not figs. 7, 8, 10-12).—CUSHMAN (part), Publ. 342, Carnegie Instit. Washington, 1924, p. 36, pl. 11, figs. 1, 2 (not fig. 3).

The following paragraphs give the original notes of Heron-Allen and Earland in regard to this species:

"The curious type figure by Millett in his Malay Monograph as a variety of *C. bulloides* occurs at practically all the Stns.,

---

EXPLANATION OF PLATE 12

FIGS. 1–5. *Tretomphalus milletti* (Heron-Allen and Earland). Figs. 1–3, × 60. 1, 2, Showing arrangement of chambers on the dorsal side. 3, Specimen with the globular chamber partially broken away. *a*, showing a portion of the outer layer with the apertural pores at the base; *b*, showing one of the grooved channels which are continued from the channels of the last 4-chambered stage represented at *c*. The small opening at the center is through the original umbilical area which is not completely covered by the final chamber; the other large white openings represent the openings through the interior of the test. Figs. 4, 5, × 120. 4, Ventral side of young specimen, showing the *Discorbis*-like stage with two added chambers, *a* and *b*. 5, Ventral view in the early 4-chambered stage.

FIG. 6. *Tretomphalus bulloides* (d'Orbigny). × 90. Ventral side, showing *Discorbis*-like chambers. Dry Tortugas, Florida.

FIG. 7. *Tretomphalus atlanticus* Cushman, n. sp. × 60. Dorsal side. Dry Tortugas, Florida.

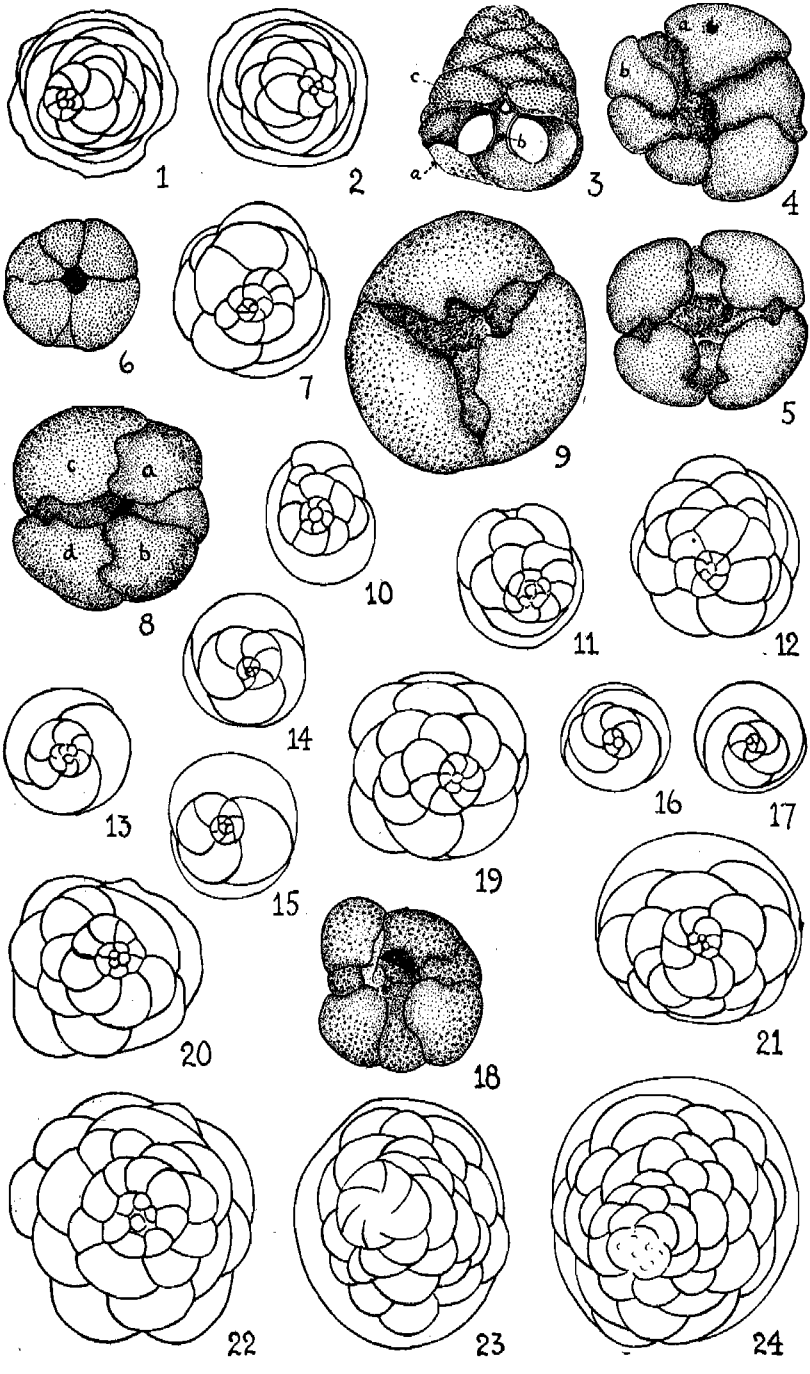
FIGS. 8–12. *Tretomphalus pacificus* Cushman, n. sp. Fig. 8, × 100. Ventral side of early stage, showing *a* and *b*, two chambers of the earlier 4-chambered stage; *c* and *d*, the first two chambers of the 3-chambered stage, the next one of which would cover chambers *a* and *b*. Fig. 9, × 100. Ventral side, showing 3-chambered stage before the final globular chamber is developed. Figs 10–12, × 60. Showing dorsal side of several specimens.

FIGS. 13–15. *Tretomphalus concinnus* (H. B. Brady). × 60. From Fiji.

FIGS. 16, 17. *Tretomphalus clarus* Cushman, n. sp. × 60. Fig. 16, Surface specimen from Rongelab Atoll, Marshall Islands. Fig. 17, From Guam.

FIGS. 18–22. *Tretomphalus planus* Cushman. Fig. 18, × 80. Early stage, showing the beginning of the supplementary chambers added to the *Discorbis*-like stage. From Pinaki Atoll. Figs. 19–22, × 60. Dorsal views. 19, From Fiji. 20, 21, From Samoa. 22, From Guam.

FIGS. 23, 24. *Tretomphalus grandis* Cushman, n. sp. × 60. Dorsal views. From Rangiroa.


1
2
c
b
a
3
a
b
4
6
7
9
5
c
a
d
b
8
10
11
12
14
13
16
17
15
19
20
18
21
22
23
24

and often in considerable numbers, even where the typical *C. bulloides* is wanting. We propose to raise it to specific rank and to associate it with the name of its author, being convinced, after a protracted examination, that the type possesses essential and constant idiosyncrasies. This decision has been arrived at after a careful examination, not only of our own specimens from all over the area of its distribution, but also of a large number of slides, prepared on board H. M. S. 'Challenger' by the late Sir John Murray and placed by him at our disposal.

"The main points of distinction between the two forms may be summarized as follows:—(i.) The rotaline portion is invariably high-domed and mainly acervuline, consisting of a small but well-marked rotaline commencement followed by a number of small but regularly formed acervuline chambers. (ii.) The balloon-chamber presents a curiously wrinkled surface, and in its most typical condition the balloon is superficially divided into four segments by arborescent markings originating from four equidistant points on the peripheral margin of the balloon. Viewed as a transparent object in balsam, it appears that these arborescent markings, which give the balloon-chamber its peculiar wrinkled appearance, are occasioned by constrictions or pleats in the inner or float-chamber, and that the float-chamber is adherent to the balloon-chamber excepting at the lobulations and along the ramifications of the arborescent markings. (iii.) The absence in the vast majority of cases of the umbilical entosolenian tube by which in the normal *C. bulloides* the inner or float-chamber communicates with the balloon and thence with the surrounding medium. (iv.) The absence of the coarse basal perforations on the balloon which are characteristic of the typical *C. bulloides*.

"It would thus appear that in the typical *C. bulloides* the lower half of the shell consists of two distinct hemispherical chambers, one suspended within the other, without actual contact anywhere, the entosolenian tube of the balloon-chamber merely fitting into the depression formed by the corresponding tube of the float-chamber without actual fusion. In *C. milletti*, on the other hand, the internal float-chamber is adherent to and is fused with the balloon-chamber, except at a number of places where the four deep lobulations of the float-chamber pass from its upper peripheral margin to the base of the test, ramifying as they go. These

ramifying passages give to the shell its typical, wrinkled appearance.

"Again, whereas in the typical *C. bulloides* there are always two well-marked forms, as already pointed out, *C. milletti* is, so far as we have observed, always acervuline and within very narrow limits of variation constant both as to size, general appearance, and colour. The test is always high-domed, and the acervuline chambers numerous and regularly formed as compared with acervuline specimens of the typical *C. bulloides*. Specimens are also in nearly all instances of a characteristic brown colour, and the initial discorbine chambers are of the type of *Discorbina concinna* Brady.

"The distribution of *C. milletti* certainly extends all over the tropical Indo-Pacific area, but we have not met with it as yet in the tropical Atlantic.

"In the Brady collection at Cambridge there is a slide of *C. bulloides* from Levuka, Fiji, which contains several specimens of this form. Brady's fig. 9, pl. cii. in F.C. 1884, suggests this wrinkled form in its general appearance, though the essential markings are not reproduced.

"Size variable—average specimens vary between .3 and .4 mm. in total height, of which about .2 mm. represents the acervuline portion of the shell; breadth of balloon-chamber averages .3 mm."

I have here figured specimens and included copies of some of the type figures from the Kerimba Archipelago off southeastern Africa. The species occurs in our material from 12 and 24 fathoms off Nairai, Fiji; from Makemo Lagoon, Paumotu Islands; and from Ocean Island in the North Pacific. It is evidently a widely distributed Indo-Pacific species. Heron-Allen and Earland also record it from Lord Howe Island in the Pacific, and from Levuka, Fiji. Millett's material was from the Malay Archipelago.

This species has a peculiar appearance as the figures show. Pl. 12, fig. 3 shows the details of the globular portion of the test. After the spiral early stage the chambers are developed in fours, equidistant, and with a deep, umbilical area with distinct channels to the exterior between the chambers. The inner portion of the final chamber leaves an opening above the umbilicus as seen in the small, central opening in our figure. The new chamber also leaves the radiate channels as tubes which then continue outward and downward as shallow grooves (*b* in our figure), and these

unite at the base leaving a large central opening which opens to the surface in four rounded areas. This is then covered by a very thin, outer layer (*a*) which is coarsely perforate at the base, and reaches to the base of the last group of four chambers. In some specimens the inner side of this layer has pustule-like thickenings which show through from the exterior as irregular, whitish spots in addition to the elongate, vertical channels which also show through the thin, outer wall. There is no free floating chamber in *T. milletti* as there seems to be in some other species, especially those with *Discorbis*-like young. The smaller chambers are distinct from those of any of the other species. They show very little inflation, and the first portion is rather regularly coiled; after this the chambers are arranged in series of fours. The wall is finely, but distinctly perforate, but the wall is smooth and clear, in this respect somewhat resembling *T. pacificus*, but that species is much more irregular in shape and arrangement of the chambers, and the perforations are larger and irregularly distributed.

As noted by Heron-Allen and Earland, there seems to be no *Discorbis*-like stage in this species which develops a globular final chamber, a character which seems to indicate that the forms previously referred to "*bulloides*" are distinct species.

TRETOMPHALUS PACIFICUS Cushman, n. sp. (Pl. 11, figs. 7 a-c; pl. 12, figs. 8-12)

Tretomphalus bulloides CUSHMAN and WICKENDEN (not H. B. BRADY), Proc. U. S. Nat. Mus., vol. 75, art. 9, 1929, p. 12, pl. 5, figs. 4 *a*, *b* (2, 3?).

Test with the earliest chambers close coiled, later with chambers arranged irregularly about the periphery, finally arranged in series of three; chambers distinct, only slightly inflated, increasing very gradually in size as added, of rather uniform shape in the coiled portion, height and breadth about equal, whole early portion strongly convex; sutures distinct, earliest ones somewhat limbate, later very slightly depressed; wall for the most part clear, with a few, irregularly placed, coarse perforations, the remainder hyaline; the globular chamber forming about a hemisphere, clear, finely perforate. Height 0.35 mm.; diameter 0.30 mm.

Holotype (Cushman Coll. No. 21558) from Cumberland Bay, Juan Fernandez Island, Chile. Besides the type locality the species occurs also in some of the *Albatross* material from this same part of the South Pacific.

unite at the base leaving a large central opening which opens to the surface in four rounded areas. This is then covered by a very thin, outer layer (*a*) which is coarsely perforate at the base, and reaches to the base of the last group of four chambers. In some specimens the inner side of this layer has pustule-like thickenings which show through from the exterior as irregular, whitish spots in addition to the elongate, vertical channels which also show through the thin, outer wall. There is no free floating chamber in *T. milletti* as there seems to be in some other species, especially those with *Discorbis*-like young. The smaller chambers are distinct from those of any of the other species. They show very little inflation, and the first portion is rather regularly coiled; after this the chambers are arranged in series of fours. The wall is finely, but distinctly perforate, but the wall is smooth and clear, in this respect somewhat resembling *T. pacificus*, but that species is much more irregular in shape and arrangement of the chambers, and the perforations are larger and irregularly distributed.

As noted by Heron-Allen and Earland, there seems to be no *Discorbis*-like stage in this species which develops a globular final chamber, a character which seems to indicate that the forms previously referred to "*bulloides*" are distinct species.

TRETOMPHALUS PACIFICUS Cushman, n. sp. (Pl. 11, figs. 7 a-c; pl. 12, figs. 8-12)

Tretomphalus bulloides CUSHMAN and WICKENDEN (not H. B. BRADY), Proc. U. S. Nat. Mus., vol. 75, art. 9, 1929, p. 12, pl. 5, figs. 4 *a*, *b* (2, 3?).

Test with the earliest chambers close coiled, later with chambers arranged irregularly about the periphery, finally arranged in series of three; chambers distinct, only slightly inflated, increasing very gradually in size as added, of rather uniform shape in the coiled portion, height and breadth about equal, whole early portion strongly convex; sutures distinct, earliest ones somewhat limbate, later very slightly depressed; wall for the most part clear, with a few, irregularly placed, coarse perforations, the remainder hyaline; the globular chamber forming about a hemisphere, clear, finely perforate. Height 0.35 mm.; diameter 0.30 mm.

Holotype (Cushman Coll. No. 21558) from Cumberland Bay, Juan Fernandez Island, Chile. Besides the type locality the species occurs also in some of the *Albatross* material from this same part of the South Pacific.

The species is perhaps closest to *T. atlanticus*, but the tendency is for the chambers to be arranged in threes in the most uniform specimens, and the surface appearance is quite different, as the chambers of *T. pacificus* are less individually convex, and the wall with its few, scattered, coarse perforations gives a decidedly different appearance. So far as is known, it is a species of the eastern South Pacific.

From the available specimens there seems to be no free, inner, float chamber, as the upper portion is attached to the under surfaces of the last three chambers formed previously to the formation of the final globular chamber. The outer wall is very thin.

In the earliest stages there is a thin, chitinous, inner layer that gives a yellowish-brown color to that part of the test.

TRETOMPHALUS PLANUS Cushman (Pl. 11, figs. 11 a-c; pl. 12, figs. 18-22)

Tretomphalus bulloides CUSHMAN (not D'ORBIGNY), Bull. 71, U. S. Nat. Mus., pt. 5, 1915, p. 26, pl. 14, figs. 3, 4; Publ. 342, Carnegie Instit. Washington, 1924, p. 36, pl. 11, fig. 3 (not 1, 2).

Tretomphalus bulloides (D'ORBIGNY), var. *plana* CUSHMAN, l. c., 1924, p. 36, pl. 10, fig. 8.

Cymbalopora (*Tretomphalus*) *bulloides* H. B. BRADY (part) (not D'ORBIGNY), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 638, pl. 102, figs. 7 (8, 12?) (not 9-11).

Test with the earliest chambers close coiled, then becoming irregularly placed about the periphery, whole upper portion strongly convex; chambers distinct, inflated, about as broad as high in the early, coiled portion, later ones very irregular in size and shape; sutures distinct, strongly depressed, earliest ones often somewhat limbate, only slightly oblique; wall very coarsely perforate, opaque, fairly thick, the earliest portion yellowish-brown, due to the inner, chitinous lining; final globular chamber usually broad and flattened at the base, usually less than a hemisphere. Height 0.30-0.35 mm.; diameter 0.40-0.45 mm.

The types of this species are from 7 fathoms off the north end of Aua Reef, Pago Pago Harbor, Samoa. The species is fairly common at several stations about Pago Pago Harbor down to 50 fathoms. It also occurs widely distributed about the Pacific Islands, in 12 and 24 fathoms off Nairai, Fiji; in 12 fathoms off Levuka, Fiji; inside lagoon at Pinaki Atoll. Brady's figure 7 in the above reference seems to be this species, and is from surface material in the Pacific.

This species is a more complex one than *T. atlanticus* which it somewhat resembles, although the shape of the coiled chambers is different, and it is a still more coarsely perforate form, tending toward the larger and more complex *T. grandis*.

The final globular chamber is usually distinctly flattened at the base or even slightly concave in the center in some specimens. The globular chamber itself is often conspicuously perforate.

TRETOMPHALUS GRANDIS Cushman, n. sp. (Pl. 11, figs. 10 a, b; pl. 12, figs. 23, 24)

Test large, earliest portion later covered by a thick, clear layer, largely concealing the earlier sutures of the spiral portion, later, and by far the largest portion, with chambers irregularly arranged about the periphery, at this stage on the ventral side with a deep umbilical depression with numerous chambers about the periphery, and with channels between, as in *Cymbaloporetta*, later filled by the large final chamber which is more than a hemisphere; chambers, except the earliest coiled ones, very distinct, inflated, of fairly uniform shape, gradually increasing in size; sutures of the earliest spiral portion strongly limbate, later nonlimbate and depressed; wall thick, opaque, coarsely and conspicuously perforate, over the coiled portion thick and mostly hyaline, that of the globular chamber much more finely perforate and thinner. Length 0.75 mm.; diameter 0.50 mm.

Holotype (Cushman Coll. No. 21555) from off Rangiroa in the Pacific. The species is so far known only from this locality where it is fairly common, and occurs in all stages.

The early portion is dark, yellowish-brown, due to the inner chitinous layer. After the few coiled chambers are formed, the spire is covered by a thick, clear layer, as in *Cymbaloporetta* and *Cymbalopora*. There seems to be no definite, free, floating chamber, as the inner layer of the globular portion is firmly attached to the ring of chambers formed before the globular chamber is developed.

There is a possibility that this may be the same as the large species from the Philippine region, with somewhat similar characters already recorded (Bull. 100, U. S. Nat. Mus., vol. 4, 1921, p. 309, pl. 59, figs. 3 *a-c*) as *T. bulloides*. The specimens are not available at the moment, and need further checking.

There is a tendency in this species for the whole test to be somewhat compressed. This is seen in the early stages of a num-

ber of specimens, and the amount of compression is thus determined before the globular chamber is developed.

T. grandis seems to be the most complex and largest of the various species. In the series of specimens which have not yet developed the globular chambers, there are series of six chambers on the ventral side with channels between them. These channels, as in *T. milletti*, are continued as tubular structures in the upper half of the globular chamber, and may be seen through the thin, outer wall.

TRETOMPHALUS CONCINNUS (H. B. Brady) (Pl. 11, figs. 8, 9; pl. 12, figs. 13-15)
Discorbina concinna H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 646, pl. 90, figs. 7, 8.

Test in the early stages *Discorbis*-like, with about five chambers in the earliest whorls, later reducing to three or four, evenly convex, periphery subacute, but not keeled, ventral side deeply concave, later with a globular chamber covering the ventral side; chambers distinct, little if at all inflated, increasing rapidly in size and relative breadth as added, the number in a whorl progressively reducing as growth takes place; sutures distinct, slightly depressed, gently curved in the early stages, strongly curved and oblique in the later stages; wall smooth, finely but distinctly perforate, globular chamber variously shaped, somewhat lateral or entirely ventral, the outer portion with the typical large pores. Length 0.30 mm.; diameter 0.20 mm.

EXPLANATION OF PLATE 13

FIGS. 1, 2. *Pyropilus rotundatus* Cushman, n. gen. and n. sp. × 50. Fig. 1, Holotype. Fig. 2, Paratype. *a*, *a*, dorsal views; *b*, *b*, ventral views; 1 *c*, side view. Off Rangiroa, Pacific.

FIGS. 3, 4. *Ungulatella pacifica* Cushman. × 135. Paratypes. Fig. 3, Adult specimen. *a*, front view; *b*, side view; *c*, apertural view. Fig. 4, Young specimen. Off Rangiroa.

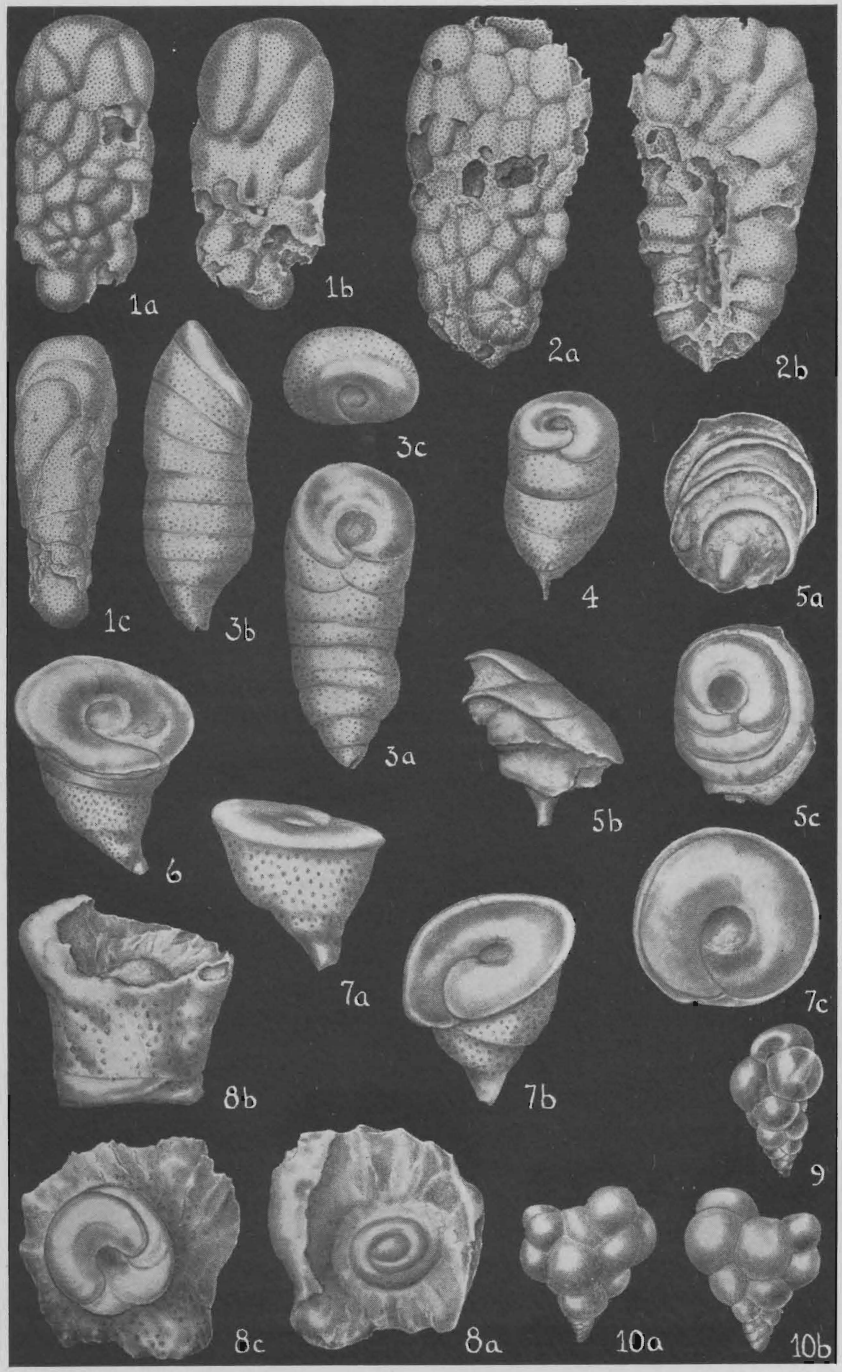
FIGS. 5 *a–c*. *Ungulatella peregrina* Cushman, n. sp. × 135. *a*, dorsal view; *b*, side view; *c*, apertural view. Off Rangiroa.

FIGS. 6, 7. *Ungulatella conoides* Cushman, n. sp. × 135. Fig. 6, Paratype. Fig. 7, Holotype. *a*, *b*, side views; *c*, apertural view. Off Rangiroa.

FIGS. 8 *a–c*. *Ungulatella capistra* Cushman, n. sp. × 100. *a*, dorsal view; *b*, side view; *c*, apertural view. Off Rangiroa.

FIGS. 9, 10. *Gümbelitria* (?) *vivans* Cushman, n. sp. × 135. Fig. 9, Holotype. Fig. 10, *a*, *b*, opposite sides of paratype, showing supplementary chambers. From off New Guinea, 129 fathoms.

Figures drawn by Margaret S. Moore.


1a
1b
2a
2b
3c
1c
3b
4
5a
3a
5b
5c
6
7a
7c
8b
7b
9
8c
8a
10a
10b

From a comparison of numerous specimens in both the *Discorbis* and *Tretomphalus* stages, it seems that the young stage of this species is the same as Brady's *D. concinna.* His figured specimens are from Tahiti, and it is common in fairly shallow water about the Pacific islands. Specimens in our collection from various localities show a wide distribution for it in the *Tretomphalus* stage. They include surface material from off Midway Island; less than 1 fathom off reef, Laysan Island; Port Lotten, Kersail, Caroline Islands; 12 and 24 fathoms off Nairai, Fiji; 12 fathoms off Levuka, Fiji; and 40-50 fathoms, also off Fiji.

There is a wide range of variation in the development of the globular chamber which seems to show the method of development of this structure already discussed. There may be more than one species included here under Brady's name, and the species with simple *Discorbis*-like young should be further studied as they are available. It has not been possible to demonstrate a definite inner "float" chamber in all of the specimens seen, and there is a possibility that it may not always be present in the more primitive forms.

TRETOMPHALUS CLARUS Cushman, n. sp. (Pl. 11, figs. 6 a-c; pl. 12, figs. 16, 17)

Test with the early stages *Discorbis*-like, the earliest whorls with about five chambers, later reduced to four, and in the adult to but three, in side view conical, the early portion somewhat pointed, ventral side concave, periphery acute, globular chamber low and broad, somewhat flattened at the base; chambers distinct, slightly inflated, increasing rapidly in size and relative breadth as added, the last *Discorbis*-like chamber very much curved, and occupying more than half of the periphery; sutures distinct, slightly limbate, strongly curved, not depressed; wall hyaline, clear, very finely perforate. Length 0.20 mm; diameter 0.25 mm.

Holotype (Cushman Coll. No. 21562) 21 fathoms, Guam Anchorage, Ladrone Islands. The species also occurs at Rongelab Atoll, Marshall Islands, and from surface material off Midway Island.

The *Discorbis* stage in some respects resembles some of the specimens figured by Brady in the *Challenger* Report under the name of *"Discorbina orbicularis* Terquem" which is not the same as Terquem's species.

The wall of this species is very clear and hyaline, and the in-

crease in length of the chambers as growth progresses is very marked, the last *Discorbis* chamber making up as much as three-fourths of the periphery. The globular chamber is low and broad, and may be smaller than the base of the *Discorbis* stage, so that a distinct flange may be left above the globular chamber. This species certainly is very different from any of the other species developing globular final chambers.

From the literature, it is evident that there are other undescribed species belonging to the genus *Tretomphalus*. The specimens figured by Moebius in 1880 from Mauritius show forms which do not seem to be identical with any of those I have here described, and the same is true of the forms figured by Earland in 1902 from South Australia. There are also records from various other parts of the world, including the Mediterranean, which have not been figured, and it may be that these species also are distinctive.

The following genus is in some respects allied to *Tretomphalus* but is apparently derived from forms similar to *Cymbaloporella*.

Genus PYROPILUS Cushman, n. gen.

Genoholotype, *Pyropilus rotundatus* Cushman, n. sp.

Test with the early stages in a trochoid spiral, later building the chambers in an elongate, oval series with an elongate, umbilical depression on the ventral side, the last-formed chambers more or less involute, and the last few covering the growing end as well as a considerable portion of the previous development, particularly on the ventral side; early chambers of a dark, yellowish-brown color, due to the inner, thin, chitinous layer, remainder of the test calcareous, coarsely perforate; last portion of the test without any general aperture, the coarse perforations of the wall evidently serving as apertures.

The relationships of this genus are with *Cymbaloporella*, particularly in the earlier stages, but in its later development the test grows outward along one axis, in a general way somewhat simulating the development seen in *Tretomphalus*.

PYROPILUS ROTUNDATUS Cushman, n. sp. (Pl. 13, figs. 1, 2)

Test elongate, pear-shaped, somewhat compressed, periphery broadly rounded, earliest portion in a trochoid spiral of 6 or 7 chambers, increasing gradually in size as added, later chambers developed more or less in a single plane, particularly on the

ventral side about an elongate central opening, later developing strongly toward one end which becomes broader and thicker than the remainder of the test; chambers distinct, somewhat inflated, earliest ones trochoid, later irregularly shaped, but somewhat inflated, and in the adult elongate and involute on the ventral side; sutures distinct, depressed, the earliest ones often slightly limbate; wall in the earliest stages with a thin, chitinous lining, the remainder of the wall calcareous, coarsely perforate; aperture in the earliest stages ventral, in the later development opening on the long, umbilical, depressed area, and in the adult formed by the coarse perforations of the test. Length 0.80-1.00 mm.; breadth 0.40-0.55 mm.; thickness 0.30-0.35 mm.

Holotype (Cushman Coll. No. 21526) from off Rangiroa in the Pacific.

This species is the only one so far known, but others are to be expected in further studies of shallow-water material from about the tropical Pacific islands. Its development is somewhat unusual, but it is evidently derived from *Cymbaloporella* by the growth in one direction in the adult, and the development of peculiar, inflated, final chambers, which in some respects remind one of the development of *Tretomphalus*.

150. THE RELATIONSHIPS OF UNGULATELLA, WITH DESCRIPTIONS OF ADDITIONAL SPECIES

By JOSEPH A. CUSHMAN

When this genus was described, it was thought from the character of the aperture and its apparent division in the early stages that its relationships were with the Buliminidae, especially the group developed from *Buliminella*. An additional suite of specimens of the genotype species, together with several other species, shows that the genus is closely allied to *Conicospirillina*, and that it has some very interesting relationships which are of direct bearing on the classification of the group. The four species here figured show a series which are enlightening. Descriptions of the three new species will be given, and a modified generic description, after which the relationships will be discussed.

Genus UNGULATELLA Cushman, 1931

Genotype, *Ungulatella pacifica* Cushman

Ungulatella CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 81.

Test probably attached, with the early portion typically conical, consisting of a series of undivided coils in an elongate spiral, which may be partially divided in the last one or two coils, the apertural face flattened and polished; wall calcareous, rather coarsely perforate; aperture, a rounded or broadly loop-shaped opening in the middle of the flattened or somewhat concave terminal face.—Recent, Pacific.

UNGULATELLA PACIFICA Cushman (Pl. 13, figs. 3, 4)

Ungulatella pacifica CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 7, 1931, p. 82, pl. 10, figs. 11, 12.

This species, already described in the above reference, is refigured here from other paratypes. It is a much more elongate and slender species than the others, and there is a tendency in the last one or two coils to have partial division of the chambers. The initial spine is less prominent than in the two following species.

UNGULATELLA PEREGRINA Cushman, n. sp. (Pl. 13, figs. 5 a-c)

Test short and broad, much compressed, initial end with a large, stout, solid spine, remainder of test composed of a spirally coiled tube, the last one or two whorls tending to show partial divisions into half coils, attached face much flattened and oblique, concave in the middle, with an outer flange-like rim; suture marked by a raised, sharp ridge, representing the peripheral flange at that stage; wall roughened on the outer side of the coils, very smooth and polished on the apertural face; aperture apparently opening on the open umbilical area. Length 0.20 mm.; diameter 0.15 mm.

Holotype (Cushman Coll. No. 21518) from off the island of Rangiroa, in the South Pacific.

This species is small and scale-like, and with its prominent initial spine and prominent, raised ridges, is very easily distinguished from the other species.

UNGULATELLA CONOIDES Cushman, n. sp. (Pl. 13, figs. 6, 7)

Test small, short and broad, conical, initial end pointed, with a large, stout, solid spine, greatest breadth of test at the aper-

tural end which is somewhat expanded into a flaring lip or flange, sides of the test uneven in length, making the flattened, apertural end at a decided angle to the elongate axis; suture mostly indistinct; wall very coarsely perforate, or even slightly papillate, the pores often partially arranged in lines, giving a peculiar ornate appearance to the surface; apertural face smooth and polished, slightly concave, especially in the middle, which has a circular depression, last-formed whorl often partially subdivided into two half coils. Length 0.15 mm.; diameter 0.15-0.20 mm.

Holotype (Cushman Coll. No. 21522) from off the island of Rangiroa in the South Pacific.

The series of specimens of this species shows little variation in the characters as shown in the figures.

UNGULATELLA CAPISTRA Cushman, n. sp. (Pl. 18, figs. 8 a-c)

Test with the main portion a broad cone, but with a thin, high flange rising even above the initial end which is smooth and rounded, the coiled chamber seeming to be partially divided toward the end into portions a half-coil in length, apertural face smooth, the central portion concave; wall coarsely perforate on the exterior of the sides. Length, including flange, 0.25 mm.; diameter, including flange, 0.30 mm.

Holotype (Cushman Coll. No. 21525) from off the island of Rangiroa in the South Pacific.

This species is highly ornate in the development of the wide, curved, and upturned flange. In some respects, this reminds one of the form figured by Heron-Allen and Earland from the Kerimba Archipelago off Southeastern Africa (Trans. Zool. Soc. London, vol. 20, 1915, pl. 51, figs. 28, 29) as included in their *Spirillina decorata*. The aperture in their form however seems to be peripheral.

This entire series of four species seems to be developed from a *Conicospirillina* ancestry. With these are specimens of a highly ornate form similar to Chapman's *Spirillina spinigera*, although the initial portion has a stout spine, and has a decided spire instead of being planispiral. It also probably is an attached form. The difference in length of coiling and the relative amount of obliquity, and compression of the test in our four species are very considerable. One of the most interesting things is the very smooth apertural face with the rounded depressed area in the middle, together with the tendency to have a partial sub-

division into half coils. This may be demonstrated by slightly wetting the specimens when the air is forced back to the first half coil, then stops temporarily, and again is forced back another half coil, showing obstructions at these points. In many respects, the smooth, polished, ventral face reminds one very strongly of *Patellinella.* The open umbilical area is also very similar, as well as the tendency to become divided into half coils. It would be only a step from such forms as *Ungulatella* to *Patellinella,* and its development very probably came about in some such manner.

It is apparent that evolution in the foraminifera has taken place very rapidly in various times and places, and that the same line of development may have taken place more than once. As probably indicating a stage in the development toward *Patellinella,* this group of species becomes of especial interest. The genus is to be looked for in other parts of the Indo-Pacific. The species are all small, and may be easily overlooked.

151. A RECENT GÜMBELITRIA (?) FROM THE PACIFIC

By JOSEPH A. CUSHMAN

Among material kindly sent me by my friend, Arthur Earland, the following species occurs. Its relationships to *Gümbelitria* are very striking. It seems to be triserial throughout in its normal state, and the walls are thin and calcareous. The aperture, while somewhat smaller than the fossil forms, nevertheless is of the same general shape, and occupies the normal position for this genus. Perhaps the most striking thing about this set of specimens is that in Pl. 13, fig. 10, in which, after the normal triserial development, there are a number of chambers tending to spread out laterally, more or less in one plane. Such a form reminds one strongly of the conditions that are developed in the Cretaceous genera *Ventilabrella* and *Planoglobulina*. It is difficult to find any supplementary apertures in these chambers such as would be normally expected in such a form. In fact, there are apparently no definite apertures visible in these later chambers. The species is a very small one, and further study of larger series will be very interesting. It is here referred to the genus *Gümbelitria* only tentatively.

GÜMBELITRIA (?) VIVANS Cushman, n. sp. (Pl. 13, figs. 9, 10)

Test minute, in the early stages triserial, tapering, greatest breadth formed by the last whorl; chambers distinct, subglobular, strongly inflated, increasing rather uniformly in size as added, of rather uniform shape throughout; sutures distinct, strongly depressed; wall thin, calcareous, very finely perforate, almost transparent; aperture, a small semicircular opening at the inner margin of the base of the last-formed chamber, in a slight depression of the inner face of the chamber. Length 0.15 mm.; diameter 0.10 mm.

Holotype (Cushman Coll. No. 21515) from *Challenger* Station 192A, off Little Ki Island, New Guinea, in 129 fathoms.

The description is given for the holotype, which seems to be the normal form, although it may possibly be the young stage only, and the figured paratype may be possibly the normal adult rather than an abnormal form as now seems probable from the series available for study.

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Thalmann, Hans E. Bibliography and Index to New Genera and Species of Foraminifera for the Year 1932.—Journ. Pal., vol. 8, No. 3, Sept., 1934, pp. 356-387.

Wright Barker, R. Some Notes on the Genus *Helicolepidina* Tobler.—l. c., pp. 344-351, pl. 47, text figs. 1 *a-e*. T.

Chapman, Frederick, Walter J. Parr and Arthur C. Collins. Tertiary Foraminifera of Victoria, Australia.—The Balcombian Deposits of Port Phillip. Part III.—Linn. Soc. Journ. Zool., vol. 38 (No. 262), April 20, 1934, pp. 553-577, pls. 8-11. T.—8 new species and varieties.

Warthin, A. S. Jr. Foraminifera from the Ross Sea.—Amer. Museum Novitates, No. 71, May 4, 1934, pp. 1-4, text figs. 1-5. R.—2 new species.

David-Sylvain, Elisabeth. Sur les grands Foraminifères du synclinal de Visso (Appenin central).—Comptes Rendus, Acad. Sci., Seance, May 7, 1934, pp. 1717, 1718. T.

Macfadyen, W. A. in Baden-Powell, D. F. W. On the Marine Gravels at March, Cambridgeshire.—Geol. Mag., vol. 71, No. 839, May, 1934, list of Foraminifera, pp. 201-203. T.

Thalmann, Hans E. Uber geographische Rassenkreise bei fossilen Foraminiferes.—Pal. Zeitschr., vol. 16, June 30, 1934, pp. 115-121. T.

Regional Distribution of the Genus *Globotruncana* Cushman, 1927 in Upper Cretaceous Sediments.—Proc. Geol. Soc. Amer. for 1933 (June, 1934), p. 111. C.

Thompson, M. L. The Fusulinids of the Des Moines Series of Iowa.—Univ. Iowa Studies in Natural History, vol. 16, No. 4, New Series, No. 284, Oct. 1, 1934, pp. 273-332, pls. 20-23. P.—13 new species.

Palmer, Dorothy K. Some Large Fossil Foraminifera from Cuba.—Mem. Soc. Cubana Hist. Nat., vol. 8, No. 4, Oct. 25, 1934, pp. 235-264, pls. 12-16, 19 text figs. C. T.—14 new species, and two new genera, *Torreina* and *Vaughanina*.

J. A. C.