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187. THE GENERA *NUSTALLIDES* FINLAY, 1939,
AND *NUSTALLINA*, N. GEN.

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ABSTRACT

The generic description of the genus *Nuttallides* Finlay, 1939, is emended to include the internal structure and apertural details. This genus has a toothplate which extends in each chamber from the septal foramen towards a depressed marginal groove, interpreted as a closed protoforamen. The species *Nuttallides subtrümpyi* Finlay is placed in the synonymy of *N. trümpyi* (Nuttall).

The new genus *Nuttallina*, from the Upper Cretaceous of Western Australia, has a toothplate similar to that of *Nuttallides*. Both genera are placed in the family Epistominidae.

INTRODUCTION

The form described in this paper as *Nuttallina coronula*, n. gen., n. sp. was first found by the writer in the Toolonga Calcilutite of the Murchison River area, Western Australia, and later in the Korojon Calcarenite of the Giralia Anticline. The writer showed the specimens to Dr. M. F. Glaessner, of the University of Adelaide, who suggested a possible relationship with the genus *Nuttallides* Finlay, 1939. Specimens of the type species of *Nuttallides* (*Eponides trümpyi* Nuttall) from the Aragon Formation of Mexico were examined and found to have an internal structure similar to that of the specimens from Western Australia. The generic description of *Nuttallides* evidently required emending to include the internal structure and apertural details, and this has been done to show the relationship between *Nuttallides* and *Nuttallina*, n. gen. In general structural features, *Nuttallides* is similar to the genus *Alabamina* Toulmin.

The writer wishes to thank Dr. N. de B. Hornibrook of the New Zealand Geological Survey, who forwarded topotype and other specimens of *Nuttallides subtrümpyi* Finlay, and topotype specimens of *N. carinotrümpyi* Finlay, *N. cretatrümpyi* Finlay and *N. tholus* Finlay; Professor J. J. Graham of Stanford University, U.S.A., who checked the writer's identification of *Nuttallides trümpyi* (Nuttall); and Dr. M. F. Glaessner of the University of Adelaide, Australia, who first suggested a possible relationship between the genus *Nuttallides* and *Nuttallina*, n. gen.

The figured specimen and sections of *Nuttallides trümpyi* (Nuttall) from the Aragon Formation of Mexico are deposited in the Department of Micropaleontology, United States National Museum, Wash-

ington, D. C. under the USNM Nos. 626138-626144. The figured specimen from New Zealand is deposited in the palaeontological collection of the Geological Survey of New Zealand under No. TF 1029/4. The holotype, paratypes and sections of *Nuttallina coronula*, n. gen., n. sp. are deposited in the Commonwealth Palaeontological Collection, Canberra, under the numbers C.P.C. 1530-1540; topotype specimens have been deposited in the United States National Museum under USNM No. 626145.

Family EPISTOMINIDAE

Genus *Nuttallides* Finlay, 1939, (emended)

Type species.—*Eponides trümpyi* Nuttall, 1930. Original designation.

Test trochoid, evolute dorsally, involute ventrally, unequally biconvex, with the ventral surface the more strongly convex, periphery poreless. Umbilical area with a poreless boss. Test calcareous, chamber walls radiate hyaline, finely perforate on both dorsal and ventral surfaces; septal walls single, imperforate. Aperture ventral, at base of chamber, with a slight lip, extending from the umbilical boss to a small groove at the periphery, formed parallel to the plane of coiling and bordered marginally by a small fold of the apertural face. Each chamber with a toothplate extending from the septal foramen diagonally across the chamber towards the peripheral groove.

Remarks.—The generic description of *Nuttallides* given by Finlay (1939) requires emending to include the internal structure and apertural characteristics. The details of the sutures given by Finlay are of specific and not generic significance.

The genus *Nuttallides* has some features suggesting a relationship with the genus *Alabamina* Toulmin, 1941, the type genus of the family Alabaminidae. The marginal groove of *Nuttallides*, formed parallel to the plane of coiling, is regarded by the writer as homologous with the groove in *Alabamina*, called by Brotzen (1948) the "scrobis septalis," and the small forward fold of the chamber at the periphery as homologous with the "tectum" of *Alabamina*. According to the interpretation of Hofker (1951) the groove to which the reduced toothplate of *Alabamina* ("infundibulum" of Brotzen) is attached is a closed protoforamen. The same interpretation may be applied to the groove of

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Nuttallides; the aperture in this genus is therefore a deutoforamen, and the genus belongs to Hofker's suborder Biforaminata deutoforaminata.

The toothplate of *Nuttallides* is more strongly developed than that of *Alabamina*, and extends the full width of the chamber from the septal foramen. The internal feature of *Alabamina* called by Brotzen the "foramen infundibulum" is absent from *Nuttallides*, and the poreless ventral boss and poreless margin of *Nuttallides* do not occur in *Alabamina*. Another difference is in the wall structure, which is granular in *Alabamina* and radiate in *Nuttallides*. In this respect, and in having a ventral boss, *Nuttallides* resembles the genus *Epistomina*, but does not have as well developed or as complex a toothplate as that genus.

The genus *Nuttallides* is in its combination of characters intermediate between the genera *Alabamina* and *Epistomina*. The classification of these forms depends on the significance given to the different features. Brotzen (1948) suggested that the marginal groove of *Alabamina* is a reduced marginal aperture, and included this genus in the Epistominidae. Hofker (1951) considered the reduced marginal aperture (protoforamen) and the sutural aperture formed by the deutoforamen to be significant, and proposed the family Alabaminidae. This view receives some support from the difference in wall structure between *Alabamina* and *Epistomina*, although Hofker did not consider this feature.

The taxonomic significance of the toothplate and the wall structure is not fully understood, but the writer prefers to place *Nuttallides* in the Epistominidae rather than in the Alabaminidae. The intermediate position of *Nuttallides* may indicate the origin of the Alabaminidae within the Epistominidae.

Nuttallides trümpyi (Nuttall)

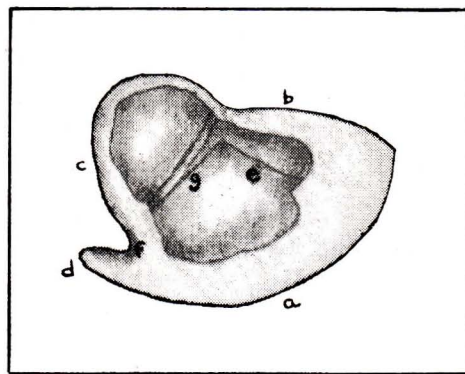
Plate 18, figures 1-13

- 1930, *Eponides trümpyi* NUTTALL, Jour. Paleontology, 4 (3), p. 287, pl. 24, figs. 9, 13, 14.
 1939, *Nuttallides trümpyi* (NUTTALL). FINLAY, Trans. roy. Soc. N. Z., 68, p. 520.
 1939, *Nuttallides subtrümpyi* FINLAY, *ibid.*, p. 521.
 1947, *Nuttallides subtrümpyi* FINLAY, N. Z. Jour. Sci. Tech., 28 (5), Sec. B, p. 286.
 1952, *Nuttallides trümpyi* (NUTTALL). BERMUDEZ, Min. de Minas e Hidrocarburos, Bol. Geol., 2 (4), p. 66, pl. 10, figs. 4a-c.
 1953, *Eponides trümpyi* NUTTALL. HAMILTON, Jour. Paleontology, 27 (2), p. 235, pl. 31, figs. 22, 23.
 1956, *Eponides trümpyi* NUTTALL. ASCOLI, Riv. Ital. Paleont., 62 (3), pp. 158, 161, 163, 182, pl. 14, fig. 7.

Diagnosis.—An unequally biconvex species with a large flattened ventral boss, rounded to subacute pore-

less margin, angulate ventral sutures and a toothplate forming a thin high ridge in each chamber.

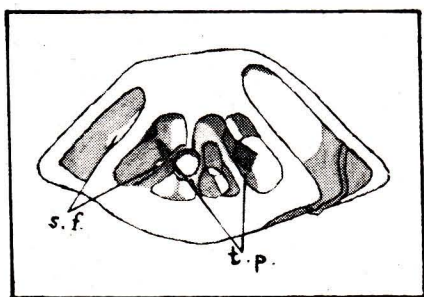
Description.—Test trochoid, unequally biconvex, the ventral surface more strongly convex than the dorsal. Periphery of test slightly lobate, particularly on last chambers, with a rounded to subacute poreless margin of clear shell material. Test calcareous, chamber walls radiate hyaline, finely perforate on both dorsal and ventral sides; septal walls single, imperforate. All chambers visible from the dorsal side, forming $3\frac{1}{2}$ -4 whorls, only those of the last whorl visible from the ventral side, with usually 7 chambers in the last whorl. Proloculus globular, chambers increasing slowly in size as added. Umbilical area on the ventral side with a distinct clear poreless boss, usually flattened across the top, giving the ventral surface a truncated appearance in side view. Sutures on ventral side narrow, distinct, smooth throughout or slightly depressed in the last two or three chambers, with a marked angularity about $\frac{1}{3}$ of their length from the umbilical boss, the angle extending forward in the direction of coiling. Sutures of the central part of the dorsal side of dry specimens obscured by shell material, on moistened specimens seen to be curved, at first almost radial, later becoming more strongly reflexed and almost tangential to the spiral whorl, with the chambers long and narrow. Aperture ventral, at the base of the chamber, a long narrow slit with a small but distinct lip, extending from the umbilical boss to a small groove at the periphery, parallel to the plane of coiling. Marginally from the groove is a small fold of the apertural face, extending forward beyond the aperture. A well developed toothplate occurs in each chamber, extending from the septal foramen towards the groove at the periphery (see text figure 1). The toothplate begins in each chamber at the sutural angle,



TEXT FIGURE 1

Internal view of last chamber of *N. trümpyi*, showing toothplate. $\times$ about 120. a. Periphery of test. b, c. Proximal and distal walls of chamber respectively. d. The "tectum." e. Septal foramen. f. Position of marginal groove. g. Toothplate.

extends diagonally as a thin high ridge across the floor of the chamber, and is attached to the following septal wall at the marginal groove. At the point of origin on the septal foramen the toothplate extends almost the full height of the chamber towards a small poreless ridge formed by a thickening of the chamber wall (Pl. 18, fig. 9 and text fig. 2); the thickening of



TEXT FIGURE 2

Camera lucida drawing of vertical section of *N. trümpyi*. Specimen from Mexico. $\times$ about 55. Showing toothplates, and thickening of the chamber wall in one chamber. s.f. Septal foramen. t.p. Toothplate.

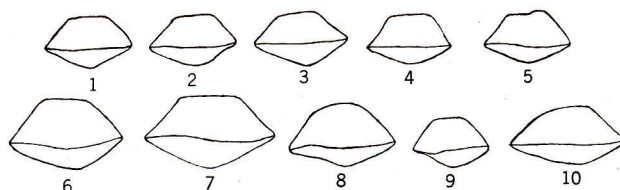
the chamber wall has not been observed to continue for any distance, and seems to be confined to the chamber wall at the sutural angle. The toothplate tapers gradually from the septal foramen to its point of attachment on following septal wall.

Dimensions.—

	Max. Diam.	Height
Specimen from Mexico	0.518 mm.	0.296 mm.
Specimen from New Zealand	0.675 mm.	0.352 mm.

Remarks.—The specimen figured from Mexico is from the Aragon Formation; that from New Zealand is from the type locality of *N. subtrümpyi* Finlay. *N. subtrümpyi* Finlay is regarded by the writer as a synonym of *N. trümpyi* (Nuttall). Finlay (1939) stated in his description of *N. subtrümpyi* "shell of entirely the same build and general features as *trümpyi*, with similar dorsal and ventral sutures." The toothplate of the New Zealand specimens is the same as that in specimens from Mexico. None of the features mentioned by Finlay can be used to separate the New Zealand specimens from those from Mexico. The peripheral margin varies from rounded to subacute in specimens from both areas. No plano-convex New Zealand specimen has been seen by the writer; the dorsal surface varies from slightly to distinctly convex. Specimens from Mexico also have a flattened ventral boss. The similar outlines of specimens from both Mexico and New Zealand are shown in text figure 3.

Thirty specimens of *N. trümpyi* from the Aragon Formation of Mexico have been measured. The maximum diameter of the test in the measured specimens



TEXT FIGURE 3

Comparison of outlines of specimens of *N. trümpyi* from Mexico and New Zealand. $\times$ about 15. 1-5. Specimens from Mexico. 6-10. Specimens from New Zealand.

ranges from 0.333 mm. to 0.629 mm. and the height from 0.175 mm. to 0.342 mm.; the mean of the ratio diameter/height is 1.737. The number of chambers in the last whorl of 25 specimens has been counted; three have 6 chambers, twenty have 7 chambers and two have 8 chambers.

Fifty specimens from New Zealand have also been measured. These specimens have a greater absolute size than those from Mexico. The maximum diameter ranges from 0.444 mm. to 0.814 mm. and the height from 0.278 mm. to 0.435 mm.; the mean of the ratio diameter/height is 1.781. A count of the number of chambers in the last whorl of 23 specimens gave thirteen specimens with 7 chambers, seven with 8 chambers and three with 9 chambers.

The diameter/height growth patterns of the specimens from Mexico and New Zealand have been compared by calculating the statistic z , using the method given by Imbrie (1956). Comparing the slope of the growth lines, the calculated value of z is 1.077, and therefore a significant difference cannot be demonstrated. A test for positional difference at a point where the distance between the growth lines approaches a maximum gave a value for z of 1.045, which again is not significant. Therefore, as far as the ratio diameter/height is concerned, there is no significant difference in the growth patterns of specimens from New Zealand and Mexico.

These statistical results, together with the observational data, lead the writer to regard *N. subtrümpyi* Finlay as a synonym of *N. trümpyi* (Nuttall).

Of the other species of *Nuttallides* described by Finlay (1940, 1947), the writer has not been able to observe a toothplate in *N. carinotrümpyi* or *N. tholus*. *N. carinotrümpyi* is a small form from the Paleocene and lower Eocene of New Zealand. *N. tholus*, occurring in the upper Senonian of New Zealand, is quite different from other species of *Nuttallides*, and would as stated by Finlay (1947) belong to another lineage of *Nuttallides*. This species was regarded by Finlay as the New Zealand representative of *Globorotalites micheliniana* (d'Orbigny), which Finlay (1940) referred to the genus *Nuttallides*. It seems probable that the species described by Finlay as *Nuttallides*

tholus should not be placed in the genus *Nuttallides*. The species *N. cretatrumpyi* described by Finlay (1947) from beds regarded as Danian in age has the same type of toothplate as *N. trümpyi* (Nuttall).

Forms identified as *Eponides* sp. cf. *E. trumpyi* were recorded by Küpper (1956) from the Maestrichtian of the Gosau Basin.

The position of the species described as *Asterigerina crassaformis* by Cushman and Siegfus (1935) is uncertain. Bermudez (1952) did not recognize supplementary chambers in this species, and placed it in *Nuttallides*. Hofker (1956) again observed supplementary chambers, and referred the species to the genus *Asterigerinoides* Bermudez, 1952. Vertical sections of *Nuttallides trümpyi* are very similar to the vertical section shown by Hofker (1956, text-figure 66d), but the toothplate of *Nuttallides* does not extend completely across the chamber to form supplementary chambers.

Genus **Nuttallina** Belford, n. gen.

Type species.—*Nuttallina coronula*, n. sp.

Test trochoid, concavo-convex to biconvex, with the ventral surface the more strongly convex. Dorsal side evolute, ventral side involute, with a small open umbilicus. Periphery with a wide poreless keel. Test calcareous, chamber walls radiate hyaline, perforate on both dorsal and ventral sides; septal walls single, imperforate. Aperture ventral, at base of chamber, with a narrow lip, beginning just above the peripheral margin of the chamber and extending into the umbilicus. Each chamber with a toothplate extending diagonally across the chamber from the septal foramen towards the peripheral margin of the following septal wall.

Remarks.—The genus *Nuttallina* is closely related

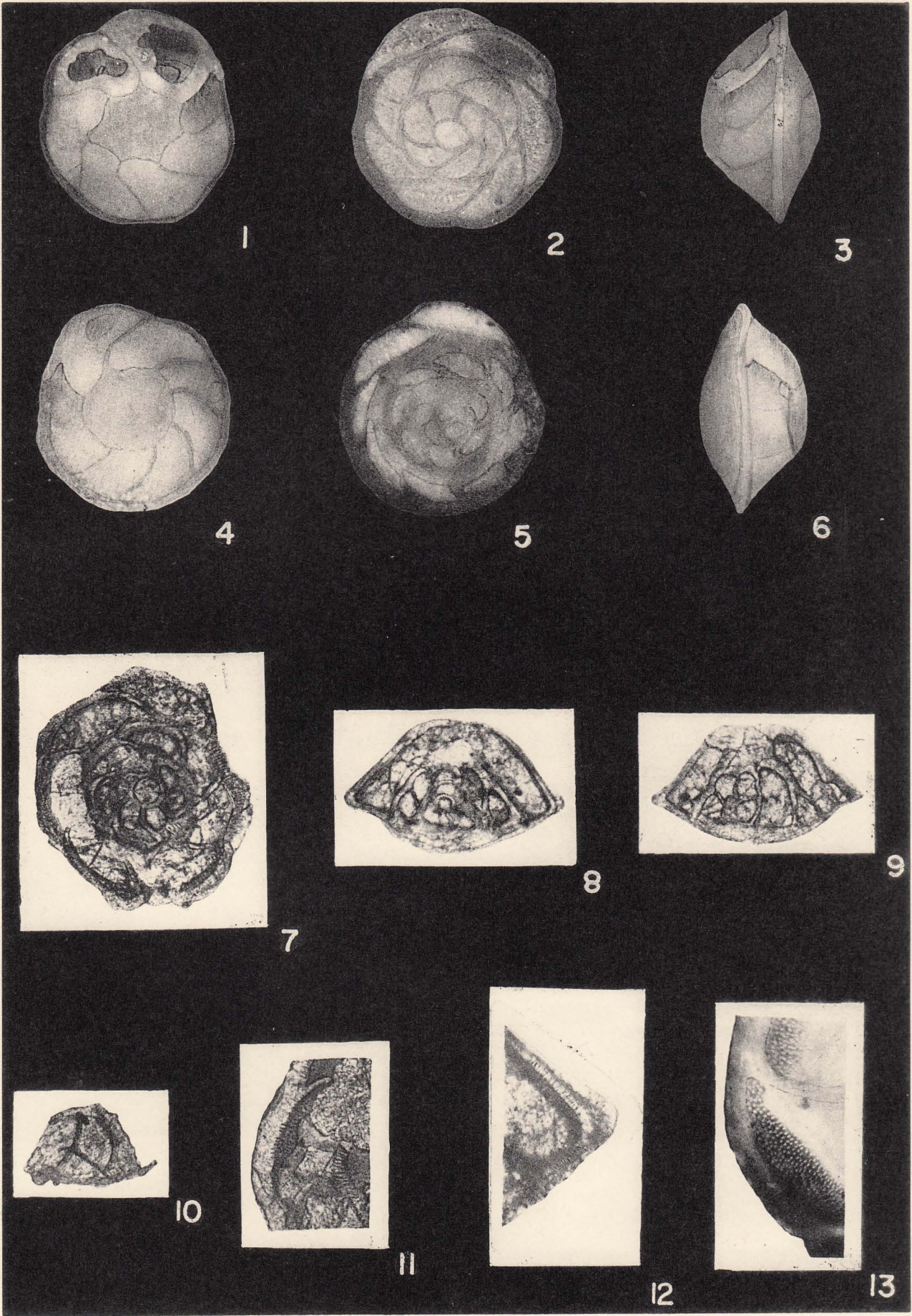
to the genus *Nuttallides* Finlay, and is here included in the family Epistominidae. The toothplate of *Nuttallina* both in its point of origin and direction across the chamber is similar to that of *Nuttallides*, but in *Nuttallina* the toothplate has a strongly folded upper edge that has not been observed in *Nuttallides*. The aperture of *Nuttallina* is in some specimens bordered marginally by a small fold of the apertural face, and the ventral umbilicus may be partly covered by a small triangular lip. These features are not constant, and are therefore not included in the generic description. The aperture of *Nuttallina* is a deuterofoamen; the protofoamen has been strongly reduced, and there is no marginal groove or other feature to indicate its position. In Hofker's classification, this genus would also be placed in the suborder Biforaminata deuterofoaminata. The perforate radial shell wall, the single imperforate septal walls, the poreless margin and position of the toothplate are features common to both *Nuttallides* and *Nuttallina*. The ventral umbilicus of *Nuttallina*, the extension of the aperture into the umbilicus, and the nature of the toothplate separate the two genera.

The species described by White (1928) as *Gyroidina florealis* may belong to the genus *Nuttallina*. This species was recorded by Cushman (1946) as *Pulvinulinella ? florealis* (White), placed in *Nuttallides* by Bermudez (1952), and referred by de Civrieux (1952) to the genus *Osangularia*. According to Cushman (1946) the apertural characters of this species are difficult to determine, but other features are those of *Nuttallina*. Information on the internal structure, whether present or absent, and its nature if present, would assist in determining the relationships of this species.

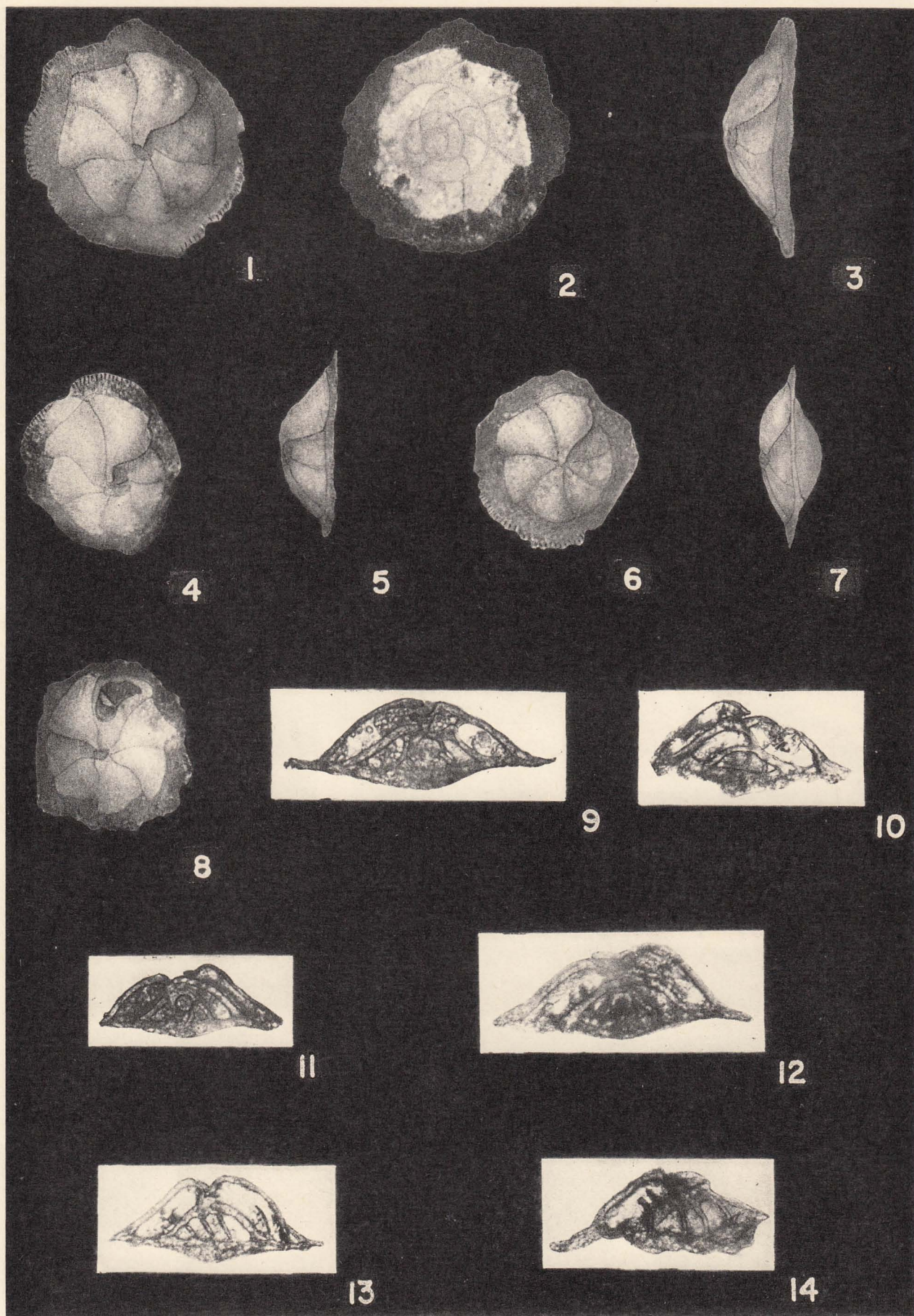
EXPLANATION OF PLATE 18

All figures are retouched photographs.
Magnifications are approximate.

FIGS.	PAGE
1-13. <i>Nuttallides trümpyi</i> (Nuttall).	94
1-3. Specimen from the Aragon Formation, Mexico (USNM No. 626138). × 60. 1. Ventral view with last two chambers opened, showing toothplates. 2. Dorsal view, specimen in xylol. 3. Side view, showing biconvex test and flattened ventral boss.	
4-6. Specimen from New Zealand (NZGS No. TF1029/4). × 46. 4. Ventral view. 5. Dorsal view, specimen in xylol. 6. Edge view.	
7. Horizontal section showing globular proloculus and perforations of test. (USNM No. 626139). × 60.	
8, 9. Vertical sections showing biconvex test and flattened ventral boss. A toothplate may be seen in figure 9, and also the thickening of the chamber wall. (USNM Nos. 626140, 626141). × 60.	
10. Section across one chamber showing the toothplate crossing from the septal foramen towards the marginal groove. (USNM No. 626142). × 60.	
11. Part of horizontal section, showing perforate chamber wall, and imperforate margin and septal wall. (USNM No. 626143). × 110.	
12. Part of vertical section shown in figure 8, showing poreless margin. × 110.	
13. Part of dorsal view of specimen in figure 1, specimen in xylol. Showing the perforate chamber wall, imperforate margin and septal wall. × 250.	



Belford: *Nuttallides* Finlay and *Nuttallina*, n. gen.



Belford: *Nuttallides* Finlay and *Nuttallina*, n. gen.

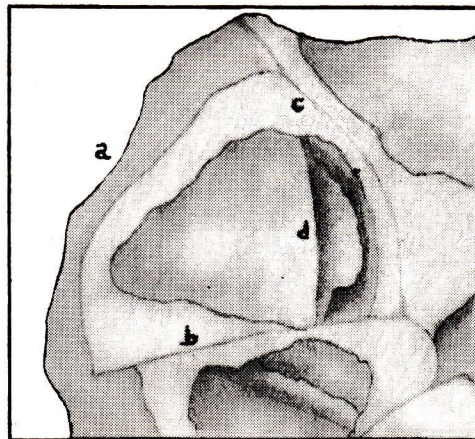
Nuttallina coronula Belford, n. sp.

Plate 19, figures 1-14

Diagnosis.—A somewhat depressed, concavo-convex to biconvex species, with a wide frilled poreless keel, sinuous ventral and reflexed dorsal sutures, small ventral umbilicus, and a folded toothplate in each chamber.

Description.—Test trochoid, somewhat depressed, concavo-convex to biconvex, with the ventral surface the more strongly convex. In specimens with a concave dorsal surface, the central part of the test is always raised. Periphery with a wide thin poreless frilled keel. Test calcareous, chamber walls radiate hyaline, finely perforate on both dorsal and ventral sides; septal walls single, imperforate. All chambers visible from the dorsal side, forming 3-3½ whorls, only those of the last whorl from the ventral side, with 6-7 chambers in the last whorl. Proloculus globular, chambers increasing slowly in size as added, with the proximal margin of each chamber extending beyond the distal margin of the previous chamber, giving a serrated appearance to the outline of the chambers. Ventral surface with a small open umbilicus, in some specimens (including the holotype) partly covered by a small triangular lip. Sutures on ventral side narrow, distinct, slightly depressed, sinuous. Sutures on dorsal side obscure on dry specimens, on moistened specimens seen to be straight or only slightly curved and strongly reflexed, the chambers long and narrow. Apertural face very low, aperture ventral, a narrow slit at the base of the chamber, with a small lip, extending from just above the peripheral margin of the chamber into the umbilicus, and in some specimens bordered marginally by a small fold of the apertural face. Each chamber with a well developed toothplate extending from the septal foramen diagonally across the floor of the chamber towards the peripheral margin of the following septal wall, in a direction which is often almost parallel to the suture. The toothplate begins on the septal foramen just below the umbilicus, and consists

of a thin high ridge with the upper edge strongly folded towards the umbilicus (*see* text figure 4).



TEXT FIGURE 4

Nuttallina coronula, n. gen., n. sp.
Paratype D. Internal view of chambers showing toothplates. a. Periphery of test. b, c. Proximal and distal chamber margins, respectively. d. Toothplate.

Dimensions.—

	Max. Diameter	Height
Holotype	0.722 mm.	0.204 mm.
Paratype A	0.592 mm.	0.167 mm.
Paratype B	0.537 mm.	0.148 mm.
Paratype C	0.555 mm.	0.204 mm.
Paratype D	0.481 mm.	0.194 mm.

Remarks.—The shape of this species in side view varies considerably, from concavo-convex to strongly biconvex. The holotype and two paratypes are plano-convex, one paratype is concavo-convex, and one biconvex. The small lip covering the umbilicus does not occur on all specimens, but possibly only the better preserved specimens show this feature. The folded upper edge of the toothplate is also not seen in all specimens. *Nuttallina coronula* is distinguished from the similar form described by White (1928) as *Gyroldina florealis* by its more compressed test, more

EXPLANATION OF PLATE 19
All figures are retouched photographs.
Magnifications are approximate.

FIGS.

PAGE

- 1-14. *Nuttallina coronula*, n. gen., n. sp. 97
- 1-3. Holotype (C.P.C. No. 1530). × 50. 1. Ventral view showing small lip over umbilicus, sinuous sutures and wide frilled keel. 2. Dorsal view, specimen in xylol, showing shape of chambers on dorsal side. 3. Edge view showing plano-convex test.
- 4-5. Paratype A (C.P.C. No. 1531). × 50. 4. Ventral view. 5. Edge view.
- 6-7. Paratype C (C.P.C. No. 1533). × 50. 6. Ventral view. 7. Edge view showing biconvex test.
8. Paratype B (C.P.C. No. 1532). × 50. Ventral view showing toothplate in penultimate chamber.
- 9-14. Vertical sections, × 54. Figs. 9-12 (C.P.C. Nos. 1535-1538) show the shape of the test, small ventral umbilicus, and the aperture extending into the umbilicus. Fig. 13 (C.P.C. No. 1539) shows the small umbilicus and a toothplate. Fig. 14 (C.P.C. No. 1540) is a thick section showing the toothplates of the last two chambers forming thin ridges in the chambers.

sinuous ventral sutures and more strongly developed frilled keel.

The specific name is the Latin *coronula*, diminutive of *corona*, crown, halo, rim, border.

Occurrence.—Holotype (C. P. C. No. 1530) from outcrop of Toolonga Calcilutite, Pillarawa Hill, Murchison River area, Western Australia, from beds about 14 feet above base of the formation (Santonian). Paratype A (C. P. C. No. 1531) from same locality and level as holotype. Paratype B (C. P. C. No. 1532) from outcrop of Toolonga Calcilutite on scarp 1 mile south of Toolonga Point, Murchison River area, Western Australia, from beds 28 feet above base of the formation (lower Campanian). Paratype C (C. P. C. No. 1533) from outcrop of Korojon Calcarene, 7 miles E.N.E. of No. 10 Bore, Cardabia, Western Australia, 38 feet above base of the formation (upper Campanian). Paratype D (C. P. C. No. 1534) from same locality and level as holotype. One vertical section (C. P. C. No. 1535) from same locality and level as holotype. Four vertical sections (C. P. C. Nos. 1536-1539) from outcrop of Toolonga Calcilutite on Meanarra Hill, Murchison River area, Western Australia. One vertical section (C. P. C. No. 1540) from same locality and level as Paratype C.

This species has been found in Western Australia in beds ranging in age from uppermost Santonian to upper Campanian. It occurs more frequently in the uppermost Santonian and lower Campanian beds of the Murchison River area.

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