

THE DISTRIBUTION OF THE FORAMINIFER *ALLIATINA EXCENTRICA* (DI NAPOLI ALLIATA) AND THE NEW GENUS *ALLIATINELLA*

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ABSTRACT. *Alliatina excentrica* (di Napoli Alliata) is recorded for the first time from the Pliocene of the Anglo-Belgian basin. The distribution of *A. excentrica* and *Alliatinella gedgravensis* in the Pliocene of Europe, and the genus *Alliatina* in Recent seas is considered. It is concluded that *A. excentrica* is a warm-water species characteristically inhabiting shallow, sub-littoral environments, and its disappearance from the Anglo-Belgian basin marks the Plio-Pleistocene boundary. The type species of *Alliatinella* is described and figured, and the genus defined. The relationship of *Alliatinella* to *Alliatina* and *Cushmanella* is discussed.

DISTRIBUTION

THE foraminifer *Alliatina excentrica* (di Napoli Alliata) has been found to be widely, but sparsely, distributed in the Gedgravian (Coralline Crag) of East Anglia. It is associated with a closely related, hitherto undescribed species, here designated *Alliatinella gedgravensis* gen. and sp. nov. Since *A. excentrica* has previously been recorded only from the Upper Pliocene 'Astian' of Italy (Napoli Alliata 1952, p. 105; Troelsen 1954, p. 465), its appearance in the Anglo-Belgian basin is of particular interest. The distribution of *A. excentrica* and *A. gedgravensis* therefore will be examined in detail.

Distribution of Alliatina excentrica and Alliatinella gedgravensis in the Gedgravian. The Gedgravian deposits described in greatest detail in the literature are those of the Sutton outlier, near Woodbridge, Suffolk. These were 'zoned' by Prestwich (1871, pp. 116-20, text-figs. 1 and 2, pl. 6, maps and sections) and later discussed by Harmer in various papers (1898, pp. 320 et seq., text-figs. 5 and 6; 1902, p. 428, text-fig. 68; 1908, p. 92; &c.). Here the secondarily indurated 'Rock Bed' (Prestwich's 'Zone g'), the comminuted-shell sands ('Zone f'), and the top of the underlying marly sands ('Zone e') are all exposed, and the basal portion of the succession is easily attainable by hand auger. The Sutton deposits therefore were very thoroughly sampled, and since larger amounts of material were collected from here than elsewhere, the majority of the writer's specimens of *A. excentrica* and *A. gedgravensis* are from this locality.

One continuous section was obtained, consisting of a standing face, pit, and fruit-tree auger boring. The site was located in a small, now disused crag-pit, situated about 100 yds. west-north-west of a cottage on Occupation Road, and an equal distance north-east of Prestwich's Pit 'F' (Prestwich 1871, pl. 6, map). The succession is 28 ft. 3 in. thick, and rests on London Clay. It is materially the same as that seen in Pit 'F' (see Prestwich 1871, p. 119, text-fig. 2). The section was continuously sampled, each sample representing a stratigraphic interval of 6 in. The samples were numbered consecutively, from the top down.

In the first series of preparations covering the section, *A. excentrica* was found in seven samples—Nos. 18, 22, 23, 26, 31, 32, and 55 (see text-fig. 1). In Nos. 23, 26, and

After washing, the preparations were thoroughly dried, sieved, and the foraminifera floated off the 90–60 fractions with carbon tetrachloride. All samples, except No. 4, which was too indurated to give satisfactory results, gave extremely rich foraminiferal concentrates (between 8,652 and 50,167 specimens per gramme of 90–60 fraction). *A. excentrica* was found in Nos. 9, 19, 24, 29, and 34, in all cases associated with *A. gedgravensis*. The latter, unaccompanied by the former, was found in Nos. 39, 44, and 49. Nos. 14 and 54 contained neither species. Details of relative abundance, &c., are given in text-fig. 1.

The distribution of the two species in the Sutton section is clearly defined. In the lower portion of the marly sands *A. excentrica* is almost absent, occurring only in sample No. 55. Above the junction between the marly sands and the comminuted-shell sand (the junction between Prestwich's 'Zones e' and 'f') it is sporadically distributed and rare. In the central part of the succession (the first 9 ft. below the junction), however, it is present, in relative abundance, in all of the eighteen samples. The distribution of *A. gedgravensis* is closely similar, although this species is more widely distributed throughout the lower portion of the marly sands than *A. excentrica*, and slightly less abundant than the latter in the central part of the section.

A lithological sequence resembling that at Sutton can be demonstrated in the much larger outlier of Orford at Richmond Farm, three-quarters of a mile south-west of the town (Harmer's Locality 9, see Harmer 1898, text-fig. 4). Here the exposed part of the Gedgravian consists of some 18 ft. of secondarily indurated, current bedded, comminuted-shell sand (Prestwich's 'Zone g'), which stands in vertical faces forming the walls of the farm stockyard. Augering at the base of one standing face has shown that the induration decreases rapidly downwards, and disappears about 5 ft. below the stockyard floor. Then, 11 ft. 8 in. below the floor, the unconsolidated comminuted-shell sands quite suddenly give place to soft, marly sands. The latter contain thin, impersistent seams of shells, and continue to the bottom of the hole at 25 ft. 6 in. below the floor. At this level caving occurred, and the hole was abandoned.

In this section the same method of sampling and numbering was used as at Sutton. *A. excentrica* and/or *A. gedgravensis* were found in samples Nos. 25, 46, 56, 60, 61, 62, 64, 65, 67, 69, 70, 73, 74, and 84. The majority of these samples are from the first 6 ft. below the comminuted-shell sand–marly sand boundary. Since no carbon tetrachloride separations were used, and the total number of specimens of the two species is not more than four in any one preparation, no reliable estimates of relative abundance can be made. Despite the limitations imposed by lack of concentrates, the distribution outlined above is clearly a reflection of that in the Sutton section. This is illustrated in text-fig. 1.

A. excentrica and *A. gedgravensis* have been found in materials from many of the classic exposures at the southern end of the Orford outcrop (Harmer's Locality 3, north of The Cliff, near Gedgrave; 6 and 7, Gedgrave Hall; and 12, Sudbourne Park). Their relative abundance in the assemblages is in harmony with that at Sutton. Both species have also been found in materials from the Tattingstone outlier south of Ipswich, but their distribution in this section has not been worked out in detail.

The occurrence at maximum abundance in a correlatable band in the Sutton and Orford outcrops suggests that the lithological break (the boundary between Prestwich's 'Zones e' and 'f') immediately overlying it has some stratigraphical significance. This

belief is reinforced when the distribution of the other foraminiferal species is considered. Although the differences between the assemblages above and below the break are largely quantitative, and are to some extent governed by current sorting (Carter 1951), they are constant, and can be recognized in all three of the Gedgravian outliers (Tattingstone, Sutton, and Orford-Aldeburgh). In a later paper the foraminiferal faunas as a whole will be discussed, and evidence will be produced favouring a subdivision of the Gedgravian into two, an upper portion correlated with the Scaldisian of the Low Countries, and a lower portion correlated with the Upper Diestian.

The occurrence of Alliatina excentrica in the Upper Diestian and Scaldisian of Belgium. In connexion with another matter the writer had occasion to examine the Casterlian and Scaldisian materials from the Kattendyk Dock excavations, Antwerp, in the Burrows and Holland Collection at the British Museum (Natural History), London (see Burrows and Holland 1897, p. 393). The specimen of '*Pulvinulina auricula* (Fichtel and Moll)' recorded from the Scaldisian (Burrows and Holland 1897, p. 391, no. 363) turned out to be *A. excentrica* (found in cell 32 of an uncatalogued slide labelled 'Scaldisian Inf. Kattendyk Docks, Antwerp, 'A)').

Although *A. excentrica* was not recorded by van Voorthuysen and Pannehoek (1951), it is sparingly present in the base of the Upper Diestian in the Kruisschans Boring, near Antwerp. Two broken specimens were found by the writer in sample No. 6.

Alliatinella gedgravensis has not been recorded from the Low Countries, nor has it been found in materials available to the writer. Its constant association with *A. excentrica* in the Gedgravian indicates that it is probably present but exceedingly rare, and has so far escaped notice by Belgian and Dutch workers.

The occurrence of Alliatina excentrica and Alliatinella gedgravensis in the Pliocene of Italy. The types of *A. excentrica* are from the Upper Pliocene 'Astian' of Castel Arquato (Piacenza), northern Italy (Napoli Alliatina 1952, p. 106). Additional specimens were recorded by Troelsen (1954, p. 465) from the Upper Pliocene of Valle Andona, northern Italy. The species is also present in Burrows and Holland's material from the 'Plaisancian' of Bordighera, Italy (in cell 14 of an uncatalogued slide labelled 'Bordighera Pliocene "B"'). It was placed by them in *Nonionina scapha* (Fichtel and Moll) (Burrows and Holland 1897, p. 390, no. 385).

Although *A. gedgravensis* has not been recorded from the Italian Pliocene it is present in the Upper Pliocene 'Astian' of Valle Andona, northern Italy. One specimen has been found in materials from that locality in the Imperial College Collections. It is associated with *A. excentrica*.

The distribution of the genus Alliatina in Recent seas. Examination of Millett's figured specimen of *Bulimina convoluta* Williamson var. *nitida* (1900, p. 280, pl. 2, figs. 10a-c) from the Malay Archipelago has confirmed Troelsen's suspicion that the species should be placed in the genus *Alliatina* (Troelsen 1954, p. 465). Millett's specimen is identical with the type figures of Cushman and McCulloch's '*Cushmanella primitiva*' (1940, pl. 18, figs. 6-10). These workers appear to have overlooked the asymmetrical form of the supplementary aperture and 'internal tube', and '*Cushmanella primitiva*' should be placed in synonymy with *Alliatina nitida* (Millett). The types of the former are from

Darwin's Bay, Tower Island, in the Galapagos Group, at 17 fathoms. The range is given as Braithwaite Bay, Socorro Island, Mexico, in 4–10 fathoms, southward to Port Utria, Colombia, in 20 fathoms, with records from points between at depths varying between 4 and 80 fathoms.

'*Bulimina convoluta* var. *nitida*' was recorded by Sidebottom (1905, p. 13) from Delos in the Grecian Archipelago, and by Heron-Allen and Earland (1915, p. 642) from the Kerimba Archipelago, East Africa. The figured specimen from Delos belongs to a species of *Alliatina*, as do the majority of the specimens recorded from the Kerimba Archipelago. This is widely distributed in the latter area, and is usually associated with a species of *Pseudobulimina*, as in the Malay Archipelago. It occurs in materials from Stations Nos. 1, 3–6, 9, 11, and 12, at depths ranging from 5 to 18 fathoms. Heron-Allen and Earland's specimens of '*B. convoluta*' from Station 11 also belong in *Alliatina*.

The genus *Alliatina* is also represented in Heron-Allen and Earland's materials from 16 fathoms, Friendly Islands (Tonga Group), '*B. convoluta* Williamson' (with a species of *Pseudobulimina*); Delos (ex Millett's Colln.) '*B. convoluta* var. *nitida*' (with *Cushmanella browni* (d'Orbigny)); and Sulu Roadstead, '*B. convoluta* var. *nitida*'. Their specimens of *B. convoluta* var. *nitida* from Port Darwin, Australia, however, should be placed in *C. brownii*.

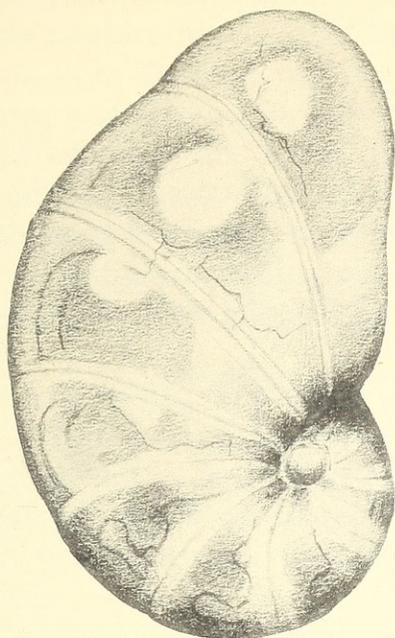
The significance of the distribution of Alliatina excentrica in the Pliocene of Italy and the Anglo-Belgian basin. Although the records of *Alliatina* in Recent seas are few, they clearly indicate that the genus characteristically inhabits shallow tropical waters. Its absence from the shallow-water assemblages of the Atlantic and North Sea coasts of Europe is a consequence of the relatively low temperatures prevailing in these areas. The occurrence of this genus in the Pliocene of the Anglo-Belgian basin suggests the existence at that time of a climate considerably warmer than that now prevailing. This hypothesis is in harmony with the evidence provided by the molluscs and the polyzoa. The rarity of *A. excentrica* in the Pliocene assemblages of the Anglo-Belgian basin probably indicates that this area was very near the northern limit of distribution of the species.

The Plio-Pleistocene boundary in the Anglo-Belgian basin is usually taken where evidence of climatic deterioration first becomes manifest with the first appearance of typically arctic species of *Elphidiella* ('*E. cf. arctica* (Parker and Jones)' of van Voorthuysen, = '*E. arctica* (Parker and Jones)' of Lagaaij = *E. hannai* (Cushman and Grant); see Lagaaij 1952, p. 203). In East Anglia this is at the base of the Waltonian Red Crag (see van Voorthuysen and Pannekoek 1951, diag. no. 2), and it is precisely here that *A. excentrica* disappears. In view of the similarity between the Plio-Pleistocene faunal sequences on the two sides of the North Sea basin it seems likely that *A. excentrica* will prove to have a similar distribution in the Low Countries, and will serve as a useful climatic-stratigraphic marker.

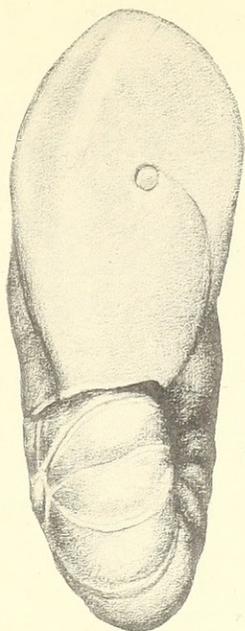
EXPLANATION OF PLATE 14

Figs. 1a–c. *Alliatinella gedgravensis* gen. et sp. nov. Holotype, Brit. Mus. Cat. No. P. 43459. 1a, dorsal view; 1b, apertural view; 1c, ventral view. × 183.

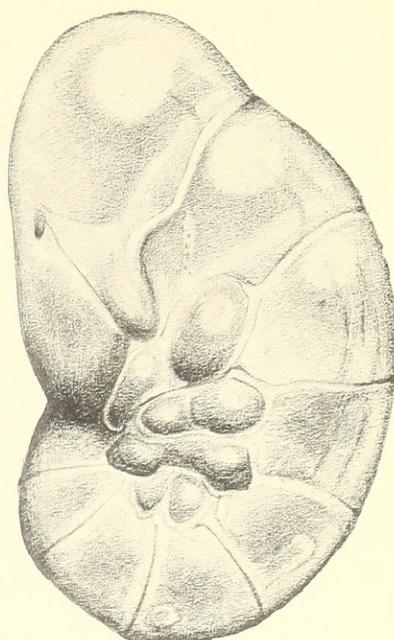
Figs. 2a–c. *Alliatina excentrica* (di Napoli Alliatina). Hypotype, Brit. Mus. Cat. No. P. 43462. 1a, dorsal view; 1b, apertural view; 1c, ventral view. × 183.



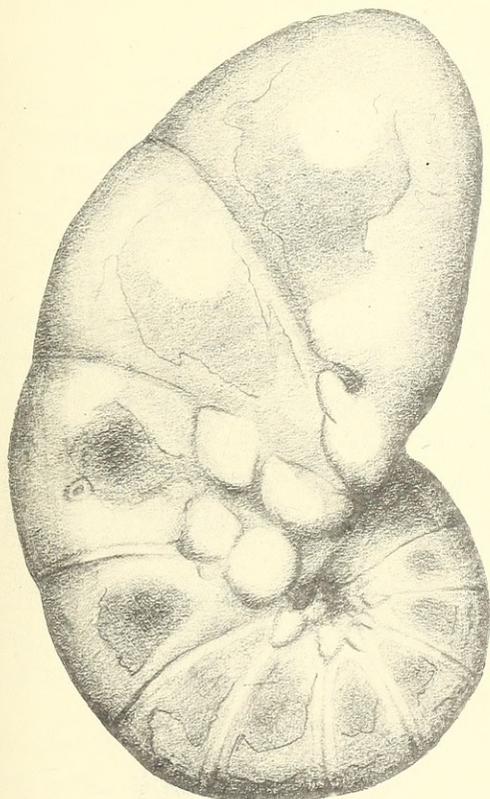
1a



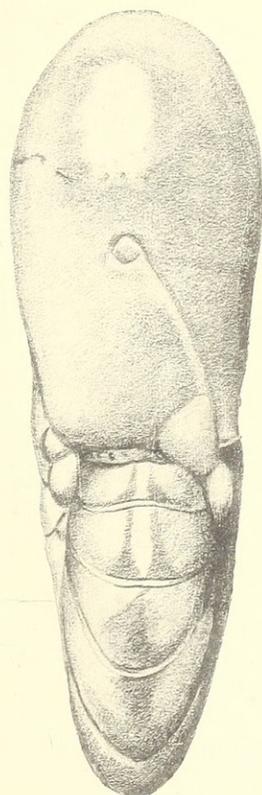
1b



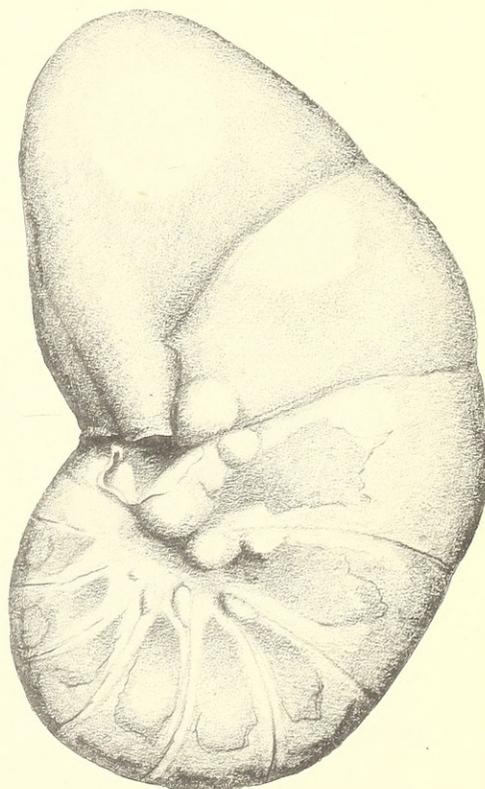
1c



2a



2b



2c

CARTER, Pliocene *Foraminifera*

Since *Alliatinella gedgravensis* has not been found in Recent material no direct evidence concerning ecologic factors governing its distribution is available. Since its distribution in the Gedgravian resembles that of *A. excentrica* it is likely that it also is a shallow, warm-water species. Its absence from the post-Gedgravian deposits in eastern England supports this belief. If the non-appearance of this species in Recent seas is real, and not due to collection failure, it must become extinct at some level in the Pleistocene or Holocene. Its total time-range cannot be worked out until more information is available concerning post-Pliocene faunal successions in areas far enough south to be relatively little affected by the Pleistocene refrigeration.

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SYSTEMATIC PALAEOONTOLOGY

Family CERATOBULIMINIDAE Glaessner (emend. Troelsen)

Genus ALLIATINA Troelsen

Type species *Cushmanella excentrica* di Napoli *Alliata*

Alliata excentrica (di Napoli *Alliata*)

Plate 14, figs. 2a-c

Pulvinulina auricula (Fichtel and Moll), Burrows and Holland 1897, pp. 390-1, no. 363 (part).

Nonionina scapha (Fichtel and Moll), Burrows and Holland 1897, pp. 390-1, no. 385 (part).

Cushmanella excentrica di Napoli *Alliata* 1952, pp. 11-13, pl. 5, figs. 1, 1a, 1b.

Alliata excentrica (di Napoli *Alliata*), Troelsen 1954, p. 465, pl. 11, figs. 4-6, 8, 9, 12.

Remarks. The Gedgravian specimens agree in most respects with those very fully described and illustrated by Troelsen (1954). In the majority, however, the supplementary aperture is closed by a very thin calcareous plate, and is non-functional. When a new chamber is added this plate is resorbed, and the resulting perforation functions as a septal foramen. The plate is very fragile, and is often broken in fossil specimens. Adult individuals of the species attain a maximum larger diameter of 0.50 mm.

Distribution. Upper and Lower Gedgravian (Pliocene) of eastern England; Upper Pliocene 'Astian', Pliocene 'Plaisancian' of northern Italy; Pliocene Upper Diestian and Scaldisian of Belgium.

Dimensions of figured specimen. Hypotype; larger diameter 0.45 mm., smaller diameter 0.28 mm., thickness 0.15 mm.

Horizon and locality. Figured hypotype; carbon tetrachloride flotation, sample no. L22/1, base of Upper Gedgravian comminuted-shell sands, about 2 ft. above its junction with the Lower Gedgravian marly sands, Harmer's Locality 7 (see Harmer 1898,

fig. 4) in disused crag-pit adjacent to Lower House Cottages, Gedgrave Hall, $1\frac{1}{4}$ miles south-west of Orford, Suffolk, England.

Repository. Figured hypotype (Brit. Mus. Cat. No. P. 43462), Dept. of Foraminifera, British Museum (Natural History), London; unfigured hypotypes (Foram. Research Cat. Nos. 150/1-8, 151/1-21, 152/1-37, 153-62), Dept. of Geology, Imperial College, London.

Genus ALLIATINELLA gen. nov.

Type species *Alliatinella gedgravensis* sp. nov.

Diagnosis. Lateral outline, wall structure, shape of chambers, position and shape of basal aperture, shape and orientation of internal partition, and direction of coiling identical in all respects with that of *Alliatina*, but coiling distinctly and consistently trochospiral, accessory chambers developed only on the ventral side, and supplementary aperture offset towards the ventral side of the apertural face. In ventral view the genus is scarcely distinguishable from *Alliatina*, from the dorsal side it shows a surprising and quite misleading resemblance to a juvenile *Cancris*. In apertural view the genus is markedly asymmetrical.

Relationships. In his paper on the Ceratobuliminidae Troelsen (1954, p. 464) discusses the relationship between the genera *Alliatina* and *Cushmanella*. Under 'Remarks' he states—'Palmer and Bermudez's figures (1936) of *Cushmanella brownii* (d'Orb.), the genotype of *Cushmanella*, are not particularly clear, but in their diagnosis they expressly state that the test is bilaterally symmetrical. Hofker (1951, fig. 11a) represents the internal tube in *C. brownii* as being bilaterally symmetrical and entirely different in its construction from the internal partition of *Alliatina*', and in 'Postscript 3'—'The assumption of a fundamental difference between *Cushmanella* and *Alliatina* is confirmed through examination of topotypes of *C. brownii* (D'Orb.) . . .' (the word 'fundamental' is deleted in the separate kindly sent to the writer by Dr. Troelsen). The writer is unable to agree with the views expressed by Dr. Troelsen. *Cushmanella* is considered to be closely related to *Alliatina*, and both to *Alliatinella*.

The differences between *Cushmanella*, *Alliatina*, and *Alliatinella* are fundamentally those of symmetry. Examination of specimens of *C. brownii* in the Heron-Allen and Earland Collection in the British Museum has shown that the 'internal tube' is identical with the inverted-V-shaped internal partition of the other two genera, except that it is symmetrically orientated relative to the plane of coiling, and free on both margins ('dorsal' and 'ventral' margins by homology with *Alliatina* and *Alliatinella*). The supplementary aperture (Hofker's 'Protoforamen', 1951, fig. 11a) is arranged parallel to the basal suture (not obliquely, as in the other two genera), and is hour-glass shaped, but these features are controlled by the position of the internal partition, and the curling under of its free margins. *C. brownii* is otherwise identical with the type species of *Alliatina*.

The relationship between *Alliatina* and *Alliatinella* is self-evident. The differences between the two genera are similar in essence to those between *Cushmanella* and *Alliatina*.

Alliatinella, *Alliatina*, and *Cushmanella* constitute a morphological series in increasing

bilateral symmetry. If Palmer and Bermudez's record of *Cushmanella* from the Late Tertiary of Cuba refers to an *Alliatina*, as is likely, the writer's belief that this series is evolutionary would be very strongly supported by the geological ranges—*Alliatinella*, Pliocene; *Alliatina*, Pliocene and Recent; *Cushmanella*, Recent.

The internal partition of *Alliatinella* is very similar in form to that of *Ceratobulimina*, and the two genera have identical wall structure and constant dextral coiling. According to Troelsen (1954, pp. 450, 453, 464) the septal foramen in the type species of *Ceratobulimina* is secondary. Hofker (1954, p. 147), however, states it to be homologous with the distal portion of the apertural foramen (supplementary aperture) of the previous chamber. In *Alliatina*, *Alliatinella*, and *Cushmanella* the supplementary aperture is apparently non-functional, and is closed by a thin plate. When a new chamber is formed the plate is resorbed, and the perforation produced functions as the septal foramen. Until this anomaly is explained the systematic position of the three latter genera must remain doubtful. They are tentatively placed in the Ceratobuliminidae.

Alliatinella gedgravensis sp. nov.

Plate 14, figs. 1a-c; text-fig. 2

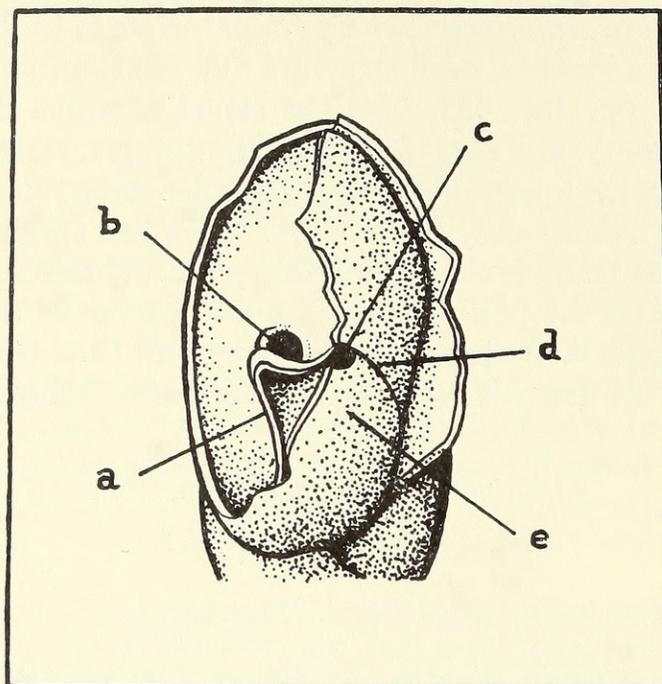
Cristellaria gibba (d'Orbigny), Jones 1895, pl. 7, figs. 19a, b.

Cristellaria gibba (d'Orbigny), Jones 1896, pp. 247-8 (part).

Cristellaria gibba (d'Orbigny), Burrows and Holland 1897, pp. 384-5, No. 233 (part).

Description. Test free, ear shaped in lateral view, with broadly rounded periphery, coiled in a low, dextral trochospiral. Chambers of two kinds: large conspicuous primary chambers, scarcely if at all inflated, and small blister-like accessory chambers arranged in two or three series, covering the sutures between the primary chambers near the umbilical margin on the ventral side, usually not developed on the suture between the ultimate and penultimate primary chambers. Sutures distinct, white, slightly depressed in the later growth stages. Apertures of two kinds: one a simple slit at the base of the apertural face, the other non-functional, an oblique oval in the apertural face, slightly offset towards the ventral side, sealed with a very thin, calcareous plate. Internal partition (see 'a', text-fig. 2) asymmetrical and inverted-V-shaped in cross-section, extending obliquely across the primary chamber, formed by a completely enclosed invagination of the ventral chamber wall. Anterior attachment of partition to inside of apertural face, marked externally by a groove (see 'd', text-fig. 2) extending obliquely from the ventral umbilicus to the top of the non-functional aperture, which is enclosed above, on the dorsal (spiral) side, and below by a fold in the partition; dorsal (spiral) margin of the partition free, running posteriorly from beneath the non-functional aperture to the base of the previously formed apertural face (septum) near the spiral suture; posterior margin joined to previously formed apertural face (septum), running from the spiral suture to the base of the septal foramen (see 'b', text-fig. 2) formed by resorption of the plate covering the previous supplementary aperture, then turning sharply down to the ventral umbilicus. Chamber walls calcareous, finely perforate, layered, with a glistening surface, outer layers thin or missing in two narrow bands running round the test, one on either side of the periphery, occasionally over the whole of the lateral surfaces of the chambers. Pores radially arranged, occasionally enlarged, and passing

right through the test wall; enlarged pores more abundant where the outer layers of wall material are thin or missing. Maximum larger diameter of adult specimens up to 0.48 mm.



TEXT-FIG. 2. *Alliatinella gedgravensis* gen. and sp. nov. Paratype, Brit. Mus. Cat. No. P. 43460. Apertural view of dissection illustrating relationship of internal partition to septal foramen. *a*, internal partition; *b*, penultimate septal foramen; *c*, ultimate septal foramen; *d*, groove on anterior surface of ultimate septum, marking line of attachment of ultimate internal partition; *e*, ultimate septum (apertural face of penultimate chamber). $\times 183$.

Remarks. The first reference to this species was by Jones (1895), who misidentified it with *Cristellaria gibba* d'Orbigny. Two figures of a Gedgravian specimen from Sutton were given (figs. 19*a* and *b* on pl. 7), one showing it in side view (fig. 19*a*), the other in apertural view. The latter shows the coiling to be planospiral. Examination of the original specimen in the Burrows Collection at the Geological Survey and Museum, London (Cat. No. Mik(T) 101001), shows that this drawing is inaccurate, and that the specimen should be placed in the species here designated *Alliatinella gedgravensis*. The illustrations for pl. 7, which were executed by either Burrows or Holland (see footnote, under plate explanation, Jones 1895), are all very formalized, and most of them are obviously based on several specimens. Fig. 19*a* is a fair representation of the dorsal view of the original, but fig. 19*b* probably illustrates a misinterpreted apertural view of *Alliatina excentrica*. It seems likely that Jones based his identifications on the figures rather than the specimen, for in his description (1896) he states—'This small subovate form is one of the many intermediate to the closely coiled *Cristellaria rotulata* and the more expanded and elongate *C. crepidula*. It has many cogeners, varying in relative thickness and other unimportant features.' Further comment is unnecessary.

In 1897 Burrows and Holland added a record of '*C. gibba*' from 'Zone g' (see Prestwich 1871, p. 121) of Gedgrave, near Orford. If the specimens so recorded are present



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