

# THE OCCURRENCE AND PALAEOBIOGEOGRAPHICAL SIGNIFICANCE OF THE FORAMINIFERID *YABERINELLA* FROM THE EOCENE OF OMAN

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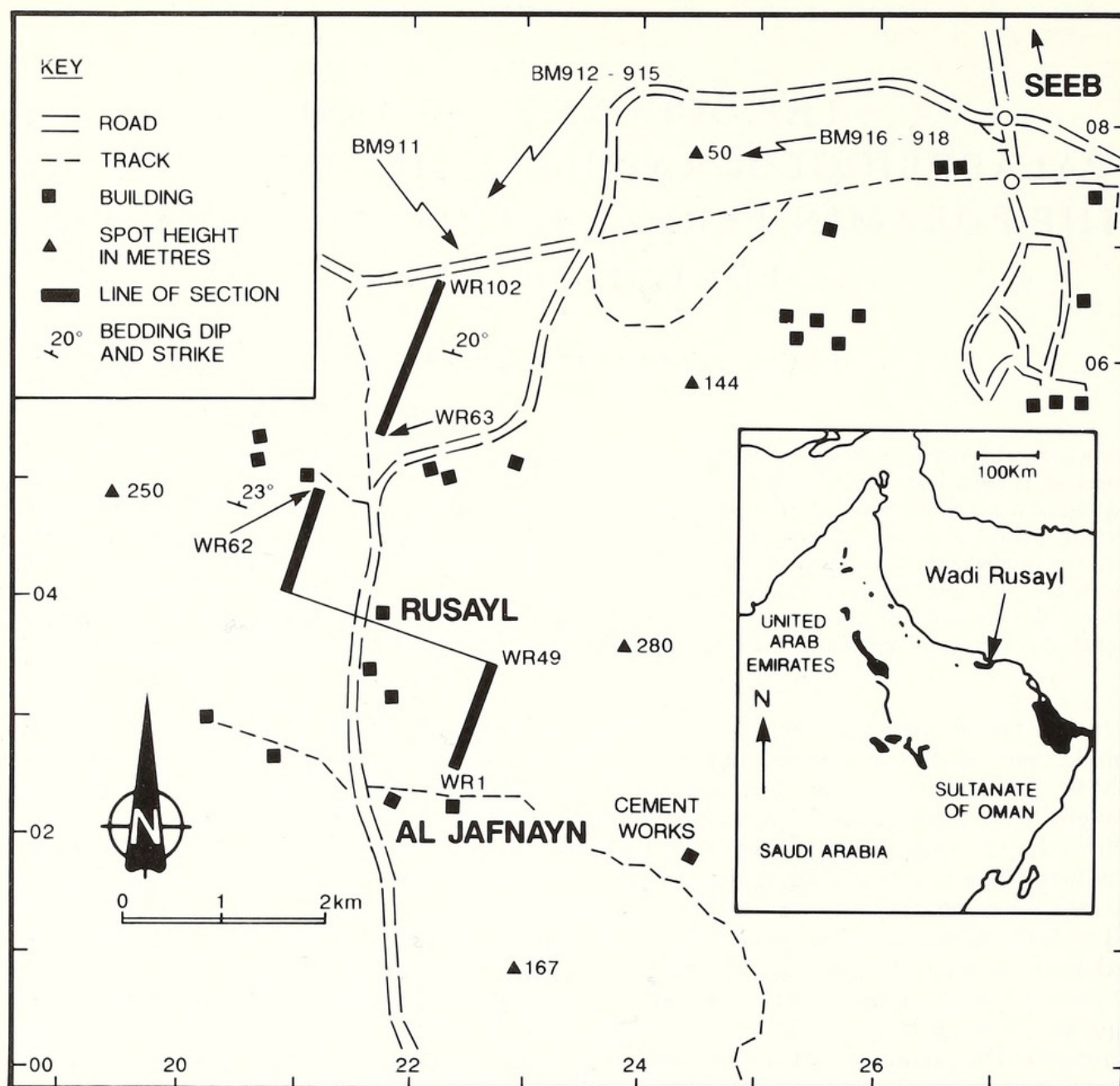
**ABSTRACT.** *Yaberinella jamaicensis* Vaughan, a genus and species previously regarded as endemic to the Americas, is described from a sample of Middle Eocene (Lutetian) limestone from coastal Oman. The new occurrence is shown to be well within the known stratigraphic range of this species in the Caribbean region. Recently published records of *Austrotrillina*, *Helicostegina*, *Helicolepidina*, *Lepidocyclina*, and *Polylepidina* are discussed briefly in the context of the disjunct distribution of *Yaberinella*. It is considered that since the widely-distributed and relatively well-studied faunas of Middle Eocene carbonate facies are apparently still so incompletely known, the case for provincialism among Palaeogene larger foraminifera is weakened, and published conclusions relating to dispersal routes for some Tertiary genera may well be premature.

DURING recent studies of the Tertiary limestones of eastern Oman (Racey 1988; White 1989) samples were taken from a series of knolls to the east of Wadi Rusayl (Text-fig. 1). One such sample (BM 911) yielded numerous specimens of *Yaberinella jamaicensis* Vaughan, a taxon hitherto thought to be confined to the Americas (Adams 1967; Hottinger 1973). The apparent endemism exhibited by *Yaberinella* was an important factor in the construction of the Tertiary faunal province hypothesis based on larger foraminifera (Adams 1967, 1973), and its discovery in Oman weakens the case for provincialism, at least during Palaeogene time.

The Tertiary succession in the coastal region of Oman has long been known to include strata of Palaeocene to Early Miocene age (Glennie *et al.* 1974; Montenat and Blondeau 1977; Racz 1979). Recent work on the nummulitids by one of us (A.R.) has shown that the upper part of the exposed sequence in the best-known section at Wadi Rusayl is mainly referable to the Middle Eocene (Lutetian). The youngest part of the underlying Seeb Limestone belongs to the *N. beneharnensis* (= *A. spira*) Zone of Schaub (1981), both marker fossils being present (Text-fig. 2). The sample yielding *Yaberinella* was collected from a 'limestone with clasts' (see p. 240), neither the base nor top of which is visible at outcrop. The Seeb Limestone lies below a largely obscured development of Upper Eocene limestone which is itself overlain by the coralliferous Ma'ahm Beds of Oligocene age.

The total thickness of Tertiary limestone in the Wadi Rusayl area is of the order of 580 m, of which 560 m is exposed. With the exception of some 50 m of late Palaeocene limestone at its base, the sequence is Eocene in age, the oldest beds probably being referable to the *Alveolina oblonga* or *A. dainellii* zones of Hottinger (1960; White in prep.). The Middle Eocene part of the sequence is about 450 m thick. Well over 100 samples have been collected from this succession during the last few years, and another 700 have been obtained from beds of equivalent age elsewhere in Oman. Other workers (e.g. Montenat and Blondeau 1977, and various oil company micropalaeontologists) have also examined numerous samples from the Wadi Rusayl area. However, despite this intensive study, *Yaberinella* has not previously been found in Oman, neither has it been reported from the Mediterranean region, the Middle East nor the Indian subcontinent, all areas from which important Middle Eocene limestones (e.g. the Khirthar Limestone, Pakistan) have been described.

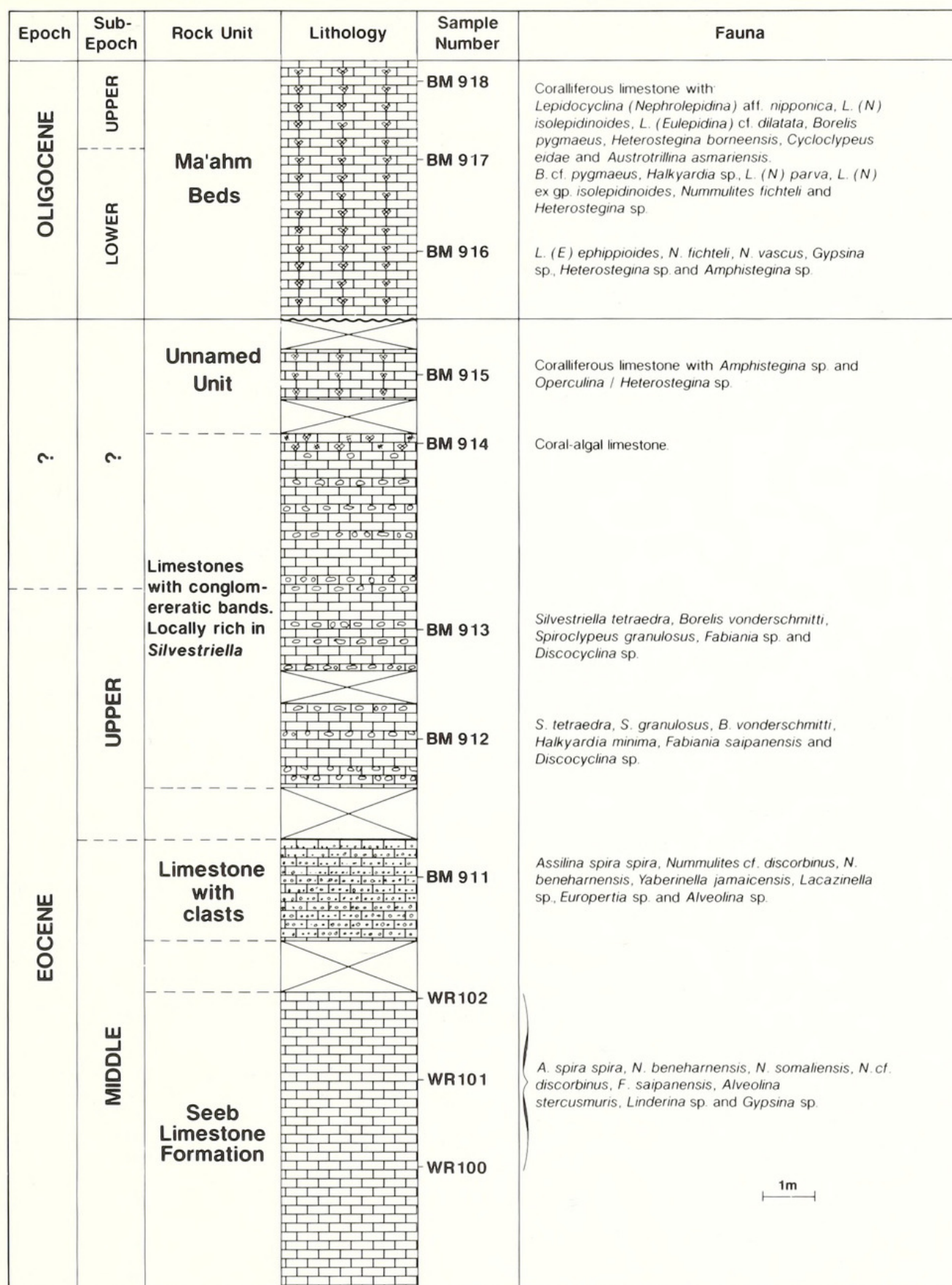




TEXT-FIG. 1. Map showing the location of Sample BM 911 in relation to the sampled succession in Wadi Rusayl, Oman.

In contrast to the thick sequence of Palaeocene to Middle Eocene carbonates exposed in Wadi Rusayl itself, the overlying succession (Text-fig. 2) is more varied. The basal 10 m was found to contain a Middle Eocene fauna, younger than anything observed in the main outcrop, and datable as Mid to Late Lutetian. Sample BM 911 yielded *Assilina spira* de Roissy and *Nummulites beneharnensis* de la Harpe (transported and penecontemporaneously redeposited if not actually reworked) along with *Yaberinella*, while two younger samples (BM 912 and 913) yielded *Borelis vonderschmitti* (Schweighauser), *Calcarina* sp., *Fabiania cassis* (Oppenheim), *Silvestriella tetraedra* (Gümbel), and *Spiroclypeus granulosus* Boussac. These two samples are therefore thought to be from the basal Upper Eocene.

The single sample from which *Yaberinella* was recovered came from a small, isolated outcrop no more than 3 m high and 7 m across: it was collected merely to complete the biostratigraphic sequence, no special importance being attached to it in the field. Not until the rock had been



TEXT-FIG. 2. Schematic stratigraphical column showing the position of Sample BM 911 in relation to the uppermost part of the Middle Eocene, the overlying Upper Eocene, and the Ma'ahm Beds in Wadi Rusayl, Oman.



disaggregated was its palaeobiogeographical significance appreciated, and by then it was too late for special note to be taken of its lithology. The washed and sieved residue was found to contain a large number of small, mostly rounded, mainly discrete, but sometimes aggregated clasts. The igneous components are thought to have been derived from the Semail Ophiolite, and the chert fragments from the Hawasina Series. Since the clasts are not scattered throughout the fragments of limestone in the coarse fraction of the residue, it is considered that they represent a thin band (or bands) of gravel, probably no more than 0.1 m thick. In view of the uncertainty attached to the lithology of this particular sample it is here referred to simply as a 'limestone with clasts'. The foraminifera occur in the carbonate matrix.

## SYSTEMATIC PALAEOLOGY

*Repository of specimens.* All material described and figured in this paper is deposited in the British Museum (Natural History), London (abbreviation BMNH).

Family SORITIDAE Ehrenberg, 1839  
Subfamily FABULARIINAE Ehrenberg, 1839  
Genus YABERINELLA Vaughan, 1928

*Type species:* *Yaberinella jamaicensis* Vaughan, 1928

*Remarks.* There is as yet no consensus of opinion regarding the terminology to be employed for the description of the internal structures of *Yaberinella*. Lehmann (1961) referred to ramps, stolons, and attics, but we prefer simpler terms and use only partitions (spiral and transverse), and tubes (central and lateral). The term stolon is, in our opinion, misleading since these structures are not (at least in the type species) simple tubes traversing thick chamber walls, as in the *Lepidocyclinidae* or *Orbitolitidae*, but layers of passages (tubes) delimited by endoskeletal deposits (partitions = 'plates' of Vaughan 1928) within the chamber lumen. The partitions may appear wavy in transverse section. Only in *Y. trelawniensis* Vaughan are the internal partitions greatly thickened (thus resembling chamber walls) as shown by Lehmann (1961, fig. 44), who illustrated tubes ('stolons') traversing massive deposits of endoskeletal material. In *Y. jamaicensis*, these tubes are formed by thin partitions and in cross-section tend to be rectangular rather than circular in shape. Fleury and Fourcade (1987, fig. 4 – explanation) postulate a somewhat different arrangement of tubes but again with greatly thickened partitions as shown by Lehmann (1961).

Although the positions of the chamber boundaries can be seen both on the surface (as sutures)

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## EXPLANATION OF PLATE 1

- Figs 1–10. *Yaberinella jamaicensis* Vaughan, 1928. 1–8, thin sections of megalospheric individuals (1–5, equatorial, BMNH P52263–P52267; 6–8, transverse, BMNH P52268–P52270) showing variation in shape, chamber growth, and proloculus size. Internal structure shows as lozenge-shaped chamberlets in figures 3 and 5 but as chevron-shaped tubes in figures 1 and 2, depending on how the spiral and transverse partitions are cut; Cole's (1952) 'small square chambers' are well seen in figures 5 and 6. 9–10, microspheric individuals; BMNH P52271–P52272 respectively; the sub-annular growth seen in fig. 10 is partly the result of regeneration after test damage. Figs 1–4 and 7,  $\times 10$ ; fig. 5,  $\times 11$ ; figs 6 and 8,  $\times 15$ ; figs 9–10,  $\times 10$ .  
Fig. 11. *Yaberinella* sp. cf. *Y. trelawniensis* Vaughan, 1929. BMNH P52273; megalospheric form; note the relatively small proloculus, numerous whorls and thick partitions,  $\times 15$ .  
Fig. 12. *Assilina spira* de Roissy, 1805. BMNH P52274; zonal marker (see Schaub 1981) occurring with *Y. jamaicensis*,  $\times 1$ .  
Fig. 13. *Nummulites beneharnensis* de la Harpe, 1926. BMNH P52275; zonal marker (see Schaub 1981) occurring with *Y. jamaicensis*,  $\times 3$ .  
All specimens from Sample BM 911, Eocene, Wadi Rusayl, Oman.







and in equatorial section (as clear areas), the 'septa' themselves appear quite structureless and are often seen to be crossed by the spiral and transverse partitions. Septa, as they are normally understood, have not, therefore, yet been observed in this genus. This is probably because the very thin apertural face (the basis of the future septum) has been destroyed by recrystallization in all known specimens.

*Yaberinella jamaicensis* Vaughan, 1928

Plate 1, figs 1–10

- 1928 *Yaberinella jamaicensis* Vaughan, p. 8, pls 4–5.  
 1952 *Yaberinella jamaicensis* Vaughan; Cole, p. 8, pl. 6, figs 1–8.  
 1961 *Yaberinella jamaicensis* Vaughan; Lehmann, p. 656, text-figs 43–46, pl. 13, figs 1–4; pl. 14, figs 1–3.  
 1969 *Yaberinella jamaicensis* Vaughan; Hottinger, p. 746, text-figs 1–2; pl. 1, fig. 1; pl. 2, figs 1, 2, 4; pl. 3, figs 1–2; pl. 4, figs 1–3; pl. 5, figs 1–6.

*Figured material.* BMNH P52263–P52270 (thin sections); BMNH P52271–P52272 (microspheric individuals). Sample BM 911 yielded 26 complete specimens and a number of large fragments.

*Age.* Middle Eocene (Mid Lutetian). Zone of *N. beneharnensis* (= *A. spira*) Schaub (1981). According to Schaub (1981, fig. 23), this is equivalent to the *Chiphragmalithus alatus* Zone (calcareous nannoplankton), which is itself equivalent to Blow's (1979) planktonic foraminiferal zones P10 to 12 (= topmost *H. aragonensis* to lowermost *G. lehneri*) – see Toumarkine and Luterbacher (1985, fig. 4) and Cavelier and Pomerol (1986, table 1). As mentioned earlier, it is possible that the assemblage is wholly or partly reworked, in which case its age could be slightly younger, *i.e.* Late Lutetian.

*Description.* Megalospheric generation, based on 16 sectioned and 8 isolated specimens.

Test large, complanate, 4–6.4 mm in maximum diameter and 1.15 mm in maximum thickness. The large subspherical to elongate proloculus (0.70–1.11 mm in maximum internal diameter), is connected to the partitioned chambers by a short neck (*goulot* of Hottinger 1969), usually offset to one side and only rarely visible in equatorial sections. All subsequent chambers are subdivided by two sets of internal partitions, one roughly paralleling the spire (spiral partitions), the other curving back towards the peripheral wall (transverse partitions). Unfortunately, septa are not usually visible in the first whorl, and the total number of chambers in the test cannot, therefore, be determined. The lowermost part of the chamber(s) in the first whorl completely embraces the proloculus. This part of the chamber has the wall of the proloculus as its floor, and the first spiral partition as its roof. It is subdivided by radiating transverse partitions which form the 'small square chambers' described by Cole (1952, p. 8, pl. 6, figs 1, 4–5). The chamber at the end of the first whorl may show from 6–12 spiral partitions. In the present material, the first visible 'septum' occurs at about 1–1½ whorls, and is followed by 3–17 (usually about 7) low, planispirally coiled, flaring peneropline chambers, which do not always increase regularly in size. The final chamber is rarely, if ever, complete in the present material. The spiral and transverse partitions are continued throughout the peneropline chambers, but with the transverse divisions becoming more oblique with respect to the spiral set. These are the 'ramps' described by Lehmann (1961) and are thin compared with the diameter of the 'stolons'. In some equatorial sections the two sets of partitions appear to intersect and form numerous lozenge-shaped chamberlets (Pl. 1, fig. 3). In others, the cavities between the partitions appear as tubes ('stolons'). These sets of parallel tubes (0.02–0.06 mm in diameter), are inclined at 80°–130° and give the test a regularly hachured appearance in thin section. Their walls (partitions) are thin (0.20–0.30 mm). The test surface is ornamented by fine ribs running at right angles to the chamber sutures. They are formed by the single layer of narrow, subepidermal tubes which overly the spiral and transverse tubes of the central region. Although true septa cannot be seen owing to recrystallization, their positions are marked by clear, structureless (recrystallized) areas in thin section. These contrast with the black spiral and transverse partitions which are seen to cross them in places. On the test surface, sutures are sometimes visible as faint depressions. Apertures not observed owing to poor preservation of the distal face of the last chamber.

*Microspheric generation.* Description based on 1 fairly complete individual and a number of large fragments.

Diameter 8 mm; initial coil of about 3.5 whorls, comprising at least 21 peneropline chambers, 9 of which occur in the last complete whorl. True annular chambers have not been observed, although the ends of the later chambers in large individuals certainly either meet or overlap, thus becoming pseudo-annular (Pl. 1, fig. 10). Proloculus and earliest part of the initial coil not seen in the present material.



*Remarks.* The relatively small number of specimens obtained from Sample BM 911 show a remarkably wide range in size. Megalospheric individuals are mainly rather larger than the types from Jamaica and have 3–17 peneropline chambers compared with about 9 in Vaughan's figured specimen (1928, pl. 5, fig. 1). Hottinger (1969) recorded individuals from the type area with from 10 to about 15 peneropline chambers. The enormous proloculus, a characteristic feature of this species, is seen in individuals from both Oman and Jamaica. The most complete microspheric individual from Oman is smaller and has fewer chambers than its Jamaican counterparts. The size and layered arrangement of the internal tubes ('stolons') appears to be the same in individuals from the two areas.

One individual (BMNH P52273; Pl. 1, fig. 11) possesses a relatively small proloculus (0.4 mm in maximum internal diameter), thicker internal walls, and a tighter and longer coil than the other specimens. It is therefore referred here to *Y. cf. trelawniensis* Vaughan, a species placed in synonymy with *Y. jamaicensis* by Cole (1952) but regarded as distinct by Hottinger (1969) and Robinson (in press). Hottinger's figures of *Y. trelawniensis* (1969, pl. 5, figs 1–6) also show thickened internal partitions.

*Associated fauna.* *Assilina spira spira* de Roissy (BMNH P52274; Pl. 1, fig. 12), *Nummulites beneharnensis* de la Harpe (BMNH P52275; Pl. 1, fig. 13), *N. cf. discorbinus* (Schlotheim), *Fabiania cf. cassis*, *Alveolina* sp., *Lacazinella* sp., *Eorupertia* sp and miliolids.

Originally described by Vaughan (1928) as having an agglutinated wall, *Yaberinella* was later found by Hans Reichel to be porcelaneous (Lehmann 1961). The internal structure of the adult chambers was analysed by Lehmann (1961, p. 656). In 1969, Hottinger redescribed and figured the two known species and demonstrated their relationship to *Fabularia*, arguing that *Y. trelawniensis* was more primitive and older than *Y. jamaicensis*, a fact confirmed by Robinson (in press) who has found that the range of *Y. jamaicensis* in the Caribbean region approximates to Blow's planktonic foraminiferal zones P12 to early P15, while that of *Y. trelawniensis* is P10 to P13.

It is difficult to relate the various Caribbean records of *Yaberinella* to the single occurrence in Oman because the associated faunas are different in the two areas, and precise control from planktonic foraminifera and/or calcareous nannoplankton is usually lacking. Nevertheless, it is clear that the Oman assemblage occurs well within the stratigraphic range of *Yaberinella* in the Caribbean, and is significantly younger than the oldest known occurrence of the genus. The fact that some individuals resemble *Y. trelawniensis* suggests that the age of this assemblage is P12 to P13, if the ranges cited by Robinson (see above) can be confirmed. The presence of *N. beneharnensis* and *A. spira* confirms that the assemblage in BM 911 cannot be older than P10 to P12, while the faunas in the overlying samples show that it cannot be as young as P15 even if reworking has occurred. A mid to late Lutetian age is therefore certain.

It is clear that the single known occurrence of *Yaberinella* in the Middle East is considerably younger than the earliest Eocene records from the Caribbean area over which there is any planktonic control. It may therefore be inferred that dispersal was from the New to the Old World, presumably by the shortest route (west to east), though in the absence of records from West Africa and the western Tethyan region generally, the direction of movement is uncertain. Hottinger (1969) showed that *Fabularia* may be the closest known relative of *Yaberinella*, but since this genus occurs in both the Tethyan and American regions it does not confirm that *Yaberinella* originated in the Americas.

The most northerly records of *Yaberinella* in the New World are believed to be those from Costa Rica (Eva 1976) and Jamaica (Vaughan 1928, 1929), and the most southerly from the Panama Canal Zone (Cole 1952). This extremely narrow latitudinal range (9°N – 18°N) will undoubtedly be extended by future work.

#### PROVINCIALISM

The discovery of *Yaberinella* in the Arabian Gulf has cast doubt on the reality of the three main faunal provinces postulated by Adams (1967). Questions had already been raised by certain



unrelated discoveries made during the last twenty years, and these are worth discussing briefly in the present context.

The mixing of American and Tethyan faunas along the western coast of North Africa has been confirmed and extended by Freudenthal's report (1972) of *Helicolepidina* together with typical American species of *Lepidocyclina* from Senegal and Portuguese Guinea. Brun, Butterlin and Monteil (1982) have recently described *Helicostegina* from this area, and Neumann, Ly and Butterlin (1986) reported various American species of *Discocyclina*, *Lepidocyclina* and *Helicolepidina* from Senegal. Of greater palaeobiogeographical significance is, however, the report by Premoli Silva (1986) of *Polylepidina* (reworked into Late Oligocene sediments), in the Nauru Basin, central Pacific. These records indicate that most supposedly endemic American genera were more widespread than was previously supposed. A recent unpublished report of *Proporocyclina* from India will, if confirmed, further reduce the degree of endemism previously attributed to American Eocene faunas. These records do not, on the other hand, alter the fact that the overall compositions of the larger foraminiferal faunas in the Tethyan, American and Indo-West Pacific regions were different throughout the Tertiary.

The incomplete nature of our knowledge of the Eocene fossil record has been further demonstrated in recent years by the discovery of *Austrotrillina* in limestones of this age in Iran (Rahaghi 1980) and off-shore Tunisia (Bonnetfous and Bismuth 1982). *Austrotrillina* is otherwise unknown from sediments older than Oligocene, and has never been reported from Late Eocene strata despite intensive world-wide studies of carbonates of this age. The discovery of *Yaberinella* in Oman indicates, however, that this deficiency may not be significant.

The presence of *Yaberinella* in the Middle East has a twofold significance. First, it removes a generally accepted example of endemism from the larger foraminifera, thus weakening slightly the case for provincialism within this group. Second, it shows that complete reliance cannot be placed on current knowledge of the palaeogeographical distribution of larger foraminiferal taxa. In this context it is worth noting that Skelton and Wright (1987) recorded a similar disjunct distribution (Oman and the Americas) for the Maastrichtian rudist genus *Torreites*.

Clearly, the well-described and abundant Middle Eocene carbonates of the Tethyan region, provide less complete information on the fossil record than is commonly supposed. This is presumably because bedding planes and other depositional hiatuses represent longer intervals of time than do the intervening sediments. The discovery of *Yaberinella* in Oman, of *Austrotrillina* in the Eocene of Iran, of *Lepidocyclina*, *Helicostegina* and *Helicolepidina* in West Africa, of *Polylepidina* in the Pacific, and possibly of *Proporocyclina* in India, indicate that shallow-water limestone faunas are not yet sufficiently well known for areas of origin and dispersal routes of individual taxa to be determined with confidence.

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