

MICROFAUNAL ANALYSIS OF THE WATTONENSIS BEDS (UPPER BATHONIAN) OF SOUTH DORSET



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The Wattonensis Beds (Upper Bathonian) are exposed in the low cliffs to the east of Rodden Hive Point (Dorset). This locality is famous for the abundance of the otolith fauna described in the 1960s. The presence of this otolith fauna is confirmed with new material collected in 2008. Along with the otoliths are a number of statoliths, the aragonitic bones found in the heads of squid-like cephalopods and almost certainly un-described. Many of the otoliths and statoliths are encrusted with adherent foraminifera, as are the numerous shell fragments found in these clays.

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INTRODUCTION

In the geological literature about the Dorset Coast the Wattonensis Beds of the Upper Bathonian are recorded as containing one of the most abundant assemblages of Jurassic otoliths in the U.K. (Stinton and Torrens, 1968; House, 1993; Cox and Page, 2002). Stinton and Torrens (1968) indicate that, in their experience, the average sample of clay from the Bathonian in the U.K. yields 1 otolith per kg of sediment while the Wattonensis Beds at Rodden Hive Point yielded the 'extraordinary' figure of 10 specimens per kg. The database on which these judgments were made is, however, somewhat limited with only the work of Frost (1924, 1926) and the research of Stinton and Torrens (1968) recording the presence of otoliths in Jurassic sediments. In our recent work on the Wootton Bassett Mud Springs (Hart *et al.*, 2006; Price *et al.*, 2009) we did find significant numbers of otoliths, although the mechanism by which they were sampled is atypical (fluid mud oozing from natural springs). Field samples were, therefore, collected from the Wattonensis Beds on the shore of the Fleet Lagoon in South Dorset in order to make a direct comparison with the work of Stinton and Torrens (1968).

Rodden Hive Point (SY 599821) is located WSW of Langton Herring on the shore of the Fleet Lagoon (Figure 1). The section is almost inaccessible, backed by private land and often rather muddy of access: permission should be sought, for both visiting and sampling, from the Strangways Estate. About 90-100 m east of the point there are abundant, beautifully preserved macrofossils littering the foreshore, all of which appear to have been washed out from the Wattonensis Beds (Cox and Page, 2002). Samples were collected from the lumachelle that marks the Elongata Beds and the soft clays that occur below, and to the west of, the shell bank. This is one of the best exposures of the Wattonensis Beds which are ~1 m thick (Figure 2). All the previous authors, beginning with Stinton and Torrens (1968) describe the shell fragments, and the

otoliths recovered from these clays, as being encrusted with 'microfaunal bryozoa and serpulids'. As part of our investigation of the otoliths and the shell material from the succession we have studied this epifauna and determined that the overwhelming majority of the taxa are not bryozoans or serpulids but adherent foraminifera. For comparison, shell fragments from the mid-Upper Jurassic of Poland (Pugaczewska, 1970) also carry abundant specimens of serpulids, bryozoans and foraminifera (including taxa described here).

OTOLITHS

Otoliths are the stato-acoustic organs of bony (teleost) fish and are often quite well preserved as fossils as they are composed of calcium carbonate (Stinton and Torrens, 1968; Lowenstein, 1971; Hart *et al.*, 2006). On each side of the fish the 'labyrinth' has three otoliths which are located adjacent to the sensory spots. The largest is the sagitta and this is located in the sacculus. The second otolith lies in the lagena (asteriscus) while the third is in the utriculus (lapillus). The sagitta is the largest and most commonly described in the fossil record. The side of the sagitta facing the median plane of the body is the 'inner side' and is usually flatter in comparison to the "outer side" that often shows a range of grooves or other features.

In their account of Bathonian otoliths, many of which came from the Wattonensis Beds of Rodden Hive Point, Stinton and Torrens (1968) created ten new taxa which represent the whole of the recovered fauna. Many of these taxa have been found in this current investigation (Figure 3). Along with the otoliths, in lesser numbers, are a number of similar microfossils that have not been described previously. These are the statoliths.

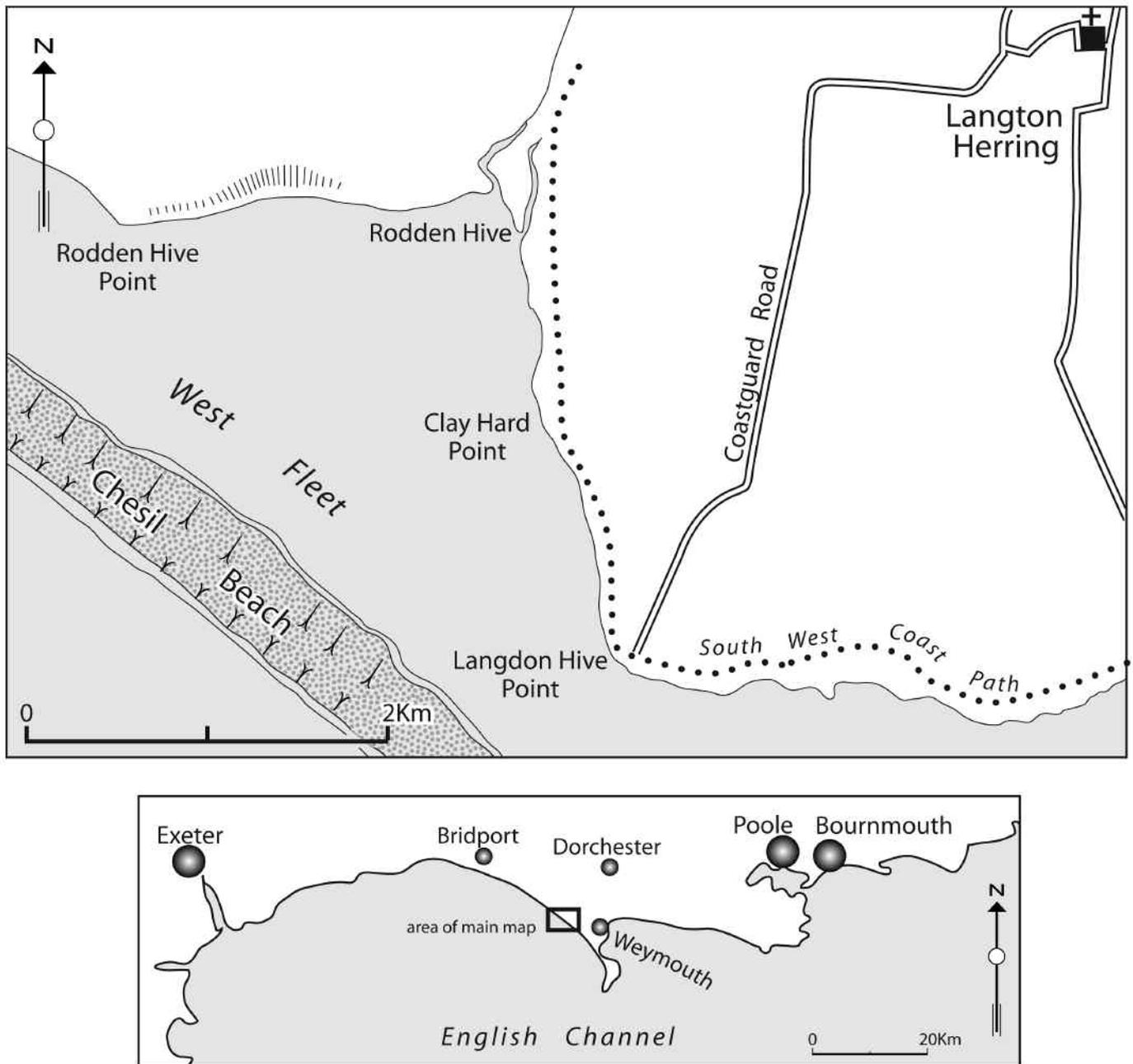


Figure 1. Locality map for the exposure of the *Wattonensis* Beds at Rodden Hive Point near Langton Herring, Dorset.

STATOLITHS

Statoliths are the small, hard, aragonitic stones which lie in the fluid-filled cavities or statocysts within the cartilaginous skulls of all living and probably all fossil members of the Coleoidea (Clarke, 1978, 2003). Their aragonitic composition, colour and size mean that they often co-occur with fossil otoliths, although they are relatively little known from Jurassic strata (Clarke *et al.*, 1980a,b; Clarke and Maddock, 1988a,b; Clarke, 2003). Although we have found a number of statoliths associated with the otolith fauna in the samples from the *Wattonensis* Beds, we cannot – at present – identify the parent animal. In form and shape, these Bathonian statoliths are similar in appearance to the only previous illustrations of a Jurassic statolith (Clarke, 2003, figures 14, 15). Work on Jurassic statoliths from the Bathonian and Callovian is on-going.

ADHERENT FORAMINIFERA

As indicated above, the majority of previous workers have indicated that shell fragments and otoliths in the *Wattonensis* Beds are covered in abundant bryozoans and serpulids. While we cannot say that there are no serpulids or bryozoans in the epifauna, all the specimens that we have seen are adherent foraminifera. Such an abundance of foraminiferal epifauna is a peculiar characteristic of the Jurassic clays in the U.K. and elsewhere in Europe, where the incidence of such faunas appears to be greater than in the Cretaceous or Tertiary successions of the same area. In the Cretaceous, where both calcareous (e.g. *Bullopora*) and agglutinated (e.g. *Placopsilina*) taxa are known, it is probable that one or two specimens may be found in most micropalaeontological samples. In the Jurassic, however, it is often found that 90% (or more) of shell fragments have at least one (or more) adherent taxon present. In many cases there can be as many as 5 on each small shell fragment or otolith.

Stage/substage		Formation	Subdivisions	Thickness (metres)	Geological Conservation Review localities	
Callovian	Lower (part)	Kellaways	Kellaways Sand	c. 40		
			Kellaways Clay			
Bathonian	Upper	Cornbrash	Upper	up to 6		
			Lower	up to 3.15 seen		
		Forest Marble	— Digona Bed —	c. 50		
			— — —	c. 1.5		
			— Boueti Bed —	c. 18		
		Frome Clay	— — —	0.6-0.9		
— — —	c. 60					
— — —	1.2-6					
Middle (part)	Fuller's Earth (part)	— — —	c. 1			
		— — —	? c. 1.5 seen			
					* combined Stewartby and Weymouth members up to 110 metres	
					not to scale	

Figure 2. Lithostratigraphy of a part of the Bathonian – Callovian interval within the Geological Conservation Review Sites on the Dorset Coast.

Adherent taxa are rarely described in detail (Armstrong and Brasier, 2005; Murray, 1991, 2006) in texts on the life and ecology of foraminifera and even reviews of foraminiferal taphonomy (e.g. Herrero and Canales, 2002) give few details. The principal publications on such taxa (especially in the Jurassic) are by Macfadyen (1941), Barnard (1950a,b, 1952, 1953, 1958), Cifelli (1957, 1959, 1960), Gordon (1962, 1965, 1967), Adams (1962), Coleman (1974, 1982), Morris and Coleman (1989) and Shipp (1978, 1989). Gordon (1965, text-figure 11) illustrates three species from the Corallian succession of southern England, all of which are pertinent to the following discussion.

The genera represented include *Bullopora* Quenstedt 1956, *Vinelloidea* Canu 1913 (= *Nubeculinella* Cushman 1930) and '*Tolypammmina* Rhumbler 1895'. In a lengthy discussion of adherent taxa, Adams (1962) has outlined the classification problems surrounding this group and discussed the wall structure of each of these genera. All of this work was in advance of scanning electron microscopy and the compilation of the taxonomic databases now in use (Loeblich and Tappan, 1964, 1987). Barnard (1958) summed up the problem thus: '*The chief problems involved in a study of fossil adherent foraminifera are due to the inadvertent mixing of genera by some authors. This is perhaps due to the different states of preservation of the specimens. In most cases it is necessary to make extensive use of thin sections to determine the wall structure.*'

In many specimens the initial chambers, or coil, are not present and this does not allow inspection of one of the most important taxonomic characters. Specimens of *Nubeculinella* often become detached, and occur as 'normal' foraminifera in the residues studied by micropalaeontologists. When this happens it can be seen that some specimens have a lower surface to their chambers while others do not. The taxonomic (or taphonomic) significance of this is not known.

TAXONOMIC NOTES

The classification scheme of Loeblich and Tappan (1964, 1987) is being followed here as the revisions of Kaminski (2004, 2008) are not fully accepted by the community. In the case of *Tolypammmina* Loeblich and Tappan (1964) is followed as this is the name by which this taxon is best known in the Jurassic, rather than the suggested Palaeozoic replacement (*Serpenuolina* Chernykh).

Superfamily AMMODISCACEA Reuss, 1862

Family Ammodiscidae Reuss, 1862

Subfamily Tolypammininae Cushman, 1928

Genus *Tolypammmina* Rhumbler, 1895

Type species *Hyperammmina vagans* Brady, 1879

'*Tolypammmina* sp.'

Diagnosis: A species of *Tolypammmina*(?) with a tubular, meandrine, fine-grained, unbranching test. The aperture appears to be a simple, terminal opening.

Discussion: *Tolypammmina* is described by Loeblich and Tappan (1987) as a Late Palaeozoic form, while the original definition of the 'type species' as *Hyperammmina vagans* Brady, 1879 is a form from the Recent. It is quite clear that neither a Recent form or a Palaeozoic taxon provide an appropriate name for this relatively simple, agglutinated form that has a given range of Ordovician to Holocene (Kaminski, 2008). This is one of the rarer taxa in the Jurassic (see Macfadyen, 1941; Barnard, 1950a, 1958; Gordon, 1965) and until we have more material it is not possible to resolve the question of its full range in the Jurassic, or the most appropriate name for the genus. No complete specimens have been found in the Wattonensis Beds.

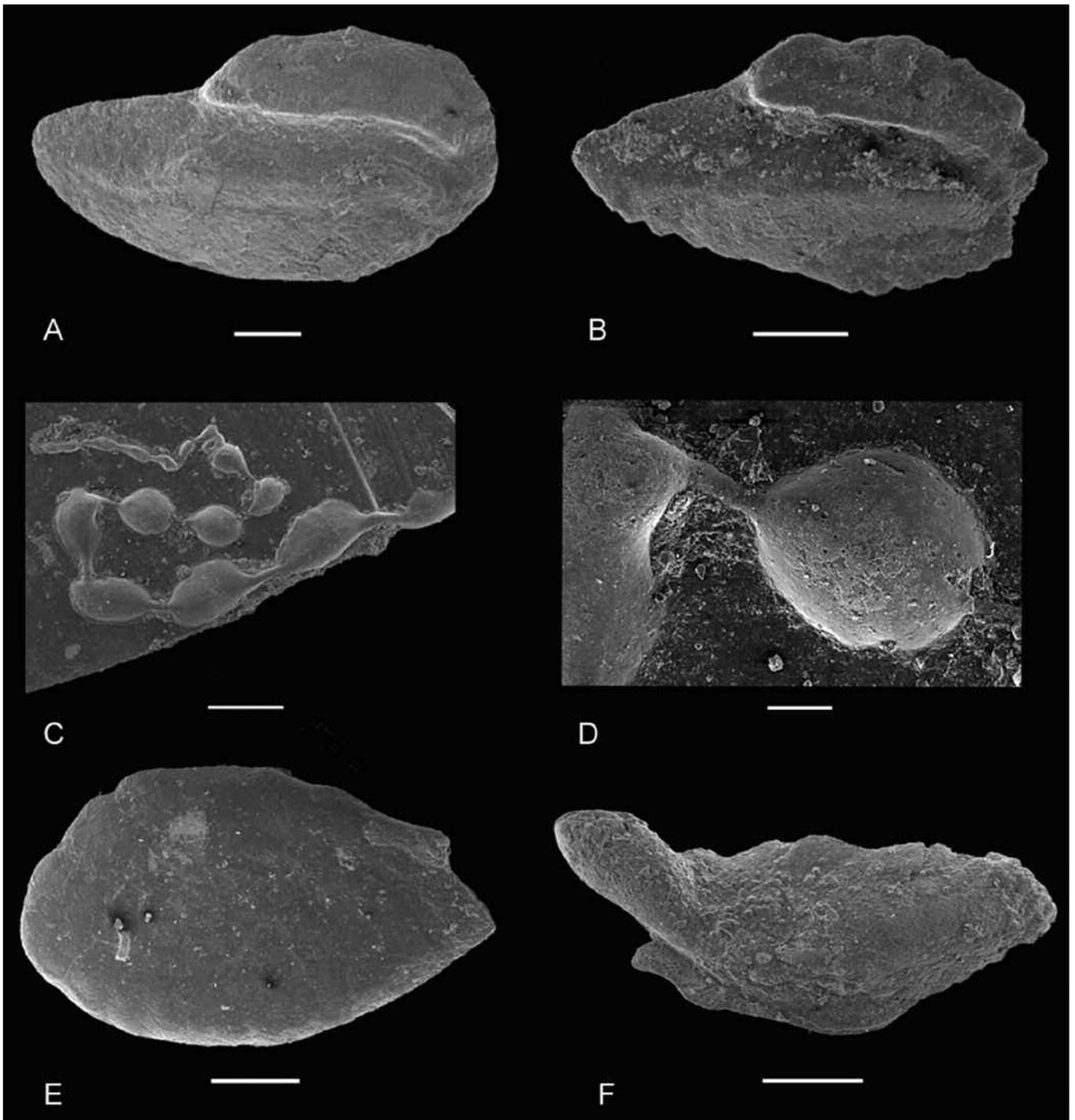


Figure 3. Scanning electron microscope images of some of the microfauna from the Wattonensis Beds at Rodden Hive Point, Dorset. **A.** *Leptolepis* sp. cf. *L. tenuirostris* Stinton & Torrens (1968); **B.** *Pholidophorus* sp. cf. *P. prae-elops* Stinton & Torrens (1968); **C.** *Bullopورا rostrata* Quenstedt (1857); **D.** *Bullopورا rostrata* Quenstedt, close-up of stolon-like neck between two chambers seen in centre-left of photograph **C**; **E.** unidentified otolith; **F.** unidentified statolith, probably new taxon. Scale bars all 500 μm except **D** which is 100 μm .

Superfamily CORNUSPIRACEA Schultze, 1854

Family Nubeculariidae Jones, 1875

Subfamily Nubeculinellinae Avnimelech and Reiss, 1954

Genus *Vinelloidea* Canu, 1913

Type species *Vinelloidea crussolensis* Canu, 1913

Vinelloidea 'bigoti' Cushman, 1930

Diagnosis: A species of *Vinelloidea* with an imperforate 'milky white' test of attached uniserial chambers that follow a

proloculus, coiled second chamber and uncoiled later growth stages. There is a simple aperture at the open end of the last chamber.

Discussion: This species is better known as *Nubeculinella bigoti* but Loeblich and Tappan (1987, p.323) suggest that *Vinelloidea crussolensis* – which was initially described as an adherent bryozoan – may be a senior synonym. The illustrations provided by Loeblich and Tappan (1987, plate 333) are not totally convincing and we have retained the specific name 'bigoti' for the present. This species has been fully described by Adams (1962), who gives the range as ?Lower Lias – Kimmeridgian. This species has previously been recorded from

the Oxfordian – Kimmeridgian by Shipp (1989) and the Oxfordian by Gordon (1965). De Jonghe (2009) records it as abundant on shell fragments in the Phaeinum Subzone (Callovian) in Wiltshire. It is, overwhelmingly, the most abundant adherent taxon in the material from the Wattonensis Beds and the Callovian.

This species frequently detaches from the host surface during taphonomy (or sample processing) and the 125-250 µm size fraction often contains large numbers of this species (often fragmented). This makes any taxonomic counts of genera/species in Jurassic strata problematic as: (1) How does one assess fragments (especially as the proloculus is almost never seen)? (2) How does one assess abundances in different size fractions as detached specimens are often in the 63-125 µm or 125-250 µm size fractions, while those still attached will be in the 250-500 µm or >500 µm size fractions.

Superfamily NODOSARIACEA Ehrenberg, 1838

Family Polymorphinidae d'Orbigny, 1839

Subfamily Webbinellinae Rhumbler, 1904

Genus *Bullopora* Quenstedt, 1856

Type species *Bullopora rostrata* Quenstedt, 1857

Bullopora rostrata Quenstedt, 1857

Diagnosis: A species of *Bullopora* with adherent, hemispherical, tear-drop shaped chambers that may be closely adjacent or, more normally, separated by stolon-like necks. The wall is calcareous, perforate with a smooth surface (when well-preserved).

Discussion: Gordon (1965, text-figure 11(20)) illustrates a form with quite closely oppressed chambers (rather than connecting necks) as *B. globulata*. The chamber arrangement is slightly different to that shown in the type figure by Barnard (1950a, p.352, text-figure 1e). In some of our material the typical stolon-like necks between the chambers only appear later in growth, earlier chambers being much more closely adjacent. Barnard (1958) attempted to describe the evolution of *Bullopora*, but our experience indicates that this may be an overly simplistic view. Even in one sample we see a great range of variation in chamber shape, length of any interconnecting necks and nature of any changes in growth direction. In many of our specimens from the Wattonensis Beds and the Oxford Clay Formation some chambers (usually the earlier ones) taper into the neck quite gradually, while in the later chambers the more rounded chambers are joined by necks that are more distinct and often change the direction of growth of the individual.

SUMMARY

There has been relatively little work on the Bathonian foraminifera in the United Kingdom and the fauna from the Wattonensis Beds of the Dorset Coast is virtually un-described: see Cifelli (1959) for a general account of Bathonian foraminifera. The adherent foraminifera, which are abundant, have their own particular problems as indicated above. Why the Middle Jurassic should contain such an extensive fauna of adherent taxa is also unknown. Colonized shell fragments, otoliths and statoliths must have been available for a certain length of time on the sea floor to allow the settlement of the protozoa and its subsequent growth. As we know little about rates of growth and chamber production in adherent foraminifera, this colonization may just represent one 'season' and this might go some way to explaining the frequency, though not why we do not see this in comparable clays in other parts of the Mesozoic (e.g. Gault Clay Formation in the mid-Cretaceous).

The statoliths and otoliths also require further work but, as our database for the Middle and Upper Jurassic expands, it is possible to identify the stratigraphic significance of a number of

key taxa. Unfortunately we are never likely to determine from which organisms they are derived unless a lagerstätte like the Christian Malford Squid Bed (Wilby *et al.*, 2004, 2006) yields an animal with the otoliths or statoliths still within the soft tissue of the parent organism.

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REFERENCES

- ADAMS, C.G. 1962. Calcareous adherent foraminifera from the British Jurassic and Cretaceous and the French Eocene. *Palaeontology*, **5**, 149-170.
- ARMSTRONG, H.A. and BRASIER, M.D. 2005. *Microfossils* [2nd Edition]. Blackwell Publishing, Oxford.
- BARNARD, T. 1950a. Foraminifera from the Lower Lias of the Dorset Coast. *Quarterly Journal of the Geological Society, London*, **105**, 347-391.
- BARNARD, T. 1950b. Foraminifera from the Upper Lias of Byfield, Northamptonshire. *Quarterly Journal of the Geological Society, London*, **106**, 1-36.
- BARNARD, T. 1952. Foraminifera from the Upper Oxford Clay (Jurassic) of Warboys, Huntingdonshire. *Proceedings of the Geologists' Association*, **63**, 336-350.
- BARNARD, T. 1953. Foraminifera from the Upper Oxford Clay (Jurassic) of Redcliff Point, near Weymouth, England. *Proceedings of the Geologists' Association*, **64**, 183-197.
- BARNARD, T. 1958. Some Mesozoic adherent foraminifera. *Palaeontology*, **1**, 116-124.
- CIFELLI, R. 1957. Variation aspects of some Bathonian (Middle Jurassic) Lagenidae (abstract). *Geological Society of America, Bulletin*, **68**, 1709.
- CIFELLI, R. 1959. Bathonian foraminifera of England. *Bulletin of Comparative Zoology, Harvard*, **121**, 265-368.
- CIFELLI, R. 1960. Variation of English Bathonian Lagenidae and its phylogenetic significance. *Journal of Paleontology*, **34**, 556-569.
- CLARKE, M.R. 1978. The cephalopod statolith – An introduction to its form. *Journal of the Marine Biological Association of the United Kingdom*, **58**, 701-712.
- CLARKE, M.R. 2003. Potential of statoliths for interpreting coleoid evolution: A brief review. *Berliner Paläobiol. Abh.*, **3**, 37-47.
- CLARKE, M.R., FITCH, J.E., KRISTENSEN, T. and MADDOCK, L. 1980a. Statoliths of one fossil and four living squids (Gonatidae: Cephalopoda). *Journal of the Marine Biological Association of the United Kingdom*, **60**, 329-347.
- CLARKE, M.R., MADDOCK, L. and STEURBAUT, E. 1980b. The first fossil cephalopod statoliths to be described from Europe. *Nature*, **287**, 628-630.
- CLARKE, M.R. and MADDOCK, L. 1988a. Statoliths of fossil coleoid cephalopods. In: CLARKE, M.R. and TRUMAN, E.R. (eds), *Paleontology and Neontology of Cephalopods*. In: WILBUR, K.M. (Ed.), *The Mollusca* (12), Academic Press Inc., London, 153-168.
- CLARKE, M.R. and MADDOCK, L. 1988b. Statoliths from living species of cephalopods and evolution. In: CLARKE, M.R. and TRUMAN, E.R. (eds), *Paleontology and Neontology of Cephalopods*. In: WILBUR, K.M. (Ed.), *The Mollusca* (12), Academic Press Inc., London, 169-184.
- COLEMAN, B.E. 1974. Foraminifera of the Oxford Clay and Kellaways Beds. Appendix 3. The geology of the new town of Milton Keynes. *Report of the Institute of Geological Sciences*, No. 74/1b.
- COLEMAN, B.E. 1982. Lower and Middle Jurassic foraminifera from the Winterborne Kingston Borehole, Dorset. In: RHYS, G.H., LOTT, G.K. and CALVER, M. (Eds), *The Winterborne Kingston Borehole, Dorset, England*. Report of the Institute of Geological Sciences, No. 81/3, 82-88.

- COX, B.M. and PAGE, K.N. 2002. Shipmoor Point – Butterstreet Cove and Tidmoor Point – East Fleet Coast, Dorset. In: COX, B.M. and SUMBLER, M.G. (Eds), *British Middle Jurassic Stratigraphy*, Geological Conservation Review Series, No. 26. Joint Nature Conservation Committee, Peterborough, 20-29.
- DE JONGHE, A. 2009. *The logging of microfossils over the Middle Jurassic 'Christian Malford Squid Bed'*. Unpublished MRes Thesis, University of Plymouth.
- FROST, G.A. 1924. Otoliths of fishes from the Upper Kimmeridgian of Buckinghamshire and Wiltshire. *Annals and Magazine of Natural History*, **14**, 139-143.
- FROST, G.A. 1926. Otoliths from fishes from the Jurassic of Buckinghamshire and Dorset. *Annals and Magazine of Natural History*, **18**, 81-85.
- GORDON, W.A. 1962. Some foraminifera from the Amptill Clay, Upper Jurassic, of Cambridgeshire. *Palaeontology*, **4**, 520-537.
- GORDON, W.A. 1965. Foraminifera from the Corallian Beds, Upper Jurassic, of Dorset, England. *Journal of Paleontology*, **39**, 828-863.
- GORDON, W.A. 1967. Foraminifera from the Callovian (Middle Jurassic) of Brora, Scotland. *Micropaleontology*, **13**, 445-464.
- HART, M.B., HENDERSON, A.S., FRAYLING, T. and ADAIR, T. 2006. Microfossils from the Wootton Bassett Mud Springs (Wiltshire, UK). *Geoscience in south-west England*, **11**, 199-204.
- HERRERO, C. and CANALES, M.L. 2002. Taphonomic processes in selected Lower and Middle Jurassic foraminifera from the Iberian Range and Basque-Cantabrian Basin (Spain). *Journal of Foraminiferal Research*, **32**, 22-42.
- HOUSE, M.R. 1993. *Geology of the Dorset Coast*, Geologists' Association Guide No. 22, London, 164pp., 32 pls.
- KAMINSKI, M.A. 2004. The new and revised genera of agglutinated foraminifera published between 1996 and 2000. In: BUBÍK, M. and KAMINSKI, M.A. (Eds), *Proceedings of the Seventh International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **8**, 47-55.
- KAMINSKI, M.A. 2008. The new and reinstated genera of agglutinated foraminifera published between 2000 and 2004. In: KAMINSKI, M.A. and COCCIONI, R. (Eds), *Proceedings of the Seventh International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **13**, 47-55.
- LOEBLICH, A.R. and TAPPAN, H. 1964. Protista 2. Sarcodina, chiefly 'Thecamoebians' and Foraminiferida. In: MOORE, R.C. (Ed.), *Treatise on Invertebrate Paleontology, Part C*. 1: 1-510, text-figs 1-399; 2: 511-900, text-figs 400-653, University of Kansas Press, USA.
- LOEBLICH, A.R. and TAPPAN, H. 1987. *Foraminiferal genera and their classification*. Van Nostrand, Reinhold, New York, 970pp. + 847 plates.
- LOWENSTEIN, O. 1971. The Labyrinth. In: HOAR, W.S. and RANDALL, D.J. (Eds), *Fish Physiology, Volume 5, Sensory Systems and Electric Organs*. Academic Press Inc., London, 207-240.
- MACFADYEN, W.A. 1941. Foraminifera of the Green Ammonite Beds, Lower Lias, of Dorset. *Philosophical Transactions of the Royal Society, London*, **B231**, 1-173.
- MORRIS, P.H. and COLEMAN, B.E. 1989. The Aalenian to Callovian (Middle Jurassic). In: JENKINS, D.G. and MURRAY, J.W. (Eds), *Stratigraphical Atlas of Fossil Foraminifera* [2nd Edition], British Micropalaeontological Society Series, Ellis Horwood Ltd, Chichester, 189-236.
- MURRAY, J.W. 1991. Ecology and distribution of benthic foraminifera. In: LEE, J.J. and ANDERSON, O.R. (Eds), *Biology of Foraminifera*. Academic Press, London, 221-253.
- MURRAY, J.W. 2006. *Ecology and applications of benthic Foraminifera*. Cambridge, Cambridge University Press, 426.
- PRICE, G.D., WILKINSON, D., HART, M.B., PAGE, K.N. and GRIMES, S.T. 2009. Isotopic analysis of coexisting Late Jurassic fish otoliths and molluscs: Implications for upper-ocean water temperature estimates. *Geology*, **37**, 215-218.
- PUGACZEWSKA, H. 1970. Traces of activity of bottom organisms on the shells of the Jurassic ostreiform pelecypods of Poland. *Acta Palaeontologica Polonica*, **15**, 425-440, plus 3 plates.
- SHIPP, D.J. 1978. *Foraminifera from the Oxford Clay and Corallian of England and the Kimmeridgian of the Boulonnais, France*. Unpublished PhD Thesis, University College, London University.
- SHIPP, D.J. 1989. The Oxfordian to Portlandian. In: JENKINS, D.G. and MURRAY, J.W. (Eds), *Stratigraphical atlas of fossil Foraminifera* [2nd Edition], British Micropalaeontological Society Series, Ellis Horwood Ltd, Chichester, 237-262.
- STINTON, F.C. and TORRENS, H.S. 1968. Fish otoliths from the Bathonian of Southern England. *Palaeontology*, **11**, 246-258.
- WILBY, P.R., HUDSON, J.D., CLEMENTS, R.G. and HOLLINGWORTH, N.T.J. 2004. Taphonomy and origin of an accumulate of soft-bodied cephalopods in the Oxford Clay Formation (Jurassic, England). *Palaeontology*, **47**, 1159-1180.
- WILBY, P.R., DUFF, K., PAGE, K. and MARTIN, S. 2006. Preserving the un preservable: a lost world rediscovered at Christian Malford, UK. *Geology Today*, **24**(3), 95-98.