EARLY SPECIES OF THE BRYOZOAN GENUS *PHAENOPORA* FROM THE CARADOC SERIES, SHROPSHIRE

by JUNE PHILLIPS ROSS

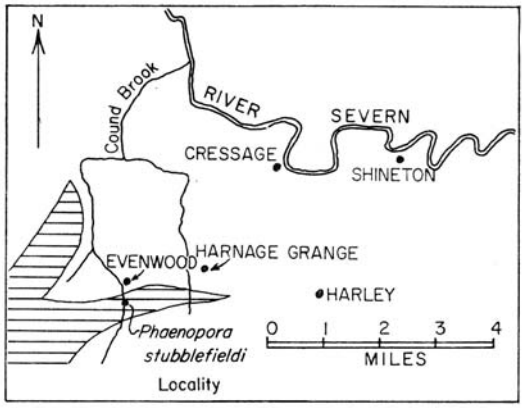
ABSTRACT. The Caradocian cryptostome *Phaenopora stubblefieldi* sp. nov. from the Hoar Edge Group, Shropshire, is one of the oldest known species of *Phaenopora*. Its morphologic features suggest a relation within the phylogenetic sequence of the escharoporid group that has its oldest known representative in the Chazy Series, North America. This group also includes the later Ordovician and Silurian genera: *Escharopora*, *Graptodictya*, *Ptilodictya*, *Stictoporella*, *Phaenopora*, and *Clathropora*.

IN south Shropshire in the region of Evenwood and Harnage (text-fig. 1) the lower part of the Caradoc Series is represented by the Hoar Edge Group (Pocock *et al.* 1938, pp. 82–85), about 100 feet thick. At its base the Lower Sandstone and Conglomerate (Dean 1960, p. 155) rests unconformably on older rocks. These beds are exposed in the Evenwood quarry where a 15-foot section (text-fig. 2) contains graptolites of the *Nemagraptus gracilis* Zone in its lower part. The graptolites include the following species as listed in Pocock *et al.* (1938, p. 250): *Dicellograptus sextans* (Hall), *Didymograptus superstes* Lapworth, *N. gracilis* (Hall), *N. gracilis* (Hall) var. *remotus* Elles and Wood, and *Orthograptus* cf. *O. calcaratus* (Lapworth) var. *acutus* Elles and Wood. The brachiopod *Harknessella subplicata* Bancroft is sparsely distributed in these beds. The overlying Hoar Edge Limestone (Dean 1958, p. 215; 1960, p. 155) in Evenwood quarry contains abundant specimens of the brachiopod *H. subquadrata* Bancroft and abundant specimens of the bryozoan *Phaenopora stubblefieldi* sp. nov. which was previously referred, by early geologists, to '*Favosites fibrosus*'. This association of species appears to characterize a calcarenitic horizon in the upper part of the Hoar Edge Group in the north-eastern exposures of the Caradoc Series in south Shropshire.

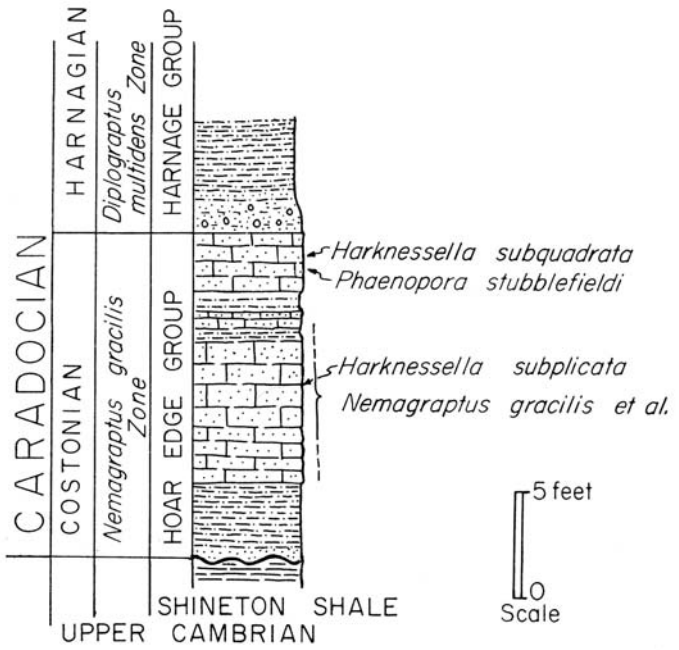
Succeeding sandstone and shale beds in the Harnage area that were placed in the Hoar Edge Group by Pocock *et al.* (1938) were reassigned to the Harnage Group (Dean 1958, p. 198) because they contain graptolites regarded as characterizing the *Diplograptus multidens* Zone. The graptolites listed by Pocock *et al.* (1938, pp. 250–1) included *Climacograptus* cf. *C. brevis* Elles and Wood, *C. caudatus* Lapworth, *C. minimus* (Carruthers), *Dendrograptus* sp., *Dictyonema* cf. *D. fluitans* Bulman, *Diplograptus multidens* Elles and Wood var. *compactus* Elles and Wood, *Orthograptus calcaratus* (Lapworth) var. *vulgatus* Elles and Wood, *O. truncatus* Lapworth, *O truncatus* var. *intermedius* Elles and Wood, and *O. truncatus* var. *pauperatus* Elles and Wood.

Environment of deposition. Phaenopora stubblefieldi sp. nov., the oldest known species of *Phaenopora*, occurs in a brachiopod-bryozoan biosparite (TIb; La, in classification of Folk, 1959). In addition to the very abundant colonies of *P. stubblefieldi* two trepostome species are common. These trepostome colonies show zooecial tubes infilled with clear sparry calcite and these contrast strongly with the short zooecial tubes of *P. stubblefieldi*

[Palaeontology, Vol. 1, Part 5, 1962, pp. 52–58, pl. 9.]



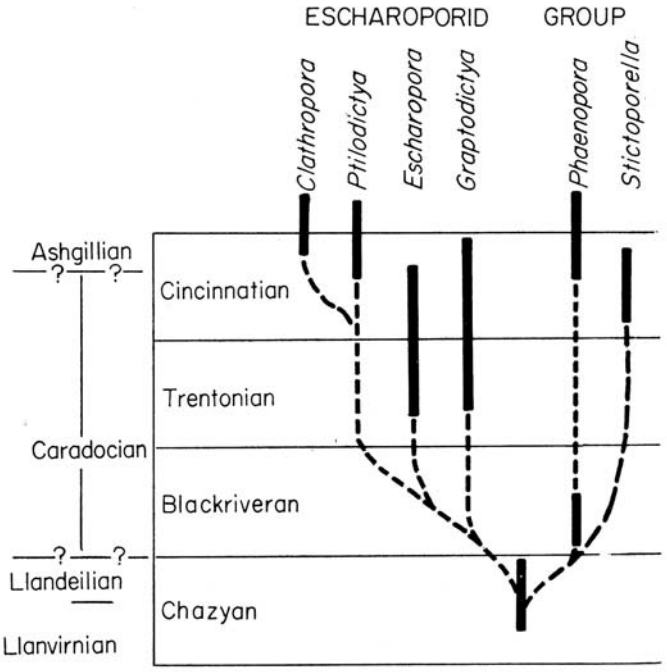
TEXT-FIG. 1. Index map of Evenwood-Harnage area; cross-shading shows outcrop of Caradocian rocks south of Evenwood. (After Callaway, C., 1877, *Quart. J. geol. Soc. London*, **33,** 645).



TEXT-FIG. 2. Measured section of Hoar Edge Group in Evenwood quarry (after Pocock *et al.* 1938).

which are infilled with terrigenous (quartz and chlorite predominantly) and carbonate material similar to that forming the rock. These features of the brachiopod-bryozoan biosparite suggest continuous sorting and removal of the clay- and silt-size fraction by persistent currents. They were possibly deposited in a sublittoral zone of at least 10 fathoms because Stach (1936) indicates that present-day cheilostomes with bifoliate, foliaceous colonies occur in such zones.

Phaenopora superba from the early Silurian of Anticosti Island, Canada, also occurs in a brachiopod-bryozoan biosparite which suggests a similar environment of deposition.



TEXT-FIG. 3. Stratigraphic range in the Ordovician of certain genera of the escharoporid group.

PHYLOGENETIC RELATIONS WITHIN THE ESCHAROPORID GROUP

The oldest known occurrence of representatives of the escharoporid group is a genus that ranges through most of the standard Chazy Series of North America (text-fig. 3; Ross, in press). Bifoliate, strap-shaped colonies of this genus have zooecia in longitudinal ranges, numerous pustules in the outer peripheral parts of the zooecial walls, a simple mesotheca, no hemisepta, and the typical escharoporid zooecial wall structure.

Phaenopora stubblefieldi sp. nov. in the Caradoc Series is the second oldest known representative of the escharoporid group (text-fig. 3). This Caradocian species of *Phaenopora* with bifoliate, explanate colonies has numerous mesopores in the outer peripheral

regions of the zooecial walls, no hemisepta, and the typical escharoporid zooecial wall structure. Ulrich (1893) described *P. wilmingtonensis* from the Cincinnatian of Illinois; and *P. superba* (Billings) of Anticosti Island, Canada, is a Silurian representative ranging into beds equivalent to the Upper Llandovery. Astrova (1955) reported late Ordovician species of *Phaenopora* in the U.S.S.R. and regarded the genus as ranging into beds equivalent to the Wenlockian. *Stictoporella* extending through the Cincinnatian in eastern United States and Canada and the late Ordovician of the U.S.S.R. is morphologically similar to *Phaenopora*. *Stictoporella* differs from *Phaenopora* in the form of its colony which is strap-shaped and in the numerous, regularly arranged mesopores that line the margins of the narrow branches.

Clathropora and *Ptilodictya* are similar in having subrectangular zooecial openings, wide zooecial walls with typical escharoporid wall structure, no mesopores, no acanthopores, and poorly defined hemisepta. The two genera differ in the form of their colonies and arrangement of the zooecia. *Clathropora* has reticulate colonies in which the zooecia are in longitudinal ranges and *Ptilodictya* has non-bifurcate stems with the longitudinal ranges set off in a median series and two lateral series. *Escharopora* is similar to *Clathropora* and *Ptilodictya* in its zooecial wall structure and in its lack of acanthopores and mesopores. However, *Escharopora* differs in having rhomboidal zooecial openings in diagonal pattern across non-bifurcate stems and a lamellate mesotheca. *Graptodictya* is similar to *Clathropora* and *Ptilodictya* in its zooecial wall structure and lack of mesopores and acanthopores. This genus is characterized by oval to round zooecial openings, pustulose zooecial walls at the zoarial surface, bifurcating strap-shaped branches, and short hemisepta.

SYSTEMATIC PALAEONTOLOGY

Order CRYPTOSTOMATA
ESCHAROPORID GROUP

Diagnostic characters of group. Bifoliate colonies having ribbon-shaped or explanate forms of growth. Zooecia are aligned in longitudinal ranges. Zooecial walls commonly are penetrated by mesopores in the outer peripheral region where thickening of the walls occurs. Acanthopores are absent. Zooecia grow at a low angle from simple mesotheca that lacks median tubuli. Zooecial walls are thin and longitudinally laminate in this inner mesothecal region. Abrupt thickening of the zooecial walls and sudden bending of the zooecial tubes marks the beginning of the outer peripheral region. In this region the zooecial walls have a distinctive laminate microstructure. The inner parts of the zooecial walls adjacent to the zooecial tubes consist of steeply inclined, distally sloping laminae; the outer parts of the zooecial walls consist of broadly curving, distally convex laminae. These laminae intertongue with laminae of adjacent zooecia to form amalgamate walls.

Remarks. This diagnosis is based on the morphology of *Escharopora* Hall, *Ptilodictya* Lonsdale, *Graptodictya* Ulrich, *Stictoporella* Ulrich, *Phaenopora* Hall, and *Clathropora* Hall. Phillips (1960, p. 17) grouped *Escharopora*, *Graptodictya*, and *Stictoporella* into the informally named taxonomic category of the escharoporid group and Ross (1960, pp. 1063–4; Ross 1961, pp. 331–2) included *Phaenopora* and *Ptilodictya*.

Genus PHAENOPORA Hall

Type species. Phaenopora explanata Hall 1852, pp. 46–47, pl. 18, figs. 6*a*, *b*, *d*, *e*; Cataract Group, Lower Silurian, Canada; designated by Ulrich (1890, p. 392).

Diagnosis. See Hall 1851, p. 399; 1852, pp. 46–47; Ross 1961, p. 332. Here restated: Bifoliate, explanate colonies having zooecia in longitudinal ranges. Two mesopores are regularly located in longitudinal zooecial walls between adjacent zooecia. These mesopores extend the complete depth of the thickened peripheral region. Additional mesopores commonly surround the zooecia but may extend only a short distance below the surface of the colonies. Acanthopores and median tubuli are absent. Superior hemisepta may occur at the base of the thickened, peripheral region.

Occurrence. Late Ordovician and early Silurian of North America and Russia; Ordovician (Caradocian) of England.

Phaenopora stubblefieldi sp. nov.

Plate 9, figs. 1–12

Material. Holotype GSM 99396; paratypes GSM 99395, 99397, 99398. From top part of quarry at east end of Black Dick's coppice, 300 yards south of Evenwood, Shropshire; Hoar Edge Limestone, Hoar Edge Group; Caradoc Series; Ordovician.

Description. The broad, undulating, explanate colonies encompass considerable areas; an incomplete colony GSM 99397 covers more than 80 sq. cm. and apparently grew from a pointed tip (Plate 9, fig. 12). The smooth, flat zoarial surfaces have no distinctive features. Growth bands are in regular, curved series (Plate 9, fig. 12).

Small, oval mesopores surround the round to oval zooecial openings and are variable in number as one or two circlets may be present in the zooecial walls (Plate 9, figs. 8, 10, 11). Longitudinal ranges of zooecia are more readily observed in deep tangential sections. Maculae consist of aggregations of numerous mesopores, 10–20 in 0·25 to 0·28 sq. mm. Simple zooecial tubes lack hemisepta but their abrupt bending into the peripheral region of thickened zooecial walls is very distinctive (Plate 9, figs. 3, 6, 7, 9). Zooecial walls have typical escharoporid microstructure (text-fig. 4). In longitudinal section the mesopores extend the full depth of the thickened peripheral region and

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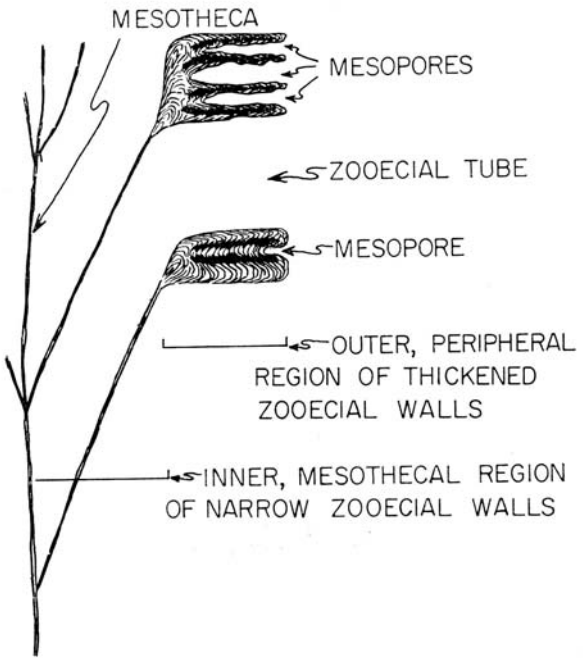
EXPLANATION OF PLATE 9

Figs. 1–12. *Phaenopora stubblefieldi* sp. nov., Hoar Edge Group, Caradoc Series. 1, Transverse section showing very slender, simple mesotheca, GSM 99398, ×50. 2, Oblique transverse section showing numerous mesopores between zooecial tubes, GSM 99395, ×20. 3, Oblique transverse section showing monticule, GSM 99398, ×20. 4, Longitudinal section showing sloping zooecial tubes bending in the peripheral region and numerous mesopores in outer peripheral region of thickened zooecial walls, GSM 99398, ×20. 5, Transverse section at edge of explanate colony, GSM 99395, ×20. 6, transverse section of slender colony, GSM 99398, ×20. 7, Transverse section crossing monticule at upper right, GSM 99396, ×20. 8, Tangential section showing numerous mesopores in zooecial walls, GSM 99396, ×20. 9, Longitudinal section showing slender zooecial walls penetrated by numerous mesopores in the outer peripheral region, GSM 99398, ×50. 10, Tangential section showing regularly arranged mesopores in zooecial walls, GSM 99396, ×50. 11, Tangential section showing more numerous mesopores in zooecial walls, GSM 99396, ×50. 12, General aspect of undulating, explanate colony, GSM 99397, ×1; proximal pointed tip of colony at right.

TABLE 1

Measurements of *Phaenopora stubblefieldi* sp. nov., in millimetres

Catalogue no.	*GSM 99396*	*GSM 99395*	*GSM 99398*
Zoarial depth	1·5	2·0 to 2·2	0·9 to 1·0
No. of zooecia in 2 mm.:			
Longitudinally	5–7	6–7	5–7
Laterally	6–7	6–8	7–8
Longitudinal interspace	0·05–0·23	0·05–0·15	0·10–0·20
Lateral interspace	0·05–0·20	0·08–0·20	0·08–0·15
Zooecial opening	(0·13–0·18)× (0·12–0·20)	(0·15–0·18)× (0·12–0·20)	(0·15–0·22)× (0·15–0·18)
Ratio: Width of zooecium in peripheral region/width of zooecium	0·57–0·60	0·45–0·47	0·50
Mesopores per zooecium at zoarial surface	7–14	>10	>12
Diameter of mesopores	0·02–0·03	(0·03–0·05)× (0·05–0·10)	(0·04–0·06)× (0·02–0·05)
Depth of mesotheca	0·01	0·01	0·01
Diameter of mesopores in maculae	0·02–0·06	Not det.	(0·05–0·10)× (0·05–0·10)



TEXT-FIG. 4. Diagrammatic sketch of skeletal microstructure observed in longitudinal sections of *Phaenopora stubblefieldi*; approx. ×50.

subdivide the zooecial walls into regular series of parallel cylinders. Laminate microstructure of the walls lining the mesopores is the same as that lining the zooecial tubes. Diaphragms are absent in both zooecial tubes and mesopores.

Remarks. Phaenopora stubblefieldi is characterized by its delicate, explanate colony having exceptionally slender walls in the inner mesothecal region, abrupt thickening of its outer peripheral region, and numerous mesopores, extending the complete depth of this peripheral region. It differs from *P. superba* (Billings), early Silurian of eastern Canada, in having fewer zooecia per 2 mm. laterally, wider zooecial walls (both longitudinally and laterally), a narrower peripheral region of thickened zooecial walls, and more numerous mesopores. The species is named for Dr. C. J. Stubblefield who has contributed greatly to the knowledge of the faunas of this region.

Acknowledgements. I express my sincere gratitude to Dr. C. J. Stubblefield of the Geological Survey of Great Britain, for the loan of material and for assistance in examining the bryozoan specimens while in London; and Dr. F. W. Anderson and Mr. J. D. D. Smith, also of the Survey, for generous assistance while examining the collections. I gratefully acknowledge financial aid for this study from the National Science Foundation, Washington, D.C., U.S.A.

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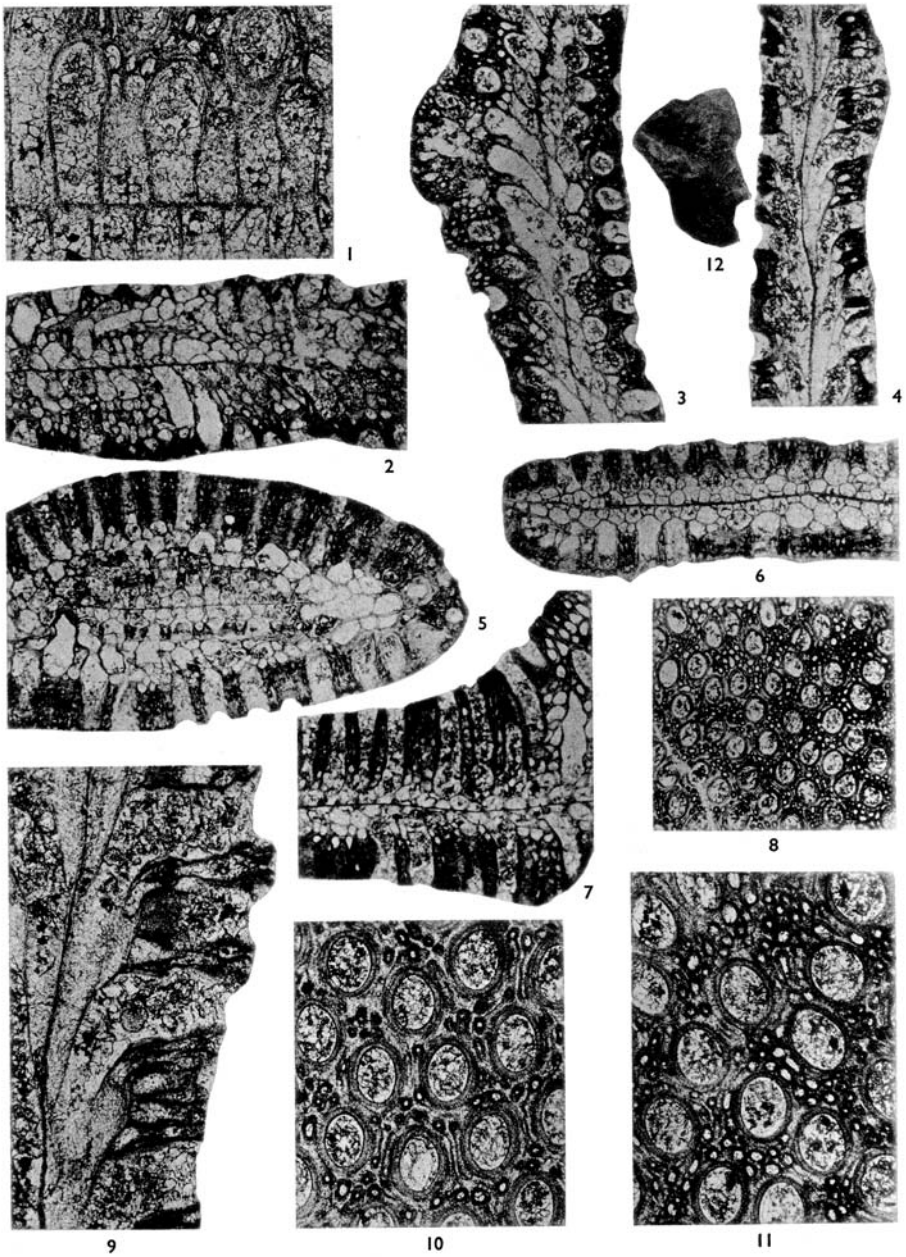
Manuscript received 7 July 1961



PHILLIPS ROSS, Ordovician Bryozoa