Brachiopods from the Jurassic of Gebel El-Maghara, Northern Sinai

HOWARD R. FELDMAN, ¹ ELLIS F. OWEN, ² AND FRANCIS HIRSCH³

ABSTRACT

This study is part of a taxonomic revision of the brachiopod faunas of the Middle Eastern "Ethiopian" Faunal Province, specifically Egypt (northern Sinai) and Israel. As a result of these studies we will be able to establish a biogeographic history of the brachiopods along the Tethyan margin, gain insight into the structure of the various brachiopod-dominated marine communities, and study the evolution of different brachiopod stocks through the Middle Jurassic.

Brachiopods were collected from approximately 2000 m of Jurassic (Dogger) limestones, shales, and sandstones at Gebel El-Maghara, northern Sinai. The sample area lies at the junction of the Indo-African and Tethyan faunal realms and consists of breached anticlines similar to those found throughout the Negev, Transjordan, the Lebanon, and the Antilebanon. No modern study of the brachiopods of this area has been undertaken within the last 65 years. Fifteen brachiopod species (11 rhynchonellids, 4 terebratulids) are reported, including the following new species: Burmirhynchia cooperi, Avonothyris variabilis, Bihenithyris pyrif. formis, and Kutchithyris parnesi.

INTRODUCTION

This project is a continuation of work undertaken by the present authors in northern Sinai (Feldman, 1987; Feldman and Owen, 1988; Feldman et al., 1982) in order to complete a taxonomic revision of the brachiopod faunas which will help us establish the early

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history of brachiopod species and their evolution within the "Ethiopian" Faunal Province. We expect to investigate the distribution of brachiopod species across faunal realm boundaries (e.g., the Indo-African Faunal Realm) and study the biogeographic history of the area as well as the structure of its marine communities.

The brachiopod, molluscan, and echinoderm faunas of Sinai were studied by Douvillé (1916), the Callovian gastropods and bivalves by Cossmann (in Douvillé, 1925) and Hirsch (1979), and the ammonites by Arkell (1952) and Parnes (1974). Structural, stratigraphic, and mapping studies were carried out by Range (1920), Moon and Sadek (1921), Hoppe (1922), Farag (1959), Al Far (1966), and Goldberg et al. (1971). Additional detailed work was done at Gebel El-Minshera by Farag and Shata (1954), Farag and Omara (1955), and Bart and Freund (1968).

Farag (1957, 1959) and Farag and Gati (1960a, 1960b) studied the brachiopods of northern Sinai and their work is noted herein and revised as necessary. Farag's (1959) faunal list, to a large extent, is taken from the works of Douvillé (1916) and Arkell (1952). Feldman (1987) described a new species of the rare genus Septirhynchia from the Callovian of Gebel El-Maghara and Feldman and Owen (1988) erected a new terebratulid genus and species (Goliathys lewyi) from the Callovian of Gebel El-Minshera. Cooper's (1989) monograph on the Jurassic brachiopods from Saudi Arabia was invaluable in understanding the taxonomy of the northern Sinai faunas.

STRATIGRAPHIC SETTING

Gebel El-Maghara (figs. 1, 2), a classic Pliensbachian-Oxfordian section approximately 2000 m thick, lies at the junction of the Indo-African and Tethyan faunal realms in the Sinai Peninsula (Picard and Hirsch, 1987). Strata were exposed for study by erosion funnels uncovering the cores of anticlines and major upwarps which can be found throughout the Sinai, Negev, Samaria, Transjordan, the Lebanon, and the Antilebanon.

The stratigraphy of Gebel El-Maghara used here is based on the work of Al Far (1966), Goldberg et al. (1971), Picard and Hirsch (1987), and our own field observations (fig. 3). In the discussion below, subunit numbers refer to those of Picard and Hirsch (1987).

Pliensbachian to Toarcian: Goldberg et al. (1971) measured and lithologically described subunits 1–6, which correlate with Al Far's (1966) Mashabba Formation. The strata outcrop south of Shushet el Maghara, in Wadi (Sadd el-) Mashabba, and are divided into two parts, each about 40–50 m thick. The lower part (subunits 1–4) consists of poorly fossiliferous reddish, coarse-to-medium grain crossbedded sandstone interdigitated with fossiliferous shale and limestone. The upper part (subunits 5 and 6) consists of algal or oncolitic pelmicrites with some shale that contain occasional brachiopods and corals.

The Rajabiah Formation overlies the Mashabba Formation and, in the lower part (subunits 7–9), consists of organogenic coralligenous pelmicritic to oolitic-oncolitic limestones with abundant solitary corals, brachiopods, and pelecypods. Subunit 10 is mainly sandstone, shale, and minor limestone. The middle part (subunits 11–13) is lithologically similar to the lower part but differs in that subunit 13 forms a conspicuous morphological scarp (22 m thick). The upper part (subunits 14–17) contains less carbonate and more of a sand-shale sequence with abundant brachiopods and bivalves.

Aalenian to Lower Bajocian: The Shusha Formation (subunits 18–28) overlies the Rajabiah Formation. It consists of coarse grained, often crossbedded, hematitic sandstones which are occasionally interlayered with oncolitic-oolitic, calcarenitic-dolomitic strata with some plant-bearing shales, sandy limestones, and silty mudstones. Goldberg et al. (1971) noted the occurrence of plant remains in nearly all subunits of the Shusha Formation.

Middle to Upper Bajocian: This sequence was divided by Al Far (1966) into three members (Mahl, Mowerib, Bir) of the Bir Maghara Formation but revision by Picard and Hirsch (1987) resulted in several changes noted below. The Mahl Member was raised to the rank of formation and the Mowerib and Bir members were combined into the Bir Maghara Formation.

The Mahl Formation (subunits 29–39) consists of a lower part of massive oolitic-
oncolitic coralline limestone with a sandstone unit (subunit 36) and shale unit (subunit 38). Throughout the formation, relatively diverse faunas of brachiopods, pelecypods, gastropods, ammonites, corals and plant remains are found.

The Bir Maghara Formation (subunits 40–48) begins with the Middle Bajocian *Dorsetensia* beds (subunit 40) and continues to the top of the Upper Bajocian *Ermoceras* beds (subunit 48). The lower part consists of oncolitic limestones, occasionally dolomitic and sandy, with some interbedded variegated shale, salt, and gypsum crusts grading into a dense, brown-gray organogenic lime unit. Above this lies a gray-green shale unit with interbedded limestone, followed by two limestone units and another shale sequence, which is capped by a brown oolitic-oncolitic limestone with interbedded shale. The Bir Maghara Formation outcrops in the Shushet el Maghara upwarp and near the Mersem Fault where it comes into direct contact with Callovian and Oxfordian strata.

*Bathonian:* The Lower Bathonian Safa Formation is an alternating sequence of sandstone and shale (subunits 49–55) with crossbedded, hematitic sands alternating with limonitic-stained sandy shales and several lenticular coal seams. The fauna is relatively poor, perhaps because of the nonmarine conditions of deposition as indicated by an absence of marine sediments (except for two 2–3 m thick oolitic limestone beds in subunit 54). The Upper Bathonian Kehailia Formation (subunits 56–69) consists, in the lower part (subunits 56–61) of shales and oolitic carbonates with some sandstone interbeds. Subunits 62–64 have no sandstone but are composed of carbonates and some shale, while subunits 65–68 consist of shales with some thin oolitic-oncolitic) limestone beds and occasional thin sandstone interbeds. Stromatoporoids were first recognized by Goldberg et al. (1971) in subunit 67, thus indicating proximity to the Callovian-Oxfordian facies typical of this group.

*Callovian:* The Zohar Formation (subunits 70–82) consists of massive bedded lithographic and calcarenitic, occasionally oolitic-oncolitic limestones showing karstic features. Silification is prevalent as indicated by nodular and layered cherts and flints as well as a silicified fauna of stromatoporoids, molluscs, and brachiopods, particularly the large rhynchonellid *Septirhynchia* (Feldman, 1987). Lewy (1981a, 1981b) recognized an unconformity between earliest and late Callovian strata based on the absence of Middle Callovian ammonites. Picard and Hirsch (1987) noted a hardground contact surface between the Callovian (Zohar) Limestone and the overlying Oxfordian Kidod shales exposed in Wadi Abu Gaza and Gebel Aroussiah as well as in Mount Hermon’s Majdal Shams section. They interpreted this as a short depositional break due to epeirogenic movements.

*Oxfordian:* The Lower Oxfordian Kidod Formation (subunits 83–87) outcrops on the northeast flank of the Maghara upwarp between the Mersem Fault and Wadi Tauriat and consists of greenish to reddish-brown shales, calcareous at the base and limonitic, with concretions at the top. Subunit 85 is composed of alternating greenish-brown, soft shale and brown, argillaceous, glauconitic thin-bedded limestone. There is one gray, argillaceous limestone unit (subunit 86) bearing a molluscan fauna. The Upper Oxfordian Beersheba Formation (subunits 88–98), exposed in Wadi Abu Gaza, Gebel Rokba, and north of Wadi Tauriat consists of light brown to light gray limestones with lenticular flint and layered chert. As in the Callovian Zohar Formation, there is silification of faunal constituents (stromatoporoids, corals, molluscs, echinoid spines), although fossils are absent from the middle subunits of the formation and more numerous at the top. North of Wadi Abu Gaza and northeast of Tauriat, yellow marls are interbedded with flinty micrites.

**Acknowledgments**

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Fig. 1. Geographic location of sample area (X).
and technician on our various excursions to the Negev and Sinai. We acknowledge the critical comments, discussions, and suggestions of the following individuals who have made this study more readable, although we accept full responsibility for all conclusions: D. V. Ager (University College, Swansea), C. H. C. Brunton (BMNH), G. A. Cooper, (USNM, retired), and Z. Lewy (GSI).

**ABBREVIATIONS**

**Institutions and Localities**

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**Measurements**

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<td>maximum width of shell</td>
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<td>T</td>
<td>maximum thickness of shell</td>
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**SYSTEMATIC PALEONTOLOGY**

**PHYLUM BRACHIPODODA**

**CLASS ARTICULATA HUXLEY, 1869**

**ORDER RHYNCHONELLIDA KUHN, 1949**

**SUPERFAMILY RHYNCHONELLOIDEA GRAY, 1848**

**FAMILY RHYNCHONELLIDAE GRAY, 1848**

**SUBFAMILY TETRARHYNCHIINAE AGER, 1965**

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Fig. 2. Locality map showing the breached anticlinal domes at Gebel El-Maghara, northern Sinai. Black arrow represents location of *Septirhynchia*-bearing beds of Feldman (1987).
GENUS SOMALIRHYNCHIA WEIR, 1925

Somalirhynchia africana Weir, 1925
Figures 4A–F


TYPE SPECIES: Somalirhynchia africana Weir, 1925.


HORIZON: Subunits 33, 43, 47, 53, 54, 64, 68, 82, Gebel El-Maghara, Sinai.

GEOLOGICAL OCCURRENCE: Lower Bajocian to Oxfordian.

REMARKS: Complete series of transverse serial sections of the genus Somalirhynchia are rarely given in systematic descriptions and interpretations of the internal structures of the type species are often taken from Muir-Wood's (1935: 95, fig. 8) original series which, in our opinion, falls short of present day standards. A more complete and up-to-date series of a recognizable species belonging to the genus is shown in a series of transverse serial sections figured by Dubar (1967: 33, fig. 7) featuring Somalirhynchia smelliei Weir from the Oxfordian of Tunisia and illustrating the well-developed septalium and high median septum in the dorsal valve and more clearly defined hinge plates and crural bases.

Somalirhynchia africana var. smelliei Weir is one of several varieties or variants which are sometimes found with the type species, ranging from a more transversely oval general outline to more produced umbonal features, more numerous and less deeply incised costae, and broader and lower arcuate anterior fold and sulcus.

A good example of the type species Somalirhynchia africana Weir collected from subunit 82 (GSI M6922), Gebel El-Maghara, is figured here (fig. 4A–C) and is one of 25 specimens from that horizon and locality showing the full range of variation in costation, convexity, and general outline (table 1). Other examples which fall within this range have been collected from Upper Callovian subunits 33 and 43 at Hamakhtesh Hagadol in the Negev, southern Israel, and one is figured here (fig. 4D–F). The species also occurs in a similar horizon at Mount Hermon, northern Israel.

Specimens figured by Dubar (1967) as Somalirhynchia cf. africana Weir (figs. 6–11) from the Oxfordian of Tunisia are also considered here to be within the morphological range of the type species and can be compared to eight specimens collected by Feldman from subunit 68, Gebel El-Maghara. An additional 21 specimens belonging to this series are housed in the collections of the Geological Survey of Israel, Jerusalem.

The geological range for the genus Somalirhynchia given by Ager (1965) is Upper Jurassic (Oxfordian). Cooper (1989: 3) gave an extended range for the genus from Lower Bathonian to Upper Kimmeridgian, but in northern Sinai the range descends from Lower Bajocian to Upper Callovian. Species assigned to this genus by Makridin (1955) and Childs (1969) from Upper Jurassic horizons...
are still in need of further investigation before these records can be established.

_Somalirhynchia bihenensis_
Muir-Wood, 1935
Figure 4G–I
_Somalirhynchia bihenensis_ Muir-Wood, 1935:101, pl. 10, figs. 5a–c.

_Holotype_: Natural History Museum, London, BMNH B.85409 from Bihen Pass, Somalia (formerly British Somaliland).

_Horizon_: Subunit 76, Gebel El-Maghara, Sinai.

_Geological Occurrence_: Lower Callovian.

_Remarks_: Differing from the type species, _Somalirhynchia africana_ Weir, in general outline, this species has an average of 30 rounded to subangular and less deeply incised and radiating costellae, flatter valves with a less posteriorly inflated dorsal valve, lower or less clearly defined median dorsal fold but maintaining a similar anterior profile to the type.
species with a broad arcuate uniplacation and moderately long linguiform extension.

The specimen figured here (fig. 4G–I) was collected from subunit 82 at the top of the Zohar Formation (Upper Callovian), Gebel El-Maghara. A smaller specimen, probably a juvenile, was collected from subunit 47 (Late Callovian) at Hamakhtesh Hagadol in the Negev. The shell figured herein differs slightly from the original figured by Muir-Wood (1935: pl. 10, figs. 5a–c) in having a more broadly transversely oval dorsal outline or slightly greater width (table 2). In all other aspects the species are identical.

The specimen described and figured by Dubar (1967: 29, pl. 2, fig. 16) from the Oxfordian of Tunisia has a great deal in common with the specimens figured here in both general outline and costation but differs slightly in having a more acutely inflated dorsal umbo.

Somalirhynchia arabica Cooper, 1989
Figures 5, 6

Somalirhynchia africana var. jordanica (Noetling, 1887) Muir-Wood, 1935: 97, pl. 10, figs. 8a, b. Somalirhynchia cf. jordanica (Noetling, 1887) Dubar, 1967: 27, pl. 2, figs. 2a–c, 3a–c, text figs. 5a, b.

Somalirhynchia arabica Cooper, 1989: 58, pl. 14, figs. 1–5, pl. 15, figs. 25–35.

Locality: Subunit 48, Gebel El-Maghara, Sinai.

Geological Occurrence: Upper Bajo-
cian.

Remarks: The broadly triangular specimen figured here agrees with the original description and figure of the species (Cooper, 1989: 58, pl. 14, figs. 1–5) particularly in general dorsal outline. Cooper (p. 59) distinguished his species from that figured by Muir-Wood as Somalirhynchia africana var. jordanica as having a more highly developed or stronger dorsal fold. Muir-Wood’s figured specimen (1935: pl. 10, fig. 8a, b) is slightly more triangular in general outline and is shown without lateral or anterior views. The specimen figured here (figs. 5, 6; table 3) is, in our opinion, nearer in morphology to both the original specimen figured by Cooper and to the specimens figured by Dubar (1967: pl. 2, figs. 2a–c, 3a–c) than to the specimen figured by Muir-Wood (1935: pl. 10, fig. 8a, b). Transverse serial sections given by Dubar (1967: 28, fig. 6) of Somalirhynchia cf. jordanica have much in common with those figured by Cooper for Somalirhynchia arabica (1989: 59, fig. 32) particularly in the slightly ventrally convergent dental lamellae and in the position and shape of the hinge plates and crural bases.

Cooper’s type and paratypes come from the Upper Dhruma Formation (Hisyan Member) and the Tuwaq Mountain and Hanifer formations, a geological range extending from Lower Callovian to Kimmeridgian.

![Fig. 5. Somalirhynchia arabica Cooper, 1989. A–C, Dorsal, lateral, anterior views, GSI M4349, x1.](image-url)
Fig. 6. *Somalirhynchia arabica* Cooper, 1989 (numbers show distance in mm between sections and [in parentheses] distance from beak): 1, 1.8 (1.8); 2, 0.3 (2.1); 3, 0.4 (2.5); 4, 0.3 (2.8); 5, 0.3 (3.1); 6, 0.4 (3.5); 7, 0.4 (3.9); 8, 0.3 (4.2); 9, 0.3 (4.5); 10, 0.4 (4.9); 11, 0.2 (5.1); 12, 0.3 (5.4); 13, 0.4 (5.8); 14, 0.2 (6.0); 15, 0.4 (6.4); 16, 0.3 (6.7); 17, 0.2 (6.9); 18, 0.2 (7.1). Scale bar equals 5 mm; GSI M4349.
**TABLE 3**

Measurements (mm) of *Somalirhynchia arabica*

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<sup>a</sup> Holotype, figured in Cooper, 1989, pl. 14, figs. 1–5, Upper Dhruma Formation and Tuwaiq Mountain Formation, Saudi Arabia.

<sup>b</sup> Figured specimen.

<sup>c</sup> Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted. (UP) refers to the upper part of subunit 82, while (LP) refers to the lower part.

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**GENUS SCHIZORIA COOPER, 1989**

*Schizoria elongata* Cooper, 1989

Figures 7, 8

*Schizoria elongata* Cooper, 1989: 55, pl. 14, figs. 17–27, text fig. 31.

**HORIZON:** Subunits 38–40, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Lower to Middle Bajocian.

**REMARKS:** The specimen figured here (fig. 7) is a medium to large elongate rhynchoellid and is larger than the holotype (table 4). The general outline, type of costellation, and poorly defined folding of the dorsal valve are similar to features noted by Cooper (1989: pl. 14, figs. 17–27).

**INTERNAL STRUCTURES:** The general transverse outlines shown in the transverse serial sections (fig. 8) conform with Cooper's (1989: 55, fig. 31), differing only in the less persistent median septum in the dorsal valve and less persistent, subparallel dental lamellae in the ventral valve. A fairly deep, well-developed septalum is noted in the specimen sectioned here from Gebel El-Maghara, a structure not seen in the series of sections sectioned by Cooper (fig. 31). In the description, however, Cooper states (p. 56) that a moderately large septalum is developed in the brachial valve, presumably between sections 9 and 10. It should be noted that the Sinai specimens are larger than Cooper's.

Cooper's holotype and paratypes of *Schizoria elongata* come from the Lower Dhruma Formation (between the Dorsetensia and Er-

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**TABLE 4**

Measurements (mm) of *Schizoria elongata*

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<sup>a</sup> Holotype, figured by Cooper, 1989, pl. 14, figs. 17–21, from Lower Dhruma Formation, Saudi Arabia.

<sup>b</sup> Figured specimen.

<sup>c</sup> Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.
moceras zones) of Saudi Arabia, equivalent to a stratigraphic range of Lower to Upper Bajocian.

Schizoria elongata differs from Sphenorhynchia plicatella, the type species of that genus, in its more elongate-oval general outline, more evenly biconvex valves, shorter, more massive umbo, and less numerous costellae.

GENUS PYCNORIA COOPER, 1989

Pycnoria compacta Cooper, 1989
Figures 9, 10

Pycnoria compacta Cooper, 1989: 51–53, pl. 12, figs. 6–10.

LOCALITY: Subunit 59, Gebel El-Maghara, Sinai.

GEOLOGICAL OCCURRENCE: Upper Bathonian.

REMARKS: Cooper described two species for his new genus Pycnoria, P. compacta and P. magna. The specimen figured here is a large (table 5), coarsely costate rhynchonellid. It was collected from subunit 59, considered to be an Upper Bathonian equivalent by European standards. Cooper’s specimens are stated (1989: 52) to have come from the Dhurma Formation (zone not specified) and are probably of similar Upper Bathonian age.

Our specimen (fig. 9) is slightly more acutely triangular in dorsal outline with a more highly developed median dorsal fold and subsequent longer linguiform extension. The 12 costae on each valve are sharp, angular, and deeply incised with two on the fold and three in the ventral sulcus.

After making a permanent cast, a series of transverse serial sections (fig. 10) was made of the specimen figured here (fig. 9) that allows comparison with Cooper’s (1989: figs. 29, 30) specimens of Pycnoria magna, the type species. Although Cooper’s specimens lack details of hinge plates and crural bases, it seems from the general transverse outline, the nature of the dental lamellae, height, persistence of the median septum, and subquadrate shape of the hinge teeth (fig. 30) that the

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\(^a\) Holotype, figured by Cooper, 1989, pl. 12, figs. 6–10, from Dhurma Formation, Saudi Arabia.
\(^b\) Figured specimen.
\(^c\) Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.

Fig. 8. Schizoria elongata Cooper, 1989 (numbers show distance in mm between sections and [in parentheses] distance from beak): 1, 2.5 (2.5); 2, 0.4 (2.9); 3, 0.6 (3.6); 4, 0.4 (3.9); 5, 0.3 (4.2); 6, 0.5 (4.7); 7, 0.4 (5.1); 8, 0.4 (5.5); 9, 0.3 (5.8); 10, 0.3 (6.1); 11, 0.4 (6.5); 12, 0.3 (6.8); 13, 0.4 (7.2); 14, 0.3 (7.5); 15, 0.4 (7.9); 16, 0.4 (8.3); 17, 0.3 (8.6); 18, 0.2 (8.8); all structures gone after 8.8 mm; scale bar equals 5 mm; GSI M6823.

Fig. 9. Pycnoria compacta Cooper, 1989. A–C, Dorsal, lateral, anterior views, GSI M6891, ×1.
Fig. 10. *Pycnoria compacta* Cooper, 1989 (numbers show distance in mm between sections and [in parentheses] distance from beak): 1, 2.4 (2.4); 2, 0.6 (3.0); 3, 0.4 (3.4); 4, 0.4 (3.8); 5, 0.3 (4.1); 6, 0.4 (4.5); 7, 0.3 (4.8); 8, 0.5 (5.3); 9, 0.4 (5.7); 10, 0.3 (6.0); 11, 0.4 (6.4). Scale bar equals 5 mm; GSI M6891.
two forms agree in details shown in Cooper's transverse serial sections.

Although our specimen is assigned here to the species *P. compacta*, it is possible that it could fall within the parameters of variation described for the species *P. magna*.

**Pycnoria magna** Cooper, 1989

Figure 11A–C

*Pycnoria magna* Cooper, 1989: 53, pl. 12, figs. 11–36; pl. 18, figs. 26–36.

**LOCALITY:** Subunit 57, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Upper Bathonian.

**REMARKS:** This is the larger of the two species described by Cooper for the genus *Pycnoria* and is the type species for the genus (table 6). It is diagnosed as large, wide, and strongly costate.

The specimen figured here has 13 strong, angular, deeply incised costae with four on a well-defined arcuate median dorsal fold and three in a shallow, comparatively narrow sulcus. It is one of several specimens collected from Gebel Maghara which include most of the minor variations depicted by Cooper in his illustrations of the species (1989: pls. 12, 18). The specimen departs slightly from the typical form in having a more highly developed median dorsal fold and a slightly wider and more broadly arcuate anterior commissure. We consider these points to be minor morphological variations seen within the full range for the species which should not be allowed to separate it from the type species that we consider stratigraphically important.

**INTERNAL STRUCTURES:** As for the species *Pycnoria compacta* Cooper, here described.

---

**TABLE 6**

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* Holotype, figured by Cooper, 1989, pl. 12, figs. 11–36; pl. 18, figs. 26–36, from Dhurma Formation, Saudi Arabia.

* Figured specimen.

* Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.
TABLE 7
Measurements (mm) of *Globirhynchia dubia*
Cooper, 1989; *G. crassa* Cooper, 1989; *G. subtriangulata* Cooper, 1989

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a Figured specimen.
b Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.

**GENUS GLOBIRHYNCHIA** BUCKMAN, 1918

*Globirhynchia dubia* Cooper, 1989

Figures 11D–F, 12

*Globirhynchia dubia* Cooper, 1989: 40, pl. 10, figs. 31–36.

**LOCALITY:** Subunits 59, 60, 64, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Upper Bathonian.

**DESCRIPTION:** Medium size (table 7), coarsely costate rhynchonellid; biconvex with dorsal valve more acutely inflated posteriorly producing subquadrate to broadly oval lateral profile; dorsal valve well developed with five angular, deeply incised costae among 17 ornamenting valves; ventral valve has similar number of costae, four of which occupy broad, moderately extensive, linguiform extension anteriorly, producing shallow sulcus.

**INTERNAL CHARACTERS:** Transverse serial sections (fig. 12) made from specimens identified as *Globirhynchia? dubia* Cooper exactly match those given by the author (Cooper, 1989: p. 41, fig. 21) for *G. subtriangulata* and also compare favorably with those of the type species *G. subobsoleta* from the Upper Inferior Oolite (Bathonian) of Gloucestershire, England.

**REMARKS:** The pattern of variation which we recognize within the specimens collected from Gebel El-Maghara, Sinai, under the generic name of *Globirhynchia* include some of the species described by Cooper (1989). We can find little justification for the separation of these forms into new taxa and have, therefore, selected the most typical of those which we acknowledge to be morphologically different.

All of Cooper's species—*G. concinna, G. crassa, G. dubia, G. subtriangulata, and G. triangulata*—were collected from zones within the Lower to Middle Dhruma Formation of Saudi Arabia, whereas the specimens figured here from Gebel El-Maghara were collected from beds equivalent to the Upper Bathonian of Europe.

*Globirhynchia crassa* Cooper, 1989

Figures 13A–C

*Globirhynchia? crassa* Cooper, 1989: 39, pl. 10, figs. 7–12.

**LOCALITY:** Subunits 59, 60, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Upper Bathonian.

**REMARKS:** The specimen figured here is one of 38 in the collection (table 7). The diagnosis given for this species by Cooper (1989)
would fit many of the specimens figured by him as both *Globirhynchia* and *Gibbirhynchia* (pl. 10). The species can be distinguished by their generic characters as seen in transverse serial sections.

*Globirhynchia subtriangulata* Cooper, 1989

Figure 13D–F

*Globirhynchia subtriangulata* Cooper, 1989: 40, pl. 10, figs. 45–55; pl. 17, figs. 28–37.

**LOCALITY:** Subunits 59, 60, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Upper Bathonian.

**REMARKS:** As with *Globirhynchia crassa* and *G. dubia*, the specimen figured here is one of 38 specimens collected from Gebel El-Maghara and compares favorably with Cooper’s figured specimens (pl. 10, figs. 45–55; pl. 17, figs. 28–37), agreeing in general size (table 7) and outline, number and type of costae, and convexity of valves.

**GENUS BURMIRHYNCHIA BUCKMAN, 1918**

*Burmirhynchia cooperi*, new species

Figure 13G–I

**DIAGNOSIS:** Small, elongate-oval, strongly costate *Burmirhynchia*.

**LOCALITY:** Subunits 46–48, Bir Maghara Formation, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Upper Bajocian.

**ETYMOLOGY:** In honor of Dr. G. A. Cooper, formerly Paleontologist Emeritus, Department of Paleobiology, Smithsonian Institution, Washington, D.C.

**DESCRIPTION:** Shells small (table 8), acutely
biconvex; dorsal valve has 16 well-defined, sharp or acutely triangular (in cross section) and deeply incised, costae; corresponding number of costae on ventral valve with four in sulcus and four on almost imperceptible median fold on the dorsal valve; umbo massive, slightly elongate, with somewhat incurved beak; foramen large, interarea broad and extensive; conjunct deltoidal plates well exposed; anterior commissure subquadrate in profile with extensive trapezoidal lingiform extension.

INTERNAL CHARACTERS: Unknown.

REMARKS: In general outline, beak features, and type of folding, this species closely resembles *Burmirhynchia? bicostata* which Cooper (1989: 16, pl. 2, figs. 50–57) described from the Lower Drhma Formation (Ermoeras Zone) of Saudi Arabia. He figured a small specimen with a narrow sulcus, less clearly defined than the specimen figured as *Burmirhynchia cooperi*. Cooper seemed uncertain about assigning his species *B. bicostata* to the genus *Burmirhynchia* because of its unknown internal structures. We feel more confident about assigning the species described and figured here to the genus *Burmirhynchia*.

The difference between Cooper’s species and our species here described is mainly in the number of costae in the sulcus.

ORDER TEREBRATULIDA WAAGEN, 1883

SUBORDER TEREBRATULIDINA WAAGEN, 1883

SUPERFAMILY TEREBRATULOIDEA GRAY, 1840

FAMILY TEREBRATULIDAE GRAY, 1840

GENUS *KUTCHITHYRIS* BUCKMAN, 1918

*Kutchithyris parnesi*, new species

Figure 14A–C

DIAGNOSIS: Medium size, pentagonal *Kutchithyris*.

LOCALITY: Subunit 64, Gebel El-Maghara, Sinai.

GEOLOGICAL OCCURRENCE: Upper Bathonian.

ETYMOLOGY: In honor of the late Dr. Abraham Parnes, Geological Survey of Israel.

DESCRIPTION: Biconvex pentagonal tere-bratulid with width almost equal to length; shells medium size (table 9); maximum width attained at midlength; ventral valve has short, massive umbo and slightly incurved beak; foramen large, circular, and permesothyrid; symphytium not exposed; dorsal valve inflated posteriorly; two well-defined carinae originate posteriorly and diverge anteriorly bordering shallow sulcus which deepens toward anterior margin; anterior commissure sulciplicate; both valves have numerous, clearly delineated, concentric growth lamellae.

REMARKS: Cooper (1989: 98, pl. 26, figs. 7–9; pl. 27, figs. 28–30) recognized two terebratulid species which he broadly assigned to *Kutchithyris?* without providing specific data. The tentative assignment is rather surprising in view of the characters seen in his species 1 (pl. 27, figs. 7–9); they concur with those described for the genus by Moore (1965: H781, H783, figs. 5a–d).

*Kutchithyris parnesi*, new species, differs from the type species of *K. acutiplicata* (Kitchin) in its less inflated dorsal valve and less acute anterior sulcipation. It differs from *Kutchithyris?* species 2 of Cooper (1989: pl. 26, figs. 28–30) in its distinct pentagonal outline and less acute anterior plication, but agrees in general outline and degree of sulcipation seen in *Kutchithyris?* species 1 (Cooper, 1989: pl. 27, figs. 7–9), regarded as of Bathonian age.

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*Holotype, figured specimen.

*Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.*

**GENUS AVONOTHYRIS BUCKMAN, 1918**

*Avonothyris variabilis*, new species

*Figure 14D–F*

**DIAGNOSIS:** Broadly subpentagonal *Avonothyris*.

**LOCALITY:** Subunit 82, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Upper Callovian.

**ETYMOLOGY:** Latin *Varius*, in allusion to the different morphotypes typical of the genus.

**DESCRIPTION:** Shell biconvex, varying in general from subpentagonal to oval with maximum width usually attained at mid-
length; average dimensions of the specimens studied (table 10) are as follows: length 31.4 mm; width 28.6 mm; thickness 22.4 mm; dorsal valve flatter than ventral valve, but occasionally has marked umbonal inflation; two faint carinae develop from just anterior to midlength, bordering wide, shallow sulcus, forming low fold which becomes more acute anteriorly; ventral valve more evenly convex with slight carination of umbonal area; umbo short, beak suberect, with large, often labiate, pedicle foramen; beak ridges epitthyrid, symphytium obscure; anterior commissure varies from almost uniplicate to biplicate, but commonly biplicate; ornamentation consists of well-defined, concentric growth lamellae.

REMARKS: The specimen figured here (fig. 14D–F) represents a group of large, variable terebratulids sometimes referred to by authors as Cereithyris wylliei (Weir) which, in our opinion, they do not resemble. Further transverse serial sections are required before the generic status of A. variabilis is established, but there can be little doubt that its present taxonomic position will be maintained.

A specimen, somewhat similar in general outline and lateral profile to Avonothyris variabilis, new species, was figured by Dubar (1967: pl. 3, fig. 20a, b) who referred it to Charltonithyris bihenensis (Weir). Dubar’s specimen is stated to have been collected from the Callovian Septirhynchia bed between Tazerdunet and Ksar Kedima, Tunisia.

**GENUS BIHENITHYRIS MUIR-WOOD, 1935**

*Bihenithyris pyriformis*, new species

Figures 14G–I, 15

**DIAGNOSIS:** Broadly oval to pear-shaped, acutely biconvex *Bihenithyris*.

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### TABLE 9

Measurements (mm) of *Kutchithyris pumensi*, New Species

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*a Holotype, figured specimen.

*b Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.*

### TABLE 10

Measurements (mm) of *Avonothyris variabilis*, New Species

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</table>

*a Holotype, figured specimen.

*b Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.*

**LOCALITY:** Subunit 64, Gebel El-Maghara, Sinai.

**GEOLOGICAL OCCURRENCE:** Upper Bathonian.

**ETYMOLOGY:** Latin *pirum* (*pyrum*), in allusion to the shell’s pear-shaped outline.

**DESCRIPTION:** Shells medium size; dorsal aspect pyriform with greatest width attained at about two-thirds shell length; lateral profile shows posterior inflation of dorsal umbo; two well-defined carinae border narrow median sulcus which begins at approximately half the length of dorsal valve and deepens anteriorly; ventral umbo massive with large circular foramen and rounded mesothyrid beak ridges; anteriorly, ventral valve develops two shallow sulci matching carinae of dorsal valve and, with a degree of lateral constriction, forms narrow sulciplicate anterior margin.

**REMARKS:** In many ways, the general outline, morphological features, and size of the specimen figured here (fig. 14G–I) agree with those of a specimen described and figured by Cooper (1989: pl. 29, figs. 23–25) as *Stenoria paralella* but, as the name suggests, that species has almost parallel flanks as opposed to the pyriform outline of *Bihenithyris pyriformis*. It also differs from our species in having a more acutely convex ventral valve and a slightly more elongate subcarinate ventral umbo.

*Bihenithyris pyriformis* resembles a specimen figured by Muir-Wood (1935: pl. 12, fig. 5a–c) as *Bihenithyris weiri* but differs from that species in its shorter umbo, more oval outline, and less anterolateral constriction.

*B. pyriformis*, new species, also resembles...
FELDMAN, OWEN, HIRSCH: BRACHIOPODS

Fig. 16. Ptyctothyris sinaiensis, new species. A–C, Dorsal, lateral, anterior views, GSI M8073, ×1.

A specimen described and figured by Muir-Wood from the Jordan Valley (1925: pl. 15, fig. 5a–c) as Heimia jabbokensis. But it differs in its smooth or rounded bead ridges; less oval general outline; and broader, less acutely sulciplicate anterior margin; and less umbonal inflation of the dorsal valve. Maximum shell width in B. pyriformis occurs more anteriorly than in H. jabbokensis.

The transverse serial sections illustrated here (fig. 15) are from the figured specimen after permanent casting. They compare favorably with those given by Muir-Wood (1935:112, fig. 13) for the type species Bihenithyris barringtoni.

Dimensions of holotype (BMNH BB.86933): (L) = 32.7; (W) = 25.5; (T) = 17.6.

TABLE 11

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<th>(T)</th>
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</tbody>
</table>

a Holotype, figured specimen.
b Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.

GENUS Ptyctothyris BUCKMAN, 1918

Ptyctothyris sinaiensis, new species
Figures 16, 17

Diagnosis: Large, oval to subtriangular Ptyctothyris.

Locality: Subunit 48, Gebel El-Maghara, Sinai.


Etymology: The name refers to the Sinai Peninsula.

Description: Shells medium to large (table 11), evenly biconvex; dorsal valve with well-marked concentric growth lamellae and two faint radiating carinae developing anteriorly and bordering shallow sulcus which deepens slightly toward anterior margin of shell; very slight lateral constriction of anterior part of valve present producing incipient sulciplicate anterior commissure; ventral valve short and massive with suberect beak, labiate pedicle foramen and well-developed epithyridid beak ridges; symphytium not exposed.

Internal Structures: From the series of transverse serial sections figured here (fig. 17) it is possible to see that a pedicle collar has developed within the posterior portion of the ventral umbo. Broad, flat cardinal process

Fig. 15. Bihenithyris pyriformis, new species (numbers show distance in mm between sections and [in parentheses] distance from beak): 1, 1.4 (1.4); 2, 0.4 (1.8); 3, 0.3 (2.1); 4, 0.3 (2.4); 5, 0.3 (2.7); 6, 0.6 (3.3); 7, 0.4 (3.7); 8, 0.5 (4.2); 9, 0.3 (4.5); 10, 0.3 (4.8); 11, 0.3 (5.1); 12, 0.4 (5.5); 13, 0.3 (5.8); 14, 0.2 (6.0); 15, 0.3 (6.3); 16, 0.3 (6.6); 17, 0.2 (6.8). Scale bar equals 5 mm; AMNH 44215.
Fig. 17. Ptyctothyris sinaiensis, new species [numbers show distance in mm between sections and [in parentheses] distance from beak]: 1, 1.95 (1.95); 2, 0.8 (2.75); 3, 0.4 (3.15); 4, 0.3 (3.45); 5, 0.6 (4.05); 6, 0.4 (4.45); 7, 0.4 (4.85); 8, 0.3 (5.15); 9, 0.4 (5.55); 10, 0.3 (5.85); 11, 0.6 (6.45); 12, 0.4 (6.85); 13,
develops early and remains until hinge plates begin to appear; strong hinge teeth articulate well with large, deep sockets in dorsal valve; brachial loop given off ventrally, beginning with gently curving and ventrally directed hinge plates which, in turn, give rise to elongate and inwardly inclined crural processes.

**REMARKS:** The specimen figured here as *Ptyctothyris sinaiensis*, new species, differs from the type species *P. stephani* (Davidson) in its narrower dorsal outline, labiate foramen, and incipient episulcation of the anterior margin.

The internal morphology as shown in the transverse serial sections (fig. 17), while agreeing with that of the type species, differs from that given for *Ptyctothyris? daghaniensis* Muir-Wood (1935: 123, fig. 20). The shapes of the hinge plates of *P.? daghaniensis* are more elongate and geniculate than those of our specimen.

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### Table 12

<table>
<thead>
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<th>Specimen</th>
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<td>34.2</td>
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</table>

*a* Figured specimen.

*b* Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.

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*Ptyctothyris? daghaniensis*

Muir-Wood, 1935

Figure 18

*Heimia furciliensis* (Haas, 1890): Muir-Wood, 1925: 187, pl. 15, fig. 6a–c.

**LOCALITY:** Subunit 82, Gebel El-Maghara, Sinai.

**GEOLoGICAL OCCURRENCE:** Upper Callovian.

**DESCRIPTION:** Shells medium to large (table 12), evenly biconvex, and oval to just subpentagonal in general outline; dorsal valve has well-developed, shallow sulcus originating approximately 15 mm from anterior commissure and bounded on either side by low carinae, or folds, developing anteriorly; some degree of anterolateral constriction present, giving rise to moderately developed paraplicate anterior commissure; ventral umbo short and massive, beak suberect; symphytium obscured and pedicle foramen large and circular; beak ridges not developed.

**REMARKS:** Muir-Wood (1935: 122, pl. 13, figs. 2a, b) described *Ptyctothyris? daghaniensis* from the “Argovian” Daghani section of Somalia. The species was poorly illustrated with one crushed specimen and a series of transverse serial sections (fig. 20). Earlier (1925: 187, pl. 15, figs. 6a–c) she described and figured a specimen as *Heimia furciliensis* (Haas) from the Bathonian of the Jordan Val-
Fig. 19. *Sphriganaria cardioides* (Douville, 1916). A–C, Dorsal, anterior, lateral views, AMNH 44211, ×1; D–F, Dorsal, anterior, lateral views, AMNH 44212, ×1; G–I, Dorsal, anterior, lateral views, AMNH 44213, ×1.

The size and morphological features of this specimen agree with numerous examples which she later determined as *Ptyctothyris? daghaniensis* in the collections of the Department of Palaeontology of the Natural History Museum, London. The species is not uncommon in the Late Callovian of Gebel El-Maghara where it occurs within the upper part of the Zohar Formation (Subunit 82).

As the serial sections of the species given in Muir-Wood’s (1935) figure 20 cannot be identified as being congeneric with *Ptyctothyris*, the present taxonomic assignment must be to the genus *Ptyctothyris* until further investigation of the species can be made.

**TABLE 13**

**Measurements (mm) of Specimens of *Sphriganaria cardioides* (Douville, 1916)**

<table>
<thead>
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*a* Figured specimens.

*b* Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.

**REMARKS:** In his description of *Sphriganaria bramkampi*, Cooper (1989: 105) referred
Douvillé's (1916) species *cardioides*, hitherto assigned to the genus *Eudesia*, to his new genus *Sphriganaria* ranging from the Bajocian to the Kimmeridgian. The three examples figured here (fig. 19) are considered to be of Upper Bathonian age. They compare favorably (table 13) with a series of specimens figured by Cooper (1989: pl. 45, figs. 1–10) which are stated to have come from the Lower Callovian of Engabashi, Gebel El-Maghara, Sinai Peninsula.

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