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

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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 pyriformis,* 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 Bartov and Freund (1968).

Farag (1957, 1959) and Farag and Gatinaud (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 (*Goliathyris 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 coralgal 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. Silicification 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 silicification 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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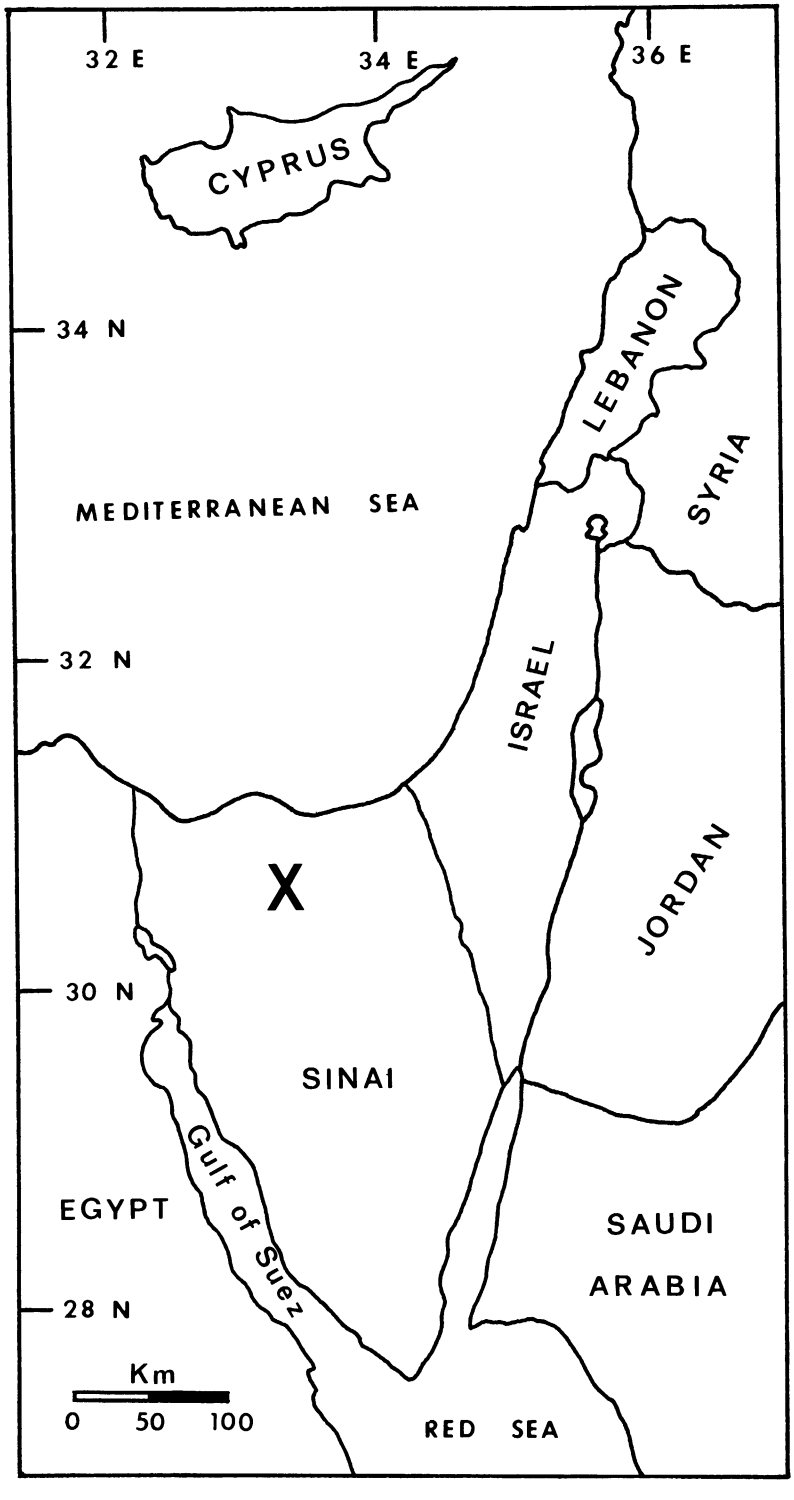


Fig. 1. Geographic location of sample area (X).

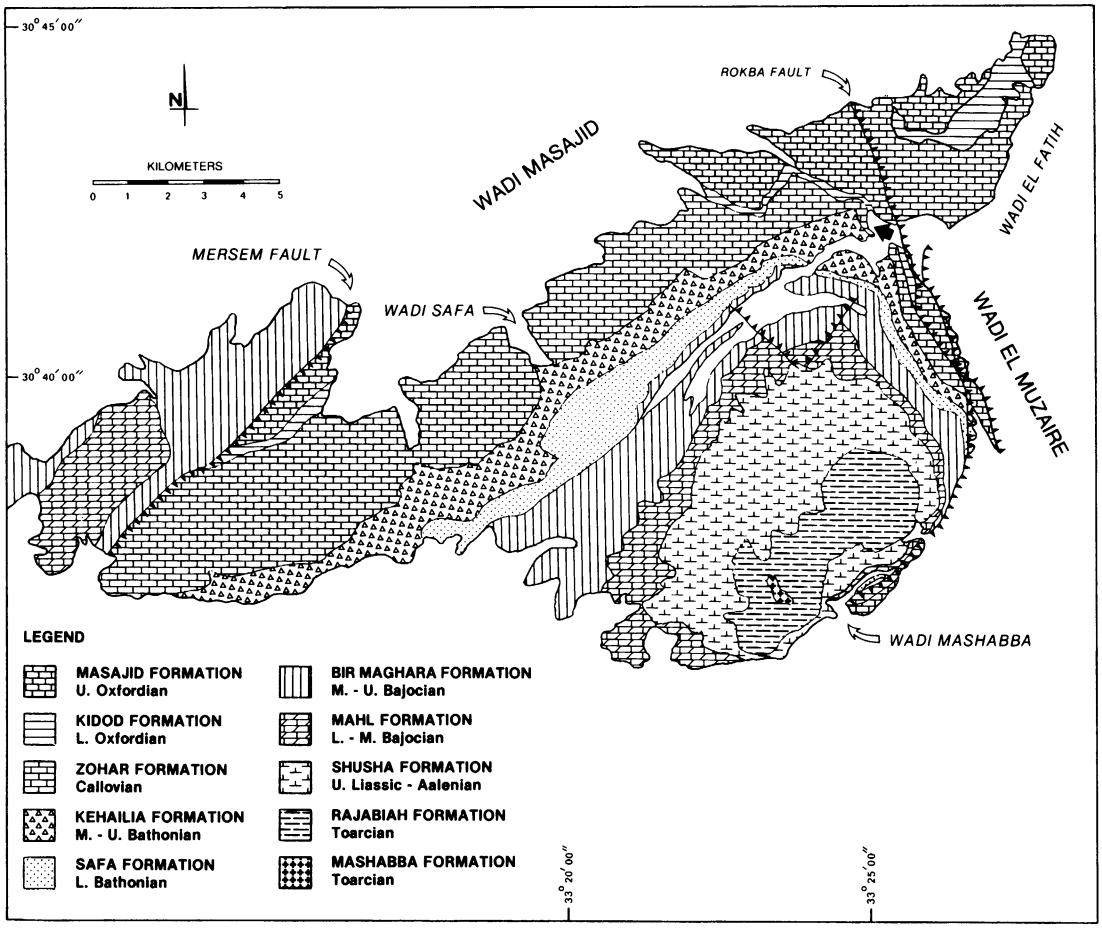


Fig. 2. Locality map showing the breached anticlinal domes at Gebel El-Maghara, northern Sinai. Black arrow represents location of *Septirhynchia*-bearing beds of Feldman (1987).

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

AMNH	American Museum of Natural History
BMNH	British Museum of Natural History
GSI	Geological Survey of Israel
USNM	Smithsonian Institution, United States National Museum

Measurements

(L)	maximum length of shell
(W)	maximum width of shell
(T)	maximum thickness of shell

SYSTEMATIC PALEONTOLOGY

PHYLUM BRACHIOPODA

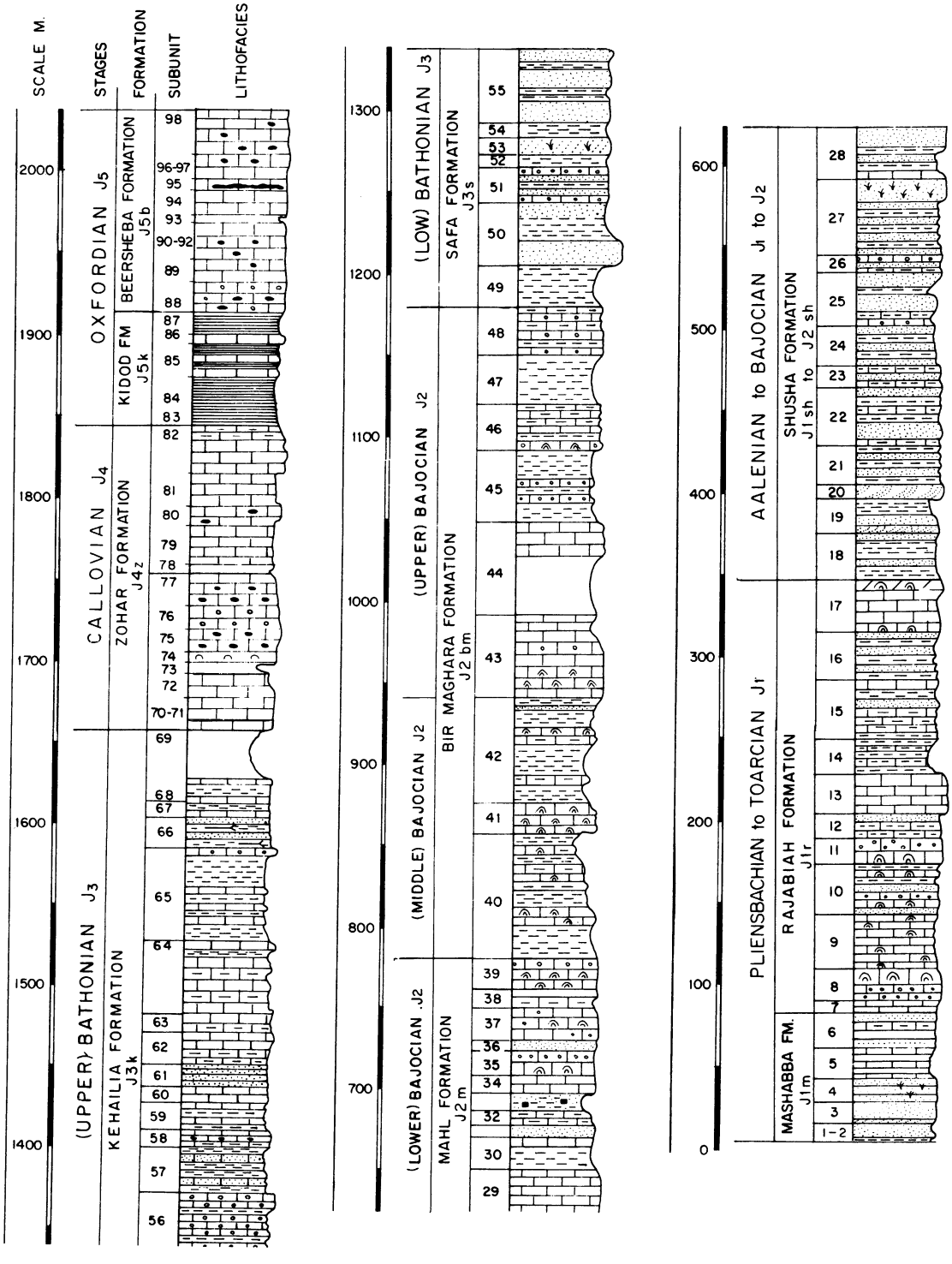
CLASS ARTICULATA HUXLEY, 1869

ORDER RHYNCHONELLIDA KUHN, 1949

SUPERFAMILY RHYNCHONELLOIDEA GRAY, 1848

FAMILY RHYNCHONELLIDAE GRAY, 1848

SUBFAMILY TETRARHYNCHIINAE AGER, 1965


SCALE M.
STAGES
FORMATION
SUBUNIT
LITHOFACIES
2000
1900
1800
1700
1600
1500
1400
(UPPER) BATHONIAN J3
CALLOVIAN J4
OXFORDIAN J5
KEHAILIA FORMATION J3k
ZOHAR FORMATION J4z
KIDOD FM J5k
BEERSHEBA FORMATION J5b
98
96-97
95
94
93
90-92
89
88
87
86
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70-71
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63
62
61
60
59
58
57
56
1300
1200
1100
1000
900
800
700
(LOWER) BAJOCIAN J2
(MIDDLE) BAJOCIAN J2
(UPPER) BAJOCIAN J2
(LOW) BATHONIAN J3
MAHL FORMATION J2m
BIR MAGHARA FORMATION J2 bm
SAFA FORMATION J3s
55
54
53
52
51
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49
48
47
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37
36
35
34
32
30
29
600
500
400
300
200
100
0
PLIENSBACHIAN to TOARCIAN Jr
AALENIAN to BAJOCIAN J1 to J2
MASHABBA FM. J1m
RAJABIAH FORMATION J1r
SHUSHA FORMATION J1sh to J2sh
28
27
26
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1-2

GENUS *SOMALIRHYNCHIA* WEIR, 1925

Somalirhynchia africana Weir, 1925
Figures 4A–F

Somalirhynchia africana Weir, 1925: 80, pl. 12, figs. 20–23. Muir-Wood, 1935: 94, pl. 10, figs. 7a–c, text figs. 7, 8. Ager, 1965: H614, figs. 497, 9a, b. Dubar, 1967: 30, pl. 2, figs. 5a, b. Abbate et al., 1974: 439, pl. 39, fig. 4. Cooper, 1989: 58, pl. 12, figs. 37–41.

TYPE SPECIES: *Somalirhynchia africana* Weir, 1925, emended Muir-Wood, 1935.

LECTOTYPE: Selected by Muir-Wood, 1935: Wylie Coll. Hunterian Museum, Glasgow University (L1393a).

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.

TABLE 1
Measurements (mm) of *Somalirhynchia africana* Weir, 1925

Specimen	(L)	(W)	(T)	Subunit
B. 78955[a]	32.5	34.7	23.5	
GSI M6922[b]	38.1	39.0	29.1	82[c]
AMNH 44178	39.6	44.5	30.6	82
AMNH 44179	40.0	41.1	31.7	82
AMNH 44180	41.4	39.1	32.4	82
AMNH 44181	39.9	39.5	32.8	82
AMNH 44182	37.0	41.1	24.7	82
AMNH 44183[b]	25.5	27.5	19.2	53, 54
BMNH BB.86880	35.1	38.0	27.2	48
BMNH BB.86881	32.0	33.5	23.0	48
BMNH BB.86882	34.0	37.5	30.0	48
BMNH BB.86883	35.0	44.5	32.0	48
BMNH BB.86884	33.0	38.0	29.1	48
BMNH BB.86885	33.1	34.5	28.4	48

[a] Species emended by Muir-Wood (1935) who figured this specimen from Bosti, N.W. of Bihendula, Somalia. No holotype selected by Weir (1925, 1929, 1930).

[b] Figured specimen.

[c] Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.

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 genus ranges from Lower Bajocian to Upper Callovian. Species assigned to this genus by Makridin (1955) and Childs (1969) from Upper Jurassic horizons

←

Fig. 3. Columnar section of Gebel El-Maghara, northern Sinai (modified from Picard and Hirsch, 1987 and used with permission of the Israel Academy of Sciences and Humanities).

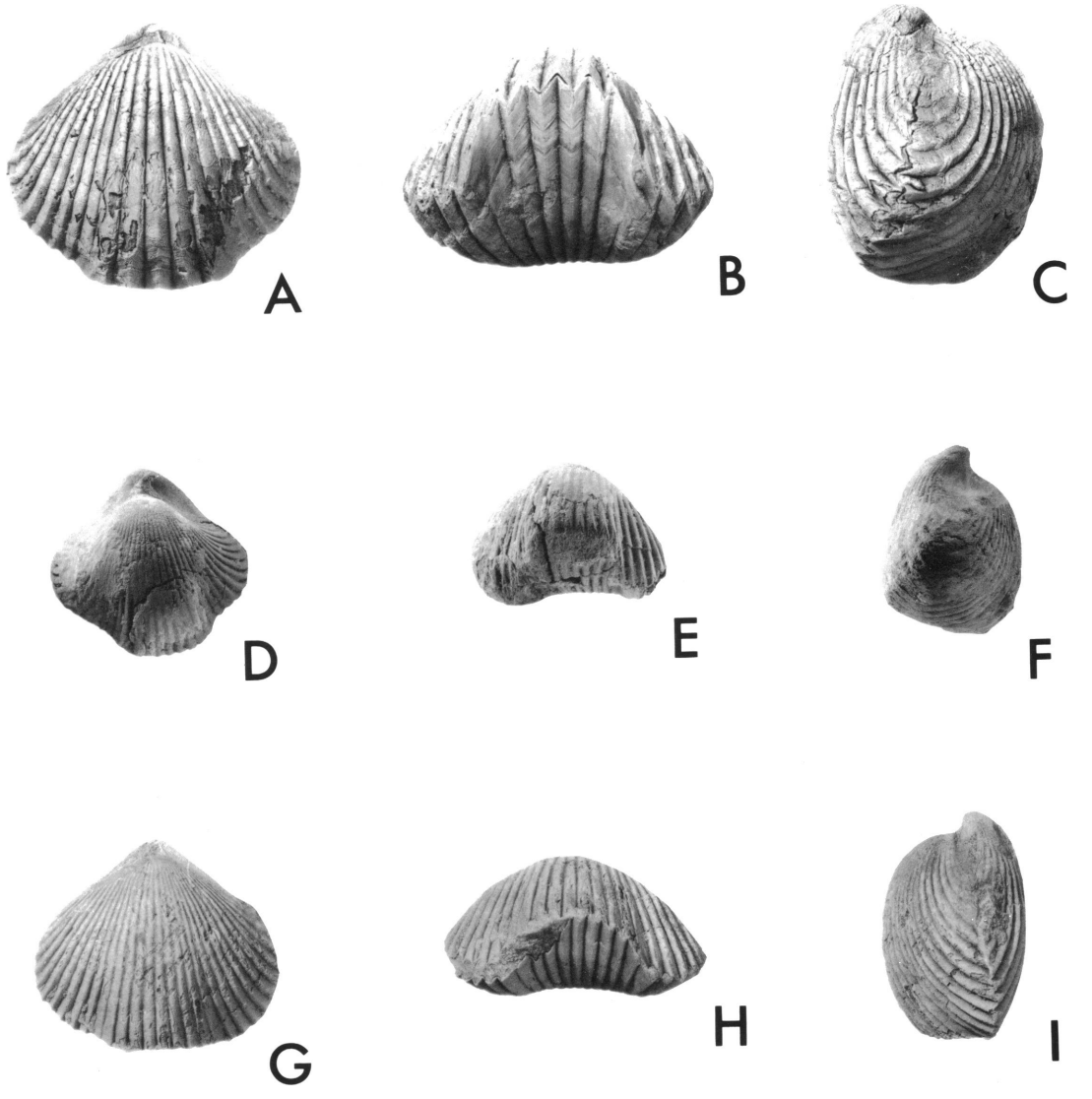


Fig. 4. *Somalirhynchia africana* Weir, 1925. **A-C,** Dorsal, anterior, lateral views, GSI M6922, ×1; **D-F,** dorsal, anterior, lateral views, AMNH 44183, ×1. *Somalirhynchia bihenensis* Muir-Wood, 1935. **G-I,** Dorsal, anterior, lateral views, AMNH 44184, ×1.

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

TABLE 2
Measurements (mm) of *Somalirhynchia bihenensis* Muir-Wood, 1935

Specimen	(L)	(W)	(T)	Comments
BMNH B.85409	27.8	30.1	19.5	Holotype, Muir-Wood, 1935: pl. 10, fig. 5a–c; Bihen Pass, Somalia.
AMNH 44184[a]	28.9	31.5	18.0	Subunit 82, Gebel El-Maghara, Sinai, Egypt.
AMNH 44185	17.1	21.3	10.9	Subunit 47, Hamakhtesh Hagadol, Negev, Israel.

[a] Figured specimen.

species with a broad arcuate uniplication 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 Bajocian.

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 Tuwaiq Mountain and Hanifer formations, a geological range extending from Lower Callovian to Kimmeridgian.

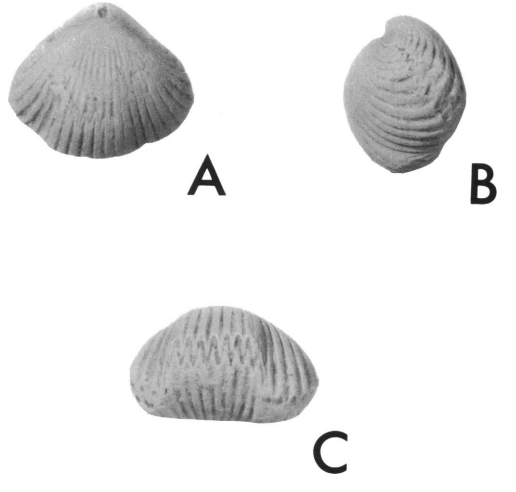


Fig. 5. *Somalirhynchia arabica* Cooper, 1989. A–C, Dorsal, lateral, anterior views, GSI M4349, ×1.

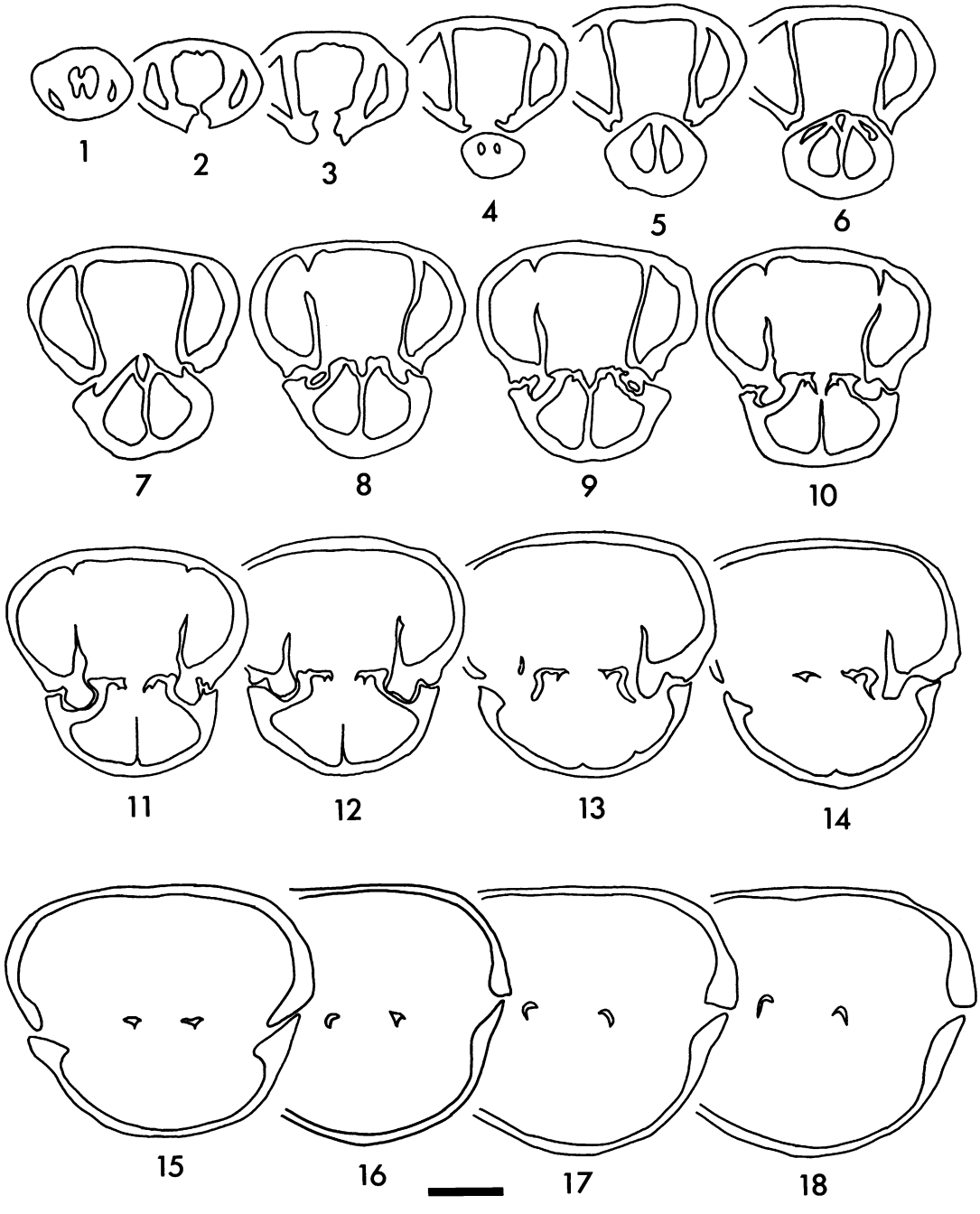


Fig. 6. *Somalirhynchia arabica* Cooper, 1989 (numbers show distance in mm between sections and [in parentheses] distance from beak): **1,** 1.8 (1.8); **2,** 0.3 (2.1); **3,** 0.4 (2.5); **4,** 0.3 (2.8); **5,** 0.3 (3.1); **6,** 0.4 (3.5); **7,** 0.4 (3.9); **8,** 0.3 (4.2); **9,** 0.3 (4.5); **10,** 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* Cooper, 1989

Specimen	(L)	(W)	(T)	Subunit
USNM 380206[a]	26.5	23.0	30.0	
GSI M4349[b]	22.0	25.0	16.5	48[c]
BMNH BB.86886	19.6	25.7	16.2	82 (UP)
BMNH BB.86887	24.7	29.0	19.9	82 (UP)
BMNH BB.86888	24.4	32.7	18.5	82 (UP)
BMNH BB.86889	21.8	27.4	17.2	82 (UP)
BMNH BB.86890	25.3	28.5	20.5	82 (LP)
BMNH BB.86891	24.2	28.8	17.7	82 (LP)
BMNH BB.86892	23.9	30.4	19.4	82 (LP)

[a] Holotype, figured in Cooper, 1989, pl. 14, figs. 1–5, Upper Dhruma Formation and Tuwaiq Mountain Formation, Saudi Arabia.
[b] Figured specimen.
[c] 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.

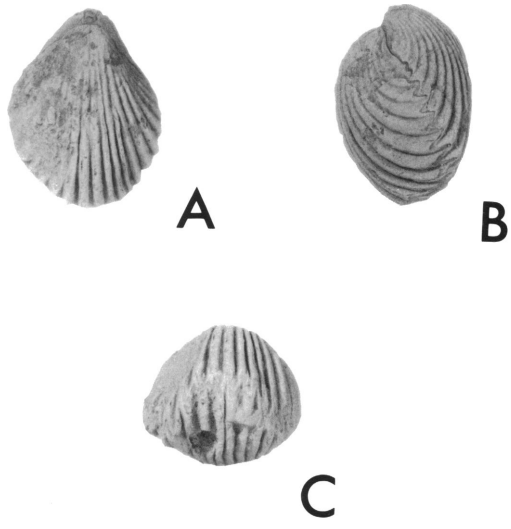


Fig. 7. *Schizoria elongata* Cooper, 1989. A–C, Dorsal, lateral, anterior views, GSI M6823, ×1.

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 rhynchonellid 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).

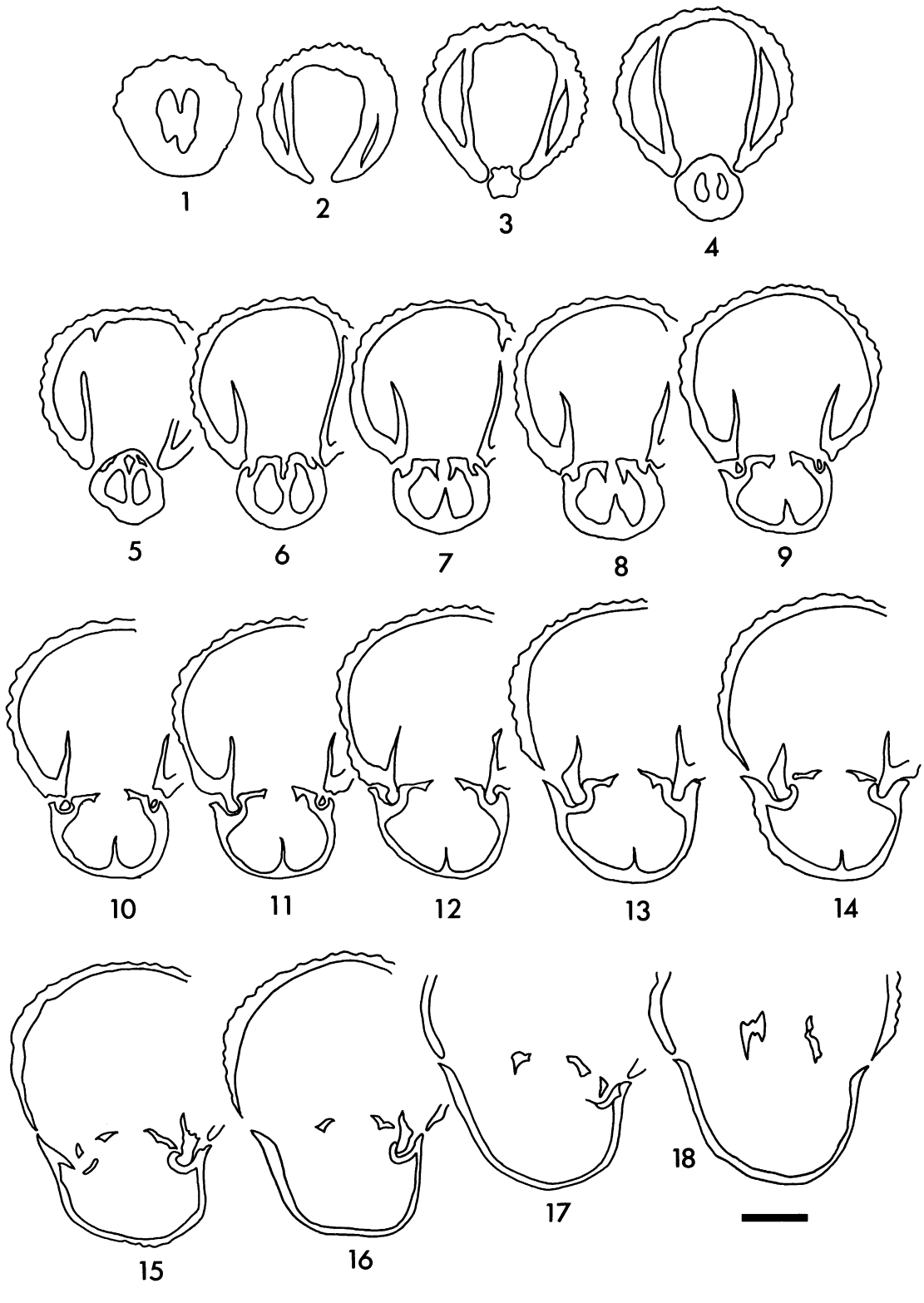
INTERNAL STRUCTURES: The general transverse outlines shown in the transverse serial sections (fig. 8) conform with Cooper's (1989: 55, fig. 31), differing only in the less persistent median septum in the dorsal valve and less persistent, subparallel dental lamellae in the ventral valve. A fairly deep,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

TABLE 4
Measurements (mm) of *Schizoria elongata* Cooper, 1989

Specimen	(L)	(W)	(T)	Subunit
USNM 380260b[a]	12.7	10.7	10.2	
GSI M6823[b]	26.5	21.0	18.4	39[c]
AMNH 44186	25.5	18.2	17.8	39
AMNH 44187	25.2	20.3	18.0	39
AMNH 44188	22.1	16.4	15.7	39
AMNH 44189	26.1	21.7	16.7	39
AMNH 44190	24.1	21.4	18.8	39
AMNH 44191	25.0	20.9	15.0	39
AMNH 44166	23.7	19.3	15.5	40
AMNH 44167	27.6	24.1	15.1	40
AMNH 44168	25.7	21.0	17.5	40
BMNH BB.86893	25.7	20.2	17.6	40
BMNH BB.86894	25.7	19.4	15.4	40
BMNH BB.86895	23.7	18.1	18.2	40
BMNH BB.86896	27.2	23.5	16.9	40

[a] Holotype, figured by Cooper, 1989, pl. 14, figs. 17–21, from Lower Dhruma Formation, Saudi Arabia.
[b] Figured specimen.
[c] Subunit numbers refer to the section at Gebel El-Maghara unless otherwise noted.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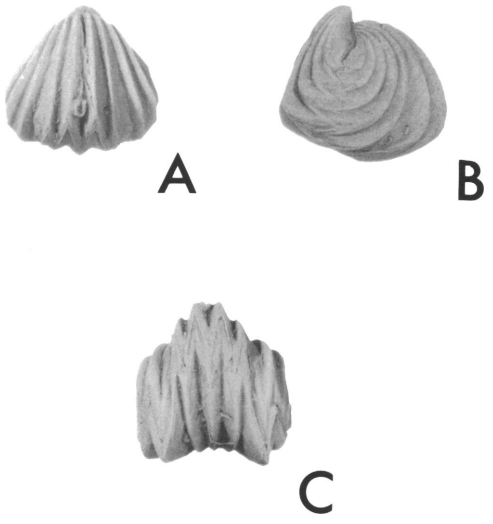


Fig. 9. *Pycnoria compacta* Cooper, 1989. A–C, Dorsal, lateral, anterior views, GSI M6891, ×1.

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
Measurements (mm) of *Pycnoria compacta* Cooper, 1989

Specimen	(L)	(W)	(T)	Subunit
USNM 380453[a]	19.0	18.0	16.3	
GSI M6891[b]	21.0	19.6	22.1	59[c]
AMNH 44192	20.1	20.0	20.2	59
AMNH 44193	27.8	19.6	20.9	59
BMNH BB.86897	23.9	25.4	19.3	57, 58
BMNH BB.86898	18.5	19.6	15.4	57, 58
BMNH BB.86899	17.8	18.9	13.7	57, 58
BMNH BB.86900	17.6	17.4	11.9	57, 58
BMNH BB.86901	22.7	23.8	19.8	57, 58

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

(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 Dhruma 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

←

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.

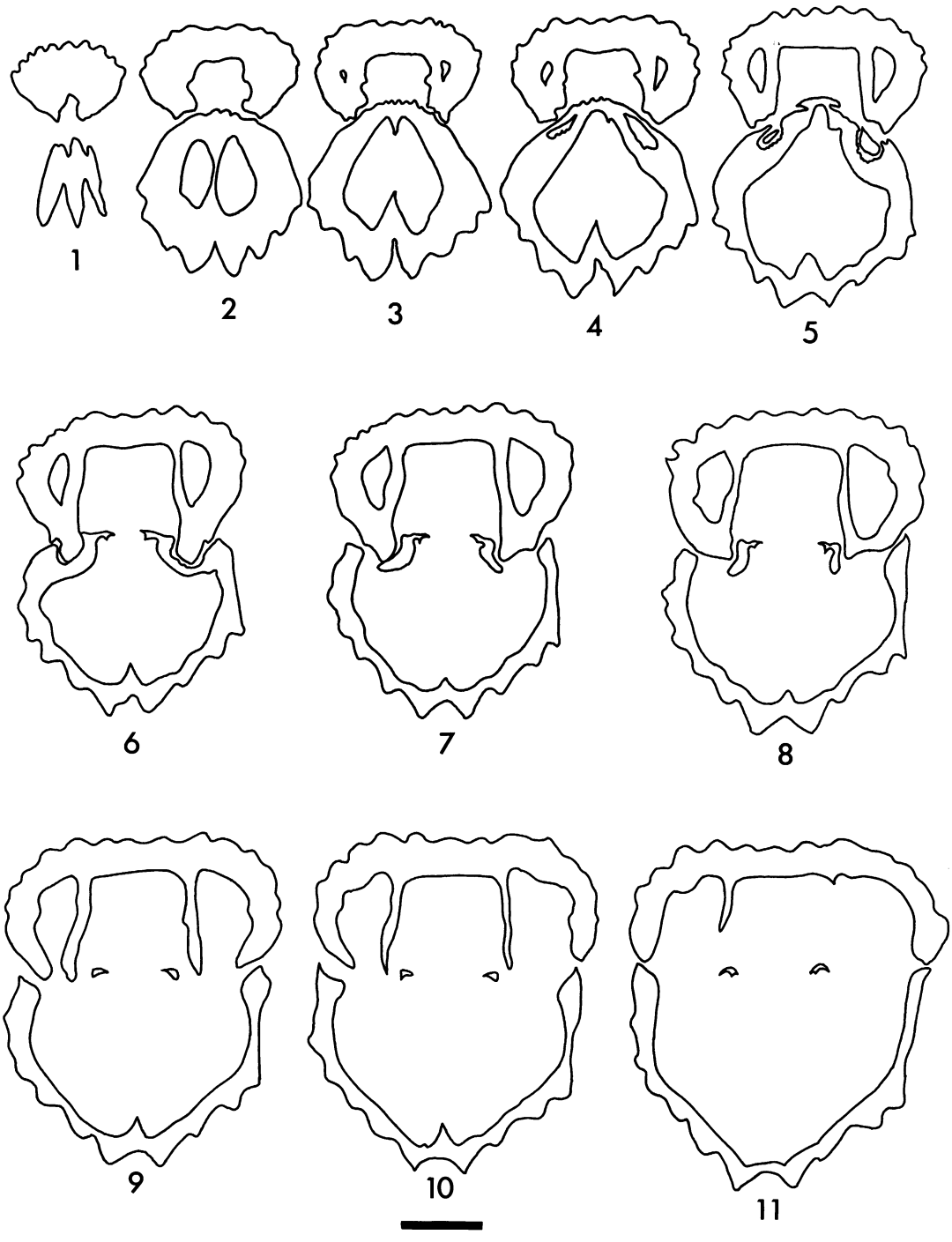


Fig. 10. *Pycnoria compacta* Cooper, 1989 (numbers show distance in mm between sections and [in parentheses] distance from beak): **1,** 2.4 (2.4); **2,** 0.6 (3.0); **3,** 0.4 (3.4); **4,** 0.4 (3.8); **5,** 0.3 (4.1); **6,** 0.4 (4.5); **7,** 0.3 (4.8); **8,** 0.5 (5.3); **9,** 0.4 (5.7); **10,** 0.3 (6.0); **11,** 0.4 (6.4). Scale bar equals 5 mm; GSI M6891.

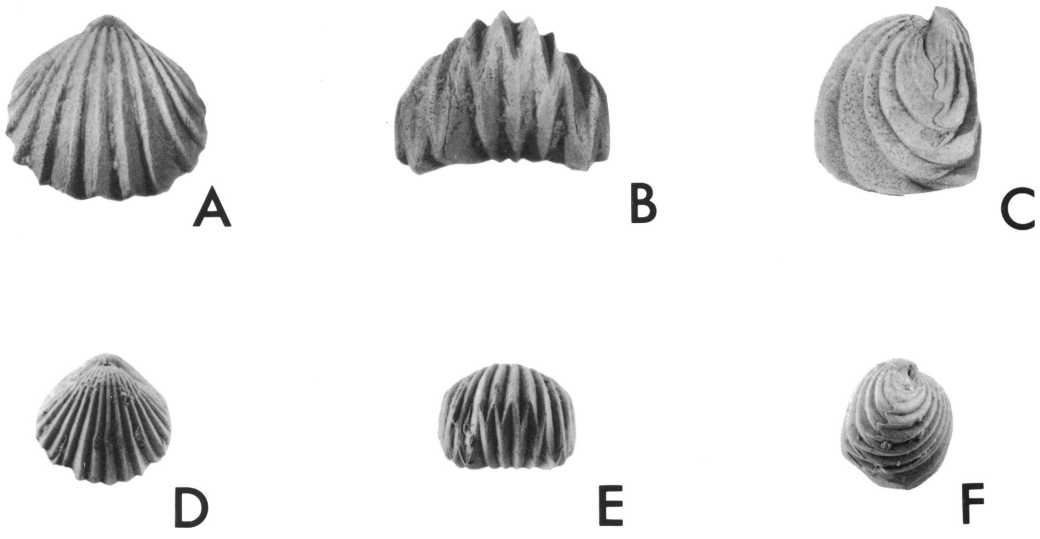


Fig. 11. *Pycnoria magna* Cooper, 1989. **A-C,** Dorsal, anterior, lateral views, AMNH 44194, ×1; *Globirhynchia dubia* Cooper, 1989. **D-F,** Dorsal, anterior, lateral views, GSI M6900, ×1.

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
Measurements (mm) of *Pycnoria magna* Cooper, 1989

Specimen	(L)	(W)	(T)	Subunit
USNM 380215a[a]	24.0	24.2	11.2	
AMNH 44194[b]	25.9	28.0	20.7	57[c]
AMNH 44195	25.4	28.0	20.7	57
AMNH 44196	23.9	25.7	21.3	57
AMNH 44169	24.9	27.3	21.2	57
AMNH 44170	26.4	29.8	20.8	57
BMNH BB.86902	26.8	27.7	23.7	57
BMNH BB.86903	25.8	28.6	21.2	57
BMNH BB.86904	25.0	27.6	21.8	57

[a] Holotype, figured by Cooper, 1989, pl. 12, figs. 11–36; pl. 18, figs. 26–36, from Dhruma Formation, Saudi Arabia.

[b] Figured specimen.

[c] 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

Specimen	(L)	(W)	(T)	Subunit
Globirhynchia dubia Cooper, 1989				
GSI M6900[a]	17.0	18.6	14.9	59, 60[b]
BMNH BB.86905	21.0	20.1	15.5	59, 60
BMNH BB.86906	18.2	18.8	14.9	59, 60
BMNH BB.86907	17.0	18.1	13.9	59, 60
BMNH BB.86908	16.1	16.0	11.9	59, 60
Globirhynchia crassa Cooper, 1989				
AMNH 44197[a]	19.2	19.0	15.1	59, 60
BMNH BB.86909	14.9	14.7	11.0	59, 60
BMNH BB.86910	15.2	15.1	12.0	59, 60
BMNH BB.86911	14.2	14.0	10.1	59, 60
Globirhynchia subtriangulata Cooper, 1989				
AMNH 44198[a]	18.9	17.6	12.8	59, 60[b]
BMNH BB.86912	17.3	19.9	10.3	59, 60
BMNH BB.86913	17.4	16.9	9.5	59, 60
BMNH BB.86914	18.9	20.1	12.7	59, 60
BMNH BB.86915	19.8	20.9	14.9	59, 60
BMNH BB.86916	15.9	17.5	16.1	59, 60
BMNH BB.86917	18.1	19.3	17.9	59, 60
BMNH BB.86918	17.5	17.9	13.7	59, 60
BMNH BB.86919	19.5	20.9	14.7	59, 60

[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
Figure 13A–C

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

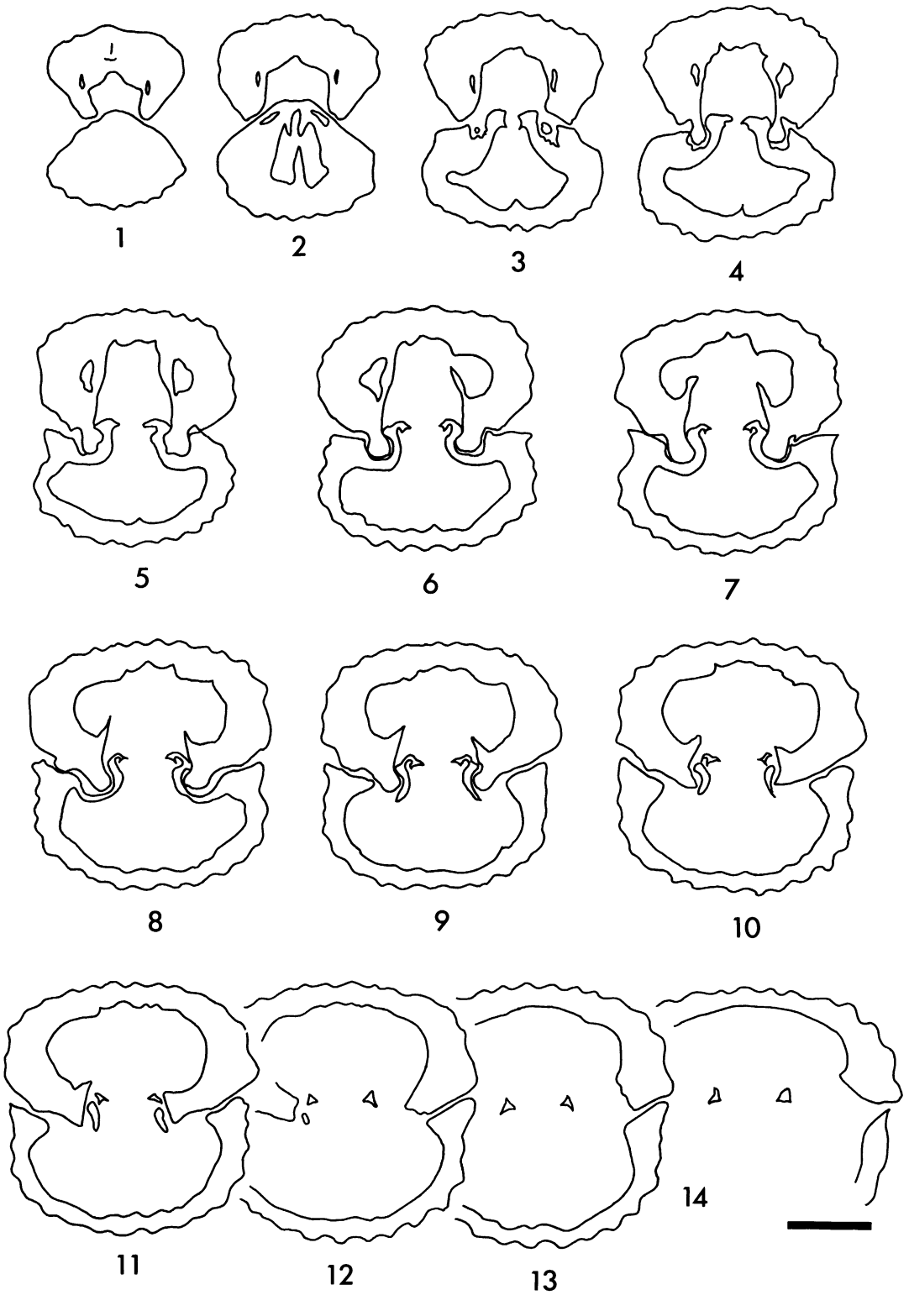
LOCALITY: Subunits 59, 60, Gebel El-Maghara, Sinai.

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: 39)

→

Fig. 12. *Globirhynchia dubia* Cooper, 1989 (numbers show distance in mm between sections and [in parentheses] distance from beak): **1,** 1.8 (1.8); **2,** 0.6 (2.4); **3,** 0.3 (2.7); **4,** 0.25 (2.95); **5,** 0.41 (3.36); **6,** 0.3 (3.66); **7,** 0.3 (3.96); **8,** 0.2 (4.16); **9,** 0.6 (4.76); **10,** 0.45 (5.21); **11,** 0,4 (5.61); **12,** 0.35 (5.96); **13,** 0.45 (6.41); **14,** 0.4 (6.81). Scale bar equals 5 mm; GSI M6900.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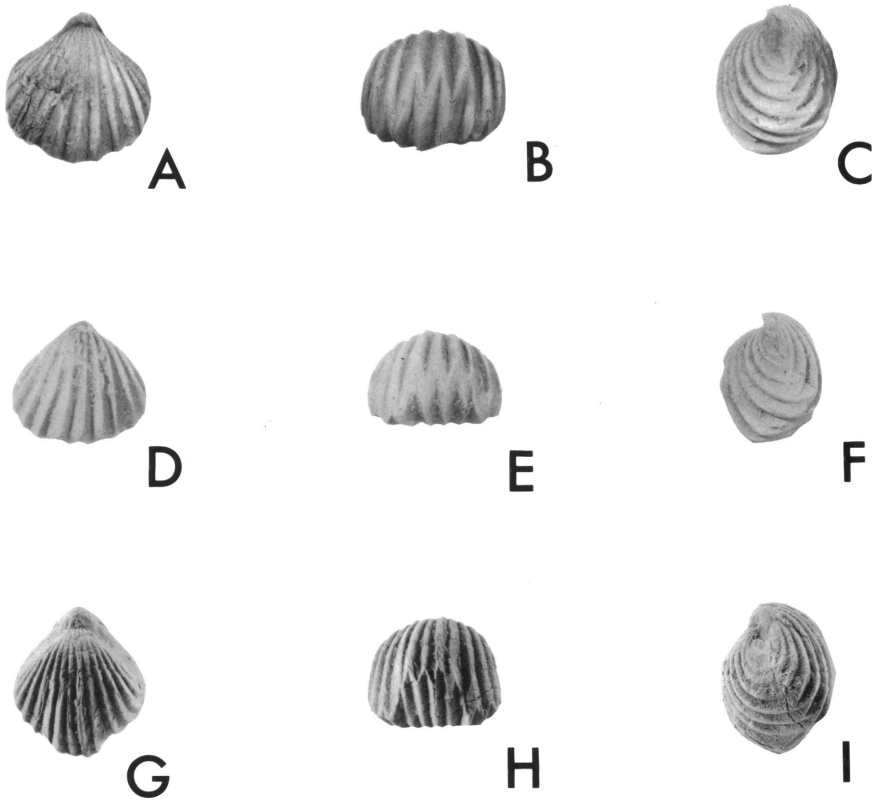


Fig. 13. *Globirhynchia crassa* Cooper, 1989. **A-C,** Dorsal, anterior, lateral views, AMNH 44197, ×1; *Globirhynchia subtriangulata* Cooper, 1989. **D-F,** Dorsal, anterior, lateral views, AMNH 44198, ×1; *Burmirhynchia cooperi,* new species. **G-I,** Dorsal, anterior, lateral views, AMNH 44199, ×1.

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 deltidial plates well exposed; anterior commissure subquadrate in profile with extensive trapezoidal linguiform 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 Dhruma Formation (*Ermoceras* 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.

TABLE 8
Measurements (mm) of *Burmirhynchia cooperi,* New Species

Specimen	(L)	(W)	(T)	Subunit
GSI M8070[a]	24.0	20.9	19.4	46–48[b]
BMNH BB.86921	23.8	22.2	17.1	46–48
BMNH BB.86922	20.1	17.7	14.2	46–48
BMNH BB.86923	23.9	22.1	17.9	46–48
BMNH BB.86924	19.4	18.9	17.0	46–48
BMNH BB.86925	21.5	18.4	16.9	46–48
BMNH BB.86926	21.3	18.7	16.3	46–48
BMNH BB.86927	23.2	21.3	18.7	46–48
BMNH BB.86928	23.89	21.5	20.1	46–48
BMNH BB.86929	21.2	17.5	15.8	46–48

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

ORDER TEREBRATULIDA WAAGEN, 1883

SUBORDER TEREBRATULIDINA WAAGEN, 1883

SUPERFAMILY TEREBRATULIDOIDEA GRAY, 1840

FAMILY TEREBRATULIDAE GRAY, 1840

GENUS *KUTCHITHYRIS* BUCKMAN, 1918

Kutchithyris parnesi, new species
Figure 14A–C

DIAGNOSIS: Medium size, pentangulate *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 terebratulid 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 permesothyridid; 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 parensi, new species, differs from the type species of *K. acutiplicata* (Kitchin) in its less inflated dorsal valve and less acute anterior sulciplication. 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 sulciplication seen in *Kutchithyris*? species 1 (Cooper, 1989: pl. 27, figs. 7–9), regarded as of Bathonian age.

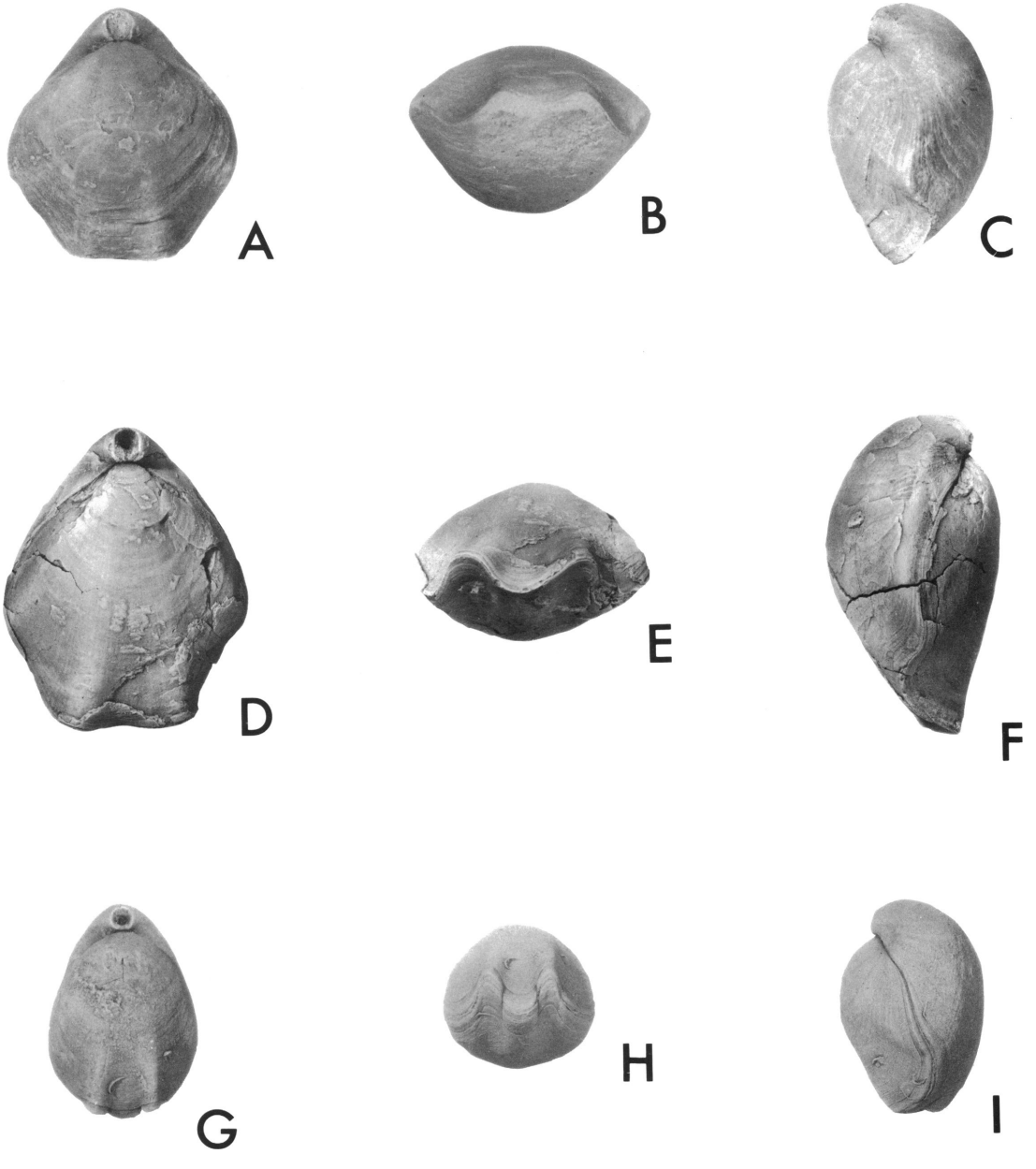


Fig. 14. *Kutchithyris parnesi,* new species. **A–C,** Dorsal, anterior, lateral views, GSI M8071, ×1; *Avonothyris variabilis,* new species. **D–F,** Dorsal, anterior, lateral views, GSI M8072, ×1; *Bihenithyris pyriformis,* new species. **G–I,** Dorsal, anterior, lateral views, AMNH 44215, ×1.

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-

TABLE 9
Measurements (mm) of *Kutchithyris parnesi*, New Species

Specimen	(L)	(W)	(T)	Subunit
GSI M8071[a]	28.6	25.7	18.5	64[b]
BMNH BB.86930	29.7	26.9	16.6	82
BMNH BB.86931	28.4	25.1	15.0	82
BMNH BB.86932	31.8	31.1	19.5	82

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

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 epithyridid, 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.*

TABLE 10
Measurements (mm) of *Avonothyris variabilis*, New Species

Specimen	(L)	(W)	(T)	Subunit
GSI M8072[a]	42.4	34.4	23.0	82[b]
AMNH 44202	39.7	30.8	21.2	82
AMNH 44203	34.8	26.4	20.5	82
AMNH 44204	34.4	26.7	20.6	82
AMNH 44205	23.5	19.2	14.9	82
AMNH 44206	35.2	28.9	22.4	82
GSI M4538	40.4	31.6	23.3	82
GSI M4361	35.2	27.8	20.8	82
GSI M4523	37.5	30.6	21.6	82

[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.

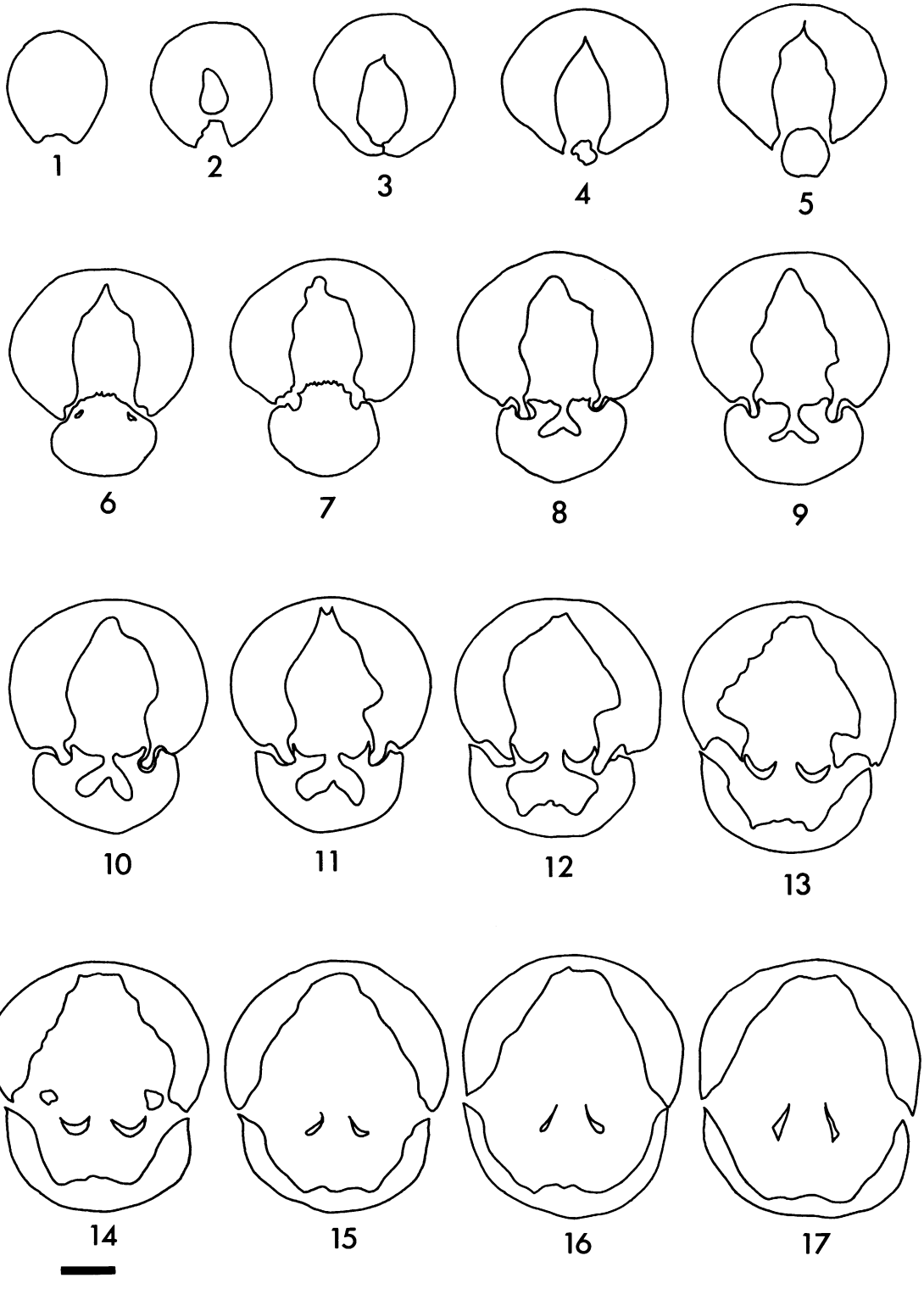
ETYMOLOGY: Latin *pirum* (*pyrum*), in allusion to the shell's pear-shaped outline.

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 mesothyridid 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 *Stenorina 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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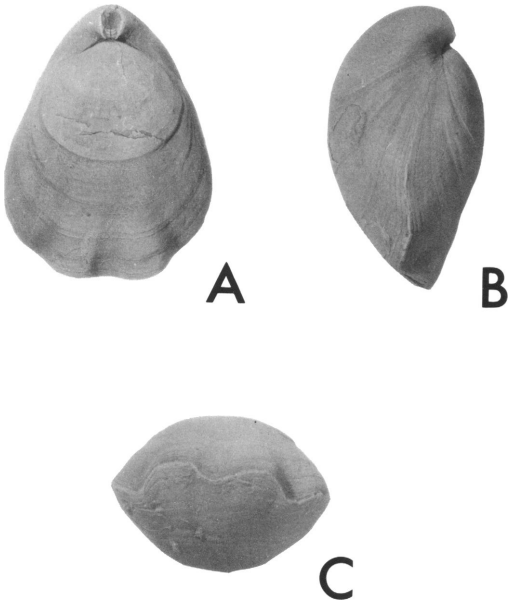

Fig. 16. *Ptyctothyris sinaiensis,* new species. A-C, Dorsal, lateral, anterior views, GSI M8073, ×1.

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 beak 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
Measurements (mm) of *Ptyctothyris sinaiensis,* New Species

Specimen	(L)	(W)	(T)	Subunit
GSI M8073[a]	42.2	34.5	23.2	48[b]
BMNH BB.86935	39.7	30.8	21.3	48
BMNH BB.86936	45.5	37.1	27.3	64
BMNH BB.86937	40.0	36.7	20.4	64
BMNH BB.86938	40.4	31.6	23.1	64

[a] Holotype, figured specimen.

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

GENUS *PTYCTOTYHRIS* BUCKMAN, 1918

***Ptyctothyris sinaiensis*, new species**
Figures 16, 17

DIAGNOSIS: Large, oval to subtriangular *Ptyctothyris.*

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

GEOLOGICAL OCCURRENCE: Upper Bajocian.

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

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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.

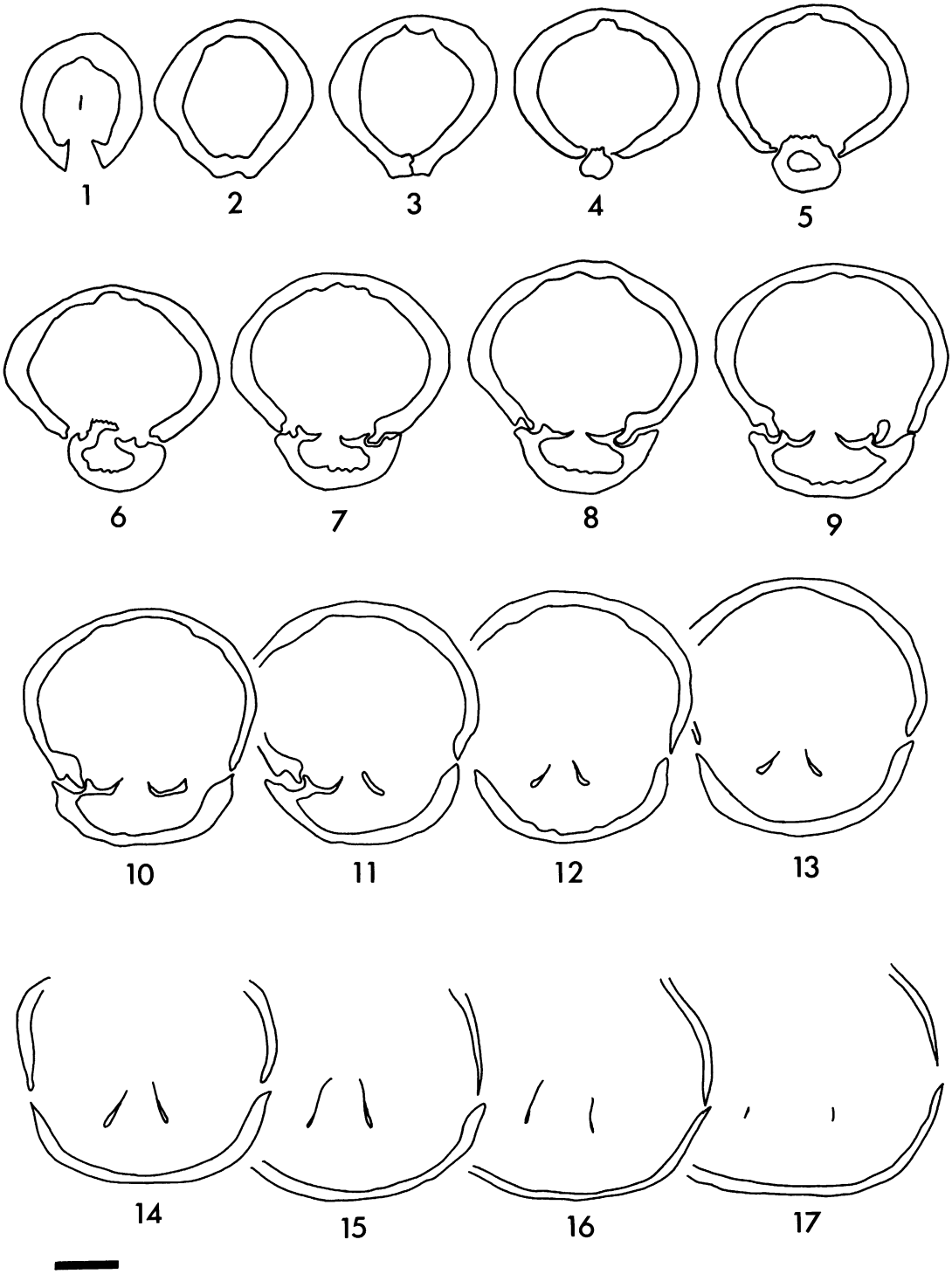

Fig. 17. *Ptyctothyris sinaiensis,* new species [numbers show distance in mm between sections and [in parentheses] distance from beak): **1,** 1.95 (1.95); **2,** 0.8 (2.75); **3,** 0.4 (3.15); **4,** 0.3 (3.45); **5,** 0.6 (4.05); **6,** 0.4 (4.45); **7,** 0.4 (4.85); **8,** 0.3 (5.15); **9,** 0.4 (5.55); **10,** 0.3 (5.85); **11,** 0.6 (6.45); **12,** 0.4 (6.85); **13,**

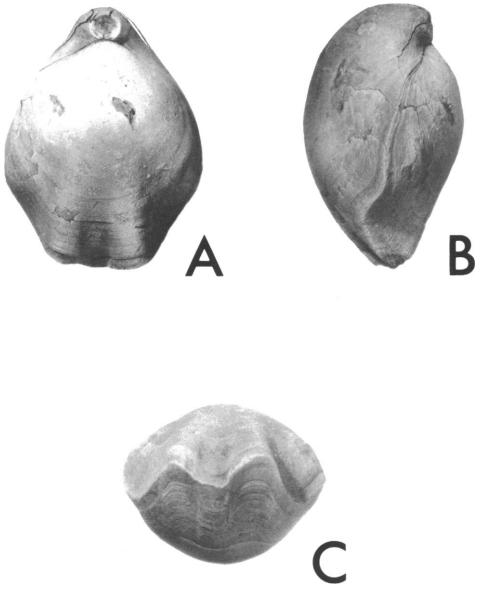

Fig. 18. *Ptyctothyris daghaniensis* Muir-Wood, 1935. A-C, Dorsal, lateral, anterior views, AMNH 44208, ×1.

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.

TABLE 12
Measurements (mm) of *Ptyctothyris*? *daghaniensis* Muir-Wood, 1935

Specimen	(L)	(W)	(T)	Subunit
AMNH 44208[a]	34.6	26.0	21.0	82[b]
AMNH 44209	38.4	29.0	23.1	82
AMNH 44210	27.4	23.2	16.8	82
BMNH BB.86940	34.1	28.4	17.9	82
BMNH BB.86941	34.0	28.5	18.7	82
BMNH BB.86942	34.2	28.1	17.5	82

[a] Figured specimen.

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

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-

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0.5 (7.35); **14,** 0.3 (7.65); **15,** 0.3 (7.95); **16,** 0.3 (8.25); **17,** 0.4 (8.65). Scale bar equals 5 mm; AMNH 44207.

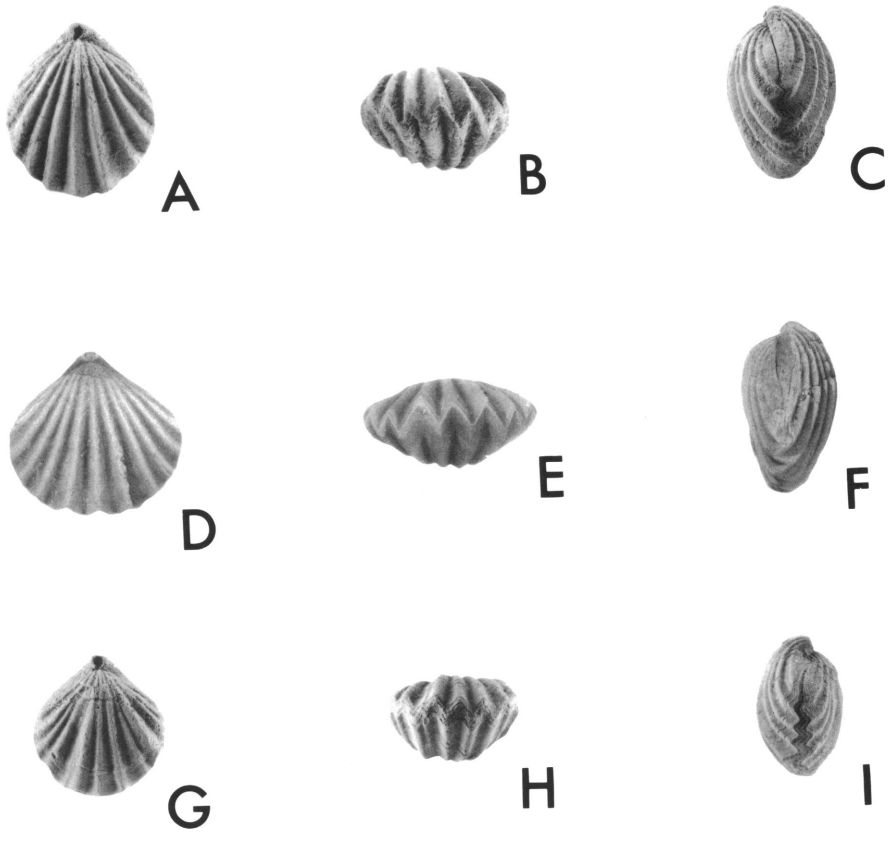

Fig. 19. *Sphriganaria cardioides* (Douvillé, 1916). **A-C,** Dorsal, anterior, lateral views, AMNH 44211, ×1; **D-F,** Dorsal, anterior, lateral views, AMNH 44212, ×1; **G-I,** Dorsal, anterior, lateral views, AMNH 44213, ×1.

ley. 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* (Douvillé, 1916)

Specimen	(L)	(W)	(T)	Subunit
AMNH 44211[a]	22.8	19.9	13.8	64[b]
AMNH 44212[a]	22.5	23.7	12.8	64
AMNH 44213[a]	18.1	17.2	11.4	64
AMNH 44214	22.5	12.8	12.8	64
BMNH BB.86943	19.7	11.4	11.4	64
BMNH BB.86944	20.4	12.3	12.3	64
BMNH BB.86945	23.1	14.0	14.0	64

[a] Figured specimens.

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

SUPERFAMILY ZEILLERIOIDEA ALLAN, 1940

FAMILY EUDESIIDAE MUIR-WOOD, 1965

GENUS *SPHRIGANARIA* COOPER, 1989

Sphriganaria cardioides (Douvillé, 1916)
Figure 19

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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