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Goliathyris lewyi, New Species (Brachiopoda, Terebratulacea) from the Jurassic of Gebel El-Minshera, Northern Sinai

HOWARD R. FELDMAN[1] AND ELLIS F. OWEN[2]

ABSTRACT

Goliathyris lewyi, new genus and species is described from the *Lamberticeras lamberti* Zone, Jurassic (Upper Callovian) of Gebel El-Minshera, northern Sinai. Homeomorphic with *Aulacothyris* spp., *G. lewyi* is questionably assigned to the family Dyscoliidae based on its internal resemblance to *Trigonithyris*, but resembles a zeilleriid externally.

INTRODUCTION

The present study is part of a preliminary investigation of the brachiopod faunas of the northern Sinai undertaken by us and colleagues in the Geological Survey of Israel. Our long-range goal is to complete a taxonomic revision of the brachiopod faunas of northern Sinai as well as those of Arabia which will help us establish the early history of brachiopod species and their evolution within the "Ethiopian" Faunal Province. Analysis of present data supports our contention that this province was invaded by brachiopods migrating from the north in Early Jurassic times which were isolated for the remainder of the Jurassic. These faunas are thought to have subsequently developed special morphological characteristics which distinguish them from their original stock. In addition, we are investigating the distribution of brachiopod species across faunal realm and province boundaries, specifically the Indo-African Faunal Realm which is now widely dispersed on various continental fragments. The Sinai is situated at the northern part of

[1] Research Associate, Department of Invertebrates, American Museum of Natural History; Associate Professor, Biology Department, Touro College, New York, New York 10036.
[2] 10 The Causeway, Horsham, Sussex, England.

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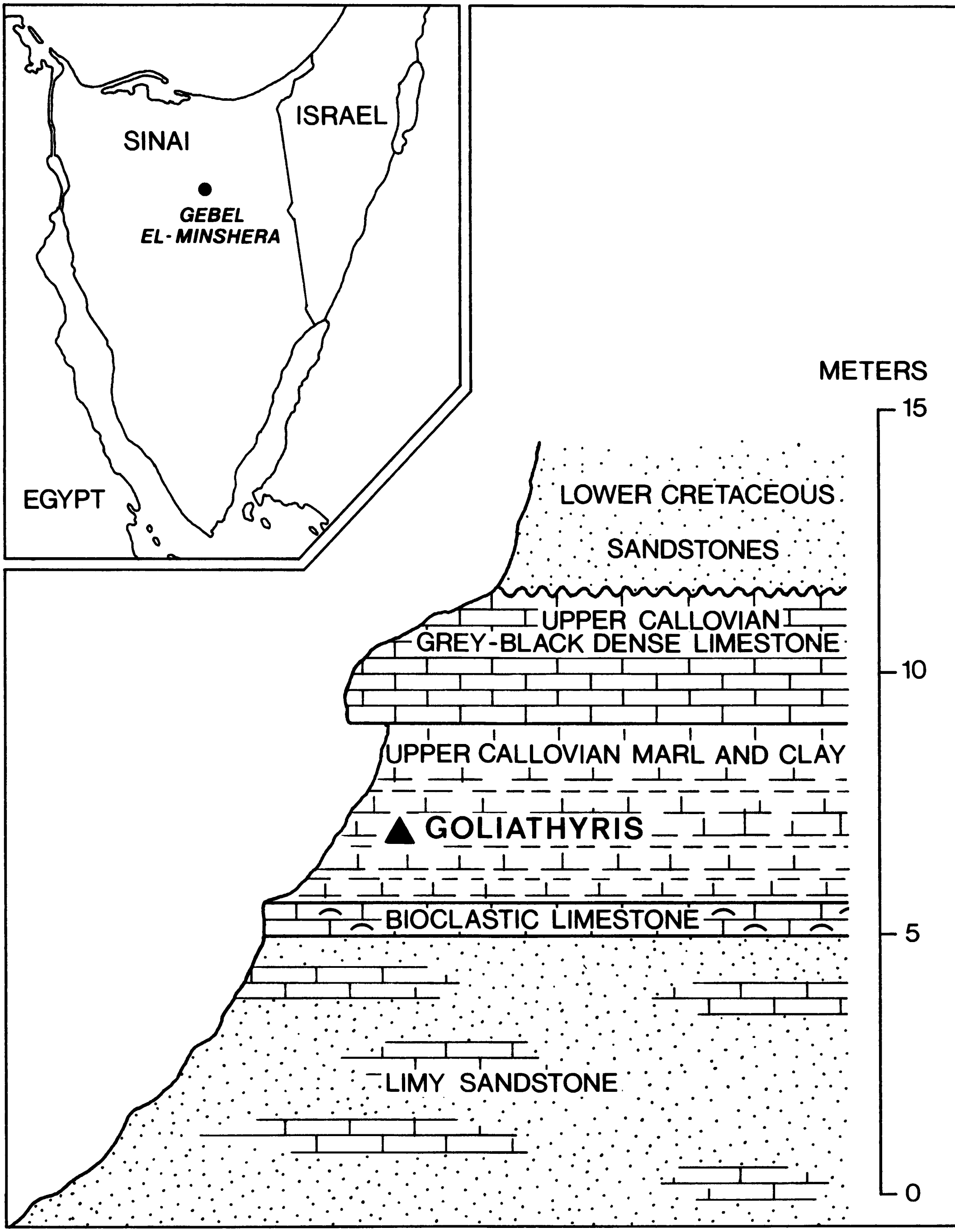

Fig. 1. Locality map of northern Sinai (inset) and detailed lithologic section of outcrop area. The triangle represents approximate strata from which *Goliathyris lewyi*, new species, was collected.

this realm and consequently the brachiopods are very likely to include species belonging to the equatorial Tethyan Realm.

Taxonomic revision of the Sinai brachiopods will also enable us to define, with greater accuracy, faunal realm and province bound-

TABLE 1

Stratigraphic Distribution of Some Jurassic Ammonites at Gebel El-Minshera, Northern Sinai, and Correlation with Ammonite Faunas in Central Saudi Arabia

Unnamed stratigraphic units, Gebel El-Minshera	Ammonites (this report)	Ammonites (Imlay, 1970)	Ammonite faunas (Arkell, 1952)
Cretaceous			
Sandstone	—	—	—
UNCONFORMITY			
Jurassic (European Upper Callovian)			
Gray-black dense limestone	*Lamberticeras lamberti* Zone *Peltoceras athleta* Zone		
Marl and clay (with *G. lewyi*)	"*Clydoniceras*" *Quenstedtoceras* *Pachyerymnoceras*	*Pachyerymnoceras*	
Bioclastic limestone	*Paracenoceras*	*Pachyceras*	
Limy sandstone	—	*Erymnoceras*	*Erymnoceras*

aries. The "Ethiopian" Faunal Province, for example, is recognizable from early in the Jurassic until the middle and possibly the end of the Cretaceous by the presence of endemic taxa at the species, genus, and family level. These endemics have been recognized in the ammonoid cephalopoda (Arkell, 1952, 1956), in the trigoniacean and crassatellacean bivalves (Kitchin, 1912), and particularly in the brachiopods (Weir, 1925; Muir-Wood, 1935). This same province has been recognized in India, East Africa, and Madagascar and at the end of the Jurassic in South America; it may also extend eastward as far as New Caledonia. Its first occurrence seems to be in the shallow seas following rifts formed during the breakup of Gondwanaland but is apparently limited at an unknown southern margin, as none of its species are known in the geosynclinal contemporaneous deposits of Antarctica or New Zealand. During much of the Early Jurassic, ubiquitous genera such as *Tetrarhynchia, Lobothyris,* and *Zeilleria,* found in the faunas of most known outcrops, became so generalized that it is difficult to plot them in terms of distribution (Ager, 1973). The description and revision of specialized forms in particular will facilitate the delineation of province boundaries as well as the recognition of faunal realms and distribution of genera.

The *Goliathyris* described herein as *G. lewyi,* new genus and species, was collected from loose debris on a slope of marl and clay (fig. 1) of Upper Callovian age along with *Pachyerymnoceras, Quenstedtoceras,* and "*Clydoniceras*" *pseudodiscus* Arkell (Cephalopoda). The marly unit is overlain by gray-black dense limestone, also of Upper Callovian age, containing within its matrix specimens of *Peltoceras trifidum* (Quenstedt), "*Clydoniceras,*" and *Pachyerymnoceras* (Cephalopoda); *Putealiceras, Pseudomelania* (Gastropoda), and unidentified corals. The top of the unit lies unconformably under a series of Lower Cretaceous sandstones. A thin, bioclastic limestone unit containing *Pachyerymnoceras* and *Paracenoceras prohexagonum* (Cephalopoda) directly underlies the marl and clay unit from which the *Goliathyris* specimens were collected.

The age of the upper part of the Jurassic strata at Gebel El-Minshera appears to be Upper Callovian (table 1) on the basis of ammonites of the *Lamberticeras lamberti* Zone (Z. Lewy, personal commun.) with a possible Upper Bathonian to Upper Callovian unconformity.

Abbreviations

AMNH American Museum of Natural History, Department of Invertebrates
GSI Geological Survey of Israel, Paleontology Division
USNM United States National Museum of Nat-

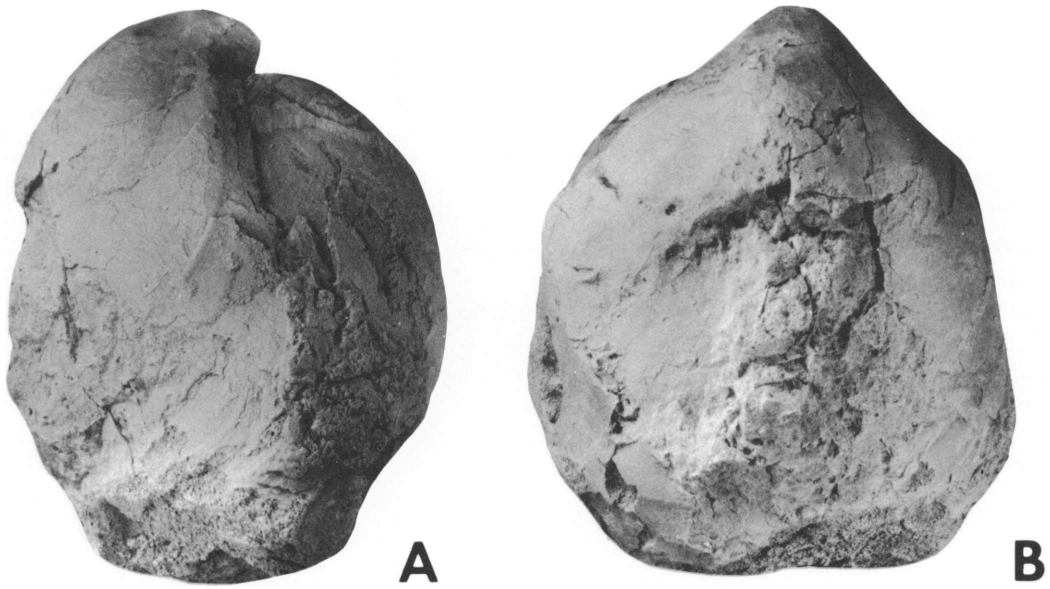

Fig. 2. *Goliathyris lewyi,* new species. A, B. Lateral, ventral views, holotype GSI M7261a. ×1.1.

ural History, Department of Paleobiology, Smithsonian Institution

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SYSTEMATIC PALEONTOLOGY

SUBORDER TEREBRATULIDINA WAAGEN, 1883

SUPERFAMILY TEREBRATULACEA GRAY 1840

FAMILY UNCERTAIN

Goliathyris, new genus

TYPE SPECIES: *Goliathyris lewyi,* new species.

INCLUDED SPECIES: Type species only.

GENERIC DIAGNOSIS: Extremely large, strongly sulcate, nonstrophic, permesothyridid with incurved dorsal umbo and massive zeilleriid beak. Broadly pentagonal in dorsal view. Hinge plates horizontal, becoming concave toward floor of brachial valve. Cardinal process massive and bilobate.

CHARACTER ANALYSIS: Based on a cladogram (fig. 6) it is postulated that *Goliathyris* is more closely related to *Trigonithyris* than to either *Dyscolia* or *Goniobrochus,* all three genera belonging to the family Dyscoliidae (Cooper, 1983; Muir-Wood, 1965). In support of this hypothesis two synapomorphies are presented (table 3): (1) noncapillate radial ornamentation, and (2) a massive cardinal process. *Goniobrochus* is more closely related to *Dyscolia* than either is to *Goliathyris* or

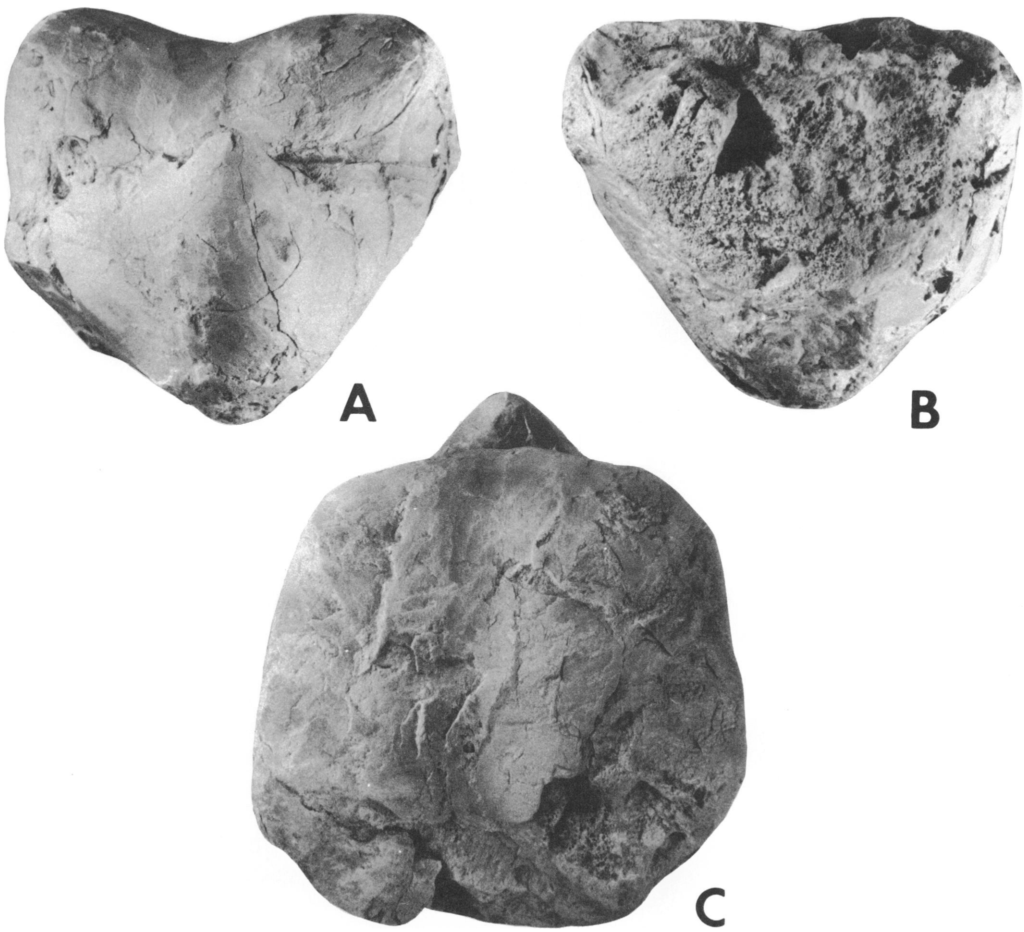

Fig. 3. *Goliathyris lewyi,* new species. A, B, C. Posterior, anterior, dorsal views, holotype GSI M7261a. ×1.1.

Trigonithyris based on the following two synapomorphies: (1) ventrally directed hinge plates and (2) square loops. *Dyscolia* differs from *Goliathyris* in its sulcate anterior commissure, permesothyridid pedicle foramen, and broadly pentagonal outline, all of which are considered plesiomorphic characters at this (generic) level of analysis. Cooper (1983) noted that *Trigonithyris* does not belong with the Dyscoliidae because of its well-developed outer hinge plates. *Goliathyris* resembles a zeilleriid externally in its beak and pedicle foramen (symplesiomorphies) but differs from the family Zeileriidae in having no dental plates or median septum. Based on analysis of the following characters the authors believe that the present classification (Cooper, 1983; Muir-Wood, 1965) in which *Dyscolia, Goniobrochus,* and *Trigonithyris* are placed in the family Dyscoliidae must be reconsidered. Clearly, the four genera do not share any apomorphic characters. Additional data, such as the exact morphology of the loop in *Trigonithyris* and *Goliathyris,* will provide information in support or rejection of the proposed cladogram (fig. 6). Characters used in the above analysis and their phylogenetic significance are described below.

1. Dental plates: The character is absent in all four genera but present in the outgroup. This gives us no information regarding relationships among the genera.

2. Hinge plates: The character (ventrally

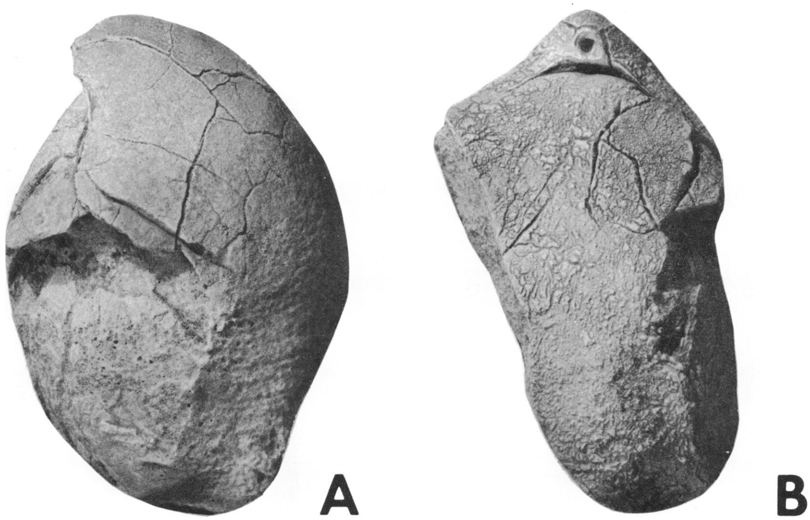

Fig. 4. *Goliathyris lewyi,* new species. A, B. Lateral, dorsal views, paratype GSI M7261b. ×1.

directed hinge plates) is found in the outgroup, *Dyscolia,* and *Goniobrochus* and thus represents a plesiomorphy at that level of analysis while its alternative character (concave hinge plates directed toward the brachial valve floor) represents a synapomorphy.

3. Cardinal process: The character is plesiomorphic in *Dyscolia* (found also in the outgroup) but synapomorphic in *Trigonithyris* and *Goliathyris.*

4. Ornamentation: The character (noncapillate radial ornamentation) is found in the outgroup, *Trigonithyris,* and *Goliathyris,* and thus represents a plesiomorphy at that level of analysis while its alternative character (zigzag capillae) represents a synapomorphy.

5. The loop: The character is found in *Dyscolia* and *Goniobrochus* and not in the outgroup, thus representing a synapomorphy uniting the two genera; it is unknown in *Trigonithyris* and *Goliathyris.* If a zeilleriid loop is eventually found in these genera it would represent a plesiomorphy.

One of the auxiliary criteria of phylogenetic apomorphy recognized by Hennig (1966) for distinguishing apomorphic from plesiomorphic characters is used in the character analysis discussed above. The criterion used here is that of geological character precedence which, according to Wiley (1981), rests on the rule that when one character is found entirely in the geologically older members of a monophyletic group while the alternative homology is found only in the geologically younger members of the same monophyletic group, then the older homolog is the plesiomorphic character. In accordance with the view that stratigraphic position not be considered as a priori evidence for character evaluation (e.g., Schaeffer et al., 1972), correlation between stratigraphic position and relative primitiveness is now being considered. The sister group *Trigonithyris-Goliathyris* is represented only by Jurassic forms (Muir-Wood, 1965; this paper) and its genera share noncapillate radial ornamentation (character 4, above) postulated as plesio-

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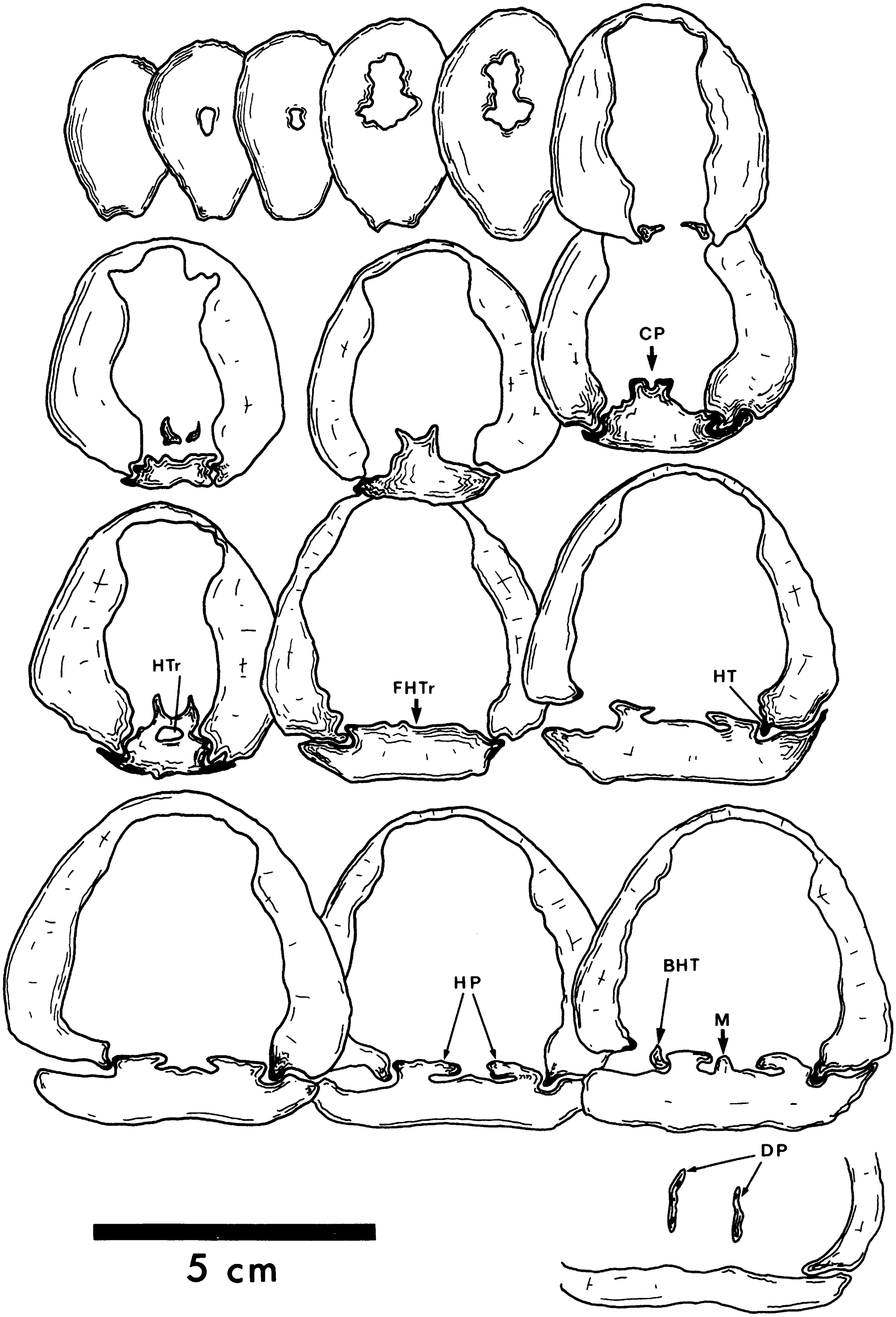
Fig. 5. Transverse serial sections of *Goliathyris lewyi,* new species. GSI M7261b. Due to the nature of the matrix it was impossible to accurately record distances of serial sections from beak. However, the distance from the last transverse serial section to the umbo is 38 mm. Abbreviations: BHT = broken hinge tooth; CP = cardinal process; DP = descending processes; FHTr = flattened hinge trough; HP =



hinge plates; HT = hinge tooth; HTr = hinge trough; M = myophragm (= euseptoidum). Note how hinge plates change from almost horizontal to slightly concavoconvex, thicken, and point toward the floor of the brachial valve.

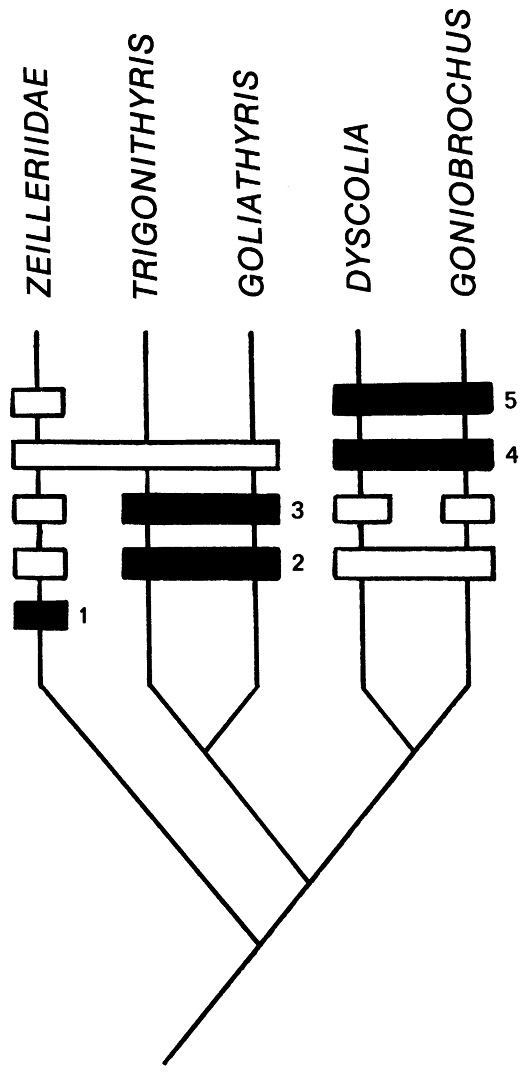


Fig. 6. A phylogenetic hypothesis of relationships among Jurassic, Pliocene, and Recent terabratulid brachiopods. See text for discussion. Filled boxes = apomorphic condition; empty boxes = plesiomorphic condition.

morphic since it is also found in the outgroup (Zeilleriidae). Zigzag capillae, found in the sister group *Dyscolia-Goniobrochus,* which ranges in age from Pliocene to Recent (Cooper, 1983), is a postulated synapomorphy, thus supporting the hypothesis that the alternative homology is the apomorphic character and is found entirely within the geologically younger members of a monophyletic group. However, upon examination of characters 2 and 3, it is evident that when applying the criterion of geological character precedence there is an incongruity in that the apomorphic homologies are found entirely within the geologically older group. Additional data will aid in resolving this problem.

ETYMOLOGY: Named after Goliath, the Philistine giant from Gath, slain by [King] David.

Goliathyris lewyi, new species

Figures 2–5

DIAGNOSIS: Only known species of the genus; same as for genus.

DESCRIPTION: The shell is extremely large (table 2, figs. 2–4), smooth, rostrate, nonstrophic, and broadly pentagonal when viewed dorsally. A small, circular pedicle foramen is present just posterior to a poorly defined beak ridge on the ventral umbo, resulting in a permesothyridid condition. The interarea is obscured by the incurved ventral umbo. A wide, moderately shallow, dorsal sulcus originating slightly anterior to the concealed dorsal umbo, widens and deepens anteriorly. Although much of the ventral exterior is poorly preserved, it is evident that a strong ventral fold opposed the dorsal sulcus. The height of the fold appears to have been significantly greater than the depth of the sulcus. The shell is concavoconvex with the ventral valve almost carinate when viewed posteriorly. The anterior commissure is not preserved but, based on shell morphology, a reconstruction seems to indicate that it is strongly sulcate. One lateral commissure is preserved, extending about two-thirds of the shell length and, although partially concealed by debris anteriorly, appears to be uniformly straight. The lateral slopes of the ventral valve are quite steep, while on the dorsal valve they flare out from the sulcus, rise dorsally, and descend at approximately a 90° angle to the lateral commissure.

Although radial ornament is absent on the smooth shell, there are some distinct, irregularly spaced growth lines on the anterior half of the specimens.

INTERNAL CHARACTERS: The following description has been obtained with great difficulty from a series of transverse serial sections (fig. 5) made through the umbonal region of a silicified specimen from the type locality at Gebel El-Minshera, northern Sinai.

TABLE 2

Measurements of *Goliathyris lewyi* Compared with Homeomorphic Species of *Aulacothyris* from the "European" and "Ethiopian" Faunal Provinces

(all measurements in millimeters)

Species	(L)	(W)	(T)	Locality	Faunal province	Age
Goliathyris lewyi, sp. nov.						
GSI M7261a	74.0*	61.2	49.5	Gebel El-Minshera	EP	JUR
GSI M7261b	72.6*	—	43.5	Gebel El-Minshera	EP	JUR
Aulacothyris jubaensis (Weir, 1929, pl. IV, fig. 15. XI)	21.9	19.8	10.2	Somaliland	EP	JUR
A. somaliensis (Stefanini, 1931, pl. VI, fig. 6. XI)	25.0	20.0	15.0	Somaliland	EP	JUR
A. resupinata						
USNM 88703	22.8	19.7	15.0	Morocco	EP	JUR
A. impressa						
AMNH 1514a	19.4	16.5	10.5	Bavaria	EUP	JUR
AMNH 1514b	15.2	13.5	8.3	Bavaria		
AMNH 1514c	16.0	14.8*	8.0	Bavaria	EUP	JUR
A. carinata						
AMNH 1509a	21.7	19.4	12.8	Bavaria	EUP	JUR
AMNH 1509b	19.7	17.1	11.1	Bavaria	EUP	JUR
AMNH 1509c	21.8	19.0	13.2	Bavaria	EUP	JUR
A. pala						
AMNH 1523a	16.6	12.1	10.0	Vils in the Tyrol	EUP	JUR
AMNH 1523b	19.7	12.9	11.5	Vils in the Tyrol	EUP	JUR
AMNH 1523c	16.9	12.0	9.5	Vils in the Tyrol	EUP	JUR
A. bernardina						
USNM 30949a	18.6	16.5	10.7	Villers-sur-mer, France	EUP	JUR
USNM 30949b	15.8	13.9	8.3	Villers-sur-mer, France	EUP	JUR
Aulacothyris sp.						
USNM 89083	21.5	16.3	11.2	England	EUP	JUR
A. blakei						
USNM 104730a	14.6	13.2	7.9	England	EUP	JUR
USNM 104730b	12.8	12.9	7.7	England	EUP	JUR
USNM 104730c	12.0	11.9	6.6	England	EUP	JUR
A. meriani						
USNM 66932a	27.8	19.1	13.8	England	EUP	JUR
USNM 66932b	21.7	16.3	12.7	England	EUP	JUR
A. gregalis						
AMNH 19303a	10.2	10.8	6.1	Sarajevo, Bosnia	EUP	TRI
AMNH 19303b	9.0	7.5	4.9	Sarajevo, Bosnia	EUP	TRI
AMNH 19303c	9.4	9.3	4.8	Sarajevo, Bosnia	EUP	TRI
A. angusta						
AMNH 1932a	7.0	6.4	4.0	Germany	EUP	TRI
AMNH 1932b	7.1	7.1	4.4	Germany	EUP	TRI

* Damaged.

TABLE 3
Data Used to Analyze the Phylogenetic Relationships of Four Genera of Terebratulid Brachiopods
Apomorphies are in italics.

Character	Outgroup (Zeilleriidae)	*Trigonithyris*	*Goliathyris*	*Dyscolia*	*Goniobrochus*
1. Dental plates	Present	Absent	Absent	Absent	Absent
2. Hinge plates	Ventrally directed	*Concave toward brachial valve floor*	*Concave toward brachial valve floor*	Ventrally directed	Ventrally directed
3. Cardinal process	Small	*Massive*	*Massive*	Small	Absent
4. Ornamentation	Noncapillate	Noncapillate	Noncapillate	*Zigzag capillae*	*Zigzag capillae*
5. Loop	Long	Unknown	Unknown	*Square*	*Square*

The umbonal cavity of the ventral valve is elongate-oval in transverse outline in the early stages and is partially filled with dense callous. The cavity gradually develops a more triangular outline, meeting and articulating early with the dorsal valve. A massive, bilobate cardinal process develops and persists until the strong, peglike hinge teeth are well inserted into the dorsal sockets. Horizontal, elongate hinge plates, showing little or no differentiation from the inner socket ridges, develop a ventrally convex transverse outline and are deflected dorsally.

No evidence was obtained of crural bases and all that remains of the obviously broken brachial loop is seen as two subparallel, inwardly curving descending processes (or possibly crural processes). Due to difficulty in sectioning and incompleteness of the shell, the last transverse serial section (fig. 5) was taken at 38 mm from the beak.

ETYMOLOGY: The species is named for Dr. Zeev Lewy, Paleontology Division, Geological Survey of Israel, Jerusalem, in recognition of his valuable contributions to the Mesozoic paleontology of the Middle East.

TYPES: The holoptype (GSI M7621a) and paratype (GSI M7621b) have been placed in repository in the paleontological collection of the Geological Survey of Israel, Jerusalem.

OCCURRENCE AND AGE: Upper Callovian, *Lamberticeras lamberti* Zone, Gebel El-Minshera, northern Sinai (latitude and longitude: 30°19′N, 33°43′E; Israel grid coordinates 9690/0219).

REMARKS: This genus internally resembles *Trigonithyris* described by Muir-Wood (1935: 131) from the ?Argovian of British Somaliland. At the time, she suggested that the genus *Trigonithyris* was allied to *Pygope* and *Pygites* but later (Muir-Wood, 1965: H807) assigned it to the family Dyscolliidae, giving its stratigraphic position as Upper Jurassic (?Oxfordian).

The transverse serial sections of the type species *Trigonithyris eruduwensis* given by Muir-Wood (1935: 132) were produced before the invention of the Croft serial grinding apparatus. Although poor by modern standards, her sections clearly indicate the well-developed cardinal process and the almost horizontal, ventrally convex, and extensive hinge plates which show little or no differentiation from the inner socket ridges—morphological characters which distinguish this genus from other terebratulid genera so far examined from the "Ethiopian" Faunal Province. *Goliathyris lewyi* has slightly concave to horizontal hinge plates (see fig. 5) which are very similar to *Trigonithyris eruduwensis* Muir-Wood. However, *G. lewyi* is sulcate while *T. eruduwensis* is rectimarginate with an erect beak and large pedicle foramen.

In *Goliathyris lewyi*, new species, the inner socket ridges appear to be more extensive and the cardinal process considerably more developed than is seen in the serial sections of Muir-Wood's genus. This may be due to the difference in relative size of the two specimens representing the species *G. lewyi* and *T. eruduwensis*. Muir-Wood's serial sections were from a small, adult form, whereas those of the very large *G. lewyi* specimen are of an old individual showing some evidence of gerontic thickening of the valves and cardinalia.

Although in its external morphology, especially its zeilleriid beak, *Goliathyris lewyi* is suggestive of some terebratulidae, such as *Rugitela impressa* (Von Buch) and *R. bernardina* (D'Orbigny), it differs from these species in its less lobate outline and deeper sulcus. *R. impressa* has marked mesothyridid beak ridges and a distinct median septum in the dorsal valve, both of which are absent in *G. lewyi*. *R. bernardina* (D'Orbigny) also differs in this way from *G. lewyi* and has shallower valves, an acuminate to subpyriform outline, and a shallower sulcus.

Weir (1929) described a new terebratulid species as *Aulacothyris jubaensis* Weir (which is also figured in Stefanini, 1931), from the Juba Limestone of Dakatch, Somaliland, ranging in age from Callovian to Corralian. Although assigned to the terebratellacean genus *Aulacothyris,* Weir's species *jubaensis* shows little of the generic characters associated with that genus apart from a similarity in general morphological outline, as is seen in the original description:

> Shell obovate-subpentagonal in outline, somewhat acuminate towards the anterior extremity, which is regularly rounded and not reentrant. In the region of greatest width, which is situated rather nearer to the posterior than to the anterior extremity of the shell, the lateral margins are subangular. Dorsal valve sulcate, the depression becoming more pronounced towards the anterior end; lateral surfaces of the dorsal valve convex, depressed to the level of the commissures. Ventral valve deep, the keel somewhat acutely rounded. Beak short, thick, closely pressed to the dorsal umbo, concealing the symphytium.

Weir (op. cit.) contended that this species was closely related to "*A. curvifrons*" a species which is currently assigned to the terebratulid genus *Pseudoglossothyris.* In general outline it has much in common with *Goliathyris lewyi,* new species, but differs from this species in its more acuminate anterior, having the dorsal valve more depressed toward the lateral margins and the pedicle foramen closer to the dorsal umbo concealing the symphytium. Also, its point of greatest width is near the posterior extremity and the lateral margin subangular.

DISCUSSION: Brachiopods from the "Ethiopian" Faunal Province are in need of study from both a taxonomic and paleobiogeographic point of view. Muir-Wood's (1934, 1935) studies on Middle Jurassic brachiopods, and especially those from the "Ethiopian" Faunal Province, need extensive revision before significant paleobiogeographic analysis can be undertaken. Evidence from East Africa suggests that there was a general faunal gradient in a north–south direction. In Callovian times the bivalve *Neocrassina unilateralis* was a southerly occurring species which was replaced northward by *Neocrassina scytalis.* These changes are believed to be partly temperature controlled and are supported by the occurrence of coral-*Diceras* deposits in the Middle Jurassic of Ethiopia but not further south.

The distribution of brachiopods follows these trends. An increased diversity of species occurs in the Callovian of Somaliland compared with beds of the same age from Tanzania while the brachiopods of Kutch, India, are somewhat intermediate in morphology. Further study of the Jurassic brachiopods of northern Sinai, East Africa, Madagascar, and India will aid in reconstructing the early history of the "Ethiopian" Faunal Province since the breakup of Gondwanaland. Since northern Sinai is situated at the tip of this province, the Sinai faunas are likely to include species belonging to the area within the equatorial Tethyan Realm which serves as a link between the European faunas and those of Afro-Indian origin.

REFERENCES CITED

Ager, Derek V.
1973. Mesozoic Brachiopoda. *In* A. Hallam (ed.), Atlas of paleobiogeography, pp. 413–436. Amsterdam: Elsevier.

Arkell, W. J.
1952. Jurassic ammonites from Jebel Tuwayq, central Arabia. Philos. Trans. R. Soc. London, ser. B, 236: 241–313.
1956. Jurassic geology of the world. Edinburgh and London: Oliver and Boyd, 806 pp.

Cooper, G. Arthur
1983. The Terebratulacea (Brachiopoda), Triassic to Recent: a study of the brachidia (loops). Smithson. Contrib. Paleobiol., 50: 1–445.

Hennig, Willi
1966. Phylogenetic systematics. Urbana: Univ. of Illinois Press, 263 pp.

Imlay, Ralph
1970. Some Jurassic ammonites from central Saudi Arabia. U.S. Geol. Surv. Profess. Pap. 643-D: D1–D17.
King, William
1850. A monograph of the Permian fossils of England. Palaeontogr. Soc., Mon., 3: 1–258.
Kitchin, F. L.
1912. Palaeontological work; England and Wales: Geol. Survey of Great Britain and Museum Pract. Geology, Mem., Summ. of Prog. for 1911: 59–60.
Muir-Wood, Helen M.
1934. On the internal structure of some Mesozoic Brachiopoda. Philos. Trans. R. Soc. London, ser. B, 223: 511–567.
1935. The Mesozoic palaeontology of British Somaliland. Pt. 7, Jurassic Brachiopoda, pp. 75–147, pls. 8–13. London: Government of the Somaliland Protectorate.
1965. Mesozoic and Cenozoic Terebratulidina. *In* R. C. Moore (ed.), Treatise on invertebrate paleontology part H, Brachiopoda, pp. H762–H816. Lawrence, Kans.: Geological Society of America and Univ. Kansas Press.
Schaeffer, B., M. K. Hecht, and N. Eldredge
1972. Paleontology and phylogeny. Evol. Biol., 6: 31–46.
Stefanini, Guiseppe
1931. Echinodermi, Vermi, Briozoi e Brachiopodi del Giuralias della Somalia. Palaeontographia Italica, 32: 81–141.
Weir, J.
1925. Brachiopoda, Lamellibranchiata, Gastropoda and Belemnites. *In* The collection of fossils and rocks from Somaliland made by Mssrs. B. K. N. Wyllie and W. R. Smellie, Monogr. Geol. Dept. Hunterian Mus., Glasgow Univ., 1(6): 79–110, pls. 11–14.
1929. Jurassic fossils from Jubaland, East Africa, collected by V. J. Glenday, and the Jurassic geology of Somaliland III. Monogr. Geol. Dept. Hunterian Mus., Glasgow Univ., 3: 63 pp., pls. 1–5.
Wiley, E. O.
1981. Phylogenetics: the theory and practice of phylogenetic systematics. New York: Wiley, 439 pp.