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BRACHIOPODS FROM THE MIDDLE TO UPPER JURASSIC STRATA OF GANGTA BET IN THE KACHCHH BASIN, WESTERN INDIA

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ABSTRACT

Gangta Bet, situated between the Wagad Uplift and Khadir Island in the Kachchh Basin, is composed of Callovian to Oxfordian fossiliferous sedimentary rocks, in which brachiopods are an important component, especially in a local marker horizon (the Brachiopod Bed). In total, six taxa are discussed here: *Bihendulirhynchia brevicostata*, *Kallirhynchia versabilis, Mycerosia rostellata*, *Somalithyris jhalarensis*, and two *Kutchithyris* species*, K. euryptycha* and *K. ingluviosa*. The genera *Mycerosia* and *Bihendulirhynchia* are new records from Kachchh and the occurring species have been previously known from the Middle to Upper Jurassic of Somalia, the Sinai Peninsula, Arabia, and the Northwest Frontier Province (Khyber Pakhtunkhwa) of Pakistan. *Somalithyris*, previously recorded from the Tithonian of Kachchh, is also present in the Callovian-Oxfordian Gangta member. This is the oldest record of the genus globally and the presence of the same species in Kachchh and Pakistan is also significant. These new descriptions from Kachchh are therefore of high palaeobiogeographic importance as they strengthen the existence of free faunal exchange between Kachchh, East Africa and Arabia during the Callovian-Oxfordian, and reveal a midway position of the North West Frontier Province of Pakistan.

Keywords: Brachiopod, Jurassic, Kachchh, Gangta Bet.

INTRODUCTION

Gangta Bet is a small islet located in the eastern part of the Kachchh Basin, western India (Fig. 1A, B). The sedimentary rocks forming the core of the island are Jurassic in age and partly very fossiliferous. Palaeontological research on Gangta Bet started already more than a century ago (Wynne, 1872; Waagen, 1873-1875), but due to its secluded position only little information on its geology emerged throughout the 20th century (Biswas, 1980). Recently, a series of articles has been published concentrating on its sedimentology (Patel and Joseph, 2012; Alberti *et al*., 2017), ammonites and biostratigraphy (Patel *et al*., 2012a; Pandey *et al.*, 2013; Kanjilal, 2014), gastropods (Alberti *et al.*, 2013), and trace fossils (Patel *et al*., 2012b). The taxonomic studies revealed a number of taxa previously unknown from the Kachchh Basin. It can therefore be assumed that a thorough review of the occurring fossil groups might be a rewarding task likely leading to the discovery of new species. Consequently, the present article concentrates on the taxonomic analyses of the brachiopods of Gangta Bet, which are in abundance and diversity only second to the molluscs. Furthermore, this study enables the establishment of the palaeobiogeographic affinities of this brachiopod fauna within a regional and global context.

GEOLOGICAL SETTING

The Jurassic outcrops of the Kachchh Basin can generally be divided into three regions (Fig. 1A): the so-called Kachchh Mainland, the Wagad Uplift, and the Island Belt. These uplifted areas are separated by the seasonally flooded salt marshes of the Great and Little Rann of Kachchh. The little islet Gangta Bet is situated between the Wagad Uplift and the Khadir Island. It has an almost circular outline with a diameter of approximately 5 km (Fig. 1C). Its most characteristic geological feature is a central uplift forming a prominent ridge and exposing the oldest strata. An east-west running fault cuts the southern limb of this central dome. A second, smaller domal structure can be found further south and exhibits younger strata (Fig. 1D).

The Jurassic succession of Gangta Bet belongs to the Gangta member of the Gadhada Formation (Biswas, 1980; Fürsich *et al*., 2001, 2013; Alberti *et al*., 2017). It is divided by several marker horizons, of which the so-called Brachiopod Bed in its lower part is the most conspicuous. This claret-coloured, oolitic wacke- to packstone is silty to sandy and highly fossiliferous containing brachiopods, bivalves, belemnites, and echinoderm fragments. It is well exposed on the northern flank of the central dome close to the temple and the ancient fort along the ridge of Gangta Bet (Fig. 1D), but can also be found on the southern flank of the central dome. Figure 2A illustrates a section measured through the Brachiopod Bed and the overlying strata. In Kachchh, the brachiopods are present right from the Bajocian to Oxfordian in considerable number as well as diversity and then are almost absent during the Kimmeridgian but reappearing briefly in Tithonian (Mukherjee, 2015). At the Gangta Bet, brachiopods are prolific at the base and also at the top, but are considerably fewer in numbers in the middle part of the succession.

Unfortunately, identifiable ammonites are very rare in the lower part of the succession (compare Pandey *et al*., 2013) and so far the age of the Brachiopod Bed could not be determined precisely. In contrast, the sedimentary rocks of the southern

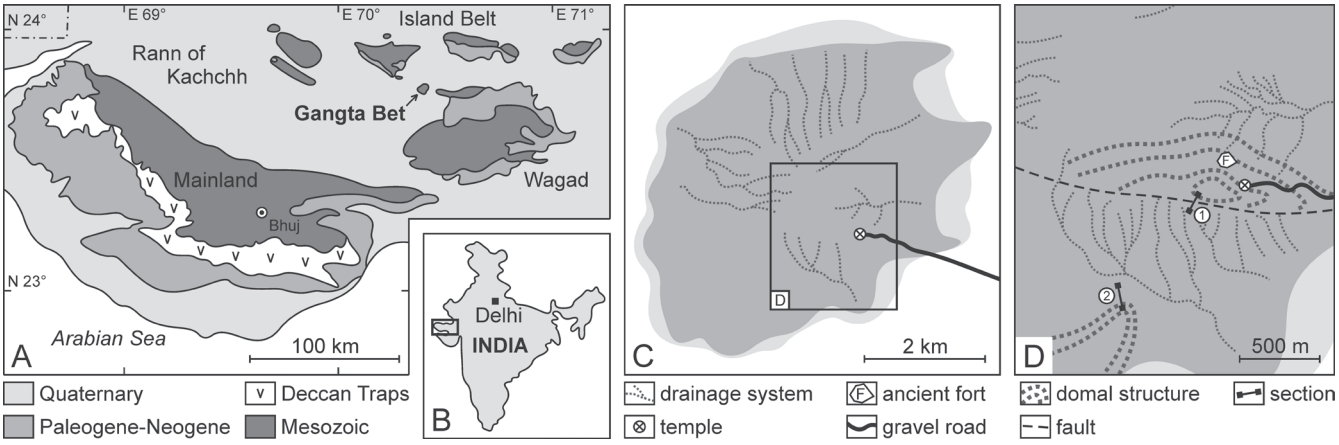

Fig. 1. Geographical and geological overview. A. Schematic geological map of the Kachchh Basin with the location of Gangta Bet (modified after Patel *et al*., 2012a; Fürsich *et al*., 2013). B. Location of the Kachchh Basin in western India. C. Overview map of Gangta Bet. D. Position of the measured sections at the central and southern dome of Gangta Bet.

dome (mostly coarse sandstones to coarse sandy limestones) contain abundant cephalopods and therefore have been named Gangta Ammonite Beds (Fig. 2B). They have been assigned to the Upper Oxfordian Bifurcatus Zone (Pandey *et al*., 2013).

MATERIAL AND METHODS

Field surveys of the Gangta Bet have been conducted in the winter months of 2011, 2013, and 2015. During these visits, detailed sections were measured and fossils were collected bed-by-bed. In total, 115 brachiopod specimens form the base of the present taxonomic study comprising six species. The specimens come mainly from the Brachiopod Bed as well as from several horizons in the Gangta Ammonite Beds (the levels are marked in the sections of Fig. 2). The specimens are kept at the Repository of the Palaeontology Laboratory, Geological Survey of India, Kolkata.

SYSTEMATIC PALAEONTOLOGY

Family **Zeilleridae** Allan, 1940
Subfamily **Zeillerinae** Allan, 1940
Genus ***Mycerosia*** Cooper, 1989
Type species: *M. amygdaliformis* Cooper, 1989

Mycerosia rostellata Kitchin, 1900
(Plate I, figs. 1-13; Fig. 3 A-E)

Zeilleria rostellata Kitchin, 1900, p. 42; pl. 9, figs 5-7.

Zeilleria (*Ornithella*) *coulsoni* Sahni, 1939, p. 6-7; pl. 1, figs 1, 9, 14; pl. 2, figs 1, 2, 5-10, 14, 15.

Zeilleria (*Ornithella*) *indica* Sahni, 1939, p. 9; pl. 1, fig. 8; pl. 2, figs 14, 15.

Lectotypes: GSI type numbers 6666 and 6668 from 'Dhosa Member, Kutch' of Kitchin's (1900) collection; 16629, 16630, 16618-16628 from '2 ¼ miles south-east of Pezu. Bannu district' of Sahni (1939) kept at Geological Survey of India (GSI) Repository.

Material: 12 specimens from two levels in the Gangta Ammonite Beds of the Gangta member, Gadhada formation on Gangta Bet (Fig. 2).

Description: Small, elliptical shells, with length always greater than width and elongated oval outline. Position of maximum width shifted to the posterior one-third of the adult shells and to about the middle in early ontogeny; position of maximum thickness also lies in the posterior one-third. Shell weakly biconvex, convexity of ventral valve much greater and dorsal valve almost flat. Shell surface smooth. Anterior commissure rectimarginate, slightly tapered; lateral commissure gently curved.

Dorsal valve flattened, slightly convex near the dorsal umbo and plane in the anterior part. Ventral valve is also most convex near the umbonal region and develops a blunt carina. No development of any fold or sulcus in both valves. Dorsal median septum, observed in some weathered specimens, extends for about one-third of the valve length. Beak small and narrow, weakly incurved; foramen small, circular. Beak ridges sharp, define a shallow pseudo-inter area. Deltidial plates broad and shallow. Short dental lamellae, central cavity of pedicle valve sub-quadrate in section and lateral cavities semi-circular; small teeth well inserted into sockets, hinge plates curved (concave); short septalium and well defined median septum.

Remarks: The genus was described by Cooper (1989) from the Tuwaiq Mountain Formation and Hanifa Formation of Saudi Arabia, ranging from the Callovian to the Kimmeridgian, but represented by a single species, the type *M. amygdaliformis*. The Gangta population is characterized by small, elliptical smooth shells having moderately convex ventral and nearly flat dorsal valves with a rectimarginate commissure, typical of *Mycerosia* (see Cooper, 1989). Kitchin (1900) described *Zeilleria rostellata* from the Dhosa Oolite member of Kachchh, but did not mention the locality. The specimens (GSI type numbers 6666, 6668) are

EXPLANATION OF PLATE I

Brachiopods from the Gangta member, Gadhada Formation, Gangta Bet. 1-13. ***Mycerosia rostellata*** (Kitchin, 1900), Ku/Ga/13/1/2 (1-4), Ku/Ga/13/1/3 (5-8), Ku/Ga/13/1/1 (9-13). 14-22. ***Bihendulirhynchia brevicostata*** (Kitchin, 1900), Ku/Ga/13/2/2 (14-17), Ku/Ga/13/2/1 (18-22). 23-28. ***Kallirhynchia versabilis*** (Kitchin, 1900), Ku/Ga/1/3/1 (23-27), Ku/Ga/1/3/3 (28). 29-36. ***Somalithyris jhalarensis*** (Muir-Wood, 1937), Ku/Ga/13/4/1 (29-32), Ku/Ga/13/4/2 (33-36). 37-40. ***Kutchithyris ingluviosa*** (Kitchin, 1900), Ku/Ga/13/5/2. 41-45. ***Kutchithyris euryptycha*** (Kitchin, 1900), Ku/Ga/13/6/1.

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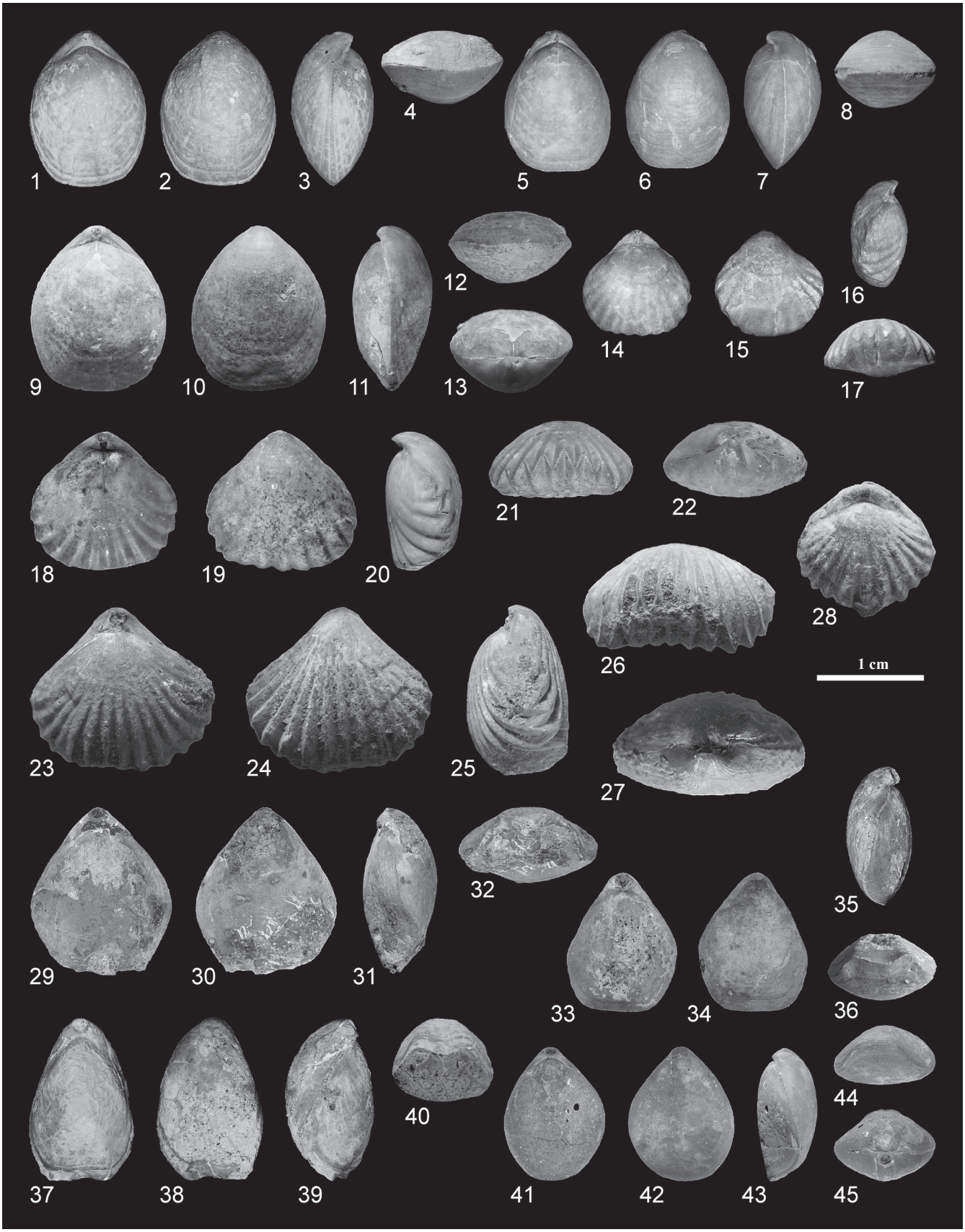
Plate I



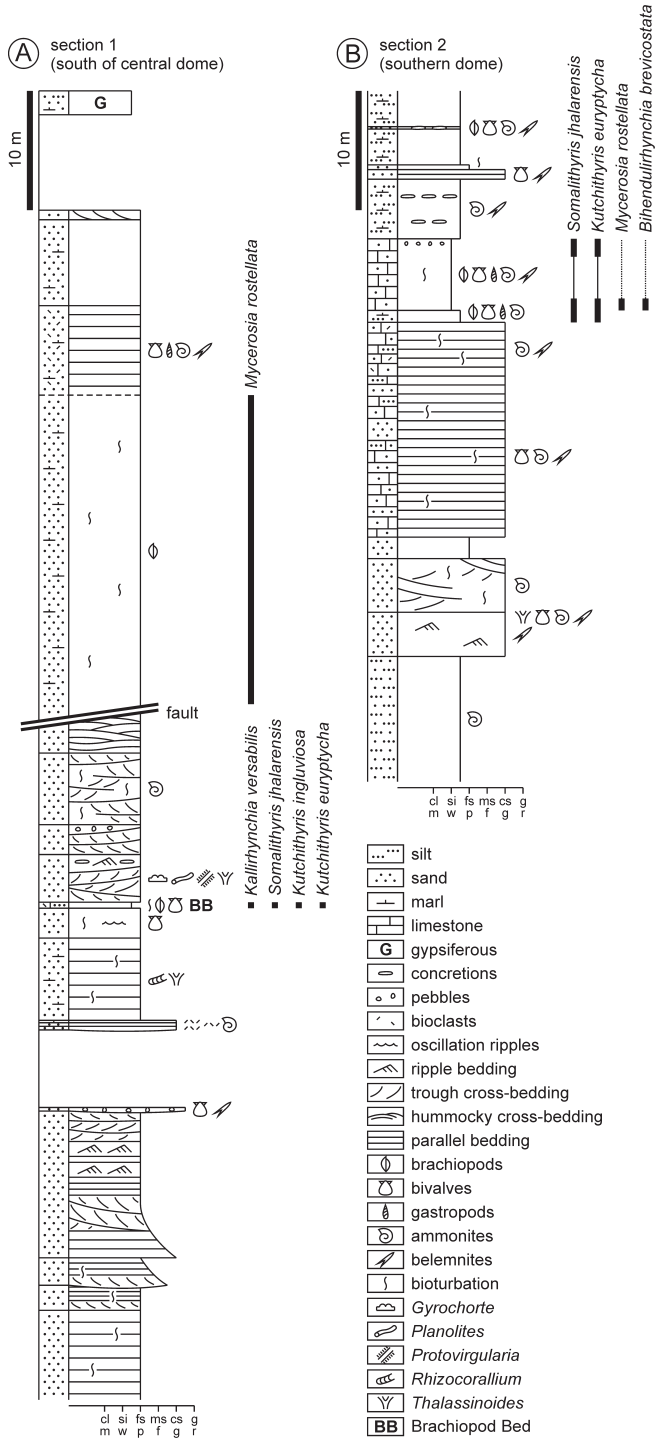


Fig. 2. Sections measured at the central and southern dome of Gangta Bet showing the stratigraphic levels from which the brachiopods described in the present study have been collected.

similar to the presently described material from Gangta Bet, as can be seen from the characteristic shape, convexity, umbonal characters, and length of dorsal median septum and presence of septalium (Plate 1; Fig.3A-E). Therefore, the species is being designated as *Mycerosia rostellata* (Kitchin). As the sectioned specimen show recrystallization, therefore the loop details are not known. The Kachchh species can be differentiated from the type by its less convex dorsal valve, which does not form the low dome in the lateral or anterior profile as can be seen in *M. amygdaliformis* (Cooper, 1989, pl. 32, figs 7-10). The type species has a characteristic 'almond shape' which can also be seen in *M. rostellata* which has a broadly elliptical shape. However, *M. rostellata* has shorter beak ridges than *M. amygdaliformis*. In addition to the record within the Kachchh Basin, *M. rostellata* is also present in the Jaisalmer Basin, where it can be found in the upper part of the Kuldhar Member (Upper Callovian), Jaisalmer Formation.

Muir-Wood (1935) described *Zeilleria latifrons* from Somalia, which has a similar shape, but is smaller and more rounded (Cooper, 1989). Weir (1938) recorded *Zeilleria subbucculenata* from the Upper Bajocian of Kenya and Douvillé (1916) described the same species from the Bathonian of the Sinai, Egypt. This species shows a considerable resemblance to *M. amygdaliformis*, but comes from older strata.

Sahni (1939) described Mesozoic brachiopods from the Bannu district, which today is part of the Northwest Frontier Province of Pakistan. In this article, Sahni (1939) recorded the species *Zeilleria* (*Ornithella*) *coulsoni* and *Z.* (*Ornithella*) *indica*. A detailed examination of the assemblage in the Geological Survey of India Central Repository (GSI type numbers 16620, 16625-27, 16630, 16635) reveal their affinity with *Mycerosia* (Sahni, 1939, pl. 2, figs 8, 9) as shown by their slender elongate shape and more inflated valves. The specimens are elongate-oval and have the characteristic almond shape with a short, incurved, sub-erect beak arising from a broad base exhibiting also beak ridges and are comparable with the Indian species *M. rostellata*. In one specimen (GSI type number 16620), the long median septum can also be seen (Sahni, 1939, fig. 1). The specimens are from Oxfordian to Kimmeridgian strata (Sahni, 1939), which is also comparable in age with the material from Arabia (Cooper, 1989) as well as with the presently described specimens from Gangta Bet. Therefore, the two species from Bannu district, *Zeilleria* (*Ornithella*) *coulsoni* and *Z.* (*Ornithella*) *indica* are being clubbed with *M. rostellata* from Gangta Bet.

Family **Rhynchonellidae** d'Órbigny, 1847
Genus ***Bihendulirhynchia*** Muir-Wood, 1935
Type species: ***B. afra*** Muir-Wood, 1935

Bihendulirhynchia brevicostata Kitchin, 1900
(Plate I, figs 14-22; Fig. 3 F, G)

Rhynchonella brevicostata Kitchin, 1900, p. 61; pl. 13, figs 1-5.

Rhynchonella brevicostata Kitchin, Muir-Wood, 1937, p. 17, pl. 1, fig. 5a-c.

Rhynchonelloidella brevicostata (Kitchin), Ghosh, 1967, p. 143; pl. 33, figs 1-11.

Lectotype: GSI type number 6709 collected from 'south west of Barasir', Kitchin's (1900) collection.

Material: 7 specimens from one level in the Gangta Ammonite Beds of the Gangta member, Gadhada Formation of Gangta Bet (Fig. 2).

Description: Small sized biconvex shell, circular, slightly flattened, length and width almost equal, but thickness much less. Position of the maximum width nearly the mid-length, and maximum thickness shifted anteriorly; ventral valve less convex than the dorsal one. Beak sharp, erect, foramen circular, beak ridges sub-angular defining narrow interareas. Lateral commissure straight with slight deflection ventrally, anterior commissure broadly uniplicate. Shell ornamented by thick, sub-angular costae restricted to anterior one-thirds.

The posterior part is characteristically smooth, costae numbering about 11-13 in both valves.

Internally, strong sub-parallel dental lamellae, teeth mallet-shaped, well inserted into sockets; sub-horizontal hinge plates, well separated from each other; calcarifer crura.

Remarks: The genus was described by Muir-Wood (1935) from the Lower Kimmeridgian of the Daghani area in Somalia, where it was represented by only one species: *Bihendulirhynchia afra*. Muir-Wood (1935) mentioned some similarity with *Rhynchonelloidella brevicostata* (Kitchin) in shell morphology, but did not include the species into the new genus. The present material comes from the Upper Oxfordian of Gangta Bet, but additional specimens belonging to the same species have been found in the Upper Callovian to Oxfordian sediments of localities within the Kachchh and Jaisalmer basins. The fossils are therefore older than *B. afra* from the Kimmeridgian of Somalia. Apart from the presently described records from the Gangta member, the species also occurs in the Dhosa Oolite member of the Chari Formation in Kachchh Mainland and also in the middle part of the Kuldhar Member (Callovian) and the Jajiya Member (Oxfordian) of the Jaisalmer Formation in the Jaisalmer Basin. The Indian population can be differentiated from *B. afra* by the subdued ridge and sinus as well as the sharper and shorter beak. The present species also does not show the posterior sinus, mentioned by Muir-Wood (1935) for *B. afra*.

Rhynchonella brevicostata Kitchin was placed in *Rhynchonelloidea* by Buckman (1918), but Ghosh (1967) placed it in *Rhynchonelloidella* and described the species from Upper Callovian to Oxfordian rocks of the Jumara Dome, western Kachchh Mainland. However, the species is presently assigned to *Bihendulirhynchia* due to the occurrence of two diagnostic features: the posterior smooth stage and the lower number of costae. These costae are coarse and generally 10 to 12 in number in the present specimens, while members of *Rhynchonelloidella* are characterized by numerous fine costae (Manceñido *et al*., 2002). In addition, *Bihendulirhynchia* has a smaller size, an uniplication with a very low fold, and a short as well as low dorsal median septum. *Rhynchonelloidella* in contrast has a strongly uniplicate anterior margin and also a well developed dorsal median septum, which is not present in the Kachchh and Jaisalmer specimens. Serial sections of *Rhynchonelloidella brevicostata* were studied by Ghosh (1967, pl. 31), which reveal divergent dental lamellae and a short median septum and a short calcarifer crura; the serial sections of *Bihendulirhynchia* (Muir-Wood, 1935, fig. 10) also reveal a short dorsal median septum, shallow septalium and calcarifer crura shaped as blades (Manceñido *et al*., 2002)

Rhynchonelloidella is mainly a Boreal and Tethyan taxon ranging from the Toarcian to the Callovian and its presence in the Oxfordian is doubtful (Owen and Manceñido, 2002). In contrast, *Bihendulirhynchia* is an Ethiopian taxon, previously recorded from the Bathonian to the Callovian and the Kimmeridgian. The genus was first described from Kimmeridgian strata of Somalia by Muir-Wood (1935), but it has been suspected to occur also in East Africa, Iran, China, and India (Ager, 1986; Manceñido *et al*., 2002).

Family **Tetrarhynchiidae** Ager, 1965
Subfamily **Kallirhynchiinae** Manceñido and Owen, 2002
Genus ***Kallirhynchia*** Buckman, 1917
Type species: *K. yaxleyensis* Davidson, 1878

Kallirhynchia versabilis Kitchin, 1900
(Pl. I, figs. 23-28)

Rhynchonella versabilis Kitchin, 1900, p. 66; pl. 14, figs 4-9.

Kallirhynchia versabilis (Kitchin), Buckman, 1918, p. 224.

Kallirhynchia versabilis (Kitchin), Ghosh, 1967, p. 77; pl. 7, figs 1-8; pl. 8, figs 1-5.

Material: 13 specimens from the Brachiopod Bed of the Gangta member, Gadhada Formation of Gangta Bet (Fig. 2).

Description: Small to medium in size, sub-pentagonal outline, valves slightly inflated, dorsi-biconvex, position of maximum width anterior to midlength and position of maximum thickness is shifted towards the posterior end. Anterior commissure with a broad, shallow plica and lateral commissure curved. Fold and sulcus develop in the dorsal and ventral valve respectively, just after mid-valve, but their strength is low. Costae strong, and sharp , 15 to 16 on each valve, 5 to 6 in fold/sulcus. Beak sharp and broad, sub-erect; foramen circular, mesothyridid, beak ridges sharp, ventral interarea shallow, dorsal interarea concealed. Strong, divergent dental plates, dorsal median septum long.

Remarks: *K. versabilis* (Kitchin) is known from the Jumara, Keera, and Nara domes of the Kachchh Mainland (Ghosh, 1967, 1990; D.M. pers. observ.), and the present specimens from Gangta Bet are very similar. Ghosh (1967, 1990), described the species on the basis of biometric growth studies of Kitchin's (1900) material, external morphology and serial sections (Ghosh, 1969, pl.vi - viii). Comparison of Kitchin's types (GSI type 6719, 6723; Kitchin, 1900 pl. XIV, figs. 4-9) with the present material from Gangta Bet show a strong similarity. Kitchin (1900) originally described the species from the 'Upper beds of Charee Group' at Dhosa village and in the neighbourhood of Wanda. But he was not certain of the exact horizon of the collection. Ghosh (1967) described the species from the 'Upper Middle Macrocephalus and Upper Macrocephalus zones' of Jumara and Nara. The species is present in the so-called Ridge Sandstone unit and the Bored Pebble Conglomerate unit in Jumara. This distribution points to a Callovian age of the species in the Mainland. *K. yaxleyensis* (Davidson), the type species, is similar to *K. versabilis* in shape, valve convexity, and commissure, but can be distinguished by the presence of sub-mesothyrid beak-ridges and symmetric as well as asymmetric specimens. Furthermore, the European species is older, occurring in the Bajocian and Bathonian (Manceñido *et al*., 2002).

Kallirhynchia is a genus of Middle Jurassic rhynchonellids ranging from the Bajocian to the Callovian. *K. versabilis* is comparatively common in the Callovian of the Kachchh Mainland, therefore it might indicate a Callovian age for the Brachiopod Bed of Gangta Bet, which so far has not yielded other time-indicative fossils.

Family **Terebratulidae** Gray, 1840
Subfamily **Terebratulinae** Gray, 1840
Genus ***Somalithyris*** Muir-Wood, 1935
Type species: *S. macfadyeni* Muir-Wood, 1935

Somalithyris jhalarensis Muir-Wood, 1937
(Pl. I, figs. 29-36)

Terebratula jhalarensis Muir-Wood, 1937, p. 18; pl. 1, fig. 25.

Terebratula banuensis Sahni, 1939, p. 13; pl. 1, figs 12, 13.

Lectotype: GSI type number 16626, from the Attock district,

now in Pakistan (Muir-Wood, 1937).

Material: 39 specimens; 7 specimens from the Brachiopod Bed and 32 specimens from three levels in the Gangta Ammonite Beds of the Gangta member, Gadhada formation on Gangta Bet (Fig. 2).

Description: Medium-sized shells with elliptical to oval outline having position of maximum width at the middle or slightly anterior to it. Weakly biconvex with convexity of dorsal valve low. Dorsal valve slightly domal at the middle with the sides gently sloping down. Low fold developed in the anterior third. Lateral commissure rounded and anterior commissure gently biplicate. Median region of ventral valve slightly swollen, extending to the anterior and having a moderately developed linguiform extension. Umbo small, beak short, suberect, foramen circular, medium in size.

Remarks: The present specimens of *Somalithyris* have the characteristic elliptical, weakly biconvex shells with a gently biplicate anterior margin and a small, suberect beak with a circular foramen. These features readily distinguish them from the more common and co-occurring species of *Kutchithyris*, i.e. *K. euryptycha* and *K. ingluviosa*.

Somalithyris was described from the Jurassic of Somalia with the two species *S. macfadyeni* and *S. bihendulensis* (Muir-Wood, 1935). These species are both characterized by biconvex shells throughout their ontogeny, which are circular to oval and elongate in outline and have an anterior commissure which is dorsally uniplicate becoming sulciplicate. Their umbo is short, the foramen is small and angular. The geological interval was questionably mentioned as Divesian to Argovian, because the material was purchased from the neighbourhood of Bihendula (Muir-Wood, 1935). Muir-Wood (1937) described *Terebratula jhalarensis* from the 'Argovian' of the Attock district which has a striking resemblance with the presently described species of *Somalithyris* from Gangta Bet. The study of the specimens kept at the GSI Repository (GSI type number 16326) revealed the typical oval, weakly biconvex, weakly plicate form, an almost plane dorsal valve and a ventral valve with a short, broad linguiform extension as well as a short, suberect beak with a large, circular foramen. These features characterize the genus *Somalithyris* and the material has therefore been placed in this taxon. *Terebratula banuensis* (Sahni) described from the Bannu area by Sahni (1939), presently in the Northwest Frontier Province, Pakistan, is also characterized by a rounded, sub-pentagonal shape and an almost flat dorsal valve with rectimarginate anterior commissure (GSI type numbers 16638, 16639). Therefore this taxon is also included into the synonymy of *Somalithyris jhalarensis*. Thus, the species *S. jhalarensis* from the Callovian and Oxfordian of India seems to be the oldest member in the *Somalithyris* clade and also shares the following synapomorphies with *Kutchithyris*: elliptical outline, biplicate anterior commissure

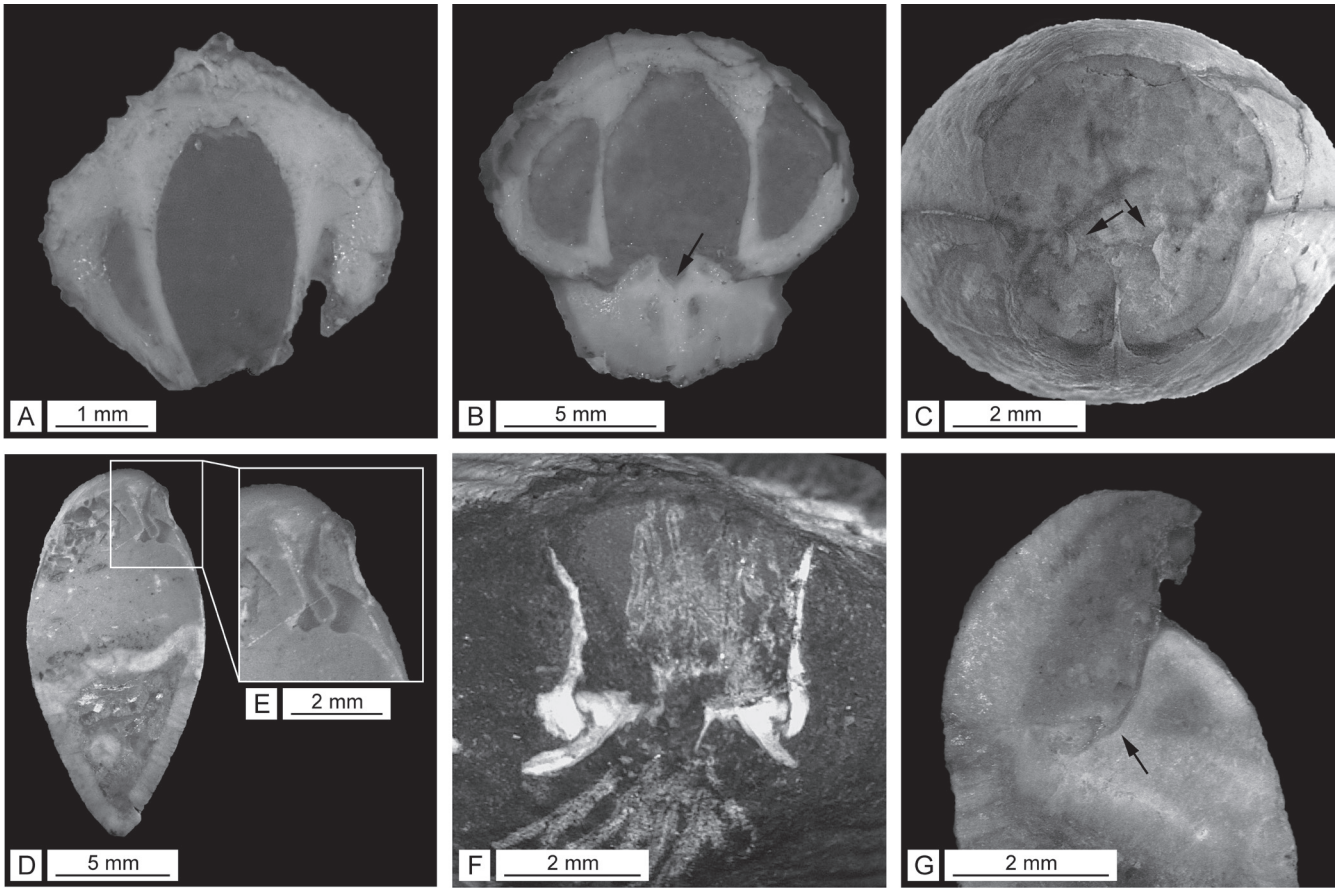


Fig. 3. Microphotographs of transverse and longitudinal sections from ***Mycerosia rostellata*** (Kitchin) (A-E) and ***Bihendulirhynchia brevicostata*** (Kitchin) (F-G). A and B. Transverse sections upto 1.0 mm from the apex, showing the pedicle chambers (A) and septalium (marked by arrow in B). C. Section at 4.0 mm from the apex, showing the median septum and development of calcarifer crura (shown by arrow). D - E. Longitudinal section showing teeth and socket, specimen is recrystallized in the anterior half. F. Section showing curved hinge plates and development of crural base. G. Longitudinal section showing development of the calcarifer crura (shown by arrow).

and plano-convex juvenile stage. Comparison of the interior of the type species *S. macfadyeni* from serial sections (Muir Wood, 1935, fig. 22) and *T. jhalarensis* (Muir Wood, 1937, fig. 3) reveal interesting similarities like a short bilobed cardinal process and hinge plates not well demarcated from inner socket ridges but the hinge plates are more strongly curved in the latter. From the external and internal comparable morphological characters it seems the species belong to *Somalithyris*.

Cooper (1989) described six new species of *Somalithyris* from the Kimmeridgian Hanifa Formation of Saudi Arabia: *S. elliptica, S. ovata, S. parva, S. rotundata, S. subcircularis*, and *S. triangulata*. But the study of the taxa from Cooper (1989) revealed that the species diversity may be less and some of the 'species' may be intraspecific variants. In fact, Cooper (1989) also cited the size as the main reason to separate the species and it seems likely that some of the taxa in fact represent different ontogenetic stages of one species (Cooper, 1989, pl. 28, figs 20-42; pl. 29, figs 1-4). This assumption is supported by the fact that all taxa have been found in the same formation and even co-occur at the same locations (KK 10-25; Cooper, 1989, Appendix 1, 2). *S. triangulata* is characterized by a subtriangular to subpentagonal shell outline, in contrast to the typical subcircular to semi-elliptical outline in *Somalithyris*. Furthermore, it also shows narrowly rounded anterolateral extremities and strongly convex valves with the maximum width shifted anteriorly, which is always in the middle in *Somalithyris*. This species therefore does not appear to belong to the genus *Somalithyris*.

S. subcircularis was also recorded in the Callovian Echellon Limestone Member of the Kamar-e-Mehdi Formation of Iran (Mukherjee & Fürsich, 2014). These specimens resemble their Arabian counterparts in overall shell morphology and shape. Their occurrence is significant considering the migration pathway of the species establishing some Ethiopian link of the Iran brachiopod fauna in the Jurassic.

The presence of the genus in the Callovian to Upper Oxfordian Gangta member is important, because *Somalithyris* has also been recorded from the Tithonian of the Kachchh and Jaisalmer basins (Mukherjee, 2009), but in the form of a different species, endemic to western India.

Family **Postepithyrididae** Tchorszhevsky, 1974
Genus ***Kutchithyris*** Buckman, 1918
Type species: *K. acutiplicata* Kitchin, 1900

Kutchithyris ingluviosa Kitchin, 1900
(Pl. I, figs. 37-40)

Material: 12 specimens (four complete, eight as single valves); from the Brachiopod Bed of the Gangta member, Gadhada Formation of Gangta Bet (Fig. 2).

Description: Medium sized, strongly biconvex, elongated shell with roughly triangular outline; position of maximum width is in the anterior one-third and position of maximum thickness at the mid-length. Lateral commissure is gently curved at the beginning but takes a sharp bend near the anterior margin; anterior commissure strongly biplicate. Dorsal valve characterized by two short folds separated by a short, deep median sinus.Beak narrow, thick and rounded, foramen circular, large.

Remarks: *Kutchithyris ingluviosa* is very common from the Middle Callovian to the Oxfordian within the Chari Formation of the Kachchh Mainland, particularly in the Jhura, Keera, Jumara, and Jara domes (Mukherjee, 2007). The present twelve specimens are all from the Brachiopod Bed and the taxa have not been recorded in the younger units. The specimens from Gangta Bet are similar to those of the Mainland in having the characteristic, triangular, weakly inflated shells with a sharply biplicate anterior commissure, but are slightly smaller (maximum length: 3.3 cm, maximum width: 2.3 cm, maximum thickness: 1.7 cm).

Kutchithyris euryptycha Kitchin, 1900
(Pl. I, figs. 41-45)

Material: 28specimens; from the Gangta Ammonite Bed and 2 broken valves from the Brachiopod Bed of the Gangta member, Gadhada Formation of Gangta Bet (Fig. 2).

Description: Small to medium sized, sub- elliptical, dorsibiconvex shells, with a characteristic marked longitudinal arching of the dorsal valve that forms a linguiform extension of the anterior commissure.

Remarks: *Kutchithyris euryptycha* has a long stratigraphic range in the Kachchh Mainland, occurring from the Upper Bathonian to the Oxfordian. The species has also been recorded from Madagascar, the Salt Range, and the Pamir (Mukherjee et al., 2003). It is characterized by a typical sub-pentagonal to elliptical shape with a prominent linguiform extension. It is most abundant in the Habo, Jhura, Keera, Jumara, and Jara domes and especially prolific in the Oxfordian Dhosa Oolite member. In Gangta Bet, *K. euryptycha* is common in the Gangta Ammonite Beds of the Gangta member, but more rarely the species occurs further below, in the Brachiopod Bed.

PALAEOGEOGRAPHICAL CONSIDERATIONS

The significance of the Gangta Bet brachiopod assemblage lies in the record of some palaebiogeographically important taxa in Kachchh during the Callovian-Oxfordian which have an impact on our understanding of the evolution of the Indo-Madagascan and Ethiopian brachiopods during the Jurassic. The terebratulid genus *Somalithyris* makes its first appearance in Kachchh and is present in the (possibly) Callovian Brachiopod Bed of the Gangta member as *S. jhalarensis*. *Somalithyris* was previously described from the Oxfordian to Kimmeridgian of Somalia by Muir-Wood (1935) and from the Kimmeridgian of Saudi Arabia by Cooper (1989). It has some similarities with *Kutchithyris* in its shell shape, its anterior commissure, as well as in the length of the loop and is likely to have originated from this genus. The genus has also been recorded in the Tithonian of Kachchh and Jaisalmer basins but as a new species (Mukherjee and Shome, 2017). The present find of *S. jhalarensis* is significant because it is the oldest record of the genus and also its presence along with the two *Kutchithyris* species, *K. ingluviosa* and *K. euryptycha*, strengthens its evolution from *Kutchithyris*.

The presence of *Bihendulirhynchia* in the Kachchh and Jaisalmer basins as revealed in this study is very significant from a palaeobiogeographic viewpoint. Specimens previously described from the Kachchh Mainland as *Rhynchonelloidella brevicostata* have now been assigned to *Bihendulirhynchia brevicostata*, because of the morphological characters (posterior smooth stage and the presence of a low number of coarse costae) but the biogeographic distribution of the two genera also adds relevance to the assignment. The rhynchonellid *Bihendulirhynchia* was previously described from the Oxfordian to Kimmeridgian of Somalia (Muir-Wood, 1935). The genus exhibits an Ethiopian affinity (Owen and Manceñido, 2002) and was not recognized from India before. The palaeobiogeographic distribution of

Rhynchonelloidella shows that it is mainly a Boreal and Tethyan taxon, present during the Toarcian to Callovian. Its presence in the Oxfordian is doubtful. *Bihendulirhynchia*, in contrast, is an Ethiopian taxon known from the Middle and Upper Jurassic (Owen and Manceñido, 2002). In fact, already Ager (1986) wrote on the probability of the presence of *Bihendulirhynchia* in Kachchh.

The genus *Mycerosia* exhibits a characteristic almond shape and was yet unrecorded from India. This zeilleriid was previously known only from Saudi Arabia, Somalia, the Sinai in Egypt, the Bannu, and the Attock district of the Northwest Frontier Province of Pakistan.

The current study thus reveals major similarities between the brachiopods of Gangta Bet and Pakistan as well as East Africa, which is significant for the brachiopod biogeography of the region.

CONCLUSIONS

The present study shows that the brachiopod diversity differs between the Kachchh Mainland and Gangta Bet. Though brachiopods are not as dominant or diverse as the ammonoids in the Jurassic succession of Gangta Bet, their study revealed a number of salient features, particularly in comparison to the brachiopod fauna of the Kachchh Mainland. Two genera, which were previously not known from the region, have been recorded in the Gangta member: *Mycerosia* and *Bihendulirhynchia*. *Somalithyris* was previously known only from Tithonian sediments and its occurrence in the Callovian-Oxfordian strata of the islet is the oldest record of the genus so far. *Kutchithyris* is the dominant genus in the Bathonian to Oxfordian rocks of the Kachchh Mainland with five species in the Oxfordian Dhosa Oolite member alone. In contrast, only two of these species have been recorded on Gangta Bet: *K. euryptycha* and *K. ingluviosa*. Both species are present in large numbers in the Jhura, Keera, Jumara, and Jara domes with *K. euryptycha* having a particularly long range spanning the Late Bathonian to Oxfordian, while *K. ingluviosa* is present from the Middle Callovian until the Oxfordian. Another recorded brachiopod is *Kallirhynchia versabilis*, which is restricted to the Bathonian to Callovian in other parts of the Kachchh Mainland (e.g., Jhura and Jumara domes). Its presence in the so-called Brachiopod Bed of the Gangta member might indicate a Callovian age of the unit.

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REFERENCES

Ager, D. V. 1986. Migrating fossils, moving plates and an expanding earth. *Modern Geology*, **10**: 377-390.

Alberti, M., Nützel, A., Fürsich, F. T. and Pandey, D. K. 2013. Oxfordian (Late Jurassic) gastropods from the Kachchh Basin, western India. *Neues Jahrbuch für Geologie und Paläontologie,* **270**: 275-300.

Alberti, M., Fürsich, F. T., Pandey, D. K. and Mukherjee, D. 2017. Overview on the Middle to Upper Jurassic succession of Gangta Bet in the Kachchh Basin, western India, with special emphasis on its lithostratigraphy, biostratigraphy, and palaeoenvironment. *Journal of the Geological Society of India*, **89**: 259-270.

Biswas, S. K. 1980. Mesozoic rock-stratigraphy of Kutch, Gujarat. *Quarterly Journal of the Geological, Mineralogical and Metallurgical Society of India,* **49**: 1-51 (for 1977).

Buckman, S. S. 1918. The Brachiopoda of the Namayu Beds, Northern Shan States, Burma. *Palaeontologia Indica, New Series,* **3**(2): 1-299.

Cooper, G. A. 1989. Jurassic brachiopods of Saudi Arabia. *Smithsonian Contribution to Palaeobiology,* **65**: 1-212.

Douvillé, H. 1916. Les terrains secondaires dans le Massif de Moghara à l'est de l'Ishme Suez. *Mémoire de l'Académie de Science de Paris*, series 2, **54**: 1-184.

Fürsich, F. T., Alberti, M. and Pandey, D.K. 2013. Stratigraphy and palaeoenvironments of the Jurassic rocks of Kachchh - Field Guide. *Beringeria, Special Issue*, **7**: 1-174.

Fürsich, F. T., Pandey, D. K., Callomon, J. H., Jaitly, A. K. and Singh, I.B. 2001. Marker beds in the Jurassic of the Kachchh Basin, western India: their depositional environment and sequence-stratigraphic significance. *Journal of the Palaeontological Society of India*, **46**: 173-198.

Ghosh, D. N. 1967. The Jurassic Rhynchonellidae from Jumara, Nara and Keera domes, Kachchh, western India. *Unpublished Ph.D. thesis, Jadavpur University, Kolkata*.

Ghosh, D. N. 1990. Biometry of two species of *Kallirhynchia* (Buckman) from Callovian beds of Kachchh, India, p. 97-100. In: *Brachiopods through Time* (Eds. MacKinnon, D.L., Lee, D.E. and Campbell, J.D.), Proceedings of the 2nd International Brachiopod Congress, New Zealand.

Kanjilal, S. 2014. Revisiting the proposed ammonite zonation of Jurassic rocks of Gangta Bet, Wagad, eastern Kachchh. *Journal of the Palaeontological Society of India*, **59**: 103-107.

Kitchin, F. L. 1900. Jurassic fauna of Cutch. *Palaeontologia Indica*, **3**, Part1: 1-87, 13pl.

Manceñido, M., Owen, E., Dong-Li, S. and Dagys, A. S. 2002. 'Hemithiriroidea' in the Revised Treatise on Invertebrate Palaeontology, Part H, vol. 4, (Ed. R. L. Kaesler *et al*.). p. 1326-1369.

Muir-Wood, H. M. 1935. Jurassic Brachiopoda, p.75-147. In: *The Mesozoic Palaeontology of British Somaliland* (Ed. MacFadyen, W.A.), Government of the Somaliland Protectorate.

Muir-Wood, H. M. 1937. The Mesozoic Brachiopoda of the Attock district. *Palaeontologia Indica Geological Survey of India*, **20**, Memoir 6: 1-34.

Mukherjee, D. 2007. A taxonomic and phylogenetic study of *Kutchithyris*– a Jurassic terebratulide from Kachchh India. *Journal of Asian Earth Sciences*, **30**: 213-237.

Mukherjee, D. 2009. Taxonomy, succession and biogeography of Middle – Upper Jurassic brachiopods of Jaisalmer. Unpublished G.S.I Report of F.S. 2005-2007, Geological Survey of India.

Mukherjee, D. 2015. Diversity dynamics of Jurassic brachiopod fauna of Kachchh and Jaisalmer basins, India. *Journal of the Palaeontological Society of India*, **60** (2): 1-9.

Mukherjee, D. and Fürsich, F. T. 2014. The Jurassic brachiopods of Iran. *Beringeria*, **44**: 107-127.

Mukherjee, D. and Shome, S. 2017. Tithonian brachiopods from the Kachchh and Jaisalmer basin, India. Neues Jahrbuch für Geologie und Paläontologie, **285**: 187-199.

Mukherjee, D., Bardhan, S., Datta, K. and Ghosh, D.N. 2003. The terebratulid *Kutchithyris* (Brachiopoda) from the Jurassic sequence of Kachchh, western India-revisited. *Palaeontological Research*, **7**: 111-128.

Owen, E. and Manceñido, M. 2002. 'Rhynchonelloidea' in the Revised Treatise on Invertebrate Palaeontology, Part H, vol. 4 (Eds. *Kaesler et al*.), p. 1279-1369.

Pandey, D. K., Alberti, M. and Fürsich, F. T. 2013. Ammonites from the Oxfordian (Bifurcatus Zone) strata of Gangta Bet, Kachchh, western India. *Journal of the Palaeontological Society of India,* **58**: 139-174.

Patel, S. J. and Joseph, J. K. 2012. Deepening upward sequence of Callovian-Oxfordian Gangta bet, Wagad, Eastern Kachchh, India. *Annual International Conference on Geological and Earth Sciences* (GEOS 2012): 13-18.

Patel, S. J., Joshi, P. N. and Joseph, J. K. 2012a. Ammonite zonation of the Jurassic rocks of the Gangta Bet area, Wagad region, Eastern Kachchh, India. *Journal of the Palaeontological Society of India,* **57**: 129-133.

Patel, S. J., Nenuji, V. and Joseph, J. K. 2012b. Trace fossils from the Jurassic rocks of Gangta Bet, Eastern Kachchh, western India. *Journal of the Palaeontological Society of India,* **57**: 59-73.

Sahni, M. R. 1939. The Mesozoic brachiopoda of the Bannu district. *Palaeontologia Indica,* New Series, **27**: 1-23.

Waagen, W. 1873-1875. Jurassic fauna of Cutch. The Cephalopoda. Memoirs of the Geological Survey of India, *Palaeontologia Indica, Series* 9, **1**: 1-247.

Weir, J. 1938. The Jurassic Faunas of Kenya, with description of some Brachiopods and Mollusca. *Monograph of the Geological Department of the Hunterian Museum, Glasgow University*, **3**: 1-63, pl. 1-5.

Wynne, A. B. 1872. Memoir of the geology of Kutch to accompany the map compiled by A.B. Wynne and F. Fedden during the seasons of 1867-68 and 1868-69. *Memoirs of the Geological Survey of India*, **9**: 1-293.

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