



COMMENTS ON THE MIDDLE JURASSIC PHOLADOMYIDS OF KACHCHH, WESTERN INDIA

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ABSTRACT

The pholadomyoids (Anomalodesmata:Bivalvia) in Kachchh is represented by the genera *Pholadomya*, *Pholadomya (Bucardiomya)*, *Pholadomya (Indomya)*, *Agrawalimya*, *Homomya*, *Pachymya*, *Pachymya (Arcomya)*, *Ceratomya*, *Ceratomyopsis*, *Gerardotia*, *Goniomya*, *Machomya*, *Osteomya*, *Pleuromya*, *Platymoidea* and *Thracia*. All of these pholadomyoids have been earlier recorded from the Middle Jurassic (Bathonian-Callovian) sediments of the different parts of Kachchh Mainland as well "islands". The genus *Agrawalimya* and the subgenus *Indomya* are endemic, while others are cosmopolitan in distribution and common elements of the Ethiopian Faunal Province. The pholadomyoids have been reviewed comprehensively and accordingly, the diagnostic morphological characters of some of these genera/ species have been emended.

Keywords: Mollusca, Bivalvia, pholadomyoids, Middle Jurassic, Kachchh

INTRODUCTION

The classic works of earlier investigators, since the beginning of the twentieth century, have already revealed the prolificacy of the Jurassic bivalves in the Kachchh Basin. The first detailed taxonomic account of the Jurassic bivalves of Kachchh has been endeavoured by Kitchin (1903) on trioniids (palaeoheterodonts), followed by comprehensive portrayal by Cox (1940,1952) on palaeotaxodonts, pteriomorphs, isofilibranchs, and palaeoheterodonts; Jaitly *et al.* (1995) on palaeotaxodonts, isofilibranchs and pteriomorphs and Fursich *et al.* (2000) on heterodonts. However, pholadomyoid bivalves received scant attention in spite of their plentiful occurrence in Kachchh. Pandey *et al.* (1996) recorded 23 pholadomyoid taxa belonging to 13 genera. Earlier, Singh *et al.* (1983) erected a new pholadomyoid genus *Agrawalimya*, Jaitly (1986a) created new subgenus *Indomya* of the genus *Pholadomya* and Jaitly (1986b) described six species belonging to five pholadomyoid genera from the Middle Jurassic of Kala Dongar, Pachchham "Island". A composite checklist of taxa belonging to different pholadomyoid genera so far recorded from the Middle Jurassic of Kachchh by Jaitly (1981, 1986a, b) and Pandey *et al.* (1996) is given below for ready reference and subsequently the taxonomic characters of the genera and species which needed revision have been discussed in detail.

GEOLOGY AND STRATIGRAPHY

Kachchh constitutes one of the important sedimentary basins of western India. It formed foreland-shelf of Indo-Baluchistan geosynclines. The basin evolved during Jurassic times due to rifting between India and Africa (Biswas, 1987). The open marine conditions prevailed during maximum part of the Mesozoic in the Kachchh Basin and a huge pile of Mesozoic marine sediments (about 2400m thick) ranging in age from Middle Jurassic to Early Cretaceous was deposited in the epicontinental sea. These sediments are traversed by numerous dykes, sills and other igneous intrusives (about 600 to 1000 m thick) which are thought to be contemporaneous with Deccan Traps. Biswas (1980) suggested that the Kachchh structure is due to six major upthrusts produced by block faulting of basement, accompanied by development of flexures along the margin of faults with steep dips towards north but gentle back

slope. According to Poddar (1959, 1964), the entire basin was uplifted during Middle to Late Pliocene, while Biswas (1971) believes that the Mesozoic sedimentation was terminated by the regional uplift during the Late Cretaceous diastrophism. The sedimentation process in the Kachchh Basin was broadly controlled by subsidence of basement due to extensional tectonics in graben while sediments influx kept pace with it (Fursich *et al.*, 2001). It can be conceived that the present configuration of these Mesozoic sediments in the Kachchh Basin is due to tectonic disturbances accompanied by abortive intrusions and subsequent erosion.

The Middle Jurassic sediments in the Kachchh Basin (Fig. 1), according to their geological distribution, occur as three units Kachchh Mainland, Pachchham Island and Eastern Kachchh. The invertebrate macrofauna, especially the ammonioids have played crucial role in the determination of age of these Middle Jurassic sediments. Situated on the southern margin of Tethys, Kachchh fauna have strong affinity to the Ethiopian Faunal Province. The oldest exposed marine Middle Jurassic sediments are at least of Late Bajocian (Jaitly *et al.*, 1980; Singh *et al.*, 1982) in age as confirmed by the occurrence of the ammonoid genus *Leptosphinctes* (Jaitly and Singh, 1983) from Kala Dongar of Pachchham Island. However, below this *Leptosphinctes*-bearing horizon in Kala Dongar, about 250 m thick marine sediments are present (Fursich *et al.*, 2001). Hence, possibility of even older sediments than Late Bajocian cannot be ruled out. The existence of Bathonian horizons have been confirmed due to occurrence of typical Bathonian ammonoid genera, e.g. *Micromphalites*, *Gracilisphinctes*, *Clydoniceras* (Singh *et al.*, 1982; Jaitly and Singh, 1984; Pandey and Callomon, 1995). The Callovian part of the Middle Jurassic of Kachchh has been extensively worked out (e.g. Spath, 1933; Kanjilal, 1978; Bardhan and Datta, 1987; Krishna and Ojha, 1996, etc) and in concurrence several Callovian ammonoid genera have been recorded. Altogether, about 700 m thick Middle Jurassic siliciclastic and carbonate sediments have accumulated in the Kachchh Basin through a series of marine transgressions exhibiting the cyclic sedimentation pattern. Broadly the siliciclastic sediments dominated in the Bajocian and Callovian, while carbonates in the Bathonian.

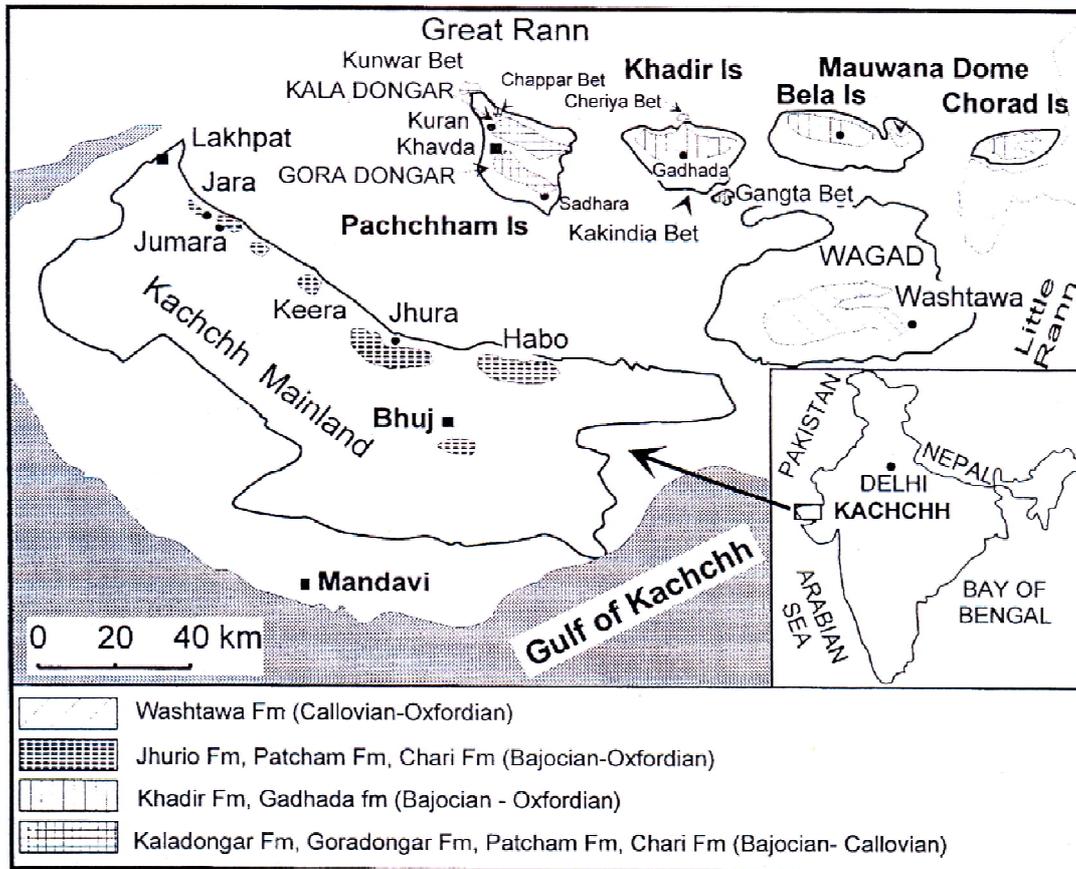


Fig.1. Location Map (after Fürsich *et al.*, 2001).

Waagen (1873-75) classified the Kachchh sediments into 'Puthum', 'Charee', Katrol and 'Oomia' groups and Ukra beds, in ascending order. Later, Rajnath (1932, 1942) restricted the term Umia Series for Lower 'Oomia' of Waagen, gave new name 'Bhuj Series' to plant-bearing beds (Upper 'Oomia' of Waagen) and placed the Ukra beds under the Bhuj Series on structural grounds. Poddar (1964) adopted Rajnath's classification but substituted the term 'Series' by 'Formation' and elevated the Ukra beds to the rank of formation. Lately, Biswas (1971, 1980) proposed a new lithostratigraphic classification by rejecting the basic classification introduced by Waagen. However, Fürsich *et al.* (2001) reviewed comprehensively all the earlier schemes of classification, and proposed a new scheme by retaining some of the lithostratigraphic terms of Biswas (1980) and the traditional terms of Waagen (1975). They also introduced Gadhada formation for the Callovian- Oxfordian sediments of Eastern Kachchh and several new members for the Bajocian-Callovian of the Kachchh Mainland and Pachchham Island.

The complete Bajocian horizon is represented in Pachchham Island as the Kaladongar Formation (Fig. 2). The Jhurio Formation of the Kachchh Mainland as well as the Khadir Formation of Khadir, Bela and Chorad islands are Bajocian-Bathonian in age. The Chari Formation (Callovian-Oxfordian) is present in the Kachchh Mainland and Eastern Kachchh. These formations are well characterized by a series of marker beds, quite useful for their identification and for genetic correlation of the different sedimentary sequences of the Kachchh Basin (Fürsich *et al.*, 2001).

SYSTEMATIC PALAEOLOGY

The principal objective behind the present article is to review and revise the already documented pholadomyoid taxa from the Middle Jurassic of Kachchh. During revision, some significant features in the morphological characters have been observed, which necessitated a change/modification in the taxonomic status of some of the already described taxa listed herein.

Genus Pholadomya G.B. Sowerby, 1823

Pholadomya (Pholadomya) kachchhensis Pandey *et al.*, 1996

Pholadomya (Pholadomya) inornata J. De C. Sowerby, 1840 Jaitly 1981, Pandey *et al.*, 1996

Pholadomya (Pholadomya) cf. inornata J. De C. Sowerby, 1840 Pandey *et al.*, 1996

Pholadomya (Pholadomya) fidicula J. De C. Sowerby 1826 Pandey *et al.*, 1996

Pholadomya (Pholadomya) hemicardia Roemer 1836 Jaitly, 1981

Pholadomya (Bucardiomya) lirata J. Sowerby 1818 Jaitly 1981, Pandey *et al.*, 1996

Pholadomya (Bucardiomya) protei (Brongniart 1821) Jaitly, 1981

Pholadomya (Indomya) rajnathi Jaitly, 1986a

Genus Agrawalimya Singh, Jaitly and Pandey, 1982

Agrawalimya pseudosulcata Singh *et al.* 1982, Pandey *et al.*, 1996.

Agrawalimya sp. A. Pandey *et al.*, 1996

Genus Gerardotia De Loriol, 1903

Gerardotia sp. A. Pandey *et al.*, 1996

- Genus *Goniomya* Agassiz, 1841
Goniomya (Goniomya) intersectans (Smith 1817) Pandey *et al.*, 1996
Goniomya (Goniomya) trapezicostata (Pusch 1837) Pandey *et al.*, 1996
 Genus *Homomya* Agassiz, 1843
Homomya gibbosa (J. Sowerby 1814) Jaitly, 1981
Homomya pachchhamensis Pandey *et al.*, 1996
 Genus *Machomya* De Loriol, 1868
Machomya khadirensis Pandey *et al.* 1996
 Genus *Osteomya* Moesch, 1874
Osteomya dilata (Phillips 1829) Jaitly, 1986 b; Pandey *et al.*, 1996
 Genus *Pachymya* J. De C. Sowerby, 1826
Pachymya (Pachymya) sp.
Pachymya (Arcomya) indica Jaitly, 1986b
Pachymya (Trychomyella) sp.
 Genus *Ceratomya* Sandberger, 1864
Ceratomya wimmisensis (Gillieron 1886) Pandey *et al.*, 1996
Ceratomya pittieri (de Loriol 1883) Pandey *et al.*, 1996
 Genus *Ceratomyopsis* Cossmann 1915
Ceratomyopsis striata (d'Orbigny 1822) Pandey *et al.*, 1996
 Genus *Pleuromya* Agassiz, 1843
Pleuromya alduini (Brongniart 1821) Jaitly, 1986b
Pleuromya uniformis J. Sowerby 1813 Pandey *et al.*, 1996
Pleuromya cf. uniformis J. Sowerby, 1813 Pandey *et al.*, 1996
Pleuromya calceiformis (Phillips 1829) Pandey *et al.*, 1996
 Genus *Platymoidea* Cox, 1964
 ?*Platymoidea* sp. A Pandey *et al.*, 1996
 Genus *Thracia* J de C. Sowerby, 1823
Thracia (Thracia) viceeliacensis d'Orbigny, 1850 Pandey *et al.*, 1996
Thracia (Thracia) tombecki de Loriol 1872 Pandey *et al.*, 1996

Recently, Bieler *et al.* (2010) designated Anomalaodesmata as order and Pholadomyoidea as superfamily. However, the classifications proposed by Cox and Newell (1969) and Skelton and Benton (1993) are more popular and practical and have been followed here for the Order Pholadomyoidea.

Order **Pholadomyoidea** Newell, 1965

Family **Pholadomyidae** Gray, 1847

Genus **Pholadomya** G.B.Sowerby, 1823

(Type species: *Pholadomya candida* G.B.Sowerby, 1823)

Remarks: There is misunderstanding regarding differentiation of the genus *Pholadomya* G.B.Sowerby from the genus *Homomya* Agassiz. If we go through the nature of the various species of these two genera recorded by earlier workers, externally, both the genera are having more or less similar outline but for a bit less prominent umbones in the some species of *Homomya*. The radial ornamentation that is prominent in the *Pholadomya* is either absent or weakly developed (only in the umbonal region) in the genus *Homomya*. However, *Homomya gibbosa* (Sowerby), the genotype from the Bathonian of the England does not exhibit any ornamental characters except for the concentric corrugations. Cox (1935) included the forms with weak radials ornament in the *Homomya*, and described his specimens of Somalia as *Pholadomya (Homomya) inornata* J. de C. Sowerby, perhaps mainly due to the presence of weak radials in the umbonal region. Cox and Newell (1969), while describing the generic characters of the *Homomya*, mentioned that “resembling *Pholadomya*

(*Pholadomya*) in shape except that in some species the umbones are less prominent; without radial ribbing, unless in earliest stages of growth”. This further created misunderstanding especially for those specimens of the both genera having intermediate/transitional pattern of radial ornament. Pandey *et al.* (1996) also mentioned that “species is difficult to place generically, as it occupies a position intermediate between radially ornamented *Pholadomya* and *Homomya*, the latter lacking radial ribs”. Since the radials in the different species of the *Pholadomya* are variable in strength (weak to prominent) and in position (from umbonal region to the middle of the shell and extending in some species up to the ventral margin). The author feels that the generic characters of the genus *Homomya* warrant a little refinement in order to avoid the confusion. The species without radial ornament should only be included in the genus *Homomya* and those with radials (irrespective of its strength and position) are included in *Pholadomya*. This should be considered as one of the most significant morphological characters, which would allow an unambiguous distinction to be made between the two genera *Pholadomya* and *Homomya*. Pandey *et al.* (1996, p.53), while describing the pholadomyoid taxa from Kachchh, incorporated specimens with radial ornament in the genus *Pholadomya* and those with concentric ornamentation only in *Homomya*, while erecting a new species *Homomya pachchhamensis*. Their observations also support the author’s contention.

Pholadomya (Pholadomya) kachchhensis nom nov.

Pholadomya (Pholadomya) kachchhensis Pandey *et al.* 1996, p.53, pl.1, figs. 1-4, 6-10.

Remarks: Pandey *et al.* (1996) proposed a new name *Pholadomya kachchhensis* for their specimens from the Middle Jurassic sediments of Kachchh, which they found similar to *Homomya douvillei* Choffat, 1892 (which actually belongs to *Pholadomya*) described by Rossi Ronchetti (1970) from the Bathonian-Callovian of northeast Afghanistan. The species name *douvillei* is already preoccupied as used by Choffat (1892) for his species *Pholadomya douvillei* from the Upper Jurassic of Portugal.

Pholadomya kachchhensis is characterized by medium to large size, ovately elongated outline with weak radials of variable strength on the shell-surface. The number of radials varies in between 10-17. Pandey *et al.* (1996) doubtfully kept *Pholadomya (Indomya) rajnathi* Jaitly 1986a in the synonymy of *Pholadomya kachchhensis*. If figures of *kachchhensis* as given by Pandey *et al.* (1996) on Pl.1, figs.1-4, 6-10 and fig.5 (refigured the holotype of *rajnathi*) are compared, these evidently belong to two different populations quite distinguishable on the basis of surface ornamentation and outline. One population (figs. 1,2,6,7 on Pl.1 of Pandey *et al.*, 1996) belongs to *Pholadomya kachchhensis* with elongated ovate outline and barely perceptible radial ornamentation, fading in midway before reaching to the ventral margin. The other population (figs.3, 4, 5, 9, 10 on Pl.1 of Pandey *et al.*, 1996) belongs to *Pholadomya (Indomya) rajnathi* having sublunate outline with conspicuous radial ribs, most of them continuing up to ventral margin. Hence, considering *rajnathi* conspecific to *kachchhensis* is unjustified. *Pholadomya (Homomya) inornata* J.de C. Sowerby recorded by Cox (1935, pl. 21, figs. 5-7) from the Callovian of Somalia is poorly preserved and judging from the size, outline and traces of radial ornament, most probably belongs to *Pholadomya kachchhensis*.

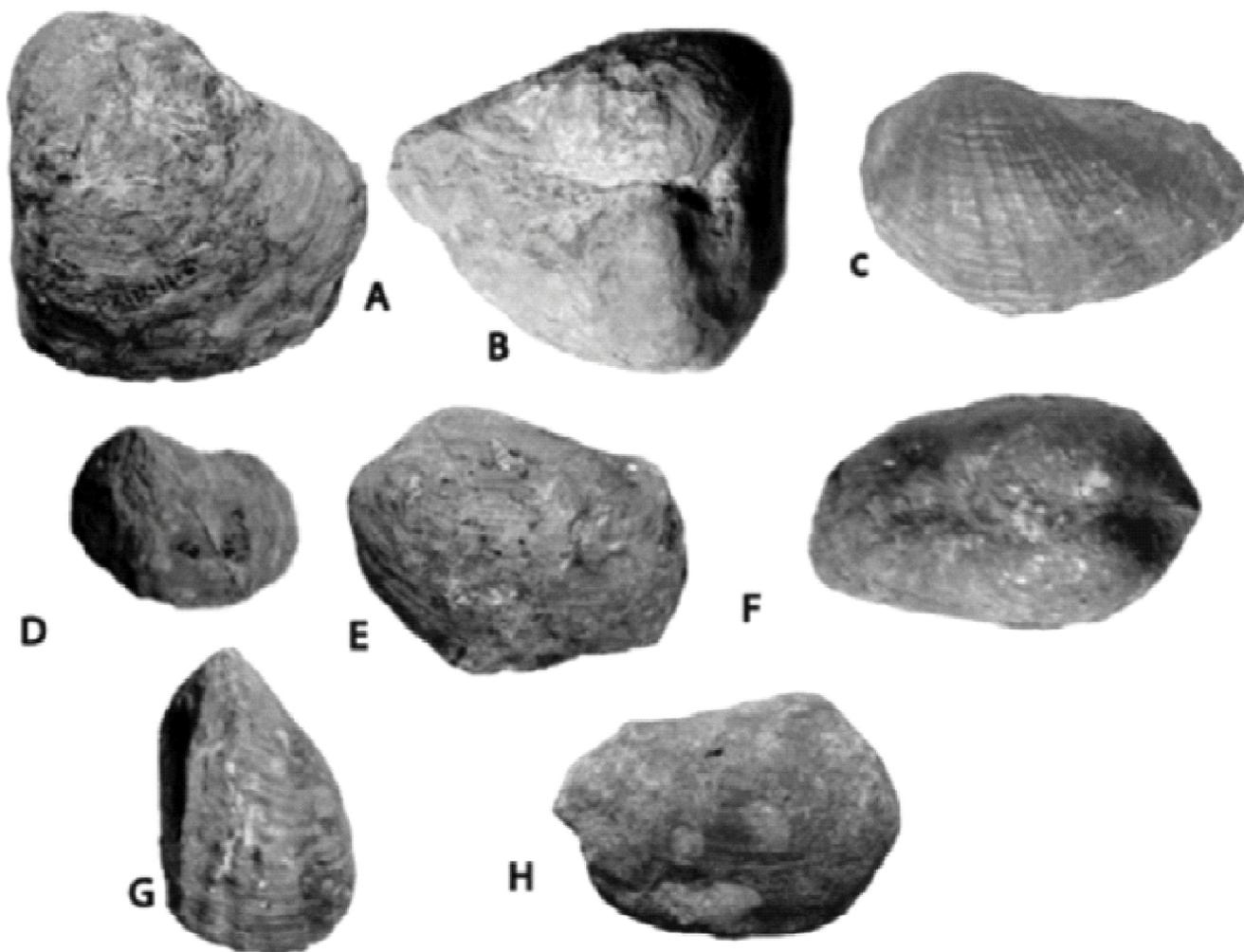


Fig. 3. Representative pholadomyoids from Kachchh
 A - B. *Pholadomya (Bucardiomya) gigantea* n.sp. (Specimen no PK/120/106):
 A. external view of valve (x 0.75) B. dorsal view (x 0.75);
 C. *Pholadomya (Indomya) rajnathi* Jaitly 1986a, Specimen No PK/139/3: external view of
 left valve (same size);
 D. *Pholadomya (Pholadomya) hemicardia* Roemer 1836. Specimen no.PK/138/18): external view
 of left valve (x1.5);
 E - F. *Homomya gibbosa* (J. Sowerby 1814). Specimen no.PK/130//76.
 E. external view of left valve (same size), F. dorsal view (same size).
 G. *Pholadomya (Bucardiomya) protei* (Brongniart 1821). Specimen no.PK/156/1: external
 view of left valve (same size).
 H. *Pachymya (Trychomyella)* sp. Specimen no. PK/130/70: external view of right valve (x 1.5).

Locality: Pachchham Island.

Horizon: Goradongar Formation, Middle Bathonian.

Pholadomya (Pholadomya) inornata J.de C. Sowerby, 1840
Pholadomya (P.) inornata Sowerby, 1840, Pandey *et al.*, p.54, pl.1,
 fig.11; pl.2, figs.1-2, 4, 6.

Remarks. *Pholadomya inornata* is relatively small sized species of the genus *Pholadomya*. Earlier authors (Cox, 1935; Ficarelli, 1968; Rossi Ronchetti, 1970, etc.) included it either under the genus *Homomya* or in *Pholadomya (Homomya)*. However, as discussed earlier due to the presence of radial ornamentation these definitely belong to the genus *Pholadomya*. The specimens of *Pholadomya inornata* from Pachchham "Island" differ from *Pholadomya kachchhensis* in their smaller size, sublunate outline, prosogyrous umbones,

weak radials and in having faint anterior sulcus. Earlier most of the specimens recorded under this species (e.g. Cossmann, 1907; Lissajous, 1912, Bouillierie, 1921, Basse, 1954, etc.) from different parts of the world, do not show the presence of radial ornamentation on the shell-surface, their insertion in the genus *Pholadomya* is erroneous and in all probability they belong to the genus *Homomya*.

Locality: Pachchham Island.

Horizon: Goradongar Formation, Middle Bathonian.

Pholadomya (Pholadomya) hemicardia Roemer, 1836
 (Fig. 3D)

Pholadomya (P.) hemicardia Roemer, 1836, Jaitly 1981, p. 276, pl. 13, fig. 11.

Remarks: The specimens are much smaller in size for the genus, lunate in outline and well inflated. The umbones appear

to be prosogyrous, protruding from the dorsal margin, situated at about anterior-third of the shell-length. Lunule and escutcheon not clearly differentiated. The posterior, ventral and anterior margins are well rounded and making almost a continuous semicircle. The surface characters are not adequately preserved, however, appears to consist of radial riblets in the dorsal half of the specimen, besides concentric corrugations on whole of the shell-surface. In outline, the Kachchh specimens are much similar to *Pholadomya hemicardia* Roemer (1836, p.131, pl.9, fig.18) and especially to the specimens described by Arkell (1935, p.336, pl. 46, figs. 5-7) from the Upper Jurassic of England. However, in the English specimens of *hemicardia* the radial ribs are covering whole of the surface of the shell, while in present specimens they appear to be present in the middle part of the surface leaving antero-dorsal and postero-dorsal regions with concentric growth lines only. In this respect the Kachchh specimens are much closer to the *Pholadomya hemicardia* described by Fürsich (1982, p.96, pl.35, figs.35A-D) from the Upper Jurassic of East Greenland, but for the anterior sulcus, which is present in the Greenland specimens.

Locality: Kala Dongar, Pachchham Island.

Horizon: Goradongar Formation, Middle Bathonian.

Subgenus Bucardiomya Rollier in Cossmann, 1912
(Type species: *Pholadomya bucardium* Agassiz, 1842)

Pholadomya (Bucardiomya) lirata (J.Sowerby, 1818)

Pholadomya (Bucardiomya) lirata Jaitly 1981, p. 277. - Fürsich *et al.*, 1994, pl.2, figs.2-3. - Pandey *et al.*, 1996, p.55, pl.2, figs. 8- 11, pl.3, figs. 1-4.

Remarks: *Pholadomya (Bucardiomya) lirata*, amongst the pholadomyoids, is perhaps the morphologically most variant species. Earlier, only specimens of taller outline (higher than long) were included in the *Pholadomya lirata*, but specimens which are longer than high are also included (keeping in view the variations in the outline). The number of radials is also quite variable in the different populations of *Pholadomya lirata* recorded from different parts of world- in Bathonian of France from 6-8 (Fischer, 1969), in the Middle Jurassic of Somalia from 6-9 (Cox, 1935) and in the Bathonian-Callovia of Kachchh from 6-9 (Pandey *et al.*, 1996). This number (irrespective of strength) ranges from 4-10 in the specimens of North Pachchham "Island". Numerically, *Pholadomya (Bucardiomya) lirata* constitutes next dominant population after *Indocorbula* amongst the bivalve populations of North Pachchham "Island" and one the most common elements amongst the Kachchh Jurassic bivalves.

Pholadomya (Bucardiomya) protei (Brongniart, 1821)
(Fig. 3 G)

Pholadomya (Bucardiomya) protei Jaitly, 1981, p. 279.

Remarks: This species is characterized trigonally ovate outline, strong inflation (maximum in the dorsal- third region of the shell- height along the second anterior radial rib) and haing 3-4 radial ribs crossed by concentric corrugations. *Pholadomya aubryi* described by Douvillé (1886, p.225, pl.12, fig.6) form the Oxfordian of Tunisia, somewhat resembles this species in general features, but has more trigonal outline and more widely interspaced radial ribs. Arkell (1935, p.333) considered *Pholadomya somaliensis* described by Cox (1935, p.192, pl.21, figs.1-2) from the Jurassic of Somalia as conspecific to *Pholadomya protei*, however, the specimens of Kachchh are much smaller in size and less trigonal in outline than the

Somalian specimens. Similarly, *Pholadomya somensis* Tamura (1960, p. 279, pl.32, figs. 10-11) from the Upper Jurassic of Japan differs in having coarser and prominent concentric ribs than the radial ribs in comparison to just reverse pattern of ornamentation in my specimens (radial ribs coarser and prominent than the concentric ribs).

The species, though common in the Ethiopian faunal province, was not known earlier from the Kachchh Basin.

Locality: Kala Dongar, Pachchham Island

Horizon: Goradongar Formation, Middle Bathonian.

Pholadomya (Bucardiomya) gigantica n. sp.
(Fig.3A-B)

Material: 3 specimens (Holotype : No. PK/120/106 and two paratypes nos.PK/1127/1, PK/120/7).

Derivation of name: Species named after its extraordinarily large size for the genus.

Diagnosis: The specimens quite large in size for *Pholadomya (Bucardiomya)*, subtrigonal outline, strongly inflated; umbones terminal, broadly rounded, incurved (more or less contiguous), protruding well beyond the dorsal margin; anterior margin typical of subgenus *Bucardiomya*; lunule small, rounded; escutcheon elongated sublanceolate; posteriorly gaping; surface ornamented with irregular, comarginal growth rugae crossed by faint radials in the umbonal region only.

Description: Same as diagnosis.

Remarks: *Pholadomya (Bucardiomya) gigantica* in its size is comparable to *Homomya pachchhamensis* Pandey *et al.* (1996), however, it is quite different in its outline (trigonal), nature of anterior margin (*Bucardiomya* type) and surface ornamentation (comarginal growth rugae crossed by faint radials in the umbonal region only).

Locality: Kala Dongar, Pachchham Island.

Horizon: Goradongar Formation, Middle Bathonian.

Subgenus Indomya Jaitly, 1986a

Remarks: The subgenus *Indomya* was created by Jaitly (1986a) from the Middle Bathonian of Kachchh to accommodate the specimens having an anterior shallow sulcus and characteristic surface ornamentation of radial and concentric ribs of almost equal strength. Pandey *et al.* (1996, p.53) considered *Indomya* a junior synonym of *Pholadomya* on the consideration that this anterior sulcus is quite common in many of the species of the genus *Pholadomya*. They also considered that the oblique posterior ridge, another characteristic feature of the species, is created due to partial erosion of the posterodorsal region. However, in the specimens of *Indomya* it is clearly seen that there is an obtuse oblique posterior ridge from where the rest of the poster dorsal region (Fig. 3C) is defined by the abrupt steeper slope and tapering to the posterior by becoming almost flat. The author agrees with Pandey *et al.* (1996) that this anterior sulcus is widespread in many species of the *Pholadomya*, but it is not present in most of the species. Zinsmeister (1978), who reviewed the genus *Pholadomya* on the basis of the Tertiary specimens from California, also did not mention anything about such sulcus, nor do his specimens show the presence of anterior sulcus and such prominent concentric and radial ribs as seen in the Kachchh specimens. There must be some difference between those with sulcus and those without it. Many of the earlier authors (e.g. Runnegar, 1976; Fürsich, 1984; Arkell, 1935; Cox, 1935, etc.) have noticed the presence of anterior sulcus but

nobody has ever emphasized its significance and relation to the form and function of the species vis-à-vis distinction. This anterior sulcus, like lunule, which is also present on the anterior side, may enable organism to check its burrowing activities by increasing the resistance to movement through sediments. The presence/absence and the prominence of the anterior sulcus are related to the depth at which the organism may have lived during its lifetime. Due to typical ornamentation (both radial and concentric ribs of equal strength and distributed throughout the shell-surface) and presence of sulcus, the author still prefers the retention of *Indomya* as a subgenus of *Pholadomya*.

Pholadomya (Indomya) rajnathi Jaitly, 1986a
(Fig. 3C)

Pholadomya (Indomya) rajnathi Jaitly, 1986a, p. 458, figs.1-4.

Remarks: *Pholadomya (Indomya) rajnathi* is characterized by its medium size, moderate inflation and sublunate outline with tapering posterior end. Umbones contiguous, orthogyrate and situated in between 6 and 8 mm from the anterior end. Lunule poorly defined, broadly ovate and small; escutcheon indistinct. An obtusely rounded ridge, defined by steeper slope of the surface posterior to it, extends obliquely from umbo slightly towards anterior to the posteroventral corner. A shallow, broadly rounded sulcus extends vertically downward from umbo and becoming shallower and wider ventrally. The surface ornamentation consists of widely spaced prominent radial ribs (of variable strength) crossing the concentric ribs. Pandey *et al.* (1996, p.53) doubtfully kept *Pholadomya (Indomya) rajnathi* with their new species *Pholadomya (Pholadomya) kachchhensis*, however, it is quite evident from the figures and description, *rajnathi* is strikingly different from *Pholadomya kachchhensis*, as the latter has different outline, larger size and the surface ornamentation consisting of faint radial ribs (none of them reaching to the ventral margin) in contrast to prominent radial (most of them reaching to the ventral margin) and concentric ribs in the former.

Genus *Agrawalimya* Singh *et al.*, 1982

(Type species: *Agrawalimya pseudosulcata* Singh *et al.*, 1982)

Agrawalimya pseudosulcata Singh *et al.*

Agrawalimya pseudosulcata Singh *et al.*, 1982.- Pandey *et al.*, 1996, p. 56, Pl.3, figs.5-10.

Remarks: The genus *Agrawalimya* has been created by Singh *et al.* (1982, p.274) for the specimens having elongate-elliptical shape, surface with coarse concentric ribs interrupted in the middle of the flank by the presence of umbonal-ventral sulcus, narrow anterior and broad posterior gapes, and having no perceptible radial ornamentation. Only fine radial pustules are visible under high magnification. Pandey *et al.* (1996) collected a few more specimens from the same horizon and localities, which exhibited some additional characters. Apart from the comarginal growth lines grading into growth rugae on the anterior and posterior sides of asymmetrically triangular shallow sulcus, their specimens also show the presence of well-demarcated elongated lunules and opisthodontic external ligaments.

The genus so far was monospecific with the genotype *Agrawalimya pseudosulcata*, Pandey *et al.* (1996) recorded *Agrawalimya* sp. A, which may be a different species. The authors of *Agrawalimya* Singh *et al.* (1982) have tentatively kept this genus in the family Pholadomyidae since till then no

known genera of the family Pholadomyidae except for the genus *Gerardotia* Lamarck was known to have an umbonal-ventral sulcus. The placement of the genus *Gerardotia* in the family Pholadomyidae itself is tentative and has been debated by earlier workers. Lorient (1903), Chavan (1952), and Zakharov and Mesezhnikov (1974) have preferred placement of the genus *Gerardotia* in the family Pholadidae Lamarck of subclass Heterodonta. However, Rollier (1913) and Pandey *et al.* (1996) placed the genus *Gerardotia* in the family Pholadomyidae. The umbonal-ventral sulcus that is the most diagnostic feature of both *Agrawalimya* and *Gerardotia* is also a common character of most of the genera of the family Pholadidae. The outline and surface ornamentation of these two genera *Agrawalimya* and *Gerardotia* are also quite close to those of Pholadidae. However, in Pholadidae though radial ornamentation is quite common but pustules are absent. This is one of the most common morphological features of the family Pholadomyidae. The presence of radial pustules in the pholadomyoids is attributed to facilitate the deep burrowing characters either by increasing friction between the valves and sediments or by trapping/simulating sand grains for more effective concealment of the shell (Runnegar, 1974). These pustules and also the shell of the most of the deep burrowers are composed of aragonitic material and preservation of the shell microstructure depends largely upon the permeability and the associated organic material (Kennedy and Hall, 1967). The thin, elliptically elongated shell with weak hinge is a significant feature of the deep-burrowing bivalves in a firm stable substrate (Stanley, 1970). *Agrawalimya* probably witnessed similar living conditions as the genus *Pholadomya* that, according to Zinsmeister (1978), is a permanent burrower and the fossil specimens occur in fine sandy siltstone with articulated valves. Also, the position of umbo in the pholadomyids is more towards the posterior margin accompanied by an expansion of the anterior part of the shell for the movement of foot from ventral to anterior position (Runnegar, 1974).

The members of the Pholadidae constitute a much specialized bivalve group adapted to boring in hard materials and some of its living examples are found only in wood and or other plant materials and their assignment with the family is easy. However, it is very difficult to establish the assignment of the fossil forms since they are distorted during fossilization in most of the cases, lacking accessory plates, siphonoplax broken off, and apophyses usually embedded in the sediments, generally not seen. These plates are thought to be significant in the assignment of the individuals to the family or even to the superfamily Pholadacea Lamarck. Since none of the Kachchh specimens so far collected exhibit the internal characters, the presence of accessory plates (which are rather preserved in exceptionally favorable conditions only) is uncertain. Moreover, the specimens from Kachchh belonging to the genus *Agrawalimya* are deep burrower rather than borer, therefore, their assignment to family Pholadidae of subclass Heterodonta seems to be uncalled-for. Pandey *et al.* (1996) collected additional specimens of *Agrawalimya* from the Middle Jurassic sediments of Kachchh and emphasized that the presence of delicate radial lines of punctae in the type specimens, which is a common surface character of the many members of the family Pholadomyidae, undoubtedly suggest that the genus *Agrawalimya* belongs to the family Pholadomyidae.

Table 1: Middle Jurassic lithostratigraphic framework of the Kachchh Basin.

Age	Kachchh Mainland	Pachchham Island		Eastern Kachchh	
		Gora Dongar	Kala Dongar	Khadir, Bela & Chorar islands	Wagad
Callovian	Chari Formation	(eroded)		Gadhada Formation	Washtawa Formation
Bathonian	Patcham Formation	Patcham Formation		Patcham Formation	(not exposed)
	Jhurio Formation	Goradongar Formation		Khadir Formation	
Bajocian		Kaladongar Formation			

Agrawalimya and *Gerardotia* have remarkable morphological difference (both in shape and vertical sulcus) from rest of the genera of the family Pholadomyidae. The author feels that these two genera needed a placement into a separate next higher taxonomic category (subfamily). However, for the time being, due to non-availability of the internal characters of *Agrawalimya* and *Gerardotia*, a new subfamily in the family Pholadomyidae has not been proposed. So far *Agrawalimya* has not been recorded outside of the Kachchh Basin, while *Gerardotia* has wide known occurrences in Europe and recently has been reported from the Kachchh basin also (Pandey *et al.*, 1996).

Genus *Homomya* Agassiz, 1842

(Type species: *Macra gibbosa* J. Sowerby, 1813)

Diagnosis: Shape similar to *Pholadomya* s.s., some species with less prominent umbones, radial ribs in early stages of growth, hinge margin smooth, uninterrupted; pallial sinus deep.

Emended Diagnosis: Elongate-ovate to obliquely-oval in shape; umbones prominent, variable in position; anterior side produced, ventral strongly convex; posterodorsal margin concave; anterior gape small and posterior gape large; surface with concentric ornamentation only; pallial sinus deep.

Homomya gibbosa (J. Sowerby, 1814)

Homomya gibbosa Jaitly, 1981, p. 288, pl.15, figs. 1a, b.

Remarks: The specimens earlier recorded with even faint radials have been excluded and only those specimens with concentric ornamentation and strong inflation (figs. 3E, F) have been included in this species. The occurrence of this species in Kachchh in the Bathonian has extends its range downwards from Callovian.

Homomya pachchhamensis Pandey *et al.*, 1996

Remarks: It is a gigantic and short (longer than high) *Homomya* with protruding umbones, subtrigonal to obliquely ovate outline, strongly ventricose, smaller anterior and larger posterior gapes and concentric ribs of irregular strength. In its large size, subtrigonal outline and somewhat cordiform anterior, *Homomya pachchhamensis* closely approaches the subgenus *Procardia* Meek, which, however, differs in having strong radial ornamentation. The subgenus *Bucardiomya* Rollier, which is quite common in the Jurassic of Kachchh, differs in its smaller size and presence of radial ornamentation.

Genus *Pachymya* J.de C. Sowerby, 1826

(Type species: *Pachymya gigas* J.de C. Sowerby, 1826)

Subgenus *Pachymya* s.s.

Pachymya (Pachymya) sp.

Pachymya (Pachymya) sp. Jaitly, 1986b, p. 40, fig.3 (only). - Pandey *et al.*, 1996, p. 60, pl.6, fig.7.

Remarks: Runnegar (1974) placed the genus *Pachymya* J. de C. Sowerby doubtfully in the family Megadesmidae Vokes 1967, especially due to its close resemblance with the genus

Myonia Dana. All the present specimens are articulated and none of them reveal the internal characters (particularly hinge plate), so that on the basis of the external characters, it is difficult to assign the genus *Pachymya* to the family Megadesmidae. Moreover, the specimens of the genus *Pachymya* exhibit more closeness in external characters (equivalved, inequilateral shells with posterior gape, external opisthodontic ligament and surface with delicate pustules) to the other genera of the family Pholadomyidae. Pandey *et al.* (1996) have also preferred the placement of the genus *Pachymya* in the family Pholadomyidae and followed the classification given by Cox and Newell (1969), while describing the anomalodesmatan bivalves from the Jurassic of Kachchh.

Subgenus *Arcomya* Roemer, 1839

(Type species: *Solen helveticus* Roemer 1839)

Pachymya (Arcomya) indica Jaitly, 1986b

Pachymya (Arcomya) indica Jaitly, 1986b, 40, figs.1-2.

Remarks: Jaitly (1986b) created a new species for his specimens from Kala Dongar, Kachchh having moderate inflation, subrectangular outline, small umbones placed at anterior-third of the shell-length, narrow lunule and escutcheon and a sharp oblique ridge running from umbo to the postero-ventral corner. Jaitly (1986b, p.40) placed it under *Pachymya (Arcomya)* especially due to weak inflation and less anteriorly situated umbones. Pandey *et al.* (1996, p.61) referred this species to *Pachymya (Pachymya)* on the ground that it has much pronounced posterior ridge, a more wedged shaped shell, reaching its greatest point of inflation at a point well posterior to the umbo. However, Cox (1969, p. N834) clearly enumerates the characters of *Pachymya (Pachymya)* as “Medium-sized to large, with umbones placed well anteriorly; moderately to strongly inflated” besides other characters. *Pachymya (Arcomya) indica*, as envisaged earlier, is weakly inflated, rather small in size, with umbones situated at anterior-third of the shell length, quite necessarily rightly sited to *Pachymya (Arcomya)* rather than to *Pachymya (Pachymya)*.

The figured specimen of the *Pachymya (Pachymya) indica* by Pandey *et al.* (1996, pl. 6, fig.7), which has definitely much anteriorly placed umbones, much pronounced posterior ridge and moderate inflation with other above-mentioned characters, certainly belongs to *Pachymya (Pachymya)*.

Subgenus *Trichomyella* Cox, 1969 (pro *Trichomya* Crickmay, 1936)

(Type species: *Trichomya amphitrite* Crickmay, 1936)

Pachymya (Trichomyella) sp.

(Fig. 3H)

Pachymya (Trichomyella) sp. Jaitly, 1986b, p.41, fig.4.

Remarks: The specimen is slightly damaged at antero-ventral margin, however, rest of the characters are satisfactorily preserved. It is characterised by subquadrate outline, feeble

inflation and inequilateral shell. The umbones small, contiguous, depressed, slightly opisthogyrate and situated at about anterior-third of the shell-length. Lunule quite narrow; escutcheon moderately deep, elongated and bounded by ridges. The dorsal and ventral margins subparallel; anterior margin narrow (approaches to wedge shape); posterior margin well rounded and gaping. Though the shell-surface is eroded at places, it appears that no oblique umbonal ridge is present. Surface is ornamented with irregular comarginal growth rugae and also crowded by radial rows of pustules.

Because of absence of oblique umbonal ridge and crowding of shell surface with radial rows of postules, this lone specimen from the Middle Bathonian of Kala Dongar appears to belong to *Pachymya* (*Trychomyella*) rather than *Pachmya* (*Arcomya*), which consists of a conspicuous oblique umbonal ridge reaching up to the postero-ventral corner. *Pachymya* (*Pachymya*) differs due to its more anteriorly placed umbones and more inflated shell, besides the presence of oblique umbonal ridge. The subgenus *Trychomyella* has so far been recorded from Callovian, so the present record extends its range to Middle Bathonian. *Arcomya* cf. *latissima* Agassiz, described by Arkell (1934, p.343, Pl.50, fig.1) from the Upper Jurassic (Trigonia bed) of England, approaches closely to the present specimen from Kala Dongar, especially in outline and ornamentation, but differs in having prominent oblique ridge on the surface. *Pachymya* (*Trychomyella*) *amphitrite* (Crickmay) from the Callovian of United States (Cox, 1969, Fig. F15.1) is another closely comparable species but is distinguished by its more protruding umbo, well concave dorsal margin and subrounded anterior margin. This specimen from Kachchh has been provisionally described here as *Pachymya* (*Trychomyella*) sp. for want of more adequately preserved material.

This is the first record of this subgenus from the Ethiopian faunal province.

Family **Chaenomyidae** Waterhouse, 1966

(*nom.transl. ex Chaenomyinae* Waterhouse 1966)

Remarks: Waterhouse (1966) created a subfamily Chaenomyinae and placed it with the Palaeozoic family Edmondiidae King of the Order Pholadomyioda for accommodating the genera *Chaenomya* Meek, *Vacunella* Waterhouse and *Oblicarina* Waterhouse with a narrow groove and ridge on the inner plate of the hinge. Later on, Runnegar (1974) re-examined Waterhouse's material and ruled out the placement of genus *Chaenomya* in the family Edmondiidae. Runnegar (1974) further raised the rank of subfamily Chaenomyinae to the family Chaenomyidae and included the genera *Chaenomya* Meek, *Argyromya* Fischer, *Cosmomya* Holdhaus and *Oestomya* Moesch, since all these genera have common characters such as elongated equivalved shells, large circular siphonal gape and external, opisthodontic ligament.

Genus **Oestomya** Moesch, 1874

(Type species: *Mya dilata* Phillips, 1829)

Oestomya dilata (Phillips, 1829)

Oestomya dilata Jaitly, 1986b, 42, figs.5-6.- Pandey *et al.*, 1996, 60, pl.5, figs. 5-9, pl.6, figs. 1-5.

Remarks: The specimens are rather small in size, subrectangular in outline with slightly opisthogyrate umbones. An oblique angular ridge runs from the umbonal region to the postero-ventral corner. Surface ornamentation consists of irregular comarginal threads, which are more conspicuous in the anterior region. Jaitly (1986b, p.42) assigned this specimen

to only known species of the *Oestomya dilata* (Phillips) with qualification. However, Pandey *et al.* (1996,p.60) collected several specimens belonging to this species from the Khadir Island of Kachchh and the present specimen is very much similar to some of them, hence, it can be assigned to the *Oestomya dilata*.

As discussed by Pandey *et al.* (1996, p.60), the genus *Oestomya* is rather rare and confined in the Jurassic Period only. It has been earlier recorded from Toarcian-Callovian of Europe, Madagascar, East Africa and India. Cox and Arkell (1948) placed the two species *Glycimeris* (*Uromya*) *oolithica* Rollier (1913, p.45) and *Anatina aegae* d'Orbigny (Thevanin, 1911, p.134, pl.26, fig. 48) in *Oestomya dilata*. Earlier, the genus *Oestomya* was represented by two species i.e. *Oestomya dilata* from the Middle Jurassic of England (Phillips, 1829) and *Oestomya coxi* from the Upper Liassic of Iran (Fantini Sestini, 1966). Pandey *et al.* (1996) considered the latter species as conspecific to *Oestomya dilata*. Therefore, the genus *Oestomya* most probably is known by its type species *Oestomya dilata* only.

Family **Pleuromyidae** Dall, 1900

Genus **Pleuromya** Agassiz, 1843

(Type Species: *Mya gibbosa* J.de C. Sowerby, 1823)

Pleuromya alduini (Brongniart, 1821)

Pleuromya alduini Jaitly 1986b, p. 42, fig.7.

Remarks: The present species has earlier been described by Jaitly (1986b,p.42) from the Kala Dongar, but Pandey *et al.* (1996, p.63) placed it doubtfully in the *Pleuromya uniformis* (J. Sowerby) on the ground that they collected 75 specimens from the different parts of Kachchh exhibiting general variations in nature and position of umbones (slightly depressed, situated in between one-third to one fourth of the shell-length from the anterior end), ventral margin (gently and evenly convex) and ornamentation (distinct, irregular growth lines). They suggested that above species from Kala Dongar belonged to their transitional forms (in between *Pleuromya uniformis* and *Pleuromya alduini*) and since it was identified on the basis of two specimens should be included in the *Pleuromya uniformis*. However, one of the specimen (better preserved) from the Kala Dongar possesses perfectly quadrate outline, well rounded anterior margin and the shell is not at all elongated in anterior-posterior direction, a characteristic feature of all the specimens so far described as *Pleuromya uniformis*. Also, the specimen of Kala Dongar does not resemble any of the figures by Pandey *et al.* (1996, pl.7, figs. 5-11) of *Pleuromya uniformis*, exhibiting transitory morphological characters. These observations suggest that the present specimen certainly belongs to *Pleuromya alduini*.

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REFERENCE

- Arkell, W.J. 1935. *A monograph of British Corallian Lamellibranchia*. Palaeontographical Society of London, London.
- Bardhan, S. and Datta, K. 1987. Biostratigraphy of Jurassic Chari Formation : a study in Keera Dome, Kutch, Gujarat. *Journal of Geological Society of India* 30: 121-130.

- Basse, E.** 1954. Invertèbres Jurassiques. In: **Basse, E., Lehmann, J.-P., Alloiteau, J. and Lefranc, J.-P.** Fossiles du Jurassiques supérieur et des 'Grès de Nubie' de la région des Sana (Yémen). *Bulletin de la Société Géologie France*, 6, 4: 655-688.
- Bielier, R., Carter, J.G. and Coan, E.V.** 2010. *Classification of Bivalve families*. p.113-133. In: *Nomenclator of Bivalve Families* (Eds. Bouchet, P. and Rocroi, J.P.), *Malacologia* 52(2): 1-184.
- Biswas, S. K.** 1971. Note on the geology of Kutch. *The Quarterly Journal of Geological, Mining and Metallurgical Society of India*, 43: 222-235.
- Biswas, S. K.** 1980. Mesozoic rock-stratigraphy of Kutch, Gujarat. *The Quarterly Journal of Geological, Mining and Metallurgical Society of India*, 43: 1-51.
- Biswas, S. K.** 1987. Regional tectonic framework, structure and evolution of the western marginal basins of India. *Tectonophysics*, 135: 307-327.
- Bouillierie, S.M. G. de la.** 1921. Guide paléontologique pour les terrains de la Sarthe. *Faune de Parcè et de Durei, Pélécytopes (Bathonien supérieur. Callovien inférieur)*, 44 p.
- Chavan, A.** 1952. Les pélecypodes des sables astartiens de Cordebugle (Calvados). *Mémoire. Suisse Paléontologie*, 69: 1-132 p.
- Choffat, P.** 1892-1893. Description de la faune jurassique du Portugal: Mollusques Lamellibranches, 1er ordre: Siphonidae. *Mémoire de Direction des Travaux Géologiques du Portugal*: 1-76.
- Cossmann, M.** 1907. Paléontologie, p. 69-147. In: *Note sur le Callovien de la Haute-Marne* (Eds. Theiry, P. and Cossmann, M.). *Bulletin de la Société Agriculture de Haut-Saône*.
- Cox, L.R.** 1935. Jurassic gastropoda and lamellibranchia, p. 148-204 In: *The geology of British Somaliland. II. Mesozoic paleontology of British Somaliland*, (8): 148-204.
- Cox, L.R.** 1940. The Jurassic lamellibranch fauna of Kachh (Cutch). *Memoir Geological Survey of India, Palaeontologia Indica*, 9, 3 (3): 157 p., 10 pls.
- Cox, L.R.** 1952. The Jurassic lamellibranch fauna of Cutch (Kachh). Families Pectinidae, Amusiidae, Plicatulidae, Limidae, Ostreidae and Trigonidae (Supplement). *Memoir Geological Survey of India, Palaeontologia Indica*, 9, 3 (4): 128 p., 12 pls.
- Cox, L. R. and Arkell, W. J.** 1948-1949. A survey of the Mollusca of the British Great Oolite Series. *Palaeontographical Society of London, Monograph.*, 102-103, XXIV + 105 p.
- Cox, L. R. and Newell, N. D.** 1969. Family Pholadomyidae Gray 1847, N827-N838. In: *Treatise on Invertebrate Palaeontology* (Eds. Moore, R.C. et al.) pt. N, mollusca 6, bivalves 2. Geological Society of America and University of Kansas Press.
- Fantini Sestini, N.** 1966. Upper Liassic molluscs from Shemshak Formation. *Rivista Italiana di Paleontologia e stratigraphia*, 72: 795-852, pl.56-60.
- Ficcarelli, G.** 1968. Fossili giuresi della serie sedimentaria del Nilo Azzurro meridionale. *Rivista Italiana di Paleontologia e Stratigraphia*, 74: 23-50, 3 figs., 1 tab., pls. 1-5.
- Fischer, J.-C.** 1969. Géologie, paléontologie et paléoécologie du Bathonien en sud-ouest du Massif Ardennais. *Mémoires de Musée de Histoire Naturelle, C*, 20: 1-319, 21 pls.
- Fürsich, F.T.** 1982. Upper Jurassic bivalves from Milne Land, East Greenland. *Bulletin Greenland Geologiske Undersogelse*, 144: 1-126 p.
- Fürsich, F.T., Heinze, M. and Jaitly, A.K.** 2000 Contributions to the Jurassic of Kachchh, western India. VIII. The Bivalve fauna. Part IV. Subclass Heterodonta. *Beringeria*, 27:63-146, 50 text figs., 18 pls.
- Fürsich, F.T., Pandey, D. K., Callomon, J. H., Jaitly, A. K. and Singh, I. B.** 2001. Marker beds in the Jurassic of Kachchh Basin, western India: Their depositional environment and sequence stratigraphic significance. *Journal of Palaeontological Society of India*, 46: 173-198.
- Jaitly, A. K.** 1981. Biostratigraphical and palaeoecological studies of the Jurassic rocks of Kala Dongar, Pachchham Island, District Kachchh, Gujarat. *Unpublished Ph. D. Thesis, Banaras Hindu University, Varanasi*.
- Jaitly, A.K.** 1986a. *Indomya*, a new subgenus of *Pholadomya* from the Middle Jurassic of Kachchh, western India (Bivalvia: Pholadomyidae). *The Veliger*, 28: 457-459.
- Jaitly, A.K.** 1986b. Revised morphotaxonomic description of six Middle Jurassic pholadomyoid clams from Kala Dongar, Pachchham Island, District Kachchh, Gujarat. *Indian Minerals*, 40: 39-46.
- Jaitly, A. K., Fürsich, F. T. and Heinze, M.** 1995. Contributions to the Jurassic of Kachchh, western India. IV. The bivalve fauna. Part I. Subclasses Palaeotaxodonta, Pteriomorphia, and Isofilibranchia. *Beringeria*, 16: 147-257, 23 figs., 1 tab., 23 pls.; Würzburg.
- Jaitly, A. K., Karkare, S. G. and Singh, C. S. P.** 1980. Igneous rocks associated with the Bajocian sediments of Kala Dongar, Pachchham Island, District Kachchh, Gujarat. *Bulletin of Earth Sciences*, 8: 1-6.
- Jaitly, A. K. and Singh, C. S. P.** 1983. Discovery of Late Bajocian *Leptosphinctes* Buckman (Jurassic Ammonitina) from Kachchh, western India. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, 1983:91-96.
- Jaitly, A. K. and Singh, C. S. P.** 1984. On the Bathonian (Middle Jurassic) ammonites *Micromphalites* Buckman and *Gracilisphinctes* Buckman from Kachchh, western India. *Geological Magazine*, 121(4): 3119-321.
- Kanjilal, S.** 1978. Geology and stratigraphy of the Jurassic rocks of Habo Hill, District Kutch (Gujarat). *Proceedings Indian National Science Academy, Part A, Physical Sciences*, 44(1): 1-15.
- Kennedy, W. J. and Hall, A.** 1967. The influence of organic matter on preservation of aragonite in fossils. *Geological Society of London, Proceedings*, 1643:253-255.
- Kitchin, F.L.** 1903. The Jurassic fauna of Cutch. The Lamellibranchia, genus *Trigonia* *Memoir Geological Survey of India, Palaeontologia Indica*, 9, 3, pt. 2, (1): 122 S., 10 pls.
- Krishna, J. and Ojha, J. R.** 1996. The Callovian ammonoid chronology in Kachchh, (India), p.151-166. In: *Advances in Jurassic Research* (Ed. Ricardi, A.C.), *Geo Research Forum*, 1-2.
- Lissajous, M.** 1907-1912. *Jurassique Maconnais*. Macon (Protat).
- Loriol, P. de** 1903. Étude sur les mollusques et brachiopodes de l'Oxfordien supérieur et moyen du Jura Lédonien. *Mémoires de la Société Paléontologique Suisse*, 30: 77-160, pl.6-19.
- Pandey, D. K., Fürsich, F. T. and Heinze, M.** 1996. Contributions to the Jurassic of Kachchh, western India. V. The bivalve fauna. Part II. Subclass Anomalodesmata. *Beringeria*, 18: 51-87.
- Phillips, J.** 1829. *Illustrations of the Geology of Yorkshire accompanied by a geological map, sections, and plates of the fossil plants and animals*. York (Wilson & Sons).
- Poddar, M. C.** 1959. Stratigraphy and oil possibilities of Kutch. *Proceedings of Symposium on the Developments of Petroleum Research, ECAFE*, 146-148.
- Poddar, M. C.** 1964. Mesozoic of western India - Their Geology and Oil possibilities. *Proceeding of 22nd International Geological Congress*, 126-143.
- Rajnath.** 1932. A contribution to the stratigraphy of Cutch. *The Quarterly Journal of Geological, Mining and Metallurgical Society of India*, 4:161-174.
- Rajnath.** 1942. The Jurassic rocks of Cutch – their bearing on some problems of Indian Geology. *Proceedings 29th Indian Science Congress*, 93-106.
- Roemer, F.A.** 1836. *Die Versteinerungen des norddeutschen Oolithen-Gebirges*. 2.: 75-134, pl.13-16, Hannover (Hahn).
- Rollier, L.** 1913. Fossiles nouveaux ou peu connus des terrains secondaires (mésozoïques) du Jura et de contrées environnantes. *Mémoires de la Société Paléontologique Suisse*, 39: 149-318, pl.13-20. Genève
- Ronchetti, C.R.** 1970. New contributions to the knowledge of the Jurassic fauna of Karhar (Northeast Afghanistan). Italian expedition to the Karakorum (K2) and Hindu Kush, *Scientific Report IV, Paleontology - Zoology - Botany*, 2: 43-74, pls. 6-11;
- Runnegar, B.** 1974. Evolutionary history of the bivalve subclass Anomalodesmatata. *Journal of Paleontology*, 48(5): 904-939.
- Singh, C. S. P., Jaitly, A. K. and Pandey, D. K.** 1982. First report of some Bajocian-Bathonian (Middle Jurassic) ammonoids and the age of the oldest sediments from Kachchh. *Newsletter on Stratigraphy*, 11: 37-40.

- Singh, G. S. P., Jaitly, A. K. and Pandey, D. K.** 1983. A new Middle Jurassic bivalve genus, *Agrawalimya*, from Kachchh (Gujarat), India. *The Veliger*, **24**: 273-275.
- Skelton, P. W. and Benton, M. J.** 1993. Mollusca: Rostroconchia, Scaphopoda and Bivalvia, p.227-264. In: *The Fossil Record 2* (Ed. Benton, M.J.), London (Chapman & Hall).
- Spath, L. F.** 1927-33. Revision of Jurassic Cephalopod fauna of Kachh(Cutch). *Memoirs of the Geological Society of India, Palaeontologia Indica*, new series **9**, *Memoir 2*(1-6): 1-945.
- Stanley, S. M.** 1970. Relation of shell form to life habits in the Bivalvia (Mollusca). *Geological Survey of America, Memoir*, **125**: 496 p.
- Tamura, M.** 1960. Heterodont and other pelecypods from the Upper Jurassic Soma Group, Japan. *Transactions Proceedings of Palaeontological Society of Japan, N.S.*, **39**: 285-292. Tokyo.
- Thevenin, A.** 1906-1923. Types du Prodrome de Paléontologie stratigraphique universelle d'Alcide d'Orbigny. Tome I. Silurien - Bathonien. *Annales de Paléontologie*, **1-12**, 1-189, Paris.
- Waagen, W.** 1873-1976. Jurassic fauna of Kutch. The Cephalopoda. *Memoirs of the Geological society of India, Palaeontologia Indica*, new series **9**, *Memoir 1*(1-4): 1-247.
- Waterhouse, J. B.** 1966. On the validity of the Permian bivalve family Pachydomidae Fischer 1887. *Journal of Geological Society of Australia*, **13**: 543-559.
- Zakharov, V. A. and Mesezhnikov, M. S.** 1974. The Volgian stage of the subarctic Ural. *Akademia Nauk USSSR, Sibirskoe Otdelenig, Instut Geologii i Geofiziki.*, **196**: 216 pp., 49 figs., 38 pls.; Novosibirsk.
- Zinsmeister, W. J.** 1978. Review of the bivalve genus *Pholadomya* from the Tertiary of California and description of two new species. *The Veliger*, **21**(2): 232-235.

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