

BATHONIAN-CALLOVIAN FAUNA OF WESTERN BELA ISLAND (KUTCH) :
 PT I—BIVALVE FAMILIES CARDIIDAE, NEOMIODONTIDAE AND CORBULIDAE

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ABSTRACT

Fifteen bivalve species belonging to the families Cardiidae, Neomiodontidae and Corbulidae have been described from the Bathonian-Callovian rocks of Western Bela Island. Out of them, nine have been given new names and one (already known from elsewhere) has been reported for the first time from India. The genus *Protocardia* was hitherto unknown from the Rann islands. *Protocardia (Protocardia) grandidieri* (Newton) and *Corbula (Corbula) lyrata* J. de C. Sowerby are the most abundantly occurring forms.

INTRODUCTION

Although Bela Island stands out prominently amidst the vast plains of the Rann as a detached mass (Fig. 1) it is an important area by reason of spectacular development of Bathonian-Callovian succession with rich crop of varied fauna and flora. The Jurassic outcrops stretch from a little east of the village of Bela ($23^{\circ}52'35''$ lati-

tude and $70^{\circ}48'13''$ longitude) to the western extremity of the island, a distance of 28.8 km along the northern border in its western part and forms a separate dome (Mouwana Hill) near the village of Mouwana which is situated in the east. There is, however, very little published account of the stratigraphy and fossil faunas of the present area lying between $23^{\circ}50'$ and $23^{\circ}57'36''$

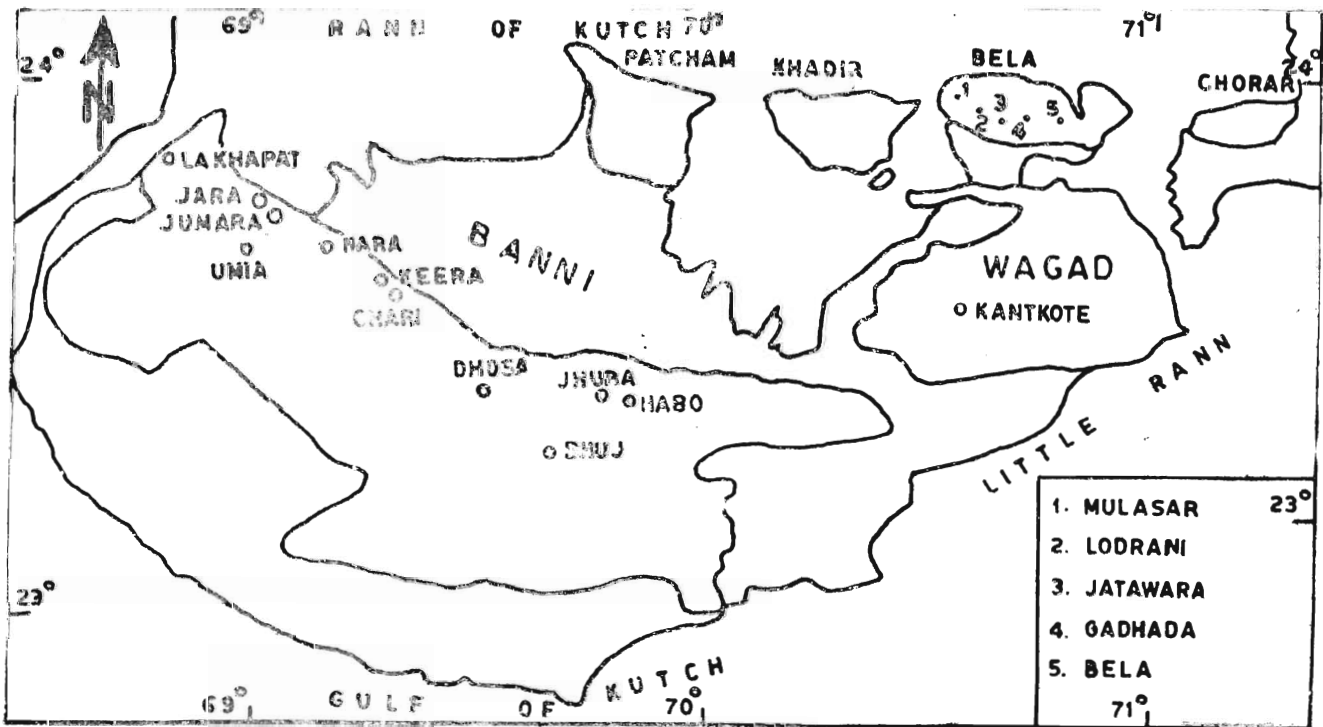


FIG. 1. LOCALITY MAP

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north latitudes and 70°32'33" and 70°49'23" east longitudes. The sequence given by Wynne (1872, pp. 111 and 114) is very general and incomplete. Only 17 bivalve species were reported by earlier workers while the cephalopods, a dominant element in Kutch faunas, were supposed to be absent in this region.

The Western Bela sequence is markedly distinct in lithology, faunal content and particularly in the presence of plant remains in a couple of beds of the succession, and differs from those in the Mainland of Kutch and other islands in the Rann. Hence, it is being designated here by a new lithostratigraphic name, Bela Formation. The stratigraphical succession is given in the Table below. This formation has been subdivided into an Upper and a Lower Member on the basis of lithology and fossil forms. Further sub-division of either Member into lower, middle and upper zones has been done informally strictly on the nature of sediments.

FOSSIL BIVALVES

About 4000 specimens of bivalves in addition to five of cephalopods were collected bed by bed by the writers. Out of them, a little more than 3000 individuals of the former have been identified and referred to 180 forms belonging to 68 genera (and subgenera) which are assigned to 34 families. Their preservation is satisfactory on the whole.

It is intended to deal here with only three families, viz. Cardiidae, Neomiodontidae and Corbulidae. They are represented by *Protocardia* von Beyrich, *Eomiodon* Cox and *Corbula* Bruguière, each belonging to the three families respectively. *Eomiodon* is known by 120 individuals whereas the other two genera have numerous specimens. They comprise fifteen species, listed below, including nine which have been given new names.

Protocardia (*Protocardia*) *dyonisea* Buvignier, *Protocardia* (*Protocardia*) *lodraniensis* sp. nov., *Protocardia* (*Protocardia*)

Table 1. Stratigraphical Succession of the Bela Formation

Formation	Member	Zone	Bed No. with lithology	Thickness (Metres)	Age
Undifferentiated Tertiaries					
—Unconformity—					
B E L A	U P	Upper or sandy zone	31 Brown, coarse-grained, calcareous sandstone	2.5+	
			30 Yellow, hard, flaggy limestone	2.0—5.0	
			29 Coarse-grained, friable sandstone	20.0—45.0	C
			28 Fossiliferous, calcareous flags with interbedded shale	3.0—9.0	A
			27 Brown sandstone	15.0—36.0	L
	P	Middle or shaly zone	26 Coralline limestone	1.0—2.0	L
			25 Brown, hard, calcareous sandstone with yellow marl at top	1.0—3.0	O
	R	Lower or calcareous zone	24 Yellow shale	?	V
			23 Fossiliferous, calcareous flags	0.08—3.0	I
			22 Green and violet shale with evaporite and lignite	3.0—3.5	A
			21 White, coarse-grained sandstone	6.0—21.0	N
			20 Yellow, sandy limestone with interbedded golden oolites, shales and marls-conglomeratic at the base	30.5—45.0	
—Disconformity—					
F O R M A T I O N	L O W E R	Upper or sandy zone	19 Yellow shale	0—5.0	B
			18 White, coarse-grained sandstone	9—0—45.0	
			17 Fossiliferous marl with thin bands of calcareous flags	1.0—10.0	A
			16 Brown, calcareous sandstone	1.5—30.5	
			15 Fossiliferous marl with thin bands of calcareous flags and lignite	6.0—30.5	T
	M I D D L E	Middle or shaly zone	14 Ferruginous siltstone and mudstone with plant fossils	0.5—9.0	
			13 Fossiliferous marl with thin bands of calcareous flags	6.0—30.0	H
			12 Ferruginous sandstone with plant fossils	1.0—15.0	
	U P P E R	Lower or sandy zone	11 Ferruginous, fossiliferous mudstone	0.5—9.0	O
			10 White sandstone	0.5—20.0	
			9 Yellow and ochre-red shales with ferruginous siltstone	1.0—24.0	N
			8 Calcareous sandstone	0.5—18.0	
			7 Yellow shale with evaporite	6.5—9.0	I
	B E L A	Lower or sandy zone	6 Calcareous sandstone	3.0	
			5 Green shale with evaporite	1.5	A
4 Gritty sandstone			30.5		
			3 Variegated shale with evaporite	6.0	N
			2 Coarse-grained, friable sandstone	36.0	
			1 Yellow shale	?	
Base not exposed					

rammurtii sp. nov., *Protocardia* (*Protocardia*) *grandidieri* (Newton), *Protocardia* (*Protocardia*) *keenae* sp. nov.; *Protocardia* (*Protocardia*) sp.; *Eomiodon baroni* (Newton), *Eomiodon rajendrai* sp. nov., *Eomiodon hayamii* sp. nov.; *Corbula* (*Corbula*) *lyrata* J. de C. Sowerby, *Corbula* (*Corbula*) aff. *kaitanensis* Cox, *Corbula* (*Corbula*) *coxi* sp. nov., *Corbula* (*Corbula*) *gadhadaensis* sp. nov., *Corbula* (*Corbula*) *minuta* sp. nov. and *Corbula* (*Corbula*) *basseae* sp. nov.

The specimens described/illustrated in the present paper are lodged in the Department of Geology, Banaras Hindu University.

For taxonomic purposes the authors have followed the classification given in the Treatise edited by Moore and others (1969). All the measurements are in millimetres. The figures in parentheses after those of height and inflation represent their percentage with respect to length.

SYSTEMATIC DESCRIPTION

<i>Class</i>	Bivalvia LINNÉ, 1758
<i>Order</i>	Veneroida ADAMS & ADAMS, 1856
<i>Family</i>	Cardiidae LAMARK, 1809
<i>Genus</i>	<i>Protocardia</i> VON BEYRICH, 1845
<i>Type species</i>	<i>Cardium hillanum</i> J. SOWERBY, 1813 ; SD HERRMANNSEN, 1847. Lower Cretaceous ; England.

Subgenus—*Protocardia* s. s.

Protocardia (*Protocardia*) *dyonisea* (BUVIGNIER)

Cardium dyoniseum Buvignier, 1852, p. 16, Pl. 13, figs. 28-29.

Protocardia dyonisea (Buvignier) : Arkell, 1934, p. 304, Pl. 42, figs. 8-11.

Protocardia cf. *dyonisea* (Buvignier) : Agrawal, 1956, p. 117.

Material : Three specimens.

Dimensions :

Sp. No.	L	H	I
B/183/88	17.5	16.3 (92.7)	11.0 (62.7)
B/64/68	22.0	20.0 (90.9)	14.0 (62.7)

Remarks : The specimens, although of variable size and proportions, are identical to the Fakirwari specimens (Singh Colln., B. H. U.) referred to this species by Singh (MS, 1961, p. 134, figs. 72a-c). The Jhura specimen (No. B-J/G/54, Agrawal Colln., B. H. U.) is less inflated than the holotype, but, as pointed out by Singh (*loc. cit.*) belongs to this species.

The present record of the species further lowers its known horizon in Kutch to the lowermost Callovian.

Horizons and Localities :

Bed No. 26 (Collorion)—N of Jatawara;

Bed No. 20 (Callovian)—N of Mulasan and
W of Regosar

Protocardia (*Protocardia*) *lodraniensis* sp. nov.¹

(Pl. I—15)

Material : Several well preserved bivalve specimens.

Description : Shell of medium size, moderate inflation and sub-quadrangular to sub-elliptical outline. Umbones prominent, pointed, slightly above the hinge line, prosoyrous and situated a little anterior to the median. Lunule absent ; escutcheon ill-defined, small and shallow where perceptible. Ligamental nymph visible in some of the specimens. Anterior and posterior margins equally and gently convex to more or less straight ; ventral margin feebly arched. Posterior part of the surface differentiated from the remainder by a sudden increase in slope and ornamented with nine to seventeen prominent radial ribs which are, as a rule, absent from a narrow strip just adjacent to the posterior margin. Surface anterior to the posterior slope smooth except for fine growth lines.

Interior not exposed in any of the specimens.

Dimensions :

Sp. No.	L	H	I
Holotype (B/88/54)	29.5	24.0 (81.3)	14.0 (47.1)
Paratype (B/47/80)	40.0	34.0 (85.0)	22.0 (55.0)

Remarks : Keen (1951 ; 1969, p. 588) considers *Protocardia* s. s. to bear well developed concentric ribs and hence, reference of the present specimens with more or less smooth central and anterior surface to this subgenus may appear to be somewhat unusual. But it may be borne in mind that the genotype *Cardium hillanum* Sowerby is also not very coarsely ribbed concentrically. Further, Cox (1965, p. 103, Pl. 16, fig. 5) also has referred *P. consobrinum* Terquem and Jourdy with almost smooth anterior and central surface like in the present species to *Protocardia* s. s. The species just referred to is undoubtedly the closest ally but that form is taller with umbones projecting much more dorsally than in the present species.

Horizons and Localities :

Bed No. 23 (Callovian)—N of Gadhada ;

Bed No. 20 (Callovian)—NW of Bela and W of
Ragosar ;

Bed No. 17 (Bathonian)—N of Lodrani ;

Bed No. 11 (Bathonian)—NW of Lodrani.

Protocardia (*Protocardia*) *rammurtii* sp. nov.¹

(Pl. I—20a, b)

Material : Holotype and a slightly broken paratype.

¹The species has been named after the village of Lodrani.

Description : Shell large, moderately inflated and sub-ovate in outline. Umbo prominent, acutely rounded, much salient dorsal to the hinge, prosogyrous and situated slightly anterior to middle of the shell-length. Dorsal margin almost straight, meeting the truncated posterior one in a rounded off angle slightly exceeding 90°, and strongly arched anterior margin in a smooth curve. Ventral margin gently but asymmetrically arched, meeting the posterior in a sharp curve and the anterior in a broad one. Inflation maximum in the centre of the shell from where the surface slopes uniformly and steeply on all sides except the dorsal, where the slope is gentle. Shell-surface smooth except for radial riblets in the posterior region demarcated anteriorly by an ill-defined carina. A narrow band adjacent to the posterior margin is smooth.

Dimensions :

Sp. No.	L	H	I
Holotype (H/152/73)	52.5	45.5 (86.7)	30.0 (57.1)

Remarks : The Somalian species *Protocardia somaliensis* Cox (1935b, p. 186, Pl. 20, figs. 2a, b) at first sight looks very similar to the present form. The Kutch species is, however, more elongated, less inflated and has a comparatively poorly defined posterior carina.

P. intexta (Münster) described by Arkell (1936, p. 372, Pl. 51, fig. 11) from the Corallian of England is a comparatively smaller and taller form and lacks the smooth posterior strip, so characteristic of the present species. *Cardium dissimile* Phillips (1829, Pl. 5, fig. 27, non J. de C. Sowerby) (= *P. subdissimile* d'Orbigny, 1850, p. 338, and *C. fallax* Phillips, 1875, p. 251) is slightly more elongate with mesial umbones and radial ribs up to the posterior margin. The preceding species *Protocardia ledraniensis* sp. nov. differs by its smaller size, more elongate form and less salient umbones.

Horizons and Localities :

Bed No. 25 (Callovian)—NE of Jatawara ;
Bed No. 20 (Callovian)—W of Ragosar.

Protocardia (Protocardia) grandidieri (NEWTON)
(Pl. I—11-13)

Corbula grandidieri Newton, 1895, p. 84, Pl. 3, figs. 15-16.

Protocardia grandidieri (Newton) : Cox, 1935a, p. 8, Pl. 1, figs. 10-15.

Material : Numerous specimens.

Dimensions :

Sp. No.	L	H	I
B/50/88	25.0	19.0 (76.0)	14.5 (58.0)
B/88/41	27.0	22.0 (80.0)	19.0 (69.0)
B/105/1	25.0	20.5 (82.0)	15.0 (60.0)
B/50/86	25.0	23.0 (92.0)	20.0 (80.0)
B/52/37	22.0	21.0 (95.4)	16.3 (73.9)
B/52/61	22.0	22.5 (102.3)	18.0 (81.8)

Remarks : Specimens belonging to this species occur extensively in the Bela Formation wherefrom hundreds of specimens have been collected. They show a wide range of variation in shape and size ; height varies from 75 percent to more than 102 percent while inflation ranges from 50 to 80 percent of the length. In general they are more gibbose than the type specimens of the species which have an inflation of about 65 per cent of the length. In some of the specimens the umbones are slightly anterior to median. In the more gibbose specimens the posterior area is at a higher level than the remainder of the surface and bears several closely spaced concentric plications crossed by faint and wavy radial threads restricted mainly in the dorsal half. In spite of all these variations in characters, they cannot be referred to more than one species since they intergrade very smoothly and occur together at the same horizon.

The Attock district specimens referred to this species by Cox (*loc. cit.*) are on the whole more elongate than the type specimens.

Horizons and Localities :

The specimens have been collected from almost all the fossiliferous horizons i.e. Bed Nos. 11, 13, 15, 17 (Bathonian), 20, 23, 26, 28 and 30 (Callovian) of all the localities.

Protocardia (Protocardia) keenae sp. nov.²
(Pl. I—1a, b)

Material : Numerous specimens.

Description : Shell generally small, occasionally of medium size, well inflated and sub-ovate to sub-quadrangular outline ; length exceeds the height and maximum inflation is in the umbonal region. Umbones more or less mesial, contiguous, prosogyrous and salient. Lunule wide and shallow. Postero-dorsal margin horizontal or sloping gently, meeting the truncated posterior margin obtusely ; antero-dorsal margin makes a shoulder-like angle with the rounded anterior one when it is horizontal, but meets in a rounded-off angle when it is more or less gently sloping. Ventral margin feebly to strongly convex, meeting the anterior and posterior margins uninterruptedly.

Surface sculpture consists of both radial and concentric patterns. The radials consist of ten fine ribs which are restricted to the posterior area where they are crossed by growth lines. The posterior area is demarcated from the main surface by a very fine ridge running from the umbo towards postero-ventral corner. The concentric component ornaments the central and anterior regions of the surface and is represented by fine, closely and evenly spaced threads up to a distance of 6 to 7 mm from the umbo and sharp, coarse but widely spaced ribs thereafter ventrally.

¹The species has been named after Dr. Ram Murti Singh.

²The species is named after Dr. Myra Keen.

Dimensions :

Sp. No.	L	H	I
Holotype (B/47/70)	14.0	12.0 (85.7)	10.0 (71.1)
Paratype (B/10/7)	13.5	12.0 (88.9)	8.5 (63.0)
„ (B/88/53)	14.0	12.5 (89.3)	8.5 (60.7)
„ (B/105/2)	18.0	15.0 (83.0)	11.0 (61.0)
„ (B/105/27)	21.5	17.0 (79.0)	11.5 (53.4)

Remarks : The specimens under study are generally small (about 12 mm long) although some may be as long as 22 mm. Development of shoulder-like angle anterior to the umbones is conspicuously present in taller individuals whereas the elongated ones (height less than 80 percent of length) do not have a shoulder.

This species differs from *P. (P.) grandidieri* (Newton) just discussed in the nature of ornamentation and position of the umbo.

Horizons and Localities :

- Bed No. 28 (Callovian)—NE of Jatawara ;
 Bed No. 20 (Callovian)—NW of Bela ;
 Bed Nos. 17 & 15 (Bathonian)—N of Lodrani.

Protocardia (Protocardia) sp.

(Pl. I—17)

Material : One specimen.

Remarks : It is a slightly crushed bivalve specimen measuring 32 mm in length, 20 mm in height and 16 mm in thickness with a more or less rectangular outline. Two diagonal ridges appear to run from the umbones to the two ends of the ventral margin. The posterior area bears 14 radial ribs and the main surface of the shell is smooth except for growth lines.

At first sight it reminds of the genus *Mactromya* Agassiz from which it can, however, be readily distinguished by the presence of radials in the posterior region. The authors are unaware of any species of *Protocardia* resembling the present specimen. However, any attempt at its specific determination is deferred till more material is available.

Horizon and Locality : Bed No. 15 (Bathonian)—N of Mulasar.

Family Neomiodontidae CASEY, 1955

Genus *Eomiodon* COX 1935

Type species *Eomiodon indicus* COX 1935a, Middle Jurassic, Kutch.

Eomiodon baroni (NEWTON)

(Pl. I—16, 19)

Astarte ? baroni Newton, 1889, p. 336, Pl. 14, figs. 9-11.

Eomiodon baroni (Newton) : Cox, 1965, p. 114, Pl. 18, fig. 11.

Material : About a hundred well preserved specimens.

Description : The specimens are of medium size, moderately inflated, equivalve, inequilateral, and subovate in outline with truncated posterior end. The test is thick. The umbones are sharply pointed, contiguous, prosogyrous, incurved and placed between the anterior-quarter and anterior-sixth of the length. Lunule is small, shallow and transversely ovate ; the escutcheon is wide, moderately excavated or well impressed, extending from the umbones to the postero-ventral angle, and delimited by sharp umbonal ridges. The anterior margin is short and convex and meets the gently arched ventral margin in a rounded off obtuse curve ; the posterior margin is long and straight, converging with the ventral margin in an acutely rounded curve. Maximum shell-inflation is along a line parallel and slightly anterior to the posterior margin.

The surface ornamentation consists of well raised, sharp, concentric ribs which become irregular and more closely crowded in the ventral-half of the surface.

Dimensions :

Sp. No.	L	H	I
B/109/90	36.0	30.0 (83.3)	15.0 (41.3)
B/110/12	24.5	21.5 (87.7)	14.0 (57.1)

Remarks : According to Cox (*loc. cit.*) *E. indicus* (Cox 1935a, p. 7, Pl. 1, figs. 17—19) is much more strongly inflated than any specimen of *E. baroni* from Madagascar, the type area of the latter form. The specimens now recorded show a wide range of variation in length to height ratio and inflation. They agree well with *E. baroni* in all respects and differ from *E. indicus* Cox by being only a little less inflated (57.1 percent of length against 62 percent of *indicus*). But this little variation can not be regarded as of specific significance, especially when one has at his disposal a series of specimens which although otherwise identical, differ in inflation by 16 per cent with intergrading valves. Hence, the two forms may be considered to be synonymous with *E. baroni* as the valid specific name because of its priority by 46 years. However, since the present authors have not the opportunity of examining the holotypes of both the species (lodged in the British Museum Natural History) and the other type specimens of *indicus* are not traceable in the G.S.I. museum, a merger of both the species is deferred for the present.

Horizon and Localities :

Bed No. 17 (Bathonian)—NE or Gadhada and N of Jatawara ;

Bed No. 11 (Bathonian)—N and NW of Lodrani.

*Eomiodon rajendrai sp. nov.*¹

(Pl. I—18a, b)

¹The species is named after Shri (since Dr.) Rajendra Prasad Kachhara.

Material : Five specimens.

Description : Shell medium to large in size, moderately inflated, elongate and sub-cuneiform. Umbones small, prosogyrous, sharply pointed, slightly incurved and situated at about anterior-fifth of the length. Anterior margin rounded, strongly convex except for a slight concavity in the region of lunule. Postero-dorsal margin feebly convex or almost straight and sloping gently from umbo to the postero-ventral corner. Ventral margin straight to feebly convex, meeting the postero-dorsal margin in a sharply acute angle of 60°—70°, and the anterior in an obtuse curve. Lunule very small and shallow; escutcheon wide, lanceolate extending from umbo to the postero ventral corner and bounded by sharp ridges. Surface ornamented with raised, sharp, concentric rugae near the umbo, which become finer, irregular and closely-spaced at the ventral margin.

Dimensions :

Sp. No.	L	H	I
Holotype (B/109/94)	33.0	24.5 (72.7)	14.5 (43.9)
Paratype (B/109/97)	38.5	27.0 (70.1)	18.0 (46.7)

Remarks : This species differs from *E. baroni* discussed earlier by its much elongate outline and more anteriorly placed umbones. *Eomiodon namatuensis* Reed (1936, p. 20, Pl. 2, figs. 1-3) from the Bathonian rocks of Namayu Series, Burma, appears to be more or less of similar outline but is of much smaller size. Moreover, the type specimens of the Burmese species are partly hidden under the matrix and so nature of the escutcheon and their complete outline is only a matter of conjecture.

Eomiodon namguriensis Cox (1965, p. 116, Pl. 18, figs. 14a, b) is of comparatively very large size.

Horizon and Locality : Bed No. 11 (Bathonian)—N and NW of Lodrani.

Eomiodon hayamii sp. nov.¹
(Pl. I—4)

Material : Fifteen specimens.

Description : Shell medium to large, moderately to strongly inflated and sub-trigonal with almost equal length and height, the latter attaining its maximum very near the anterior margin. Umbones prominent, pointed, prosogyrous, small, and placed at anterior-eighth of the shell-length. Anterior margin gently convex, meeting the convex ventral margin in a rounded-off obtuse angle. Postero-dorsal margin long, nearly straight or gently arched, sloping down steeply and meeting the ventral margin acutely. Lunule small, poorly defined, shallow; escutcheon well defined, lanceolate and bounded by sharp ridges. Ligament nymph clearly visible near the umbonal region.

Shell-surface ornamented with narrow, sharp, thin, widely but irregularly spaced ribs; they are less prominent near the anterior and postero-dorsal margins. Escutcheon smooth except for fine growth lines.

Dimensions :

Sp. No.	L	H	I
Holotype (B/51/32)	22.0	22.0 (100.0)	11.5 (52.2)
Paratype (B/204/98)	27.0	25.5 (94.0)	13.5 (49.0)

Remarks : The present species has a much taller outline than all the species of the genus described/discussed on earlier pages. *E. namyauensis* Reed (1936, p. 21, Pl. 2, fig. 4), described from the Bathonian of Namayu Series, Burma, and *E. chumphonensis* Hayami (1960, p. 284, text figs. 1-2) from the Jurassics of Thailand, are distinguished by more pointed and more projected umbones. The African species *E. dinosaurianus* Cox (1965, p. 116, Pl. 18, figs. 15a, b; 16a, b) is comparatively smaller in size and of ovate outline.

Horizons and Localities :

Bed No. 17 (Bathonian)—NE of Gadhad
Bed No. 11 (Bathonian)—N of Lodrani.

Order Myoida STOLICZKA, 1870

Family Corbulidae LAMARACK, 1809

Genus *Corbula* BRUGUIÈRE

Type species : *Corbula sulcata* LAMARACK, 1801; SD SCHMIDT, 1818, Recent; W. Africa.

Subgenus *Corbula* s. s.

This genus has been supposed to range from Cretaceous to Recent (Keen in Moore and others, 1969, p. N692). *Corbulomima* Vokes is the only genus of the family assigned to the Jurassic. However, several species of *Corbula* have been recorded from Jurassic by earlier workers. Dentition of those forms conforms with that of *Corbula*. The specimens here referred to six species show typical dentition of *Corbula* s. s., restricted to Recent by Keen (*loc. cit.*).

Corbula (Corbula) lyrata J. DE C. SOWERBY
(Pl. I—8-10)

Corbula lyrata J. de C. Sowerby, 1840, Pl. 21, fig. 13 and explanation.
Corbula pectinata J. de C. Sowerby, 1840, Pl. 61, figs. 4, 4a and explanation.

Corbula pectinata J. de C. Sowerby: Newton, 1895, p. 83, Pl. 3, figs. 17-18.

Corbula lyrata J. de C. Sowerby: Cox, 1935a, p. 11, Pl. 1, figs. 7-9.

Material : About 400 specimens.

Description : The specimens range from small to medium in size and trigonal to trigonally ovate in outline with length equal to, or slightly in excess of, the height. Inflation varies from 50 percent to as high as 92 percent of the shell-length. The umbones are tumid, incurved, orthogyrous, contiguous and mesial or sub-

¹The species has been named after Prof. Dr. I. Hayami.

mesial. Antero-dorsal and postero-dorsal margins are almost straight and gently inclined, the corresponding profiles are straight and concave respectively. The anterior margin is short and acutely rounded; the posterior end is short and pointed in smaller specimens but more or less rostrate in larger ones. The ventral margin is feebly to strongly convex. Lunule is deeply excavated while the escutcheon is well defined, with slightly produced posterior termination, and bounded by carinated margins. The carina of the left valve is low and straight but that of the right valve is strong and arched, and occasionally a shallow, smooth sulcus, just anterior to it, runs from the umbo to the posterior end. The shell surface bears bold, sharp, elevated and irregular concentric ribs. The interspaces bear close-set transverse crenulations or striae which are pronounced on the left valve and nearly obsolete on the right valve.

The hinge structure of the right valve consists of one stout cardinal tooth with one posterior lateral tooth, while the left valve has one posterior cardinal and two lateral ones.

Dimensions :

Sp. No.	L	H	I
B/141/86	20.0	15.5 (75.2)	10.0 (50.0)
B/88/71	20.5	18.5 (90.2)	19.0 (92.6)
B/90/75	20.0	19.0 (95.2)	14.75 (73.7)
B/88/88	15.0	11.0 (73.3)	8.5 (56.7)

Remarks : There is a good deal of variation in shape and size of the shell, and also nature of the carina. In some of the specimens from Bed No. 23 the umbones are situated in the posterior-half of the shell-length. But a careful comparison at equal stages of growth makes it impossible to separate them under more than one species. An equal range of variation is found in the nature of the posterior end which becomes pointed and rostrate with increase in size. Variations in concentric ornamentation from thick, rounded ribs to sharp, narrow ones which occasionally project sufficiently in the form of flanges is, of course, abrupt, but cannot be considered to be of specific significance. On the whole, they agree well with the type figures. *Corbula pectinata* J. de C. Sow. (*loc. cit.*), also figured by Newton (*loc. cit.*) is in no way different from the present species and hence, has been considered here as a synonym. Judging only by the figures, Newton's specimens appear to be a little taller than the present ones but they are otherwise indistinguishable specifically.

The species was so far recorded only from the Bathonian, but the present occurrences extend its range up in Callovian.

Horizons and Localities : The specimens occur extensively in almost all fossiliferous beds Nos. 11, 13, 15,

17 (Bathonian), 20, 23, 26, 28, 30 (Callovian) of the Bela Formation.

Corbula (Corbula) aff. kaittanensis Cox
(Pl. I—2)

Material : Five specimens.

Description : The specimens are small and sub-trigonal, length only slightly exceeding the height. Right valve is large and more strongly inflated than the left; both valves are attenuated posteriorly. The umbones are rounded, prominent and placed slightly anterior to the middle of the length. The lunule and escutcheon are ill-defined. The antero-dorsal margin is straight and sloping steeply to the broadly rounded anterior end; the postero-dorsal profile is parasigmoidal; the ventral margin is gently convex. The shell-surface is ornamented with narrow and slightly unevenly spaced, sharp but fine concentric threads.

Dimensions :

Sp. No.	L	H	I
B/150/55	8.8	7.0 (87.5)	6.5 (81.2)
B/168/31	5.0	4.2 (84.0)	2.5 (50.0)

Remarks : These well preserved bivalve specimens agree with *Corbula kaittanensis* Cox (1965, p. 125, Pl. 19, figs. 13a, b) from the Oxfordian of Tanganyika in general outline and other characters, but differ in the absence of sinuosity near the posterior extremity, and lesser convexity of the ventral margin. Moreover, Cox's species is from a higher horizon, i.e. Oxfordian.

Horizon and Localities : Bed No. 28 (Callovian)—N and NE of Jatawara.

Corbula (Corbula) coxi. sp. nov.¹
(Pl. I—5a, b)

Material : Sixteen specimens.

Description : Shell small, moderately inflated, almost equivalve and trigonally ovate. Umbones small, rounded, obtuse, more or less mesial. Lunule and escutcheon poorly demarcated and shallow. Dorsal margins straight, sloping gently from the umbo; antero-dorsal profile concave. Anterior and posterior margins acutely rounded to sub-angular, ventral margin gently arched. Posterior rostrum absent or rudimentary. A sharp carina extends from the umbo to the postero-ventral corner in each valve; it is more prominent on the right valve than on the left. The area posterior to the carina is narrow and convex in the right valve but concave in the left.

Shell-surface ornamented with fine, sharp, concentric ribs which gradually increase in strength ventrally, the umbonal region remaining smooth up to a height of

¹The species has been named in memory of Dr. L. R. Cox.

2-3 mm. In addition, radial threads are present in some interspaces near the ventral margin of the left valve.

Dimensions :

Sp. No.	L	H	I
Holotype (B/118/16)	12.0	9.5 (79.2)	6.0 (50.0)
Paratype (B/118/14)	13.0	9.0 (69.2)	6.0 (46.2)

Remarks : Lycett (1863) described a small form under the name *Corbula involuta* Münster (p. 63, Pl. 37, figs. 4, 49) from the Great Oolite of Kirklington, which was later considered to be a synonym of *Corbula buckmani* Lycett (*op. cit.*, pp. 63, 64, 121, Pl. 37, fig. 8) by Cox and Arkell (1948, p. 42). The latter species is definitely attenuated posteriorly but the former, as judged from the figure, does not appear to be rostrate or attenuated at all as mentioned by Lycett. The two forms present different outlines and do not appear to be conspecific. The present species appears to be the nearest ally of the Kirklington form which differs by its much finer ornamentation and absence of radials in the interspaces near the ventral margin of the left valve. *Corbula buckmani* is readily distinguished by its attenuated posterior end and finer ornamentation. The African species *C. kailtanensis* Cox (1965, p. 125, Pl. 19, figs. 13a, b) is more inequivalve, and has submesial umbones and feebler concavity along the antero-dorsal profile. In addition it lacks the radial threads in ventral interspaces of the left valve.

Horizons and Localities :

Bed No. 23 (Callovian)—NE of Gadhada ;
Bed No. 17 (Bathonian)—N of Lodrani.

Corbula (Corbula) gadhadaensis sp. nov.¹

(Pl. I—3a, b)

Material : Four specimens

Description : Shell medium sized, strongly inequivalve, pyriform. Right valve larger and strongly inflated; its surface falls abruptly at about posterior-fourth of the length to form a concave area which bears a sharp carina placed slightly posterior to median. Left valve smaller, moderately inflated in the anterior-half and flat to concave in the posterior-half with a parallel-sided, rather wide, canal-like structure adjacent to, and running parallel to the postero-dorsal margin. Umbo of the right valve prominent, broadly rounded, strongly incurved and prosogyrous; that of the left valve narrow and pointed, placed posterior to and concealed partly under the right umbo. Antero-dorsal margin almost straight and steeply sloping while the postero-dorsal one concave and equally inclined. Anterior margin short, obtusely rounded; posterior end produced in a rostrum, its extremity situated slightly dorsal to the middle of the shell height. Ventral margin asymmetrical but gently arched. Shell-surface

ornamented with fine, evenly-spaced, concentric riblets; in the right valve the riblets are stronger than those on the left and do not continue over the concave area.

Dimensions :

Sp. No.	L	H	I
Holotype (B/118/3)	12.0	9.5 (79.2)	6.5 (54.2)
Paratype (B/141/67)	13.0	10.6 (80.8)	6.5 (50.0)

Remarks : This new species bears resemblance only to the Callovian form *Corbula daghaniensis* Cox (1935b, p. 193, Pl. 21, fig. 3) described from Somalia, which is known by its right valve. However, the present species can be distinguished by its lesser inflation, more produced rostrum and strongly inequivalve shell.

Horizon and Localities : Bed No. 23 (Callovian)—N. and NE of Gadhada.

Corbula (Corbula) minuta sp. nov.

(Pl. I—7, 14)

Material : Numerous specimens.

Description : Shell small, inequivalve, pyriform, unevenly inflated. Umbones prominent, placed anterior to the median, contiguous, prosogyrous and slightly incurved. Lunule heart-shaped, well-excavated; escutcheon absent. Antero-dorsal margin short, straight and inclined at an angle of about 35°; postero-dorsal margin long, concave and gently sloping. Anterior margin acutely rounded; posterior margin rostrate and angular; ventral margin gently but asymmetrically arched. An oblique carina extends from the umbo to the postero-ventral corner separating a posterior area which is rather broad and concave on the left but narrow and convex on the right valve. The carina of the right valve is demarcated anteriorly by a groove.

Surface ornamented with evenly-spaced, fine sharp, well-raised concentric threads which are numerous and attenuated near the rostrum in the left valve. Hinge is only partly exposed showing one thick and raised anterior cardinal with a pit, and a narrow, elongate, posterior lateral in the right valve; a posterior cardinal and sockets corresponding to the right valve teeth are present in the left valve.

Dimensions :

Sp. No.	L	H	I
Holotype (8/150/49)	11.25	8.1 (72.0)	8.0 (71.0)
Paratype (B/150/70)	10.0	6.0 (60.0)	5.5 (55.0)
Paratype (B/150/67)	9.2	6.5 (70.7)	5.0 (54.3)

Remarks : The present species is characterized by its small size and differs in this respect from all the corbulid forms described from Kutch. *Corbula kailtanensis* Cox (1965, p. 125, Pl. 19, figs. 13a, b) differs readily by its

¹The species is named after the village of Gadhada.

smaller rostrum, more mesial umbones, parasigmoidal postero-dorsal margin and strongly arched ventral margin. The English Bathonian species *Corbula buckmani* Lycett (*op. cit.*) is comparatively bigger and non-rostrate. *Corbula mandwaensis* Cox (1965, p. 121, Pl. 19, figs. 7a, b, 8a, b) from the Bajocian (?) of Tanganyika is another comparable species which has, however, mesial umbones and strongly convex anterior margin.

Horizon and Localities : Bed No. 28 (Callovian)—NE of Jatawara and N of Gadhada.

Corbula (Corbula) bassae. sp. nov.¹

(Pl. I—6a, b)

Material : Numerous specimens.

Description : Shell of medium size, only slightly inequivalve and trigonal with length almost equal to or slightly in excess of the height. Both valves strongly gibbose, inflation of the right being a little more than that of the left valve ; they taper posteriorly to form a short and blunt rostrum. Umbones prominent, mesial and incurved ; the left umbo is placed behind, and rides over, the right umbo. Antero-dorsal margin straight, gently sloping ; postero-dorsal margin longer, feebly concave and steeply sloping. Anterior margin short and acutely convex. Ventral margin gently convex but for a slight-sinuosity near its posterior end, which corresponds to a sulcus on the sides running from the umbo to the postero-ventral corner. Shell surface ornamented with fine, closely-spaced, rounded, concentric threads. Posterior-half of the left valve bears, in addition, some radial threads.

Dimensions :

Sp. No.	L	H	I
Holotype (B/152/14)	15.0	13.5 (90.0)	12.5 (83.8)

Remarks : *Corbula hulliana* Morris (1857, p. 104, Pl. 1, fig. 6-6c ; also Arkell 1931, p. 598, Pl. 49, figs. 10, 11) is the only form which compares closely with the species now described. It has, however, no definite rostrum and its umbones are less incurved. From the Kutch species of *Corbula*, described on the preceding pages, it is readily distinguished by the presence of radial threads over the posterior-half of its left valve.

Horizons and Localities :

Bed No. 26 and 23 (Callovian)—N and NE of Gadhada and Jatawara ;

Bed No. 17 (Bathonian)—N of Gadhada and N, NE and NW of Lodrani and Mulasar.

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¹The species is named in honour of Madam É. Basse of France.

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EXPLANATION OF PLATE

PLATE I

(All illustrations are of natural size, unless otherwise stated)

1. *Protocardia (Protocardia) keena* sp. nov. Holotype (B/47/70). Bed No. 23, Upper Member of Bela Formation (Callovian), N of Gadhada (a) LV ext., (b) Dorsal view ($\times 1.14$)
2. *Corbula (Corbula) aff. kailtanensis* Cox. LV ext. (B/150/55). Bed No. 28, Upper Member of Bela Formation (Callovian), NE of Jatawara ($\times 1.8$)
3. *Corbula (Corbula) gadhadaensis* sp. nov. Holotype (B/118/3). Bed No. 23, Upper Member of Bela Formation (Callovian), NE of Gadhada (a) LV ext., (b) Dorsal view ($\times 1.6$)
4. *Eomiodon hayamii* sp. nov. RV ext. of Holotype (B/51/32). Bed No. 17, Lower Member of Bela Formation (Bathonian), NE of Gadhada.
5. *Corbula (Corbula) coxi* sp. nov. Holotype (B/118/16). Bed No. 23, Upper Member of Bela Formation (Callovian), NE of Gadhada. (a) LV ext., (b) Dorsal view ($\times 2$)
6. *Corbula (Corbula) basseae* sp. nov. Holotype (B/152/14). Bed No. 23, Upper Member of Bela Formation (Callovian), NE of Gadhada. (a) LV ext. ($\times 1.3$), (b) Dorsal view ($\times 1.6$)
7. *Corbula (Corbula) minuta* sp. nov. Holotype (B/150/49). Bed No. 28, Upper Member of the Bela Formation (Callovian), NE of Jatawara (a) RV ext. ($\times 1.8$), (b) Dorsal view ($\times 2$)
8. *Corbula (Corbula) lyrata* (J. de C. Sowerby). (B/90/71), Bed No. 15, Lower Member of Bela Formation (Bathonian), N of Lodrani. (a) LV ext., (b) Dorsal view.
9. *C. (C.) lyrata*. RV int. (B/174/17) showing dentition. Bed No. 23, Upper Member of Bela Formation (Callovian), N of Jatawara ($\times 1.4$)
10. *C. (C.) lyrata*. LV int. (B/155/18) showing dentition. Same horizon and locality. ($\times 1.4$)
11. *Protocardia (Protocardia) grandidieri* (Newton). (B/88/41). Bed No. 17, Lower Member of Bela Formation (Bathonian), N of Lodrani (a) LV ext., (b) Post. view.
12. *P. (P.) grandidieri*. RV int. (B/88/40). Same horizon and Locality.
13. *P. (P.) grandidieri*. LV int. (B/88/46). Same horizon and Locality.
14. *Corbula (Corbula) minuta* sp. nov. LV int. (B/150/40) showing dentition. Bed No. 28, Upper Member of Bela Formation (Callovian), NE of Jatawara. ($\times 2$)
15. *Protocardia (Protocardia) lodraniensis* sp. nov. LV ext. of the Holotype (B/88/54). Bed No. 17, Lower Member of Bela Formation (Bathonian), N of Lodrani.
16. *Eomiodon baroni* (Newton). RV ext. (B/216/78). Bed No. 17, Lower Member of Bela Formation (Bathonian), NE of Gadhada.
17. *Protocardia (Protocardia) sp.*, RV ext. (B/69/2). Bed No. 15, Lower Member of Bela Formation (Bathonian), N of Mulasar.
18. *Eomiodon rajendrai* sp. nov. Holotype (B/109/94). Bed No. 11, Lower Member of Bela Formation (Bathonian), NW of Lodrani. (a) RV ext., (b) Dorsal view.
19. *Eomiodon baroni* (Newton). LV int. (B/52/98) showing dentition. Bed No. 17, Lower Member of Bela Formation (Bathonian), NE of Gadhada.
20. *Protocardia (Protocardia) rammaurtii* sp., nov. Holotype (B/152/73). Bed No. 26, Upper Member of Bela Formation (Callovian), NE of Jatawara. (a) RV ext., (b) enlargement of posterior part showing radials.

