Some Unknown Arcid Bivalves from the Turonian (Late Cretaceous) of Central India

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Abstract: Five arcid bivalves have been recorded for the first time from the Turonian (Late Cretaceous) sediments exposed in the form of the Nodular Limestone Formation of the Bagh Group, Lower Narmada Basin of central India. These benthic bivalves are represented by Barbatia (Cucullaearca) cf. clellandi Stoliczka, Breviarca baghensis sp. nov., Glycymeris sp., Trigonarca camerunensis Riedel, Trigonarca galdrina d’Orbigny and Grammatodon cf. japeticum Forbes. All these five species have been systematically described with remarks on their occurrences outside the Narmada Basin.

Keywords: Bivalvia, Arcid, Taxonomy, Late Cretaceous, Central India.

1. Introduction

The superfamily Arcoidea, though having its origin in Paleozoic have much evolutionary diversification during Mesozoic which continued further to Recent. Most of them are known from shallow marine settings with a benthic mode of life. In the Indian subcontinent these are fairly represented in the Jurassic (Jaitly et al., 1995). During Cretaceous Period, there is a global dispersal of these arcids from equatorial to polar regions with some modification in taxodont dentition (Buick, 2009). The modification in dentition is also accompanied by change to duplivinicular ligament with thickening of anterior and posterior ends due to addition of material (Thomas et al., 2000). With the increase in the global temperature during Late Cretaceous there is sudden decline in the density of these arcids (Souji and Radhakrishnan, 2013) as we also observed in the Bagh Group. The arcids of the Bagh Group, Lower Narmada Basin of central India have both semi-infaunal and epifaunal mode of life. The semi-infaunals preferred sandy to muddy substrate of the shallow marine environment while the epifaunal are nestlers with byssus sinus in the middle of the ventral margin and are found in hard calcareous substrate. The morphology and small size of these nestlers promote relatively quiet and nutrient deficient habitat.

The present contribution includes the systematic description of the bivalve species based on 8 moderately well preserved specimens collected from Turonian sediments cropping out in the form the Nodular Limestone Formation of the Bagh Group exposed near the villages Chakrur, Sitapuri and Rampura of Dhar district, Madhya Pradesh. Out of the 5 species differentiated, Trigonarca camerunensis Riedel recorded for first time from the Indian subcontinent, Barbatia (Cucullaearca) cf. clellandi Stoliczka, Trigonarca galdrina d’Orbigny and Grammatodon cf. japeticum Forbes are new to the Narmada basin while Breviarca baghensis is new to the science. Almost all the specimens are disarticulated and also subjected to some diagenetic alteration. The record of these five species from the Narmada Basin may in turn help in better understanding of the palaeobiogeography in and around the Indian subcontinent during Turonian interval (Late Cretaceous).

2. Geology of the Area

Narmada Basin formed by rifting in the middle part of the Indian subcontinent through twisting and northward movement of the Indian plate resulted in the formation of an intracratonic graben delimited by Narmada-Son Lineament (Biswa, 1982, 1999, 2005-6; Gupta et al., 1972, 1997; Chandra, 1977; Acharya et al., 1998; Tripathi, 2006; Khan, 2015; West, 1962; Merh, 1995; Anand and Rajaram, 2004). The Cretaceous sediments directly overlie the crystalline rocks of Precambrian age. These Cretaceous sediments of the Narmada Basin are popularly known as „Bagh Beds” (Fig. 1) and now recognized as Bagh Group (Jaitly and Ajane, 2013). The geology and stratigraphy of the „Bagh Beds” have been variously reviewed and modified from time to time by several workers (Bose, 1884; Rode and Chiplonkar, 1935; Singh and Srivastava, 1981; Akhtar and Khan, 1997; Kumar et al., 1999). However, it has been comprehensively reviewed in recent years by Tripathi (2006) and Jaitly and Ajane (2013), which is followed here in the present work. The Bagh Group of the Narmada basin has been differentiated into Nimar Sandstone, Nodular Limestone and Coralline Limestone formations in ascending order. Further, the Nimar Sandstone Formation is subdivided into Bagh Cave and Baria members while the Nodular Limestone Formation into Karondia and Chirakhan members in ascending order (Table 1).
3. Systematic Palaeontology

Authors have followed the standard methodology earlier used in Moore *et al.* (1969) and recently revised by Carter *et al.* (2011) for taxonomic description. All the measurements are in millimeter. The following abbreviations have been used for taxonomic representations:

H: height; L: length; I: Inflation; BV: both valves; LV: left valve; RV: right valve; S. No: Serial Number.

**Repository:**
The specimens of the present study are stored in the Stratigraphy and Invertebrate Palaeontology Laboratory, Department of Geology, Banaras Hindu University.

**Subclass:** Pteriomorphia Beurlen, 1944  
**Order:** Arcida Lamarck, 1809  
**Superfamily:** Arcoidae Lamarck, 1809  
**Family:** Arcidae Lamarck, 1809

**Subfamily:** Arcinae Lamarck, 1809  
**Genus:** Barbatia Gray, 1842  
**Subgenus:** Cucullaearca Conard, 1865  
**Type species:** *Byssosarca lima* Conard, 1847; SD Stoliczka, 1871

**Barbatia (Cucullaearca) cf. clellandi (Forbes)**  
(Fig. 2A)

1846 *Arca clellandi* Forbes, p.139, p. 14, fig.4.  
1871 *?Scapharca clellandi* Forbes: Stoliczka, p.356, pl. 17, fig. 35.

**Material:** Single specimen (BHU2014/Ck1/90)  
**Horizon:** Nodular Limestone,  
**Locality:** Chakur Village, Dhar District

**Dimensions:**

| S.No | Specimen No. | H (mm) | L (mm) | I (mm) |
|------|--------------|--------|--------|--------|
| 1    | BHU2014/Ck1/90 | 8      | 15     | 6(RV)  |

**Description**
The shell is subquadrate in outline, small and moderately inflated. Umbo though broken along antero-dorsal margin, appears to be small, prosogyrous and slightly protruding above dorsal margin and situated about 25% length from the anterior margin. A faint umbonal ridge runs obliquely towards the posterior margin. Antero-dorsal and anterior margins are broken but apparently the anterior one is broader and rounded. Postero-dorsal margin is long and straight and posterior margin feebly rounded. Both anterior and posterior margins merging smoothly with symmetrically rounded ventral margin. The ventral margin has a median sinus. Surface is ornamented with fine growth lamellae intersected by fine radial threads.

**Remarks**
*Arca clellandi* has been recorded by to Forbes (1846) from the Cretaceous rocks of Cauvery Basin which has been later doubtfully kept under the genus *?Scapharca* Gray, 1847 by Stoliczka (1871, p.356). Additionally, according to Newell (in Moore *et al.* 1969, p. 256) the genus *Scapharca* ranges in age from Oligocene to Recent. The sub-quadrate outline, median sinus in ventral margin, remnant of amphidatic cardinal area and cancellate ornamentation allow us to keep *Arca clellandi* Forbes under *Barbatia (Cucullaearca)* Conard. This specimen from the Bagh Group has been assigned to *Barbatia (Cucullaearca) cf. clellandi* (Forbes) with qualification due to its poor state of preservation.

**Subfamily:** Noetiinae Stewart, 1930  
**Genus:** Breviarca Conard, 1872  
**Type species:** *Arca centenaria* Say, 1824

**Breviarca baghensis** sp. nov.  
(Figs. 2B, C)

**Material:** Single specimen (BHU2014/Rn3/12)  
**Horizon:** Nodular Limestone Formation  
**Locality:** Near Ramapura Village, Dhar District
Dimensions:

| S.No | Specimen No. | H (mm) | L (mm) | I (mm) |
|------|--------------|--------|--------|--------|
| 1    | BHU2014/ Ra3/12 | 8      | 11     | 4(RV)  |

Etymology: After the Bagh town, Central India.

Diagnosis:
Shell small, subtrapezoidal, postero-ventrally elongated and radially ornamented, hinge with taxodont dentition having posterior series longer than anterior one.

Description:
The present specimen represents the right valve which is small, sub-trapezoidal in outline, strongly inflated and postero-ventrally elongated. Umbo prominent, slightly raised above dorsal margin with 105° umbonal angle, opisthogyrous, situated at about 40% of length from the anterior end. Antero-dorsal margin small, rounded and forming steep declivation with umbonal ridge. Anterior margin gently convex and merges smoothly with asymmetrically rounded ventral margin. Postero-dorsal margin comparatively longer with steep declivation. Posterior margin is produced and evenly rounded. Anterior umbonal ridge obtusely rounded and almost vertical. Posterior umbonal ridge is oblique and fades before reaching postero-ventral corner. Hinge long, narrow and straight with numerous transverse teeth. The posterior series of teeth longer than the anterior series. The shell surface is ornamented with numerous obtusely rounded marginal ribs becoming scabrous due to presence of ventrally arcuate scales. The radials posterior to posterior ridge are finer and separated by narrower interspaces. All these radials are beaded throughout at regular intervals. The radials are forming scalloped ventral margin.

Remarks:
This specimen from the Bagh Group in its small size (L=11, H=8) and subtrapezoidal outline is quite distinct from the all the known species of Breviarca Conard from the Late Cretaceous. The umbo is also anteriorly positioned while in most of the known species of Breviarca it is mesial to submesial. In size and surface ornamentation, the present specimen is comparable to Breviarca umbonata Conard recorded by Richards (1991, p. 83, pl. 13, figs. 12, 13) from the Cretaceous of New Jersey but in B. umbonata the umbo is mesial and the shell is subtrigonal. Breviarca habita Stephenson (1952, p. 60, pl. 10, fig. 19, 20) and also recorded by Scott (1970, p. 59, pl. 1, figs. 11-12) from Kiowa Formation, Kansas has some resemblance in size (smaller) and ornamentation but due to mesial umbo, the outline is quite different. This lone specimen is perfectly preserved and depicting all the diagnostic morphological features definitely belonged to a new species.

Family: Glycymerididae Newton, 1922
Subfamily: Glycymeridinae Newton, 1922
Genus: Glycymeris De Costa, 1778
Type species: Arca orbicularis De Costa, 1778 (= Arca glycymeris, Linné, 1758)

Glycymeris sp.
(Figs. 2D, E, F, G)

Material: Two specimens (BHU2014/Ks6/9, BHU2014/Si 7/24)
Horizon: Nodular Limestone
Locality: Kosdana and Sitapuri villages, Dhar district

Dimensions:

| S.No | Specimen No. | H (mm) | L (mm) | I (mm) |
|------|--------------|--------|--------|--------|
| 1    | BHU2014/ Ks6/9 | 22     | 17     | 9(RV)  |
| 2    | BHU2014/Si7/24 | 22     | 16     | 9(RV)  |

Description and Remarks:
The specimens are of moderate size, approaching subquadrate shape, moderately inflated and postero-ventrally elongated. Umbones small, pointed, bending inward to just reach dorsal margin of the hinge plate and not projecting beyond that. The anterior margin rather small and convex whereas posterior margin broadly concave. Shell attains its maximum inflation in the middle from where it slopes gently towards the dorsal margin and steeply towards rest of the margins. The broadly convex ventral margin meets the anterior margin at obtuse angle and with broadly concave posterior margin at acute angle. The narrow, slightly curved hinge plate consists of series of small, parallel teeth. The surface is eroded but appears to have faint concentric ribs near the postero-ventral margin. Due to broken margins, its specific identification has been differed and recorded here as Glycymeris sp.

Subfamily: Arculaceinae Newell, 1969
Genus: Trigonarca Conrad, 1862
Type species: Cucullaea macoensis Conard, 1860

Trigonarca camerunensis Riedel
(Figs. 2H, I)
1932 Trigonarca camerunensis Riedel, p.43, pl. 7, figs. 2-7
1954 Trigonarca camerunensis camerunensis Riedel, Reyment, p. 675
1957 Trigonarca camerunensis Riedel, Dartevelle & Freneix, p. 28, pl. 2, figs. 2-9

Material: Single specimen (BHU2014/Si3/11)
Horizon: Nodular Limestone
Locality: Sitapuri Village, Dhar district

Dimensions:

| S.No | Specimen No. | H(mm) | L(mm) | I (mm) |
|------|--------------|-------|-------|--------|
| 1    | BHU2014/Si3/11 | 18     | 22     | 7(RV)  |

Description:
Shell small, subtrigonal, postero-ventrally elongated with moderate inflation. Length is appreciably greater than height. Umbo prominent, prosogyrous, slightly protruding above the dorsal margin and anteriorly situated. Antero-dorsal margin concave and anterior margin feebly rounded and produced, postero-dorsal margin almost straight and posterior margin obliquely truncated. Both anterior and posterior margins are merging smoothly with broadly rounded ventral margin. A faint posterior carina separates a small, feebly convex posterior region. Surface is eroded but near the ventral margin coarse commarginal ribs are present. Hinge plate subarcuate having thick platforms near the

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antero-dorsal and postero-dorsal margins. The dentition consists of small series of teeth.

Remarks:
Although the lone present specimen is not much postero-ventrally elongated but in its subarcuate hinge with oblique teeth and thick margins of hinge plate resembles well to *Trigonoarca camerunensis* Riedel particularly recorded by Dertevelle & Freneix (1957, p. 28, pl. 2, figs. 2-9) from the Cretaceous of Angola. *T. camerunensis* has been so far confined to Upper Cretaceous (Cenomanian-Campanian) of central and east African regions, its record from the Turonian of central India is noteworthy.

*Trigonoarca galdrina* d’Orbigny
(Fig. 2J)

1871 *Trigonoarca galdrina* d’orbigny: Stoliczka, p. 355, pl. 18, figs. 2-5.

Material: Single specimen (BHU2014/Rn1/26)
Horizon: Nodular Limestone
Locality: Near Rampura Village, Dhar district

Dimensions:

| S. No | Specimen No. | H(mm) | L(mm) | I(mm) |
|-------|--------------|-------|-------|-------|
| 1     | BUH2014/Rn1/26 | 8     | 13    | 6(LV) |

Description:
The shell is small, subtrapezoidal, strongly inflated with wide cardinal area. Right valve is slightly smaller and more inflated than the left valve. Umbo blunt, prosogyrous, slightly incurved anteriorly, nearly protruding from the hinge and situated at approximately at one-third of length from the anterior end. Both antero-dorsal and postero-dorsal margins are feebly concave. Anterior margin rounded whereas posterior margin slightly produced and both are merging with straight ventral margin in regular curves. A faint carina extends obliquely from umbo to postero-ventral corner. Ornamentation is obscured by erosion.

Remarks:
The present specimen closely resembles to *Grammatodon japeticum* Forbes: Stoliczka, pl. 18, pl. 6-11

Horizon: Nodular Limestone
Locality: Near Karondia Village, Dhar district

Dimensions:

| S. No | Specimen No. | H(mm) | L(mm) | I(mm) |
|-------|--------------|-------|-------|-------|
| 1     | BUH2014/K-10 | 12    | 18    | 12(BV) |
| 2     | BUH2014/Kar2/36 | 11    | 16    | 10(BV) |

Description:
The shell subtrapezoidal, strongly inflated with wide cardinal area. Right valve is slightly smaller and more inflated than the left valve. Umbo blunt, prosogyrous, slightly incurved anteriorly, nearly protruding from the hinge and situated at approximately at one-third of length from the anterior end. Both antero-dorsal and postero-dorsal margins are feebly concave. Anterior margin rounded whereas posterior margin slightly produced and both are merging with straight ventral margin in regular curves. A faint carina extends obliquely from umbo to postero-ventral corner. Ornamentation is obscured by erosion.

Remarks:
The present specimen closely resembles to *Grammatodon japeticum* Forbes: Stoliczka, p. 350, pl. 18, figs. 6-11) from south India in most of the characters, but in view of the absence of surface ornamentation, it has been tentatively assigned to *G. cf. japeticum*. It has almost similar outline as in *Grammatodon (Nanovis) subcrenulatus* Kendrik and Vartack (2007, p. 20, figs. 3E-J) recorded from Karai Formation (Albian), Cauvery Basin, south India but is less inflated and possesses faint umbal carina. *G. (N.) yokoyamai* Yabe and Nagao from the Upper Neocomian - Albian of Japan by Hayami (1980, p. 428-430, pl.52, figs 1-6) closely resembles to the present species but Japanese species has prominent cancellate ornamentation along with sharp anterior and posterior umbal carinae.

**Family:** Parallelodontidae Dall, 1898

**Subfamily:** Grammatodontinae Stephenson, 1941

**Genus:** Grammatodon Meek & Hayden, 1861

**Type species:** *Arca (Cucullaea) inornata* Meek & Hayden, 1859

*Grammatodon cf. japeticum* Forbes

![Figure 2: Arcid Bivalve from Nodular Limestone Formation (Turonian), Bagh Group.](image-url)
A *Barbatia (Cucullaea) cf. celledandi* (Stoliczka, 1871) External view of right valve x2 (specimen no. BHU2014 ck1/90).

B, C *Breviarca baghensis* sp. nov. B. External view of right valve x2 (specimen no. BHU2014 Rn3/12), C. Internal view of right valve x2 (same specimen).

D, E, F, G *Glycymeris* sp. D. External view of right valve x1.5 (specimen no. BHU2014 Ks6/9), E. Internal view of right valve x1.5 (same specimen), F. External view of right valve x1.5 (specimen no. BHU2014 Si7/24), G. Internal view of right valve x1.5 (same specimen).

H, I *Trigonarca camerunensis* Riedel (Dertevelle and Freneix,1957) H. External view of right valve x1.5 (specimen no. BHU2014 Si3/11), I. Internal view of right valve x1.5 (same specimen).

J. *Trigonarca galdrina d’Orbigny* (Stoliczka, 1871) External view of left valve x2 (specimen no. BHU2014 Rn1/26).

K, L *Grammatodon cf. japetum* Forbes (Stoliczka, 1871) K. External view of Right valve x1.5 (specimen no. BHU2014 K-10) L. Dorsal view x1.5 (same specimen).

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