



## Fossils bivalves from the Upper Bhuban unit, Bhuban Formation of western Aizawl, Mizoram, India

Victor Zochhuana Ralte

Department of Geology, Mizoram University Aizawl 796 004, India

Received 10 February 2012 | Accepted 12 March 2012

### ABSTRACT

The intraformational conglomeratic bands and brown silty-sandstones of the Upper Bhuban unit, Bhuban Formation of western Aizawl, India, have yielded 44 species of bivalves belonging to 26 genera and 17 families. Out of these 44 species, seven species, namely *Barbatia* sp., *Arcopsis* sp., *Cyclocardia* sp., *Clinocardium* sp., *Cultellus* sp., *Gari (Psammobia) kingi* (Noetling), and *Corbula (Corbula) mekranica* Vredenburg are reported and illustrated for the first time from the Bhuban Formation of Mizoram. The first-five species listed above, however, could not be identified at the specific level for want of better-preserved materials and more detail information. A close study of these fossil assemblages reveals that, the Upper Bhuban unit of Bhuban Formation of western Aizawl has a geological age ranging from Aquitanian to Burdigalian, i.e. Lower Miocene age (20 to 23 million years).

**Key words:** Bhuban Formation; bivalves; intraformational conglomerate; silty-sandstone.

### INTRODUCTION

The bivalves described and illustrated in this paper come from the six fossil localities of Upper Bhuban unit, Bhuban Formation of western Aizawl city. The fossil yielding beds in the study area comprise mainly of two rock types namely, intraformational conglomeratic bands and silty-sandstones. There are six fossil localities in the study area. These bivalves are found in association with fish remains mainly in the form of teeth and dental plates, and poorly preserved gastropods, decapods,

and mono generic form of a foraminifer (*Ammonia* sp.).

The preservation of bivalves is generally poor and mostly in the form of moulds and casts of isolated valves except for some few specimens. However, the essential external features are observable enough to facilitate the identification up to species level. The identification of genera and species is mainly based on the external morphological characters and comparison with the type specimens. Internal features have also been considered wherever observable. The classification adopted for the systematic study of bivalves is after Newell, 1965.<sup>1</sup> All the fossil materials described and illustrated herein are housed at

Corresponding author: Ralte  
Phone: +91-9436151276  
E-mail: [vicralte@yahoo.co.in](mailto:vicralte@yahoo.co.in)

the Palaeontology Laboratory of the Department of Geology, Mizoram University, India.

## MATERIALS AND METHODS

### Geological settings

Geologically, Mizoram is a part of the Tripura-Mizoram Accretionary belt of Cenozoic age. It is considered to be the southern extension of the Surma basin.<sup>2-5</sup> The entire sedimentary succession of Mizoram consists of a rhythmic alternation of arenaceous and argillaceous rocks with a thickness of about 8000 meters. Main rock types exposed in this area are sandstone, siltstone, shale, mudstone, sand rock, silt and their admixture of varying proportions along with a few pockets of shell-limestone, calcareous sandstone and intraformational conglomerates.

The Tertiary rocks of Mizoram have been grouped sequentially into Barail, Surma and Tipam Groups in ascending order of their age respectively. The Surma Group is divisible into a lower Bhuban Formation and an upper Boka Bil Formation. Bhuban Formation is further divisible into lower, middle and upper Bhuban Units.<sup>6-8</sup>

### Fossil localities descriptions

The first fossil locality is Bika quarry (N 23° 45' 184" – E 92° 40' 792") located about 13 km on the western fringe of Aizawl towards Mizoram University road (Fig. 1). Fossils were collected from the two intraformational calcareous conglomeratic bands at 0.95-1.30 m and 8.50-8.65 m levels respectively.

The second is Ruata quarry (N 23° 45' 143" – E 92° 40' 631"), located about 12 km west of Aizawl city on the right side Sakawrtuichhun road. It is the strike continuation of the first fossil locality. There are two fossiliferous intraformational calcareous conglomeratic bands, the lower one at 0-0.33 m and the upper one at 4.5-4.9 m stratigraphic

levels.

Small exposure just opposite to Youth Hostel, Luangmual West on the right side of Aizawl to Geology and Mining Office road constitutes the third fossil locality (N 23° 44' 241" – E 92° 41' 606"). It is a road-cut section and is about 6 km from Aizawl. The fossiliferous bed at this locality is represented by 27 m thick brown coloured silty-sandstone.

The fourth fossil locality is a road cut section right in front of Faith Academy School and is around 5.5 km from Aizawl at the right side of Mizoram University road (N 23° 44' 241" – E 92° 41' 756"). Fossiliferous horizon at this locality consists of a nearly 20 m brown coloured silty-sandstone.

The fifth fossil locality (N 23° 44' 121" – E 92° 41' 713") as shown in Figure 1 consists of nearly 11.0 m thick silty-sandstone that is fine grained, well bedded and compact.

The sixth locality is at about 7.5 km from Aizawl on the Aizawl to Luangmual Complex road at Zonuam (N 23° 44' 006" – E 92° 41' 821"). A fourteen meter thick brown silty-sandstone constitutes fossiliferous bed.

## RESULT AND DESCRIPTIONS

### Systematic palaeontology

Order NUCULOIDA Dall, 1889  
Family NUCULIDAE Gray, 1824  
Genus *Nucula* Lamarck, 1799  
*Nucula (Nucula) agrawali* Tiwari, 1992  
(Plate 1, Figs. 1-2)

#### Dimensions (mm):

Sp. no.	Length	Height	Inflation	
B/GZ-216	28.00	18.00 (64.24)	10.00 (35.71)	BV
B/GZ-217	30.00	22.00 (73.33)	16.00 (53.33)	BV

**Description:** Two complete specimens are recovered from locality no. 6. The distinguishing characters of the species, viz. subtrigonal to transversely elongate outline, moderate inflation, small, pointed, opisthogyrous and posterior-fifth umbo are clearly discernable in the specimens at hand. Besides, the specimens closely resemble with the speci-

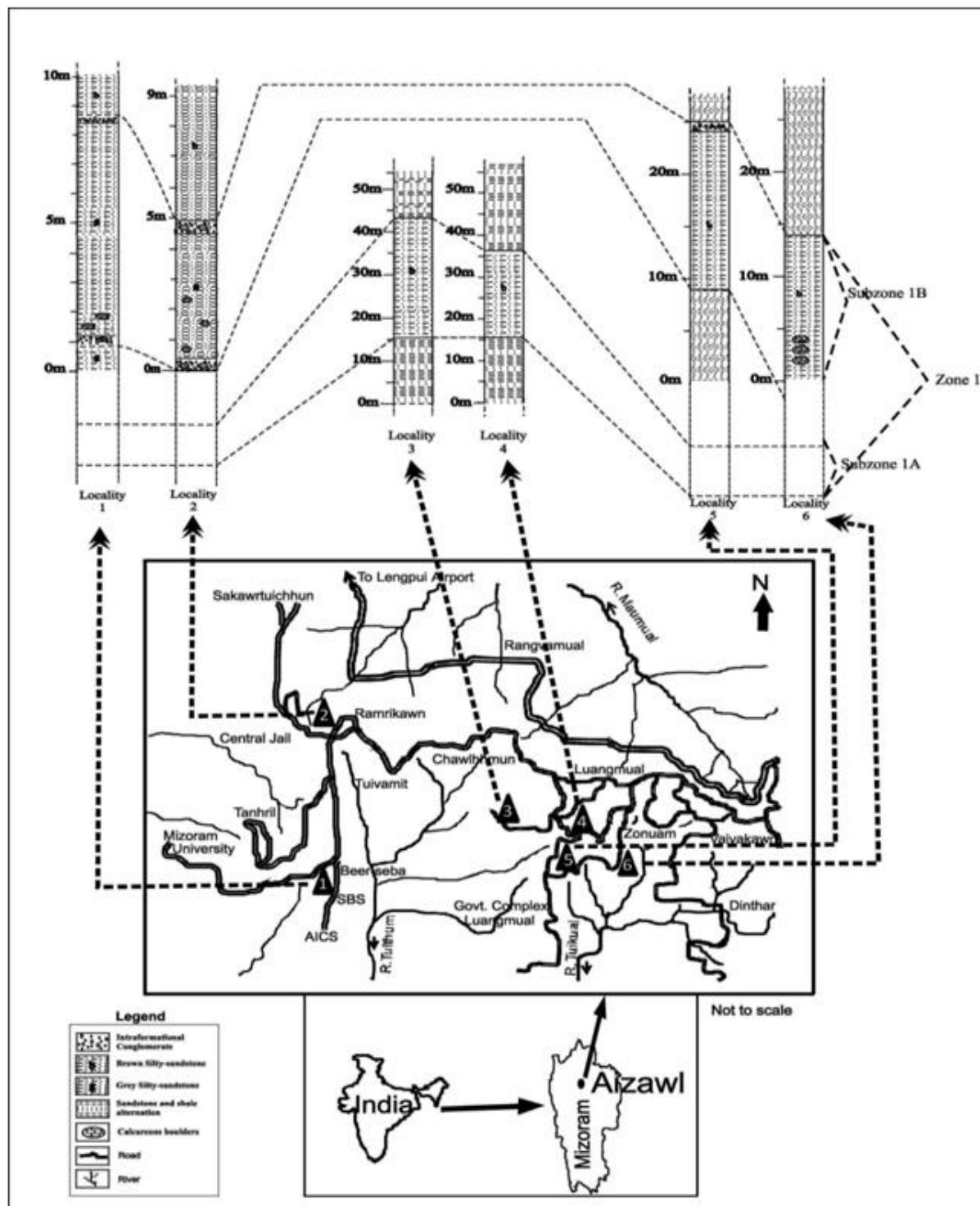


Figure 1. Location map of the study area and litho-column of the fossil localities.

Fossils bivalves from the Upper Bhurban unit

Table1. Geological age range of the bivalves species of the study area.

Name of species	Oligocene				Miocene			Pliocene			Recent
	Sannoian	Rupelian	Chattian	Stampian	Aquitanian	Burdigalian	Helvetian	Tortonian	Plaisancian	Astian	Sicilian
<i>Nucula (Nucula) agrawali</i> Tiwari					—	—	—	—	—	—	—
<i>Portlandia (Portlandia) ovatoelongata</i> Mazumder					—	—	—	—	—	—	—
<i>Barbatia bataviana</i> Martin var. <i>carinata</i> Noetling					—	—	—	—	—	—	—
<i>Barbatia</i> sp.											
<i>Trisidos semitorta</i> (Lamarck)	—	—	—	—	—	—	—	—	—	—	—
<i>Anadara (Anadara) craticulata</i> (Nyst)					—	—	—	—	—	—	—
<i>Anadara (Anadara) daviesi</i> Mukerjee					—	—	—	—	—	—	—
<i>Anadara (Anadara) garoensis</i> Mukerjee						—	—	—	—	—	—
<i>Anadara (Anadara) luangmualensis</i> Tiwari					—	—	—	—	—	—	—
<i>Anadara (Anadara) trapezoida</i> Tiwari					—	—	—	—	—	—	—
<i>Arcopsis</i> sp.											
<i>Pinna (Pinna) cf. rufis</i> Linné					—	—	—	—	—	—	—
<i>Chlamys (Argopecten) senatoria</i> (Gmelin)					—	—	—	—	—	—	—
<i>Pecten (Pecten) mathuri</i> Tiwari					—	—	—	—	—	—	—
<i>Diplodonta (Diplodonta) incerta</i> d'Archiac					—	—	—	—	—	—	—
<i>Diplodonta (Diplodonta) rotundatus</i> (Montagu)						—	—	—	—	—	—
<i>Cyclocardia</i> sp.											
<i>Astarte (Bythiamena) striata</i> Tiwari					—	—	—	—	—	—	—
<i>Mactra (Mactra) protoreeesii</i> Noetling					—	—	—	—	—	—	—
<i>Clinocardium</i> sp.											
<i>Lutraria philippinarum</i> Reeve					—	—	—	—	—	—	—
<i>Lutraria (Lutraria) saingengai</i> Tiwari					—	—	—	—	—	—	—
<i>Cultellus (Cultellus) zulloi</i> Tiwari					—	—	—	—	—	—	—
<i>Cultellus</i> sp.											
<i>Tellina (Angulus)</i> sp.											
<i>Tellina (Eurytellina) cf. piligrimi</i> Cox					—	—	—	—	—	—	—
<i>Tellina (Moerella) indifferens</i> Noetling						—	—	—	—	—	—
<i>Tellina (Tellinella) loknathi</i> Tiwari						—	—	—	—	—	—
<i>Apolymetis (Apolymetis) aizawlensis</i> Tiwari						—	—	—	—	—	—
<i>Apolymetis (Apolymetis) grimesi</i> Noetling						—	—	—	—	—	—
<i>Gari (Psammobia) kingi</i> (Noetling)					—	—	—	—	—	—	—
<i>Gari (Gari) natensis</i> Noetling						—	—	—	—	—	—
<i>Glossus (Cytherocardia) cytheroides</i> (Mayer)						—	—	—	—	—	—

<i>Callista (Callista) pseudoumbonella</i> Vredenburg	— —
<i>Callista (Costacallista) erycina</i> (Linné)	— — — — — — — —
<i>Dosinia (Dosinia) peralta</i> Vredenburg	— — — — —
<i>Dosinia (Dosinia) subpenicillata</i> Vredenburg	— — — — —
<i>Clementia (Clementia) papyracea</i> (Gray)	— — — — — — — —
<i>Paphia (Paphia) rotundata</i> (Linné)	— —
<i>Paphia (Callistotapes) pseudoliratus</i> Vredenburg	— —
<i>Paphia (Paphia) jhai</i> Tiwari	— —
<i>Timoclea (Timoclea) scabra</i> (Hanley)	— — — — — — — —
<i>Corbula (Corbula) mekranica</i> Vredenburg	— —

mens of the same species reported from the Upper Bhuban unit of Bhuban Formation of Mizoram.<sup>9,10</sup> Hence, identification is confirmed.

Family NUCULANIDAE Adams and Adams, 1858

Genus *Portlandia* Murch, 1857

***Portlandia (Portlandia) ovatoelongata*** Mazumder, 2004 (Pl. 1, Fig. 3)

**Dimensions** (mm): The lone specimen numbering B/GZ-218 has: Length 21.00; Height 15.00 (71.42); Inflation 11.00 (52.38).

**Description:** The presently described specimen is a right valve collected from locality no. 6. This lone specimen, on direct comparison, matches well with the holotype (K17/B/98) of *Portlandia (Portlandia) ovatoelongata* of the Mazumder's collection from Kolasib<sup>10</sup> in all diagnostic characters like elongate-ovate outline, thick and slightly opisthograte umbo, triangular umbonal profile, nature and configuration of margins, antero- and posteroventral furrows and broad undulations with fine concentrics. Thus, assigned to this form.

Order ARCOIDA Stoliczka, 1871

Family ARCIDAE Lamarck, 1809

Genus *Barbatia* Gray, 1842

***Barbatia (Barbatia) bataviana*** Martin var. *carinata* Noetling, 1939 (Pl. 1, Figs. 4–5)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation
B/R-59	27.00	28.00 (c.103.70)	9.00 (33.33) RV

B/R-60 20.00 25.00 (c.125.00) 7.00 (35.00) RV

**Description:** The material consists of two isolated right valves extracted from locality no. 2. In general outline, dimensional ratios and external features, the two specimens at hand greatly resemble *Barbatia (Barbatia) bataviana* Martin var. *Carinata* Noetling from the Baghmaria and Dalu localities of the Garo Hills, Meghalaya<sup>12</sup> excepting for the larger size of the former. Hence, these are assigned to this form without reservation.

***Barbatia* sp. (Pl. 1, Fig. 6)**

**Dimensions** (mm): The lone specimen numbering B/B-55 has: Length 31.0; Height 13.0 (71.42); Inflation 6.00 (19.35).

**Descriptions:** The material consists of one right valve recovered from locality no. 1. The valve is transversely elongate, length nearly two and a half times than the height, moderately inflated maximum inflation being behind the umbo. Umbo sub-median, pointed anteriorly with a prominent umbonal profile. Dorsal margin straight and ventral margin with a median sinuosity. Anterior margin narrowly rounded whereas posterior one broadly rounded. Valve surface covered with flat radial ribs separated by the interspaces of equal width. These are crossed over by numerous concentric growth lines producing cancellate ornamentation. Internal features not discernible. Specific identification is not attempted in the absence of other details.

Genus *Trisidos* Röding, 1798

*Trisidos semitorta* Lamarck, 1819 (Pl. 1, Fig. 7)

**Dimensions** (mm): Specimen no. B/R-57 has the following dimensions: Length 34.00, Height 15.00 (44.11); Inflation 6.00 (17.64)

**Descriptions:** This lone specimen (left valve) is from locality no. 2. The specimen at hand matches well with *Trisidos semitorta* (Lamarck) recorded from the Gaj beds of Kachchh and Sind<sup>12</sup> in respect of general proportion, in the cancellate ornamentation produced by prominent raised radial ribs traversed by fine growth lines and in twisted hinge. On these counts, it also matches well with the same species reported from Garo Hills.<sup>11</sup>

Genus *Anadara* Gray, 1847

*Anadara (Anadara) craticulata* (Nyst), 1847 (Pl. 3, Figs. 8-9)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation	NR
B/GZ-220	18.00	18.00 (100.00)	9.00 (50.00)	BV 28
B/GZ-221	18.00	18.00 (100.00)	7.00 (38.88)	LV 26

**Descriptions:** One complete bivalved and one left valve are collected from the locality no. 6. The specimens under examination show all the essential features of the species under reference like broadly elliptical outline, moderate inflation, unequal radial ribs with granulation on the anterior side and umbonal position. Hence, it is referred to as *Anadara (Anadara) craticulata* (Nyst).

*Anadara (Anadara) daviesi* Mukerjee, 1939

(Pl. 1, Figs. 10-11)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation
B/YL-63	17.00	11.00 (64.70)	7.00 (41.17) LV
B/R-64	24.00	18.00 (75.00)	9.00 (37.50) LV

**Descriptions:** Two left valves are collected from locality no. 1 and 3. Species diagnostic characters like elongate and sub-ovate outline, height about 60% of the length, moderate inflation, oblique posterior margin, broad and flattened radial ribs and distinct granulations towards anterior to anterior-third of

valves are well marked in the present specimens. Hence, the assignment.

*Anadara (Anadara) garoensis* Mukerjee, 1939 (Pl. 1, Fig. 12)

**Dimensions** (mm): Specimen no. B/R-86 has the following dimensions: Length 31.00, Height 18.00(58.06); Inflation 8.00 (25.80); No. of ribs 28.

**Descriptions:** One left valve collected from locality no. 1 represents this specimen. It shows the entire essential characters of the species *Anadara (Anadara) garoensis* originally described from the Miocene of Garo Hills, Meghalaya<sup>11</sup> viz., sub-rhomboidal shape, anterior-third umbo and in the inflation, number and nature of radial ribs and in the nature of posterior carina. Therefore, it is assigned to the Mukerjee's species.

*Anadara (Anadara) luangmualensis* Tiwari, 2001 (Pl. 1, Fig. 13)

**Dimensions** (mm): Specimen no. B/R-58 has the following dimensions: Length 24.00, Height 18.00 (75.00); Inflation 8.00 (33.33)

**Descriptions:** The material here is one left valve from locality no. 2. The diagnostic characters of the species are sub-quadrilateral outline, strongly and evenly convex flanks, steeply inclined posterior area with wing like posterior end and thick and closely spaced radials crossed over by concentrics producing reticulate pattern of ornamentation.<sup>13</sup> These characters are very well marked in the lone specimen at hand therefore it is assigned to this species without any hesitation.

*Anadara (Anadara) trapezoida* Tiwari, 2001 (Pl. 1, Fig. 14)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation
B/B-62	16.00	25.00 (156.25)	9.00 (56.25) LV
B/B-69	9.00	13.00 (144.44)	5.00 (55.55) RV

**Descriptions:** One left and right valves are collected from locality no. 1. The diagnostic characters of the species are sub-terminal umbo, obliquely trapezoidal outline, angular

posterior carina, steeply sloping posterior margin and almost parallel postero-dorsal and ventral margins.<sup>13</sup> All these features are well marked in both the specimens at hand. Hence, the assignment.

Family NOETIIDAE Stewart, 1930

Genus *Arcopsis* Koenen, 1885

*Arcopsis* sp. (Pl. 1, Fig. 15)

**Dimensions** (mm): Specimen no. B/R-56 has: Length 20.00; Height 15.00 (75.00); Inflation 5.00 (25).

**Descriptions:** The material at hand is one right valve from locality no. 2. It is rhomboidal in outline, moderately inflated and umbo is situated one-third from the anterior. The umbo is prosogyrate and distinct. Dorsal margin is straight, anterior and posterior margins are rounded and merge smoothly with the dorsal and ventral margins. Ventral margin is flat. It has a postero-ventral carina that is more prominent towards the dorsal margin and becomes feeble towards the ventral margin. Posterior area is small and moderately sloping. There is a feeble median sulcus running from umbo to the ventral margin. Valve surface is covered with thirty-eight fine and nearly equally spaced bifurcating ribs. These are in turn crossed over by concentric growth lines producing nodes at the intersections. The interspaces are narrower than the ribs. Specific identification is not attempted for the want of better-preserved material. This is the first report of the genus from the Miocene sediments of Mizoram.

Order MYTILOIDA Ferussac, 1822

Family PINNIDAE Leach, 1819

Genus *Pinna* Linné, 1758

*Pinna (Pinna)* cf. *rudis* Linné (Pl. 1, Fig. 16)

**Dimensions** (mm): Specimen no. B/GZ-227 has: Length 27.00; Height 28.00 (103.70).

**Descriptions:** The presently described specimen is a complete one collected from locality no. 6. General outline and radial ornamentation along with a few commarginal undula-

tions of the present specimen at once reminds the species *Pinna (Pinna) rudis* Linné. However, it is referred to as *Pinna (Pinna) cf. rudis* for the want of more details and better-preserved specimens.

Order PTERIOIDA Newell, 1965

Family PECTINIDAE Rafinesque, 1815

Genus *Chlamys* Röding, 1798

*Chlamys (Argopecten) senatoria* Gmelin, 1791 (Pl. 1, Figs. 17–19)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation	NR
B/YL-86	13.00	13.00 (100.00)	3.00 (23.07) RV	24
B/B-87	17.00	19.00 (111.76)	4.00 (23.52) RV	28
B/FZ-88	15.00	17.00 (113.33)	6.00 (40.00) LV	24

**Descriptions:** The material consists of one left and two right valves locality no. 1, 3 and 4. The diagnostic characters of this species are: sub-orbicular with the height only slightly in excess of the length, its surface covered with about 24 wide radial ribs and the interspaces occupied by the fine, closely spaced undulating squamae.<sup>14</sup> All these characters are well defined in the present specimens. Hence, the identification.

Genus *Pecten* Müller, 1776

*Pecten (Pecten) mathuri* Tiwari MS, 1992

(Pl. 1, Figs. 20a,b; Pl. 2, Fig. 1)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation
B/FZ-91	22.00	19.00 (86.36)	6.00 (27.27) BV
B/B-93	18.00	18.00 (100.00)	3.00 (16.66) RV

**Descriptions:** One complete specimen and one right valve from locality no. 1 and 4. The specimens at hand have sub-orbicular outline with evenly rounded anterior, posterior and ventral margins, and its antero-dorsal is slightly more elongate than the postero-dorsal. The right valve of the species is oblique and slender, more convex than the left one. In all these characters, the specimens at hand approach the species *Pecten (Pecten) mathuri* Tiwari, which was reported from Surma Group of rocks from Aizawl and Lunglei of Mizoram.<sup>9</sup> Hence, named accordingly.



Plate 1. **1a.** *Nucula (Nucula) agrawali* Tiwari (B/GZ-216) exterior of left valve (X 1.20); **1b.** *Nucula (Nucula) agrawali* (B/GZ-216) exterior of right valve (X 1.20); **2a.** *Nucula (Nucula) agrawali* Tiwari (B/GZ-217) exterior of left valve (X 1.00); **2b.** *Nucula (Nucula) agrawali* Tiwari (B/GZ-217) exterior of right valve (X 1.00); **3.** *Portlandia (Portlandia) ovatoelongata* Mazumder (B/GZ-218) exterior of right valve (X 1.50); **4.** *Barbatia (Barbatia) bataviana* Martin var. *carinata* Noetling (B/R-59) exterior of right valve (X 1.20); **5.** *Barbatia (Barbatia) bataviana* Martin var. *carinata* Noetling (B/R-60) exterior of right valve. (X 1.20); **6.** *Barbatia* sp. (B/B-55) exterior of right valve (X 1.00); **7.** *Trisidos semitorta* (Lamarck) (B/R-57) exterior of left valve (X 1.00); **8a.** *Anadara (Anadara) craticulata* (Nyst) (B/GZ-220) exterior of right valve (X 1.20); **8b.** *Anadara (Anadara) craticulata* (Nyst) (B/GZ-220) exterior of left valve (X 1.20); **9.** *Anadara (Anadara) craticulata* (Nyst) (B/GZ-221) exterior of right valve (X 1.50); **10.** *Anadara (Anadara) daviesi* Mukerjee (B/R-64) exterior of left valve (X 1.20); **11.** *Anadara (Anadara) daviesi* Mukerjee (B/YL-63) exterior of left valve. (X 1.50); **12.** *Anadara (Anadara) garoensis* Mukerjee (B/R-86) exterior of left valve (X 1.00); **13.** *Anadara (Anadara) luangmualensis* Tiwari (B/R-58) exterior of left valve (X 1.50); **14.** *Anadara (Anadara) trapezoida* Tiwari (B/B-62) exterior of left valve (X 1.00); **15.** *Arcopsis* sp. (B/R-56) exterior of right valve (X 1.50); **16.** *Pinna (Pinna)* cf. *rudis* Linné (B/GZ-227) exterior of left valve (X 1.00); **17.** *Chlamys (Argopecten) senatoria* (Gmelin) (B/YL-86) exterior of right valve (X 2.00); **18.** *Chlamys (Argopecten) senatoria* (Gmelin) (B/FZ-88) exterior of left valve (X 1.50); **19.** *Chlamys (Argopecten) senatoria* (Gmelin) (B/FZ-88) exterior of right valve (X 1.50); **20a.** *Pecten (Pecten) mathuri* Tiwari MS (B/YL-91) exterior of left valve (X 1.20); **20b.** *Pecten (Pecten) mathuri* Tiwari MS (B/YL-91) exterior of right valve (X 1.20).

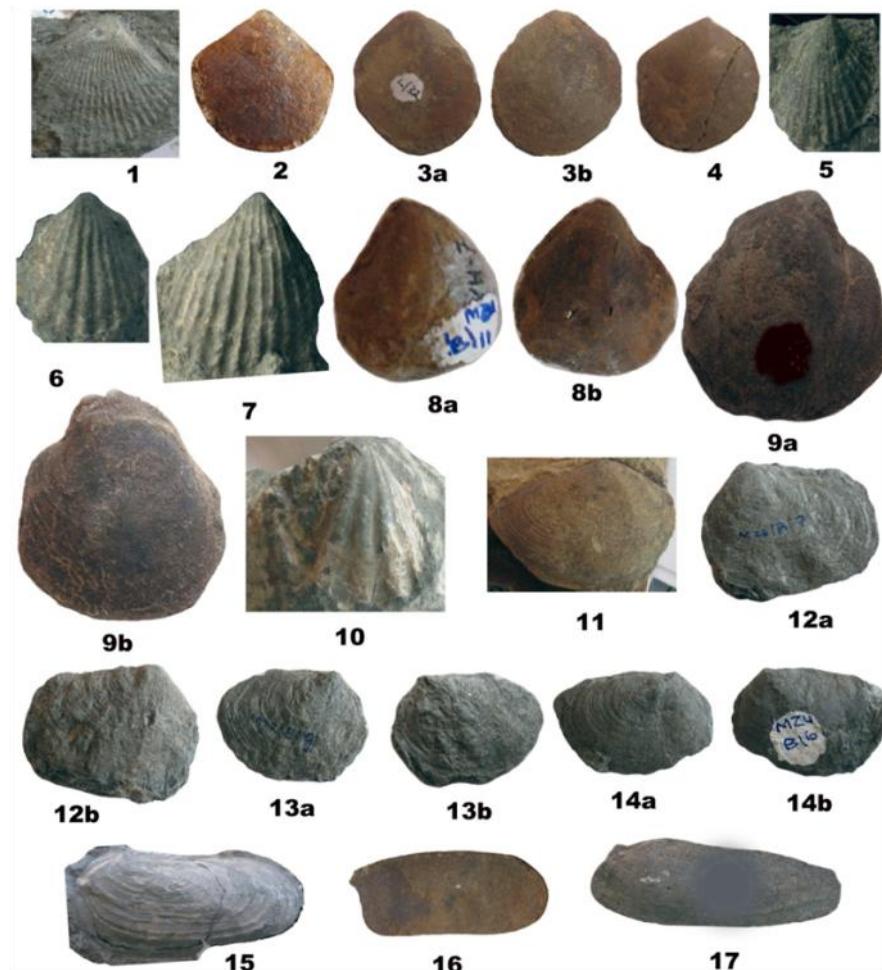


Plate 2. **1.** *Pecten (Pecten) mathuri* Tiwari MS (B/B-93) exterior of right valve (X 1.50); **2.** *Diplodonta (Diplodonta) incerta* d'Archiac (B/YL-20), exterior of right valve (X 1.20); **3a.** *Diplodonta (Diplodonta) incerta* d'Archiac (B/GZ-233) exterior of left valve (X 1.00); **3b.** *Diplodonta (Diplodonta) incerta* d'Archiac (B/GZ-233) exterior of right valve (X 1.00); **4.** *Diplodonta (Diplodonta) rotundatus* (Montagu) (B/GZ-232) exterior of right valve (X 1.20); **5.** *Cyclocardia* sp. (B/B-114) exterior of right valve (X 1.00); **6.** *Cyclocardia* sp. (B/B-117) exterior of right valve (X 1.20); **7.** *Cyclocardia* sp. (B/B-115) exterior of right valve (X 1.00); **8a.** *Astarte (Bythiamena) striata* Tiwari (B/YL-11) exterior of left valve (X 1.50); **8b.** *Astarte (Bythiamena) striata* Tiwari (B/YL-11) exterior of right valve (X 1.50); **9a.** *Astarte (Bythiamena) striata* Tiwari (B/LG-234) exterior of right valve (X 1.00); **9b.** *Astarte (Bythiamena) striata* Tiwari (B/LG-234) exterior of left valve (X 1.00); **10.** *Clinocardium* sp. (B/B-106) exterior of left valve (X 1.00); **11.** *Mactra (Mactra) protoreeesii* Noetling (B/B-29) exterior of left valve (X 1.50); **12a.** *Lutraria philippinarum* Reeve (B/B-7) exterior of left valve (X 1.00); **12b.** *Lutraria philippinarum* Reeve (B/B-7) exterior of right valve (X 1.00); **13a.** *Lutraria philippinarum* (B/B-9) exterior of right valve (X 1.00); **13b.** *Lutraria philippinarum* Reeve (B/B-9) exterior of left valve (X 1.00); **14a.** *Lutraria philippinarum* Reeve (B/B-6) exterior of right valve (X 1.00); **14b.** *Lutraria philippinarum* Reeve (B/B-6) exterior of left valve (X 1.00); **15.** *Lutraria saigengai* Tiwari (B/R-1) exterior of left valve (X 1.00); **16.** *Cultellus (Cultellus) zulloi* Tiwari (B/GZ-238) exterior of right valve (X 1.00); **17.** *Cultellus* sp. (B/R-200) exterior of left valve (X 1.00).



Plate 3. **1.** *Cultellus* sp. (B/R-200) exterior of right valve (X 1.00); **2a.** *Tellina (Angulus)* sp. (B/GZ-242) exterior of right valve (X 1.00); **2b.** *Tellina (Angulus)* sp. (B/GZ-242) exterior of left valve (X 1.00); **3a.** *Tellina (Angulus)* sp. (B/GZ-241) exterior of left valve (X 1.00); **3b.** *Tellina (Angulus)* sp. (B/GZ-241) exterior of right valve (X 1.00); **4.** *Tellina (Eurytellina) cf. piligrimi* Cox (B/GZ-251) exterior of right valve (X 1.20); **5a.** *Tellina (Moerella) indifferens* Noetling (B/LG-252) exterior of left valve (X 1.00); **5b.** *Tellina (Moerella) indifferens* Noetling (B/LG-252) exterior of right valve (X 1.00); **6a.** *Tellina (Moerella) indifferens* Noetling (B/LG-253) exterior of right valve (X 1.00); **6b.** *Tellina (Moerella) indifferens* Noetling (B/LG-253) exterior of left valve (X 1.00); **7.** *Tellina (Tellinella) loknathi* Tiwari (B/B-15) exterior of right valve (X 1.00); **8a.** *Apolymetis (Apolymetis) aizawlensis* Tiwari and Kachhara (B/GZ-258) exterior of left valve (X 1.00); **8b.** *Apolymetis (Apolymetis) aizawlensis* Tiwari and Kachhara (B/GZ-258) exterior of right valve (X 1.00); **9.** *Apolymetis (Apolymetis) aizawlensis* Tiwari and Kachhara (B/GZ-259) exterior of left valve (X 1.00); **10a.** *Apolymetis (Apolymetis) grimesi* Noetling (B/GZ-263) exterior of right valve (X 1.00); **10b.** *Apolymetis (Apolymetis) grimesi* Noetling (B/GZ-263) exterior of left valve (X 1.00); **11.** *Apolymetis (Apolymetis) grimesi* Noetling (B/R-12) exterior of right valve (X 1.00); **12a.** *Apolymetis (Apolymetis) grimesi* Noetling (B/GZ-262) exterior of right valve (X 1.00); **12b.** *Apolymetis (Apolymetis) grimesi* Noetling (B/GZ-262) exterior of left valve (X 1.00); **13.** *Gari (Gari) natensis* Noetling (B/FZ-23) exterior of right valve (X 2.50); **14.** *Gari (Psammobia) kingi* Noetling (B/LG-264) exterior of right valve (X 1.00); **15a.** *Glossus (Cytherocardia) cytheroides* Mayer (B/R-48) exterior of right valve (X 1.20); **15b.** *Glossus (Cytherocardia) cytheroides* Mayer (B/R-48) exterior of left valve (X 1.20).



Plate 4. **1.** *Callista (Callista) pseudoumbonella* Vredenburg (B/R-5) exterior of right valve (X 1.20); **2.** *Callista (Costacallista) erycina* (Linné) (B/R-42a) exterior of right valve (X 1.00); **3.** *Dosinia (Dosinia) peralta* Vredenburg (B/B-3) exterior of right valve (X 1.20); **4.** *Dosinia (Dosinia) peralta* Vredenburg (B/LG-4) exterior of right valve (X 1.50); **5.** *Dosinia (Dosinia) subpenicillata* Vredenburg (B/B-19) exterior of left valve (X 1.00); **6.** *Dosinia (Dosinia) subpenicillata* Vredenburg (B/B-25) exterior of left valve (X 1.00); **7.** *Clementia (Clementia) papyracea* Gray (B/GZ-266) exterior of right valve (X 1.50); **8a.** *Clementia (Clementia) papyracea* (Gray) (Sp. no. B/B-8) exterior of right valve (X 2.00); **8b.** *Clementia (Clementia) papyracea* Gray (B/B-8) exterior of left valve (X 2.00); **9a.** *Clementia (Clementia) papyracea* Gray (B/GZ-2) exterior of right valve (X 1.00); **9b.** *Clementia (Clementia) papyracea* Gray (B/GZ-2) exterior of left valve (X 1.00); **10a.** *Paphia (Paphia) rotundata* Linné (B/FZ-2) exterior of left valve (X 1.50); **10b.** *Paphia (Paphia) rotundata* Linné (B/FZ-21) exterior of right valve (X 1.50); **11.** *Paphia (Paphia) rotundata* Linné (B/FZ-30) exterior of right valve (X 1.00); **12b.** *Paphia (Paphia) rotundata* Linné (B/GZ-269) exterior of left valve (X 1.00); **12b.** *Paphia (Paphia) rotundata* Linné (B/GZ-269) exterior of right valve (X 1.00); **13.** *Paphia (Paphia) rotundata* Linné (B/GZ-268) exterior of right and left valve (X 1.00); **14a.** *Paphia (Paphia) jhai* Tiwari MS (B/LG-215) exterior of left valve (X 2.00); **14b.** *Paphia (Paphia) jhai* Tiwari MS (B/LG-215) exterior of right valve (X 2.00); **15a.** *Paphia (Paphia) jhai* Tiwari MS (B/LG-22) exterior of left valve (X 1.00); **15b.** *Paphia (Paphia) jhai* Tiwari MS (B/LG-22) exterior of right valve (X 1.00); **16.** *Paphia (Callistotapes) pseudoliratus* Vredenburg (B/LG-272) exterior of right valve (X 1.50); **17.** *Paphia (Callistotapes) pseudoliratus* Vredenburg (B/FZ-40) exterior of right valve (X 2.00); **18.** *Timoclea (Timoclea) scabra* Hanley (B/YL-83) exterior of left valve (X 2.50); **20.** *Corbula (Corbula) mekanica* Vredenburg (B/B-203) exterior of right valve (X 2.50); **21.** *Corbula (Corbula) tunicosulcata* Vredenburg (B/B-54) exterior of right valve (X 2.50); **22.** *Corbula (Corbula) tunicosulcata* Vredenburg (B/B-204) exterior of right valve (X 2.50).

Order VENEROIDA H. Adams and A. Adams, 1856

Family UNGULINIDAE Adams and Adams, 1857

Genus *Diplodonta* Brönn, 1831

*Diplodonta (Diplodonta) incerta* d'Archiac, 1850 (Pl. 2, Figs. 2-3)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation	
B/YL-20	17.00	17.00 (100.00)	4.00 (25.00)	RV
B/GZ-233	20.00	22.00 (110.00)	8.00 (40.00)	BV

**Descriptions:** One complete specimen and one right valve are collected from locality no. 3 and 6. The general proportion and external characters of the ornamentation of the specimen collected from the above two fossil localities are identical with *Diplodonta incerta* reported from the Gaj beds of Sind.<sup>12</sup> Hence the assignment.

*Diplodonta (Diplodonta) rotundatus* Montagu, 1803 (Pl. 2, Fig. 4)

**Dimensions (mm):** The lone specimen numbering B/GZ-232 has: Length 19.00; Height 21.00(110.52); Inflation 7.00 (36.84).

**Descriptions:** Only one right valve is collected from locality no. 6. On account of its small size, less prominent umbo, less oblique outline and more expanded posterior area, this specimens are assigned to *Diplodonta (Diplodonta) rotundatus* Montagu.

Family CARDITIDAE Fleming, 1828

Genus *Cyclocardia* Conrad, 1867

*Cyclocardia* sp. (Pl. 2, Figs. 5-7)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation	NR
B/B-114	19.00	25.00 (131.57)	6.00 (31.57)	RV 16
B/B-115	20.00	22.00 (110.00)	7.00 (35.00)	RV 16
B/B-117	16.00	18.00 (112.50)	5.00 (31.25)	RV 16

**Descriptions:** Three right valves collected from locality no. 1 represents the species. The valves are tall, thick, sub-trigonal in shape and strongly inflated. Umbo prosogyrous, prominent and situated anterior-third of the valve length. Dorsal margin curved, anterior margin short and concave and joins the ven-

tral margin at an obtuse angle, posterior margin long and sloping ( $35^{\circ}$ ) and joins ventral margin obtusely. Ventral margin obliquely rounded being larger towards antero-ventral than the postero-ventral one. A feeble carina runs from the umbo towards both the antero-ventral and the postero-ventral corners forming moderately sloping anterior and posterior areas. Anterior carina is moderately curved whereas posterior one is fairly straight. Surface ornamented with sixteen strong radial ribs. These ribs are stronger in the middle portion than in the anterior and posterior areas. Interspaces also follow the same pattern. Though the valve surface is worn out in all the specimens at hand, it seems to bear fine concentrics and nodes may be seen towards the ventral margin. Internal characters not observable. It could not be identified up to the species level due to poor preservation.

**Remarks:** The species under the name *Cyclocardia mutabilis* reported from the Miocene of the Garo Hills of Meghalaya<sup>15</sup> are much shorter than the presently described one; hence, they cannot be merged. This is the first report of the genus from Mizoram.

Family ASTARTIDAE d' Ordigny, 1844

Genus *Astarte* J. Sowerby, 1816

*Astarte (Bythiamena) striata* Tiwari, 1992  
(Pl. 2, Figs. 8-9)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation	
B/YL-11	15.00	16.00 (106.66)	8.00 (53.33)	BV
B/LG-234	25.00	28.00 (112.00)	14.00 (56.00)	BV

**Descriptions:** The materials at hand are two complete specimens collected from locality no. 3 and 5. The specimens under consideration tally well with the holotype of *Astarte (Bythiamena) striata* Tiwari in view of their broadly trigonal outline, slightly inequilateral valves, height slightly in excess of length, moderate inflation, curved and pointed prosogyrous umbo that are placed at anterior-third of the shell length and surface of shell covered with dense sets of fine concentric striations. Hence, their assignment to this spe-

cies is beyond doubt.

**Family CARDIIDAE Lamarck, 1809**

**Genus *Clinocardium* Keen, 1936**

***Clinocardium* sp. (Pl. 2, Fig. 10)**

**Dimensions** (mm): Specimen no. B/B-106 has the following dimensions: Length 24.00, Height 21.00 (87.50); Inflation 7.00 (29.16); No. of ribs 9.

**Descriptions:** Only one poorly preserved left valve is collected from locality no. 1. In slightly oblique and sub-ovate outline, much asymmetrical ventral margin rising rapidly in posterior region, and flat topped radial ribs, the present specimen resembles well with *Clinocardium andoi* Itoigawa and Shibata the Miocene of Niu Mountains, Japan.<sup>16</sup> It also matches well with the specimens of the same species reported from the Miocene of Garo Hills, Meghalaya<sup>15</sup> in these respects. However, my specimen bears nine strong radial sculptures as compared to numerous weak radials of the earlier reported specimens. Moreover, further comparison is not possible due to poor preservation. Hence, it is left to the open nomenclature.

**Family MACTRIDAE Lamarck, 1809**

**Genus Linné, 1767**

***Mactra* (*Mactra*) *protoreevesii* Noetling, 1901 (Pl. 2, Fig. 11)**

**Dimensions** (mm): Specimen no. B/B-29 has the following dimensions: Length 23.00, Height 17.00 (73.91); Inflation 3.00 (13.04).

**Descriptions:** One left valve collected from the brown silty-sandstone of locality no. 1 represents this specimen. The characteristic features of this species are disproportion between the size of anterior and posterior regions, presence of a broad, flattened keel running from umbo towards the posterior margin and extremely elongate anterior and the short acuminate posterior regions. The specimen at hand therefore, can be merged with the species *Mactra protoreevesii* Noetling described and illustrated from the Garo Hills of Meghalaya.<sup>11</sup> Hence, the assignment. Identification

is further confirmed by the direct comparison of the specimen with Sp. no. MT/4/8 from the Upper Bhutan Formation of Mizoram.<sup>9</sup>

**Genus *Lutraria* Lamarck, 1759**

***Lutraria philippinarum* Reeve, 1854 (Pl. 2, Figs. 12–14)**

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation
B/B-6	29.00	20.00 (68.96)	10.00 (34.48) BV
B/B-7	32.00	26.00 (81.25)	12.00 (37.50) BV
B/B-9	28.00	21.00 (75.00)	8.50 (30.35) BV

**Descriptions:** Three poorly preserved bivalved specimens are recovered from locality no. 1. The diagnostic character of the species *Lutraria philippinarum* Reeve is compressed, elongate-ovate and somewhat arcuate outline with anterior one-sixth umbo.<sup>14</sup> These characters can be clearly seen in the specimens under study in spite of their poor preservation. In addition to above, the ornamentation also seems to be similar, i.e. coarse and undulating growth lines. Identification is confirmed.

***Lutraria* (*Lutraria*) *saigengai* Tiwari MS, 1992 (Pl. 2, Fig. 15)**

**Dimensions** (mm): Specimen no. B/R-1 has the following dimensions: Length 43.00, Height 22.00 (51.16); Inflation 11.00 (25.58)

**Descriptions:** One well preserved bivalve specimen is extracted from locality no. 2. Compressed nature with gapping at both the ends, transversely-elliptically outline, height nearly half of the length, anterior-third to anterior-fourth umbo, broad rounded margins and commarginal bands becoming wider towards ventral margin remind at ones the species *Lutraria* (*Lutraria*) *saigengai*, which was a new species reported from the Surma Group of rocks of Mizoram.<sup>9</sup> However, the present specimen is larger in size and more inflated. Since these differences are of trivial nature, it is identified as *Lutraria* (*Lutraria*) *saigengai*.

**Family CULTELLIDAE Davies, 1935**

**Genus *Cultellus* Schumacher, 1817**

***Cultellus* (*Cultellus*) *zulloi* Tiwari MS, 1992**

(Pl. 2, Fig. 16)

**Dimensions** (mm): Specimen no. B/GZ-238 has the following dimensions: Length 36.00, Height 16.00 (44.44); Inflation 3.00 (8.33).

**Descriptions:** The specimen at hand is a right valve recovered from locality no. 6. These specimens have perfectly elliptical outline excepting near umbonal region, their length is about 2.3 to 2.8 times than the height, and they have a shallow groove on either side of the umbo all along the dorsal margin. These have small and low umbones placed anterior-forth of the shell-length. In all the above characters, these specimens approach very closely to *Cultellus (Cultellus) zulloi* Tiwari. Hence, their assignment is justified.

*Cultellus* sp. (Pl. 2, Fig. 17; Pl. 3, Fig. 1)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation	
B/R-200	30.00	11.00 (36.66)	3.00 (10.00)	BV
B/R-201	24.00	10.00 (41.66)	4.00 (16.66)	BV

**Descriptions:** Two complete juvenile specimens recovered from locality no. 1 represent this species. The shell is thin, highly compressed and narrowly elongated and seems to be gaping at both the ends. Umbo is small, indistinct and situated about anterior-third to one-fourth of the shell-length. Antero-dorsal is short and gently sloping whereas postero-dorsal is long and straight. Anterior and posterior margins are narrowly rounded and ventral margin is flat. Surface appears to be smooth. Poor preservation of the specimen does not warrant specific identification and comparison with other known forms of the species.

Family TELLINIDAE de Blainville, 1814

Genus *Tellina* Linné, 1758

*Tellina (Angulus)* sp. (Pl. 3, Figs. 2–3)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation	
B/GZ-241	27.00	16.00 (59.25)	7.00 (25.92)	BV
B/GZ-242	27.00	16.00 (59.25)	8.00 (29.62)	BV

**Descriptions:** Two bivalved specimens are collected from locality no. 6. These two speci-

mens show essential characters of the subgenus *Tellina (Angulus)* described from Surma Group of rocks of Mizoram,<sup>9</sup> viz. compressed, inequilateral, subelliptical nature of the shell and sub-median and low umbo. Further, there is a strong similarity between the two in the nature of the margins and the nature and numbers of furrows and flexures. Hence, these are identified as *Tellina (Angulus)* sp. Their assignment under a new species is however deferred for the want of better-preserved materials.

*Tellina (Eurytellina)* cf. *pilgrimi* Cox, 1936

(Pl. 3, Fig. 4)

**Dimensions** (mm): Specimen no. B/GZ-251 has the following dimensions: Length 25.00, Height 17.00 (68.00); Inflation 6.00 (24.00).

**Descriptions:** The presently described specimen is one right valve from locality no. 6. In dimensional ratios and general outline, the specimen at hand resembles paratype of *Tellina pilgrimi* originally described from Persia.<sup>14</sup> Further comparison is not possible due to poor preservation. Hence, these are referred to as *Tellina (Eurytellina)* cf. *pilgrimi* Cox.

*Tellina (Moerella) indifferens* Noetling, 1901 (Pl. 3, Figs. 5–6)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation	
B/LG-252	35.00	25.00 (71.42)	12.00 (24.28)	BV
B/LG-253	34.00	25.00 (73.52)	12.00 (35.29)	BV

**Descriptions:** Two bivalved specimens from locality no. 5 represent this species. The diagnostic characters of this species are smooth and rather flat surface, elongate triangular outline, sub-terminal to sub-median umbo, narrow elongate anterior, and short and rounded posterior. All these characters are well marked in the three specimens available for study. Hence, specific assignment of these specimens is confirmed.

*Tellina (Tellinella) loknathi* Tiwari, 1992

(Pl. 3, Fig. 7)

**Dimensions** (mm): Specimen no. B/B-15 has

the following dimensions: Length 46.00, Height 26.00 (56.52); Inflation 3.00 (6.52).

**Descriptions:** One right valve embedded in matrix is collected from locality no. 1. The specimen at hand matches well with *Tellina loknathi* reported from Lunglei of Mizoram<sup>9</sup> in dimensional ratios, nature and position of umbo, configuration of margins and nature and number of flexures and furrows. Though the surface is worn out and surface sculpture could not be clearly seen, the worn out surfaces give the feeling of growth lines that become wider towards the ventral surface like in Tiwari's collections. Thus these have been assigned to *Tellina (Tellinella) loknathi* Tiwari.

***Apolymeris (Apolymeris) aizawlensis*** Tiwari and Kachhara, 2000 (Pl. 3, Figs. 8–9)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation
B/GZ-258	34.00	24.00 (70.58)	13.00 (38.23) BV
B/GZ-259	31.00	19.00 (61.29)	10.00 (32.25) RV

**Descriptions:** One complete specimen and one right valve from locality no. 6 represent this species. In trigonally-ovate outline, slightly inequivaled and strongly inequilateral character, in nature and position of umbones, in the nature and number of furrows and flexures and in ornamentation, these specimens, particularly specimen no. B/GZ-258, are identical to the holotype of *Apolymeris (Apolymeris) aizawlensis* described from Miocene of Mizoram.<sup>17</sup> Author could not make any distinction between the two sets of specimens. Hence, the assignment.

***Apolymeris (Apolymeris) grimesi*** Noetling, 1901(Pl. 3, Figs. 10–12)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation
B/R-12	20.00	22.00 (110.00)	4.00 (20.00) RV
B/GZ-262	33.00	31.00 (93.93)	15.00 (45.45) BV
B/GZ-263	26.00	25.00 (96.15)	14.00 (53.84) BV

**Descriptions:** Two bivalved and one broken right valve are recovered from locality no. 2 and 6. They resemble very closely with *Apolymeris grimesi* (Noetling) reported from the

Miocene of Garo Hills, Meghalaya<sup>11</sup> in respect of general configuration, dimensional ratios and in the nature, number and disposition of flexures and furrows. This species has also been reported from the Miocene of the Garo Hills, Meghalaya<sup>14</sup> and on comparison it found to match well with the present specimens in above characters.

**Family PSAMMOBIIDAE Fleming, 1828**

**Genus *Gari* Schumacher, 1817**

***Gari (Gari) natensis*** Noetling, 1901 (Pl. 3, Fig. 13)

**Dimensions (mm):** The lone specimen (Sp. no. B/FZ-23) has the following dimensions; Length 15.00; Height 8.00 (53.33); Inflation 2.00 (13.33).

**Descriptions:** The present specimen (right valve) comes from the locality no. 4. It matches well with *Gari (Gari) natensis* Noetling (1901) with respect to outline, posterior region and ornamentation. Nodes produced by the concentric lines crossing over the carina are also faintly preserved in the present specimen. Moreover, it also matches very well with the specimens of the same species reported from the Miocene of Garo Hills, Meghalaya<sup>14</sup>. Hence, the assignment seems to be correct.

***Gari (Psammobia) kingi*** Noetling, 1901(Pl. 3, Fig. 14)

**Dimensions (mm):** Specimen no. B/LG-264 has the following dimensions: Length 30.00, Height 16.00 (48.00); Inflation 6.00 (20.00).

**Descriptions:** One right valve from locality no. 5 represents this species. In general proportions, external characters of ornamentation and dimensional ratios and nature and number of posterior keels and furrows, the presently described specimen resemble very closely with the holotype of *Gari kingi* Noetling (1901). Further, it has been compared with the same species from the Miocene of Baghmara, Meghalaya<sup>11</sup> and found to match well expecting the smaller size of the latter. Therefore, its identification is beyond doubt.

Family GLOSSIDAE Gray, 1847

Genus *Glossus* Poli, 1795

***Glossus (Cytherocardia) cytheroides*** Mayer, 1969 (Pl. 3, Figs. 15 a,b)

**Dimensions** (mm): Specimen no. B/R-48 has the following dimensions: Length 23.00, Height 25.00 (108.69); Inflation 11.00 (47.82).

**Descriptions:** One complete specimen is collected from locality no. 2. This specimen at hand reminds at once, *Glossus (Cytherocardia) cytheroides* Mayer reported from the Bhuban rocks of Kolasib, Mizoram,<sup>10</sup> in respect of elongate-ovate outline, prominent prosogyrous umbo placed anterior-fifth, nature of margins, a postero-ventral ridge and in ornamentation. Hence, the assignment. However, the present specimen is a taller form as compared to Kolasib. Hence, the assignment is justifiable.

Family VENERIDAE Rafinesque, 1815

Genus *Callista* Poli, 1791

***Callista (Callista) pseudoumbonella*** Vredenburg (Pl. 4, Fig. 1)

**Dimensions** (mm): Specimen no. B/R-5 has the following dimensions: Length 25.00, Height 20.00 (80.00); Inflation 12.00 (48.00).

**Descriptions:** One fairly preserved right valve from locality no. 1 represents this species. The species *Callista (Callista) pseudoumbonella* Vredenburg reported and described from the Miocene of Hlimen, Mizoram<sup>9</sup> have diagnostic characters like ovate outline, strong inflation, thick umbo, produced anterior and its ornamentation. All these characters are well marked in the present specimen. Hence, the identification is beyond doubt.

***Callista (Costacallista) erycina*** Linné, 1758  
(Pl. 4, Fig. 2)

**Dimensions** (mm): Specimen no. B/R-42(a) has the following dimensions: Length 32.00, Height 23.00 (71.87); Inflation 6.00 (18.75).

**Descriptions:** One incomplete right valve is collected from locality no. 2. The species *Callista (Costacallista) erycina* Linné is known to have extremely variable form ranging from

normal type to the more elongate and lanceolate types.<sup>9,11</sup> The present specimen is lanceolate type and matches well with the general outline and external characters of ornamentation of the species under consideration. As such, this has been assigned to *Callista (Costacallista) erycina* Linné without any reservation.

Genus *Dosinia* Scopoli, 1777

***Dosinia (Dosinia) peralta*** Vredenburg (Pl. 4, Figs. 3–4)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation
B/B-3	21.00	23.00 (109.52)	4.00 (19.04) RV
B/LG-4	19.00	21.00 (110.52)	3.20 (16.84) RV

**Descriptions:** The specimens at hand are two right valves collected from locality no. 1 and 5. The diagnostic characters of the species are sub-orbicular outline, height slightly more than the length, moderate inflation, symmetrical ventral margin, long and straight postero-dorsal margin, concavity at the anterior end and fine concentric growth lines. All these characters can be clearly seen in the isolated valves at hand. Hence, the assignment.

***Dosinia (Dosinia) subpenicillata*** Vredenburg, 1928 (Pl. 4, Figs. 5–6)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation
B/B-19	29.00	27.00 (93.10)	5.00 (17.24) LV
B/B-25	39.00	36.00 (92.30)	5.00 (12.82) LV

**Descriptions:** The materials consist of two isolated left valves from locality no. 1. The diagnostic features in the species *Dosinia subpenicillata* are orbicular form expanded in an antero-posterior direction with feeble convexity, almost horizontal ligamental margin and surface sculpture consists of fine and numerous concentric ridges.<sup>12</sup> All these characters are clearly marked in the two specimens at hand. Therefore, these can be assigned *Dosinia subpenicillata* without any reservation.

Genus *Clementia* Gray, 1842

***Clementia (Clementia) papyracea*** Gray,

1825 (Pl. 4, Figs. 7–9)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation	
B/FZ-2	32.00	20.00 (62.5)	13.00 (40.62)	BV
B/B-8	15.00	15.00 (100.00)	7.00 (46.66)	BV
B/GZ-266	27.00	17.00 (62.96)	8.00 (29.62)	RV

**Descriptions:** One incomplete bivalved and one fragmentary right valve are collected from locality no. 1, 4 and 6. Though the species *Clementia (Clementia) papyracea* Gray is a variable form, it has a characteristic ornamentation, i.e. coarse concentric undulations that are in turn finely striated. This typical surface sculpture can be clearly seen in all the specimens at hand. Therefore, these have been assigned to the species under consideration.

Genus *Paphia* Roeding, 1798

*Paphia (Paphia) rotundata* Linné, 1969 (Pl. 4, Figs. 10–13)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation	
B/FZ-21	25.00	16.00 (64.00)	9.00 (36.00)	BV
B/FZ-30	30.00	17.00 (56.66)	5.00 (16.66)	RV
B/GZ-268	21.00	12.00 (62.50)	4.00 (19.04)	LV
B/GZ-269	32.00	20.00 (62.50)	12.00 (37.50)	BV

**Descriptions:** Three bivalve specimens, one left and right valves each are collected from locality no. 4 and 5. These specimens have been assigned to *Paphia (Paphia) rotundata* Linné owing to almost total similarity with this species in respect of general outline, dimensional ratios, nature and positions of umbo and in surface ornamentation. The identification has been further confirmed by the direct comparison of the present specimens with the same species reported from Miocene of Mizoram.<sup>9</sup>

*Paphia (Paphia) jhai* Tiwari MS (Pl. 4, Figs. 14–15)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation	
B/LG-22	32.00	19.00 (59.37)	13.00 (40.62)	BV
B/LG-215	16.00	10.00 (62.50)	6.00 (37.50)	BV

**Descriptions:** The specimens at hand are the two complete specimens from locality no. 5.

They exhibits all the diagnostic characters like overall shape, dimensional ratios, position of umbo and external sculpture of the species *Paphia (Paphia) jhai* Tiwari (1992). On direct comparision, these are also found to match very closely with the holotype of Tiwari's collection. Hence, the identification.

*Paphia (Callistotapes) pseudoliratus* Vredenburg, 1928 (Pl. 4, Fig. 16–17)

**Dimensions (mm):**

Sp. no.	Length	Height	Inflation	
B/FZ-40	16.00	11.00 (68.75)	3.00 (18.75)	RV
B/LG-272	17.00	15.00 (88.23)	3.00 (17.64)	RV

**Descriptions:** Two broken right valves are collected from locality no. 4 and 5. Diagnostically compressed outline, elongate-ovate shape, narrowly rounded anterior and posterior margins; elongate ill defined lunule and prominent concentric sculpture separated by narrow interstices are satisfactorily marked in all the specimens of the present collection. On the account of the above characters, these match very well with the *Paphia (Callistotapes) pseudoliratus* Vredenburg and are accordingly assigned.

Genus *Timoclea* Brown, 1827

*Timoclea (Timoclea) scabra* Hanley, 1844 (Pl. 4, Figs. 18–19)

**Dimensions:** Dimensions could not be measured due to fragmentary nature of the specimens.

**Descriptions:** Two fragmentary left valves from locality no. 3 and 5 represent this species. The diagnostic characters of the species in question are ovate-trigonal outline, moderate inflation, rounded posterior and ventral margins and concentric growth lines crossed over by fine radials. The radials become more prominent just anterior to the posterior slope. Though the specimens under study are fragmentary and other characters could not be ascertained, the characteristic surface sculpture i.e. concentric growth lines crossed over by the fine radials and the radial in turn becoming prominent just anterior to posterior

slope, can be clearly seen in all the specimens available for the study. Thus, these can be safely merged with *Timoclea (Timoclea) scabra* Hanley on account of the above characters.

Order MYOIDA Stoliczka, 1870  
Family CORBULIDAE Lamarck, 1818  
Genus *Corbula* Bruguiere, 1797  
***Corbula (Corbula) mekranica*** Vredenburg, 1928 (Pl. 5, Fig. 2)

**Dimensions** (mm): Specimen no. B/B-203 has the following dimensions: Length 13.00, Height 12.00 (92.30); Inflation 3.00 (23.07).

**Descriptions:** The presently described specimen is one right valves embedded in the matrix recovered from locality no. 1. When comparing *Corbula (Corbula) tunicosulcata* with *Corbula (Corbula) mekranica*, there is not much difference between the two species excepting that the former is more inequivaled and less elongate.<sup>12</sup> Mizoram examples are also more inequivaled and less elongate, hence these are clubbed with *Corbula (Corbula) mekranica* Vredenburg. These, on comparison with the same species reported from the Miocene of Mizoram,<sup>9,10</sup> it is also found to match very well. Hence, assignment is confirmed.

***Corbula (Corbula) tunicosulcata*** Vredenburg  
(Pl. 5, Figs. 3–4)

**Dimensions** (mm):

Sp. no.	Length	Height	Inflation	
B/B-54	15.00	10.00 (66.66)	4.00 (26.66)	LV
B/B-204	15.00	9.00 (60.00)	5.00 (33.33)	RV

**Remarks:** The specimens at hand are one left and right valves each embedded in the matrix collected from locality no. 1. The specimens under study have broadly triangular, flattened and moderately incurved umbo, high inflation, elongated and contracted posterior portion with a prominent curvilinear ridge and surface with broadly spaced angular costae. These can be compared very well with new species *Corbula (Corbula) tunicosulcata* christened by Vredenburg (1928). Hence, the assignment.

## DISCUSSION AND CONCLUSION

The six fossil localities of the study area have yielded 44 species of bivalves belonging to 26 genera and 17 families. Out of these 44 species, seven species, namely *Barbatia* sp., *Arcopsis* sp., *Cyclocardia* sp., *Clinocardium* sp., *Cultellus* sp., *Gari (Psammobia) kingi* (Noetling), and *Corbula (Corbula) mekranica* Vredenburg are reported and illustrated for the first time from the Bhurban Formation of Mizoram. However, identification at the specific level could not be attempted for the first-five species listed above for want of better-preserved materials and more information.

Out of the known geological age range of 38 bivalve species of the study area (Table 1), only four species (10.5%) are found to have an age range starting from Rupelian (Lower Oligocene). From these four species, *Clementia (Clementia) papyracea* Gray has an age range extending up to Recent, *Trisidos semitorta* Lamarck up to Silician, *Tellina Eurytelina* cf. *pilgrimii* Cox up to Helvetian, *Gari (Psammobia) kingi* Noetling ranges up to Aquitanian. Three species out of the 38 bivalves species of the study area has a geological age range of Aquitanian to Recent; one species from Auitanian to Silician; three species from Aquitanian to Plaisancian; four species from Aquitanian to Helvetian; nineteen species (50%) has an age range from Aquitanian to Burdigalian; two species from Burdigalian to Recent; and two species have an age ranging from Burdigalian to Helvetian.

A close study of these fossil assemblages of the study area reveals that, majority of the species has a geological age ranging from Aquitanian to Burdigalian. Therefore, it can be inferred that, the Upper Bhurban unit of Bhurban Formation is of Aquitanian to Burdigalian age, i.e. Lower Miocene (~ 20 to 23 million years).

## ACKNOWLEDGEMENT

The author gratefully thanks Ms. Lal-

chawimawii, Research scholar, Department of Geology, Mizoram University for her help during the identification of the specimens. Mr. J. Malsawma and Jimmy Lalnunmawia, research scholars in the Department are also thankfully acknowledged for assisting me during the entire fieldwork and also for preparing the illustrations.

## REFERENCES

1. Moore RC see *treatise* (1969-71). Treatise on Invertebrate Paleontology, Pt. N, Moollusca 6, Bivalvia. *Geol Soc Amer Univ Kansas*, 1-3, N1-N1224.
2. Evans P (1964). Tectonic framework of Assam. *J Geol Soc Ind*, **5**, 80-96.
3. Ferdous SH & Renaut RW (1996). Preservation of primary porosity in Neogene clastic reservoirs of the Surma Basin, Bangladesh. *AAPG Bulletin*, 80.
4. Rahman MJJ & Faupl P (2003). The composition of the subsurface Neogene shales of the Surma Group from the Sylhet Trough, Bengal Basin, Bangladesh. *Sediment Geol*, **115**, 407-417.
5. Sarkar K & Nandy DR (1977). Structures and tectonics of Tripura-Mizoram area, India. *Geol Surv India (NER)*, **7**, 11.
6. Ganju JL (1975). Geology of Mizoram. *Bull Geol Min Met Soc Ind*, **48**, 17-26.
7. Karunakaran C (1974). Geology and Mineral resources of the states of India. *Misc Publ Geol Surv India*, 30, 93-101.
8. Ganguly S (1975). Tectonic evolution of Mizo Hills. *Bull Geol Min Met Soc India*, **48**, 28-40.
9. Tiwari RP (1992). Palaeontological and biostratigraphic studies of the Surma Group rocks around Aizawl and Lunglei, Mizoram, India. *Unpublished Ph.D. Thesis of Gauhati University*, p. 287.
10. Mazumder BI (2004). A Study of Miocene invertebrates from the area around Kolasib, Mizoram. *Unpublished Ph.D. Thesis of Nagaland University, Kohima*, p. 259.
11. Mukerjee PN (1939). The fossil fauna of the Tertiary of Garo Hills, Meghalaya. *Paleontol Ind N S*, **28**, 1-101.
12. Vredenburg EW (1928). Description of Mollusca from the post-Eocene Tertiary Formation of north-western India: Gastropoda (in part) and Lamellibranchiata. *Mem Geol Surv India*, **50**, 351-506.
13. Tiwari RP (2001). Neogene palaeontology of the Surma Group, Mizoram, India. 1-The Arcoida (Mollusca : Bivalvia). *J Paleontol Soc India*, **46**, 147-160.
14. Cox LR (1936). Fossil Mollusca from Southern Persia (Iran) and Bahrein Island. *Paleontol Ind N S*, **22**, 1-69.
15. Lyngdoh BC (2004). A study of Mollusca from the Garo Group of Meghalaya, India, *Unpublished Ph.D. Thesis of Nagaland University, Kohima*, p. 66.
16. Nakagawa T (1998). Miocene Molluscan Fauna and Palaeoenvironment in the Niu Mountains, Fukui Prefecture, Central Japan. *Sci Rep Inst Geosci Univ Tsukuba Sec B*, **19**, 61-185.
17. Tiwari RP & Kachhara RP (2000). Two new species of *Apolymetis* (Bivalvia: Tellinidae) from the Miocene of Mizoram, India. *Tertiary Res*, **20**, 79-84.