



## FIRST RECORD OF *PRESSASTARTE* ZAKHAROV AND *PINGUIASTARTE* KELLY (MOLLUSCA: BIVALVIA) FROM THE TURONIAN (UPPER CRETACEOUS) OF THE BAGH BEDS, CENTRAL INDIA

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### ABSTRACT

The genus *Pressastarte* Zakharov, 1970 and the subgenus *Pinguiastarte* Kelly, 1992 (Family Astartidae) have been recorded from the Turonian (Upper Cretaceous) of the Bagh Beds, central India for the first time. The *Pressastarte* Zakharov is represented by two species: *Pressastarte* (*Pressastarte*) *lincolnhirensis* Kelly 1992 and *Pressastarte* (*Pressastarte*) var. *clavertensis* Duff, 1978 in the Bagh Beds. *Pressastarte* (*Pinguiastarte*) *senecta* (Woods, 1906) and *Pressastarte* (*Pinguiastarte*) var. *pressula* Zakharov 1970 are the two recorded species of the subgenus *Pinguiastarte*. On the basis of the present record, henceforth the *Pressastarte* (*Pinguiastarte*) ranges from the Middle Jurassic (Middle Bathonian) to the Late Cretaceous (Turonian).

**Keywords:** Bivalvia, Astartidae, Bagh beds, Upper Cretaceous, Turonian, Central India

### INTRODUCTION

The family Astartidae d'Orbigny, 1844 is one of the most common veneroid elements during the Mesozoic. Scarlato and Stareebogatov (1979) elevated it to superfamily category. But most of the bivalve experts still follow the classification incorporated in Treatise (Moore *et al.*, 1969). Morphologically, it is highly variable bivalve group and it is characterised by equilateral to highly inequilateral valves, trigonal to subquadrate in outline, surface ornamented with variable commarginal ribs (both in strength and distribution on the flank) and with both external and inframarginal ligaments. It has three subfamilies Astartinae d'Orbigny, 1844, Eriphylinae Chavan, 1952 and Opinae Chavan, 1952. These three subfamilies are more distinctly differentiated on the hinge and ligament characters. Externally, Astartinae has subtrigonal to subtrapezoidal outline and more or less curved umbo; Eriphylinae has crassatelliform outline and pointed beaks and Opinae has typical oblong or transversely carinated shell with very high beaks. Of these, Astartinae has been most worked out and represented by more than 35 genera/and subgenera from Devonian to Recent. However, during the Mesozoic, it has poor record in the Triassic. It may be that some of the genera confined to the Jurassic may later range back to Triassic, e.g. *Praeconia* (Hautmann, 2001). There was much evolutionary diversification during Jurassic times, especially during the Middle Jurassic (e.g. Zakharov, 1970; Duff, 1978; Kelly, 1992; Fürsich *et al.*, 2002). Still, a comprehensive revision of this family is required (Garderner and Campbell, 2002). During Cretaceous, it is represented by 13 genera/and subgenera, which may be related to the rapid boost in the global marine biodiversity during that time (Purdy, 2008). Particularly, the Cenomanian/Turonian boundary witnessed a strong environmental fluctuation at global scale affecting the increase in the diversity pattern of fauna (Grandstein *et al.*, 2008).

*Pressastarte* was introduced by Zakharov (1970) as a subgenus of *Neocrassina* to include tiny, highly compressed species with strongly denticulate margin. It is distinguished from *Lyapiennella* Zakharov, 1970 in being much smaller and in having more compressed shells with small umbonal cavity; PIV

(posterior lateral tooth) less differentiated from nymph, and less developed lunule. *Coelastarte* Böhm carries some similarities to *Pressastarte* in general outline, but the latter in having a more posteriorly placed PII (posterior lateral tooth) together with less developed lunule and less penetrating escutcheon (Duff, 1978). The shells of *Pressastarte* are both thick and thin with broad hinge plate as in *Neocrassina* (*Pressastarte*) *ungulata* (Lycett, 1863) and narrow hinge plate as in *Neocrassina* (*Pressastarte*) *clavertensis* Duff, 1978.

Kelly (1992) further added *Eriphyla* to this family, which originally belonged to Eriphylinae (Zakharov, 1970). Kelly (1992) assigned *Pressastarte* a generic status and created a new subgenus *Pinguiastarte* to accommodate weakly to moderately inflated *Pressastarte* with conspicuous commarginal ribs, regularly distributed throughout the shell surface. However, Fürsich *et al.* (2000) identified four species of *Pressastarte* (*Pinguiastarte*) from the Chari Formation (Callovian-Middle Jurassic) of the Kachchh Basin, India and they mentioned that the commarginal ribs are variable in strength on the entire shell-surface.

The hinge formula of *Pressastarte* as specified by Zakharov (1970) is AI- 3a- 3b- PI/ AII-2-4b- PII. The structure of the lateral and cardinal teeth is also variable in strength, shape, size and elongation. It is difficult to differentiate between the Late Jurassic species of *Pressastarte* due to much variation in external and internal morphological characters (Duff, 1978). These Jurassic and the Cretaceous astartids required a thorough examination essentially based on the population studies (Duff, 1978). We are not in position to work out these variations as we have insufficient number of specimens required for the purpose.

The present communication records these unknown compressed astartids from the Turonian (Late Cretaceous) of the Bagh Beds, central India.

### GEOLOGY

The intracratonic Narmada Basin of west-central India received a few meter thick Late Cretaceous siliciclastic and calcareous sediments as a consequence of global sea level rise. These sediments of the Lower Narmada Basin are popularly

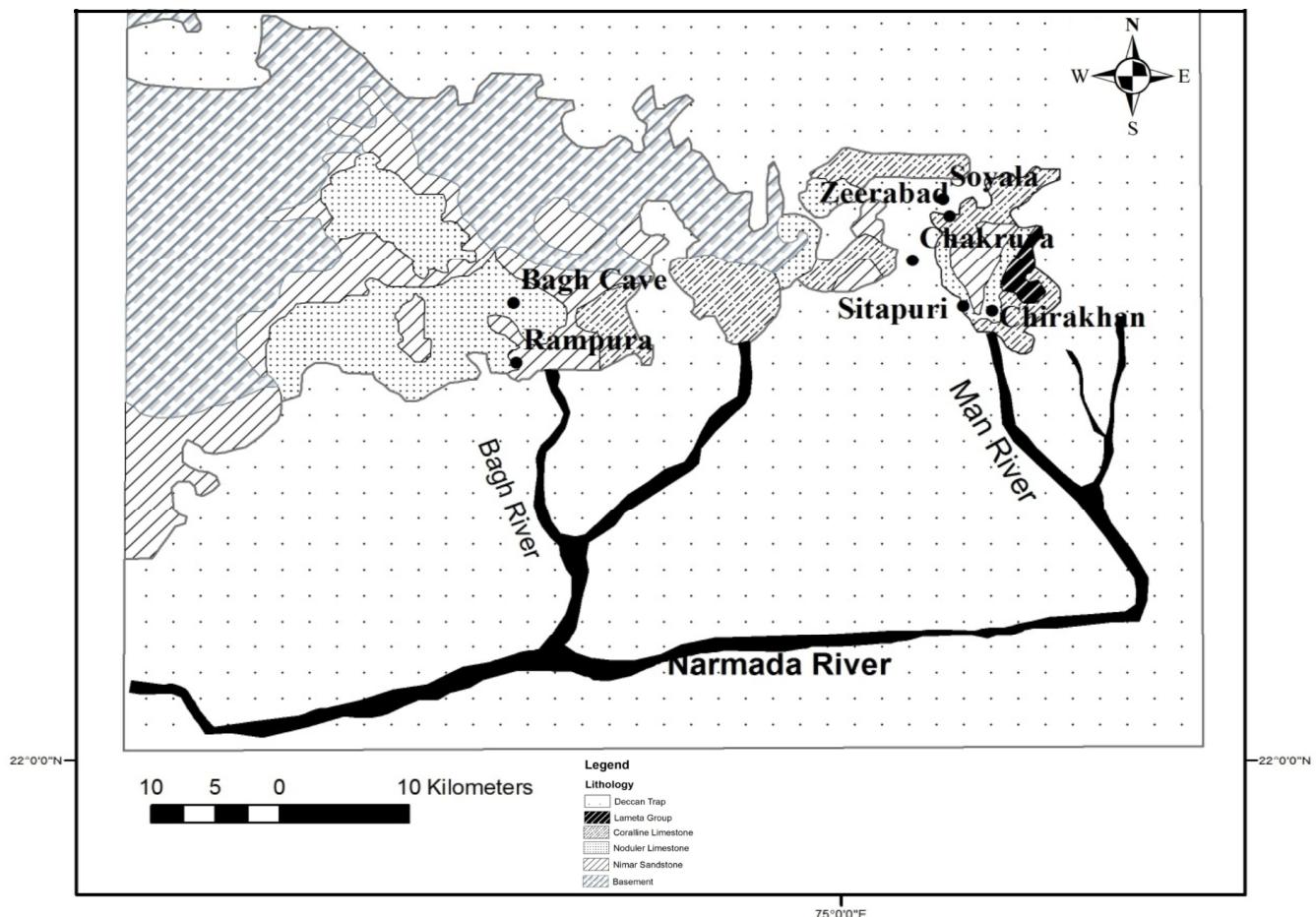


Fig. 1. Geological Map (modified after Jaitly and Ajane, 2013).

known as the Bagh Beds with type locality near Bagh caves of central India (Fig. 1). The geology of the Bagh Group of sediments has been comprehensively reviewed by Jaitly and Ajane (2013). These authors subdivide the Bagh Group into three formations Nimir Sandstone, Nodular Limestone, and Coralline Limestone formations in ascending order, ranging from Cenomanian to Coniacian (Fig. 2). The Nodular Limestone Formation is further subdivided into two members, lower Karondia Member and upper Chirakhan Member. The astartids described here are collected from the Turonian Nodular Limestone Formation.

Lameta Group and Deccan Traps			
Group	Formation	Member	Age
Bagh	Coralline Limestone		Coniacian
	Nodular Limestone	Chirakhan	
		Karondia	Turonian
	Nimir Sandstone		Cenomanian
Crystalline rocks			

Fig. 2. Stratigraphy of the Bagh Group (after Jaitly and Ajane, 2013).

**Repository:** All the described specimens are kept in the Invertebrate Palaeontology Lab., Centre of Advanced Studies in Geology, Banaras Hindu University, Varanasi 221005.

## SYSTEMATIC PALAEONTOLOGY

*Family Astardiae d'Orbigny, 1844  
Subfamily Astartinae d'Orbigny, 1844  
Genus Pressastarte Zakharov, 1970  
(Type species: *Astarte tremblazensis* de Loriol, 1901).  
Subgenus Pressastarte s.s.  
*Pressastarte* (*Pressastarte*) var. *clavertensis* Duff, 1978  
(Figs. 3E, F)  
var. *Pressastarte* (*Pressastarte*) *clavertensis* sp.nov. - Duff, 1978, p. 95,  
pl.11, figs. 4-7, 9-11; text-fig. 29.*

*Material:* Three specimens (Nos. BHU 2015 III4, BHU 2015 III13, BHU 2015 III33) have been recorded from the Nodular Limestone Formation of Sitapuri and Chakrur (Dist. Dhar).

*Description:* Specimens small, suborbicular, compressed with small and slightly protruding prosogyrate umbones; Antero-dorsal margin imperceptibly concave, postero-dorsal margin weakly convex, anterior and posterior margins equally rounded and merging smoothly with gently curved ventral margin. Lunule slightly elongate and shallow; escutcheon much elongated and moderately deep. The shell surfaces eroded but preserved part consists of strong commarginal ribs. Internal characters unknown.

*Measurements:*

Specimen No.	Height(mm)	Length(mm)	Inflation(mm)
BHU 2015 III4	12.00	15.00	4.00 (LV)
BHU 2015 III13	16.00	18.00	8.00 (BV)
BHU 2015 III33	17.00	18.00	7.00 (BV)
Range	12-17	15-18	7-8
Mean	15	17	7.5

*Remarks:* Based on suborbicular outline, compressed shells and development of umbones, lunule, and escutcheon, the Bagh specimens resemble well *Pressastarte* (*Pressastarte*) *clavertensis* Duff, 1978 from the Lower Oxford Clay (Middle Jurassic) of England. *P. (P.) clavertensis* is distinguished from closely allied species *Neocrassina* (*P.*) *ungulata* (Lycett, 1863) on the basis of ornamentation, which is not perceptible in our specimens. Since *P. (P.) clavertensis* has been recorded from the Middle Oxford Clay (Middle Jurassic) and our specimens are from the Turonian (Late Cretaceous), visualising the long geological age gap, these have been provisionally described here as a variety of *Pressastarte* (*Pressastarte*) *clavertensis* Duff, 1978.

*Pressastarte* (*Pressastarte*) *lincolnshirensis* Kelly, 1992  
(Figs. 3G, H; K-M, Text-fig.)

*Pressastarte* (*Pressastarte*) *lincolnshirensis* sp. nov. – Kelly, 1992, p. 116, pl. 27, figs. 1, 4.

*Material:* Six specimens (Nos. BHU 2015 III6, BHU 2015 III7, BHU 2015 III 12, BHU 2015 III 19, BHU 2015 III 23, BHU 2015 III 40) have been recorded from the Nodular Limestone Formation of Chakrur (Dist. Dhar).

*Description:* Specimens medium-sized, subovate, and highly compressed; umbones small, prosogyrate, and barely protruding above dorsal margin. Antero-dorsal margin slightly concave to straight; postero-dorsal margin straight; anterior and posterior margins regularly convex and merging smoothly with convex ventral margin; both lunule and escutcheon elongated and moderately deep. In well-preserved specimens, a small and posteriorly sloping posterior area is preserved, which is demarcated by a faint posterior umbonal ridge from the main shell surface. The shell surfaces eroded but traces of coarse commarginal ribs are traceable along the dorsal area. Left valve hinge consists of two cardinal teeth (2 and 4b) and two laterals AII and PII; Cardinal tooth 2 trigonal, thick and subparallel to lunular margin; 4b narrow, acutely elongated and somewhat undifferentiated from nymph; both the laterals AII and PII are lamellar (Fig. 4).

*Measurements:*

S. No	Specimen No.	Height (mm)	Length (mm)	Inflation (mm)
1	BHU 2015 III6	16.00	20.00	7.00 (BV)
2	BHU 2015 III7	22.00	28.00	5.00 (LV)
3	BHU 2015 III 12	16.00	19.00	4.00 (LV)
4	BHU 2015 III 19	17.00	19.00	7.00 (BV)
5	BHU 2015 III 23	19.00	20.00	4.00 (LV)
6	BHU 2015 III 40	17.00	20.00	5.00 (LV)
	Range	16-22	19-28	7-10
	Mean	17.83	21	8.33

*Remarks:* *Pressastarte* (*Pressastarte*) *lincolnshirensis* differs from *P. (P.)* var. *clavertensis* Duff, 1978 and *P. (P.) striatocostata* (Münster in Goldfuss and Münster, 1837) described by Kelly (1992, p.112) from the Lower Cretaceous of

Lincolnshire (England) in having a more elongate commissural margin and a small posterior area. In the original specimens of *Pressastarte* of Zakharov (1970, pl. 13, figs.5-8), the shell surface comprises coarse commarginal ribs regularly distributed in the entire shell surface. However, Duff (1978) and Kelly (1992) mentioned that these coarse commarginal ribs are weak and/or lacking along the ventral area. The present specimens, though poorly exhibiting ornamental features, show traces of coarse concentric ribs in the umbonal area and faint commarginal ribs near the ventral margin.

*Subgenus* *Pinguiastarte* Kelly, 1992

(*Type species:* *Astarte senecta* Woods, 1906)

*Pressastarte* (*Pinguiastarte*) *senecta* (Woods, 1906)

(Figs. 3A-D)

*Astarte senecta* Woods, 1906, p.106, pl. 14,13-20.

*Astarte sinuicostata* Chiplonkar and Badve, 1972, p. 91, pl. 3, figs. 1-3, 6, test-figs. 6,7.

*Astarte* cf. *Astarte senecta* Woods - Chiplonkar and Badve, 1972, p. 93, pl. 3, fig. 5.

*Material:* Two articulated specimens (Nos. BHU 2015 III1 and BHU 2015 III35) from the Nodular Limestone Formation of Sitapuri and Rampura.

*Description:* Specimen (no. BHU 2015 III1) large (L=38.0 mm) while specimen (no. BHU 2015 III35) smaller in size (L= 21.0 mm). Larger specimen sub-trigonal in outline, height is slightly greater than length (H/L about 126%), moderately inflated (I/L about 44%) with small, prosogyrate umbones; antero-dorsal margin moderately convex; postero-dorsal straight; anterior and posterior margins rounded and merge with asymmetrically curved ventral margin in rounded off obtuse angles; lunule and escutcheon elongated and narrow (lunule less elongated and deeper than escutcheon). Smaller specimen more or less rounded, compressed, with still much smaller umbones; antero-dorsal margin almost straight, postero-dorsal margin convex and meeting the ventral margin in a regular curve. Ornamentation of both specimens consisting of sharp, coarse commarginal ribs separated by narrow interspaces. These commarginal ribs folded sharply close to postero-dorsal margin and meet the postero-dorsal margin obliquely. Internal characters unknown.

*Measurements:*

S. No	Specimen No.	Height (mm)	Length (mm)	Inflation (mm)
1	BHU 2015 III1	39.00	38.00	17.00 (BV)
2	BHU 2015 III35	21.00	21.00	8.00 (BV)

*Remarks.* *Astarte senecta* Woods (1906) from the Lower Cretaceous of England shows remarkable variations in general outline and size. The smaller specimen (no. BHU 2015 III35) from the Bagh Bed falls well within the range of characters of *A. senecta*; Similarly the other specimen (no BHU 2015 III1) strongly resembles *P. (Pinguiastarte) senecta* of Kelly in general outline and ornamentation but differs only in being larger (L= 39 mm). Kelly (1992) erected a new subgenus of *Pinguiastarte* to accommodate those pressastartids which are compressed but moderately inflated with coarse persistent commarginal ribs over the entire flank. He designated *A. senecta* Woods (1906) as subgenotype of his new subgenus *Pinguiastarte*. *Astarte sinuicostata* Chiplonkar and *Astarte* cf. *A. senecta* Woods recorded by Chiplonkar and Badve (1972) from the same locality and horizon fall well within the range of the characters of *Pressastarte* (*Pinguiastarte*) *senecta*. *Astarte* (*Astarte*)

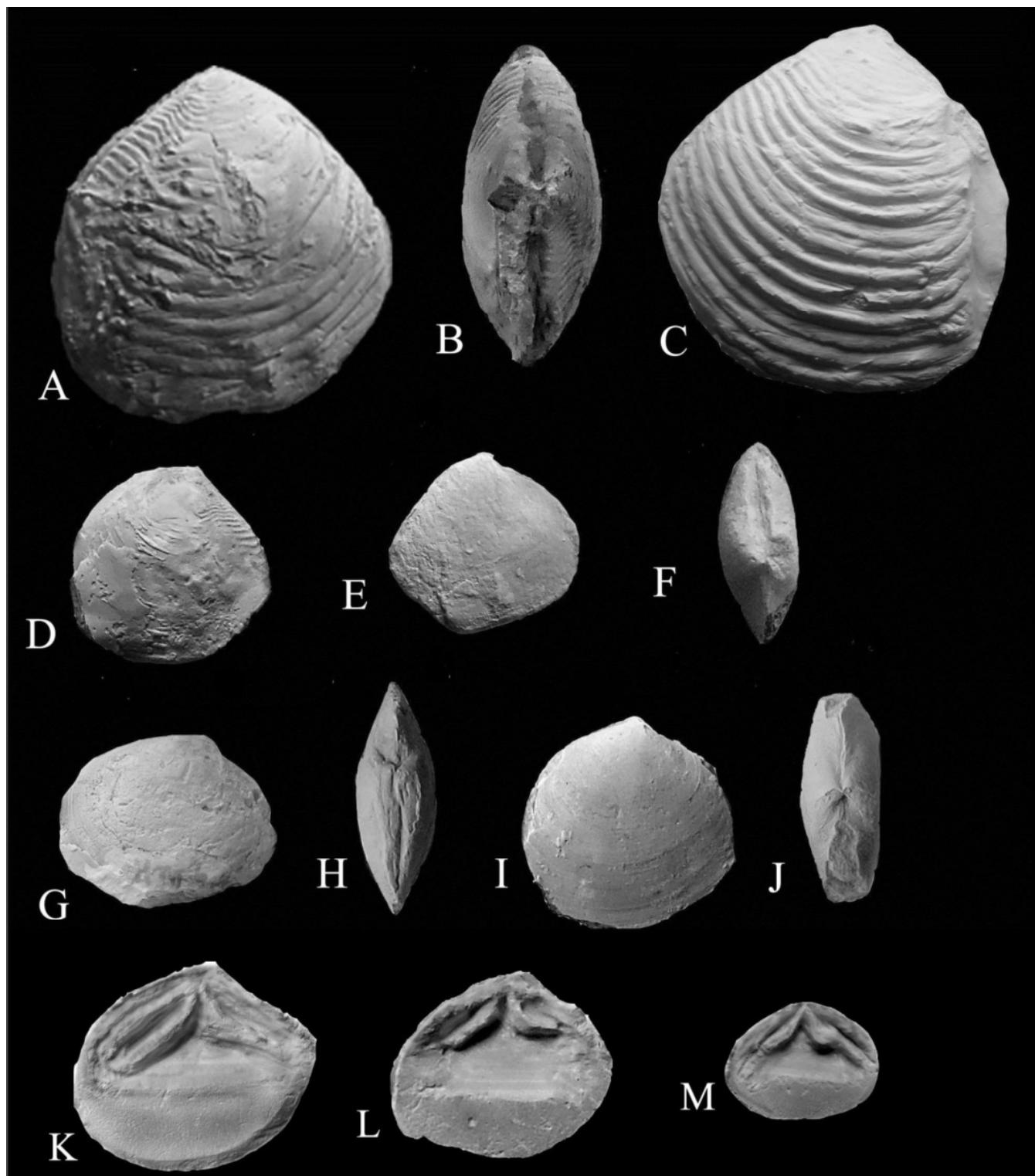


Fig.3. Compressed astartids from the Nodular Limestone Formation (Turonian), Bagh Beds.

- A, D. *Pressastarte (Pinguiastarte) senecta* (Woods, 1906). External view of right valve x 1.5 (specimen no. BHU 2015 III1), B. Dorsal view x 1.5 (same specimen), C. External view of left valve x1.5 (same specimen), D. External view of right valve x2.5 (specimen no. BHU 2015 III35).
- E, F. *Pressastarte (Pressastarte)* var. *clavertensis* Duff, 1978  
E. External view of right valve x2.5 (specimen no BHU 2015 III13), F. Dorsal view x 2.5 (same specimen).
- G, H, K-M. *Pressastarte (Pressastarte) lincolshirensis* Kelly, 1992  
G. External view of right valve x 1.5 (specimen no. BHU 2015 III 19), H. Dorsal view x1.5 (same specimen); K-M. Internal views of left valve x3 (K-specimen no. BHU 2015 III7, L- specimen no. BHU 2015 III 40 and M- specimen no. BHU 2015 III6).
- I, J. *Pressastarte (Pinguiastarte)* var. *pressula* Zakharov, 1970  
I. External view x 2 (specimen no. BHU 2015 III11), J. Dorsal view x 2 (same specimen).

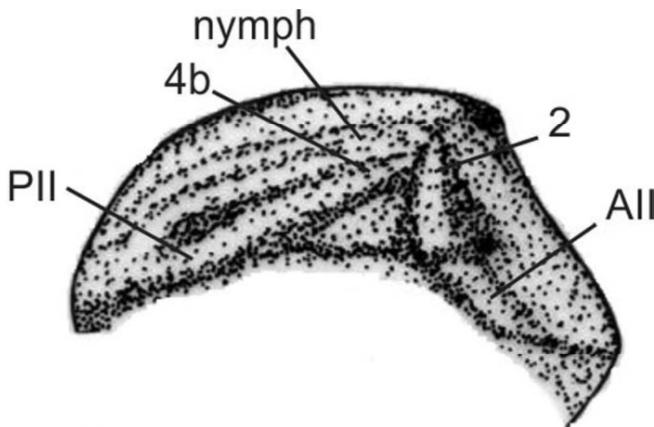


Fig. 4. Hinge of the left valve of *Pressastarte* (*Pressastarte*) *lincolnshirensis* Kelly 1992, Specimen no BHU2015III7(x3).

*subsenecta* Yabe and Nagao, 1926 described by Hayami and Oji (1980, p.432, pl.53, figs.1-6) from the Early Cretaceous of Japan belongs to *Pinguiastarte* and may be a variant species of *Pressastarte* (*Pinguiastarte*) *senecta* (Woods).

*Pressastarte* (*Pinguiastarte*) var. *pressula* Zakharov, 1970  
(Figs. 3I, J)

var. *Neocrassina* (*Pressastarte*) *pressula* sp. nov.-Zakharov, 1970, p.105, pl.13, fig. 6.

var. *Pressastarte* (*Pinguiastarte*) *pressula* Zakharov -Kelly, 1992, p.116, pl. 27, figs. 6-13; text-fig.70.

**Material:** Three articulated specimens (Nos. BHU 2015 III11, BHU 2015 III16 and BHU 2015 III20) from the Nodular Limestone Formation of Sitapuri and Chakrur (Dist. Dhar).

**Description:** Specimens (BHU 2015 III16 and BHU 2015 III20) rounded in outline, subequilateral and moderately inflated. Specimen (BHU 2015 III11) is slightly transversely elongate. Maximum inflation lies in the umbonal region, die out towards anterior, posterior and ventral margins; umbones small, almost ortho-to prosogyrate and barely protruding above dorsal margin. Lunule small, shallow and broadly lanceolate; escutcheon deep and elongated. Antero-dorsal margin slightly indented, postero-dorsal almost straight to slightly convex; both anterior and posterior margins are regularly convex and meeting the strongly rounded ventral margin in smooth curves. Though surface is eroded, traces of commarginal ribs are perceptible throughout the flank. Internal characters unknown.

#### Measurements:

S. No	Specimen No.	Height (mm)	Length (mm)	Inflation (mm)
1	BHU 2015 III11	21.00	21.00	8.00 (BV)
2	BHU 2015 III16	19.00	21.00	9.00 (BV)
3	BHU 2015 III20	18.00	20.00	8.00 (BV)
	Range	18-21	20-21	8-9
	Mean	19.33	20.67	8.33

**Remarks:** The present specimens agree well with the type species from Volgian, Russia recorded by Zakharov (1970) and those described by Kelly (1992) from the Middle to Upper Volgian of East England. These specimens are from the Turonian of central India but are strikingly similar in all the morphological features to *Pressastarte* (*Pinguiastarte*) *pressula*, which have no record of from any of the post-Middle Jurassic horizons. Hence

these have provisionally been reported here as a variety of *P. (P.) pressula*. The earlier described species *P. (P.) senecta* (Woods, 1906) is easily differentiated from the present species by its typical subtrigonal valves and archetypal posteriorly sinuated coarse commarginal ribs.

#### STRATIGRAPHICAL REMARKS

These compressed astartids are relatively uncommon in record in comparison to other astartids from the different parts of the world. The genus *Pressastarte* is more common in the Jurassic and known from the Callovian of India and Germany, Oxfordian of France, Germany, Switzerland, Lithuania, central Russian Platform and Kimmeridgian of France. In the Cretaceous, till now it has been exclusively reported from the Upper Ryazanian of eastern England. The subgenus *Pinguiastarte* is more common in the Middle Jurassic (Bathonian) of Europe, Spitsbergen, Greenland, Ural, East Africa, India and Japan; while it has poor record in the Cretaceous with the sole occurrence in Valanginian (Early Cretaceous).

The present record of *Pressastarte* and *Pinguiastarte* from the Turonian (Late Cretaceous) is significant, since earlier in the Cretaceous they have been known only from the Valanginian (Early Cretaceous). The type species of *Pressastarte*, *Astarte trembiensis* de Loriol, 1901 is from the Oxfordian of Jura Bernois, while *Astarte senecta* described by Woods (1906) from the Early Valanginian of North Yorkshire, has been subsequently designated as a type species of *Pinguiastarte* by Kelly (1992). In view of these occurrences, the range of the genus *Pressastarte* can now be considered from the Middle Jurassic (Callovian) to the Late Cretaceous (Turonian) and *Pinguiastarte* from the Middle Jurassic (Middle Bathonian) to the Late Cretaceous (Turonian). Further, the occurrences of these two in the Late Cretaceous may be useful in supplementing the understanding of the global palaeobiogeography during Jurassic-Cretaceous times.

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#### REFERENCE

- Chiplonkar, G.W. and Badve, R.M. 1972. Palaeontology of the Bagh Beds - I-Bivalvia (excluding Inoceramidae and Ostreace). *Journal of the Palaeontological Society of India*, **17**: 67-114.
- Duff, K.L. 1978. Bivalvia from the English Lower Oxford Clay (Middle Jurassic). *Monograph of the Palaeontographical Society of London*, 137 pp., 13 pls.
- Fürsch, F.T., Heinze, M. and Jaitly, A.K. 2000. Contributions to the Jurassic of Kachchh, Western India. VIII. The bivalve fauna. Part IV. Subclass Heterodontia. *Beringeria*, **27**:63-146.
- Gardner, R.N. and Campbell, H.J. 2002. Middle to Late Jurassic bivalves of the genera *Neocrassina* and *Trigonopsis* from New Zealand. *New Zealand Journal of Geology and Geophysics*, **45**: 323-347.
- Goldfuss, A. and Münster, G. 1862-1863. *Petrefacta Germaniae*, 2<sup>nd</sup> Edition. Leipzig.
- Gradstein, F.M., Ogg, J. and Ogg, G. 2008. The geological time scale, p. 125-136. In: *Stratigraphy. Terminology and practice*. (Eds. Rey, J. and Galeotti, S.), *Editions TECHNIP*, Paris. 125-136.
- Hautmann, M. 2001. Die Muschelfauna der Nayband-Formation (Ober Trias, Nor-Rhät) des östlichen Zentraliran. *Beringeria*, **29**:1-181.

- Hayami, I. and Oji, T.** 1980. Early Cretaceous bivalvia from the Choshi District, Chiba Prefecture, Japan. *Transactions of the Proceedings of Palaeontological Society of Japan*, **120**: 419-448.
- Jaitley, A. K. and Ajane, R.** 2013. Comments on *Placenticeras mintoi* (Vredenburg, 1906) from the Bagh Beds (Late Cretaceous), central India with special reference to Turonian Nodular Limestone horizon. *Journal of Geological Society of India*, **81**: 565-574.
- Kelly, S. R. A.** 1992. Bivalvia of the Spilsby Sandstone and Sandringham Sands (Late Jurassic-Early Cretaceous) of Eastern England. *Monograph of the Palaeontographical Society of London, Part 2*, 95-123.
- Family Astartidae d'Orbigny.** 1844. p.N. 562-N571. In: *Treatise on Invertebrate Palaeontology* (Eds Moore, R.C.), Pt N2(of3), Mollusca **6**, Bivalvia, Geological Society of America and University of Kansas Press.
- Purdy, E.G.** 2008. Comparison of taxonomic diversity, strontium isotope and sea-level patterns. *International Journal of Earth Sciences*, **97**: 651-664.
- Scarlato, O.A. and Starobogatov, Y.I.** 1979. General evolutionary patterns and the system of the class Bivalvia. *Transactions of the Zoological Institute and Academy of Science, USSR*, **80**: 5-38.
- Woods, H.** 1906. A monograph of the Cretaceous Lamellibranchia of England. *Monograph of the Palaeontographical Society of London*, **2**, Part. III: 97-132.
- Zakharov, V.A.** 1970. Late Jurassic and Early Cretaceous bivalves of the Serbia North and their ecology Part 2. Family Astartidae. *Transactions of Institute of Geology and Geophysics, SB Academy of Sciences, USSR, Nauka, Moscow, Russian*, **11**:1-144.

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