

Taxonomic revision of the Late Cretaceous Pectinid Bivalves *Neithea* (Drouet) and *Plicatula* (Lamarck) from the Trichinopoly Group, Cauvery Basin, South India

DEEP NARAYAN TIWARI, ANAND KUMAR JAITLEY, BINDHYACHAL PANDEY, JAI PRAKASH GAUTAM,* & ASHISH KUMAR SINGH

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The two bivalve genera *Neithea* and *Plicatula* (family Pectinidae) are all together represented by ten species in the present collection from the Late Cretaceous (Turonian - Coniacian) sediments of the Kulakkalnattam and Anaipadi formations of Trichinopoly Group, Cauvery Basin, south India. The genus *Neithea* consists of five species, namely *Neithea (Neithea) coquandi*, *Neithea (Neithea) quinquecostata*, *Neithea (Neithea) aff. gibbosa*, *Neithea cf. sexcostata*, and *Neithea (Neithella) notabilis*. Similarly, the genus *Plicatula* also comprises five species namely *Plicatula (Plicatula) ferryi*, *Plicatula (Plicatula) hirsute*, *Plicatula (Plicatula) multicostata*, *Plicatula batnesis* and *Plicatula instabilis*. Out of these, *Neithea (Neithea) coquandi*, *Neithea (Neithella) notabilis*, *Plicatula (Plicatula) ferryi*, and *Plicatula (Plicatula) hirsute* are a new record from the Cauvery Basin. All these ten species have been systematically described here. Most of these bivalve species are cosmopolitan in occurrence and in turn may be quite helpful in understanding the global palaeobiogeography during Turonian-Coniacian interval.

ARTICLE HISTORY

Manuscript received: 27/04/2022
Manuscript accepted: 05/10/2022

Keywords: Taxonomy, Late Cretaceous, Bivalvia, Pectinidae, Trichinopoly Group, Cauvery Basin.

Department of Geology, Banaras Hindu University, Varanasi 221005, India. *Corresponding author's e-mail: jaiprakashgtm12@gmail.com

INTRODUCTION

The NE-SW trending Cauvery Basin is considered one of the important sedimentary basins formed during Cretaceous times. It lies in the southeastern sector of India and has been subdivided into Sivganga, Thanjavur, Ariyalur, Vriddachalam, and Puducherry sub-basins. (Fig. 1, A, B). This basin comprises an almost complete stratigraphic record of sediments ranging in age from the Barremian to the Maastrichtian. The deposition of the marine sediments in the basin is attributed to a series of transgressions and regressions during Aptian - Maastrichtian time. Among the above-mentioned five subbasins, the Ariyalur Sub-basin has rich potential to work in the field of stratigraphy and palaeontology due to the abundance of diverse fossil groups.

These Cretaceous sediments of the basin have been lithostratigraphically organized by Blanford (1862) into Uttatur, Trichinopoly and Ariyalur Groups (Table 1). Subsequent workers (e.g. Bhatia and Jain, 1969; Sastry *et al.*, 1972; Sundaram and Rao, 1986; Sundaram *et al.*, 2001; Verma, 2015; Gautam *et al.*, 2019a, b; Pandey *et al.*, 2021a, b) preferred to retain the classification of Blanford (1862) with minor changes. We follow here the framework of Pandey *et al.* (2021a, b) presented in Table (1).

The thick pile of marine fossiliferous sediments in the basin are well known all over the world for its rich invertebrate

faunal record comprising bivalves, ammonoids, gastropods, nautiloids, belemnoids, echinoids, brachiopods, corals, bryozoan, etc. Among these, bivalves are one of the most abundant groups present in almost all marine stratigraphic horizons of the Cauvery Basin. The present work is mainly based on bivalves particularly *Neithea* and *Plicatula* (family Pectinidae), collected from the exposed sediments of Trichinopoly Group of the Aiyalur Sub-basin of the Cauvery Basin. This group of rocks unconformably overlies the Uttatur Group and conformably underlies the Ariyalur Group of rocks. This group has its further subdivisions into the lower Kulakkalnattam Formation and the upper Anaipadi Formation (Sundaram *et al.*, 2001). Lithologically, the Kulakkalnattam Formation of the Trichinopoly Group comprises sandstone and conglomerate in the lower part and inter-layered mudstone, shale, and sandstone in the upper part. The Anaipadi Formation lies conformably over the Kulakkalnattam Formation and consists of siltstone, mudstone, and varied sandstones.

PREVIOUS WORK

The early workers recorded various species of *Neithea* although assigned to different genera from the Cretaceous

Table 1. General stratigraphy of the Cretaceous of the Cauvery Basin, south India (after Pandey *et al.*, 2021a, b).

GROUP	FORMATION	MEMBER	AGE
Ariyalur	Kallamedu		Maastrichtian
	Kallankurichchi		Santonian - Campanian
	Sillakkudi		
Trichinopoly	Anaipadi		Turonian - Coniacian
	Kulakkalnattam		
Unconformity			
Uttatur	Karai	Kunnam	Albian-Cenomanian
		Odiyam	
	Dalmiapuram		Barremian-Aptian
Terani			
Unconformity			
Crystalline Basement (Precambrian)			

successions of different sectors of India. Forbes (1846) recorded *Pecten quinquecostatus* (Sowerby, 1814) from the Ariyalur Group of Puducherry and Vriddachalam localities of south India. Forbes' specimens were later renamed *Neithea* (*N.*) *regularis* (von Schlotheim) by Dhondt (1973). Stoliczka (1871) recorded the above species of Sowerby under *Vola* (Klein, 1753) and *Janira* (?*Neithea*) *laevis* (Drouet, 1824) from the Uttatur, Trichinopoly, and Ariyalur groups of the Cauvery Basin. Dhondt (1973) published a monograph in which she extensively revised numerous European species of *Neithea*, some of which occur also in Asia and Africa. She was of opinion that specimens described as "*Vola*" *quinquecostata* by Stoliczka (1871) from the Aptian - Maastrichtian of Cauvery Basin are actually *Neithea* and may be represented by five species, viz., *N. quinquecostata* (Sowerby, 1814), *N. syriaca* (Conrad)? or *N. coquandi* (Peron)?, *N. regularis* (von Schlotheim)?, *N. sexcostata* (Woodward)? and *N. gibbosa* (Pulteney)?. Dhondt further expected the presence of the sixth species of *Neithea* in the Cauvery Basin by relocating "*Vola*" *laevis* Drouet of Stoliczka (1871) as the synonym of *N. aequicostata* (Lamarck). These records of the different species of *Neithea* were further supplemented by Chiplonkar and Tapaswi (1975) by describing *Neithea pseudobellula* and a subspecies *N. pseudobellula elevata* from the Uttatur Group, which is also the first endemic Indian taxa of the genus. Chiplonkar and Tapaswi (1977) further presented the record of morphologically diverse "*Neithea* (*Neithiops*) *quinquecostata* (Sowerby)" from the Uttatur, Trichinopoly, and Ariyalur groups. Kendrick and Vartak (2007) have also reported the presence of several species of *Neithea* from the Uttatur Group. Among which, *N. aequicostata* (Lamarck), *N. cf. hispanica* (d'Orbigny), *N. gibbosa* (Pulteney), and *N. quinquecostata* (J. Sowerby), exhibit closer affinity to the western European Cenomanian species.

Spengler (1923) recorded *Neithea faujasi* (Pictet and Campiche, 1870) from Assam followed by Bhattacharya and Bhattacharya (1987) from NE India. Dhondt (1973) considered *Janira faujasi* (Pictet and Campiche, 1870) as *Pectinites regularis* (von Schlotheim, 1813), which after revision is recognized as *Neithea regularis*. Dhondt (1973) also recorded *Neithea alpina* (d'Orbigny) from the Bagh Beds, Narmada Basin, central India. Later Chiplonkar and Joshi (1976) reported *Neithea morrissi* (Pictet and Renevier, 1858) also from the Turonian of Bagh Beds. However,

Dhondt (1973) considered it synonymous with *N. syriaca* (Conrad, 1852). But the Indian specimens, seems to be variable in characters and their right valves have different sculpture from Conrad's species (Dhondt, 1973).

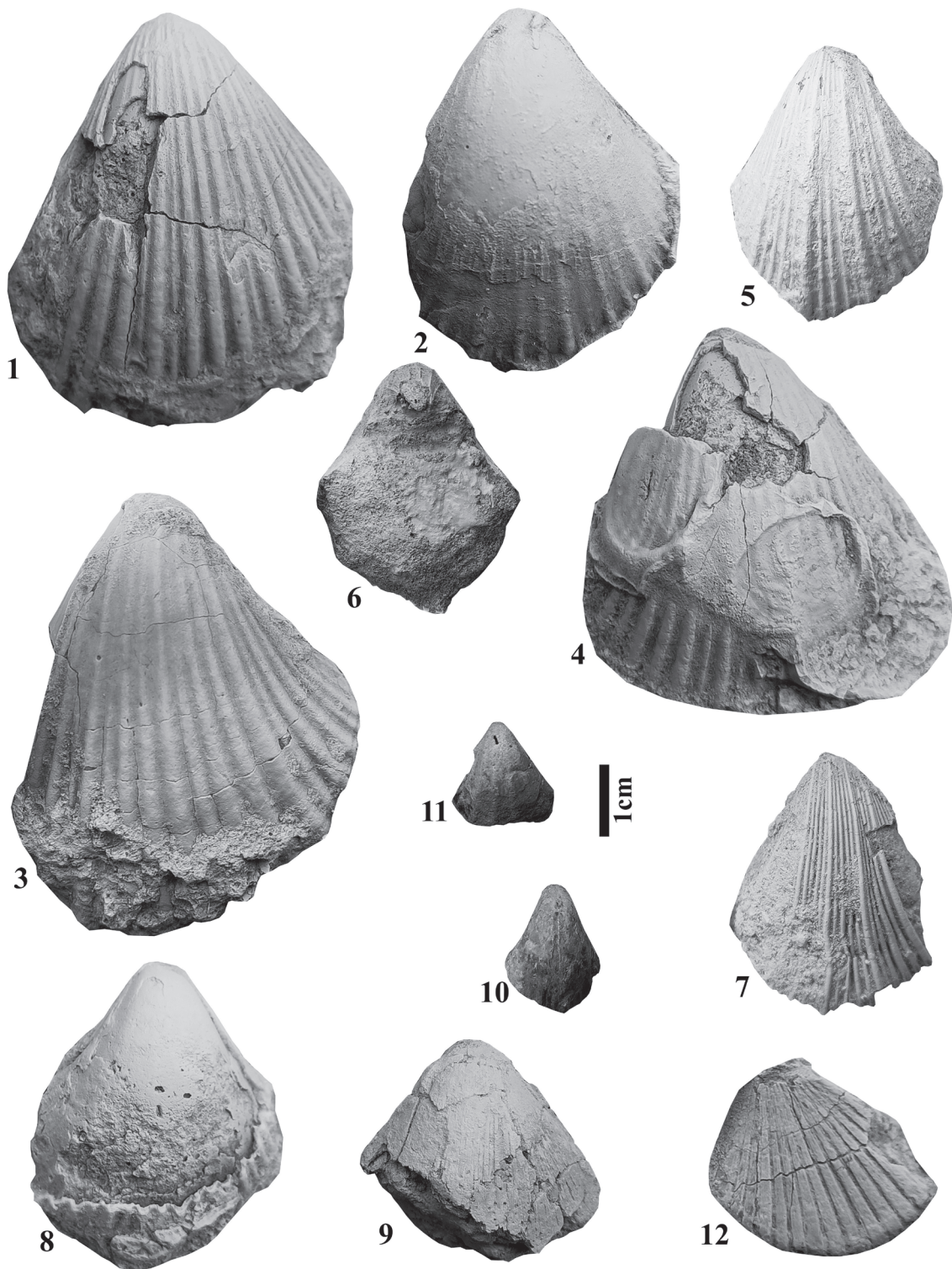
The genus *Plicatula* has a worldwide occurrence and it is quite abundant, especially during the Cretaceous. Like *Neithea*, *Plicatula* was also a widespread, warm-water bivalve during the Cretaceous (Kauffman, 1973). However, Watson (1930) and Cox and Hertlein (1969) have reported the occurrence of a few alive species of this genus only from warm regions. *Plicatula* has not been so common during the Cretaceous in India and is represented by only a few species. *Plicatula sessilis* Stoliczka (1871) and *Plicatula multicostata* Forbes recorded by Stoliczka (1871) respectively form the Uttatur Group and Trichinopoly Group of the Cauvery Basin. Chiplonkar and Tapaswi (1939) recorded *Plicatula pastilliformis* from the Trichinopoly Group appears to be quite a closely allied species to *Plicatula instabilis* (Stoliczka). Further, *Plicatula batnesis* (Coquand) was described by Chiplonkar (1939) and Kumar (2016) from the Turonian of Narmada Basin. Stoliczka (1871) also recorded *P. instabilis* (Stoliczka) and *P. striatocostata* (Stoliczka) from the Ariyalur Group, which may in turn become conspecific with *Plicatula batnesis* (Coquand) from the Narmada Basin. *Plicatula* (*Trichiplicatula*) *distincta* a new species of Chiplonkar and Tapaswi (1976) from the Trichinopoly Group (Turonian - Coniacian), south India is almost similar in outline and surface ornamentation to *P. batnesis*.

PRESENT INVESTIGATION

Based on the previous study, it has been realized that the different species of both genera *Neithea* and *Plicatula*, so far recorded from the Cretaceous of India have been little studied. The exact taxonomic features and variability of characters in the earlier defined species are poorly known and the type specimens have not been reexamined since the description of the species for the first time. A thorough taxonomic revision of these *Neithea* and *Plicatula* bivalves collected from Kulakalnattam and Anaipadi formations of the Trichinopoly Group has been attempted in the present study for a better understanding of these genera recorded from Ariyalur Sub-basin of the Cauvery Basin.

MATERIALS AND METHODS

Over 500 bivalve specimens have been collected from Kulakalnattam and Anaipadi formations of Trichinopoly Group, Cauvery Basin, south India. Out of which 100 specimens belong altogether to ten pectinid bivalve species (5 species each of *Neithea* and *Plicatula*) described here in the present work. The collection comprises moderately to poorly preserved specimens in the majority except for a few well-preserved specimens. The abraded nature of the surface also indicates the allochthonous nature of these bivalves.



EXPLANATION OF PLATE-I

Figures 1-4 *Neithea (Neithea) coquandi* (Péron, 1877), 1. (BHUKKN/12) $\times 1.5$, External view of right valve; 2. (BHUKKN/14) $\times 1.5$, External view of right valve; 3. (BHUKKN/13) $\times 1.5$, External view of right valve; 4. (BHUKKN/11) $\times 1.5$, External view of right valve; **5-7** *Neithea (Neithea) quinquecostata* (J. Sowerby, 1814) 5. (BHUAdan26/17) $\times 1.5$, External view of right valve; 6. (BHUAdan26/17) $\times 1.5$, Internal view of right valve; 7. (BHUAdan26/15) $\times 1.5$, External view of right valve; **8-9** *Neithea (Neithea) aff. gibbosa* (Pulteney, 1813); 8. (BHUKul/16) $\times 1.5$, External view of right valve; 9. (BHUKul/7) $\times 1.5$, External view of right valve; **10-11** *Neithea (Neithella) notabilis* (Münster in Goldfuss, 1833); 10. (BHUKKN/20) $\times 1.5$, External view of right valve; 11. (BHUKKN/19) $\times 1.5$, External view of right valve; **12** *Neithea cf. sexcostata* (Woodward, 1833) (BHUAdan/9) $\times 1.5$, External view of left valve.

The collected specimens were cleaned, prepared, and repositied in the Stratigraphy and Invertebrate Palaeontology Laboratory, Department of Geology, BHU. These specimens were coated with magnesium fume and photographed and taxonomically described. The taxonomic classification proposed by Cox *et al.* (1969) in the Treatise on Invertebrate Palaeontology (volume 1-3, part N) has been primarily used. The subsequent modifications are done by Bieler *et al.* (2010) and Carter *et al.* (2011) have also been followed, where ever needed. The morphological terminologies given in the glossary in the Treatise on Invertebrate Palaeontology (Cox *et al.*, 1969) have been used. The linear dimensions have been measured in millimeters using a vernier caliper. The following abbreviations have been used in the systematic description:

Sl. No: serial number of measured specimens; L: shell length; H: shell height; I: inflation of shell

R.V. - Right valve; L.V. - Left valve; B.V. - Both valves

SYSTEMATICS

Class Bivalvia Linnaeus, 1758
 Subclass Pteriomorpha Beurlen, 1944
 Order Pectinida Gray, 1854
 Superfamily Pectinacea Refinesque, 1815
 Family Pectinidae Refinesque, 1815
 Genus *Neithea* Drouet, 1824
Type species *Pecten aequicostatus* Lamarck, 1819
 Subgenus *Neithea* s.s.

Neithea (*Neithea*) *coquandi* (Péron, 1877)
 (Pl. I, Figs. 1-4)

Janira tricostata sp. nov., Coquand, 1862, p. 219, pl. 13, figs 3-4.

Janira coquandi sp. nov. Péron, 1877, p. 501-509, pl. 7, fig. 2.

Pecten (*Neithea*) *shawi* sp. nov., Pervinquierè, 1912, p.136, pl. 9, figs 1-6.

Pecten (*Vola*) *shawi* Pervinquierè - Blanckenhorn, 1934, p.191, pl. 9, fig. 24

Neithea (*Neithea*) *coquandi* (Péron) - Dhondt, 1973, p. 26, pl. 3, fig. 1a-c.

Neithea (*Neithea*) *coquandi* (Péron) - Andrade *et al.*, 2004, p. 29, figs 4.1- 4.5. (and synonymy there in).

Neithea (*Neithea*) *coquandi* (Péron) - Abdel - Gawad *et al.*, 2004b, pl. 1, fig. 11.

Neithea (*Neithea*) *coquandi* (Péron) - Schneider *et al.*, 2013, p. 581, Text-fig.12H.

Neithea (*Neithea*) *coquandi* (Péron) - Mendir *et al.*, 2021, p.13, figs A-C.

Material: Four specimens (BHUKKN/11, BHUKKN/12, BHUKKN/13 and BHUKKN/14).

Horizon: Kulakkalnattam Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: Near Garudamangalam village.

Dimension

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUKKN/11	52	48	21 (RV)
2	BHUKKN/12	51	43	17 (RV)
3	BHUKKN/13	62	44	22 (RV)
4	BHUKKN/14	50	35	20 (RV)

Description: All these four specimens are right valves, strongly convex, equilateral, and oval in shape. The umbones, orthogyrous, mesial in position, incurved, and finally bending over the dorsal margin. Antero- dorsal and postero - dorsal margins are long and almost straight. Both the anterior and posterior margins are almost equally rounded and merging smoothly with a gently convex ventral margin. The surface ornamentation consists of five strong primary radial costae separated by wider interspaces with three less strong secondary radials. The primary and secondary radials are evenly curved, flat-topped and some of them are sharply crested. The interspaces between primary and secondary radials are gradually widening towards the ventral margin acquiring fan shape. The auricles are damaged in all four specimens.

Remarks: These specimens due to their typical ornamental pattern are resembling adequately with *Neithea* (*Neithea*) *coquandi* recorded by different authors quoted in the synonymy. *Neithea* (*Neithea*) *coquandi* is characterized by the intercalatory ribs in between two primary ribs which are five in number. This surface feature is not known in any of the species of *Neithea* in the published literature. Andrade *et al.*, (2004) discussed in detail this species which they recorded from the Aptian - Cenomanian of Brazil. Earlier Dhondt (1973) reviewed the status of *Neithea* (*Neithea*) *coquandi* and did palaeobiological analysis by recording its distribution from Albian - Cenomanian of Angola, Cenomanian of Egypt, Iraq, Israel, Turonian of France and the Santonian of Somalia and Turkey.

This is the first record of the species from the Turonian sediments of India.

Distribution: Albian - Santonian of southern Europe, the Middle East, and northern and western Africa, upper Aptian - Cenomanian of Brazil (Andrade *et al.*, 2004), and Turonian - Coniacian of India (a present record).

Neithea (*Neithea*) *quinquecostata* (J. Sowerby, 1814)
 (Pl. I, Figs. 5-7)

Pecten quinquecostata J. Sowerby, 1814, p. 122-123, pl. 56, figs 4-8.

Vola quinquecostata (J. Sowerby) - Stoliczka, 1871, p. 437, pl. 31, figs 1-6, pl. 37, figs 4-9.

Vola quinquecostata (J. Sowerby) - Choffat, ?1902, p.149.

Neithea (*Neithea*) *quinquecostata* (J. Sowerby) - Dhondt, 1973, p. 29-37, pl. 2, figs 2a-e. (and synonymy there in).

Neithea (*Neithiops*) *quinquecostata* (J. Sowerby) - Chiplonkar and Tapaswi, 1977, p. 200-202.

Neithea (*Neithiops*) *quinquecostata* (J. Sowerby) - Chiplonkar and Tapaswi, 1979, p. 143 - 145, 154 and 162.

Neithea (*Neithiops*) *quinquecostata* (J. Sowerby) - Dhondt and Dieni, 1993, p.194.

Neithea (*Neithea*) *quinquecostata* Cleavelly and Morris, 2002, p. 127, pl. 21, fig. 10.

Neithea (*Neithiops*) *quinquecostata* (J. Sowerby) - Kendrick and Vartak, 2007, p. 54, fig. 12.

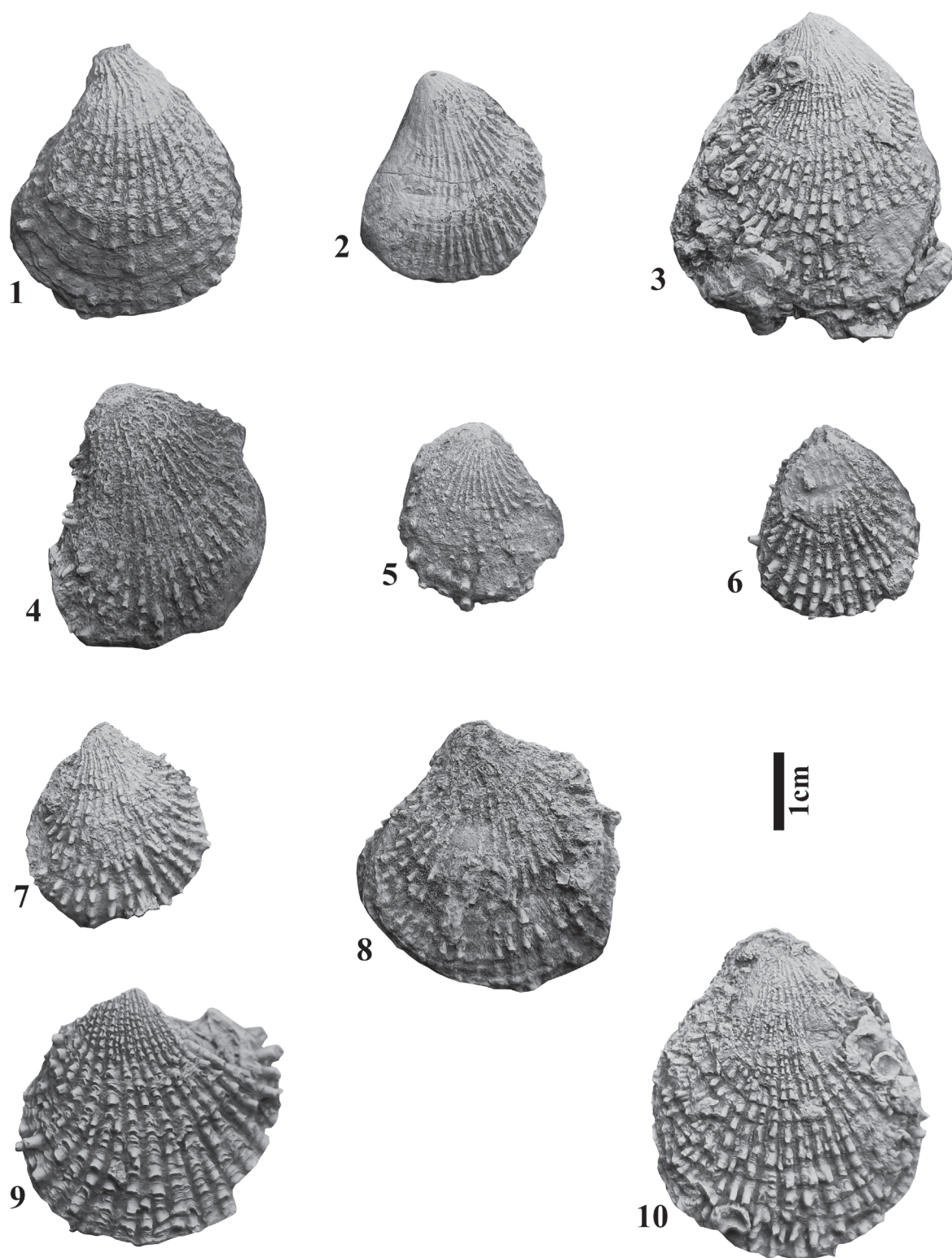
Neithea (*Neithea*) *quinquecostata* - Mekawy and Abu Zied, 2008, p. 305, pl. 2, fig. 9.

Neithea (*Neithea*) *quinquecostata* - Benyoucef *et al.*, 2012, pl. 3, fig. 12, figs 1-2.

Neithea quinquecostata (J. Sowerby) - Schneider *et al.*, 2013, p. 580, Text-fig. 12J, K.

Material: Two specimens (BHUAdan26/17 and BHUAdan26/15).

Horizon: Kulakkalnattam Formation of Trichinopoly Group, Cauvery Basin, south India.



EXPLANATION OF PLATE-II

Figures 1-2 *Plicatula (Plicatula) ferryi* (Coquand, 1862) 1. (BHUSM/1) x 1.5, External view of right valve; 2. (BHUSM/4) X 1.5, External view of right valve; **3-4** *Plicatula (Plicatula) hirsute* (Coquand, 1880) 3.(BHUSM/9) X 1.5, External view of right valve; 4.(BHUSM/6) X 1.5, External view of right valve; **5-6** *Plicatula (Plicatula) multicosata* (Forbes, 1846) 5. (BHUSM/17) X 1.5, External view of left valve; 6.(BHUSM/20) X 1.5, External view of right valve; **7-8** *Plicatula batnesis* (Coquand, 1880) 7.(BHUSM/23) X 1.5, External view of left valve; 8.(BHUSM/25) X 1.5, External view of right valve; **9-10** *Plicatula instabilis* (Stoliczka, 1871) 9. (BHUANP/33) X 1.5, External view of left valve; 10. (BHUANP/29) ×1.5, External view of right valve.

Locality: Near Garudamangalam village.
Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUAdan26/17	34	25	28 (LV)
2	BHUAdan26/15	38	27	32 (LV)

Description: These specimens are medium in size, sub ovate, dorsally narrowed with height appreciably more than its length. Umbones orthogyrous, incurved, and bending over dorsal margin. Antero- dorsal and posterior- dorsal regions have six prominent primary radial costae and each pair of which is intercalated by four finer radials. The spacing of intercalary radials is increasing from the anterior to the posterior margin. The auricles are damaged but appear to be small and with very fine radials crossed by fine commarginal ribs. The nature of the right valve is unknown.

Remarks: These two specimens are identical to *Neithea (Neithea) quinquecostata* recorded from different parts of the globe by the earlier authors (quoted in synonymy). The distribution of *N. (N.) quinquecostata* has been discussed in detail by Kendrick and Vartak (2007) who inferred that it is a long-ranging (Barremian - Maastrichtian) species and widely distributed in the Mediterranean region (Algeria, Syria, Jordan), northern Europe and South Africa, etc.

Distribution: Turonian - Maastrichtian of Italy (Dhont and Dieni, 1993), Barremian - Campanian of England (Woods, 1908; Cleevely and Morris, 2002), Portugal (Choffat 1902) and Algeria (Benyoucef *et al.*, 2012). In Egypt, it is known from the Santonian of the eastern desert (Abbass, 1962) and Upper Barremian - Maastrichtian of Sinai (Mekawy and Abu - Zeid, 2008). Stoliczka's (1871) Chiplonkar and Tapaswi (1973) and (Kedrick and vartak, 2007) Cenomanian of the Cauvery Basin of south India and Turonian - Coniacian of India (a present record).

Neithea (Neithea) aff. gibbosa Pulteney, 1813
(Pl. I, Figs. 8, 9)

Neithea (Neithea) aff. gibbosa Pulteney - Kendrick and Vartak, 2007, p. 54, fig. 12E.

Material: Two specimens (BHUKul/7 and BHUKul/16).

Horizon: Kulakkalnattam Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: Near Garudamangalam village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUKul/7	25	27	14 (RV)
2	BHUKul/16	38	32	16 (RV)

Description and Remarks: These two specimens are imperfectly preserved, medium in size, equilateral, gibbous, and subtriangular in shape. The umbones are orthogyrous, mesial in position, and bent inwardly. Antero - dorsal and posterior - dorsal margins are short and slightly concave. Both anterior and posterior margins are well-rounded and the ventral margin is broken. The surfaces of both these specimens are quite eroded and only remnants of radial ribs are present. Therefore, it is very difficult to assign them to any of the known species of *Niethea*. However, the right valve is evenly convex and gibbous and comparable with *N. gibbosa* Pulteney recorded earlier from the present area

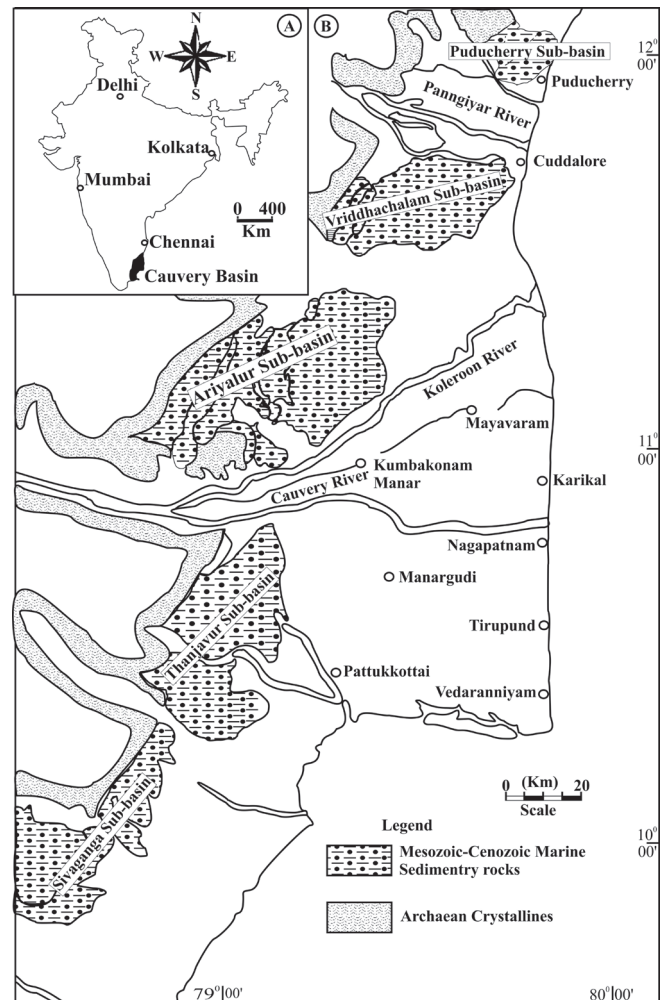


Figure 1. Location of A. Cauvery Basin and B. Five Sub-basins of the Cauvery Basin (modified after Banerji, 1972; after Pandey *et al.*, 2021b).

by Kendrick and Vartak (2007, p. 54, fig. 12E). Accordingly these two specimens have been provisionally described here as *Neithea (Neithea) aff. gibbosa*.

Neithea cf. sexcostata Woodward, 1833
(Pl. I, Fig. 12)

cf. Neithea (Neithea) sexcostata Woodward - Dhondt and Dieni, 1993, p. 185, pl. 5, figs 5 - 6; Text fig. 6.

Material: Single specimen (BHUAdan/9).

Horizon: Kulakkalnattam Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: Near Garudamangalam village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUAdan/9	23	26	4(LV)

Description and Remarks: The Present specimen is incomplete and broken along dorsal and anterodorsal margins. It is a left valve whose internal characters are only visible. The specimen is medium size, triangular and subequilateral in outline. The posterior margin is well-rounded merging with an asymmetrically rounded ventral margin in the obtuse curve. The ribs appear to be narrowly rounded becoming

broader in the ventral half and separated by linear interspaces. It appears that fine striae are also present along anterior and posterior margins. In these characters, the specimen shows a superficial resemblance to *Pecten (N.) sexcostata* Woodward especially described by Dhondt and Deini (1993) from the Cretaceous of NE Italy. However, the incomplete nature of this specimen permits only its qualitative identification and is recorded here as *Neithea* cf. *sexcostata* Woodward.

Distribution: Cenomanian - Maastrichtian of Europe (e.g. France, England, Austria, Belgium, Bulgaria and England) (Dhondt, 1973), Turonian of Bagh bed, Narmada Basin, Central India, and Turonian - Coniacian of India (a present record).

Subgenus *Neithella* Hayami, 1965

Neithea (Neithella) notabilis Münster in Goldfuss, 1833
(Pl. I, Figs. 11,12)

Pecten notabilis Münster, Goldfuss, 1833, p. 56, pl. 93, figs 3a-c.

Neithea (Neithella) notabilis Münster in Goldfuss - Dhondt, 1973, p. 66-70, pl. 4, fig.2 (and synonymy there in).

Neithea (Neithella) notabilis Münster in Goldfuss - Andrade *et al.*, 2004, p. 34-35, pl. 4, figs 21-26.

Material: Two specimens (BHUKKN/19 and BHUKKN/20).

Horizon: Kulakkalnattam Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: Near Garudamangalam village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUKKN/19	11	8	4 (RV)
2	BHUKKN/20	13	7	5 (RV)

Description: These two right valve specimens are quite small in size, strongly convex, slightly inequilateral and oval in shape. Umbones incurved, mesial and almost orthogyrus. The shell surfaces are eroded but remnants of ornamentation is clearly visible. The valve carries six prominent primary ribs separated by concave and more wider interspaces than the thickness of ribs. The primary ribs are narrowly rounded with obtuse crest. The interspaces bear four thin unequally spaced secondary ribs. The character of auricles unknown. The antero - dorsal and postero - dorsal margin are long and feebly concave. Anterior and posterior margins are broadly convex. Both specimens are broken along ventral margins.

Remarks: Dhondt (1973) and Andrade *et al.*, (2004) have extensively discussed morphological features of *Neithea (Neithella) notabilis*. Both of them pointed out many variations in size, the convexity of the valve, and the ribbing pattern of this species. The present specimens are more similar to *N. (N.) notabilis* described by Dhondt (1973) from Europe in size and nature of primary and secondary ribs in comparison to *N. (N.) notabilis* recorded by Andrade *et al.*, (2004) from Brazil. *N. (N.) notabilis* is a rather cosmopolitan species known from the Aptian to Turonian horizons of different parts of the world. The present record from the Turonian (Kulakanattam Formation) of the Cauvery Basin falls well within this range.

This is the first record of the species from India.

Distribution: Aptian to the Cenomanian - Turonian boundary of Europe (Dhondt, 1973); Aptian of Japan and

Cenomanian - Turonian of Madagascar; middle and upper (?) Cenomanian of the Sergipe Basin, Brazil. (Andrade *et al.*, 2004) and Turonian - Coniacian of India (present record).

Genus *Plicatula* Lamarck, 1801

Type species *Spondylus plicatus* Linné, 1758

Subgenus *Plicatula* s.s.

Plicatula (Plicatula) ferryi Coquand, 1862
(Pl. II, Figs. 1, 2)

Plicatula ferryi sp. nov., Coquand, 1862, p. 221, pl.16, figs 7-10.

Plicatula batnensis sp. nov. Coquand, 1880, p.162, (photo Heinz: pl.

3).

Plicatula ferryi Coquand - Pervinquier, 1912, p.160, pl. 9, figs 22a-b; pl.12, figs 6-14.

Plicatula ferryi Coquand - Blanckenhorn, 1934, p. 194.

Plicatula ferryi Coquand - Darteville, and Freneix, 1957, p. 84-87, pl. 10, figs 2-11, 13, 19.

Plicatula ferryi Coquand - Barber, 1958, p.19, pl. 7, fig. 5.

Plicatula ferryi Coquand - Abbass, 1962, p. 63, pl. 7, figs1-5, 26.

Plicatula ferryi Coquand - Abdel - Gawad and Zalut, 1992, pl. 5, fig. 2.

Plicatula ferryi Coquand - El -Sheikh *et al.*, 1998, pl. 2, fig. h.

Plicatula ferryi Coquand - El-Hedeny *et al.*, 2001, p. 299, figs 3a-d. (and synonymy there in).

Plicatula ferryi Coquand - Abdel - Gawad *et al.*, 2004a, pl.5, fig.12.

Plicatula ferryi Coquand - El Qot, 2006, p.63, pl. 12, figs 5-10; text-fig. 10b.

Plicatula ferryi Coquand - Abdel - Gawad *et al.*, 2007, pl. 5, fig. 7.

Plicatula ferryi Coquand - Mekawy, 2007, p. 224, pl. 4, figs 4, 5.

Plicatula ferryi Coquand - Aouissi, 2019, p. 48, pl. 5, fig. 4a-b.

Plicatula ferryi Coquand - Mendir *et al.*, 2021, p.14, fig. 6H.

Materials: Nine specimens (BHUSM/1, BHUSM/2, BHUSM/3, BHUSM/4, BHUSM/11, BHUSM/12, BHUSM/13, BHUSM/14 and BHUSM/21).

Horizon: Anaipadi Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: West of Saradamangalam village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUSM/1	30	24	12(BV)
2	BHUSM/2	29	22	6(BV)
3	BHUSM/3	31	26	13(BV)
4	BHUSM/4	24	22	6(BV)
5	BHUSM/11	23	12	7(BV)
6	BHUSM/12	26	17	7(BV)
7	BHUSM/13	18	16	6(BV)
8	BHUSM/14	19	16	6(BV)
9	BHUSM/21	30	24	7(BV)

Description: These specimens are small to medium in size, orbicular shape, and subequilateral in nature. Umbones are orthopterous, pointed, and auricles obscure. Anterior and posterior margins are well-rounded, merging smoothly with well-rounded ventral margins. The left valve is almost flat to very little convex but the right valve is appreciably convex and bears a small sub-circular attachment area in some of the specimens. Shell surface ornamented with numerous fine radial ribs with ventrally projecting small spines. Some of the ribs on the anterior and posterior sides are fan-wise displaced. Ribs are bifurcating at the different stages of growth. The intervening spaces are narrower and more smooth. The radial ribs are crossed by several, thick concentric growth lamellae giving the shell surface imbricating ornamentation. Spines

are more conspicuous in the right valve in comparison to the left valve.

Remarks: *Plicatula (Plicatula) ferryi* Coquand is quite common in different parts of Africa (Coquand, 1862; Collignon, 1934; Darteville and Freneix, 1957). This species exhibits quite a variation in outline and surface sculptures. In the fineness of radial ribs and outline *Plicatula (Plicatula) ferryi* resembles superficially to another African species *Plicatula hirsute*, a new species described by Coquand (1862) and also by Darteville and Freneix (1957, p.88, pl.10, fig. 12; pl.11, figs 6-13a,b,c; pl.12, figs 1-5). But the imbricating shell structure due to the presence of thick concentric lamellae, a most conspicuous feature of *Plicatula (Plicatula) ferryi* is lacking in *Plicatula hirsute*. Stoliczka (1871, p. 445) included one specimen (pl. 34, fig. 19) from the Ariyalur Group in his species *Plicatula instabilis* having fine radiating ribs and also imbricating concentric sculpture which may belong to *Plicatula (Plicatula) ferryi* rather than *Plicatula instabilis*.

This is the first record of the species from India.

Distribution: Cenomanian - Santonian of Algeria (Coquand, 1862; Benyoucef *et al.*, 2012), Tunisia (Pe'ron, 1890; Pervinque' re, 1912), Santonian of Syria (Blanckenhorn, 1934) Turonian of Nigeria (Barber, 1958), Cenomanian of Morocco (Freneix, 1972), Turonian - Campanian of Egypt (Abbass, 1962; Fawzi, 1963; Abdel - Gawad and Zalut 1992; El - Sheikh *et al.*, 1998; Abdel - Gawad *et al.*, 2004; El Qot, 2006; Abdel - Gawad *et al.*, 2007; Mekawy, 2007; El Qot *et al.*, 2013; Mendir *et al.*, 2021) and Turonian - Coniacian of India (a present record).

Plicatula (Plicatula) hirsuta Coquand, 1880
(Pl. II, Figs. 3, 4)

Plicatula hirsuta sp. nov. - Coquand, 1880, p. 165.

Plicatula hirsute Coquand - Pervinque' re, 1912, p.164, pl.10, figs 12-16.

Plicatula hirsute Coquand - Darteville and Freneix, 1957, p. 88, pl. 10, fig. 12, pl. 11, figs 138, 1c, pl. 12, figs 1-5.

Plicatula hirsute Coquand - Toni, 1969, p. 531, pl.1, fig. 2.

Plicatula (Plicatula) hirsute Coquand - Abdel Aal, 1973, p.83, pl.3, fig.4.

Plicatula (Plicatula) hirsuta Coquand - El- Hedeny, 1996, p. 92, pl. 5, fig. 3.

Plicatula (Plicatula) hirsuta Coquand - El- Hedeny, 2001, p. 302, pl. 4, figs r-u.

Materials: Six specimens (BHUSM/6, BHUSM/7, BHUSM/8, BHUSM/9, BHUSM/10 and BHUSM/15).

Horizon: Anaipadi Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: West of Saradamangalam village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUSM/6	32	28	10 (BV)
2	BHUSM/7	22	23	9 (BV)
3	BHUSM/8	22	19	10 (BV)
4	BHUSM/9	38	29	9 (BV)
5	BHUSM/10	23	26	7 (BV)
6	BHUSM/15	26	22	8(BV)

Description: The specimens are medium-sized, ovate in shape, weakly inflated, and subequilateral. Umbones are pointed, narrow, and submesial. Antero - dorsal and posterior-dorsal margins elongated and straight, and anterior, posterior, and ventral margin are rounded. In some specimens, anterodorsal and posterodorsal margins are arcuate (fan shape) in nature. The surface is ornamented with numerous fine, closely spaced radial ribs. The radial ribs bear numerous small spines which are slightly elevated and bending ventrally. In the later stages of the growth the primary radial ribs are regularly bifurcating. These radials are crossed by concentric growth lines which are more conspicuous near the ventral margin.

Remarks: The present specimens in outline, feeble inflation and surface ornamentation are similar to the Late Cretaceous African species *Plicatula hirsuta* Coquand, recorded by different authors quoted in synonymy. *Plicatula (Plicatula) ferryi* in surface features and outline superficially resembling to *Plicatula hirsuta*, but imbricating shell ornamentation is not visible in *Plicatula hirsuta*.

This is the first record of the species from India.

Distribution: Maastrichtian sediments in south Tunisia Pervinque' re (1912), Coniacian - ? lower Campanian of Cameroon, Gabon and Congo (Darteville *et al.* 1957) and Coniacian - Santonian of Egypt (Toni, 1969; Abdel Aal, 1973; El-Hedeny, 1996, 2001) and Turonian - Coniacian of India (a present record).

Plicatula (Plicatula) multicosata Forbes, 1846
(Pl. II, Figs. 5, 6)

Plicatula multicosata sp. nov. Forbes, 1846, p.155, pl. 18, fig.3.

Plicatula multicosata Forbes - Stoliczka, 1871, p. 446, pl. 34, figs 15-18.

Plicatula multicosata Forbes - Cottreau, 1922, p. 35, pl. 3, figs 9-14.

Plicatula (Plicatula) cf. *multicosata* Forbes - Abdel Aal, 1973, p.84, pl.3, fig. 5.

Plicatula multicosata Forbes - El - Hedeny, 1996, p. 93, pl. 5, fig. 4.

Plicatula (Plicatula) multicosata Forbes - El - Hedeny, 2001, p.302, pl.4, figs r-u.

Materials: Six specimens (BHUSM/16, BHUSM/17, BHUSM/18, BHUSM/19, BHUSM/20 and BHUSM/22).

Horizon: Anaipadi Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: West of Saradamangalam village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUSM/16	28	23	13(BV)
2	BHUSM/17	20	18	7(BV)
3	BHUSM/18	25	22	6(BV)
4	BHUSM/19	20	22	7(BV)
5	BHUSM/20	19	18	9(BV)
6	BHUSM/22	19	18	7(BV)

Description: These specimens are medium in size, subovate in shape, weakly inflated and slightly inequilateral. Umbones are pointed, narrow and submesial. The right valve is more inflated than the left valve. Shell surface is ornamented with numerous radials, mostly bifurcating in later stage of growth. The radials are flexuous rather undulating having more or less well projecting spines, which are irregular both in size and distribution.

Remarks: The outline and nature of the valves of the present specimens are identical to *Plicatula multicostata* Frobes from Trichinopoly Group described specially by Stoliczka (1871: p. 446). It differs from others because of the uneven convexity of valves. The radial ribs in the present specimen are not so coarse as in the Stoliczka's specimens, but the general characters like radials bifurcating in the later stages of growth, becoming slightly more thicker and irregular, bearing thick scaly spines are clearly shown by the present specimens. *P. ferryi* the associated species in the same horizon is quite similar in general outline, while the more convexity of the left valve consisting less number of radials distinguishes it from *P. multicostata*, *P. batnesis* (Coquand, 1880, p. 162, pl. 3) is another closely allied species but consists of fewer and more widely spaced radial ribs.

Distribution: Coniacian - Santonian of Egypt (El-Hedeny, 1996, 2001), Campanian - Maastrichtian of Madagascar (Cottreau, 1922) and Turonian - Santonian Trichinopoly Group of India (Stoliczka, 1871) and Turonian - Coniacian of India (a present record).

Plicatula batnesis Coquand, 1880
(Pl. II, Figs. 7, 8)

Plicatula batnesis Coquand, 1880, p. 162, pl. 3.

Plicatula batnesis Coquand - Pervinquier, 1912, p. 162, pl. 9, fig. 21.

Plicatula batnesis Coquand - Chiplonkar, 1939, p. 276, pl. 13, fig. 5.

Plicatula aff. *batnesis* Coquand - Fawzi, 1963, p. 33.

Plicatula cf. *batnesis* Coquand - Freneix, 1972, p. 83, pl. 4, fig. 12a-b.

Plicatula batnesis Coquand - Abdel - Gawad and Gameil, 2002, p. 84, pl. I, fig. 22.

Plicatula batnesis Coquand - Kumar, 2016, p. 70, pl. 5, figs 3-7.

Materials: Four specimens (BHUSM/23, BHUSM/24, BHUSM/25 and BHUSM/26).

Horizon: Anaipadi Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: West of Saradamangalam village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUSM/23	26	23	6 (BV)
2	BHUSM/24	25	21	6 (BV)
3	BHUSM/25	40	32	6 (BV)
4	BHUSM/26	28	24	12 (BV)

Description: All these four specimens are medium in size, ovate in shape and moderately inflated. Umbones are prominent and submesial. Both valves are convex, the right valve is more convex than the left valve. The dorsal margin is fairly convex, and anterodorsal and anterior margins are gently rounded and make the broad obtuse curve at the posteroventral corner. Poster - dorsal margin is slightly concave, posterior margin is broadly rounded and framed together with asymmetrically curved ventral margin to give postero - ventral elongation to the shell. The attachment area is moderate in size, subelliptical situated close to the dorsal margin. Shell surface ornamented with 12-18 moderately thick radial ribs, developing plications like appearance at the ventral margin. The rib consists of ventrally directed spines at regular intervals. The radials are crossed by both concentric growth lines and growth lamellae

Remarks: *Plicatula batnesis* Coquand is highly variable in outline and surface features. Although the present specimens

are inadequately preserved but fall well within the range of morphological characters of *P. batnesis* Coquand recorded by earlier workers (quoted in synonymy). *P. instabilis* Stoliczka and *P. striatocostata* Stoliczka (1871, p. 414, pl. 34, fig. 20; p. 445, pl. 34, figs 3 - 14. pl. 104, fig. 3) from the Ariyalur Group are exactly similar in outline and surface features, but for the primaries which are not bifurcating and there is no sign of the presence of finer secondary radial ribs in between two coarse primary ribs as seen in the Narmada Basin specimens recorded by Chiplonkar (1939, p. 276, pl. 13, fig. 5). *Plicatula (Trichiplicatula) distincta* a new species of Chiplonkar and Tapaswi (1976) from the Trichinopoly Group (Turonian - Santonian), south India is quite similar in outline and surface ornamentation to *P. batnesis*.

Distribution: Cenomanian - Santonian of Egypt (Fawzi, 1963; Gawad and Gameil, 2002), Cenomanian - Senonian of Tunisia (Pe'ron, 1890; Pervinquier, 1912), Turonian of India (Chiplonkar, 1939; Kumar, 2016), Cenomanian - Santonian of Algeria (Benyoucef *et al.*, 2021) and Turonian - Coniacian of India (a present record).

Plicatula instabilis Stoliczka, 1871
(Pl. II, Figs. 9, 10)

Plicatula instabilis sp. nov., Stoliczka: 1871, p. 445, pl. 34, fig. 3-14, 19; pl. 46, fig. 3.

Plicatula instabilis Stoliczka - Basse, 1933, p. 105, pl. 3, figs 2-11.

Plicatula numidica Coquand - Abbas, 1962, p. 60, pl. 7, figs 6-7.

Plicatula numidica Coquand - Chiplonkar and Tapaswi, 1976, p. 108, 109, pl. 1, figs 20, 12.

Plicatula instabilis Stoliczka - Kumar, 2016, p. 72, Pl. 5, figs 8 - 11.

Materials: Eight specimens (BHUANP/27, BHUANP/28, BHUANP/29, BHUANP/30, BHUANP/31, BHUANP/32, BHUANP/33 and BHUANP/34).

Horizon: Anaipadi Formation of Trichinopoly Group, Cauvery Basin, south India.

Locality: East of Kulakkalnattam - Anaipadi village.

Dimension:

Sl. No	Specimen no.	H (mm)	L (mm)	I (mm)
1	BHUANP/27	26	23	6(BV)
2	BHUANP/28	25	21	6(BV)
3	BHUANP/29	40	32	10(BV)
4	BHUANP/30	28	24	9(BV)
5	BHUANP/31	26	27	8(BV)
6	BHUANP/32	26	28	9(BV)
7	BHUANP/33	27	32	12(BV)
8	BHUANP/34	24	27	8(BV)

Description: These specimens are moderate in size, tall, elongate - ovate in shape and weakly inflated. Umbones are sharp, pointed and almost flat with small, circular attachment area. Anterior and posterior margins broadly rounded and merging smoothly with equally rounded ventral margin. Shell surface is ornamented with 9 - 11 radial ribs which increase in number by bifurcation in the later stages of growth. These ribs are crowded by more or less ventrally projecting spines, whose thickness increase with the thickness of radial ribs. The intervening spaces are smooth, moderately shallow and almost of the same width as the thickness of the ribs. The surface is covered with concentric growth lamellae whose number is quite variable.

Remarks: *Plicatula instabilis*, the new species described by Stoliczka (1871) from the Trichinopoly Group of Ariyalur Sub-basin, is exhibiting much variation in outline from trigonally ovate to ovate, number and nature of primary ribs and associated surface features. The present specimens fall well within the range of characters as exhibited by Stoliczka's specimens. This present species appears to be similar to *P. (P.) pastilliformis* Chiplonkar and Tapaswi (1939, p. 144, pl. 3, fig.10) but is taller in outline and ribs are more closely crowded on the surface. Chiplonkar (1939) mentioned that "The ornamentation is extremely variable, individually and from causes of preservation of the surface", the number of radials in *Plicatula instabilis* is also variable and increases with growth and identical in outline and surface ornamentation to the present species. The attachment areas in most of the specimens of *Plicatula* also vary from small too the large (Cox and Hertlein, 1969, N377). *P. georgiana* Fritzsche recorded by Casadio *et al.* (2005, p. 514, fig. 4) from the Northern Patagonia has similar outline and area of attachment but differs in large size, trifurcate radial ribs with stout spines and presence of sub-central oblique growth lines. The present specimens are also much similar to *P. instabilis* recorded from Madagascar by Basse (1933, p. 105, pl. 3, figs 2-11) and from Senegal by Tessier (1952).

Distribution: Campanian - Maastrichtian of India (Stoliczka, 1871; Chiplonkar and Tapaswi, 1976) Late Cretaceous of Madagascar by Basse (1933) and Turonian - Coniacian of India (a present record).

CONCLUSIONS

The detailed taxonomic revision of the pectinid bivalve genera *Neithea* and *Plicatula* and their constituent species recorded from the Trichinopoly Group of the Ariyalur Sub-basin, Cauvery Basin has been attempted for the first time in light of modern taxonomic trends. Out of the ten described species (5 each of *Neithea* and *Plicatula*), four species (*Neithea (Neithea) coquandi*, *Neithea (Neithella) notabilis*, *Plicatula (Plicatula) ferryi* and *Plicatula (Plicatula) hirsute* have been recorded for the first time from Cauvery Basin, south India. These occurrences are quite useful in global palaeobiogeography (would be discussed separately).

ACKNOWLEDGEMENT

The authors extend their thanks to the Head, Centre of Advanced Study, Department of Geology, BHU Varanasi for providing the necessary facilities to carry out the present work. Deep Narayan Tiwari acknowledges the financial support of UGC-RF in the form of R/Dev/Sch/UGC/Rs/2016-2017/19100/27/5/15.

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