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Turonian (Late Cretaceous) Heterodont Subfamilies: Lucininae, Eriphylinae and Opinae (Bivalvia: Veneroida) from the Narmada Basin, central India

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Eight species belonging to the genera/subgenera *Lucina*, *Parvilucina* (*Microloripes*), *Callucina*, *Eriphyla* (*Lyapinella*), *Crassatellina* and *Opis* of the three subfamilies Lucininae, Eriphylinae and Opinae have been reported here from the Turonian (Late Cretaceous) of Narmada Basin, India. Out of these, the two species *Crassatellina minuta* and *Opis reticulata* have been newly created. The overall characters of the subfamily Opinae, the genus *Callucina* and the subgenus *Eriphyla* (*Lyapinella*) have also been reviewed here.

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INTRODUCTION

Bivalve mollusks are usually divided into five subclasses on the basis of morphology and fossil history (Moore, 1969). Of these, the subclass Heterodonta is by far the most diverse major group of Bivalvia, encompassing richly speciose families such as the Cardiidae, Tellinidae, Veneridae and Lucinidae. Taxonomically, veneroids are one of the most complex groups of heterodont bivalves owing to their remarkable similarity in external morphological characters. Taxonomists have to look for the internal morphological characters like ligaments, dentition and presence or absence of siphons for their consequential identification. The ligament - based division is only helpful for the identification up to order level as all the veneroids have opisthodetic parvinicular ligaments with the presence of fusion layer and nymph. The dentition pattern is one of the ideal characters for generic level distinction not only for veneroids but for most of the heterodonts (Jaitly and Mishra, 2009). All other shell characters like nature of lunule, escutcheon, sculpture, etc are quite variable (Keen, 1969), even though they cannot be overlooked. Due to vagueness of choosing these characters, there is quite inconsistency in their identification needing frequent emendations in their taxonomic placement during subsequent revisions. Further, the problem of inconsistency in their identification may also either be due to morphological convergence or paedomorphosis (Mikkelsen *et al*., 2006).

The heterodonts described herein belong to the three veneroid subfamilies Lucininae Fleming, Eriphylinae Chavan and Opinae Chavan. The lucinoids are usually bi-siphonate, while eriphylinids and opinids are non-siphonate or sometime uni-siphonate (Allen, 1960; Kauffman, 1967). The general dentition pattern of Subfamily Lucininae is represented by one bifurcated cardinal and two lateral teeth in the right valve and two cardinals and four laterals in the left valve. In some lucinid genera (e.g. *Here* s.s.), anterior cardinal tooth is rarely developed or obscured due to encroachment of lunule (Briton, 1972). In the Eriphylinae, especially in the genus *Eriphyla* Gabb, two cardinal and two lateral teeth are usually present in both the valves. The third Subfamily Opinae Chavan is characterized by the presence of one strong cardinal in the right valve and two cardinal teeth in the left valve. The lateral teeth are absent in most of the genera of this Subfamily (Chavan, 1969). In some cases due to the basic similarity in dentition of some genera of a particular group, the nature of hinge plate and dentition pattern are not enough for the proper taxonomic identification. Here, other morphological features like shell outline, shell micro-structure and surface ornamentation are taken in account (Dall, 1901; Chavan, 1937-1938, 1969; Bretsky, 1976). Often recurrent changes have to be made in their generic/species status during the process of continual attempt to assign them to a more valid classification (Vokes, 1980; Schneider, 2001; Sepkoski, 2002).

Earlier 18 genera and 30 species of venerid heterodonts have been reported from the Bagh Group (Chiplonkar, 1939; Chiplonkar and Badve, 1972; Dassarma and Sinha, 1975). Eight species of the six venerid heterodont genera are described here from the Nodular Limestone Formation (Turonian) of Bagh Group. Only two species *Lucina fallax* Forbes and *Opis corniformis* Chiplonkar are common with the earlier record. The present article is in sequel to the

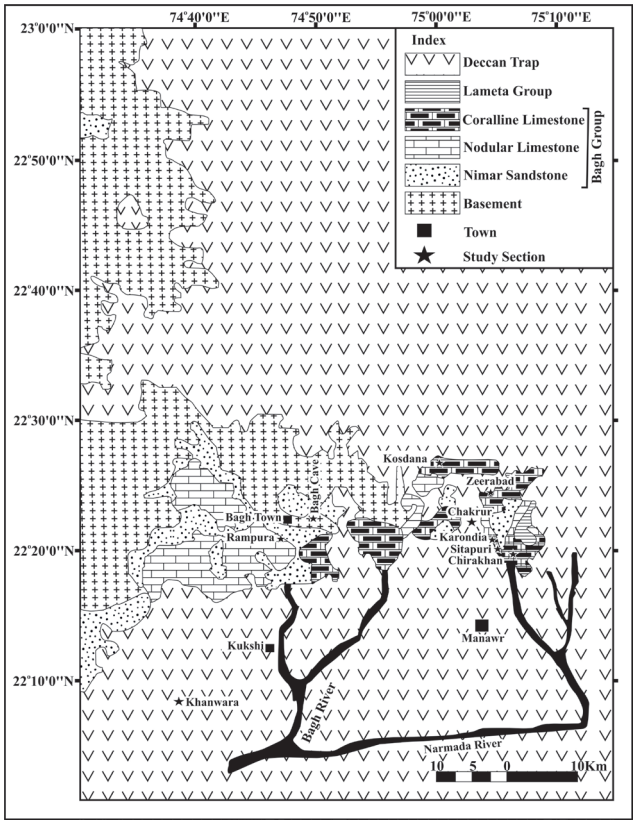


Fig. 1. Geological Map of Bagh area (after Kumar *et al*., 2018, a, b).

work of revision of the Late Cretaceous bivalves of the Narmada Basin. An attempt has also been made here to review taxonomic status of *Callucina* Dall, *Eriphyla* Gabb and Subfamily Opinae Chavan in light of the contemporary systematic developments (Pojeta, 1978; Prezant, 1998; Waller, 1998; Canapa *et al*., 1999; Harper *et al*., 2000; Carter *et al*., 2000; Jaitly and Mishra, 2009 etc).

GEOLOGY

Narmada Basin is an intracratonic rift basin lies between longitude 72°32′ E to 81°32′ E and latitude 21°20′ N to 23°45′ N and restricted by ENE-WSW trending graben (Biswas, 1987; Acharyya and Lahiri, 1991; Tripathi, 2006). The basin received about 30 m thick siliciclastic and calcareous sediments during the Late Cretaceous time as a consequence of global Cenomanian Sea level rise. These marine Late Cretaceous deposits are popularly known as Bagh Beds and have been subsequently assigned to Bagh Group (Akhtar and Khan, 1997; Tripathi 1995 a, b, 2006; Jaitly and Ajane, 2013; Jaitly *et al*., 2015). First lithostratigraphic account of Bagh Group has been proposed by Blanford (1869) who recognized four lithounits namely Sandstone and Conglomerate, unfossiliferous Nodular Limestone, fossiliferous Argillaceous Limestone and Coralline Limestone. These lithounits were formally named by Bose (1884) as Nimar Sandstone, Nodular Limestone, Deola - Chirakhan Marl and Coralline Limestone formations in ascending order (Fig.1).

Table 1. Present scheme of the lithosratigraphic classification of the Cretaceous sediments of the Narmada Basin (after Jaitly and Ajane, 2013).

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

This basic lithostratigraphic classification of Bose (1884) was frequently modified by the subsequent workers (e.g. Rode and Chiplonkar, 1935; Roy Chowdhury and Sastri, 1962; Murty *et al*., 1963; Poddar, 1964; Sahni and Jain 1966; Pal, 1971; Wadia, 1975; Dassarma and Sinha, 1975; Singh and Srivastava, 1981; Ramasamy and Madhavaraju, 1993; Taylor and Badve, 1995; Akhtar and Khan, 1997; Kumar *et al*., 1999; Kennedy *et al*., 2003; Tripathi, 1995 a, b, 2006; Tripathi and Lahiri, 2000; Smith, 2010). Finally, Jaitly and Ajane (2013) gave a more persuasive lithostratigraphic framework by redefining the Bagh Group and deemed that it consists of only three major lithounits namely Nimar Sandstone, Nodular Limestone (inclusive of Deola - Chirakhan Marl) and Coralline Limestone formations in ascending order (Table 1), which is wide in usage (Kumar *et al*., 2018a, b).

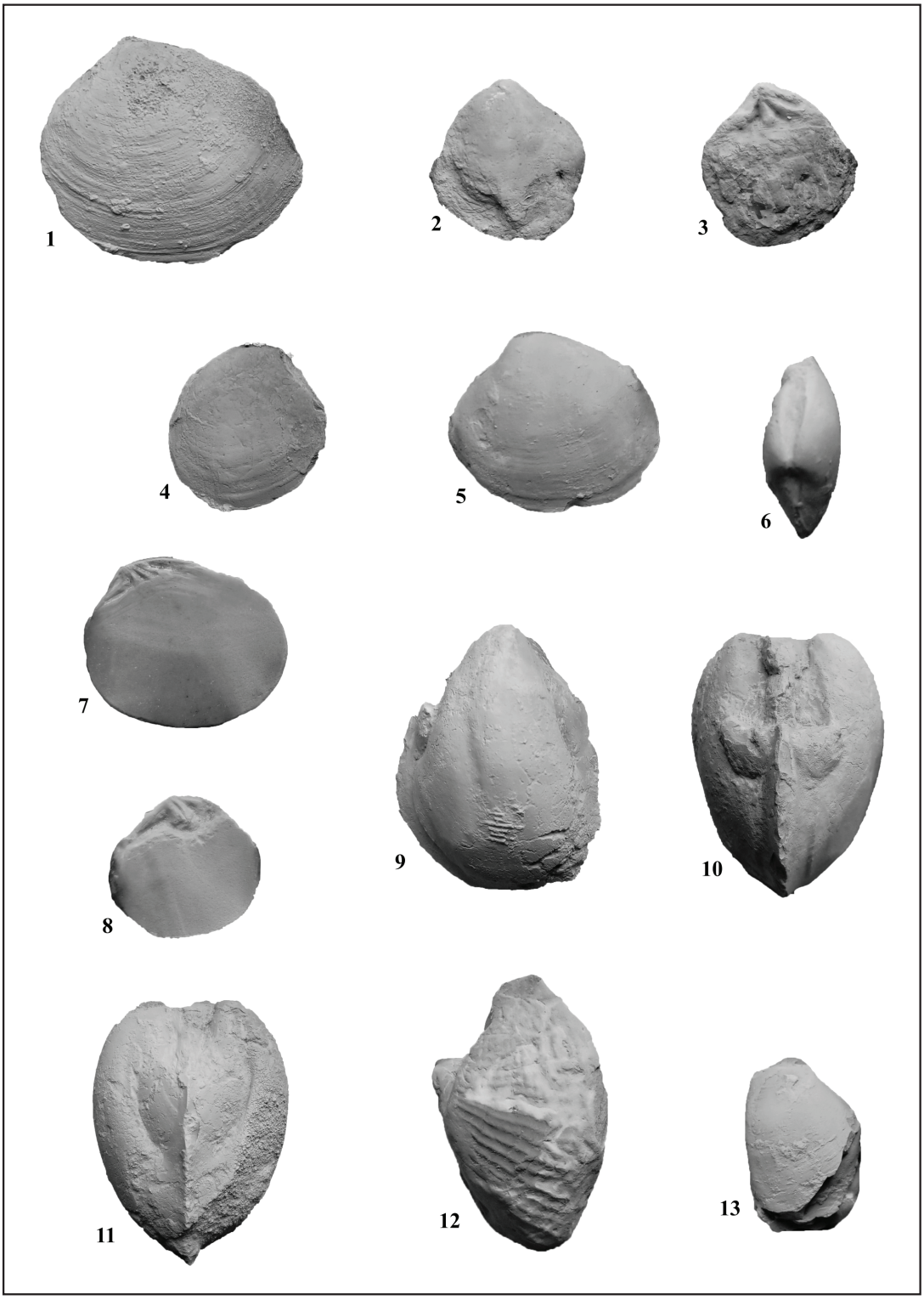
MATERIAL AND METHODS

More than 1000 specimens of heterodont bivalves have been collected from the Nodular Limestone Formation (Bagh Group) from the different localities of the lower Narmada Basin (Fig. 2).

150 specimens belonging to six genera namely *Lucina*, *Parvilucina*, *Callucina*, *Eriphyla*, *Crassatellina* and *Opis* have been described here. Most of the specimens are moderate to poor in preservation; however, a few specimens are well preserved. The fossil shells collected from the nodular limestone are relatively better in preservation than those in marls. Most of the specimens occur as internal moulds or composite moulds. The articulated shells are few in number and surface features in most of them are inadequately preserved. None of these fossil specimens were collected in life position. Few specimens are diagenetically altered from original aragonitic to recrystallized calcitic shells. Overall these belong to parautochthonous to allochthonous population.

The specimens were manually cleaned by using pneumatic hammer and prepared for the identification. These are numbered by using acronym form of locality, collection year, bed number and number of specimens in each sample. The specimens are coated with magnesium fume for the purpose of photography to show uniform morphological characters. The systematic classification proposed by Bieler *et al*. (2010) and Carter *et al*. (2011) have been followed here. The list of synonyms contains only those references

Plate I



EXPLANATION OF PLATE I

1. *Lucina fallax* (Forbes, 1846), (BHU2014/Kw6/2) x2, External view of left valve; 2, 3. *Parvilucina* (*Microloripes*) cf. *juvenis* (Stanton, 1895), (BHU2014/Si5/4) x2, 2. External view of right valve; 3. Internal view of right valve; 4. *Callucina* sp., (BHU2014/Ck1/25) x2, External view of right valve; 5, 6. *Eriphyla* (?*Lyapinella*) sp., (BHU2014Sn3/45) x2, 5. External view of right valve; 6. Dorsal view of both valves; 7, 8. *Crassatellina minuta* n. sp.; 7. (BHU2014/Kar2/4) x2, Internal view of right valve; 8. (BHU2014/CK1/11) x2, Internal view of right valve; 9-11. *Opis corniformis* (Chiplonkar, 1939), (BHU2014/Sn3/41) x1, 9. External view of right valve, 10. Anterior view, 11. Posterior view; 12. *Opis reticulata* n. sp., (BHU2014/Ck1/20 - Holotype) x2, External view of right valve; 13. *Opis* sp. indet, (BHU2014/Bn3/52) x2, External view of left valve.

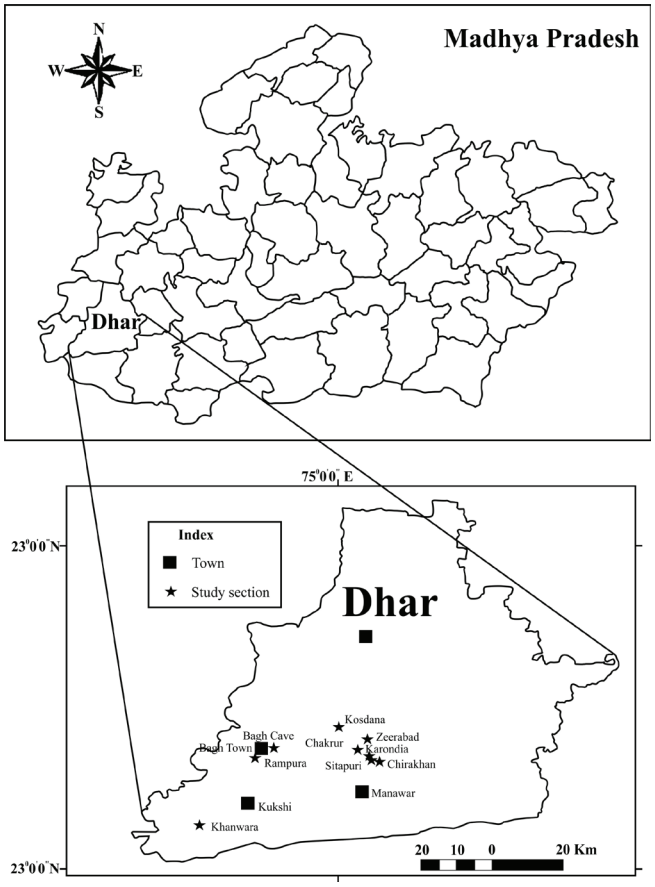


Fig. 2. Important localities with the location of the studied sections in the Dhar District, Narmada Basin, India (modified after Kumar *et al*., 2018b).

which have been verified by the authors and relevant to the present work.

All the linear measurements are taken in millimeter (mm). The following abbreviations are used in the description of the fauna:

L: length; H: height; I: inflation; BV: both valves; RV: right valve; LV:left valve; cd: calculated dimension (incomplete specimens were reconstructed in order to estimate the approximate dimensions of the assumed complete specimens).

All the recorded specimens have been kept in the Stratigraphy and Invertebrate Palaeontology Laboratory, Department of Geology, Banaras Hindu University, Varanasi, India.

SYSTEMATICS

Class **Bivalvia** Linnaeus, 1758
Subclass **Autobranchia** Grobben, 1894
Order **Veneroida** Adams and Adams, 1856
Superfamily **Lucinacea** Fleming**,** 1828
Family **Lucinidae** Fleming**,** 1828
Subfamily **Lucininae** Fleming**,** 1828
Genus ***Lucina*** Bruguiere**,** 1797

Type species Venus jamaicensis Spengler, 1784
Lucina fallax Forbes, 1846
(Pl. I, Fig. 1)

Lucina fallax Forbes, 1846, p. 143, pl. 17, fig. 8.
Lucina fallax Stoliczka, 1871, p. 256, pl. 13, fig. 13, pl. 14, figs 3-5, 7 and 8.
Lucina fallax Baroni *et al*., 1953, p. 95, pl. 6, fig. 1.
Lucina aff. *fallax* Fawzi, 1963, p. 66.
Lucina malwica Chiplonker and Badve, 1972, p.111, pl. 3, fig. 27.
Lucina sitapuriensis Chiplonker and Badve, 1972, p. 111, pl. 3, fig. 31.
Lucina fallax El Qot, 2006, p. 70, pl.14, figs 7, 8, 9a - b, 10a - b.
Lucina (*Lucina*) cf. *fallax* Jaitly and Mishra, 2009, p. 254, fig. 4a.
Lucina fallax Ayoub-Hannaa, 2011, p. 127, pl. 11, figs 7 - 8, text fig. 3.22.
Lucina fallax Kumar, 2014, p. 506, fig. 2i.

Material: Eight specimens (BHU2014/Si2/1, BHU2014/Kw6/2, BHU2014/Kar2/1, BHU2014/Kar2/20, BHU2014/Si6/14, BHU2014/Sn3/83, BHU2014/Si2/29 and BHU2014/Si13) from Sitapuri, Karondia and Kanwara areas of Dhar District, Madhya Pradesh.

Description: The specimens suborbicular to orbicular and moderate in size. The shells moderately inflated; inflation variable; maximum inflation at about 1/5th from the dorsal margin in the mid shell region. Umbones blunt, prominent and submesial. Lunule small, moderately deep and circular. A faint ridge runs obliquely from umbo towards postero - ventral margin separating relatively flat posterior region from the main shell surface. Anterior margin rounded, posterior margin straight and sharp; ventral margin broadly rounded and sharp edged. Surface ornamented with sharp concentric lamellae intercalated by straie.

Dimensions:

Specimen No.	H (mm)	L (mm)	I(mm)
BHU2014/Si2/1	41	46	11 (LV)
BHU2014/Kw6/2	21	28	9.5(BV)
BHU2014/Kar2/1	29	30	11(BV)
BHU2014/Kar2/20	30	30	4(BV)
BHU2014/Si6/14	34.5	33	5(BV)
BHU2014/Sn3/83	22	21	8(RV)
BHU2014/Si2/29	20	19	8(BV)
BHU2014/Si13	17	19	8(BV)

Remarks: *Lucina fallax* Forbes is one of the most common lucinid species in both space and time during the Cretaceous (Stoliczka, 1871; Baroni, 1953; Chiplonker and Badve, 1972; El Qot, 2006; Jaitly and Mishra, 2009; Ayoub-Hannaa, 2011; Kumar, 2014). Earlier Kumar (2014) observed that *Lucina malwica* and *Lucina sitapuriensis* recorded by Chiplonkar and Badve (1972, p.111, pl. 3, figs 27 and 31) from the present area are almost identical to *Lucina fallax* Forbes in general morphological characters like tumidity of umbo, height/length ratio and surface features. He correctly considered these two new species of Chiplonkar and Badve (1972) as junior synonym of *L. fallax*. The two specimens of *L. fallax* collected earlier by Kumar (2014) are relatively much large in size (46 mm in length) than the present specimens (30 to 19 mm in length) from the same locality and horizon. Both the large and small specimens are identical in rest of the morphological (both external and internal) characters. Presumably size of the shell is not an important feature for the recognition of *L. fallax.*

Lucina (*Codakia*) *percrassa* Stoliczka (1871, p. 255)

from the Late Cretaceous of Cauvery Basin, south India, shows superficial semblance to the *L. fallax* especially in outline and surface ornamentation, but *L.* (*C.*) *percrassa* is more inflated with denticulate internal margin. *Lucina cleburni* White (1881, p. 140, pl. I, figs 3 and 4) from Arkansas and Colorado (United States National Museum) and *Lucina parva* Stephenson described by Richards *et al*. (1991, p.198, pl. 31, figs 10, 11) from New Jersey, North Carolina are other two intimately related species, but former is more inflated and latter has more truncated anterior margin than *L. fallax*.

Genus ***Parvilucina*** Dall, 1901

Type species *Lucina tenuisculpta* Carpenter, 1864
Subgenus *Microloripes* Cossmann, 1910 (1912)
Types species *Lucina dentata* Defrance, 1823

Parvilucina (*Microloripes*) cf. *juvenis* (Stanton, 1895)
(Pl. I, Figs 2, 3)

cf. *Parvilucina juvenis* Kirkland, 1996, p. 43, pl. 3, figs P-S, U; pl. 4, figs H, I.

Material: Four reasonably preserved disarticulated valves (BHU2014/Sm25, BHU2014/Si3/70, BHU2014/Si5/4 and BHU2014/Si2/33) from Sitapuri area of Dhar District, Madhya Pradesh.

Dimensions:

Specimen No.	H (mm)	L (mm)	I (mm)
BHU2014/Sm25	29	26	7(RV)
BHU2014/Si3/70	20	19	8(RV)
BHU2014/Si5/4	18	17	6(RV)
BHU2014/Si2/33	20	16	5(LV)

Description and Remarks: Specimens are broken along margins. The hinge plate of one of the specimens (BHU2014/Si5/4) shows cardinal 3b. The acute umbonal angle and small, thin and slightly oblique 3b permits placement of present specimens in the genus *Parvilucina* Dall and subgenus *Microloripes* Cossmann. The genus *Parvilucina* ranges from Late Cretaceous to Recent and has widespread occurrence on both north and south margins of the Tethys. Subgenus *Microloripes* is more common during Cenozoic and its occurrence in the Late Cretaceous was uncertain (Moore *et al*., 1969, p. N 499). The present specimens are from the Turonian, therefore, the subgenus *Microloripes* unquestionably existed during Cretaceous, at least up to Turonian.

In nearly circular outline (reconstructed), moderate inflation and acute umbonal angle, these specimens are quite comparable to *Parvilucina juvenis* (Stanton) described by Kirkland (1996, p. 43, pl. 3, figs P, S - U; pl. 4, figs H, I) from the Turonian of northeastern Arizona. In view of incomplete shells, these Sitapuri specimens are provisionally recorded here as *Parvilucina* (*Microloripes*) cf. *juvenis* (Stanton).

Genus ***Callucina*** Dall, 1901

Type species *Callucina keenae* Chavan, 1971

Remarks: *Callucina* was first proposed by Dall (1901) in Moore *et al*. (1969, p. N494), with *Lucina radians* Conrad as monotype. Chavan (1971, p. N1215) specified that the type specimen *L. radians* Conrad of *Callucina* Dall, is a junior homonym of *L. radians* Boy de St. Vincent, so that it is permanently invalid and presented *Callucinakeenae* (Chavan) as replacement type species. This has been confirmed by many of the later workers (e.g. Turgeon *et al*., 1998; Glover and Taylor, 2008; Taylor *et al*., 2011; Taylor and Glover, 2016 etc). Further *Lucina radians* was used as the type species of the genus *Phacoides* Agassiz, which was earlier considered as a junior synonym of the genus *Lucina* (Moore *et al*., 1969, p. N492) and as a subgenus of *Lucina* (Bretsky, 1976). Presently the generic status of *Phacoides* Agassiz has been reinstated with *P. pectinatus* Gmelin as the type species (type by monotypy) as mentioned by Taylor and Grover (2016).

Chavan (1959 in Moore, R. C., 1969) identified two subgenera *Callucinopsis* and *Pseudolucinisca* in the genus *Callucina,* which are basically differentiated on the basis of surface sculpture and different nature of cardinal teeth. Glover *et al.* (2008) reviewed the status of *Callucina* and *Pseudolucinisca.* They redefined the morphological characters of the genotype *Callucina keenae* and accordingly modified the diagnostic features of the genus *Callucina. Callucina hoernesi* (Deshayes) figured by Chavan (1961, figs 62, 9 a, b) as an example of *Callucina* is unacceptable since it is easily distinguished from the type species *Callucina keenae* by the presence of both anterior and posterior laterals and different kind of adductor scars. Glover *et al*. (2008, p. 444) further suggested that most of earlier known species described under *Callucina* require a thorough revision in context of the existing emended diagnosis of the type species *Callucina keenae.* The relationship between *Callucina* and *Pseudolucinisca* is also imprecise and both may be treated as separate, distinct genera (Glover *et al*., 2008).

Callucina sp.
(Pl. I, Fig. 4)

Material: Single specimen of right valve (BHU2014/Ck1/25) from Chakrur of Dhar District, Madhya Pradesh.

Dimension:

Specimen No.	H (mm)	L (mm)	I (mm)
BHU2014/Ck1/25	19	17	4(RV)

Description and remarks: Shell small, suborbicular, slightly higher than long and moderately inflated. Umbo small, blunt, rounded, prosogyrous, situated at about 1/3rd from the anterior margin. Anterior margin gently curved, larger than well rounded posterior margin. The specimen broken along the antero - dorsal margin, so that exact nature of lunule is not discernable, however, it appears to be asymmetrical in nature and feebly excavated. A faint carina runs from umbo to postero - ventral end separating a narrow posterior region. Hinge plate with two cardinals, obliquely radiating and bifid in nature. The anterior and posterior nymphs present. The surface ornamented with lamellae of uneven thickness, more perceptible in the ventral half. In these diagnostic features the present specimen can be well placed in the genus *Callucina.* This genus is globally well represented in the Cenozoic,

but has poor record in the Cretaceous. Many of the known Cretaceous lucinid genera and species needed a careful revision, which may in turn belong to diverse taxonomic rank.

C. esbedensis recorded by Freneix (1972) from the Cretaceous of Tarfaya Province of the of southwestern Morocco is so far the only available superficially comparable species, but *C. esbidensis* has quite perceptive laterals, which as per the new diagnosis does not fit in the genus *Callucina*. In all probability the present specimen stands for a new species but provisionally recorded here as *Callucina* sp. for want of more and better material.

Subfamily **Eriphylinae** Chavan, 1952
Genus ***Eriphyla*** Gabb, 1867
Type species *Eriphyla umbonata* Gabb, 1864
Subgenus Lyapinella Zakharov, 1970
Type species Eriphyla (*Lyapinella*) *asiatica* Zakharov, 1970

Remarks: The genus *Eriphyla* Gabb is characterized by rounded, almost equilateral outline and obliquely depressed lunule. Zakharov (1970) created a new subgenus *Lyapinella* for taller eriphylids. Kelly (1992) pointed out that relationship between *Eriphyla* and *Lyapinella* is uncertain. *Lyapinella* differs from *Eriphyla* in having less circular rather ovate outline, more prominent umbo and a different hinge formula. He assigned a generic status to *Lyapinella* and viewed that it is more related to *Neocrassina* rather than *Eriphyla* in hinge characters and accordingly placed it in the Subfamily Astartinae. Accordingly he described *L. asiatica* (Zakhrov), *L. rawsoni* n. sp. and *L. laevis* (Phillips) under the Subfamily Astartinae from the Late Jurassic - Early Cretaceous of the different parts of eastern England, East Greenland, North Urals and Siberia. However, as discussed below, *Lyapinella* is considered here a subgenus of *Eriphyla* as originally suggested by Zakharov (1970).

Eriphyla (?*Lyapinella*) sp.
(Pl. I, Figs 5, 6)

Material: Two articulated specimens (BHU2014/Kar2/12 and BHU2014Sn3/45) from Karondia and Sitapuri areas of Dhar District, Madhya Pradesh.

Dimensions:

Specimen No.	H (mm)	L (mm)	I (mm)
BHU2014/Kar2/12	18	22	9(BV)
BHU2014Sn3/45	18	22	9(BV)

Description: Specimens small, almost equilateral, subrounded, length slightly greater than height and moderately inflated. The maximum inflation in the umbonal region, rest part of the shell compressed. Umbo small, a bit prosogyrous, barely protruding above dorsal margin. Antero - dorsal margin quite small and feebly concave, postero - dorsal long and gently arched, anterior and posterior margins equally rounded, anterior slightly produced, ventral margin asymmetrically rounded. Lunule small, obliquely depressed. Escutcheon narrow, elongated (lanceolate), relatively deep. Surface eroded but remnant of coarse commarginal ribs is visible near the ventral margin.

Remarks: The placement of these two specimens in the genus *Eriphyla*or (*Lyapinella*) is tricky. Both the specimens have articulated valves and internal characters are not visible. In the available external characters (subrounded shape, barely perceptible umbo and lunule), they show close affinity to the genus *Eriphyla*, as *Lyapinella* is characterized by tall, subovate shells with well perceptive umbones (Zakharov, 1970). However, present specimens are of much smaller in size. Most of the species recorded earlier under *Eriphyla*or *Lyapinella* are much larger in size (e.g, Woods, 1906; Zakharov, 1970; Dassarma and Sinha, 1975; Kelly, 1992 etc.) except for a few specimens of *L. laevis* (Phillips) described by Kelly (1992). The same species has been recorded by Woods (1906) as *Astarte* (*Eriphyla*) *laevis* (Phillips) from the Early Cretaceous of England. All the specimens of this species illustrated by Woods are tall and inequilateral, while Kelly's figs no. 1, 2 and 3 (Pl. 26) of *L. laevis* are more or less equilateral with length slightly in excess of height. *Lyapinella duboisiana* (d' Orbigny) reported by Kelly (1992, pl. 24, figs 7a-c) is another closely comparable species especially in subrounded outline but appears to be much more inflated; besides umbo is more prominent than present specimens.

These two specimens although much smaller in size, externally show close affinity with *Eriphyla.* Their exact affinity with *Lyapinella* could not be established in want of internal characters, able it some similarities in external characters. Therefore, these two Bagh specimens have been provisionally described here as *Eriphyla* (?*Lyapinella*) and their specific identification has been presently differed in need of some better - preserved specimens. Dassarma and Sinha (1975, pl. 6, fig.1) recorded *E. obovata* (Sow.) from the present area seems to be incorrect (it is not an *Eriphyla*) due to its strikingly different outline, it apparently belongs to *Lyapinella.*

Genus ***Crassatellina*** Meek, 1871
Type species *Crassatellina oblonga* Meek, 1871

Crassatellina minuta n. sp.
(Pl. I, Figs 7, 8)

Etymology: For the small sized *Crassatellina*.

Diagnosis: Small *Crassatellina* with variable outline (subovate to transversely trapezoidal); ligament external, opisthocline; surface with coarse commarginal ribs.

Material: Thirteen specimens (BHU2014/Ch6/11, BHU2014/Kar2/4, BHU2014/Ch5/5, BHU2014/CK1/8, BHU2014/Si2/28, BHU2014/Bn3/6, BHU2014/CK1/11, BHU2014/Ck1/16, BHU2014/Ck1/17, BHU2014/Bn3/24, BHU2014/Ba4/5, BHU2014/Si7/27 and BHU2014/Si7/14) from Karondia, Chirakhan, Chakrur, Sitapuri and Bariya areas of Dhar District, Madhya Pradesh.

Holotype: Specimen no BHU2014/Kar2/4 from Karondia is designated here as the holotype.

Dimensions:

Specimen No.	H (mm)	L (mm)	I (mm)
BHU2014/Ch6/11	16	20	8(BV)
BHU2014/Kar2/4	19	25	6(RV)
BHU2014/Ch5/5	17	20	5(LV)
BHU2014/CK1/8	15	20	4(LV)
BHU2014/Si2/28	19	24	7 (RV)
BHU2014/Bn3/6	18	21	9(BV)
BHU2014/Ck1/11	21	24	6(RV)

BHU2014/Ck1/16	22	25	10(BV)
BHU2014/Ck1/17	20	22	8(BV)
BHU2014/Bn3/24	21	25	10(BV)
BHU2014/Ba4/5	17	20	6(LV)
BHU2014/Si7/27	18	22	9(BV)
BHU2014/Si7/14	20	24	5(LV)

Description: Specimens small in size for the genus, outline variable from subovate to transversally subtrapezoidal, moderately inflated and much inequilateral. The maximum inflation at the umbonal region from where the shell surface tapers towards all margins. Umbo small, pointed, slightly prosogyrous, submesial to anterior quarter of the shell length. The antero - dorsal appreciably concave, postero - dorsal long and gently curved, posterior margin broadly rounded, anterior rounded, somewhat produced. Some of the specimens are posteriorly produced with subtruncated posterior margin. Ventral margin unevenly curved. Lunule, small, weakly excavated, escutcheon elongate and lanceolate, ligament external and opisthocline. A prominent nymph projected from beak along dorsal margin. Surface eroded but appears to have coarse commarginal ribs near ventral margin and fine co - marginals on rest of the surface. The right valve hinge plate moderately broad and thick. It has two cardinal teeth - 3a triangular, 3b elongated and bifid in nature. Posterior laterals not visible. The anterior lateral (AI) thin but adequately perceptible, subparallel to the ventral margin of the hinge plate and extends up to the inner side of the umbo almost touching the tip of 3a.

Remarks: The genus *Crassatellina* is characterized by rather moderately large size specimens like *C. oblonga* Meek recorded by Scott (1970) from the Early Cretaceous of Kansas and *C. hollandi* Feldmann and Kammer (1976) from the Maastrichtian of south Dakota (exceptionally large size). In present collection the genus *Crassatellina* is represented by thirteen specimens, all are much smaller in size than these two species. Although few specimens of the *C. oblonga* recorded by Meek and Hayden (1856) are of comparable size but *C. oblonga* has an oblong outline in comparison to subovate - subtrapezoidal outlines of present specimens. In the available literature of the Late Cretaceous crassatellinids, no similar species has been found, hence, these specimens have been specified as new species *Crassatallina minuta*.

Subfamily **Opinae** Chavan, 1952

Remarks: Squires and Saul (2009) extensively reviewed subfamily Opinae and emended its original diagnostic characters given by Chavan (1969). Now it consists of distinctly carinated trigoniform shells, narrow umbones, well elevated incurved beaks and less prominent commarginal ribs. Their narrow, vertically elongated hinges of each valve contain strong and trigonally expanded cardinal teeth. Both anterior and posterior lateral teeth are obsolete. The surface ornamentation of the Subfamily Opinae has been emended here from less prominent commarginal ribs as mentioned by Squires and Saul (2009) to well perceptible commarginalribs displayed by the present specimens.

Genus ***Opis*** Defrance, 1825

Type species *Trigonia cardissodes* Lamarck**,** 1819

Opis corniformis Chiplonkar, 1939
(Pl. I, Figs 9-11)

Opis corniformis Chiplonkar, 1939, p. 275, pl. 12, fig. 2.
Opis corniformis Chiplonkar and Badve, 1972, p. 111, pl. 3, figs 36, 37.
Opis concentricus Dassarma and Sinha, 1975, p. 42, pl. 5, figs 8, 9.

Material: Fourteen specimens: seven articulated (BHU2014/CH1, BHU2014/Kar2, BHU2014/CK1/1, BHU2014/Si7/2, BHU2014/Kar5/5, BHU2014/Sn3/41 and BHU2014/Sm15), five left valves (BHU2014/CH5/14, BHU2014/CK1/4, BHU2014/Kar5/4, BHU2014/Si2/14 and BHU2014/Ba5/20) and two right valves (BHU2014/Si4/2 and BHU2014/Kos3/18) from Karondia, Chirakhan, Chakrur, Sitapuri and Kosdana areas of Dhar District, Madhya Pradesh.

Dimensions:

Specimen No.	H (mm)	L (mm)	I (mm)
BHU2014/CH1	46.5	34	28(BV)
BHU2014/Kar2	48	31.5	35(BV)
BHU2014/CH5/14	50	35	15(LV)
BHU2014/CK1/1	49	32	31(BV)
BHU2014/Si7/2	51	33	34(BV)
BHU2014/Kar5/5	55	34	39(BV)
BHU2014/CK1/4	54	34	18(LV)
BHU2014/Kar5/4	47	31.5	20(LV)
BHU2014/Si2/14	46	28	20(LV)
BHU2014/Si4/2	52	35	16(RV)
BHU2014/Kos3/18	45.5	30	19(RV)
BHU2014/Ba5/20	35	25	11.5(LV)
BHU2014/Sn3/41	63	50	46(BV)
BHU2014/Sm15	33	21	23(BV)

Description: The specimens medium sized, reasonably taller, subtrigonal, moderately inflated, inequilateral and equivalved. Umbo almost mesial, acute, prosogyrus, incurved and substantially raised from the hinge line. Antero - dorsal and postero - dorsal margins almost straight, both make a cordiform profile at commissural plane. A sharp ridge runs throughout the commissural plane. Anterior and posterior margins short, obliquely rounded, merging with asymmetrically rounded ventral margin in acute angles. Surface ornamented with sharp, regularly spaced commarginal ribs.

Remarks: The pattern of the umbonal ridge of the present specimens fairly resembles to the *Opis elevate biangulata* Stephanson (1954, p. 32, pl. 7, fig. 15, 16) from the Raritan Formation (Cenomanian) of New Jersey but it is still much taller. *Opis corniformis* Chiplonkar can be distinguished from *Opis somageinitziana* Stoliczka (1871, p. 288, pl. 10, fig. 11) from the Utattur Group of south India, by its more attenuated beaks, more rounded antero - ventral margin and less convex ventral margin. Another closely comparable species *Opisbicornis* Geinitz (1871 - 75, p. 227, pl. 50, fig. 1 - 3) from the Upper Cenomanian of Bohemia has shorter and less incurved beaks, more oblique shell and more convex ventral margin. *Opis elegans* d'Orbigny (1844, p. 35, pl. 254,

figs 4 - 9) from the Turonian of Sarthe has more oblique shell and more incurved and less produced beak. The described species shows close affinity to *Opis haldonensis* Woods (1904, p. 119, pl. 18, fig. 1) from the Upper Greensand of England. The only observable difference is that the Indian specimens are less taller with more elevated beaks. *Opis corniformis* Chiplonkar is an endemic species and has no record outside of the Narmada Basin. The type specimens of Chiplonkar (1939) are quite poor in preservation with eroded shell surfaces. The present specimens are better preserved and clearly show sharp, regularly spaced coarse commarginal ribs. *Opis concentricus*, a new species erected by Dassarma and Sinha (1975) from the present area on the basis of the presence of sharp concentric ribs, is now morphologically identical to *O. corniformis*.

Opis reticulata n. sp.
(Pl. I, Fig. 12)

Etymology: For the reticulate ornamentation.

Diagnosis: *Opis* with quite acute postero - ventral angulation and reticulate ornamentation.

Material: Two specimens (BHU2014/Ck1/20 and BHU2014/Si7/21) from Chakrur and Sitapuri areas of Dhar District, Madhya Pradesh.

Holotype: Specimen no BHU2014/Ck1/20 from Chakrur is designated here as holotype.

Dimensions:

Specimen No.	H (mm)	L (mm)	I (mm)
BHU2014/Ck1/20	31	19	22(RV)
BHU2014/Si7/21	25	19	9(LV)

Description: The specimens appreciably tall, almost equilateral, subtrigonal in outline (in plan, chordate in profile) and strongly inflated. Beak high, narrow and incurved. Posterior umbonal ridge sharply angulated and extends up to the postero - ventral extremity. The surface slopes on both sides of this ridge, the steeper posterior part barely visible in the plan view. Anterior margin broadly curved, ventral margin unevenly arched, making an acute angle with postero - ventral angulations, posterior margin is obliquely curved. The nature of lunule, escutcheon and corcelet is not clear. Surface ornamented with commarginal ribs, regularly crossed by radials to acquire reticulate pattern of ornamentation. The hinge plate is broad, triangular with large, triangular cardinal tooth (3b).

Remarks: These two specimens are closely resembling to *Opis californica* Stanton described by Squires and Saul (2009, p. 1318, text - fig. 4) but differ in postero - ventral angulation, which is more acute in the American specimens. Although the type specimens of Stanton (1895, p. 18, pl. 7, figs 1-4a) are of comparable size and outline, but have different ornamental pattern. The earlier described *Opis corniformis* Chiplonkar (1939, pl. 12, fig. 2) is of much larger size and also lacks reticulate ornamentation. Woods (1906, p. 118, pl. 17, figs 8 - 12) described *Opis neocomensis* d'Orbigny from the Early Cretaceous of England which superficially resembles in general outline but differs in surface features.

The reticulate ornamentation has not been noticed in any of the species of *Opis* so far described in the available literature.

Opis sp. indet.
(Pl. I, Fig. 13)

Material: Two poorly preserved specimens (BHU2014/ Bn3/52 and BHU2014/ Bn3/34) from Chakrur and Sitapuri areas of Dhar District, Madhya Pradesh.

Dimensions:

Specimen No.	H (mm)	L (mm)	I (mm)
BHU2014/Bn3/52	21	14	9(RV)
BHU2014/ Bn3/34	21	16	8(LV)

Remarks: The specimens are fragmentary in nature and hinge characters are not preserved. These are small specimens, trigonally elongated, with high beaks and well perceptible posterior carina. In these characters, these two specimens certainly belong to the genus *Opis* Defrance, however, specific identification is presently differed due to fragmentary nature of shells.

CONCLUSIONS

Altogether eight heterodont bivalve species (*Lucina fallax*, *Parvilucina* (*Microloripes*) cf. *juvenis*, *Callucina* sp., *Eriphyla* (?*Lyapinella*) sp., *Crassatellina minuta* n. sp., *Opis corniformis*, *Opis reticulata* n. sp. and *Opis* sp. indet.) have been recorded from the Turonian of the Bagh Bed, out of which two are new to science (*Crassatellina minuta* n. sp., and *Opis reticulata* n. sp.). In addition, *Parvilucina* (*Microloripes*) cf. *juvenis*, *Callucina* sp. and *Eriphyla* (?*Lyapinella*) sp. are also not known earlier from the Narmada Basin. During taxonomic revision, it has been inferred that the genera *Callucina* and *Pseudolucinisca* are two separate and distinct genera and *Lyapinella* is a subgenus of *Eriphyla*, as created originally by Zakharov (1970) contrary to Kelly (1992), who considered *Lyapinella* as genus more related to *Neocrassina* rather than *Eriphyla*. These bivalves have less significance in biostratigraphy of the region but inturn, these are quite useful in paleobiogeographical studies.

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