OSTRACODA FROM THE MIDDLE EOCENE OF ASSAM

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ABSTRACT. A traverse across the middle Eocene part of the Sylhet Formation in the Deopani Region of Assam has yielded a well-preserved Tertiary ostracod fauna. Of the twenty-nine species, twenty-two are new, one has previously been recorded elsewhere and six are left under open nomenclature. A further specimen is left under open nomenclature as a probable new subspecies of one of the new species described here. Examination of their distribution enables three successive faunas to be recognized above a lower group of beds which has not yet yielded ostracods.

The Eocene ostracod faunas of eastern India are virtually unknown and work presented here on material recovered from Assam in the Deopani traverse across the Sylhet Formation enables us to go some way towards filling this gap. The only record of ostracods from this area is by Guha (1970) who noted *Bairdia* sp., *Paracypris* sp., *Platella* sp., *Uroleberis* sp., and *Schizocythere* sp. in the middle Eocene Sylhet Limestone subcrops of Teok in a borehole drilled by the Oil and Natural Gas Commission comparable with those from Kutch in western India. In dealing with principally upper Tertiary rocks in Burma, Gramann (1975) described a small Eocene fauna of *Phalcocythere yawensis* Gramann, 1975 and *Paijenborchella* (*Eopaijenborchella*) cf. *P. eocaenica* (Triebel) and mentioned the occurrence of the genera *Cytherella*, *Cytherelloidea*, *Krithe*, and *Trachyleberis* (*Acanthocythereis*), but the nearest Burmese locality is at least 500 miles away and the fauna is of little relevance to the Assam material. There is a considerable literature on the Eocene faunas of western India and Pakistan (see Guha (1968), Khosla (1972), Khosla and Pant (1981*a*, *b*), Latham (1938), Lubimova *et al.* (1960), Siddiqui (1971, 1981) and Sohn (1970)). Guha and Shukla (1973) also described faunas of similar age from southern India but all these localities are well over a thousand miles away and, with the single exception of *Bairdia beraguaensis*, have no species in common with Assam.

Roy and Mukherjee (1976) have shown that the Mikir Hills Plataeau, an extension of the Shillong Massif, consists of an Archaean metamorphic complex and represents a foreland spur on the craton which acted as a barrier between the Himalayan Trough in the north and the Naga–Lusai Geosyncline in the south. The Massif forms a broad arch because of its greater plunge to the east and here two shelf regions of the aforementioned troughs coalesce. The Kopili Valley separates the Mikir Hills Massif from the Shillong Massif. Further west both massifs extend below the Bengal alluvium and merge with the Chotanagpur Archaean Shield.

Only the southern and south-eastern parts of the Mikir Hills Massif subsided and formed the shelf zone of the Naga–Lusai geosyncline in which middle Eocene to Quaternary sedimention took place. In consequence the southern and south-eastern parts of the Mikir Hills expose a sedimentary sequence ranging in age from middle Eocene to Pliocene and Roy and Mukherjee established the sequence in Table 1.

The present work is based on a traverse across the exposed rocks in the Dhansari Valley. Eleven samples were collected on the Deopani Traverse from 26° 13′ 11″ N, 93° 48′ 11″ E to 26° 13′ 58″ N, 93° 44′ 56″ E and all samples yielded Foraminifera except DP2. Samples DP6, DP7, DP8, DP10 have not yielded the larger Foraminifera but the smaller benthonics included *Cibicides* spp., *Heterolepa* sp., *Cycloloculina* sp., *Rotalina* sp., *Florilus* sp., *Bolivina* sp., *Discorbis* sp., *Brizalina* sp., and *Nonion* sp. Sample DP11, collected about 107 m (350 feet) above the base of the Sylhet Formation, yielded about 120 specimens belonging to eighteen species including *Linderina* sp., *Rotalia* sp., *Cibicides* sp.,

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Heterolepa sp., *Bolivina* sp., *Discorbis* sp., *Nummulites atacicus* Leymerie, 1846, *Operculina* sp., *Anomalinella rostrata* (Brady), 1881, *Elphidium* sp., *Amphistegina* sp., *Halkyardia* sp., and miliolids. The foraminiferal assemblage is dominated by *Nummulites atacicus* and suggests a middle Eocene age.

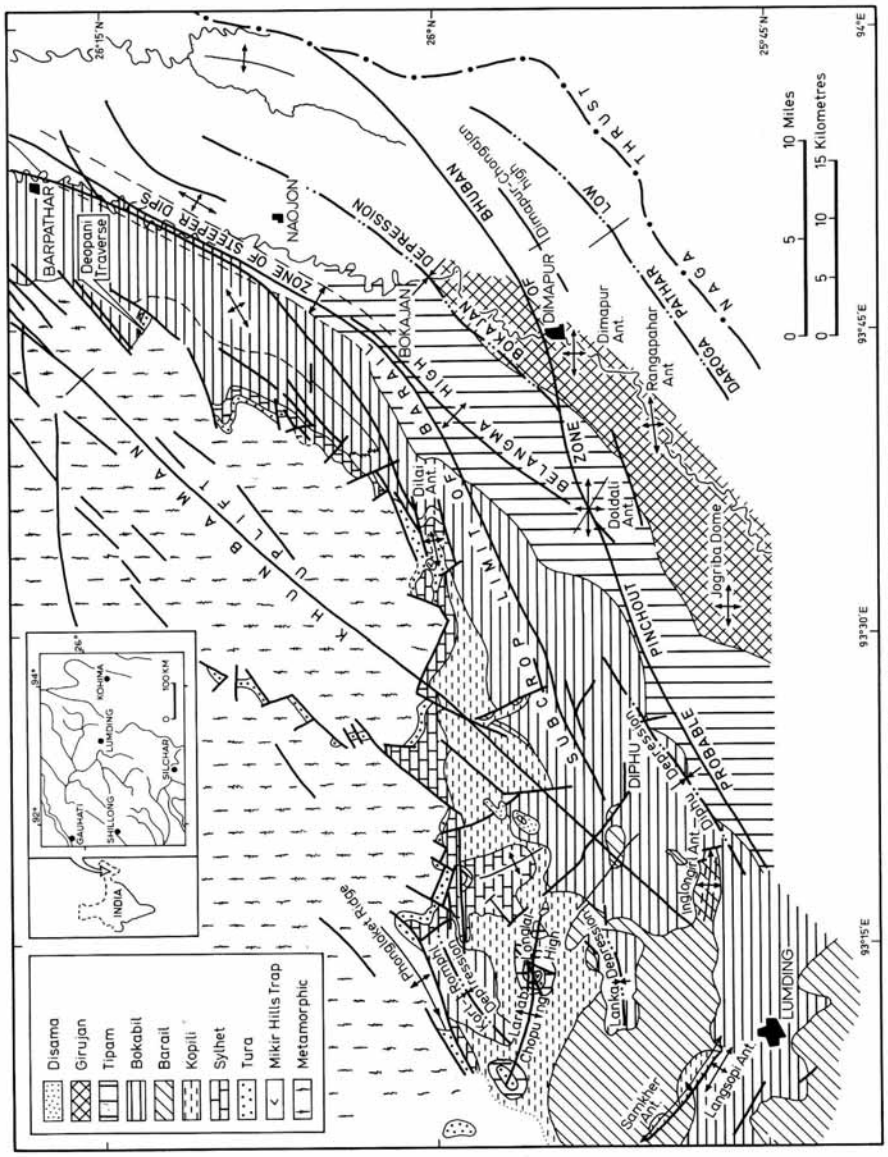
Sample DP13, a fossiliferous, light yellow, argillaceous limestone, was collected just above the contact between the Sylhet Formation and the Bokabil Formation. This contained a fairly rich assemblage of benthonic foraminiferids comprising eighty specimens of fourteen species including *Linderina* sp., *Cibicides* sp., *Planulinoides* sp., *Heterolepa* sp., *Cycloloculina* sp., *Reussella* sp., *Nummulites atacicus*, *Pararotalia* sp., *Pyrgo* sp., and miliolids which indicate a middle Eocene age. Compared with DP11 the proportion of miliolids (62·5%) is very high.

TABLE 1. General succession in the area. The Jaintia group in the subsurface of Upper Assam was divided into the Tura, Sibsagar, and Kopili Formations by Pandey (unpublished O.N.G.C. report, 1972). In the latter, Pandey proposed the term 'Sibsagar Formation' for a shale limestone unit occurring above the Tura and below the Kopili in the Upper Assam sequence, homotaxial with the 'Sylhet' of the Mikir Hills and Prang Formation (in part) of Meghalaya State, Assam. The term Sibsagar Formation was extended to include the 'Sylhet' strata of the Mikir Hills (Mohan, unpublished report 1973) in order to avoid using the term 'Sylhet' since the latter was originally proposed for a group of limestone and sandstone strata in the Khasi and Jaintia Hills of Meghalaya State which range in age from late Paleocene to middle Eocene. The 'Sylhet' of the Mikir Hills has close lithological similarities to, and is coeval with, the Sibsagar Formation but the term has been retained here following the usage of the field mapping parties.

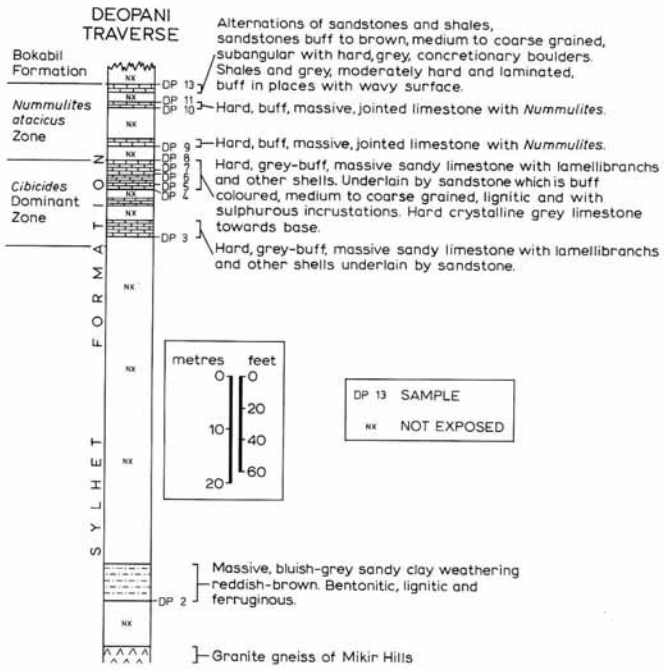
AGE	GROUP	FORMATION	APP. THICKNESS IN METRES
		Alluvium and terrace deposits	
Quaternary		-- Unconformity -----	
		Disama Formation	15+
		---------- Unconformity -----	
	Tipam	Girujan Formation	300+
		Tipam Formation	600
Neogene	Surma	Boka Bil Formation) Harihajan Mbr.) Bhelijan Mbr.	900
		---------- Unconformity -----	
	Barail	Not subdivided	400
Paleogene	Jaintia	Kopili Formation	350
		Sylhet Formation	155
		Tura Formation	30
		---------- Unconformity -----	
Pre-Tertiary	Mikir Hills Trap		10
		---------- Unconformity -----	
Pre-Cambrian	Metamorphic complex		

SYSTEMATIC PALAEONTOLOGY

Diagnoses are given of new species but descriptions are superfluous since, with the exception of two single photographs on Plate 7, all specimens are figured by means of stereoscopic paired prints. Where apposite, attention is drawn to important features under 'Remarks'. All material is deposited in the Museum, Palaeontology Laboratory, Keshava Deva Malaviya Institute of Petroleum Exploration, Oil and Natural Gas Commission, Dehra Dun, whose registered numbers are given throughout.



TEXT-FIG. 1. Location of the Deopani Traverse (after Roy *et al.*, 1975).



TEXT-FIG. 2. Position of samples and lithology in the Deopani Traverse.

Subclass OSTRACODA Latreille, 1806
Order PODOCOPIDA Muller, 1894
Suborder PLATYCOPINA Sars, 1866
Genus CYTHERELLA Jones, 1849
Cytherella deopanica sp. nov.

Plate 40, figs. 1–5

Holotype. A male carapace, IPE/H02/03/979.

Paratypes. One male and three female carapaces and valve IPE/P02/03/978, 1032, 1033, 1037.

Type horizon. DP6.

Derivation of name. After the location of the traverse along the Deopani River.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/979	668 μm	348 μm	312 μm
Paratype, male carapace, IPE/P02/03/978	652 μm	354 μm	280 μm
Paratype, female right valve, IPE/P02/03/1037	670 μm	410 μm	190 μm
Paratype, female carapace, IPE/P02/03/1033	650 μm	440 μm	345 μm
Paratype, female carapace, IPE/P02/03/1032	660 μm	440 μm	390 μm

Diagnosis. A *Cytherella* which in side view is narrower anteriorly than posteriorly, with a distinct dorsal angle at, or immediately behind mid-height. Anterior dorsal margin straight, posterior margin rounded with the right valve overlapping the left valve all the way round. Surface faintly pitted. Greatest width at two-thirds (male) or three-quarters (female) length.

Remarks. C. deopanica is perhaps closest to *C. sylvesterbradleyi* Reyment, 1963 from the late Paleocene of Nigeria as figured by Foster *et al.* (1983) where there is close correspondence in dorsal view. The overlap of the left valve by the right in side view is more uniform, however, and is particularly well seen in the posterior region; the anterodorsal margin is straighter. These comments are less applicable to the holotype figured by Reyment (1963, pl. 1, fig. 1) but in that specimen the height is much greater in proportion to the length, the greatest height lies much further posteriorly and the outline tapers less anteriorly. *C. utilis* Bertels, 1968 from the Maastrichtian and *C.* sp. aff. *C. utilis* Bertels, 1973 from the lower Tertiary of Argentina have the greatest height more posteriorly in lateral view and the anterodorsal margin is distinctly concave. *C. unguiformis* Kollmann, 1962 from the middle Eocene of Istria (Jugoslavia) is generally similar but differs in the more concave anterodorsal margin, the lesser taper anteriorly and the lack of overlap of the left valve by the right valve posteroventrally in side view. *C. montensis* Marlière, 1958 from the Montian of Belgium is shorter in proportion to the length and lacks the pitted surface.

Cytherella assamensis sp. nov.

Plate 40, figs. 6–9

Holotype. ?Male carapace IPE/H02/03/1036.

Paratype. Three ?female carapaces and valves IPE/P02/03/1034, 1035, 1038.

Type horizon. DP8.

Derivation of name. From the State of Assam.

Dimensions of figured specimens.

	Length	Height	Width
Paratype, ?female carapace, IPE/P02/03/1034	465 μm	310 μm	215 μm
Paratype, ?female carapace, IPE/P02/03/1035	430 μm	295 μm	210 μm
Holotype, ?male carapace, IPE/H02/03/1036	540 μm	350 μm	245 μm
Paratype, ?female carapace, IPE/P02/03/1038	650 μm	440 μm	215 μm

Diagnosis. In lateral view oval, tapering strongly posteriorly where it is much more narrowly rounded than anteriorly. Greatest height immediately behind mid-length, pitted surface. The shell is characteristically 'pinched in' just below the anterodorsal margin so that the latter gives the impression of a slight ridge. Overlap of the left valve by the right valve is complete but slight. Sexes difficult to differentiate.

Remarks. Whilst comparable in no other way the specimen of *C. sylvesterbradleyi* Reyment figured by Foster *et al.* (1983, pl. 14, fig. 6) from the late Paleocene of Nigeria shows a similar 'pinching in' of the anterodorsal margin and pitting. Compared with *Platella guzeratensis* of Guha (1965) from the Paleogene of Gujarat State the present species tapers more posteriorly and lacks the prominent subcentral depression. *C. rajui* Guha and Shukla, 1973 from the lower Eocene of Virdhachalam, Tamilnadu (11° 39′ 45″ N, 79° 23′ 47″ E; 11° 37′ N, 79° 18′ 12″ E) is difficult to interpret because if their pl. 1, fig. 19 is a right valve as stated, it appears that their pl. 1, fig. 4 must be a left valve and not a right valve. If this interpretation is correct the shape is somewhat similar but it lacks the pinching in below the anterodorsal margin and the surface is smooth.

Cytherella barpatharensis sp. nov.

Plate 40, figs. 10–12

Holotype. Male carapace IPE/H02/03/1043.

Paratype. Male carapace IPE/P02/03/1060, female carapace IPE/P02/03/1049.

Type horizon. DP8.

Derivation of name. From the town of Barpathar which lies north-east of the Deopani Traverse.

Dimensions of figured specimens.

	Length	Height	Width
Paratype, male carapace, IPE/P02/03/1060	485 μm	285 μm	205 μm
Holotype, male carapace, IPE/H02/03/1034	505 μm	260 μm	170 μm
Paratype, female carapace, IPE/P02/03/1049	530 μm	300 μm	215 μm

Diagnosis. A very elongate species with the greatest height in side view at approximately two-thirds the length. Female much more vaulted posteriorly in lateral view than the male which tapers noticeably. Very compressed in dorsal view with a tendency to form a marginal rim posteriorly. Pitting fine but particularly noticeable posteriorly. Right valve overlaps the left valve all round.

Remarks. Nothing closely resembling this is reported in the literature. There is some resemblance in outline to *C. elongata* Swanson, 1969 from the upper Oligocene of New Zealand but *C. barpatharensis* differs in having a finely pitted surface and gently rounded ends.

Cytherella hastata sp. nov.

Plate 41, figs. 1–5

Holotype. Male carapace IPE/H02/03/1041.

Paratypes. Male and female carapaces IPE/P02/03/1063, 1048.

Type horizon. DP11.

Other horizons. DP13 including figured specimens IPE/B02/03/1055, 1062.

Derivation of name. Latin *Hasta* 'a spear' in reference to its shape in dorsal view.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/1041	470 μm	250 μm	180 μm
Paratype, male carapace, IPE/P02/03/1063	465 μm	270 μm	190 μm
Paratype, female carapace, IPE/P02/03/1048	445 μm	255 μm	170 μm
Male carapace, IPE/B02/03/1055	440 μm	240 μm	
Female carapace, IPE/B02/03/1062	490 μm	290 μm	205 μm

EXPLANATION OF PLATE 40

Figs. 1–5. *Cytherella deopanica* sp. nov. 1, male carapace from left, holotype, IPE/H02/03/979, DP6, ×66. 2, male carapace in dorsal view, paratype, IPE/P02/03/978, DP6, ×61. 3, female right valve, internal view, paratype, IPE/P02/03/1037, DP8, ×60. 4, female carapace in dorsal view, paratype, IPE/P02/03/1033, DP8, ×70. 5, female carapace from right, paratype, IPE/P02/03/1032, DP8, ×58.

Figs. 6–9. *Cytherella assamensis* sp. nov. All from sample DP8. 6, ?female carapace from left, paratype, IPE/P02/03/1034, ×84. 7, ?female carapace from right, paratype, IPE/P02/03/1035, ×88. 8, ?male carapace in dorsal view, holotype, IPE/H02/03/1036, ×76. 9, ?female right valve, internal view, paratype, IPE/P02/03/1038, ×57.

Figs. 10–12. *Cytherella barpatharensis* sp. nov.. All from sample DP8. 10, male carapace in dorsal view, paratype, IPE/P02/03/1060, ×94. 11, male carapace from left, holotype, IPE/H02/03/1043, ×91. 12, female carapace from left, paratype, IPE/P02/03/1049, ×81.

NEALE and SINGH, *Cytherella*

Diagnosis. Carapace elongate and pitted, tapering posteriorly with the greatest width at approximately three-quarters length in the male and a little more posteriorly in the female. Greatest height behind the mid-length in the male (Pl. 41, fig. 2) and at about two-thirds length in the female (Pl. 41, fig. 3). The carapace anterior of the greatest height is almost parallel sided, tapering only slightly, whereas posteriorly it tapers strongly. The pitting is strongest in the posterior third of the shell but varies greatly according to preservation (cf. Pl. 2, figs. 1, 4).

Remarks. The more strongly pitted forms came from DP13 but there seems no good reason to regard them as specifically distinct. There is some resemblance to *C. terminopunctata* Holden, 1964 as figured by Bertels (1975) from the middle Maastrichtian of Argentina but the posterior punctation is more marked in the Indian species and the shape of the male in the Argentine species corresponds more closely in shape with the female of *C. hastata* and is very different from the male of the Indian species. There are no other closely comparable forms figured in the literature.

Cytherella antheriformis sp. nov.

Plate 41, figs. 6–9

Holotype. Male carapace IPE/H02/03/941.

Type horizon. DP8.

Derivation of name. From its resemblance to the anther of a flowering plant when seen in dorsal view.

Dimensions of figured specimen.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/941	440 μm	235 μm	200μm

Other figured specimens lost.

Diagnosis. The coarsely pitted carapace tapers anteriorly with the greatest height at approximately three-quarters length. Anterodorsal margin long and straight, sloping gently anteriorly, posterodorsal margin merging into the evenly rounded posterior margin. Ventral margin gently convex. Sexual dimorphism very marked with the males much longer in proportion to the height than the females. In dorsal view the greatest width is at about three quarters length, the females being much wider than the males.

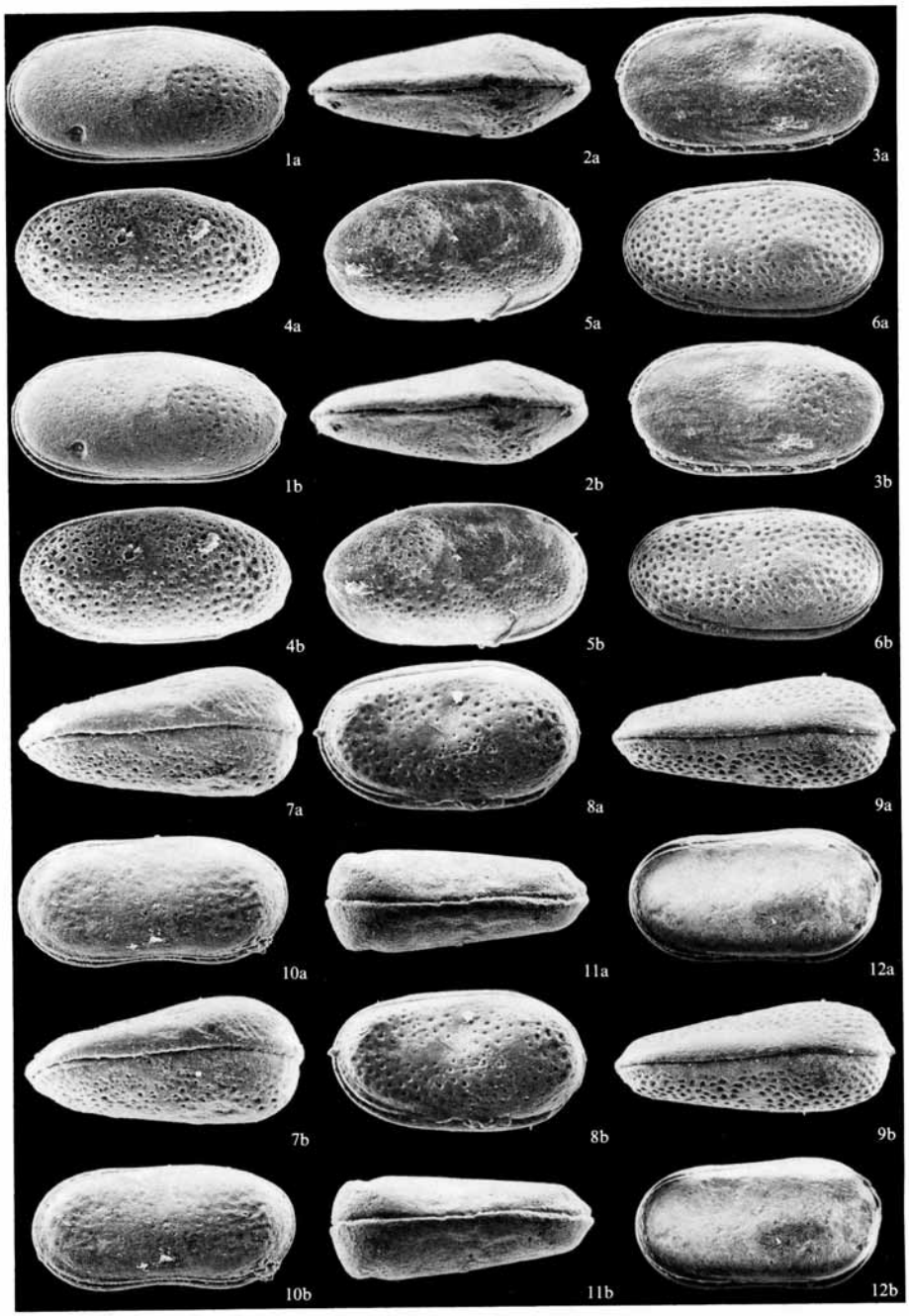
Remarks. This differs from the previous species in the anterior tapering of the carapace seen in side view and the stronger punctation. There are no closely comparable species figured in the literature.

EXPLANATION OF PLATE 41

Figs. 1–5. *Cytherella hastata* sp. nov. 1–3 from sample DP11; 4, 5 from sample DP13. 1, male carapace from left, holotype, IPE/H02/03/1041, ×98. 2, male carapace in dorsal view, paratype, IPE/P02/03/1063, ×99. 3, female carapace from left, paratype, IPE/P02/03/1048, ×97. 4, male carapace from left, IPE/B02/03/1055, ×98. 5, female carapace from right, IPE/B02/03/1062, ×86.

Figs. 6–9. *Cytherella antheriformis* sp. nov. 6, male carapace from left, holotype, IPE/H02/03/941, DP11, ×95. 7, female carapace in dorsal view, specimen lost, DP8. 8, female carapace from left, specimen lost, DP8. 9, male carapace in dorsal view, specimen lost, DP8.

Figs. 10–12. *Cytherella ventroconcava* sp. nov. All from sample DP11. 10, male carapace from left, holotype, IPE/H02/03/1042, ×105. 11, male carapace in dorsal view, paratype, IPE/P02/03/940, ×99. 12, female carapace from left, paratype, IPE/P02/03/938, ×92.



NEALE and SINGH, *Cytherella*

Cytherella ventroconcava sp. nov.

Plate 41, figs. 10–12.

?1976 *Cytherella* sp. 9. Ducasse and Grekoff, pp. 138–9, pl. 1, figs. 1–2.

Holotype. Male carapace IPE/H02/03/1042.

Paratypes. Male and female carapaces IPE/P02/03/940, 938.

Horizon. DP11.

Derivation of name. From its markedly concave ventral margin in side view.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/1042	420 μm	210 μm	150 μm
Paratype, male carapace, IPE/P02/03/940	435 μm	240 μm	200 μm
Paratype, female carapace, IPE/P02/03/938	450 μm	250 μm	200 μm

Diagnosis. In lateral view elongate with markedly concave ventral margin especially in the right valve. Anterior end evenly rounded, posterior end with supracurvature well shown in Pl. 2, fig. 10. Sexual dimorphism well developed with the female higher in proportion to the length than the male and with the greatest height at about five-sixths length. Better preserved forms show evidence of surface punctation. In dorsal view characteristically straight sided.

Remarks. The concave ventral margin and straight sides in dorsal view make this species very distinctive. It is closest to *Cytherella* sp. 9. Ducasse and Grekoff, 1976, a form recovered from the lower Eocene of DSDP Site 246 in the south-eastern Indian Ocean. Their figured specimen in lateral view shows infracurvature anteriorly and is not evenly rounded like *C. ventroconcava* but the two species are very similar in dorsal view. It is not possible to say whether Ducasse and Grekoff's (1976) specimen falls within the range of variation of the present species and so it is only tentatively referred here in the synonymy. *C. tawaica* (later corrected to *C. tawica*) Singh and Tewari, 1966 (in Tewari and Singh) from the Kalakot Formation (late early Eocene) of the Subathu Group of Jammu and Kashmir State is longer, not so markedly concave ventrally and the carapace is more pointed anteriorly in dorsal view.

Cytherella sp.

Plate 42, figs. 1, 2

Horizon. DP13.

Dimensions of figured specimens.

	Length	Height	Width
Carapace IPE/X02/03/1052	450 μm	310 μm	240 μm
Carapace IPE/X02/03/1053	430 μm	280 μm	220 μm

Remarks. It has not been possible to refer these specimens to any described species and the material is insufficient and not distinctive enough to warrant a name.

Genus CYTHERELLOIDEA Alexander, 1929

Cytherelloidea sp. juv.

Plate 42, fig. 3

Type horizon. DP8.

Dimensions of figured specimen.

	Length	Height	Width
Carapace IPE/X02/03/964	360 μm	205 μm	125 μm

Remarks. Only a single specimen of this species has been found and because of this and its small size, which suggests a juvenile, it is left under open nomenclature. It differs from *C. barkhaensis* Tewari and Tandon, 1960 from the lower Miocene of Kutch in lacking an oblique ridge extending from the posterior region to the anterodorsal region.

Suborder PODOCOPINA Sars, 1866
Superfamily BAIRDIACEA Sars, 1866
Family BAIRDIIDAE Sars, 1888
Genus BAIRDIA M'Coy, 1844
Bairdia beraguaensis Singh and Tewari, 1966

Plate 42, fig. 4

1966 *Bairdia beraguaensis* Singh and Tewari, in Tewari and Singh, pp. 119–120, pl. 1, fig. 4a–d.
1970 *Bairdia beraguaensis* Singh and Tewari; Sohn, p. 60, pl. 1, fig. 56.
1972 *Bairdia beraguaensis* Singh and Tewari; Khosla, p. 483, pl. 1, fig. 8.
1984 *Bairdia beraguaensis* Singh and Tewari; Singh, pp. 141–144.

Dimensions of figured specimen.

	Length	Height	Width
Carapace IPE/B02/03/910	940 μm	550 μm	390 μm

Remarks. This is the only species from Assam which is known from elsewhere on the Indian subcontinent. It has been described by Tewari and Singh (1966) from argillaceous limestones of late early Eocene age in Jammu and Kashmir State. The type material has been refigured by Singh (1984).

Superfamily CYPRIDACEA Baird, 1845
Family PONTOCYPRIDIDAE Muller, 1894
Genus PROPONTOCYPRIS Sylvester-Bradley, 1947
Propontocypris eocaenica sp. nov.

Plate 42, figs. 5–7

Holotype. A carapace IPE/H02/03/929.

Paratypes. Six specimens IPE/P02/03/1010, 1012, 1431–1434.

Type horizon. DP11.

Derivation of name. From its stratigraphical occurrence in the Eocene.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, carapace, IPE/H02/03/929	410 μm	220 μm	165 μm
Paratype, carapace, IPE/P02/03/1012	405 μm	205 μm	160 μm
Paratype, carapace, IPE/P02/03/1010	410 μm	205 μm	165 μm

Diagnosis. A *Propontocypris* with triangular outline in side view showing anterior infracurvature, greatest height just behind one-third length and strongly tapering, narrowly rounded, posterior end.

Remarks. Fossil Cypridacea are only very rarely recorded from the Eocene of this mid-Tethyan area when they are generally referable to *Paracypris*. There is nothing closely comparable to the present form.

Family SCHIZOCYTHERIDAE Howe, 1961
Genus PAIJENBORCHELLA Kingma, 1948
Subgenus EOPAIJENBORCHELLA Keij, 1966
Paijenborchella (*Eopaijenborchella*) *assamensis* sp. nov.

Plate 42, figs. 8–12; Plate 43, figs. 1–3

Material. 142 specimens from sample DP8 and nineteen specimens from sample DP11.

Holotype. A male carapace IPE/H02/03/907.

Paratypes. Three male and four female carapaces IPE/P02/03/908, 950, 953, 997.

Type horizon. DP8.

Derivation of name. From its occurrence in Assam.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/907	415 μm	205 μm	220 μm
Paratype, male carapace, IPE/P02/03/951	510 μm	260 μm	240 μm
Paratype, female carapace, IPE/P02/03/908	360 μm	210 μm	175 μm
Paratype, female carapace, IPE/P02/03/950	350 μm	200 μm	200 μm
Paratype, female carapace, IPE/P02/03/953	360 μm	200 μm	180 μm
Paratype, female carapace, IPE/P02/03/997	340 μm	195 μm	165 μm
Paratype, male carapace, IPE/P02/03/998	310 μm	150 μm	140 μm
Paratype, male carapace, IPE/P02/03/999	400 μm	190 μm	190 μm

Diagnosis. A species with deep median sulcus, strong mid-rib and gently convex ventral margin in side view. Strong sexual dimorphism, the females shorter in proportion to the height and wider than the males.

Remarks. Ornamentation is somewhat variable as can be seen by comparing Plate 42, figs 10 and 12 and is probably a preservational phenomenon. *P. assamensis* differs considerably from all other described species of the genus. *P. eocaenica* Triebel 1949 differs markedly in shape having a much more convex ventral outline and the same is true for *P. lomata* and *P. marssoni* Triebel, 1949. *P. tricostata* (Lienenklaus, 1900) as figured by Szczechura (1977) from the Eocene of Eastern Poland has a much more strongly developed ventral rib which gives the carapace an alate appearance and a more concave posteroventral outline amongst other differences. *P. berggreni* Krstic, 1979 from the Miocene of Iran differs in outline and the ventral rib rises strongly anteriorly; the species from the Neogene of Japan assigned to this genus by Ishizaki (1966) are much more quadrate and other recorded species are not closely comparable.

Paijenborchella (*Eopaijenborchella*) sp.

Plate 43, fig. 4

The same sample that provided the abundant specimens of *P. assamensis* also yielded a single specimen of the genus which showed strong reticulation and a short straight mid-rib. In addition the flanks of the dorsal sulcus show rows of fine pits on each flank. This appears to lie outside the range of variation shown by the previous species but because of its rarity it is here left under open nomenclature.

EXPLANATION OF PLATE 42

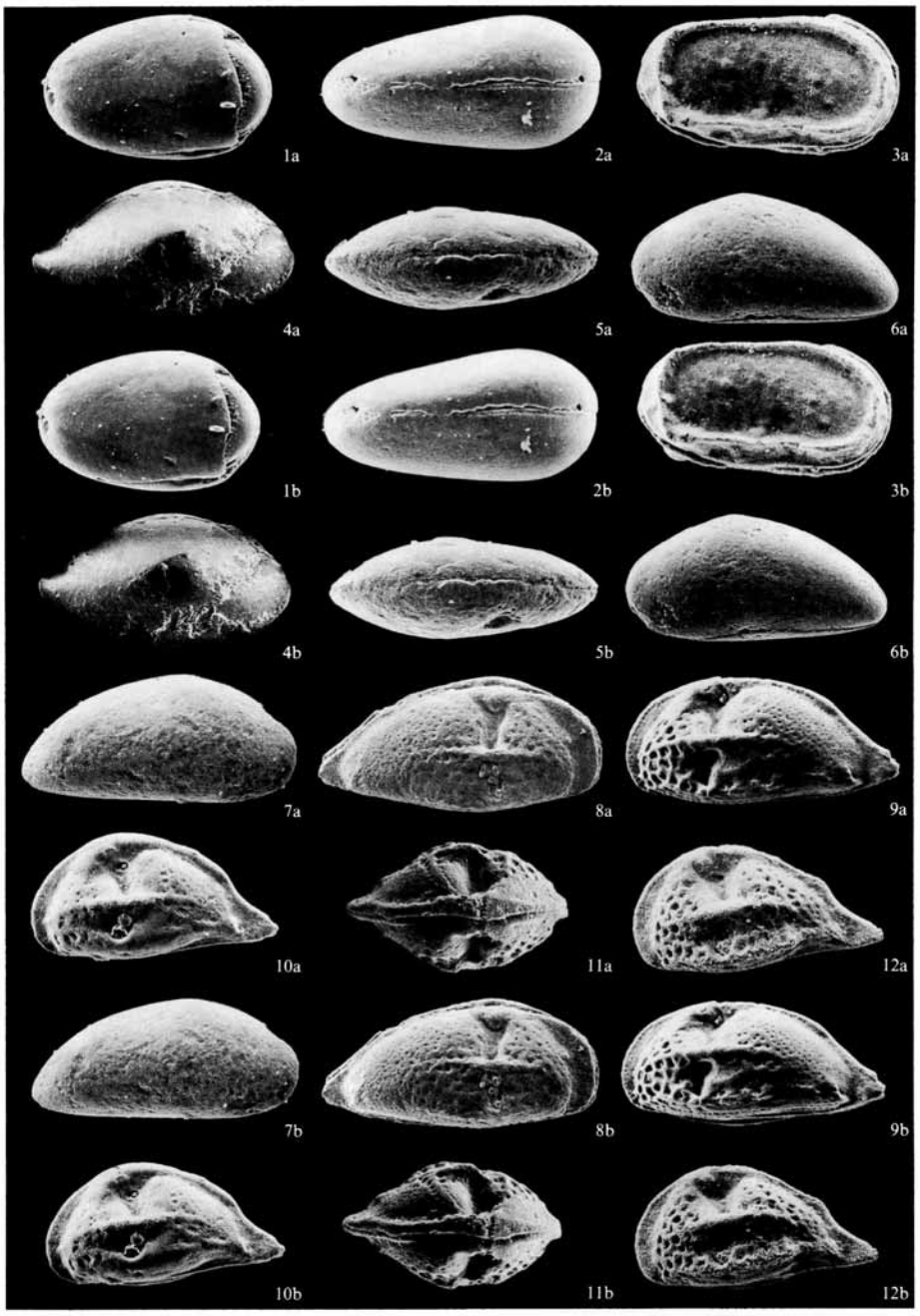
Figs. 1, 2. *Cytherella* sp. 1, carapace from left, IPE/X02/03/1052, DP13, ×82. 2, carapace in dorsal view, IPE/X02/03/1053, DP13, ×107.

Fig. 3. *Cytherelloidea* sp. juv., carapace from right, IPE/X02/03/964, DP8, ×116.

Fig. 4. *Bairdia beraguaensis* Singh and Tewari 1966, carapace from right, IPE/B02/03/910, DP13, ×45.

Figs. 5–7. *Propontocypris eocaenica* sp. nov. All from sample DP11. 5, carapace in dorsal view, paratype, IPE/P02/03/1012, ×106. 6, carapace from left, holotype, IPE/H02/03/929, ×102. 7, carapace from right, paratype, IPE/P02/03/1010, ×107.

Figs. 8–12. *Paijenborchella* (*Eopaijenborchella*) *assamensis* sp. nov. All from sample DP8. 8, male carapace from right, paratype, IPE/P02/03/951, ×90. 9, male carapace from left, holotype, IPE/H02/03/907, ×102. 10, female carapace from left, paratype, IPE/P02/03/908, ×119. 11, female carapace in dorsal view, paratype, IPE/P02/03/950, ×101. 12, female carapace from left, paratype, IPE/P02/03/953, ×114.



NEALE and SINGH, *Eocene Ostracoda*

Dimensions of figured specimen.

	Length	Height	Width
Female carapace IPE/X02/03/954	370 μm	230 μm	250 μm

Horizon. DP8.

Paijenborchella? enigma sp. nov.

Plate 43, fig. 5

Holotype. Carapace IPE/H02/03/971.

Paratype. Carapace IPE/P02/03/972.

Type horizon. DP6.

Derivation of name. From the problematic generic placing of this species.

Dimensions of figured specimen.

	Length	Height	Width
Holotype, carapace, IPE/H02/03/971	510 μm	230 μm	220 μm

Diagnosis. An elongate species with typical sulcus crossed by the median rib as in *Paijenborchella*, but lacking the characteristic drawn out posteroventral caudal process of that genus.

Remarks. This species raises considerable problems in its generic placement as is obvious from the diagnosis. Apart from the lack of a sharp caudal process and in consequence the more uniform height, the other features all fit well within that genus. It has not been possible to find anything closely comparable to this species.

Genus SCHIZOCYTHERE Triebel, 1950

Schizocythere deopanica sp. nov.

Plate 43, figs. 6–9, 11

Holotype. Female carapace IPE/H02/03/920.

Paratypes. Four carapaces IPE/P02/03/921–924.

Other material. Thirty specimens from DP11, two specimens from DP8.

Type horizon. DP11.

Derivation of name. After the Deopani River area of Assam where the material was collected.

EXPLANATION OF PLATE 43

Figs. 1–3. *Paijenborchella* (*Eopaijenborchella*) *assamensis* sp. nov. All from sample DP8. 1, female carapace in ventral view, paratype, IPE/P02/03/997, × 132. 2, male carapace in ventral view, paratype, IPE/P02/03/998, × 148. 3, male carapace in dorsal view, paratype, IPE/P02/03/999, × 114.

Fig. 4. *Paijenborchella* sp., female carapace from right, IPE/B02/03/954, DP8, × 103.

Fig. 5. *Paijenborchella? enigma* sp. nov., carapace from left, IPE/H02/03/971, DP6, × 85.

Figs. 6–9, 11. *Schizocythere deopanica* sp. nov. All from sample DP11. 6, female carapace from right, holotype, IPE/H02/03/920, × 98. 7, female carapace from left, paratype, IPE/P02/03/922, × 95. 8, female carapace in dorsal view, paratype, IPE/P02/03/923, × 95. 9, male carapace from left, paratype, IPE/P02/03/921, × 93. 11. male carapace in dorsal view, paratype, IPE/P02/03/924, × 100.

Figs. 10, 12. *Krithe oryza* sp. nov. All from sample DP11. 10, female carapace from left, paratype, IPE/P02/03/1001, × 105. 12, male carapace from left, paratype, IPE/P02/03/1005, × 82.

NEALE and SINGH, *Paijenborchella*, *Schizocythere*, *Krithe*

Dimensions of figured specimens.

	Length	Height	Width
Holotype, female carapace, IPE/H02/03/920	400 μm	240 μm	210 μm
Paratype, female carapace, IPE/P02/03/923	420 μm	255 μm	220 μm
Paratype, male carapace, IPE/P02/03/921	410 μm	250 μm	220 μm
Paratype, female carapace, IPE/P02/03/922	400 μm	255 μm	230 μm
Paratype, male carapace, IPE/P02/03/924	410 μm	255 μm	220 μm

Diagnosis. A species whose strong reticulate ornamentation includes a strong posterodorsal tubercle with a rib from its posterior slope to the posterodorsal corner.

Remarks. This species shows the usual, heavily reticulate carapace typical of the genus, a genus widely recorded from throughout the northern hemisphere in beds of Eocene to Miocene age. It is very close to *S. gujaratensis* Guha, 1968 which has been well figured by Siddiqui (1981) who found it in the middle upper Eocene of the Zao River Section in the Sulaiman Range, Pakistan. The present species is very close in possessing a similar posterodorsal tubercle but differs consistently in the presence of a rib from the posterior slope of this to the posterodorsal corner of the valve. The anterodorsal part of the valve is also less excavated and there are differences in the detailed arrangement of the fossae where the diagonal alignment across the shell does not depart so strongly from the horizontal. Its close similarity to the western species from Kutch and the Sulaiman Range suggest that it is of similar Eocene age.

Other species placed in *Schizocythere* are not closely comparable.

Family CUSHMANIDEIDAE Puri, 1973
Genus CUSHMANIDEA Blake, 1933
Cushmanidea distincta sp. nov.

Plate 46, fig. 11

Holotype. Carapace IPE/H02/03/976

Horizon. DP8

Derivation of name. From its easily recognized appearance.

Dimensions of figured specimen.

	Length	Height	Width
Holotype, carapace, IPE/H02/03/976	512 μm	164 μm	156 μm

Diagnosis. A slightly boomerang-shaped species of *Cushmanidea* which is very long in proportion to height where the ratio is more than three to one.

Remarks. Cushmanidea is not a commonly encountered genus and *C. tewarii* Khosla, 1972 from the Eocene of Rajasthan appears to be the only other record from the Tertiary of the Indian subcontinent. Whilst represented by only one specimen the present form is sufficiently distinctive to warrant a name rather than leaving it under open nomenclature.

Family KRITHIDAE MANDELSTAM, 1960
Genus KRITHE Brady, Crosskey and Robertson, 1874
Krithe oryza sp. nov.

Plate 43, figs. 10, 12; Plate 46, fig. 13

Holotype. Carapace IPE/H02/03/925.

Paratypes. Carapaces IPE/P02/03/1001, 1005.

Type horizon. DP11.

Derivation of name. Greek *Oryza*, 'rice', from its resemblance to a grain of rice.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/925	540 μm	270 μm	250 μm
Paratype, female carapace, IPE/P02/03/1001	430 μm	225 μm	210 μm
Paratype, male carapace, IPE/P02/03/1005	555 μm	270 μm	250 μm

Diagnosis. A species almost exactly half as high as long with gently convex ventral outline and gently convex dorsal outline. Greatest height in the male lies at approximately three-quarters the length, in the female just posterior of mid-length.

Remarks. Because all the material consists of closed carapaces it has not been possible to ascertain the nature of the hinge and thus whether it should be placed in *Krithe* or *Dentokrithe* Khosla and Haskins, 1980 (type species *Krithe indica* Tewari and Tandon, 1960 from the middle Eocene of Western India). From this latter species *K. oryza* differs in the more vaulted dorsal margin and in the somewhat narrower anterior part of the valve as seen in lateral view. The differences are perhaps most clearly seen, however, in the even rounding of the anterior margin of *K. oryza* in side view compared with the infracurvature of *D. indica*. The ventral margin is also more convex in the present species. Differences from the Indian Miocene *D. autochthona* (Lubimova and Guha) are obvious and seen in the concave ventral margin and well-developed posterodorsal region with almost vertical posterior margin of the Miocene form.

Krithe cf. *K. oryza*

Plate 44, fig. 1

Material. A single carapace IPE/B02/03/977.

Type horizon. DP8.

Dimensions of figured specimen.

	Length	Height	Width
Carapace IPE/B02/03/977	448 μm	220 μm	220 μm

Remarks. This specimen occurred *c.*12 m (40 feet) lower in the section than *K. oryza*. It compares closely with the female of the last species which it resembles in size but shows slight differences in shape with anterior and posterior ends being a little more narrowly rounded in side view and the antero- and posterodorsal margins a little straighter. Lacking a full range of material from DP8 it is not possible to place the present form unequivocally in *K. oryza* and so here the question is left open.

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Tribe ECHINOCYTHEREIDINI Hazel, 1967
Genus ALOCOPOCYTHERE Siddiqui, 1971
Alocopocythere bhandarii sp. nov.

Plate 44, figs. 2–4

Holotype. Carapace IPE/H02/03/957.

Paratypes. Six other specimens from the same sample.

Type horizon. DP8.

Derivation of name. In honour of Sri L. L. Bhandari, Director of the Keshava Deva Malaviya Institute of Petroleum Exploration, O.N.G. Commission, Dehra Dun.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/957	640 μm	340 μm	330 μm
Paratype, female carapace, IPE/P02/03/955	550 μm	320 μm	330 μm
Paratype, female carapace, IPE/P02/03/958	560 μm	340 μm	325 μm

Diagnosis. Carapace strongly pitted but with the anterior marginal rim smooth or only faintly ribbed. Just behind mid-length a short, distinctive rib starts at about one-quarter height and runs upwards and slightly posteriorly to about mid-height.

Remarks. A considerable number of *Alocopocythere* species has been described from early Tertiary rocks of the western India/Pakistan/Saudi Arabia area but none is closely comparable with the present species and its distinct ornamentation.

Alocopocythere dhansariensis sp. nov.

Plate 44, figs. 5–7, 9

Holotype. Male carapace IPE/H02/03/962.

Paratypes. Eighty-three specimens from Horizon DP8 including IPE/P02/03/960, 961, 963.

Other material. Thirteen specimens from DP11.

Type horizon. DP8.

Derivation of name. After the Dhansari Valley where the specimens were collected.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/962	530 μm	250 μm	220 μm
Paratype, female carapace, IPE/P02/03/960	450 μm	245 μm	230 μm
Paratype, female carapace, IPE/P02/03/963	470 μm	260 μm	240 μm
Paratype, male carapace, IPE/P02/03/961	510 μm	240 μm	220 μm

Diagnosis. An elongate species with well-developed marginal pits all round the carapace of which seven are present on the anterior marginal rim. Prominent surface pitting which tends to be smoothed out in the posteroventral part of the valve.

Remarks. Other species are not close. The closest comparison is to be found among the Pakistan material where the male of *A. rupina* Siddiqui, 1971 is close in shape to the female of the present species but differs in ornamentation and shape in dorsal view as well as in the different dimorphism.

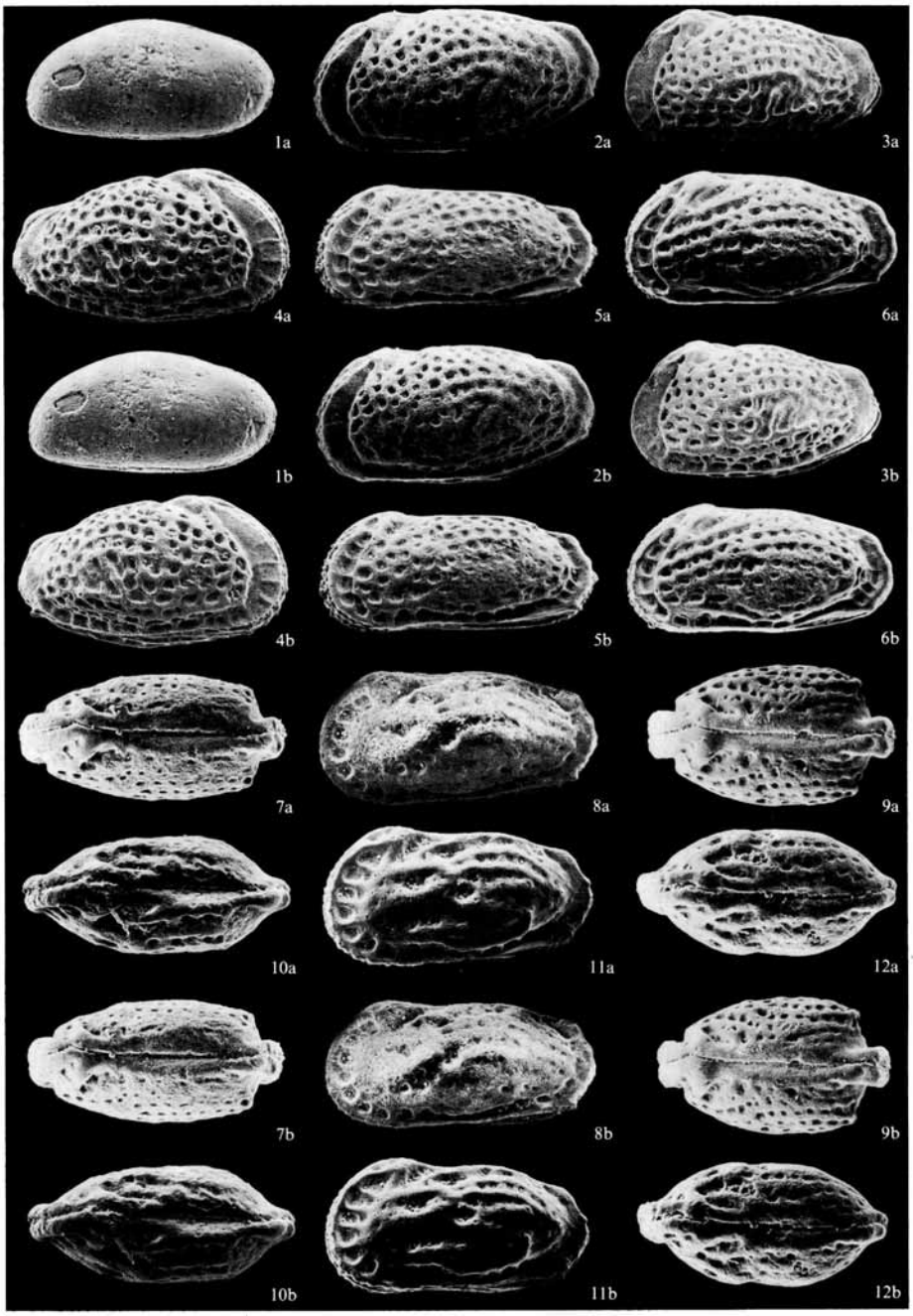
EXPLANATION OF PLATE 44

Fig. 1. *Krithe* cf. *K. oryza*, carapace from left, IPE/B02/03/977, DP8, ×89.

Figs. 2–4. *Alocopocythere bhandarii* sp. nov. All from sample DP8. 2, male carapace from left, holotype, IPE/H02/03/957, ×73. 3, female carapace from left, paratype, IPE/P02/03/958, ×75. 4, female carapace from right, paratype, IPE/P02/03/955, ×82.

Figs. 5–7, 9. *Alocopocythere dhansariensis* sp. nov. All from sample DP8. 5, male carapace from left, holotype, IPE/H02/03/962, ×87. 6, female carapace from left, paratype, IPE/P02/03/960, ×98. 7, male carapace in dorsal view, paratype, IPE/P02/03/963, ×86. 9, female carapace in dorsal view, paratype, IPE/P02/03/961, ×74.

Figs. 8, 10–12. *Alocopocythere talukdari* sp. nov. All from sample DP11. 8, male carapace from left, holotype, IPE/H02/03/934, ×82. 10, male carapace in dorsal view, paratype, IPE/P02/03/935, ×83. 11, female carapace from left, paratype, IPE/P02/03/933, ×86. 12, female carapace in dorsal view, paratype, IPE/P02/03/937, ×77.



NEALE and SINGH, *Krithe*, *Alocopocythere*

Alocopocythere talukdari sp. nov.

Plate 44, figs. 8, 10–12

Holotype. Male carapace IPE/H02/03/934.

Paratypes. One male and two female carapaces IPE/P02/03/935, 933, 937.

Type horizon. DP11.

Derivation of name. In honour of Sri Samrendra Nath Talukdar, Member Exploration, O.N.G. Commission, Dehra Dun.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/934	550 μm	280 μm	255 μm
Paratype, female carapace, IPE/P02/03/933	510 μm	290 μm	255 μm
Paratype, male carapace, IPE/P02/03/935	520 μm	300 μm	245 μm
Paratype, female carapace, IPE/P02/03/937	530 μm	280 μm	240 μm

Diagnosis. Carapace with well-developed marginal pits and with the pits on the general surface of the valve subdued at the expense of the ribbing developed between them. Dorsal margin in side view gently triconvex.

Remarks. The only species resembling this is *A. orectommata* Al-Furaih, 1980 from the Palaeocene of Saudi Arabia but this differs in the less inflated ribbing and in the detailed rib pattern in the anterodorsal region of the valve.

Alocopocythere polygona sp. nov.

Plate 45, figs. 1–3

Holotype. Male carapace IPE/H02/03/987.

Paratypes. Two female carapaces IPE/P02/03/984, 988.

Horizon. DP13.

Derivation of name. A reference to the polygonal shape of the surface pitting.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/987	568 μm	330 μm	304 μm
Paratype, female carapace, IPE/P02/03/984	540 μm	310 μm	300 μm
Paratype, female carapace, IPE/P02/03/988	640 μm	352 μm	356 μm

Diagnosis. A species with rather smooth anterior and posterior marginal areas and polygonal pitting on the valve surface. Female very rotund in dorsal view.

Remarks. There is little in the literature with which this can be compared although *A. transversa* Morphotype F described by Siddiqui (1971) from the upper Eocene of the Rakhi Nala Section of Pakistan has a number of features reminiscent of the present species. However, the marginal rim in his Morphotype shows strong pitting anteriorly and posteriorly and the ventral margin lacks the even, elegant curve of the present species.

Subfamily BUNTONIINAE Apostolescu, 1961

Genus BUNTONIA Howe, 1935

Buntonia royi sp. nov.

Plate 45, figs. 4–7

Holotype. Male carapace IPE/H02/03/968.

Paratypes. Female carapace IPE/P02/03/969.

Type horizon. DP6.

Other horizons. DP8, including figured specimens IPE/B02/03/980, 982.

Derivation of name. In honour of Sri T. K. Roy, Superintending Geologist, K.D.M.I.P.E., O.N.G.C., who contributed much to our understanding of the geology of the Assam Region.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/968	410 μm	215 μm	180 μm
Paratype, female carapace, IPE/P02/03/969	390 μm	240 μm	180 μm
Male carapace IPE/B02/03/980	400 μm	220 μm	164 μm
Male carapace IPE/B02/03/982	336 μm	236 μm	196 μm

Diagnosis. A species with well-developed pitting dominating over subdued ribbing and dorsally directed termination of the posterior margin.

Remarks. The present species differs from *B. awadi* Bassiouni, 1969 from the Eocene of Jordan in which the ventral part of the valve shows a characteristic bulge/overhang and the dorsal margin is slightly concave or undulating.

Family LOXOCONCHIDAE Sars, 1925
Genus LOXOCONCHA Sars, 1866
Loxoconcha? sp.

Plate 46, fig. 6

A single specimen which appears to belong in this genus but in which the caudal process is much drawn out.

Horizon. DP8.

Dimensions of figured specimen.

	Length	Height	Width
Carapace IPE/X02/03/983	276 μm	152 μm	144 μm

Remarks. This single specimen has a narrower and more pronounced caudal process than that found in most members of the genus although forms of comparable shape have been illustrated. *Loxoconcha* is typical of shallow shelf seas and is not normally recorded in this part of Tethys. This carapace is very small compared with most species and although showing distinctive and well-developed ornamentation there must remain some doubt about whether it is a full adult and actually lived in the place where it was found. For this reason it is left under open nomenclature.

Family PARACYTHERIDEIDAE Puri, 1957
Genus PARACYTHERIDEA G. W. Muller, 1894
Paracytheridea? superdimorphica sp. nov.

Plate 45, figs. 8–10

Holotype. A male carapace IPE/H02/03/966.

Paratypes. A male and a female carapace IPE/P02/03/965, 967.

Type horizon. DP8.

Derivation of name. In reference to the extraordinary dimorphism seen in this species as interpreted here.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/966	380 μm	170 μm	155 μm
Paratype, female carapace, IPE/P02/03/965	330 μm	180 μm	140 μm
Paratype, male carapace, IPE/P02/03/967	350 μm	170 μm	155 μm

Diagnosis. A species in which four ribs radiate from the anteroventral corner. One runs to the anterior cardinal angle. Two lie ventrally, the upper one being discontinuous and forming the boundary between the ventral and lateral surface. A median rib runs to the posterodorsal corner. The median rib disappears at the median sulcus and reappears posteriorly as a short double rib. In the female this part is elevated to form a strong tubercle which affects the dorsal outline in side view.

Remarks. This material has been placed provisionally in the genus *Paracytheridea* to which it has certain affinities although it most certainly does not belong there. Unfortunately all the material consists of closed carapaces and it is impossible to determine the hinge structure and other features necessary to establish a new genus. Interpretation, based on three specimens from the same horizon, was also difficult at the specific level. Two of the specimens differ greatly in shape from the third but in all of them the anterior half of the valve is very similar. The posterior half, however, shows very marked differences in that the higher form has the dorsoposterior area of ornamentation raised to form a strong tubercle which affects the dorsal outline of the shell in side view (Pl. 45, fig. 9). In the same area the lower, more elongate form has ridges in a low inverted 'V' which appear to represent the same elements but are not raised to form a marked tubercle. Detailed examination of Pl. 45, figs. 9, 10 will show other differences such as the greater inflation of the upper ventral rib in the higher form. Since these are all from the same sample, the latter is interpreted as a female and the lower forms are interpreted as males, one of which is selected as the holotype. There is nothing described from the Indian sub-continent which is closely comparable with the present species.

Family CYTHERURIDAE G. W. Muller, 1894
Subfamily CYTHERURINAE G. W. Muller, 1894
Genus CYTHERURA Sars, 1866
Cytherura eocaenica sp. nov.

Plate 46, fig. 10

Holotype. Carapace IPE/H02/03/947.

Type Horizon. DP11.

Derivation of name. From its occurrence in the Eocene.

Dimensions of figured specimen.

	Length	Height	Width
Holotype, carapace, IPE/H02/03/947	390 μm	150 μm	110 μm

Diagnosis. An elongate species with well-developed dorsocentral and ventrocentral longitudinal ribs which run the length of the valves. Between these two ribs there are two strong, short longitudinal ribs

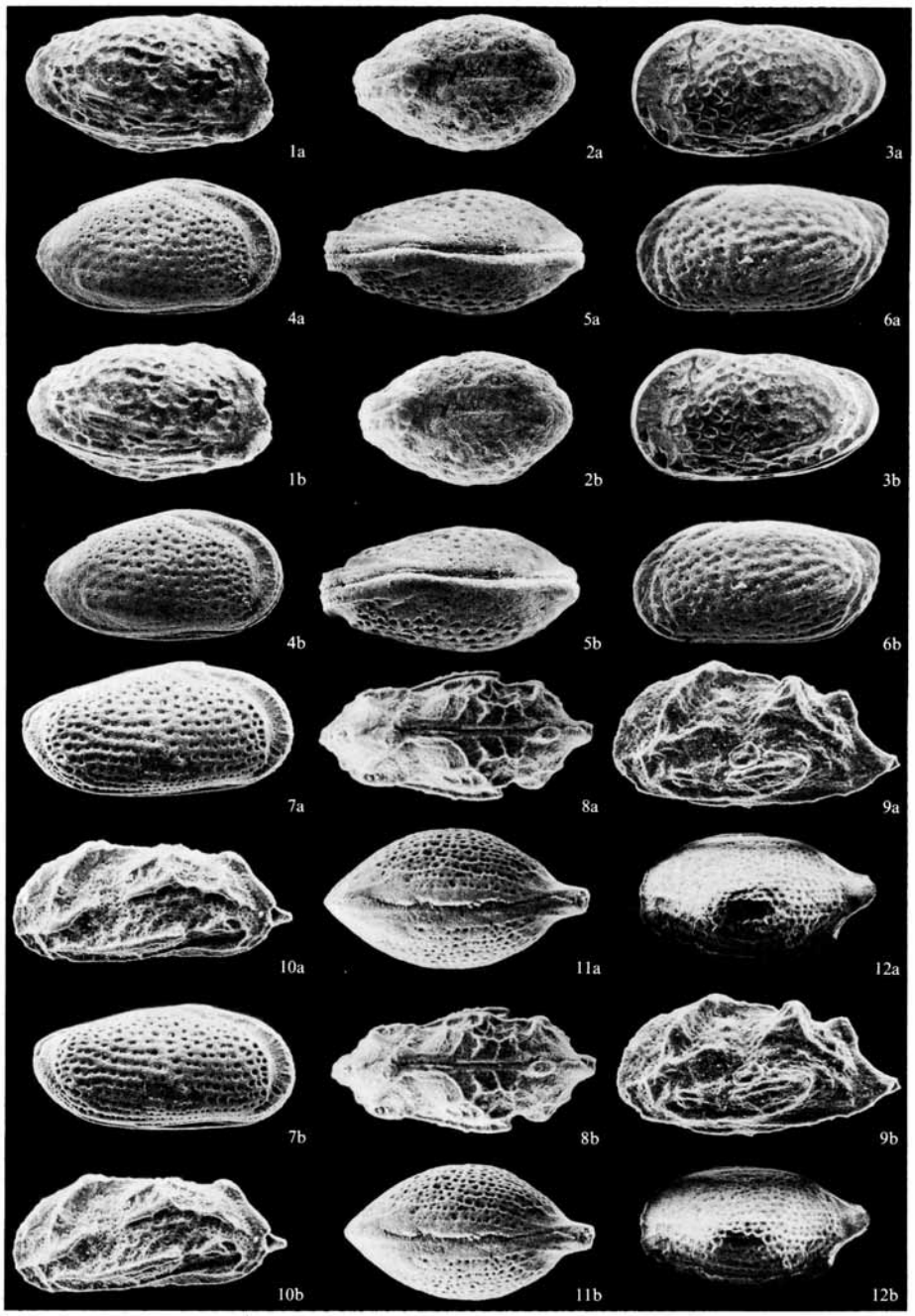
EXPLANATION OF PLATE 45

Figs. 1–3. *Alocopocythere polygona* sp. nov. All from sample DP13. 1, female carapace from right, paratype, IPE/P02/03/984, × 74. 2, female carapace in dorsal view, paratype, IPE/P02/03/988, × 58. 3, male carapace from left, holotype, IPE/H02/03/987, × 73.

Figs. 4–7. *Buntonia royi* sp. nov. 4, female carapace from right, paratype, IPE/P02/03/969, DP6, × 103. 5, male carapace in dorsal view, IPE/B02/03/982, DP8, × 125. 6, male carapace from left, holotype, IPE/H02/03/968, DP6, × 100. 7, male carapace from right, IPE/B02/03/980, DP8, × 110.

Figs. 8–10. *Paracytheridea? superdimorphica* sp. nov. All from sample DP8. 8, male carapace in dorsal view, paratype, IPE/P02/03/967, × 126. 9, female carapace from left, paratype, IPE/P02/03/965, × 142. 10, male carapace from left, holotype, IPE/H02/03/966, × 118.

Figs. 11, 12. *Semicytherura indica* sp. nov. All from sample DP11. 11, carapace in dorsal view, paratype, IPE/P02/03/917, × 119. 12, carapace from left, paratype, IPE/P02/03/916. × 105.



NEALE and SINGH, *Eocene Ostracoda*

in the anterior fifth of the valves which also join the anterior margin. About nine other finer longitudinal ribs occur on the lateral surface of which three lie between the two stronger ribs. The posterior end of the carapace is marked off from the main body of the valve and is reticulate and immediately behind the anterior rim the valve is strongly depressed between the ribs.

Remarks. This single specimen is so distinctive and so well preserved that it is unlikely to be confused with any other taxon and is therefore named. It has not been possible to determine hinge structure, nature of marginal areas, or muscle scar pattern and it is here referred to *Cytherura* on the basis of its general shape, both the elongation and particularly the posterior outline in side view being reminiscent of that genus. The dominantly longitudinal ornamentation, however, is more typical of *Semicytherura* than the present day species of *Cytherura*. When more, well-preserved material is available it may be necessary to re-consider the generic placement of this taxon.

Genus SEMICYTHERURA Wagner, 1957

Semicytherura indica sp. nov.

Plate 45, figs. 11, 12; Plate 46, figs. 1, 3

Holotype. Carapace IPE/H02/03/915.

Paratypes. Three carapaces IPE/P02/03/916, 917, 994.

Type horizon. DP11.

Derivation of name. From its occurrence in the Indian sub-continent.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, carapace, IPE/H02/03/915	370 μm	200 μm	180 μm
Paratype, carapace, IPE/P02/03/917	360 μm	200 μm	180 μm
Paratype, carapace, IPE/P02/03/916	370 μm	210 μm	200 μm
Paratype, carapace, IPE/P02/03/994	330 μm	210 μm	185 μm (broken)

Diagnosis. A finely reticulate species in which the individual lines of fossae are separated by fine longitudinal ribs which number about eighteen on the main body of the valve.

Remarks. As only closed carapaces were available for study this species is provisionally placed in *Semicytherura* on the basis of the curved dorsal margin rather than in *Cytherura* where the type species is very different and has a straight dorsal margin. Nevertheless, when good material showing

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EXPLANATION OF PLATE 46

Figs. 1, 3. *Semicytherura indica* sp. nov. Both from DP11. 1, carapace from right, holotype. IPE/H02/03/915, × 105. 3, carapace from left, paratype, IPE/P02/03/994, × 118.

Fig. 2. *Semicytherura indica* sp. nov. ?subsp. nov., carapace from right, IPE/B02/03/1017, DP13, × 125.

Figs. 4, 5. *Cytheropteron reticuloradiata* sp. nov. 4, carapace from right, holotype, IPE/H02/03/973, DP8, × 106. 5, carapace from left, IPE/B02/03/995, DP11, × 134.

Fig. 6. *Loxoconcha*? sp., carapace from left, IPE/X02/03/983, DP8, × 156.

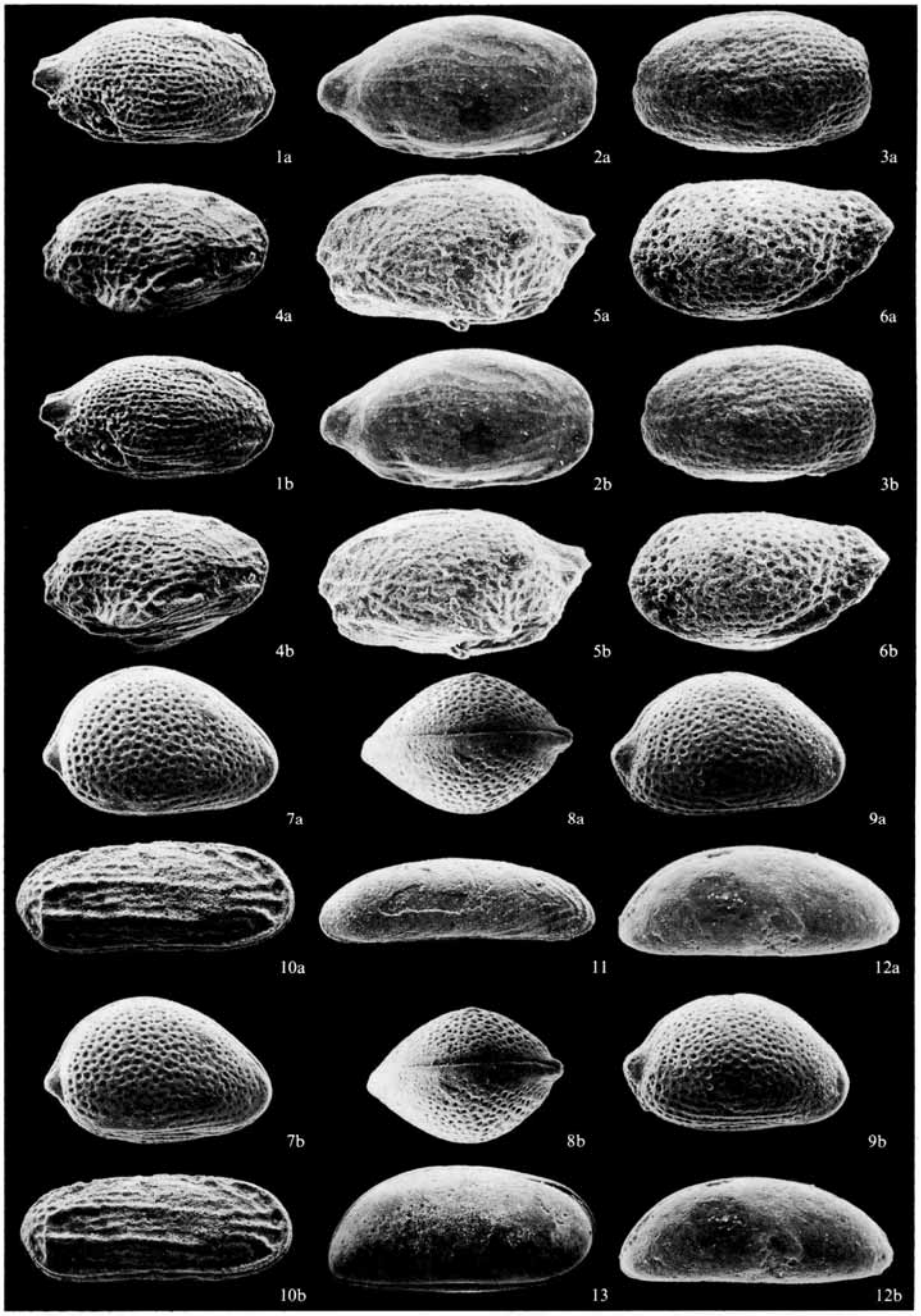
Figs. 7–9. *Uroleberis armeniaca* sp. nov. 7, female carapace from right, IPE/B02/03/913, DP11, × 88. 8, female carapace in dorsal view, IPE/B02/03/914, DP11, × 85. 9, male carapace from right, holotype, IPE/H02/03/275, DP13, × 86.

Fig. 10. *Cytherura eocaenica* sp. nov., carapace from right, holotype, IPE/H02/03/947, DP11, × 115.

Fig. 11. *Cushmanidea distincta* sp. nov., carapace from right, holotype, IPE/H02/03/976, DP8, × 88.

Fig. 12. *Xestoleberis*? sp., carapace from right, IPE/X02/03/1016, DP8, × 167.

Fig. 13. *Krithe oryza* sp. nov., carapace from right, holotype, IPE/H02/03/925, DP11, × 80.



NEALE and SINGH, *Eocene Ostracoda*

the internal features on which the generic differences are essentially drawn become available, it may be necessary to transfer this species to another genus of the Cytheruridae. The closest comparable species appears to be that from the lower Palaeocene of Saudi Arabia recorded as *Semicytherura* sp. by Al-Furaih (1980). The material figured here is closest to his presumed female dimorph in shape although not generally so vaulted dorsally nor so convex ventrally. The surface ornamentation is not well preserved in Al-Furaih's specimens but fine reticulation and ribbing were present and although the details cannot be made out the general size of the reticules is closely comparable with the Assam species. *S. rameshi* (Singh and Misra), 1968 from the Fuller's Earth (Eocene) of Rajasthan, and described also from the Eocene of Rajasthan by Khosla (1972) with its relatively coarse reticulation and greater alation is not close.

Semicytherura indica sp. nov. ?subsp. nov.

Plate 46, fig. 2

Material. A carapace IPE/B02/03/1017.

Type horizon. DP13.

Dimensions of figured specimen.

	Length	Height	Width
Carapace IPE/B02/03/1017	360 μm	200 μm	160 μm

Remarks. The single specimen comes from Sample DP13 *c.*4.5 m (15 feet) above the sample yielding *S. indica* s.s. The specimen agrees in general shape and in the pattern of the main longitudinal ribs running across the shell. The whole ornamentation is smoothed out, however, although suggestions of fine reticulation are perhaps seen in places. Until more material is found it is impossible to say whether this is merely a phenomenon of preservation or whether this represents a new subspecies which may be useful stratigraphically.

Subfamily CYTHEROPTERINAE Hanai, 1957
Genus CYTHEROPTERON Sars, 1866
Cytheropteron reticuloradiata sp. nov.

Plate 46, figs. 4, 5

Holotype. Carapace IPE/H02/03/973.

Type horizon. DP8.

Other Material. A carapace IPE/B02/03/995 from DP11.

Derivation of name. A reference to the reticulation which appears to radiate from the alae.

Dimensions of figured specimens.

	Length	Height	Width
Holotype. Carapace IPE/H02/03/973	350 μm	235 μm	210 μm
Carapace IPE/B02/03/995	335 μm	210 μm	175 μm

Diagnosis. A reticulate species of *Cytheropteron* in which the longitudinal ribs 'V' down towards the alae and four ribs sweep down to the edge of the ala.

Remarks. In the holotype (Pl. 46, fig. 4) there is the suggestion of a swelling where an eye tubercle would be expected, but careful examination shows that this is not an ocular structure and that the specimen is thus not referable to *Oculocytheropteron* Bate, (1972). The specimen from DP11 occurs *c.*12 m (40 feet) higher in the section and the ornamentation is not so well preserved. The principal elements appear to be identical, however, and at present there is no reason to consider it a different taxon.

Family XESTOLEBERIDIDAE Sars, 1928
Genus UROLEBERIS Triebel, 1958
Uroleberis armeniaca sp. nov.

Plate 46, figs. 7–9

Holotype. Male carapace IPE/H02/03/912.

Other material. Two female carapaces IPE/P02/03/913, 914 from Sample DP11.

Type horizon. DP13.

Derivation of name. Latin *armeniacum*, 'apricot' in reference to its resemblance to an apricot stone.

Dimensions of figured specimens.

	Length	Height	Width
Holotype, male carapace, IPE/H02/03/912	440 μm	295 μm	275 μm
Female carapace, IPE/B02/03/913	445 μm	310 μm	280 μm
Female carapace, IPE/B02/03/914	400 μm	270 μm	240 μm

Diagnosis. A species of *Uroleberis* with short but well-developed caudal process and pitting which becomes finer peripherally. The greatest height lies at approximately two-thirds length and the anterior end is fairly narrowly rounded.

Remarks. Uroleberis is commonly encountered in the Middle Eastern and Indian part of Tethys and a number of species has been described. *U. kutchensis* Guha, 1968 from the middle Eocene of Kutch, and found also by Khosla (1972) in the middle Eocene of Rajasthan, has a very marked posteroventral projection not seen in the Assam species. The same is true of *Uroleberis? chamberlaini* Sohn, 1970 from the early Tertiary Meting Limestone of Pakistan. None of the four species from the Palaeocene of Saudi Arabia figured by Al-Furaih (1980) are closely comparable. The two species from the lower Eocene of Tamilnadu by Guha and Shukla (1973) are even further removed.

Xestoleberis? sp.

Plate 46, fig. 12

Horizon. DP8.

Dimensions of figured specimen.

	Length	Height	Width
Carapace IPE/X02/03/1016	270 μm	110 μm	115 μm

Remarks. Information on this single specimen is limited to the general shape and the fact that the left valve appears to be slightly larger than the right. It is similar to some of the more elongate species of *Xestoleberis*, especially the male dimorphs, and it is here provisionally referred to that genus pending further information.

FAUNAL COMPARISONS

The closest comparable faunas are those described from the Eocene of western India and Pakistan over a thousand miles away. Generic similarity is close as seen in the presence of *Cytherella*, *Cytherelloidea*, *Bairdia*, *Paijenborchella*, *Schizocythere*, *Alocopocythere*, *Semicytherura*, *Krithe*, *Uroleberis*, and *Xestoleberis* in both areas. These largely cosmopolitan genera confirm that there is no isolation of the Assam area at the generic level of development. There is almost no correspondence at the specific level, however, which consequently may be regarded as due principally to geographical distance from other known faunas. The incidence of generic representation also shows some differences.

The Platycopina are very well developed in the Eocene of Assam where eight species have been

recognized although two are rare and not well enough known to be named. In general this group tends to be neglected since recognition is dependent on few morphological parameters and so many authors restrict their studies to the Podocopina. However, three species have been described from western India but none of these are seen in Assam. Here the *Cytherella* fauna is not closely comparable with any hitherto described Eocene fauna although in certain cases there is some resemblance to species described from Argentina, Nigeria, and New Zealand. The genus *Cytherella* gives the impression of being much better developed and much more diverse than elsewhere in the sub-continent and forms a higher proportion of the fauna. On the other hand *Cytherelloidea* is rare, a feature reflected in the faunas from other comparable areas during the Eocene. Unlike the Eocene of western India, *Bairdia* does not form a large element in the fauna and the single species is referred to *B. beraguaensis* and is the only one common to this area and western India.

As in western India and Pakistan the cytheracean genera *Alocopocythere*, *Schizocythere*, *Paijenborchella*, and *Uroleberis* are well represented albeit by different species. In contrast spinose and tuberculate forms such as *Trachyleberis* and *Actinocythereis* together with genera such as *Stigmatocythere* and *Occultocythereis* are absent. Finally the Cytheruridae, although still not common, appear to be much better represented than in western India although this may be simply a matter of collection failure in the latter area.

Palaeoecologically, it is clear that the fauna is fully marine. *Cytherelloidea*, although rare, is present, a fact which together with the larger benthonic Foraminifera suggests a warm sea with a year-round temperature which did not fall below about 11 °C. Depth is more difficult to assess accurately. Clearly the fauna is not littoral or abyssal. *Cytherella*, which forms such an important element in the fauna, ranges over a wide range of depths at the present day from shallow, even brackish, environments to bathyal and even abyssal depths. In the latter habitats the genus is usually represented by large, smooth species. Here the high incidence of punctate forms is more in accord with an inner shelf locale. This is supported by the occurrence of *Alocopocythere* which is still extant and ranges from the Red Sea and Persian Gulf to Western Australia (Siddiqui, 1983). Typically, it lives in shallow marine areas from the eulittoral down to about 200 metres. Negative evidence is provided by the absence of delicately spined or blind Trachyleberidae and a lack of planktonic Foraminifera. Thus the general aspect of the fauna suggests that it is a relatively shallow water shelf fauna.

STRATIGRAPHIC SUCCESSION OF FAUNAS

Detailed study of the ostracod faunas from the middle Eocene Sylhet Formation reveals a striking biostratigraphical succession of faunas (text-fig. 3). One of the most distinctive elements in the fauna is the genus *Alocopocythere* which in the early Tertiary is known to range from Arabia to Assam and to extend more widely later. This genus evolves rapidly and in consequence its species have a relatively short range in time which makes them invaluable biostratigraphical indicators. They have proved particularly useful in this respect in western India and Pakistan (see Siddiqui 1983). Conveniently, each of the Assam faunas contains a unique species of *Alocopocythere* which is used to designate them. The following divisions are recognized:

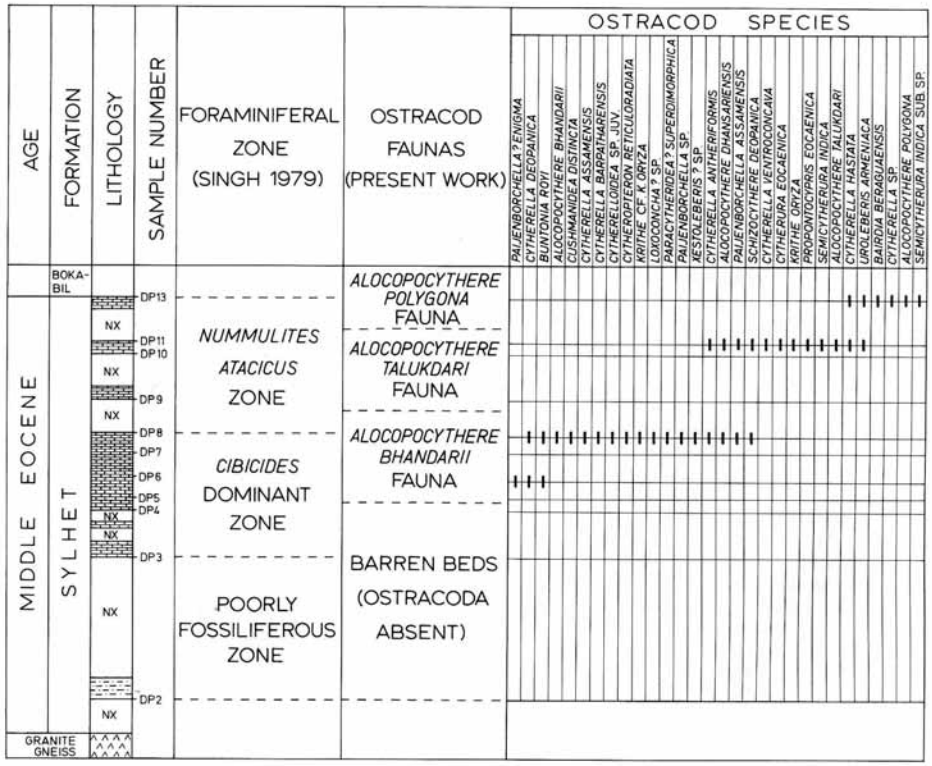
1. Barren Beds. Ostracods have not been obtained so far from some 82 m (270 feet) of beds below the first recorded fauna even though Foraminifera occur in some of the beds. The presence of Foraminifera suggests that ostracods should be present, even if rare, and every opportunity should be taken to carry out further collecting in this part of the section.

2. The *Alocopocythere bhandarii* Fauna. This is found in DP6 and DP8 and thus extends over at least 2 metres (6 feet) of strata. The earliest development in DP6 is small with only three species of which only the rare *Paijenborchella*? *enigma* is confined to that horizon. *Cytherella deopanica* and *Buntonia royi* both occur in DP8 along with the rest of the typical fauna. Sample DP7, collected between DP6 and DP8, consisted of hard limestone from which it was impossible to extract ostracods. However, about 2 m (6 feet) above DP6, sample DP8 yielded a good fauna of seventeen species of which *Alocopocythere bhandarii* is chosen as nominate species. Besides the three species

already named other species found only in DP8 are *Cytherella distincta*, *C. assamensis*, *C. barpatharensis*, *Cytherelloidea* sp. juv., *Cytheropteron reticuloradiata*, *Krithe* cf. *K. oryza*, *Loxoconcha*? sp., *Paijenborchella* sp., *Paracytheridea*? *superdimorphica*, and *Xestoleberis*? sp. In addition *Cytherella antheriformis*, *Alocopocythere dhansariensis*, *Paijenborchella assamensis*, and *Schizocythere deopanica* occur here and also range up into the overlying assemblage.

3. The *Alocopocythere talukdari* Fauna. Named after *A. talukdari* which only occurs here, this fauna is found in material collected from DP11 which lies 10–12 m (35–40 feet) above DP8. Samples DP9 and DP10 collected between here and the previous fauna in DP8 were hard, intractable limestones from which no specimens could be extracted. In addition to the four species ranging up from below, there are five species not found outside this horizon, namely *Cytherella ventroconcava*, *Cytherura eocaenica*, *Krithe oryza*, *Propontocypris eocaenica*, and *Semicytherura indica*. Two species, namely *Cytherella hastata* and *Uroleberis armeniaca* range up into the overlying assemblage.

4. The *Alocopocythere polygona* Fauna. This was found in Sample DP13 lying 1·5–3 m (5–10 feet) above DP11. Besides the two species ranging up from below and the nominate species, three other forms occur here, namely *Bairdia beraguaensis*, what is thought to be a new subspecies of *Semicytherura indica*, and *Cytherella* sp.



TEXT-FIG. 3. Distribution of Ostracoda in the Deopani Traverse. For lithologies, thicknesses, and positions of samples see text-fig. 2.

DISCUSSION

The three faunas are quite distinct but are obviously based on limited samples from a single traverse. For this reason they are here treated as successive faunas rather than as zones or assemblage zones. When further work on boreholes and at outcrop has confirmed the picture obtained in the Deopani Traverse they may be raised to full zonal status.

These faunas cover the foraminiferal zones of '*Cibicides* Dominant' below and '*Nummulites atacicus*' above established by Singh (1979). The only species in common with western India or elsewhere is *Bairdia beraguaensis* which occurs in the Eocene of Jammu and Kashmir State. This precludes any attempt at comparison with the zonal system established in western India.

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