

Taxonomy and palaeoenvironments of Callovian ostracoda from the Morondava Basin (south-west Madagascar).

WOLFGANG METTE and MARKUS GEIGER

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Abstract. 18 ostracod species from the lower to middle Callovian of the Morondava Basin in south-west Madagascar, including the new species *Acrocythere oculata*, *Fastigatocythere globosa*, *Fastigatocythere trisulcata* and the new subspecies *Trichordis praetexta magna*, are described. The genus *Fastigatocythere* WIENHOLZ is amended and the taxa *Amicytheridea* BATE, *Batella* KHOSLA, JAKHAR & MOHAMMED and *Habocythere* KHOSLA, JAKHAR & MOHAMMED are suggested to be subgenera of *Fastigatocythere*. The diverse ostracod assemblages, which comprise 33 species, can be assigned to shallow open marine environments with a predominance of siliciclastic sedimentation. They display similarities with Callovian faunas from the north-western part of Madagascar (Majunga Basin) and India (Cachchh).

■ *Ostracods, taxonomy, facies, Callovian, Madagascar*

Zusammenfassung: 18 Ostrakodenarten, einschließlich der neuen Arten *Acrocythere oculata*, *Fastigatocythere globosa*, *Fastigatocythere trisulcata* und die neue Unterart *Trichordis praetexta magna*, werden aus dem unteren und mittleren Callov des Morondava Beckens in Südwest Madagaskar beschrieben. Die Gattung *Fastigatocythere* WIENHOLZ wird emendiert und die bisherigen Gattungen *Amicytheridea* (BATE), *Batella* KHOSLA, JAKHAR & MOHAMMED und *Habocythere* KHOSLA, JAKHAR & MOHAMMED werden als Untergattungen zu *Fastigatocythere* gestellt. Die artenreichen Ostrakodenvergesellschaftungen, die insgesamt 33 Arten umfassen, stammen aus einem offen marinen Milieu mit vorwiegend siliziklastischer Sedimentation und weisen enge Beziehungen zu Faunen aus dem Nordwesten Madagaskars (Majunga Becken) und aus Indien (Kachchh) auf.

■ *Ostrakoden, Taxonomie, Fazies, Callov, Madagascar*

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Introduction

With regard to ostracod evolution the Middle Jurassic was a period of significant changes. One of the most important evolutionary trends at that time was the remarkable diversity increase from early to late Middle Jurassic times, which was mainly the result of radiation events among several families of the Cytheracea, particularly the Progonocytheridae (WHATLEY 1990). This development is also reflected by ostracods of the South Gondwana Fauna, which have been recorded from East Africa, India, Madagascar, Australia and South America, and in particular by the rich Callovian to Kimmeridgian faunas which have been described from Madagascar (GREKOFF 1963, RAFARA 1990). The material from Madagascar, therefore, provides a key to understanding the evolution of the South Gondwana Fauna. The studies by both GREKOFF and Rafara were, however, confined to the Majunga Basin in north-west Madagascar. During recent years the sedimentary successions of the Morondava Basin, in the south-western part of Madagascar have been subjected to detailed field work and biostratigraphical investigations (LUGER et al. 1994, this paper). Micropalaeontological research in south-west Madagascar, which formed part of an interdisciplinary project on the development of the Morondava Basin and the early rifting processes between East and West Gondwana, yielded ostracod assemblages which are similar to those from the Majunga Basin but also include some new endemic taxa.

Sections and depositional environments

The ostracods presented in this paper were obtained from the Amparambato (S 23°00.001', E 044°24.929'), Antainakanga (S 22°58.330', E 044°24.247') and Behevo (S 23°01.105', E 044°24.940') sections, which are located about 15 km south-west of the town of Sakaraha (Fig. 1). On the basis of their ammonite faunas the Amparambato section (Fig. 3) belongs to the late lower

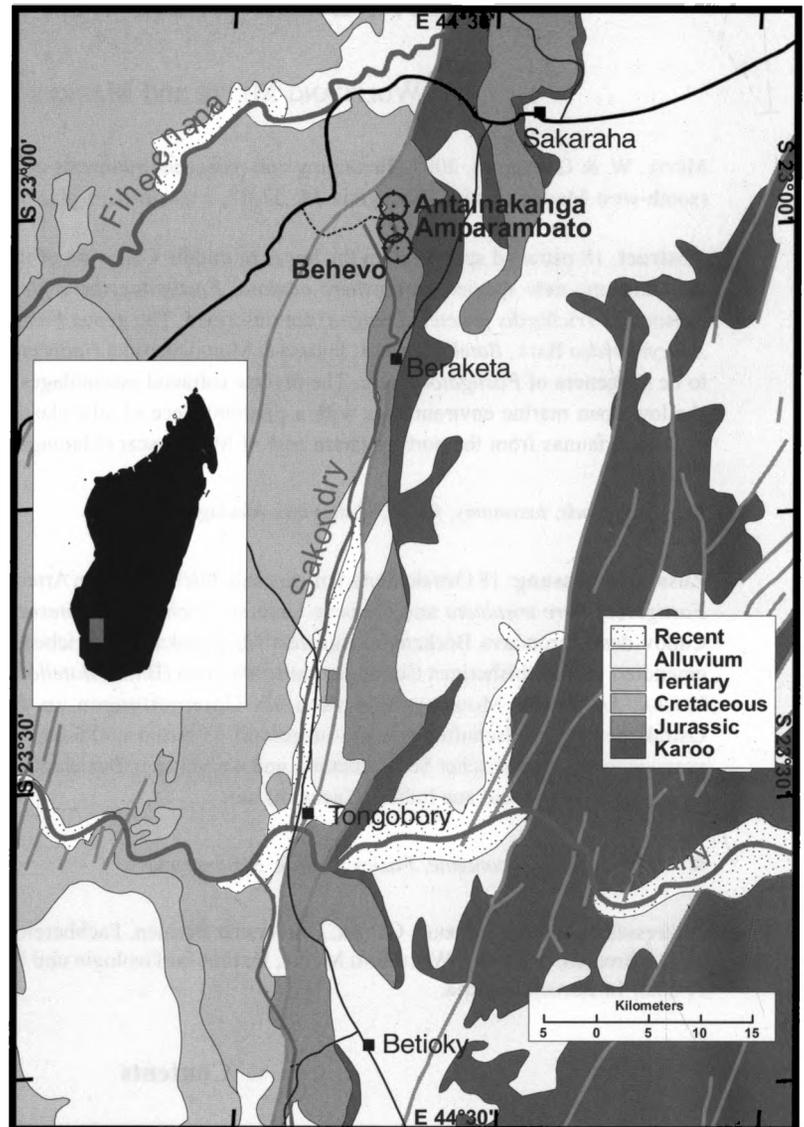


Fig. 1: Geological map with location of study area and sites of sections.

Callovian (*Indosphinctes patina* zone), the Antainakanga section (Fig. 2) to the early lower Callovian and the Behevo section (Fig. 4) to the lower or middle Callovian.

The lithofacies development and the fossil record show that, during the Callovian, open marine conditions with periods of agitated shallow water were established in the south-western Morondava Basin. Permineralized wood in the Behevo section suggests a proximal shoreline. The three sections mentioned above display a similar lithofacies, consisting predominantly of calcareous mudstones and siltstones with intercalated iron-oolitic siltstones and sandstones, oolitic limestones and carbonate-cemented large-scale cross-stratified sandstones. The fine-grained siliciclastics were probably deposited on a shallow outer shelf and the oolitic sediments are interpreted as oolitic shoals of shallow,

(GREKOFF 1963); 4 species occur in the Callovian of India (Kachchh - KHOSLA et al., 1997), 2 species are recorded from Saudi Arabia and 1 species is also recorded from the Callovian of Tanzania (BATE 1975, DEPECHE et al. 1987), the Near East (ROSENFELD et al. 1987a, ROSENFELD & HONIGSTEIN 1991) and North Africa (CHARRIERE et al. 1994, METTE 1995, 1997). The Callovian faunas of northern Somalia (METTE 1993) and Argentina (MUSACCHIO 1979, BALLENT & WHATLEY 2000) have no

species in common with the material presented in this paper.

Material

The holotypes and paratypes are housed at the Institute of Geology and Palaeontology at Innsbruck University, under the number Me 2001.

Biostratigraphy: sections: samples:	EARLY LOWER CALLOVIAN	LATE LOWER CALLOVIAN (<i>Indosph. patina</i> zone)		LOWER - MIDDLE CALLOVIAN
	Antainakanga	Amparambato		Behevo
	1	22	18	2
<i>Acrocythere oculata</i> n.sp.			X	
<i>Bairdia</i> sp.	X			
<i>Cytherella collapsa</i> GREKOFF	X			
<i>Cytherella index</i> OERTLI				X
<i>Cytherella</i> cf. <i>obscura</i> LUBIMOVA & MOHAN	X			
<i>Cytherella</i> sp.1		X	X	
<i>Cytherelloidea</i> sp.2	X			
<i>Cytheropteron</i> sp.1				X
<i>Cytheropteron</i> spp.		X	X	
<i>Fastigatocythere</i> (A.) <i>globosa</i> n.sp.		○		
<i>Fastigatocythere</i> (A.) <i>triangulata</i> (BATE)		X		X
<i>Fastigatocythere</i> (B.) <i>befotakaensis</i> (GREKOFF)	●			
<i>Fastigatocythere</i> (B.) <i>falcula</i> (GREKOFF)		○	X	X
<i>Fastigatocythere</i> (H.) <i>bicrucata</i> (GREKOFF)				○
<i>Fastigatocythere</i> (F.) <i>trisulcata</i> n.sp.		X	X	○
<i>Fastigatocythere</i> sp.1				X
<i>Fastigatocythere retusa</i> (GREKOFF)				X
<i>Lophocythere</i> ? sp.				X
<i>Majungaella mundula</i> (GREKOFF)		○	○	
<i>Neurocythere whatleyi</i> (KHOSLA, JAKHAR & MOH.)				X
<i>Oligocythereis</i> ? sp.1				X
<i>Oligocythereis</i> ? sp.2	X			
<i>Oligocythereis</i> ? spp.		X		X
<i>Paracypris</i> spp.	X		X	X
<i>Pleurocythere</i> ? sp.				X
<i>Procytheridea</i> ? sp.1			X	
<i>Schuleridea</i> ? sp.				X
<i>Trichordis devexa</i> (GREKOFF)		X	○	
<i>Trichordis parvicarinata</i> Khosla & Jakhar	○			
<i>Trichordis praetexta magna</i> n.ssp.		○	X	
<i>Cytherideinae</i> gen. indet. sp. 1				X
<i>Cytherideinae</i> gen. indet. sp. 2			X	
<i>Cytherideinae</i> ? gen. indet. sp.				X

X = rare (less than 5% of specimens) ○ = abundant (5-50% of specimens) ● = dominant (more than 50% of specimens)

Fig. 5: Stratigraphic range and relative abundance of ostracods.

Systematic Palaeontology

WOLFGANG METTE

The following abbreviations have been used: c = carapace, rv = right valve, lv = left valve, L = length, H = height, W = width.

Order Podocopida MÜLLER 1894

Suborder Platycopina SARS 1866

Family Cytherellidae SARS 1866

Genus *Cytherella* JONES 1849

Type species. *Cytherina ovata* ROEMER 1840

Cytherella sp. 1

Pl. 8, Figs. 8-9

? 1975 *Cytherella* cf. *collapsa* GREKOFF. - BATE, p. 171-172, pl. 1, fig. 11

Dimensions (mm).		L	H
Female	M3/20 lv	0.57	0.30
	M3/33 lv	0.58	0.34
	M3/34 lv	0.63	0.36
	M3/35 lv	0.61	0.35
	M3/36 rv	0.58	0.31
	M3/21 c	0.56	0.34
Male	M3/37 lv	0.52	0.28

Material. 3 carapaces and 13 valves.

Remarks. *Cytherella* sp.1 has a similar shallow dorsomedian sulcus and a similar carapace outline to *Cytherella* cf. *collapsa* from the middle Callovian of Tanzania (BATE 1975). However, the assignment of presented specimens to *C.* cf. *collapsa* is uncertain because the latter species has not been described in detail and only a left valve has been illustrated. *Cytherella* sp.1 is presumably not conspecific with *Cytherella collapsa* Grekoff because it is not constricted at the dorsal and ventral margins and, in contrast to *C. collapsa*, its dorsomedian muscle scar depression is much broader and shallower. In comparison with *Cytherella mediasulcata* Mette from the lower Callovian of Somalia, the species from Madagascar has a more convex posterodorsal margin on both valves and a shallower dorsomedian sulcus.

Distribution. Lower Callovian of the Morondava Basin (Amparambato section), Madagascar.

Cytherella cf. *obscura* LUBIMOVA & MOHAN 1960

Pl. 9, Figs. 1-2

? 1960 *Cytherella obscura* LUBIMOVA & MOHAN. - LUBIMOVA, GUHA & MOHAN, p. 15-16, pl. 1, fig. 1a, b.

Dimensions (mm).		L	H
Female	M5/22 c	0.68	0.38
Male	M5/21 c	0.68	0.36

Material. 3 carapaces and 2 valves.

Remarks. The present species is represented by only 5 adult specimens, which are morphologically similar to *C. obscura* LUBIMOVA & MOHAN from the upper Bathonian - Callovian of India (LUBIMOVA et al. 1960). Because of the low number of specimens, the morphological variability, and the range in sizes, the present material could not be investigated in sufficient detail. The specific assignment to *C. obscura* is, therefore, questionable.

Distribution. Lower Callovian of the Morondava Basin (Antainankanga section), Madagascar.

Genus *Cytherelloidea* ALEXANDER 1929

Type species. *Cytherelloidea williamsoniana* (JONES 1849)

Cytherelloidea sp. 2

Pl. 9, Figs. 5-6

Dimensions (mm).		L	H
	M5/25 lv	0.58	0.29
	M5/26 lv	0.60	0.30
	M5/27 rv	0.61	0.34

Material. 3 carapaces and 6 valves.

Remarks. *Cytherelloidea* sp. 2 differs from *Cytherelloidea paradifficila* KHOSLA, JAKHAR & MOHAMMED and *Cytherelloidea difficila* LUBIMOVA & MOHAN in the absence of a median ridge and the inclination of the posterodorsal margin of the left valve. In contrast to *Cytherelloidea weberi* STEGHAUS 1951 and *C. paraweberi* OERTLI, the present species has a shallow dorsomedian muscle scar depression and no median ridge. Because of the low number of specimens (3 valves) the species is left under open nomenclature.

Distribution. Lower Callovian of the Morondava Basin (Antainakanga section), Madagascar.

Suborder Podocopina SARS 1925

Family Cytheruridae SARS 1925

Subfamily Cytherurinae SARS 1925

Genus *Acrocythere* (NEALE 1960) MALZ 1961

Type species. *Acrocythere haueriviana* (BARTENSTEIN 1956)

Remarks. In the Callovian – Oxfordian of North Africa, the Near East, Madagascar and India occur the following 5 species of *Acrocythere* which are morphologically very similar and therefore suggested to be closely related: *Acrocythere* sp.1 METTE 1995, *Acrocythere* ? sp. (in KHOSLA et al. 1997), *Acrocythere* sp. (in ROSENFELD et al. 1987b), *Acrocythere* sp. A RAFARA 1990, *Acrocythere oculata* n.sp. (this paper).

These species are characterized by a similar pattern of 4 longitudinal ribs (dorsal, median, ventrolateral and ventral ribs). The dorsal rib has a broad lamelliform shape, extends from the posterior to the anterior cardinal angle and rises distinctly above the dorsal margin. The median rib is very sinuous and extends from the posterior margin (posterodorsal slope) to the anteroventral margin. In the posterior half the median rib first ascends to the subdorsal area and then descends towards the anteroventral margin. The median rib may be connected to the dorsal and ventrolateral ribs by a sub-vertical rib behind mid-length. In the anterior, between mid-length and 2/3rd of carapace length, the median rib bifurcates into a sinuous anterodorsal branch, which reaches the anterodorsal transverse ridge, and an anteroventral branch, which either extends to the anterior margin or tapers out in the anteromarginal area (below mid-height). The ventrolateral rib extends from the posterior margin (posteroventral slope) to the anteroventral margin. The ventral rib extends from the posteroventral to the anteroventral surface area, and may overhang the ventral margin. There may be another short longitudinal ventral ridge close to the mid-ventral margin. A more or less prominent eye node occurs anterodorsally. The transverse anterodorsal rib runs from the frontal side of the eye node to the anterior margin or tapers out in the anterodorsal marginal area. The intercostal area is ornamented by more or less prominent tubercles and may show a more or less strong and regular honeycomb-type reticulation.

Acrocythere oculata n. sp.

Pl. 6, Figs. 9-10; Pl. 7, Figs. 1-4

? 1997 *Acrocythere* ? sp. KHOSLA, JAKHAR & MOHAMMED, p. 32, pl. 7, fig. 6.

Derivation of name. *L. oculus* eye. Referring to the occurrence of very prominent eye tubercles.

Holotype. A female carapace, M4/31, Pl. 7, Fig. 3.

Type locality. Amparambato section (head of the Amparambato River), 1 km SSE of the village of Amparambato near Sakaraha, SW Madagascar (S 23°00.001' / E 044°24.929').

Type horizon. Silty marl, about 5 m above an ammonite horizon of lower Callovian age (*Indosphinctes patina* Zone), lower Callovian, sample 18.

Paratypes. 15 valves and carapaces of males and females.

Occurrence. Amparambato section, sample 18, lower Callovian, SW Madagascar.

Dimensions (mm).		L	H
Female	M4/37 c	0.38	0.22
	M4/38 c	0.35	0.20
	M4/39 c	0.37	0.21
	M4/32 c	0.38	0.20
	M4/29 lv	0.38	0.22
	M4/40 lv	0.40	0.24
Holotype	M4/31 lv	0.38	0.22
	M4/41 rv	0.35	0.22
Male	M4/42 c	0.44	0.21
	M4/34 c	0.42	0.20
	M4/30 lv	0.44	0.22

Material. 9 carapaces and 5 valves.

Diagnosis. A species of *Acrocythere* with a weak intercostal reticulation and indistinct tubercles on the lateral surface, very prominent eye tubercles and a striate ornamentation of the anterior margin.

Description. The carapace is sub-rectangular in lateral view with the greatest height at the anterior cardinal angle. The greatest length is at mid-height. In dorsal view the outline is also sub-rectangular with parallel and straight (males) or gently convex (females) median flanks and rapidly tapering straight or slightly convex anterior and posterior flanks. Narrow, laterally compressed zones occur on the anterior and posterior margins. The dorsal margin is straight and distinctly (females) or gently

EXPLANATION OF PLATE 1

Figs. 1-10. Sample 02, Behevo section, lower – middle Callovian.

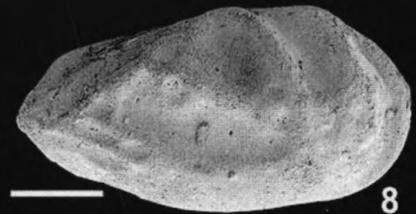
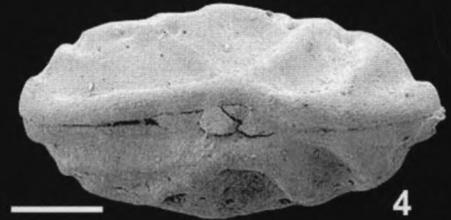
1-3. *Fastigatocythere* (*Habocythere*) *bicrucata* (GREKOFF, 1963). 1. Female, left valve, M2/2. 2. Female, right valve, M2/3. 3. Female, right valve, internal view, M2/1.

4-10. *Fastigatocythere* (*Fastigatocythere*) *trisulcata* n.sp.. 4. Male, carapace, paratype, dorsal view, M2/19. 5. Female, left valve, holotype, M2/24. 6. Female, right valve, paratype, M2/23. 7. Male, left valve, paratype, M2/25. 8. Male, right valve, paratype, M2/22. 9. Female, right valve, paratype, internal view, M2/30. 10. Female, left valve, paratype, internal view, M2/26.

Unless otherwise stated all figures are external views.

Scale bar 100 µm.

Plate 1



(males) inclined towards the posterior margin. The anterior margin is broadly rounded and slightly infracurved. The ventral margin is slightly concave in front of mid-length. In lateral view the ventral outline is straight or slightly concave and the ventrolateral ridges overhang the mid-ventral margin. The posterior margin has a triangular shape; it is pointed at mid-height, has a straight posterodorsal slope and consists of a broadly convex (females) or straight (males) posteroventral segment. The lv slightly overlaps the rv at the posterodorsal and anterodorsal margins.

The lateral surface is ornamented by a short transverse anterodorsal rib and four longitudinal ribs (dorsal, median, ventrolateral and ventral ribs). The median rib is s-shaped and starts at the posterodorsal margin. In the posterior half, the median rib ascends to the subdorsal area and descends towards the anteromedian area. At maximum height the median rib is connected to the dorsal rib by a short sub-vertical rib. In front of this sub-vertical rib the median rib is connected to the ventrolateral rib by a second, more or less distinct, sub-vertical rib. The anterodorsal branch of the median rib is sinuous and meets the short transverse anterodorsal rib. The anteroventral branch tapers off in the anteromedian area, in front of the anterior cardinal angle. The dorsal rib extends from the posterodorsal to the anterodorsal cardinal angle and strongly rises above the dorsal margin. The ventrolateral rib extends from the posteroventral margin to the anteroventral margin. It is connected to the median rib by a more or less distinct sub-central and sub-vertical rib. The ventral rib extends from the midventral to the anteroventral surface area. The transverse anterodorsal rib originates on the frontal side of the eye node and tapers off at about 2/3rd of carapace height. The intercostal area is partly covered by an indistinct regular honeycomb-type reticulation and small tubercles. The intercostal ribs are most strongly

developed at the crest of the longitudinal ribs and taper out in the broad intercostal areas. Short, radially arranged ribs occur on the anterior margin. Sexual dimorphism is distinct: the males are more elongate in lateral and dorsal view than the females and, the dorsal margin on the females is more steeply inclined to the posterior end.

Internal features. The hinge is antimerodont. On the lv it consists of a long, crenulated, median hinge bar and terminal sockets with 5 loculi. The hinge elements on the rv are complementary. The inner lamella is relatively broad and the inner margin and line of concrescence coincide. The internal surface is ornamented by relatively large openings of the normal pore canals. The anterior marginal pore canals are simple, long, straight, widely spaced and 7 or 8 in number. The posterior marginal pore canals are poorly preserved. They are probably 3 or 4 in number.

Discussion. The present specimens are very similar to *Acrocythere* ? sp. from the upper Bathonian-Callovian of India (KHOSLA, JAKHAR & MOHAMMED 1997). Because of the poor quality of the picture and the short description its conspecificity with the presented species is uncertain. *A. oculata* from the Morondava Basin also shows similarity in carapace outline and ornamentation with *Acrocythere* sp. A Rafara from the Oxfordian of the Majunga Basin. The species from Majunga Basin is therefore, suggested to represent a descendant of *A. oculata*. The species from the Morondava Basin differ in the striate ornamentation of the anterior margin and in carapace size; it is about 0,05 mm greater than *Acrocythere* sp. *A. oculata* also has a blunter posterior end than the latter species, and large, round, eye tubercle close to the anterodorsal cardinal angle. The oblique anterodorsal rib on the present specimens is relatively short and weak, and the carapace outline in dorsal view is more convex. Furthermore, in contrast to the species

EXPLANATION OF PLATE 2

Figs. 1-2. *Fastigatocythere (Fastigatocythere) trisulcata* n.sp., sample 02, Behevo section, lower-middle Callovian. 1. Male right valve, paratype, internal view, M2/32. 2. Female, right valve, paratype, M2/29.

Figs. 3-8. *Fastigatocythere (Batella) falcula* (GREKOFF, 1963), sample 22, Amparabato section, lower Callovian. 3. Female carapace, dorsal view, M4/9. 4. Male, right valve (of carapace), M4/4. 5. Male, left valve (of carapace), M4/1. 6. Female, right valve, M4/2. 7. female, right valve, internal view, M4/6. 8. Male, left valve, internal view, M4/7.

Figs. 9,11. Sample 02, Behevo section, lower-middle Callovian.

9. *Fastigatocythere* sp.1, right valve, M2/10.

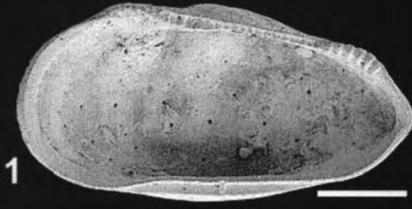
11. *Fastigatocythere retusa* (GREKOFF), right valve, M2/43.

Fig. 10. *Fastigatocythere (Batella) befotakaensis* (GREKOFF, 1963), female, left valve, M5/11 sample 01, Antainakanga section lower Callovian.

Unless otherwise stated all figures are external views.

Scale bar 100 μ m.

Plate 2



from the Majunga Basin the present specimens have a sub-vertical rib, which extends from the median longitudinal rib to the ventrolateral longitudinal rib. The present species is also very similar to *Acrocythere* sp.1 METTE in carapace outline, but it differs in the presence of a sub-vertical rib between the median and ventrolateral ribs, the large round eye tubercles, the radial ribs on the anterior margin, the weak reticulation of the lateral surface and the short anterodorsal rib.

Acrocythere sp. from the Oxfordian in Israel (ROSENFELD et al. 1987b) is poorly preserved and, therefore, cannot be compared with the present material in detail. However, *A. oculata* has a more steeply inclined posterodorsal margin and a more distinct posterior cardinal angle. In addition the present species differs in the sinuous shape of the anterodorsal branch of the median longitudinal rib.

Distribution. *A. oculata* occurs in the lower Callovian of the Morondava Basin (Amparambato section), Madagascar. Specimens which possibly belong to the presented species have been recorded from the Callovian Chari Formation (*Progonocythere laeviscula* zone) of India (KHOSLA et al. 1997).

Family Progonocytheridae SYLVESTER-BRADLEY 1948

Subfamily Progonocytherinae SYLVESTER-BRADLEY 1948

Genus *Fastigatocythere* WIENHOLZ 1967

Remarks. According to the original definition (WIENHOLZ 1967) the genus *Fastigatocythere* is characterized by an entomodont hinge, an inverted chevron-type (triangular or sub-triangular) rib pattern, a distinct anterodorsal sulcus and 7-9 anterior marginal pore canals. The definition of *Fastigatocythere* was later amended (WHATLEY & BALLENT 1996) by extending the definition

of hinge structure and the range in number of marginal pore canals. Following the amended definition, those genera which show the typical ornamentation of a sub-triangular rib pattern, a lobodont hinge and/or up to 14 anterior pore canals (*Amicytheridea*, *Glyptogatocythere*, *Zerqacythere*) were also incorporated into the genus. Because of the differences in hinge structure and number of radial pore canals the latter genera as well as *Fastigatocythere* (sensu WIENHOLZ 1967) are, however, classified herein as subgenera of *Fastigatocythere* (sensu WHATLEY & BALLENT 1996). The genus *Habocythere* KHOSLA, JAKHAR & MOHAMMED also has an inverted chevron-type rib pattern, 2 transverse anterodorsal sulci, a lobodont hinge and 7-10 anterior marginal pore canals. According to the amended definition by WHATLEY & BALLENT (1996), the genus *Habocythere* should be assigned to *Fastigatocythere* but because of its lobodont hinge, *Habocythere* is in this paper also regarded as a subgenus of *Fastigatocythere*. *Batella* KHOSLA, JAKHAR & MOHAMMED was suggested to differ from other genera of the Progonocytherinae in the lobodont hinge and the occurrence of 17-21 anterior and 5-6 posterior radial pore canals. In this paper *Batella* is classified as a subgenus of *Fastigatocythere* because of the ornamentation by sub-triangular ribs, the occurrence of a distinct anterodorsal sulcus and the lobodont hinge.

Amended diagnosis. The amended definition of *Fastigatocythere* by WHATLEY & BALLENT (1996) with respect to carapace shape, ornamentation, hinge and other internal features, is adopted. The number of anterior marginal pore canals is usually 7 to 14, but may range up to 21.

Subgenus *Fastigatocythere* (WIENHOLZ 1967)

Type species. *Fastigatocythere rugosa* WIENHOLZ 1967

EXPLANATIONS OF PLATE 3

Figs. 1-2. *Fastigatocythere (Batella) befotakaensis* (GREKOFF, 1963), sample 01, Antainakanga section, lower Callovian. 1. Male carapace, dorsal view, M5/7. 2. Male, left valve, internal view, M5/1.

Figs. 3-10. Amparambato section, lower Callovian. 3-6. *Fastigatocytheridea (Amicytheridea) globosa* n.sp..3. Female, left valve (of carapace), holotype, M3/16, sample 22. 4. Female, right valve (of carapace), paratype, M3/17, sample 22. 5. Male, left valve (of carapace), paratype, M3/18, sample 22. 6. Female, left valve, paratype, internal view, M3/14, sample 22.

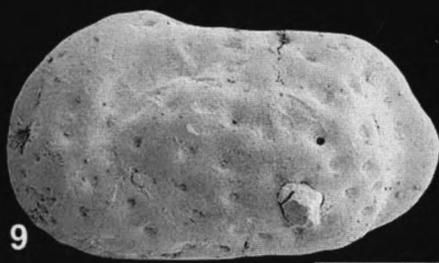
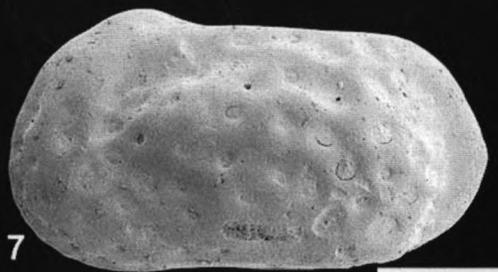
8. *Fastigatocythere (Amicytheridea) triangulata* (BATE, 1975), female, left valve, M3/19, sample 22.

7, 9-10. *Trichordis praetexta magna* n. ssp..7. Male, left valve, paratype, M3/7, sample 22. 9. Female, left valve, paratype, M3/6, sample 18. 10. Female, right valve (of carapace), holotype, M3/10, sample 22.

Unless otherwise stated all figures are external views.

Scale bar 200 µm.

Plate 3



Fastigatocythere sp. 1

Pl. 2, Fig. 9

? 1997 *Habocythere* sp. KHOSLA, JAKHAR & MOHAMMED, p. 18, pl. 4, fig. 10

Dimensions (mm).	L	H
M2/10 rv	0.60	0.32

Material. 2 valves.

Remarks. It is suggested that this species is possibly conspecific with *Habocythere* sp. KHOSLA, JAKHAR & MOHAMMED from the Callovian of India (KHOSLA et al. 1997), because the two species have a similar outline and ornamentation. As for the latter species, the present specimens have a long vertical median sulcus and a long transverse anterodorsal sulcus. The hinge could not be investigated in detail because of poor preservation and the lack of adult specimens.

Distribution. *Fastigatocythere* sp.1 occurs in the lower-middle Callovian of the Morondava Basin (Behevo section) of Madagascar and possibly also in the Callovian upper Chari Formation (*Pirileberis remota* zone) of India (KHOSLA et al. 1997).

Fastigatocythere (Fastigatocythere) trisulcata n.sp.

Pl. 1, Figs.4-10

Derivation of name. *L. tria* three and *sulcus* groove. Referring to the occurrence of three sulci.

Holotype. A female left valve, M2/24, Pl.1 ,Fig.5.

Type locality. Section Behevo (escarpment), 4 km south of the village of Amparabato, west of the Amparabato River near Sakaraha, (S 23°01.105' / E 044°24.940'), SW Madagascar.

Type horizon. Carbonaceous siltstone, lower – middle Callovian, sample 02.

Paratypes. 68 valves and carapaces of females and males.

Occurrence. Behevo section, sample 02, lower - middle Callovian, Amparabato section, samples 18, 22, lower Callovian, SW Madagascar.

Dimensions (mm).	L	H	W
Female M2/44 c	0.42	0.28	
M2/20 c	0.42		0.24
M2/45 lv	0.40	0.25	
M2/26 lv	0.43	0.28	
Holotype M2/24 lv	0.46	0.30	
M2/23 rv	0.40	0.22	
M2/46 rv	0.44	0.25	
Male M2/19 c	0.46		0.23
M2/47 c	0.46	0.24	
M2/27 lv	0.42	0.24	
M2/48 lv	0.45	0.25	
M2/21 rv	0.48	0.24	
M2/49 rv	0.47	0.22	
M2/22 rv	0.43	0.22	

Material. 7 carapaces and 51 valves.

Diagnosis. The species is characterized by the occurrence of 3 very distinct, broad sulci: two transverse sulci on the anterodorsal and dorsomedian part of the lateral surface and a longitudinal sulcus on the ventromedian and posteromedian region. A few relatively large puncta occur on the anteroventral and posteromedian part of the lateral surface .

Description. The outline is sub-triangular in lateral view and sub-ovate in dorsal view, with narrow, laterally compressed anterior and posterior marginal zones. The maximum length is at 2/5th of the height, the greatest height is at the anterior cardinal angle and the greatest width is at mid-length. The dorsal margin is straight and distinctly inclined towards the posterior end. The rv has distinct anterior and posterior cardinal angles. The ventral margin is straight and hidden behind the ventrolateral carapace tumidity. The posterior margin is narrowly rounded on the left valve. In the rv the posterior margin is pointed below mid-height, and rectangular, with a straight posterodorsal part and a gently convex

EXPLANATION OF PLATE 4

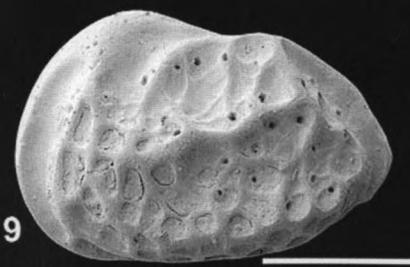
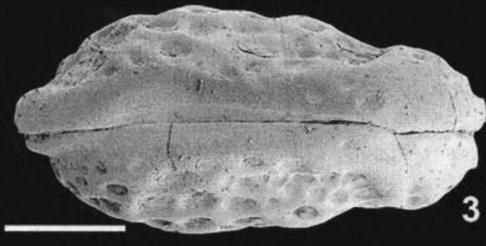
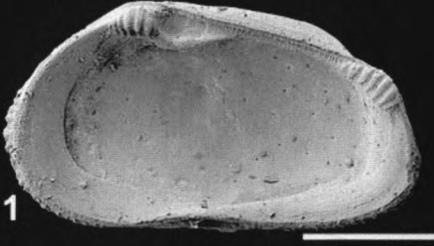
Figs. 1-4. *Trichordis praetexta magna* n.ssp., Amparabato section, lower Callovian. 1. Female, right valve, paratype, internal view, M4/26, sample 18. 2. Female, left valve, paratype, internal view, M4/27, sample 18. 3. Male carapace, paratype, dorsal view, M3/12, sample 22. 4. Female carapace, paratype, dorsal view, M3/11, sample 22.

Figs. 5-8. *Trichordis parvicarinata* (KHOSLA & JAKHAR, 1993), sample 01, Antainakanga section, lower Callovian. 5. Female, left valve (of carapace), M5/14. 6. Female right valve (of carapace), M5/18. 7. Male, left valve, M5/13. 8. Male, left valve (of carapace), M5/19. Figs. 9-10. *Trichordis devexa* (GREKOFF, 1963), sample 18, Amparabato section, lower Callovian. 9. Female, left valve, M4/19. 10. Male, carapace, dorsal view, M4/14.

Unless otherwise stated all figures are external views.

Scale bar 200 µm.

Plate 4



posteroventral part. The anterior margin is broadly rounded and distinctly infracurved. The lv overlaps the rv along the posterodorsal and anterodorsal margins and more strongly at the dorsal margin, with a maximum at the anterior cardinal angle.

The lateral surface is strongly ornamented by 5 prominent ribs, which delimit 3 deep and broad sulci. There are 3 ribs originating in the anterodorsal area: the anterior, dorsal and anterodorsal ribs. They delineate 2 broad and deep oblique sulci. The anterior and anterodorsal ribs are distinctly convex towards the anterior margin. The anterior rib extends from the anterior cardinal angle to the anteroventral area and separates the ornamented lateral surface from the anterior marginal zone which is laterally compressed. The anterodorsal rib extends from a point immediately behind the anterior cardinal angle to the anteroventral area at 1/3rd of the height. The dorsal rib has a triangular shape; it originates from the same point as the anterodorsal rib and extends to the mid-height of the posteromedian area. On the rv the anterodorsal and dorsal ribs are connected and form a roof-shaped rib which rises above the dorsal margin. In the lower half of the lateral surface is a longitudinal s-shaped sulcus, which is bounded by a median and a ventrolateral longitudinal rib. The median rib extends from the posteromedian to the anteromedian area and intersects the anterodorsal rib. The ventrolateral rib also starts in the posteromedian area, and reaches the anterodorsal rib. The median sulcus is additionally bounded posteriorly by a relatively thin, more or less distinct, v-shaped rib. The anteroventral and posteromedian part of the lateral surface is additionally ornamented by a few relatively large puncta. Sexual dimorphism is very distinct: in contrast to the subtriangular females the males are much more elongate in lateral view.

Internal features. There are 9 simple, straight and widely spaced anterior marginal pore canals and 4 posterior marginal pore canals. The hinge is entomodont. In the lv the median hinge element is coarsely

denticulated; the denticles gradually increase in size towards the anterior end. The anterior socket is subdivided into 5 loculi and the posterior socket into 6 loculi. Above the median hinge bar is a broad accommodation groove. The hinge elements of the rv are complementary. The inner lamella is relatively narrow. Avestibulate.

Discussion. The species is closely related to *Fastigatocythere* (*Habocythere*) *ventrisulcata* (KHOSLA, JAKHAR & MOHAMMED et al. 1997) from the Callovian of India because the two species correspond in the carapace outline and the shape of the 3 sulci. The species from Madagascar differs in having a less densely punctate lateral surface and in being smaller. Furthermore, the hinge of *F. trisulcata* is entomodont, whereas, the hinge of *F. ventrisulcata* is lobodont. Because of the entomodont hinge structure the present species is assigned to *F. (Fastigatocythere)*.

Distribution. *F. trisulcata* occurs in the lower-middle Callovian of the Morondava Basin (Amparambato and Behevo sections), Madagascar.

Subgenus *Amicytheridea* (BATE 1975) DEPECHE 1987

Type species. *Amicytheridea oblonga* DEPECHE 1987

Remarks. The genus *Amicytheridea*, which was established by BATE (1975) and later amended by DEPECHE et al. (1987), has been synonymized with *Fastigatocythere* by WHATLEY & BALLENT (1996) because of the similar carapace shape, ornamentation and post-ocular sulcus. The lobodont hinge was suggested to differ only slightly from the entomodont hinge and was, therefore, not accepted as a generic character. However, *Amicytheridea* also differs from most other species of *Fastigatocythere* in the high number (14) of anterior marginal pore canals. In addition, the lateral surface shows a characteristic type of sculpture: a very regular

EXPLANATION OF PLATE 5

Figs. 1-4. *Trichordis devexa* (GREKOFF, 1963), sample 18, Amparambato section, lower Callovian. 1. Male, left valve (of carapace), M4/21. 2. Male, right valve (of carapace), M4/13. 3. Female, right valve, internal view, M4/15. 4. Male, left valve, internal view, M4/20.

Figs. 5-10. Sample 02, Behevo section, lower -middle Callovian.

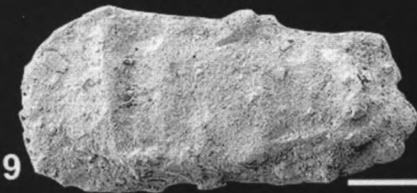
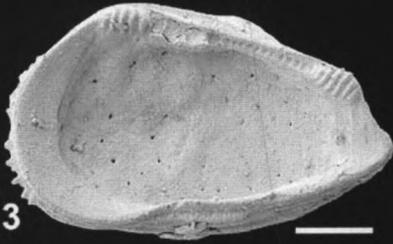
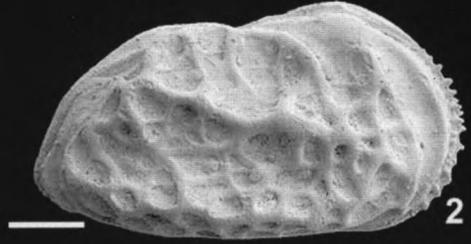
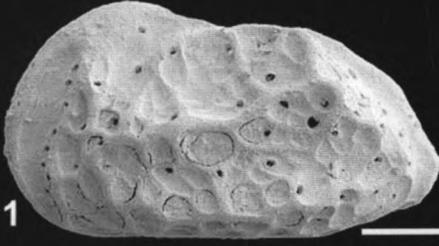
5-8, 10. *Neurocythere whatleyi* (KHOSLA & JAKHAR, 1997). 5. Left valve, M3/3. 6. Right valve (of carapace), M3/5. 7. Right valve, internal view, M3/2. 8. Left valve, internal view, M3/1. 10. Right valve, M3/4.

9. *Lophocythere* ? sp., male, left valve, M2/40.

Unless otherwise stated all figures are external views.

Scale bar 100 µm.

Plate 5



triangular arrangement of ribs, a very distinct and straight anterodorsal sulcus and no dorsomedian sulcus. *Amicytheridea* is, therefore, here classified as a subgenus of *Fastigatocythere*. The species which was described as *Amicytheridea diaellaensis* (BASHA) from the Callovian of Saudi Arabia (DEPECHE et al. 1987) has a sub-central sulcus and no distinct sub-triangular rib pattern, and is, therefore, omitted from the subgenus *Amicytheridea*.

The following species are included in the subgenus *Amicytheridea*:

Fastigatocythere (A.) dhruaensis (DEPECHE, MANIVIT, LE NINDRE & VASLET)

Fastigatocythere (A.) globosa n.sp.

Fastigatocythere (A.) ihopyensis (GREKOFF) (in BATE 1975)

Fastigatocythere (A.) malzi (BASHA)

Fastigatocythere (A.) oblonga (DEPECHE)

Fastigatocythere (A.) triangulata (BATE)

Fastigatocythere (Amicytheridea) globosa n. sp.

Pl. 3, Figs. 3-6

? 1975 *Amicytheridea ihopyensis* (GREKOFF 1963). BATE, p. 191-192, pl. 7, figs. 10-13, text-Fig. 10a-c.

1997 *Amicytheridea* sp. KHOSLA, JAKHAR & MOHAMMED, pl. 2, figs. 8-9.

Derivation of name. *L. globosus* globose. Referring to the globose carapace outline.

Holotype. A female carapace, M3/16, Pl. 3, Fig. 3.

Type locality. Amparabato section (river bed, head of the Amparabato River), 1 km SSE of the village of Amparabato near Sakaraha, SW Madagascar (S 23°00.001' / E 044°24.929').

Type horizon. Calcareous sandstone, 20 cm below a lower Callovian ammonite horizon (*Indosphinctes patina*- Zone), sample Ampara 22.

Paratypes. 16 valves and carapaces of males and females.

Occurrence. Amparabato section, sample 22, lower Callovian, SW Madagascar.

Dimensions (mm).		L	H
Female	M3/14 lv	0.52	0.34
	M3/38 lv	0.48	0.31
	M3/17 lv	0.52	0.36
Holotype	M3/16 c	0.50	0.34
	M3/39 c	0.52	0.36
	M3/15 rv	0.50	0.30
Male	M3/40 c	0.58	0.34
	M3/18 c	0.56	0.34
	M3/41 rv	0.56	0.33

Material. 9 carapaces and 9 valves.

Diagnosis. A species of *Fastigatocythere (Amicytheridea)* with a short sub-ovate outline, a strongly convex dorsal margin and a lobate hinge with a coarsely denticulate median hinge bar in the lv and three very prominent anteriomedian teeth.

Description. The carapace has a short, sub-ovate outline in lateral and dorsal view and is strongly convex. The greatest length is at 1/3rd of the carapace height, the greatest height is at 3/5th of carapace length and the greatest width at mid-length. The dorsal margin of the left valve is strongly convex. In the rv the mid-dorsal margin is straight, distinctly inclined towards the posterior and with distinct cardinal angles. The anterior margin is broadly rounded and strongly infracurved. The ventral margin is slightly convex and hidden by a ventrolateral carapace tumidity. The posterior margin is pointed at 1/3rd of carapace height and shows a short posterodorsal concavity. At the anterior and posterior ends narrow marginal zones occur, which are laterally compressed. The lv overlaps the rv along all margins, most distinctly on the dorsal margin.

EXPLANATION OF PLATE 6

Figs. 1-2. *Lophocythere* ? sp., sample 02, Behevo section, lower – middle Callovian. 1. Male, incomplete left valve, M2/41. 2. Female, right valve, M2/39.

Figs. 3, 6. *Majungaella mundula* (GREKOFF, 1963), sample 22, Amparabato section, lower Callovian. 3. Female, left valve, M3/25. 6. Female, left valve, internal view, M3/24.

Fig. 4. *Pleurocythere* ? sp., right valve, M2/38, sample 02, Behevo section, lower – middle Callovian.

Figs. 5-10. Sample 18, Amparabato section, lower Callovian. 5. Cytherideinae gen. indet. sp. 2, right valve (of carapace), M4/25.

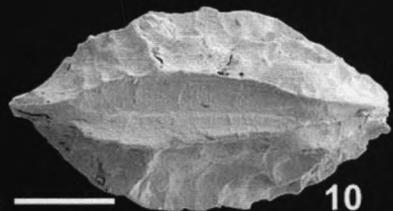
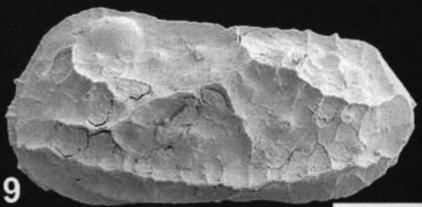
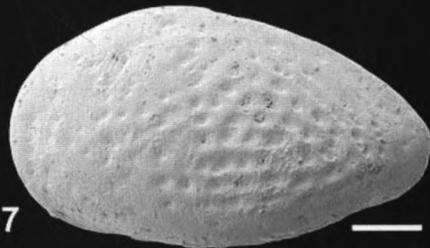
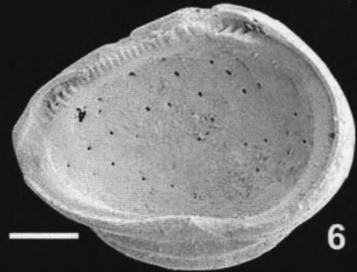
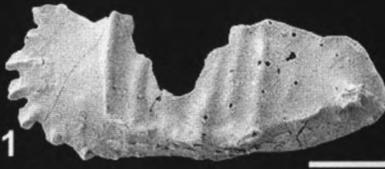
7-8. *Procytheridea* ? sp.1. 7. Left valve, M4/22. 8. Left valve, internal view, M4/23.

9-10. *Acrocythere oculata* n.sp.. 9. Male, left valve, paratype, M4/30. 10. Female, carapace, paratype, dorsal view, M4/32.

Unless otherwise stated all figures are external views.

Scale bar 100 µm.

Plate 6



The lateral surface shows a sub-triangular pattern of ribs and the apex of the triangle is located at mid-length. There are 4 lateroventral ribs which are distinctly convex; they are upturned posteriorly and pass into 4 gently convex posterodorsal ribs. The anterodorsal ribs are straight and 2 in number. The 3 inner ventrolateral ribs originate in the anteromedian area, where they meet the anterodorsal ribs. The outer ventrolateral rib is prolonged by an anterior rib which starts at the eye node and delimits the anterior marginal compressed zone. In front of the anterodorsal ribs is a broad transverse sulcus, which extends from the anterior cardinal to mid-height and is delimited anteriorly by the anterior rib. The intercostal area is subdivided by smaller ribs. In the central and anteromedian part of the lateral surface, the sub-triangular rib pattern breaks up into a coarse reticulation. The eye nodes are relatively indistinct and have a shallow and elongate shape. Sexual dimorphism is distinct: males have a less strongly convex dorsal margin and are more elongate than females.

Internal features. Anterior marginal pore canals 12 to 14, simple, straight and widely spaced. At the posterior end are 6 simple, slightly curved, marginal pore canals. 5 of these pore canals are closely spaced and situated directly at the posterior end whilst the remaining 1 occurs separately, above the posterior end. The hinge is lobodont. The hinge of the lv consists of a median bar with a coarsely denticulate median and posteromedian part and 3 very prominent denticles on the anteromedian part. In dorsal view the first 2 anteromedian denticles project strongly beyond the hinge margin. The terminal hinge elements of the lv consist of an anterior socket which is subdivided into 5 loculi and a posterior socket with 6 loculi. Above the median hinge bar there is a very broad accommodation groove. The hinge elements of the rv are complementary. The inner lamella is

moderately broad and the inner margin coincides with the line of concrescence.

Discussion. The species is assigned to the subgenus *Amicytheridea* because of its lobodont hinge, the number and shape of anterior marginal pore canals and the triangular rib pattern. The specimens from the Callovian of Tanzania, which were erroneously determined by BATE (1975) as *Amicytheridea ihopyensis* (GREKOFF), may be conspecific with *Fastigatocythere (A.) globosa* because of the similar carapace outline and ornamentation. However, the anteromedian hinge element appears to be different and, because of the poor preservation of the material from Tanzania, the assignment of *A. ihopyensis* in BATE (1975) to *F. globosa* remains doubtful. The present species shows clear differences from *Fastigatocythere (Amicytheridea) triangulata* (BATE). The external differences are the more strongly convex dorsal margin and the irregular reticulation of the central and anteromedian lateral surface. The internal differences are the occurrence of three very prominent anteromedian teeth and the greater number of anterior radial pore canals.

In contrast to *Fastigatocythere (Amicytheridea) oblonga* (DEPECHE), which is probably synonymous with *Fastigatocythere bakeri* (BASHA), the present specimens show a more regular sub-triangular rib pattern and the posterodorsal margin of the rv is more distinctly angular. *F. globosa* differs from *Fastigatocythere (Amicytheridea) dhrumaensis* (DEPECHE) in the more distinct triangular ribs and in the shorter posterodorsal slope.

Distribution. *F. globosa* occurs in the lower Callovian of the Morondava Basin (Amaparambato section), Madagascar, and in the Callovian Chari Formation (*Progonocythere laeviscula* zone) of India (KHOSLA et

EXPLANATION OF PLATE 7

Figs. 1-4. *Acrocythere oculata* n. sp., sample 18, Amparambato section, lower Callovian. 1. Male, left valve, paratype (identical to specimen of Pl. No.), M4/30. 2. Male, right valve (of carapace), paratype, M4/33. 3. Female, left valve (of carapace), holotype, M4/31. 4. Female, left valve, paratype, internal view, M4/29.

Fig. 5. *Cytheropteron* sp. 1, left valve (of carapace), M2/7, sample 02, Behevo section, lower-middle Callovian.

Fig. 6. *Cytheropteron* sp., right valve, M4/28, sample 18, Amparambato section, lower Callovian.

Figs. 7-10. Sample 02, Behevo section, lower-middle Callovian.

7. Cytherideinae ? gen. sp. indet, left valve, M2/6.

8. *Schuleridea* ? sp., right valve, M2/17.

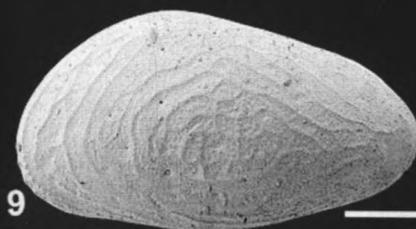
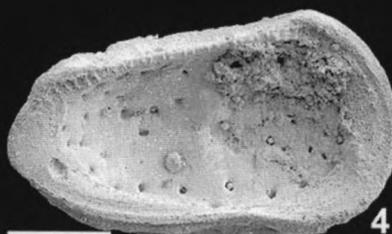
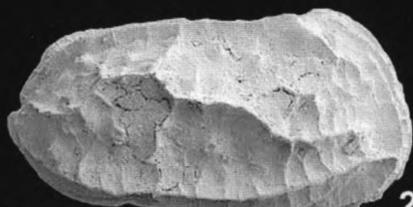
9. Cytherideinae gen. indet sp.1, left valve, M2/15.

10. *Oligocythereis* ? sp., right valve, M7/6.

Unless otherwise stated all figures are external views.

Scale bar 100 µm.

Plate 7



al. 1997). There is another possible occurrence of the species in the middle Callovian of Tanzania (BATE 1975).

Subgenus *Batella*
(KHOSLA, JAKHAR & MOHAMMED 1997)

Type species. *Batella befotaensis* (GREKOFF 1963)

Remarks. The genus *Batella* was established by KHOSLA et al. (1997), who suggested that this genus differs from other genera of the Progonocytherinae in the lobodont hinge structure, the occurrence of 17-21 anterior and 5-6 posterior marginal pore canals, and in details of the surface ornamentation. However, as a result of the amendments to the definition of the genus *Fastigatocythere*, both by WHATLEY & BALLENT (1996) and in this paper, *Batella* is assigned to *Fastigatocythere*.

Fastigatocythere (Batella) befotakaensis
(GREKOFF 1963)

Pl. 2, Fig. 10; Pl. 3, Figs. 1-2

- * v 1963 *Progonocythere befotakaensis* n. sp.. GREKOFF, p. 1733, pl. 3, figs. 77-80, pl. 8, figs. 215, 217.
1976 *Progonocythere befotakaensis* GREKOFF. GUHA, p. 88, pl. 2, figs. 12 a,b, 13.
1997 *Batella befotakaensis* (GREKOFF). KHOSLA et al., p. 12, 14, pl. 2, figs. 10-13.

Dimensions (mm).		L	H	W
Female	M5/2 lv	0.58	0.36	
	M5/45 lv	0.58	0.39	
	M5/11 lv	0.50	0.31	
	M5/46 lv	0.60	0.39	
	M5/8 c	0.58	0.34	
	M5/9 c	0.60	0.37	
	M5/47 rv	0.55	0.35	
	M5/4 rv	0.60	0.36	

Male	M5/1 lv	0.66	0.36	
	M5/48 lv	0.64	0.37	
	M5/49 lv	0.70	0.39	
	M5/6 c	0.68	0.39	
	M5/7 c	0.64		0.36
	M5/50 rv	0.65	0.37	

Material. 15 carapaces and 58 valves.

Remarks. The lateral surface is covered by a sub-triangular rib-pattern. The apex of the triangle is located on the dorsal margin at mid-length. It encloses a central area with coarse reticulation. In contrast to the specimens described by GREKOFF (1963) and KHOSLA et al. (1997) the posterodorsal and ventral ribs on the presented material are more distinct and the coarse reticulation between the ribs in the anteroventral, ventral and posteroventral areas is less strongly developed. These differences in ornamentation are suggested to be a result of intraspecific variability.

Distribution. The species occurs in the upper Bathonian and lower Callovian of the Majunga Basin, Madagascar (GREKOFF 1963), the lower Callovian of the Morondava Basin (Antainakanga section), Madagascar and the Callovian Chari Formation (*Progonocythere laeviscula* Zone) of India (KHOSLA et al. 1997, GUHA 1976).

Genus *Majungaella* GREKOFF 1963

Type species. *Majungaella perforata* GREKOFF 1963

Majungaella mundula (GREKOFF)

Pl. 6, Figs. 3, 6

- * v 1963 *Progonocythere mundula* n.sp.. GREKOFF, p. 1738, pl. 4, figs. 92-95.
1975 *Majungaella mundula* (GREKOFF). BATE, p. 185-186, pl. 5, figs. 10-13.
1990 *Majungaella mundula* (GREKOFF). RAFARA, p. 423, pl. 2, figs. 3-5.

EXPLANATION OF PLATE 8

Figs. 1-4. *Oligocythereis* ? sp.1, sample 02, Behevo section, lower-middle Callovian. 1. Left valve (of carapace), M7/10. 2. Right valve, M7/9. 3. Right valve, internal view, M7/8. 4. Left valve, internal view, M7/7.

Fig. 5. *Oligocythereis* ? sp., left valve, M7/11, sample 22, Amparambato section, lower Callovian.

Figs. 6-7. *Oligocythereis* ? sp. 2, sample 01, Antainakanga, lower Callovian. 6. Right valve, internal view, M6/34. 7. Right valve, M6/36.

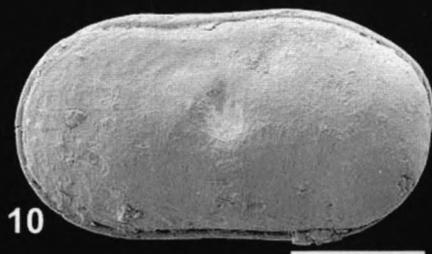
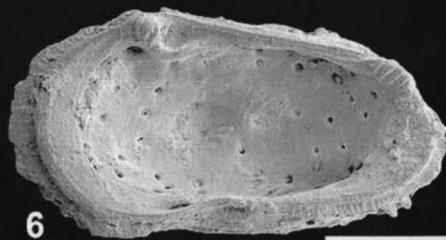
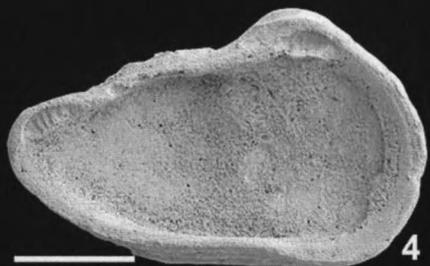
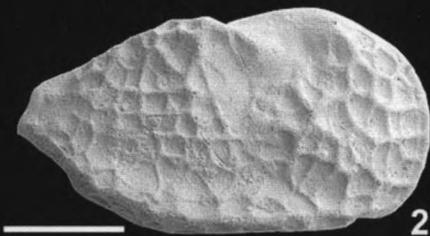
Figs. 8-9. *Cytherella* sp.1. 8. Female, right valve (of carapace), M3/21. 9. Female, left valve, M3/20.

Fig. 10. *Cytherella collapsa* GREKOFF, 1963, female, left valve (of carapace), M5/24, sample 01, Antainakanga section, lower Callovian.

Unless otherwise stated all figures are external views.

Scale bar 200 µm.

Plate 8



Dimensions (mm).			L	H
Female	M3/42	rv	0.48	0.34
	M3/43	rv	0.46	0.32
	M3/44	lv	0.49	0.36
	M3/24	lv	0.50	0.36
	M3/25	lv	0.50	0.39
	M3/30	lv	0.52	0.38
Male	M3/28	rv	0.54	0.32
	M3/31	lv	0.56	0.35
	M3/45	lv	0.57	0.37
	M3/29	lv	0.54	0.36
	M3/46	lv	0.54	0.35

Material. 25 carapaces and 60 valves.

Remarks. The lateral surface of *Majungaella mundula* is covered by puncta which show a tendency to be arranged in indistinct rows extending from the posterior dorsal margin to the anterior ventral margin. These rows are straight to slightly convex in the median part of the surface and become successively convex towards the posterior end. The ventral and ventrolateral surface is covered by four longitudinal ribs. The hinge of *M. Mundula* is strongly entomodont. The hinge bar of the lv consists of a finely denticulate posteromedian part and an anteromedian part with 3 prominent denticles. The anterior socket is divided into 4 loculi and the posterior socket has 6 loculi. There are 14 to 15 short, straight, simple and closely spaced anterior marginal pore canals. The present specimens show a distinct sexual dimorphism. Male carapaces are somewhat more elongate and have a more triangular outline in lateral view than female carapaces, because of their straight posterodorsal margin. The females also differ in their more narrowly rounded posterior end. With regard to carapace size the present material differs from the relatively small specimens of the Majunga Basin and is more similar to the material from the Callovian of Tanzania.

Distribution. *M. mundula* has been described from the Callovian of the Majunga Basin (GREKOFF 1963, RAFARA 1990), the lower Callovian of the Morondava Basin (Amparabato section), Madagascar, and the middle Callovian of Tanzania (BATE 1975). The species was also found in unpublished material from the Callovian Chari Formation of India (Kachchh) which was provided by F.T. FÜRSICH (Würzburg).

Genus *Trichordis* GREKOFF 1963

Subgenus *Trichordis* (GREKOFF 1963)
KHOSLA & JAKHAR 1993

Type species. *Trichordis praetexta* GREKOFF 1963

Remarks. According to the original definition (KHOSLA & JAKHAR 1993) *Trichordis* was subdivided into the subgenera *Trichordis* (*Trichordis*) and *Trichordis* (*Paratrachordis*). *Trichordis* (*T.*) has a median hinge element with two closely spaced denticles and a long smooth posterior bar. *Trichordis* (*P.*) is characterized by a entomodont - lobodont hinge structure. Whatley & Ballent (in press) state that the differences in the hinge do not justify the erection of the two subgenera and propose to suppress the subgenera *Trichordis* and *Paratrachordis*. The amended diagnosis of the latter authors is adopted herein.

Trichordis praetexta magna n. ssp.

Pl. 3, Figs. 7, 9-10 ; Pl. 4, Figs. 1-4

? 1976 *Trichordis* sp. cf. *T. praetexta crispa* GREKOFF. GUHA, p. 89, pl. 2, fig. 17.

Derivation of name. *L. magnus* large. Referring to the relatively large carapace size.

Holotype. Female carapace, M3/10, Pl. 3, Fig. 10.

Type locality. Amparabato section (erosional gully and creek, head of the Amparabato River), 1 km SSE of the village of Amparabato, near Sakaraha, SW Madagascar (S 23°00.001' / E 044°24.929').

Type horizon. Calcareous sandstone, 20 cm below a lower Callovian ammonite horizon (*Indosphinctes patina*-Zone), sample Ampara 22.

Paratypes. 68 female and male valves and carapaces.

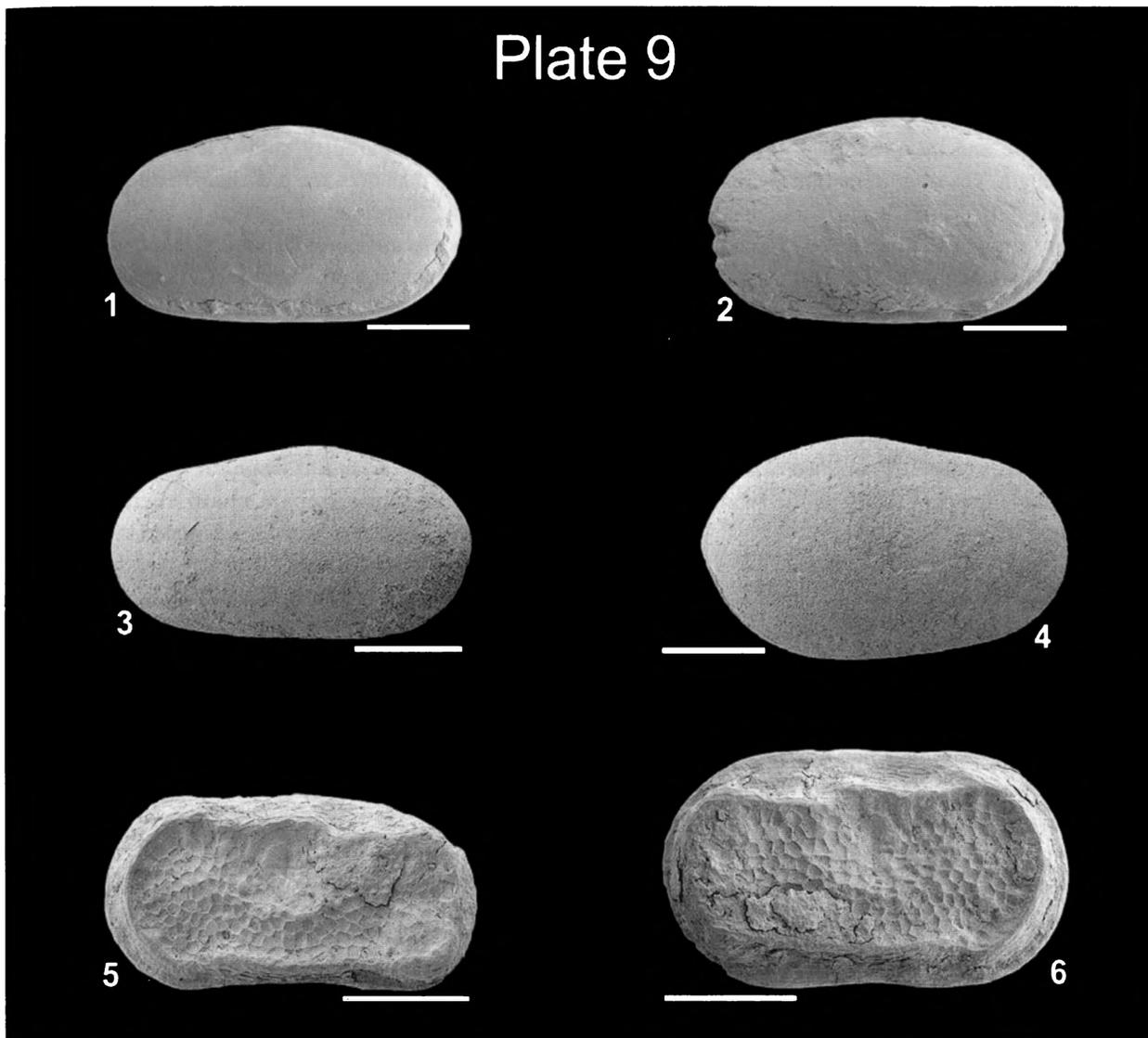
Occurrence. Amparabato section, samples 18, 22, lower Callovian, SW Madagascar.

Dimensions (mm).			L	H	W	
Female	M3/9	rv	0.64	0.36		
Holotype	M3/10	rv	0.70	0.40		
	M3/13	rv	0.62	0.35		
	M3/6	lv	0.70	0.40		
	M3/47	c	0.66	0.39		
	M3/48	c	0.67	0.40		
	M3/49	c	0.68	0.40		
	M4/27	c	0.68	0.38		
	M3/50	c	0.68	0.42		
	M3/51	c	0.69	0.40		
	M3/11	c	0.72		0.37	
	Male	M3/52	rv	0.72	0.40	
		M3/7	lv	0.78	0.42	
		M3/53	lv	0.74	0.40	
M3/12		c	0.78		0.38	
M3/54		c	0.74	0.40		
M3/55		c	0.76	0.40		
	M3/56	c	0.76	0.42		

Material. 16 carapaces and 43 valves.

Diagnosis. A relatively large subspecies of *Trichordis praetexta* with distinct sexual dimorphism.

Plate 9



EXPLANATION OF PLATE 9

Figs. 1-2. *Cytherella* cf. *obscura* LUBIMOVA & MOHAN, 1960. 1. Female, left valve (of carapace), M5/21. 2. Male, left valve (of carapace), M5/22.

Figs. 3-4. *Cytherella index* OERTLI, 1959, sample 02, Behevo section, lower-middle Callovian. 3. Left valve, M2/35. 4. Right valve, M2/34.

Figs. 5-6. *Cytherelloidea* sp.2, sample 01, Antainakanga section, lower Callovian. 5. Left valve, M5/25. 6. Right valve, M5/27.

Unless otherwise stated all figures are external views.

Scale bar 200 μ m.

Description. The carapace outline is sub-rectangular in lateral view, with sub-parallel dorsal and ventral margins, and irregularly ovate in dorsal view. The greatest length is below mid-height, the greatest height is at the anterior cardinal angle and the greatest width is at 2/5th of carapace length. The anterior margin is broadly rounded and distinctly infracurved. In the lv the dorsal and ventral margins are straight and parallel. The anterior cardinal angle of the lv strongly rises above the dorsal margin. In the rv the dorsal margin is strongly inclined towards the posterior and the median part is hidden by the dorsal rib. The posterior margin of the lv consists of a steeply inclined and straight posterodorsal part, with a short concavity and a convex posteroventral part. The posterior margin of the rv is distinctly pointed below mid-height. The lv strongly overlaps the rv on the anterodorsal and posterodorsal margins.

The lateral surface is ornamented by 3 broad and shallow longitudinal ribs. There is an anterior-dorsal rib which runs parallel to the dorsal and anterior margins and extends from the posterior cardinal angle to the anteroventral margin. The median longitudinal rib is very broad and located in the central part of the lateral surface. The anterior-dorsal and median ribs are separated from each other by a deep convex sulcus which extends from the subdorsal area to the anteroventral area. The 3rd rib is indistinct; it is located on the posteroventral margin and forms a weak ventrolateral carapace inflation. A smooth and laterally compressed marginal zone occurs towards the posterior. The eye node is a very shallow and indistinct structure on the anterodorsal rib, which is hardly discernible. On the lateral surface, except for the posterior marginal zone and the anterodorsal area, are about 30-40 large openings of the normal pore canals. Sexual dimorphism is distinct: the females are shorter and less elongate than the males in lateral view. In dorsal view the females show a weak posterior carapace tumidity.

Internal features. The anterior marginal pore canals are simple, straight, widely spaced and 8-9 in number. At the posterior end are 4 simple and widely spaced marginal pore canals. The hinge is lobodont and, on the lv, consists of a smooth median bar with two prominent anteromedian teeth, which are, on some specimens, subdivided into 4 lobes. The terminal hinge sockets of the lv are subdivided into 5 (anterior) and 6 (posterior) loculi. The hinge elements of the rv are complementary.

Discussion. The present material is almost identical to *T. praetexta* GREKOFF from the Bathonian and Callovian of the Majunga Basin in Madagascar, in carapace outline, ornamentation, number and arrangement of normal pore canal openings and in the internal features. The present specimens differ from the above mentioned species in

some subtle external features. The median rib is less strongly developed on *T. praetexta magna* and the carapace is generally 0.1-0.2 mm larger than the carapace of *T. praetexta*. Furthermore, the specimens described by GREKOFF apparently show less distinct sexual dimorphism than does the present material. The present material is, therefore, suggested to represent a new subspecies. Specimens of the same size, carapace outline and ornamentation, were described from the Late Jurassic of India (GUHA 1976), and possibly belong to the present subspecies. *T. praetexta magna* n. ssp. was also recognized in material from the Callovian Chari Formation of India (Kachchh).

Distribution. *T. praetexta magna* n. ssp. occurs in the lower Callovian (Amparambato section) of the Morondava Basin, SW Madagascar and in the Callovian Chari Formation of India (Kachchh). Another possible occurrence in the Upper Jurassic of India was reported by GUHA (1976).

Trichordis devexa (GREKOFF 1963)

Pl. 4, Figs. 9-10 ; Pl. 5, Figs. 1-4

* v 1963 *Lophocythere devexa* n. sp.. GREKOFF, p. 1729-1730, pl. 2, figs. 49-52.

1997 *Trichordis (Paratrichordis) devexa* (GREKOFF). KHOSLA et al., pl. 6., fig. 8.

Dimensions (mm).		L	H	W
Female	M4/11 rv	0.48	0.29	
	M4/15 rv	0.50	0.30	
	M4/19 lv	0.48	0.32	
	M4/43 lv	0.50	0.33	
	M4/17 c	0.48		0.26
	M4/44 c	0.50	0.31	
Male	M4/12 rv	0.54	0.28	
	M4/16 rv	0.54	0.29	
	M4/20 rv	0.56	0.29	
	M4/18 lv	0.54	0.30	
	M4/13 lv	0.56	0.30	
	M4/45 lv	0.57	0.34	
	M4/21 c	0.54	0.30	
M4/14 c	0.56		0.27	

Material. 23 carapaces and 58 valves.

Remarks. The hinge of the lv consists of a crenulated median bar with 3 very prominent anterior denticles and a finely denticulate middle and posterior part. The anterior socket is divided into 5 loculi and the posterior socket into 6 loculi. The rv has complementary hinge elements. Above the median bar of the lv is a broad accommodation groove. The hinge of the rv consists of complementary elements. At the anterior margin occur 13-15 short, straight, and simple marginal pore canals.

The posterior marginal pore canals are 5 in number.

Distribution. *Trichordis devexa* is recorded from the middle Callovian of the Majunga Basin, Madagascar (GREKOFF 1963), the lower Callovian of the Morondava Basin (Amparambato section), Madagascar and the Callovian Chari Formation (*Progonocythere laeviscula* zone) of India (KHOSLA et al. 1997).

Genus *Neurocythere* WHATLEY 1970

Type species. *Cythere bradiana* JONES 1884

Neurocythere whatleyi (KHOSLA & JAKHAR 1997)

Pl. 5, Figs. 5-8, 10

- v 1963 *Lophocythere* 323b. GREKOFF, p. 1730, pl. 2, fig. 48.
1997 *Nophrecythere whatleyi* n. sp.. KHOSLA et al., p. 20-22,
pl. 5, figs. 6-7.

Dimensions (mm).		L	H
M3/1	lv	0.40	0.24
M3/3	lv	0.42	0.26
M3/5	c	0.44	0.26
M3/2	rv	0.40	0.22
M3/4	rv	0.38	0.22

Material. 1 carapace and 5 valves.

Remarks. The present species was originally assigned to *Nophrecythere*. In agreement with WHATLEY et al. (2001), the genus *Nophrecythere* is, in this paper, regarded as a junior synonym of *Neurocythere*. In contrast to the species description by KHOSLA et al. (1997), *N. whatleyi* has 4 longitudinal ribs; 3 on the lateral surface and an indistinct 4th rib on the ventral surface. The dorsal rib extends from the anterodorsal area at 2/3rd of carapace length to the posteromedian part of the lateral surface. The dorsal rib is bow-shaped and rises above the mid-dorsal margin. The median, lateroventral and ventral ribs converge towards the anteroventral area.

The median rib runs from the posterodorsal area, where it is connected to the dorsal rib, to the anterior margin, and is gently inclined towards the anteroventral margin. At two thirds of carapace length, just behind the eye node, the median rib bifurcates into an anterodorsal branch and an anteroventral branch. The anterodorsal branch is strongly angled and consists of an anterodorsally directed segment and a posterodorsally directed segment, which merge into the eye node. The anteroventral branch is straight and reaches the anteroventral margin.

The lateroventral rib is less distinct than the dorsal and median ribs. It extends from the posteromedian area

to the anteroventral area. The lateroventral rib is connected to the median rib by a number of vertical and oblique ribs. In the posteromedian and median area there are three relatively long and distinct vertical ribs. In the anteroventral area are three or four short and oblique ribs. The ventral rib runs from the posteroventral area to the anteroventral area. It is connected to the lateroventral rib by a number of short, oblique ribs.

The species has an entomodont hinge. The anterior and posterior teeth of the right valve are subdivided into 5 lobes. The inner margin is moderately broad and coincides with the line of concrescence. Radial pore canals are not preserved.

Distribution. *Neurocythere whatleyi* is distributed in the Callovian (*Progonocythere laeviscula* zone) of India (KHOSLA et al. 1997). In Madagascar the species occurs in the lower-middle Callovian of the Morondava Basin (Behevo section) and the middle Callovian of the Majunga Basin (GREKOFF 1963).

Genus *Lophocythere* SYLVESTER-BRADLEY 1948

Type species. *Cytheridea ostreata* JONES & SHERBORN 1988

Lophocythere ? sp.

Pl. 5, Fig. 9; Pl. 6, Figs. 1-2

- ? 1993 *Lophocythere* sp.. METTE, p. 92, pl. 3, figs. 13, 14

Dimensions (mm).		L	H
Female M2/39	rv	0.46	0.27
Male M2/40	lv	0.56	0.26
	M2/41 lv	0.48	0.20

Material. 3 valves.

Remarks. The species shows a similar outline and ornamentation to *Lophocythere* ? sp. from the lower Callovian of northern Somalia (METTE 1993). The poor preservation of the present material precludes a more detailed comparison with the specimens from Somalia. In valve outline and ornamentation *Lophocythere* sp. is also very similar to *Lophocythere propinqua* MALZ from the Bathonian of France and England. The specimens from Madagascar differ in the occurrence of a straight anterior rib, running vertically from the anterodorsal to the anteroventral margin, and in the narrowly rounded posterior margin of the left valve.

Distribution. The presented species has been found in the lower-middle Callovian of the Morondava Basin (Behevo section), Madagascar.

Subfamily **Procytherinae** LUBIMOVA 1955Genus *Procytheridea* PETERSON 1954Type species. *Procytheridea exempla* PETERSON 1954*Procytheridea* ? sp. 1

Pl. 6, Figs. 7-8

Dimensions (mm).	L	H
M4/22 lv	0.60	0.34
M4/23 lv	0.56	0.30

Material. 2 valves.

Remarks. The present species is thought to belong to *Procytheridea* because of the antimerodont hinge structure. The median hinge bar of the lv is coarsely denticulate and the posterior socket is subdivided into 7 loculi. The inner lamella is moderately broad; the inner margin and line of concrescence coincide. The ribs on the external surface extend more or less parallel to the dorsal and ventral margins. On the anteromedian area the ornamentation has been removed by abrasion. Because of the poor preservation the ornamentation cannot be described in more detail. With respect to external features *Procytheridea* ? sp.1 is similar to *Progonocythere haboensis* KHOSLA & JAKHAR, particularly in carapace outline. In contrast to *P. haboensis* the lateral surface of the present specimens is coarsely reticulated. *Procytheridea ihopyensis* Grekoff differs from the present specimens in its stronger ornamentation and its much shorter median hinge bar.

Distribution. The present species has been found in the lower Callovian of the Morondava Basin (Amparambato section), Madagascar.

Family **Trachyleberididae** SYLVESTER-BRADLEY 1948Genus *Oligocythereis* SYLVESTER-BRADLEY 1948Type species. *Cythereis fullonica* JONES & SHERBORN 1888*Oligocythereis* ? sp. 1

Pl. 8, Figs. 1-4

Dimensions (mm).	L	H
M7/10 c	0.68	0.36
M7/7 lv	0.69	0.42
M7/8 rv	0.77	0.42
M7/36 rv	0.72	0.40
M7/9 rv	0.68	0.38

Material. 1 carapace and 4 valves.

Remarks. Although the hinge of the present species is poorly preserved it undoubtedly has an entomodont structure, with a hinge bar which is finely denticulated in the posterior half and dentate in the anterior half. The anterior tooth of the rv is subdivided into 5 lobes and the posterior socket of the lv has 5 or 6 loculi. The inner lamella is moderately wide and the inner margin and line of concrescence coincide. Radial pore canals are not preserved. The lateral surface is ornamented by a ventrolateral rib which extends from the posterior end to the anteroventral margin, and by a dorsal bow-shaped rib which runs from the posterodorsal margin to the anterodorsal area just in front of mid-length. The latter rib overlaps the posterior and median dorsal margin. The lateral surface, including the longitudinal ribs, is covered by a coarse irregular reticulation which is most strongly developed on the anterior third and posterodorsally. Along the ventrolateral rib the reticulation is relatively fine. The dorsomedian and anterodorsal area is smooth. Furthermore, the species is characterized by relatively shallow eye nodes. *Oligocythereis* ? sp. 1 differs from the other species of this genus by the absence of a sub-central tubercle, relatively weak eye nodes and the absence of prominent ribs and tubercles on the median part of the lateral surface. Because of the low number of specimens the species is left in open nomenclature.

Distribution. *Oligocythereis* ? sp. 1 has been found in the lower-middle Callovian of the Morondava Basin (Behevo section), Madagascar.

Oligocythereis ? sp. 2

Pl. 8, Figs. 6-7

Dimensions (mm).	L	H	W
M6/35 rv	0.70	0.38	
M6/36 rv	0.76	0.40	
M6/37 c	0.84		0.42

Material. 1 carapace and 3 valves.

Remarks. The species is only represented by a few, poorly preserved specimens. The posterior lateral surface is ornamented by a posteroventral rib, a median rib and a very broad posterodorsal rib. The posterodorsal rib starts in the mid-dorsal region, rises above the posterodorsal margin and merges posteriorly in the median longitudinal rib. The median rib is weak and reaches the distinct sub-central tubercle, which is located shortly in front of the middle. The area between the ribs is coarsely reticulated. The eye tubercle is very distinct and hemispherical. A few coarse denticles occur on the posteroventral margin.

The inner lamella is moderately wide anteriorly and the inner margin and line of concrescence coincide throughout. The hinge is paramphidont. On the right valve the median hinge element consists of a narrow groove in the posterior and median part, and a very broad anterior socket. The posterior and anterior teeth are subdivided into 5 lobes. The anterior tooth is short and distinctly inclined to the dorsal margin. A similar hinge structure has been recorded from *Exopthalmocythere*. However, with respect to carapace outline and ornamentation the present specimens are more similar to *Oligocythereis*.

Oligocythereis ? sp. 2 has a similar type of ornamentation to *Oligocythereis irregularis* ROSENFELD, OERTLI, HONIGSTEIN & GERRY from the Oxfordian of Israel, but it differs in its larger size and in some details of the ornamentation. One difference in ornamentation is the much broader posterodorsal rib of the present species. Other characteristic features are the presence of a median longitudinal rib and the occurrence of denticles on the posteroventral margin. The present species differs from *Oligocythereis* ? aff. *fullonica* (JONES & SHERBORN), which was described from the Bathonian – Kimmeridgian of Saudi Arabia, Israel and Sinai (MAYNC 1966, ROSENFELD et al. 1987a, DEPECHE et al. 1987, ROSENFELD & HONIGSTEIN 1991, ROSENFELD & HONIGSTEIN 1998), in the carapace size and outline (particularly in the straight dorsal margin), and the occurrence of denticles on the posterior margin.

Distribution. *Oligocythereis* ? sp. 2 occurs in the lower Callovian of the Morondava Basin (Antainakanga section), Madagascar.

Family Cytherideidae SARS 1925

Subfamily Cytherideinae SARS 1925

Cytherideinae gen. indet. sp. 1

Pl. 7, Fig. 9

? 1984 *Eocytheridea* ? sp. 2. DEPECHE, p. 325, pl. 9, figs. 12-13

Dimensions (mm).	L	H
M2/15 lv	0.52	0.28

Material. 2 valves.

Remarks. The species has a very similar ornamentation to *Eocytheridea* ? sp. 2 DEPECHE from the Lower Bathonian of France (DEPECHE 1984). The lateral surface is completely covered by delicate ribs which are arranged in a sub-triangular pattern and merge centrally into an irregular reticulation pattern. In lateral view *Eocytheridea* ? sp. has a similar outline to *Eocytheridea* ? sp. 2, but in contrast to the latter species it has a straight posterodorsal margin. The present species has an antimerodont hinge with 6 lobes in the anterior tooth and a faintly locellate narrow median groove. The posterior tooth is not completely preserved, but has 6 or more lobes. The anterior inner lamella is narrow and there are probably not more than 8 or 10 straight anterior marginal pore canals. In carapace shape and ornamentation the present species is similar to the genus *Eocytheridea* BATE, but it differs from the latter taxon in the antimerodont hinge and the lower number of radial pore canals.

Distribution. Lower-Middle Callovian of the Morondava Basin (Behevo section), Madagascar.

Cytherideinae gen. indet. sp. 2

Pl. 6, Fig. 5

Dimensions (mm).	L	H
M4/25 rv	0.48	0.24

Material. 2 carapaces and 2 valves.

Remarks. The anterior and posterior hinge elements of the present species are not preserved. The median hinge element of the right valve is a finely crenulated groove. The hinge structure is therefore probably antimerodont. The anterior part of the inner lamella is moderately broad and the inner margin coincides with the line of concrescence. The species differs from *Procytheridea* ? sp. 1 in the smooth lateral surface and the more steeply inclined posterodorsal margin.

Distribution. The present species occurs in the lower Callovian of the Morondava Basin (Amparambato section), Madagascar.

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d'Histoire Naturelle, Paris) kindly made the ostracod type-material from Madagascar accessible for examination. Many thanks are due to R.C. WHATLEY (University of Wales) for having thoroughly reviewed the manuscript.

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