

# Ostracoda from the Miocene Marada Formation of Libya

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## ABSTRACT

The ostracods of the Miocene Marada Formation from three wells in the east of the Sirt Basin are described. These indicate ages ranging from Aquitainian to Tortonian. Four biozones are recognised: *Pokornyyella deformis minor* (=Aquitainian), *Aurilla soummamensis* (=Burdigalian), an interval zone of Mid Miocene age, and *Ruggieria tetraptera tetraptera* (=Tortonian). 55 species have been identified, 22 of which are known from other Mediterranean localities. Six new species are described: *Actinocythereis sirtensis* sp. nov., *Bythocypris tripoliensis* sp. nov., *Cyprideis maradaensis* sp. nov., *Cytheridea joshensis* sp. nov., *Gammudi*, *Hermanites zaltanensis* sp. nov., and *Paijenborchellina keeni* sp. nov., Gammudi. *J. Micropalaeontol.*, 12 (1): 121-139, August 1993.

## INTRODUCTION

The Sirt Basin is one of several sedimentary basins developed on the East Saharan Craton (Fig.1). Subsidence began in the Cretaceous, continued through the Tertiary, with the accumulation of more than 6000m of sediment. Miocene sediments are only present in Libya in the northern Sirt Basin, adjacent areas of the Cyrenaica Platform, and a small area around Al khums which is 120km east of Tripoli. During the Early-Mid Miocene a shallow marine gulf, fringed by lagoons and bordered by a coastal plain existed over the northern Sirt Basin (Fig 1). The deposits of the Cyrenaica Platform are shallow marine carbonates, while the thicker sediments of the Sirt Basin include shales as well as clastics and carbonates. The Miocene of the Cyrenaica Platform is entirely Middle Miocene in age (Desio, 1928), while that of Al Khums (Al khums Formation) has recently been dated on the basis of foraminifera (Innocenti & Pertusati, 1984) and ostracods (Al Waer, 1988, 1992) as Late Miocene, although they were previously believed to be Mid Miocene. The Marada Formation is traditionally regarded as being Early-Mid Miocene in age. The Miocene is usually unconformable with the underlying rocks, except in the south central Sirt Basin where it is conformable with the Oligocene Diba Formation.

The wells studied here were drilled by the Wintershall Company in the eastern Sirt Basin on onshore concession 97 (Fig. 1.), and penetrate some 1200ft. of sediment referred to the Marada Formation. The samples are ditch cuttings, each representing 30-60ft of well drilling. While it is impossible to determine the true distribution of microfossils in the wells, the first appearance downhole can be ascertained, and features such as numerical abundance and nature of preservation give some clues as to the probability of *in situ* occurrence. The ostracod fauna recovered from these samples is a typically diverse infralittoral fauna, with many species in common with the Miocene of the Mediterranean

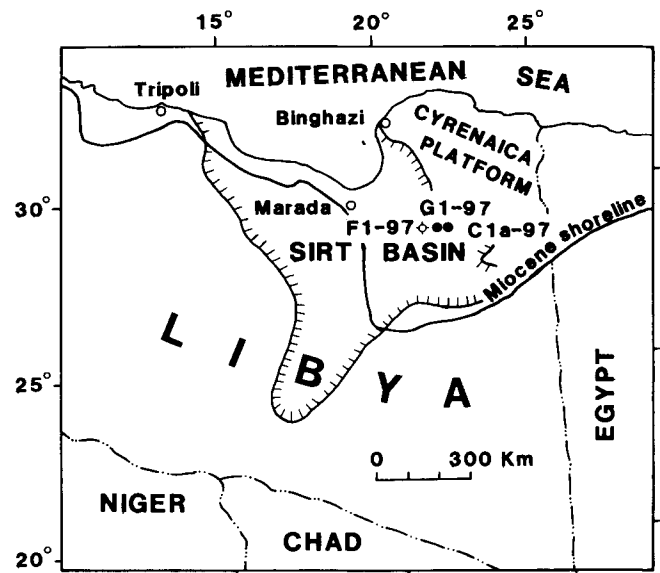


Fig.1. Map showing the Sirt Basin, the Miocene shoreline, and the position of the wells.

area in general.

## THE MARADA FORMATION

Desio introduced the name Marada Series for the succession of Dor Marada, some 50km northwest of Jabal Zaltan (Fig.1). The type section consists of 80m of shale interbedded with sand and limestone, with some gypsum layers. It contains a marine fauna which Desio considered indicated a Langhian (Burdigalian) - Helvetian age, ie. Early to mid Miocene. Mammalian studies (Aramborg & Magnier, 1961; Magnier, 1964; Savage & White, 1965; and Savage & Hamilton, 1973) suggest Early Miocene, including

Burdigalian, for the formation at Jabal Zaltan. Hughes (1974 unpublished internal report B. G. S. No PDL 74/5, in Benfield and Wright 1980) studied core samples taken from about 60-70 ft below the top of the Marada Formation in Borehole J(C1-95) (Lat, 27° 27', Long, 20° 43'), located 85km North West of well F1-97 studied here. On the basis of foraminiferal species such as *Borelis melo* (Fichtel & Moll) he suggested a Middle Miocene age for this part of the Marada Formation. Innocenti & Pertusati (1984) studied the Marada Formation of the area immediately to the north of the type area, using both macro and microfossils, including ostracods, and recognised two foraminiferal assemblages. The first of these indicates an Early Miocene age, with *Miogypsina gunteri* Cole, *Miogypsinoide bantamensis* Drooger, *Archias aduncus* (Fichtel & Moll), *Miogypsinoides aff dehaerti* Van Den Fleak, *Miogypsinoides cf complanatus* Schlumberger, *Miogypsina* sp, and *Miogypsinoides* sp. An Early Miocene age is also supported by the occurrence of rare *Operculina*, *Heterostegina*, and *Lepidocyclus*, genera which range across the Oligocene-Miocene boundary. The second Assemblage contains *Borelis melo*, the first appearance of which is considered to be a good indicator for the base of the Middle Miocene, although the species ranges from the Middle Miocene to the Messinian. Thus the second assemblages was taken to indicate Middle Miocene.

Selley (1969) and El-Hawat (1980) studied the sedimentary facies of the Marada Formation in its type area, recognising fluvial, estuarine channels, tidal inlets and flats, lagoons, barrier bar and beaches, marine banks, and marine delta fans. The succession in the type area has a thickness of 80-150m; it increases in thickness northwards into the centre of the basin, with a maximum recorded thickness of 2800ft (853m) (Wright & Benfield 1980).

The wells studied here were drilled to the east of the type area, in a region which was a trough during the Miocene where some 365m (1200ft) of sediment accumulated. The sediments penetrated by the wells differ from those of the type area; most of the succession consists of fossiliferous limestones (marly calcarenites, some calcilutites) with common shale horizons. It is not easy to correlate these sediments with the facies described by Selley (1969) and El-Hawat (1980). The fauna (see below) indicates the predominance of shallow marine conditions, probably infralittoral, throughout the succession. Brackish water ostracods such as *Cyprideis* and *Neocyprideis* occur

commonly in the lower part of the Marada Formation in the wells studied, but there is no correlation between their abundance and type of sediment. Therefore they cannot be regarded as representative of the lagoonal shale facies of Selley and El-Hawat. Lagonal facies however were clearly present in the vicinity of the wells. There is no evidence of barrier bar, beach, tidal flat, estuarine channels or fluvial facies, because the area was presumably seaward of these facies.

#### PREVIOUS STUDIES OF THE MIOCENE OSTRACODS OF LIBYA

While the Miocene ostracods of the Mediterranean area have been widely studied during the past 100 years, only four studies have been published on the Miocene ostracods of Libya. The first was by Van Hinte *et al* (1980) who recorded ostracod faunas from the side wall core of the offshore well B1-NC35A, located about 140km north east of Tripoli on the Pelagian platform. The lithology of the core shows intercalation of anhydrite between marl beds. The marls above the anhydrite were considered to be Pliocene in age, and marls below the anhydrite Miocene. The evaporites are probably evidence of the Messinian event in the area. 41 species of ostracods were recorded, including 23 named species. 11 species were only present above the evaporites, and of 30 species recorded from the Miocene only *Acanthocythereis hystrix*, *Chrysocythere cataphracta* and *Neomonoceratina laskarevi* have been found in this study. The reason for this great difference in faunas is partly due to stratigraphy as the faunas of Van Hinte *et al* are mostly younger than those of the Marada Formation, and partly due to facies where the samples of Van Hinte *et al* indicate predominantly circalittoral-upper bathyal (75-500m) conditions.

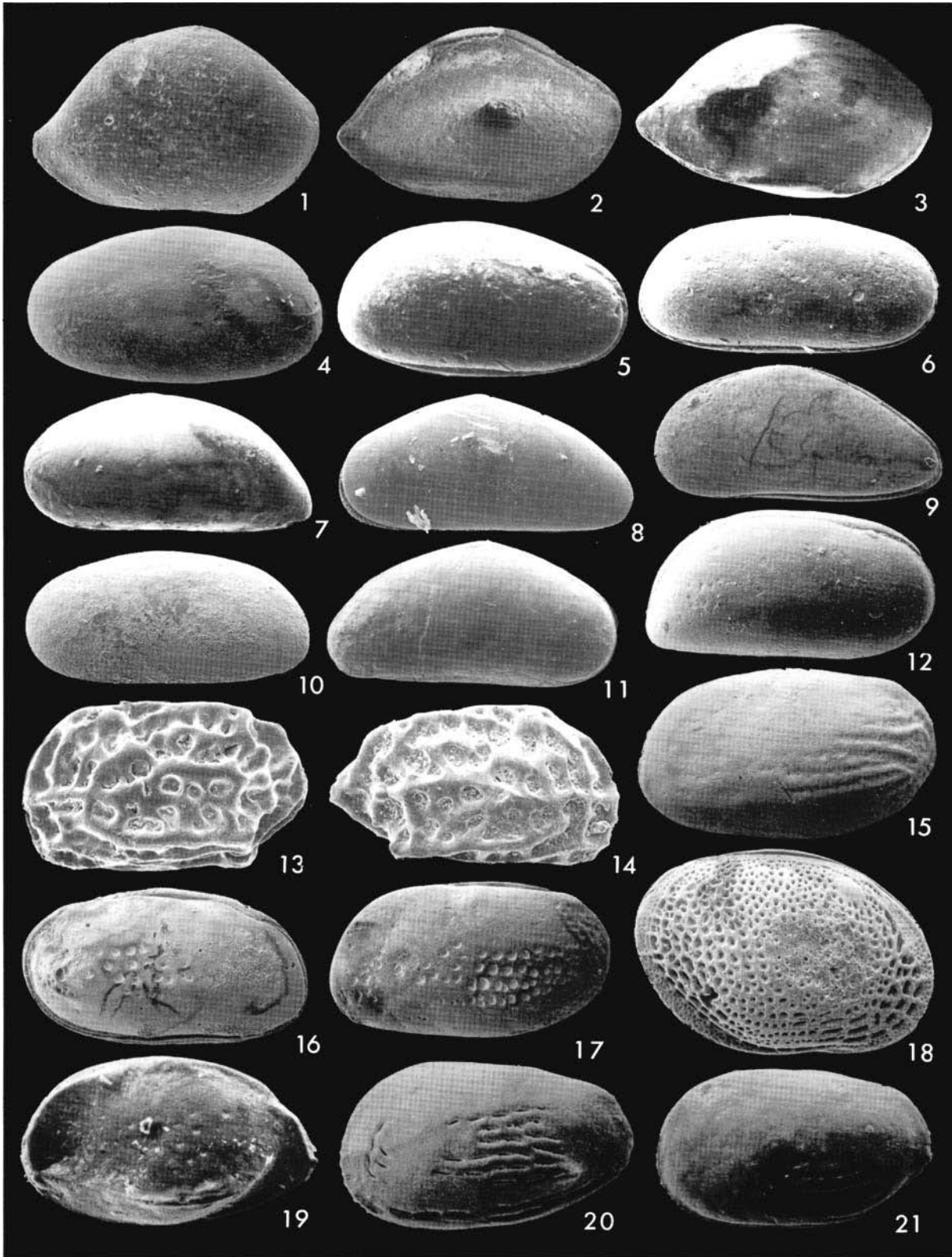
El-Waer (1988, 1992) described the ostracod fauna of the late Miocene Al Khums Formation, recording 39 species including eight new species. The following species are in common between the Al Khums and Marada Formation: *Actinocythereis spinosa*, *Actinocythereis libyaensis*, *Carinivalva carinata*, *Chrysocythere alkhumia*, *Cistocythereis qabilatashur-fahensis*, *Cnestocythere truncata*, *Keijella africana*, *Neomonoceratina mouliana*, *Ruggieria tetaptera tetaptera*. The difference between the faunas can be accounted for by the difference in age.

Szczuchura & Abd-Elshafy (1989) studied the ostracods and foraminifera from the ?middle Miocene of the western

#### Explanation of Plate 1

In the following descriptions, L = left, R = right, F = female, M = male, C = carapace, V = valve. Catalogue numbers refer to the collections of the Hunterian Museum, University of Glasgow; measurements are in  $\mu\text{m}$ .

**Fig.1.** *Bairdoppilata triangulata* Edwards: A12718, x70, L 728. **Fig.2.** *Bairdoppilata* sp.A: A12716, x55, L909. **Fig. 3.** *Bairdoppilata* sp.B: A12717, x80, L650. **Figs4-6.** *Bythocypris tripoliensis* sp. nov.: **Fig.4,** F L C, 12672 x63, L 816; **Fig.5,** F R C, A86912671, Holotype x58, L; **Fig.6** M R C, 12670, x63, L800. **Fig.7.;** *Paracypris* aff. *polita* Sars: R C A12683, x 49, L 979. **Fig.8.** *Paracypris* sp.A: L C, A12677, x65, L 784. **Fig.9.** *Paracypris* sp.: L C, A12680, x 80, L 644. **Fig.10.** *Dispontocypris schwejeri* Van Den Bold: L C A12675, x53, L 934. **Fig.11.** *Proponocypris* sp.: R C, A12681, x 58, L 869. **Fig.12.** *Krithe papillosa* (Bosquet): F R C, A12621, x 85, L 588. **Figs 13, 14.** *Cnestocythere truncata* (Reuss): **Fig.13,** F L C, A12592, x 103, L 473; **Fig.14,** F R C, A12593, x95, L 524. **Fig.15.** *Cytheretta* sp. A: M L C, A12666, x 60, L 833. **Figs 16, 17,** *Cytheretta* cf *semipunctata* (Bornemann): **Fig.16,** F R C, A12669, x61, L 810; **Fig. 17,** F L C, A 12668, x60, L 816. **Fig.18.** *Loxococoncha* gr. *ovulata* (Costa): F R C, A12651, x90, L 544. **Fig.19.** *Carinivalva carinata* (Moyes): M L C, A12598, x80, L637. **Fig.20.** *Keijella punctigibba* (Capeder): F L C, A12616, x78, L 632. **Fig.21.** *Keijella africana* El-Waer: F L C, A12613, x68, L 725.



coast of the Gulf of Suez, Egypt, and from the Marada Formation of the central Sirt Basin. They recorded 55 species of ostracods from the Hommath Formation, although only 14 species are positively identified to specific level and include four new species described by Szczechura: *Cytherelloidea sissinghi*, *Neomonoceratina keiji*, *Neomonoceratina ruggierii*, and *Hemicyprideis aegyptiaca*. All of these new species were also recorded from the Marada Formation. In this study only *Neomonoceratina keiji* has definitely been found, together with another 11 species recorded by Szczechura & Abd-Elshafy. Szczechura & Abd-Elshafy state that about 70% of Egyptian species are present in the Marada Formation of Libya. This is not found to be the case with the species recorded in this study where there is a considerable difference. The species in common between Egypt and Libya are: *Chrysocythere cataphracta*, *Cistacythereis cf caelatura*, *Cnestocythere truncata*, *Cytherella* sp. B, ?*Cytheridea*, *Falsocythere maccagnoii*, *Hermanites haidingeri*, *Keijella africana*, *Neomonoceratina keiji*, *Neomonoceratina ruggierii*, *Pokornyyella deformis minor*, *Ruggieria tetraptera tetraptera*. The fauna described from the Hommath Formation suggests the presence of Lower Miocene sediments.

No other systematic works have been published, although several faunal lists have been recorded. In a study of the middle Miocene Al-Jhaghbab Formation of eastern Cyrenaica, Bellini (1969) listed the following species identified by Ascoli: *Neomonoceratina* aff. *N. helvetica* Oertli, *Miocyprideis* sp, *Cytherella* sp, *Ruggieria* aff. *Ruggieria tetraptera tetraptera* Seguenza, *Loxoconcha* aff. *L. punctatella* Reuss, *Aurila* sp, *Chrysocythere* aff. *C. cataphracta* Ruggieri, *Hermanites* sp, *Krithe* sp, *Cytheretta* aff. *C. jurinei* Muenster, *Quadracythere* sp, *Loxoconcha* sp, *Aurila* ? aff. *A. deformis* Reuss, *Cuneocythere* ? sp, *Quadracythere* sp, *Trachyleberis* ? sp, *Paijenborchella* ? sp. The identifications are not accurate enough to allow any comparison with the ostracods of the Marada Formation.

Innocenti & Pertusati (1984) recorded 19 ostracod species from the Marada Formation: *Aurila cicatricosa* (Reuss), *Aurila diecii* (Sissingh), *Aurila impressa* (Ruggieri), *Aurila longa* Ruggieri, *Aurila punctata* (Von Munster), *Aurila trigonella* (Reuss), *Bairdia subdeltoidea* (Von Munster), *Bairdoppilata octopunctata* Ruggieri, *Chrysocythere cataphracta* (Ruggieri), *Cletocythereis minor* (Ruggieri) *Cnestocythere truncata* (Reuss), *Cytheridea acuminata* Bosquet, *Kangarina coarctata* Ruggieri, *Loxoconcha punctatella* (Ruggieri), *Loxoconcha variesculpata* (Ruggieri) *Neomonoceratina*

*mediterranea* (Ruggieri), *Neomonoceratina mouliana* (Sissingh), *Ruggieria tetraptera tetraptera* (Seguenza), *Tenedocythere mediterranea* (Ruggieri). This list of species is so different from that recorded in this study that, because they are not illustrated, it is impossible to make any valid comparisons.

#### SYSTEMATIC DESCRIPTIONS

The material described here is stored in the collections of the Hunterian Museum, University of Glasgow, and the numbers refer to its catalogue.

Subclass **Ostracoda** Latreille, 1806.

Order **Podocopida** Müller, 1894.

Suborder **Platycopa** Sars 1866.

Family **Cytherellidae** Sars, 1866.

Three species of *Cytherella* Jones 1849 have been recognised (Fig.2). *Cytherella* cf. *pulchella* Ruggieri 1967 differs from the type material from the Upper Tortonian of Italy in the arrangement of the pits and in lacking a truncated posterior in dorsal view; it is more similar to *C. pulchella* described by Aruta (1982) from the Middle-Upper Miocene of Sicily, differing in its smaller size and less truncated postero-ventral margin. Six specimens were recovered; five of these are punctate, the sixth is smooth, and is interpreted as polymorphism (See Keen 1982). *Cytherella* sp. A. has much coarser pitting; it is identical to *Cytherella* sp. cf. *Cytherella vandenboldi* Sissingh 1972 of El Waer 1992 (p.1460, pl.1 fig.1) from the Upper Miocene of Libya; it differs from *C. vandenboldi* in lacking a truncate posterior margin in dorsal view. *Cytherella* sp. B has been described and illustrated by Szczechura and Abd-Elshafy as *Cytherella* sp. (1989, p. 290, pl. 2a-b,?). One specimen of the genus *Cytherelloidea* Alexander, 1929 has been found, illustrated as *Cytherelloidea* sp.

**Material.** *C. cf. pulchella*, 3 carapaces and 3 valves; No A12653-655 from Well F1-97 at depth 1590-1740ft; *C.sp.A*, 2 carapaces; No A12646,7 from Well C1a-97 at depth of 770ft. *C.sp.B*, 4 carapaces; No A12644,5 from Wells C1a-97 at depth 770 ft and F1-97 at depth 1530ft. *Cytherelloidea* sp., 1 carapace, No A12652 from Well G1-97 at depth 1230 feet.

Suborder **Podocopina** Sars, 1866

Superfamily **Bairdiacea** Sars, 1888

Family **Bairdiidae** Sars, 1888

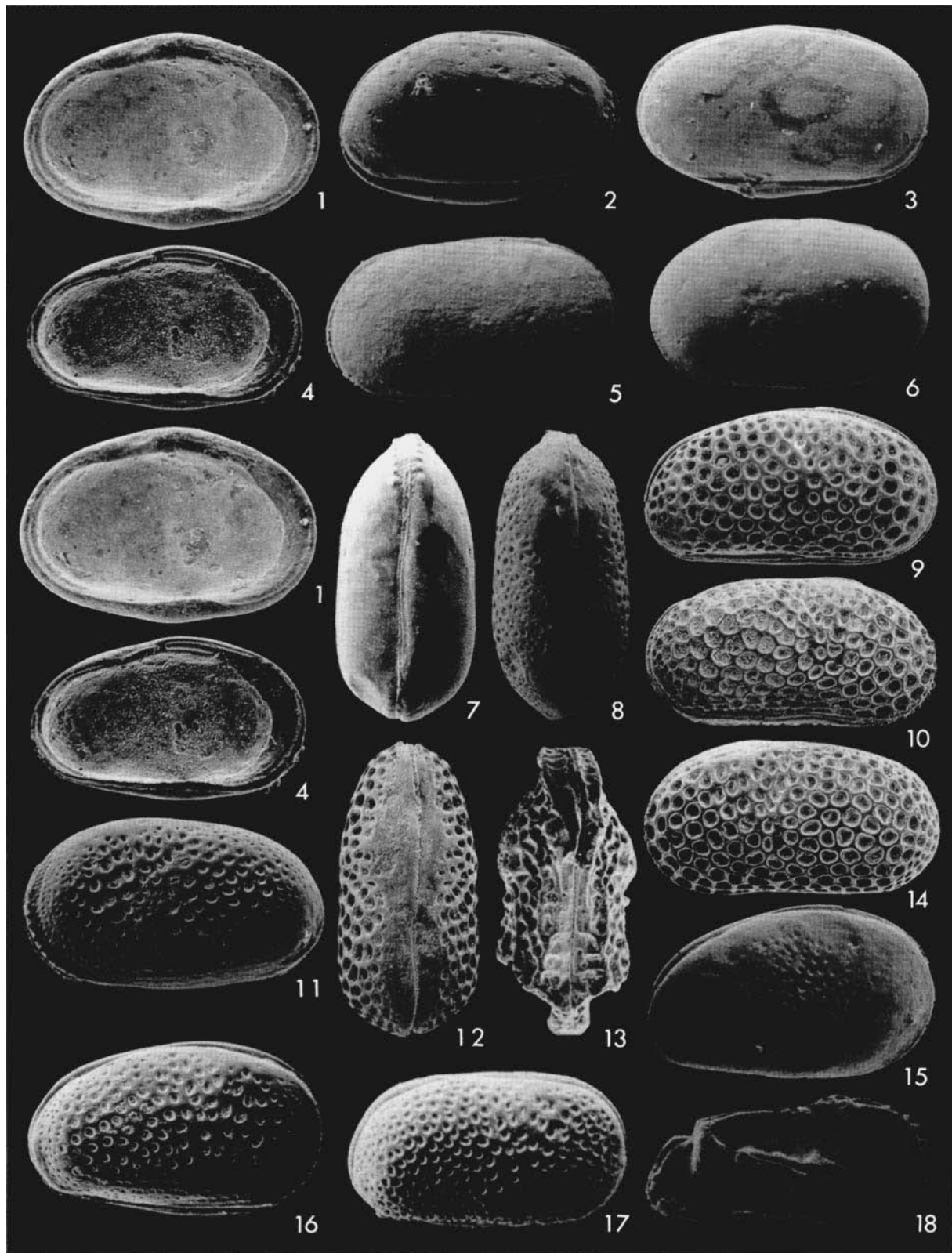
Genus **Bairdoppilata** Coryell, Sample & Jennings, 1935

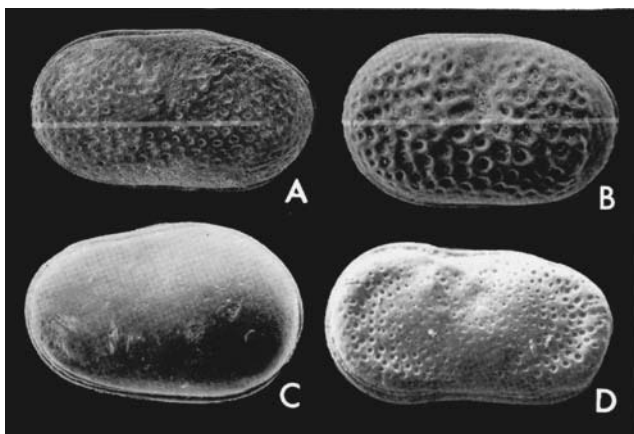
Three species of this genus have been recognised. *Bairdoppilata triangulata* Edwards, 1944 is conspecific with the species described under this name by Keij (1955) and

#### Explanation of Plate 2

Figs 1,4 stereoscopic paired photographs, internal views.

Figs 1-3, 7. *Cyprideis maradaensis* sp. nov.: Fig.1, F L V, Holotype, A12581, x75, L 670; Fig.2, F R C, A12582, x73, L 735; Fig.3, M R C, A12583, x79, L 639; Fig.7, F V C, A12585, x78, L 651. Figs 4,8, 11, 16. ?*Cytheridea* sp.: Fig.4, F L V, A12708, x88, L 558; Fig.8, F D C, A12710, x90, L 566; Fig.11, M L C, A12709, x83, L 624; Fig.16, M R C, A12707, x83, L 618. Fig.5. *Cyprideis* sp.A: R C, A12586, x78, L 658. Fig.6. *Neocyprideis* sp.: L C, A12591, x68, L 755. Figs 9,10, 12, 14. *Cytheridea joshensis* sp. nov. Fig.9, F R C, Holotype, A12711, x90, L 566; Fig.10, M R C, 12713, x83, L 612; Fig.12, F D C, 12714, x98, L 525; Fig. 14, M L V, 12712, x88, L 588. Fig.13. *Hermanites zaltensis* sp. nov.: F D C, A12701, x64, L 781. Fig.15. *Cytheridea* sp. R C, A12715, x90, L 520. Fig.17. *Cyprideis* sp. B: R C, A12589, x73, L 668. Fig.18. *Neocaudites nudicosta* (Yassini): R C, A12687, x80, L 637.





**Fig.2.** A. *Cytherella* cf. *porchella* Ruggieri, female left car, A12654, x64, L 625; B. *Cytherella* sp. A, left car, A12646, x77, L 519; C. *Cytherella* sp. B, left car, A12644, x60, L 673; D. *Cytherelloidea* sp., left car, A12652, x85, L 600.

Moyes (1965) from the Aquitanian of southwest France, but it is not clear whether these should really be placed into Edwards' species which was described from the Miocene of North Carolina, U.S.A. *Bairdoppilata* sp. B and differs from *Bairdoppilata* sp. A in its smaller size and in having a more evenly curved dorsal margin, more pointed posterior, and a less upwardly curved postero-ventral area.

Genus *Bythocypris* Brady, 1880

**Material.** *B. triangulata*, 2 valves; No A12718, from Well C1a-97 at depth 1730 feet; *B. sp. A* 2 carapaces, No A12716 from Wells G1-97 at depth 1260ft and F1-97 at 1530 ft.; *B. sp. B*, 2 carapaces; No A1271 from Wells G1-97 at depth 1540ft and F1-97 at 1110ft.

*Bythocypris tripoliensis* sp. nov

(Pl. 1, figs 4-6)

**Derivation of name.** After the capital of Libya.

**Diagnosis.** Carapace elongate in lateral outline; dorsal margin arched; surface smooth.

**Holotype.** Female right carapace; No A12671, from well G1-97 at depth of 1540ft.

**Material.** Twenty five carapaces and one valve, occurring throughout all three wells; No A12670-673.

**Description.** Carapace elongate in lateral view, with greatest height near centre of carapace. Left valve larger than right, overlapping all around margin; dorsal margin arched; ventral margin slightly convex in left valve.

relatively straight in right; anterior margin broadly rounded; posterior margin obliquely rounded; carapace ovoid in dorsal view; maximum length centrally. The surface of the carapace is smooth. Internal features not observed. Sexual dimorphism is distinct with smaller and more elongate males.

**Dimensions of figured specimens (in  $\mu\text{m}$ ).**

	Length	Height	L/HH
Female right carapace; No A12671	869	459	1.85
Female left carapace; No A12672	816	432	1.88
Male right carapace; No A12670	800	368	2.17

**Remarks.** This shows some similarity to the specimens described as *Bythocypris alejo* Reymont by Carbonnel (1986), although the outline is not quite the same, the species described here being more elongate. It is also similar in size to *Disopontocypris schwejeri* Van Den Bold (1966), but differs from the latter in the outline of the dorsal and anterior margins; in *B. tripoliensis* the dorsal margin slopes downwards towards the anterior giving a more tapered anterior in the female, and has a more humped dorsal margin.

Superfamily **Cypridacea** Baird, 1845

Family **Cyprididae** Baird, 1845

Subfamily **Disopontocypridinae** Mandelstam, 1956

Genus **Disopontocypris** Mandelstam, 1956

*Disopontocypris schwejeri* Van Den Bold, 1966

(Pl. 1, fig. 10)

**Material.** 9 carapaces and 1 valve; only present in Well C1a-97 between 770-950 ft.; No A12674-76.

**Remarks.** This was originally described from the Neogene of Gabon (Van Den Bold 1966), and subsequently from the Burdigalian of Algeria (Coutelle & Yassini, 1974) and the Neogene of Senegal (Carbonnel 1986). The specimens described here are larger than those listed above:

	Length	Height
Right carapace; No A12674	984	468
Left carapace; No A12675	934	436
Coutelle & Yassini (1974)	620	430
Van Den Bold (1966)	790	370
Carbonnel (1986)	850	420

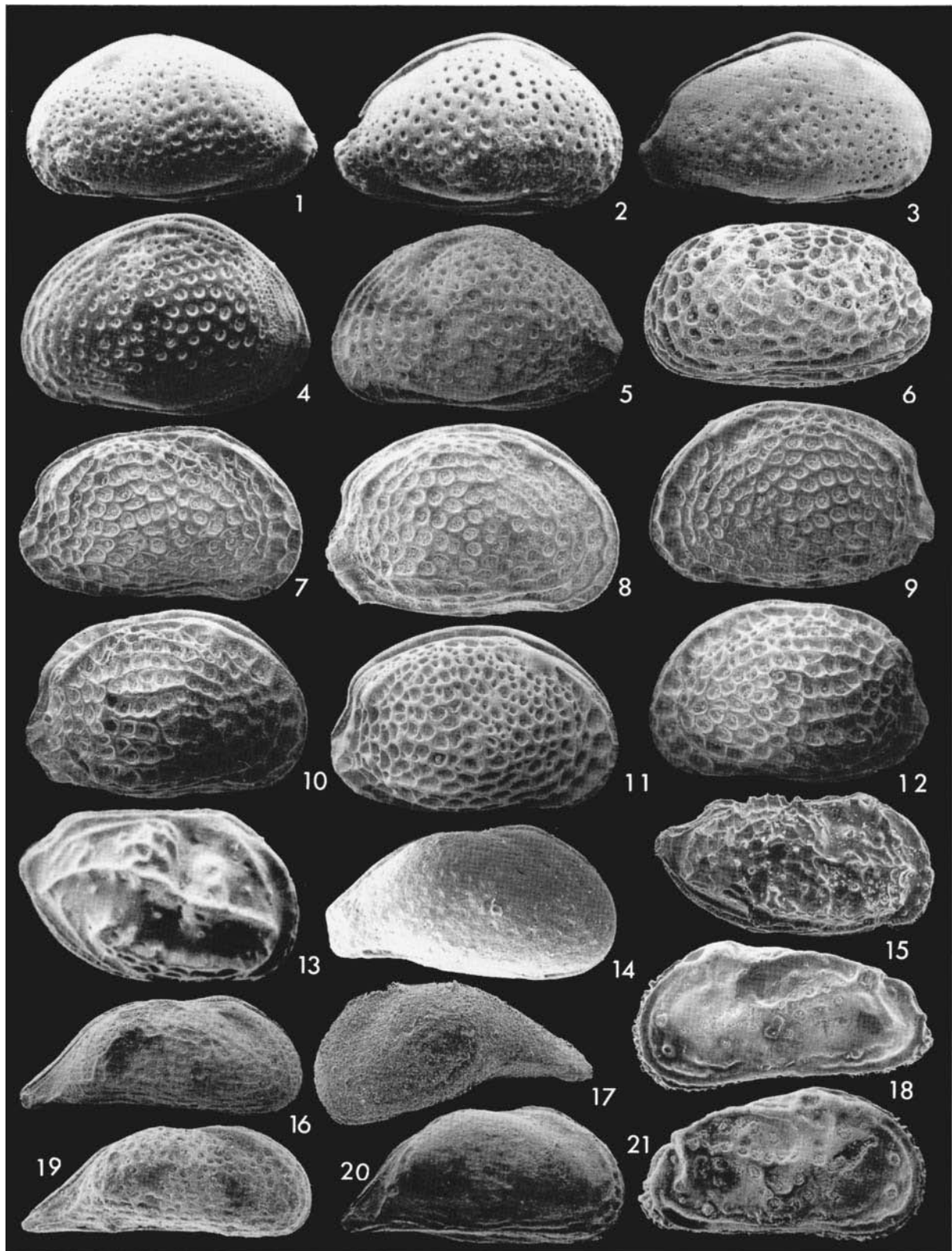
There seems to be an error in the dimensions given by Coutelle & Yassini according to their photographs. The Libyan specimens are very similar in outline to those illustrated by Carbonnel.

**Explanation of Plate 3**

**Figs 1-3.** *Aurila soummamensis* Coutelle & Yassini: **Fig.1**, M L C, A12559, x71, L 711; **Fig.2**, F R C, A12562, x78, L 685; **Fig.3**, M R C, A12558, x 74, L 693. **Figs 4,5.** *Aurila* gr. *convexa*: **Fig.4**, F L C, A12566, x 100, L 510; **Fig.5**, M L C, A12569, x90, L 556.

**Fig.6.** *Urocythereis* cf. *sorocula* (Seguenza): L C, A12706, x93, L 541. **Figs 7-9.** *Pokornyella deformis minor* (Moyes): **Fig.7**, M R C, A12624, x73, L 689 **Fig.8**, F R C, A12625, x68, L 725; **Fig.9**, F L C, A12626, x70, L 714. **Figs 10, 12.** *Pokornyella* sp.: **Fig.10**, F R C, A12630, x 75, L 653; **Fig.12**, M L C, A12631, x 75 L 680. **Fig.11.** *Pokornyella* cf. *deformis*: F R C, A12632a, x 67, L 748. **Fig.13** *Neomonoceratina keiji* Szczechura: F R C, A12608, x103, L 468. **Figs 14, 17.** *Paijenborchellina libyca* Szczechura: **Fig.14**, F R C (posterior broken), A12688, x85, L 588; **Fig.17**, F L V, A12689, x73, L 703. **Fig.15.** *Neomonoceratina laskerevi* Krstic & Pietrzeniuk: M R C, A12602, x90, L 561. **Figs 16,19, 20.** *Paijenborchellina keeni* Gammudi sp. nov.: **Fig.16**, M R C, Holotype, A12691, x 78, L 850; **Fig. 19**, M R C, A12692, x76, L 666; **Fig. 20**, F R C, A12690, x78, L 638. **Figs 18, 21.** *Falsocythere maccagnoi* Ciampo: **Fig. 18**, M L C, A12685, x85, L 600; **Fig.21**, F R C, A12684, x90, L 538





Family **Paracyprididae** Sars, 1923Genus **Paracypris** Sars, 1866

Three species of this genus have been recognised. *Paracypris* aff. *P. polita* Sars 1866 resembles *Paracypris polita* Sars (1866) described from the Burdigalian of South West Anatolia, Turkey, by Gokçen (1986); the latter differs in lateral outline, being more elongate and having a more tapered posterior margin and more obliquely rounded anterior margin. *Paracypris polita* described from the Upper Oligocene-Helvetian of the Aquitaine Basin (Keij, 1955 and Moyes 1965), differs in being more elongate and in having a highly tapered posterior. *Paracypris* sp. A shows similarities with *Paracypris rosefieldensis* described from the lower Miocene of Southern Trinidad (Van Den Bold, 1957) but the latter has a more pointed posterior and it is larger. *P. sp. A* differs from *Propontocypris* sp. in the pointed posterior margin and smaller size. *Paracypris* sp. shows some similarities to *Paracypris* sp. described from the Neogene of Rhodes (Mostafawi, 1989), but the latter differs in having maximum height at 1/3 length of carapace from anterior, dorsal margin is slightly rounded, and postero-dorsal margin slightly curved rather than straight. This species also shows some similarities with *Paracypris polita* Sars described from the Burdigalian of south west Anatolia, Turkey (Gokçen 1986), but differs in having a longer and curved antero-dorsal margin.

**Material.** *P. aff. P. polita*, 1 carapace; No A12683 from Well C1a-97 at depth 1730 feet. ; *P. sp. A*, 5 carapaces, No A12677-79 from Well F1-9 at 990, 1170 ft.; *P. sp.*, 1 carapace, No A12680 from Well F1-97 at depth 1290 ft.

Family **Pontocyprididae** G. W. Müller, 1894Genus **Propontocypris** Sylvester-Bradley, 1947**Propontocypris** sp.

(Pl. 1, fig. 11)

**Material.** 2 carapaces; No A12681-682 from Well C1a-97 at depth of 1340 ft.

Superfamily **Cytheracea** Baird, 1850Family **Cytheridae** Baird, 1850Genus **Cnestocythere** Triebel, 1950**Cnestocythere truncata** (Reuss, 1850)

(Pl. 1, figs. 13, 14)

**Material.** 2 carapace and 1 valve; No A12592-3; Well Gi-97, 1570 ft.; Well F1-97, 1050, 1230.

**Remarks.** This widespread species, first described from the

Tortonian of the Vienna Basin (Reuss 1850) is also recorded from the Aquitanian-Burdigalian of France (Keij 1955, Moyes 1965, and Carbonnel 1969) from the Tortonian of central Sicily (Ruggieri 1962), from the Upper Miocene of Libya (El-Waer, 1992) and from the ?middle Miocene Marada Formation and Hommath Formation of Egypt (Szczechura & Abd-Elshafy 1989). Triebel (1950) described two species from the Tortonian of the Vienna Basin: *Cnestocythere lamellicosta* n.sp. and *C. truncata* (Reuss); the former has sharp and high ridges while the latter has low rounded ridges, our specimens have low and rounded ridges.

Family **Cytherettidae** Triebel, 1952Genus **Cytheretta** G. W. Müller, 1894

Two species are recorded, *Cytheretta* cf. *semipunctata* Bornemann, 1885 and *Cytheretta* sp. A. The former is similar to *Cytheretta* aff. *semipunctata* described from the Lower Miocene of the Rhone Basin in France (Carbonnel 1969), but differs in shape and arrangement of punctae. In our specimens these are variable in size, forming four rows in the postero-central area and extending both posteriorly and anteriorly as scattered and smaller sized punctae; the remainder of the carapace is smooth.

*Cytheretta* sp. A has an ornamentation consisting of seven longitudinal ridges in the posterior part of the carapace, with weakly developed reticulation between them; one specimen also has very indistinct rows of punctae in the antero-ventral part of the valve. It is similar to *Cytheretta ishizakii* Bonaduce et al 1992, described from the Sahelian of offshore Tunisia. It differs in lacking the postero-ventral punctae which characterise *C. ishizakii*. El Waer (1992) described two species, *Cytheretta* sp. A and *Cytheretta* sp. B from the late Miocene of Libya. They appear to us to be conspecific, the only difference being the greater prominence of the punctae in *Cytheretta* sp. A. Our species lacks the punctae present in the postero-dorsal, central, and ventral areas of El Waer's species. The presence of these punctae also separates El Waer's species from *C. ishizakii*. These three taxa do appear to be closely related however. **Material.** *Cytheretta* cf. *semipunctata*, 3 carapaces; No A12667-669 from Well F1-97 at 1230 ft. *Cytheretta* sp. A 6 carapaces; No 12663-666 from Well C1a-97 at depth of 770 feet.

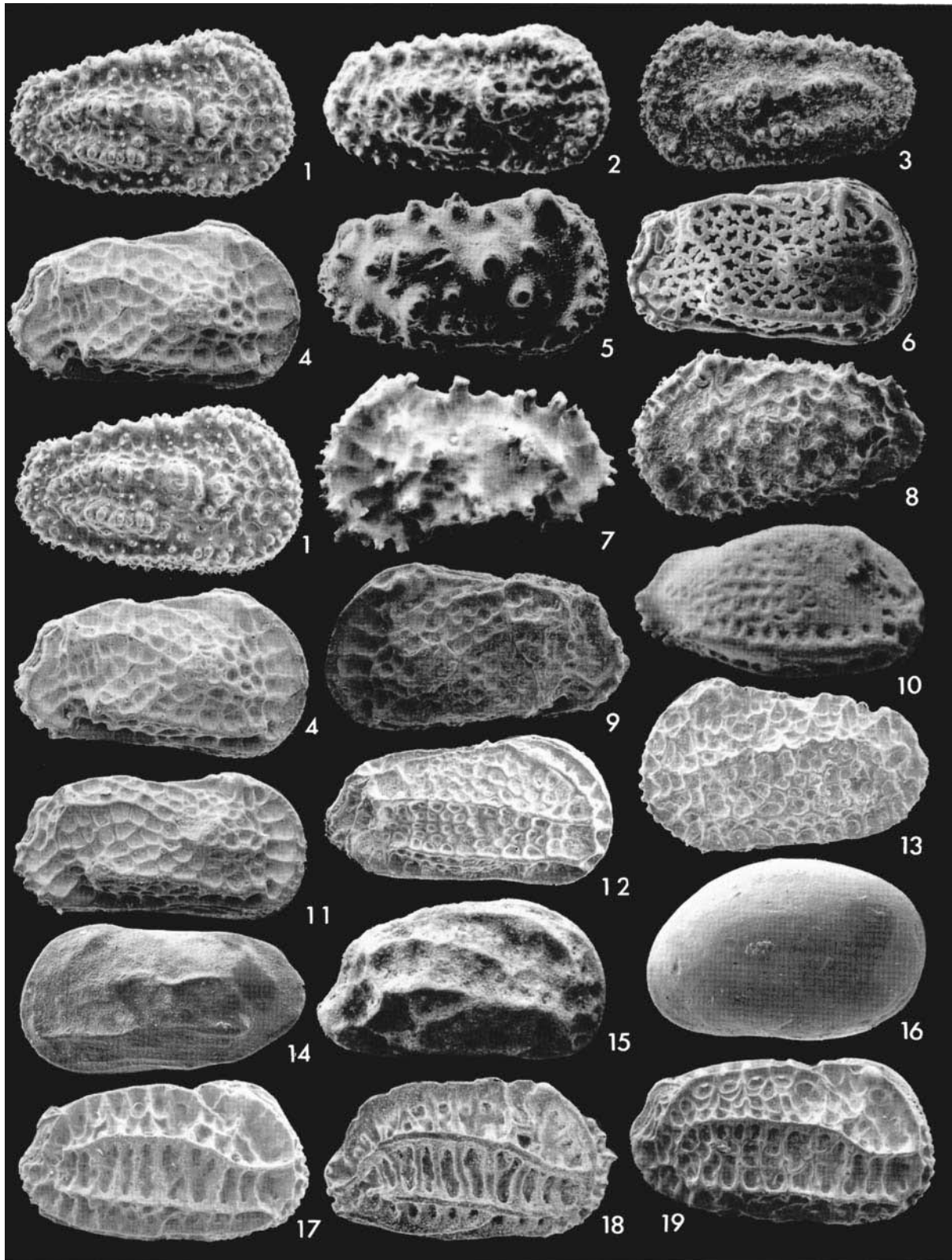
Family **Cytherideidae** Sars, 1925

## Explanation of Plate 4

Figs 1, 4 stereoscopic paired photographs.

Figs 1-3. *Actinocythereis sirtensis* sp. nov.: Fig. 1, F R C, Holotype, A12556, x80, L 638; Fig. 2, M R C, A12554, x74, L 700; Fig. 3, M L C, A12555, x76, L 672. Figs 4, 9, 11. *Hermanites zaltanensis* sp. nov.: Fig. 4, F R C, A12699, x60; L 841 Fig. 9, F L C, A12700, x60, L 875; Fig. 11, M R C, Holotype, A12698, x53, L 952. Fig. 5. *Actinocythereis libyaensis* El-Waer: F R C, A12553, x70, L 714. Fig. 6. *Hermanites haidingeri haidingeri* (Reuss): F R C, A12704, x70, L 714. Fig. 7. *Actinocythereis spinosa* El-Waer: L V, A12550, x60, L 815. Fig. 8. *Acanthocythereis hystrix* (Reuss): F L C, A12634, x70, L 742. Fig. 10. *Ruggieria* aff. *dorukae* Bassiouni: M R V, A12641, x73, L 669. Fig. 12. *Cistocythereis qabilatshurfahensis* El-Waer: R C, A12594, x90, L 566. Fig. 13. *Cistocythereis* cf. *caelatura* Uliczny: F L V, A12659, x80, L 637. Fig. 14. *Ruggieria tetraptera tetraptera* Sequenza: M R C, A12638, x60, L 833. Fig. 15. *Caudites* sp.: R C, x64, L 765. (specimen lost) Fig. 16. *Xestoleberis* cf. *reymenti* Ruggieri: F L C, A12696, x95, L 515. Fig. 17. *Chrysocythere cataphracta cataphracta* Ruggieri: F R C, A12573, x70, L 716. Fig. 18. *Chrysocythere alkhumia* El-Waer: F R V, A12571, x83, L 599. Fig. 19. *Chrysocythere paradisus* Doruk: F R C, A12579, x68, L 772.





Subfamily *Cytherideinae* Sars, 1925  
 Genus *Cytheridea* Bosquet, 1852  
*Cytheridea joshensis* sp. nov Gammudi  
 (Pl.2, figs 9, 10, 12, 14.)

**Derivation of name.** After Josh village, Libya.

**Diagnosis.** A species of *Cytheridea* with surface ornamented by large deep rounded pits.

**Holotype.** Female right carapace; No A12711; well C1a-97 at depth 770ft.

**Material.** Twenty carapaces; No A12711-714. Present in all three well

**Description.** Carapace subovoid in lateral view; with greatest height near anterior; anterior margin evenly rounded, some specimens have very fine spines in the antero-ventral area; posterior margin obliquely rounded; dorsal margin slightly convex and gently sloping posteriorly; ventral margin straight in left valve while in right valve it is slightly concave centrally; maximum height at dorsal cardinal angle. Surface of carapace ornamented by large deep rounded pits; the area of the muscle scars has fossae arranged in a group like the petals of flowers. In dorsal view carapace has almost parallel sides, with bluntly rounded anterior, and posterior margins widest near posterior. Internal features not known. Sexual dimorphism is pronounced, males being more elongate than females.

**Dimensions of figured specimens (in  $\mu\text{m}$ ).**

	Length	Height	L / H
Female right carapace; No A12711	566	305	1.85
Male right carapace; No A12713	612	315	1.94
Male left valve; No A12712	588	308	1.92

**Remarks.** This shows slight similarities to *Cytheridea fournieri* described by Carbonnel (1969) from the Lower Miocene of the Rhone Basin, especially with the surface ornamentation, anterior and ventral margins. The lateral outline differs from typical *Cytheridea* in being less tapered towards the posterior and with a posterior cardinal angle which is quite angular.

***Cytheridea* sp.**

(Pl.2, fig.15.)

**Material.** Five carapaces; No A12715. from Wells C1a-97 at depth 1220ft, G1-97 at 670, 970 and 1010ft and F1-97 at 1530ft.

**Remarks.** This is similar to *Cytheridea josephinae* Kollmann 1960, recorded from the middle Tortonian of Austria, but differs in the postero-ventral area being broadly rounded as well as in the ornamentation which consists of different sized weak punctae situated in the centre of the valves, the remainder of the carapace being smooth.

**? *Cytheridea* sp.**

(Pl.1, figs 4,8,11,16 )

1989 ?*Miocyprideis* cf *italiana* Szczechura, p. 94-95, pl. 4, figs.1-11.

**Material.** 13 carapaces and seven valves; No A12707-710.

**Description-** Carapace subtrapezoid to subrectangular in lateral outline; anterior margin broadly rounded; posterior

margin obliquely rounded; dorsal margin straight or slightly convex with distinct cardinal angle; ventral margin sinuate, concave in posterior half and slightly convex anteriorly; left valve larger than right and strongly overlapping the whole margin except central anterior. The anterior and posterior ends are flattened; there are 9-10 anterior denticles. Surface of carapace ornamented by rounded pits, the marginal pits are very fine and arranged in rows parallel to the carapace margins. The hinge is tripartite; in the left valve there is an anterior elongate crenulate socket with a thickened ventral wall, a prominent crenulate median element which is sharply defined both to anterior and posterior and situated on a thickened part of the dorsal wall, and a posterior crenulate groove deepening posteriorly; the anterior and posterior elements are of approximately the same length, the median element slightly shorter. Muscle scars typical of the genus. **Dimensions of figured specimens (in  $\mu\text{m}$ ).**

	Length	Height	L / H
Male right carapace; No A12707	618	357	1.73
Female left valve; No A12708	558	388	1.43
Male left carapace; No A12709	624	351	1.77
Female Dorsal view; No A12710	566	-	272

**Remarks.** The generic assignment of this species is difficult. Lateral outline suggests *Cytheridea*, i.e. the highest point is towards the anterior rather than the centre or posterior as in *Cyprideis*, *Neocyprideis* and *Miocyprideis* Kollman 1960. The hinge however is not that of typical *Cytheridea*, as the posterior element cannot be subdivided into two parts. The tripartite hinge resembles that of *Miocyprideis* and *Hemicyprideis* Malz & Triebel 1970, but differs in having a short median element and in the massive nature of the anterior and median elements. The thickened ventral wall of the anterior socket is reminiscent of *Vetustocytheridea* Apostolescu 1956, while the overall appearance also suggests *Hemicyprideis*. Bonaduce *et al* (1992) described a new species, "*Cytheridea*"*nasuta*, from the Pliocene of offshore Tunisia which resembles our species in shape, ornament, hinge and muscle scars, although the dorsal margin is straighter and the species is larger (c.720 $\mu\text{m}$ ).

Genus *Cyprideis* Jones, 1857

***Cyprideis maradaensis* sp. nov.**

(Pl.2, figs 1-3, 7)

**Derivation of name.** After Marada Oasis 120km south Sea shore.

**Diagnosis.** Massive carapace ovate to reniform and smooth with scattered sieve pore canals gives the surface a punctate appearance.

**Holotype.** Female left valve; No A12581, well F1-97 at depth of 1320ft.

**Material.** Sixteen carapaces and one valve; No A12581-585; Wells C1a-97, G1-97 and F1-97.

**Description.** Carapace ovate to reniform in lateral view, left valve markedly larger than the right; dorsal margin of left and right valves differ in outline, left valve is almost straight while the right is arched; maximum height at the

centre of the carapace; anterior margin broadly rounded with some seven small spines on both valves; posterior margin obliquely rounded; ventral margin nearly straight but slightly concave in the antero-ventral area while in the left valve weakly convex; Surface of carapace has scattered punctae; some of these are seen to be sieve type normal pore canals, others are too ill preserved to be sure whether they are pore canals. Internal feature very clear and typical of the genus. Males smaller and slightly more elongate than females.

**Dimensions of figured specimens (in  $\mu\text{m}$ ).**

	Length	Height	L / H
Female left valve; No A12581	670	445	1.50
Female right carapace; No A12582	735	442	1.66
Male right carapace; No A12583	639	379	1.68

**Remarks-** This differs from any described species.

***Cyprideis* sp. A**

(Pl.2, figs.7)

**Material.** 8 carapaces; No A12586-588 from Well C1a-97 at depth 1340 feet. **Remarks.** This species is placed in *Cyprideis* on the basis of subrectangular lateral outline as no internal feature have been observed. It has some similarities with *Cyprideis similis* (Bradely) figured by Van Den Bold. (1963) from the Upper Miocene and Pliocene of Trinidad. The latter species differs in having a more truncated posterior end and lacks the small postero-ventral flange present in our species. The carapace is smooth to slightly pitted, and sexual dimorphism is not pronounced.

***Cyprideis* sp. B.**

(Pl.1, fig.17)

**Material.** 3 Carapaces; No A12589 from Well G1-97, 1510-1570 ft.

**Remarks.** This species is very similar to *Cyprideis* sp. A in lateral outline; it differs in having an ornamentation of prominent pits; finer pits arranged in four rows parallel to the anterior and posterior margins, and coarse pits over the remainder of the carapace; it is also has a small posteroventral spine in the right valve. No internal features have been observed.

**Genus *Neocypridies* Apostolescu, 1956**

***Neocyprideis* sp**

(Pl.2, fig. 6)

**Material.** 5 carapaces; No A12590-91. Wells C1a-97 at depth, 1280, 1550; G1-97, 880; F1-97, 840 ft.

**Remarks.** This is placed in *Neocypridies* on the basis of lateral outline; no internal feature have been observed. It shows some similarity to *Neocyprideis rara* Goerlich, 1953 subspecies *cerestel* in Carbonnel (1969) recorded from the Upper Oligocene of France, but differs in having a more rounded postero-dorsal margin.

Subfamily **Krithinae** Mandelstam in Bubikan, 1958

Genus ***Krithe*** Bradely, Crosskey & Robertson, 1874

***Krithe papillosa*** (Bosquet), 1852

(Pl.1, fig. 12)

**Material.** Thirty carapaces and eight valves from throughout all wells; No. A12619-23.

Family **Cytheruridae** G. W. Müller, 1894

Genus ***Paijenborchellina*** Kuznetsova, 1957

***Paijenborchellina libyca*** Szczechura, 1980

(Pl.3, figs 14, 17)

**Material.** 5 carapaces and 1 valve; No A12688-689 from Wells C1a-97 at depth 1400, 1610ft, G1-97 at 1470ft and F1-97 at 780,810 ft.

**Remarks.** This was described from outcrops of the Upper Miocene of the northern Sirt Basin between Marada Oasis and the Dahra oil fields (Szczechura, 1980).

***Paijenborchellina keeni* sp. nov** Gammudi

(Pl. 3, figs 16, 19, 20)

**Derivation of name.** In honour of Dr. M.C. Keen.

**Diagnosis.** Caudal process relatively short; whole carapace reticulate; central area with weak longitudinal ribs, the ventral most of which is clearly defined at the posterior where it bends sharply downwards.

**Holotype.** Male right carapace; No A12691, well F1-97 at depth of 810ft.

**Material.** Ten carapaces; No A12690-93; Well C1a-97, 1340ft.; G1-97, 640; F1-97, 780-810 ft.

**Description.** Carapace pear shaped in lateral view; anterior margin slightly obliquely rounded; dorsal margin rounded and saddle like; ventral margin straight; maximum height at antero-dorsal area one third from anterior, i.e. at maximum curvature dorsally; reticulation over entire carapace surface. One specimen (Pl.3, fig. 20) is poorly reticulate but has well developed reticulation around the anterior margin; this may be due to preservation or indicate infraspecific variation. Central area with longitudinal ribs, ventral most of which is clearly defined at posterior where it bends sharply downwards; there is a weak depression parallel to the anterior margin. Internal features not known. Sexual dimorphism is distinct, with more elongate males.

**Dimensions of figured specimens (in  $\mu\text{m}$ ).**

	Length	Height	L / H
Male right carapace; No A12691	650	258	2.5
Male right carapace; No A12692	666	253	2.63
Female right carapace; No A12690	638	316	2.00

**Remarks.** *Paijenborchellina keeni* shows some similarities to *Paijenborchellina libyca* (Szczechura, 1980) differing in having a relatively short caudal process, in lateral outline, as well as having differently shaped reticulation. *P. punctata* El-Waer 1992 differs in being finely punctate and is also more elongate.

Family **Hemicytheridae** Puri, 1953

Genus ***Aurila*** Pokorny, 1955

***Aurila soummamensis*** Coutelle & Yassini, 1974

(Pl.3, figs1-3)

1974 *Aurila soummamensis* n sp Coutelle & Yassini, 1974. p.93, pl.1, figs.10, 11, 13, 14, 17, & pl.3, fig.11.

1979 *Aurila soummamensis* Coutelle & Yassini, Bassiouni, p.123, pl. 20, figs.12-15.

1984 *Aurila soummamensis* Coutelle & Yassini, Gokcen, p.47-48, figs.1-5.

**Diagnosis.** A species of *Aurila* with triangular lateral outline; dorsal margin broadly arched and ornamented with fine to medium punctae.

**Material.** 25 carapaces and 2 valves; No A12558-56 from the lower parts of all wells; from 1070 downwards in C1a-97, 880 in G1-97, and 1020 in F1-97.

**Remarks.** *Aurila soummamensis* is recorded from the Lower Miocene of Algeria (Coutelle & Yassini 1974) and Turkey (Bassiouni, 1969, Gokcen 1984).

*Aurila gr convexa* Baird, 1850  
(Pl.3, figs 4,5)

**Material.** Fifteen carapaces and four valves; No A12565-570; C1a-97, 830,1130, 1280-1340; G1-97, 1100,1230; F1-97, 1200, 1410, 1500, 1590-1650.

**Description.** Carapace triangular in lateral view; dorsal margin rounded to arched; maximum height slightly behind centre of carapace; anterior margin obliquely rounded; posterior margin truncate with very short caudal process; ventral margin concave in the anterior part and slightly convex posteriorly; left valve larger than right valve and strongly overlaps the right; the surface is ornamented by variable sized punctae; anterior margin with four parallel rows of quadrate reticulation. No internal feature were observed. Sexual dimorphism is distinct, males being more elongate than females.

**Remarks.** *Aurila gr convexa* is similar to *Aurila (Aurila) maculosa* (Uliczny 1969) in lateral outline but the latter has its maximum height located at the mid length of the carapace while in our specimens the maximum height is situated just to the posterior of mid length.

Genus *Caudites* Coryell and Field, 1937

*Caudites* sp.  
(Pl.4, fig. 15)

**Material.** One carapace lost after photography, from Well C1a-97 at 1070ft.

Genus *Pokorniyella* Oertli, 1956

*Pokorniyella deformis minor* (Moyes, 1965)  
(Pl.3, figs 7-9)

1955 *Hemicythere deformis* Reuss, Keij, p.123, pl. 8, figs. 5-7.

1965 *Hemicythere deformis minor* Moyes n ssp p.99, pl.13, figs. 1-4

1977 *Pokorniyella deformis minor* (Moyes), Ruggieri, Russo, Bossio, pl.1, figs 2-4b.

1979 *Pokorniyella deformis minor* (Moyes), Bassiouni, p.112-113. pl.19, figs. 18-21.

1986 *Hemicythere deformis minor* Moyes, Gokçen, p. 47, pl. 3, figs 11-21.

1989 *Pokorniyella deformis minor* (Moyes), Szczechura & Abd-Elshafy, p. 306-307, pl. 6, Fig. 1,2a ,2b.

**Material.** 25 carapaces and 4 valves from all wells; No A12624-629.

**Remarks.** *Pokorniyella deformis minor* Moyes is smaller than the nominate subspecies. It is recorded from the lower Miocene of the Aquitain Basin in France (Moyes, 1965), the lower Miocene of Turkey (Bassiouni, 1979), the lower Aquitanian to Burdigalian of the Kale-Yensehir region of Turkey (Gokçen 1985-86) and is described from ?middle Miocene of the central Sirt Basin and western coast of the Gulf of Suez, Egypt (Szczechura & Abd-Elshafy 1989). Ruggieri, Russo & Bossio (1977), have illustrated topotype material of both *Pokorniyella deformis deformis* and *Pokorniyella deformis minor*. The diagnostic feature of *P. deformis minor*, apart from smaller size, is the presence of a short ridge at the postero-dorsal angle.

*Pokorniyella cf P. deformis* (Reuss) 1850.  
(Pl.3, fig. 11)

**Material-** Eight carapaces from Well C1a-97 at depth of 770 to 1160 ft, G1-97 at 640, 910-970ft and F1-97 at 1120-1150, 1200-1230ft.; No A12632.

**Remarks.** The specimens differ from *Pokorniyella deformis minor* in having a more arched dorsal margin, especially at the posterior, having a stronger ventral ridge and in being coarsely punctate rather than reticulate. It has fine punctae around the dorsal and antero-dorsal margins.

*Pokorniyella* sp.  
(Pl.3, figs 10, 12)

**Material-** Twelve carapaces and two valves from Wells C1a-97 at depth 950,1010, 1280 ft, G1-97 at 1160ft and F1-97 at 690 and 720ft; No A12630-631.

**Remarks.** This is similar to *Procythereis sulcatopunctatus* (Reuss 1850) described from the middle Miocene of Turkey by Bassiouni (1979), but differs in having a more curved dorsal margin, and a more obliquely rounded anterior margin. This is very similar to *Procythereis sulcatopunctatus* of El-Waer (1992)) from the Upper Miocene Al khums Formation of Libya.

Genus *Urocythereis* Ruggieri, 1950  
*Urocythereis cf. U. sorocula* Uliczny,1969  
(Pl.3, fig.6)

**Material.** One carapace from Borehole G1-97 at depth of 1190 ft; No A12706.

**Remarks.** This shows great similarities in lateral outline to *Urocythereis sorocula* from the Pliocene of Reggio di Calabria (Sissingh, 1972) but the latter differs in having elongate groove more or less parallel to the anterior margin which is weakly developed in our species, as well as differences in the pattern of reticulation. *U. sorocula* is also described from the Pliocene of Spain (Carbonnel & Magne, 1977).

Family *Loxoconchidae* Sars, 1925  
Genus *Loxoconcha* Sars,1866  
*Loxoconcha gr ovulata* (Costa), 1853  
(Pl.1,fig. 18)

1853 *Cytherina ovulata* Costa, p.177, pl.16, fig.7.

1984 *Loxoconcha* gr *ovulata* (Costa), Bonaduce & Russo, p. 434, pl. 5, fig. 9.

**Material.** Eight carapaces; No A12648-651; Well C1a-97,950,1130,1220, 1610; Well G1-97, 1190,1260, 1540; Well F1-97, 960, 990, 1080, 1230, 1260, 1440, 1500, 1560-1620.

**Remarks.** This is very similar to the *Loxoconcha* gr *ovulata* Costa described from the lower Tortonian-Early Messinian of Capo S. Marce, western Sardinia by Bonaduce & Russo (1984). Our specimens differ in having a less curved dorsal margin.

Family **Schizocytheridae** Howe, 1961

Genus *Neomonoceratina* Kingma, 1948

*Neomonoceratina keiji* Szczechura, 1989

(Pl.3, fig.13)

1989 *Neomonoceratina keiji* Szczechura p. 921-992, pl. 8, fig. 2-7 & 10, 11.

**Material.** 190 Carapaces and 20 valves from all wells and all depths; No A12606-611.

**Diagnosis.** A species of *Neomonoceratina* with reticulation present but poorly developed; reticulation is strongest to the posterior of dorsal sulcus and below the ventral ridge; much of the surface is smooth with prominent pore cones.

**Remark.** This is similar to *Neomonoceratina miocaenica* (El-Waer 1988) from the Upper Miocene of N.W Libya. El-Waer's species differs in having stronger reticulation present over the whole surface, a less accentuated ventral ridge and the antero-dorsal ridge running from eye tubercle to join with the median ridge. The variation in the reticulation in figured species compared with *N. miocaenica* is suggestive of ecophenotypic variation. However, no variation has been observed in the specimens studied and as this common species is found throughout the wells, reticulation is regarded as a genuine character for differentiating species. This species occurs throughout the Marada Formation as well as in the Hommath formation of ?middle Miocene age of the western coast of the Gulf of Suez (Egypt).

*Neomonoceratina laskarevi* Krstic & Pietrzeniuk, 1972

(Pl.3, fig. 12)

1972 *Neomonoceratina laskarevi* Krstic & Pietrzeniuk, 110, pl.1-3.

1973 *Neomonoceratina mouliana* Sissingh, Doruk Stereo Atlas of Ostracod shells, 1,

1980 *Neomonoceratina laskarevi* Krstic & Pietrzeniuk, Van Hinte, 212, pl. 1.2, fig. 5.

1982 *Neomonoceratina laskarevi* Krstic & Pietrzeniuk, Aruta, 118, pl.4, figs 15-17.

1985 *Neomonoceratina mouliana* Sissingh, El-Waer, 40, pl. 4, figs 36.

1988 *Paijenborchellina laskarevi* Krstic & Pietrzeniuk, Bonaduce *et al.*, pl. 1, fig. 5.

1989 *Neomonoceratina ruggierii* Szczechura, 293-294, pl. 8, figs. 1, 7, 9, 12-15.

**Material.** 34 carapaces and 4 valves from all wells and horizons; No A12602-05.

**Remarks.** The reticulation is not as prominent as that illustrated by other workers, while the pore conuli are more

prominent. The specimens figured by Van Hinte (1980) and Bonaduce, *et al.* (1988) are very similar to the specimens studied here; it is not clear whether the differences noted warrant specific or subspecific separation. The figured specimen differs from typical *N. laskarevi* in having a more ornamentated posterodorsal area, and a more prominent median ridge.

Family **Trachyleberididae** Sylvester-Bradley, 1948

Genus *Acanthocythereis* Howe, 1963.

*Acanthocythereis hystrix* (Reuss, 1850)

(Pl.4, fig.8)

**Material.** Two adult carapaces and one Juvenile carapace from Well F1-97 at depth 1590 and 1800ft ; No A12633-635.

**Remarks.** This species has a long stratigraphic range from Miocene to Recent, and is widely distributed in the Mediterranean area and adjoining regions. A complete synonymy can be seen in Athersuch (1979) and Mostafawi (1981). It was first described from the Badenian (Middle Miocene) of the Vienna Basin (Reuss 1850).

Genus *Actinocythereis* Puri, 1953

*Actinocythereis libyaensis* El-Waer, 1992

(Pl.4, fig. 5)

**Material.** 4 carapaces from Well C1a-97 at depth of 770 feet; No A12551-553.

**Remarks.** This was described from the Upper Miocene Al Khums Formation of North west Libya (Al-Waer, 1992).

*Actinocytheries spinosa* El-Waer, 1988.

(Pl.4, fig.7)

**Material.** One left valve from Well G1-97 at depth of 1040 feet; No A12550.

**Remarks.** El-Waer based his new species on 3 left valves from the Late Miocene Al khums Formation. These are all more elongate than the specimen described here, so there is the possibility of sexual dimorphism, those figured by El-Waer being male while that described here is female. A feature not mentioned by El-Waer is the presence of reticulation at the posterior as well as anterior.

*Actinocythereis sirtensis* sp. nov

(Pl.4, figs 1-3 )

**Derivation of name.** After the Sirt Basin

**Diagnosis.** A species of *Actinocythereis* characterized by well developed surface reticulation as well as three longitudinal rows of spines.

**Holotype.** Female carapace; No A12557, well F1-97 at depth of 1490ft.

**Material-** five carapaces; No A12554-557 from Wells C1a-97, 1730, 1850 ft. & F1- 97, 1590.

**Description.** Carapace subrectangular in lateral view; maximum height at anterior cardinal angle; dorsal margin straight; ventral margin slightly convex and curved upward posteriorly; anterior margin broadly rounded, with marginal denticles and a row of eight small tubercles around the anterior rim; posterior margin subtriangular,

with spines. Carapace ornamented by three longitudinal rows of spines or nodes; dorsal row consists of six spines, some being bifid; median row starts from antero-central area and consists of six spines formed into two groups of three spines separated by a small gap; seven spines form the median row which ends in a central posterior position; ventral row is the shortest, consists of eight spines starting at the middle of the ventral margin runnings backwards ending in the postero-ventral area. The remainder of carapace reticulate with subrounded pits. Internal features not known. Sexual dimorphism is distinct, males being more elongate.

#### Dimensions of figured specimens (in $\mu\text{m}$ ).

	Length	Height	L / H
Male right carapace; No A12554	700	365	1.91
Male left carapace; No A12555	672	342	1.96
Male left carapace; No A12556	638	341	1.87
Female right carapace; No A12557	658	332	1.98

**Remarks.** This differs from *Actinocythereis spinosa* El-Waer, 1988 in having a well defined median row of spines, while *A. spinosa* lacks the well defined reticulation of *A. sirtensis*; *A. libyaensis* differs in the arrangement of the median large spines as well as having a smooth carapace.

Genus *Carinivalva* Sissingh, 1973  
*Carinivalva carinata* (Moyes), 1965  
 (Pl.1, fig.19)

**Material.** 30 carapaces and two valves distributed throughout all three wells; No A12597-601.

**Remarks.** This species was first described from the Upper Miocene of the Aquitain Basin and is also recorded from the Rhone Basin (Carbonnel, 1969), from the Upper Miocene Tortonian of Portugal (Nascimento, 1983) and from the Upper Miocene of Al Khums Formation of North West Libya (El-Waer, 1988).

Genus *Chrysoythere* Ruggieri, 1962

**Remarks.** Species of *Chrysoythere* are separated on the basis of lateral outline, the exact pattern of the median longitudinal ridge, and details of the intercostal ornamentation. Using these criteria three distinct species can be recognized in the material studied. The first of these is regarded as being conspecific with *Chrysoythere cataphracta cataphracta* Ruggieri, 1962 in which the median ridge ends before reaching the posterior, and the intercostal ornamentation is dominated by vertical connecting ribs giving rise to vertically oriented elongate reticulation. The second species is placed in *C. paradisus* Doruk, 1973; the ornamentation is identical, although the posterior dorsal angle is less rounded than in Doruk's illustration. *C. paradisus* differs from *C. cataphracta* in having smaller, more even reticulation between the longitudinal ridges. *C. cataphracta muricata* El-Waer 1992 differs from *C. paradisus* in being slightly elongated and in details of ornamentation. The third species is identified as *C. alkhumia* El-Waer 1992 which is similar to *C. cataphracta*, but has a prominent downturned median ridge at the posterior giving a very

characteristic outline to the median ridge. *Chrysoythere cataphracta* of Bassiouni (1979) differs from all these Libyan specimens in details of longitudinal ridges and intercostal ornamentation.

Variation in the intercostal ornament is seen in illustrations of *C. cataphracta* given by various authors. The longitudinal ridges are connected by a series of vertical ribs giving the impression of very coarse vertically orientated elongate reticulae; in Ruggieri's original illustration these elongate reticulae can be seen to be subdivided by weak horizontal reticulation; this character appears to vary in strength, i.e. in Aruta (1982), the intercostal ornamentation seems to consist of small even reticulation, while in Carbonnel (1986), the reticulation is almost non-existent as in the Libyan specimens. The dorsal margin of the left valve is parallel to the ventral margin and does not show the slight posterior tapering seen in the illustration of Ruggieri (1962) and of Aruta (1982) but is similar to those of Sissingh (1972) and Carbonnel (1986).

**Material.** *C. cataphracta cataphracta*, 15 carapaces and 1 valve, Well C1a-97, 770, 1160, 1340, 1400, 1730; Well G1-97, 640, 1130, 1350; Well F1-97, 990, 1020, 1170; *C. paradisus*, 8 carapaces and 1 valve, Well C1a-97, 770; Well F1-97, 600, 660, 690, 900, 930, 1140, 1530; *C. alkhumia*, 1 valve, Well F1-97, 930.

Genus *Cistacythereis* Uliczny, 1969  
*Cistacythereis qabilatashurfahensis* El-Waer, 1992.  
 (Pl.4, fig.12)

**Material.** Six carapaces from Wells C1a-97 at 770 and 1160 ft and F1-97 at 1260-1290 ft; No A12594-596.

**Diagnosis.** A species of *Cistacythereis* with three strong longitudinal ridges and a fourth ridge parallel to the anterior margin; prominent deep fossae and strong muri.

**Remarks.** This was described from the Upper Miocene Al Khums Formation, N.W. Libya.

*Cistacythereis* cf. *C. caelatura* Uliczny, 1969  
 (Pl.4, fig.13)

1989 *Cistacythereis* cf. *C. caelatura* Szczechura, 298-99, pl.1, fig.2, pl.3, figs 10-12.

**Material.** 20 carapaces and six valves from Wells C1a-97 at 770, 830, 950, 1070-1160, and F1-97 at 720-810, 870-930, 990-1050, 1140, 1170. ; No A 12656-662.

**Remarks.** This is similar to *C. caelatura* originally described from the Pliocene of Greece (Uliczny, 1969), but differs in having weaker lateral longitudinal ridges and more numerous intercostal reticulation. The specimens described by Szczechura & Abd-Elshafy (1989) from the ?Miocene Hommath Formation of Egypt and the Marada Formation of Libya show variation in ornamentation but include specimens identical to those described here.

Genus *Falsocythere* Ruggieri, 1972  
*Falsocythere maccagnoi* Ciampo, 1971  
 (Pl.3, figs 18, 21)

1971 ?*Occultocythereis maccagnoi* Ciampo, p.27, pl.2, fig.7-9,



pl. 3, fig. 1.

**Material.** Four carapaces from Wells C1a-97 at depth of 1730 feet and F1-97 at depth of 1590 ft.; No A12684-686.

**Remarks.** This is similar to the specimen from the Upper Miocene (Messinian), of the Borehole B1-NC35A, situated in north east Tripoli figured by Van Hinte (1980) as *Occultocythereis dhorni* Puri; it differs in the dorsal ridge which is strongly curved rather than straight as shown in Van Hinte's figure, as well as in the surface ornamentation. Van Hinte's material differs from *Occultocythereis dhorni* as described and figured from the Mediterranean area by Puri (1968, pl. 1 fig. 8), in having a straight ventral margin instead of a convex margin and lacks the prominent swelling in the antero-central area. *Falsocythere maccagnoi* has been described from the Pliocene of Algeria (Yassini 1979) the Marada Formation of the central Sirt Basin, and the Hommath Formation Egypt (Szczechura & Abd-Elshafy 1989).

*Neocaudites nudicosta* (Yassini 1979)

(Pl. 2, fig. 18)

**Material.** 1 carapace; No A12687, from Well F1-97, 1590 ft.

**Remarks.** Our specimen is similar to that illustrated by Bonaduce *et al* (1992) from the Upper Miocene of offshore Tunisia; these authors also placed Szczechura & Abd-Elshafy's *Falsocythere maccagnoni* in this species.

Genus *Hermanites* Puri, 1955

*Hermanites haidingeri haidingeri* Reuss, 1850

(Pl. 4, fig. 6)

**Material.** Six carapaces from Well F1-97 at depth 1020ft; No A12703-705.

**Remarks.** This was first described from the Upper Miocene of the Vienna Basin (Reuss, 1850). The specimens studied here differ from *Hermanites haidingeri* described from the Pliocene of Algeria (Yassini, 1979-80) in having a slightly shorter dorsal ridge. This species is commonly placed in the genera *Cletocythereis* Swain 1963 or *Grinioneis* Liebau 1975.

*Hermanites zaltanensis* sp. nov.

(Pl. 2, fig. 13; Pl. 4, figs 4, 9, 11)

**Derivation of name.** After Jabal Zaltan, 60 km south of the Marada Oasis.

**Diagnosis.** A species of *Hermanites* with three longitudinal ridges; dorsal and median ridges curved and nearly parallel; dorsal ridge separated from eye tubercle by depression, joining the median ridge posteriorly; ventral ridge straight, surface ornamented by coarse reticulation.

**Holotype.** Male right carapaces; No A12698, well C1a-97 at depth of 770ft.

**Material.** Five carapaces; No A12698-702; Well C1a-97, 770 ft and F1-97, 660.

**Description.** Carapace elongate to subrectangular in lateral outline; the maximum height at anterior cardinal angle; dorsal margin appears to be humped at posterior due to the overhanging of the dorsal ridge; ventral margin straight to slightly concave in the middle; anterior margin broadly

rounded; posterior margin concave in the upper part, while the ventral part possesses five short spines; three longitudinal ridges are present; the dorsal ridge is curved, ending in a slight node which connects the dorsal and median ridges; a weak median ridge runs from the subcentral tubercle towards the posterior and is nearly parallel to the dorsal ridge; the ventral ridge is strongly developed and almost straight, starting from antero-ventral area and running backwards nearly parallel to the ventral margin, ending in a small node in the postero-ventral area. The surface of the carapace is reticulate, with deep fossae of different polygonal shapes. Rounded subcentral tubercle is prominent. The eye tubercle is very clear and rounded. Internal features could not be observed. Sexual dimorphism clear and distinct, with more elongate males

**Dimensions of figured specimens (in  $\mu\text{m}$ ).**

	Length	Height	L / H
Male right carapace; No A12698	952	467	2.03
Female right carapace; No A12699	841	483	1.74
Female left carapace; No A12700	875	475	1.84

**Remarks.** This is very similar to *H. abundans* El-Waer 1992 described from the Upper Miocene Al Khums Formation of North west Libya. *H. zaltanensis* differs from the latter in having a broadly rounded anterior margin unlike the obliquely rounded margin of *H. abundans*, in having a stronger ventral ridge, and in details of the reticulation. It is also larger (male 952 cf. 826). *Hermanites transcostata* Khalaf, 1982 from the middle Miocene of Iraq differs in the outline of the ventral and anterior margins, and in having much coarser surface reticulation. *H. zaltanensis* is very similar in lateral outline to *H. tschopi* (Van Den Bold, 1946) described from the Neogene of Senegal and Guinea (Carbannel, 1985), but the latter differs in being shorter than our specimens, and the ventral ridge connects with the anterior ridge. There is doubt about the generic assignment; we have followed El Waer 1992.

Genus *Keijella* Ruggieri, 1957.

*Keijella africana* El-Waer, 1988

(Pl. 1, fig. 21)

**Material** Ten carapaces and one valve from wells C1a-97 at 770 and 1130 ft and F1-97 at 750 ft.; No A12612-14.

**Remarks.** *Keijella africana* was described from the Upper Miocene Al khums Formation and the ?middle Miocene of Libya and Egypt (Szczechura & Abd- Elshafy 1989).

*Keijella punctigibba* Capeder, 1902

(Pl. 1 fig. 20)

1902 *Cythere punctigibba* Capeder, pl. 14, figs. 26

1987 *Keijella punctigibba* Capeder, Keen, pl. 2, fig. 4.

**Material.** 14 carapaces and two valves from Wells C1a-97 at depth 770 & 950 ft and G1-97 at 750 ft.; No A12615-618.

**Description.** Carapace ovate to subrectangular in lateral view, with very distinct postero-ventral spine. Ornamentation consists of a series of slots arranged into 7-8 rows mainly located in the central-posterocentral area;

ventral slots run from the antero-ventral area backwards into the postero-ventral area, and anterior slots are present in the central anterior area; remainder of carapace is smooth. Some specimens bear spines along the anterior and posterior margins. Sexual dimorphism is pronounced, males being more elongate than females. **Remarks.** This species was first described from the Tortonian of Scrivia, Italy (Capeder 1902) and is also recorded from the Upper Miocene of Malta (Keen 1987). It is very similar to *Keijella hodgii* Bradley, but differs in having larger areas of ornamentation, and also in lateral outline.

Family *Xestoleberididae* Sars, 1928

Genus *Xestoleberis* Sars, 1866

*Xestoleberis cf. reymonti* Ruggieri, 1967

(Pl.4, fig.16)

**Material.** 30 carapaces from throughout all wells at all horizons; No A12694-697.

**Remarks.** This differs from *Xestoleberis reymonti* described from the Miocene of Alloctono Dell val Marecchia of Italy in having a slightly concave ventral margin.

Family uncertain

Genus *Ruggieria* Keij, 1957.

*Ruggieria tetraptera tetraptera* Sequenza, 1869

(Pl.4, fig.14)

**Material.** 41 carapaces and two valves from all wells and horizons; No A12636-640.

**Remarks.** The figured specimen is close to *Ruggieria tetraptera tetraptera* figured by Keen (1987) from the upper Miocene of Malta, and to the specimen figured by El-Waer (1992) from the Upper Miocene Al Khums Formation. Szczechura & Abd-Elshafy (1989) described this species from ?middle Miocene Marada Formation of the central Sirt Basin and the western coast of the Gulf of Suez, Egypt.

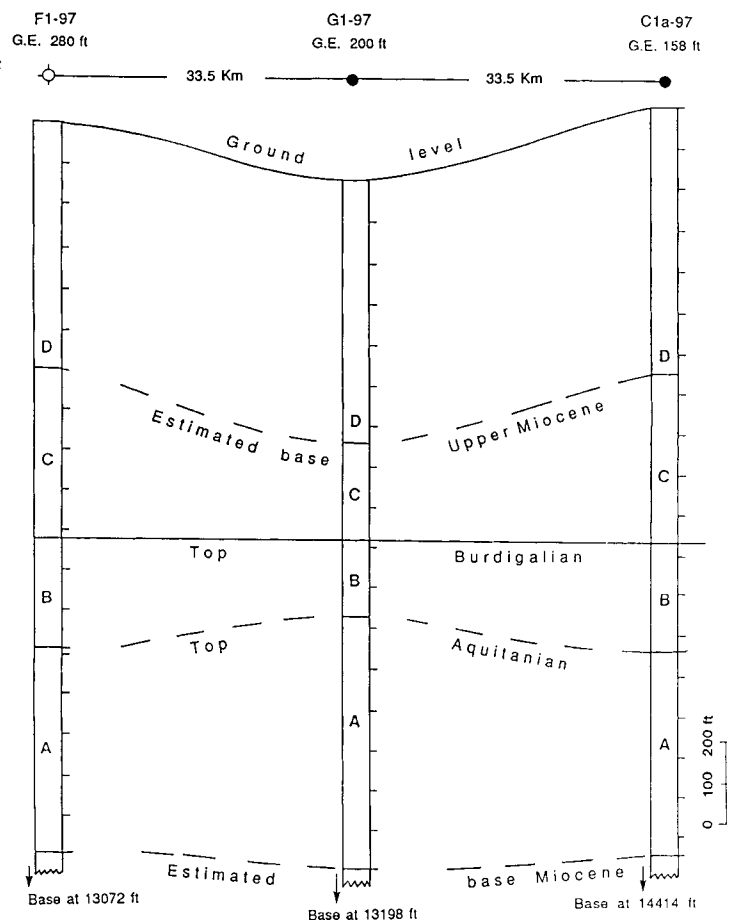
*Ruggieria aff dorukae* Bassiouni, 1979

(Pl.4, fig.10)

**Material.** Two carapaces and one valve from Well G1-97 at depth 1260 ft; No A12641-643

**Remarks.** *Ruggieria dorukae* was recorded from Lower Miocene of Turkey (Bassiouni, 1979) and subsequently recorded from the Burdigalian of south west Anatolia, Turkey (Gokçen, 1986). The Libyan specimens differ from these in the presence of a smooth area in the anterior region; this feature is original, but preservation in two of the specimens makes it difficult to describe. It is not clear whether this is of specific importance or not, and lack of material makes it impossible to discern whether or not variation exists within the Libyan material. Mostafawi (1987) figured specimens of *Ruggieria dorukae* from the Middle Miocene of Kos, Greece, which also have a smooth area at the anterior, although this area is smaller than in the Libyan specimens.

#### OSTRACOD FAUNAS FROM THE MARADA FORMATION



**Fig. 3.** The proposed biozones of the Marada Formation showing correlation between the wells. The datum is taken as the top of the Burdigalian. A, *Pokornyella deformis minor* Biozone, B *Aurila soummamensis* Biozone, C Interval Biozone, D, *Ruggieria tetraptera tetraptera* Biozone.

The ostracod fauna described here differs from previously described Miocene faunas from Libya (Bellini 1969; Van Hinte *et al* 1980; Innocenti and Pertusati 1984; El-Waer 1988, 1992) due to differences in age and facies. It also differs from the fauna described by Szczechura & Abd-Elshafy (1989) from the Miocene of Egypt and the Marada Formation of the north central Sirt Basin. It is difficult to account for this latter difference; the presence of *Pokornyella deformis minor* and *Aurila cf soummamensis* in their samples suggests an Aquitanian age, i. e. Lower Miocene. If this is correct, this could be a factor in accounting for the differences, i.e. their fauna is of Aquitanian age while the majority of the species recorded here come from Burdigalian or later sediments. Slight differences in facies and geographical location may also be involved. Fifty five species have been identified in this study; twenty two of which have been described from various localities in the Mediterranean area and north Africa; six species are new; the remainder are left in open nomenclature, although some of these are very similar to species already described. Sixteen species are important for stratigraphical age

STAGES	TURKEY
	<b>Gokcen 1985</b>
<b>Tortonian</b>	
<b>Serravallian</b>	<i>Carinocythereis datum plane</i>
<b>Langhian</b>	
<b>Burdigalian</b>	<i>Neomonoceratina helvetica</i> <i>Aurila soummamensis</i> <b>Super zone</b>
<b>Aquitainian</b>	

LIBYA
<b>Proposed zones</b>
<i>Ruggieria tetraptera tetraptera</i>
<b>Interval zone</b>
<i>Aurila soummamensis</i>
<i>Pokornyyella deformis minor</i>

Fig. 4. Correlation between proposed biozonation of the Miocene of Turkey and Libya, Upper Miocene

determination; four of these are restricted to the Lower Miocene, nine to the Upper Miocene, while three species have longer ranges but still provide stratigraphical information. In general the species recorded in Fig.3 are part of a widespread Mediterranean fauna, and most of the remaining species are closely related to widespread species. The fauna is markedly different from that described from Iraq (Khalaf,1982) where there are no species found in common to the two countries. The Libyan fauna also differs from those of central and northern Europe.

The stratigraphical range of the ostracods is based on published records from localities in Algeria, Austria, Belgium, Cyprus, Egypt, France, Greece, Italy, Libya, Malta, Tunisia, and Turkey. The stratigraphical and geographical distribution of each species has been discussed in the systematic section.

**Lower Miocene species.** The typical species is *Aurila soummamensis*, described from the Burdigalian of Algeria, and from the lower Miocene of Turkey (Bassiouni, 1979). Gokçen (1984) used this species to define the Lower Miocene (Burdigalian) Biozone in the Neogene sequences of Turkey. *Pokornyyella deformis minor* (Moyes 1965), described from the lower Miocene of Aquitain, France, and the lower Miocene of Turkey (Bassiouni, 1979 and Gokçen 1984) is also a useful marker species, restricted to the Aquitainian.

**Middle Miocene.** No species have been found in this study which are restricted to the Middle Miocene; three species are present which are recorded from the Middle Miocene, but range into later periods: *Cnestocythere truncata*, (Aquitainian- Tortonian), *Chrysocythere paradisus* (Langhain-Tortonian), and *Acanthocythereis hystrix* (Langhain-Pliocene). Thus, although they are not restricted to the Middle Miocene, their first appearance indicates Middle Miocene or later periods, and the interval between their first appearance and first appearance of typical Upper Miocene ostracods can be regarded as Middle Miocene.

**species.** Most of the species identified in this study are restricted to the Tortonian (Upper Miocene), e.g. *Actinocythereis spinosa*, *A. libyaensis*, *Chrysocythere alkhumia*, *C. cataphracta*, *C. paradisus*, *Keijella punctigibba*, *Carinivalva carinata*, while some species range into the Pliocene e.g. *Acanthocythereis hystrix*, *Neomonoceratina laskarevi*, *Ruggieria tetraptera tetraptera*.

**OSTRACOD BIOZONES OF THE MARADA FORMATION**

Ostracod biozones are proposed for the Marada formation in the eastern Sirt Basin based on the first appearance downhole of one or more index species. The species chosen are known to have a wide geographical distribution, their stratigraphic ranges are short and well documented, they are easily identified, and they are reasonably abundant.

Several biozonations based on ostracods have been published for different provinces of the Mediterranean Neogene: Carbonnel (1969) on the Aquitainian-Tortonian of the Rhone basin in France, Sissingh (1972) on the late Cenozoic of the south Aegean Islands, and Jircek (1974), on the Neogene sediments of the Czechoslovakia and Paratethys. Gokçen (1984) recognised a Burdigalian-early Langhian zone based on *Neomonoceratina helvetica* (Oertli) and *Aurila soummamensis* in the Neogene sequences of Turkey (Fig.4). The following four biozones have been recognised in the Marada Formation of the sequences studied, in ascending order (Fig. 3.).

**A- *Pokornyyella deformis minor* Biozone.** The top of this zone is recognised by the first occurrence downhole of *Pokornyyella deformis minor*; its base has not been determined. This zone is probably equivalent to the Aquitainian.

**B-*Aurila soummamensis* Biozone.** The top of this zone is recognised by the first occurrence downhole of *Aurila soummamensis*; the base is defined by the first appearance downhole of *Pokornyyella deformis minor*. This is equivalent to the Burdigalian.

**C- An interval Biozone.** This zone lies between the top of

the *Aurila soummamensis* zone and the level taken to be the base of the *Ruggieria tetraptera tetraptera* Zone. This is taken to be equivalent to the Middle Miocene but as discussed earlier there is a lack of characteristic species.

**D-Ruggieria tetraptera tetraptera Biozone.** This assemblage zone is recognised by the abundance of characteristic Upper Miocene species.

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