

Ostracoda from the lower Messinian of Lampedusa Island: systematics and chronostratigraphical significance

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ABSTRACT – The Messinian shallow water marine carbonate succession of Lampedusa Island was extensively sampled. Levels referable to the Capo Grecale Member and the overlying Vallone della Forbice Member yielded abundant and diversified ostracod faunas. Systematic analysis revealed 28 species, of these 5 are left in open nomenclature. *Loxoconcha lipadusensis* is described herein as new. The recovered ostracod assemblages can be reliably correlated with those known from the pre-evaporitic Messinian shallow water deposits of the Mediterranean. From a palaeoecological viewpoint the associations are dominated by shallow marine taxa, while euryhaline and brackish species are more randomly represented. They suggest a nearly normal salinity shallow environment, referable to the upper part of the inner neritic zone.

RIASSUNTO – [Ostracodi del Messiniano inferiore dell'Isola di Lampedusa: sistematica e significato cronostratigrafico] – È stata realizzata una campionatura della successione carbonatica supra-miocenica affiorante nell'Isola di Lampedusa. Alcuni livelli riferibili al Membro Capo Grecale e al sovrastante Membro Vallone della Forbice hanno fornito ostracofaune piuttosto abbondanti e diversificate. Sono state riconosciute 28 diverse specie, 5 delle quali sono lasciate a nomenclatura aperta e *Loxoconcha lipadusensis* è descritta come nuova. Le associazioni ad ostracodi risultano perfettamente correlabili con quelle di analoghi depositi del Messiniano inferiore preevaporitico dell'area mediterranea. Dal punto di vista paleoambientale l'ostracofauna è dominata da taxa litorali con presenza sporadica di forme eurialine e/o salmastre e offre pertanto indicazioni di un ambiente deposizionale marino poco profondo (riferibile alla parte superiore della zona neritica interna) con caratteristiche fisico-chimiche pressoché normali.

INTRODUCTION

Lampedusa Island together with Linosa and Lampione form the so-called Pelagian Archipelago. They are situated at the north-eastern margin of the present-day Tunisian shelf and south-west of the main grabens of the Sicilian Strait. Except for Linosa, which is entirely composed of Late Pleistocene volcanics, the most southerly islands of Lampione and Lampedusa represent the only subaerial outcrops of Tertiary sediments within the central area of the Pelagian Block. From a general point of view the Pelagian Block belongs to the northern margin of the African Plate and forms part of the foreland of the Maghrebian fold-and-thrust belt that extends from North Africa to Sicily (Burrollet *et al.*, 1978).

Lampedusa Island has been the subject of geological and palaeontological studies since the 1950's (Segre, 1954, 1960; Bonnefous & Artru, 1968; Borsetti & Colantoni, 1973). The paper of Grasso & Pedley (1985), to which the reader is referred for further information, provides a detailed stratigraphical and structural analysis of the carbonates exposed in the island. The above-mentioned authors placed the whole carbonate succession in the Lampedusa Formation, which can be subdivided into the following three members (from the base to the top): Cala Pisana

Member, Capo Grecale Member and Vallone della Forbice Member. The carbonates exhibit a varied range of strata and are clearly affected by considerable syndepositional activity. They are collectively referable to coral reef facies dominated by *Porites*, *Tarbellastraea* and *Halimeda* communities, which are typical of the Upper Miocene coral reef belt in the Central and Western Mediterranean.

Segre (1960) placed the Lampedusa carbonates within the Miocene and Bonnefous & Artru (1968) referred them to the Helvetian. Recently Borsetti & Colantoni (1973) and Grasso & Pedley (1985) assigned the Lampedusa Formation to the Upper Miocene. The latter authors placed the mid Capo Grecale Member within the Tortonian on the basis both of the palaeontological content (presence of few coral genera dominated by *Porites* sp.; abundance of *Borelis melo melo* and absence of *Borelis melo curdica*) and the strong similarity with the Upper Coralline Limestone Formation of the Maltese Archipelago. The uppermost levels of the youngest member, which are composed of wackstones with abundant, but low diversity bivalve faunas, are tentatively referred to the lower Messinian.

The purpose of this paper is to illustrate the ostracod assemblages of the Lampedusa Formation and to discuss their chronostratigraphical significance.

CHRONOSTRATIGRAPHICAL IMPLICATIONS

On the basis of data gleaned from the literature and the unpublished research of the present authors the identified taxa can be divided in three main groups.

The first consists of long-ranging species such as *Triebelina varipila* (Müller), *Callistocythere pallida* (Müller) and *Grinoneis haidingeri* (Ruggieri).

The second group includes taxa whose range is restricted to the Upper Miocene. They are: *Neonesidea nigrescens* (Ruggieri), *Callistocythere montana* Doruk, *Aurila freudenthali* Sissingh, *Aurila impressa* Ruggieri, *Peteraurila musculus* Aruta & Ruggieri.

Finally, the most notable group consists of taxa, which are known only from the lower pre-evaporitic Messinian and/or from the so-called "Sahelian" deposits. The species belonging to this third group are listed below (those reported only from the "Sahelian deposits" and those occurring both in the "Sahelian" and lower Messinian strata are marked by the symbol [S] and [lower M-S] respectively):

- Sylvestra bismuthi* Bonaduce, Russo & Barra [S]
- Sylvestra gravida* Bonaduce, Russo & Barra [S]
- Miocyprideis ornatissima* Bonaduce, Ruggieri, Russo & Bismuth [S]
- Capsocythere sicula* (Aruta) [lower M-S]
- Carinocythereis cultrata* (Ruggieri & Russo) [S]
- Tegmenia tegminata* Bonaduce, Ruggieri & Russo [S]
- Arutella sahelensis* (Aruta) [lower M-S]
- Aurila babinoti* Bonaduce, Ruggieri, Russo & Bismuth [S]
- Aurila malzi* Bonaduce, Ruggieri, Russo & Bismuth [S]
- Aurila ? serpyllum* Bonaduce, Ruggieri, Russo & Bismuth [S]
- Aurila ? sp. 1* Bonaduce, Ruggieri, Russo & Bismuth [S]



Text-fig. 2 - Layer rich in oysters in the Vallone Imbriacoli Beds (Cala Calandra; samples 38, 39).



Text-fig. 3 - Horizon with abundant bivalves in the Punta Maccaferri Beds (Cala Pisana; samples 13, 14).

- Dorukella bella* Russo, Bonaduce & Ruggieri [S]
- Helioocythere brontotherium* Bonaduce, Ruggieri & Russo [S]
- Pokornyyella italica* Ruggieri, Russo & Bossio [lower M-S]
- Tenedocythere subulata* Bonaduce, Ruggieri & Russo [S]
- Loxoconcha lipadusensis* sp. nov. [lower M-S].

The above-listed taxa are characteristic of and exclusive to the widespread, littoral deposits which precede the salinity crisis in the Central and Western Mediterranean and they have been collectively indicated as the "Sahelian faunas" in past literature. Sissingh (1971), Ciampo (1986) and Miculan (1992) discussed in detail the ambiguity inherent in the use of the "Sahelian" stage. We would only mention that the time-equivalent to the "Sahelian" is difficult to establish and has been referred by different authors both to the lower pre-evaporitic Messinian and to the wider interval comprising either part of the Tortonian or the lower Messinian.

In terms of the ostracod faunas it must be pointed out that several taxa of the so-called "Sahelian faunas" have never been reported with certainty from well-dated Tortonian strata. Furthermore, whenever the benthic and/or planktonic foraminifers provided reliable bio-chronostratigraphical indications, the levels containing the "Sahelian faunas" have been referred to the lower pre-evaporitic Messinian. Specifically, we refer to the Greensands and the Upper Coralline Limestone in the Maltese Archipelago (Russo & Bossio, 1976), the Calcare di Rosignano Formation in Tuscany (Bossio *et al.*, 1978, 1981), the uppermost levels of the Rio Mazzapiedi-Castellania Section (S. Agata Fossili Formation) in the Piedmont Basin, the Calcareni di Andrano Formation in the Salentine Peninsula (Bossio *et al.*, 1989, 1991), the Vigleno Formation of the Piacenza

Subapennines (Miculan, 1992), the carbonate and marly deposits of the Sorba Basin, SE Spain (Conesa & Babinot, 1990) and, finally, the Calcarei di San Nicola Formation in the Tremiti Islands (Dall'Antonia, 2001).

On the basis of the above-mentioned data, we regard the occurrence of *Arutella sabeliensis*, *Capsacypthere sicula* and *Pokornyyella italica*, which are widely reported from lower Messinian deposits, as making it possible to assign confidently the Vallone Imbriacoli Beds (Capo Grecale Member) and the overlying Vallone della Forbice Member to the lower pre-evaporitic Messinian interval.

PALAEOECOLOGICAL CONSIDERATIONS

The recovered associations are mainly composed of typical littoral marine species. The commonest taxa usually belong to the genera *Aurila*, *Pokornyyella* and *Arutella*. The genera *Callistocythere*, *Loxoconcha*, *Carinocythereis*, *Miocyprideis*, and *Xestoleberis* are also locally quite abundant. There are scattered occurrences of such taxa as *Miocyprideis*, *Leptocythere* and *Cyprideis*, often with phenotypic tubercles, which indicate salinity. Such a faunal composition suggests a shallow (inner neritic) marine environment with nearly normal physico-chemical properties. Weak, temporary hypoaline water influences from an adjacent lagoon may explain the sporadic occurrence of brackish and euryhaline forms.

SYSTEMATIC NOTES

In this section the taxa encountered are briefly discussed. A new species is herein described. All the figured specimens are deposited in the Ostracoda Collection of Prof. A. Bossio (C.O.B. 25-72), Department of Earth Sciences, University of Pisa, Italy.

Subclass OSTRACODA Latreille, 1806
Order PODOCOPIDA Müller, 1894
Suborder PODOCOPA Sars, 1866
Superfamily BAIRDIACEA Sars, 1866
Family BAIRDIIDAE Sars, 1888
Genus NEONESIDEA Maddocks, 1969

NEONESIDEA NIGRESCENS (Ruggieri, 1962)
Pl. 2, fig. 10

1962 *Bairdia nigrescens* RUGGIERI, pp. 11-12, text-figs. 4, 4a; pl. 1, figs. 7-8.

Our specimens have a somewhat more regular ventral margin than those described by Ruggieri (1962). The species is reported from the Tortonian of Enna, Sicily (Ruggieri, 1962), the Upper Miocene of the South Aegean Islands (Sissingh, 1972), the lower Messinian of the Maltese Archipelago (Russo & Bossio, 1976) and the Vigoleno Formation, Piacenza Subapennines (Miculan, 1992).

Genus TRIEBELINA Van den Bold, 1946

TRIEBELINA RARIPILA (Müller, 1894)
Pl. 2, fig. 8

1894 *Bairdia raripila* MÜLLER, p. 274, pl. 13, fig. 37; pl. 15, figs. 5-7, 28.

This long-living species, whose distribution ranges from Upper Miocene (Doruk, 1974) to Recent (Müller, 1894; Bonaduce *et al.*, 1976), occurs only in sample 38.

Superfamily CYTHERACEA Baird, 1850
Family LEPTOCYTHERIDAE Hanai, 1957
Genus CALLISTOCYTHERE Ruggieri, 1953

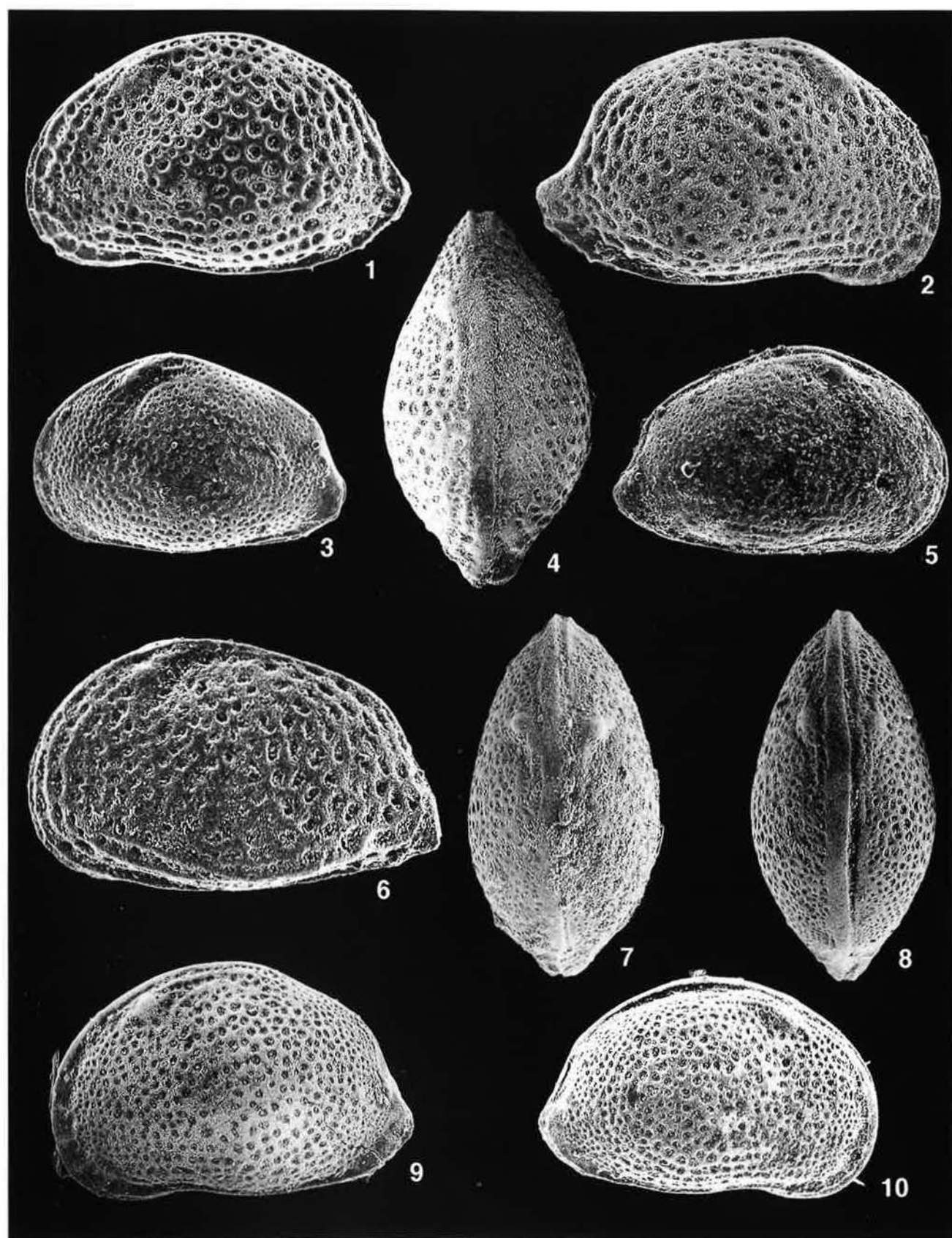
CALLISTOCYTHERE MONTANA Doruk, 1980
Pl. 5, fig. 4

1980 *Callistocythere montana* DORUK, pp. 139-142, pl. 7/140, figs. 1-2; pl. 7/142, figs. 1-3.

This distinctive species was originally described by Doruk (1980) from the Upper Miocene (Tortonian according to the Author) of the Mersin region, Turkey. It has been successively reported from the Upper Miocene of many localities of the Mediterranean area (Aruta, 1983; Ciampo, 1986; Bonaduce *et al.*, 1992; Miculan, 1992; Babinot & Boukli-Hacene, 1998).

EXPLANATION OF PLATE 1

- Figs. 1, 2, 4 - *Aurila impressa* Ruggieri, 1976b. 1) LV, external view, sample 38, C.O.B. 27, (x 100); 2) RV, external view, sample 42, C.O.B. 28, (x 100); 4) C dorsal view, sample 38, C.O.B. 29, (x 90).
Figs. 3, 5, 7 - *Aurila malzi* Bonaduce, Ruggieri, Russo & Bismuth, 1992. 3) LV from C, external view, sample 46, C.O.B. 35, (x 70); 5) RV from C, external view, sample 46, C.O.B. 36, (x 70); 7) C dorsal view, sample 46, C.O.B. 37, (x 80).
Fig. 6 - *Aurila freudenthali* Sissingh, 1972. LV, external view, sample 38, C.O.B. 34, (x 100).
Figs. 8-10 - *Aurila* sp. cf. *A. cicatricosa* (Reuss, 1850). 8) C dorsal view, sample 38, C.O.B. 30, (x 80); 9) LV, external view, sample 38, C.O.B. 31, (x 80); 10) RV from C, external view, sample 40, C.O.B. 32, (x 80).



CALLISTOCYTHERE PALLIDA (Müller, 1894)
Pl. 5, fig. 3

1894 *Cythere pallida* MÜLLER, pp. 354-355, pl. 28, fig. 17.

Our specimens possess a moderately prominent ornament and a well defined anterior depression, which separates the short antero-dorsal marginal rib from the inner oblique rib connecting the eye tubercle to the antero-ventral area. *C. pallida* (Müller) is known from the Upper Miocene (Aruta, 1983; Ciampo, 1986) to the Recent (Müller, 1894; Breman, 1975; Bonaduce *et al.*, 1976) of the Mediterranean.

Genus SYLVESTRA Doruk, 1973b

SYLVESTRA BISMUTHI Bonaduce, Russo & Barra, 1990
Pl. 5, fig. 6

1990 *Sylvestra bismuthi* BONADUCE, RUSSO & BARRA, pp. 282, 284, pl. 2, fig. 1.

A single carapace of this species, belonging to the thermophilic genus *Sylvestra* Doruk, 1973b (see Bonaduce *et al.*, 1990) was recovered in sample 44.

SYLVESTRA GRAVIDA Bonaduce, Russo & Barra, 1990
Pl. 5, fig. 5

1990 *Sylvestra gravis* BONADUCE, RUSSO & BARRA, p. 284, pl. 2, figs. 4-5.

This species is rare in samples 40 and 45. As *S. bismuthi* it was previously known only from the "Sahelian" of the Gulf of Gabes (Bonaduce *et al.*, 1990, 1992).

Family CYTHERIDEIDAE Sars, 1925
Genus MIOCYPRIDEIS Kollmann, 1960

MIOCYPRIDEIS ORNATISSIMA Bonaduce, Ruggieri,
Russo & Bismuth, 1992
Pl. 5, figs. 1-2

1992 *Miocyprideis ornatissima* BONADUCE, RUGGIERI, RUSSO & BISMUTH, p. 72, pl. 20, figs. 14-15.

This species described by Bonaduce *et al.* (1992) from the "Sahelian" of the Gulf of Gabes is relatively common in our material.

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Genus CAPSACYTHERE Bonaduce, Ruggieri & Russo,
1988

CAPSACYTHERE SICULA (Aruta, 1966)
Pl. 3, fig. 3

1966 *Falunia sicula* ARUTA, p. 4, text-fig. 2/1; pl. 1, fig. 1.

A very distinctive species, which is widely distributed in the Messinian of the Mediterranean area. It is reported from the "Sahelian" of Sicily (Aruta, 1966, 1983; Bonaduce *et al.*, 1988b) and the Gulf of Gabes (Bonaduce *et al.*, 1992) as well as from the lower Messinian of the Maltese Archipelago (Russo & Bossio, 1976, cited as *Olimfalunia* aff. *sicula*), Tuscany (Bossio *et al.*, 1981) and the Salentine Peninsula (Bossio *et al.*, 1989, 1991). According to Guernet *et al.* (1996) *C. sicula* is indicative of the marine lower Messinian.

Genus CARINOCYTHEREIS Ruggieri, 1956

CARINOCYTHEREIS CULTRATA (Ruggieri & Russo,
1980)
Pl. 5, figs. 7-8

1980 *Oclusacythereis cultrata* RUGGIERI & RUSSO, pp. 33-34, text-fig. 7.

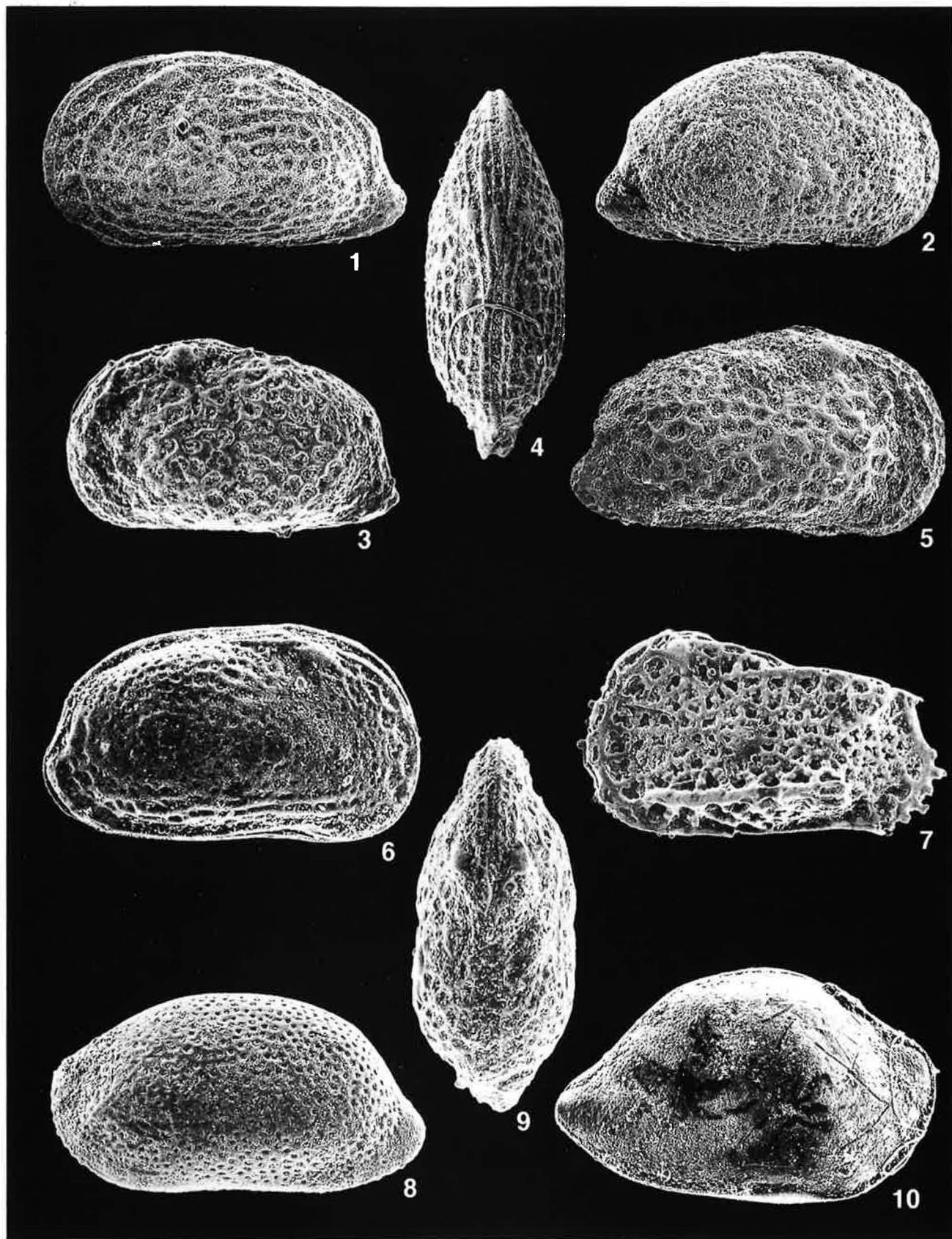
Following the opinion Mostafawi (1989), the present authors regard the genus *Oclusacythereis* as a junior synonym of *Carinocythereis*. *C. cultrata* was originally described from the "Sahelian" near Trapani (Ruggieri & Russo, 1980). S.E.M. photographs are provided by Bonaduce *et al.* (1992, p. 56, pl. 16, figs. 6-7; pl. 26, fig. 5).

Genus GRINIONEIS Liebau, 1975

GRINIONEIS HAIDINGERI (Reuss, 1850)
Pl. 2, fig. 7

EXPLANATION OF PLATE 2

- Figs. 1, 4 - *Aurila* ? sp. 1. 1) LV from C, external view, sample 40, C.O.B. 41, (x 95); 4) C dorsal view, sample 40, C.O.B. 42, (x 95).
Fig. 2 - *Aurila* sp. cf. *A. doliaris* Bonaduce, Ruggieri, Russo & Bismuth, 1992. RV from C, external view, sample 52, C.O.B. 33, (x 90).
Figs. 3, 5, 9 - *Aurila* ? *serpyllum* Bonaduce, Ruggieri, Russo & Bismuth, 1992. 3) LV from C, external view, sample 40, C.O.B. 38, (x 100); 5) RV, external view, sample 40, C.O.B. 39, (x 100); 9) C dorsal view, sample 40, C.O.B. 40, (x 100).
Fig. 6 - *Aurila babinoti* Bonaduce, Ruggieri, Russo & Bismuth, 1992. RV from C, external view, sample 38, C.O.B. 26, (x 100).
Fig. 7 - *Grinioneis haidingeri* (Reuss, 1850). LV, external view, sample 38, C.O.B. 47, (x 90).
Fig. 8 - *Triebelina varipila* (Müller, 1894). LV, external view, sample 38, C.O.B. 71, (x 100).
Fig. 10 - *Neonesidea nigrescens* (Ruggieri, 1962). RV from C, external view, sample 40, C.O.B. 60, (x 65).



1850 *Cypridina haidingeri* REUSS, p. 78, pl. 10, figs. 13a-d.

This long-lived species is known from the Eocene (Bosquet, 1852) to the Lower Pleistocene (Ruggieri, 1953, 1973, 1976a).

Genus TEGMENIA Bonaduce, Ruggieri & Russo,
1988

TEGMENIA TEGMINATA Bonaduce, Ruggieri & Russo,
1988b
Pl. 3, fig. 2

1988b *Tegmenia tegminata* BONADUCE, RUGGIERI & RUSSO, pp.
352, 354, text-figs. 2a, b; pl. 3, figs. 1-7.

The species, reported from the "Sahelian" of Sicily (Bonaduce *et al.*, 1988b) and the Gulf of Gabes (Bonaduce *et al.*, 1992), occurs randomly in our material. It is relatively common only in sample 52.

Family HEMICYTHERIDAE Puri, 1953

Subfamily HEMICYTHERINAE Puri, 1953

Genus ARUTELLA Bonaduce, Ruggieri & Russo, 1987

ARUTELLA SAHELIENSIS (Aruta, 1966)
Pl. 3, fig. 5

1966 *Mutilus cimbaeformis sahelensis* ARUTA, pp. 5-6, text-fig. 5;
pl. 1, fig. 7.

This species is well known from several Italian localities: "Sahelian" of Sicily (Aruta, 1966; Aruta e Buccheri, 1978; Bonaduce *et al.*, 1987) and the Gulf of Gabes (Bonaduce *et al.*, 1992); lower Messinian of Tuscany (Bossio *et al.*, 1978, 1981), Piedmont Basin (Ciampo, 1986) and Piacenza Subapennines (Miculan, 1992). S.E.M. photographs are provided by Bonaduce *et al.* (1987, pp. 265-266, text-fig. 6/2; pl. 4, figs. 1-2) and Bonaduce *et al.* (1992, p. 26, pl. 6, fig. 13).

Genus AURILA Pokorný, 1955

AURILA BABINOTI Bonaduce, Ruggieri, Russo &
Bismuth, 1992
Pl. 2, fig. 6

1992 *Aurila babinoti* BONADUCE, RUGGIERI, RUSSO & BISMUTH
pp. 26-27, pl. 7, figs. 1-2.

This species is known only from the "Sahelian" of the Gulf of Gabes (Bonaduce *et al.*, 1992). The few recorded specimens (L = 0.69-0.73; H = 0.39-0.42; W = 0.14-0.15 mm) are larger than the type material.

AURILA sp. cf. A. CICATRICOSA (Reuss, 1850)
Pl. 1, figs. 8-10

The recovered material (35 carapaces and 15 valves) falls fairly well into Reuss' species *sensu* Ruggieri, 1975 (pp. 425-427). Our specimens are, however, more delicately and densely punctate than those figured by Brestenská & Jiríček (1978, pl. 6, fig. 1) and Miculan (1992, p. 118, pl. 4, fig. 3). Furthermore, they almost completely lack postero-ventral spines.

AURILA sp. cf. A. DOLIARIS Bonaduce, Ruggieri,
Russo & Bismuth, 1992
Pl. 2, fig. 2

The few specimens recovered (1c and 4 valves) are very similar to *Aurila doliaris* Bonaduce, Ruggieri, Russo & Bismuth (1992, p. 32, pl. 8, figs. 3-4). They possess, however, a slightly different lateral outline, with a more prominent caudal process and a more arched dorsal margin. *A. doliaris* is known from the "Sahelian" near Palermo, Sicily (Aruta, 1983) and the "Sahelian" of the Gulf of Gabes (Bonaduce *et al.*, 1992).

AURILA FREUDENTHALI Sissingh, 1972
Pl. 1, fig. 6†

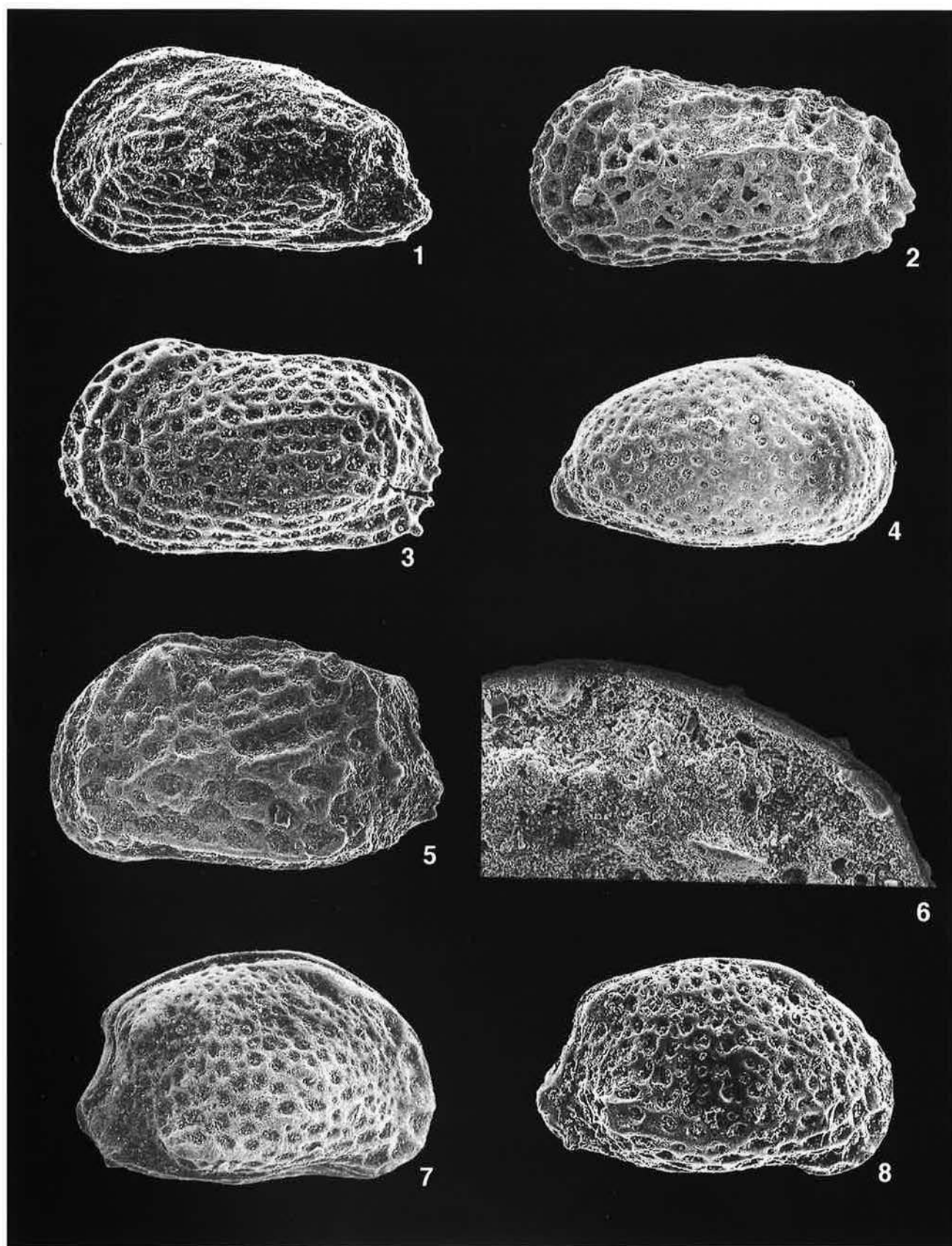
1972 *Aurila freudenthali* SISSINGH, pp. 116-117, pl. 9, fig. 3.

This characteristic species, reported from the Upper Miocene of the Eastern Mediterranean (Sissingh, 1972; Doruk, 1973a) and the "Sahelian" of the Gulf of Gabes (Bonaduce *et al.*, 1992), was recovered only in sample 38.

AURILA IMPRESSA Ruggieri, 1976b
Pl. 1, figs. 1-2, 4

EXPLANATION OF PLATE 3

- Fig. 1 - *Dorukella bella* Russo, Bonaduce & Ruggieri, 1984. LV from C, external view, sample 40, C.O.B. 46, (x 100).
Fig. 2 - *Tegmenia tegminata* Bonaduce, Ruggieri & Russo, 1988b. LV, external view, sample 46, C.O.B. 69, (x 100).
Fig. 3 - *Capsacynthia sicula* (Aruta, 1966). LV, external view, sample 38, C.O.B. 45, (x 100).
Figs. 4, 6 - *Peteraurila musculus* Aruta & Ruggieri, 1980. 4) RV, external view, sample 52, C.O.B. 63, (x 80); 6) RV, detail of the hinge, sample 52, C.O.B. 64, (x 150).
Fig. 5 - *Arutella sahelensis* (Aruta, 1966). LV, external view, sample 40, C.O.B. 25, (x 100).
Figs. 7-8 - *Pokornyyella italica* Ruggieri, Russo & Bossio, 1977. 7) RV from C, external view, sample 40, C.O.B. 65, (x 80); 8) RV, external view, sample 52, C.O.B. 66, (x 80).



1976b *Aurila convexa impressa* RUGGIERI, pp. 177-178, 180, text-figs. 1-2; pl. 1, figs. 1, 5a-b.

Ruggieri (1993) extended the concept of this species, including in *Aurila impressa* forms with uniform, coarse punctate ornament or with puncta becoming distinctly smaller and more closely spaced toward the periphery, as are our specimens. The species is frequent in the Tortonian-lower Messinian and the "Sahelian" of Italy (Ruggieri, 1993). It is reported also from the lower Messinian of Algeria (Babinot & Boukli-Hacene, 1998).

AURILA MALZI Bonaduce, Ruggieri, Russo & Bismuth, 1992
Pl. 1, figs. 3, 5, 7

1992 *Aurila (Alboaurila) malzi* BONADUCE, RUGGIERI, RUSSO & BISMUTH, p. 30, pl. 7, figs. 14-15 (*cum syn.*).

The species is quite well represented in our material. The specimens recovered display a considerable degree of variability in the L/H ratio and in the shape of the dorsal margin.

AURILA ? SERPYLLUM Bonaduce, Ruggieri, Russo & Bismuth, 1992
Pl. 2, figs. 3, 5, 9

1992 *Aurila (?) serpyllum* BONADUCE, RUGGIERI, RUSSO & BISMUTH, p. 33, pl. 11, figs. 1-4.

Only four carapaces and a right valve of this peculiar species were recorded. Being unable to observe the internal features clearly, we could not clarify the doubtful generic assignment given by Bonaduce *et al.* (1992).

AURILA ? sp. 1
Pl. 2, figs. 1, 4

Only three complete carapaces were recorded in samples 40 and 44. They correspond well to *Aurila* (?) sp. 1 figured by Bonaduce *et al.* (1992, p. 34, pl. 8, fig. 12) in size and ornament. Although the poorly preserved material does not allow the erection of a

new taxon, a short diagnosis based on the main distinctive characters of this species is given herein.

Diagnosis – Subrectangular, elongate in lateral view: ventral margin nearly straight, dorsal margin feebly arched, posterior extremity characterized by an evident posterior cardinal angle and a prominent sub-ventral caudal process. Surface ornament reticulate: reticulae variable in shape, size and arrangement. In the posterior half they tend to align longitudinally, whereas anteriorly they become smaller and are more concentrically arranged. The muri, which form the reticulae, converge irregularly in the centre of the valve. A strongly arched rib extends subparallel to the anterior margin from the weak eye tubercle to the antero-ventral area. Anterior to this rib, two rows of large rhomboidal reticulae occur. Carapace in dorsal view compressed with subparallel sides and acuminate extremities.

Size (mm) – L = 0.69; H = 0.37; W = 0.13.

Remarks – As in the case of *Aurila ? serpyllum* Bonaduce, Ruggieri, Russo & Bismuth, we were not able to provide a more reliable generic attribution than that suggested by Bonaduce *et al.* (1992).

Genus DORUKELLA Ruggieri, 1984

DORUKELLA BELLA Russo, Bonaduce & Ruggieri, 1984
Pl. 3, fig. 1

1984 *Dorukella bella* RUSSO, BONADUCE & RUGGIERI, pp. 139-140, pl. 2, figs. 1-9.

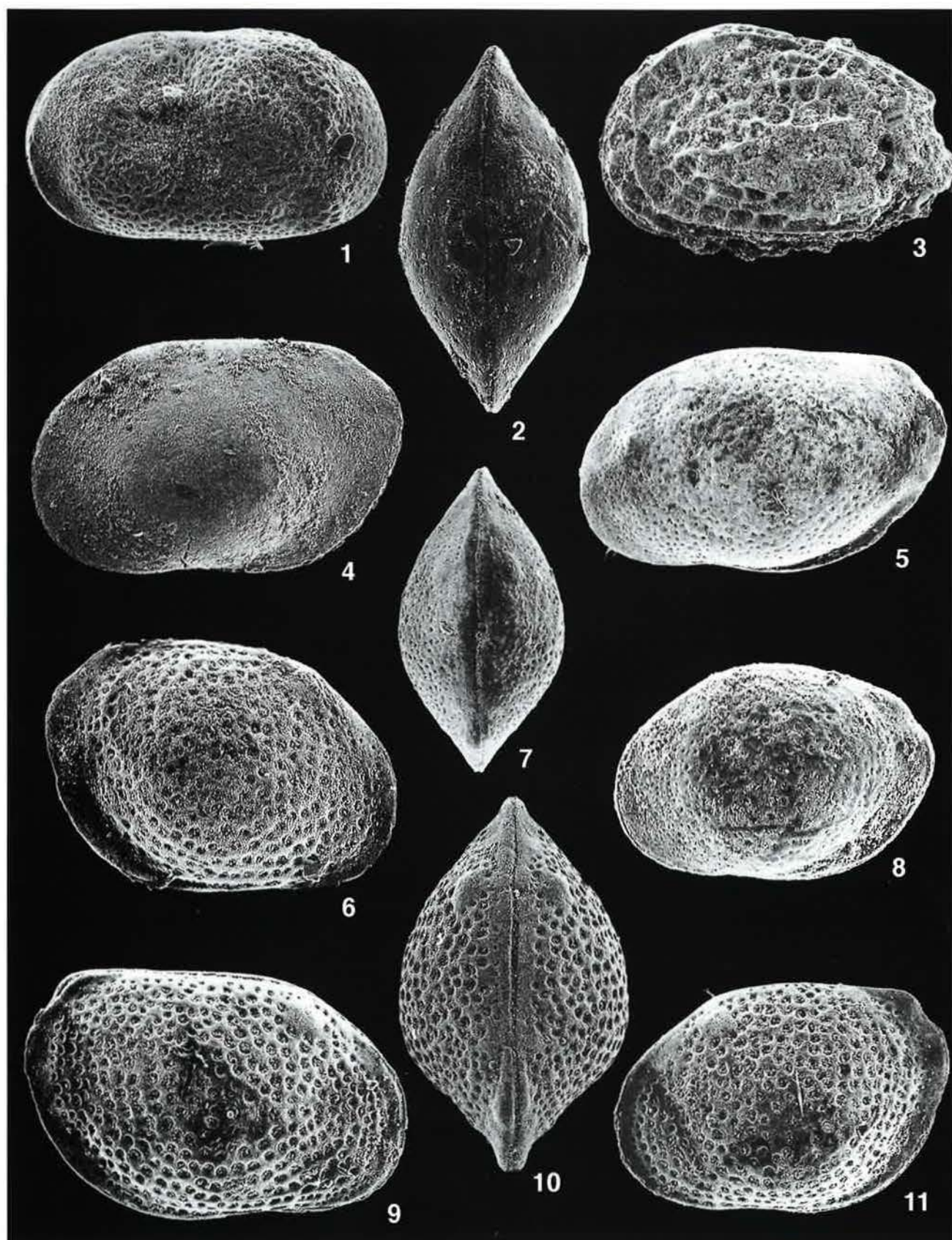
According to Russo *et al.* (1984) the genus *Dorukella* can be regarded as typical of coral reef facies. The present species was recovered in the "Sahelian" of Sicily (Russo *et al.*, 1984) and the Gulf of Gabes (Bonaduce *et al.*, 1992).

Genus PETERAURILA Aruta & Ruggieri, 1980

PETERAURILA MUSCULUS Aruta & Ruggieri, 1980
Pl. 3, figs. 4, 6

EXPLANATION OF PLATE 4

- Fig. 1 - *Cyprideis* sp. LV, external view, sample 38, C.O.B. 72, (x 75).
Figs. 2, 4 - *Loxoconcha* sp. aff. *L. perspicua* Bonaduce, Ruggieri, Russo & Bismuth, 1992. 2) C, dorsal view, sample 38, C.O.B. 53, (x 110); 4) LV from C, external view, sample 38, C.O.B. 54, (x 110).
Fig. 3 - *Tenedocythere subulata* Bonaduce, Ruggieri & Russo, 1985. LV from C, external view, sample 52, C.O.B. 70, (x 90).
Figs. 5, 7-8 - *Loxoconcha* sp. 1. 5) LV from male C, external view, sample 40, C.O.B. 55, (x 95); 7) Female C, dorsal view, sample 38, C.O.B. 56, (x 95); 8) LV from female C, external view, sample 38, C.O.B. 57, (x 95).
Figs. 6, 9-11 - *Loxoconcha lipadusensis* sp. nov. 6) Paratype, Female RV, external view, sample 38, C.O.B. 49, (x 100); 9) Holotype, RV from male C, external view, sample 38, C.O.B. 50, (x 100); 10) Paratype, Female C, dorsal view, sample 40, C.O.B. 51, (x 110); 11) Paratype, Female LV, external view, sample 40, C.O.B. 52, (x 100).



1980 *Petevaurila musculus* ARUTA & RUGGIERI, pp. 21-24; text-figs. 1-8.

The species is frequent in the "Sahelian" of Southern Italy, especially Sicily (Aruta & Ruggieri, 1980; Aruta, 1983); it was recorded also in the "Sahelian" of the Gulf of Gabes (Bonaduce *et al.*, 1992) and in the uppermost Tortonian-lower Messinian of the Sorbas Basin, SE Spain (Conesa & Babinot, 1999).

Family THAEROCYTHERIDAE Hazel, 1967
Genus HELIOCYTHERE Bonaduce, Ruggieri & Russo, 1988

HELIOCYTHERE BRONTOTHERIUM Bonaduce, Ruggieri & Russo, 1988b
Pl. 5, fig. 9

1988b *Heliocythere brontotherium* BONADUCE, RUGGIERI & RUSSO, p. 358, pl. 4, figs. 12-15.

The species, erected by Bonaduce *et al.* (1988b) from the "Sahelian" of Cozzo della Volpe near Palermo (Sicily), is also known from the "Sahelian" of the Gulf of Gabes (Bonaduce *et al.*, 1992). Only a single, ill-preserved carapace was recovered in sample 44.

Genus POKORNYELLA Oertli, 1956

POKORNYELLA ITALICA Ruggieri, Russo & Bossio, 1977
Pl. 3, figs. 7-8

1977 *Pokornyella italica* RUGGIERI, RUSSO & BOSSIO, pp. 130, 132, 134-135, text-figs. 1/1, 2, 3/2; pl. 1, figs. 9-10; pl. 2, figs. 1-4.

According to Ruggieri *et al.* (1977) the species is rather common in the "Sahelian" strata of the Mediterranean area. Notably, it occurs in the lower Messinian of the Maltese Archipelago, (Russo & Bossio, 1976), Tuscany (Bossio *et al.*, 1981), the Piedmont Basin (Ciampo, 1986), the Salentine Peninsula (Bossio *et al.*, 1989), the Piacenza Subapennines (Ruggieri *et al.*, 1977; Miculan, 1992) and the Sorba Basin (Conesa & Babinot, 1990). *P.*

italica is moderately abundant in samples 38, 40, 42, 44, 45, 46, 50 and 52.

Genus TENEDOCYTHERE Sissingh, 1972

TENEDOCYTHERE SUBULATA Bonaduce, Ruggieri & Russo, 1985
Pl. 4, fig. 3

1985 *Tenedocythere subulata* BONADUCE, RUGGIERI & RUSSO, p. 535, pl. 6, fig. 5; pl. 10, fig. 1.

A single carapace was recovered in sample 52. The species is known from the "Sahelian" of Sicily (Bonaduce *et al.*, 1985) and the Gulf of Gabes (Bonaduce *et al.*, 1992).

Family LOXOCONCHIDAE Sars, 1925
Genus LOXOCONCHA Sars, 1866

LOXOCONCHA LIPADUSENSIS sp. nov.
Pl. 4, figs. 6, 9-11

1976 *Loxoconcha punctatella* RUSSO & BOSSIO, pp. 223 *partim* (*non Cypridina punctatella* Reuss, 1850).

1981 *Loxoconcha punctatella* BOSSIO, BRADLEY, ESTEBAN, GIANNELLI, LANDINI, MAZZANTI, MAZZEI & SALVATORINI, pp. 26, 30 *partim* (*non Cypridina punctatella* Reuss, 1850).

1983 *Loxoconcha punctatella* ARUTA, p. 118, pl. 4, figs. 5-7 (*non Cypridina punctatella* Reuss, 1850).

1992 *Loxoconcha* aff. *punctatella* MICULAN, p. 124, pl. 6, figs. 3, 5.

Material – At least 100 carapaces and 10 valves (including juveniles).

Etymology – From Lipadusa, the name Renaissance authors (Cluverio and Ariosto) used for Lampedusa Island.

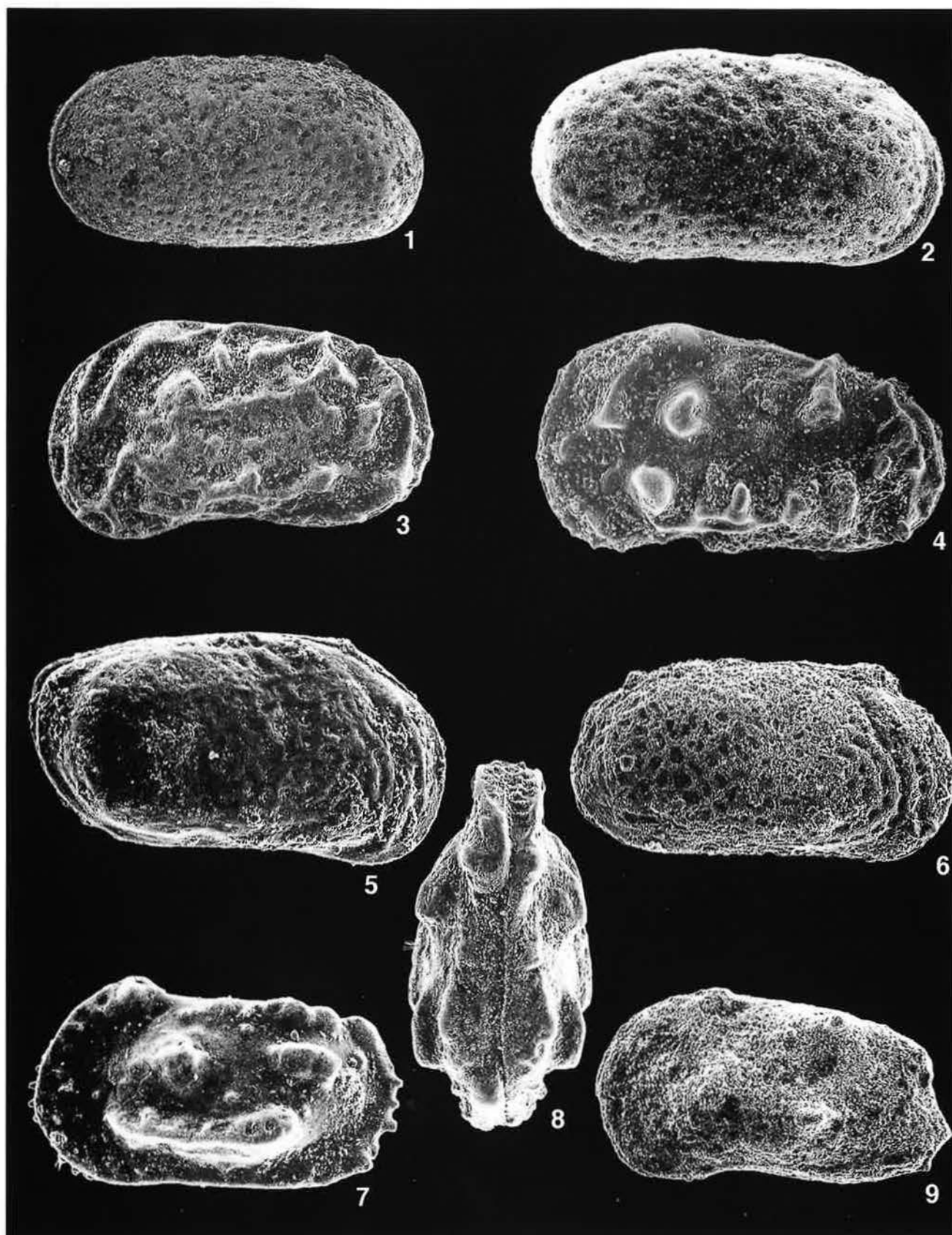
Holotype – A male carapace (Pl. 4, fig. 9), sample 38, C.O.B. 50.

Type-locality – Cala Calandra, eastern coast of Lampedusa Island.

Type-level – Vallone Imbriacole Beds, Capo Grecale Member of the Lampedusa Formation (lower Messinian).

EXPLANATION OF PLATE 5

- Figs. 1-2 - *Miocyprideis ornatissima* Bonaduce, Ruggieri, Russo & Bismuth, 1992. 1) LV, external view, sample 38, C.O.B. 58, (x 105); 2) RV, external view, sample 52, C.O.B. 59, (x 105).
Fig. 3 - *Callistocythere pallida* (Müller, 1894). LV, external view, sample 40, C.O.B. 44, (x 150).
Fig. 4 - *Callistocythere montana* Doruk, 1980. LV, external view, sample 38, C.O.B. 43, (x 160).
Fig. 5 - *Sylvestra grava* Bonaduce, Russo & Barra, 1990. RV from C, external view, sample 40, C.O.B. 68, (x 135).
Fig. 6 - *Sylvestra bismuthi* Bonaduce, Russo & Barra, 1990. RV from C, external view, sample 44, C.O.B. 67, (x 150).
Figs. 7-8 - *Carinocythereis cultrata* (Ruggieri & Russo, 1980). 7) LV, external view, sample 38, C.O.B. 61, (x 95); 8) C, dorsal view, sample 38, C.O.B. 62, (x 95).
Fig. 9 - *Heliocythere brontotherium* Bonaduce, Ruggieri & Russo, 1988b. LV from C, external view, sample 44, C.O.B. 48, (x 80).



Paratypes – 1 female right valve (Pl. 4, fig. 6), sample 38, C.O.B. 49; 1 female carapace (Pl. 4, fig. 10), sample 40, C.O.B. 51; 1 female left valve (Pl. 4, fig. 11), sample 40, C.O.B. 52.

Diagnosis – A large, strongly inflated species of *Loxoconcha* with subrhomboidal outline. Surface ornament coarsely punctate, the puncta are uniformly circular in shape and concentrically arranged.

Description – Female valves subrhomboidal in lateral view. Dorsal margin nearly straight or slightly convex; ventral margin medianly sinuous. Anterior margin rounded with apex below mid-height. Posterior margin oblique with short, blunt subdorsal caudal process. Surface ornament coarsely punctate, only the marginal anterior and posterior areas are smooth. The puncta are uniformly circular in shape and concentrically arranged; they tend to become smaller and closely spaced towards the peripheral areas. Eye-tubercle low, but clearly visible. In dorsal view the female carapaces are strongly inflated with maximum width beyond mid-length and acuminate extremities. Sexual dimorphism pronounced with males more elongate and laterally compressed than females.

Size (mm) –

	L	H	W
Holotype	0.69	0.44	0.19
Range of observed female sp.	0.60-0.70	0.41-0.48	0.18-0.21
Range of observed male sp.	0.63-0.74	0.39-0.45	0.17-0.20

Remarks – As previously noted by Miculan (1992), the present species strongly resembles *Loxoconcha punctatella* (Reuss, 1850). They can be distinguished, however, by the different nature of the ornament anteriorly. In Reuss' species the puncta tend to align radially and to form short radial ribs at the anterior end, whereas in *L. lipadusensis* they are concentrically arranged. Furthermore, the present species has a more quadrate lateral shape, with less convex dorsal margin (especially the right valve) and a more inflated dorsal outline.

Previous records – The species seems to be restricted to the lower Messinian: lower Messinian of the Maltese Archipelago (Russo & Bossio, 1976); lower Messinian of the Calcare of Rosignano Formation in Tuscany (Bossio *et al.*, 1981); "Sahelian" of Bonfornello, Palermo, Sicily (Aruta, 1983); lower Messinian of Vigoleno, Piacenza Subapennines (Miculan, 1992).

LOXOCONCHA sp. aff. *L. PERSPICUA* Bonaduce,
Ruggieri, Russo & Bismuth, 1992
Pl. 4, figs. 2, 4

This rare species (only four carapaces were recovered) is similar to *Loxoconcha perspicua* Bonaduce,

Ruggieri, Russo & Bismuth (1992, pp. 81-82, pl. 24, figs. 7-9) in the completely smooth lateral surface. The present species has, however, a more rectangular lateral outline and more compressed extremities.

LOXOCONCHA sp. 1

Pl. 4, figs. 5, 7-8

Although the species is probably new, the material at our disposal (2 female and 4 male carapaces) is insufficient to erect a new taxon.

Diagnosis – A medium-sized species of *Loxoconcha* with subovate lateral outline lacking a distinct caudal process. Lateral surface ornamented by small, shallow pits, which are concentrically arranged; perimarginal areas smooth. Eye tubercle weakly developed. Dorsal outline moderately inflated with maximum width at mid-length. Sexually dimorphic: males larger, proportionally more elongate and compressed than females.

Size (mm) –

	L	H	W
Females	0.60-0.61	0.41-0.42	0.16
Males	0.68-0.72	0.41-0.45	0.17-0.18

Remarks – The present species is superficially similar to *Loxoconcha* aff. *stellifera* Müller figured by Bonaduce *et al.* (1992, p. 82, pl. 24, fig. 11), but differs in the more pronounced surface ornament (bigger size of the pits) and the more inflated dorsal profile.

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