

A REVISION OF THE “NORTHERN GUEST” OSTRACODA (CRUSTACEA) OCCURRENCE IN THE QUATERNARY OF THE MEDITERRANEAN AREA

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ABSTRACT: Faranda C. & Gliozzi E., *A revision of the “northern guest” Ostracoda (Crustacea) occurrence in the Quaternary of the Mediterranean area.*

In this paper the revision of the “northern guest” ostracods widespread in the Mediterranean area during Quaternary time is proposed. The abundant literature on this topic lists up to twenty-three species. They have been critically revised and a list of only twelve true “northern guests” is provided: *Acanthocythereis dunelmensis* (NORMAN, 1865), *Bythocythere turgida* SARS, 1866, *Bythocythere zetlandica* ATHERSUCH, HORNE & WHITTAKER, 1983, *Cythere lutea* MÜLLER 1785, *Cytheropteron depressum* (BRADY & NORMAN, 1889), *Cytheropteron punctatum* BRADY, 1868, *Cytheropteron testudo* SARS, 1870, *Hemicythere villosa* (SARS, 1865), *Paradoxostoma abbreviatum* SARS, 1866, *Paradoxostoma ensiforme* BRADY, 1866, *Paradoxostoma tenuissimum* (NORMAN, 1869) and *Semicytherura angulata* (BRADY, 1868). These species are generally rare, being found with very few specimens and mainly in one locality. Only *Cytheropteron testudo* and *Cytheropteron punctatum* have been reported with a wide geographical distribution in Italy and in the Aegean Sea. The twelve “northern guest” ostracods entered the Mediterranean at different times, being more abundant in the Early Pleistocene Sicilian substage. Only one study on the Last Glacial Maximum marine ostracods has been carried out recording the presence of *C. testudo*. The record of loose valves of “cold” ostracod species (*C. testudo*, *P. tenuissimum* and *B. turgida*) among the living Mediterranean assemblages suggests that they could have migrated into the Mediterranean even during Late Pleistocene time. In this paper, a critical revision of the existing literature about “northern guest” ostracods is presented, together with their stratigraphical and geographical distribution in the Mediterranean, and three new “northern guest” ostracod species are added.

RIASSUNTO. Faranda C. & Gliozzi E., *Revisione della presenza dell'ospite freddo Ostracoda (Crustacea) nel Quaternario dell'area mediterranea.*

In questo lavoro viene proposta la revisione critica degli ostracodi “ospiti nordici” che si diffusero nel Mediterraneo durante le fasi climatiche fredde che caratterizzarono il Quaternario. L'abbondante, seppure frammentaria letteratura esistente su questo argomento, elenca ventitré specie di ospiti nordici; in seguito alla presente revisione questo numero è ridotto a sole dodici specie di ostracodi che possono essere considerati veri “ospiti nordici”: Acanthocythereis dunelmensis (NORMAN, 1865), Bythocythere turgida SARS, 1866, Bythocythere zetlandica ATHERSUCH, HORNE & WHITTAKER, 1983, Cythere lutea MÜLLER 1785, Cytheropteron depressum (BRADY & NORMAN, 1889), Cytheropteron punctatum BRADY, 1868, Cytheropteron testudo SARS, 1870, Hemicythere villosa (SARS, 1865), Paradoxostoma abbreviatum SARS, 1866, Paradoxostoma ensiforme BRADY, 1866, Paradoxostoma tenuissimum (NORMAN, 1869) e Semicytherura angulata (BRADY, 1868). Queste specie sono generalmente rare sia nelle associazioni, dove spesso sono rappresentate da pochissime valve, sia come presenza nell'area mediterranea, essendo prevalentemente segnalate in una sola località. Solo Cytheropteron testudo e Cytheropteron punctatum sembrano avere una distribuzione geografica piuttosto ampia, sia nel Mediterraneo centrale (Italia) sia in quello orientale (Mare Egeo). Le dodici specie di ostracodi “ospiti nordici” migrarono nel Mediterraneo in tempi quaternari diversi e risultano più abbondanti in corrispondenza del sottopiano Siciliano. L'unico studio sulle ostracofaune marine dell'ultimo Pleniglaciale ha permesso di registrare la presenza di C. testudo anche nella parte alta del Quaternario. È possibile che a questa specie ne possano venire aggiunte almeno altre due (P. tenuissimum and B. turgida) le cui valve isolate, prive di parti molli, sono state rinvenute nei fondali del Mediterraneo insieme ad ostracofaune viventi.

Keywords: Marine ostracods, northern guests, Mediterranean, Quaternary, stratigraphic distribution.

Parole-chiave: ostracodi marini. Ospiti nordici, Mediterraneo, Quaternario, distribuzione stratigrafica.

1. INTRODUCTION

At the 18th International Geological Congress (London, 1948), the lower boundary of the Quaternary Era (Tertiary/Quaternary boundary) was established “at the horizon of the first indication of the climatic deterioration in the Italian Neogene succession” (PILLANS & NAISH, 2004, p. 2272). Consistent with this recommendation, the basal part of the Quaternary included the “Cala-brian”, a marine Mediterranean stage defined by Gig-

noux (1910) at S. Maria di Catanzaro (Calabria, southern Italy) and originally assigned by this author to the Pliocene. In fact from the S. Maria di Catanzaro outcrop some “northern guest” molluscs such as *Arctica islandica* were collected, and their presence indicated a climatic cooling, as pointed out by Suess (1883-1909). Several studies followed, in which numerous “northern guest” molluscs, foraminifers and ostracods were listed, and their appearance in the Mediterranean area occurred in different Pleistocene times (RUGGIERI, 1975, 1977,

1980; RUGGIERI & SPROVIERI, 1977; MALATESTA & ZARLENGA, 1986). Recently, through the stable isotope analyses of marine foraminifers, a first global cooling was detected in correspondence to the Marine Isotopic Stage 100 (RAYMO *et al.*, 1989), which falls about 60 ka after the Middle/Late Pliocene boundary (Piacenzian/Gelasian GSSP at Monte S. Nicola section (Sicily) (RIO *et al.*, 1998). This discovery led the scientific community to discuss the possibility to move the Pliocene/Quaternary boundary down to the base of the Gelasian. After around twenty years of heated debates (CITA & CASTRADORI, 1994 with references; VAI, 1996 with references; SUC *et al.*, 1997 with references), in 2007 the INQUA and ICS stratigraphic commissions have jointly proposed a new stratigraphic assessment of Pliocene and Quaternary (OGG, 2007) (Fig. 1), ratified by the ICS Commission during May 2009 (CITA, 2009; MASCARELLI, 2009). In this new global stratigraphic scheme, the Neogene/Quaternary boundary corresponds to the base of the Gelasian Stage (2.588 Ma), which represents the first stage of the Quaternary System and also the first stage of the Pleistocene series (GIBBARD *et al.*, 2010). At present, the Quaternary system includes the ratified or proposed standard stages Gelasian, Calabrian, Ionian and Tarantian (RIO *et al.*, 1998; CITA *et al.*, 2006). Thus, in this paper, also the “cold” ostracods that entered the Mediterranean during the Gelasian are considered Quaternary “northern guests”, since, as re-defined by RUGGIERI (1977), a species can be considered a true Mediterranean “northern guest” if it is at present living outside the Mediterranean, at more northern latitudes, and entered the Mediterranean area during the “cold” global climatic oscillations. Moreover, we consider stratigraphically useful to maintain the subdivision of the Calabrian stage into the Santernian, Emilian and Sicilian Mediterranean regional substages, as defined by RUGGIERI *et al.* (1984) for the Mediterranean.

2. THE “NORTHERN GUEST” OSTRACODS IN THE LITERATURE: A CRITICAL REVISION

The first author who signalled the presence of “cold” ostracods in the Mediterranean was RUGGIERI (1952a) who recovered a fragment of *Cytheropteron testudo* SARS 1870 from the lower Pleistocene grey sands of Imola (northern Italy). Since then, Ruggieri and other authors have discussed the presence of “northern guest” ostracods in several papers (RUGGIERI, 1956, 1959, 1971, 1973, 1974, 1975, 1976, 1977, 1980; RUGGIERI *et al.*, 1976, 1977; RUGGIERI & SPROVIERI, 1977; SISSINGH, 1976; FARANDA & GLIOZZI, 2008), giving a rather long list of species:

Actinocythereis dunelmensis (NORMAN, 1865)
Argilloecia cylindrica SARS, 1866
Bythocythere dromedaria SARS, 1866
Bythocythere insignis SARS, 1869
Bythocythere zetlandica ATERSUCH, HORNE & WHITAKER, 1983
Cluthia keiji NEALE, 1975
Cythere lutea MÜLLER, 1785
Cytheropteron depressum (BRADY & NORMAN, 1889)
Cytheropteron latissimum (NORMAN, 1865) = *Cytherop-*

teron sp. ex gr. *C. latissimum* (NORMAN, 1865)
Cytheropteron punctatum BRADY, 1868
Cytheropteron testudo Sars, 1869
Hemicythere villosa (SARS, 1866)
Leptocythere macallana (BRADY & ROBERTSON, 1869)
Macrocypris minna (BAIRD, 1850)
Muellerina problematica (SEGUENZA, 1884)
Muellerina sp. nov. cf. *M. abissicola* (SARS, 1866);
Nereina (?) sp. ind.
Paradoxostoma abbreviatum SARS, 1866
Paradoxostoma ensiforme BRADY, 1868
Semicytherura angulata (BRADY, 1868)
Semicytherura producta (BRADY, 1868)
Thaerocythere (?) sp.
Xiphichilus tenuissimus (NORMAN, 1869)

The validity as “northern guests” of some of these species was discussed in several papers by Ruggieri and by other authors. In particular:

Argilloecia cylindrica SARS, 1866 - some valves recovered by COLALONGO (1966) at Le Castella (Calabria, southern Italy) and referred to this northern species (COLALONGO, 1966; RUGGIERI, 1971) were subsequently revised by GRECO *et al.* (1974 p. 174) and assigned to the species *Zabythocypris antemacella* (Maddocks); the specimens from Le Castella and Monasterace [Calabria, Southern Italy of GRECO *et al.* (1974)] have been recently included by AIELLO, BARRA & BONADUCE (1996a) within their new species *Anchistrocheles interrupta*.

Bythocythere dromedaria SARS, 1866 - RUGGIERI (1956) assigned to this species some juvenile valves from the ?Santernian of Talignano (Parma, northern Italy) and from the Emilian of Sciacca (Sicily, near Bar Maddalena); afterwards, RUGGIERI (1973) reported immature valves from Pliocene deposits (no localities are specified), thus, this author cancelled the species from its “northern guest” list. We have seen the Ruggieri Ostracod Collection (ROC.) stored at the Paleontological Museum “G.G. Gemmellaro” (Palermo University), but, at present, it has not been possible to check the Pliocene specimens since they are not in the collection, whereas the specimen from Talignano (ROC N° 1651) is not a *Bythocythere* but a juvenile of *Pseudocythere* (Fig. 2).

Bythocythere insignis SARS, 1869 - According to RUGGIERI (1973), the valves recovered at Ficarazzi (RUGGIERI, 1956) and Acqua dei Corsari (Palermo, Sicily) and referred to this species must be ascribed to *Monoceratina mediterranea* SISSINGH, 1972.

Macrocypris minna (BAIRD, 1850) - Ruggieri (1973) doubtfully included this species in its list of “northern guests” because it was recorded only by SEGUENZA (1883-86) and never recovered again. Indeed, Seguenza dubitatively referred an anterior fragment of a valve of Macrocypridae to *Macrocypris minna?* and he did not provide any illustration.

Muellerina sp. nov. cf. *M. abyssicola* (SARS, 1866) - RUGGIERI (1973) recognised a new species of *Muellerina*, from the Emilian of Foce del Verdura (Sciacca, Sicily) and compared it with the northern species *M. abyssicola* (SARS 1866) suggesting that the Italian specimens could be either a subspecies of this taxon or a new species phylogenetically linked to it. Afterwards, RUGGIERI (1975) referred *Muellerina* sp. nov. cf. *M. abyssicola* to the fossil species *Muellerina problematica*

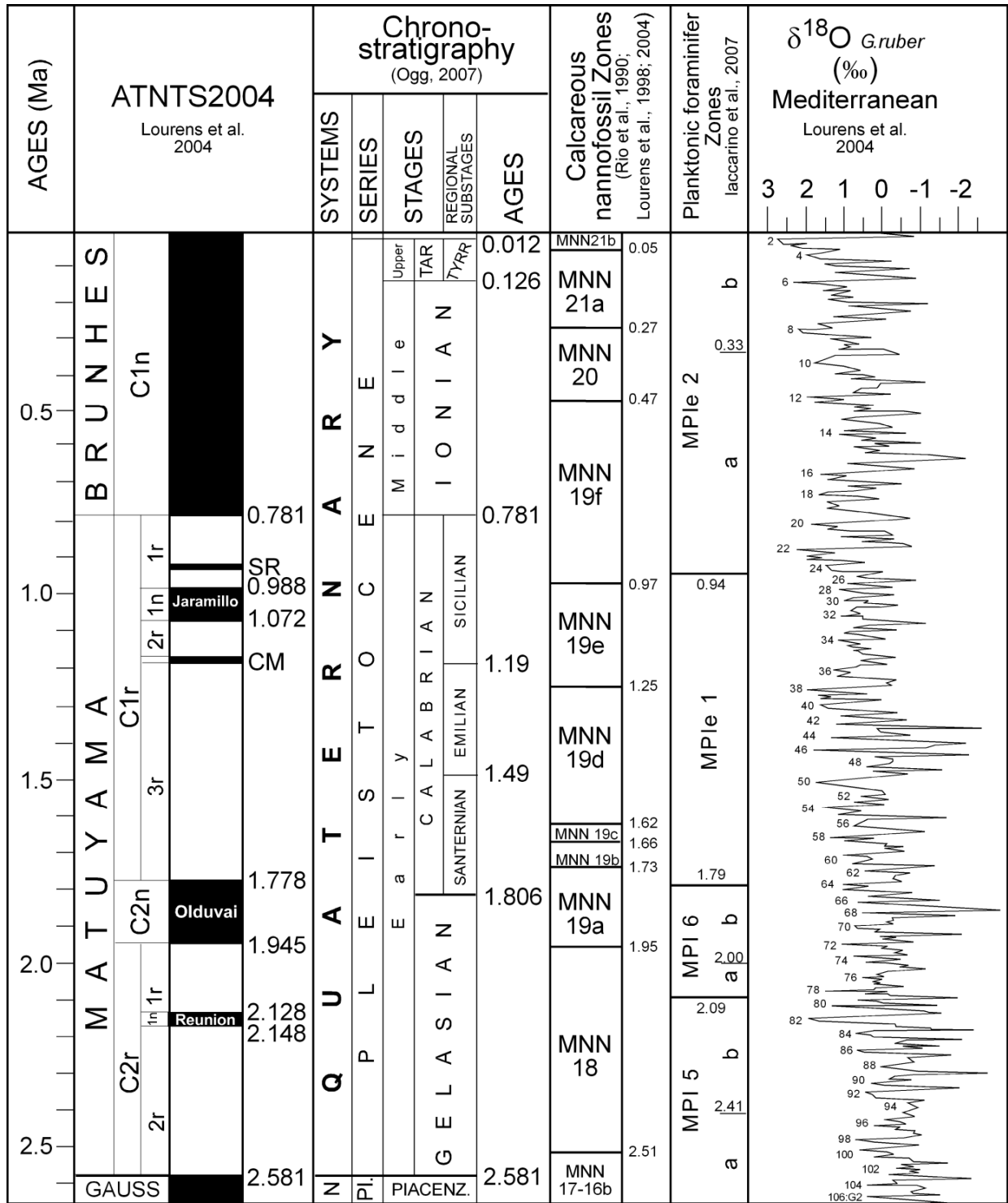


Fig. 1 - Magnetostratigraphy, chronostratigraphy, biostratigraphy and oxygen isotope stratigraphy of the Quaternary System (Isotopic scale from LOURENS *et al.*, 2004).

Magnetostratigrafia, cronostratigrafia, biostratigrafia e stratigrafia isotopica del Sistema Quaternario (scala isotopica da LOURENS et al., 2004).

(SEGUENZA, 1884) but, because of its affinity with *M. abyssicola*, he continued to consider this species as a northern guest (RUGGIERI, 1977, 1980, 1991; RUGGIERI & SPROVIERI, 1977) even if it is a fossil species. YASSINI (1979) recovered *Muellerina latimarginata* (SPEYER, 1863) (= *M. problematica*) in the Piacenzian-Gelasian of

Algeria and, more recently CIAMPO (1992) recovered *M. problematica* at S. Todaro (Calabria, southern Italy) in the Zanclean (MPI 3), thus, this species can no longer be considered a Quaternary "northern guest".

Leptocythere macallana (BRADY & ROBERTSON, 1869) - RUGGIERI *et al.* (1976, 1977) included this spe-



Fig. 2 - *Pseudocythere* sp.: broken left juvenile valve (transmitted light). This specimen is stored in the ROC slide N° 1651 under the name *Bythocythere dromedaria* - Talignano (Parma). Bar corresponds to 0.1 mm.

Pseudocythere sp.: *valva sinistra giovanile rotta in luce trasmessa. L'esemplare è conservato nella Collezione Ostracodi Ruggieri teca N° 1651 con il nome Bythocythere dromedaria - Talignano (Parma). La barra corrisponde a 0.1 mm.*

cies among the ostracod "northern guests" because it had been recovered from several Calabrian deposits of Calabria and Sicily (RUGGIERI, 1952b; RUGGIERI *et al.*, 1976, 1977). ATHERSUCH *et al.* (1989) consider the Mediterranean species *Leptocythere levis* (MÜLLER, 1894) a younger synonym of this species. RUGGIERI & D'ARPA (1993) did not agree with this position. However, they recovered *L. macallana* in the Piacenzian of Altavilla (Sicily), thus the species cannot be included any more among the Quaternary "northern guests".

Cytheropteron latissimum (Norman, 1865) = *Cytheropteron* sp. ex gr. *C. latissimum* (NORMAN, 1865) - RUGGIERI (1975) records the presence of *C. latissimum* in the Sicilian deposit of Acqua dei Corsari (Ficarazzi, Sicily). In his paper of 1977, RUGGIERI changed the attribution of this species, considering it a species of *Cytheropteron* different although similar to *C. latissimum*. Unfortunately, Ruggieri did not clearly characterise it taxonomically, nor did he illustrate it. The slide of this species within the Ruggieri ostracod collection is empty.

Cluthia keiji NEALE, 1975 - This species occurs for the first time in the Mediterranean area in the Calabrian (Santernian). RUGGIERI (1977) and RUGGIERI & SPROVIERI (1977) included *C. keiji* within the "cold species" which migrated into the Mediterranean in correspondence with the onset of the first Pleistocene cooling episode. RUGGIERI (1977) himself stated that it could not be considered a true "northern guest" since the species adapted to the Mediterranean climatic conditions and it is still living in this region. *Cluthia keiji* was recovered by CARBONNEL & BALLELIO (1982) in the Piacenzian deposits of the Rhône valley, thus it cannot be considered as either a Quaternary "northern guest" nor a "émigrés du Nord attardés" sensu GIGNOUX (1913) (RUGGIERI, 1977).

Thaerocythere (?) sp. (in RUGGIERI, 1977) = *Nereina* (?) sp. indet. (in RUGGIERI, 1980) - We agree with RUGGIERI (1977) that the specimens collected and illustrated from the Sicilian of the Valle del Belice (Sicily) cannot be referred with certainty to the genus *Thaerocythere* HAZEL, 1967. The shape of the posterior border and the ornamentation of the valve illustrated by RUGGIERI (1977) point to the genus *Grinioneis* LIEBAU, 1975.

In any case, the Sicilian valves are completely different from the Recent arctic species *Thaerocythere crenulata* (SARS, 1866). The same specimens cannot be referred to the arctic genus *Nereina* MANDELSTAM, 1957 because the hinge is different, smooth in *Nereina* but with a crenulated bar in the Valle del Belice specimens. Thus, the doubtful attribution of these valves as a possible "northern guest" cannot be accepted.

Following our revision, the specimen hosted as *Thaerocythere* (?), Valle del Belice, in the Ruggieri Ostracod Collection at Palermo (N° 2766) is referable to *Muellerina problematica*, and is not the specimen illustrated by RUGGIERI (1977). Probably, a dislocation of the stored valve occurred and the original specimen identified as *Thaerocythere*(?) must be considered lost.

Semicytherura producta (BRADY, 1868) - RUGGIERI (1976) reports this species from the Calabrian of Chirco, Ciantrato (Marsala, Sicily) and Ficarazzi (Sicily). During the revision of the Ruggieri's collection these specimens have not been found. In the collection there is one never published broken valve from Via del Fante (Palermo, Sicily), (G.O.C. N° 2593C), from which it is impossible to confirm the identification. Thus, for the moment, the presence of *S. producta* in the Mediterranean during Quaternary is dubitative.

In conclusion, only the following 11 species, reported with the updated nomenclature, can be considered true "northern guest" ostracods:

- Acanthocythereis dunelmensis* (NORMAN, 1865)
- Bythocythere zetlandica* Athersuch, HORNE & WHITAKER, 1983
- Cythere lutea* MÜLLER, 1785
- Cytheropteron depressum* (BRADY & NORMAN, 1889)
- Cytheropteron punctatum* BRADY, 1868
- Cytheropteron testudo* SARS, 1869
- Hemicythere villosa* (SARS, 1866)
- Paradoxostoma abbreviatum* SARS, 1866
- Paradoxostoma ensiforme* BRADY, 1868
- Paradoxostoma tenuissimum* (NORMAN, 1869)
- Semicytherura angulata* (BRADY, 1868)

To this list one more species should be added, not noted by Ruggieri as a Quaternary "northern guest" since he recovered it from the Gelasian of Castellarquato (Piacenza) (RUGGIERI, 1976): *Bythocythere turgida* (SARS, 1866).

3. STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF THE QUATERNARY "NORTHERN GUEST" OSTRACODS IN THE MEDITERRANEAN AREA

Acanthocythereis dunelmensis (NORMAN, 1865) (Fig. 3)

- 1865 *Cythereis dunelmensis* sp. n. - Norman, pp. 22, Pl. 7, Figs. 1-4.
- 1967 *Acanthocythereis* (?) *dunelmensis* (Norman) - Hazel, p. 34.
- 1969 *Trachyleberis dunelmensis* (Norman) nov. comb. - Yassin, p. 49.
- 1977 *Actinocythereis dunelmensis* (Norman) nov. comb. - Ruggieri, p. 83, Fig. 1.
- 1989 *Acanthocythereis dunelmensis* (Norman) nov. comb. - Athersuch *et al.*, pp.132-134, Fig. 52; Pl. 3, Fig. 10.

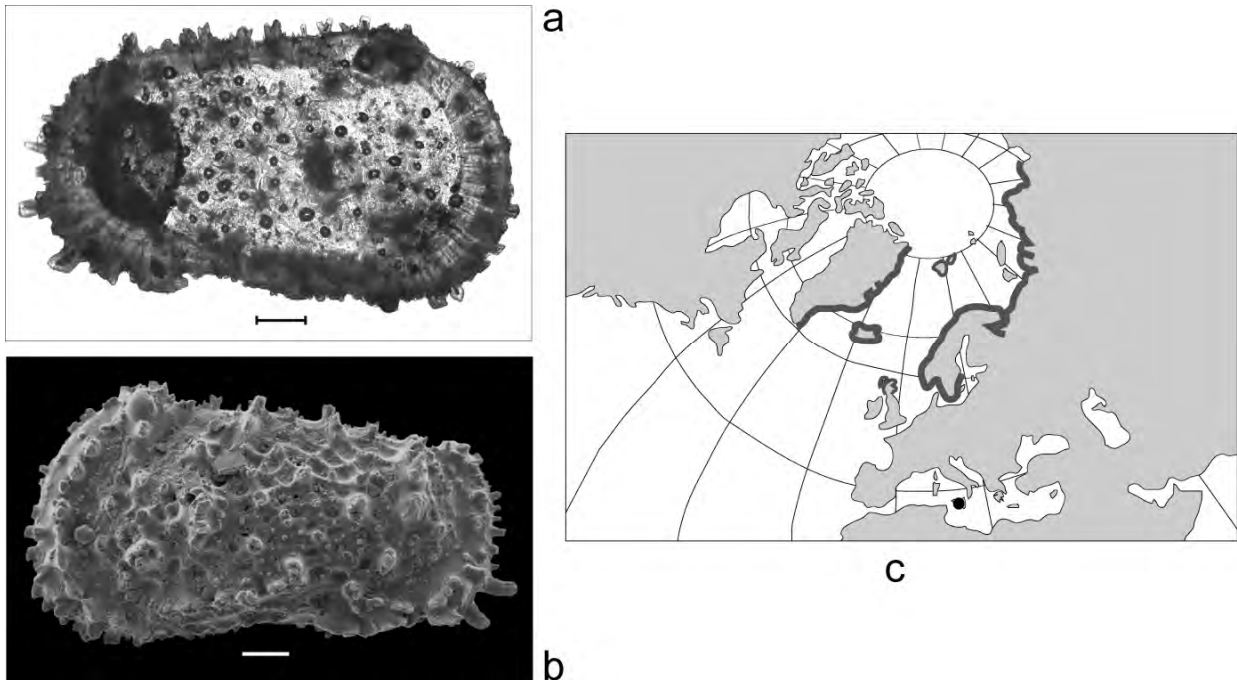


Fig. 3 - *Acanthocythereis dunelmensis*: (a) right valve under transmitted light, (b) left valve under SEM from Catarinicchia (Belice Valley, Sicily), Sicilian age; (ROC slide N° 2760); (c) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Acanthocythereis dunelmensis: (a) valva destra in luce trasmessa, (b) valva sinistra in scansione elettronica, provenienti dalla località Catarinicchia località (Valle del Belice, Sicilia), età Siciliano; (Collezione Ostracodi Ruggieri teca N° 2760); (c) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo nel Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

Recent distribution: S. Baltic Sea, Öres, Bohuslän, N. Norway, Iceland and Arctic Seas, Shetlands, NE British Isles, East Greenland (ATHERSUCH *et al.*, 1989; MALZ, 1989; HANSSON, 1998; FRENZEL *et al.*, 2010); Hornsund (South Spitsbergen) (MACKIEWICZ, 2006); Laptev Sea (N. Russia) (STEPANOVA *et al.*, 2003, 2007, 2010).

Ostracod bioprovince: Celtic - Arctic (Fig. 4)

Ecology: It inhabits the marine inner outer shelf environment (50-100 m), in polyhaline-euhaline conditions and water temperatures that range from -2 to 13 (19)°C (WILKINSON, 2005; STEPANOVA *et al.*, 2007, 2010; FRENZEL *et al.*, 2010).

Fossil distribution in the Mediterranean:

Calabrian (Sicilian): Belice, (Sicily) (RUGGIERI, 1977, 1980).

***Bythocythere turgida* SARS, 1866**
(Fig. 5)

1866 *Bythocythere turgida* sp. nov. - SARS, p. 84, Pl. 107, Figs. 1-12.

Bythocythere turgida is a problematic species. The original drawings by SARS (1866, 1928) are the only available illustrations of this species. ATHERSUCH *et al.* (1983), revising the *Bythocythere* species from the British coasts, split this species into three different taxa: *B. turgida*, at present distributed only on the Norway coasts, *B. robinsoni* ATHERSUCH, HORNE & WHITTAKER, 1983, and *B. bradleyi* ATHERSUCH, HORNE & WHITTAKER, 1983, living only in the British waters. Unfortunately these Authors did not illustrate *B. turgida* s.s. MALZ & JELLINEK (1984) agree with ATHERSUCH *et al.* (1983)

and discuss the possible attribution of their specimen to *B. turgida*. In the present paper we consider the specimen illustrated by MALZ & JELLINEK (1984) from the Calabrian (Emilian) of Peloponnesus (Greece) as males of



Fig. 4 - Eastern Atlantic ostracod bioprovinces (redrawn from FRENZEL *et al.*, 2010).

Bioprovince ad ostracodi dell'Atlantico orientale (ridisegnata da FRENZEL *et al.*, 2010).

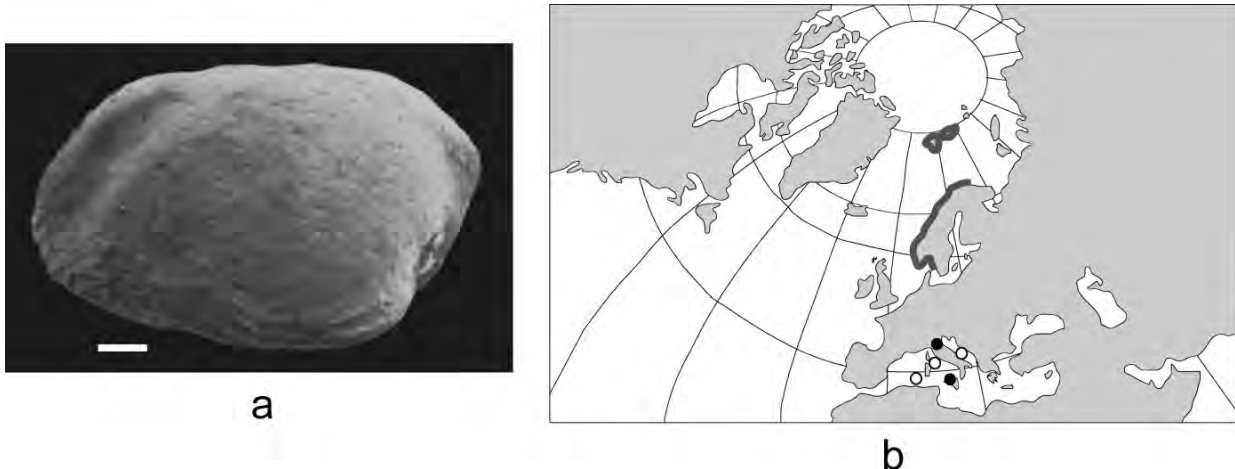


Fig. 5 - *Bythocythere turgida*: (a) left valve from Breman, 1976; (b) present geographical distribution (dark grey line), early Pleistocene distribution in the Mediterranean area (black dot), Last Glacial Maximum distribution in the Mediterranean (white circle). Bar corresponds to 0.1 mm.

Bythocythere turgida: (a) valva sinistra da Breman, 1976; (b) distribuzione geografica attuale (linea grigio scura), distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri) e durante il Pleniglaciale (cerchi bianchi). La barra corrisponde a 0.1 mm.

B. puncticulata RUGGIERI, 1976. Even the specimen from the Zanclean of Bou Ismail (Algeria) illustrated as *Bythocythere turgida* by YASSINI (1979) could be a female of the same species.

The *Bythocythere turgida* specimen from Partanna (Sicily, early Calabrian) recovered in the ROC slide N° 2526 is not referable to this species but to a juvenile male of *B. puncticulata* RUGGIERI, 1976 (Fig. 6).

The inclusion of *B. turgida* within the list of the living Mediterranean species (AIELLO *et al.*, 1995) is due to the recovery of some loose valves from the Adriatic and Tyrrhenian seas (BONADUCE *et al.*, 1976, 1983; BREMAN, 1976; ARBULLA *et al.*, 2001, 2004). According to RUGGIERI (1976) the specimens collected by Breman in the Adriatic Sea must be considered as subfossil and referable to the Last Pleniglacial Maximum migration. We suppose that also the BONADUCE *et al.* (1976) specimens from the same sea were subfossil. ARBULLA *et al.* (2001, 2004) recover the few juvenile valves of *B. turgida* from La Maddalena (Sardinia) in a sample at 2-7 m of depth. Such shallow depth lead us to infer that these specimens too are subfossil.

In conclusion, we consider *Bythocythere turgida* as a true "northern guest".

Recent distribution: Koster Channel, Oslofjord, S and W Norway, Spitzbergen (ATHERSUCH *et al.*, 1983; MALZ & JELLINEK, 1994; HANSSON, 1998).

Ostracod bioprovince: Norwegian - Arctic (Fig. 4)

Ecology: According to Elofson (1941) it is a polyhaline-euhaline species that inhabits shallow to rather deep waters (20-140 m)

Fossil distribution in the Mediterranean:

Gelasian: Castellarquato (Piacenza, northern Italy) (RUGGIERI, 1976)

Calabrian (Emilian): Cinisi (Palermo, Sicily) (RUGGIERI, 1976).

Tarantian (Last Pleniglacial): Adriatic Sea (BONADUCE *et al.*, 1976; BREMAN, 1976)

Tyrrhenian Sea (Maddalena Island) (ARBULLA *et al.*, 2001; 2004)

Western Mediterranean Basin (near Algerian coast) (BONADUCE *et al.*, 1983)

***Bythocythere zetlandica* ATHERSUCH,
HORNE & WHITTAKER, 1983
(Fig. 7)**

1983 *Bythocythere zetlandica* sp. nov. - Athersuch, Horne & Whittaker, p. 73, Figs. 5c, 41-n; Pl. 2, Figs. 5-8.

In the ROC slide N° 856 a broken juvenile specimen is stored labelled *Bythocythere cf. B. zetlandica* collected from the Gelasian Capocolle clays (Forlì, northern Italy) (Fig. 8). We have revised it and we prefer to leave it in open nomenclature since it does not seem a juvenile of *B. zetlandica*.

Recent distribution: Shetlands, N. Britain (ATHERSUCH *et al.*, 1989; HANSSON, 1998).

Ostracod bioprovince: Celtic (Britannic) (Fig. 4)

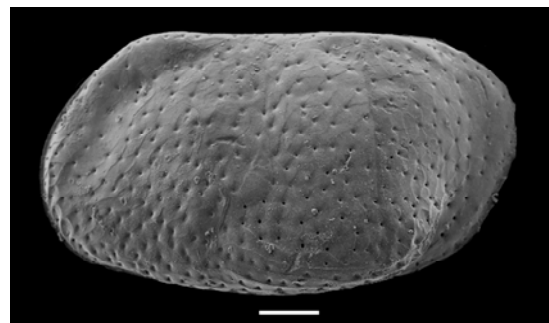


Fig. 6 - *Bythocythere puncticulata*: left juvenile male valve. This specimen is stored in the ROC slide N° 2526, Partanna (Sicily, early Calabrian), labelled as *Bythocythere cf. B. turgida*. Bar corresponds to 0.1 mm.

Bythocythere puncticulata: valva sinistra maschile giovanile. L'esemplare è conservato nella Collezione Ostracodi Ruggieriteca N° 2526, Partanna (Sicilia, Calabrian inferiore) con il nome *Bythocythere cf. B. turgida*. La barra corrisponde a 0.1 mm.

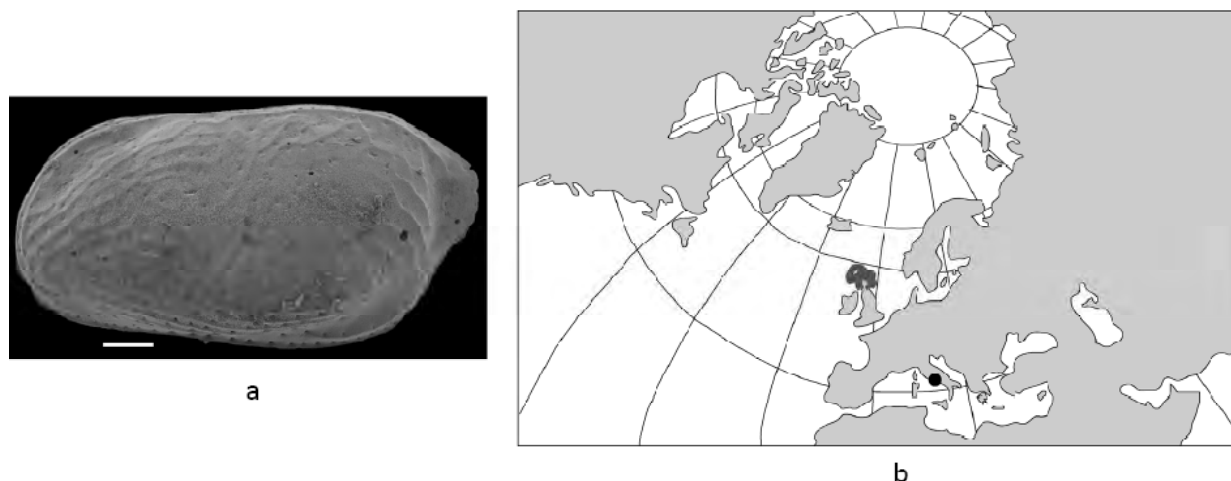


Fig. 7 - *Bythocythere zetlandica*: (a) left valve from Monte Mario (Roma, Latium), Santernian age; (Glozzi's Ostracod Collection (GOC) slide N° M83/4/15). (b) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Bythocythere zetlandica: (a) valva sinistra da Monte Mario (Roma, Lazio), età Santerniano; (Collezione Ostracodi Glozzi teca N° M83/4/15). (b) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri) La barra corrisponde a 0.1 mm.

Ecology: inner circalittoral waters around British coasts (ATHERSUCH *et al.*, 1989)

Fossil distribution in the Mediterranean:

Calabrian (Santernian): Monte Mario (Rome, central Italy), from the 2° *A. islandica* level (FARANDA & GLOZZI, 2008).

***Cythere lutea* O.F. MÜLLER, 1785**

(Fig. 9)

1785 *Cythere lutea* sp. n. - O.F. MÜLLER, p. 65, Pl. 7, Figs. 3-4.

1818 *Cytherina lutea* (O.F. MÜLLER) nov. comb. - LAMARCK, p. 125.

1941 *Cythere lutea* O.F. MÜLLER - SYLVESTER-BRADLEY, p. 27, Figs. 15-18 (with full synonymy)

Recent distribution: Kieler Bucht, Öres, Bohuslän, Bergen, N. Norway, Iceland and Arctic Seas, Shetlands, SW British Isles, Scilly Isles, W France (HANSSON, 1998; FREIWALD *et al.*, 1998; MACKIEWICZ, 2006); Kent coast (Isle of Thanet) (BRUCE, 2002); North Yorkshire (HULL, 1998); from S. Norway to N France (ATHERSUCH *et al.*, 1989); subfrigid to mild temperate waters of the Atlantic and Pacific Ocean (HANAI, 1977). A subspecies (*Cythere lutea omotenipponica* HANAI, 1959) reaches the warm temperate climatic zone along the Pacific coast of Japan (HANAI, 1977).

Ostracod bioprovince: Celtic - Arctic (Fig. 4)

Ecology: The species inhabits shallow waters (30-50 m) with sandy bottom or populated by coralline algae. It withstands meso- to euhaline salinities and a wide range of temperature (-2 to 22°C) (FREIWALD *et al.*, 1998; FRENZEL *et al.*, 2010).

Fossil distribution in the Mediterranean:

Calabrian (Sicilian): Lo Sperone (Palermo, Sicily) (RUGGIERI, 1971, 1973).

***Cytheropteron depressum* BRADY & NORMAN, 1889**

(Fig. 10)

1889 *Cytheropteron depressum* sp. n. - BRADY & NORMAN, p. 447, Pl. 34, Figs. 39-42.

Recent distribution: SW British Isles, (ATHERSUCH *et al.*, 1989; HANSSON, 1998); Scilly Isles (NEALE, 1970).

Ostracod bioprovince: Celtic (Britannic) (Fig. 4)

Ecology: Inner circalittoral marine environment (ATHERSUCH *et al.*, 1989)

Fossil distribution in the Mediterranean:

Calabrian (Santernian): Monte Mario (Rome, central Italy), from the 2° *A. islandica* level (FARANDA & GLOZZI, 2008).

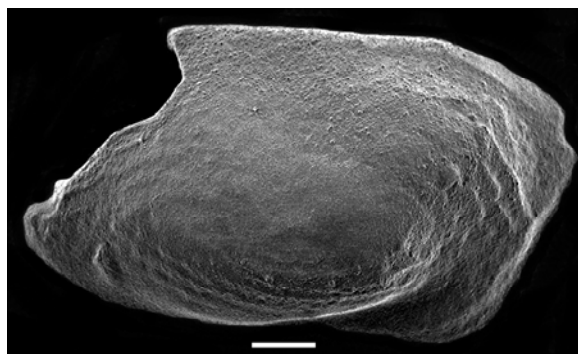


Fig. 8. *Bythocythere* sp.: left juvenile broken valve. This specimen is stored in the ROC slide N° 856 under the name *Bythocythere* cf. *B. zetlandica* - Gelasian Capocolle clays (Forlì, northern Italy). Bar corresponds to 0.1 mm.

Bythocythere sp.: valva sinistra giovanile rota. Questo esemplare è conservato nella Collezione Ostracodi Ruggieri teca N° 856 col nome *Bythocythere* cf. *B. zetlandica* - Gelasiano, argille di Capocolle (Forlì, Italia settentrionale). La barra corrisponde a 0.1 mm.

***Cytheropteron punctatum* BRADY, 1868**
(Fig. 11)

1868 *Cytheropteron punctatum* nov. sp. - BRADY, p. 449, Pl. 34, Figs. 45-48.

Recent distribution: Korshavn, S. Norway, Bergen, British Isles, Bay of Biscay (HANSSON, 1998).

Ostracod bioprovince: Celtic - Norwegian (Fig. 4)

Ecology: PENNEY (1993) collected this species from the silty bottom of the Norway Channel at a depth comprised between 190 and 270 m, bottom temperature between 6.5-7°C, and euhaline salinity.

Fossil distribution in the Mediterranean:

Calabrian: Tavoliere delle Puglie (southern Italy) (RUGGIERI, 1959).

Crete (SISSINGH, 1972).

Calabrian (Santernian): Valle del Tronto (Marche, central Italy) (PUCCI, 1956; RUGGIERI, 1973).

Vrica (Calabria, southern Italy) about 10 m above the first occurrence of *Cytheropteron testudo* (COLALONGO & PASINI, 1980; PASINI & COLALONGO, 1994).

Calabrian (Emilian): Vrica (Calabria, Southern Italy) (COLALONGO & PASINI, 1980; PASINI & COLALONGO, 1994).

Cala Bianca (Marina di Camerota, Campania, southern Italy) (CIAMPO, 1976).

Calabrian (Sicilian): Ficarazzi (Palermo, Sicily) (RUGGIERI, 1956, 1973).

S. Maria di Catanzaro (Calabria, southern Italy) (SISSINGH, 1973a).

Monasterace (Calabria, southern Italy) (GRECO *et al.*, 1974).

***Cytheropteron testudo* SARS, 1869**
(Fig. 12)

1869 *Cytheropteron testudo* nov. sp. SARS, p. 173, Pl. 105, Fig. 1.

Recent distribution: Lofoten, Spitsbergen, Koster Channel, Hardangervikfjord (HANSSON, 1998); Laptev Sea (N. Russia) (STEPANOVA *et al.*, 2003); Scoresby Sound, W Greenland (WHATLEY *et al.*, 1996, 1998; MACKIEWICZ, 2006); Murray Island (E Greenland), Newfoundland (BENSON *et al.*, 1984), Norwegian coast down to the Skagerrak (RUGGIERI, 1971, 1973, 1977). The report of this species in the Bay of Biscay (YASSINI, 1969) concerns only loose valves. The possible distribution of *C. testudo* in the Southern Hemisphere is discussed by several authors (SWANSON & AYRESS, 1999; DIXON, 2006; JELLINEK *et al.*, 2006) but this problem is beyond the topic of the present paper.

Ostracod bioprovince: Norwegian - Arctic (Fig. 4)

Ecology: It is a rather deep species. It has been reported from Norway at depths comprised between 80 and 240 m (FREIWALD *et al.*, 1998) and down to 300 m (PENNEY, 1993) at bottom temperatures comprised between 7.0 and 7.4°C. ELOFSON (1941) reports *C. testudo* from Skagerrak at 270 m of depth and from Spitzbergen at 150 m at bottom temperatures from -2° to 10°C.

Fossil distribution in the Mediterranean:

Gelasian: M. S. Nicola (Sicily) at 68 m (sample 35) (AIELLO *et al.*, 1996b, 2000; BONADUCE & SPROVIERI, 1984).

Camerano (Forlì, northern Italy) (RUGGIERI, 1977, 1978, 1996).

Castrocaro (Forlì, northern Italy) (RUGGIERI, 1977, 1978, 1996).

"Calabrian": Kos (Greece, Aegean Sea) (MOSTAFAWI, 1981, 1986).

Rhodes (Greece, Aegean Sea) (MOSTAFAWI, 1989).

Zakinthos (Greece, Ionian Sea) (TSAPRALIS, 1981).

Calabrian (Santernian): Vrica (Calabria, southern Italy), about 10 m above the sapropel e (COLALONGO & PASINI, 1980; PASINI & COLALONGO, 1994).

Ribera (southern Sicily) (RUGGIERI, 1977).

Cosenza (Calabria, Southern Italy) (RUGGIERI, 1952b).

Calabrian (Emilian): Vrica (Calabria, southern Italy) (COLALONGO & PASINI, 1980; PASINI & COLALONGO, 1994).

Imola (northern Italy) (RUGGIERI, 1952a, 1975).

Mar Piccolo (Taranto, southern Italy) (CIAMPO, 1971).

Porto Recanati (Ancona, central Italy) (RUGGIERI, 1971).

Località "il Carmine" (Crotone, Calabria, southern Italy) (RUGGIERI, 1952a).

Località in destra del Verdura (Sciaccia, Sicily) (RUGGIERI, 1973).

Calabrian (Sicilian): Le Castella (Calabria, southern Italy) (COLALONGO, 1966).

S. Maria di Catanzaro (Calabria, southern Italy) (SISSINGH, 1973a).

Ficarazzi (Palermo, Sicily) (SISSINGH, 1973b).

Mar Piccolo (Taranto, southern Italy) (CIAMPO, 1971).

Porto Recanati (Ancona, central Italy) (RUGGIERI, 1971).

Località "il Carmine" (Crotone, Calabria, southern Italy) (RUGGIERI, 1952a).

Località in destra del Verdura (Sciaccia, Sicily) (RUGGIERI, 1973).

Pizzo Longo (Crotone, Calabria, southern Italy) (this paper, together with *G. truncatulinoides excelsa*).

Tarantian (Last Pleniglacial): Gulf of Taranto (MONCHARMONT-ZEI *et al.*, 1985)

Adriatic Sea (BREMANN, 1976)

***Hemicythere villosa* (SARS, 1866)**
(Fig. 13)

1866 *Cythereis villosa* nov. sp. - SARS, p. 42.

1868 *Cythere villosa* (SARS) - BRADY, p. 411, Pl. 29, Figs. 28-32.

1925 *Hemicythere villosa* (SARS) - SARS, p. 182, Pl. 84, figs. 1-13.

1941 *Cythereis (Eucythereis) villosa* SARS - ELOFSON, pp. 287-288.

Recent distribution: Kieler Bucht, Öres, Bohuslän, North Sea, N. Norway, Iceland, Bear Island (Swalbard), British Isles, Scilly Isles, Bay of Biscay (HANSSON, 1998); Kent coast (Isle of Thanet) (BRUCE, 2002); Davis Strait (Baffin Bay) (ELOFSON, 1941), Atlantic North America (Virginia coast) (HULINGS, 1966); Britain and NW European coasts (ATHERSUCH *et al.*, 1989).

Ostracod bioprovince: Celtic - Arctic (Fig. 4)

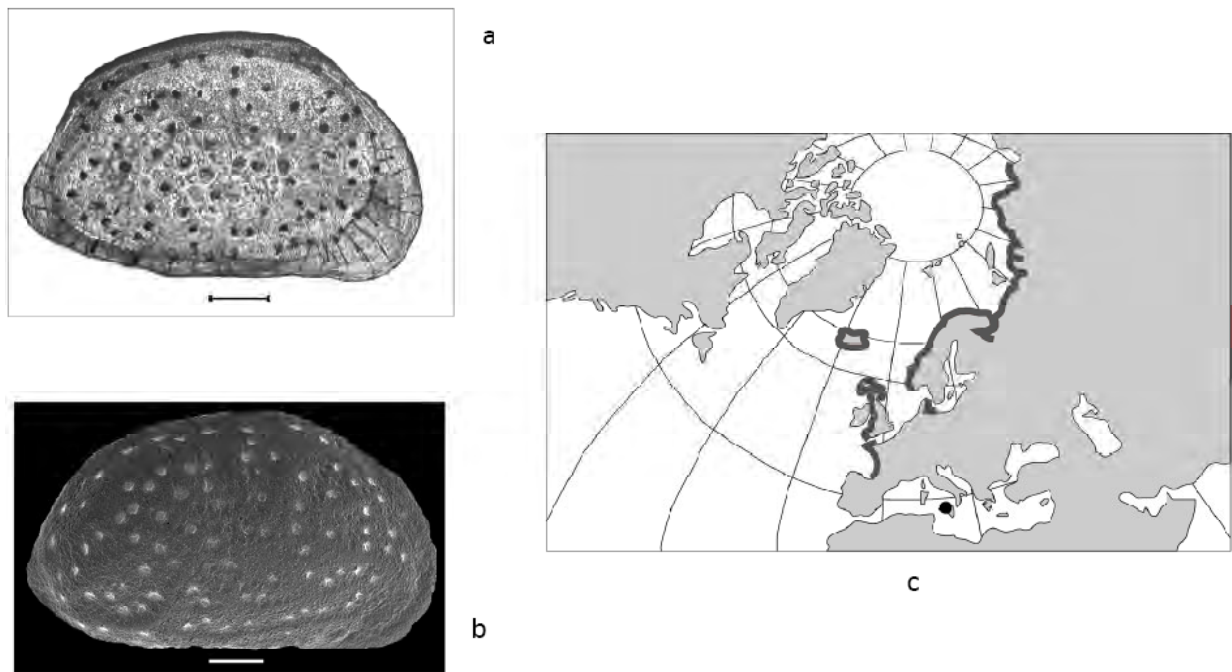


Fig. 9 - *Cythere lutea*: (a) right valve (transmitted light), (b) right valve under SEM from Sperone locality (Palermo), Calabrian (Sicilian) (ROC slide N° 1623); (c) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Cythere lutea: (a) valva destra in luce trasmessa, (b) valva destra in scansione elettronica dalla località Sperone (Palermo, Sicilia), Calabrian (Siciliano) (Collezione Ostracodi Ruggieri teca N° 1623); (c) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

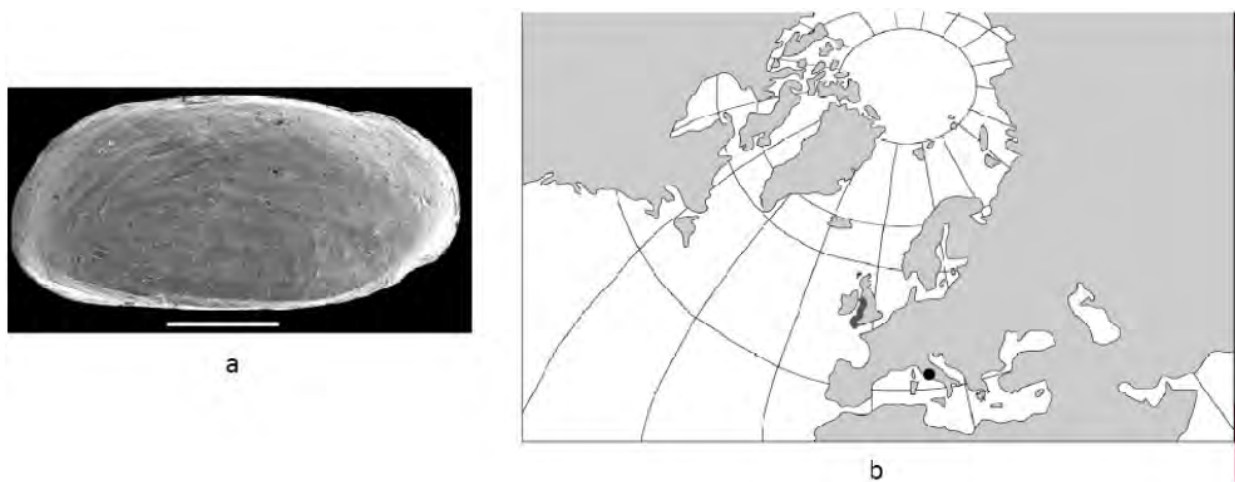


Fig. 10 - *Cytheropteron depressum*: (a) left valve from Monte Mario (Roma, Latium), Santernian age; (GOC slide N° M114/1/5). (b) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Cytheropteron depressum: (a) valva sinistra da Monte Mario (Roma, Lazio), età Santerniano; (Collezione Ostracodi Gliozzi teca N° M114/1/5). (b) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

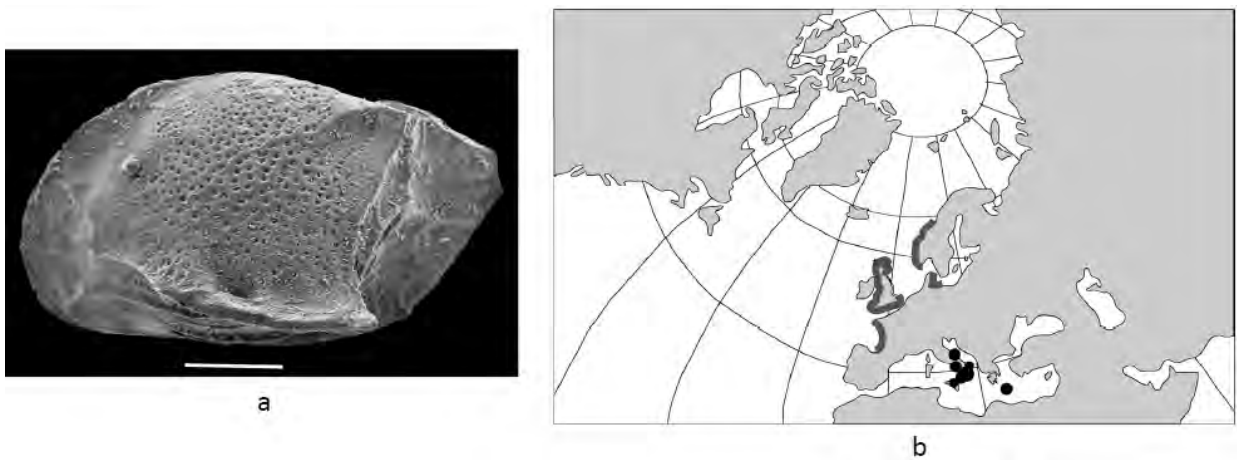


Fig. 11 - *Cytheropteron punctatum*: (a) right valve from Monasterace (Calabria), Sicilian age; (ROC slide N° 2313). (b) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Cytheropteron punctatum: (a) valva destra dalla località Monasterace (Calabria, Italia meridionale), età Siciliano; (Collezione Ostracodi Ruggieri teca N° 2313). (b) distribuzione stratigrafica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

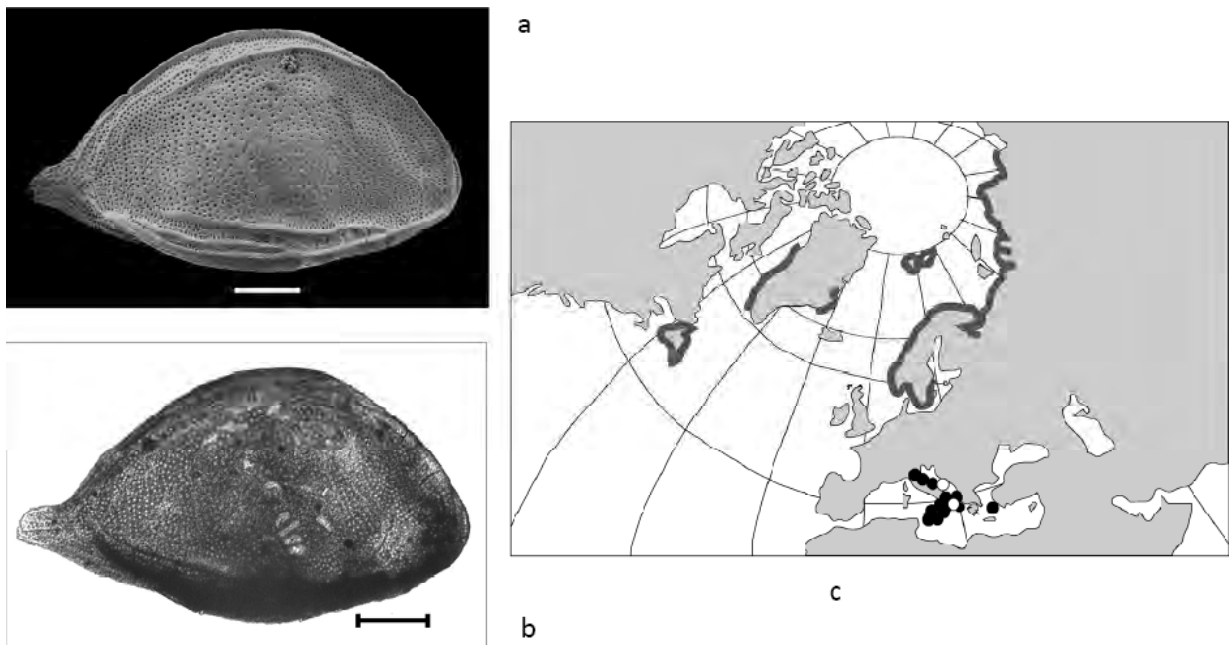


Fig. 12 - *Cytheropteron testudo*: (a) right valve (transmitted light), (b) right valve under SEM from "il Carmine" locality (Crotona, Calabria), Emilian age; (ROC slide N° 924). (c) present geographical distribution (dark grey line), early Pleistocene distribution in the Mediterranean area (black dot), Last Glacial Maximum distribution in the Mediterranean (white circle). Bar corresponds to 0.1 mm.

Cytheropteron testudo: (a) valva destra in luce trasmessa, (b) valva destra in scansione elettronica dalla località "il Carmine" (Crotona, Calabria), età Emiliano; (Collezione Ostracodi Ruggieri N° 924). (c) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri) ed il Pleniglaciale (cerchi bianchi). La barra corrisponde a 0.1 mm.

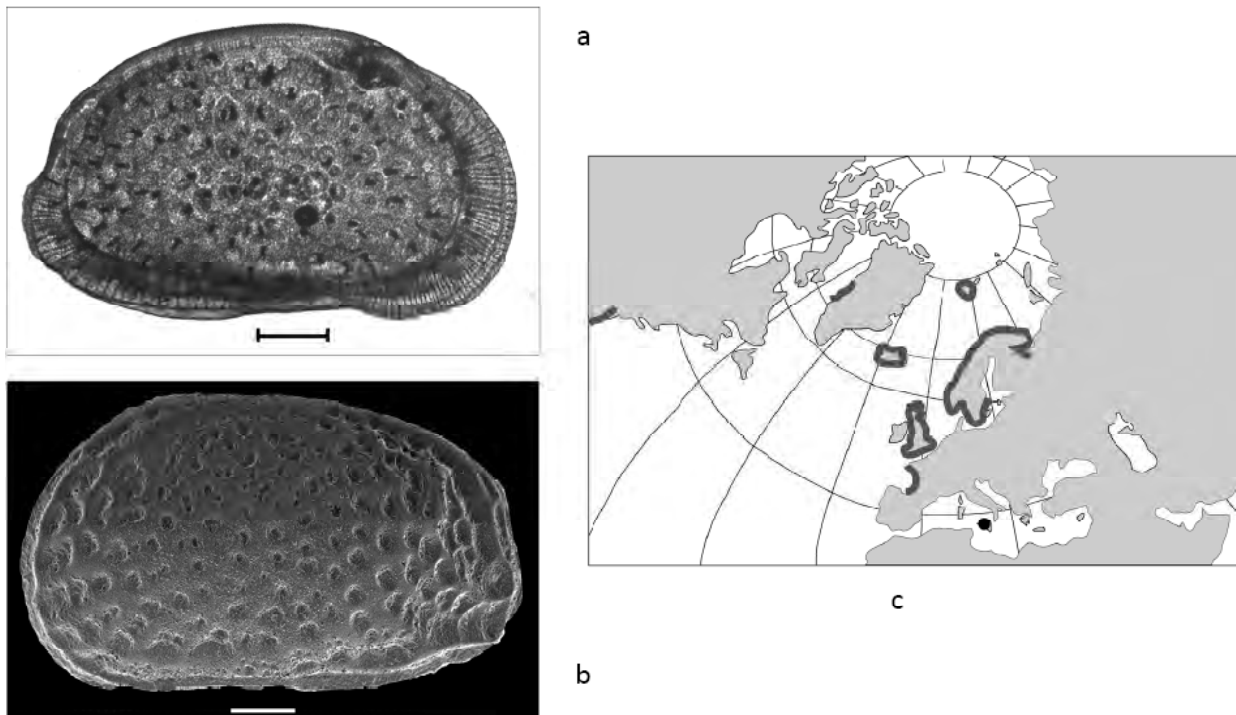


Fig. 13 - *Hemicythere villosa*: (a) right valve in transmitted light, (b) left valve under SEM from Sperone (Palermo) (ROC slide N° 1640); (c) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Hemicythere villosa: (a) valva destra in luce trasmessa, (b) valva sinistra in scansione elettronica dalla località Sperone (Palermo, Sicilia) (Collezione Ostracodi Ruggieri teca N° 1640); (c) distribuzione stratigrafica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

Ecology: It inhabits marine very shallow to shallow waters with vegetated sandy bottoms and water temperatures that range from 0 to 22°C in mesohaline-euhaline conditions (ELOFSON, 1941; ATHERSUCH et al., 1989; FRENZEL et al., 2010).

Fossil distribution in the Mediterranean:

Calabrian (Sicilian): Lo Sperone (Palermo, Sicily) (RUGGIERI, 1971; 1973, 1980; SISSINGH, 1976).

***Paradoxostoma abbreviatum* SARS, 1866**
(Fig. 14)

1866 *Paradoxostoma abbreviatum* sp. nov. - SARS, p. 94

Recent distribution: S. Baltic, Öres, Bohuslän, Holland, Bergen, Shetlands, British Isles, N France, ?Bay of Biscay (HANSSON, 1998); British Isles, Norway, Baltic, Helgoland and N France (ATHERSUCH et al., 1989); North Yorkshire (HULL, 1998).

Ostracod bioprovince: Celtic (?Gasconyan) - Norwegian (Fig. 4)

Ecology: *P. abbreviatum* is typical of mesohaline to euhaline very shallow to shallow waters (0.2 to 20 m) with vegetated and highly oxygenated sandy bottoms, and water temperatures that range from 2 to 5°C (ELOFSON, 1941; ATHERSUCH et al., 1989; FRENZEL et al., 2010).

Fossil distribution in the Mediterranean:

Calabrian (Santernian): Monte Mario (Rome, central Italy), from the 2° *A. islandica* level (FARANDA & GLIOZZI, 2008).

***Paradoxostoma ensiforme* BRADY, 1868**
(Fig. 15)

1868 *Paradoxostoma ensiforme* sp. nov. - BRADY, p. 460, Pl. 35, Figs. 8-11.

Recent distribution: Bohuslän, Holland, ?S and W Norway, Shetlands, SW British Isles, N France, ?Bay of Biscay (ATHERSUCH et al., 1989; HANSSON, 1998); North Yorkshire (HULL, 1998).

Ostracod bioprovince: Celtic (?Gasconyan) - Norwegian (Fig. 4)

Ecology: The species inhabits mesohaline to euhaline very shallow to shallow waters (5 to 18 m on vegetated bottom and down to 50 m on detritic sands), and a wide range of water temperatures (ELOFSON, 1941; ATHERSUCH et al., 1989; FRENZEL et al., 2010).

Fossil distribution in the Mediterranean:

Calabrian (Santernian): Monte Mario (Rome, central Italy), from the 2° *A. islandica* level (FARANDA & GLIOZZI, 2008).

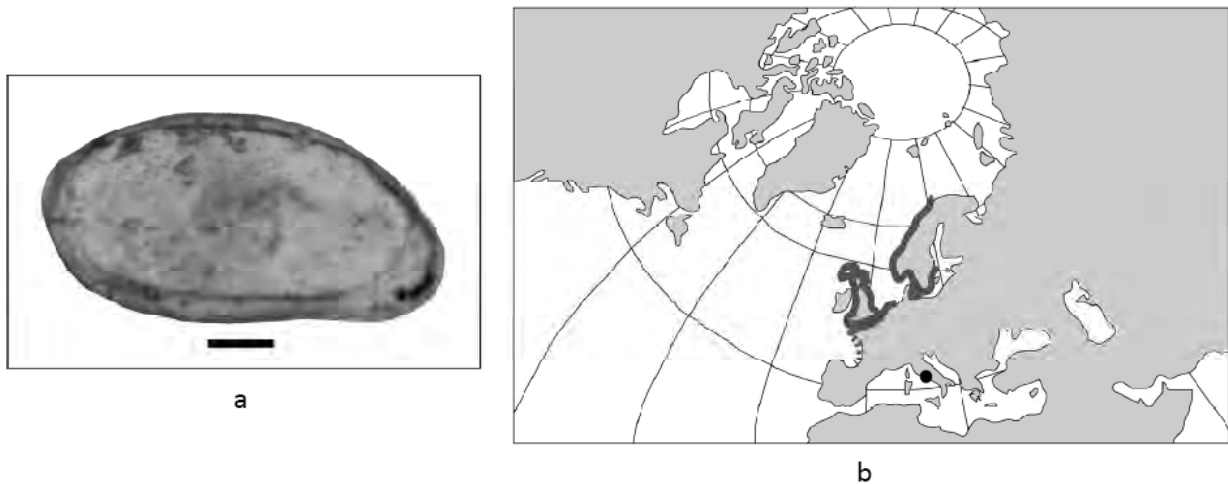


Fig. 14 - *Paradoxostoma abbreviatum*: (a) right valve from Monte Mario (Roma, Latium), Santernian age; (GOCollection slide N° T30/1). (b) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Paradoxostoma abbreviatum: (a) valva destra proveniente da Monte Mario (Roma, Lazio), età Santerniano; (Collezione Ostracodi Gliozzi teca N° T30/1). (b) distribuzione stratigrafica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

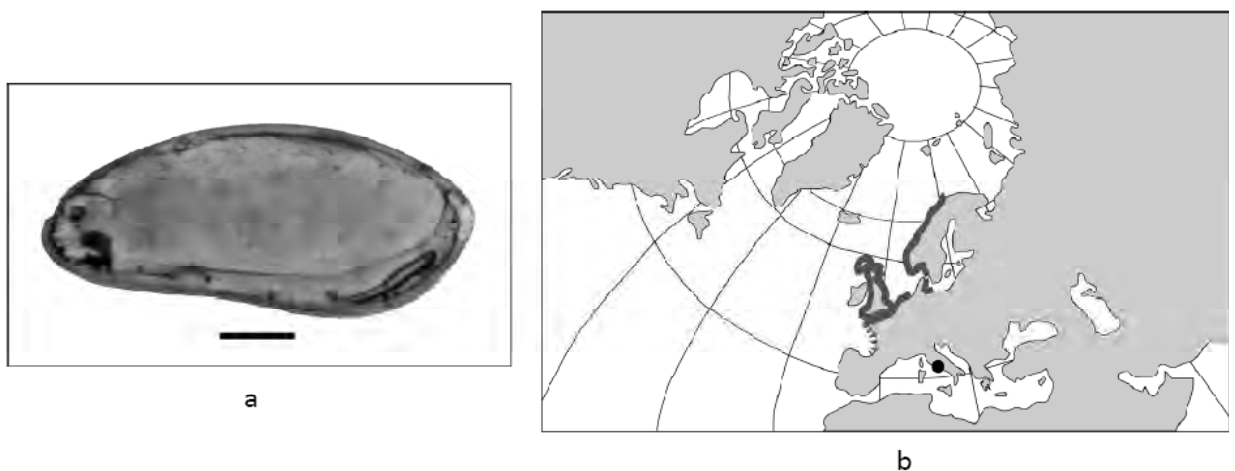


Fig. 15 - *Paradoxostoma ensiforme*: (a) left valve from Monte Mario (Roma, Latium), Santernian age; (GOC slide N°T30/2). (b) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Paradoxostoma ensiforme: (a) valva sinistra proveniente da Monte Mario (Roma, Lazio), età Santerniano; (Collezione Ostracodi Gliozzi teca N°T30/2). (b) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

***Paradoxostoma tenuissimum* (NORMAN, 1869)**
(Fig. 16)

- 1869 *Bythocythere tenuissimum* sp. nov. - Norman, p. 294.
1870 *Xiphichilus tenuissimum* (Norman) - Brady, p. 369, Pl. 12, Figs. 6-9.
1889 *Machaerina tenuissima* (Norman) - Brady & Norman, p. 238, Pl. 21, Figs. 13-14.
1985 *Paradoxostoma tenuissimum* (Norman) - Horne & Whitaker, p. 182, Figs. 30A-E, 31A-F, 32A-E, 44D-E, 45D-E

Recent distribution: British Isles from Scotland and Shetlands (HANSSON, 1998; ATHERSUCH *et al.*, 1989).

Ostracod bioprovince: Celtic (Britannic) (Fig. 4)

Ecology: *P. tenuissimum* is considered one of the most deep species of the genus, inhabiting waters

down to 50-100 m (ATHERSUCH *et al.*, 1989).

Fossil distribution in the Mediterranean:

- Calabrian (Emilian): Cosenza (Calabria, southern Italy), together with *Hyalinea balthica* (RUGGIERI, 1975).
Calabrian (Sicilian): Casa Schifo (between Gela and Vittoria, Sicily) (RUGGIERI, 1975).
Tarantian (Last Pleniglacial): Adriatic Sea (BONADUCE *et al.*, 1976; BREMAN, 1976)

***Semicytherura angulata* (BRADY, 1868)**
(Fig. 17)

- 1868 *Cytherura angulata* sp. nov. - Brady, p. 440, Pl. 32, Figs. 22-25.

- 1957 *Semicytherura angulata* (Brady) - Wagner, p. 84, Pl. 39.

Recent distribution: Kieler Bucht, Belt Sea, Bohüslan,

Hölland, Hardnger Fjord, Iceland, Shetlands and SW British Isles (HANSSON, 1998); British Isles and Northern Europe (ATHERSUCH *et al.*, 1989); ?Bay of Biscay (YASSINI, 1969).

Ostracod bioprovince: Celtic (Britannic) - Norwegian (Fig. 4)

Ecology: The species inhabits mesohaline to euhaline very shallow to shallow waters (5 to 10 m) in ma-

rine and estuarine conditions, with vegetated bottom, and a wide range of water temperatures (ELOFSON, 1941; ATHERSUCH *et al.*, 1989).

Fossil distribution in the Mediterranean:

Calabrian (Emilian): Apennine piedmont near Forli (northern Italy) (RUGGIERI *et al.*, 1976).

Calabrian (Emilian or Sicilian): Chirco, Digerbato and Ciantrato (Marsala, Sicily) (RUGGIERI, *et al.* 1977).

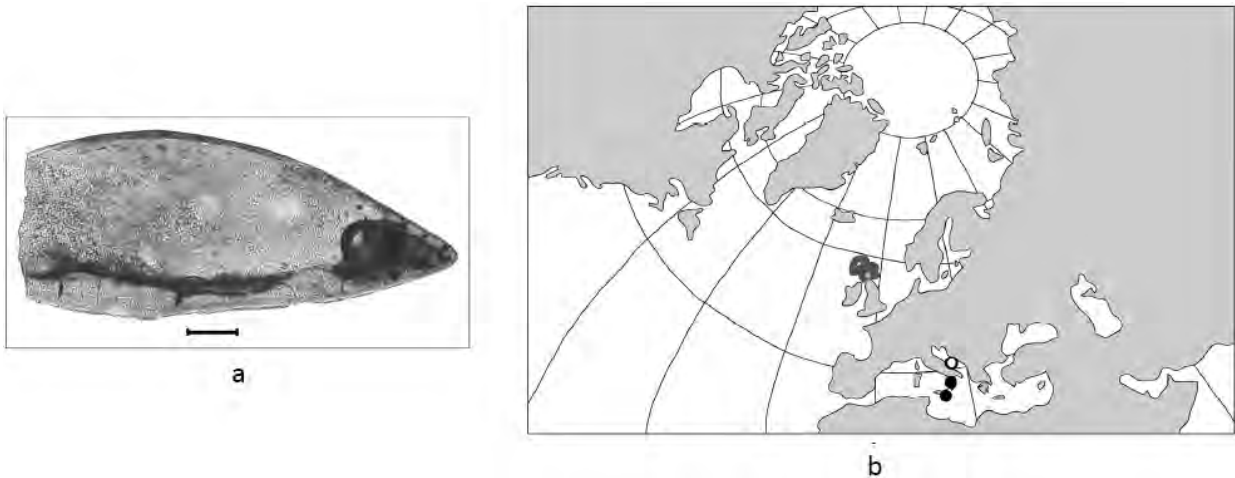


Fig. 16 - *Paradoxostoma tenuissimum*: (a) broken left valve from Cosenza (Calabria), Emilian age; (ROC slide N° 745); (b) present geographical distribution (dark grey line), early Pleistocene distribution in the Mediterranean area (black dot), Last Glacial Maximum distribution in the Mediterranean (white circle). Bar corresponds to 0.1 mm.

Paradoxostoma tenuissimum: (a) valva sinistra rotta proveniente da Cosenza (Calabria, Italia meridionale), età Emiliana; (Collezione Ostracodi Ruggieri teca N° 745); (b) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri) e il Pleniglaciale (cerchi bianchi). La barra corrisponde a 0.1 mm.

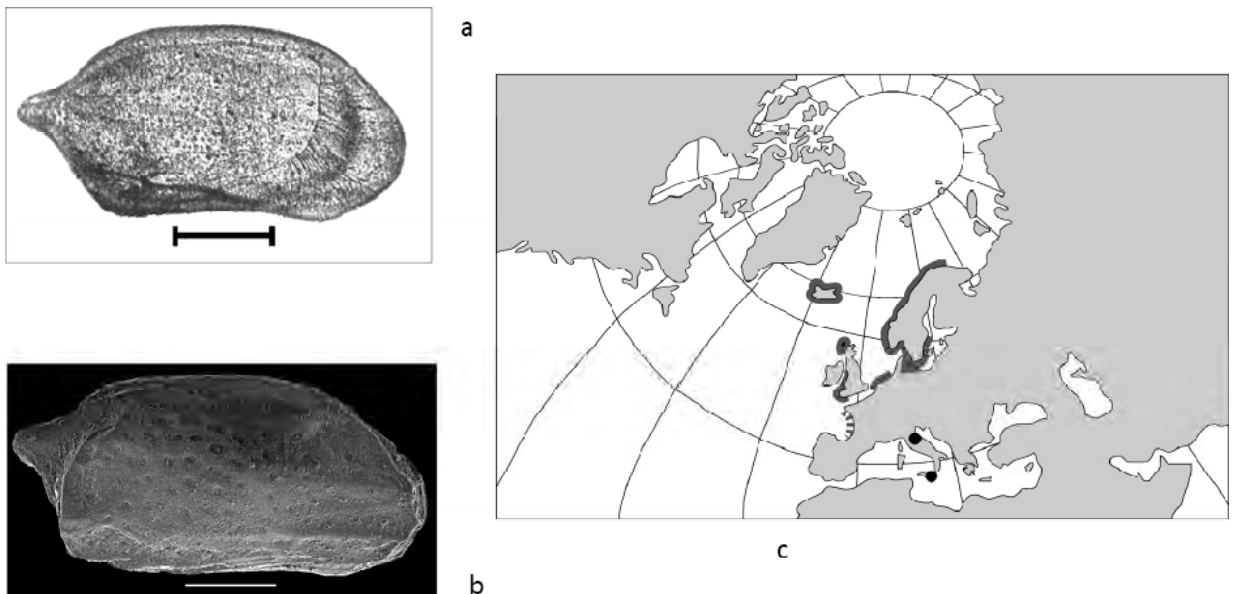


Fig. 17 - *Semicytherura angulata*: (a) right valve in transmitted light, (b) right valve under SEM from Digerbato well (Marsala), Emilian or Sicilian age; (ROC slide N° 2622); (c) present geographical distribution (dark grey line) and early Pleistocene distribution in the Mediterranean area (black dot). Bar corresponds to 0.1 mm.

Semicytherura angulata: (a) valva destra in luce trasmessa, (b) valva destra in scansione elettronica provenienti dal pozzo Digerbato (Marsala, Sicilia), età Emiliana o Siciliana; (Collezione Ostracodi Ruggieri teca N° 2622); (c) distribuzione geografica attuale (linea grigio scura) e distribuzione nel Mediterraneo durante il Pleistocene inferiore (punti neri). La barra corrisponde a 0.1 mm.

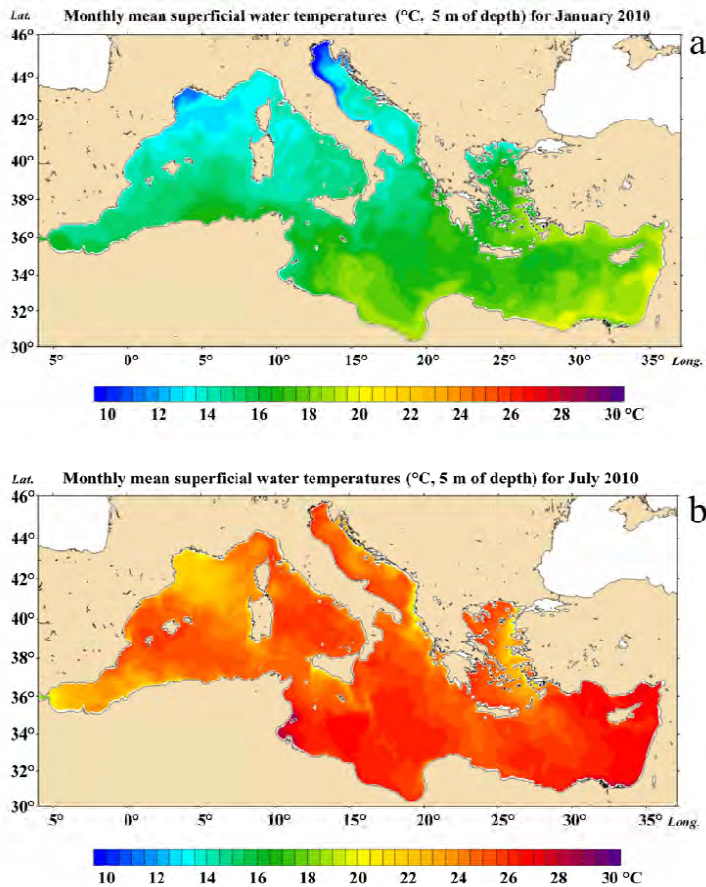


Fig. 18 - Map of average monthly sea surface temperatures in the Mediterranean region (5 m of depth) during (a) January 2010 and (b) July 2010 (from INGV Operational Oceanography Group, Italy http://gnoo.bo.ingv.it/mfs/analysis_archive.htm).

Carta delle temperature medie mensili delle acque superficiali (5 m di profondità) del Mediterraneo per i mesi di (a) Gennaio 2010 e (b) Luglio 2010 (da INGV Operational Oceanography Group, Italy (http://gnoo.bo.ingv.it/mfs/analysis_archive.htm)).

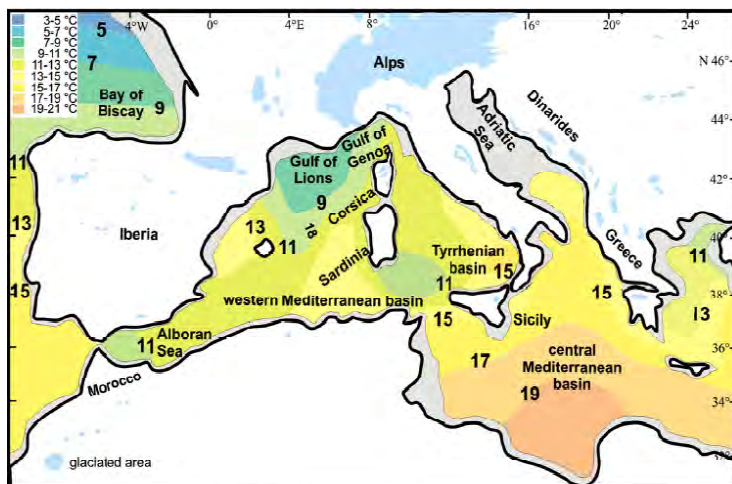


Fig. 19 - Map of average annual sea surface temperatures in the Mediterranean region during the phase of maximum glacier expansion during the Last Glacial Maximum (~23,000 yr B.P.) (modified from KUHLEMANN et al., 2008).

Carta delle temperature medie annue delle acque superficiali del Mediterraneo durante la massima espansione dei ghiacci corrispondente all'ultimo Pleniglaciale (~23,000 anni fa) (modificato da Kuhlemann et al., 2008).

4. DISCUSSION AND CONCLUSION

The critical revision of the “cold” ostracods recovered in the Mediterranean Quaternary proposed in this paper reduces the number of the true “northern guest” from the 22 species reported in literature only to 12 confirmed taxa. They are generally rare within their assemblages, often represented only by a single specimen from a single locality. Only *C. testudo* and *C. punctatum* have been reported with a wide Mediterranean geographical distribution in Italy and in the Aegean Sea. Almost all the “northern guest” ostracods have their present southernmost distribution in the Celtic bioprovince except *B. turgida* and *C. testudo* that are more northern species, presently widespread only from the Norwegian to the Arctic bioprovince. Data on the ecological requirements of the listed “cold” ostracods lead to divide them into three groups on the basis of the water depth: the shallow (infralittoral) species (*C. lutea*, *H. villosa*, *P. abbreviatum*, *P. ensiforme*, and *S. angulata*); the circalittoral species (*A. dunelmensis*, *B. turgida*, *B. zetlandica*, *C. depressum*, and *P. tenuissimum*); the circalittoral-upper epibathial species (*C. punctatum* and *C. testudo*). Temperature ranges are known only for few species, but two groups can be recognized: eurythermal species, such as *C. lutea* and *H. villosa*, and cold stenothermal species as *C. punctatum*, *C. testudo* and *P. abbreviatum*. The temperature ranges of this latter group (-2 to 10°C) does not fit neither the monthly mean temperatures of the Mediterranean superficial waters for

January and July 2011 (Fig. 18) nor the mean annual temperature of the Mediterranean superficial waters as inferred by KUHLEMANN et al., 2008 for the Last Glacial Maximum (Fig. 19). Their presence in the Quaternary Mediterranean deposits can be explained by their settlements in deeper habitats, in search of lower temperatures: *C. punctatum* and *C. testudo* have been recovered in the Mediterranean in associations with lower epibathial species, whereas the epiphytal inner infralittoral *P. abbreviatum* moved towards the outer infralittoral bottoms. On the contrary, in the Quaternary, the eurythermal species occurred in the Mediterranean in the same range of depths as present.

The conclusion reached with this revision leads to a comparison with the “northern guest” molluscs (MALATESTA & ZARLENGA, 1986). Quaternary “northern guest” ostracod species are fewer than mollusc species (twelve against fifty-three) but in both cases they are generally rare within their assemblages. In fact also among molluscs, very few species can be considered common (> ten localities: *Pseudamussium septemradiatum* (MÜLLER, 1776), *Arctica islandica* (LINNAEUS,

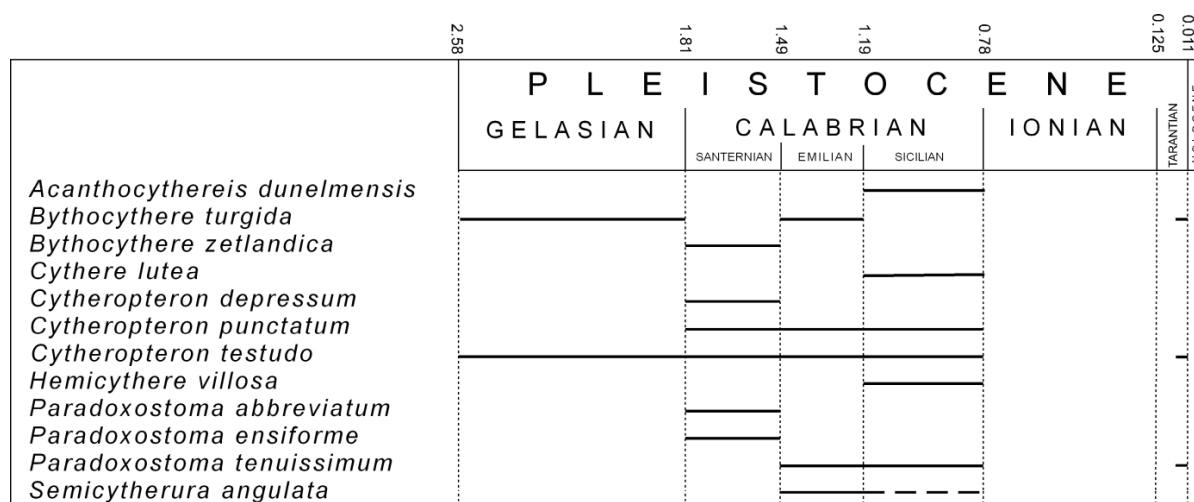


Fig. 20 - Stratigraphic distribution of the "northern guest" ostracods in the Mediterranean area.

Distribuzione stratigrafica degli ostracodi "ospiti nordici" nel Mediterraneo.

1767), *Lunatia montagui* (FORBES, 1838), *Neptunea contraria* (LINNAEUS, 1771), *Buccinum undatum* LINNAEUS, 1767 and *Buccinum humpreysianum* BENNET, 1825). Like the "northern guest" molluscs, also ostracods entered the Mediterranean at different times (Fig. 20), being more abundant in the Sicilian substage. "Northern guest" molluscs were reported also from the last Glacial Maximum deposits of Cap Cr us (MARS, 1958), confirming that the migration of "cold" species into the Mediterranean followed the cyclic cold climate oscillations. "Northern guest" ostracods have been mainly recorded in the lower Quaternary sediments, but one study on the Last Glacial Maximum ostracods (MONCHARMONT-ZEI *et al.*, 1985) reports the presence of *Cytheropteron testudo* in deposits of the Ionian Sea. Additionally, in some papers dealing with modern Mediterranean ostracod faunas some other "cold" species are listed, recovered as loose valves. For example, BREMAN (1976) and BONADUCE *et al.* (1976) reported loose valves of *Cytheropteron testudo*, *Bythocythere turgida* and *Paradoxostoma tenuissimum*, whose presence in the Adriatic Sea could be better linked to reworked remains of the Last Glacial Maximum.

In conclusion, this revision of the "northern guest" ostracods suggests that they could be a valuable tool for interpreting cold climatic events in a sedimentary succession, but further studies are needed to improve the knowledge of the Quaternary "cold" ostracod contingent in the Mediterranean.

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