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The brackish water ostracod *Cyprideis torosa* (Jones) in marine deposits: the case of the Adriatic Sea

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ABSTRACT – *Cyprideis torosa* (Jones), which is one of the most common brackish water species, has been found in the thanatocoenoses sampled at the offshore bottoms of the Adriatic Sea. *C. torosa* is characterized by the presence of both well-preserved adults and juveniles valves. This evidence should exclude transport processes and, in consequence, should ensure its autochthony. Findings of autochthonous specimens of *C. torosa* occur in some marine settings of the Saline Gulf (NE Sardinia). There, this species was found in nearshore settings, which are characterized by the presence of fresh water submarine springs, and that may have created favourable conditions such as microhabitats of brackish water. In the Adriatic Sea the situation is quite different. In fact, *C. torosa* has been found in several offshore sampling stations that are far away from any fresh water influence and are located in correspondence to deposits with a high content of sand related to late Quaternary littoral settings (e.g., nearshore, lagoon) that characterized the central-northern Adriatic region. During the Holocene transgression, these deposits were subsequently preserved and eventually eroded. Moreover, the location of the offshore sampling stations containing *C. torosa* seems to have a pattern following that of the Holocene shorelines in the northern Adriatic area. Then, *C. torosa* found within these deposits has to be considered part of an autochthonous late Quaternary brackish water ostracod fauna, that also contains other very shallow marine species tolerating strong fresh water influence, together with rare non-marine ones. Subsequently, some modern deeper water ostracods may have contaminated this fauna as it results from the presence of an apparently mixed brackish/marine ostracod assemblage.

RIASSUNTO – [L'ostracode paralico *Cyprideis torosa* (Jones) in depositi marini: il caso del mare Adriatico]. Il rinvenimento di ostracodi non marini in depositi è di solito segnalato in ambienti di piattaforma influenzati dall'acqua dolce. Questi ostracodi sono spesso considerati trasportati. *Cyprideis torosa* (Jones), che è una tra le specie paraliche più conosciute, è stata trovata nelle tanatocenosi in fondali di piattaforma relativamente profonda, spesso molto abbondante e rappresentata da esemplari adulti e giovani in buono stato di conservazione, tanto da sembrare autoctona. Rinvenimenti di *C. torosa* autoctona in ambienti marini sono comunque stati segnalati, come nel Golfo di Saline (Sardegna nord-orientale). In questa località, *C. torosa* è stata rinvenuta in fondali costieri poco profondi caratterizzati dalla fuoriuscita di sorgenti sottomarine d'acqua dolce, in grado di produrre microambienti a salinità ridotta favorevoli per la sua vita. Il caso dell'Adriatico è del tutto differente, in quanto *C. torosa* è stata trovata in numerose stazioni di campionatura spesso molto al largo e lontano dall'influenza continentale. Inoltre, i suoi rinvenimenti corrispondono a depositi con elevato contenuto sabbioso frequentemente segnalati nei fondali relativamente profondi dell'Adriatico e legati ad ambienti costieri e lagunari tardo-quaternari. Inoltre, almeno nell'Adriatico settentrionale, l'ubicazione delle stazioni di campionatura con *C. torosa* sembra seguire le variazioni delle linee di rive durante l'Olocene. Alla luce di questi dati, dunque, *C. torosa*, trovata talora in questi depositi assieme ad altri ostracodi non marini, può essere considerata autoctona e indicativa di ambienti paralici tardo-quaternari. All'inizio dell'Olocene, il mare, avanzando sulla pianura che caratterizzò gran parte dell'Adriatico centro-settentrionale durante l'Ultimo Massimo Glaciale, produsse ambienti costieri e paralici. Questi depositi, contenenti anche ostracodi non marini, inclusa *C. torosa*, rimasero in posto o furono, talora, erosi. Successivamente, ostracodi attuali marini di piattaforma più profonda possono essersi sovrapposti determinando una fauna ad ostracodi apparentemente mista di forme paraliche e marine.

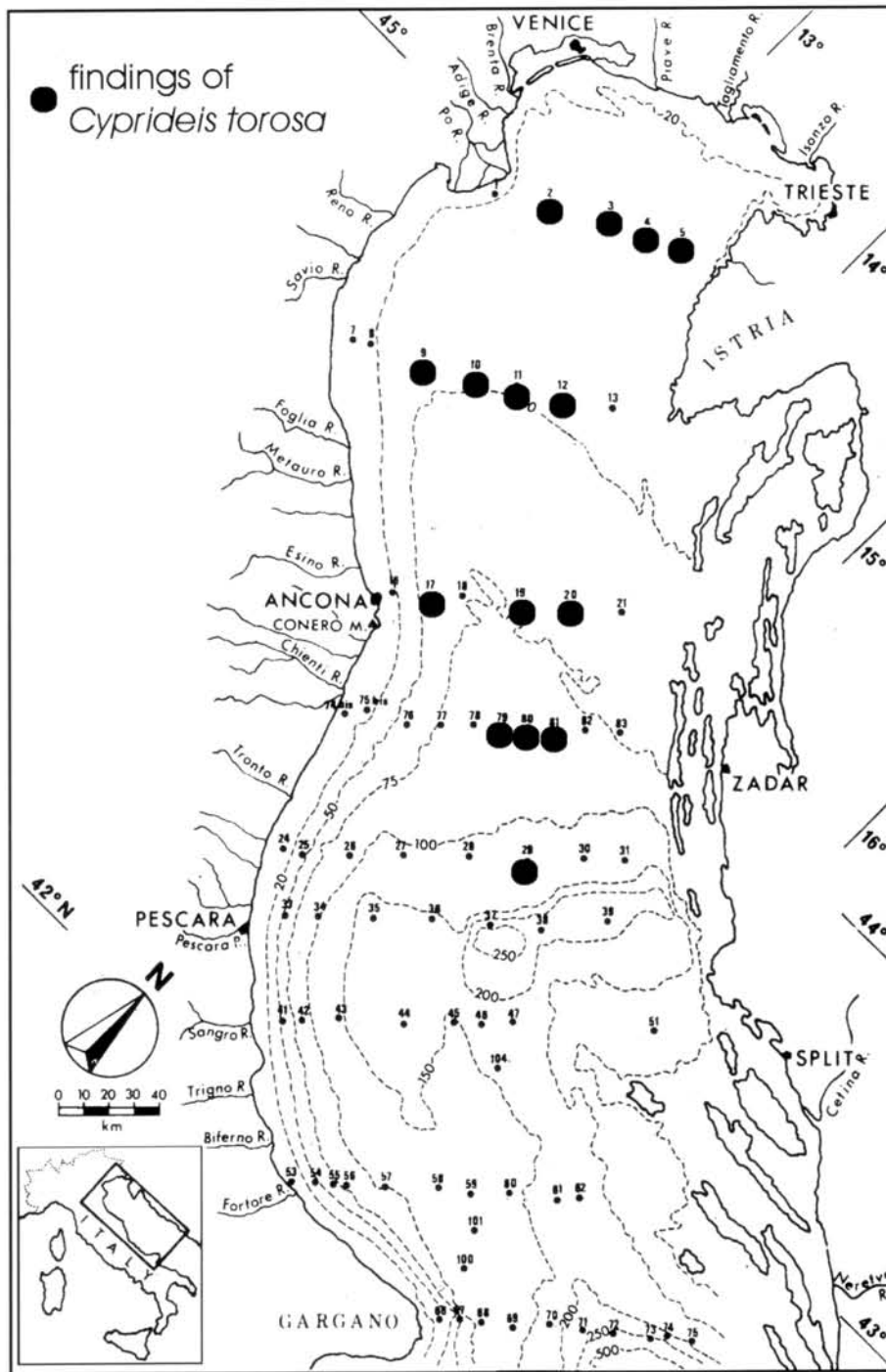
INTRODUCTION

Cyprideis torosa (Jones) is one of the most common brackish water ostracods. It is present in several settings of the paralic domain such as lagoons, coastal ponds, delta-related settings, and nearshore settings, which are strongly fresh water influenced, and other marginal marine settings of Europe, Central Asia to Western Asia, Iceland, Mediterranean region and Central Africa, as documented by Athersuch *et al.* (1989). Moreover, Decima (1964) reported the common occurrence of this species in the Italian territory during the Quaternary. This author also found scattered specimens in the Messinian of Sicily. *C. torosa* is also mentioned from other Mediterranean sectors during the Pliocene (Sissingh, 1972) and the Quaternary (Tsapralis, 1981; Pugliese & Stanley, 1991).

This species occurs in the recent Italian brackish

water settings as recorded in some coastal lakes near Naples by McKenzie (1963), in a Sardinian coastal pond by Vismara Shilling & Ferretti (1987), and in the Orbetello lagoon by Montenegro & Pugliese (1995). In the Adriatic area, most findings of recent specimens of *C. torosa* occur in lagoons (Bonaduce *et al.*, 1974; Montenegro & Pugliese, 1996; Ruiz *et al.*, 1999), and in nearshore settings that are strongly influenced by fresh water (Colalongo, 1968) and tidal flats (Arbulla *et al.*, 2001; Pugliese in Pervesler *et al.*, 2002).

Moreover, the finding of fossil records confirm *C. torosa* as a paralic marker. It has been found in Holocene lagoon deposits of boreholes drilled at Venice (Ascoli, 1966-67), at Caorle (Marocco *et al.*, 1996) and in the alluvial plain of the archaeological site of Aquileia (Pugliese *et al.*, 1999). *C. torosa* has been also found in the late Pleistocene low salinity deposits of



Text-fig. 1 - Location map of the sampling stations studied by Bonaduce *et al.* (1976). The findings of *Cyprideis torosa* are reported after Bonaduce *et al.* (1976, modified). The small dots correspond to the stations without *C. torosa*.

Cres Island (Schmidt *et al.*, 2001) and in those of the Po River delta (Bondesan *et al.*, in preparation).

However, *C. torosa* is also present on the recent sea floors, as reported by Bonaduce *et al.* (1976) in the offshore thanatocoenoses of the northern and central Adriatic (Text-fig. 1). This report discusses the presence of *C. torosa* on these Adriatic sea floors in order

to evaluate whether this species should be considered either autochthonous or allochthonous.

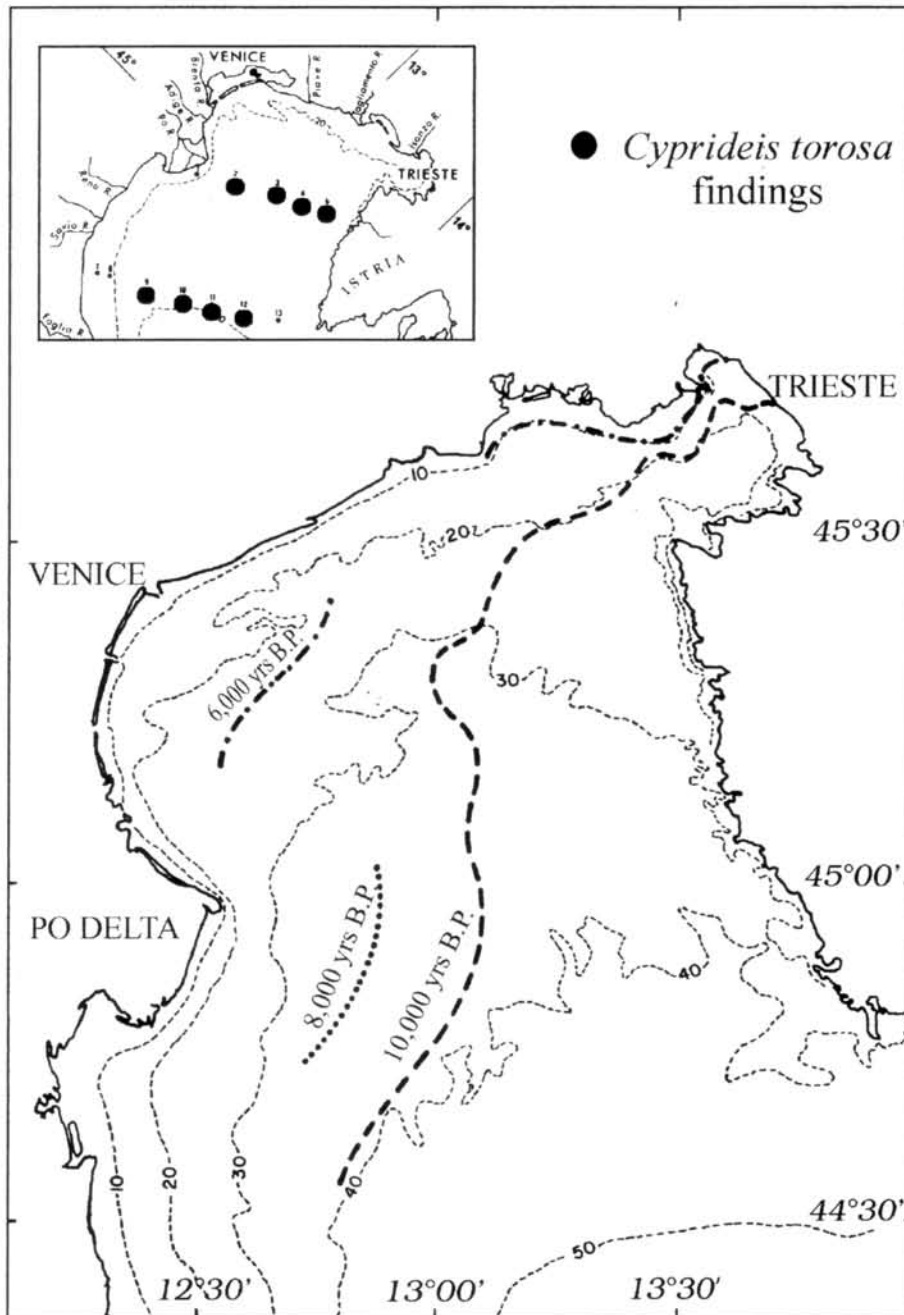
AUTOCHTHONOUS OR ALLOCHTHONOUS?

As mentioned above, Bonaduce *et al.* (1976) recorded the occurrence of *C. torosa* in offshore thana-

tocoenoses of the northern and central Adriatic Sea (Text-fig. 1). This species has been found in grab samples at sampling stations within the depth-range 15-210 m. In these stations, it is represented by adult specimens (males and females) together with juveniles. The joint presence of adults and juveniles should indicate that the life cycle of *C. torosa* was completed *in situ*. Most specimens are well preserved. All these aspects should indicate the autochthony of *C. torosa* in the above mentioned sampling stations. Moreover, as reported by Bonaduce *et al.* (1976), the autochthony

of *C. torosa* in these stations may be also confirmed by the joint presence of species that are typical of very shallow marine settings strongly influenced by fresh water (*Leptocythere* spp., *Neocytherideis fasciata*, *Pontocythere turbida*, *Semicytherura incongruens*, *Semicytherura sulcata*, etc.) and rare brackish water species (*Leptocythere lagunae*, *Loxoconcha stellifera*), together with other ones displaced from nearby fresh water environments (*Candona* spp., *Ilyocypris* sp.).

Bonaduce *et al.* (1976) discussed these findings by suggesting the autochthony of *C. torosa* equivocal.



Text-fig. 2 - Shorelines variations during the Holocene after Marocco (1991, modified) and location map of the findings of *Cyprideis torosa* in the northern Adriatic Sea.

Actually, they considered the possibility that this species was displaced from brackish water setting. However, they provisionally included it *C. torosa* in a list of Adriatic ostracod communities of sea floors characterized by high sandy content.

The possible occurrence of autochthonous *C. torosa* in marine deposits was already discussed by Arbutta *et al.* (2000). These authors found autochthonous specimens of *C. torosa* in some marine settings of the Saline Gulf (NE Sardinia). There, this species was found in nearshore settings characterized by the presence of fresh water submarine springs, which may have created favourable brackish water microhabitats. Thus, the possibility to find autochthonous *C. torosa* requires the presence of submarine fresh water springs. Concerning the northern Adriatic Sea, this possibility can be excluded since there is no evidence of submarine fresh water springs offshore.

Following Bonaduce *et al.* (1976), it is possible to propose another hypothesis for the occurrence of *C. torosa* in the Adriatic offshore. These authors observed that the findings of *C. torosa* always correspond to offshore deposits characterized by a high sand content. As mentioned above, they provisionally included this species in the sandy ostracod community. From a sedimentological point of view, sandy deposits should correspond to coastal settings. However, these Adriatic deposits are offshore and, in agreement with several authors (i.e. Brambati & Venzo, 1969; Colantoni *et al.*, 1990; Cattaneo & Trincardi, 1999), they should be related to the late Quaternary evolution of the Adriatic area. Around the Last Glacial Maximum, the northern and central Adriatic sea was characterized by a wide alluvial plain. Subsequently, the Holocene transgression took place, affecting this alluvial plain, and old barrier-lagoon systems formed. As documented by Colantoni *et al.* (1990), the Holocene transgression did not occur at a constant rate. These depositional systems, which formed during relative still-stand or slower rate of sea level rise, could be partly preserved in relation with a subsequent rapid submersion.

Moreover, Marocco (1991) published a study on the shoreline variations in the northern Adriatic region during the Holocene. On the basis of the data derived from several cores, this author proposed the shorelines characterizing 10,000 years, 8,000 years, and 6,000 years B.P. (Text-fig. 2). These variations clearly demonstrate landward changes in the shoreline position that might well correspond to the presence of the above mentioned coastal and brackish water material in the modern offshore.

The comparison between the offshore findings of *C. torosa*, which seems autochthonous, and the shorelines changes shows a good correspondence. Actually, these findings seem to fit the changes in the shoreline position during the time span between 6,000 years and 10,000 years B.P.

After having been submerged, these old deposits became a new substrate for the subsequent Holocene

benthic communities, including ostracods. These modern sea floors are characterized by several circalittoral species (i.e., *Argilloecia acuminata*, *Bosquetina dentata*, *Cytheropteron* spp., *Henryhowella parthenopea*, *Polycopse* spp., *Pterygocythereis* spp.), as documented by Bonaduce *et al.* (1976). Thus, these deposits present two overlapping ostracod faunae: the first one is represented by the brackish water *C. torosa*, together with other brackish, very shallow marine (strongly tolerating the fresh water influence) and displaced fresh water species; the second one consists of circalittoral taxa. Both faunae are autochthonous: the first one was autochthonous before and during the Holocene indicating coastal settings strongly influenced by fresh water and wetlands; the second one is autochthonous today and testifies the modern circalittoral settings.

CONCLUSIONS

The finding of *C. torosa* in offshore Adriatic ostracod faunae evidences that these ostracods underwent a complex taphonomic history. The joint presence of brackish water, including *C. torosa*, very shallow marine (tolerating a strong fresh water influence) and circalittoral species may be related to the Quaternary evolution of the Adriatic Sea. In particular, pre-Holocene brackish water and coastal settings were submerged during the Holocene. Subsequently, pre-Holocene and Holocene residual deposits containing brackish water ostracods, together with those indicating marine settings influenced by fresh water, finally became new deeper sea-floors favourable for the modern circalittoral ostracods.

This same situation might also have occurred in some other Mediterranean offshore settings. Then, the case recorded in the Adriatic sea would suggest caution in the interpretation of results from similar palaeoenvironments. However, we confirm here that ostracods represent the most effective tool for the interpretation of apparently complicated palaeoenvironmental evolutions.

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