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Role of the artificial structures on biodiversity: the case of arthropod fauna in the North Adriatic lagoons

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SUMMARY - *Role of the artificial structures on biodiversity: the case of arthropod fauna in the North Adriatic lagoons* - The lagoons of the North Adriatic region are site of several anthropic activities, which express themselves also with the abundance of artificial structures like the wooden poles (*bricole*). These become suitable substrate for the colonization of numerous species that, in their absence, would not find an opportune substrate in the natural soft bottoms of the lagoon. Using the arthropod taxocoenosis as study-case, in this work we provide evidence that the presence of artificial hard substrates has a double effect on the biodiversity of this *taxon*, as they promote the settlement of (i) a much larger pool of species than the one of the surrounding soft bottoms and (ii) of species which are new for the Adriatic transitional environments. In particular, an amphipod already known in the Mediterranean but new for the Adriatic, *Ampithoe ferox* (Chevreux), has been recorded on the artificial hard substrates of the Sacca di Goro (Po delta). In order to facilitate the identification of this scarcely known species, we provide a key to distinguish it from the more common congener *Ampithoe ramondi* Audouin.

RIASSUNTO - *Il ruolo delle strutture artificiali sulla biodiversità degli artropodi lagunari nord adriatici* - Le lagune della regione nord-adriatica sono sede di numerose attività antropiche; per questo è frequente trovarvi diverse strutture artificiali tra cui le bricole di legno. Queste costituiscono un substrato idoneo alla colonizzazione di numerose specie che non troverebbero un habitat opportuno nei fondali naturali delle lagune. Considerando la taxocenosi degli artropodi come modello di studio, in questo lavoro si prova che la presenza di substrati duri artificiali ha un duplice effetto sulla biodiversità di questo taxon, poiché favorisce l'insediamento (i) di un pool di specie ben più consistente rispetto a quello degli adiacenti fondi molli e (ii) di specie nuove per gli ambienti di transizione adriatici. In particolare, per i fondi duri artificiali della Sacca di Goro (delta del Po) viene segnalata la presenza dell'anfipode *Ampithoe ferox* (Chevreux), già noto per il Mediterraneo ma nuovo per l'Adriatico. Al fine di facilitare l'identificazione di questa specie poco conosciuta, viene fornita una chiave per distinguerla dalla ben più diffusa congenerica *Ampithoe ramondi* Audouin.

Key words: North Adriatic lagoons, artificial hard substrates, arthropods, peracarid crustaceans, *Ampithoe ferox*
Parole chiave: lagune nord adriatiche, fondi duri artificiali, artropodi, crostacei peracaridi, *Ampithoe ferox*

1. INTRODUCTION

Several authors have recently investigated the biological communities of artificial *vs* natural hard substrates in marine environments: for example Badalamenti *et al.* (2002) studied the molluscs taxocoenosis in a Sicilian artificial reef, Smith & Rule (2002) the motile fauna along the ports of the eastern Australian coast, Bulleri & Chapman (2004) the macroflora and macrofauna in a port of the Tyrrhenian coast of Italy, Perkol-Finker *et al.* (2006) the coral reef community in Israel.

All these studies, considering different components of the biocoenosis, different environments and different geographical locations, agree with the fact that the artificial substrate community is significantly different and often less diverse than the natural substrate community. Moreover, Glasby & Connell (2001), Savini *et al.* (2004), Bulleri & Airoldi (2005) and Farrell & Fletcher (2006) observed that the abundance of artificial structures along the coasts is responsible for the spread of non-indigenous species, providing stepping stones and allowing colonization of previously inaccessible areas.

Therefore, literature demonstrates that artificial structures may negatively affect biodiversity in marine environments, but their role in lagoon environments, where natural hard substrate is very scarce or even absent due to the sandy/silty composition of the sedimentary bottom, has not been explored yet.

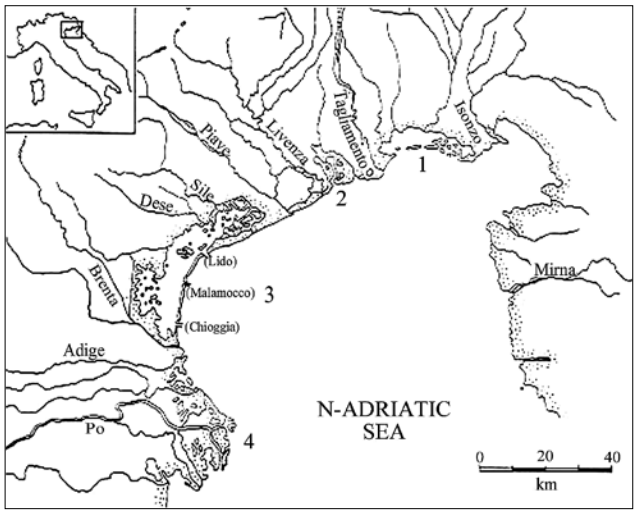
In this paper we focus the attention on the arthropod fauna, and in particular on the crustacean peracarids, living in some North Adriatic lagoons, and investigate the role of artificial structures on their biodiversity by analysing the available literature information, integrated with original data.

2. STUDY AREA

We considered as case-study the lagoons located in the northern part of the Adriatic Sea (Fig. 1): this region includes several lagoons of the "bar-built estuary" type (*sensu* Pritchard 1967), among which the biggest Italian ones (Venice and Grado-Marano). All these lagoons are interested, at different degrees, by anthropic activities, and for this reason the artificial substrates related to human exploitation of these environments are abundant and well distributed. In particular, we considered samples collected from the wooden poles, locally named *bricole*, that mark the navigable canals of these lagoons.

3. METHODS

In absence of natural hard substrates, we evaluated the role of artificial structures on biodiversity in the North Adriatic lagoons by comparing the fauna that colonizes the *bricole* with the "natural" fauna that lives within the sandy/ silty lagoon bottoms.



1: Grado-Marano
2: Caorle
3: Venice (with indication of its three sub-basins)
4: Po delta (the Sacca di Goro is the southernmost lagoon)

Fig. 1 - Map of the North Adriatic coast of Italy; progressive numbers mark the coastal lagoons from north to south.
Fig. 1 - Mappa della costa italiana nord-adriatica; i numeri progressivi segnano le lagune costiere da nord a sud.

Among the whole macrobenthic community we had to choose the most opportune biological model to compare the two types of bottom. In fact, the soft bottom fauna is typically composed of annelids, molluscs, arthropods, echinoderms and minor taxa, whereas the hard substrate macrobenthos is much more taxonomically distinct, including almost all the marine taxa from sponges to tunicates. For this reason a specific, more restricted taxocoenosis had to be selected.

The crustacean peracarids are well represented in number of species and abundance of individuals in both substrates; moreover they are rather well studied in the North Adriatic lagoons, therefore a certain amount of information is available for comparing the natural soft bottoms and artificial hard substrates communities. In particular, our research group owned large datasets of peracarids from the artificial hard substrates of the considered lagoons, and for the comparison purposes we used a combination of new data and data already published in Sconfietti & Mulatto (1993), Sconfietti & Danesi (1996) and Marchini *et al*. (2004). The methods of collection of hard substrate samples are described in such papers. As regards the soft bottom peracarids, we could obtain useful information from Pranovi & Giovanardi (2000), Balducci *et al*. (2001), Mistri *et al*. (2001) and Occhipinti-Ambrogi & Gola (2001).

Finally, as regards the role of artificial structures in the introduction of new species, we checked within the list of first records of arthropods for the North Adriatic lagoons, obtained from Mizzan (1999), the ratio of species firstly collected from hard substrates over the total.

4. RESULTS AND DISCUSSION

Table 1 shows the results of the comparison between the peracarid taxocoenosis of the natural soft bottoms and artificial hard substrates in these North Adriatic lagoon basins: in the lagoon of Venice, considering all its three sub-basins (from north to south: Lido, Malamocco and Chioggia), and in the Sacca di Goro, the southernmost lagoon of the Po River delta. In all the considered lagoon basins the results are similar: together with a reduced set of species exclusive of the soft-bottom habitat, and with another small set of species which are common to the two types of substrate, the species collected only on the wooden *bricole* are largely dominant (61% of the whole data set).

Generally, planar surfaces tend to become colonized by a suspension-feeding sessile fauna with pelagic development, whereas motile species with directly devel-

Tab. 1 - Number of crustacean peracarid species in natural soft bottoms and artificial hard substrates of some North Adriatic lagoon basins.
Tab. 1 - Numero di specie di crostacei peracaridi nei fondi molli naturali e fondi duri artificiali di alcuni bacini lagunari nord adriatici.

LAGOON BASINS		VENICE			GORO	Total (%)
		Lido	Malamocco	Chioggia		
Source	soft bottoms	Balducci *et al.* (2001)	Occhipinti-Ambrogi & Gola (2001)	Pranovi & Giovanardi (2000)	Mistri *et al.* (2001)	
	hard substrates	Sconfietti & Mulatto (1993)	Sconfietti & Danesi (1996)	present study	Marchini *et al.* (2004)	
Number of species	Only present in soft bottoms	1	6	6	1	**19%**
	Present in soft bottoms and hard substrates	2	5	1	3	**20%**
	Only present in hard substrates	21	21	19	11	**61%**
	Total	**24**	**36**	**26**	**15**	

oping larvae prefer complex substrates (Rule & Smith 2005), which provide them protection against predators, surfaces for food processing, site for courtship and mating, nursery for juveniles (Aikins & Kikuchi 2001). The wooden *bricola* is a planar, simple substrate, but it is made complex by the upright sessile epifauna, which builds three-dimensional structures and also contributes in the erosion of the wood by means of boring species like the bivalve *Teredo navalis* L. and the isopod *Limnoria lignorum* (Rathke). As a result, the colonized *bricola* represents a suitable substratum for both tube-dwelling (e.g., *Corophium* spp., *Tanais dulongii* (Audouin)) and free living species (e.g., *Melita palmata* (Montagu) or *Caprella* ssp., especially the recently found *Caprella scaura* Templeton; see Sconfietti *et al*. 2005; Krapp *et al*. 2006).

Table 2 reports a list of arthropods "new" for the Adriatic lagoons, with indications of place, time and type of substrate of their first collection. Five out of nine species were firstly observed on samples scraped from the *bricole*, and their subsequent findings are relative to samples from artificial hard substrates (Sconfietti & Mulatto 1993; Sconfietti & Danesi 1996; Sconfietti *et al*. 2005; Savini *et al.* 2006).

The last species in order of time is a gammaridean amphipod of the family Ampithoidae, *Ampithoe ferox* (Chevreux) (Fig. 2), that was recently found on the *bricole* of the Sacca di Goro, in samples of the years

Tab. 2 - Chronological list of first records of arthropods in the North Adriatic lagoons, with indication of the substrate type where the detection was made (from Mizzan 1999).
Tab. 2 -Elenco cronologico delle prime segnalazioni di artropodi nelle lagune nord adriatiche, con indicazione del tipo di substrato su cui il rilevamento fu effettuato (da Mizzan 1999).

Place / year *	Species	Taxon	Origin	Substrate *
Grado-Marano / 1949	*Callinectes sapidus*	Decapoda Portunidae	AO	not reported
Venice / 1980	*Elasmopus pectenicrus*	Amphipoda Melitidae	IO	*bricole*
Venice / 1981	*Callinectes danae*	Decapoda Portunidae	AO	not reported
Venice / 1981	*Paracereis sculpta*	Isopoda Sphaeromatidae	PO	*bricole*
Venice / 1983	*Ammothea hilgendorfi*	Picnogonida Ammotheidae	IP	*bricole*
Venice / 1992	*Dyspanopeus sayi*	Decapoda Xanthidae	AO	bivalve farming beds
Venice / 1994	*Caprella scaura*	Amphipoda Caprellidae	IP	*bricole*
Sacca di Scardovari / 1994	*Rhithropanopeus harrisii*	Decapoda Xanthidae	AO	not reported
Sacca di Goro / 2000	*Ampithoe ferox*	Amphipoda Ampithoidae	AO, M	*bricole*

* of first collection in the North Adriatic lagoons
(AO= Atlantic Ocean, IO= Indian Ocean, PO= Pacific Ocean, IP= Indo-Pacific, M= Mediterranean Sea)

2000, 2001 and, more abundant, in 2004. Although this species is not new in the Mediterranean and in the Italian coasts, being already reported for the Tyrrhenian Sea (Krapp-Schickel 1982), its presence in the Adriatic Sea has never been detected before. Moreover, *A. ferox* was not observed in previous studies of hard substrates in the Sacca di Goro (Parisi *et al*. 1991), neither in more recent surveys of the soft bottoms (Mistri *et al*. 2001; Munari pers. comm.), thus showing that the artificial structures have again represented the preferential site for the establishment of a new arthropod in a North Adriatic lagoon.

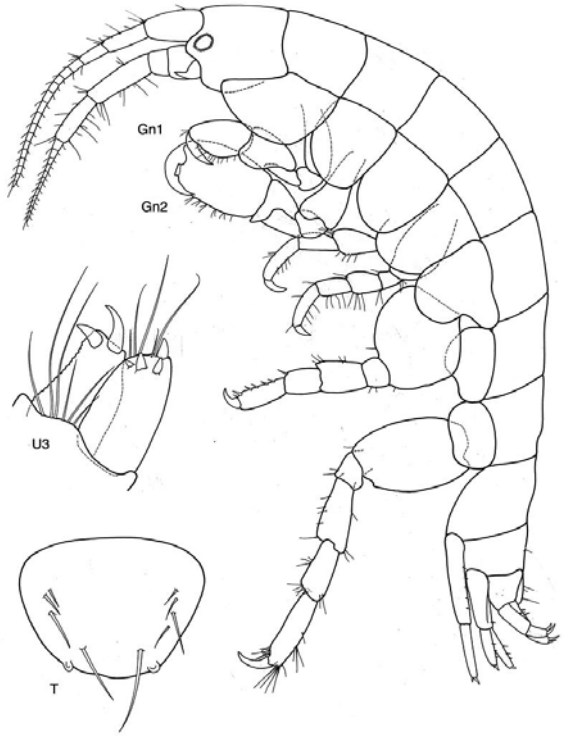


Fig. 2 - *Ampithoe ferox* (Chevreux, 1902) male specimen from the Sacca di Goro (Po River delta). Gn1,2= gnathopod 1, 2; U3= uropod 3; T= telson.
Fig. 2 - Esemplare maschio di Ampithoe ferox *(Chevreux, 1902) dalla Sacca di Goro (delta del Fiume Po). Gn1,2= gnathopode 1,2; U3= uropode 3; T= telson.*

The most widespread and abundant *Ampithoe* species in the North Adriatic lagoons is *Ampithoe ramondi* Audouin, which is also listed in a recent taxonomic report of Italian lagoon peracarids (Sconfietti 2004), where *A. ferox* is not mentioned. In order to compensate this lack of information and to avoid further taxonomic misunderstandings, we provide a new complete drawing of this poorly known species (Fig. 2), based on a mature male specimen of the Sacca di Goro, together with a key including the most important characters for distinguishing *A. ramondi* (*sensu* Krapp-Schickel 1982) and *A. ferox* (Tab. 3).

5. CONCLUSIONS

In this paper we provide evidences of the fact that artificial hard substrates, such as the wooden *bricole* of the North Adriatic lagoons, are responsible for the presence of a large number of arthropod species that, in absence of such artificial structures, could not find a suitable habitat for attachment, nutrition and reproduction in the natural soft bottoms of these lagoons.

Therefore, artificial structures generate a local increase of biodiversity, regarding not only arthropods but

Tab. 3 - Key for distinguishing *A. ramondi* (*sensu* Krapp-Schickel, 1982) and *A. ferox*.
Tab. 3 - Chiave per distinguere A. ramondi *(*sensu *Krapp-Schickel, 1982) and* A. ferox.

Md palp	with long and dense setae distally and along distal half margin	*A. ramondi*
	with setae only at distal end, not along margin	*A. ferox*
Gn1 palm	defined	*A. ramondi*
	not defined	*A. ferox*
Gn2 male propodus	anterodistally with many setae longer than propodus	*A. ramondi*
	with short setae	*A. ferox*
Gn2 male propodus	distally widening, palm excavate, oblique	*A. ramondi*
	with parallel margins, palmar corner with right angle, palm with hump in adult males	*A. ferox*
U3 peduncle	distally with many robust setae; outer ramus with backwards bent hook shaped "spines"	*A. ramondi*
	distally with few robust setae; outer ramus distally with "spines" not or much less backwards bent	*A. ferox*
T	trapezium shaped, subdistally with 2 long setae, about same length as telson, and many setae along the margins	*A. ramondi*
	margins rounded, subdistally 2 setae which are less long than telson, and only few setae marginally	*A. ferox*

also a large number of suspension-feeder sessile invertebrates (sponges, cnidarians, serpulids, bivalves, bryozoans, ascidians) that are typically related to the hard substrate habitat. On the other hand, the *bricole* can also represent preferential sites for the settlement of new species: the case of the amphipod *A. ferox*, new for the Adriatic Sea and repeatedly found on the wooden poles of the Sacca di Goro (but never within its soft bottoms), is only the most recent one of a crowded list of arthropods whose establishment in the North Adriatic lagoons seems related to the presence of artificial hard structures.

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