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First record of the protected species *Pinna nobilis* (Linnaeus, 1758) in the Aquatina Lagoon (NATURA 2000 site IT9150003, South-East Italian coastline)

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Abstract

Information on the presence of *Pinna nobilis* (Linnaeus, 1758) in the Mediterranean Sea is largely reported in literature because it is an endemic and, at the same time, endangered species. Besides, this record contributes to enlarge the spatial distribution of this species in the South-East Italian coastline (Adriatic Sea). *P. nobilis* is a protected species under the EU Habitats Directive (1992). In particular, *P. nobilis* has been recorded for the first time in the Aquatina Lagoon, a transitional water ecosystem included in the NATURA 2000 site "*Aquatina di Frigole*" (IT9150003). Therefore, this finding underlines the role of transitional water ecosystems as "nursery habitats" for *P. nobilis* as well as the relevance of conservation actions introduced by the EU with the NATURA 2000 network for preserving the biodiversity.

Keywords

pen shell, *Pinna nobilis*, transitional water ecosystems, NATURA 2000 network

Introduction

The key species *Pinna nobilis* Linnaeus, 1758, also called pen/fan shell, is an endemic species identified in the Mediterranean Sea since the Miocene Era (Gómez-Alba 1988). It is the largest bivalve mollusc in the Mediterranean Sea, exceeding one metre in total

length (García-March and Vincente 2006), living up to 27 years (García-March et al. 2008) at depths ranging from 0.5 to 60 m (Butler et al. 1993). Its main habitat is marine soft-bottom, with the presence of seagrass meadows of *Posidonia oceanica* (L.) Delile 1813 and/or *Cymodocea nodosa* (Ucria) Asch. 1870 (Zavodnik, Hrs-Brenko & Legac 1991). Besides, it was also recognised in unvegetated estuarine areas (Addis et al. 2009) and unvegetated soft bottoms of marine areas (Katsanevakis 2005). Regarding its ecological role, *P. nobilis* is a "filter feeder species" and its surfaces are usually colonised by other benthic species, including algae and macroinvertebrates, thus increasing the local biodiversity. For these reasons, *P. nobilis* supplies many ecosystem services by retaining a large amount of organic matter from suspended detritus (e.g. water clarity), hosting other species (e.g. biodiversity) and attracting scuba-divers (e.g. tourism and recreation). From the time of the Egyptians and Romans, this species has been considered a marine resource for human exploitation due to the high-value of handmade cloth obtained from the byssus, the so-called "sea silk" and as a food source in some Mediterranean regions by traditional uses and cooking (Katsanevakis et al. 2011). Nowadays, *P. nobilis* is a protected species under the EU Habitats Directive (1992), Bern Convention and Barcelona Convention Protocol (Annex II). For its ecological relevance, currently the pen shell is a target species for assessing the descriptor 1 "*Biological diversity*" and 4 "*Status of the single structural components of ecosystems*" of the "Marine Strategy Framework Directive (MSFD 56/EC, 2008)" of the European Union to be applied practically to achieve Good Environmental Status (GES) by 2020.

Despite its ecological relevance, the conservation actions and the current interest as a target species in the MSFD, *P. nobilis* is highly vulnerable to illegal exploitation and it is threatened by abiotic and biotic sources of perturbations (e.g. climate change, parasites). For all the above reasons, a more detailed description of the occurrence of *P. nobilis* in the Mediterranean Ecoregion is required to preserve this species.

Here, we describe the first record of *P. nobilis* in a transitional water ecosystem located in Italy along the coastline of the South Adriatic Sea (Aquatina Lagoon) and included in a NATURA 2000 site. In this lagoon, the presence of *P. nobilis* has never been previously recorded. This finding suggests that Mediterranean coastal lagoons could be considered as "nursery ecosystems" for the recruitment of the species as well as for other marine species and underlines the effectiveness of the NATAURA 2000 network for preserving the biodiversity.

Materials and methods

The high relevance of this first record is due to the fact that the species *P. nobilis* has been recognised in a transitional water ecosystem, Aquatina Lagoon (40.442463°N – 18.237675°E; Fig. 1), included in the NATURA 2000 site named "*Aquatina di Frigole*" (IT9150003).

At the beginning of January 2018 and during an exceptional low tide, we observed some specimens of *P. nobilis* had partially emerged. After this finding, we conducted

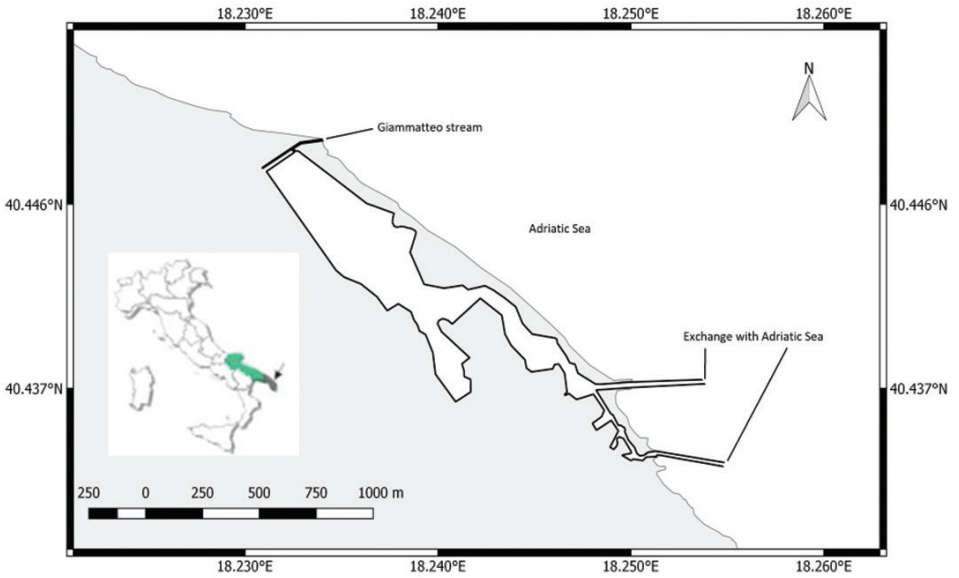

Figure 1. Location and map of Aquatina Lagoon (South-East Italian coastline). The lagoon is included in the NATURA 2000 site "*Aquatina di Frigole*" - IT9150003.

in the area close to the lagoon mouth an underwater *visual census* (Fig. 2) along 3 transects of 20 m length and 2 m width in order to survey and count the fan mussel *P. nobilis* specimens, to estimate the population density and to monitor the individual vitality and size, measured according to García-March and Vicente (2006). Sampling was carried out during the first week of February 2018 in the Aquatina Lagoon. The lagoon's surface is 42 hectares, representing about 3% of the whole NATURA 2000 site "*Aquatina di Frigole*" (IT9150003). Its maximum depth is approx. 1.5 m, while its maximum tidal excursion, on an annual basis, is approximately 34 cm (Petrocelli et al. 2009). It is linked to the nearby sea by a channel 15 m wide and 400 m long. The Aquatina Lagoon is characterised by a superficial saltwater-bearing stratum and a relatively low depth. The sediments of the lagoon are colonised by *Cymodocea nodosa* and *Posidonia oceanica* debris. Aquatina is a shallow water body, so that decomposition and biogeochemical processes in the lagoon sediment interfere strongly with the nutrient dynamics in the water column. In the wet season, the phytoplankton community (Giacobbe et al. 1996) is principally constituted by nanoplanktonic taxa (*Cyanophycees* and *Phytoflagellates*), while in the dry season, the phytoplankton community is dominated by the microplankton fraction, *Navicula* spp., *Cylindrotheca closterium*, *Prorocentrum micans* and *Prorocentrum minimum*. Improving water exchange with the sea is leading to an increase in marine species in the lagoon which are substituting the freshwater species (Cappello et al. 2005).

The study of population structure of *P. nobilis* shows an instantaneous image and provides a quantitative approximation of the stock of the population. The possibility

Figure 2. A specimen of *Pinna nobilis* in the Aquatina Lagoon (NATURA 2000 site "*Aquatina di Frigole*" IT9150003).

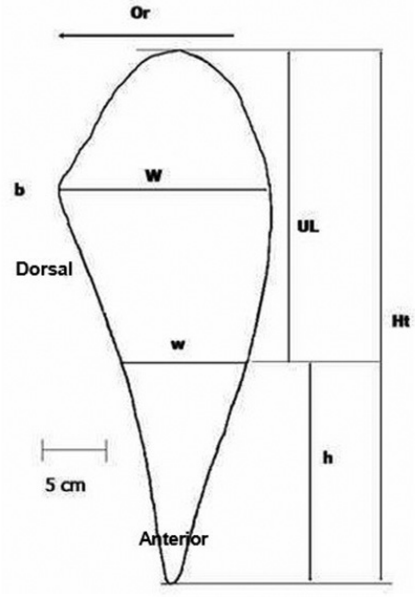

Figure 3. Measurements of interest to estimate the orientation and body-size of *Pinna nobilis*. *In situ* can be measured: W and w, maximum and minimum width respectively; UL, unburied length and Or, orientation of the gape. Maximum shell length (Ht) and length of the buried part (h) can be measured by removing the specimens from the bottom. Besides, Ht can be estimated by applying specific mathematical models (Garcia-March and Vicente 2006).

Figure 4. Biometric measurements of *Pinna nobilis*. Due to an exceptional low-tide day, some specimens were partially emerged.

and benefits of carrying out an explorative sampling should always be the first aspect to be considered when a field survey to study *P. nobilis* populations is going to be undertaken. This is the cheapest and fastest option, but also that in which the least information is compiled. Data gathered is qualitative or the counts of individuals are inaccurate and not referred to a surface area and few statistics -if any- are required to analyse the results. The specimens found were measured according to the protocol proposed by García-March and Vicente (2006) (Fig. 3). In situ, for all recorded animals, the unburied length (UL), maximum width (W) and minimum width (w) were measured by a measuring-tape (Fig. 4). The estimation of maximum antero-posterior shell length of *P. nobilis* cannot be made directly because individuals do not withstand the shedding of the byssus when unburied. Consequently, maximum shell length (Ht) must be estimated indirectly, using empirical equations to relate the measurements of unburied shell parts with Ht. The total height of the fan shell was estimated by using the equation: Ht = UL+(1.79w + 0.5) according to Garcia-March et al. (2002) and Garcia-March and Vicente (2006). Three measurements are basic for estimating Ht, i.e. maximum and minimum width (W and w) and unburied length (UL). Gape orientation (Or) was measured by a compass. This is important from an ecological point of view because orientation of the gape indicates the position of maximum drag force

(Fd) supported by the shell and also in determining the composition of the epibiontic community living on the shell. It is measured with respect to the bend of the shell (dorsal part). For convenience, the bend /dorsal part are always at the opposite side where the orientation is measured. Finally, temperature, dissolved oxygen, salinity and the pH of the water column were measured and recorded by means of a hand-held multiprobe (YSI 556 - YSI Inc., Yellow Springs, OH).

Results

Eleven specimens of *P. nobilis* were recorded; they were orientated in the North-East direction, ranging from 5° to 80° NNE. Maximum and minimum widths were 15.16 cm ± 0.726 and 13.81 cm ± 0.611, respectively and the unburied length was 16.66 cm ± 0.441. The abiotic parameters of water column were also recorded (temperature 12.69°C ± 0.207, dissolved oxygen 7.21 $mg*l^{-1}$ ± 0.278, salinity 24.77 PSU ± 0.963, pH 7.73 ± 0.084).

Discussion

Probably the presence of *P. nobilis* in the Aquatina Lagoon is relatively recent because the species was not recorded in the last update of NATURA 2000 Standard Data Forms (2015). This finding can be justified by the availability of food which seems to be a driving force in determining the patchy distribution of *P. nobilis* populations. In marine habitats, the fan mussel seems to favour meadows of the marine seagrass with *P. oceanica* and *C. nodosa* (Zavodnik et al., 1991) and its distribution is strictly overlapped with the presence of *P. oceanica* meadows (Richardson et al. 1999). Coppa et al. (2013) stated that a higher efficiency in the filtering activity of *P. nobilis* on the meadow borders is related to a satisfactory hydrodynamic for efficient filtering action, explaining the specimen aggregation on the edges. In contrast, within the meadow where the water flow is reduced by seagrass leaves (Koch et al. 2006, Manca 2010), the efficiency of filtering activity of the fan shells could be reduced. In general, the distribution of all benthic macroinvertebrate species is related to bottom habitat types (Galuppo et al. 2007).

In the Aquatina Lagoon, the relative position of the specimens in relation to the meadows was not studied because only dead leaves of *P. oceanica* were present in the lagoon bottom. Besides, the presence of *P. nobilis* in the proximity of the lagoon mouth could be justified by a constant hydro-dynamism and water exchanges with the sea and the recruitment of juveniles from the sea. Since *P. nobilis* is actually exposed to many abiotic and biotic sources of perturbations that are dramatically depleting the populations in the Mediterranean Sea (Vázquez-Luis et al. 2017), this new record becomes significantly relevant in confirming the presence of a new population in the Adriatic Sea. Actually, the ecological assessment of lagoons, traditionally done by the sampling

of the benthic macroinvertebrate communities (Evagelopoulos et al. 2008; Pinna et al. 2013), requires the application of time-consuming and high cost procedures; on the contrary, the monitoring of *P. nobilis*, the largest body-size benthic macroinvertebrate species of the Mediterranean Sea, is faster and cheaper and could suggest the developing of new and smart ecological indicators for rapid assessment of Mediterranean lagoons, as well as for innovative eco-genomic tools (Pawlowski et al. 2018). The results of our research show the relevance of the NATURA 2000 network as an effective tool for biodiversity conservation at EU scale and, moreover, underline the importance of Mediterranean transitional water ecosystems as "nursery habitat" for *P. nobilis* as well as their potential use for promoting breeding programmes in the Aquatina Lagoon and future restocking of resistant juvenile individuals. Until now, the interest in the monitoring of *P. nobilis* is focused only on marine ecosystems but we hope that the monitoring programmes for *P. nobilis* in EU countries will also be extended to transitional aquatic ecosystems as soon as possible.

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