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Rapid Communication

First record of *Dyspanopeus sayi* (Smith, 1869) (Decapoda: Brachyura: Panopeidae) in a Sardinian coastal lagoon (western Mediterranean, Italy)

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Abstract

The non-indigenous mud crab *Dyspanopeus sayi* (Smith, 1869), native to the western Atlantic, was recorded for the first time in a Sardinian lagoon. The first three specimens of this crab species were collected in the central area of the Santa Gilla lagoon on December 2013. Occurrence of the species was also recorded on December 2018 (102 specimens) and their main morphometric features were quantified. Although there are no certainties regarding the precise arrival date of this alien crab in Sardinia, its presence in the Santa Gilla lagoon might be related to the import of mussels for aquaculture purposes.

Key words: alien species, non-indigenous species, mud crab, transitional waters, Mediterranean Sea

Introduction

Introduction of non-indigenous species (NIS), altering the natural distribution of the biota and impacting biodiversity, represents a worldwide threat to the integrity of native communities (Carlton 1989; Occhipinti-Ambrogi 2007). The Mediterranean Sea has been exceptionally susceptible to biological invasions and it is considered among the world's most invaded seas, hosting currently more than 700 NIS (Galil et al. 2017).

Among the Mediterranean NIS, the mud crab *Dyspanopeus sayi* (Smith, 1869), native to the western Atlantic, was recorded for the first time a few decades ago. *D. sayi* is an euryhaline and eurythermic species, inhabiting estuaries and shallow coastal marine waters, from the intertidal zone down to ca. 45 m depth, where it typically occupies tridimensional complex habitats, like biogenic substrates (Williams 1984; Newell et al. 2007; Gibbons 1984; Micu et al. 2010). This species spread from the Western Atlantic to the Northeastern Atlantic and the North Sea (Ingle 1980; Clark 1986). The first Mediterranean record of *D. sayi* dates back to 1991, when it was observed in the Venice lagoon (Froglia and Speranza 1993; Mizzan 1995) and where, nowadays, it is the most common crab species, exceeding in abundance the native ones (Schubart et al. 2012). Most probably, it was introduced in the lagoon by shipping, as larvae in ballast waters or accidentally through exchanges of aquaculture products (Froglia and Speranza 1993; Galil et al. 2002). Since then, the species has spread into other areas, colonising different locations across almost the whole Mediterranean Sea. The species has been to date found in the Po River Delta (Northern Adriatic Sea) (Turolla 1999), in the Black Sea (Micu et al. 2010), in the Ebro Delta (Spain) (Schubart et al. 2012), in a central-southern Adriatic lagoon (Ungaro et al. 2012), in a Tyrrhenian lagoon (Thessalou-Legaki et al. 2012) and, more recently, in Greece and Sicily (Ulman et al. 2017).

We report here data on the first record of this species in a Sardinia lagoon (Santa Gilla lagoon, Southern Sardinia, Tyrrhenian Sea) and, giving data about its distribution and morphometric features, provide insights for better understanding the invasive process and the potential impacts on the invaded ecosystem.

Materials and methods

Study area

The Santa Gilla lagoon covers an area of about 1300 ha and is located in the southern coast of Sardinia (Tyrrhenian Sea), close to the urban area of Cagliari, lying between the historic and industrial ports (Figure 1). The Santa Gilla lagoon is one of the most important wetlands in Sardinia, is classified as Special Protection Area (Directive 79/ 409/CEE), Wetland of International Importance under the Ramsar Convention (DM 03/09/1980) and Site of Community Importance (ITB040023, Directive 92/43/CEE).

In the southernmost part, the lagoon opens to the sea through a channel and in the northernmost part receives two freshwater inflows. The average depth is 1 m (maximum depth 2 m in the artificial channel). The sediments are mainly sandy silt in the whole lagoon, with a purely muddy area located in the northern part (Degetto et al. 1997; Frontalini et al. 2009; Atzori et al. 2018).

This lagoon represents an important area for commercial harvesting of benthic mollusc bivalves, like *Ruditapes decussatus* (Linnaeus, 1758), *Ruditapes philippinarum* (Adams and Revee, 1850) and *Cerastoderma glaucum* (Bruguière, 1789), farming of the mussel *Mytilus galloprovincialis* Lamarck, 1819 and the oyster *Magallana gigas* (Thunberg, 1793), and for fishing of different euryhaline fish species.

Sampling sites and methods

The first specimens of *D. sayi* in the lagoon were obtained from sediment samples collected during surveys aimed at characterizing the macrozoobenthic community of the lagoon along the salinity gradient (Supplementary material Table S1). During that study, six stations were investigated in September and December 2013 and in March and June 2014 (B2, B4, E1, E3,

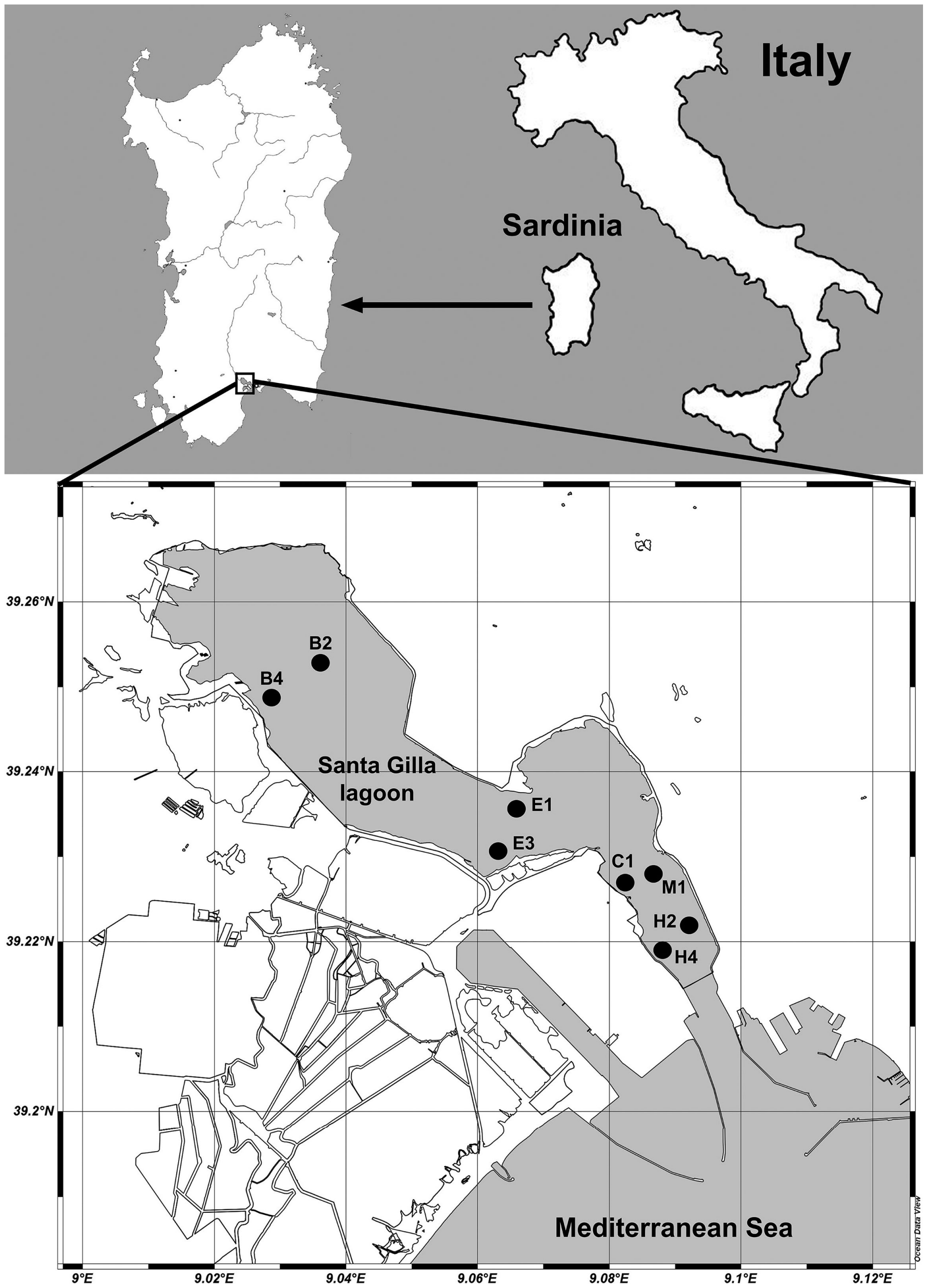

Figure 1. Localization of the stations investigated in the Santa Gilla lagoon.

H2 and H4) (Figure 1). At each of the six stations samples were collected in triplicate every three months by means of a Van Veen grab. In each station, depth (cm) were measured and temperature (°C), salinity, conductivity (ms/cm), dissolved O_2 (mg/l; %sat) and pH of the water were recorded with a multiparametric probe (Hanna HI 9828). In the laboratory the macrofauna was sorted and specimens of the species *D. sayi* were identified based on the morphological description provided by Williams (1965) and Abele (1972): oval, arcuate carapace, small median notch on front, minutely granular; 5 teeth on each anterolateral margin, first 2 coalescent and near ocular lobe margin, last 3 prominent and variable in shape; first male pleopod with a low medial lobe broadly rounded; fingers of chelae

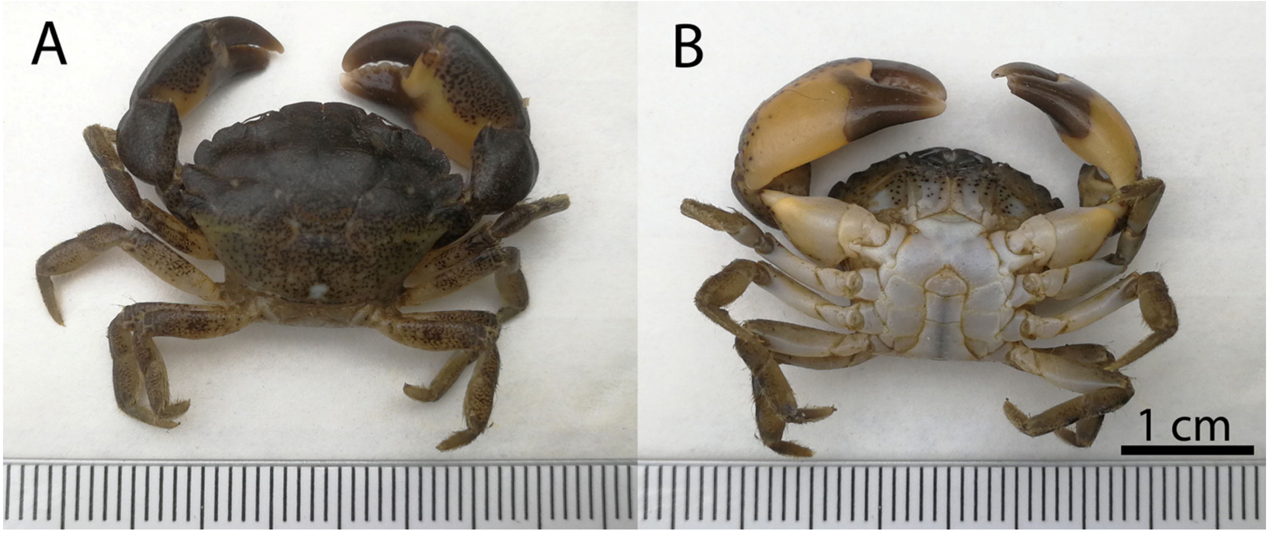

Figure 2. Adult male of *Dyspanopeus sayi* from Santa Gilla lagoon: A) dorsal view B) ventral view. Photo by Serenella Cabiddu.

variable in color, from ivory to black (Figure 2). After the first record, additional specimens were obtained on December 2018 from a site characterized by a complex biogenic and mineral substrate using a shellfish rake (C1) and manually from the suspended socks containing the mussel *M. galloprovincialis* (M1) (Figure 1).

For each specimen, the carapace width (CW; between fifth anterolateral spines); the chela length (CL; as the distance from the tip of the fixed finger to the joint with the tibia), and the chela height (CH; as the maximum height in the plane of movement of the movable finger) were measured to the nearest mm using a dial calliper.

Results and discussion

On December 2013, a total of three male specimens of the NI crab were obtained in the central area of the lagoon (E3; Figure 1). Until 2011, when another survey of the macro-zoobenthic communities was conducted, the crab was not present in the lagoon. This would suggest that the introduction of *D. sayi* in the Santa Gilla lagoon could have been occurred between 2011 and 2013. This hypothesis, however, should be considered with caution as the sampling gear (a grab) used is not appropriate to collect vagile species like crabs. After the first record, a total of 102 specimens were captured on December 2018. From this sample, the sex ratio, calculated as the relationship between the female specimens and the total population (females/(females+males)), was 0.51.

In its native habitat, *D. sayi* maximum size is 30 mm CW, with males being significantly larger and with larger chelae than females (Naylor 1960; Williams 1984; Strieb et al. 1995). The three first males captured in the Santa Gilla lagoon ranged in CW from 9 to 16.2 mm and in CL from 7.1 to 12.2 mm. Overall, the size of the 102 specimens captured in December 2018 ranged in CW from 4.5 to 22.8 mm (mean ± SD = 15.6 ± 3.9) for males, and from 4.7 to 20.7 mm (mean ± SD = 15.9 ± 3.1) for females. Specimens of *D. sayi* collected in the Santa Gilla lagoon resulted, therefore, smaller than those reported for other Mediterranean regions (Schubart et al. 2012; Cilenti et al. 2014; Aubert and Sauriau 2015; Katsanevakis et al. 2014).

Moreover, in contrast to previous studies (Williams 1984), specimens from the Santa Gilla lagoon showed similar size of the chelae in males and females (mean CL/CW ratio = 0.38 and CH/CW = 0.76 in males; mean CL/CW ratio = 0.36 and CH/CW = 0.77 in females).

The absence of ovigerous females in the study area might be explained by the unsuitable sampling periods (December 2013 and 2018), in its native habitat, *D. sayi* reproduces from June to October (Dittel and Epifanio 1982). Notably, in the northern Adriatic Sea ovigerous females have been observed in September (Mizzan 1999) and in the Ebro Delta ovigerous females have been captured in August and September (Schubart et al. 2012; Marco-Herrero et al. 2013). Further qualitative samples of *D. sayi* conducted in June 2019 yielded egg-bearing females in the socks containing mussels. Though we couldn't assess the relative importance of reproducing specimens, their presence supports the hypothesis of a self-sustaining population being resident in the Santa Gila lagoon.

The presence of a potentially self-sustaining population of *D. sayi* in the Santa Gilla lagoon deserves particular attention since this species is a common predator of shallow water bivalves. Previous studies conducted in small locally restricted areas of the Adriatic Sea revealed that *D. sayi* has the potential to exterminate mollusk populations, such as *M. galloprovincialis*, *Mytilaster lineatus* (Gmelin, 1791), *Ostrea edulis* (Linnaeus, 1758) and *Magallana gigas* (Mizzan 1998). Thus, beside the record of another potentially invasive alien species in Sardinian wetlands, we pinpoint here that, since the Santa Gilla lagoon is an important site for shellfish farming and aquaculture of commercial value bivalve species, a specific monitoring activity is urged to address the level of invasion and the potential and actual impacts of *D. sayi* on the biodiversity and functioning of the lagoon.

During our surveys, we consistently observed the presence of *D. sayi* in association with the native commercially important green crab *Carcinus aestuarii* (Nardo, 1847) on either subtidal or intertidal biogenic beds, which most probably serve as both a refuge and food source for both species and are also a preferred substrate for juveniles (Day and Lawton 1988; Hedvall et al. 1998). In native *D. sayi* areas (N Atlantic Ocean) where *C. aestuarii* is an allochthonous invasive species, a distributional overlap could result in increased competition between the two species for food or space (Gehrels et al. 2016). Nevertheless, since *C. aestuarii* could also prey on *D. sayi*, in particular in those areas where the habitat complexity is reduced (Gehrels et al. 2016), we may expect that in the Santa Gilla lagoon *C. aestuarii* regulates the local abundance and distribution of populations of *D. sayi*. Further studies are needed to test this hypothesis.

As in other Mediterranean sites, the introduction of *D. sayi* in the Santa Gilla lagoon is due to two most probable drivers: shipping (this lagoon is located between two ports) and the presence of mussel farms. Shipping is a reliable vector for *D. sayi* as it has a planktonic larval development which consists of four zoeal stages and a megalopa and lasted from 14 to 27 days depending on the temperature (Chamberlain 1957; Marco-Herrero et al. 2013), enabling its safe transport in ballast waters between distant regions (Galil et al. 2002). On the other hand, it has also been shown that marine currents are essential for the transport, hence for connectivity of marine plankton organisms (Berline et al. 2014; Bray et al. 2017; Palmas et al. 2017). In this context, transport via marine currents should also be considered for the dispersal of invasive species (Wasson et al. 2001; Johnston and Purkis 2011). Moreover, as reported for other Tyrrhenian and Adriatic sites, this species could have been introduced accidentally through the import of mussels for aquaculture purposes (Thessalou-Legaki et al. 2012; Cilenti et al. 2014). In this regard, it is noticeable that *D. sayi* populations have been consistently reported on longlines of commercial mussel farms in several locations in the Ionian Sea (Katsanevakis et al. 2014). Also, *D. sayi* preys preferentially on bivalve mollusks, such as *M. galloprovicialis*, by crushing (small and medium sized mussels) or chipping (large sized mussels) their shells with their larger chelae (Mistri 2004; Kapiris et al. 2014).

The presences of *D. sayi* in the Santa Gilla lagoon underlines the vulnerability of this area to the introduction and spreading of allochthonous and invasive species in Sardinian waters. *D. sayi* is thereafter included in the list of the eight alien benthic invertebrates species previously recorded in this lagoon which include: the bivalve mollusks *Ruditapes philippinarum*, experimentally introduced since 1987 (Cottiglia and Masala Tagliasacchi 1988), and *Arcuatula senhousia* (Benson, 1842) (Atzori et al. 2013; Cabiddu et al. 2014), the amphipod *Caprella scaura* Templeton, 1836 (Cabiddu et al. 2013) and the polychaetes *Naineris setosa* (Verrill, 1900) (Atzori et al. 2016), *Hydroides dianthus* (Verrill, 1873) (Bianchi et al. 1984), *Hydroides elegans* (Haswell, 1883) (Bianchi et al. 1984), *Ficopomatus enigmaticus* (Fauvel, 1923) (Bianchi 1979) and *Desdemona ornata* Bense, 1957 (Carrada 1987).

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Supplementary material

The following supplementary material is available for this article:

Table S1. Geo-referenced distribution data and values of water variables at different stations in the Santa Gilla lagoon.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2020/Supplements/BIR_2020_Cabiddu_etal_Table_S1.xlsx