

Rapid Communication**Distribution of the alien species *Callinectes sapidus* (Rathbun, 1896) in Sardinian waters (western Mediterranean)**

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OPEN ACCESS**Abstract**

The distribution of the Atlantic blue crab *Callinectes sapidus* is reported from marine, transitional and freshwater environments along the coasts of Sardinia (Italy, western Mediterranean Sea). Professional and recreational fishermen accidentally collected male and female specimens using fishtraps, gillnets or fyke nets depending on the site. This note represents a new contribution to the knowledge on the ongoing colonization of Mediterranean coastal ecosystems by this invasive species.

Key words: Atlantic blue crab, Portunidae, non-indigenous species, invasive species, lagoons, Mediterranean Sea, island ecosystems

Introduction

The Atlantic blue crab, *Callinectes sapidus* Rathbun, 1896 (Crustacea, Portunidae), is a decapod species native to the Western Atlantic, where it is commonly found in coastal areas from Nova Scotia to Argentina (Nehring 2011). *Callinectes sapidus* inhabits muddy and sandy substrates from few meters up to 90 m in depth, but it generally dwells at depths < 35 m (Hill et al. 1989), feeding on alive preys (fish, molluscs, and crustaceans), carcasses and algae (Hines et al. 1987). It is an euryhaline and eurythermal species, with similar tolerance limits for the juveniles and adult stages (Costlow 1967; Tagatz 1969). This varied ecological tolerance, its strong swimming capacity and life-history traits, such as high fecundity, allow it to be one of the most invasive species in the Mediterranean Sea (Streftaris and Zenetos 2006). Ballast waters have probably been the driver of both introduction and spread of the species towards Europe and the Mediterranean (Nehring 2012).

This species was firstly introduced in northern Europe in 1900 (Bouvier 1901); subsequently, its distribution range has progressively expanded and

in 1949 this species was firstly described for the Mediterranean area in the Grado lagoon (Giordani Soika 1951). Later, the blue crab has expanded its distribution almost throughout the Mediterranean: eastern basin (Bulgurkov 1968; Snovsky and Galil 1990; Yağlıoğlu et al. 2014; Orhan et al. 2015; Perdikaris et al. 2015; Daban et al. 2016), Adriatic Sea (Beqiraj and Kashta 2010; Dulčić et al. 2010; Dulčić et al. 2011) and western Mediterranean (Castejón and Guerao 2013; González-Wangüemert and Pujol 2016; Garcia et al. 2018).

In Italy, *C. sapidus* has been reported from the Ligurian (Tortonese 1965; Suaria et al. 2017), Tyrrhenian (Cavaliere and Berdar 1975; Bisconti and Silvi 2005), Ionian (Gennaio et al. 2006; Mancinelli et al. 2013; Carrozzo et al. 2014; Stasolla and Innocenti 2014) and Adriatic coasts (Florio et al. 2008; Mancinelli et al. 2016; Cilenti et al. 2015; Manfrin et al. 2015, 2016). Recently, some specimens were recorded in Sardinian coasts (Culurgioni et al. 2018; Piras et al. 2019).

The present note describes the distribution and the spreading of *C. sapidus* in marine, transitional and freshwater sites in Sardinia (Italy, western Mediterranean Sea) in the period 2017–2018, adding this species to the seven non-indigenous decapod species reported from the island in the last decades (see Frogliia 2010; Mura and Corda 2011; Stasolla and Innocenti 2014; Amouret et al. 2015; Cabiddu et al. 2018; Orrù et al. 2006; Salvadori et al. 2014).

Materials and methods

Data were derived from the monitoring of fishing activities and research programs on the ecology of Sardinian marine coastal areas, lagoons and ponds, carried out by the Regional Agency for Agricultural Research of Sardinia (Agris), the University of Sassari and the Institute of Anthropic Impact and Sustainability in marine Environment of the National Research Council of Italy (IAS-CNR).

After the first report of *Callinectes sapidus*, posters with basic indications for its identification were displayed along the Sardinian coasts at lagoons, harbours and commercial activities frequented by anglers and tourists, including areas not directly subjected to routinely monitoring programs, in order to achieve the most complete information about its actual distribution.

Study sites

Callinectes sapidus catches/reports/records were from marine, transitional (lagoons, estuaries), and freshwater (river, ponds) ecosystems, located along the coastline of Sardinia (Figure 1; Supplementary material Table S1), from April 2017 to October 2018. All the involved lagoons are exploited for commercial fishing (Fenza et al. 2014). The lagoons of Is Benas (code ITB030035), Cabras (ITB030036), S'Ena Arrubia (ITB030016),

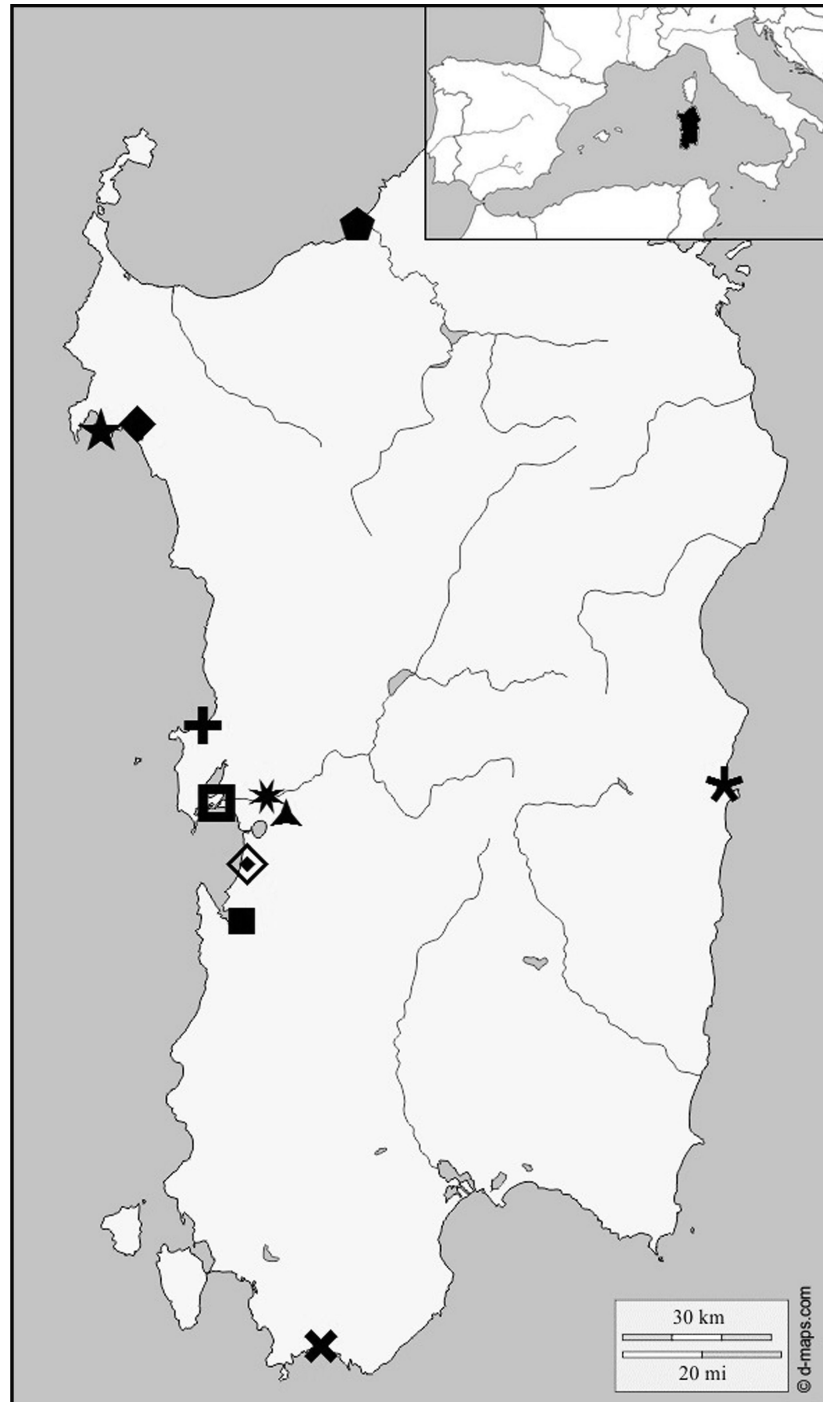


Figure 1. Records of *Callinectes sapidus* in Sardinia. ◆ Coghinas estuary; ◆ Calich lagoon; ★ Lazzaretto beach; + Is Benas lagoon; □ Cabras lagoon; * Tirso river; ▲ Fenosu ponds; ◇ S'Ena Arrubia lagoon; ■ Marceddi lagoon; ✕ Porto Budello; ★ Tortoli lagoon.

Marceddi (ITB030032), the Lazzaretto beach (ITB010042), and the estuary of the Coghinas river (ITB010004) are included in the European Nature 2000 network as Sites of Community Importance (SCI). The first four (codes ITB034007, ITB034008, ITB034001, ITB034004, respectively) are also designated as Special Protection Areas for birds (SPA), while the Cabras Lagoon and the estuary of Coghinas river are Special Areas of Conservation (SAC) (European Community 2019).



Figure 2. Left: Adult male of *C. sapidus* from Cabras Lagoon. Right: Adult female of *C. sapidus* from S'Ena Arrubia Lagoon.

Catching typology, identification and morphometric analyses of Callinectes sapidus

The catches from lagoons were made by local professional fishermen, those from the other sites came from recreational anglers.

The blue crabs were caught by professional fyke nets, gillnets and crab/fish traps (Table S1). Two individuals, from S'Ena Arrubia and Cabras lagoons, were analysed in situ for identification according to Williams (1974), Millikin and Williams (1984) and Ogburn et al. (2011).

Specimens were ascribed to the genus *Callinectes* based on morphological characters, namely the lack of spines in the inner margin of the carpus of cheliped (Ogburn et al. 2011), which differs from the other genera of portunid crabs. The species *C. sapidus* shows two triangular teeth in the frontal margin of the carapace, between the inner orbital teeth (Williams 1974; Millikin and Williams 1984). Male specimens were identified by the examination of the inverted T-shaped abdomen (Millikin and Williams 1984; Baldwin and Johnsen 2009) (Figure 2), while females are characterized by blue and white claws and red dactyls, and from the typical shape of the abdomen (Millikin and Williams 1984; Baldwin and Johnsen 2009) (Figure 2).

The crabs were weighed with a digital scale (total weight, TW), and the carapace length (as the distance between the center of the anterior interorbital margin and the center of the posterior margin, CL) and width (as the distance between the tips of posterior anterolateral spines, CW) were measured to the nearest mm. Individuals from the other sites were identified from photographs.

Results and discussion

Documented presence of *Callinectes sapidus* has been reported in Sardinia from 11 different sites along a coastline of about 1,100 km (from Coghinas estuary to Tortoli lagoon) (Figure 1). A total of 99 specimens (39 males and 60 females) of *Callinectes sapidus* were found in six transitional, two marine and three freshwater environments. Details on the occurrence of the blue crab are resumed in Table S1. The species appeared more densely distributed in the transitional waters of the western and north-western coast of the island, while only few records were found in the other areas.

The first record of the blue crab in Sardinian waters were based on photographs of two male specimens found in the S'Ena Arrubia lagoon in April 2017. Later, this identification was validated by two successive captures from S'Ena Arrubia lagoon (July 26, 2017) and from Cabras lagoon (October 30, 2017), for which the specimens were made available to us (Figure 2). The blue crab captured in the S'Ena Arrubia lagoon weighed 321 g, with CL and CW of 72 and 169 mm, respectively, while the specimen captured in the Cabras lagoon weighed 389 g, with CL and CW of 80 and 170 mm, respectively.

Among the possible pathways of introduction of the species in Sardinia, the accidental introduction of juveniles together with imported bivalve seed should be considered as a likely vector, along with ballast waters, which is considered the primary vector of introduction of this species in Europe (Nehring 2011). This seems consistent with the fact that the main Sardinian ports are important for both national and international ship traffic. Interestingly, S'Ena Arrubia lagoon is only 4 km south of the industrial port of Oristano and 6 km north of an important shellfish factory. Moreover, as reported by a professional fisherman, medium-sized blue crabs may be found among the lots of *Carcinus aestuarii* Nardo, 1847 that are purchased from other lagoons in Italy to be used as bait in octopus fishing. Both adults *C. sapidus*, with their strong swimming ability, and larvae, which may cover distances of 30 to 80 km in surface coastal waters (Hines et al. 1995), can quickly expand the distribution area starting from the primary introduction point.

According to photographs and to fishermen's observations, ovigerous females occurred in S'Ena Arrubia and Calich lagoons in spring and summer 2017 and 2018. They were observed also in the marine area of Porto Budello. Despite the finding of ovigerous females, to date the total number of specimens collected is too low, so there is no current evidence that the spreading of *C. sapidus* is the result of successful reproduction of already established populations, as previously observed in Albanian and Italian coasts of Adriatic Sea (Beqiraj and Kashta 2010; Cilenti et al. 2015). On the other hand, since current data do not derive from a focussed monitoring program but mainly from casual findings by anglers and amateurs, the real population could be actually more abundant than

currently reported. However, the increased number of individuals captured in the S'Ena Arrubia Lagoon (from four in 2017 to 55 in 2018) would suggest the existence of at least one structured population in this site.

This paper describes the initial distribution of *C. sapidus* in Sardinia and gives novel information on the colonization of the western Mediterranean basin by this invasive crab. These data, and a recent record in a lagoon of the south-western coast (Piras et al. 2019), suggest that the blue crab in the near future will potentially occur in other Sardinian areas with similar environmental characteristic.

The spread of *C. sapidus* along the coasts of Sardinia is constantly under observation thanks to the virtuous interaction among researchers and professional and amateur anglers. In this regard, the results encourage the integrative use of citizen science in the collection of reports. The standardization of a combined approach may enhance the amount of data on the occurrence of other non-indigenous species, at the same time promoting public awareness and environmental education (Poursanidis and Zenetos 2013; Azzurro et al. 2018). Further studies will aim to localize stable populations of *C. sapidus* and describe the local dynamics of colonization. These may include the study of larval dispersion, with the design of models that take into account the hydrodynamic conditions around Sardinia (see Palmas et al. 2015, 2017). Moreover, it would be important to assess the impact of *C. sapidus* on the affected ecosystems, by evaluating its trophic position and comparing it to those of native decapods and fish, which can suffer from its aggressive competition and predation (see Carrozzo et al. 2014). Even the direct and indirect influence of the blue crab on fishing activities should be considered, e.g. the predation on valuable commercial fish and shellfish, and the damage exerted with claws on fishing gears, as repeatedly reported by professional fishermen. Combined management and mitigation strategies should be considered, including the exploitation of *C. sapidus* as a high-value fishery resource (Mancinelli et al. 2017).

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Supplementary material

The following supplementary material is available for this article:

Table S1. Records of *Callinectes sapidus* in Sardinia: Sites of collection and their main abiotic factors; date, type of gear, number (N) of specimens collected, and references.

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