

Rapid Communication**Rapid invasion of the American blue crab *Callinectes sapidus* Rathbun, 1896 in the North-East of the Iberian Peninsula**Miguel Angel Fuentes^{1,2,*}, Laura Torrent², Sergio Barrera² and Dani Boix¹¹GRECO, Institute of Aquatic Ecology, University of Girona. Campus Montilivi, 17071 Girona, Spain²Natura Montfred, J. M. Gironella i Pous 1-3, 17005 Girona, Spain

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OPEN ACCESS**Abstract**

We report new localities for *Callinectes sapidus* in the Iberian Peninsula that widen the north-eastern limit of its distribution by more than 206 km along the Iberian Mediterranean coastline. This invasive species has been captured in the estuaries of the Fluvià, Muga and Ter rivers and has become established in the Fluvià River in only nine months since the first individual was detected. These reports show how rapid expansion of *C. sapidus* can be and that this may be preceded by the presence of isolated individuals.

Key words: invasive alien species, new distribution range, Iberian Mediterranean coastline**Introduction**

The blue crab or Atlantic blue crab, *Callinectes sapidus* Rathbun, 1896, is a Western Atlantic species ranging from Nova Scotia (Canada) to the north of Argentina, typically found in estuaries and brackish waters. The blue crab is a euryhaline and eurythermal species, surviving in waters of up to 45 °C (Powers 1977) and dissolved oxygen concentrations of less than 0.08 mg/l (Williams 1974). Moreover, it is an omnivorous species with a high trophic flexibility (Mancinelli et al. 2017c) and a predator of fish, molluscs, other crustaceans and some macro-algae such as *Ulva* sp. and *Spartina* sp. (Gennaio et al. 2006). As a key benthic predator (Lipcius and Hines 1986), *C. sapidus*' diet overlaps with those of Mediterranean native crabs (Mancinelli et al. 2013). Such characteristics, plus its massive body size, aggressive behaviour and voracity, fast growth and short reproduction cycle, explain the prevalence of this species in native and introduced locations and why it is described as one of the 100 most harmful invasive species in the Mediterranean (Streftaris and Zenetos 2006).

The first European record of the blue crab is from the Atlantic seashore of France (Bouvier 1901). Although the species has not established itself along the Atlantic coastline of Europe, it has been regularly observed in

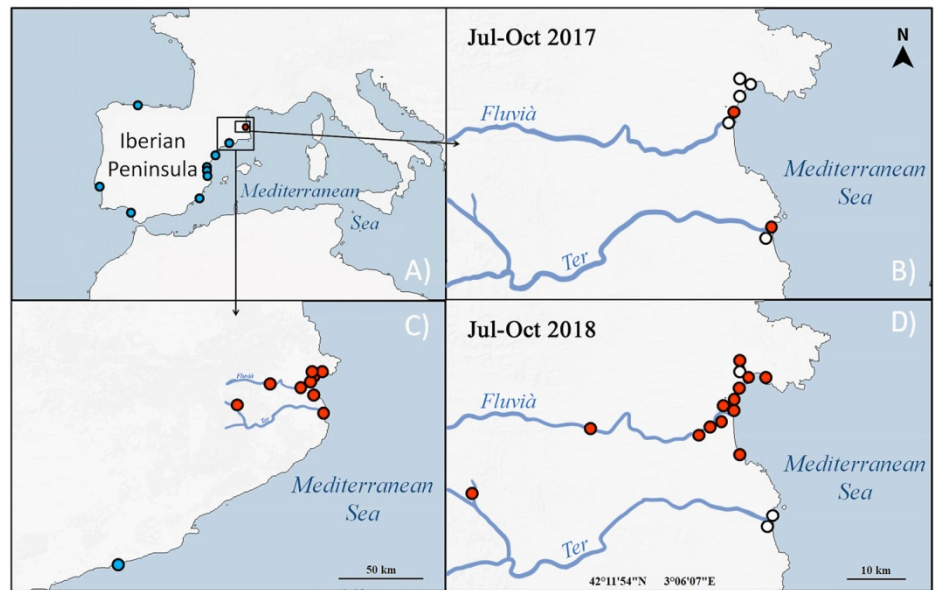


Figure 1. Locations of new records of *Callinectes sapidus*. Previous records in the Iberian Peninsula are shown in panel A (blue circles). The nearest location where *C. sapidus* was known previously is shown in panel C (blue circle). New records of *C. sapidus* are shown in panel B (2017) and panel D (2018) (red circles). Sampling locations without *C. sapidus* captures in this study are shown with white circles. For details see Supplementary material Table S1.

different countries from Denmark (the North and Baltic Seas) to Portugal. The first Mediterranean record dates from 1949 in the north of the Adriatic Sea (Giordani-Soika 1951), and since then it has been widely observed throughout the eastern basin. The first records of the blue crab on the Iberian Mediterranean coastline are from Murcia (Abelló 2010) and the Ebro delta in 2012 (Castejón and Guerao 2013). Currently, it is considered an established species on the Iberian Mediterranean coastline in the Ebro River, in many coastal lagoons in Valencia and in the Mar Menor lagoon in Murcia (Servicio de Vida Silvestre 2016; Mancinelli et al. 2017b). In addition, several observations of the blue crab at the Foix River mouth have been documented since 2015 (Broglia et al. 2018), this being the most northern population of its known distribution on the Iberian Mediterranean coastline.

Here we report the first records of blue crab in three new river basins of the North-Eastern Iberian Peninsula and evaluate how fast the invasion can be by means of two specific samplings performed at the time of detection and the following year.

Materials and methods

Two observations were made during 2017 in two separate protected wetland areas (Figure 1). Our first observation was made in the La Pletera salt marshes (Supplementary material Table S1) in the Ter River basin, part of the Natural Park “Montgrí, les Illes Medes i el Baix Ter” (PNMIMBT).

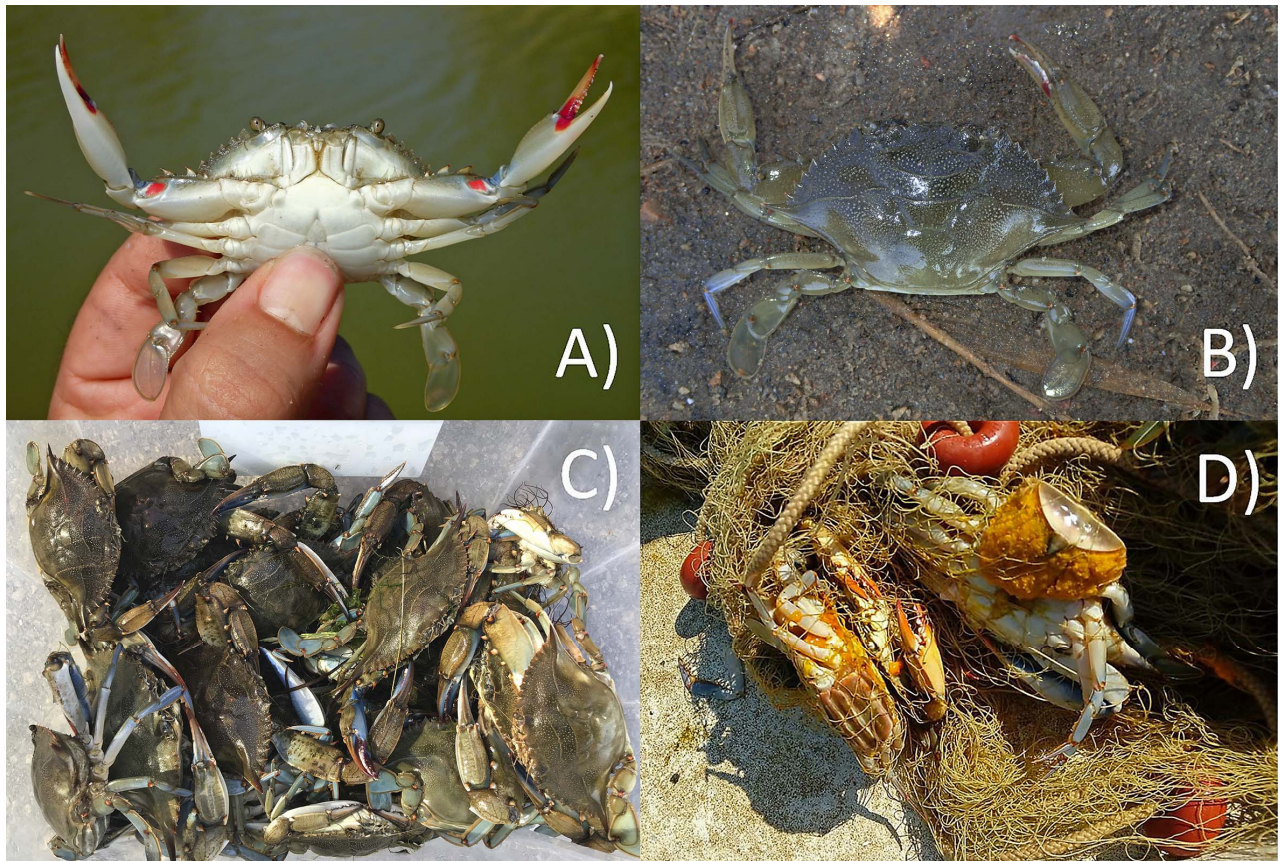


Figure 2. Immature individual of *Callinectes sapidus* captured in the Pletera salt marshes in July 2017. Panel A, ventral view; panel B, dorsal view (©M.A. Fuentes). Panel C, adults of *Callinectes sapidus* captured in the Rec Sirvent channel and the Fluvià River mouth in July 2018 (©M.A. Fuentes). Panel D, gravid females of *Callinectes sapidus*, captured in the sea off Can Comas beach in June 2018 (©Joan Clotas).

There, a solitary individual (carapace width 60 mm) was captured by means of a fyke net on 13th July 2017 (Figure 2A, B) during sampling for the “Life Pletera” project (LIFE13 NAT/ES/001001). The area “La Pletera” is a Mediterranean salt marsh, defined as a “priority habitat of community interest” by the European Habitat Directive (habitat code 1150), and hosts one of the last-known natural populations of the Iberian toothcarp (*Aphanius iberus*), an Iberian Peninsula endemic fish labelled as endangered (Crivelli 2006). Two previous Life projects (“Life Ter Vell”, LIFE NAT/ES/000035; and “Life Emyster”, LIFE 04NAT/ES/000059) were conducted in this area, and a third one (“Life Pletera”), whose aim is to recover the Iberian toothcarp’s lost habitat, is currently being finalised. The second observation was made in the “Rec Sirvent” (Table S1), a waterbody connected to the Fluvià River in the Natural Park “Els Aiguamolls de l’Empordà” (PNAE) on 26th September 2017. There, a solitary adult male of about 130 mm carapace width was found. In both cases, identification was based on the coloration pattern and distribution of the carapace spines (Williams 1974).

In order to evaluate the magnitude of the invasion, one sampling campaign was performed in each area during October 2017. Thirty-one

fyke nets, using dead fish as bait, were placed in the Ter River mouth and in the ponds of the La Pletera salt marshes in the PNMIMBT. Using the same methodology, 20 fyke nets were installed in the PNAE, focusing on the Fluvià River mouth, the Rec Sirvent channel, the Muga River mouth, the Santa Margarida channels and the Rovina salt marshes (Table S1). The total capture effort for each fyke net was 33 hours.

Finally, a second sampling campaign was carried out in July 2018 using the same methodology and locations as in the previous year. The sampling effort was only performed in the PNAE, because in the PNMIMBT seasonal sampling of the coastal wetlands had already been done in 2018, both as part of the “Life Pletera” project and by the technicians working in the Natural Park.

Results and discussion

The two individuals of *Callinectes sapidus* detected in July and September 2017 represent the first records of the species in the Ter and Fluvià River basins. Although native crabs, exotic crayfish, other invertebrates and fish were captured during the sampling campaign in October 2017, no blue crabs were captured nor observed (Table S1). Moreover, additional surveys performed in 2017 and 2018 by Natural Park technicians and the research monitoring carried out within the framework of the “Life Pletera” project revealed no other blue crabs. However, in July 2018 we captured one adult male in the Santa Margarida channels (CPUE; 0.07 individuals/trap/day), one adult female in the Muga River mouth (CPUE; 0.25 individuals/trap/day) and 46 individuals in the Fluvià River mouth and the Rec Sirvent channel (CPUE; 2.40 individuals/trap/day), of which 12 were adult females (one gravid) and 34 were adult males (Table S1 and Figure 2C). In addition, several records have been documented between July and October 2018 in nearby locations by the authors, PNAE technicians, local fishermen and the Mosquito Control Service of the Bay of Roses and the Baix Ter (Table S1). Two adult males were also found in inland fluvial courses in Cogoll and Esponellà (Rural Agent Corps of Catalonia, *pers. comm.*). These are likely to be human introductions because the lack of fluvial connectivity would prevent natural arrival of blue crabs to these locations. Moreover, more than 25 individuals were captured from May to July 2018 in the sea off Can Comas beach (close to the Fluvià River mouth) by local fishermen (Joan Clotas, *pers. comm.*) using trammel nets at depths between 3 and 20 m (Figure 2D). These new records widen the north-eastern limit of blue crab distribution by 206 km along the Iberian Mediterranean coastline.

The results obtained imply a rapid invasion with a fast increase in density and distribution of the species in the studied area in just nine months. While the blue crab has not been detected again in the Ter River mouth and the Pletera salt marshes since July 2017, it has become widely

established in the Fluvià River mouth area. The reason could be that the Fluvià River has a more substantial connection with the sea than the Ter River because the Fluvià River mouth is kept open artificially during the summer to allow boat passage from the river to the sea. The highest abundance of blue crabs was caught in the Fluvià River at the beginning of summer, coinciding with when the river mouth was dredged. This allowed adult blue crabs to penetrate the river from the sea (at that time, local sea fishermen captured numerous individuals in the surrounding area) (Figure 2D). Our observations could correspond to a marine dispersion phase, as we detected specimens across many littoral localities in addition to the sea. In fact, this species has been described as an efficient marine disperser (Gennaio et al. 2006) for two main reasons. First, because adults have high swimming capacity, exceeding 1 m/s (Spirito 1972). Second, this species is characterized by a long planktonic larval phase (30 to 70 days) (Holthuis and Gottlieb 1955) facilitating effective larval transport within ballast waters (Perdikaris et al. 2016) and sea currents along the coasts.

Although the impact of the blue crab invasion on the Iberian littoral ecosystem has not been thoroughly studied, Catalan governmental agencies have reported that this species is becoming an economic problem for the local fishing sector in areas where it has already become established, since it damages fishing nets and commercial clam cultures (López and Rodon 2018). The same report pointed out the negative effect of *C. sapidus* on native crab species such as *Carcinus aestuarii* Nardo, 1847. Conversely, it is already a valuable fishing resource in the Ebro delta and is sold in several local markets (Mancinelli et al. 2017a).

In conclusion, our results show a rapid expansion of *C. sapidus* in the Iberian Mediterranean coastline that was preceded by the presence of isolated individuals. In addition, our investigation suggests that the colonization has been driven by adult individuals from the sea and, specific to the Fluvià River, by a continuous connection with the sea. Therefore, we recommend that the staff of both Natural Parks make efforts to monitor and manage this species going forward in order to prevent undesirable impacts. Finally, we also recommend that the Spanish and Catalan governments make the public aware of the negative effects of this species in order to avoid more cases of human-mediated jump dispersal.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Records (number of individuals) of blue crabs (*Callinectes sapidus*) captured in the sampling campaigns (Catch) or observed (Obs.) between July and October in 2017 and 2018 at the PNAE and PNMBT Natural Parks as well as independent documented observations from reliable sources. (-) Location where no sampling points (traps) were placed. (*) Sampling methodology used was not specific for the blue crab.

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