# *Accelerated invasion of decapod crustaceans in the southernmost point of the Atlantic coast of Europe: A non-natives' hot spot?*

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INVASION NOTE

# Accelerated invasion of decapod crustaceans in the southernmost point of the Atlantic coast of Europe: A non-natives' hot spot?

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**Abstract** Observations of previously unrecorded non-native species in the Gulf of Cadiz (Spain), situated between the Atlantic Ocean and the Mediterranean Sea, have accelerated since 1980, and increased rapidly in the past 5 years. Four new records of decapod crustaceans have been detected in this region: the African snapping shrimp *Alpheus* sp., the West African cleaner shrimp *Lysmata uncicornis*, the Indo-West Pacific giant tiger prawn, *Penaeus monodon*, and the Atlantic blue crab *Callinectes sapidus*. The introduction and establishment of these species into the coastal waters of this region, the southernmost Atlantic coast of Spain may have been influenced by recent anthropogenic alteration of habitat, particularly estuaries and salt marshes, and by climate change facilitating the spread of warm water biota.

**Keywords** *Callinectes sapidus* · *Alpheus* sp. · *Penaeus monodon* · *Lysmata uncicornis* · Tropicalization · African Creep · Ocean sprawl

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## Introduction

Biological invasions may have accelerated as a consequence of expanded connectivity (Hulme et al. 2017). The increase in shipping, both commercial and recreational, risks the transport of ballast and biofouling assemblages (González-Ortegón et al. 2007; Cuesta et al. 2016; Galil et al. 2019). Climate change may enhance the establishment of introduced species, as well as the poleward shift in distribution of numerous species over decades (Sorte et al. 2010; Canning-Clode and Carlton 2017; Pinsky et al. 2020). The climate driven range shifting of West African marine species northwards into European waters has been termed "African Creep" by Canning-Clode and Carlton (2017).

Given the risk of invasion, predicting the population growth patterns of non-native species (NNS) is imperative for effective management. We use NNS as an inclusive term for species occurring outside of its natural range, whether it was introduced intentionally/unintentionally by humans (non-indigenous species, NIS), as well as climate driven species (CDS) extending their range naturally.

The Gulf of Cadiz (GoC), Spain, adjoining the Straits of Gibraltar, may be increasingly vulnerable to introductions, both from the much-invaded Mediterranean Sea and through the northward expansion of African biota, that is African Creep species (Cuesta et al. 2016; Canning-Clode and Carlton 2017; Galil et al. 2018; Guastella et al. 2019). Over the past four

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decades, the southwestern coast of Spain has been transformed. Its four main harbours have been expanded (Fremont 2007)—the port of Algeciras ranks first in Spain in container traffic volume, and second among all Mediterranean ports (Acosta et al. 2007). Beaches have been reconstructed (e.g. in Algeciras, Cadiz and Huelva), the Guadalquivir estuary made navigable at the cost of the adjacent saltmarshes (Del Moral Ituarte 1991), and the Guadiana and the Guadalquivir dammed (Clavero et al. 2004; Morais 2008). The massive coastal sprawl, changes in water-usage and dynamic flow characteristics of the main rivers, in addition to climate anomalies may facilitate invasions (Duarte et al. 2013; Firth et al. 2016; Winder et al. 2011). Estuaries are particularly prone to NNS due to high exposure to transport vectors (e.g. Niimi 2004) and extensive anthropogenic impacts (Marchand et al. 2002). In the estuaries and salt-marshes that dominate the GoC coastline, NNS have previously been recorded including the Western Atlantic Squeteague *Cynoscion regalis* (Bloch & Schneider, 1801) (Béarez et al. 2016; Bañón et al. 2017), the Mummichog *Fundulus heteroclitus* (Linnaeus, 1766) (Bernardi et al. 1995) and some crustaceans (Ros et al. 2014; Reyes-Mártinez and González-Gordillo 2019). Previous records (1973–2015) of non-native crustacean decapods in the GoC (Fig. 2) include the Red swamp crayfish *Procambarus clarkii* (Girard, 1852) intentionally introduced in the 1970's (Geiger et al. 2005), the accidental introductions of the mitten crab *Eriocheir sinensis* H. Milne Edwards, 1853, recorded in the Guadalquivir estuary in 1987, the mud crab *Rhithropanopeus harrisii* (Gould, 1841) in 1990 (Cuesta et al. 1991) and the oriental shrimp *Palaemon macrodactylus* Rathbun, 1902 in 1999 (Cuesta et al. 2004; González-Ortegón et al. 2010). CDS such as African crabs—*Callinectes pallidus* (de Rochebrune, 1883) (as *C. exasperatus* (Gerstaecker, 1856)) and the pea crab *Afropinnotheres monodi* R.B. Manning, 1993—have expanded their distributions and recently colonized the region (Subida et al. 2011; Cuesta et al. 2015).

## Results and discussion

### Recent increase of non-native decapod crustaceans in the Gulf of Cadiz

In the last five years, four new records of decapod crustaceans have been detected in the GoC from local fishermen (see Figs. 1 and 2): the African snapping shrimp *Alpheus* sp. Fabricius, 1798 (Palero et al., in prep.) in saltmarshes and estuarine intertidal, the West African cleaner shrimp *Lysmata uncicornis* Holthuis and Maurin, 1952 in the marine subtidal (González-Ortegón et al. 2020), the Indo-West Pacific giant tiger prawn, *Penaeus monodon* Fabricius, 1798 in the mouth of the Guadalquivir estuary (Anyanwu et al. 2011; Dr. Arias, Institute of Marine Sciences, pers. com.), and the Atlantic blue crab *Callinectes sapidus* Rathbun, 1896. The latter has long been known from Europe and recently recorded from the Atlantic coast of the Iberian Peninsula (Gaudêncio and Guerra 1979; Cabal et al. 2006; Nehring 2011; Ribeiro and Veríssimo 2014; Morais et al. 2019). It was detected in 2017 in several localities in the GoC (both adults and juveniles in the Guadalquivir estuary, in the saltmarshes of Doñana, San Fernando, Sancti Petri and Rio San Pedro) and Malaga coast (Fig. 1). In July 2020, blue crabs specimens were observed in the Guadalete river and the saltmarshes of Cetina in Puerto Real, both places situated in the GoC. The cumulative number of non-native decapod crustaceans in the GoC, from 1973 to 2020 mentioned above, shows a steady rate of records per decade (Fig. 2).

Newly established species, both human-introduced non-indigenous and climate-shifted non-natives, may become invasive in the new host environment. Some species may prove to have economic and ecological impacts in the GoC. The recent (2017, 2018) increase in populations of the African snapping shrimp and the blue crab in local coastal habitats (estuaries, saltmarshes, beaches), raised the concern of fishers (González-Ortegón, unpublished communications with fishermen). These concerns should be validated by scientific surveys in order to provide the authorities with sufficient data as to their effect on local ecosystem services and biodiversity.

The GoC is increasingly vulnerable to non-native species due to the region's high shipping volume, rise in seawater temperature, and extensive anthropogenic changes.

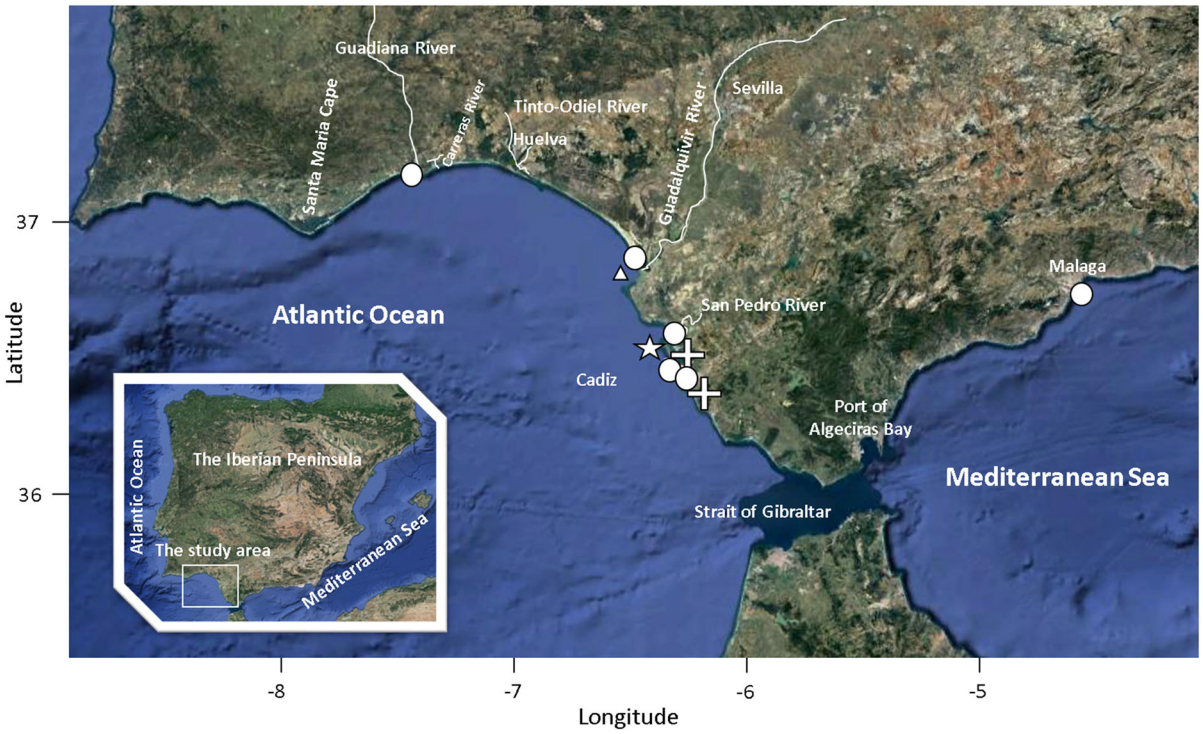


**Fig. 1** Map of the Gulf of Cadiz with the locations of the non-native records (dot = *Callinectes sapidus*; cross = *Alpheus* sp.; star = *Lysmata uncicornis*; triangle = *Penaeus monodon*)

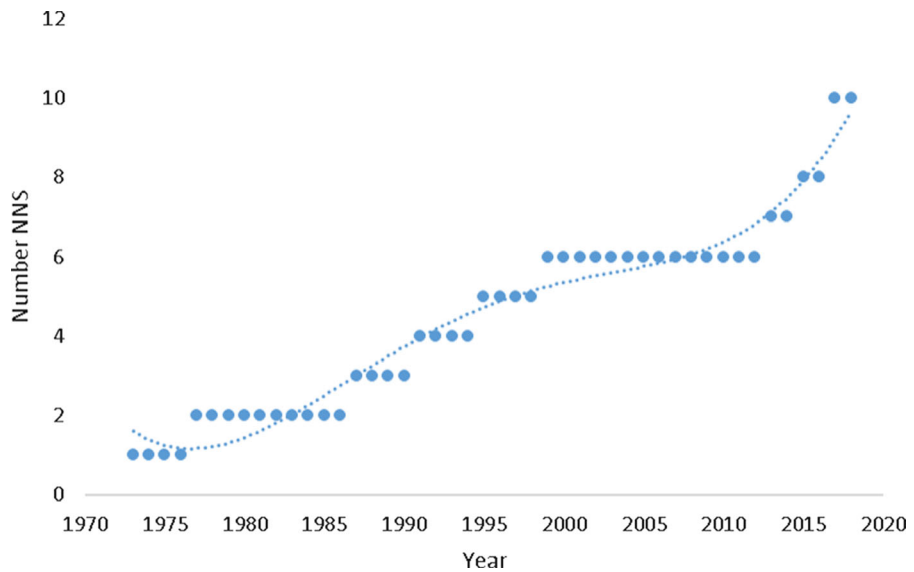


**Fig. 2** Cumulative number of the latest ten NNS decapod crustaceans detected in the Gulf of Cadiz from 1970 to 2020 with the best-fitted curve. Data from 1973 to 2015 are from Geiger et al. 2005, Cuesta et al. 1991, Cuesta et al. 2004 and González-Ortegón et al. 2010. Records from 2015 to 2020 from local fishermen and Palero et al. (in prep.)

The most effective management of marine introductions is control of vectors (Ojaveer et al. 2018). Therefore, the most pressing issue is the identification of the main regional vectors, coupled with a 'Horizon

scanning' study of possible introductions (e.g. *C. sapidus* may have arrived with currents from a nearby source population on the southern Portuguese coast (Morais et al. 2019), or through secondary dispersal by shipping (Garcia et al. 2018)). The warming of the region's seawater may intensify the propagule pressure and establishment success of West African marine biota in the GoC. It is worth highlighting the worldwide range extension of other CDS decapods such as fiddler crabs in the US (Johnson 2014; Rosenberg 2018), Argentina (Truchet et al. 2019) and Africa (Peer et al. 2015) or swimming crabs in the US (Johnson 2015; Sadowski et al. 2018). Climate driven range shifting is inevitable and may escalate with increasing temperatures. Warming-driven latitudinal range shifts prompt complex biological responses that may result in community-level changes (Booth et al. 2011). However, improved assessments of future range shifts may provide forewarning of impending alterations to existing communities and habitats and afford management time for mitigation and adaptation measures (Pinsky et al. 2020). It is imperative that urgent studies of these early arrivals be initiated to establish possible impacts, to nature and to nature's contributions to humans.

This understanding goes hand in hand with estimates of potential damage they may cause and both the importance of, and the potential for, mitigating further invasion effects. On the Spanish Mediterranean coast *C. sapidus* populations have been causing negative socioeconomic impacts by preying on bivalves and damaging fishing nets (López and Rodon 2018).

## Conclusions

We predict that the southwestern Iberian Peninsula will increasingly see the arrival and establishment of West African biota, which has already began (i.e. *A. monodi, C. pallidus* and *L. uncicornis*, and the African snapping shrimp *Alpehus* sp). Warming seawater will likely favor an "African creep" along the western European coast. Improved knowledge of the West African marine biota would advance efforts to monitor their spread.

In order to preserve biodiversity, the ecological and economic effects of these four species should be assessed and, if needed, managed. Although, at the moment we lack information about the impact of these species in the GoC, in the case of the blue crab which is a commercial species with a higher potential damage, commercial use could eradicate or control its population as previously suggested by Box et al. (2020).The results of these studies will be of great interest for the management and conservation of the European Atlantic seaboard biota. Future projects may provide information on the possible impacts of non-native species on the community organization and ecosystem functioning in the GoC (e.g. *C. sapidus* and *P. monodon*, which may impact local commercial fisheries). The study of the invasiveness traits of these species will allow identification the most vulnerable native species.

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**Authors contribution** All authors developed the concepts and wrote the manuscript.

**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

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