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Tracking the invasion of the red swamp crayfish  
*Procambarus clarkii* (Girard, 1852) (Decapoda Cambaridae)  
in Sicily: a “citizen science” approach

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## SUMMARY

The first record of the red swamp crayfish in Sicily dates back to 2003 and, since then, the species seemed to be confined to a few localities in western Sicily. A small “citizen science” project carried out from November 2016 onwards led to the creation of the “Sicilian *Procambarus* working group” (SPwg), which aims at monitoring the distribution and impact of the species in Sicily. To date, the SPwg found the red swamp crayfish in five new sites on the island, thus doubling the number of local sites of occurrence. The new *Procambarus clarkii* sites lie in different river basins, some of them located several hundred kilometres from the invaded areas known to date, suggesting the existence of multiple independent releases of the species in the wild. The need of better informing the local

population on the risks exerted by invasive species on biological diversity, and of carefully monitoring the impact of *P. clarkii* on the Sicilian inland water biota is briefly stressed.

## INTRODUCTION

Several alien crayfish species are currently known to occur in Europe, and the ever-increasing number of new occurrence records suggests that findings of such species will further increase in the near future (Kouba et al. 2014). To date, the only allochthonous crayfish species reported from the wild in Sicilian inland waters is the red swamp crayfish *Procambarus clarkii* (Girard 1852) (Marrone and Naselli-Flores 2015), which is included in the list of alien species of concern in the EU regulation 1143/2014 on the prevention and management of invasive alien species.

The red swamp crayfish was first reported in Sicily from the nature reserve “R.N.I. Lago Preola e Gorgi Tondi” by D’Angelo and Lo Valvo (2003), and some years later it was observed in a reservoir located approximately 90 km away, along the northern coast of the island (Di Leo et al. 2014). Attempts aimed at controlling and eradicating the *P. clarkii* populations occurring in the “R.N.I. Lago Preola e Gorgi Tondi” (D’Angelo et al. 2008) were unsuccessful, and the known populations are nowadays thriving in both the known sites (Maccarrone et al. 2016, Ottonello et al. 2017, SPwg, *unpubl. data*).

The impact of *Procambarus clarkii* populations on the invaded ecosystems is well-known, and is mainly due to the alteration of ecosystem structure and functioning, with possible significant consequences on human well-being as well (Gherardi 2007, Ficetola et al. 2012, Souty-Grosset et al. 2016). In particular, invaded areas showed a widespread biodiversity loss with a consequent ripple effect on local trophic webs. For example, in the nature reserve “R.N.I. Lago Preola e Gorgi Tondi”, *P. clarkii* is currently a substantial part of the diet of the endemic Sicilian pond turtle *Emys trinacris* Fritz et al. 2005 (Ottonello et al. 2017). This could lead to a long-term detrimental effect on the chelonian species, due to the accumulation of harmful concentrations of trace elements and toxic microcystins in the muscles of the crayfish (Naselli-Flores et al. 2007, Bellante et al. 2015). Last but not least, *P. clarkii* is the vector

of the pathogen of the “crayfish plague”, *Aphanomyces astaci* (Schikora 1903) (Aquiloni et al. 2011, Marino et al. 2014), an oomycete which proved to be able to infect also the freshwater crab genus *Potamon* Savigny, 1816 (Svoboda et al. 2014). This genus is present in Sicily with the autochthonous species *P. fluviatile* (Herbst 1785).

In the light of the invasiveness of the species and of the threats exerted on the autochthonous biota, a “citizen science” program was launched to deepen the knowledge on *P. clarkii* current distribution in Sicily.

## METHODS

On November 2016, the informal “Sicilian *Procambarus* working group (SPwg)” was established at the Department STEBICEF of the University of Palermo; the aim of the SPwg is to coordinate the reports of occurrence of the red swamp crayfish in Sicily provided by amateur or non-professional scientists.

To get in touch with the highest possible number of contributors from the whole region, at the same time limiting the risk of spreading information on *P. clarkii* distribution among hobbyists interested in the captive breeding of the species, the SPwg published a Facebook private page (“*Procambarus clarkii* in Sicilia”) administrated by FPF, GG and FM. This page, available at:

<https://www.facebook.com/groups/118298848647315/>, was also promoted on the Facebook page “Fauna Siciliana” (available at <https://www.facebook.com/groups/faunasiciliana/>).

The latter page deals with the terrestrial and inland water fauna of Sicily, counts more than 16,000 members (16,184 members on 20<sup>th</sup> June, 2017) and is largely visited by naturalists, researchers, and nature-photographers from throughout the region. Each time a relevant post dealing with *P. clarkii* was published on the “Fauna Siciliana” page, the author of the post was invited to join the “*Procambarus clarkii* in Sicilia” page, providing a picture documenting the observation, with the date and the geographical coordinates of the site.

Table 1. Known distribution of *Procambarus clarkii* in Sicily at May 2017, including both published and novel sites. Latitude and Longitude are expressed as geographical coordinates, decimal degrees (Map datum: WGS84). \*: Located within the R.N.I. “Lago Preola e Gorghi Tondi”

River basin	Municipality	Site	Latitude	Longitude	Altitude (m a.s.l.)	Habitat type	Source
Fiume Irminio	Ragusa (RG)	Fiume Irminio	36.996840	14.778049	388	River	Present work
Fiume San Leonardo	Augusta (SR)	Fiume San Leonardo	37.343166	15.088748	3	River	Present work
Torrente Senia	Venetico (ME)	Pantani di Venetico	38.212611	15.364333	6	Quarry pond	Present work
Fiume Simeto	Catania (CT)	Canale Buttaceto	37.437703	15.047918	7	Canal	Present work
Fiume Arena	Mazara del Vallo (TP)	Lago di Murana *	37.626475	12.634279	4	Pond	Present work
Fiume Arena	Mazara del Vallo (TP)	Lago Preola *	37.620374	12.641136	4	Pond	Bellante et al., (2015)
Fiume Arena	Mazara del Vallo (TP)	Gorgo Alto *	37.612475	12.649554	3	Pond	Maccarrone et al. (2016)
Fiume Arena	Mazara del Vallo (TP)	Gorgo Medio *	37.611327	12.651033	3	Pond	Bellante et al. (2015)
Fiume Arena	Mazara del Vallo (TP)	Gorgo Basso *	37.609080	12.655051	2	Pond	D’Angelo & Lo Valvo (2003)
Fiume San Leonardo	Caccamo (PA)	Lago Rosamarina	37.938619	13.635133	170	Reservoir	Di Leo et al. (2014)

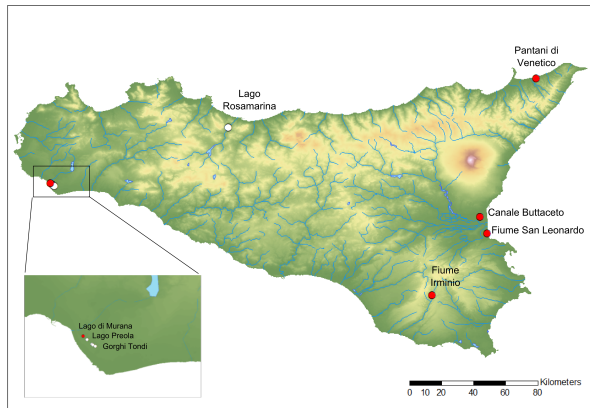


Figure 1. Map of the published (white circles) and novel (red circles) occurrence sites of *Procambarus clarkii* in Sicily.

## RESULTS AND DISCUSSION

As of May 5<sup>th</sup>, 2017, 47 members joined the “*Procambarus clarkii* in Sicilia” page, providing six well-supported reports for five unpublished localities of the species. A collection of the observations made from November 22<sup>nd</sup>, 2016 to May 31<sup>st</sup>, 2017 is summarised in table 1; figure 1 shows a map of both published and novel occurrence localities.

All the novel occurrence localities of the species are on mainland Sicily, while no records of the species are to date available for the circum-Sicilian archipelagos, which is possibly due to the scarcity of permanent water bodies on the smaller islands. The new occurrence localities and the published ones lie several tens to hundreds of km apart from each other (Fig. 1) and belong to different river basins (Tab. 1).

Accordingly, the current distribution of *Procambarus clarkii* in Sicily cannot be ascribed to an autogenous range expansion of the species through active dispersal. The active dispersal hypothesis has been proposed for the African clawed frog *Xenopus laevis* Daudin 1802, another highly invasive alien species occurring in Sicilian inland waters (Faraone et al. 2008). For *P. clarkii*, instead, distribution likely derives from multiple deliberate and independent introduction events, as

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already observed in other regions in southern Italy (Cilenti et al. 2017).

However, the “Buttaceto” and “San Leonardo” sites (Tab. 1), although belonging to two different river basins, are separated by a relatively short distance ( $\approx 11$  km) and the territory between them is characterized by the presence of two rivers (Simeto and Gornalunga) and several natural and artificial wetlands (coastal swamps, artificial ponds, agricultural channels). It will therefore be important to check if there is a connection between these two sites, and if they are in fact just “the tip of the iceberg” of a larger area inhabited by *Procambarus clarkii*.

The evidence of multiple, independent releases in the wild of a renown invasive species highlights the widespread lack of awareness about the risks of biological invasions. It is therefore necessary to better inform the local population on how invasive species threaten the local (and global) biological diversity. This is particularly relevant for those species, as the red swamp crayfish, which might have a significant impact on ecosystem structure and functioning and that are difficult or impossible to eradicate once established. In these cases, the prevention of further introductions in the wild is the only suitable method to limit their distribution. In Sicily, it is urgent to verify the actual spatial distribution of each of the new populations, their density and their connectivity. It is also very important to monitor the impact of *Procambarus clarkii* on the breeding success of autochthonous amphibians, for which data are to date lacking. The possible long-term detrimental impact on the turtle *Emys trinacris* and the freshwater crab *Potamon fluviatile*, mediated by the altered trophic web and the spread of pathogens, need also to be investigated.

The Sicilian *Procambarus* working group (SPwg) will keep on collecting data on *P. clarkii* distribution in Sicily, both through the help of volunteer contributors and carrying on dedicated field activities. Everyone who is interested in cooperating with us is encouraged to join our Facebook page or contact the corresponding authors of this note.

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