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On the occurrence of *Phallocryptus spinosus* (Milne-Edwards, 1840) in Sicily (Crustacea, Branchiopoda)

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SUMMARY

The distribution, status, and phenology of the anostracan *Phallocryptus spinosus* in Sicily are described. The only population of the species to date known to occur with certainty on the island inhabits a few temporary water bodies located within the Natura2000 site “ITA010006 - Paludi di Capo Feto e Margi Spanò”. In these sites, the species co-occurs with an interesting halophilous flora and crustacean fauna. Based on available data, the concentration of dissolved salts in the water bodies seems to be the main driver of the life histories of the co-existing populations of the anostracans *Artemia salina* and *Phallocryptus spinosus*.

INTRODUCTION

The thamnocephalid anostracan genus *Phallocryptus* Birabén, 1951 includes fairy shrimp species inhabiting hypo- to hypersaline water bodies in the arid or semiarid regions of Africa, Eurasia, and the Americas (Rogers 2003, 2006). In the Palaearctic region, three *Phallocryptus* species are currently known to occur: *P. spinosus* (Milne-Edwards, 1840), *P. tserensodnomi* Alonso & Ventura, 2013, and *P. fahimii* Schwentner, Rudov & Rajaei, 2020. In addition, based on molecular data, a very divergent *P. spinosus* clade from Botswana, Algeria and Morocco is likely a further different species pending a formal description (Alonso

and Ventura 2013; Ketmaier et al. 2013; Schwentner et al. 2020).

Phallocryptus spinosus is the only *Phallocryptus* species to date reported for Italy, where it occurs in Sardinia, Apulia, and Sicily (Alfonso & Marrone 2021). However, the available information and conservation status of the populations of the species differ in these regions: *P. spinosus* is still widespread in Sardinia (Marrone et al. 2021, and unpublished data), whereas no recent records for the species are available for Apulia, where the species is perhaps locally extinct (Alfonso 2017), and no precise distribution data are currently available for Sicily, thus hampering the monitoring and

management of the species (Marrone et al. 2009). This note reviews the existing information about the occurrence and distribution of *Phallocryptus spinosus* in Sicily with the aim of providing exact locality data for the species and some information about its phenology on the island.

MATERIALS AND METHODS

An extensive bibliographical review about *Phallocryptus spinosus* in Sicily was carried out based on the dataset of the author, including ‘grey literature’ and “Natura 2000 (N2K)” documents (“standard data forms” and “management plans”), plus an extensive literature search through the databases of Google Scholar (<https://scholar.google.it/>) and SCOPUS (www.scopus.com) using the key-words: “scientific name of the species” and “Sicil*”. The three different binomia and spellings used for the species in recent literature (i.e., “*Branchinella spinosa*”, “*Phallocryptus spinosa*”, and “*Phallocryptus spinosus*”, see discussion in Marrone et al. 2016) were implemented.

Field surveys were carried out in potentially suitable habitats throughout the islands from 2001 to 2022. In each site and on each sampling date, electrical conductivity and water temperature were recorded with a Hanna Instrument HI9835 multiprobe. Crustacean samples were collected by means of three different nets: a 125 µm mesh-sized towing net was used in the open waters; a 200 µm hand net was used for the benthic and littoral zones, and a further 600 µm hand net was specifically used for catching adult anostracans, which may be easily overlooked when using the conventional zooplankton sampling techniques. Collected samples were fixed in situ in 95% ethanol. Anostracans were identified according to Cottarelli and Mura (1983), Alonso (1996), Rogers (2003), Alonso and Ventura (2013) and Schwentner et al. (2020). The co-occurring copepods were identified according to Dussart (1967) and Kiefer (1978), and ostracods

according to Meisch (2000) and Rasouli et al. (2016). Collected crustacean samples are stored in the author’s crustacean collection at the University of Palermo, Italy, and are available for loan on request. Four *Phallocryptus spinosus* specimens collected on 30/11/2018 in TP109 and preserved in 95% ethanol were deposited in the crustacean collection of the Zoology Section “La Specola,” Natural History Museum, University of Florence (Italy) with the collection number “MZUF 672”.

RESULTS AND DISCUSSION

Up to 2006, no evidence of the occurrence of *Phallocryptus spinosus* in Sicily was available (Marrone and Mura 2006). The first reference mentioning the occurrence of the genus *Phallocryptus* in Sicily is based on resting eggs identified as *Phallocryptus* sp., collected in 2005 in “Pantano Grande” and “Pantano Roveto” within the Nature Reserve “Oasi faunistica di Vendicari” (Moscatello and Belmonte 2009). Unfortunately, no active stages of the species were observed by these authors, and the same wetlands were extensively sampled for crustaceans from 2003 to 2006 by the author of the present note, who did not find any anostracan. The actual identity and current viability of this alleged *Phallocryptus* population in south-eastern Sicily must therefore be verified.

Conversely, a stable population of *Phallocryptus spinosus* was regularly observed from February 2007 onwards in two shallow temporary ponds within the N2K site ITA010006 “Paludi di Capo Feto e Margi Spanò”, a coastal wetland covering an area of about 30 hectares and characterized by a diverse halophilous vegetation dominated by saltbushes (Fig. 1; Brullo and Furnari 1976; Barone et al. 2007; Troia and Napolitano 2017). The occurrence of the species was immediately reported to the managing body of the N2K site, stressing the need of paying particular attention to its preservation (Guastella 2009). The WGS84 geographical coordinates of the two ponds where

the species was observed are the following: 37.678119 N, 12.498980 E (site “TP109”), and 37.678516 N, 12.500282 E (site “TP114”).

In these ponds, *Phallocryptus spinosus* coexists syntopically (but not always synchronically, see below) with the anostracan

Artemia salina (Linnaeus, 1758), the copepods *Calanipeda aquaedulcis* Krichagin, 1873 and *Cletocamptus retrogressus* Schmankevitch, 1875, and the ostracods *Arctocypris mareotica* (Fischer, 1855) and *Heterocypris* sp. (Vecchioni et al. 2019; Pieri et al. 2020, and unpublished data).



Figure 1. An overview of the site coded TP109 within the N2K site ITA010006 “Paludi di Capo Feto e Margi Spanò” (30th November 2018).

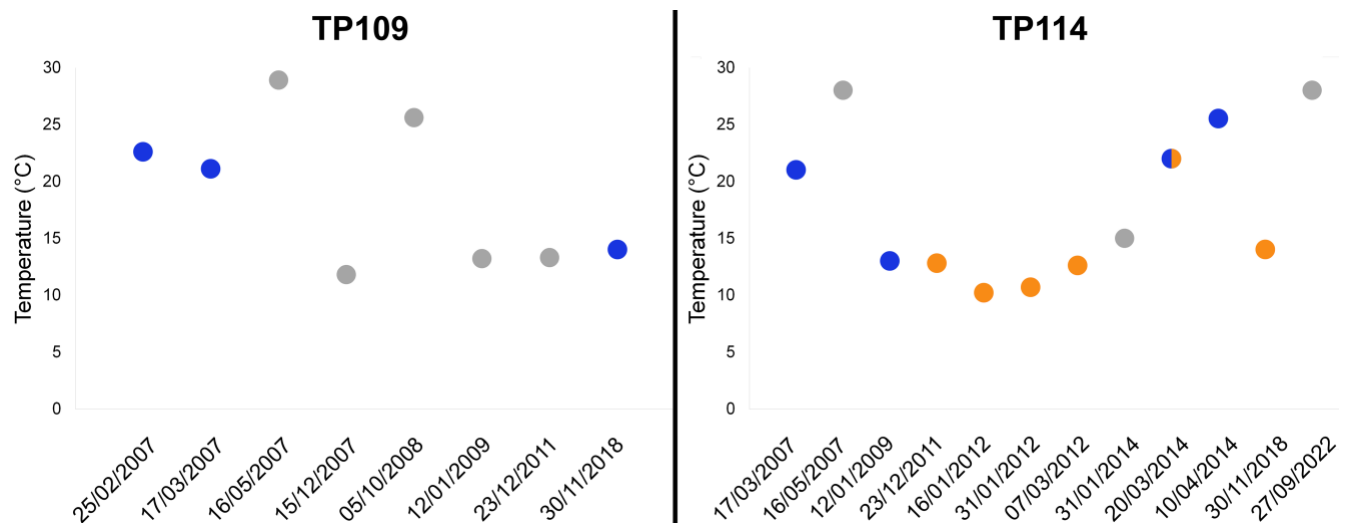


Figure 2. Occurrence of *Phallocryptus spinosus* (blue circles), *Artemia salina* (orange circles), and no anostracans (grey circles) in the sites TP109 and TP114 based on water temperature.

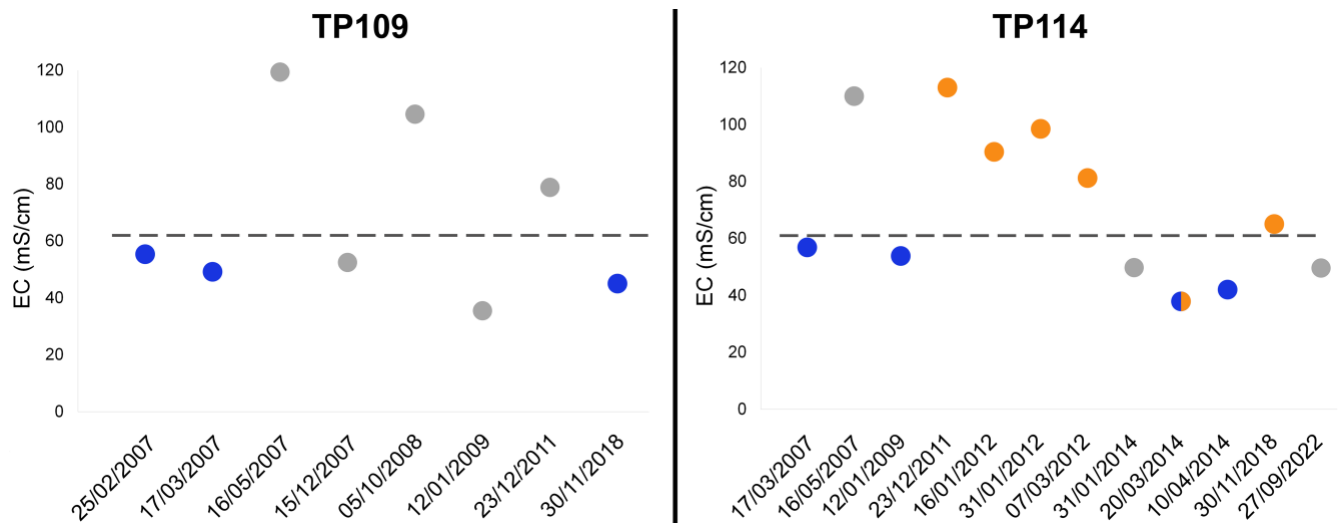


Figure 3. Occurrence of *Phallocryptus spinosus* (blue circles), *Artemia salina* (orange circles), and no anostracans (grey circles) in the sites TP109 and TP114 based on electrical conductivity (EC). The dashed line shows the alleged electrical conductivity threshold observed for the two species in Margi Spanò.

The co-existence of *Phallocryptus spinosus* with other halophilous anostracans such as *Artemia* spp. and *Branchinecta media* (Schmankewitsch, 1873) is recurring throughout the distribution range of the species (e.g., Rogers 2003, and references therein). When co-existing with other anostracans, interspecific competition seems to be limited by a shift in their life histories, and species occurrence is putatively controlled by water temperature, photoperiod, and/or the concentration of dissolved salts (e.g., Mura 1987; Moscatello et al. 2002; Rais and Amarouayache 2018). However, temperature and photoperiod seem to play a secondary role in determining the occurrence of *P. spinosus* and *A. salina* in Margi Spanò, since both anostracan species could be observed during winter and spring months, with water temperatures ranging between 13 and 25.5 °C (*P. spinosus*) and between 10.2 and 22 °C (*A. salina*) (Fig. 2). Despite this large overlap in tolerated photoperiod and temperature ranges, the two species do not usually coexist in Margi Spanò and appear to be separated by electrical conductivity values.

Based on available data, in Margi Spanò *P. spinosus* was observed for electrical conductivity values ranging between 38 and 59

mS/cm, whereas *A. salina* was mostly observed for electrical conductivity values between 65 and 113 mS/cm (Fig. 3). However, on 20th March 2014, adults of *Artemia salina* and *Phallocryptus spinosus* were observed coexisting, albeit at very low densities, in TP114, with an electrical conductivity of 38 mS/cm and a water temperature of 22 °C. Unfortunately, the patchiness of available environmental and occurrence data prevents from drawing sound inferences about the phenology of these anostracan populations, and the realisation of a regular monitoring of the site is desirable to better understand their ecology and phenology.

The occurrence of *Phallocryptus spinosus* in Sicily is not unexpected, since the island falls within its known distribution range and potentially suitable habitats for the species are still widespread along the coasts of the island. Moreover, *P. spinosus* is rather common in northern Tunisia (Marrone et al. 2016), which is located less than 150 km in a straight line from Margio Spanò and the southwestern Sicilian coast, and aquatic birds might act as effective dispersal vectors for the resting eggs of *P. spinosus* during their migration trips from and to northern Africa.

In the light of the uncertain status of the *Phallocryptus spinosus* populations reported for Apulia and south-eastern Sicily, the population of the species occurring in Margio Spanò should be adequately managed to grant its long-term persistence.

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