

New records of *Pachygrapsus maurus* (H. Lucas, 1846) (Crustacea: Decapoda) in Balearic Islands (Western Mediterranean Sea)

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The current distribution of *Pachygrapsus maurus* in the Mediterranean Sea is not well known. This species seems to share niches with other species of the same genus, such as *Pachygrapsus marmoratus* and *Pachygrapsus transversus*. We report the presence of *P. maurus* in Es Vedrà, Es Vedranell and els Illots de Ponent, as first records in Ibiza. Abundance data of *P. marmoratus* and *P. maurus* is provided and carapace width and length (CW × CL) of collected individuals were measured.

Keywords: *Pachygrapsus maurus*; *Pachygrapsus marmoratus*; Zoogeography; Mediterranean Sea; Balearic islands.

NOVA CITA DE *PACHYGRAPSUS MAURUS* (H. LUCAS, 1846) (CRUSTACEA: DECAPODA) A LES ILLES BALEARS (MAR MEDITERRÀNIA OCCIDENTAL). La distribució actual de *Pachygrapsus maurus* a la mar Mediterrània no és ben coneguda. Sembla que aquesta espècie comparteix nínxols amb altres espècies del mateix gènere, com *Pachygrapsus marmoratus* i *Pachygrapsus transversus*. Aquest treball evidencia la presència de *P. maurus* a Es Vedrà, Es Vedranell i els Illots de Ponent, com a primer registre a Eivissa. Es proporcionen dades d'abundància de *P. marmoratus* i *P. maurus* i mesures de l'amplada i la longitud toràcica (CW × CL) dels individus recollits.

Palabras clave: *Pachygrapsus maurus*; *Pachygrapsus marmoratus*; Zoogeografia; Mar Mediterrània; illes Balears

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Introduction

Pachygrapsus Randall, 1840 is a genus of decapod crustaceans revised in 2005 (Poupin *et al.*, 2005) and currently

including 14 species (WoRMS, 2021). In the Mediterranean Sea this genus is represented by three species: *P. marmoratus* (Fabricius, 1787), *P. maurus* (Lucas, 1846) and *P. transversus* (Gibbes, 1850). These

species can be easily distinguished based on morphological features (Zariquiey, 1968). Despite this, the distribution of *P. maurus* and *P. transversus* is currently not sufficiently clear. In the eastern Mediterranean Sea, *P. marmoratus* and *P. transversus* overlap their niches, dominating in habitats formed by boulders (Warburg *et al.*, 2011; Arab *et al.*, 2015). Previous studies indicate that *P. maurus* has a preference for exposed and topographically complex rocky areas (Crocetta *et al.*, 2011). While *P. marmoratus* shows a wide and uniform geographic distribution, *P. maurus* is patchily distributed across the Mediterranean Sea. The distribution of *P. maurus* includes the Macaronesia and the Western Mediterranean, from the Canary Islands to the Italian coast, while in the eastern Mediterranean its presence appears to be sporadic, with some records in Greece and the southern coast of Turkey (Crocetta *et al.*, 2011). *P. maurus* and *P. marmoratus* seem to present a disaggregated distribution in the Mediterranean Sea, with cores in the Algero-Provencal and Levantine basins, and sporadic records elsewhere (Giacobbe *et al.*, 2018). *P. maurus* was cited for the first time on European coasts in 1968, specifically in Cap de Creus (NW Mediterranean Sea) (Zariquiey, 1968). Latest studies expand the range of this species in the north-central Mediterranean Sea, bringing new records in the Messina Strait area and Gulf of Naples, Italy (Giacobbe *et al.*, 2018) and Maltese Islands (Crocetta *et al.*, 2011). The first record of *P. maurus* in the Balearic archipelago (Garcia Socias and Gràcia, 1988) was from Mallorca, but studies on the distribution of *P. maurus* have not been carried out and no quantitative data has been published.

This work presents the first study of *P. maurus* populations in Ibiza Island,

specifically in Es Vedrà, Es Vedranell and els Illots de Ponent, providing new information on the distribution of this species in the Mediterranean Sea.

Materials and methods

Study area and data collection

The Natural Reserves of Es Vedrà, Es Vedranell and els Illots de Ponent are a group of islets located in the western side of Ibiza, included in the Balearic Sea, off the eastern coast of the Iberian Peninsula (Fig. 1). They form two protected maritime-terrestrial natural spaces, covering an area of 232.7 hectares, included in the Natura 2000 Network and, therefore, have the protection status of Places of Community Importance and Special Protection Area for Birds, in addition to the autonomous ANEI (Natural Area of Special Interest). The islets are clustered in two areas, one formed by Es Vedrà, Sa Galera d'Es Vedrà and Es Vedranell; and the other comprises the Illots de Ponent: Sa Conillera, Illa des Bosc, Escull Llarg, S'Espartar, Es Frare, Na Gorra, Es Vaixell, Na Bosc and Na Plana. In addition, in our exploration, two more remote islets not included in the Reserve were added: Escull de Tramuntana and Escull des Cap Vermell.

During June 2019, the islands and islets coastlines were completely surveyed in order to quantify and evaluate the colonies of the vermetid mollusk *Dendropoma lebeche*. In total, 28.44 km of shoreline were prospected. The transects started at approximately 09:00 am and ended at sunset. Transects were carried out by two people with a support vessel, walking along the coast and snorkeling when necessary. GPS points were taken at the beginning and end of each transect. At the beginning of the field survey, the presence of colorful spotted crabs, similar to the common *Pa-*

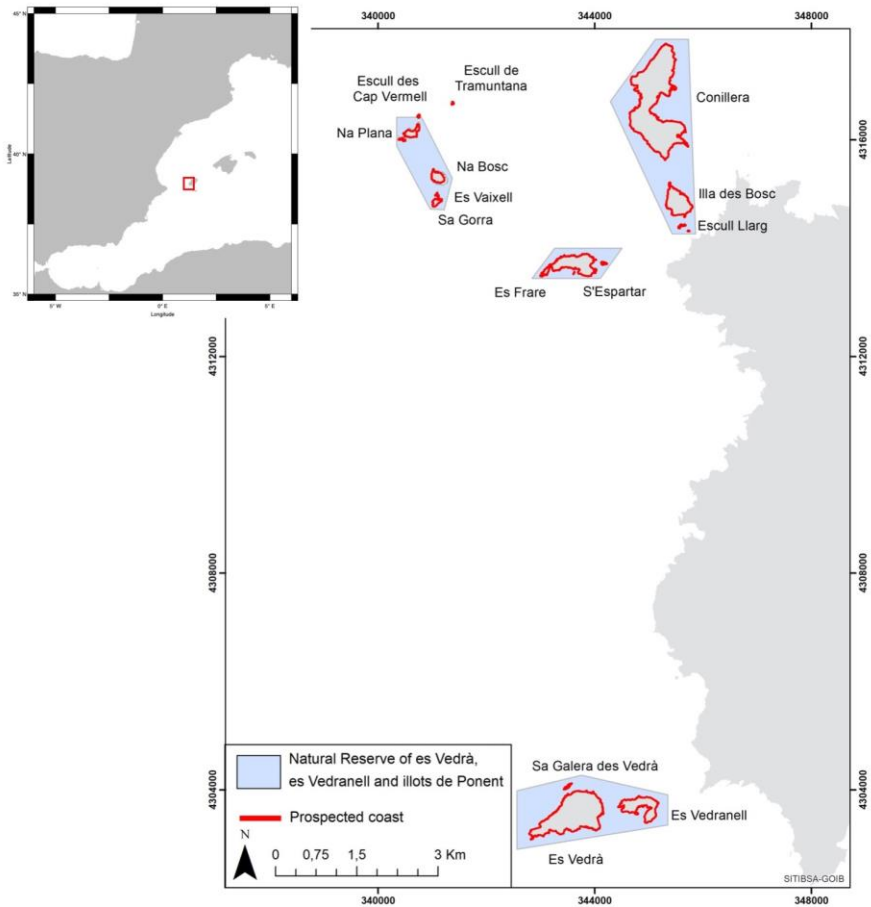


Fig. 1. Natural Reserves of Es Vedrà, Es Vedranell and Illots de Ponent.

Fig. 1. Reserva Natural de es Vedrà, es Vedranell i els illots de Ponent.

chygrapsus marmoratus, caught our attention. As we were not able to identify them *in situ*, we decided to include the count of all the individuals of both *P. marmoratus* and the colorful spotted crabs, later identified as *P. maurus*, that were seen during the fieldwork. Moreover 12 individuals were captured for further identification, having a clear preliminary evidence that they belonged to two different species due to the coloration and external appearance and characteristics. The

collected individuals were preserved in 70% ethanol (Fig. 2A and 2B).

Data analysis

Individuals of both *P. maurus* and/or *P. marmoratus* were geopositioned with GPS. Thus, the number of individuals per islet was mapped. The maps were made with ArcMap 10.4. To contrast the identification of individuals *in situ*, 12 individuals collected were identified to species level and sexed under binocular lens in the labo-

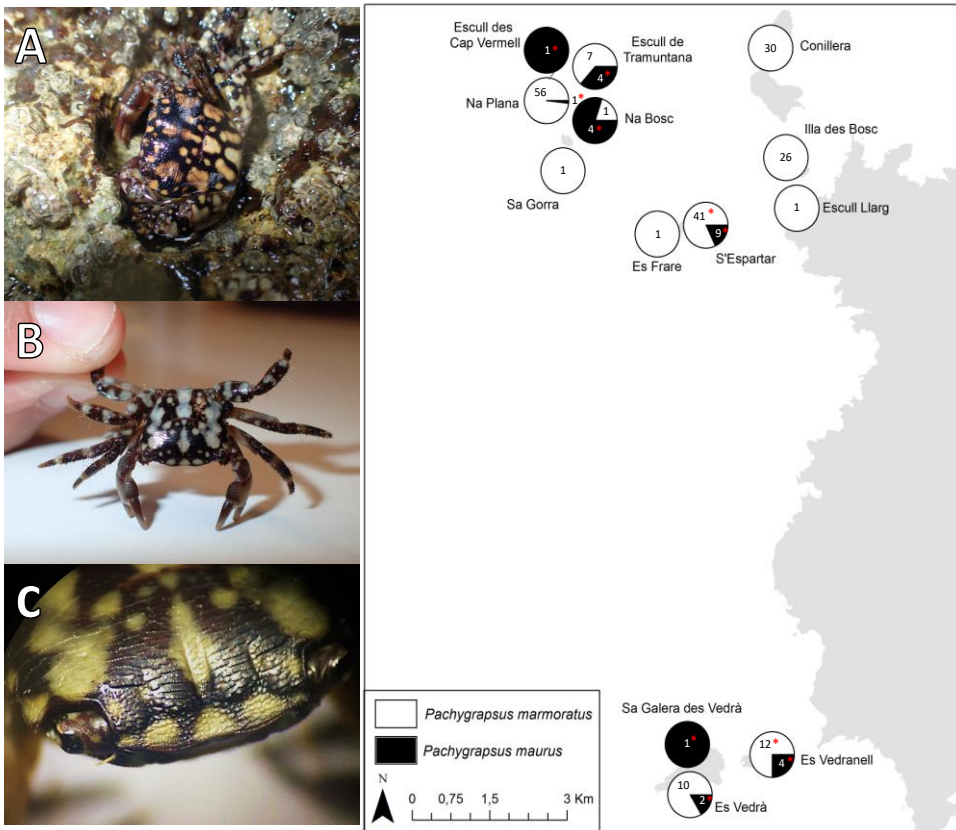


Fig. 2. A: *P. maurus* in situ, highlights the spotted orange color. **B:** one of the *P. maurus* captured individuals. **C:** rostrum of *P. maurus* under binocular lens. **D:** Number of individuals of *P. marmoratus* (white) and *P. maurus* (black) sampled in each islet of the Natural Reserve of es Vedrà, es Vedranell and els illots de Ponent. Red asterisks in portions indicate that at least one individual of that species was captured on that islet.

Fig. 2. A: *P. maurus* in situ, resalten les taques taronges. **B:** un dels individus capturats de *P. maurus*. **C:** rostrum de *P. maurus* sota lent binocular. **D:** Nombre d'individus de *P. marmoratus* (blanc) i *P. maurus* (negre) mostrejat a cada illot de la Reserva Natural d'es Vedrà, es Vedranell i els illots de Ponent. Els asteriscs vermells en proporcions indiquen que almenys un individu d'aquesta espècie va ser capturat en aquell illot.

ratory (Fig. 2C). Carapace width and length (CW × CL) were measured with Vernier calipers.

Results

P. marmoratus is a large size species (ranging from 5.6 x 7.2– 28.2 x 32.4 mm) with subquadrate carapace. Lateral margins with 2 teeth behind the exorbital angle. It

presents a flattened dorsal surface with transverse striae in the gastric, liver and branchial regions; mesogastric, cardiac, intestinal regions smooth or with short striae. The infraorbital margin deeply denticulate medially, deep external notch, oriented obliquely. Distributed along the West Atlantic, Mediterranean and Black seas. *P. maurus* is a medium-size species (CL 10–20 mm) with a lateral margins of carapace with 1 tooth behind exorbital angle. The anterior margin is front distally angular with the infraorbital margin slightly denticulated and a outer notch obliquely oriented. The carapace presents a marbled colour pattern.

A total of 212 individuals of the genus *Pachygrapsus* were counted during the fieldwork. From these, 26 were classified as *P. maurus*, while 186 corresponded to *P. marmoratus*. The highest number of *P. maurus* individuals were counted in S'Espartar (9 ind.), while in Conillera, Illa des Bosc, Escull Llarg, Sa Gorra and Es Frare none were sighted. The number of *P. marmoratus* in the islets was considerably higher than in bigger islands/islets, reaching a maximum of 56 individuals in Na Plana. We highlight that *P. marmoratus* was found in all the islets except Sa Galera des Vedrà and Escull des Cap Vermell, two of the smallest islets in the Reserves (Fig. 2D). *P. maurus* was not detected in the eastern part: Conillera, Illa des Bosc and Escull Llarg, and in Sa Gorra. No specimens of either species were found in Es Vaixell. In 3 islets *P. maurus* was detected in higher abundances than *P. marmoratus*: Escull des Cap Vermell, Na Bosc and Sa Galera des Vedrà (Fig. 2D).

From 12 individuals collected, 10 were identified as *P. maurus* (8 males and 2 females) and 2 as *P. marmoratus* (1 male and 1 female). All *P. maurus* specimens showed 1 tooth behind exorbital angle and

the typical marbled colour pattern, black with yellow-orangish or, more rarely, bluish spots. *P. marmoratus* individuals presented 2 teeth behind exorbital angle and a greenish-brown colour pattern with legs and claws purplish.

Pachygrapsus maurus: Specimen A1 (13.0 × 11.0 mm) female, ovigerous, collected Na Bosc; A2 (15.0 × 14.0 mm) male collected in Na Plana; A3 (14.0 × 15.0 mm) male collected in S'Espartar; A4 (20.0 × 21.0 mm) male collected in Na Bosc; A5 (7.0 × 6.0 mm) male collected in Es Vedrà; A6 (10.0 × 8.0 mm) male collected in Es Vedranell; A7 (10.0 × 10.0 mm) male collected in Es Vedranell; A8 (11.0 × 10.0 mm) male collected in Sa Galera; A9 (13.0 × 10. mm) female, ovigerous collected in Escull de Tramuntana; A10 (9.0 × 9.0 mm) male collected in Escull des Cap Vermell.

Pachygrapsus marmoratus: B1 (14 × 14.5 mm) male collected in S'Espartar; B2 (8.0 × 7.0 mm) female collected in Es Vedranell.

Discussion

The report of *P. maurus* on Balearic Islands highlights the lack of knowledge about the distribution of this species in the Northwest Mediterranean Sea. While the possible expansion of this species has been studied in the northern central Mediterranean (Crocetta *et al.*, 2011; Giacobbe *et al.*, 2018), the presence and distribution of *P. maurus* in the Balearic Sea and Levantine coast has not been the target of intensive studies. There are different hypotheses about the origin of these crabs, raised by different authors. Some assume that *P. maurus*, *P. transversus* and *P. marmoratus* have coexisted in the Mediterranean Sea for centuries, but their correct distribution has not been detailed due to the lack of

extensive field studies and misidentifications/taxonomic impediments, (Crocetta *et al.*, 2011; Lipei *et al.*, 2017). This agrees with the cryptic behavior hypothesis of *P. maurus* and *P. transversus*, and therefore, the few individuals potentially sampled so far could have been assigned by default to juveniles of *P. marmoratus* in previous studies (Crocetta *et al.*, 2011). Other authors suggest that the expansion of *P. maurus* may be favored by anthropogenic factors, since crabs have been seen associated with marine debris that guarantees the possibility of being transported over long distances (Holthius, 1958; Wenner, 1985). A third hypothesis points out that in the past centuries, bridge populations were established between the eastern Atlantic-western Mediterranean and the eastern Mediterranean (Giacobbe *et al.*, 2018). Being a thermophilic species, *P. maurus* expansion in the Mediterranean might be favored by the superficial circulation from the Strait of Gibraltar and allowing its establishment on the Levantine coasts (Çevik *et al.*, 2006).

The ecological plasticity of *P. maurus* may be higher than expected (Giacobbe *et al.*, 2018). While some authors indicate that the *P. maurus* habitat is limited to exposed and topographically complex rocky areas (Crocetta *et al.*, 2011), other records indicate that it thrives in sheltered environments (Shaiek *et al.*, 2017). Our records suggest the preference of *P. maurus* to exposed sites, since the highest abundances found in the present work correspond to exposed coasts with steep rocky coastlines. This should be verified in future studies that focus on the influence of different abiotic parameters on the distribution of the species. At the same time, regarding a possible competition between the congeneric species, *P. marmoratus*, it has always been found to be

dominant when coexisting with *P. maurus* (Flores and Paula, 2001; Hasan *et al.*, 2008). It seems that *P. marmoratus* and *P. maurus* share the same niche, but mature *P. marmoratus* males reach larger sizes allowing them to defend their territory from other individuals (Cannicci *et al.*, 2002). Normally, *P. maurus* mature individuals are smaller than *P. marmoratus* ones, so they are not perceived as competitors (Giacobbe *et al.*, 2018).

We assume that this was not the main objective of the scheduled fieldwork, which may suppose the underestimation of the number of individuals during the transects. Also, misidentification of individuals in the field is unlikely due to the color contrast and sizes of *P. maurus*. In terms of densities, although our data is not accurate enough, our observations suggest that densities of *Pachygrapsus* spp. in Na Plana are higher to the rest of the islets, mainly of *P. marmoratus*. To find out more accurate densities of each studied species in each islet should be the aim of future studies, including which are the main drivers that determine the densities and distributions of the two species. However, previous similar fieldworks that have been carried out covering the coastlines of Valencia (170 km) (Bayle-Sempere *et al.*, 2004, Ramos-Esplá *et al.*, 2008), and Mallorca (32 km), together with other sites in the rest of the Balearic Islands (Vázquez-Luis, 2016) have never detected *P. maurus* before.

This work reports the first record of *Pachygrapsus maurus* in the archipelago of Ibiza and widens the distribution of this species in the Balearic Sea, until now only reported once (García Socías and Gràcia, 1988). The Mediterranean distribution of *P. maurus* is still uncertain given that large areas of the coast have not been systematically explored for this species, and also because its similarity with the other

two species of the same genus that share the same niche. Future extensive field studies in the rest of the Balearic Islands and the Northwestern Mediterranean Sea have to be encouraged to provide a better knowledge on the zoogeography of the genus *Pachygrapsus*.

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