EARLY LIFE STAGES OF COMMON BRACHYURAN SPECIES FOUND IN SHALLOW WATERS OF TENERIFE ISLAND

Aitor Ugena*, Estefanía González-González, Iván Cano

Abstract

Brachyurans plays an important economic and ecological role worldwide, due to their relevance in marine ecosystems, acting as preys, predators, and scavengers. In the Canary Islands, several species are also considered important marine fishing resources. Despite this, little is known about its taxonomical characteristics and their early life ecology. This study utilized artificial larval collectors in the Canary Islands' shallow rocky areas to observe juvenile settlements of main brachyuran species. In total, juvenile stages of six common species of the archipelago, belonging to five different families of the infraorder Brachyura, were collected and described. In addition, representative measures as well as high detailed photography's of these crustaceans were taken to provide useful information for the identification at its early life stages. Furthermore, we provide the first evidence of the reproduction success of the invasive species *Cronius ruber* throughout direct observation of juveniles of this species in the archipelago.

Keywords: identification, juveniles, settlement, taxonomy.

ETAPAS DE VIDA TEMPRANA DE BRAQUIUROS COMUNES EN AGUAS SOMERAS DE LA ISLA DE TENERIFE

Resumen

Los braquiuros desempeñan un importante papel económico y ecológico en todo el mundo, debido a su relevancia en los ecosistemas marinos, actuando como presas, depredadores y carroñeros. En las Islas Canarias, varias especies se consideran también importantes recursos pesqueros. Aun así, poco se conoce sobre sus características taxonómicas y su ecología de vida temprana. Este estudio utilizó colectores artificiales de larvas en las zonas rocosas poco profundas de las Islas Canarias para observar los asentamientos juveniles de las principales especies de braquiuros. En total, se recogieron y describieron estadios juveniles de seis especies comunes del archipiélago, pertenecientes a cinco familias diferentes del infraorden Brachyura. Además, se tomaron medidas representativas, así como fotografías de estos crustáceos, para proporcionar información útil para la identificación en sus primeros estadios de vida. Además, proporcionamos la primera evidencia del éxito reproductivo de la especie invasora *Cronius ruber* a través de la observación directa de juveniles de esta especie en el archipiélago.

Palabras clave: asentamiento, identificación, juveniles, taxonomía.

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INTRODUCTION

Brachyuran crustaceans are an infraorder within the class Malacostraca, with about 6500 species, being the group inside the decapods order with the highest species richness. These crustaceans are known to play an important ecological role by participating in the energetic flow of trophic networks in marine ecosystems (Paul 1981; Heck and Hambrook 1991). Some species are exclusively herbivores, such as is the case of *Maguimithrax spinosissimus* (Spadaro and Butler 2021), other species are mainly scavengers such as some *Pagurus* spp. (Ramsay *et al*. 1997) and some behave as active predators of a wide range of organisms, as is the case of some portunid crabs such as *Scylla paramamosain*, or *Cronius ruber* which is present in the archipelago (Paul 1981; Saqib *et al*. 2023; Alonso 2019). Related to this predatory role, brachyurans could become a serious threat to local biodiversity when they act as an invasive species, especially when they have active predatory behavior and high reproductive potential, as in the case of *C. ruber* (Hollebone and Hay 2008; Griffen and Bryers 2009). On the other hand, these organisms also play an important economic role in aquaculture, fisheries, and shellfish resources, being a large part of the world consumption of decapod crustaceans, which has an annual world intake of 5 million tons valued at US$ 13.1 billion. (Sánchez 2010; Bondad-Reantaso *et al*. 2012).

In the Canary Islands brachyurans such as *Percnon gibbesi* (H. Milne Edwards 1853), *Pachygrapsus marmoratus* (Fabricius 1787) and some Xantidae species like *Lophozozymus incisus* (H. Milne Edwards 1834) or *Xantho poressa* (Olivi 1792) are considered a valuable resource due to their use in professional and recreational fishing. While other species like *Plagusia depresa* (Fabricius 1775) and *Grapsus adscensionis* (Osbeck 1765), are often used as a seafood resource. The use of these species by the local population in the archipelago has led to the overexploitation of some, such as *P. gibbesi* and *X. poressa* (Forner *et al*. 2019). Contrastingly, species such as *C. ruber* (Lamarck 1818), an invasive portunidae crab with high dispersion capabilities, has demonstrated to be a voracious predator which can prey over a great variety of local species posing a serious threat to local marine species of the archipelago (Triay-Portella *et al*. 2022). The first record of this species in the Canary Islands was reported in 2008 in Tenrife (Maggio *et al*. 2021), however the first published paper of *C. ruber* was out in 2018 reporting the presence of this species in the warm waters of the south of the island of Gran Canaria. (Triay-Portella *et al*. 2018).

Despite the ecological and economic importance of these invertebrates in the Canary Islands, little is known about their ecology and taxonomy of the juvenile phase of these species, in contrast with their adult phases (Pérez 1995). Better knowledge of the early life stages of this group of species is essential to shed some

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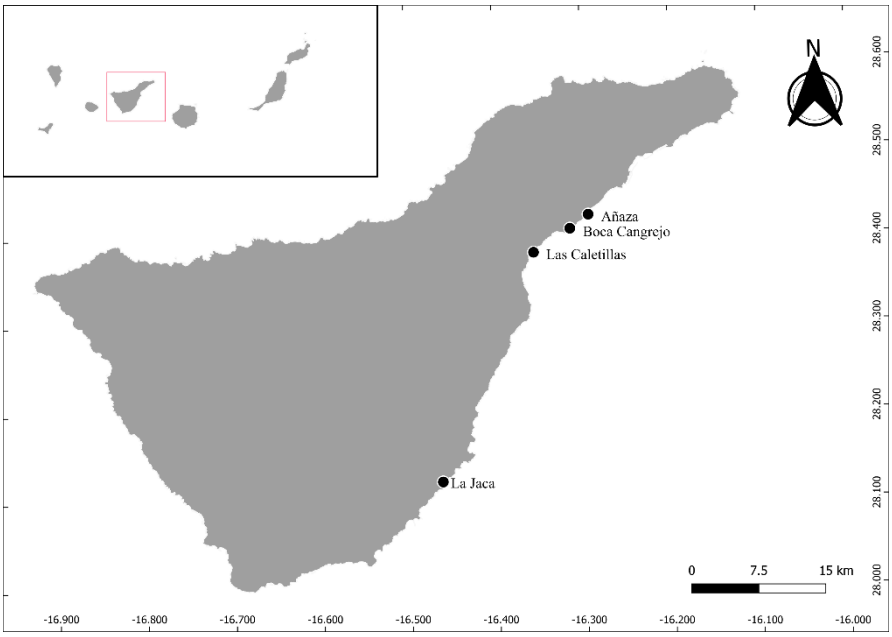

Figure 1. Map of Tenerife Island with the 4 study points.

light on their population dynamics. Therefore, our main objective was to provide taxonomical information of the early life stages of some of the most common brachyurans in the Canary Islands, to facilitate their identification in subsequent studies.

MATERIALS & METHODS

Study area

This study was conducted on the eastern shore of Tenerife Island, four rocky bottom sites were selected to deploy juvenile brachyuran collectors: Añaza (28.4204060 N – 16.2954172 W), Boca Cangrejo (28.4061537 N – 16.27429 W), Las Caletillas (28.3814250 N – 16.3552938 W) and La Jaca (28.12087153 N – 26.46111758 W) (Fig. 1)

Specimens collection and measurement

The brachyuran specimen collection was made throughout the use of larval artificial collectors, a frequent tool used in the study of marine invertebrate's larval settlement (Balsalobre *et al*. 2016). Each artificial collector was made by 30 moulded

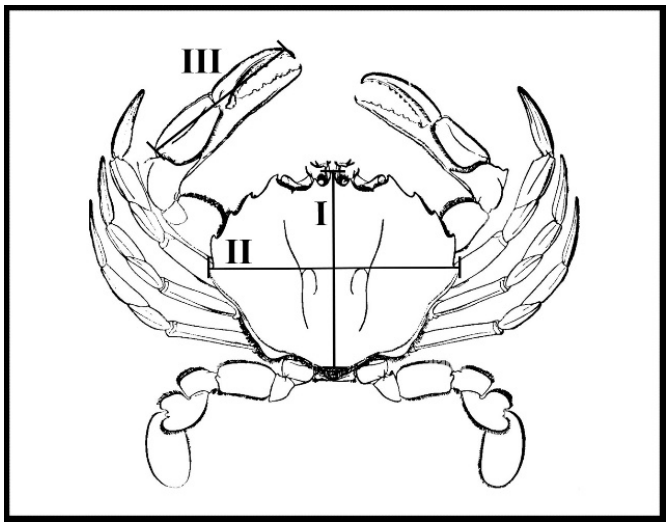

Figure 2. Diagram of the brachyurans body parts measured. (I). Caparace length. (II): Caparace width. (III). Chela length.

3.9 cm in diameter plastic balls originally used as fish-tank filters (biofilters). Each ball had 0.04 m^2 surface area which made it a favourable artificial substrate for certain larval settlement and subsequent metamorphosis, these balls were wrapped in a nylon net to avoid their loss. Samplers were placed at 10 m depth and anchored to the bottom by a 0.5 m long plastic rope. An air-filled plastic bottle was attached to the opposite side with another 0.15 m plastic rope to maintain vertical position and height off the bottom. This design has been previously used by Hernández and collaborators on several occasions (Hernández *et al*. 2006; Hernández *et al*. 2010). We deployed a total of 3 artificial collectors on each of the 4 studied sites, preserving at least 5 meters between each one, making a total of 12 experimental units. Thirty days after deployment, collectors were removed by severing the anchor that held them to the substrate. The samples were stored in plastic bags to avoid the possible loss of invertebrates during their transport to the laboratory.

Once in the laboratory, the collectors were deposited into plastic boxes for subsequent disassembly and washing by using pressurised water. The extracted content was shifted through a sieve with a 100 µm mesh. The resultant sediments were transferred to individual containers and preserved with 70% ethanol.

A stereomicroscope (Leica EZ4) was used for sediment analysis. For this, a small quantity of sediment was inspected on a glass plate using tweezers. All the marine invertebrates found were separated for a later identification. Brachyurans have been identified to species level, a complex task due to the lack of information on their early stages, instead, we have used descriptions of adults from various studies of the most common brachyuran species of the Canary Islands as Maggio (2021), Relini (2000), Reuschel (2007), Pillai (2013) and Pérez (1995), comparing

their morphological similarities and differences. Subsequently, they were photographed, and stored in individual containers with 70% ethanol.

Photographic images were taken for all the brachyuran species founded: *Lophozozymus incisus*, *Xantho poressa*, *Pachygrapsus marmoratus*, *Percnon gibbesi*, *Acanthonyx lunulatus* and *Cronius ruber*. The length and width of 3 to 10 individuals, depending on the availability of the specimens founded, were measured based on the morphology described by Spivak (2016) using the program ImageJ (Rueden *et al*. 2017). The length measurement was taken from the front to the abdominal sternites, whereas the width was measured from sternites located on the first pair of thoracic appendages. Chela dimensions were obtained by measuring from the dactyl apex to the constriction of the first appendage (Siam 2011). (Fig. 2)

RESULTS & DISCUSSION

Systematic of specimens collected

Phylum Arthropoda
Class Malacostraca
Subclass Eumalacostraca
Order Decapoda
Infraorder Brachyura
Family Xanthidae
Lophozozymus incisus (H. Milne Edwards 1834)
Xantho poressa (Olivi 1792)
Family Grapsidae
Pachygrapsus marmoratus (Fabricius 1787)
Family Percnidae
Percnon gibbesi (H. Milne Edwards 1853)
Family Epialtidae
Acanthonyx lunulatus (Risso 1816)
Family Portunidae
Cronius ruber (Lamarck 1818)

Taxonomical description

Family Xanthidae

This is the largest family of brachyuran crustaceans, with 572 species described and diversified into 132 genera, both marine and freshwater (De Grave *et al*. 2009). Their carapace (shell) is wider than its length, oval or sub-rectangular in shape with an arched anterior lateral edge. The frontal region is broad and trans-

verse, with a central incision. The terminal part of the chela is usually black in color (Bakker *et al*. 2022).

Lophozozymus incisus

Habitat and distribution: this species is present in the Mediterranean Sea, Cape Verde Islands, Azores, Canary Islands, the west and south coasts of the British Isles, reaching its limit in the west of Scotland. Usually present on rocky bottoms, where it easily finds shelter, at depths ranging from 0 to 100 m (Coquereau *et al*. 2016).

Early settlers' morphology: the species has a diamond-shaped carapace with incisions, in the middle and upper part of the lateral edge appearance of large spines, these spines are seen from the juvenile stage and as the individual develops, they increase in size. The chelae have small, rounded protuberances all over their surface, the legs and chelae have a similar length (Fig. 3. A).

Average measurements ± SD: width of carapace 3.05 ± 0.72 mm; length of carapace 2.59 ± 0.55 mm; chela length 1.03 ± 0.55 mm (Fig. 4); n = 10 individuals.

Xantho poressa

Habitat and distribution: this species is present throughout the Black Sea and the Mediterranean Sea, as well as in the northeastern Atlantic Ocean, ranging from the Canary Islands to Portugal. It can be found in the intertidal and subtidal, mainly under rocks, and from 0 to 15 m deep (Spivak *et al*. 2010).

Early settlers' morphology: the species has a smooth oval carapace wider than long, with slightly rounded anterolateral edges with pronounced teeth. The chelipeds are very developed with black ends, in the case of the fixed finger, this dark coloration is extended somewhat by the rest of the propodeum (Fig. 3. B).

Average measurements ± SD: width of carapace: 2.93 ± 0.11 mm; length of carapace: 3.62 ± 0.38 mm; chela length: 2.52 ± 0.2 mm (Fig. 4) with n = 3 individuals.

Family Grapsidae

This family of brachyuran crustaceans is distributed in 10 different genera and grouped in the superfamily Grapsoidea. The members of this family are mainly marine and littoral crabs which can appear in lagoons, estuaries and rivers (De Grave *et al*. 2009). They commonly have a quadrangular shell, with a wide frontal area and straight lateral edges (Katsanevakis *et al*. 2007).

Pachygrapsus marmoratus

Habitat and distribution: this species is distributed along the European coasts from the British Isles to the Black Sea, including the Canary Islands. It is a small semi-terrestrial crustacean usually found under intertidal rocks or boulders, especially at high hydrodynamic coasts. It is the most common grapsoideo at inter-

tidal rocky coasts and it can inhabit from 0 m to 2 meters depth (Pérez 1995; Katsanevakis *et al*. 2007).

Early settlers' morphology: this species has a quadrangular carapace with the front part wider than the back one, up to 4 cm wide in its adult phase, the sides are straight, with three claw-like spines on each side of the front part, which is a taxonomic characteristic of the species. Their coloration can be very variable, going throughout greenish, brownish, or slightly purplish, sometimes uniform, but there are also individuals which presents yellowish or greenish marbling. It has hairy legs and strong chelae with black tips, which are slightly unequal and usually larger in males than in females (Fig. 3. C).

Average measurements ± SD: width of carapace: 2.11 ± 0.56 mm; length of carapace: 2.61 ± 0.38 mm; chela length: 1.33 ± 0.44 mm (Fig. 4) with n =10 individuals.

Family Percnidae

Percnidae is a family of marine crabs that are grouped in the superfamily Grapsoidea. Within this family, the genus *Percnon* is the most abundant with 11 species described. The most distinctive morphological characteristic of this genus is the flat, oval shape bodies (Relini *et al*. 2000).

Percnon gibbesi

Habitat and distribution: this species is widely distributed, from Cabo San Lucas (Baja California) to Chile, including the Galapagos Islands in the eastern Pacific, from Fort Macon (North Carolina), Bahamas and Bermuda, to the archipelago of Fernando de Noronha, Brazil, including the West Indies in the western Atlantic, and from the Azores and Madeira to Angola in the eastern Atlantic including the Canary Islands (Nizinski 2003), although it is known for increasing their abundance in the Mediterranean sea since its first sighting in 1999 (Pérez 1995; Katsanevakis *et al*. 2011). It is usually found in the infralittoral of rocky coasts, according to Deudero *et al*. (2005) it can be found from the shallow intertidal to shallow subtidal to 8 m depth, presenting maximum abundances between 0 to 4 m depth, although in the Canary Islands this species can be present at depths up to 20 m.

Early settlers' morphology: this species presents a flat, longer than wider carapace in its adult phase, that shows a slightly oval shape with four teeth on each side in the anterolateral zone. It has a reddish-brown color, with yellow bands on the legs and bluish spots on the carapace. It has short chelipeds in relation to the length of the rest of the legs and spines on the merus (Fig. 3. D).

Average measurements ± SD: width of carapace: 5.95 ± 0.58 mm; length of carapace: 6.67 ± 0.59 mm; chela length: 1.70 ± 0.44 mm (Fig. 4) with n = 10 individuals.

Family Epialtidae

The Epialtidae family are compounded by marine and freshwater crabs. It is the most abundant of the superfamily Majoidea, with 385 of the 960 recognized species (Ng *et al*. 2008). In general, this family presents species with oval bodies, like a drop, with a thinner front part and long legs, although not all the species fulfill these characteristics in this family.

Acanthonyx lunulatus

Habitat and distribution: this species is distributed across Mediterranean and Atlantic waters, from Portugal to Namibia, including the Azores. They are mainly found in seaweed beds, but they are also present in coral substrates. It can be found from 0 to 20 m depth (Guerao and Abelló 1996).

Early settlers' morphology: this species presents a spiny pyriform carapace, longer than wider, in the juvenile stage, the spines are not fully formed, and bulges can be seen in the carapace. It has two characteristic large spines in the front between the two eyes. The chela is spineless, with a molariform tooth at the apex, when the chela is closed, a cleft is formed between the fixed finger and the dactyl. The walking legs have tubercles, with light villi and slight spines (Fig. 3. E).

Average measurements ± SD: width of carapace: 4.28 ± 0.73 mm; length of carapace: 6.39 ± 0.96 mm; chela length: 2.05 ± 0.41 mm (Fig. 4) with n = 10 individuals.

Family Portunidae

Family of marine and brackish crabs, with a carapace wider than its length, reaching its maximum length in the last pair of antero-lateral teeth. This family are composed by almost 230 species, commonly known as swimming crabs. They live in a great variety of substrates, from 0 to 200 meters in depth and are mainly strict predators (Maggio *et al*. 2021).

Cronius ruber

Habitat and distribution: this species has a worldwide distribution from North Carolina to Florida, Gulf of Mexico, Central America, the West Indies, northern South America from the Guianas to Brazil, eastern Atlantic coasts from Senegal to Angola, Cape Verde, Madeira and Canary Islands, eastern Pacific coast from California to Peru and the Galapagos Islands (Fransozo *et al*. 2002; Maggio *et al*. 2021). It can inhabit from shallow rocky sublittoral zones with different macroalgae communities until 20 meters in depth (Maggio *et al*. 2021).

Early settlers' morphology: this species presents a smooth hexagonal carapace with spines on the lateral edges as well as a ridge along the carapace, it has four spines in the frontal zone without including the orbital ones, the first two are more pointed. The chelae are strong and long with spines on the outside of the che-

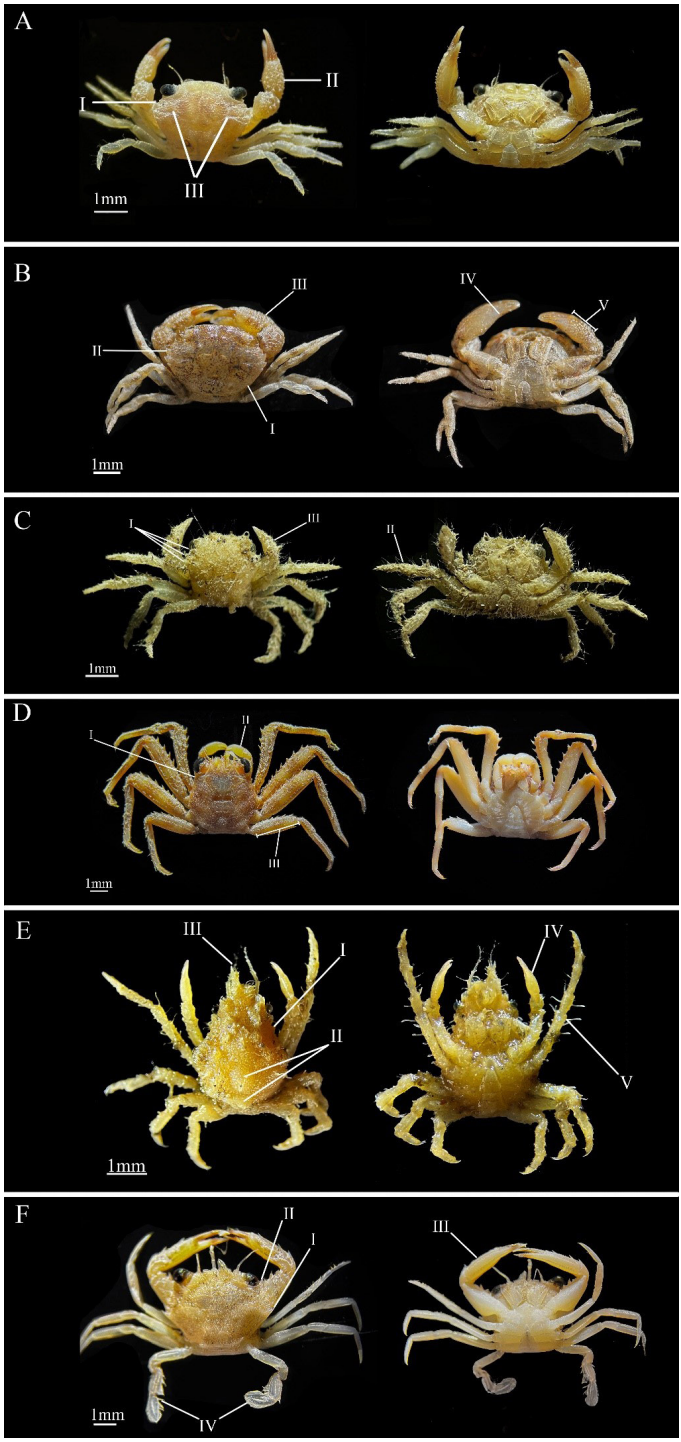

Figure 3. Dorsal and ventral view of juveniles. Scale bars = 1 mm.

A. *Lophozozymus incisus*. (I). Lateral spines; (II). Chelae protuberance; (III). Caparace incisions.

B. *Xantho poressa*. (I). Anterolateral border; (II). Pronounced teeth; (III). Chelae; (IV). Fixed finger; (V). Propodeum.

C. *Pachygrapsus marmoratus*. (I). Three claw-like spines; (II). Hairy legs; (III). Chelae.

D. *Percnon gibbesi*. (I). Anterolateral teeth; (II). Chelae; (III). Merus.

E. *Acanthonyx lunulatus*. (I). Semi-formed spines; (II). Bulges; (III). Frontal large spine; (IV). Chelae; (V). Leg.

F. *Cronius ruber*. (I). Lateral spines; (II). Orbital spine; (III). Chelae; (IV). Last pair of legs.

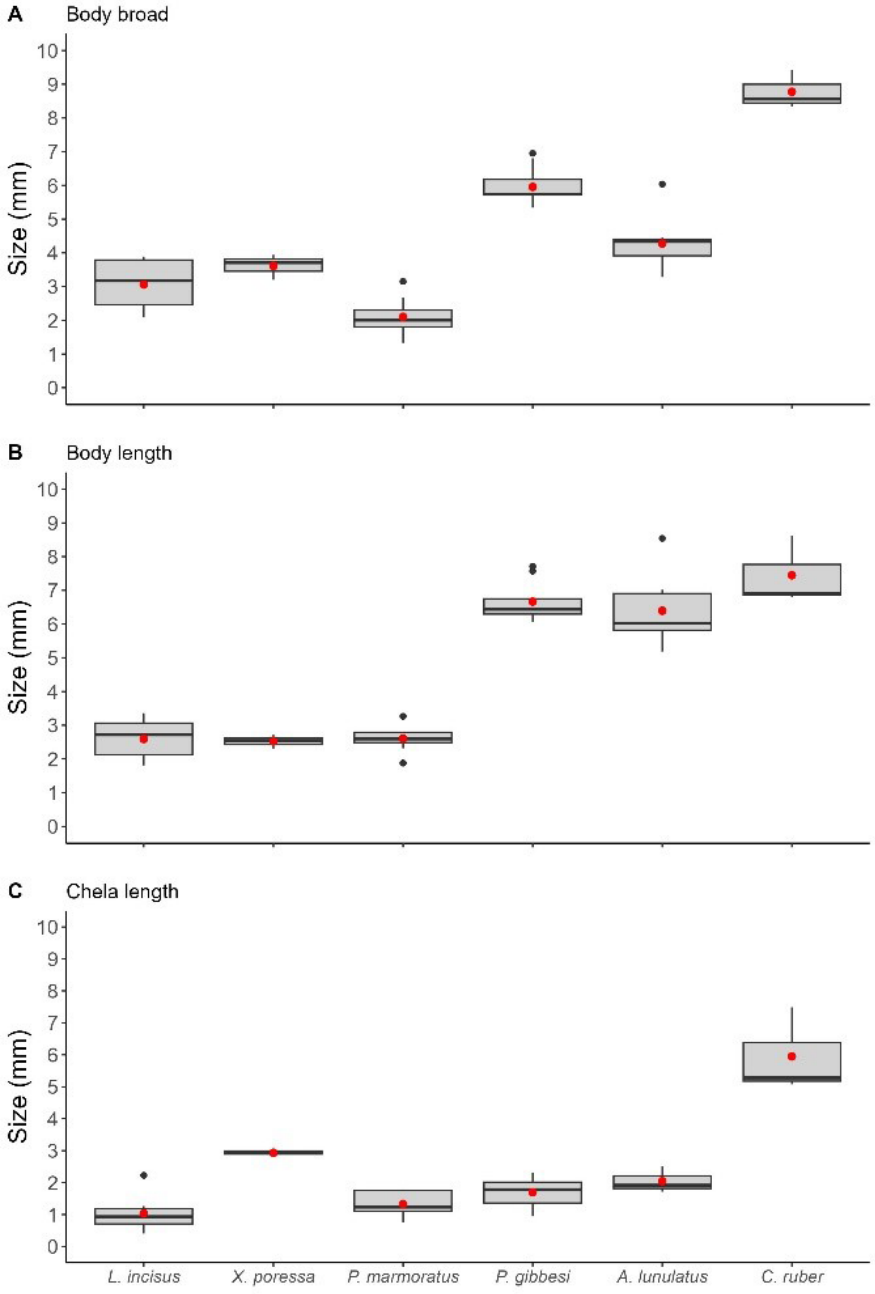

Figure 4. Boxplot representing the size in mm of (A) body broad, (B) body length and (C) chela length, of the decapods found in our study area. Red points represent the mean size of each body part.

lae. The legs have a similar length to the chelae and the terminal shape of the last pair of legs that are shaped like a shovel, which give them the common name of "paddler crabs" (Fig. 3. F).

Average measurements ± SD: width of carapace: 8.78 ± 0.58 mm; Length of carapace: 7.45 ± 1.02 mm; Chela length: 5.95 ± 1.34 mm (Fig. 4) with n = 4 individuals. The results show that *C. ruber* in its juvenile phase is the species that we have analyzed with the biggest size in all body measurements taken compared to juveniles of the other crab species; therefore, knowing that it is an invasive species, this may be a relevant factor in their survival, adaptation and competitive capacity to our waters.

There is very little information available of the early life stages of these brachyuran species in the Canaries. Another biological and ecological aspects such as taxonomic characteristics, distribution, larval survival and settlement, and the environmental factors that affects early life stages of these species are also unknown in the archipelago. Given the economic and ecological importance of these species, more studies assessing their early life ecology and population structure are needed in order to have a better understanding and to promote appropriate management actions of these marine resources. This paper is a useful tool for the identification of these important early stage brachyuran species and can be helpful for future studies. Moreover, this is the first study that confirms the presence of *Cronius ruber* early juvenile settlement in the Canaries, thus, verifying the reproductive success and the total adaptation of this non-native species to our archipelago.

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Authors contributions

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Methodology, Data curation: A.U., E.G.G., I.C.
Investigation: A.U., E.G.G.
Visualization: A.U.
Writing-Review and Editing: E.G.G., I.C.
Conceptualization, Supervision: I.C.

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