

# Latitudinal patterns in the life-history traits of three isolated Atlantic populations of the deep-water shrimp *Plesionika edwardsii* (Decapoda, Pandalidae)



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## ABSTRACT

Patterns in the life-history traits of the pandalid shrimp *Plesionika edwardsii* are studied for the first time in three isolated Atlantic populations (Madeira, Canaries and Cape Verde Islands) to gain an understanding of their latitudinal variations. The maximum carapace size of the populations studied, as well as the maximum weight, showed clear latitudinal patterns. The patterns observed may be a consequence of the temperature experienced by shrimps during development, 1.37 °C higher in the Canaries and 5.96 °C higher in the Cape Verde Islands than in Madeira. These temperature differences among populations may have induced phenotypic plasticity because the observed final body size decreased as the temperature increased. A latitudinal north-south pattern was also observed in the maximum size of ovigerous females, with larger sizes found in the Madeira area and lower sizes observed in the Cape Verde Islands. A similar pattern was observed in the brood size and maximum egg size. Females of *P. edwardsii* produced smaller eggs in the Cape Verde Islands than did those at the higher latitude in Madeira. *P. edwardsii* was larger at sexual maturity in Madeira than in the Cape Verde Islands. The relative size at sexual maturity is not affected by latitude or environmental factors and is the same in the three areas studied, varying slightly between 0.568 and 0.585. *P. edwardsii* had a long reproductive season with ovigerous females observed all year round, although latitudinal variations were observed. Seasonally, there were more ovigerous females in spring and summer in Madeira and from winter to summer in the Cape Verde Islands. *P. edwardsii* showed a latitudinal pattern in size, with asymptotic size and growth rate showing a latitudinal compensation gradient as a result of an increased growth performance in the Madeira population compared to that of the Cape Verde Islands.

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## 1. Introduction

A species can adjust its life-history traits to environmental conditions through plasticity or genetic variations, thereby giving the species the ability to have a wide geographical distribution (Cardoso and Defeo, 2004; Marshall et al., 2008). In this regard, the fitness of a species plays an important role in its distribution and abundance; the reproductive and growth components of fitness are two of the most important processes because they require the greatest energy inputs in the life cycle of an organism (Sastry, 1983; Sexton et al., 2009). Among the reproductive components,

egg production is an important evolutionary and ecological trait that reflects the maternal energy investment and influences the offspring and maternal fitness (Briones-Fourzán et al., 2010). Other aspects, such as moult cycles, synchronization between reproduction and moulting, and size-related growth rate, are the main biological processes regulating growth in crustaceans. These biological processes are linked to external abiotic factors, such as temperature, hours of daylight, and food availability, which can stimulate or inhibit growth processes (Company and Sardà, 2000). All of these aspects are important because the accumulation of small fitness differences throughout the life cycle results in important differences in overall fitness, which affects the ability of distribution and abundance of the species (Sexton et al., 2009).

In species occurring along broad latitudinal gradients, such as the deep-water shrimp species of the genus *Plesionika* Bate, 1888,

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local phenotypic plasticity or genetic variations in environmental conditions may be observed as differences in growth and reproductive features among populations (Wehrmann and Lardies, 1999; Marshall et al., 2008; Briones-Fourzán et al., 2010). Species of the genus *Plesionika* play an important ecological role in benthic ecosystems, and the life-history traits of species living in these habitats, such as *Plesionika edwardsii* (Brandt, 1851), may need to adapt to deep environmental features (Carbonell and Abelló, 1998; Vafidis et al., 2005).

*P. edwardsii* inhabits the eastern Atlantic, from the southwest of Spain to Angola, including Madeira, Canary and Cape Verde Islands (González et al., 2001). These three archipelagos are located in the Canary Current System, which is one of the Large Marine Ecosystems of the World and Linked Watersheds (LMEs) across global oceans (Sherman and Hempel, 2009). They are characterized by their singular bathymetry, hydrography and productivity, as well as their ability to support marine populations that have adapted their feeding, reproductive and growth strategies (Hernández-León et al., 2007). The region of Madeira is dominated by the Canary Current system, which induces a southward net transport (Caldeira and Sangrà, 2012). The presence of a seamount at the southeast end of Madeira produces a localized island upwelling of cold nutrient-rich waters around the coasts (Caldeira et al., 2002). The Canary Islands are characterized by the presence of the first 500 m of depth of Eastern North Atlantic Central Water (Hernández-Guerra et al., 2002). Meanwhile, the sea waters off the Cape Verde Islands are under the influence of the North Equatorial Counter-Current and the Canary Current. The seasonal circulation patterns of this Counter-Current mainly show their influence in the south-eastern part of the archipelago (Marques et al., 2009).

In this work, latitudinal variations in the life-history traits of *P. edwardsii*, including depth distributions and demography, are analysed as indicators of biogeographic trends along a latitudinal gradient in the three island regions. This comparison can reveal how this species responds to geographic environmental variations with regard to their life-history traits, providing more information for a better understanding of the relationship between variation in fitness and environment and between fitness and abundance (Sexton et al., 2009). A thorough understanding of their ecology, mainly the reproductive, growth and brood size strategies, and their latitudinal differences would be of great interest considering that deep-water species are especially vulnerable to exploitation (Polidoro et al., 2008).

## 2. Materials and methods

### 2.1. Sampling and data collection

Shrimp caught around the Madeira (MA), Canary (CIS) and Cape Verde (CVS) archipelagos (Fig. 1) during 22 research cruises conducted between 2006 and 2012 were studied. Shrimp were captured with multiple semi-floating shrimp traps deployed at approximately 2.5 m above the sea floor, with a 56 × 57 cm base length and a 57 cm height, covered with a 15 × 20-mm plastic mesh. Each trap had one troncoconical opening that had an inner diameter of 19 cm. The fishing gear consisted of 75 traps on a fishing rope separated from each other by 15 m. Atlantic chub mackerel (*Scomber colias*) was used as bait, and immersion times ranged from 20 to 24 h. For each cruise, salinity and temperature data were obtained along the water column using a CTD sensor.

The study areas were randomly sampled from a depth of 50–500 m. The sampled locations varied from trip to trip, and the sampling effort across the bathymetric range was equally distributed at 50 m intervals, with eight strata prospected: 100–149, 150–199, 200–249, 250–299, 300–349, 350–399, 400–449, and

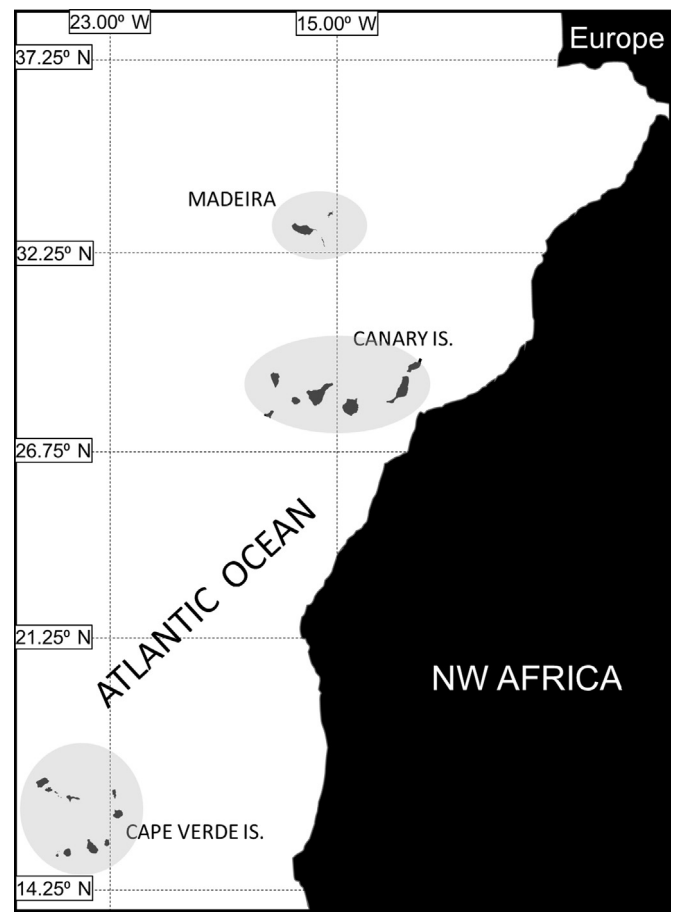


Fig. 1. Geographical location of the study areas of Madeira, Canaries, and Cape Verde Islands..

450–500 m. During each cruise, an average of 225 traps for each depth stratum were deployed over the sea ground, covering sandy, muddy, and rocky bottoms, with a total of 1800 traps used. The standardized mean biomass (in weight per trap) of each stratum was analysed and tested for differences among the strata using ANOVA. Additionally, the standardized mean biomass (in weight per trap) of the strata of highest abundance were compared for differences among archipelagos using ANOVA.

Five traits from each shrimp were measured: carapace length, weight, maturity stage, egg number, and egg volume. Further, five traits of each population were estimated, namely, length at maturity, fecundity, reproductive output, growth rate and maximum length.

Carapace length (CL, from the posterior edge of the eye socket to the mid-dorsal rear edge of the carapace) was measured with a digital calliper to the nearest 0.01 mm, and the total weight (TW) was measured to the nearest 0.01 g. Shrimp were sexed under a binocular microscope based on the presence or absence of the appendix masculina on the endopod of the second pleopod, together with the examination of the shape of the endopod of the first pleopod (King and Moffitt, 1984). The ovigerous condition of females was also recorded based on the presence of external or remaining eggs on the pleopods (King and Moffitt, 1984).

### 2.2. Relationships between main variables and sex ratio

The CL–TW relationship was estimated for males and females using a power equation. The equality of the two CL–TW regressions estimated by sexes was assessed using an *F*-test (Sachs, 1982). Differences between the expected value from the isometric

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