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A geometric morphometric analysis of two sympatric species of the family Aeglidae (Crustacea, Decapoda, Anomura) from the La Plata basin

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ABSTRACT

The crustaceans of the family *Aeglidae* are endemic to the southern regions of South America. Geometric morphometrics was used to assess differences in size and shape between two sympatric species of the family, *A. uruguayana* and *A. platensis.* Eleven landmarks on the dorsal region of the cephalothorax were recorded on 57 adult specimens. Interspecific and intraspecific differences in size and shape were analyzed through univariate and multivariate statistics performed on the generalized procrustes analysis aligned coordinates. Shape differences between *A. uruguayana* and *A. platensis,* and between males and females, were readily identifiable along the first and the second relative warp. MANOVA showed these differences to be significant. Intraspecific comparisons also revealed a significant sexual dimorphism in cephalothorax shape. Two-way ANOVA on centroid size did not show any significant difference between species nor between sexual.

KEY WORDS: *Aegla* - Crustaceans - Geometric morphometrics - Sexual dimorphism.

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INTRODUCTION

The crustaceans of the *Aeglidae* family Dana, 1952 are endemic to the Austral zone of South America. It is a freshwater group, and the only anomurans living in inland waters (Schmitt, 1942). *Aegla* sp. occurs in many different habitats such as lakes, streams, swamps, caves, rivers and lagoons (Hobbs, 1979, Bond-Buckup & Buckup, 1994). Their distribution is from 20°60' S 47°40' W (Municipio de Franca, San Pablo, Brasil) to 50°01'10" S 75°18'45" W (Isla Madre de Dios, Chile) (Bond-Buckup & Buckup, 1994).

Previous researchers investigated the morphology and biometry of this group, and found minor interspecific and major intraspecific variation (Moreira, 1901; Ortmann, 1902; Schmitt, 1942; Vaz-Ferreira *et al.*, 1945; Ringuelet, 1948a, b, 1949a, b, c, 1960, 1961; Williamson & Fontes, 1955; Lopretto 1978a, 1979, 1981; Jara & Lopez, 1981; Martin, 1984; Jara, 1986; Martin & Abele, 1988; Schuldt *et al.*, 1988). Morphometric characters commonly used in taxonomic studies on Aeglidae included: total cephalothorax length, width and curvature of the extraorbital sine, orbiter spine length, prominent rostrum, sharp careening and presence of spines on epimerous II (Schmitt, 1942; Ringuelet, 1949a; Bond--Buckup & Buckup 1994). However, there are several problems in the use of these characters for species determination (Ortmann, 1902; Vaz-Ferreira *et al.*, 1945; Schuldt *et al.*, 1988), as the morphology is highly conservative within the genus (Ringuelet, 1949b).

Aegla uruguayana Schmitt, 1942 and *A. Platensis* Schmitt, 1942, are sympatric and morphologically similar species occurring at La Plata basin (Morrone, 1996). Differences are evident only at the chelae, and third and fourth thoracic sternite (Schmitt, 1942; Ringuelet, 1949a).

Here we explore the potentialities of the geometric morphometrics to describe interspecific differences and sexual dimorphism between *A. uruguayana* and *A. platensis.*

MATERIALS AND METHODS

Only adult specimens were used, i.e., with a cephalothorax larger than 9 mm (Bueno & Bond-Buckup, 2000). The sample includes 30 specimens of *A. uruguayana* (males n = 15 and females n = 15), and 27 specimens of *A. platensis* (males n = 14 and females n = 13). The specimens of *A. uruguayana* are housed at the Museo de Ciencias Naturales "Florentino Ameghino", collection numbers MFA-ZI - N°. 10 and MFA-ZI - N°. 90 from Setúbal lagoon, Santa Fe province; at the Crustacean Collection of the Instituto Nacional de Limnología (INALI-CONICET--UNL), coll. no. A1 and A3 from Las Pencas stream, Entre Ríos province; coll. n. A2 from Urquiza stream, Entre Ríos province, coll. no. A4 from Sauce Grande stream, Aldea María Luisa, Entre Ríos province. The specimens of *A. platensis* are housed in the Instituto Miguel Lillo, coll. no. 00114 from the Maraga River, Dpto. Chilligasta, Tucumán province, Argentina.

Digital images of the dorsal region were taken with a Kodak EZ 200 digital camera. On each image the x y coordinates of the following eleven landmarks were digitized on the cephalothorax using the program TpsDig (Rolhf, 2001a): anterior extreme of the rostrum (L1), orbital spine (L2 and L11), anterolateral spine (L3 and L10), first hepatic lobe (L4 and L9), precervical wide (L5 and L8), and cephalothorax posterior region (L6 and L7) (Fig. 1). Following Bookstein (1997), these eleven landmarks are of types II and I.

The configurations of landmarks were translated, standardized to the centroid size, and aligned through the Generalized Procrustes Analysis (GPA, Rohlf & Slice, 1990) using the program TpsRelw (Rohlf, 2001b). The same program was used to perform a relative warp analysis, i.e., principal components of weight matrix (Rolhf, 1993).

Two-way MANOVA was run on the aligned coordinates to test for species and sex differences. Discriminant analyses were performed on GPA residuals to test for species and sex differences. Finally, ANOVA was run to test for differences in centroid size between species and sexes. All statistical analyses were performed using SPSS.

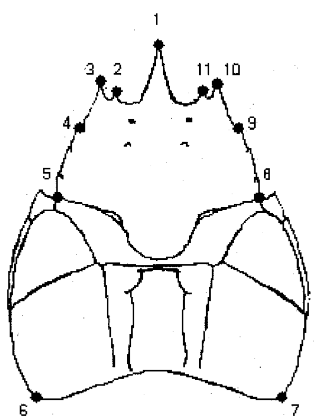

Fig. 1 - Location of the landmarks collected on the cephalothorax.

RESULTS

The ANOVA on centroid size did not reveal any significant differences in size between sexes or species.

Figure 2 shows the scatterplot of the first two relative warps (62.97% of total variation) and related deformation grids. The first relative warp clearly separates the two species. Deformation grids show that main changes in shape are related to the rostral region (L1, L2, L3, L10, L11), which is longer in *A. uruguayana* than in *A. platensis* (Fig. 2). Additionally, the anterior region of the cephalothorax (L2, L11, L3, L10 - the forehead - and L4, L9) is wider in *A. uruguayana* than in *A. platensis* (Fig. 2). Cephalothorax differences shown by the second relative warp are related to the median region (L5, L8 region), which is wider in *A. platensis* than in *A. uruguayana.*

Males and females of the two species show a distinct distribution along the second relative warp. Females of both crab species show a wider posterior region width; furthermore, the anterior and middle regions (L1, L2, L11, L3, L10, L4, L9, L5, L8) are slightly wider in males than in females (Fig. 2).

The two-way MANOVA showed that these differences between species and between sexes are significant, but the species and sex interaction is not significant (Table I). More specifically, MANOVA revealed a significant sexual dimorphism in *A. platensis* (Wilks' λ = 0.159; P = 0.044), but not in *A. uruguayana* (Wilks' λ = 0.252; P = 0.096). Finally, discriminant analyses between species, run separately for each sex, reinforced evidence of species distinction (Table II).

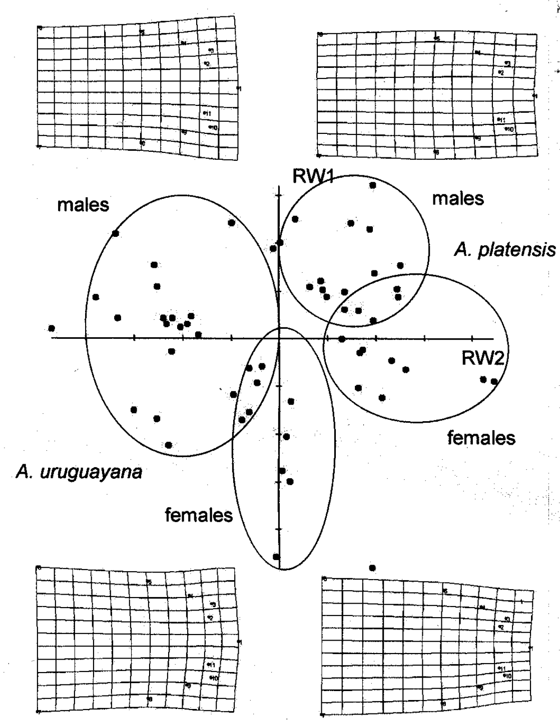

Fig. 2 - Scatter plot of the first and second relative warp scores of *A. uruguayana* and *A. platensis*, showing the interspecific and intraspecific shape differences. The grids show shape changes in males and females of the two species.

DISCUSSION

The landmarks chosen included characters used in previous studies and known for their great taxonomic and phylogenetic value (Schmitt, 1942; Ringuelet, 1949a; Bond-Buckup & Buckup, 1994), together with new ones.

Geometric morphometrics revealed significant interspecific differences in the shape of the anterior region of the cephalothorax (rostrum, orbital and anterolateral spines). These results confirm previous observations by Schmitt (1942) and Ringuelet (1949a) who showed that *A. uruguayana* has a wider forehead (orbital and extra-orbital sine) than *A. platensis*, as well as a longer (prominent) rostrum, but these Authors did not quantify the differences.

TABLE I - *Two-way MANOVA on GPA residuals for species, sex, and for species and sex interaction.*

Effect	Wilks' λ	df1	df2	P
Species	0.0870	18	36	0.0001
Sex	0.4050	18	36	0.0030
Species * sex	0.6430	18	36	0.3810

TABLE II - *Discriminant analysis between* A. uruguayana *and* A. platensis, *separately for females and males.*

Effect	Wilks' λ	df	P
Females	0.074	16	0.0001
Males	0.062	18	0.0001

According to Ringuelet (1948b), shape differences have no relationship with ecological conditions, although in later works (Ringuelet, 1949a) he suggested that the tendency to reduce the ornamentation, length of the rostrum and width of the forehead would represent an adaptation to life among rocks or sand stratum of river and streams. However, as these sympatric species live in similar habitats, we suggest that shape differences could be likely related to an evolutionary response following population fragmentation, facilitated by possible species plasticity (Schmitt, 1942).

Bond-Buckup & Buckup (1994) analyzed sexual dimorphism in *A. uruguayana* and *A. platensis* through traditional measurements and found that only the precervical/forehead lengths ratio was significantly dimorphic. However, they did not consider the posterior region of cephalothorax, which shows consistent differences (Fig. 2, Table I) that likely are functionally adaptive. This family exhibits direct development (i.e., larval stage is absent), and eggs and juveniles are carried by the female in the abdomen (Buckup *et al.*, 1996; Bueno & Bond-Buckup, 1996). López (1965) and Lopretto (1978b) found that in Aeglidae the abdomen is wider in females than in males, and dimorphism in the abdomen morphology is reported for many species of Decapoda (Magalhães & Türkay, 1996). Thus, differences in the width of the posterior region of the cephalothorax in *A. uruguayana* and *A. platensis* are related to sexual dimorphism in the abdomen.

The present geometric morphometrics analysis showed hitherto unrecorded differences and proved to be a precise tool for shape analysis in this family of anomurans.

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