Geographical distribution of *Aegla schmitti* Hobbs III, 1979 (Decapoda Anomura Aeglidae) and morphometric variations in male populations from Paraná State, Brazil

André Trevisan and Setuko Masunari

(AT, SM) Departamento de Zoologia, Instituto de Ciências Biológicas, Universidade Federal do Paraná. Centro Politécnico, Jardim das Américas, Caixa Postal 19020, 81531-980, Curitiba, Paraná, Brasil.

(AT) E-mail: andretrevisan@ufpr.br.

**Abstract**

Geographical distribution of the freshwater anomuran *Aegla schmitti* and the morphometric variation among populations from different streams of Paraná State that are separated by Serra do Mar mountains were studied. The study was based on specimens deposited at Museum of Natural History of Capão da Imbuia (MHNCI) and on the literature. For morphometric analyses, the following dimensions were obtained from adult male specimens: cephalothorax length, rostrum length, rostrum base width, frontal width, cephalic area length, pre-cervical width, carapace maximum width, longest chelar propodus length, widest chelar propodus width, telson length and its maximum width. Principal Components Analysis (PCA) and Discriminant Function Analysis (DFA) were used to discriminate morphometric differences among populations. Fourteen new records were obtained for *A. schmitti* in Paraná State, and its occurrence limits were extended to the municipality of Matinhos (to East), but remained to Ponta Grossa (to West), to Iporanga (to North) and Canoinhas (to South). PCA analysis formed four main groups, two of them including specimens from Matinhos River and Guaricana Hydroelectric Dam (rivers east of Serra do Mar mountains), a central one composed of populations from Mato Grande, Piraquara and Iraí River B (downstream) (rivers west of Serra do Mar mountains) and the last one formed by animals from Iraí River A (upland stream) (rivers west of Serra do Mar mountains). The results suggest that reproductive isolation of the populations, which are submitted to diverse abiotic variables, can be provoking morphometric alterations at least in males of *A. schmitti*.

Key words: Aeglidae, intraspecific variations, Paraná State, Brazil.

**Introduction**

The unique freshwater anomuran genus *Aegla* Leach, 1820 has over 60 species whose distribution is limited to the Neotropical Region of South America, from south of Minas Gerais State in Brazil to southern Chile (Bond-Buckup et al., 2008; Santos et al., 2009). Taxonomic studies of these crabs have been initiated approximately sixty years ago with Schmitt (1942) who described fifteen new species and their geographical distribution. Later, Argentinean species have been recorded (Ringuelet, 1949; Lopretto, 1978a, 1978b, 1979, 1980a, 1980b) and six new species were described from Rio Grande do Sul State from Brazilian waters (Buckup and Rossi, 1979). These authors described the geographical distribution of the genus and the occurrence of sympatric species. Bond-Buckup (1994) carried out an extensive revision of the family Aeglidae, including identification keys, diagnoses, measures, geographical distribution and description of 20 new species.

More recently, the natural history, population dynamics and evolution of aeglids have been studies by several authors (Bahamonde and Lopez, 1961; Lopez, 1965; Rodrigues and Hebling, 1978; Bueno and Bond-Buckup, 2000; Swiech-Ayoub
and Masunari, 2001a, b; Noro and Buckup, 2002; Pérez-Losada et al., 2004; Colpo et al., 2005; Gonçalves et al., 2006; Teodósio and Masunari, 2009).

Morphometric research in aeglids is usually related to the relative growth, in which some dimensions especially those of secondary sexual characters grow faster than others (Colpo et al., 2005; Viau et al., 2006 and Bueno and Shimizu, 2008; 2009). These authors showed that species can initiate a differential growth of the chelae in the males, and of the abdomen in the females when passing from juvenile to adult stage, in a pattern described by Hartnoll (1974; 1978; 1982).

Intraspecific variations in body dimension were only studied in Aegla uruguayana Schmitt, 1942 from Uruguay: the cephalothorax lengths of three different populations were analyzed, but no significant differences were found (Vaz-Ferreira et al., 1945). However, these variations are well known in some groups of crustaceans such as caridean and penaeid shrimps that can also be related to sexual dimorphism (Kapiris and Thessalou-Legaki, 2001; Tzeng et al., 2001; Tzeng, 2004; Anastasiadou et al., 2004; Anastasiadou and Leonards, 2008; Anastasiadou et al., 2009). On the other hand, sexual dimorphism in aeglids is well known (Bueno et al., 2000; Colpo et al., 2005; Viau et al., 2006; Bueno and Shimizu, 2009).

There are seven species of Aegla recorded for Paraná State (Bond-Buckup and Buckup, 1994; Bond-Buckup, 2003) and the biology of these species are poorly known in Paraná area since the studies are limited to the population structure of Aegla castro Schmitt, 1942 (Swiech-Ayoub and Masunari, 2001a, b) and Aegla schmitti Hobbs III, 1979 (Teodósio and Masunari, 2009). According to Bond-Buckup (1994), A. schmitti is the most common and largely distributed aeglid species in this area; its geographical distribution is limited from Iporanga city, São Paulo State (northern limit) to the municipality of Canoinhas, Santa Catarina State (southern limit) and from Guaratuba city (eastern limit) to Ponta Grossa city (western limit).

Based on the deposited lots of aeglids in the Museum of Natural History of the Capão da Imbuia (MHNCI) and a literature review (Bond-Buckup and Buckup, 1994; Bond-Buckup, 2003) the present work aims to update the geographical distribution of this species in Paraná State. Additionally, it is proposed to explore morphological variations within male populations coming from streams and rivers located on both sides of Serra do Mar mountains which is an important geographical barrier in Paraná State.

**Material and Methods**

**Geographical distribution**

The geographical distribution of A. schmitti was obtained from the literature and was updated based on the deposited specimens in MHNCI, Curitiba city. The specimens were identified with the aid of identification keys and diagnoses from Bond-Buckup (1994, 2003) and a distribution map was elaborated using the program ArcView GIS 3.2.

Whenever geographical coordinates of the collection site were not available, data from a specialized internet site (Species link) that show geographical coordinates of deposited specimens in scientific collections were used. If missing record of the exact collection stream occurred only the municipality name and coordinate were used as the reference point.

**Examined material** [municipality, river, collection date (collector), number of males (m), females (f), ovigerous female (fov) or juvenile (juv), (lot)]; Quatro Barras, Taquari River, 04-09.x.1987 (Cury, M.R. and Wosiacki, W.B.) 2 f, 3 m, (371); Iraí River, 13.ix.1991 (Grandó, E.T.), 2 f, 4 m, (454); Iraí River, xi.1998 (Abilhôa, V. and Moura Leite, J.C.), 32 m, (484); Araucária, Guajuvira River, 08.iii.1992 (Wosiacki, W.B.), 2 m, (452); Passaúna River, 23.ix.1966 (Cordeiro, A.M. and Ribeiro, J.C.), 1 f, 5 m, (938); Passaúna River, 23.ix.1966 (Cordeiro, A.M. and Ribeiro, J.C.), 1 f, (939); Passaúna River, 23.ix.1966 (Cordeiro, A.M. and Ribeiro, J.C.), 1 m, (947); Passaúna River, 23.ix.1966 (Cordeiro, A.M. and Ribeiro, J.C.), 6 f, 1 fov, 3 m (1128); Piraquara, Iraí River, 31.x.1991 (Cordeiro, A.A. and Grandó E.T.), 4 f, 6 m (456); Iraí River, 17.x.1964 (Alexandre, Z.), 1 m, (561); Iraí River, 17.x.1964 (Alexandre, Z.), 1 m, (563); Iraí River, 17.x.1964 (Alexandre, Z.), 1 m, (567); Iraí River, 17.x.1964 (Alexandre, Z.), 1 f, (568); Iraí River, 17.x.1964 (Alexandre, Z.), 1 f, (573); Iraí River, 17.x.1964 (Alexandre, Z.), 1 f, (574); Iraí River, 17.x.1964 (Alexandre, Z.), 1 m, (575); Mato Grande River, no date (no collector), 1 m, (671); Iraí River, 25.xi.1998 (Abilhôa, V.), 16 m, (814); Mato Grande River, 21.
Morphometric variation in adult males

Voucher specimens of *A. schmitti* coming from localities geographically separated by Serra do Mar mountains were analyzed: two localities east of Serra do Mar mountains – Matinhos River (municipality of Matinhos) and Guaricana Hydroelectric Dam (Guaratuba) – and four localities west of these mountains – two in Piraquara municipal district (Mato Grande River and Piraquara River) and two sites in Iraí River A and B (municipalities of Quatro Barras and Pinhais, respectively), these last ones located in Iguaçu River Basin. These samples were selected because the number of specimens was sufficient for the study of morphometric variability at a population level.

The following dimensions were obtained, exclusively, from adult males: cephalothorax length (CL – from tip of the rostrum to the posterior margin of carapace), rostrum length (RL – from the tip of the rostrum to the posterior margin of orbital sinus), rostrum base width (RW – distance between the two internal margins of the orbital cavity), frontal width (FW – distance between the two anterolateral spines of the carapace), length of cephalic area (CRL – from the posterior margin of orbital sinus to the posterior cervical groove), pre-cervical region width (CW – carapace width by the third hepatic lobes), carapace maximum width (MCW), longest length of chelae propodus (QL), widest width of chelar propodus (QW), telson length (TL – measured along the middle line) and telson maximum width (TW) (Fig. 1).

All the measurement values were log_{10} transformed to verify the normality assumption. To remove the effect of CL (X) variation on characteristic length (Y), the allometric equation \( Y = aX^b \) was used (Tzeng, 2004). The measures were standardized according to the formula \( Y_i^* = Y_i / X_i \). ANOVA test was used to compare the dimension measures of various populations coming from different localities (Zar, 1996).
Principal Components Analysis (PCA) and Discriminant Function Analysis (DFA) were used to identify morphometric differences among the populations. Both analyses are quite useful for the evaluation of variations within species (Thorpe, 1980). The first was used to verify the morphometric differences among the populations and to determine the contribution of each dimension in the total variance (Kovach, 1999; Anastasiadou et al., 2009). On the other hand, the DFA was used to detect the functions capable of performing maximum discrimination between two categories, and also to identify which dimensions have the strongest power of discrimination among the groups within the set of analyzed dimensions (Ayres et al., 2007; Souza et al., 2009). All variables with values of F > 0 were considered for the discrimination of groups. The results were graphically plotted for the visual detection of the formed groups.

Results

Geographical distribution of Aegla schmitti

A total of 441 specimens of A. schmitti were examined, from which, 356 (80.73%) were males, 80 (18.14%) females, 4 (0.90%) ovigerous females and 1 (0.23%) juvenile. Fourteen new occurrences for the species were recorded for rivers from the municipalities of Araucaria, Pinhais, Matinhos, Tunas do Paraná, and Agudos do Sul, and from new localities of the municipalities with former records in Curitiba, Guaratuba, São José dos Pinhais and Tijucas do Sul.
With this revision the geographical distribution of the species was extended to Matinhos River Basin to the East, but the remaining limits were maintained in Ponta Grossa city as the westernmost limit, and in north-south direction, from Iporanga city, São Paulo State (northern limit) to the municipality of Canoinhas, Santa Catarina State (southern limit) according to Bond-Buckup (1994) (Fig. 2).

Morphometric variation in adult males

The morphometric measurements were carried out in 134 males of *A. schmitti*: 20 from Matinhos River, 18 from Mato Grande River, 29 from Piraquara River, 16 from Guaricana Dam, 31 and 20 from Iraí River A and B, respectively (Fig. 2). The average values of all dimensions for each population are also presented in Table I.

The average LC varied from 23.58 mm to 29.09 mm, with significant differences (Anova, $F = 24.09; p < 0.01$) between populations from Litorânea Basin (Guaricana Dam and Matinhos River) and those from Iguaçu River Basin: the former are smaller in size. The remaining dimensions ($RL, RW, FW, CRL, CW, MCW, QL, QW, TL$ and $TW$) also showed statistical differences among populations (Table I).

According to PCA analysis, 99.81% of the data variation was explained by two axes: Axis 1 with 99.12% and Axis 2 with 0.69%. All body di-
dimensions contributed to the variation of the data in the Axis I (except chelae dimensions). The positive values of chelae dimensions, due to the absence of statistical difference among the populations, explain the presence of an isolated group with only those two dimensions in the Axis II (Fig. 3).

Four groups of population were formed with DFA: the first was composed of individuals from Guaricana Dam and the second, from Matinhos River. These two groups belong to localities east of Serra do Mar mountains, Litorânea Basin of Paraná State. In the central area of the graphic, a group composed of populations coming from Rio Iraí B, Mato Grande and Piraquara Rivers is visible; the last group is formed by populations from Rio Iraí A (Fig. 4).

**Discussion**

The new longitudinal limit established for *A. schmitti* and a significant number of first records observed in the present study indicate that future research will certainly change the current bioge-
A detailed species survey in those localities can demonstrate a continuous distribution of *A. schmitti* from southern São Paulo State to northern Santa Catarina State, with main area of distribution in Paraná State, on both sides of Serra do Mar mountains.

Additional knowledge that could come from these inventories is a secure diagnosis of the conservation status of *Aegla* species. Pérez-Losada et al. (2009), after a revision on the current degree of conservation of the genus *Aegla* based on the distribution and genetic diversity of species in southern South America, concluded that, from a total of 70 analyzed species 43 were considered unthreatened (UN), 18 threatened (CR, VU or EN), two extinct in the wild (EW) and seven did not have available data (DD, NE) for the classification, according to the criteria of the International Union for Conservation of Nature (IUCN).

Furthermore, according to Pérez-Losada et al. (2009), Paraná State shows a large number of *Aegla* species threatened with extinction. This information reinforces the urgent necessity to increase the knowledge about systematics and distribution of species, biology, ecology and evolution, in order to establish conservation strategies for the fauna of freshwater ecosystems.

The results of the present study suggest that the Serra do Mar mountains did not represent a barrier for *A. schmitti* distribution along the rivers that drain that area. Perez-Losada et al. (2004) presented a biogeographic discussion about *Aegla* based on molecular data and a literature review. In this work they highlighted a discrepancy between the phylogenetic relationships of the group and the current pattern of South America drainage (assuming a Pacific origin for the genus), probably as a result of the changes provoked by Paraná Sea formation (sea transgression of Atlantic Ocean) and the Serra do Mar mountains final uplift in the Late Tertiary.

The current distribution of *A. schmitti* along the rivers of both Iguazu and Litorânea Basins suggests that Serra do Mar mountains final uplift happened after the species dispersion over the area, and that the isolation of these populations caused subsequent morphometric differentiation, as indicated by biometric data in the present study. This assumption is based on Perez-Losada’s (2004) idea that some groups of aeglids speciated about 10.7 ± 1.1 millions of years (my), and therefore clearly after the Serra do Mar mountains final uplift.

---

**Figure 4.** *Aegla schmitti*. Discriminant Function Analysis for the body dimensions. • = Matinhos River; △ = Mato Grande River; ▲ = Piraquara River; ○ = Guaricana Hydroelectric Dam; □ = Irai (A) River and ■ = Irai (B) River.
(~ 12 my) and the Paranan Sea regression. However, studies on distribution patterns of other sympatric and non-sympatric aeglid species based on molecular and biogeographic tools is desirable, in order to clarify the biogeographic history of *A. schmitti*.

A comparison between the results of intraspecific variation of the present study and those from the literature is difficult because the only known work of Vaz-Ferreira *et al.* (1945) with *A. uruguayana*, did not show significant differences in size between populations. Distinctly from populations of this species, those of *A. schmitti* obtained from Litorânea Basin (east of Serra do Mar mountains) were smaller (CL) than those from Iguazu River Basin (west of Serra do Mar mountains) in the present study. Furthermore, the variation in rostrum length (RL) among populations may indicate a probable reproductive isolation, mainly between those located on opposite sides of the Serra do Mar mountains. This assumption is based on the formation of the four groups through DFA.

The results of DFA indicate that in the first discriminant function, all measures support the separation of the groups previously known. In the same way, as observed in PCA, the chelae dimensions do not seem to be responsible for the separation of the observed groups, as they represent the values of the second discriminant function (Table II).

The absence of differences in the chelae size in the examined populations could be associated with the necessity of those animals in having large chelae for feeding and other reproductive activities. This result suggests that, despite the reproductive isolation, this characteristic can be easily disseminated among males of all populations of *A. schmitti*, in a convergent form. This inference is supported by the research of Almerão *et al.* (2010), who mention that males of *A. platensis* use large chelae in agonistic confrontations and when guarding females after fertilization; on the other hand, females of this species employ the chelae only for cleaning the abdominal chamber after the egg laying. These activities are essential for survival of the populations.

The formation of a fourth group in DFA analysis composed of individuals coming from Iraí River A (Iguazu River Basin), can be related to the fact that all somatic dimensions of these animals are largest among the populations studied (Table I). For this reason, even after the data standardization, it can generate statistical noise. On the other hand, the sampling method of the deposited animals at the museum was variable (Odette Lopez Lopes, personal communication): in some cases through gill net fishing, another through electro-fishing. In the latter case, sampling is biased towards larger adult males, and certainly this factor influenced the present analysis.

The present study presents an initial contribution to the understanding of the differential process of geographic isolation of aeglids, mainly in Paraná State. Additionally, the study opens new perspectives that should be approached, such as the analysis of the distribution pattern of genus *Aegla* in the area based on molecular analysis to determine the degree of differentiation of these populations, and to know the real role of Serra do Mar mountains as a physical and/or climatic barrier for the current distribution of the family Aeglidae in Paraná State.

**Acknowledgements**

We thank the National Council for Scientific and Technological Development (CNPq) from the Brazilian Ministry of Science and Technology for the financial support granted to the first author, Dr. Márcia Arzua and M. Sc. Odete Lopes Lopez from Museum of Natural History of Capão da Imbuia for the permission to access deposited aeglid lots. We are also grateful to Prof. Dr. Luís Amilton Foerster from Federal University of Paraná for language revision. This is Contribution No. 1821 of Department of Zoology, Federal University of Paraná.

**References**

Almerão, M.; Bond-Buckup, G. and Mendonça Jr. M de S. 2010. Mating behavior of *Aegla platensis* (Crustacea,


Submitted 14 February 2010

Accepted 24 May 2010