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RESEARCH ARTICLE

Gauchergasilus euripedesi (Copepoda, Ergasilidae) parasitizing different species of fish from two environments in southern Brazil

Moisés Gallas[1], Laura R. P. Utz[1]

1 *Laboratório de Ecologia Aquática, Escola de Ciências da Saúde e da Vida, Pontifícia Universidade Católica do Rio Grande do Sul. Avenida Ipiranga, 6681, Partenon, Porto Alegre, 90619-900, Rio Grande do Sul, Brazil*

Corresponding author: Moisés Gallas (mgallas88@gmail.com)

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Abstract

The parasitic copepod *Gauchergasilus euripedesi* (Montú, 1980) Montú & Boxshall, 2002 was described from plankton samples and specimens found in four fish species from the estuarine area of Patos Lagoon, state of Rio Grande do Sul (RS), Brazil. Later, one different fish species was reported parasitized with *G. euripedesi* in the same locality. Species of *Astyanax* Baird & Girard, 1854 (*Astyanax henseli* Melo & Buckup, 2006 and *Astyanax lacustris* (Lütken, 1875)) and *Psalidodon* Eigenmann, 1911 (*Psalidodon eigenmanniorum* (Cope, 1894) and *Psalidodon* aff. *fasciatus* (Cuvier, 1819)) were collected in two environments (Pintada Island, municipality of Porto Alegre and Itapeva Lagoon, municipality of Terra de Areia, RS) to investigate their parasites. The copepods found in the gill arches were counted, processed, mounted in permanent slides, and photographed using light microscopy, or processed for observation in scanning electron microscopy. Specimens of *P. eigenmanniorum* from Pintada Island, *A. lacustris* and *P.* aff. *fasciatus* from Itapeva Lagoon, were parasitized by *G. euripedesi*, with prevalences of 29.03% (*A. lacustris*), 10.34% (*P. eigenmanniorum*), and 9.68% (*P.* aff. *fasciatus*). Measurements obtained for specimens of *G. euripedesi* were similar to those found in the literature, except for egg sacs which were larger in the specimens examined in the present study. In addition to being the first report of *G. euripedesi* parasitizing species of fish (*A. lacustris*, *P. eigenmanniorum*, and *P.* aff. *fasciatus*), the results presented here also extend the known geographic distribution of the copepod species.

Keywords
Astyanax, characid, copepod, ergasilid, Itapeva Lagoon, Pintada Island, *Psalidodon*

Introduction

The copepod genus *Gauchergasilus* Montú & Boxshall, 2002 was proposed to accommodate the species *Gauchergasilus euripedesi* (Montú, 1980) Montú & Boxshall, 2002, anteriorly included in the genus *Ergasilus* von Nordmann, 1832 (Montú 1980; Montú and Boxshall 2002). In the original description of *G. euripedesi*, the specimens were collected from plankton samples and from larvae of the following estuarine and marine fish species: *Brevoortia pectinata* (Jenyns, 1842), *Gobiesox* sp., *Lycengraulis grossidens* (Agassiz, 1829), and *Micropogonias furnieri* (Desmarest, 1823) in the estuarine area of the Patos Lagoon (Montú 1980). Later, redescription of females and corrected description of males, were based on plankton samples collected in the estuarine area of Patos Lagoon (Montú and Boxshall 2002). In addition, females of *G. euripedesi* were found in *M. furnieri* by Velloso and Pereira Jr. (2010) in the pre-limnic region of the Patos Lagoon estuary, and in *Geophagus brasiliensis* (Quoy & Gaimard, 1824) by Rassier et al. (2015) also in the estuarine area of Patos Lagoon. Araujo and Boxshall (2001) reported *G. euripedesi* obtained from plankton samples collected in the Piauí River estuary. Currently the genus *Gauchergasilus* is monotypic (Montú and Boxshall 2002; Luque et al. 2013).

The Patos Lagoon system (which includes the Guaíba Lake) comprises the largest lacunar system found in South America (Noronha 1998), and presents at least 170 fish species (Langeani et al. 2009). In Guaíba Lake and its north limit known as Jacuí Delta, species of *Astyanax* Baird & Girard, 1854 (*Astyanax henseli* Melo & Buckup, 2006 and *Astyanax lacustris* (Lütken, 1875)) and *Psalidodon* Eigenmann, 1911 (*Psalidodon eigenmanniorum* (Cope, 1894) and *Psalidodon* aff. *fasciatus* (Cuvier, 1819)) have been reported (Buckup et al. 2007; Lucena et al. 2013; Terán et al. 2020). From these species, *A. lacustris*, *P. eigenmanniorum*, and *P.* aff. *fasciatus* occur also in the Tramandaí basin, which includes several interconnected lagoons (Lucena et al. 2013; Malabarba et al. 2013).

In Brazil, parasitic crustaceans have been reported in species of *Astyanax* and *Psalidodon*: *Argulus juparanaensis* Lemos de Castro, 1950, *Dolops* sp., *Ergasilus* sp., *Paracymothoa astyanaxi* Lemos de Castro, 1955, and *Lernaea cyprinacea* Linnaeus, 1758 in *Astyanax bimaculatus* (Linnaeus, 1758) (Eiras et al. 2010; Luque et al. 2013; Vasconcelos et al. 2013); *Dipteropeltis hirundo* Calman, 1912 and *Ergasilus* sp. in *Psalidodon fasciatus* (Cuvier, 1819) (Eiras et al. 2010; Luque et al. 2013); *Acusicola* sp., *Amplexibranchius bryconis* Thatcher & Paredes, 1985, *Brasergasilus* sp., *Ergasilus* sp., *L. cyprinacea*, and *Vaigamus* sp. in *A. lacustris* (Gallio et al. 2007; Eiras et al. 2010; Luque et al. 2013; Pádua et al. 2015; Camargo et al. 2016; Corrêa et al. 2016). Thus, the goal of the present study is to report new hosts and new localities for *G. euripedesi* in the state of Rio Grande do Sul.

Methods

Specimens of *A. lacustris* (*n* = 42), *A. henseli* (*n* = 35), *P. eigenmanniorum* (*n* = 29), and *P.* aff. *fasciatus* (*n* = 54) were collected in Pintada Island (30°17'11"S, 51°18'01"W), Jacuí Delta, municipality of Porto Alegre, while specimens of *A. lacustris* and *P.* aff. *fasciatus* (*n* = 31 each) were sampled from Itapeva Lagoon (29°36'16"S, 49°59'28"W), municipality of Terra de Areia, state of Rio Grande do Sul, southernmost Brazil (Fig. 1). Fish were collected with seine and fyke nets, and packed individually in plastic bags to avoid parasite loss and contact between hosts until necropsy. Host identification followed Bertaco and Lucena (2010), Lucena et al. (2013) and Lucena and Soares (2016). Host systematics followed Terán et al. (2020).

Gills arches of the fishes were removed with the aid of fine-tip scissors, placed in a jar with formalin solution 1:4,000, and shaken at least 50 times (Gallas et al. 2016) to obtain detached copepods. The material was examined under stereomicroscope and the copepods were collected and stored in 70° GL ethanol (Amato et al. 1991). Copepods were mounted *in toto* in Faure's mounting medium without clarification. Two specimens were prepared for scanning electron microscopy (SEM), where they

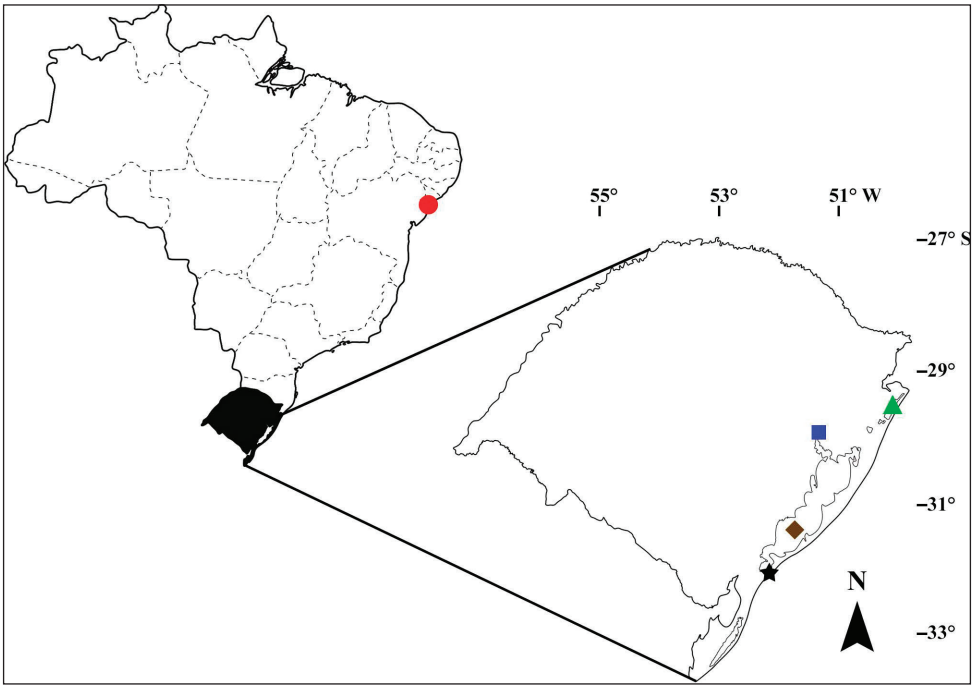

Figure 1. Map showing the distribution of *Gauchergasilus euripedesi* in Brazil and in the State of Rio Grande do Sul (in enlarged detail): previous localities are the Piauí River estuary (red circle) and the Patos Lagoon estuary (black star) including the pre-limnic region (brown diamond); the new localities are the Jacuí Delta (blue square) and Lagoon Itapeva (green triangle).

were dehydrated in an ethanol series to critical point dried. The copepods were mounted on stubs, coated with carbon and gold, and then examined in a Field Emission Electron Microscope (FESEM), Inspect F50, FEI at 'Laboratório Central de Microscopia e Microanálise' (LabCEMM) at Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil.

Measurements are shown in micrometers (μm) unless otherwise indicated. They represent the minimum and maximum values followed by mean, standard deviation, and sample size in parenthesis. In the description, the terminology follows Huys and Boxshall (1991). Photomicrographs were made using an Olympus BX50 microscope and prepared using ADOBE'S PHOTOSHOP CS2. The parameters of infestations such as prevalence, mean intensity and abundance were used according to Bush et al. (1997). Voucher copepod specimen was deposited in the 'Coleção de Crustáceos do Museu de Ciências e Tecnologia da PUCRS' (MCP), Porto Alegre, RS, Brazil.

Results

Gauchergasilus Montú & Boxshall, 2002

Gauchergasilus euripedesi (Montú, 1980) Montú & Boxshall, 2002
Figs 2, 3

Description based on eight adult females. Body cyclopiform, 0.62–0.81 mm (0.71 ± 0.07 mm; $n = 8$) long, disregarding the antennae and the caudal setae. Prosome apparently 5-segmented, 0.45–0.67 mm (0.56 ± 0.07 mm; $n = 8$) long, 200–310 (243 ± 37; $n = 8$) widest in the first segment. Urosome 5-segmented, with small fifth somite; a genital double-somite, and 3-segmented abdomen. Urosome 120–180 (147 ± 22; $n = 8$) long. Genital double-somite 70–90 (76 ± 7; $n = 8$) long, 80–110 (99 ± 11; $n = 8$) wide. Abdomen 50–100 (64 ± 18; $n = 8$) long, 60–70 (62 ± 4; $n = 8$) wide. Caudal rami longer than wide, 20–30 (23 ± 4; $n = 8$) long. Each caudal rami armed with 4 setae, the lateral are longer than the median. Egg sacs 350–780 (557 ± 140; $n = 6$) long, 100–150 (119 ± 21; $n = 6$) wide, fixed in the genital double-somite. Pigments in the body distributed from prosome to abdomen and caudal rami.

Antennules 5-segmented, segmental setation: 11, 5, 4, 2 + aesthetasc, 7 + aesthetasc; antennules 80–95 (87 ± 7; $n = 5$) long. Antennae 4-segmented; coxobasis short and unarmed; first endopodal segment robust, with a seta on inner margin; second endopodal segment curved, with two setae on inner margin, one next to the limit with the first endopodal segment and the other next to the median region; third endopodal segment short; distal claw curved, with a conspicuous barb in the middle of the concave margin. Antennae 330–410 (374 ± 26; $n = 7$) long; distal claw 70–90 (81 ± 8; $n = 7$) long.

Swimming legs 1–4 biramous where all rami are 3-segmented, except 2-segmented endopod in leg 1, and 2-segmentend exopod in leg 4. Spine and seta formula of legs 1–4 distributed as follows: all coxae unarmed; all bases with 1 seta on

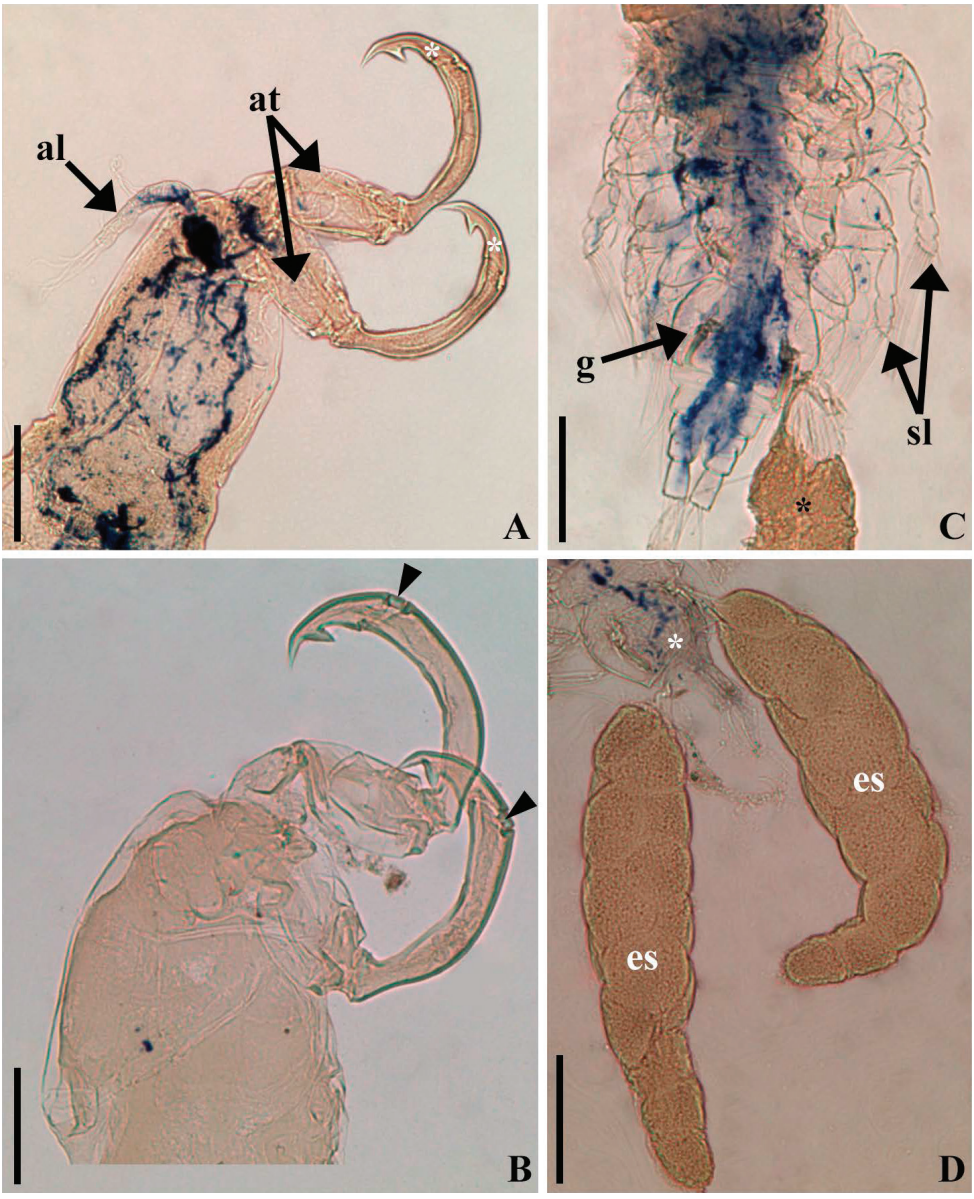

Figure 2. Photomicrographs of *Gauchergasilus euripedesi*. **A.** Anterior end, lateral view, showing the body with pigments, antennule (al), antennae (at) and distal claw (white asterisks). **B.** Anterior end, lateral view, showing the antennae and the third endopodal segment (black arrow heads). **C.** Prosome and urosome, dorsal view, showing the pigmentation along the body, the swimming legs (sl), genital double-somite (g) and the egg sac (black asterisk). **D.** Posterior end, showing the genital double-somite (white asterisk) and egg sacs (es). Scale bars: 100 μm (**A, B, C**); 150 μm (**D**).

each leg; exopod – leg 1: I-0, 0-1, II,5; leg 2: I-0, 0-1, I,6; leg 3: I-0, 0-1, I,6; leg 4: 0-0, I,5; endopod – leg 1: 0-1, II,5; leg 2: 0-1, 0-2, I,4; leg 3: 0-1, 0-2, I,4; leg 4: 0-1, 0-2, I,3.

Taxonomic summary and parameters of infestations:

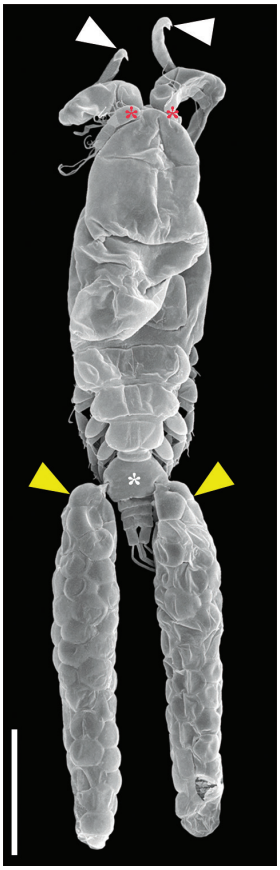

Figure 3. Scanning electron microscopy of *Gauchergasilus euripedesi*, dorsal view, showing the antennae (white arrow heads), antennules (red asterisks), genital double-somite (white asterisk) and egg sacs (yellow arrow heads). Scale bar: 150 μm.

Hosts: *Astyanax lacustris* (Lütken, 1875), *Psalidodon eigenmanniorum* (Cope, 1894), and *Psalidodon* aff. *fasciatus* (Cuvier, 1819).

Localities: Jacuí Delta, Pintada Island, municipality of Porto Alegre, and Itapeva Lagoon, municipality of Terra de Areia, state of Rio Grande do Sul, Brazil.

Site of infestations: gills.

Prevalences: 29.03% (*A. lacustris* from Itapeva Lagoon), 10.34% (*P. eigenmanniorum*), and 9.68% (*P.* aff. *fasciatus* from Itapeva Lagoon).

Mean intensities of infestations: 1.11 (*A. lacustris* from Itapeva Lagoon), 1 (*P. eigenmanniorum*), and 3.67 (*P.* aff. *fasciatus* from Itapeva Lagoon).

Mean abundances of infestations: 0.32 (*A. lacustris* from Itapeva Lagoon), 0.1 (*P. eigenmanniorum*), and 0.35 (*P.* aff. *fasciatus* from Itapeva Lagoon).

Amplitude of intensity of infestations: 1–2 copepods (*A. lacustris* from Itapeva Lagoon), 1 copepod (*P. eigenmanniorum*), and 1–9 copepods (*P.* aff. *fasciatus* from Itapeva Lagoon).

Voucher specimen of copepod deposited: MCP 3219.

Table 1. Comparison of the parameters of infestations of *Gauchergasilus euripedesi* in different studies.

Host	Prevalence (%)	Mean intensity	Mean abundance	Amplitude of intensity	Reference
Micropogonias furnieri (*n* = 94)	14.89	2.79	0.41	*	Velloso and Pereira Jr. (2010)
Geophagus brasiliensis (*n* = 79)	32.91	2.42	0.79	1–63	Rassier et al. (2015)
Astyanax lacustris (*n* = 31)	29.03	1.11	0.32	1–2	Present study
Psalidodon eigenmanniorum (*n* = 29)	10.34	1	0.1	1	Present study
Psalidodon aff. *fasciatus* (*n* = 31)	9.68	3.67	0.35	1–9	Present study

* not given by the authors.

Discussion

The ergasilid copepods are described mainly based on their morphology including shape and number of segments in each appendage, segmental setation, in addition to the patterns of spines and setae (Montú 1980; Araujo and Boxshall 2001; Montú and Boxshall 2002). The specimens of *G. euripedesi* found in this study presented all of the traits described by Montú (1980) and Montú and Boxshall (2002) as well as presented the measurements similar to those specimens reported by the two studies. However, the specimens found in the present study presented larger egg sacs (350–780 long) than the specimens (232 long) examined by Montú (1980). These differences could be the result of incompletely developed egg sacs of the specimens analyzed by Montú (1980) or due to a variation not reported until now. Therefore, most measurements in the present study represent new data for *G. euripedesi*.

The parameters of infestations of *G. euripedesi* available are presented in Table 1. In general, parameters of the host species examined in the present study are more similar to those reported for *M. furnieri* (Velloso and Pereira Jr. 2010), but smaller than those found in *G. brasiliensis* (Rassier et al. 2015). These differences do not seem to be related to the number of hosts examined, since the two most sampled hosts (*M. furnieri*, *n* = 94 and *G. brasiliensis*, *n* = 79) presented differences between them. Moreover, they also presented differences in comparison with the hosts examined in the present study (*A. lacustris*, *n* = 31; *P. eigenmanniorum*, *n* = 29; and *P.* aff. *fasciatus*, *n* = 31). In addition, considering the tolerance to salinity variations, *G. euripedesi* prefers low salinity levels found in the Patos Lagoon estuary (Velloso and Pereira Jr. 2010), thus, the infestations found in Guaíba Lake and Itapeva Lagoon should be higher than those reported by Velloso and Pereira Jr. (2010) and Rassier et al. (2015). More studies are necessary to explain the different levels of infestations of *G. euripedesi*. Other factors such as the availability of hosts, presence of different hosts species in the same area, characteristics of the environments, to name a few, must be considered since salinity levels do not seem to be the only or the main factor influencing infestations by *G. euripedesi*.

In Brazil, the ergalisid crustaceans that have been reported in *A. lacustris* and *P. fasciatus* include one species (*A. bryconis*) and four undetermined species (*Acusicola* sp., *Brasergasilus* sp., *Ergasilus* sp., and *Vaigamus* sp.) (Eiras et al. 2010; Luque et al. 2013; Pádua et al. 2015; Camargo et al. 2016). Until now, previous reports of fish parasitized by *G. euripedesi* include larvae of *B. pectinata*, *Gobiesox* sp., *L. grossidens*,

and *M. furnieri* (Montú 1980), and adult specimens of *G. brasiliensis* and *M. furnieri* (Velloso and Pereira Jr. 2010; Rassier et al. 2015). In additional reports, the specimens of *G. euripedesi* were collected from plankton samples, since only females are known to be parasitic (Araujo and Boxshall 2001; Montú and Boxshall 2002). This is the first report of *G. euripedesi* parasitizing species of *Astyanax* (*A. lacustris*) and *Psalidodon* (*P. eigenmanniorum* and *P.* aff. *fasciatus*), in which all species are considered new hosts. These new reports reflect the potential high number of parasitic crustaceans that are still underestimated as pointed out by Luque et al. (2013).

This study also extends the known geographic record of *G. euripedesi* in the lagunar system of Patos Lagoon to the Jacuí Delta, and includes a new locality record (Itapeva Lagoon). It is possible that *G. euripedesi* could be found in other localities throughout the territory between southern and northeast Brazil since its distribution is only known in the states of Rio Grande do Sul and Sergipe (Araujo and Boxshall 2001; Montú and Boxshall 2002).

Conclusions

The specimens of *G. euripedesi* presented morphology and measurements (except for large egg sacs reported here) similar to the specimens reported in previous studies. The species *A. lacustris*, *P. eigenmanniorum*, and *P.* aff. *fasciatus* are reported as new hosts for *G. euripedesi*, thus, increasing the list of fishes species parasitized by crustaceans in Brazil. The present study also extends the known distribution of *G. euripedesi* in southern Brazil and contributes to the knowledge of the biodiversity of copepod parasites in the region.

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