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Short Communication

Composition, abundance and biomass of a fish assemblage in a southern Brazilian coastal stream during polyhaline/euhaline condition

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Abstract: The coastal streams of southernmost Brazil, Rio Grande do Sul state, are marked by a period of regular marine intrusion resultant from intense oceanic winds. In the present study we aimed to investigate the species composition, abundance and relative biomass of the ichthyofauna in the lower stretch of a coastal stream during summer, a period of regular marine intrusion. Estreito is a coastal hydrological complex composed by lakes, swamps and a perennial stream, located at the central-south portion of the coastal plain of Rio Grande do Sul state. During the summer of 2018, the ichthyofauna of lower Estreito stream was sampled by beach hauls applied in 17 random points distributed in a stretch of ca. 2km. Measurements at the sampled stretch revealed salinities between 19.3 to 31.3 ppt, characterizing the studied system as polyhaline/euhaline during summer. The sample of 4,533 specimens revealed the occurrence of 20 species, being the great majority marine-dwelling. The most abundant species were the anablepid *Jenynsia lineata* (70.3%), the cichlid *Geophagus brasiliensis* (19.3%) and the the mugilid *Mugil curema* (7.5%). The highest relative biomass was recorded for *J. lineata*, followed by *M. curema* and *G. brasiliensis*. The dominance of marine-dwelling species in the assemblage composition and the high abundance of limnic-estuarine *J. lineata* corroborate previous studies conducted in other washouts of Rio Grande do Sul.
Keywords: *Jenynsia lineata, Mugil curema, Geophagus brasiliensis, ichthyofauna dynamics, salinity, washout.*

Composição, abundância e biomassa de uma assembléia de peixes em um arroio costeiro do sul do Brasil durante condição polihalina/euhalina

Resumo: Os arroios costeiros do extremo sul do Brasil, estado do Rio Grande do Sul, são marcados por um período de regular intrusão marinha resultante de intensos ventos oceânicos. No presente estudo nós tivemos como objetivo investigar a composição de espécies, abundância e biomassa relativa da ictiofauna no trecho inferior de um arroio costeiro durante o verão, período de regular intrusão marinha. Estreito é um complexo hidrológico costeiro composto por lagoas, pântanos e um arroio perene, localizados na porção centro-sul da planície costeira do Rio Grande do Sul. Durante o verão de 2018, a ictiofauna do baixo arroio Estreito foi amostrada por arrastos de praia aplicados em 17 pontos aleatórios distribuídos em um trecho de cerca de 2 km. Medidas no trecho amostrado revelaram salinidades entre 19.3 e 31.3 ppt, caracterizando o sistema estudado como polialino/euhalino durante o verão. A amostra de 4.533 espécimes revelou a ocorrência de 20 espécies, sendo a grande maioria habitantes marinhos. As espécies mais abundantes foram o anablepídeo *Jenynsia lineata* (70,3%), o ciclídeo *Geophagus brasiliensis* (19,3%) e o mugilídeo *Mugil curema* (7.5%). A maior biomassa relativa foi registrada para *J. lineata*, seguido por *M. curema* e *G. brasiliensis*. A dominância das espécies marinhas na composição da assembléia e a alta abundância da espécie límnica-estuarina *J. lineata* corrobora estudos prévios conduzidos em outros sangradouros do Rio Grande do Sul.
Palavras-chave: *Jenynsia lineata, Mugil curema, Geophagus brasiliensis, dinâmica da ictiofauna, salinidade, sangradouro.*

Introduction

Coastal streams are considered marine-freshwater ecotones, hosting diverse fish assemblages composed of freshwater, estuarine and marine dwelling species (Whitfield 1999, Bastos et al. 2013). These systems, also known as "washouts", are abundant in the southernmost Brazilian coast (Rio Grande do Sul state), draining wetlands and lagoons distributed along a stretch of ca. 620 km of sandy deposits. The coastal streams or washouts of Rio Grande do Sul coastal plain (RSCP) are strongly influenced by climatic parameters such as precipitation and evaporation, which act directly on systems dynamics of discharge and connection to the sea (Figueiredo & Calliari 2006). Thus, coastal streams represent singular scenarios for studies on the ichthyofauna occurring in transient environments.

In view of the high representiveness of coastal stream or washouts in RSCP, few studies concerning the ichthyofauna in these systems were conducted. Bastos et al. (2013, 2014) surveyed the ichthyofauna occurrying in three coastal streams located in the southern segment of RSCP. Oliveira et al. (2014) investigated the role of mullets in transport of marine nutrients into the freshwater food webs in one of the coastal streams studied by Bastos et al. (2013, 2014). In this same system, Oliveira et al. (2018) verified the use of freshwater habitats by juveline mullets through the analysis of otolith chemistry.

"Estreito" is a hydrological complex which covers an area of ca. 453 hectares in the central-south portion of RSCP (São José do Norte municipality). This complex is composed by interconnected coastal lakes, perennial and intermittent peripheral swamps and a perennial coastal stream connected to the Atlantic Ocean (Gianuca & Tagliani 2012). The Estreito complex is recognized for its importance for the conservation of the local biodiversity (Burger & Ramos 2006, Gianuca & Tagliani 2012) and therefore it is inserted in a Permanent Protection Area, which implies in a protected territory with restrictions to human use. However, the pine silviculture established in the surroundings has been causing profound changes in the landscape, including the extinction of coastal streams (Gianuca & Tagliani 2012). During summer, Estreito is submitted to frequent and intense oceanic winds, causing frequent marine intrusions in the fluvial system (Oliveira & Calliari 2006). Herein we aimed to investigate the species composition, abundance and relative biomass of the fish assemblage occurring in the lower Estreito stream during its period of regular of marine intrusion. Despite being a typical limnic system, we hypothesize a higher representativeness of marine species when compared to limnic species, which will reflect on higher richness, abundance and biomass of marine-related taxa.

Material and Methods

Sampling campaigns were performed during the summer of 2018 in 17 random points distributed on a stretch of ca. 2 km of the lower Estreito coastal stream (Figure 1). Bottom varies from sandy to muddy and vegetation is composed by *Ruppia maritima* L. stands. Maximum depth does not exceed two meters. Fishes were captured using a beach seine net (10 x 2.5 m, 5 mm mesh size). Seventeen seine hauls were applied, each covering a distance of approximately 40 meters. Salinity was measured using a multiparameter water quality checker (Horiba®, model U50) at each sampling point. Captured fishes were euthanized in clove oil solution, fixed in 10% formalin, and conserved in 70% ethanol in the Ichthyological Collection of Genetics Laboratory at the Universidade Federal do Rio Grande (CILG). Collection was authorized by the Brazilian environmental agency "Instituto Chico Mendes para Conservação da Biodiversidade" (ICMBio) (license nº 56947-1). All the adopted procedures are in accordance with the protocols of the institutional committee for ethics in animal use (CEUA-FURG). Specimens were identified according to Heemstra & Randall (1993), Fischer et al. (2004) and Froese & Pauly (2018).

Relative abundance was calculated as the ratio between species-specific abundance and total abundance, with values presented as percentages of the total. Summary statistics (mean, standard deviation and range) of total length (in millimeters) was calculated for the species with a sample size greater than 10 individuals. For species with smaller sample size, the range or absolute values were presented. The biomass (in grams) of each species was obtained by weighing the formolized specimens, drained from conservative. Relative biomass of each especies was calculated as the ratio between species-specific biomass and total biomass.

Results and Discussion

Salinity at the sampled points varied from 19.3 to 31.3 ppt, characterizing the system as polyhaline/euhaline during the period of study. A total of 4,533 specimens belonging to 20 species, 14 families and 10 orders were collected (Table 1). The richest order and family were Gobiiformes and Gobiidae, comprising five and three species respectively. The one-sided livebearer *Jenynsia lineata* (Jenyns, 1842) was the most abundant species, followed by the pearl cichlid *Geophagus brasiliensis* (Quoy & Gaimard, 1824), and the white mullet *Mugil curema* Valenciennes, 1836 (Table 1). The highest relative biomass was recorded for *J. lineata*, followed by *M. curema* and *G. brasiliensis* (Table 1). As expected, the fish assemblage found in lower Estreito stream during the period of regular marine intrusion was composed mainly by marine-dwelling species, which comprised 70% of the species richness. By the other hand, marine-dwelling species encompassed only 9.8% of total abundance and 33.1% of total biomass. The species *Elops saurus* Linnaeus, 1766, *Platanichthys platana* (Regan, 1917), *Odontesthes argentinensis* (Valenciennes, 1835), *Awaous tajasica* (Lichtenstein, 1822), *Ctenogobius stigmaticus* (Poey, 1860), *Gobionellus oceanicus* (Pallas, 1770), *Epinephelus marginatus* (Lowe, 1834), *Menticirrhus littoralis* (Holbrook, 1847), *Citharichthys spilopterus* Günther, 1862 and *Paralichthys orbignyanus* (Valenciennes, 1839) were not recorded by Bastos et al. (2013, 2014) in the coastal streams located further south. These species, however, were recorded in larger marine-freshwater ecotonal systems of RSCP, comprised by the estuaries of coastal lagoons and rivers (Ramos & Vieira 2001, Loebmann & Vieira 2005, Burns et al. 2010). Our specimens of marked goby *C. stigmaticus* represent the second record for Rio Grande do Sul. This species had only previously been recorded in the state for the estuary of the Patos lagoon (Burns et al. 2010. The dusky grouper *E. marginatus* is considered as threatened in Rio Grande do Sul state (FZB 2014). The habits, number of collected specimens, relative abundance, summary statistics of total length and relative biomass of all recorded species are shown in Table 1.

The high representativeness of marine-dwelling species was expected in view of the regular marine intrusion and consequent high levels of salinity during the sampling period. However, a higher

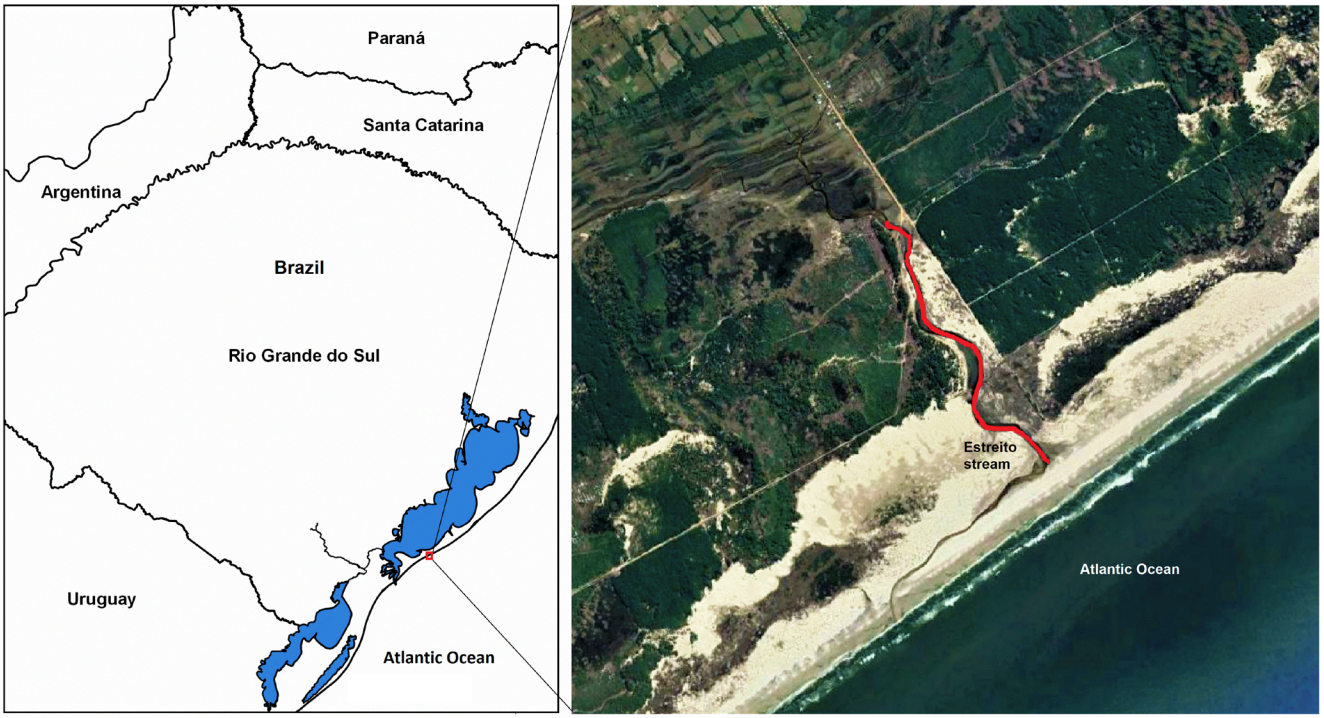

Figure 1. Location of Estreito stream and the sampled stretch (in red).

occurrence of strictly limnic species was also expected due to the connection with limnic systems such as lakes and swamps, located at a short distance from the sampled stream stretch. Instead, a unique strictly limnic species (*Hyphessobrycon igneus* Miquelarena, Menni, López & Casciotta, 1980) was recorded. Comparatively, Bastos et al. (2014) found more than half of the assemblages in three coastal streams located at the southern coastal plain of Rio Grande do Sul were composed by limnic species. Interestingly, the higher proportion of freshwater species found in their study remained even during summer, when marine intrusion events were detected. Nevertheless, salinity in these systems was much lower than that recorded in Estreito stream, ranging from 0 to 2. Thus, it is possible that the high salinity limits the occurrence of strictly limnic species in the lower Estreito stream, at least during summer.

Despite the high representativeness in the species composition, marine-dwelling species contributed little to abundance, except for the white mullet *M. curema*, the third species in order of abundance and the second in order of relative biomass in our sample. Bastos et al. (2014) found a similar pattern of abundance for marine species, where the majority of species were few abundant and higher abundances were recorded only for mullets (*M. curema* and *M. liza*). *Mugil curema* is a catadromous species commonly found in shallow marine waters, coastal lagoons and washouts (Fischer et al. 2004). The use of coastal streams habitats by juvenile mullets is well documented in RSCP (Bastos et al. 2014, Oliveira et al. 2014, 2018) and the exclusive occurrence of juveniles of *M. curema* in our sample, based on the available data for size at sexual maturity (Froese & Pauly 2018), reinforce these evidences. Thus, it seems that *M. curema* is the only marine species to use intensively lower Estreito stream during the period of regular marine while the other marine-dwelling species are occasional inhabitants in the system.

The one-sided livebearer *J. lineata* was the most abundant species in the present study, and concentrated half of the total biomass. *Jenynsia lineata* is a limnic-estuarine species (Assumpção et al. 2016) with a punctual record in marine waters (Calviño & Alonso 2016). *Jenynsia lineata* was one of the most abundant species in the systems studied by Bastos et al. (2013). There are evidences that *J. lineata* is especially abundant in systems with marine influence and also in typical freshwater environments (Garcia et al. 2003, Bastos et al. 2003). Mai et al. (2005) also verified that juveniles of *J. lineata* showed higher growth rate and survival in intermediate salinities. Therefore, lower Estreito stream fits as a suitable environment for the occurrence and development of *J. lineata*.

The cichlid *G. brasiliensis* was the second species in order of abundance and the third in order of relative biomass in our study. *Geophagus brasiliensis* presented low abundance or was absent in Bastos et al. (2013) summer samples. The high abundance of *G. brasiliensis* in lower Estreito stream is remarkable considering that it is a typical limnic species (Assumpção et al. 2016). Cichlids are typically freshwater inhabitants and few species can tolerate brackish waters (Froese & Pauly, 2018). Evidences of salinity tolerance by *G. brasiliensis* were obtained through controlled essays, where the species was submitted to increased salinity treatments (De Graff & Coutts 2010, Gutierre et al. 2014). Notwithstanding, the species has been found in estuarine systems (e.g. Garcia et al. 2001, Benincá et al. 2012), but those records were not accompanied by appropriate data on salinity. Thus, the tolerance of *G. brasilensis* to high salinity in natural environment (19.3-31.3 ppt) and its high relative abundance under this condition is herein recorded.

In the present study we verified the predominance of marine-related species in a coastal stream under a regime of regular marine intrusion in RSCP. Meanwhile, the highest abundance and biomass corresponded to

Table 1. Fish species recorded in lower Estreito stream (Rio Grande do Sul state, southern Brazil) during polyhaline/euhaline conditions (summer of 2018), habits (marine (M), estuarine (E) and limnic (L)), number of captured specimens (N), relative abundance (N%), summary statistics of total length in millimeters (mean ± one standard deviation (range)), absolute biomass (W) and relative biomass (W%) in grams.

Taxon	Habit	N (N%)	Total length (mm)	W (W%)
Elopiformes				
Elopidae				
Elops saurus Linnaeus, 1766	M, E	2 (0.04)	(70-74)	0.6 (0.02)
Clupeiformes				
Clupeidae				
Platanichthys platana (Regan, 1917)	E, L	7 (0.15)	(39-56)	5.7 (0.15)
Characiformes				
Characidae				
Hyphessobrycon igneus Miquelarena, Menni, López & Casciotta, 1980	L	1 (0.02)	27	0.7 (0.02)
Atheriniformes				
Atherinopsidae				
Atherinella brasiliensis (Quoy & Gaimard, 1824)	M, E	9 (0.20)	(36-49)	2.6 (0.07)
Odontesthes argentinensis (Valenciennes, 1835)	M, E, L	16 (0.35)	56 ± 8 (41-156)	30.1 (0.77)
Cyprinodontiformes				
Anablepidae				
Jenynsia lineata (Jenyns, 1842)	E, L	3187 (70.31)	35 ± 8 (10-73)	1953.0 (49.86)
Poeciliidae				
Phalloceros caudimaculatus (Hensel, 1868)	E, L	16 (0.35)	26 ± 3 (19-30)	3.0 (0.08)
Gobiiformes				
Eleotridae				
Eleotris pisonis (Gmelin, 1789)	M, E, L	10 (0.22)	101 ± 13 (80-120)	112.1 (2.86)
Dormitator maculatus (Bloch, 1792)	M, E, L	1 (0.02)	85	6.3 (0.16)
Gobiidae				
Awaous tajasica (Lichtenstein, 1822)	E, L	3 (0.07)	(45-93)	7.5 (0.19)
Ctenogobius stigmaticus (Poey, 1860)	M	27 (0.60)	66 ± 8 (40-78)	55.1 (1.41)
Gobionellus oceanicus (Pallas, 1770)	M, E, L	2 (0.04)	(110-145)	16.1 (0.41)
Cichliformes				
Cichlidae				
Geophagus brasiliensis (Quoy & Gaimard, 1824)	E, L	874 (19.28)	29 ± 14 (14-197)	648.9 (16.57)
Perciformes				
Carangidae				
Trachionotus marginatus Cuvier, 1832	M	28 (0.62)	46 ± 10 (28-66)	35.1 (0.90)
Serranidae				
Epinephelus marginatus (Lowe, 1834)	M	4 (0.09)	(77-89)	27.9 (0.71)
Sciaenidae				
Menticirrhus littoralis (Holbrook, 1847)	M	1 (0.02)	77	3.7 (0.09)
Micropogonias furnieri (Desmarest, 1823)	M, E	3 (0.07)	(129-138)	84.1 (2.15)
Mugiliformes				
Mugilidae				
Mugil curema Valenciennes, 1836	M, E, L	338 (7.46)	57 ± 14 (10-110)	920.9 (23.51)
Pleuronectiformes				
Paralichthyidae				
Citharichthys spilopterus Günther, 1862	M, E, L	2 (0.04)	(49-53)	1.9 (0.05)
Paralichthys orbignyanus (Valenciennes, 1839)	M, E	2 (0.04)	(46-53)	1.8 (0.05)
Total		4533 (100)		3917. 1 (100)

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a limnic/estuarine species with high toleration to increased salinity. Our data corroborate previous studies in similar southward systems, leading to the recognition of a possibly recurrent pattern in coastal streams or washouts of RSCP. More studies based on larger spatial and temporal coverage may contribute to the seasonal dynamics and diversity of the ichthyofauna in these peculiar environments.

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Author Contributions

Fernando Marques Quintela: Substantial contribution to concept and design of the study; contribution to data collection; contribution to manuscript preparation.

Fabiano Corrêa: Contribution to data analysis and interpretation; contribution to critical revision, adding intelectual content.

Adriana Gava: Substantial contribution to concept and design of the study; contribution to data collection; contribution to critical revision, adding intelectual content.

Conflict of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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