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SHORT REPORT **Open Access**

Presence of the red jollytail, *Brachygalaxias bullocki* (Regan, 1908) (Galaxiformes: Galaxiidae), in freshwater forested wetlands from Chile

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Abstract

Background: *Brachygalaxias bullocki* (Regan, 1908) is a small-sized freshwater fish species (41 to 46 mm) and endemic to Chile. Its biology has still various knowledge gaps, and its distribution range has been reduced in the last decade due to human intervention.

Findings: In this article, for the first time, its presence in forested wetlands of Chile (38°52′ to 39°02′ S) is documented. The presence of this species in these ecosystems is restricted to wetlands with permanent water regime and depths ranging from 15.7 to 83.5 cm.

Conclusions: The physicochemical habitat conditions show important seasonal variations, suggesting that *B. bullocki* is resistant to a wide range of temperatures, as well as different levels of dissolved oxygen and conductivity.

Keywords: *Brachygalaxias bullocki*; Fish fauna; Forested wetlands; Conservation

Findings

Brachygalaxias bullocki (Regan, 1908) is an endemic, small-sized (41 to 46 mm) fish species (Stokell 1954; Cifuentes et al. 2012). It is endemic to Chile and still several knowledge gaps about its biology exist (Habit and Victoriano 2012). It is a strict freshwater species inhabiting a wide variety of habitats, such as wetlands and floodplains in large rivers, small streams and littoral zones in lakes (McDowall 1971; Campos 1985). *B. bullocki* prefers habitats with submerged vegetation (both terrestrial and aquatic), either riffles or pools (García et al. 2012). Its distribution range has been described from the Itata River (36°28′ S) to the Maullín River (41°06′ S) and in the Chiloé Island (41°45′ to 43°25′ S) (Habit and Victoriano 2012). However, this distribution range has been reduced in the last decade mainly in those basins affected by high human intervention (Habit et al. 2010), as a result of forestry, urban growth, effluent discharges and species introduction (Ortiz-Sandoval et al. 2009; Correa-Araneda et al. 2010). Consequently, *B. bullocki* changes in the past 26 years from a vulnerable status of conservation (Glade 1988; Campos et al. 1998) to almost endanger (MMA 2014). Our goal is to document, for the first time, the presence of this species in forested wetlands of Chile, providing more evidence on the high conservation value of these ecosystems.

Fish samples were taken every 2 months, between April 2011 and March 2012, in five forested wetlands (38°33′ to 39°02′ S) (Figure 1A, Table 1) by means of a hand net. The largest possible number of microhabitats were sampled for 10 min (water column, islets, banks, roots, stems) (n = 6). Voucher individuals were preserved for further taxonomic identification (McDowall 1973; Ruiz and Marchant 2004).

In order to characterize the habitat, physicochemical parameters of the water were *in situ* measured (pH, conductivity, dissolved oxygen, temperature and turbidity). In addition, water samples were taken for their subsequent laboratory analysis (sulfate, total phosphorous, nitrates and total suspended solids). The hydroperiod of the wetlands was determined by means of autonomous sensors of water level (HOBO U20-001-02), which were calibrated for measurements at 1-h intervals during a period of 1 year (April 2011 to March 2012).

The results showed that all fish specimens collected corresponded to *B. bullocki* (n = 9) (Figure 1B). Although

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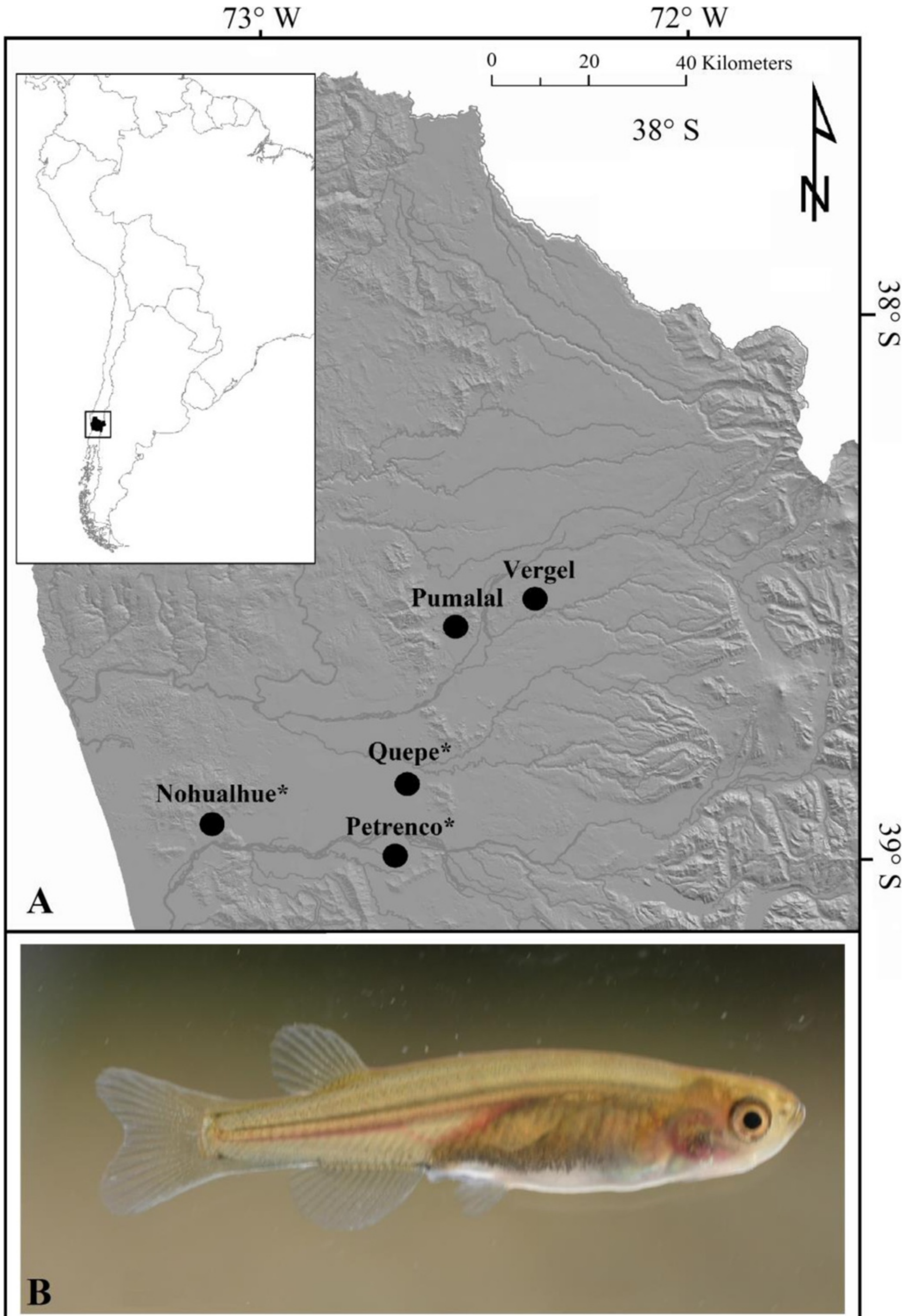

Figure 1 Location map of the studied wetlands (A) and image of an adult *Brachygalaxias bullocki* (B). *Wetlands where *B. bullocki* was recorded.

there may be certain features similar to the conspecific species *Brachygalaxias gothei* (Busse 1982), the latter species has been only described for small ponds near Talca (35°25′33.23″ S to 71°39′31.94″ W) (SUBPESCA 2005). In addition, Berra et al. (1995), Dyer (2000) and Ruiz and Marchant (2004) propose that *B. gothei* is a synonym of *B. bullocki*. The same criterion was used in the conservation status classification processes (MMA 2014).

B. bullocki was collected only in wetlands with a permanent water regime (Petrenco, Quepe, Nohualhue) (Table 1), which remained flooded throughout the year with depths that ranged between 15.7 and 83.5 cm. In contrast, wetlands with temporary water regime (Vergel, Pumalal) had a dry phase that lasted between 150 and 160 days (Table 1), which would be critical for the presence of *B. bullocki*. Beyond to water regime, all study sites are metabolically

Table 1 Presence and absence of *Brachygalaxias bullocki* in wetlands and their geographical, biological, morphometric and hydrological characterizations

	Petrenco	Quepe	Nohualhue	Vergel	Pumalal
Brachygalaxias bullocki	x	x	x		
South coordinates	39°02′20.29″	38°52′26.36″	38°58′0.72″	38°33′43.64″	38°35′55.34″
West coordinates	72°39′45.27″	72°36′56.02″	73° 4′34.59″	72°19′27.93″	72°30′59.57″
Vegetation association	Temu-pitra	Temu-pitra	Temu-pitra	Temu-pitra	Temu-pitra
Wetland surface (ha)	269	346	107	138	192
Elevation (masl)	94	95	26	182	158
Hydric regime	Permanent	Permanent	Permanent	Temporary	Temporary
Hydroperiod (days)	365	365	365	199	215
Non-flooded phase (days)	0	0	0	166	150
Maximum depth (cm)	69.7	59.9	83.5	82.4	51.5
Minimum depth (cm)	30.8	15.7	22.1	0	0

similar, since they accommodate temu-pitra forests (Correa-Araneda et al. 2011, 2012), belonging to the vegetation association of *Blepharocalyo-Myrceugenietum exsuccae* (Ramírez et al. 1995).

The preference of *B. bullocki* in habitats with submerged vegetation (García et al. 2012), where it lays its eggs (Campos 1972), is consistent with its presence in forested wetlands, dominated by native woody vegetation from 10 to 15 m in height (Correa-Araneda et al. 2012) of Myrtaceae family trees, including *Myrceugenia*, *Blepharocalyx*, *Luma*, *Tepualia* and Winteraceae (*Drimys winteri* JR et G. Forster) (Hauenstein et al. 2005; Correa-Araneda et al. 2011). Dead individuals from this vegetation create islets, roots and branches (Correa-Araneda et al. 2012), generating a highly heterogeneous habitat. These environments are particularly different from other wetlands, due to the permanent presence of large woody debris (LWD), low water temperatures and low light penetration. Therefore, these wetlands are metabolically similar to headwater rivers (Vannote et al. 1980), but with no current velocity. Indeed, these heterogeneous habitats when combined with low or null water current velocity result in optimal conditions for *B. bullocki*.

As reported by Campos (1972), *B. bullocki* feeds mainly on insect larvae, chironomids, amphipods, copepods and cladocerans. Consistently, Correa-Araneda et al. (In press) reported Chironomidae, Crustacea and Oligochaeta as dominant invertebrate taxa in permanent and temporary wetlands. Particularly in permanent wetlands, Chironomidae, Asellidae, *Hyalella* sp., Oligochaeta and *Smicridea* sp. are the taxa with the highest frequency of occurrence.

Physicochemical characteristics of the water in sites where *B. bullocki* was present showed an important seasonal variability, with some extreme values considering fish persistence (Table 2). Water has acidic pH (4.4 to 6.4) and has low conductivity in winter (37 μS/cm) and medium in summer (92 μS/cm). Dissolved oxygen showed drastic variations between winter (6.5 to 10.5 mg/L) and summer (2.2 to 3.6 mg/L). These levels recorded in summer, generally insufficient for the survival of fish fauna, indicate that

Table 2 Mean values of physicochemical variables recorded in forested wetlands (*n* = 3)

		Petrenco		Quepe		Nohualhue		Vergel		Pumalal	
	Unit	Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
pH	1 to 14 (H^+)	6.4	5.8	6.4	5.9	4.4	6.1	4.0	6.2	2.0	5.4
Conductivity	μS/cm	78.0	37.3	92.1	69.5	37.4	32.2	2.7	47.4	47.3	61.6
Dissolved oxygen	mg/L	2.2	6.5	3.6	7.0	2.6	10.5	5.8	7.0	1.1	5.8
Temperature	°C	12.5	7.3	16.0	8.4	8.6	6.9	8.1	7.6	3.7	7.3
Turbidity	NTU	3.0	42.5	8.8	30.7	6.9	7.5	73.3	5.9	100.0	171.7
DBO_5	mg/L	2.9	1.5	1.5	1.2	1.8	1.0	4.5	1.0	2.3	2.8
Total phosphorus	mg/L	0.1	0.0	0.1	0.0	0.0	0.0	0.2	0.0	1.7	0.1
NO_3^-	mg/L	0.4	0.1	347.2	1,069.0	358.5	0.8	0.3	4,719.0	0.1	0.5
TSS	mg/L	14.0	8.1	18.4	7.7	10.0	7.6	97.6	1.9	650.7	43.8
SO_4^{2-}	mg/L	3.3	0.5	3.8	1.1	3.6	1.1	4.1	0.6	1.1	1.8

Sum, summery; Win, wintry; TSS, total suspended solids.

in this season *B. bullocki* should migrate to more oxygenated areas, perhaps to ecotones with fluvial ecosystems, as recorded by Valdovinos et al. (2012). Temperature had the highest values in summer, ranging from 8.6°C to 16°C. Turbidity was higher in winter, peaking at 42.5 nephelometric turbidity units (NTU), whereas in summer the average maximum was 8.8 NTU. The same happened with total suspended solids, with a maximum value of 18.4 mg/L in summer. Seasonal changes of these variables are mainly due to an increase in sediment due to surface runoff during winter, which would involve significant changes to the fish fauna, as the decrease in light penetration affects the predator-prey relation (ANZECC and ARMCANZ 2000). Phosphorus levels were generally low, unlike nitrate, which reached 1,069 mg/L in the wetland Quepe in winter. Sulfate, used by primary producers, presented the same trend as the temperature and inversely to the dissolved oxygen, with the highest values in summer (3.8 mg/L). Therefore, summer conditions in these forested wetlands represent extreme conditions for the fish fauna. This is particularly relevant for *B. bullocki*, considering that young of the year of the species occur during spring and summer (Valdovinos et al. 2012).

This new record of *B. bullocki* reinforces the high conservation value of the forested wetlands and informed new characteristics of the habitat of an endemic fish species, with severe conservation status.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
FC carried out the sample collection and species identification and drafted the manuscript. PDR participated in the sampling and water physicochemical analyses and helped to draft the manuscript. EH carried out the final identification of the species and helped to draft and translate the manuscript. All authors read and approved the final manuscript.

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