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Review Article [[Q1: Q1]]

First report the role of benthic macroinvertebrates as preys for native fish in Toltén river (38° S, Araucania region Chile)

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(With 1 figure)

Abstract

The Toltén river is located in the 137 years old Araucania region, Chile (38° S), and is characterized by low alterations through human interference due agriculture and towns in its surrounding basin, the presence of native fishes and salmonids, and by its lake effluent regime originated from Villarrica lake. The aim of the present study was to make a review of ecological role of the benthic inland water macroinvertebrates as preys for native fishes of the River Toltén, in order to understand their importance in the ecosystem of the river. The literature revealed that the main prey for native fishes are Chironomidae larvae, nevertheless there are not specific reports for Tolten river. The exposed results are similar with similar native species for Patagonia, and these native species would have prey for introduced salmonids, or these species would have prey competition with introduced salmonids in according to the literature descriptions for Argentinean and Chilean Patagonia.

Keywords: Toltén river, North Patagonia, Chironomidae, native fishes, prey, predation salmonids.

Primeiro relate o papel dos macroinvertebrados como presas de peixes nativos no rio Toltén (38° S, região da Araucanía, Chile)

Resumo

O rio Toltén está localizado na região da Araucanía, com 137 anos de idade, Chile (38° S), e é caracterizado por baixas alterações por interferência humana devido à agricultura e cidades da bacia circundante, pela presença de salmonídeos e pelo regime de efluentes dos lagos. do lago Villarrica. O objetivo do presente estudo foi fazer uma revisão do papel ecológico dos macroinvertebrados bentônicos de águas interiores do rio Toltén, a fim de entender sua importância no ecossistema do rio. A literatura revelou que as principais presas de peixes nativos são as larvas de Chironomidae, no entanto, não há relatos específicos para o rio Tolten. Os resultados expostos são semelhantes com espécies nativas semelhantes para a Patagônia, e essas espécies nativas teriam presa por salmonídeos introduzidos, ou essas espécies teriam competição de presas com salmonídeos introduzidos de acordo com as descrições da literatura para a Patagônia Argentina e Chilena.

Palavras-chave: rio Toltén, Patagônia Norte, Chironomidae, peixes nativos, presas, salmonídeos predadores.

1. Introduction

The northern Patagonian Chilean rivers (38-41°S) are characterized by their origin from lake effluents (Niemeyer and Cereceda, 1984). These circumstances have generated, and still continue to generate, a specific composition in the benthic communities that are adapted to these particular flow conditions (Colin et al., 2012; Piedra et al., 2012).

The literature about macroinvertebrates in this kind of rivers is quite fragmented, and mainly describes the presence of Malacostraca such as amphipods of the genus *Hyalella* (S.I. Smith), freshwater crabs of the genus *Aegla* (Leach, 1820), and the southern Chilean river prawn, *Samastacus spinifrons* (Phillippi, 1882) (De los Ríos-Escalante et al., 2013; Jara, 2013; Rudolph, 2013), and Diptera, Trichoptera and Ephemeroptera larval stages (Figueroa, 2000; Figueroa et al., 2006, 2007), many of these groups are currently endangered due to human-induced alterations in their habitats and the introduction of

alien salmonids species since 1914 (Golusda, 1907, 1927; Barros, 1931; Wetzlar, 1979; Jara et al., 2006; Encina et al., 2017; Vega et al., 2017). The (introduced) salmonids, specifically, constitute non-selective, active predators (Soto et al., 2006, 2007; Fierro et al., 2012, 2015, 2016; Piedra et al., 2012; Valdovinos et al., 2012; Vargas et al., 2010, 2015). Also, some rivers of this kind have undergone alterations in their surrounding drainage basins, viz., through anthropogenic enterprises as agriculture, deforestation, forestatation, growing cities, industry, among others, these new conditions affect the water quality (Kristensen et al., 2009), and, by consequence, also the benthic species that are sensitive to water pollution are affected in their abundance (Figueroa et al., 2007; 2007; Tello et al., 2010; Vega et al., 2013, 2017; Gorski et al., 2015; Nimptsch et al., 2015).

The River Tolten is located in the young Araucania region founded in 1881 (Figure 1) and originates in the Villarrica lake (Niemeyer and Cereceda, 1984; Barile et al., 2018); its course includes zones with low levels of human intervention, close to its origin, and zones with increasing of human interference from the towns of Pitrufquén, and Toltén (Niemeyer and Cereceda, 1984). After 137 years the Araucanía region needs to have an inventory of its macrofauna of benthic invertebrates as a baseline to evaluate the impact of the anthropogenic activities growth and to generate conservation measures for the ecosystem of the rivers of the Toltén river basin (Yoshida and Uieda, 2014). Also, to know the roles of the macrofauna of the river and particularly of the native fish and introduced salmonids.

The aim of the present study was to make a review of the role of macroinvertebrate inland water in the ecosystem(s) of the Toltén river, which constitutes an important resource for the Araucania region as a fresh water source and also as a habitat for macroinvertebrates and fishes species.

2. Material and Methods

It was searched literature published between 1980 to present year, from scientific data bases (Scopus, 2019) and university libraries of the Araucania region for river

Figure 1. Map of Tolten river.

Toltén macroinvertebrate data obtained from thesis from 1980 to present year. Taxonomic names were confirmed and corrected in according to specialized literature (Jara et al., 2006; Dominguez and Fernandez, 2009; De los Ríos-Escalante et al., 2013; Jara, 2013; Rudolph, 2013). The online bibliographic database of the Universidad Catolica de Temuco, Chile, mainly Science Direct and Scielo, was used. In order to know the geographical distribution of the mentioned species and update their systematic classification, the link of (Global Biodiversity Information Facility, 2019) of the Global Biodiversity Information Facility (GBIF) was used.

3. Results and Discussion

3.1. Benthic communities under potentially native conditions

The reported studies for Toltén river are not precise about benthic invertebrate species (Ta, with exception to the presence of Ephemeroptera *Andesiops ardua* Vera et al. (2015), decapods *Aegla abtao* and *Aegla rostrata* (Jara, 2013), and crayfish *Samastacus spinifrons* (Rudolph, 2013), and *Hyalella chiloensis* (De los Ríos-Escalante et al., 2020). These scarce reports would be similar to existing descriptions of other Patagonian rivers (Arenas, 1995; Figueroa et al., 2007, 2007, 2010, 2013; Fierro et al., 2012, 2015, 2016; Encina et al., 2017). Previous reports thus indicate that the taxa Plecoptera, Ephemeroptera and Trichoptera larval stages and *Aegla* are abundant under turbulent flow, associated with a high oxygen concentration and much particulate matter that makes a food source (Oyanedel et al., 2008; Moya et al., 2009).

Nevertheless there are not detailed records about other invertebrates. We are not aware of the characteristics of the benthic ecosystem of the rivers of the Toltén river basin, however, there is no doubt that its current state reflects a degree of impact due to the diverse anthropogenic activities and climate change, reason why It makes it fundamental at this time to have a baseline of knowledge for future research (Vargas et al., 2010).

3.2. Trophic interactions between macroinvertebrates and fish

The literature about the trophic role of macroinvertebrate in inland waters revealed that in those ecosystems there are herbivorous, detritivores, shredders, omnivorous, carnivorous, and feed on vegetal residuals that originated from the surrounding catchment basins (Figueroa, 2000; Oyanedel et al., 2008, 2011; Moya et al., 2009; Encina et al., 2017; Vega et al., 2020). According to the literature (Tables 1 and 2), the amphipods feed on dead vegetal matter and macrophytes, whereas the Ephemeroptera, Trichoptera and Plecoptera larval stages are shredders and decapods feed on dead vegetal matter and also predate on freshwater mollusks, finally freshwater mollusks (gastropoda) are herbivores, detritivorous and scrappers.

The literature described the diet of five native species from Tolten river, *Trichomyecterus aerolatus* (Noa, 2013, Ferrada, 2015), *T. chiltoni* (Saez, 2013), *Cheirodon australe* (Quezada, 2014), *Percillia gillissi* (Padilla, 2015), and *Odonthestes mauleanum* (Bastías, 2013), their preys are mainly aquatic insects larvae, being Chironomidae larvae a common prey for all studied species (Table 2). The main preys reported (Table 3) were Chironomidae larvae for *T. aerolatus* (Noa, 2013, Ferrada, 2015), *T. chiltoni* (Saez, 2013), *C. australe* (Quezada, 2014), whereas for *P. gillissi* the main prey were Ephemeroptera larvae (Padilla, 2015), these results would indicate that *T. aerolatus, T. chiltoni* and *C. austral* would predate on the same prey, whereas *P. gillissi* would have a different main prey, that would indicate an specialized predation. Unfortunately, there are few reports of other native species, although it would be possible found predator prey interactions between *P. trutta* that would predate on decapods of *Aegla* genus (Encina et al., 2017), and simultaneously *Aegla* and aquatic insects can be an important preys for *O. mykiss* (Ruiz, 1993; Palma et al., 2002; Pascual and Ciancio, 2007; Penaluna et al., 2009), and these results are similar to observations for *O. tschawytsha* in the Allipen river, which is located in the same region, as well as for other rivers in northern Patagonia between 39° and 41°S (Soto et al., 2006, 2007; Arismendi et al., 2009).

Table 1. Trophic role of benthic invertebrate found Patagonian rivers (see: Vega et al., 2020).

Taxa	Role
Platyhelminthes	Predators, scavenger
Mollusca, Gastropoda	Herbivores, detritivorous, scrappers
Crustacea, Decapoda	Omnivores.
Crustacea, Amphipoda	Detrivorous (vegetal dead)
Insecta, Coleoptera	Predators
Insecta, Diptera	Herbivores, carnivores, scavengers, schredders, decomposers
Insecta, Ephemeroptera	Herbivores, schredders, detritivorous, carnivores, omnivores
Insecta, Hemiptera	Carnivores
Insecta, Plecoptera	Herbivores, schredders, carnivores
Insecta, Trichoptera	Perifiton scrapers, schredders, detritivorous, predators

Table 2. Carnivore freshwater native fish alimentation for Araucanian region. (P = Phylum; SP = Sub Phylum; C = Class; SpC = Superclass; SbC = Sub Class; O = Order; SO = Sub Order; F = Family.

Item	A	B	C	D	E
P. Arthropoda, C. Insecta					
O. Diptera, F. Chironomidae	X	X	X	X	X
O. Ephemeroptera					
F. Baetidae	X	X	X	X	
F. Leptophlebiidae	X			X	
F. Potamanthidae	X				
Ephemeroptera unidentified				X	
O. Plecoptera					
F. Austroperlidae		X			
F. Diamphipnoidae	X	X	X		
F. Gripopterygidae	X		X		
F. Perlidae	X		X		
Plecoptera unidentified				X	
O. Trichoptera					
F. Hydropsychidae (la)	X	X	X		
Trichoptera unidentified				X	
O. Coleoptera					
F. Elmidae				X	
F. Girinidae				X	
F. Hygrobiidae	X		X		
O. Odonata					
Familia NN					X
P. Nematoda un identified			X		
P. Arthropoda, C. Chelicerata					
O. Acari			X		
P. Arthropoda, C. Crustacea					
O. Branchiopoda.					
F. Daphniidae			X		
O. Maxillopoda					
C. Ostracoda					X
SbC. Malacostraca					
O. Peracarida					
S.O. Amphipoda. F. Hyalellidae			X		X

A = *Trichomycterus aerolatus* (Noa, 2013; Ferrada, 2015); B = *T. chiltoni* (Saez, 2013); C = *Cheirodon australe* (Quezada, 2014); D = *Percilia gillissi* (Padilla, 2015); E = *Odonthestes mauleanum* (Bastías, 2013).

The current presence of salmonids acclimatized to Chilean inland waters has evoked management regulations, which include a specific open sport fisheries season ranging between November and March (Chile, 2016). In spite of these measurements and the possible monitoring of their effects, there are only some previous studies that report about temporal variations in the potential preys of salmonids, as there are the young of the native fishes and benthic macroinvertebrates, but fortunately similar situations have been reported upon for other Chilean inland water ecosystems (Campos, 1972, 1973, 1985; Campos et al., 1993a, b, 1998; Arenas, 1978; Vila et al., 1999; Habit et al., 2006, 2010, 2012; Soto et al., 2006, 2007; Arismendi et al., 2009; Colin et al., 2012; Piedra et al., 2012; Valdovinos et al., 2012; Vargas et al., 2015; Encina et al., 2017; Vega et al., 2013; 2017).

3.3. Current trends in the ecology of macroinvertebrates in Tolten river

The current situation with regard to the ecosystem(s) of the River Tolten as estimated herein from literature data as well as a series of preliminary observations. Concurrently, it is necessary to perform detailed studies on the role of both the native and the introduced fishes in the now existing ecosystems, especially also their influence on the abundance of the various macroinvertebrate benthic species (see. e.g., Campos, 1973; Urzúa et al., 1977; Ferriz, 1984, 1989, 2000; Artigas et al., 1985; Ruiz et al., 1993; Ruiz, 1996; Ferriz and Salas, 1996; Macchi et al., 1999, 2007; Ruzzante et al., 1998; Habit et al., 2006, 2010, 2012; Soto et al., 2006, 2007; Colin et al., 2012; Piedra et al., 2012; Valdovinos et al., 2012; Vargas et al., 2015).

Other important factor that would affect the trophic interactions between fishes and benthic invertrebrates, in Tolten river would be the human intervention in the surrounding basin (Encina et al., 2017), in high zones there are agricultural zones, whereas in the medium zones of the stream, there is one small town (Pitrufquén), and in low zones of the stream there is one small town (Toltén) inevitably with the associated anthropogenic pollution (Rivera et al., 2004), such as was observed for Cautin river and Gibbgs channel that are associated to Temuco town (Figueroa, 2000; Correa-Araneda et al., 2010; Santiago et al., 2016)

Another important aspect is formed by the component of the salmonids in the ecosystem(s). These fishes are active predators on macroinvertebrates and fish, while the native fish, that predate, inter alia, on microcrustaceans and small larval insects stages. Together, these elements in the food web would have a potential cascade effect considering the trophic interactions between benthivorous fishes, and top predator fishes that would affect the low trophic levels on which also the macroinvertebrates must be important at bottom level (Habit et al., 2005; Soto et al., 2006, 2007; Arismendi et al., 2009; Penaluna et al., 2009). The literature revealed the existence of such cascade effects in small rivers and streams with presence of salmonids, where, in contrast, it is possible to find abundant populations of native fishes and benthic macroinvertebrates in both Argentinean and Chilean Patagonian rivers (Fischer, 1963; Grossman, 1993; Soto et al., 2006, 2007; Young et al., 2010; Ibarra et al., 2011), as part of complex trophic web interaction systems when no introduced salmonids are present (Ings et al., 2009; Woodward et al., 2010; Schmid-Araya et al., 2012). In conclusion, according to the present extensive literature research as well as to the preliminary observations made until now, it would be necessary to study the populations of benthic macroinvertebrates with an emphasis on the conservation biology of these taxa. Only then it shall be able to actually

Table 3. Summary of indicators used in stomach contents analysis (Nf: Numeric frequency; Of: Occurrence frequency; NNI: Numeric importance index) for native fishes reported at Tolten river. P = Phylum; SP = Sub Phylum; C = Class; SpC = Superclass; SbC = Sub Class; O = Order; S.O. = Sub Order; F. Family.

Item	A			B			C			D			E		
	Nf %	Of %	IIN %	Nf %	Of %	IIN %	Nf %	Of %	IIN %	Nf %	Of %	IIN %	Nf %	Of %	IIN %
P. Arthropoda, C. Insecta															
O. Diptera, F. Chironomidae (larvae)	64.9	93.8	62.9	86.5	70.6	78.1	94.1	95.0	94.5	81.1	98.3	89.3	31.4	13.3	20.4
O. Diptera, F. Chironomidae (pupae)	17.6	58.4	49.7	4.9	35.3	13.2	1.6	15.0	4.9	2.3	38.3	9.5			
O. Ephemeroptera															
F. Baetidae (ni)	1.38	12.3	22.8	1.3	17.6	4.8	1.1	10.0	3.3	< 0.1	0.8	0.1			
F. Leptophlebiidae	0.83	9.2	19.7	0.4	5.9	1.6									
F. Potamanthidae	0.28	3.1	11.4												
Ephemeroptera undentified													1.4	3.3	2.1
O. Plecoptera															
F. Austroperlidae															
F. Diamphipnoidae	0.83	7.6	18.0	0.9	14.7	3.6	0.5	5.0	1.6	< 0.1	0.8	0.1			
F. Gripopterygidae	8.53	29.2	35.1							0.1	4.1	0.7			
F. Perlidae	0.55	6.1	16.2	0.6	5.9	1.9				0.1	1.6	0.4			
Plecoptera unidentified													54.3	63.3	58.6
O. Trichoptera															
F. Hydropsychidae (la)	4.95	32.3	36.9	1.2	23.5	5.2	1.6	15.0	4.9						
Trichoptera unidentified													2.9	3.3	2.1
O. Coleoptera															
F. Elmidae													5.7	6.7	6.2
F. Girinidae													1.4	6.7	4.4
F. Hygrobiidae	0.14	1.5	8.1												
O. Odonata unidentified													2.9	3.3	2.1
P. Nematoda unidentified										2.0	39.1	10.7			
P. Arthropoda, C. Chelicerata															
O. Acari															
P. Arthropoda, C. Crustacea															
O. Branchiopoda.															
F. Daphniidae										< 0.1	0.8	0.1			
O. Maxillopoda															
S.C. Malacostraca															
O. Peracarida															
S.O. Amphipoda. F. Hyalellidae										10.9	45.8	22.3			

A = *Trichomycterus aerolatus* (Ferrada, 2015); B = *Trichomycterus aerolatus* (Noa, 2013); C = *T. chiltoni* (Saez, 2013); D = *Cheirodon australe* (Quezada, 2014); E = *Percilia gillissi* (Padilla, 2015). References for used indicators: Nf (Hyslop, 1980); Of (Windell, 1971); IIN (Windell, 1971).

evaluate their important role in the ecosystem of the river as detritivorous of particulate organic matter, among others, and as prey of the endemic, native fishes. This would also clearly reveal the potential threats posed by the predation activity of introduced salmonids, and as a result of the changes due to human alterations in the surrounding catchment basins.

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