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## Research Article

# Diet of juvenile *Percichthys trucha* (Teleostei: Percichthyidae) in Northern Patagonia: the importance of the littoral zone

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**Abstract:** The creole perch, *Percichthys trucha* is endemic to southern South America. The objective of this work was to identify the food groups of juvenile perch (up to one year old) in its natural environment, the Espejo Chico Lake. A total 99 individuals fromwere caught, measured and weighed, and their condition factor (K) was calculated. In the diet analyses, nine different groups (orders) were found in the stomach contents: Diplostraca, Cyclopoida, Amphipoda, Diptera, Coleoptera, Ephemeroptera, Plecoptera, Hymenoptera and Odonata. Food items showed no correlation with fish size (<29, 30-49, 50-69 and 70-89 mm). Diptera and amphipods inhabiting littoral areas were the main food items of the juveniles. We can suppose that the Creole perch prefer the littoral zone as a nursery; this obviates the need to migrate to the limnetic zone, since the littoral zone provides better food, stable physical habitats and refuge, and a higher concentration of dissolved oxygen than deeper zones, both for macroinvertebrates and perch.

**Keywords:** Connectivity, Habitat, Native fish, Food items, Patagonia.

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## Introduction

The Creole perch, *Percichthys trucha* (Valenciennes, 1833) (Percichthyidae) is endemic to southern part of South America, inhabiting Patagonian river and lakes from 38ºS to 55ºS (Arratia 2003). This species is a key member of fish communities in Patagonian freshwater bodies, being the largest native fish species within its range (reaching up to 430 mm in length). Its presence modulates the composition of fish communities in the region; before introduction of salmonids, it was the sole top predator (Macchi et al. 2007; Lopez Cazorla & Sidorkewicj 2011; Fernández et al. 2018).

*Percichthys trucha* spawns during October-November in shallow vegetation of littoral areas (Buria et al. 2007). Their eggs are developed in 19-26 days in a temperature ranging 8-20°C, and embryos hatch at sizes of 5.4-7.0mm. Depending on their diet, they can reach 40mm total length (TL) 150 days after hatching (Crichigno et al. 2014). Previous studies have analyzed the diet of older Creole perch (over one year old) reporting insect larvae and pupae (Chironomidae: Diptera), amphipods (*Hyalella*), crayfishes (*Samastacus* spp.), freshwater crabs (genus *Aegla*), and *Galaxias maculatus* as its diet (Juncos et al. 2013). In the laboratory, the Creole perch was 5.4mm on hatching, and 100% of hatched individuals feed for the first time between 2-4-day post hatching (Crichigno et al. 2014). In Patagonia, Argentina (Rivadavia Lake), main diet items of juvenile perch (10-49mm standard length=SL) were chironomid larvae (Diptera) and amphipods (Amphipodae) (Lattuca et al. 2008). No studies have been carried out during first stages of the life cycle of

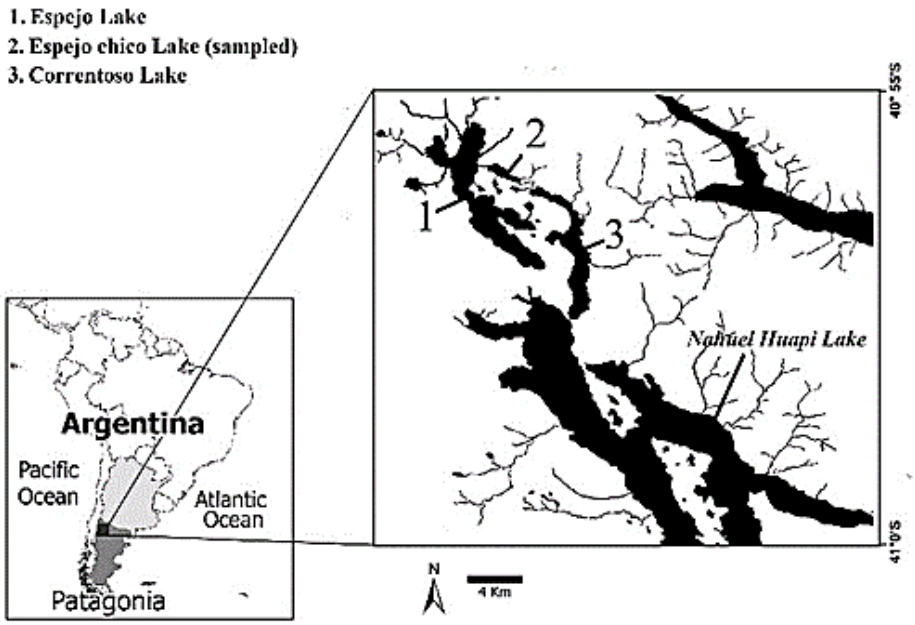


**Fig.1.** Map of Correntoso basin (40º66´S, 71º66´O), Argentina; 1, Espejo Lake; 2, Espejo Chico Lake (sampled); 3, Correntoso Lake.

the Creole perch in northern Patagonia. Hence, this work was aimed to identify the food groups of juveniles Creole perch in northern Patagonia Argentina, up to one year old, in its natural habitat.

## Materials and Methods

**Study area:** The Correntoso basin (40º66´S, 71º66´W) covers 419.06km$^2$ locating in northern Argentine Patagonia, within Nahuel Huapi National Park (NHNP), one of the largest national parks in southern South America. The Correntoso basin comprises the Espejo, Espejo Chico and Correntoso lakes, which are all interconnected by a river and also fed by tributary streams, some of which are connected by shallow lagoons (Fig. 1). It is also connected to Nahuel Huapi Lake, the largest water body in NHNP, which drains into the Limay River. The Espejo Chico Lake presents an area of 0.040Km$^2$ and a maximum depth of 100m, locating between the Espejo and Correntoso lakes. Its aquatic vegetation is present near-shore in small patches, dominated by *Myriophyllum* sp., *Juncus* sp., *Scirpus californicus*, *Isoëtes savatieri* and *Equisetum bogotensis* (Thomasson 1959). This basin presents three native fish species of *G. maculatus* (Jenyns, 1842), *G. platei* (Steindachner, 1898) and *P. trucha* (Cuvier & Valenciennes, 1840), and three introduced one, including *Salmo trutta* (Linnaeus, 1758), *Salvelinus fontinalis* (Mitchill, 1814) and *Oncorhynchus mykiss* (Brevoort 1856) (see Fernández et al. 2018).

**Fish collection:** Fishes were caught using seine nets in littoral areas (<4m depth) of Espejo chico Lake during all seasons, between 2015 and 2018. Relative abundance was calculated as captures per unit effort (CPUEN), standardizing the number of fishes caught by the seining distance (for seine nets) per 100. Total length of each individual was measured to the nearest mm and weighed to the nearest gram, and scales were sampled over the lateral line of individuals. To corroborate that the individuals were less than a year old, scales were mounted on slides and annulation patterns were evaluated based on Lopez Cazorla & Sidorkewicj (2011). We calculated the condition factor (K) using the equation of $K=100W / L^3$, where W=total weight in gram of the fish and L=total length in millimeter.

**Diet analyses:** The entire stomach contents of each specimen preserved in 80% alcohol. The procedure for the diet analysis involved dissection and stomach removal. The contents were washed out with normal

**Table 1.** Frequency of occurrence prey items (F%) of juvenile perch.

| Prey items | subphylum | Order | Family | frequency of occurrence (% F) |
|---|---|---|---|---|
| PHYLUM ARTHROPODA | CRUSTACEA | **Cyclopoida** | | 0.4 |
| | | **Amphipoda** | Hyalellidae | 41 |
| | | **Diplostraca** | Chydoridae | 9.7 |
| | INSECTA | **Coleoptera** | | 0.4 |
| | | **Diptera** | Chironomidae SubFamily: Tanypodinae and | 45 |
| | | **Ephemeroptera** | | 0.9 |
| | | **Hymenoptera** | | 0.6 |
| | | **Odonata** Infraorder Zygoptera | Lestidae | 1.1 |
| | | **Plecoptera** | | 0.9 |

saline and examined under stereo microscope. Food items were identified to the lowest possible taxonomic level using local taxonomic literature (Massaferro 2011). In the case of highly degraded organisms, only heads were counted. Given the low juveniles abundance, we analyzed the diet of total sample without discriminating by season.

For each fish, frequency of occurrence (%F), percentage by number (%N) and contribution of each food category (i) were determined as follows: $\%F_i=100\ N_i\ N_t^{-1}$, where $N_i$ is the number of fishes containing prey category i in the stomach and $N_t$ is the total number of fishes containing food in the stomach. $\%Ni=100\ Ni\ Nt^{-1}$, where $N_i$ is the total number of items of prey category i, and $N_t$ is the total number of items of all prey categories (Lattuca et al. 2008). We considered variation in the diet according to size based on Lattuca et al. (2008), grouping individuals into four size categories (<29, 30-49, 50-69 and 70-89mm).

**Data analyses:** A spearman range was used to correlate the total items in each stomach with the total length and weight of fishes, and the total-length groups with the frequency of occurrence of items (%) and richness of food items (Fritz 1974).

## Results

A total of 98 Creole perch juveniles were caught during the sampling period in Espejo chico Lake (CPUEN=3.26). The overall size distribution ranged 22-88mm (mean=37.4±12mm). The overall weight distribution ranged 0.13-8.26g (mean=0.96±1.3g). The condition factor (K) of juveniles ranged 0.69-1.55 (mean=1.17±0.16). Of total fish caught, 24% had empty stomach. The number of food items within each stomach was not correlated with fish size (ρ; P=0.078; N=98), or fish weight (ρ; P=0.055; N=98). No significant correlation found between size and food items (ρ; P=0.73; N=98, $P>0.05$) for each food item.

Nine groups (orders), inhabiting the littoral zone, were found in the stomach contents, belonging to Diplostraca (fam. Chydoridae), Cyclopoida, Amphipoda, Diptera (fam. Chironomidae; subfam. Chironominae and Tanypodinae), Coleoptera, Ephemeroptera, Plecoptera, Hymenoptera and Odonata (fam: Lestidae). Analysis based in frequency of occurrence (%F) showed that the order Diptera accounted for 45% of items in the stomach contents, followed by Amphipoda (41%) and Cladocera (9.7%) (Table 1); although there was no significant correlation between juvenile size and food item, we observed that smaller sized individuals consume a higher number of orders. The smallest size, <29mm, fed on six orders (Cyclopoida, Diplostraca, Amphipoda, Diptera, Ephemeroptera

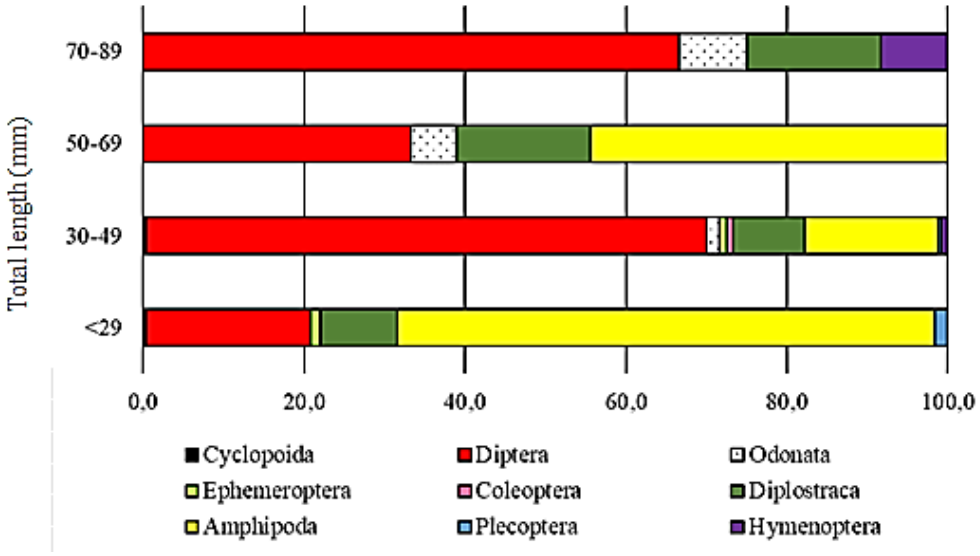


**Fig.2.** Juvenile perch diet; frequency of occurrence of food items (%F) by Total Length class.

and Hymenoptera); individuals of 30-49mm group fed 9 orders (Cyclopoida, Diplostraca, Amphipoda, Diptera, Ephemeroptera Coleoptera, Odonata, Plecoptera and Hymenoptera); those of 50 -69mm fed 4 orders (Diplostraca, Amphipoda, Diptera and Odonata), and those 70-89mm fed on 4 orders (Diplostraca, Diptera, Odonata and Hymenoptera) (Fig. 2).

## Discussion

Littoral zooplankton and macroinvertebrates were the most important items in the diet of *P. trucha* in 0+ age class, in natural environments. In this study, we found that juveniles, up to one year old and under 88mm TL, fed on nine different orders. Diptera, Amphipoda and Diplostraca are the most important food items. This information is in agreement with previous studies carried out in a Patagonian lake (Rivadavia Lake), which indicated similar food items for perch less than one year of age, listing: chironomid larvae (Diptera), Anisoptera larvae (Odonata), copepods (Cyclopoida Copepoda), amphipods, and Oligocheta (Lattuca et al. 2008). All the studied perch juveniles presented a favorable health status according to the condition factor (K), suggesting that these food items provide the energy necessary for their growth in the littoral zone.

A change in diet was observed as size increased; the diversity of food items decreased and Amphipoda were replaced by Hymenoptera and Odonata. This could be because the larger the size of the individual have larger mouth, therefore they can consume larger food items with greater energetic value, such as larvae, pupae and adult insects (Ciancio & Pascual 2006; Juncos et al. 2011). Similarly, previous studies mentioned a shift in the diet of *P. trucha*, incorporating larvae, juveniles and adults of *G. maculatus* into their diet when they reach 95mm, and *Samastacus* sp. at a larger size (Macchi et al. 2007; Juncos et al. 2015). This shift (with a reduced number of food items and an increase in the energy quality of the prey) may be associated with an increase in size and sexual maturity. In a natural environment, juveniles are associated with near-shore habitats of the shallow littoral zone, with abundant submerged vegetation, and about half a cohort matures sexually by their first year (Fernandez et al. 2019).

The littoral zone in Patagonian shallow lakes provides the macroinvertebrate community with stable habitats, a diverse food source, refuge from predators, and a higher concentration of dissolved oxygen than deeper zones (Sagrario et al. 2009). In fact, the chironomid larvae which are constituted the main food item for perch (45%), are frequently associated with the sediment of the lakes where they

inhabit, as well as the submerged macrophytes, which use as support, refuge and a food source (Williams et al. 2016). In addition, several studies have reported the importance of macrophytes in shallow lakes as refuges for zooplankton that migrats to the edge of macrophyte during daytime (diel horizontal migration to seek refuge from planktivorous fish) (Balseiro 1992). These studies and our results indicate that macrophytes patches of the littoral zone are key elements in lake functioning, distribution of a macroinvertebrates and zooplankton assemblies, and fish population.

In freshwater lakes, connections between littoral and pelagic habitats vary according to lake size and type, and depend on the daily and seasonal movement patterns of the fish species, and their food items (cladocerans and copepods) (Dolson et al. 2009). Some fishes such as galaxiids (*G. maculatus* and *G. platei*) and the atherinid *(Odonthestes hatcheri*) connect the littoral and pelagical habitat in Patagonia. Soon after hatching, they migrate from the littoral into the pelagic habitat and return to the littoral area after metamorphosis (Milano et al. 2006). Previous studies carried out in Patagonia found galaxiid larvae, but did not find *P. trucha* larvae in the limnetic zone (Barriga et al. 2002; Rechencq et al. 2011). This, added to the diet of juveniles (up to one year old) associated with the littoral zone leads us to suppose that Creole perch prefer the littoral zone as a nursery. In this way, they avoid the need to migrate to the limnetic zone, since the littoral zone provides refuge and diverse and abundant food items; unlike other native fish, perch do not connect the littoral and limnetic areas.

## Conclusion

In this study, we have presented a first record of the diet of perch juveniles (up to one year old). Our study provides basic information on the condition factor (K) and diet of a major fraction of perch populations in the Correntoso system. *Percichthys trucha* is an important predator of the macroinvertebrate community in Espejo Chico lake. Our results contribute to knowledge of this species for future studies and conservation plans.

## Acknowledgements

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**مقاله پژوهشی**

# رژیم غذایی نابالغین سوف ماهی کرئول *Percichthys trucha* (شعاع بالگان: پرسیکتیده) در پاتاگونیای شمالی: اهمیت ناحیه لیتورال

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**چکیده:** سوف ماهی کرئول *Percichthys trucha* گونه بومزاد بخش جنوبی آمریکای جنوبی است. هدف از انجام این پژوهش شناسایی گروه‌های غذایی در نابالغین (تا سن یک سالگی) در محیط طبیعی آن در دریاچه اسپچوپیکو بود. در مجموع ۹۹ مورد ماهی نابالغ صید، اندازه گیری و وزن شد و فاکتور وضعیت (K) آن‌ها محاسبه گردید. در تجزیه و تحلیل‌های رژیم غذایی، نه گروه مختلف در محتوای معده این ماهیان یافت شد: شامل Diplostraca (Chydoridae)، Cyclopoida، Amphipoda، Diptera، Coleoptera، Ephemeroptera، Plecoptera، Hymenoptera و Odonata. بین ارقام غذایی و اندازه ماهی (<۲۹، ۳۰-۴۹، ۵۰-۶۹ و ۸۹-۷۰ میلی متر) هیچ همبستگی معنی داری مشاهده نشد. گروه Diptera و آمفیپدهای ساکن مناطق لیتورال اصلی‌ترین ارقام غذایی این ماهیان بودند. می‌توان این‌گونه فرض کرد که سوف ماهی کرئول، منطقه لیتورال را به‌عنوان منطقه نوزادگاهی ترجیح می‌دهد، و با توجه به این‌که این زون دارای غذای بهتر، زیستگاه‌ها و پناهگاه‌های پایدارتر و غلظت اکسیژن محلول بالاتری نسبت به زون‌های عمیق‌تر است، نیاز به مهاجرت به زون لمنتیک در این ماهی و همچنین بی‌مهرگان کفزی را رفع می‌کند.

**کلمات‌کلیدی:** ارتباط، زیستگاه، ماهی بومی، گزینه‌های غذایی، پاتاگونیا.