*Zoodiversity*, **55**(3): 195–200, 2021
DOI 10.15407/zoo2021.03.195

UDC 574.58:595.2(23.071:83)

# FIRST DESCRIPTIONS OF AQUATIC ARTHROPODS IN AN UNPOLLUTED NATIVE FOREST RELICT (RUCAMANQUE, 38° S, ARAUCANIA REGION, CHILE)

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**First Descriptions of Aquatic Arthropods in an Unpolluted Native Forest Relict (Rucamanque, 38° S, Araucaria Region, Chile). De los Ríos-Escalante, P., Alejandro Espinosa, A., Núñez, P.** — The Araucania region (38° S, Chile) originally had native perennial forest in middle valleys regions, that was gradually replaced by towns and agricultural zones during the last century, nevertheless there is some relicts of these native forests that are preserved, one of these relicts is Rucamanque, a protected area in the surrounding of Temuco town. The aim of the present study was a first aquatic Arthropoda description in a stream of this protected area using species co-occurrence and niche overlap null models. The results of species co-occurrence null model revealed that species associations are random, whereas the results of niche sharing revealed that species reported have different ecological niches, and in consequence there is not interspecific competence. The exposed results revealed the presence of aquatic fauna representative for unpolluted streams; similar descriptions were found for other similar inland water ecosystems in Argentinean and Chilean Patagonia.
Key words: aquatic insects, crustaceans, community, null models, Patagonia, relict forest.

## Introduction

The inland water fauna in Chile is characterized by their marked endemism (Jara et al., 2006; Domínguez & Fernández, 2009; De los Ríos-Escalante et al., 2013; Jara, 2013; Rudoplh, 2013), that is enhanced at small spatial scales, such as small valleys (Jara, 2013; Rudolph, 2013). In this context, there are many species poorly studied or endangered by habitat reduction because during the last century it has a marked replace of native perennial forest by different kind of human activities, such as towns or agricultural zones (Jara, 2013; Rudolph, 2013).

In this context, in northern Chilean Patagonia (38–42° S), there are many protected areas with native perennial forest with many kind of unpolluted water bodies such as wetlands, streams and small lakes associated, that are poorly studied in their aquatic fauna (Correa-Araneda et al., 2017). Also, other important risk for invertebrate native species conservation is the presence of introduced salmonids that are very invasive species that has a strong predator against native benthic fauna, specifically insects and crustaceans (Soto et al., 2006, 2007; Encina et al., 2017).

In this context, the main component of benthic fauna in aquatic streams are larvae of aquatic insects, and decapods (Valdovinos et al., 2010), being some of these groups very sensitive to aquatic pollution, being a potential bio-indicator species (Figueroa et al., 2003, 2007; Correa-Araneda et al., 2010; De los Ríos-Escalante et al., 2020 a; Figueroa & De los Ríos-Escalante, in press). In this context, it would have species present only in unpolluted zones, such as native forest zones as protected areas, that are located in mountain zones with long mountain paths and access difficult (De los Ríos-Escalante et al., 2013).

One of these sites is the called Rucamanque, that is a zone located in mountains (400 m a. s. l.) in middle valley in the surrounding of Temuco town, this site is a relict of perennial native forest, that would be the original vegetation before Chilean occupation and colonization of Araucania region (Salas, 2002, Fierro et al., 2011). This site is unpolluted with presence of small pristine streams (Barra & Riquelme, 2017; Riquelme & Barra, 2017). The aim of the present study is do a first community description of aquatic Arthropoda, collected in a stream of Rucamanque forest, using null models in ecology for determine the presence or absence or structured patterns.

**Material and methods**

Study area: Rucamanque forest (38°39´ S; 72°35´ W, fig. 1) is a relict of native forest located in the surroundings of Temuco town with 435.1 Ha, this site has native forest with *Aetoxicon punctatum* Ruiz et Pav., *Nothofagus obliqua* (mirb) Oerst., *Eucryphia cordifolia* Cav., *Laurelia sempervirens* Ruiz et Pav, *Persea lingue* Ruiz et Pav., *Lauereliopsis philipiana* (Looser) Schode and *Weinmannia trichosperma* Cav. (Salas, 2002; Fierro et al., 2011). This site has numerous mountain paths with small streams with access difficult, the studied site was a small stream located inside the park after walking a long mountain paths (Riquelme & Barra, 2017).

The site was visited at April and May 2017, that corresponded to southern autumn, when the stream is present, because it has low flow in summer due dry season the stream is located in mountain slope with native forest. Benthic samples were taken using 50 x 50 cm Surber net randomly of 500 $m^2$ mesh size, five samples at April, and three samples at May. Collected specimens were fixed in absolute ethanol, quantified and identified in according to literature descriptions (Dominguez & Fernandez, 2009).

A species presence/absence matrix was constructed, with the species in rows and the sites in columns. Thirdly we calculated a Checkerboard score ("C-score"), which is a quantitative index of occurrence that measures

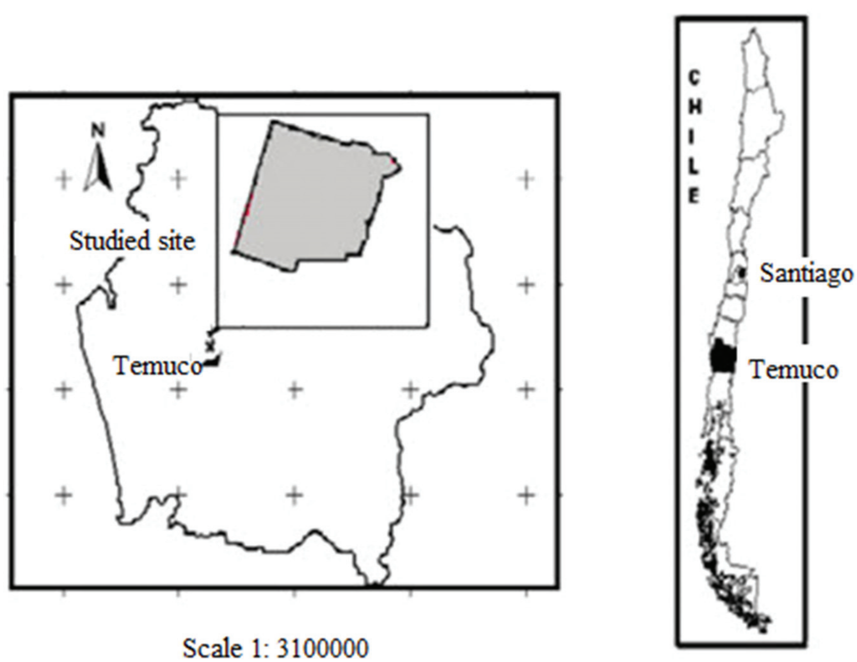


Fig. 1. Map of studied site (adapted from Fierro et al., 2011).

the extent to which species co-occur less frequently than expected by chance (Gotelli, 2000). A community is structured by competition when the C-score is significantly larger than expected by chance (Gotelli, 2000; Tondoh, 2006; Tiho & Josens, 2007). Thirdly we compared co-occurrence patterns with null expectations via simulation. Gotelli & Ellison (2013) suggested the as statistical null models Fixed-Fixed: in this model the row and column sums of the matrix are preserved. Thus, each random community contains the same number of species as the original community (fixed column), and each species occurs with the same frequency as in the original community (fixed row). The null model analyses were performed using the software R (R Development Core Team, 2009) and the package EcosimR (Gotelli & Ellison, 2013; Carvajal-Quintero et al., 2015).

For niche overlap analysis was built an individual matrix in which rows and columns represented species and sites respectively and it was tested if niche overlap significantly differed from the corresponding value under the null hypothesis (in example random assemblage), it was applied for data of the second field period. It used Pianka index. This model is based in median table that show the probability in that the niche sharing is compared with the niche overlap of the community simulated (Gotelli & Ellison, 2013). The niche amplitude can be retained or reshuffled, when it is retained it preserves the specialization of each species, whereas when it is reshuffled normally it used a wide utilization gradient and in fact, it will occur a wide niche overlap in the simulated community in comparison to the real community. Also, the zero states are retained or simulated the zero participation in the observed matrix is maintained or not in each simulated matrix. In the present study it used the algorithm RA3 (Gotelli & Ellison, 2013; Carvajal-Quintero et al., 2015). The model RA3 retains the amplitude and reshuffled the zero conditions (Gotelli & Ellison, 2013). This null model analysis was carried out using the software R (R Development Core Team, 2009) and the package EcosimR (Gotelli & Ellison, 2013; Carvajal-Quintero et al., 2015).

## Results and discussion

The results revealed the presence of low species number and abundances for two sampled periods, being the sample of May with high species number and high individual abundances (table 1), the species reported corresponded mainly to aquatic insect (Ephemeroptera, Plecoptera and Trichoptera) and the decapod *Aegla manni* that are representative of unpolluted streams. The results of null models revealed first that species associations are random, or without structuration for two sampled periods and for total data (table 2), whereas the niche sharing revealed niche sharing due absence of interspecific competition absence for both sampled periods and total data (table 2).

The exposed results agree with observations for unpolluted central and north Patagonian rivers (36–40° S), where the observed groups are dominant under low or null human intervention (Figueroa et al., 2003, 2007), similar result has been observed

**Table 1. Macroinvertebrate abundances (in ind/m$^2$) obtained in study site (38°39′41″ S; 72° 35′57″ W)**

| Taxon | April | | | | | May | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 |
| Oligochaeta | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Insecta | | | | | | | | |
| Ephemeroptera | | | | | | | | |
| *Chiloporter* sp. Lestage 1831 | 0 | 0 | 0 | 0 | 0 | 8 | 4 | 0 |
| *Asthenopus* sp. Eaton, 1871 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Plecoptera | | | | | | | | |
| *Diamphipnoa* sp. Gerstaecker, 1873 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 |
| *Diamphanopsis* sp. Illies, 1960 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 |
| Perlidae indet. | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| Trichoptera | | | | | | | | |
| *Plectromacronema* sp. Ulmer, 1906 | 0 | 8 | 0 | 8 | 0 | 4 | 0 | 0 |
| Anamalopsychidae indet. | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| Trichoptera indet. | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 |
| Crustacea | | | | | | | | |
| Malacostraca | | | | | | | | |
| Decapoda | | | | | | | | |
| *Aegla manni* Jara, 1980 | 8 | 4 | 0 | 0 | 1 | 0 | 0 | 8 |

**Table 2. Results of null models for corrected data**

| | Mean index | Observed index | Variance | P |
|---|---|---|---|---|
| Species co-occurrence | | | | |
| Total | 1.577 | 1.536 | 0.005 | 0.323 |
| April | 1.142 | 1.157 | 0.006 | 0.642 |
| May | 0.500 | 0.532 | 0.008 | 0.999 |
| Niche sharing | | | | |
| | Mean index | Observed index | Variance | P |
| Total | 0.173 | 0.177 | 0.002 | 0.412 |
| April | 0.253 | 0.227 | 0.006 | 0.555 |
| May | 0.382 | 0.568 | 0.018 | 0.145 |

for pristine rivers and streams in central Patagonian rivers (44–46° S), and mountain rivers in Araucania region (De los Ríos-Escalante et al., 2020 a; Solís-Lufí et al., 2021; Figueroa & De los Ríos-Escalante, in press) where both groups are markedly dominant (Oyanedel et al., 2008; Moya et al., 2009; Valdovinos et al., 2010). In this context, the presence of aquatic insect larvae and decapods is interesting on the biogeographical view point, because insects in comparison to crustaceans have more dispersion capacity by flying adult stages that can be colonize new habitats, whereas decapods, do not have this dispersion capacity, but they can stay permanently in water bodies (Valdovinos et al., 2010). These results would agree with first crustacean descriptions for Rucamanque, where was found *A. manni* and *Parastacus* sp. breathers (Riquelme & Barra, 2017), and also it was observed the presence of a *Samastacus spinifrons* adult specimen (fig. 2, personal observations).

The presence of decapods, are representative also in inland water bodies of Chilean Patagonia (Jara, 2013), and they are an important component in benthic communities (Encina et al., 2017; Vega et al., 2017; Solis-Lufí et al., 2022; De los Ríos-Escalante et al., 2020 b; Figueroa & De los Ríos-Escalante, In press). In this context, the decapods and aquatic insect larvae reported in the present study are important as shredders, because they would feed on vegetable matter that are very important component in unpolluted zones in streams (Schmid-Araya et al., 2012; Encina et al., 2017; Vega et al., 2017; Figueroa & De los Ríos-Escalante, in press). The reported site has not fish populations, and in this context, the reported fauna would agree with descriptions of Encina et al. (2017).

The results of null models, agree with literature descriptions for Chilean inland waters, where it was found non-structured patterns in species associations, due few species with many species repeated by sites, but niche sharing revealed niche sharing due absence of interspecific competition absence for both sampled periods and total data that is similar to observed for mountains streams (De los Ríos-Escalante et al., 2020 a), but markedly opposite to other inland water ecosystems such as north Patagonian lakes (De los Ríos-Escalante & Woelfl, 2017). These results would agree with literature about benthic fauna in Chilean

Fig. 2. Photograph of *Samastacus spinifrons* (Phillippi, 1882) collected in Rucamanque stream.

rivers, where it is possible found many repeated species and ecological specialization among a wide geographical gradient (Figueroa et al., 2003, 2007; Palma et al., 2013).

The exposed results would indicate that would be necessary more systematic ecological study for understand structure and function of aquatic invertebrate in unpolluted sites, and the importance as source role for conservation biology.

The present study was founded by project MECESUP UCT 0804, and Universidad de la Frontera (Forestal Sciences Department), also the author express his gratitude to M. I., and S. M. A. for their valuable comments for improve the manuscript.

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Received 31 July 2020
Accepted 5 May 2021