Scientific Note

Null models for explain aquatic insects communities in a northern Patagonian river (Maquehue 38°S, Araucanía region, Chile)

Modelos nulos para explicar comunidades de insectos acuáticos en un río del norte de la Patagonia (Maquehue 38°S, Región de la Araucanía, Chile)

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Abstract. The communities of aquatic insects in Chilean inland waters are characterized by the presence of determined species in function of water quality, but there is scarce information about statistical ecology in insects communities structure. The aim of the present study was to apply the null models for explain the structure of aquatic insects in Maquehue, a small river located in an agricultural zone close to Temuco town (38°S, Araucanía region, Chile). The results of species co-occurrence null models revealed that species associations are random, whereas the niche sharing revealed that species share ecological niche, and in consequence there are interspecific competition. The reported taxa are similar with communities for other north Patagonian rivers, about community structure.

Key words: Aquatic insects; invertebrate communities; Patagonia.

Resumen. Las comunidades de insectos acuáticos en aguas continentales chilenas se caracterizan por la presencia de determinadas especies en función de la calidad del agua, pero hay escasa información sobre estadística ecológica de la estructura comunitaria de los insectos acuáticos. El objetivo del presente estudio es aplicar modelos nulos para explicar la estructura de comunidades de insectos acuáticos en Maquehue, un pequeño río situado en una zona agrícola cerca de la ciudad de Temuco (38°S, Región de la Araucanía, Chile). Los resultados del modelo nulo de co-ocurrencia de especies revela que las asociaciones de especies son aleatorias, mientras que el modelo nulo de sobreposición de nicho arrojó que las especies comparten el nicho ecológico y en consecuencia hay competencia interespecífica. Los taxones reportados son similares a los de las comunidades de otros ríos del norte de la Patagonia en cuanto a su estructura comunitaria.

Palabras clave: Insectos acuáticos; comunidades de invertebrados; Patagonia.

The aquatic insect communities in Chilean rivers and streams are characterized by the presence of high species richness and high endemism (Figueroa *et al.* 2003, 2007, 2010,

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2013; Moya *et al.* 2009; Oyanedel *et al.* 2008; Figueroa and De los Ríos-Escalante 2022), the literature revealed the existence of endemic species (Vera *et al.* 2015; Domínguez and Fernández 2009). The literature mentioned that community's species changes in function to water quality (Figueroa *et al.* 2003, 2007; De los Ríos-Escalante *et al.* 2020; Figueroa and De los Ríos-Escalante 2022), nevertheless, the literature of statistical ecology on aquatic invertebrates are scarce (De los Ríos-Escalante *et al.* 2020; Figueroa and De los Ríos-Escalante 2022). The aim of the present study is to describe benthic insect's aquatic communities, using null models in ecology, specifically species co-occurrence and niche sharing, in benthic aquatic communities' insects in a small river named Maquehue, in an agricultural zone close to Temuco, Araucanía Region, Chile.

The Maquehue river is a tributary of Imperial-Cautín river system (Niemeyer and Cereceda 1984; Rivera *et al.* 2004; Acuña 2020), it is located in an agricultural zone at south of Temuco town, in a site of Universidad de la Frontera. The studied site has perennial native forests with *Nothofagus alpina* (Poepp & Endl), *N. dombeyi* (Mirb), *N. obliqua* (Mirb) and *Laurelia sempervirens* (Ruiz & Pav) as dominant species, that is a typical vegetal community of middle and mountain valleys in Araucanía region (Luebert and Plitscoff 2006), this site has approximately 10 m width, subsamples were collected in a random transect along 30 m, the site has soft bottom with muddy bottom with many trunks and branch fragments. The site was visited in July 2021, samples (n = 6) were taken using Surber net (30 x 30 cm), sampled were fixed in absolute ethanol and identified and quantified in according to literature descriptions (Domínguez and Fernández 2009).

A community is structured by competition when the C-score is significantly larger than expected by chance (Gotelli 2000; Tondoh 2006; Tiho and Johens 2007). Consequently, we compared co-occurrence patterns with null expectations via simulation using statistical null models Fixed-Fixed (Gotelli and Ellison 2013). 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). Although the present results did´t allow the identification at genus and species level, the reported groups have specific ecosystem function (Figueroa *et al*. 2003, 2007). The null model analyses were performed using the software R (R Development Core Team 2020) and the package EcosimR (Gotelli and Ellison 2013; Carvajal-Quintero *et al.* 2015).

For niche overlap analysis, an individual matrix was built in which rows and columns represented species and sites, respectively. This matrix was used to test if the niche overlaps significantly differed from the corresponding value under the null hypothesis (random assemblage). The models show the probability of niche sharing compared to the niche overlap of the theoretically simulated community (Gotelli and Ellison 2013). The niche amplitude can be retained or reshuffled and when it is retained it preserves the specialization of each species.

In contrast, when it is reshuffled, it uses a wide utilization gradient of specialisation. Furthermore, zero participation in the observed matrix can be maintained or omitted. In the present study, we used the RA3 algorithm (Gotelli and Ellison 2013; Carvajal-Quintero *et al.* 2015). This algorithm retains the amplitude and reshuffles the zero conditions (Gotelli and Ellison 2013). This null model analysis was carried out using the software R (R Development Core Team 2020) and the package EcosimR (Gotelli and Ellison 2013; Carvajal-Quintero *et al.* 2015).

The results revealed, the presence of four taxa, *Andesiops* sp. (Ephemeroptera: Baetidae), *Dolophilodes* sp. (Trichoptera: Philopotamidae), and two groups of Diptera (Tipulidae and Ceratopogonidae), being Tipulidae the less abundant group followed than *Andesiops* sp., *Dolophilodes* sp., and Ceratopogonidae (Tab. 1). The results of null model analysis revealed that the species associations are random, whereas the niche sharing revealed that species share ecological niche, and in consequence there are interspecific competition (Tab. 2).

Table 1. Abundances per grid (30 * 30 cm) of aquatic insect taxa observed in studied site. / Abundancia por cuadrante (30 * 30 cm) de insectos acuáticos observados en el sitio de estudio.

Taxa / Site	S 1	S 2	S 3	S 4	S 5	S 6	Mean ± standard desviation
Ephemeroptera							
Baetidae							
Andesiops sp.	0	1	4	1	0	0	1.0 ± 1.5
Trichoptera							
Philopotamidae							
Dolophilodes sp.	0	0	1	0	1	0	0.3 ± 0.5
Diptera							
Ceratopogonidae	0	1	2	0	5	1	1.5 ± 1.9
Tipulidae	0	0	0	0	1	0	0.2 ± 0.4

Table 2. Results of null models (species co-occurrence and niche sharing) for species reported in the present study. / Resultados de los modelos nulos (co-ocurrencia de especies y sobreposición de nicho) para las especies reportadas en el presente estudio.

	Observed index	Mean index	Standard effect size	Variance	P
Species co-occurrence	1.167	1.200	-0.210	0.026	0.795
Niche sharing	0.590	0.306	2.237	0.016	0.026

The observed results of reported taxa composition agree with similar observations for north Patagonian rivers in middle valleys (Figueroa *et al.* 2003; Vega *et al.* 2020; Figueroa and De los Ríos-Escalante 2022; Solís-Lufí *et al.* 2022), coastal zones (Fierro *et al.* 2012, 2015), and for Mediterranean central Chilean river (Figueroa *et al.* 2007), that would correspond to insects' assemblages of medium zones of the river bed with marked human intervention of their surrounding basin due human intervention. Similar results have been reported for northern Argentinean Patagonian rivers close to Chilean boundary (Miserendino and Pizzolon 2000; Miserendino 2001, 2004, 2005; Miserendino *et al.* 2018).

The use of null models for ecology is an interesting point of view for study community structures, that is based in absence of patterns or structures in communities, that reduces the error risk in comparison to traditional statistical analysis (Gotelli 2000; Tondoh 2006; Tiho and Johens 2007). Although the null models have been applied mainly for terrestrial environments (Tondoh 2006; Tiho and Johens 2007; Carvajal-Quintero *et al.* 2015). In Chilean rivers this kind of null models has been applied only for an upper riverbed in Araucanía region, where was found similar results for species associations random, and presence of niche sharing (De los Ríos-Escalante *et al.* 2020). The causes of random in species associations would be due to the presence of many repeated species and low species number (Tiho and Johens 2007), that is a similar scenario observed for Chilean rivers, also similar results have been reported for niche sharing analysis where insects share their ecological niche with consequent interspecific competence (Carvajal-Quintero *et al.* 2015; De los Ríos-Escalante *et al.* 2020). Although the present results in species descriptions only work at genus and family level (for Diptera), the results of null models, and absolute species abundances are similar with benthic invertebrate reported for mountains streams where it was work at family level (De los Ríos-Escalante *et al.* 2020; Solís-Lufí *et al.* 2022). Also, the taxonomic studies on benthic invertebrate, mainly aquatic insects would revealed the existence of

functional groups in function to environmental tolerance that can be used as bioindicators or for use water quality indices (Figueroa *et al*. 2003, 2007; Miserendino *et al*. 2018), that would agree with community patterns (Figueroa and De los Ríos-Escalante 2022; Solís-Lufí *et al*. 2022). On this basis, the exposed results in term of taxa compositions and abundance would agree with the descriptions of water quality indices adapted for (Figueroa *et al*. 2003, 2007), and community patterns (Figueroa and De los Ríos-Escalante 2022; Solís-Lufí *et al*. 2022) for central-southern Chilean rivers. As conclusion, the use of null models can be an interesting view point for study community patterns, and it can be an interesting tool for support ecological observations.

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