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AQUATIC INSECTS COMMUNITIES IN A SALINE WATER SOURCE— ANTOFAGASTA, CHILE

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ABSTRACT

The aquatic insects include mainly larval stages, that hatch into adults, as occurring in some Diptera, which can generate problems in human health in tropical regions as these can transmit diseases. Some of these are reported from inland and coastal saline waters. The present study is an attept to apply the null models to explain the structure of aquatic insects a small saline water source located at south of Antofagasta town (23°47' S, Chile), using species associations and niches sharing null models. The results reveal a low taxa number, specifically of Diptera (Ephydridae, Ceratopogonidae and Nematocera). The null models of species associations reveal that the associations are random. Evaluation of the niche sharing reveal that species share ecological niches, and as a consequence there are interspecific competition. The reported taxa are similar with communities for inland water saline ecosystems as far as community structure and taxonomic groups are concerned.

Key words: Aquatic insects, null models, saline waters, Antofagasta, Chile, Ephydridae, Ceratopogonidae, Nematocera, community ecology, larvae, water source, species, associations, nitch sharing

The aquatic insects involve mainly larval stages that inhabit standing and running waters (Dominguez and Fernandez, 2009). Within the aquatic insects there are groups that inhabit inland saline waters (Hershey et al., 2010; Artigas et al., 2018), or intertidal pools (Hershey et al., 2010). These aquatic insects in some cases lead to problems for human health, due transmissions of tropical diseases. Thus, the most important insects group in saline waters are different kinds of Diptera larvae that are more tolerant to salinity fluctuations in comparison to others (Hershey et al., 2010; Artigas et al., 2018). The present study aims to determine, using null model the aquatic communities in a small saline water source located at south of Antofagasta in Chile. This will help understand the presence of aquatic insects as potential vectors of tropical diseases.

MATERIALS AND METHODS

The studied site is a small saline water stream located at south limit of Coloso Campus of the Antofagasta University (23°42'20" S; 70°25'21"W, geographical location obtained using GPS GARMIN etrex 22x). The water source is intubated, and its outflow is located outside university campus generating a small stream of >100 m with 20 cm width. Site was visited in March 2022, and salinity was measured with refractometer ATC. From studied sites nine 2 ℓ samples of water were taken and screened with 100 mm mesh size (Soto and De los Ríos, 2006). The collected material was fixed in absolute ethanol and identified and quantified following literature (Domínguez and Fernández, 2009).

A community is structured by competition when the C-score is significantly larger than expected by chance (Gotelli et al., 2015). Consequently, this study compared co-occurrence patterns with null expectations via simulation using statistical null models-Fixed-Fixed (Gotelli et al., 2015; Carvajal-Quintero et al., 2015). 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 present results though did not do identification at genus and species level, the reported groups have specific ecosystem function (Figueroa and De los Rios-Escalante, 2022). The null model analyses were performed using the software R (R Development Core Team 2020) and the package EcosimR (Gotelli et al., 2015; 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 whether 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 et al., 2015). 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, RA3 algorithm was used (Gotelli et al., 2015; 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 et al., 2015; Carvajal-Quintero et al., 2015).

The water body has 20 g/ ℓ salinity, that probably would indicate the presence of saline water source. The results revealed the presence three insects groups, the most abundant were Ephydridae in pupa stages, followed by Ceratopogonidae larvae, and Nematocera larvae (Table 1). The results of null model analysis revealed that the species associations are random, whereas the niche sharing revealed that species does not share ecological niche, and in consequence there are not interspecific competition (Table 2). The results revealed the existence of Diptera larval stages; unfortunately these stages are difficult for identify at species level, and due this reason were identified at family level (Dominguez and Fernandez, 2009). The existence of Diptera at salinity waters as practically exclusive components is well known from saline lakes in Bolivian Altiplano at salinities upper than 50 g/ ℓ (Williams et al., 1995); whereas at salinities lower than 6 g/ ℓ other aquatic insects such as Hemiptera (families Corixidae and Dolichopodidae) were found. At salinity level of 47 g/ ℓ Saldidae (Hemiptera) were found, whereas Diptera was found between 4.0-85.0 g/ ℓ, of these Ephydridae is the most halotolerant family with *Neoephydra* genus that was reported. Williams et al. (1995) reported Chironomidae, *Hydrophorus* (Dolichopodidae), and Ephydridae such as *Parastacatella hirticrus*, and *P. pena* with salinities between 4.0-6.0 g/ ℓ. Similar high diversity of aquatic insects at salinity level between 0.6-2.4 g/ ℓ was reported in benthic environment of Bolivian saline lakes; the taxa reported were Naididae, Ortocladinae, Podonominae, Tanypodidae, Simulidae, Ceratopogonidae, Tipulidae, Ephydridae, Corixidae, Baetidae, Leptoceridae, Hydroptilidae, Elmidae and Dytiscidae (Dejoux, 1993). Similar results were found for Bolivian (Molina et al., 2022) and Chilean (Vila et al., 2020) inland saline waters in Andes mountains.

The ecological role of aquatic insects in saline water, indicate that Ephydridae, Chironomidae and Ceratopogonidae are grazers on algae and bacteria (Bradley, 2018); if we consider the reports of aquatic insects in saline lakes of low species diversity at upper salinity levels, and the presence of green and brown algae in littoral of the studied sites, the present results agree with those of earlier workers. The results of species co-occurrence null models revealed that species associations are random, due to the presence of many repeated species in sampled sites. There are no ecological niche sharing indicating probably that the species reported would be selective grazers on benthic algae in the studied site. It is a different situation in comparison to studies on

Table 1. Abundances (No./ ℓ) of aquatic Diptera observed

Taxa/ Site	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	Mean± SD
Diptera										
Ephydridae (pupa)	4	2	3	4	3	2	4	13	9	4.9 ± 3.7
Ceratopogonidae (larvae)	1	1	5	1	0	0	2	2	3	1.7 ± 1.6
Nematocera (pupa)	2	0	0	0	0	0	0	1	1	0.4 ± 0.7

Table 2. Results of null models (species co-occurrence and niche sharing) for species reported

	Observed index	Mean index	Standard effect size	Variance	p
Species co-occurrence	< 0.001	< 0.001	NaN	< 0.001	0.999
Niche sharing	0.606	0.490	1.157	0.010	0.120

Chilean rivers, where it is found to be random in species associations, and with ecological niche sharing (De los Ríos-Escalante et al., 2020; De los Ríos and Santibáñez, 2022; Figueroa and De los Ríos-Escalante, 2022).

The results observed in the present study in this small saline water stream would be the first description of aquatic insects. These results agree with literature descriptions for saline standing waters (Bradley, 2018). Also, it is the first description in natural water source, which have not not reported halophilic invertebrates such has been observed for saline lakes (Williams et al., 1995; Williams, 1998; Vila et al., 2020; Molina et al., 2022). Although classic reports describe that Diptera inhabits mainly in low quality waters in term of nutrients and organic matter concentration in freshwater rivers (Figueroa and De los Ríos-Escalante, 2022). The presence of Diptera in the studied site, would be due probably by two reasons, the salinity of studied site, and the filamentous green and brown algae that would be grazed by Diptera larvae.

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AUTHOR CONTRIBUTION STATEMENT

PD-E planned, designed this study and write the manuscript. JM provided laboratory equipment and contributed in field works. JN analyzed specimens and contribute in data analysis.

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CONFLICT OF INTEREST

No conflict of interest.

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