Spatial distribution of *Hyalella patagonica* Cunningham, 1871 (Amphipoda) on Andean Patagonian river (Truful-Truful river, 38°S, Araucania region, Chile)

Distribución espacial de *Hyalella patagonica* Cunningham, 1871 (Amphipoda) en un río Andino Patagónico (río Truful-Truful, 38°S, Región de la Araucanía, Chile)

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ABSTRACT

The amphipod *Hyalella patagonica* is widespread in Andean inland waters in Argentinean and Chilean Patagonia, this species inhabits in littoral zones of rivers, streams, lakes and lagoons, that have mainly aggregated patterns of spatial distribution in according to the literature. The aim of the present study is to apply different kinds of aggregation models to explain the spatial distribution of *H. patagonica* collected in a North Andean Patagonian stream. It was applied different kinds of dispersion coefficients to understand *H. patagonica* spatial pattern. The results revealed that *H. patagonica* population has an aggregated distribution, but not necessarily a negative binomial distribution which is a frequent probabilistic model associated with ag-

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gregated spatial distribution. The results would be similar to patterns observed for *Hyalella* genus in Patagonian inland waters.

Keywords — *Hyalella patagonica*, Patagonia, littoral, aggregated distribution.

RESUMEN

El anfípodo *Hyalella patagonica* está muy extendido en aguas interiores andinas de la Patagonia argentina y chilena, esta especie habita en zonas litorales de ríos, arroyos, lagos y lagunas, que según la literatura tienen patrones de distribución espacial principalmente agregados. El objetivo del presente estudio es aplicar diferentes tipos de modelos de agregación para explicar la distribución espacial de *H. patagonica* colectada en un arroyo del norte de la Patagonia. Se aplicaron diferentes tipos de coeficientes de dispersión para comprender el patrón espacial de *H. patagonica*. Los resultados revelaron que la población de *H. patagonica* tiene una distribución agregada, pero no necesariamente una distribución binomial negativa, que es frecuente en el modelo probabilístico asociado a la distribución espacial agregada. Los resultados serían similares a los patrones observados para el género *Hyalella* en aguas interiores de la Patagonia.

Palabras clave — *Hyalella patagonica*, Patagonia, litoral, distribución agregada.

INTRODUCTION

The amphipods of *Hyalella* genus are widespread in South American inland waters (Gonzalez, 2003; Jara, Rudolph, Gonzalez, 2006), that inhabits mainly in littoral zones of rivers, streams, lakes and lagoons (Encina et al., 2017), within this genus the species *H. patagonica* inhabits along Argentinean and Chilean Patagonia, mainly in Andean inland waters at north Patagonia (38-41°S), and low altitude waterbodies in central and southern Patagonia (41-54°S), being possible found it at south of Beagle channel (De los Ríos-Escalante, Mansilla, Anderson, 2012).

The ecology of this genus reported that these individuals live in littoral zones grazing on macrophytes and vegetal dead matter, and being prey of native fishes and introduced salmonids, or aquatic birds in fish less water bodies (Encina et al., 2017). The individuals joins groups that have aggregated groups, that can be explained with defined probabilistics models such as negative binomial distribution (De los Ríos-Escalante, 2017; De los Ríos-Escalante and Mansilla, 2017), as well as other probabilistic patterns (De los Ríos-Escalante, Mansilla, Anderson, 2011) The presence of aggregated patterns in benthic fauna and their respective mathematical models has been studied with details by Elliot (1975), who described for Fernandes, Busoli and Barbosa (2003) for study terrestrial insects and serve as basis for recent studies on littoral invertebrates (De los Ríos-Escalante, 2017; De los Ríos-Escalante and Mansilla, 2017).

The aim of the present study was apply dispersion coefficients for study spatial patterns in *H. patagonica* population from Truful-Truful river, a north Patagonian Andean water body in the surrounding of Conguillío National Park, and determine if it is possible found a negative binomial distribution associated to aggregated pattern.

MATERIAL AND METHODS

Study site: Truful-Truful river in the south access of Conguillío National Park (38°47'08" S; 71°38'18" S; Fig. 1) is located in Araucania region, in Andes mountains at south of Conguillio National Park, a protected area with marked volcanic influence due Llaima volcano activity (Niemeyer and Cereceda, 1984; Lillo et al., 2011), Allipen river that is part of Tolten river basin (Niemeyer and Cereceda, 1984; Solís-Lufí et al., 2022), the site was visited in May 2019 before winter storms.

The studied site is the called "volcanic slag and high peaks", characterized by forest communities with *Nothofagus pumilio* (Poepp. & Endl.) Krasser y *Azara alpina* Poepp. & Endl. (Luebert and Pliscoff, 2018) and *Araucaria araucana* (Gajardo, 1994), that can be a kind of ecotone of two communities forest. The vegetational gradient begin at north with *N. dombeyi* (Mirb.) Oerst., 1871 and *Austrocedrus chilensis* (D.Don) Pic-Serm. & Bizzarri, whereas at Northeast has shrubs of *Fucsia magellanica* Lam and introduced *Rubus ulmifolius*; Schott, in Oken, Isis, fasc. v. 821, 1818, close to the

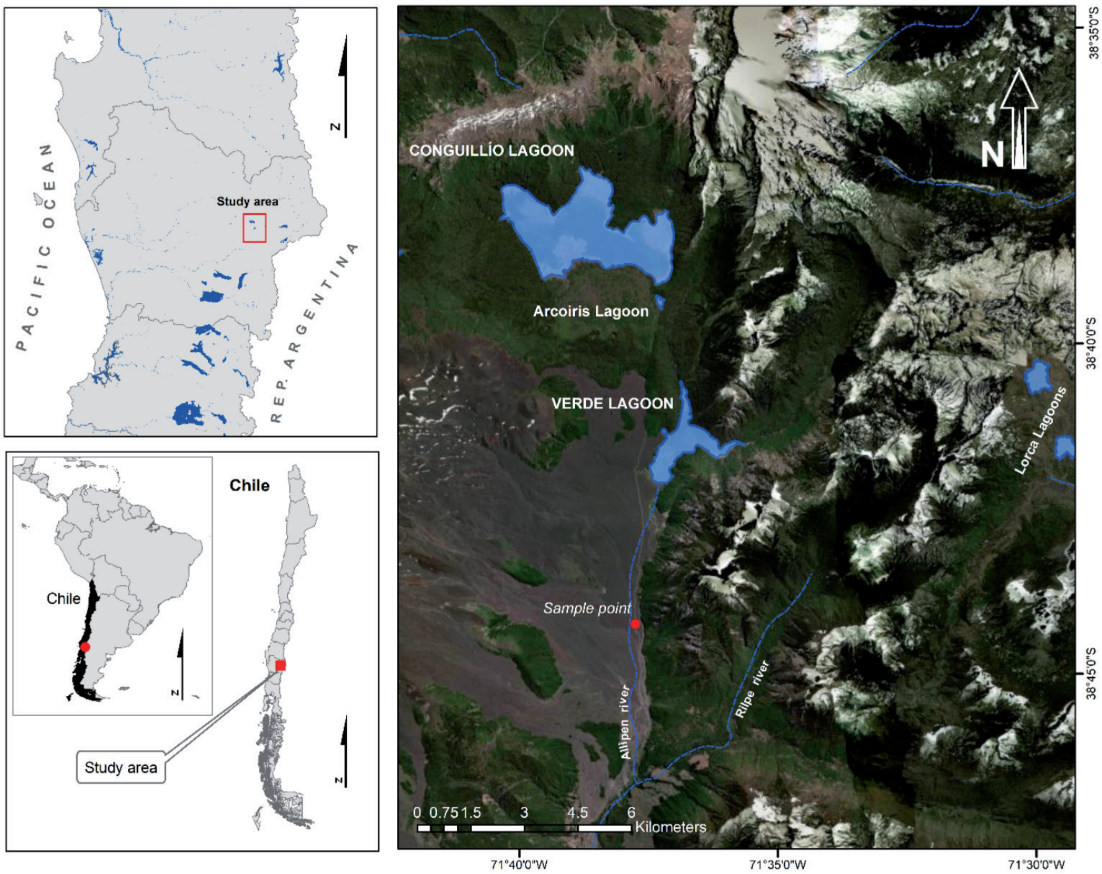

Fig. 1. Map of studied site, Truful-Truful, Conguillío National Park, Chile.

Fig. 1. Mapa del sitio en estudio, Truful-Truful, Parque Nacional Conguillío, Chile.

site where is the Allipen river, the vegetation included *F. magellanica* and Baccharis linearis (Ruiz & Pav.) Pers. (Lillo et al., 2011)

Sampling procedures: the studied site as sampled using a 50 x 50 cm Surber net with 100 mm mesh size, a total of 16 samples were collected. The collected specimens were fixes in absolute ethanol for their identification in according to descriptions of Gonzalez (2003).

Data analysis: Variance/mean ratios were calculated to determine if the spatial distribution pattern of the studied populations was associated, uniform or random (Zar, 1999; Fernandes et al., 2003). First, we registered the number of individuals for each sample, and then determined the variance and mean of each sample as a way to determine the spatial pattern for both species. So, if the variance-mean ratio value is 1, the distribution is random; whereas if the variance mean ratio is lower than 1, the distribution is uniform; and finally, if the variance mean ratio is greater than 1, the spatial distribution is aggregated (Zar, 1999; Fernandes et al., 2003). As the results denoted presence of aggregated distribution, it was verified it in according to literature descriptions (Elliot, 1975, Zar, 1999, Fernandes et al., 2003), and the results were contrasted with other dispersion index appropriated for aggregated spatial distribution (Elliot, 1975).

RESULTS AND DISCUSSION

The results of variance mean ratio revealed the existence of spatial distribution aggregated pattern (Table 1), nevertheless, the data did not adjust to negative binomial distribution (c^2 observed = 34.590 > c^2 table $_{(a\ =\ 0.05;\ n\ =\ 15)}$ = 28.336; Fig. 2). The

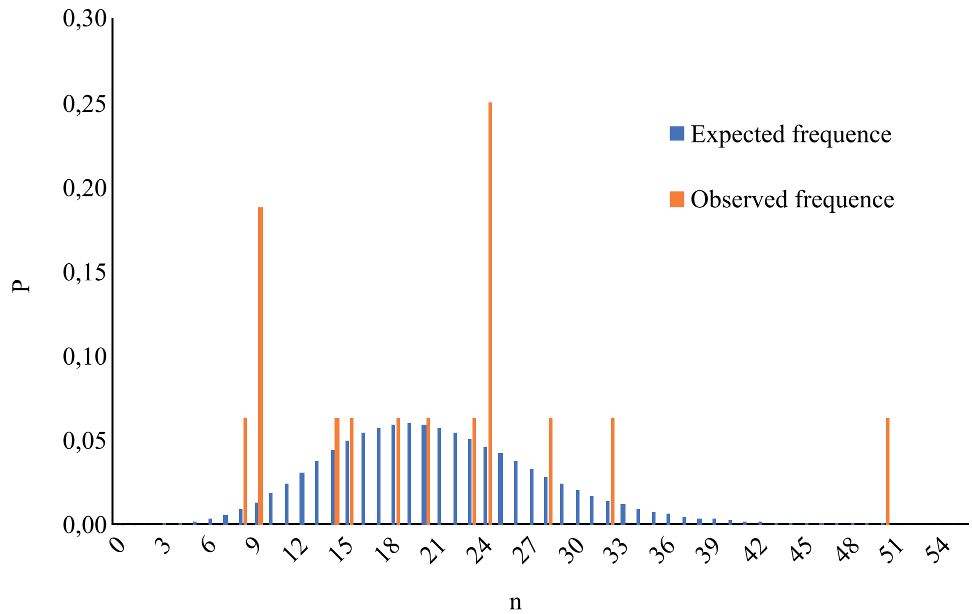

Fig. 2. Graph of estimation of negative binomial distribution for *H. patagonica* population of Truful-Truful river.

Fig. 2. Gráfico de estimación de distribución binomial negativa para población de *H. patagonica* del rio Truful-Truful.

Table 1. Results of dispersion index for *H. patagonica* for studied site (transcription from Elliot, 1975, page 74).

Tabla 1. Resultados del índice de dispersión para *H. patagonica* para el sitio estudiado (transcripción de Elliot, 1975, página 74).

Dispersion index	Formula	Observed result	Uniform	Random	Aggregated
Variance / mean	$s^2/\bar{x}$	5.62	0	1	$\sum x$
	$(s^2/\bar{x})(n-1)$	84.30	0	$n-1$	$\sum x(n-1)$
David and Moore (1954)	$(s^2/\bar{x})-1$	4.62	–1	0	$\sum x-1$
Lexis coefficient	$s^2\sqrt{\bar{x}}$	25.58	0	1	$\sqrt{\sum x}$
Charlier coefficient	$\frac{100*(\sqrt{s^2-\bar{x}})}{\bar{x}}$	47.28	Imaginary	0	$100n(1-\frac{1}{\sum x})$
Green (1966)	$\frac{(s^2/\bar{x})-1}{(\sum x)-1}$	0.01	$\frac{-1}{\sum x-1}$	0	1
Morisita index	$\left(\frac{\sum x^2-\sum x}{(\sum x)^2-\sum x}\right)*n$	16.60	0	1	$\sum x$

results of dispersion coefficients proposed by aggregated distribution described by Elliot (1975), denoted that specimens distribution have aggregated pattern (Table 1).

The results about spatial distribution of inland water crustaceans revealed the existence of aggregated spatial distribution (De los Ríos-Escalante et al. 2011; De los Ríos-Escalante and Mancilla 2017; De los Ríos-Escalante, 2017; Diawol, Musin, Collins, Giri, 2021), that is a very frequent pattern of inland water benthic invertebrates (Elliot, 1975; Gray, 2005). Although the statistical literature described that aggregated distribution implies negative binomial distribution pattern (Zar, 1999), that is supported by statistical ecological references (Fernandes et al. 2003; Diawol et al., 2021), it is not obligatory situation (Elliot, 1975), that was observed on the basis of field evidences (De los Ríos-Escalante et al., 2011; De los Ríos-Escalante and Mancilla, 2017), the cause of the absence of associations between negative binomial distribution and aggregated pattern is due probably to complex ecological process, such as environmental heterogeneity (Elliot, 1975; Benton, Lapsley, Beckerman, 2002). This environmental heterogeneity specifically in stochastics changes in abiotic parameters, would have combined effect with biological interactions such as predator-prey interactions and migration process that can be enhanced in fragmentary habitats would explain these changes in spatial distribution patterns observed in the present study (Bull et al., 2007; De Roissart, Wang, Bonte, 2015; Deharnais, Reuman, Costantino, Cohen, 2018; Baaloudj et al., 2020; Baaloudj, De los Ríos-Escalante, Esse, 2024; Rouibi et al., 2021; Chaib et al., 2023).

The obtained results have the disadvantage of low observation numbers, that would not generate the possibility of estimate more detailed probabilistic models (Elliot, 1975; Gotelli and Ellison, 2004). Nevertheless, it supports the possibility of found other probabilistic models that would explain complex ecological patterns.

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