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SHORT COMMUNICATION

Non randomness in spatial distribution in two inland water species malacostracans

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Abstract The benthic crustaceans do not have random spatial distribution under natural conditions, this means that these species can have a determined pattern such as associated or uniform. In this work we studied a non-random spatial pattern in two freshwater malacostracan species, *Aegla cholchol* (Decapoda) from Cautin river, and *Hyalella patagonica* (Amphipoda) from Quillelhue lake (38°S, Araucania Region, Chile) respectively. The data revealed that both species have an associated pattern, and negative binomial distribution. These results agree with similar observations for other inland water benthic species from Southern Chilean rivers and streams.

1. Introduction

The macrozoobanthos crustaceans in Chilean Patagonian inland waters have amphipods of the genus *Hyalella* and decapoda of the genus *Aegla* and *Samastacus* (Jara et al., 2006). Many of the studies are oriented to taxonomy (González, 2003; Jara et al., 2006) and the first related to the ecology of these organisms have been restricted primarily to the rivers of central and northern Patagonia (Figueroa et al., 2003, 2007, 2009, 2013; Oyanedel et al., 2008; Córdova et al., 2009; Palma et al., 2009).

The amphipods of Patagonian (51–54°S) Chilean inland waters belong to three species: *Hyalella patagonica* Cunningham, 1871, *H. franciscae* González & Wattling, 2003, and *H. simplex* Schellenberg, 1943 (González, 2003; Gonzalez and Watling, 2003; De los Ríos-Escalante et al., 2013a, 2013b, 2014a,b). The *Aegla* genus includes 20 endemic species in Chile distributed between 31 and 45°S, and crayfishes of Family Parastacidae with six species belonging to *Parastacus, Samastacus* and *Virilastacus* genus (Jara et al., 2006; De los Ríos-Escalante et al., 2013b; Jara, 2013). The aim of the present study is to analyze the spatial distribution patterns of the key species for Chilean inland waters *Hyalella patagonica* and *Aegla cholchol*.

2. Materials and methods

Hyalella patagonica specimens were collected during January 2012 in the littoral zone of Quwillelhue lake (39°34′S; 71°32′W), using a Surber net of 80 μm mesh size, removing submersed vegetation and stones in the sampled quadrant (25 cm × 25 cm) (Dominguez and Fernández, 1999). Individuals of *Aegla cholchol* were collected in littoral zone of Cautin river, close to Cajón town (38°45′S; 72°40′W) during January

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2006, using the same sampling device, removing submersed stones in the sampled quadrant with the opening facing the current of the river (Dominguez and Fernández, 1999). The specimens were preserved with absolute ethanol and then counted at the laboratory.

Variance/mean ratios were calculated to determine if the spatial distribution pattern of the studied populations was associated, uniform or random (Zar, 1999; Fernándes 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; Fernándes et al., 2003). After this, data were examined using the Poisson, binomial or negative binomial distributions as appropriate probabilistic models of the spatial distribution patterns results obtained by Variance/mean ratio. If the first analysis denoted associated, uniform and random spatial distribution, a second step analysis was applied with the negative binomial, positive binomial, and Poisson probability distributions, respectively (Fernándes et al., 2003), all these statistical analysis were done using Xlstat software.

Table 1 Density in ind/m^2 (average + variance) and results of negative binomial distribution for *H. patagonica* and *A. cholchol* populations included in the present study.

Density	2.909 + 6.291	1.500 + 2.684
Variance/mean ratio	2.163	3.125
Results of Poisson distribution		
c2 observed	3.167	1076.501
c2 table	15.507	15.507
P	< 0.001	< 0.001
Results of binomial distribution		
c2 observed	414.009	4110159.994
c2 table	15.592	15.592
P	< 0.001	< 0.001
Results of negative binomial distribution		
c2 observed	16.008	4.534
c2 table	14.067	14.067
P	< 0.001	0.717

H. patagonica; *A. cholchol*.

3. Results and discussion

The mean densities observed were 2.909 ind/m^2 for *Hyalella patagonica* and 1.500 ind/m^2 for *Aegla cholchol* (Table 1). The results of the variance mean ratio revealed the aggregated condition of spatial distribution for 2.163 and 3.125 for *H. patagonica* and *H. cholchol* respectively (Table 1), nevertheless *H. patagonica* has not adjusted to the mentioned probabilistic models, whereas *A. cholchol* has a negative binomial distribution (Table 1; Fig. 1).

For both the species, observed densities were similar to those reported for *A. rostrata* Jara, 1977 (0.0–14.4 ind/m^2) and for *H. patagonica* 0.0–24.0 ind/m^2 in a small urban river in Temuco area, Chile (Correa-Araneda et al., 2010) and for *A. alacalufi*, Jara, 1982 (3 ind/m^2). Although, for *H. patagonica* the observed density was low in comparison to the earlier reported value of 40 ind/m^2 in southern Chilean rivers (Oyanedel et al., 2008).

The presence of aggregated pattern for observed taxa would be associated to ecological strategies for optimal and efficient resources utilization and protection against environmental

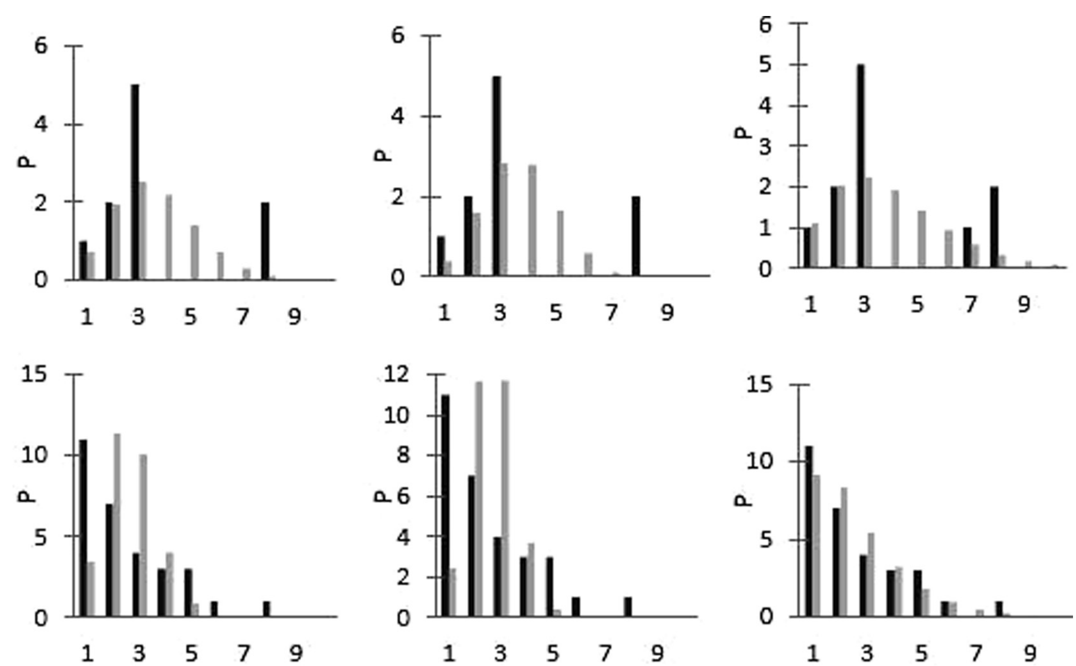

Figure 1 Results of spatial distribution: Poisson (left), binomial (centre) and negative binomial (right) for *H. patagonica* (first row) and *A. cholchol* (second row). (Black bars: observed frequence; grey bars: expected frequence.)

stressors (Gray, 2005; De los Rios-Escalante et al., 2011). In this scenario *Aegla* species are representative of low polluted zones in rivers and lakes where they feed on dead animal, vegetal particulated matter and benthic organisms (Lara and Moreno, 1995; Figueroa et al., 2003, 2007). Whereas that *Hyalella* genus is more abundant in zones with more organic matter content in the sediments and moderate organic pollution, it would feed on macrophytes and dead vegetals (De los Rios-Escalante et al., 2011).

Negative binomial distribution has been suggested for explaining associated spatial distributions (Zar, 1999; Fernándes et al., 2003), and it has been applied in studies for terrestrial insects (Maruyama et al., 2002; Fernándes et al., 2003), ectocommensals (De los Ríos-Escalante et al., 2014), parasites (Shaw et al., 1998; Peña-Rehbein and De los Ríos-Escalante, 2012; Peña-Rehbein et al., 2013), and macrozoobenthos (Gray, 2005; Noro and Buckup, 2010; De los Rios-Escalante et al., 2011; De los Ríos-Escalante and Mansilla, 2017; Elliot, 1999). The negative binomial distribution is not an obligatory condition for aggregated spatial pattern, a possible cause would be strong environmental heterogeneity (Benton et al., 2002; De los Rios-Escalante et al., 2011).

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