



The presence of the genus *Hyaella* (Smith, 1875) in water bodies near Puerto Williams (Cape Horn Biosphere Reserve, 54° S, Chile) (Crustacea, Amphipoda)

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Abstract. The common amphipod genus *Hyaella* Smith, 1875 has been described in inland waters between northern Patagonia (38° S) and the southern zones of Tierra del Fuego Island (54° S). The aim of the present study is to analyse the species associations of the genus *Hyaella* using a presence/absence matrix and to study the spatial distribution of *H. patagonica* in small streams on Navarino Island in the Cape Horn Biosphere Reserve, an unpolluted and pristine protected area with sub-Antarctic native forests. The results of contingency table analysis indicate that the species reported from the study area are associated and that the *H. patagonica* populations have similar densities and an associated spatial distribution. Nevertheless, the negative binomial distribution does not fit the abundance data from the populations. This result agrees partially with similar findings for benthic macroinvertebrates, such as inland water decapods and insects. Ecological and limnological topics are discussed.

Keywords: spatial distribution, benthic macroinvertebrates, crustacea, inlandwater

Resumen. Presencia del género *Hyaella* (Smith, 1875) en cuerpos de agua cercanos a Puerto Williams (Reserva de la Biósfera del Cabo de Hornos, 54° S, Chile) (Crustacea, Amphipoda). El género de anfípodos *Hyaella* Smith, 1875, es un género de amplia distribución que ha sido descrito para aguas continentales desde el norte de la Patagonia (38° S) hasta la zona sur de la isla de Tierra del Fuego (54° S). El objetivo del presente estudio es analizar la distribución espacial del género *Hyaella* usando una matriz de presencia/ausencia de especies y estudiar la población de *H. patagonica* en pequeños arroyos en la isla Navarino, en la Reserva de la Biósfera del Cabo de Hornos, que es un área prístina y sin contaminar con bosque nativo sub-antártico. Se aplicó un análisis de tablas de contingencia y se encontró que las especies reportadas están asociadas. Las especies recolectadas mostraron una densidad similar, y un patrón de distribución asociado. No obstante las poblaciones no se ajustaron a una distribución binomial negativa. Estos resultados concuerdan parcialmente con otras descripciones para macroinvertebrados bentónicos tales como decápodos e insectos de aguas continentales. Se discuten tópicos ecológicos y limnológicos.

Palabras clave: distribución espacial, macroinvertebrados bentónicos, crustáceos, aguas continentales

Introduction

The benthic crustacean fauna of Chilean Patagonian inland waters is characterised by the presence of amphipods of the genus *Hyaella* and decapods of the family Parastacidae and the *Aegla* genus (Jara *et al.* 2006). Current knowledge of the

status of these species is primarily limited to systematic studies, the identity of many species have taxonomic problems (González 2003; Jara *et al.* 2006). Previous ecological studies of this fauna have been restricted primarily to the rivers of central and northern Patagonia, where benthic crustaceans are

low in abundance compared with aquatic insects (Figueroa *et al.* 2003, 2007, 2009; Oyanadel *et al.* 2008; Córdova *et al.* 2009, Palma *et al.* 2009).

The amphipod species of Chilean inland waters are restricted to particular regions (González, 2003). The species *H. patagonica* Cunningham, 1871, *H. franciscae* González & Watling, 2003, and *H. simplex* Schellenberg, 1943 are found in southern Patagonia (51-54° S) (Gonzalez & Watling 2003). Similar findings have been reported for Argentinean Patagonia and for the Argentinean zone of Tierra del Fuego Island (Dos Santos *et al.* 2008). However, no quantitative ecological studies of the population dynamics of these amphipods have previously been conducted. The purpose of this study is to study the ecology of *Hyaella* genus analysing the species associations of the genus *Hyaella* using a contingency tables and to analyse the spatial distribution and abundance of *H. patagonica* collected in small streams on northern Navarino Island near the town of Puerto Williams in the Cape Horn Biosphere Reserve, a protected area with unpolluted and pristine sub-Antarctic perennial native forests (Rozzi *et al.* 2007; Ibarra *et al.* 2010).

determined with a Garmin eTrex Legend H GPS. Amphipod specimens were collected in littoral zones using a Hess net (10 * 10 cm and 2 mm mesh size) based on the descriptions of Dominguez & Fernandez (2009), and fixed in absolute ethanol for identification in the laboratory according to the descriptions in Gonzalez (2003). For the first objective data was collected in a visit done the 05th February 2010 a 2 x 2 contingency table analysis was applied to each pair of amphipod species to detect associations between the species (Zar 1999). The data were analyzed with the Xlstat 5.0 software.

The study included a second visit (12th February 2010) to the area sample one river and two small streams. A total of 20 samples for each site were collected in littoral zones using a Hess net (10 * 10 cm and 2 mm mesh size in a surface of 50 * 50 cm) based on the descriptions of Domínguez & Fernández (2009). The homoscedasticity of the data was verified using a Bartlett test, and one-way ANOVA (Underwood 1978) was applied to investigate potential differences in density of sites studied (Zar 1999). In the second stage of the analysis, variance/mean ratios were calculated to characterise the spatial distributions of the populations as associated, uniform or random (Zar 1999; Fernández *et al.* 2003). Subsequent to these analyses, the data were examined using an appropriate probabilistic model of the spatial distribution patterns identified. The associated, uniform and random spatial distributions were analysed with the Poisson, Binomial and Negative Binomial distribution probabilities distributions, respectively (Fernández *et al.* 2003) using a Kolmogorov-Smirnov test and the software Xlstat 2008 (www.addinsoft.com).

Results

The results of our research showed that the study sites have low values of temperature, total dissolved solids, and conductivity and weakly acids and basic pH (Table I). The contingency table showed that each pair of *Hyaella* species was dependent ($P < 0.05$; Table II). The density data exhibited variance homogeneity ($\chi^2 = 5.176$; $P = 0.075$; Table II), and the densities did not differ significantly among sites ($F = 1.281$; $P = 0.281$; Table II). The variance-to-mean ratio showed that the populations have an associated spatial distribution (Table II). However, a Poisson distribution fitted the data corresponding to Casa Vieja stream, whereas the Binomial distribution did not fit the data, and Negative Binomial distribution fitted the data corresponded to Mountains in Róbaló river and Casa Vieja Stream (Table II, Figure 2).

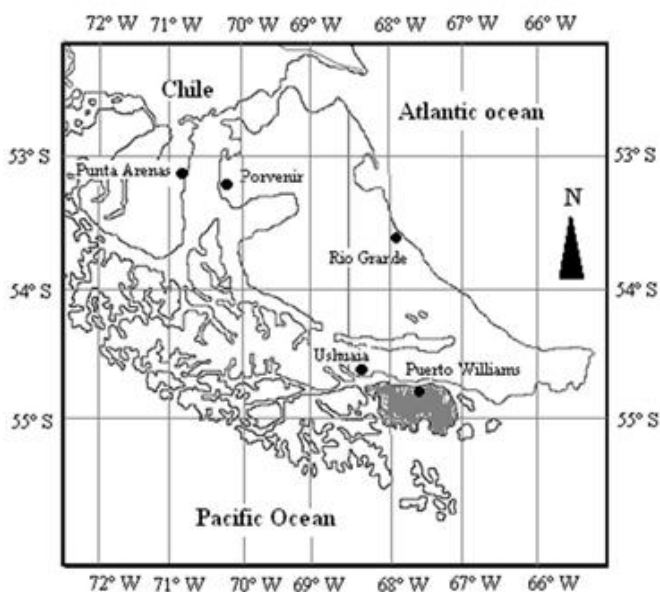


Figure 1. Map with geographical locations of study sites (Navarino Island in grey).

Materials and Methods

The study area is located near the town of Puerto Williams on Navarino Island on the shore of Beagle Channel within the Cape Horn Biosphere Reserve (Fig. 1). Temperature, conductivity, total dissolved solids and pH were measured in situ with a HI 98129 sensor, and geographical locations were

Table I. Geographical locations, conductivity (mS/cm), total dissolved solids (ppt), pH, and altitude (m a.s.l.), and amphipod species investigated in this study. (Abreviatures: HP = *Hyalella patagonica*; HS: *Hyalella simplex*; HF: *Hyalella franciscaae*)

Geographical location	HP	HS	HF	mS/cm	°C	ppt	pH	m a.s.l.	Site
54°59'31.2" S 67°40'53.1"W	x			0.02	5.10	0.01	9.80	478	Mountains Robalo river
54°59'30.7"S 67°40'52.9"W	x			0.01	6.70	0.01	8.89	471	Stream
54°56'17.7"S 67°37'23.4"W	x			20.00	8.10	10.00	8.36	1	Peatland
54°56'27.5"S 67°39'26.6"W	x		x	0.04	10.80	0.01	9.80	5	Estuary Robalo river
54°56'24.8"S 67°39'29.1"W	x		x	0.18	11.40	0.09	9.92	5	Pool close to Robalo river
54°56' 33.4"S 67°37'13.2"W	x			0.18	10.20	0.08	9.20	0	Casa vieja stream
54°55'47.8"W 67°33'43.8W		x	x	0.10	10.70	0.06	8.57	14	Stream
54°55'59,4"S 67°31'14.0"W		x	x	0.01	11.30	0.04	8.25	6	Stream
54°56'07.7"S 67°29'23.2"W		x		0.11	16.90	0.04	9.15	1	Stream
54°56'25.3"S 67°37'19.2"W	x			0.06	10.30	0.03	7.75	22	Peatland
54°56'27.8"S 67°37'23.2"W	x			0.07	14.10	0.03	7.34	22	Peatland
54°56'33.5"S 67°37'17.1"W				0.01	10.30	0.01	5.05	29	Peatland
54°56'33.5"S 67°37'13.2"W				0.02	12.40	0.01	5.21	29	Peatland
54°56'19,7"S 67°38'18.9"W				0.12	12.00	0.05	8.18	17	Lagoon
54°56'26.9"S 67°42'09.5"W	x			0.07	9.60	0.03	8.16	0	Los Bronces stream

Discussion

The results about presence of two model of special distribution observed in the present study can be biological process such as spatial variations in example cluster formations that can be or not detectable in sampling area (Elliot 1983), that can be due behaviour of studied individuals, in example spatial distribution variations in freshwater bivalve *Diplodon chilensis* in predator presence and absence

(Lara & Moreno 1985). The density value of *H. patagonica* was partially in agreement with descriptions of this species for an urban stream in Temuco (Correa-Araneda *et al.* 2010) and in southern Chilean rivers (Oyanedel *et al.* 2009). Although Hyalellid amphipods are widely distributed in the rivers and lakes of continental Chile (González 2003; De los Ríos *et al.* 2007, 2010; Vega *et al.* 2010), their abundance is generally low

in comparison to other benthic invertebrates, primarily aquatic insects (Figueroa *et al.* 2003, 2007). The use of the negative binomial distribution as a probabilistic model to explain associated spatial distributions has been described in the literature (Zar 1999) for terrestrial insects (Maruyama *et al.* 2002;

Fernández *et al.* 2003), and river benthic macroinvertebrates (Gray 2005). Nevertheless, it is possible that a population with an associated spatial distribution will not follow a negative binomial distribution. Instead, it may follow a gamma distribution (Benton *et al.* 2002).

Table II. Results of contingency table analyses, homoscedasticity tests and one-way ANOVA for density data and spatial distributions found in this study.

	<i>H. patagonica</i>	<i>H. simplex</i>
Present	9	3
Absent	6	12
χ^2 observed: 927.110 > χ^2 table: 3.841; p < 0.05		
	<i>H. patagonica</i>	<i>H. franciscae</i>
Present	9	4
Absent	6	11
χ^2 observed: 525.590 > χ^2 table: 3.841; p < 0.05		
	<i>H. simplex</i>	<i>H. franciscae</i>
Present	3	4
Absent	12	11
χ^2 observed: 29.870 > χ^2 table: 3.841; p < 0.05		

RESULTS OF ANOVA AND SPATIAL DISTRIBUTION

	Mountains in Robalo river	Pool close to Robalo river	Stream Casa vieja
Density (ind/L)	4.60 ± 18.15	2.90 ± 6.52	3.80 ± 9.22
Variance / Mean ratio	4.11	2.24	3.95
Results of Poisson distribution			
D	0.337	0.318	0.232
P	0.016	0.027	0.202
Results of binomial distribution			
D	0.495	0.396	0.334
P	< 0.001	0.002	0.017
Results of negative binomial distribution			
D	0.238	0.314	0.243
P	0.179	0.030	0.160
Homocedasticity (Bartlett test)	χ^2 observed = 5.176; P = 0.075		
One way ANOVA	F observed = 1.286; P = 0.281		

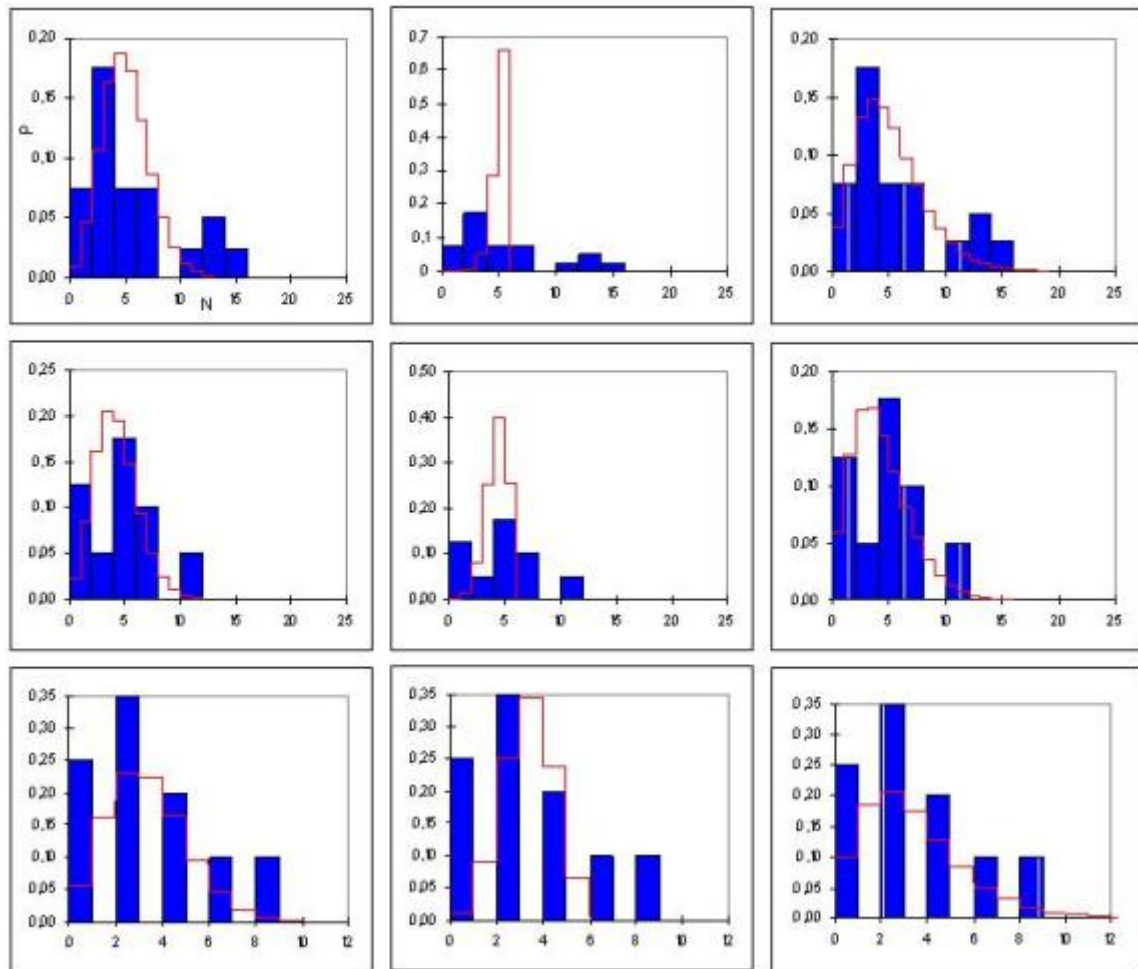


Figure 2. Figures of spatial distribution: Poisson (left), binomial (centre), and negative binomial (right) for mountains in Robalo river (first row), pool close to Robalo river (second row) and Casa Vieja stream (third row) respectively. (line = expected frequency, bars = observed frequency).

The present study was done in a reduced zone of Navarino island, if we considerate that Navarino island belongs to a island group, pristines, unpoluted with low human intervention and with access difficult located in southern South American extreme (Rozzi *et al.* 2007), it is probable that the ecosystems don't have significant variations within an island (Moorman *et al.* 2006). If we considerate these antecedents, it is probable that the studied population belong to a large population (Atmar & Patterson 1993; Almeida-Neto & Ulrich 2011), in this scenario, it would have a large *Hyaella* populations located in Navarino island. Additional ecological studies are needed to understand the temporal and spatial population dynamics of inland-water amphipods and the ecological niches of amphipod species.

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