BRANCHINECTA (BRANCHIOPODA, ANOSTRACA) AS BIOINDICATOR OF OLIGOTROPHIC AND LOW-CONDUCTIVITY SHALLOW WATER BODIES IN SOUTHERN CHILEAN PATAGONIA

BRANCHINECTA (BRANCHIOPODA, ANOSTRACA) COMO BIOINDICADOR DE CUERPOS DE AGUA SOMEROS, OLIGOTRÓFICOS Y DE BAJA CONDUCTIVIDAD EN LA PATAGONIA AUSTRAL DE CHILE.

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ABSTRACT

Southern Patagonia is characterized by its semi-arid climate with numerous small temporal and permanent shallow ponds. The aquatic crustacean species of these water bodies are characterized by high endemism and species richness. The present study was done in six shallow ponds in the surroundings of Punta Arenas (53°S, Chile). Samples for conductivity, total dissolved solids, chlorophyll and crustacean zooplankton and littoral species were taken. The study revealed that *Branchinecta* was observed under conditions of low conductivity (0.55 mS/cm), low salinity (0.28 g/l) and low chlorophyll concentration (2,70 µg/l), in comparison to sites without fairy shrimp that had high conductivity (3.58 mS/cm), total dissolved solids (1.80 mg/l) and chlorophyll 12.80 µg/l) concentrations. These results partially agree with previous descriptions for central and southern Patagonian water bodies, indicating the presence of fairy shrimp in low conductivity waters. The descriptions of presence of *Branchinecta* and other associated micro crustaceans are similar to records from unpolluted water bodies in Antarctica. Results from other fairy shrimp habitats denote a wide gradient of mineral concentrations. Other ecological and biogeographical topics are discussed.

Key words: *Branchinecta*, zooplankton, conductivity, oligotrophy

RESUMEN

La zona sur de la Patagonia se caracteriza por su clima semiárido, y presenta numerosas lagunas poco profundas, ya sea superficiales o permanentes. La fauna acuática de estos ecosistemas se caracteriza por su alto endemismo y riqueza de especies. El presente estudio se realizó en las cercanías de la ciudad de Punta Arenas (53° S, Chile), e incluyó seis pequeñas lagunas superficiales. Se colectaron muestras para análisis de conductividad, sólidos totales disueltos, clorofila y crustáceos zooplanctónicos

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y litorales. El presente estudio reveló que las especies de *Branchinecta* fueron observadas en condiciones de baja conductividad (0,55 mS/cm), salinidad (1,80 g/l) y baja concentración de clorofila (2,7 µg/l); valores notablemente bajos en cuanto a la conductividad (3,58 mS/cm), sólidos totales disueltos (1,80 g/l) y concentración de clorofila (12,80µg/l) observados para sitios sin poblaciones de *Branchinecta*. Los resultados observados concuerdan parcialmente con las primeras descripciones para la zona sur de la Patagonia. La presencia de *Branchinecta* y otros microcrustáceos asociados es similar a las descripciones para cuerpos de aguas continentales prístinos de la Antártica. Por otro lado, resultados similares se observaron para ecosistemas árticos, que presentan camarones duende y alta riqueza de especies a pesar de su baja productividad primaria. Los resultados publicados para otros biotopos de camarones duende denotan un amplio gradiente de concentraciones de minerales. Se discutieron tópicos ecológicos y biogeográficos.

Palabras clave: *Branchinecta*, zooplankton, conductivity, oligotrophy.

INTRODUCTION

Southern Patagonia (51°-53° S), is characterized by its cold and semi arid climate; and by the presence of numerous permanent and temporal shallow ponds, that have different conductivity levels (Soto *et al.* 1994; De los Ríos 2005). The aquatic crustaceans of these ecosystems are characterized by their marked endemism and a relative high species richness in conditions of low and moderate conductivity (Soto *et al.* 1994; Soto & De los Ríos 2006; De los Ríos 2005). These patterns are similar with descriptions for sub-Antarctic island in Southern Atlantic (Dartnall 2005; Pugh *et al.* 2002; Hannsson *et al.* 1996).

The aquatic crustacean assemblage of these water bodies is characterized by a marked dominance of calanoid copepods of the *Boeckella* genus with a relative high species richness (Soto & De los Ríos 2006, Modenutti *et al.* 1998). The main regulator factors of this assemblage are the conductivity and chlorophyll concentrations, because at oligotrophy and low to moderate conductivity the calanoid copepods are dominant, whereas in mesotrophy and low conductivity the daphnids are abundant (Soto & De los Ríos 2006). Finally at high conductivity, the Anostracan *Artemia persimilis* (Piccinelli & Prosdocimi 1968) is dominant (Campos *et al.*, 1996; De los Ríos 2005).

Within the species described in the zooplankton assemblages, at low conductivity it was reported the presence of fairy shrimps *Branchinecta* spp. (De los Ríos 2005). Currently there is scarce literature about Chilean fairy shrimp populations, the available literature only describes the presence of Anostracans for Southern Patagonian shallow ponds (Soto 1990[1]; De los Ríos 2005). Also, there are descriptions of fairy shrimp populations in Antarctic water bodies (Peck 2005, 2004; Campos *et al.* 1978). These results agree with the descriptions of Brték & Mura (2000) and Belk & Brték (1995), that indicate the exclusive presence of *Branchinecta* genus for Southern South America. In agreement with descriptions of De los Ríos (2005), Branchinecta in Southern Patagonia (45 - 53°S) is present in conditions of low salinity (approximately 1 g/l), and this genus is associated with copepods such as *Boeckella popei* and *Parabroteas sarsi* and daphnids such as *Daphnia dadayana*. The aim of the present study is to understand some basic topics of Southern Chilean fairy shrimp populations, specifically about use of this genus as indicator of conductivity and trophic status on the basis of field work observations in ponds in the surroundings of Punta Arenas town (53° S, Chile).

MATERIAL AND METHODS

The studied site was visited in October 2006, the zone is a plain along the shore of Magallanes Strait to the east of Punta Arenas city (53° S, Chile). Nine shallow ponds were studied, the studied sites were located along the main road between Punta Arenas and the Kon-Aiken plain (Table 1). The study site is one of the southern most zones in Chile, and one of the problems for its systematic study is the exposition to strong winds ca. 100 km/h) in

[1] Soto, D. 1990. Biomasa zooplanctónica de lagunas Patagónicas y su relación con el flamenco Chileno (*Phoenicopterus chilensis*). *Actas Primer Taller Internacional de Especialistas en Flamencos Sudamericanos*, San Pedro de Atacama, Chile. 84-102.

spring and summer, and the low temperatures with freezing of superficial layers in small water bodies in winter (Soto *et al.* 1994). Samples were collected for determining the conductivity, total dissolved solids and chlorophyll a concentrations (Wetzel & Likens 1991). Also vertical hauls were taken in the middle and the shore with an Apstein net 20 cm diameter and 100 μm mesh size. The collected specimens were fixed with absolute ethanol and were identified with the descriptions of Araya & Zúñiga (1985), Reid (1985), Bayly (1992) and Brték & Mura (2000). Conductivity, total dissolved solids and chlorophyll concentrations were classified in accordance to fairy shrimp presence or absence. A Mann-Whitney non parametric test was applied using the software Xlstat.

Also, as reference information for zooplankton crustacean species richness, conductivity and salinity were recorded in ephemeral shallow ponds near Balmaceda Airport (45° 54' 29'' S; 71° 43' 06'' W), ephemeral pools near of Torres del Paine National Park (Vega del Toro) and ephemeral pools near the study site (Kon Aikén) collected in October 2001 (geographical references are specified in De los Ríos 2005). The conductivity and salinity data were obtained using an YSI-30 sensor, and zooplankton species were identified according to specialized literature (Araya & Zúñiga 1985, Reid 1985, Bayly 1992 and Brték & Mura 2000).

RESULTS AND DISCUSSION

The studied sites show low conductivity and total dissolved solids, whereas the chlorophyll concentration was variable but tending toward oligotrophy in the farthest zones, toward oligo-mesotrophy in Laredo ponds, and toward eutrophy in Rio Seco, which was located in an small urban zone (Table 1). The fairy shrimp population reported was *B. gaini* and the other zooplankton species observed were mainly *B. popei, P. sarsi* and *D. dadayana* (Table 1). The results of statistical analysis revealed that *Branchinecta* occurs at low values of conductivity, total dissolved solids and chlorophyll *a* concentrations, whereas in sites with absence of *Branchinecta* the values of these parameters were significantly higher ($p < 0.005$; Table 1). The information collected in ephemeral ponds near Balmaceda Airport agree with the descriptions for fairy shrimp habitats close to Punta Arenas (Table 2).

These results agree with the descriptions of Pugh *et al.* (2002), who described *B. gaini* and *B. granulosa* for freshwater lakes and ponds in Palmer and Graham lands, and Shettland and Orkney islands. The literature indicates that some fairy shrimp species are endangered (Rogers & Pereira 2007) due to exotic species introduction, habitat fragmentation, or pollution (Leyse *et al.*, 2005; Peck, 2004; Starkweather 2005). Results

TABLE 1. Conductivity, total dissolved solids (TDS), chlorophyll a (Chl a) concentration and species reported in the sites studied.

Ponds	Latitude/ Longitude	Conductivity Ms/cm	TDS g/L	Chl *a* μg/l	Species reported
Pond 1	52° 51' 56'' S 70° 55' 14'' W	0.64	0.33	2,2	*Parabroteas sarsi* (Mrázek 1901), *Boeckella popei* (Mrázek 1901), *Daphnia dadayana* (Paggi 1999), *Branchinecta* spp.
Pond 2	52° 51' 56'' S 70° 55' 14'' W	0.70	0.36	2,5	*P. sarsi, B. popei, D. dadayana, Branchinecta* spp.
Pond 3	52° 51' 56'' S 70° 55' 14'' W	0.48	0.25	4,1	*P. sarsi, B. popei, D. dadayana, Branchinecta* spp.
Pond 4	52° 51' 56'' S 70° 55' 14'' W	0.42	0.22	2,5	*P. sarsi, B. popei, D. dadayana, Branchinecta* spp.
Pond 5	52° 51' 56'' S 70° 55' 14'' W	0.49	0.25	2,4	*P. sarsi, B. popei, D. dadayana, Branchinecta* spp.
Pond 6	52° 51' 56'' S 70° 55' 14'' W	0.56	0.28	2,4	*P. sarsi, B. popei, D. dadayana, Branchinecta* spp.
Laredo 1	52° 57' 31'' S 70° 49' 48'' W	6.14	3.09	4,4	*B. popei, D. dadayana, Chydorus sphaericus* (Müller 1785)
Laredo 2	52° 57' 31'' S 70° 49' 48'' W	2.29	1.15	5,4	*B. popei, D. dadayana, Ch. sphaericus*
Rio seco	53° 06'13'' S 70° 53' 10''W	2.30	1.16	28,6	*B. popei, Microcyclops* spp. *D. dadayana*

TABLE 2. Conductivity and salinity, and species reported for three fairy shrimp habitats in Aisen and Magallanes regions collected in October 2001 (Cf: De los Ríos 2005).

Localities	Latitude/ Longitude	Conductivity Ms/cm	Salinity g/L	Species reported
Balmaceda	45° 53' 45'' S 71° 42' 38'' W	0,27	0,10	*P. sarsi, B. gracilipes, B. popei*, *D. ambigua* (Scourfield 1947), *D. similis* (Claus 1876), Cyclopoid copepodites, *Branchinecta* spp.
Vega del Toro	51° 08' 13'' S 72° 32' 02'' W	2,15	1,30	*P. sarsi, B. michaelseni* (Mrázek 1901), *B. popei*, Cyclopoid copepodites, *D. dadayana* (Paggi 1999), *D. pulex, Neobosmina chilensis* (Daday 1902), *Branchinecta* spp.
Kon Aikén	52° 53' 37'' S 70° 55' 09' W	0,54	0,20	*P. sarsi, B. brevicaudata* (Brady 1875*), B. popei,* Cyclopoid copepodites, *D. dadayana* (Paggi 1999), *Neobosmina chilensis* (Daday 1902), *Branchinecta* spp.

obtained in the present study indicate that southern Chilean fairy shrimps are present in conditions of low conductivity and oligotrophy (Table 1). This is a practically unpolluted condition when compared to sites without fairy shrimp populations (Table 1), such as Laredo, that is a semi-industrial zone with aquaculture and chemical industries, and Rio Chico, that is located within a small urban zone with active poultry and agriculture.

The oligotrophy observed in the fairy shrimp habitats agree with descriptions of Manca & Mura (1997) and Vincent & Rautio (2006), which denoted low primary productivity, and that zooplankton species fed on benthic material such as microbial mats and detritus. Vincent & Rautio (2006) reported the existence of a resuspension process for obtain available feeding particles by crustaceans such as fairy shrimps. If we consider that the strong winds of Magallanes region can cause a mixing depth of 70 m in deep lakes (Soto 2002), it is likely that in presence of such winds, a whole mixing should occur in shallow water bodies of Magallanes (Soto 2002), same as descriptions for similar ecosystems in Argentinean Patagonia (Zagarese *et al.* 1998; Modenutti *et al.* 1998). Our results agree with descriptions of Antarctic fairy shrimp feeding, that is, a detritivorous diet (Paggi 1994), similar to the observations of the copepod *B. popei* (Pezzani-Hernández 1975), which coexists with fairy shrimps in Antarctic inland water bodies (Campos *et al.* 1978).

The available descriptions of Chilean fairy shrimp populations, denoted the presence of the *Branchinecta* genus (De los Ríos 2005), for small shallow ponds in Aisen region (45° S), shallow ponds in Magallanes region south of Torres del Paine National Park (51° S), near of Punta Arenas town (53° S). Also, the presence of Anostracans (Soto, 1990)[1] that likely belong to *Branchinecta* spp., in small temporal shallow ponds north of Punta Arenas (52° S). The descriptions of De los Ríos (2005), report that Chilean fairy shrimp populations inhabit low salinity sites (1 g/l; Table 2), while Soto (1990)[1] describes the presence of only Anostracans. Both De los Ríos (2005) and Soto (1990)[1] reported on associated aquatic crustaceans, similar to our results. Hannsson *et al.* (1996), reported an absence of fairy shrimps in water bodies of South Georgia in small water bodies with 2.4-8,5 µS/cm of conductivity, 0.15 – 9.70 µg/l of chlorophyll "a" and 1.00 – 12.00 µg/l total phosphorus.

From a geographical viewpoint, the sites included in the studies of De los Ríos (2005) and Soto (1990)[1] are located far from zones with human intervention, most of these being sheep ranches with low human activity (De los Ríos 2005; Soto 1990)[1], while Laredo and Río Seco ponds have a marked human intervention. As comparison, it was reported the presence of scarce fairy shrimps populations in subsaline water bodies in Northern Andes mountains (Hurlbert *et al.* 1984, Belk & Brték 1995). The literature described that the salinity is the main regulator of zooplankton assemblages (De los Ríos & Crespo 2004; De los Ríos 2005; Soto & De los Ríos 2006), on this basis it is likely that fairy shrimp in Altiplano occurs at similar conditions than southern Patagonia.

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