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First observations of the aquatic invertebrate fauna in ephemeral Atacama River (22° S, Antofagasta Region, Chile)

P. De los Rios Escalante[a*], K. Górski[b], P. Acevedo[c], M. Castro[c]

[a] *Universidad Catolica de Temuco Facultad de Recursos Naturales Escuela de Ciencias Ambientales Casilla 15-D Temuco Chile*
[b] *Departamento de Ecología, Facultal de Ciencias, Universidad Católica de la Santísima Concepción, Concepción, Chile*
[c] *Universidad de la Frontera Temuco Chile*

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Abstract

The invertebrate communities of the northern Chilean rivers are characterised by their marked endemism and specificity of their community structure in different basins. The river systems located in the Atacama Desert are endorheic and are affected by the rainy period of January-February commonly known as the "Bolivian winter". The present study is the first report on the observations of arthropods in the ephemeral Atacama River during a period of the "Bolivian winter". The Atacama River is characterised by species with poor invertebrate assemblage dominated by diapausing crustaceans (cladocera, copepod, ostracoda) and dispersing aquatic insects (ephemeroptera and diptera larvae).

Keywords: Crustaceans; Insects; Chilean arid zone; Atacama river; Bolivian winter

1. Introduction

The Atacama Desert in northern Chile is the most arid desert in the World. It accommodates intermittent and endorheic Rivers originating from the Andes range that discharge into natural salt flats (Niemeyer and Cereceda, 1984). This region receives rainfall during January and February (period locally referred to as "Bolivian winter") that feeds the local freshwater ecosystems (Niemeyer and Cereceda, 1984; De los Rios-Escalante, 2010; Riveros *et al.*, 2012). There are no studies available on aquatic fauna in river ecosystems of the region with the exception of the Loa River (De los Ríos-Escalante *et al.*, 2010; De los Ríos-Escalante and Mardones, 2013; Palma *et al.*, 2013).

The intermittent rivers located in the Atacama Desert are expected to be colonised by aquatic fauna during the period of rainfall, similar to other ephemeral pools (De los Rios-Escalante and Robles, 2013). This study focused on the Atacama River which flows through the town of San Pedro de Atacama. The Atacama River originates in the Andes range and discharges into the Atacama salt flats (Salar de Atacama). At present, the river is canalised for agricultural purposes and the main course is intermittent with freshwater flowing during the period of the "Bolivian winter" (Niemeyer and Cereceda, 1984). The aim of the present study is to provide a basic description of aquatic invertebrates in the Atacama River during the "Bolivian winter".

2. Materials and Methods

Three invertebrate samples from the lower reaches of the Atacama River were collected on the 21st of February 2015 (Table I, Fig. 1). The samples were collected by filtering 50 L of water through a 50 µm mesh net for each sampled site. The filtered water was collected just below the surface using a

* Corresponding author. Tel.: +56 45 2205694
Fax: +56 45 2205694
E-mail address: prios@uct.cl

5 L bucket. Material retained on the net was preserved in 60–70% ethanol (final concentration). Specimens were identified according to the descriptions of Araya and Zúñiga (1985), Gomez *et al.* (2007), Dominguez and Fernandez (2009) and Karanovic (2012), and quantified as individuals per litre (ind/L).

Meteorological data for 2014 from San Pedro de Atacama were obtained from Dirección General de Aguas, Ministerio de Obras Públicas, Chile (www.dga.cl). Furthermore, two satellite images (10th February 2014 and 18th June 2014) corresponding to the multispectral Operational Land Imager (OLI) of LandSat-8 were used to assess wet area within the Atacama River during "Bolivian winter". Radiometric correction and reflectance calibration was applied to each image (Felde *et al.*, 2003). After the calibration, the spectral index Global Vegetation Moisture Index (GVMI) was used to assess the wet area (Ceccato *et al.*, 2002; Yebra *et al.*, 2013), following the equation:

$$GVMI = \frac{(\rho_{nir} + 0.1) - (\rho_{swir} + 0.02)}{(\rho_{nir} + 0.1) + (\rho_{swir} + 0.02)}$$

where ρ_{nir} and ρ_{swir} are the reflectance in close infrared bands (NIR: 850-878 nm) and medium infrared (SWIR: 1556-1651 nm) respectively (Barsi *et al.*, 2014).

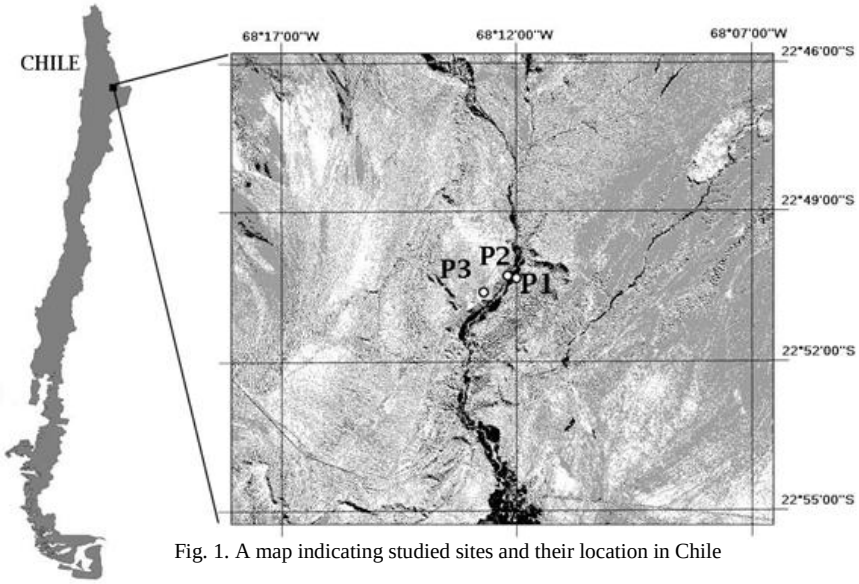

Fig. 1. A map indicating studied sites and their location in Chile

Table 1. Altitude, geographical location, and species reported (in Ind/L) for three sites in Atacama river

Site	P1	P2	P3
Altitude (m a.s.l.)	2522	2494	2536
Geographical location	22° 50' 21" S 68° 12' 11" W	22° 50' 21" S 68° 12' 12" W	22° 50' 33" S 68° 13' 04" W
Crustacea			
Cladocera			
Chydoridae			
Chydorus sphaericus (O.F. Müller, 1785)	0	0	1
Copepoda			
Cyclopoida			
Cyclopoid copepodite	0	0	1
Harpacticoida			
Canthocamptidae			
Cletocamptus sp. Schmankevitsch, 1875	2	0	84
Ostracoda			
Candonidae			
Candona sp. Baird, 1845	2	0	383
Insecta			
Ephemeroptera			
Lepohyphidae			
Yaurina sp	0	0	12
Diptera			
Ceratopogonidae	0	0	29

3. Results and Discussion

Very low invertebrate abundances were observed at the upstream site (P1), where specimens of *Clethocamptus* sp. and *Candona* sp. were found, whereas at P2 no invertebrate specimens were reported (Table I, Fig. 1). At the downstream sample (P3) multiple species and higher abundances were observed. Furthermore, at this site *Clethocamptus* sp. and *Candona* sp. were the most abundant of all species recorded (Table I).

Meteorological data during the year before sampling (2014) indicate a low rain period during January (two days of rainfall in total, 12.5 mm, DGA, 2015), whereas no rain was reported during other months with the exception of May with just 0.3 mm (DGA, 2015). Unfortunately, no meteorological data were available for 2015. The winter wet image was compared to the summer wet image, based on the GVMI index (Fig. 1). This image displays in gray scale a qualitative change (winter / summer) of soil wetness: in white the areas without or with weak changes, in grey, areas with moderate changes while areas with strong changes are black. Figure 2 shows images of GVMI index from 10th February 2014 (up) and 18th June 2014 (low).

In this study, the arthropod assemblages reported in the Atacama River are comparable to those reported for the Loa River, a permanent river located in the same region (De los Ríos *et al.*, 2010; Palma *et al.*, 2013). Similar to the Loa River, the ephermal Atacama River seems to be colonised by diapausing crustaceans (De los Ríos-Escalante and Robles, 2013) or dispersing aquatic insects that use these water bodies as a habitat for larval stages (Dominguez and Fernandez, 2009; Valdovinos *et al.*, 2010). Furthermore, the presence of harpacticoids and ostracods in the river probably resulted from the drift from upstream reaches and lentic habitats (De los Ríos-Escalante *et al.*, 2015).

The January-February rain period ('Bolivian winter') was previously reported to play a governing role in the aquatic ecosystems of the Atacama region, it drives the hydrological regimes of the rivers in the region (Peredo-Parada *et al.*, 2009, 2011; Gascoin *et al.*, 2011; Jimenez, 2012; Romero *et al.*, 2013; Rojas *et al.*, 2014; Valdes, 2014) and affects populations of riverine ostracods that generate diapausing eggs (Scheihing *et al.*, 2011). The present study is the first report of the abundance and species composition of the invertebrate fauna in the ephemeral Atacama River and as such, is the first step towards advancing the understanding of its ecology and biogeography. Further studies at larger spatial and temporal scales are needed to advance the understanding of hydrological patterns and their relation with aquatic communities in the Atacama River.

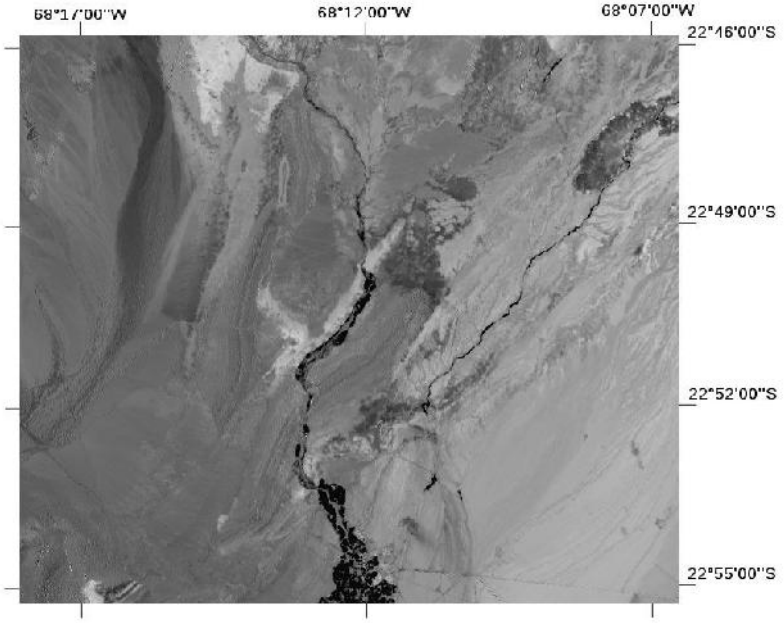

Fig. 2. Satellite images with relative wetness (from GVMI index) in the Atacama River, for January (upper) and June (lower)

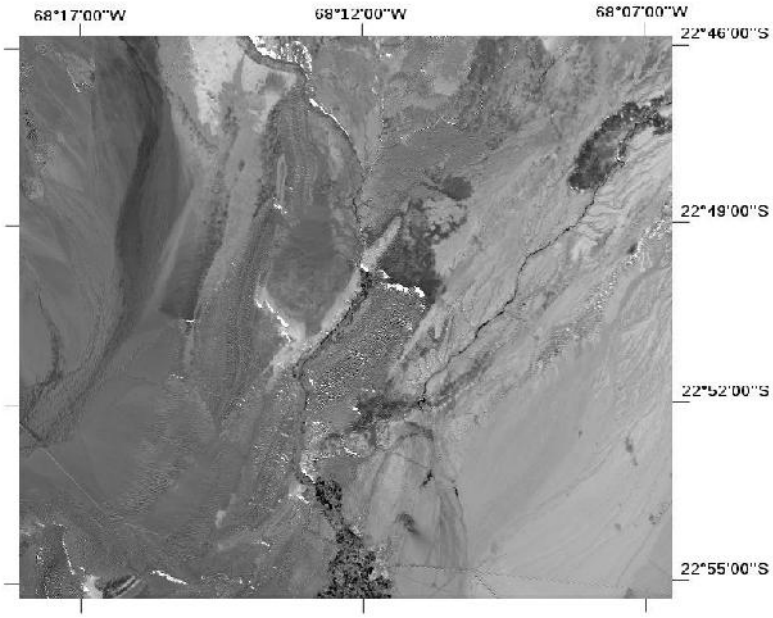

Fig. 2. Satellite images with relative wetness (from GVMI index) in the Atacama River, for January (upper) and June (lower)

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