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Extension of the known distribution range and habitat use of the Tiger Crab *Aegla concepcionensis* Schmitt, 1942 (Decapoda, Aeglidae)

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ABSTRACT

Extension of the known distribution range and habitat use of the Tiger Crab *Aegla concepcionensis* Schmitt, 1942 (Decapoda, Aeglidae)

The tiger crab *Aegla concepcionensis* Schmitt, 1942 (Decapoda, Aeglidae) is a threatened freshwater decapod, endemic of Chile, with significant gaps in knowledge about its biology and ecology. The aim of this work was to contribute to the knowledge of the ecology of *A. concepcionensis*, through the extension of its known distribution range, recorded in a new type of ecosystem, and the description of the physicochemistry, vegetation and benthic macroinvertebrate and microalgal communities of those sites, which provides information about habitat use of the species. Our results show the presence of *A. concepcionensis* until 270 km south of the previously described range and reveal that the species inhabits streams and lakes. *A. concepcionensis* is associated to environments with cold and temperate waters, well oxygenated, with neutral pH and low conductivity, and characterized by low anthropic intervention, which is reflected in the high proportion of native riverine plant species and the high diversity of macroinvertebrate and microalgal benthic communities. We conclude that the previously restricted known distribution range of this species was mainly due to low sampling effort or misidentifications. Our results indicate that anthropic intervention should be avoided or minimized in the distribution area of *A. concepcionensis*, especially in those areas associated with urban expansion and touristic activities in streams and lakes.

Key words: *Aegla concepcionensis*, distribution, habitat, freshwater, Chile

RESUMEN

Extensión del rango de distribución conocido y uso de hábitat del cangrejo tigre* Aegla concepcionensis *Schmitt, 1942 (Decapoda, Aeglidae)

El cangrejo tigre Aegla concepcionensis *Schmitt, 1942 (Decapoda, Aeglidae) es un decápodo de agua dulce amenazado, endémico de Chile, con importantes brechas en el conocimiento de su biología y ecología. El objetivo de este trabajo fue contribuir al conocimiento de la ecología de* A. concepcionensis*, a través de la extensión del conocimiento de su distribución geográfica, registrado en un nuevo tipo de ecosistema, y la descripción fisicoquímica, vegetal y de las comunidades de macroinvertebrados bentónicos y microalgas bentónicas de esos sitios, lo cual brinda información acerca de nuevos usos de hábitat de la especie. Nuestros resultados muestran la presencia de* A. concepcionensis *hasta 270 km al sur del rango previamente descrito y que la especie habita en arroyos y lagos. Se asoció a ambientes con aguas frías y templadas, bien oxigenadas, con pH neutro y baja conductividad, que se caracterizaron por presentar baja intervención antrópica, reflejada en la alta proporción de especies vegetales nativas ribereñas y la alta diversidad de las comunidades bentónicas de macroinvertebrados y microalgas. Concluimos que su previamente restringido rango de distribución conocido se debía principalmente al bajo esfuerzo de muestreo o a identificaciones taxonómicas erróneas. Nuestros resultados indican que se debe evitar o minimizar la intervención antrópica en el área de distribución de* A. concepcionensis*, especialmente en aquellas áreas asociadas con la expansión urbana y actividades turísticas en arroyos y lagos.*

Palabras clave: Aegla concepcionensis*, distribución, hábitat, agua dulce, Chile*

INTRODUCTION

Aegla concepcionensis Schmitt, 1942, commonly referred to as Tiger crab or Pancora, is a freshwater decapod endemic of Chile, which belongs to the Aeglidae family. This family is composed of 83 species and subspecies, of which 20 (18 species and 2 subspecies) are present in Chile, all included in the genus *Aegla* Leach, 1820. The genus *Aegla* has been described as endemic to the neotropical region in South America, which is distributed between latitudes 20° 18’ S in Brazil and 50° 34’ S in Chile (Santos & De Siqueria Bueno, 2020) and it is the only taxon of the Anomura infraorder that is restricted to fresh waters (Schmitt, 1942; Bond-Buckup et al., 2008; Jara, 2013; Santos et al., 2017). According to fossil evidence (Feldmann, 1986; Feldmann et al., 1998), the origin of freshwater aeglids is marine. Invasion of fresh waters occurred due to marine transgressions that occurred during the early formation of the Andean Mountain range in the Late Cretaceous-Early Tertiary, around 90 to 60 million years ago (Pérez-Losada et al., 2004), with dispersion in the region between the Pacific and Atlantic oceans (Pérez-Losada et al., 2004; Bueno et al., 2016).

The species *A. concepcionensis* has been poorly studied, with details about its biology or ecology mostly unknown, but it has been categorized as threatened. It is a benthic species that inhabits clean-water streams with sandy, quartzite-mycum substrates, mixed with leaf litter and woody detritus (Smith-Ramírez et al., 2005). It prefers areas of low depth and current speed but well oxygenated, since it has high oxygen demand (Bond-Buckup & Buckup, 1994; Dalosto & Santos, 2011). The geographical distribution of *A. concepcionensis* has also been little studied but it seems that, like other species of the genus *Aegla*, it has a relatively small distribution area. Most species in the genus are restricted to a single or a few drainage basins, which means they are highly endemic (Tumini et al., 2018). In particular, *A. concepcionensis* has been described as a micro-endemism, with a distribution area restricted to streams of the Biobío basin, around the city of Concepción (Jara, 1996, 2013; Bahamonde et al., 1998)

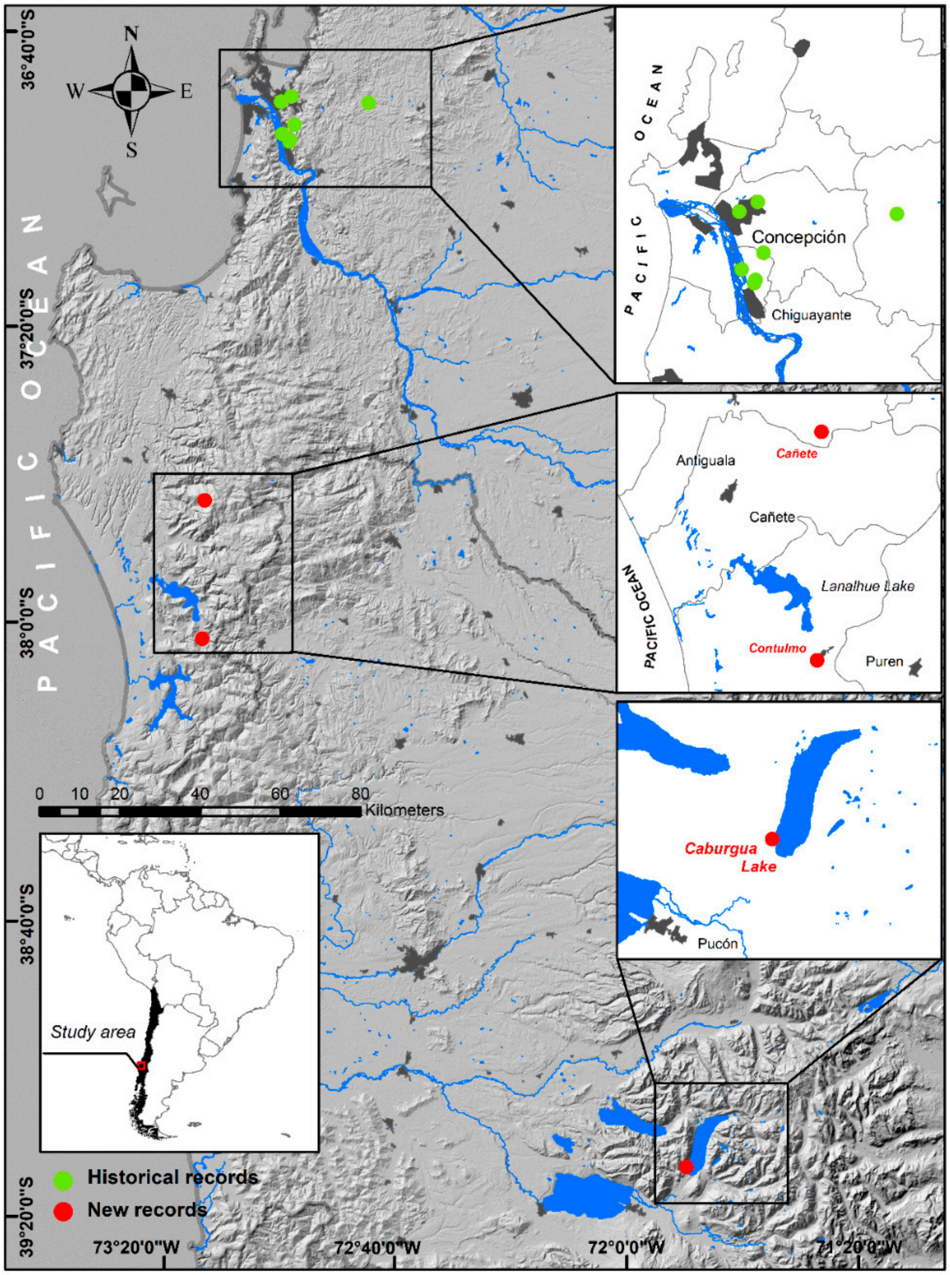

Figure 1. Geographical distribution of *A. concepcionensis* based on historical reports (Schmitt, 1940; Jara, 1996, 2013; Bahamonde et al., 1998; Oyanadel & Valdovinos, 2004; MMA, 2013; Valdovinos, 2019) and new reports (this study). *Distribución geográfica de* A. concepcionensis *basada en los reportes históricos (Schmitt, 1940; Jara, 1996, 2013; Bahamonde et al., 1998; Oyanadel & Valdovinos, 2004; MMA, 2013; Valdovinos, 2019) y en los nuevos reportes (este estudio).*

(Fig. 1). However, here we report the presence of this species at new sites outside this area and in a new type of habitat, thus extending its known range of geographical distribution and providing a more complete description of its habitat use.

MATERIALS AND METHODS

Study area and sampling strategy

The study area corresponded to low-order streams located in the coastal area of the Chilean Mediterranean zone (37° 30’ 0” S – 38° 0’ 0” S) and one lacustrine ecosystem located in the lowlands of Andean Mountain range in Southern Chile (39° 10’ 46.70” S - 71° 48’ 35.84” O) (Fig. 1). Specifically, samples were collected from 10 streams: Quirilao 1 and 2, Piedra Laja, Contulmo 1, El Peral, Salto Rayén, Los Notros, Puente Mecano, El Canelo and Paillahue, and from Caburgua lake.

The studied streams are located in the Mediterranean coastal area of Chile, at the base of the Nahuelbuta mountain range. The climate is perhumid Mediterranean with a maritime influence, according to the classification of Di Castri & Hajek (1976), with annual precipitation of 1294 mm and average annual temperature of 13.1 °C (Luebert & Pliscoff, 2006). The Nahuelbuta mountain range is formed by metamorphic rock from the Precambrian and Palaeozoic crystalline basement, as well as intrusive and volcanic rocks, mainly from the Tertiary and Quaternary. It presents a mountainous relief, with moderate to strong slopes and flat surfaces, reaching heights over 650 m a.s.l.. The main economic activities of the area are tourism, small-scale agricultural and industrial forestry (Illustrious Municipality of Cañete, 2015).

The Caburgua lake, located in the foothills of the Andes, has a type of perhumid Mediterranean climate characterized by the presence of cool, mild summers and cold, wet winters. Annual rainfall is 2500 mm and average annual temperature is 12 °C (Di Castri & Hajek, 1976; CONAF, 1999). The Andean Mountain range is considered a large raised block, more than 2000 m a.s.l., made up of clastic-volcanic rocks from the Upper Cretaceous and by granites, on which volcanic rocks have been deposited during the Tertiary and Quaternary (IREN, 1970). It presents a mountainous relief, with very steep slopes and deep-water ecosystems due to the action of glaciations, which have deposited lateral moraines, and volcanism (Figueroa, 1983; CONAF, 1999). The main economic activity is tourism, followed by the agriculture and forestry (PRC, 2019).

In each stream, samples of benthic fauna (n = 6) were collected during February (summer) and July (winter) of 2019, using a Surber net (30x30 cm; 250 µm mesh). Each sample was taken for 5 minutes and including all the habitats present (Rodríguez-Capítulo et al., 2009; Santos et al., 2017). In the lake, the samples were taken manually at 3 m of depth through snorkelling in littoral zone. In both cases, the samples were *in situ* examined and individuals of the Aeglidae family were separated. We measured their total length (cm), identified their sex, photographed them in high-resolution for later identification. Finally, the individuals were returned to their natural habitat.

A. concepcionensis taxonomic identification

The identification of the photographed specimens was done based on the Species Background file of the MMA (2014) used in the Regulation of Classification of species (CERs) and Jara (1996). All the diagnostic characters described in the literature (Schmitt, 1942) were compared, which include: an elongated triangular-linked face, with the rostral cavity crest containing two rows of small corneal scales; presence of a wide, protuberant and convex gastric area, with smooth shell side edges; predactilar lobe of the chelipods included in the palmar crest; antero-lateral angle of the second acute abdominal epimer containing an apical scale; and presence of a dimeric telson and pereiopods with blue-grey transverse bands interspersed with orange-yellow bands.

Benthic macroinvertebrate sampling and analysis

For the characterization of the benthic macroinvertebrate community to which *Aegla concepcionensis* was associated, streams were sampled during the summer and winter seasons, considering areas located at least 100 m upstream of bridges to avoid human intervention. The macroinvertebrate samples (n = 6) were extracted using a Surber net of 0.09 m^2 area and 250 µm mesh opening. To take samples, the Surber net was located upstream, washing the larger rocks in front of its entrance, and removing the thick substrate in order to extract the adhered individuals, in such a way that the organisms were dragged by the current to the bottom of the net (Figueroa et al., 2007; Correa-Araneda et al., 2021). The samples were previously cleaned in the field to remove the finest sediment, rocks, and woody material. They were later stored and transported to the laboratory in labelled plastic containers and fixed in 96 % ethanol (Cornejo et al., 2019). We identified individuals to the family taxonomic level (Thorne & Williams, 2003) using a trinocular stereoscopic magnifying glass (EUROMEX-HOLLAN NexiusZoom EVO NZ. 1903-PG), identification guides and keys (Flint, 1983; Peña, 1996; Roldán, 1996; Domínguez & Fernández, 2001, 2009), as well as consultations with specialists.

Benthic microalgal sampling and analysis

To characterize the community of benthic microalgae, rocks were selected at random (n = 3) from the substrate of the streams. On the upper face of each rock a 1 cm^2 quadrant was delimited, from which all the biofilm was extracted by scraping the attached microalgae. The material obtained was fixed with 5 % lugol for subsequent taxonomic identification in the laboratory (Gómez et al., 2009). For identification, a gridded Sedgewick-Rafter (S-R) counting chamber was used, by means of the longitudinal transect method, where a minimum of 100 cells of the most abundant taxon present in each ocular field were counted. For the identification of diatoms, oxidations and permanent preparations were carried out (Gómez et al., 2009; APHA-AWWA-WEF, 2012). The microalgae were identified using the keys of Parra et al. (1982), Rivera (1983), Simonsen (1987), Krammer & Lange-Bertalot (1991), Parra & Bicudo (1996), Round & Bukhtiyarova (1996) and bases updated international data (eg, https://www.algaebase.org, https://www.gbif.org).

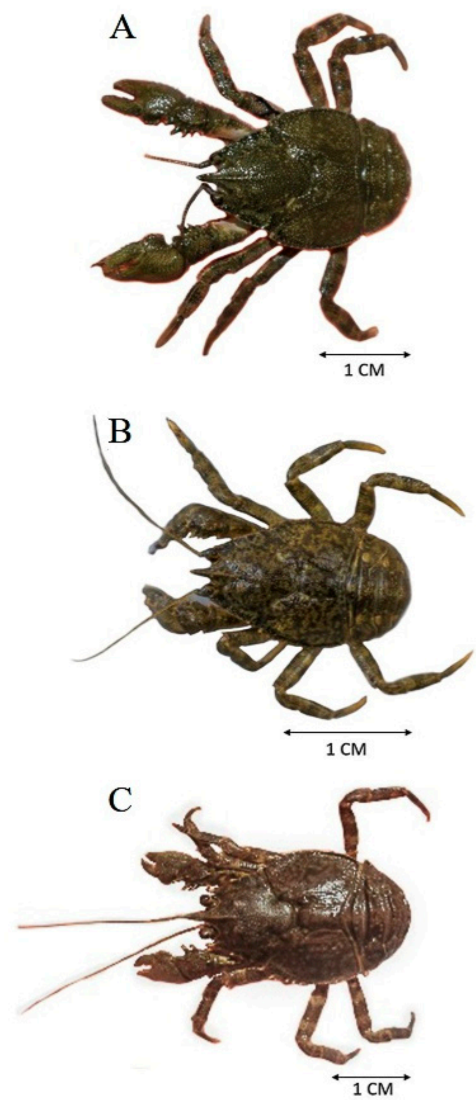

Figure 2. Images of adult's individuals of *A. concepcionensis* from Piedra Laja stream (A), Peral stream (B) and Caburgua lake (C). *Imágenes de individuos adultos de* A. concepcionensis *provenientes del arroyo Piedra Laja (A), Arroyo Peral (B) y lago Caburgua (C).*

Habitat characterization

To characterize the aquatic environment of *A. concepcionensis* we measured pH, conductivity (µS/cm), dissolved oxygen (mg/L), oxygen saturation (%), temperature (°C), total suspended solids (mg/L) and salinity (ppm) three times in situ with a multiparameter equipment (Hanna HI9829) in all sites where it was found; additionally, the physicochemical characteristic of the water were measured in winter and summer in streams and in summer in the lake. The depth (cm) (streams and

Table 1. Physicochemical ecosystem and atmospheric variables (mean, minimum and maximum values) of the new sites with the presence of *A. concepcionensis*. DO = Dissolved Oxygen, TSS = Total suspended solids. *rock walls. *Variables fisicoquímicas y atmosféricas (promedio, mínimo y máximo) de los nuevos sitios con presencia de* A. concepcionensis . *DO = Oxígeno disuelto, TSS = Sólidos suspendidos totales. *Paredes rocosas.*

	Piedra Laja stream						Peral stream						Caburgua lake		
Season	Winter			Summer			Winter			Summer			Summer		
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Physicochemical ecosystem variables															
Temperature (°C)	9.02	9.02	9.02	11.18	11.18	11.18	10.04	10.04	10.04	12.46	12.46	12.46	23.56	23.54	23.57
DO (mg/L)	17.31	17.14	17.34	16.78	16.73	16.86	17.62	17.54	17.66	13.41	13.38	13.43	8.50	7.8	9.10
Oxygen saturation (%)	150.23	147.5	154	152.73	152.2	153.5	155.27	155.2	155.4	125.60	125.2	126.1	115.3	90.40	118.50
Conductivity (µS/cm)	37.00	37.00	37.00	43.00	43.00	43.00	44.00	44.00	44.00	38.00	38.00	38.00	38.00	38.00	38.00
Salinity (ppm)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
pH	7.22	7.18	7.26	6.51	6.51	6.53	6.72	6.7	6.73	6.70	6.69	6.70	7.68	7.66	7.69
TSS (mg/L)	19.00	19	19	22.00	22.00	22.00	22.00	22.00	22.00	19.00	19.00	19.00	19.00	19.00	19.00
Depth (m)	0.25	0.10	0.40	0.19	0.06	0.3	0.23	0.05	0.35	0.05	0.03	0.07	3.00	2.5	10
Width (m)	2.25	1	4	1.20	0.4	1.6	1.25	0.5	2.5	0.70	0.2	1.2	-	-	-
Velocity (m/s)	0.23	0.02	0.48	0.09	0.04	0.19	0.36	0.02	1.08	0.32	0.02	0.5	-	-	-
Flow (m^3/s)	0.25	0.012	0.58	0.03	0.001	0.05	0.14	0.002	0.33	0.01	0.001	0.04	-	-	-
Substrate size (cm)	25	15	35	25	15	35	25	15	35	25	15	35	250	200	300*
Habitat kind		Natural			Natural			Natural			Natural			Natural	
Atmospheric variables															
Mean Temperature (ºC)	8.48	0.00	14.00	13.57	5.3	24.3	7.92	-2.2	17.5	15.76	0.8	34.1	15.98	2.5	16.4
Relative humidity (%)	83.49	62.6	96	73.23	63.2	89.8	82.38	71.3	90.6	67.30	59	87.1	69.69	41.3	85.9
Accumulated precipitation (mm)	8.18	0	62.7	0.56	0	16.7	4.23	0	39.8	0.44	0.00	11.1	3.74	0.00	49.10
Atmospheric pressure (mbar)	1055	1040	1066	1014	1010	1018	1013	998	1024	1009	1005	1014	983.33	978	987
Solar radiation (Mj/m^2)	7.14	0.2	13.6	25.26	6.3	30.2	-	-	-	-	-	-			
Wind speed (km/h)	6.82	0.5	14.7	7.14	3.5	11.2	3.23	0.1	11.6	5.75	2.1	10.5	3.93	1.9	9.4

lake), width (cm), speed (m/s) and flow (m^3/s) at each stream site were also determined. To characterize the riparian vegetation, we used an adaptation of the methodology described by Vidal (2005), which consists of registering vascular species adjacent to the watercourse, considering a 10 m transect perpendicular to each riverbank. Vascular plant species were identified using Vidal (2005). The climatic variables mean temperature (Tm), maximum (Tmax), and minimum (Tmin), relative humidity (HR), accumulated precipitation (PPT), atmospheric pressure (mbar), ultraviolet solar radiation (Mj/m^2) and wind speed (km/h; Table 1) of the sampling month, were obtained from the environmental databases of the INIA (2020), in order to analyse the environment with which aquatic organisms interact directly or indirectly (Schaefer et al., 2008).

Statistical analyses

The community structure of the benthos (macroinvertebrates and microalgae) was analysed using the indices of taxonomic richness (S), total abundance (N), Shannon diversity (H'), and Palou's evenness index (J') (Krebs, 1988). Community indexes were calculated for each community using Primer V.6 software (Diverse analysis; Clarke & Gorley, 2006). To compare the mean range of the related samples and determine the existence of significant differences the Wilcox test was used ($p < 0.05$). This analysis was carried out with function in the R agricolae package (Mendiburu, 2020).

RESULTS

We found 4 specimens of *A. concepcionensis* in Caburgua lake and in 2 out of the 10 streams stud-

Table 2. Presence/absence matrix and phytogeography origin (P.O.; N = Native, E = Exotic) of riparian vegetation in sites with presence of *A. concepcionensis*. *Matriz de presencia/ausencia y origen fitogeográfico (P.O.; N = Nativo, E = Exótico) de la vegetación rivereña en los sitios con presencia de* A. concepcionensis .

Taxa	Piedra Laja stream	Peral stream	Caburgua lake	P.O.
Aextoxicaceae				
Aextoxicon punctatum Ruiz & Pav.	X			N
Blechnaceae				
Blechnum hastatum Kaulf.	X	X		N
Blechnum mochaenum G. Kunkel	X	X		N
Blechnum chilense (Kaulf.) Mett.	X			N
Celastraceae				
Maytenus boaria Molina			X	N
Ciperaceae				
Carex sp.	X			N
Dicksoniaceae				
Lophosoria quadripinnata (J.F. Gmel.) C. Chr.	X			N
Dryopteridaceae				
Megalastrum spectabile (Kaulf.) A.R. Sm. & R.C. Moran	X			N
Elaeocarpaceae				
Aristotelia chilensis (Molina) Stuntz	X	X	X	N
Ericaceae				
Gaultheria mucronata (L. f.) Hook. & Arn.	X			N
Eucryphiaceae				
Eucryphia cordifolia Cav.			X	N
Lardizabalaceae				
Boquila trifoliolata (DC.) Decne.	X	X		N
Loranthaceae				
Tristerix corymbosus (L.) Kuijt	X			N
Monimiaceae				
Peumus boldus Molina		X	X	N
Myrtaceae				
Eucalyptus globulus Labill.	X	X		E
Luma apiculata (DC.) Burret	X		X	N
Nothofagaceae				
Nothofagus obliqua (Mirb.) Oerst.	X	X	X	N
Nothofagus dombeyi (Mirb.) Oerst			X	N
Onagraceae				
Fuchsia magellanica Lam.	X		X	N
Oleaceae				
Fraxinus sp.			X	E
Philesiaceae				
Lapageria rosea Ruiz & Pav.	X	X		N
Pinaceae				
Pinus radiate D. Don	X	X		E
Poaceae				
Chusquea quila Kunth	X	X	X	N
Polypodiaceae				
Synammia feuillei (Bertero) Copel.	X			N
Proteaceae				
Gevuina avellana Molina			X	N
Rosaceae				
Rubus ulmifolius Schott	X	X	X	E
Rubiaceae				
Nertera granadensis (Mutis ex L.f.) Druce		X		N
Salicaceae				
Populus sp.			X	E
Urticaceae				
Pilea elegans Gay	X			N
Verbenaceae				
Rhaphithamnus spinosus (Juss.) Moldenke	X			N
Vitaceae				
Cissus striata Ruiz & Pav.	X	X		N

ied, which correspond to the Piedra Laja and Peral streams. We found 2 males at the first stream, 1 female at the second and 1 female in the Caburgua lake (Fig. 2). The male specimens had an average cephalothorax length of 1.52 + 0.45 cm, while the female specimens had an average cephalothorax length of 0.7 + 0.14 cm.

Water physicochemistry in the summer and winter at the 2 streams were *A. concepcionensis* was collected were the following: temperature, 9.02-12.46 °C; pH, 6.51-7.22, oxygen concentration, 13.41-17.62 mg/L; oxygen saturation, 125.6-155.27 %; conductivity, 37-44 µS/cm; salinity, 0.02 ppm and total suspended solid concentration, 19-22 mg/L (Table 1). In Caburgua lake the average values of the physicochemical variables of the water in the summer were: temperature, 23.56 ± 0.02 °C; pH, 7.68 ± 0.02; oxygen concentration, 8.50 ± 0.06 mg/L; oxygen saturation, 115.3 ± 7.83 %; conductivity, 38 ± 0.00 µS/cm; salinity, 0.02 ± 0.00 ppm and total suspended solid concentration, 19.00 ± 0.00 mg/L (Table 1). Regarding the depth (streams and lakes) and the water velocity (streams), the average values of the sites studied according to the season (winter and summer) are presented in Table 1. The riparian vegetation at these 3 sites consisted of 31 species, of which 83.9 % were native and 16.1 %

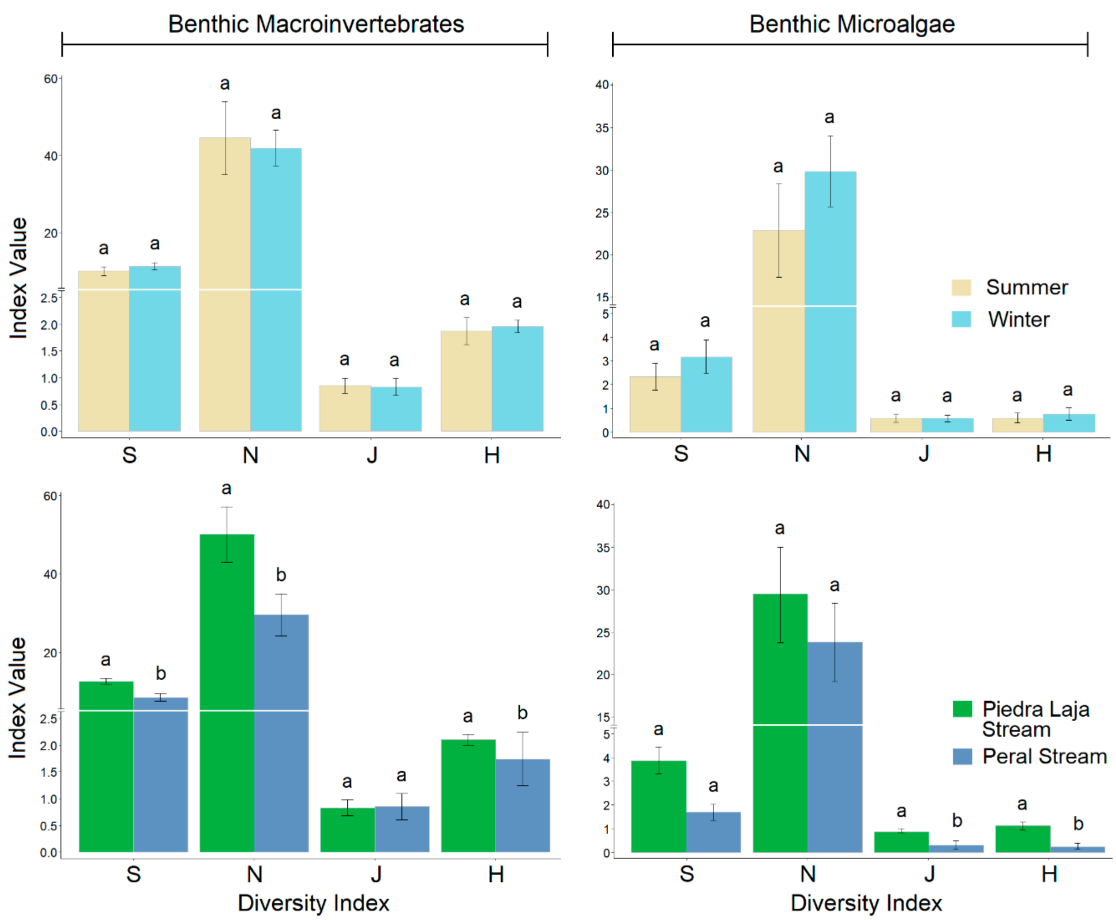

Figure 3. Indices of the macroinvertebrate (left) and microalgae (right) benthic communities recorded in the streams for seasons (upper) and sampling sites (lower), different letters indicate statistically significant differences. *Índices comunitarios de macroinvertebrados (izquierda) y microalgas (derecha) bentónicas registradas en los arroyos por estaciones (superior) y sitios de muestreo (inferior), letras diferentes indican diferencias estadísticamente significativas (*p *< 0.05).*

exotic (Table 2). We registered 23, 13 and 13 plant species at the Piedra Laja stream, Peral stream and Caburgua lake respectively, of which 11 species were common between streams and 4 taxa between all sites. The most abundant families were Blechnaceae, Myrtaceae and Nothofagaceae (Table 2).

The climatic variables in summer and winter in the streams where *A. concepcionensis* were collected are the following: average temperature, 7.92-15.76 °C; relative humidity, 67.3-83.49 %; precipitation accumulation, 0.44-8.18 mm; atmospheric pressure, 1009-1055 mbar; solar radiation, 7.14-25.26 Mj/m^2; wind speed, 3.23-7.14 km/h (Table 1). Caburgua lake in the summertime registered: average temperature of 15.98 °C; relative humidity, 69.69 %; precipitation accumulation, 3.74 mm; atmospheric pressure, 983.33 mbar; wind speed, 3.93 km/h (Table 1).

In summer season, in the Piedra Laja and Peral streams, respectively, showed a macroinvertebrate taxonomic richness of 12 and 8, an abundance of 66.17 and 22.8 individuals/0.09 m^2, a diversity of Shannon of 2.08 and 1.68, and an evenness of 0.85 in both. In the winter season the richness was 13 and 9, abundance was 47.5 and 36.3 individuals/0.09 m^2, Shannon diversity was 2.13 and 1.8 and evenness was 0.82 and 0.85 (Table 3; Fig. 3-left). Results from the Wilcox test showed that macroinvertebrate community was similar among seasons (Fig. 3-left) and different among sampling sites, showed statistically differences in the S, N and H indexes (Fig. 3-left). For microalgae, in the summer season the above streams showed a taxonomic richness of 3 and 1, an abundance of 31.3 and 14.3 cel/cm^2, a Shannon diversity of 0.98 and 0.21, and an evenness of 0.85 and 0.31. In the winter season, taxonomic richness was 4 and 2, abundance was 27 and 33 cel/cm^2, Shannon diversity was 1.22 and 0.3, and evenness 0.83 and 0.32 (Table 4; Fig. 3-right). Results from the Wilcox test showed that microalgae community was similar among seasons (Fig. 3-right) and different among sampling sites, showed statistically differences in the J and H indexes (Fig. 3-right).

DISCUSSION

A. concepcionensis had been previously described as a micro-endemic species with its geographical distribution limited to the Biobío region in Chile (Bahamonde et al., 1998; Jara, 2013). The first record of the species was made by Schmitt (1940) in the city of Concepción. Then Jara (1996) described its presence in the Villa Vergara and Nonguén streams, a stream flowing into the Pineda Lagoon, and a stream and waterfall in the campus of the University of Concepción. Bahamonde et al. (1998) reported its presence in the Andalién river basin and confirmed the distribution described by Jara (1996). Oyanadel & Valdovinos (2004) reported its presence in the Cárcamo stream, which is located within the grounds of the Universidad de Concepción. Subsequently, Jara (2005) suggested that it could be present in a stream at the Cayumanqui hill (Quillón), bit he could not confirm it. The MMA (2013) reported the presence of the species in the Lircay and San Onofre streams and in a tributary of San Onofre. The same year, Jara (2013) confirmed the distribution described in 1996 and added the Manantiales and Estadio Árabe streams in Chiguayante city. Finally, Valdovinos (2019) corroborated its presence in different areas of the Andalién river basin, including the lower middle course of the Andalién River, the Nonguén stream, the Laguna Pineda and streams in the Cayumanqui hill.

All the above reports supported the micro-endemism of the species to the Andalién river basin, in the surroundings of Concepción city (Jara, 1996, 2013; Bahamonde et al., 1998; Valdovinos, 2019). However, our results show a wider geographical distribution of the species, as we recorded its presence in streams and one lake located ca. 120 km and 270 km respectively at south of the limit previously described, in completely disconnected basins, which correspond to an extension of the known distribution range. The streams where we found *A. concepcionensis* are part of short river basins that drain towards the Pacific from the Nahuelbuta mountain range at the height of the Cañete and Contulmo cities, the streams where *A. concepcionensis* was collected drain towards Lanalhue lake, whose origin is tectonic (Stefer et al., 2010). The Caburgua lake, it's located in the base of Andean Mountain range, has a glacial origin, absence of industrial or agricultural activities and oligotrophic waters. Never-

Table 3. Abundance (N° ind/0.09 m^2) of benthic macroinvertebrates in sites with presence of *A. concepcionensis*. *Abundancia de macroinvertebrados bentónicos en los sitios con presencia de* A. concepcionensis .

Taxa	Piedra Laja stream Winter	Piedra Laja stream Summer	Peral stream Winter	Peral stream Summer
Tricladida				
Dugesidae	0.015 ± 0.036			
Oligochaeta	0.165 ± 0.237		0.06 ± 0.109	
Lombriculidae		0.48 ± 0.25		
Gastropoda				
Amnicolidae	0.15 ± 0.32	0.285 ± 0.453		0.27 ± 0.34
Chilinidae		0.03 ± 0.07		
Bivalvia				
Sphariidae			0.015 ± 0.036	
Amphipoda				
Hyalellidae	0.03 ± 0.07			
Ephemeroptera				
Leptophlebiidae	0.765 ± 0.562		0.705 ± 0.453	0.015 ± 0.033
Siphlonuridae	0.105 ± 0.119		0.135 ± 0.203	
Baetidae	0.285 ± 0.216	0.12 ± 0.15	0.045 ± 0.049	
Coloburiscidae				0.015 ± 0.033
Plecoptera				
Gripopterygidae	0.105 ± 0.183		0.66 ± 0.35	0.03 ± 0.04
Perlidae	0.12 ± 0.13		0.015 ± 0.036	0.165 ± 0.141
Eustheniidae	0.06 ± 0.07	0.015 ± 0.036		0.03 ± 0.06
Austroperlidae				0.075 ± 0.08
Diamphipnoidae	0.045 ± 0.075	0.315 ± 0.246	0.18 ± 0.24	0.015 ± 0.033
Notonemouridae	0.24 ± 0.21		0.15 ± 0.21	
Trichoptera				
Limnephilidae	0.015 ± 0.036		0.015 ± 0.036	
Sericostomatidae	0.705 ± 0.477	1.305 ± 0.675	0.33 ± 0.32	0.24 ± 0.31
Leptoceridae	0.015 ± 0.036	0.075 ± 0.119	0.015 ± 0.036	
Hydroptilidae				0.015 ± 0.033
Hydropsichidae	0.945 ± 0.320	1.02 ± 1.31	0.27 ± 0.53	0.105 ± 0.096
Ecnomidae		0.045 ± 0.075		0.06 ± 0.13
Philopotamidae	0.045 ± 0.049		0.015 ± 0.036	
Odontoceridae	0.015 ± 0.036			
Anomalopsichidae	0.03 ± 0.04		0.03 ± 0.04	0.15 ± 0.29
Helicopsichidae	0.015 ± 0.036	0.12 ± 0.29		
Calamoceratidae	0.015 ± 0.036		0.075 ± 0.088	
Glossosomatidae	0.045 ± 0.049			
Coleoptera				
Psephenidae	0.015 ± 0.036	0.42 ± 0.43		
Elmidae	0.09 ± 0.13	0.51 ± 0.40		

Cont.

Table 3. (cont.)

Taxa	Piedra Laja stream Winter	Piedra Laja stream Summer	Peral stream Winter	Peral stream Summer
Diptera				
Chironomidae	0.075 ± 0.067	0.57 ± 0.37	0.045 ± 0.11	0.135 ± 0.135
Athericidae		0.135 ± 0.124		0.105 ± 0.12
Simulidae	0.045 ± 0.049	0.225 ± 0.246	0.45 ± 0.6	0.015 ± 0.033
Ceratopogonidae		0.03 ± 0.04		0.015 ± 0.033
Dixydae			0.015 ± 0.036	
Limoniidae	0.06 ± 0.07			0.48 ± 0.394
Tipulidae	0.015 ± 0.036		0.03 ± 0.04	
Empididae				0.015 ± 0.033
Megaloptera				
Corydalidae	0.015 ± 0.036	0.09 ± 0.13		0.09 ± 0.07
Odonata				
Libellulidae		0.045 ± 0.11		0.015 ± 0.033
Entognata				
Collembola	0.015 ± 0.036			
Hirudinea		0.03 ± 0.07		
Arachnida				
Acari		0.03 ± 0.04		
Decapoda				
Aeglidae	0.015 ± 0.036	0.06 ± 0.07		
N.N.				

theless, in the summer season it is one of the most visited natural places in south of Chile for the practice of touristic activities, which, depending on their intensity and type (motor boats), could be generating negative effects in this population (Fig. 1). The species has probably always inhabited these sites without being discovered, which evidences the scarce knowledge of the benthic fauna of fresh waters in southern Chile.

Regarding morphology, some reports indicate that its maximum length (from the end of the rostrum to the posterior edge of the cephalothorax) is 3.3 cm in males and 2.3 cm in females, which is consistent with the sexual dimorphism reported for the genus (Burns, 1972; Jara, 1996). It is potentially omnivorous, since it feeds on carrion and detritus accumulated in the substrate, and it is possibly preyed upon by native birds such as *Ceryle torquata* (ringed kingfisher) and introduced fish such as *Oncorhynchus mykiss* (rainbow trout) and *Salmo trutta* (brown trout), both species are of Eurasian origin, with a fairly aggressive, opportunistic behaviour, flexibility and phenotypic plasticity (Burns, 1972; Arenas, 1978; Palma et al., 2002; Bond-Buckup et al., 2008; Arismendi et al. 2012; Ayllón et al., 2021).

The ecology of *A. concepcionensis* is mostly unknown, which is critical in order to establish its real conservation status, which has undergone several changes over time: Bahamonde et al. (1998) first categorized the species as vulnerable; Pérez-Losada et al. (2002) suggested it should be classified as extinct in the wild; Jara (2005) described it as endangered and declared it extinct around the city of Concepción; Pérez-Losada et al. (2009) classified it as a critically endangered; and the MMA (2014) categorized it as endangered, this being its current classification. Studies

Table 4. Abundance (N° cel/cm^2) of benthic microalgae in sites with presence of *A. concepcionensis*. DO = Dissolved Oxygen, TSS = Total suspended solids. *rock walls. *Abundancia de microalgas bentónicas en los sitios con presencia de* A. concepcionensis.

Taxa	Piedra Laja stream		Peral stream	
	Winter	Summer	Winter	Summer
Bacillariophyceae				
Achnanthidium minutissimum (Kützing) Czarnecki 1994	1.20 ± 2.08	-	-	-
Amphora sp.	-	-	2.00 ± 3.46	12.60 ± 4.76
Fragilaria capucina Desmazières 1830	12.60 ± 7.85	2.40 ± 2.75	-	-
Gomphonema angustatum (Kützing) Rabenhorst 1864	-	-	-	1.80 ± 3.12
Gomphonema olivaceum (Hornemann) Ehrenberg 1838	-	-	0.67 ± 1.15	-
Melosira varians C.Agardh 1827	4.20 ± 4.16	-	-	-
Navicula sp.	0.60 ± 1.04	-	29.37 ± 5.08	-
Navicula cryptocephala Kützing 1844	-	2.40 ± 2.75	-	-
Nitzschia inconspicua Grunow 1862	6.60 ± 6.81	12.60 ± 8.25	-	-
Cyanophyceae				
Oscillatoria sp.	-	-	0.67 ± 1.15	-
Conjugatophyceae				
Oedogonium sp.	1.80 ± 1.80	13.80 ± 3.75	-	-

that address the classification of the conservation status of the species are scarce and restricted to a reduced geographical area, the product of which has had so many modifications. However, based on our results, we propose to maintain its current classification, due to the context of anthropic intervention, mainly related to forestry monoculture and intensive tourism activities. For this reason, it is necessary to implement measures to protect these ecosystems.

Regarding the habitat use of *A. concepcionensis*, our study suggests that it inhabits areas with low human intervention, where the riparian forest is dominated by native species (Table 2). This might be related to the fact that this vegetation allows a lower and more stable water temperature than outside the canopy, provides constant inputs of allochthonous organic matter that serve as food for this species and many other in the benthic community (Tables 3 and 4), and allows the multifunctionality of stream ecosystems to be maintained (López-Rojo et al., 2019). Similarly, Jara (2005) and Valdovinos (2019) reported the greatest abundance of specimens of this species in areas with more allochthonous plant litter inputs at the Cárcamo stream (University of Concepción).

We found that *A. concepcionensis* used shallow waters, both streams and lakes, which remain well oxygenated throughout the year, probably because it has high oxygen demand like other species of the Aeglidae family (Jara, 2005; Dalosto & Santos, 2011). This is consistent with the results obtained by MMA (2013), who described the presence of the species in a stream of moderate current with oxygen concentration and saturation of 9.15 mg/L and 93.8 %, respectively. In relation to its thermal regime, our results suggest that the species use cold and temperate waters (9.02–23.46 °C), also in accordance with MMA (2013), which reported the presence of the species at 15.5 °C. Ideally, experimental studies should corroborate its range of thermal tolerance, which would allow to project the possible sites suitable for the distribution of the species and the potential effects of climate change on its distribution range.

Rallo & García-Arberas (2002), established that conductivity (µS/cm), pH and $NO3^-$ and $PO4^-$, directly influence decapod biology. They also showed that the optimal values of these mentioned chemical variables should range between 41-891 µS/cm, and between 7.3-8.9 pH (Rallo et al., 2004). These reports are consistent with the conductivity and pH values recorded in the streams and lake studied (Table 1).

We found that the species use streams with neutral pH – which is consistent with that reported by MMA (2013) – and low conductivity, which indicates low human impact. Additionally, the high diversity of macroinvertebrate and microalgal benthic communities at the same sites supports their low intervention (Tables 3 and 4). Jara (2005) indicated that the species has probably disappeared around the city of Concepción during the last decade, as a result of the conjunction of intense forest fires, summer droughts (due to the destruction of native forest and climate warming) and the contamination of the water bodies by sewage discharge. There are, however, no specific studies that have related these stressors to population responses.

Potential risks for the species include practices for the maintenance of reservoirs, which contribute to the alteration of the dynamic's natural channels such as abnormal sediment supply. Alterations in the continuity of water flow and sudden increase in flow; and the destruction of native forest due to fires, or in favour of agriculture of plantations, which significantly affects nutrient cycles and the dynamics of aquatic communities (López-Rojo et al., 2019). On this basis, it would be necessary more ecological studies, that involves habitats density in different ecosystems for understand its behaviour such as has been described for other species of *Aegla* genus (De los Ríos-Escalante, 2017; De los Ríos-Escalante et al., 2019). Also, it is necessary more studies about distribution of *Aegla* genus considering their biogeography at regional scales (De los Ríos-Escalante et al., 2013). Based on our study and those cited above, we conclude that its previous and restricted known distribution range is mainly due to, scarce studies, low sampling effort and/or misidentifications due to lack of specialists. Particularly relevant is that, due to the current good state of conservation of its habitat in the new sites described, anthropic intervention should be minimized; especially those areas associated with urban expansion and pollutants touristic activities towards the streams and lakes.

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