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Conservation

Shelter, ecophysiology and conservation status of *Plectostylus araucanus* (Pulmonata: Bothriembryontidae) in the fragmented Maulino Forest, central Chile

Refugio, ecofisiología y estado de conservación de Plectostylus araucanus *(Pulmonata: Bothriembryontidae) en el bosque fragmentado Maulino, Chile central*

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Abstract

Terrestrial mollusks are one of the least studied groups of terrestrial invertebrates, especially in the Neotropics. In Chile, there is scarce biological and ecological information about many genera, even though the group is quite diverse and occupies different habitats along the country. *Plectostylus araucanus* is the most recently described species and one of the few arboreal species found only in the coastal native forest of central-south of Chile. In this study, we recorded a new locality for *P. araucanus* in the Maule region and described ecological and physiological characteristics. The new locality is placed 204 km northwards of the type locality. Based on different records, *Plectostylus araucanus* is proposed as an endangered (EN) species under the distribution criterion of IUCN. Most of the specimens of *P. araucanus* were found living in tree cavities and away from the edge of native forest fragments. Physiological measures showed monthly differences, especially between some months of summer and fall and between months of the same season (i.e., summer). We discuss the implications of our results in the microhabitat selection, thermoregulation and habitat use by this tree snail, and the importance of this data in management and conservation for other native malacofauna.

Keywords: Habitat fragmentation; Microhabitat; Tree cavities; Tree snail; Thermoregulation

Resumen

Los moluscos terrestres son uno de los grupos de invertebrados menos estudiados, especialmente en el neotrópico. En Chile, hay poca información biológica y ecológica sobre muchos géneros, a pesar de que el grupo es bastante diverso y ocupa diferentes hábitats a lo largo del país. *Plectostylus araucanus* fue la última especie descrita, con características arborícolas y restringida al bosque costero del centro-sur de Chile. En este trabajo, se describen características ecológicas y fisiológicas de *P. araucanus* y registramos una nueva localidad en la región del Maule, la cual se encuentra a 204 km al norte de la localidad tipo. Basados en diferentes registros, *P. araucanus* se propone como una especie en peligro (EN) según el criterio de distribución de la UICN. La mayoría de los especímenes de *P. araucanus* se encontraron viviendo en las cavidades de los árboles en fragmentos de bosque nativo y a una distancia moderada del borde de estos. Las medidas fisiológicas mostraron diferencias entre meses, especialmente entre meses de verano y otoño, y meses dentro de la misma estación (por ejemplo, verano). Se discuten las implicaciones de nuestros resultados en la selección de microhábitats, la termorregulación y el uso del hábitat de esta especie, y su uso en el manejo y conservación de otras especies de malacofauna nativa.

Palabras clave: Fragmentación del hábitat; Microhábitat; Cavidades de los árboles; Caracol arborícola; Termorregulación

Introduction

Terrestrial mollusks are one of the least studied groups of terrestrial invertebrates (Lydeard et al., 2004). They represent a key component in the decomposition and nutrient cycle in soil (Jones et al., 1994; Meyer III et al., 2011, 2013; Valdovinos & Stuardo, 1988), provide food for other invertebrates and vertebrates (Martin, 2000; Nyffeler & Symondson, 2001), and determine plant composition (Hulme, 1996; Peters, 2007). Land snails are recognized as human perturbation indicators, due to their low dispersal capabilities and their dependence on microhabitats for survival and mating (Baur & Baur, 1988; Ström et al., 2009). Furthermore, terrestrial mollusks can be a good indicator for climate change, because of their ectothermic condition (Nicolai & Ansart, 2017).

Neotropical overview of land snails is still poor in many countries (Régnier et al., 2015), highlighting the malacological studies performed in Argentina (Cuezzo et al., 2013), Brazil (Simone, 2006), Colombia (Linares & Vera, 2012), Cuba (Espinosa & Ortea, 2009), Ecuador (Breure & Borrero, 2008) and Peru (Breure & Avila, 2016). In Chile, the study of land snails has been focused especially in the description of new species (Araya & Aliaga, 2015; Araya & Breure, 2016; Miquel & Araya, 2013, 2015; Valdovinos & Stuardo, 1988, 1989); as well as studying their distributional range and reporting new records of exotic species (Araya, 2015a, b, 2016; Araya & Catalán, 2014; Araya et al., 2016, 2017; Cádiz & Gallardo, 2007; Martínez-de los Ríos, 2017; Stuardo & Vega, 1985; Valdovinos, 1999; Valdovinos & Stuardo, 1989). Also, the study of their natural history and ecological characteristics has been poor (Cádiz & Gallardo, 2008; Jackson & Jackson, 2011; Valdovinos & Stuardo, 1988). However, in Chile the biological and ecological information about many genera is scarce, although these species are diverse and occupy many habitats along the climatic gradient of the country.

Plectostylus Beck 1837 (Pulmonata: Bothriembryontidae) is a recognized genus of endemic South American land snails, represented in Chile by 13 species distributed from Iquique, Tarapacá region, to del Diablo Island, Aysén region (Stuardo & Vega, 1985; Valdovinos & Stuardo, 1988). This genus is largely extant in different ecosystems, inhabiting areas from coastal deserts and coastal scrublands in northern Chile (Araya, 2016; Araya & Catalán, 2014; Jackson & Jackson, 2011), to coastal and Valdivian forest in central and southern parts of the country (Smith-Ramírez et al., 2007; Valdovinos & Stuardo, 1988). Relevant information on taxonomy and the systematic position of *Plectostylus* has been discussed by different authors (Breure & Romero, 2012; Valdovinos & Stuardo, 1988; Van Bruggen et al., 2016). On the other hand, several authors (Araya, 2016; Araya & Catalán, 2014; Jackson & Jackson, 2011; Valdovinos & Stuardo, 1988) highlight the deficiency in information about ecology, which is still poorly understood and represent critical gaps, especially concerning changes in land use and global warming. These threats represent some of the most important drivers in biodiversity loss of terrestrial and freshwater mollusks worldwide (Beltramino et al., 2015; Cordellier et al., 2012; Lydeard et al., 2004; Pearce & Paustian, 2013; Régnier et al., 2009, 2015).

Plectostylus araucanus Valdovinos & Stuardo, 1988 is the most recently described species of the genus, found in the forest of the Araucanía region, central-southern Chile (Valdovinos & Stuardo, 1988). This species is characterized by its large globose-ovate shell of up to a few cm in height, the presence of strong and noticeable growth lines (Fig. 1A, B), a brown periostracum, and a white columellar lip with a notorious angle in its middle part (Valdovinos & Stuardo, 1988). Currently, the known distribution for this species is from the coastal forest of the Nahuelbuta Mountains and its surrounding areas. Both *P. araucanus*, as well as *Plectostylus vagabondiae* Brooks, 1936, are true tree snails that probably feed on bryophytes living on the cortex of trees (Valdovinos & Stuardo, 1988). Due to the scarce ecological information on *P. araucanus*, the aim of this study is to characterize the habitat type, shelter preferences and some physiological aspects of this arboreal snail, in a locality where it was newly discovered, which belongs to the fragmented and endangered Maulino Forest (Alaniz et al., 2016; Miranda et al., 2017), with the goal to further protect this species under IUCN criteria and by national biodiversity protection laws.

Materials and methods

This study was conducted in the National Reserve Los Queules, Tregulemu (35º59'14.38" S, 72º41'21.96" W) in surrounding fragments of deciduous native forest (< 100 ha) and Monterey pine tree (*Pinus radiata*) plantations. Native fragments were variable in size, ranging from 29 to 242 ha. Native forest is mainly composed of endemic trees such as *Gomortega keule* (Molina, 1782) Baill., *Aextoxicon punctatum* Ruiz et Pav., *Cryptocarya alba* (Molina) Looser, *Peumus boldus* Molina, and native shrubs located in the understory (Bustamante et al., 2005; Rodríguez et al., 2018). The study site has a Mediterranean climate, with 6 months of rain (April-September) and 6 months of heat (October-

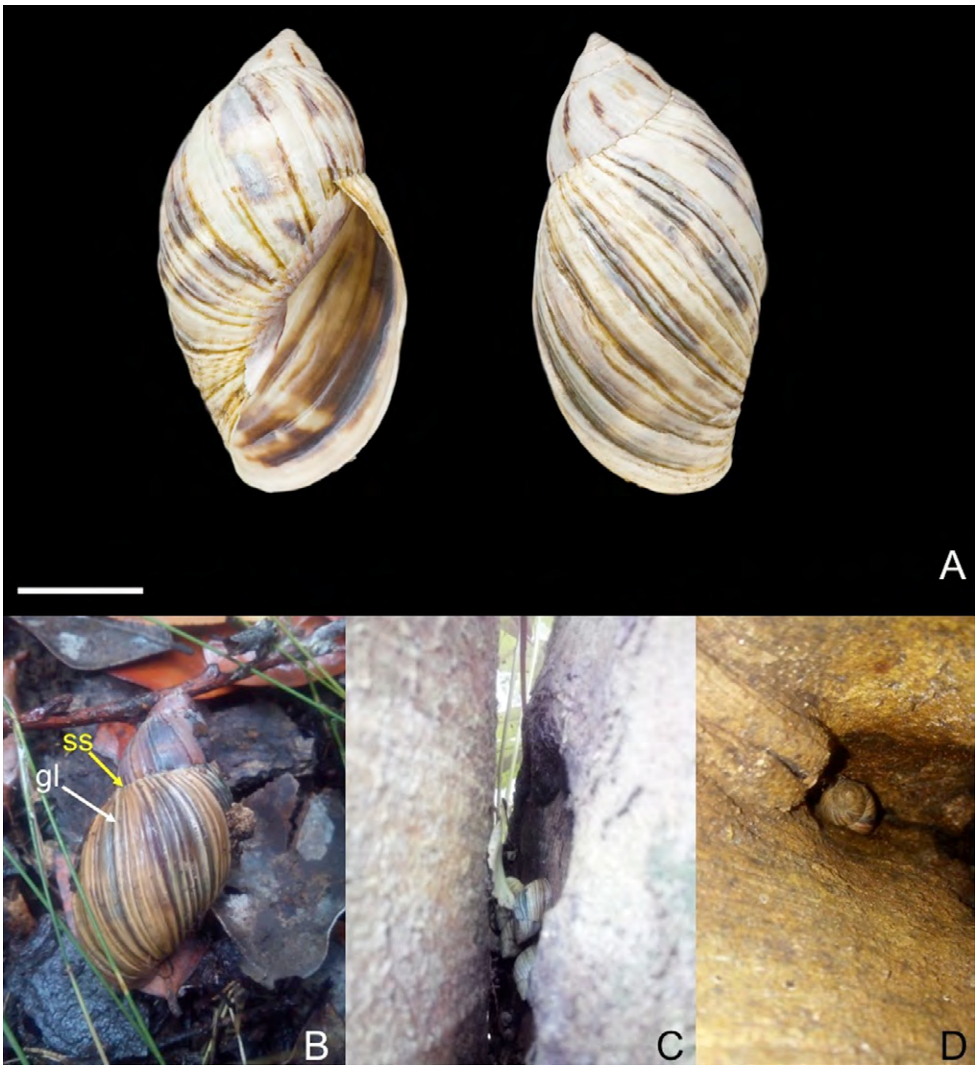

Figure 1. *Plectostylus araucanus* Valdovinos & Stuardo, 1988. A) details of ventral and dorsal view. White bar represents 1cm of scale (photo: Patricia Henríquez-Piskulich); B) dorsal view in situ; C) groups of young *P. araucanus* in a crevice of *Aextoxicon punctatum*, and D) inside a cavity of *A. punctatum*. gl = Growth lines in last whorl; ss = sinuous suture. Scale bar = 1 cm.

March; Di Castri & Hajek, 1976). The summer is very dry and hot reaching 40 ºC in the middle of the afternoon (15:00-16:00 pm), especially in sites without canopy such as pine plantations produced by the edge effect and fragmentation (Tuff et al., 2016). However, there is a high probability of rain in summer months because the new location in which *P. araucanus* was found is in the coastal mountain range and has an oceanic influence that generates morning mist in the highest hills. On the other hand, falls offer more precipitations and moderate average temperatures (i.e., 12-14 ºC; Di Castri & Hajek, 1976), both in native forest as well as in pine plantations (Chen et al., 1999).

In order to build the distributional range and to, posteriorly, evaluate the conservation status of *P. araucanus*, localities were extracted from literature (Valdovinos & Stuardo, 1988) and personal records. The conservation status under IUCN criteria, was evaluated using the minimum convex polygon method, evaluating the *B* criteria by calculating the extension of occurrence (EOO) and area of occupancy (AOO) using R's *red*-package (Cardoso, 2017) in R software ver.3.4.1 (R Core Team 2017).

Seven different fragments of native forest surrounded by the Monterey pine plantation were selected. These were selected because the native forest fragments were structurally very complex in contrast with the young pine plantations. These conditions were not presented by other fragments, because they were surrounded by clearcut stands or mature pine plantations. The young pines did not exceed one year of age and 152 cm of height, in average. Each fragment was sampled with perpendicular transects from the physical edge and visited every month during summer (December 2017-February 2018) and autumn (March-May 2018; N total = 42). Only one transect of 240 m was placed per fragment (120 m inside the native forest and 120 m in the pine plantations), to avoid pseudoreplication. The edge, defined as the physical limit between 2 different ecosystems (Laurance et al., 2002), was considered as the departing point in the transect. From this point, monitoring stations were placed at 2, 10, 20, 40, 80 and 120 m at both ends of the forest edge following Chen et al. (1999). In each monitoring station, we prospected a 40 m wide strip, sampling by transect a total of 4,800 m^2. In addition, at each station where tree snails were found, the type of habitat that it occupied was characterized (i.e., cavities, base of the tree, morphological anomalies of the tree, etc.), the height of the forest floor to which the snail was found was measured using a measuring tape, canopy coverage (%) was calculated using discrete values (i.e., 0, 25, 50, 75, 100), and all other species present at each particular tree was noted. All fragments studied are independent from each other, or at least separated by 500 m, for an independent response. In each monitoring station, the ambient temperature (At) was measured each month using one data logger by station (KEYLOG model KTL-508 with 0.1 ºC of sensibility; accuracy from 0 °C to + 70 °C (± 0.25 °C); n = 13).

Only 10 tree snails were measured, since 2 were found damaged by the snail killing beetle (Lampyridae). To obtain thermal data of the tree snails in situ, we measured body temperature (Bt) and body moisture (Bm) each month. We took these non-invasive temperature measurements by taking the thermometer lasers to the surface of the tree snails following protocols like those used for other invertebrates (Barahona-Segovia et al., 2016; Taucare-Ríos et al., 2017). These records were always made on the shell of the animals because the soft parts of the tree snails were not always exposed. We also measured the tree cavity temperature (Ct) to compare with their habitat temperature. Differences in temperature and moisture variables were analyzed by repeated measured Anova using months as fixed factor and Bt, Bm and Ct as response variables. To meet the statistical assumptions, we used Shapiro-Wilk test and Cochran C test to probe normality and homoscedasticity, respectively. When differences were significant ($P<0.05$), we used a *posteriori* Tukey test for multiple comparisons. In addition, we used the mean value of Bt, Bm, Ct and At by month and performed Spearman rank R correlation between these variables in order to find any relation between them. All measures were taken using an infrared thermometer (EXTECH Instruments, model 42509, range: -20 to 510 °C). Statistical analyses were performed with the software STATISTICA (Statsoft, 2004).

Diagnostic characters were compared in situ following Valdovinos & Stuardo (1988) for the identification of *Plectostylus araucanus* (Fig. 1A, B). This species is characterized by its ovate-globose and relatively thin and slightly translucent shell, with 5 to 6 convex whorls and a last large whorl, with an oblong shape. The spire is high, conical; of about half the height of the shell. The suture line is slightly sinuous, more marked in the last whorl. The protoconch is sculptured with a weak axial striation of narrow riblets, restricted near the sutural area; while the surface of the shell is densely covered with marked and tight growth lines; with a pattern formed by a few spiral brown stripes, more noticeable on the last whorl. The aperture of *P. araucanus* is ovate-oblong, somewhat iridescent in the inside, of about half the height of shell; the external lip has a semi-ovate curvature, while the columellar lip has a noticeable angle in its middle part. The columella is twisted, thickened, reflected, and in some cases forming a small umbilical slit, while the columellar callus is very thin, and of white color. The periostracum of this species is of a dark brown color. Internal organs of *P. araucanus* were not reviewed since none of the specimens were sacrificed.

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Results

Previously, the distribution of *P. araucanus* was based only on 12 specimens collected from 5 localities in the mountain range Nahuelbuta Mountains and in surrounding areas of the Araucanía region. The specific localities in literature are Angol, Contulmo National Park, Nahuelbuta National Park, the west side of Nahuelbuta Mountains (Valdovinos & Stuardo, 1988), and Oncol Park, Valdivia (Valdovinos et al., 2005; Table 1, Fig. 2). The new localities recorded belong to the Los Queules National Reserve in the Maulino Forest located in the Maule region and are located 204 km northwards of the type locality (Table 1; Fig. 2).

Plectostylus araucanus is currently present in 3 localities: Nahuelbuta Mountains, Valdivian forest and the Maulino Forest ecosystem. Quantitative populations as well as habitat quality were not evaluated, and therefore, criteria A, C, D (with exception of VU D2) and E are difficult to evaluate. Nevertheless, the EOO calculated is 2880 km^2 and AOO is 28 km^2, with values that are within the thresholds for the endangered category using criteria B1 and criteria B2. Threats observed in the field, as wildfires or native tree exploitation could have the biggest impact. On the other hand, the increase of temperature in the edge (i.e., edge effect, Laurance et al., 2002; Tuff et al., 2016), could threaten the subpopulations in each locality, which are already highly fragmented by forestry, livestock, crops and urbanization. Therefore, we evaluated *P. araucanus* as "Endangered" using criterion B (EN B1ab [i, ii, iii, iv] + 2ab [i, ii, iii, iv]).

Plectostylus araucanus was only found in 2 native fragments (26.4 and 242 ha of size, respectively) in the Maulino Forest. These fragments were characterized by the presence of tree species such as *A. punctatum*, *C. alba*, *P. boldus*, *G. keule*, *P. punctata*, *N. obliqua*, and *L. apiculata*. Monterey pine plantation was not occupied by this tree snail species. From the 55 tree snails found between December 2017 and May 2018, 21.8% (n = 12) corresponded to *P. araucanus.* In the 49 studied transects, *P. araucanus* primarily occupied tree cavities, cracks or shadows of branches of *A. punctatum* (66.7%; Fig. 1C, D), *C. alba* (16.7%), *L. apiculata* (8.3%) and forest floor (8.3%) (Table 1). Canopy coverage ranged between

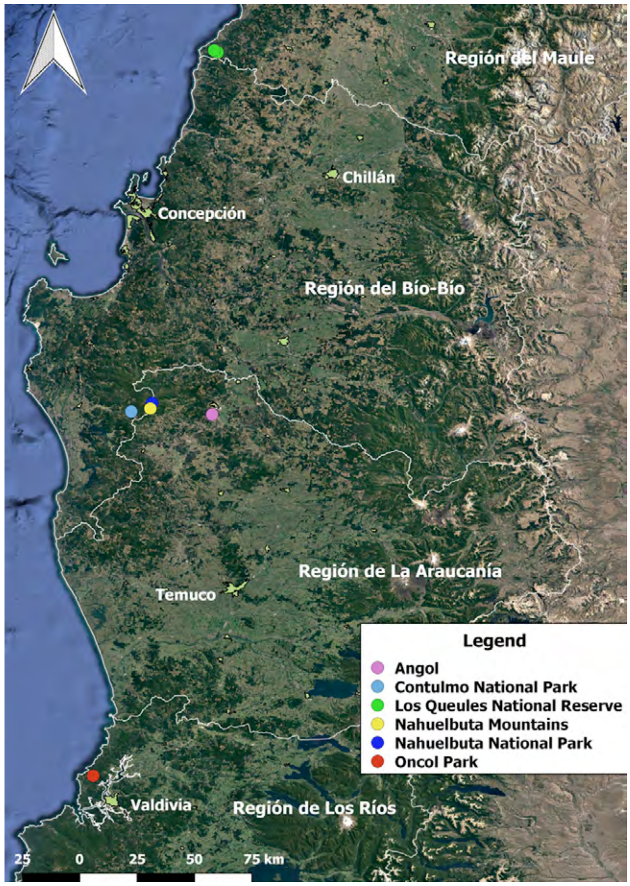

Figure 2. Distribution map of *Plectostylus araucanus* Valdovinos & Stuardo, 1988. Each locality represented with different colors. Type locality in green.

Table 1

Records of *Plectostylus araucanus* in literature and from the present study.

Localities	°S	°W	Record	Regional distribution
Angol	-37.846203	-72.716909	Valdovinos & Stuardo, 1988	Araucanía region
Contulmo National Park	-37.831643	-73.130988	Valdovinos & Stuardo, 1988	Araucanía region
Nahuelbuta National Park	-37.788353	-73.024256	Valdovinos & Stuardo, 1988	Araucanía region
Nahuelbuta Mountains	-37.815483	-73.033260	Valdovinos & Stuardo, 1988	Bío Bío region
Oncol Park	-39.700092	-73.326112	Valdovinos et al., 2005	Los Ríos region
Los Queules National Reserve	-35.987559	-72.689234	This study	Maule region
Los Queules National Reserve	-35.977355	-72.706049	This study	Maule region

75-100% (Table 2). The mean height of the cavities in which the tree snails were found was of 174.27 ± 14.75 cm. The tree snails were distributed mainly between 20 and 40 m from the edge to the inside of the forest.

Tree snails (n = 10) had a minimum mean temperature of 9.83 ± 0.11 ºC and a maximum mean temperature of 15.99 ± 0.08 ºC, with a range of 9.1-16.5 ºC. We found statistically significant differences between months in Bt, Bm and Ct ($F_{(4,45)}$ = 179.31; p < 0.0001; $F_{(4,45)}$ = 51.10; p < 0.0001 and $F_{(4,45)}$ = 138.83; p < 0.0001, respectively; Fig. 3A). Bt and Ct were higher in some months (i.e. January: 15.99 ± 0.08 °C and 16.09 ± 0.10 °C respectively; Tukey p <0.05) than others (i.e., December: 9.83 ± 0.11 ºC and 10.14± 0.12 ºC respectively). However, Bm showed an opposite pattern to the other variables (Fig. 3B). Spearman correlation between At with Bt and Ct were negative and not significant (r = -0.085; p = 0.87 and r = -0.028; p = 0.95; Fig. 4A, B). On the other hand, correlation between At and Bm was positive but not significant (r = 0.25; p = 0.53; Fig. 4C). Finally, we found a positive, powerful and significant relation of Bt with Ct (r = 0.94; p = 0.0048; Fig. 4D).

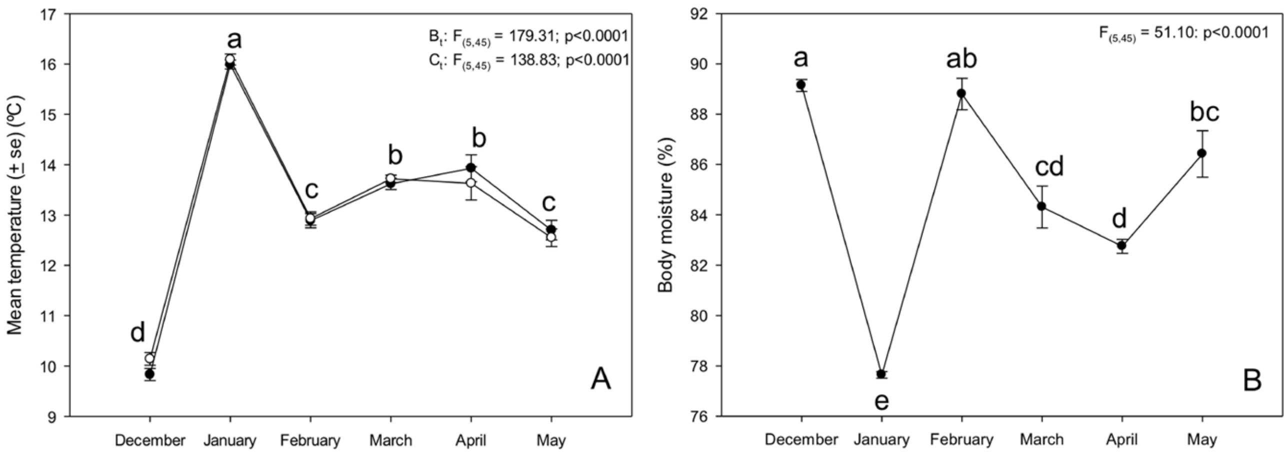

Figure 3. Values of the variables that influence the physiological condition of *Plectostylus araucanus* Valdovinos & Stuardo, 1988, and the values of the Anova results. A) Mean body temperature (Bt) (± s.e.) and mean tree cavity temperature (Ct) (± s.e.) and B) body moisture (%) of *Plectostylus araucanus* from December to May. Closed circles represent Bt; open circles represent Ct. The same letters above bars represent homogeneous groups (Tukey; p > 0.05).

Table 2

Habitat characterization of *Plectostylus araucanus* Valdovinos & Stuardo 1988 in Maulino Forest fragments. Negative distances in DE represent monitoring stations in the interior of native forest. DE = Distance from tree snails to the edge; CC = canopy coverage; NA = not applicable.

ID	DE (m)	Habitat	Tree species	CC (%)	Height (cm)
1	-40	cavity	*Aextoxicon punctatum*	100	211
2	-40	cavity	*Aextoxicon punctatum*	100	211
3	-40	cavity	*Aextoxicon punctatum*	100	211
4	-40	cavity	*Aextoxicon punctatum*	100	211
5	-40	cavity	*Aextoxicon punctatum*	100	211
6	-40	cavity	*Cryptocarya alba*	75	186
7	-40	cavity	*Cryptocarya alba*	75	182
8	-20	cavity	*Aextoxicon punctatum*	75	155
9	-20	cavity	*Aextoxicon punctatum*	75	155
10	-20	cavity	*Aextoxicon punctatum*	75	129
11	-40	branches	*Luma apiculata*	100	35
12	-40	forest floor	NA	75	NA

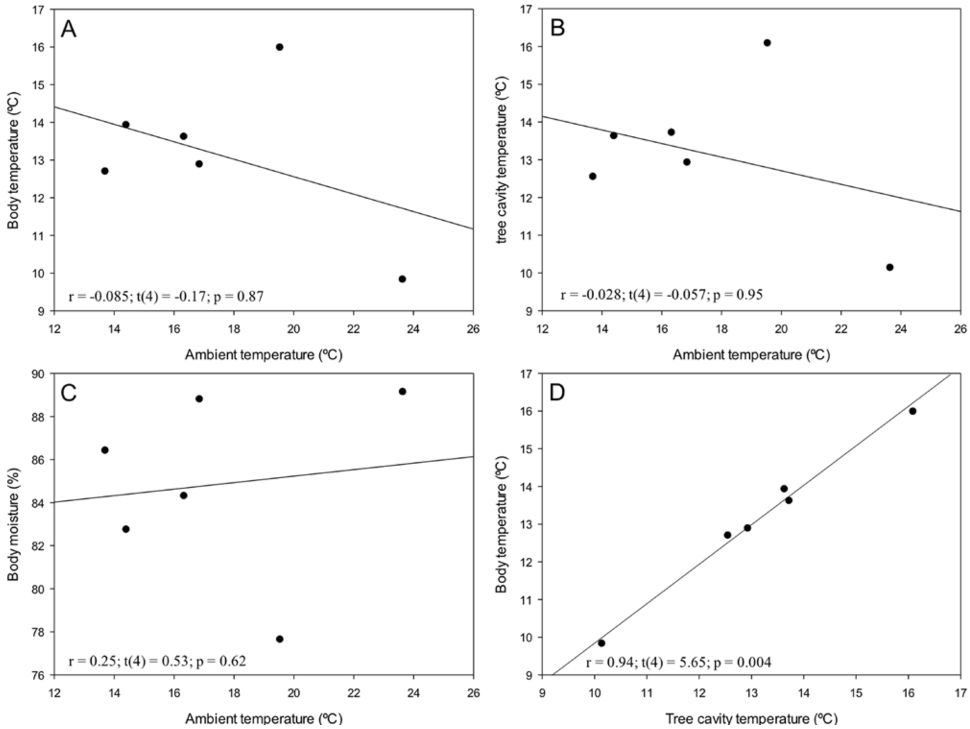

Figure 4. Spearman correlation between. A) At and Bt; B) At and Ct; C) At, Bm, and D) Bt and Ct. All graphs show the value of correlation.

Discussion

The ecological and physiological knowledge, as well as the distribution of the Chilean malacofauna is still poorly understood, even when considering the large number of species cited for the country (Stuardo & Vega, 1985). Moreover, considering that many natural areas to date are severely fragmented, obtaining information on numerous aspects of these species is very useful for future work in biological conservation. Here, we report a new locality as the northernmost record for *P. araucanus* and provide notes about its habitat use and shelter. In addition, we evaluated physiological data of tree snails with the aim to provide a baseline of information for its conservation.

Although some information has been provided for snails of the genus *Plectostylus* from northern Chile, this work is the first that brings new ecological and physiological data from tree snails of the southern forest. Valdovinos & Stuardo (1988) and Valdovinos et al. (2005) mentioned that *P. araucanus* is an arboreal species, something that our work confirms. However, both previous studies provide few quantitative data on habitat use by this species. The few specimens documented use tree cavities, with a high mean height relative to the forest floor, and to some minimum distances away from the edges of each forest fragment (40 m inside the native forest; Barahona-Segovia et al., 2019). These cavities were almost never abandoned by snails, probably due to the fact that snails are capable of detecting and evaluating relatively small potential resource patches from a distance, enabling them to limit costly explorations (Dahirel et al., 2015). These cavities contained fecal material with different degrees of humidity, which suggests that the snails could maintain temporary homes and only go out at night.

Tree snail species use cavities as a place in which they can maintain body temperature and moisture. In our work, the tree snails sampled never left the cavities, but showed changes in Bt and Bm in different months in their microhabitats. For example, in January, tree snails increased Bt, while Bm decreased. This has been documented, for example, in other land snails, such as *Theba pisana* (Müller), which avoid changes in ambient temperature due to sun and wind exposure, using behavioral thermoregulation or by selecting certain microhabitats (Cowie, 1985). Another fact that reinforces the dependence of the use of microhabitats, it is the close relationship of Bt with the temperature of the cavity. Tree snails in some months (i.e., January) with thermal stress could activate metabolic down-regulation and therefore, maintain Bt by selecting microhabitats and compensating the decrease in Bm (Nicolai & Ansart, 2017). In addition, microhabitat selection is the most used behavioral alternative for decreasing body temperature (McBride et al., 1989; Chapperon & Seuront, 2011). On the other hand, *P. araucanus* lives at a low height level compared to the overall height of the trees in the forest (above 30 m), probably to avoid desiccation and thermal stress from the highest part of the trees, as has been documented in other land snails (Cowie, 1985). Finally, edge effect can produce a thermal gradient, with the environmental temperature increasing towards the edge of the fragment (Barahona-Segovia et al., 2019; Laurance et al., 2002; Tuff et al., 2016), which could have negative effects on the survival of land snails near the edge, especially in a global warming framework. In fact, we measured the survival of tree snails, being very low at the edge and increasing at 40 m to the interior of the native forest (Barahona-Segovia et al., 2019). Although these results suggest a potential relationship between temperature and survival, the approach of this work does not allow us to affirm that the low survival is due to physiological limitations of *P. araucanus*.

The Maulino Forest could represent the northern limit for many species of plants and animals, especially, for endangered animal or plant species. In recent decades, many species whose distributions were limited to the north by the Nahuelbuta Mountains range have been recorded in the reserves or native fragments associated with this type of coastal forest. Many of these species are currently classified as endangered or vulnerable by IUCN or local ministry of environment. Thus, new records in this particular ecosystem range from bryophytes (Müller & Pereira, 2006); endangered trees (Alarcón et al., 2007); endangered frogs (Cuevas & Cifuentes, 2010; Puente-Torres et al., 2017), to bats (Rodríguez-San Pedro et al., 2015). These records show that the distribution of many species was at one point continuous to the Maule region, and due to habitat loss and fragmentation produced by urbanization, crops and forest plantations (Miranda et al., 2017), these populations have been separated, with few connections between them. Our new record of *P. araucanus* in this area reinforces this fact, in particular, since the native forest sampled is surrounded by an anthropic matrix. It is composed principally by pine plantations, which is exposed to high solar radiation and wind fluctuations and therefore, extreme environmental conditions for tree snails (Chen et al., 1999; Laurance et al., 2002; Tuff et al., 2016), where they cannot survive. In addition, is structurally poorer than native forest and provides less or null thermal shelters to sensitive native species. In land snails, habitat fragmentation produced by any anthropogenic factor can generate metapopulations that could be genetically structured and have changes in shell morphology (Schweiger et al., 2004), homogenization of the land snail community composition (Hodges & McKinney, 2018), changes in dispersion abilities (Baur & Baur, 1990) and in diversity (Wall et al., 2018).

In Chile, the only protected terrestrial mollusks are the ones present in the Juan Fernández islands (MMA, 2018). Our new record, allows us to expand the distributional range of this species of tree snail and thus, evaluate its extinction risk using the B criteria of the IUCN (2014). Following IUCN (2014) "*the term locality is defined as a distinctive geographical or ecological area in which a single threatening event can rapidly affect all individuals of the present taxon. The size of a locality depends on the area covered by the threat and may include part of one or many subpopulations of the taxon*". Therefore, our justification is based on the fact that this tree snail species only has 3 known localities that are susceptible to any anthropic event that can destroy them. For example, Chile has experienced an episode of forest fires that can be described as an extreme "fire storm" with very rapid propagations of up to 8,200 ha/hour and with exceptional heat intensities of more than 60,000 kW/m and called by expert in wildfires as sixth generation (UE, 2017). This event consumed more than 500,000 ha of plantations and forests, affecting 53 conservation areas, including parks and national reserves (CONAF, 2017). The Maulino Forest was the second most damaged native ecosystem, losing close to 1,000 ha (CONAF, 2017). Thus, our work includes the suggestion of Valdovinos et al. (2005) and allows us to place *P. araucanus* as an "endangered" species using our records and its previous geographical distribution in its form of EOO or AOO, confirming that this species has a low abundance as suggested by Valdovinos et al. (2005). Threats such as forest fires, habitat loss, habitat fragmentation and probably, climate change, could be the main threat for *P. araucanus* and, in general, for the malacofauna in Chile. Therefore, the category assigned for this species meets the thresholds necessary to evaluate it.

In conclusion, our work allowed us to obtain relevant ecological and physiological data of *P. araucanus* that can be used in a future for conservation work of this species, or other native snails of the same genus. Our data suggests that *P. araucanus* can use microhabitats for thermoregulation and maintain active its biological functions, providing a complementary overview to its natural history mentioned by Valdovinos & Stuardo (1988) and Valdovinos et al. (2005). In addition, following the proposal by Valdovinos et al. (2005), and added to the fragmentation of the habitat and its known low EOO and AOO, this species is considered as endangered. Therefore, our results can be used to develop a better protection of these species of tree snails and apply a better habitat management based on this new ecological and physiological information.

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