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Original article

Movement patterns and home range in *Diplomystes camposensis* (Siluriformes: Diplomystidae), an endemic and threatened species from Chile

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We document movement patterns and home range of *Diplomystes camposensis*, an endemic and threatened freshwater catfish from Chile. We tracked the movements of seven individuals of different body size (13.5 to 19 cm SL) using portable radio telemetry equipment to investigate movement patterns in relation to day/night activity and habitat use in the San Pedro River (Valdivia Basin). Tracked movements and model-based analyses revealed that *D. camposensis* has a large home range and high mobility. The average home range was 0.068163 ± 0.033313 km^2, and the average area of higher activity was 0.005646 ± 0.011386 km^2. The mean linear home range was 387.4 m. The results also showed that movements were longer during the night, supporting nocturnal habits. Movements tended to be in an upstream direction for some individuals, although these differences were not significant when data was pooled. Large home range and movements suggest that the species may require large river areas to meet ecological demands, an aspect that could be severely affected by fragmentation. These results, along with previously published genetic data, suggest that the conservation of *D. camposensis* would be seriously threatened by hydromorphological alterations (*e.g.* lack of connectivity), such as those resulting from dam building.

Keywords: Endangered species, Fragmentation, Habitat use, Kernel, Radio telemetry.

En este trabajo documentamos patrones de movimiento y estimación de ámbito de hogar de *Diplomystes camposensis*, un siluriforme endémico y amenazado del Sur de Chile. Por medio de radio telemetría, se monitorearon 7 individuos con un rango de tamaño entre 13.5 y 19 cm de longitud estándar, para evaluar patrones de movimiento con respecto al uso de hábitat y tiempo de actividad (dia/noche) en la zona del Río San Pedro, Cuenca del Río Valdivia. Los resultados muestran que *D. camposensis* tiene un ámbito de hogar grande y una alta movilidad. El ámbito de hogar fue de 0.068163 ± 0.033313 km^2 con un área promedio de mayor actividad de 0.005646 ± 0.011386 km^2. El ámbito de hogar lineal medio fue de 387.4 m. Los resultados también mostraron que la especie presenta una mayor actividad por la noche y una tendencia hacia un mayor flujo de movimiento en dirección aguas arriba, aunque esto último no fue significativo. Un ámbito de hogar grande y su alta movilidad sugieren que la especie podría requerir de amplias zonas del río para satisfacer sus demandas ecológicas. Al igual que estudos previos con datos genéticos, estos resultados sugieren que la especie *D. camposensis* se vería perjudicada por alteraciones en la hidromorfología del cauce (*e.g.* falta de conectividad) tales como aquellas que resulten de la construcción de represas.

Palavras clave: Especie amenazada, Fragmentación, Kernel, Radio telemetría, Uso de Habitat.

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Introduction

The Chilean freshwater ichthyofauna includes a high number of endemic species (Dyer, 2000), many of which are threatened (Campos *et al.,* 1998; Habit *et al.,* 2006). An important group within the Chilean freshwater fish fauna is the catfish family Diplomistydae, endemic to the Austral sub region of South America (Arratia, 1983, 1987; Muñoz-Ramírez *et al.,* 2010). Species in this small family (one genus and five species; Muñoz-Ramírez *et al.,* 2014; Arratia, Quezada-Romegialli, 2017) are considered among the most primitive catfish (living or extinct), being placed by some authors as the sister group of all other catfish families (*e.g.* Arratia, 1987, 1992; Hardman, 2005; Lundberg, Baskin, 1969), or at least as one of the three main lineages (Sullivan *et al.,* 2006). Unfortunately, species present in the Chilean province are considered endangered (Supreme Decree nº 51/2008, Ministry General Secretariat of the Presidency, Chile), and despite their importance for understanding catfish evolution, species are still poorly known in many aspects of their ecology (*e.g.* reproductive behaviour, population ecology).

Historically, *Diplomystes* species from Chile followed a North–South allopatric distribution from the Aconcagua River basin in the north to the Valdivia River basin in the south (Vila *et al.,* 1996), but currently, the range of the genus has been reduced in its northern limit, being extirpated from two river basins, the Aconcagua and the Maipo systems (Arratia, 1987; Muñoz-Ramírez *et al.,* 2010). Habitat fragmentation and the introduction of invasive species have been suggested as the main threats to the conservation of *Diplomystes* (*e.g.* Arratia 1983; Campos *et al*., 1998; Habit, 2005). However, because these species inhabit rithral zones (Arratia, 1983; Habit, 2005), mostly found in areas close to the Andes, other factors like dam building (Link, Habit, 2015) may become relevant threats for their conservation as these alterations can impact connectivity and affect natural hydrological dynamics (Campos *et al*., 1998; Habit, 2005).

Diplomystes camposensis (Arratia, 1987) is an endemic species with a distribution range restricted to some areas of the Valdivia River basin (which has a drainage area of 10,275 km^2), inhabiting rithral parts of the Cruces, Enco, San Pedro, and Calle Calle rivers (Arratia, 1987; Campos *et al.,* 1998; Habit *et al.,* 2009; Colin *et al*., 2012; but see Muñoz-Ramírez *et al*., 2014). In addition, the species occupies a small portion of the basin, being documented only in rithral stretches of high-order rivers, and considered absent from lakes and low-order rivers (Habit *et al.,* 2009). The scarce ecological information on the species indicates that small juveniles prefer shallow habitats and they move from riffles to pools with low flow velocity, in summer. Juveniles mainly use riffles (depth <1m), where the smaller sizes make a major use of shallow riffles (García *et al.,* 2012). Sexual maturity occurs when catfishes reach 120 mm of total length. Furthermore, populations present in the San Pedro River exhibit low genetic diversity and a high gene flow (Muñoz-Ramírez *et al*., 2016; Victoriano *et al.,* 2012). Although the family has been assumed to have nocturnal feeding behavior (Link, Habit, 2015), no empirical evidence has been yet published supporting this claim supporting this claim. Species feed mainly on small to medium-sized invertebrates (Beltrán-Concha *et al.,* 2012). *D. camposensis* is considered as endangered by the Chilean government due to habitat loss, water quality reduction and deleterious effects caused by alien species (Supreme Decree nº 51/2008, Ministry General Secretariat of the Presidency, Chile). However, accelerated dam-building may represent one of the most important impacts nowadays, as increasing demands of hydropower require dams in areas that are the typical habitat of *Diplomystes*. Unfortunately, the scarce information of the species' ecology is limiting our understanding about the impacts of potential threats on the conservation of its populations.

Because species survival will largely depend on species— and ontogenetic stage-specific—movement patterns and home ranges, it is essential to collect basic information on movement patterns. Biotelemetry has emerged as a valuable tool to investigate movement patterns of endangered species (Cooke, 2008). Telemetry studies provide the most reliable and efficient method for determining movement patterns in fish (Winter, 1996) and potential effects of dams in a given segment of river (Hahn *et al.,* 2007; Lucas, Frear, 1997). These approaches have also been widely used in studying the effectiveness of fish passage (Bunt *et al.,* 1999, 2012; Travade *et al.,* 1989), and to provide key biological information about conservation and management of threatened species (*e.g.* Moser, Ross,1995). In this study, we analyse—using radio telemetry for the first time in a Chilean endemic species—the movement patterns of *D. camposensis* in the San Pedro River (main tributary of the Valdivia River). Specifically, we will test whether i) *Diplomystes* is a mobile species and ii) whether it has a preference for nocturnal rather than diurnal activity (Link, Habit, 2015). Testing these hypotheses, and knowing the magnitude and type of areas needed for the daily activities of this species will add useful information to its ecology.

Materials and Methods

Study Area. This study was conducted in the San Pedro River, a tributary of the Valdivia River in Southern Chile (39°45'37"S, 72°34'48"W; see Fig. 1). This basin has a sequence of eight oligotrophic Andean lakes at its origin, beginning with the Lácar lake in Argentina and ending in the Riñihue lake in Chile, whose outlet is the beginning of the San Pedro River. The San Pedro River has (see fig. 1 of **S1** - Available only as online supplementary file accessed with the online version of the article at http://www.scielo.br/ni) a natural flow regime whose hydrological variation depends on the upstream lakes—although the construction of hydropower dams is being evaluated, which would create changes to the natural flow regime. The study area (Fig. 1) comprises 40 km of the San Pedro River, where we recognized three habitat zones (following Wilkes *et al.,* 2016) characterized by different hydrogeomorphological traits, from the Riñihue lake outlet (39º46'33"S, 72º27'21"W) to 500 m downstream of the confluence of the San Pedro with the Quinchilca River (39º51'10"S, 72º45'34"W).

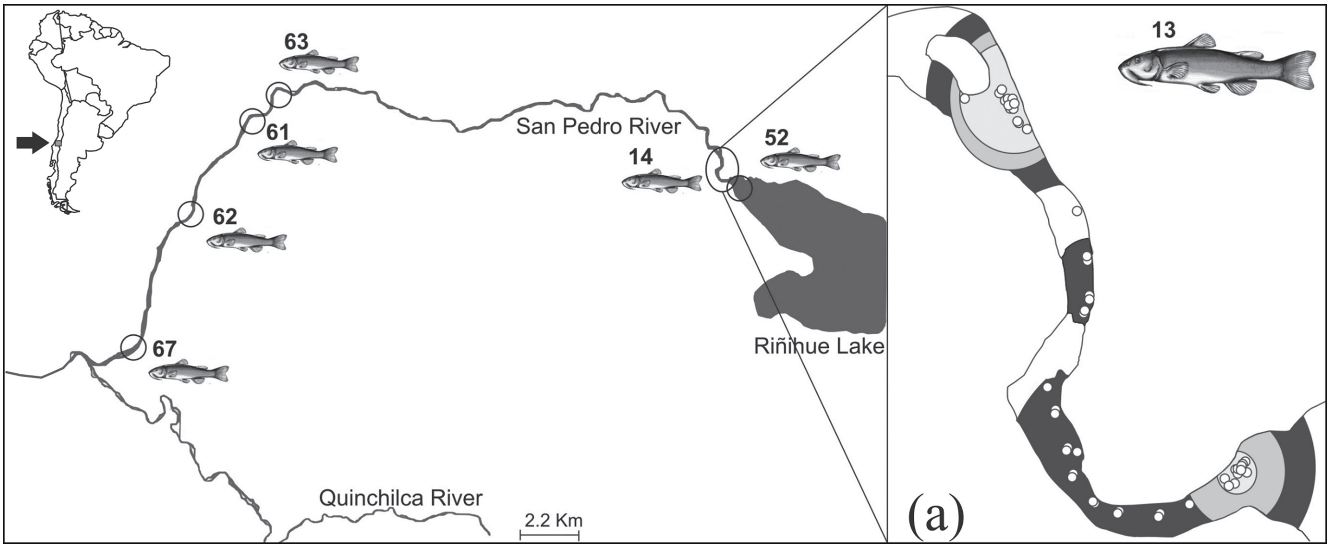

Fig. 1. Study area showing the main course of the San Pedro River, which has its origin in the Riñihue Lake outlet. The confluence with the Quinchilca River is located 40 kilometres downstream, forming the Calle-Calle River. Zoomed area represents kernel home range for individual RT 13. Areas in dark grey, light grey, and white correspond to estimation using 95%, 70% and 50% density, respectively.

Fish Capture, Radio Implantation and Telemetry. Adult specimens of *D. camposensis* were captured by electrofishing and, hook and line, using circle hooks with no barb to minimize injures. Each individual was transported to the lab where they were weighed, measured, and then maintained individually in 500 L aquaria for 24 hours with filtered and UV-sterilized river water. For surgery, individuals were anesthetized with benzocaine 20% (1mL : 5000L), until minimum frequency in opercular movement was observed. Radio transmitters of 0.8 g and 2.8 g of weight (NTC-6-1 and NTC-4-2L, respectively, LOTEK, USA) were implanted in individuals with body mass ≥ 40 g. The first radio transmitter type was implanted in the individual RT 13, while the second type was used in all remaining individuals. Expected transmitter life was 46 and 186 days for the first and second type, respectively. From March 2006 to February 2007 we implanted radio transmitters in 7 individuals in the peritoneal cavity according to the procedure described in Solis-Lufí *et al.,* (2009). After surgery, fishes were maintained in recovery aquaria for 72 hours with similar conditions to the acclimatization period, applying an antibiotic bath during one hour per day with Sol-Flox® solution (0.15:1000). Each fish was released in the same location where it was captured during day time, corresponding to the initial point of tracking (designated as E0) (see tab. 1 and fig. 2 of **S1** - Available only as online supplementary file accessed with the online version of the article at http://www.scielo.br/ni).

Tracking was conducted with portable equipment (Lotek ® Receiver SRX 400A), during day (6:01 - 20:30 hours) and night hours (20:31 - 6:00 hours), until the radio transmitters failed (maximum lifespan of transmitters was 172 days). Tracking periods were not the same for all individuals (see Tab.1) which depended on when fishes were released into the river. Tracking effort differed among individuals due to differences in fish detectability. Tracking frequency of each individual was performed every 2 days, but not all individuals were detected all the time, so localization events were variable (Tab.1). When we detected the first radio signal from a fish, we located every 30 minutes until the fish did not show movement during 5 consecutive periods. This typically occurred when fishes moved to a refuge habitat from where signal was not obtained by the receiver antenna. During tracking, we walked along the riverside and we registered locations (UTM coordinates) at 3 m of precision by GPS (Garmin eTrex H), distance to riverside, date, and hour for each individual record. To get accurate positions of each fish, we measured intensity of the signal using triangulation according to Springer (1979). The specific river stretches where individuals were captured, released, and tracked are represented in Fig. 1.

Data Analysis. Coordinates of detection points of each specimen were saved as a thematic layer and located on aerial pictures and on cartography of the San Pedro River hydrological network (Official Chilean Maps IGM, scale 1:50.000), from where we measured the length of all stretches traveled by each fish in ArcView 3.2. Movements were analyzed using Animal Movement V2.0, an ArcView application (Hooge *et al.,* 2001). To analyze movement patterns we used records from individuals with multiple recaptures. Seven individuals were detected multiple times and included in the majority of analyses, except individual R 52, that was excluded for night-day comparison analyses due to the lack of night measurements (Tab. 1).

Tab. 1. Body size (weight and SL), number of recaptures (radio signal records) and radio tracking period for 7 individuals of *Diplomystes camposensis*. RT code: Specific radio transmitter code. SL: Standard Lenght.

RT Code	SL (cm)	Weight (g)	Number of Recaptures	Radio tracking Period
13	19.9	142.9	80	28 september- 20 november 2006
14	17.3	118.7	42	3 october-20 november 2006
52	18.5	91.7	9	13 february-22 february 2007
61	15.0	75.0	29	5 december-27 december 2006
62	13.5	44.7	84	27 december 2006-25 january 2007
63	17.5	90.5	22	11 february -19 february 2007
67	16.0	78.0	50	14 november-12 december 2006

From these data, four movement indicators were measured for each individual with the purpose of knowing the magnitude of displacement within a given period (Tab.1). First, total movement was estimated as the sum of the absolute distances of all movement segments for a given fish. Second, average movement distance was estimated as the average distance (m) of all segments recorded for a given fish between consecutive detection points (including zero values). Third, cumulative directional movement was estimated as the sum of all movement segments, with upstream movements designated as positive and downstream movements designated as negative (see Khan *et al.,* 2004). This is an aspect that should be evaluated to generate mitigation measurements of impacts due to a hydroelectric plant (*e.g.* for management plans aiming at the maintenance of gene flow). Fourth, average distance from E0 (the release site) was estimated as the average of the linear distances (m) between each detection point and E0. Since the fish were caught feeding at night (ostensibly due to prey presence in mouth), we calculate how far they traveled from E0 (catch and release site) to investigate whether there is any tendency to return to feeding sites (E0). Shorter E0 distances, which indicate that detection points were close to the release point, could indicate that there is fidelity of feeding sites.

Considering the common, although unsupported claim that *D. camposensis* is more active during the night than during the day (see Link, Habit, 2015), differences between diurnal and nocturnal movements were tested using the Friedman's test (non-parametric, repeated measures) in R (R Development Core Team 2017). For this test we used the average movement distance using Day and Night categories as treatments and each fish specimen as the blocks (except for specimen 52 due to insufficient data). Multiple values for each specimen were averaged for each combination of treatments and blocks.

Fixed kernel home range was estimated for each individual using the Animal Movement Extension (Hooge, Eichenlaub, 1997) in ArcView 3.2 software. Kernel home range is an estimation of isopleths that contain a fixed percentage of the utilization density which is an indicator of time spent by animals in a specific area (Hooge *et al*., 2001; Hemson *et al*., 2005). Estimations of home range size at 95, 70 and 50 percent density were calculated to determine total area used by the fish (95%) and to identify where successively higher zones of activity (70% and 50%) were located in the river (Worton, 1989). Kernel method works through a grid of probability density to assign a value to each of the observed points which is the average of all the values that intersect at a point (Seaman, Powell, 1996; Worton, 1989). The grid width is known as smoothing parameter or bandwidth (h) and it is one of the critical factors for the method of Kernel (Silverman, 1986). Very small values of this parameter reveal details of the structure of the data resulting in home ranges as disconnected islands. Conversely, high values have the effect of overestimating the home range size (Silverman, 1986). In this case, the smoothing parameter was calculated by Animal Movement using the ad-hoc method based in Silverman (1986). Additionally, we calculated the linear home range for each individual which corresponds to the length of the river stretch used by fish. To estimate the linear home range, we measured the distance between the two farthest points where the fish were recorded during the radio tracking periods (Khan *et al*., 2004).

The relationship between body mass and home range size was determined through simple correlation. Because of the low sample size (n = 7 fish) a resampling procedure was used to get a robust estimate of the significance of the correlation. Values of home range size were randomly shuffled (without replacement) and the correlation was calculated between the shuffled values of home range size and body mass via Pearson's r. This procedure was repeated 10,000 times to generate a random distribution against which the observed correlation value was compared. The correlation was considered significant if at least 95% of the randomized r values were lower than the non-randomized (observed) value of r. Because the number of tracking days (Tab. 1) may be correlated with estimates of home range size, we used the residuals from the regression between home range size and number of days tracked to re-evaluate the relation between home range size and body mass.

Testing fish mobility. We tested how mobile *D. camposensis* was by modelling its movement under different scenarios using the *fishmove* R-package. This package predicts movement parameters of leptokurtic fish dispersal based on a meta-analyis of heterogeneous fish movement in rivers (Radinger, Wolter, 2014). We obtained the predictions under three different scenarios, mobile population (1% site fidelity), intermediate population (50% fidelity), and sessile population (99% fidelity) using the body sizes (L) reported in Tab. 1, the aspect ratio of the caudal fin (SO) set to 1.2, a time period (T) set to 28 days (the maximum number of days an individual was tracked in this study) and a stream order of 4 (estimated in this study; see supplementary material for further methodological details and fig. 2 of **S1** - Available only as online supplementary file accessed with the online version of the article at http://www.scielo.br/ni). To test whether movements in *D. camposensis* were consistent with a mobile, intermediate, or sessile species, we sampled from the distributions obtained to estimate the probability of finding the values equal to or more than the mean linear home range (387.4 m) under the three scenarios. A scenario is rejected if the p-value is significant ($p < 0.05$).

Results

Diplomystes camposensis individuals moved upstream, downstream, and across the river (transversal), during both day and night (Fig. 2). Tracking period was different for each fish ranging from 8 to 52 days. We found that the major distance traveled by fish was 2,840 m and 2,284 m in RT 13 and RT 14, respectively (Fig. 2). Comparing distance versus tracking time we observed that total movement varied from 383.5 m traveled in 28 days to 1,462 m traveled in 9 days, for RT 61 and RT 52, respectively (Tab. 1). Distances were not correlated neither with tracking period (number of days) (p= 0.06) nor recaptures (p= 0.61).

Results for second indicator, average movement distance calculated for each fish varied between 4.6 ± 1.3 m (average ± SE) traveled in 28 days and 163 ± 62 m traveled in 9 days, in individuals RT 62 and RT 52, respectively. Average movement distance across all individuals was different between day and night time (see Fig. 3c). The average distance recorded during the day was 18.6 ± 6.7 m, while the average distance travelled at night was 33.3 ± 12.9 m. This difference was statistically significant under the Friedman test (Friedman chi-squared = 6; p = 0.014).

Cumulative directional movement (CDM) averaged for seven individuals showed an overall tendency for movement in the downstream direction (-174.4 ± 29.6 m), with no significant differences between movements registered at night and day time (Friedman chi-squared = 0.67, p= 0,41) (see Fig. 3b). Distances for RT 14 and RT 67 tended to be upstream during both night and day, with greater movements during day (negative value far from zero) than during the night (negative value near zero). In contrast, RT 62 traveled downstream during night and upstream during day time.

In relation to the average distance from E0 (or release site) and considering the average across individuals, results showed that distance from E0 was 573 ± 51.4 m during day and 283 ± 43.1 m at night time (Fig. 3a). Results did not show significant differences between day and night (Friedman chi-squared = 0.4, p=0.41).

Average area of the 95% probability home range was 0.068 ± 0.033 km^2, and major utilization density areas were 0.019 ± 0.010 km^2 for 70% probability kernel home range and 0.011 ± 0.005 km^2 for 50% probability kernel home range. Furthermore, linear home range was 0.387 ± 0.104 km.

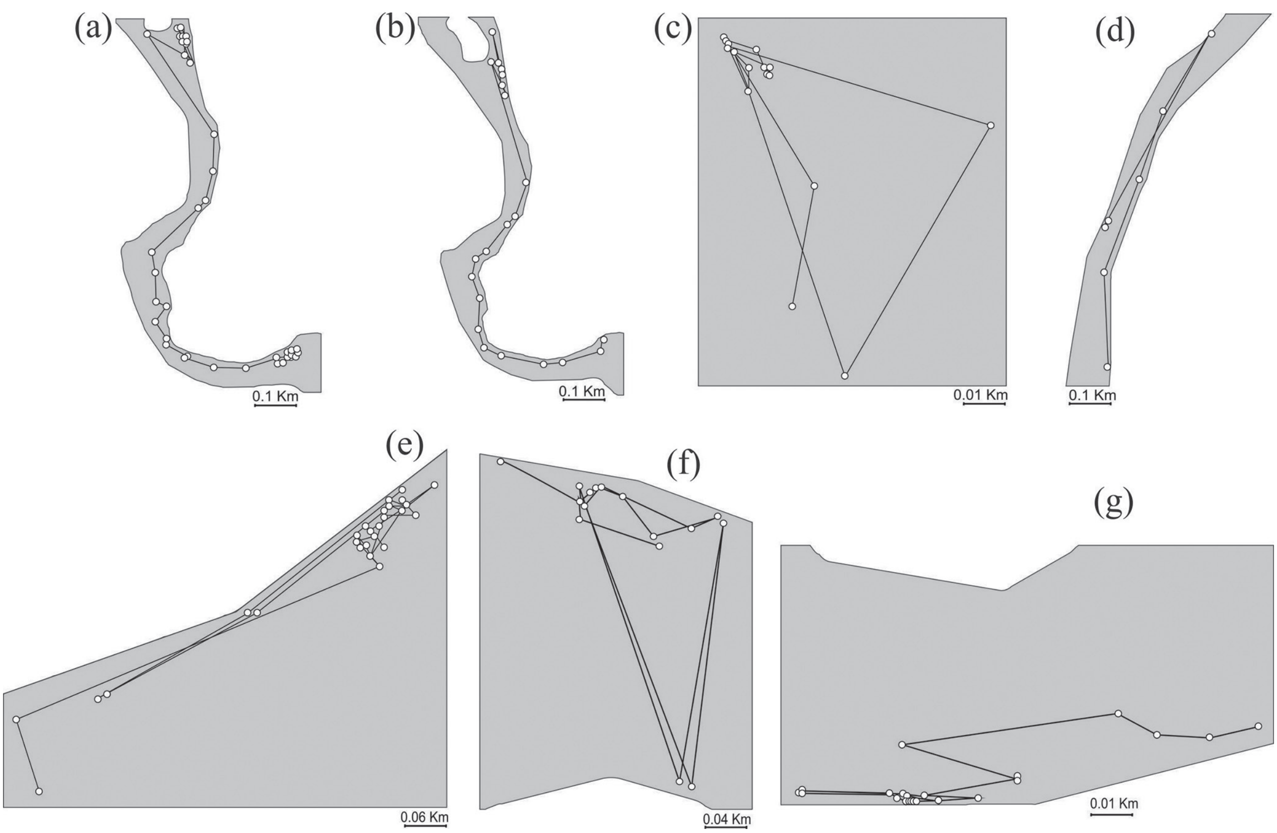

Fig. 2. River sections showing movement patterns (black lines) for each of the seven individuals of *Diplomystes camposensis* studied. a) RT 13, b) RT 14, c) RT 52, d) RT 61, e) RT 62, f) RT 63, g) RT 67. Note that scales are different in each case. Please refer to Fig. 1 for reference to the location of these areas within the main study area (San Pedro River).

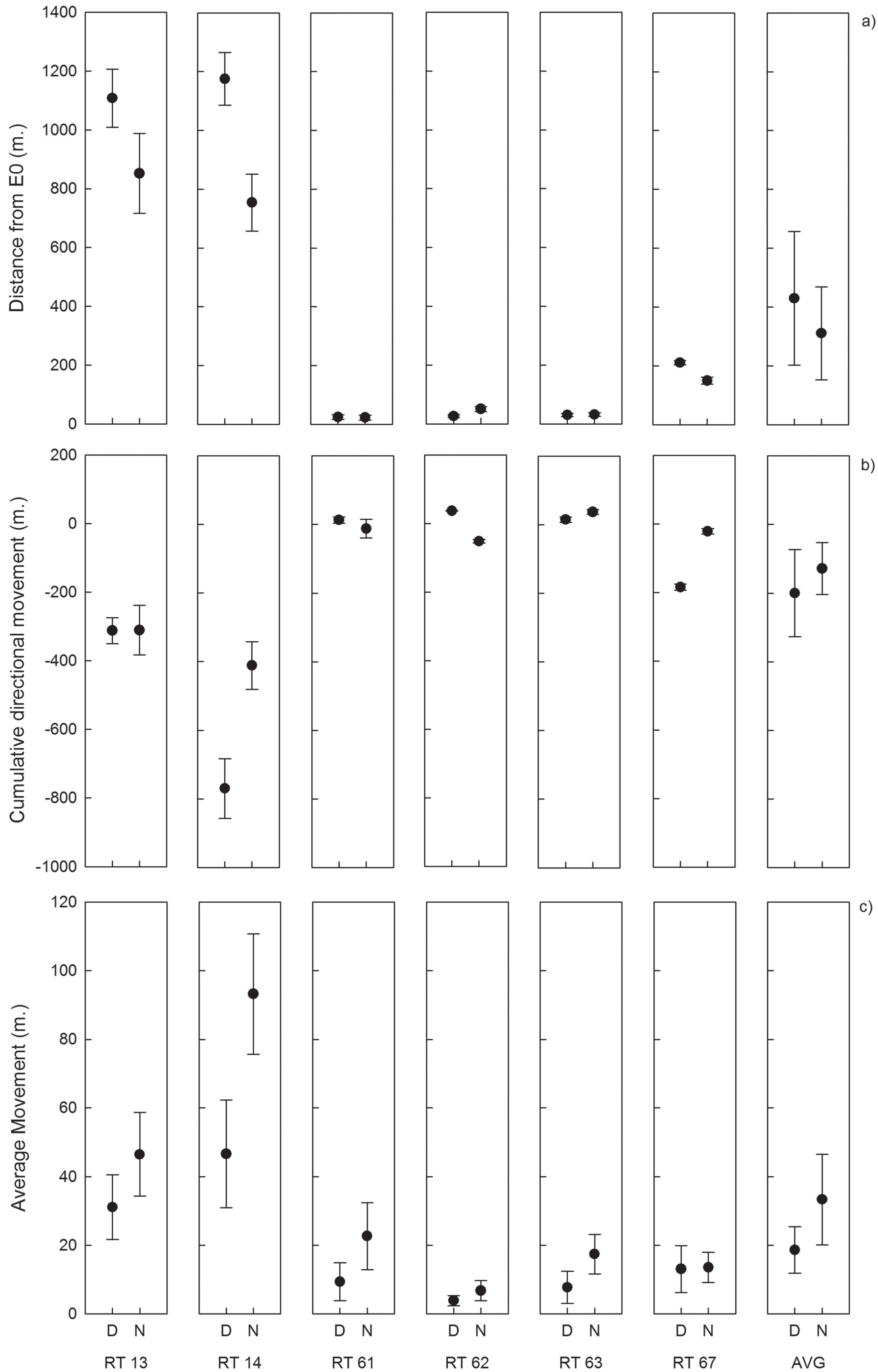

Fig. 3. Three measures of movement of *Diplomystes camposensis*. The x-axis shows six individuals and the combined data during day (D) and night time (N). The y-axis shows values of a) distance from E0 (m); b) Cumulative directional movement (m), and c) Average movement (m), differentiating between displacements upstream (positive) or downstream (negative) in direction. Black squares show mean value and whiskers show standard error. Individual R 52 not included here due to the lack of night measurements.

Body mass was significantly correlated with home range size. Home range was larger for fishes with greater mass (Fig. 4; $R^2_{(95\%)}$=0.74, p<0.05; $R^2_{(70\%)}$=0.81, p<0.01; $R^2_{(50\%)}$=0.79, p<0.01), and the pattern remained significant after accounting for number of days tracked, although with lower fit ($R^2_{(95\%)}$=0.41, p=0.06; $R^2_{(70\%)}$=0.51, p<0.05; $R^2_{(50\%)}$=0.48, p<0.05). We found no significant relationship between body mass and lineal home range.

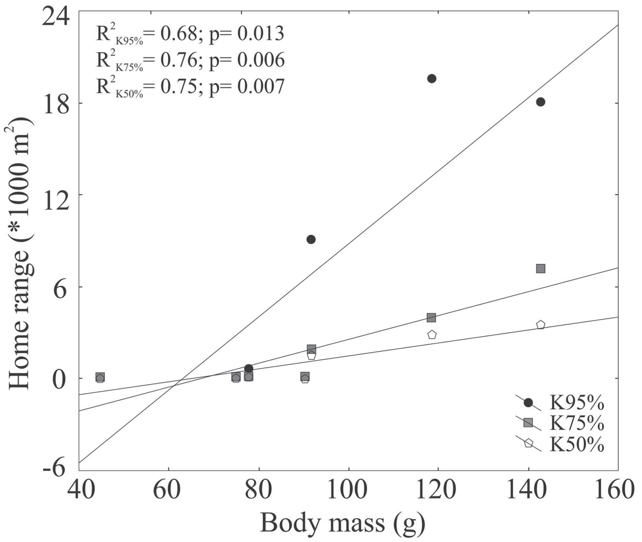

Fig. 4. Relationship between body mass (g) and Kernel home range (m²). Black circles, gray squares, and white pentagons correspond to Kernel estimation with 95%, 75%, and 50% density, respectively.

Fish movement modelling results. The use of a modelling approach to evaluate fish movement produced a range of predictions for the breath of movement of *D. camposensis*, assuming the three mobility scenarios tested (low, intermediate, and high mobility; see fig. 2 of **S1** - Available only as online supplementary file accessed with the online version of the article at http://www.scielo.br/ni). When comparing these predictions against the observed linear home range of the species (387.4 m), we found that both the models of low mobility and intermediate mobility were statistically rejected (p= 0.001 and p= 0.034, respectively), whereas the model of high mobility was not (p= 0.088). In other words, the probability of sampling a home range value equal to or larger than the observed was extremely low under the low and intermediate mobility scenarios. Therefore, the scenario of high mobility for *D. camposensis* was strongly supported.

Discussion

Diplomystidae is one of the most threatened taxa of the freshwater fish fauna of Chile (Arratia, 1983; Habit *et al.,* 2009; Muñoz-Ramírez *et al.,* 2010). Historically, species in the genus *Diplomystes* were assumed to have low movement capacity, as were most native Chilean fish species, because of their relatively small body size (Link, Habit, 2015; but see Buria *et al*., 2007). Paradoxically, little information has been published about Chilean freshwater fish movements (Piedra *et al*., 2012) hence, those claims had not yet found support in empirical data. Our data and analyses show that adults of *D. camposensis* exhibit substantial movement. Movements of *Diplomystes camposensis* were smaller than those of large-bodied Siluriformes found in the large tropical South American rivers (*i.e* 400 to 600 km; Bonetto *et al.,* 1981; Paiva, Bastos, 1982), although these are migratory fish for which larger movement are expected. In contrast, movement patterns of *D. camposensis* were larger than those predicted based on its body size, caudal fin shape and habitat (stream order) (Radinger, Wolter, 2014). Previous work has shown indirect evidence of high mobility for *D. camposensis*. For example, patterns of genetic diversity and lack of genetic structure have suggested high levels of gene flow (Victoriano *et al.,* 2012), while low rates of recapture found by Piedra *et al*. (2012) in capture-recapture studies could also suggest high mobility. Our telemetry data is the first direct empirical evidence of the high mobility of the species and it is consistent with the previous indirect evidence. It is unlikely that Chilean *Diplomystes* are migratory fish because all the data available suggest they inhabit a very specific type of habitat (large order rivers, boulder substrate, and well oxygenated, middle to fast flowing water) with little or no records in other habitats (Habit *et al*., 2009; García *et al*., 2012).

Our study shows that *D. camposensis* is active during day and night, although it was clearly more active during the night. These results support previous suggestions that the species was nocturnal and it is in agreement with empirical data from other catfish that show nocturnal (Casatti, Castro, 1998; Yu, Peters, 2003; Hahn *et al*., 2007) or crepuscular (Paxton, 1997) behavior. Other indexes (cumulative distance and distance travelled from the release site) did not show significant differences between day and night, which could be due to a lack of statistical power. Both the number of marked individuals and the number of tracking days should be increased to statistically confirm other tendencies such as the general trend showing these catfish move upstream, and remain moving closer to the riparian zone (E0) at night. Nocturnal behavior may be associated with feeding activity (Hossain *et al*., 1999) because several benthic invertebrates avoid predation by hiding in the river substrate during day time, and feed only during dusk or night time (Townsend, 2003). The main prey of *D. camposensis* is the decapod *Aegla rostrata* (Habit *et al.,* 2009; Beltrán-Concha *et al*., 2012), whose availability increases during crepuscular-nocturnal time when they feed on macroinvertebrates in the drift (Figueroa *et al.,* 2000; Moya *et al.,* 2002). In addition, nocturnal behaviour in *D. camposensis* may represent a defensive mechanism against visually orientated predators such as salmonids (Metcalfe, Arnold, 1997) or birds. At night, *Diplomystes* may have moved upstream and into shallow riparian areas to feed, but remained far from riparian zones in deeper pools during the day to potentially avoid predation by piscivorous birds, like *Phalacrocorax brasilianus* (Barquete *et al.,* 2008).

Comments on conservation implications. The movements described here are of considerable magnitude for a species of the size of *D. camposensis* (Radinger, Wolter, 2014; Minns, 1995). This supports previous reports of high gene flow levels inferred in the population of the San Pedro River based on mitochondrial DNA analyses (Habit *et al.,* 2009; Victoriano *et al.,* 2012), and these movements appear to be involved in ecologically important activities of the species. Accordingly, construction of a hydropower station might generate significant negative impacts on this species, as it has been demonstrated previously for other catfish species from South America (*e.g.* Barthem *et al.,* 1991; Hahn *et al.,* 2007; Makrakis *et al.,* 2007). Fragmentation of an already small population with low genetic diversity (Habit *et al.,* 2009; Victoriano *et al.,* 2012) and relatively large home range (relative to the size of the Valdivia basin) could carry a number of conservation problems. First, small populations are more exposed to inbreeding and genetic drift which accelerates the loss of genetic diversity and may causes inbreeding depression (Newman, Pilson, 1997; Keller, 1998; Saccheri *et al.,* 1998). Second, the interruption of movement between areas of the river may prevent both the rescue of populations that may go locally extinct (Hanski, 1991) and the movement of genes that might be beneficial in scenarios of environmental change (Tallmon *et al.,* 2004). The total absence of diplomystids in smaller river systems such as all the coastal basins and low-order rivers (*i.e* diplomystids have only been documented in Andean, high-order basins) (Muñoz-Ramirez *et al*., 2010), may well be indirect evidence of the need for larger areas to allow population persistence. Therefore, considering that the species may require maintaining a high magnitude of movement and it is already in a vulnerable condition (Habit *et al*., 2006), maintenance of movement patterns and connectivity in *Diplomystes camposensis* appears to be essential for its conservation. A potential mitigation measure for the impact of dams on habitat fragmentation could be the construction of fishways interconnecting the isolated areas. Diplomystids have been collected previously in irrigation canals (Habit, 1994), and genetic evidence has suggested diplomystids from central Chile are using irrigation canals to migrate between, otherwise, isolated basins (Muñoz-Ramírez *et al.,* 2015), indicating diplomystids may successfully use artificial passages to overcome the need of movements between river areas. Studies will be needed to understand whether this potential solution could work for *D. camposensis* and whether it could generally work for other fish species in the basin.

Further studies will be needed to evaluate other potential aspects of the species biology including its dependence on riparian habitats, so other mitigation practices can be properly evaluated and proposed.

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