

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 km², and the average area of higher activity was 0.005646 ± 0.011386 km². 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 (día/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 km² con un área promedio de mayor actividad de 0.005646 ± 0.011386 km². 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 estudios 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.

Palabras 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 Diplomystidae, 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 n° 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 km²), 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 <1 m), 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 n° 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 (39°46'33"S, 72°27'21"W) to 500 m downstream of the confluence of the San Pedro with the Quinchilca River (39°51'10"S, 72°45'34"W).