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Effects of electrofishing on tadpoles of *Calyptocephalella gayi* (Duméril & Bibron 1841) (Anura, Calyptocephalellidae) in a low-order stream of south-central Chile

Efectos de la pesca eléctrica en renacuajos de *Calyptocephalella gayi* (Duméril & Bibron 1841) (Anura, Calyptocephalellidae) en un estero de bajo orden del centro-sur del Chile

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Abstract. The effects of electrofishing sampling on tadpoles of *Calyptocephalella gayi* are described for the first time, in a low order stream of the south-central Chile. A total of 37 tadpoles were captured with an electric impulse configuration between 40 to 48 hz and an output power that ranges from 130.5 to 170.1 w. The tadpoles that where inside the boundaries of the electric field showed an electrotetany (tetanic muscular contraction) and electronarcosis (immobility) effects for a period between 3-5 s, before they complete recovery. No damage or physical injuries were found on the tadpoles after the applied electric impulse. We consider the electrofishing sampling a safe and effective technique for the collection of tadpoles *Calyptocephalella gayi* and other amphibians, serving as a potential tool for conservation studies.

Keywords: Early stage, Electric field, Giant Chilean frog, sampling methods

Resumen. Se describe por primera vez los efectos de la pesca eléctrica sobre larvas de *Calyptocephalella gayi* en un estero de bajo orden de la zona centro-sur de Chile. Se capturó un total de 37 larvas con una configuración de impulso eléctrico entre 40 a 48 hz y una potencia de salida que osciló entre 130.5 a 170.1 w. Las larvas presentes dentro del campo eléctrico mostraron efectos de electrotetania (contracción muscular) y electronarcosis (inmovilidad) por un intervalo de tiempo entre 3-5 s, antes de recuperación de la movilidad natural. No se encontraron daños físicos en las larvas posterior a la aplicación del impulso eléctrico. Consideramos la aplicación de la pesca eléctrica una técnica segura y efectiva para la recolección de larvas de anfibio, sirviendo como una potencial herramienta para estudios de conservación.

Palabras clave: Campo eléctrico, estadios larvales, método de muestreo, Rana Chilena

Electrofishing has been considered one of the least harmful techniques for collecting fish but involves a dynamic, complex, and poorly understood mix of physics, physiology, and behavior (Snyder 2003a). The possibility of catching fish without harming them for translocations, population restoring and many other ecological studies, is a great achievement that allows electrofishing sampling (Bohlin et al. 1989, Allard et al. 2014). Nevertheless, the exposure to an electric field, generated between the electrodes, can potentially cause injuries and physiological stress in aquatic organisms: depigmentation of the skin, internal bleeding, fractures, and dislocations of the spine in fish (Snyder 2003b, Miranda and Kidwell 2010) and loss of the pereiopods in freshwater decapods (Catchpole and Ruiz 2018). Although is usually a technique used for sampling fish, it can also be useful for the collection of early stages and adults of amphibians. In Chile, electrofishing sampling has been applied in frogs of the genus *Xenopus laevis* (Daudin 1802) (Catchpole and Medina 2018a) and *Telmatobufo australis* Formas 1972 (Catchpole and Medina 2018b). The metamorphosis from tadpole to adult provides an additional advantage, since any physical injury on the caudal fin of the tadpole would be, by default, temporary, and not be perpetuated to the following stages, due to the loss of this morphological structure (Allen and Riley 2012).

The Chilean giant frog, *Calyptocephalella gayi* (Duméril and Bibron 1841), is a monotypic and endemic species of Chile, distributed naturally between the Regions of Atacama and Los Lagos,

and between the altitudinal range of 30 and 1,266 m (Mella and Horta-Pizarro 2019), preferably inhabiting stagnant waters bodies, lagoons, and swamps with abundant aquatic and riparian vegetation (Charrier 2019). Due to overexploitation as a hydrobiological resource, the disappearance and contamination of the habitats, and the competition and predation with invasive species such as *X. laevis* (Charrier 2019, Fibla et al. 2020, Vélez 2014), it is currently classified as a vulnerable species according to the Chilean Ministry of Environment (DS Nº50/2008 MINSEGPRES) and the IUCN (2019).

Figure 1: View of the sampling site S3 in Villa Hueso stream. Photograph by Sam Catchpole.

A field study was conducted in March 2021 in three sections of the Villa Hueso stream, a tributary of the Maule River, located in the mediterranean region of Chile (Fig.1). The capture and quantification of the tadpoles of *C. gayi* were conducted using a SAMUS 725 MP portable electrofishing equipment with a cathode electrode made by a 0.50 cm diameter copper cable with an extension of 2.50 m, and an anode electrode corresponded to a 35 cm diameter stainless steel ring, covered by a 10 mm mesh. The electrical impulse configuration used ranged from 10 to 80 hz, with an output power between 120 to 175 w, and a duration of the impulse between 1.0 to 2.5 s. The captured tadpoles were measured and weighed using a millimeter ruler and a 0.10 g precision digital weight scale. All capture activities were carried out with a fishing research permission, resolution N° E-2020-432 dated 08/12/2020, by the Sub-secretary of Fisheries and Aquaculture of Chile (SUBPESCA). In addition, the physicochemical parameters of the water were analyzed using a multiparameter sensor, model HI9829 (Hanna Instrument). The current velocity was also measured using a flow meter (Flowatch model). The morphological characteristics of the stream (depth, width, and type of substrate) were described along an 80 m fluvial section. The depth was determined by a limnetic ruler and the fluvial width was measured using a metric tape. The classification of the substrate was established visually.

Table 1: Hydrodynamic and morphology characteristics of the Villa Hueso stream.

Site	Velocity (m/s)	Width (m)	Depth (cm)	Substrate type
S1	0.01 ± 0.00	3.51 ± 0.43	153.00 ± 34.41	Fine sand
S2	0.50 ± 0.05	4.71 ± 0.78	37.35 ± 10.45	Gravel
S3	0.15 ± 0.02	3.76 ± 0.83	26.77 ± 12.53	Gravel

In three sampling sites, a total of 37 tadpoles were captured with an average of 69.01 ± 26.72 mm total length (TL) and a bodyweight (BW) of 9.32 ± 8.65 g. The characteristics of the habitat used by the tadpoles correspond to pools and riparian zones with the presence of aquatic vegetation. The current velocity presented a mean of 0.22 ± 0.02 m/s. The morphology of the stream exhibited a width of 3.93 ± 0.63 m and a depth of 72.73 ± 70.02 cm (Table 1). Regarding the physicochemical parameters of the water, the dissolved oxygen concentration presented a mean of 5.90 ± 0.39 mg/l, the pH 7.44 ± 0.26, the conductivity 155.78 ± 14.74 µs/cm, the temperature 19.64 ± 0.98 °C, the potential reduction oxide 32.76 ± 4.80 mV and total dissolved solids 78.39 ± 6.87 mg/l (Table 2).

The electric field generated by the fishing equipment covered an area of approximately 2 m in diameter between the electrodes. The electrical impulse configuration with effective response from the tadpoles was between 40 to 48 hz, and an output power that ranges from 130.50 to 170.10 w (Table 3). The tadpoles located on the boundaries of the electric field showed a flight reaction, moving away and hiding between the aquatic vegetation and the bed of the stream. While those found inside the electric field exhibited from electrotetany to electronarcosis effects. Tadpoles bigger than 70 mm TL described initially a lethargy of their movements, with a perpendicular approach to the anode electrode (positive electrotaxis). Immediately afterwards, electrotetany became evident through convulsions and/or muscular spasms all over the body and caudal fin of the tadpole. Also, asynchronous movements in respiration and mouth opening were recorded. After that, galvanonarcosis (galvanotaxis) stage was reached, described by the buoyant effect of the tadpole in the water column. This narcosis (sedation) effect was maintained for a short period, between 3-5 s before total recovery, swimming in the opposite direction to the electric field. The smaller tadpoles (> 70 mm) showed attraction to the anode electrode (negative electrotaxis), causing an electrotetany reaction and then galvanonarcosis, but with a very fast recovery, less than the bigger tadpoles. The electric field can generate several unwanted and harmful effects on fish and other aquatic organisms (Snyder 2003a,b, Miranda and Kidwell 2010). In amphibians, the information is scarce regarding the effects of the electric field, however, laboratory studies have determined that frequencies above 60 hz in adult stages can have a temporary detriment on their jumping abilities and prey consumption (Allen and Riley 2012). Catchpole and Medina (2018a,b) used electrofishing to capture tadpoles and adults of the species *X. leavis* and *T. australis* but did not give details of the behavior and potential effects.

Table 2: Physicochemical parameters (mean ± SD) of Villa Hueso stream (N = 30 data units for each parameter). Symbology: ORP: Oxidation-Reduction Potential. DO: Dissolved Oxygen. TDS: Total Dissolved Solids. T: Temperature. Cond.: Conductivity.

Site	pH	ORP (mV)	DO (mg/l)	TDS (mg/l)	T (°C)	Cond. (µs/cm)
S1	7.18 ± 2.01	32.51 ± 6.11	5.80 ± 2.01	86.21 ± 17.89	18.87 ± 3.32	172.11 ± 18.98
S2	7.70 ± 0.81	37.70 ± 6.50	5.56 ± 1.72	73.30 ± 12.76	19.31 ± 2.67	143.43 ± 25.21
S3	7.46 ± 1.35	28.10 ± 8.71	6.34 ± 2.25	75.62 ± 20.21	20.76 ± 3.46	151.82 ± 20.87

Table 3: Configuration of the electric field emitted by the Samus 725 MP electric fishing equipment and the effects on the tadpoles. Symbology: TL= Total Length.

Electric field configuration			Effects on the tadpoles	
Frequency (hz)	Time of impulse (s)	Output power (w)	< 70 mm TL	> 70 mm TL
> 35 hz	1.0 - 2.5	120.21 – 154.50	No effect	No effect
40-48 hz	1.0 - 2.5	130.50 – 170.10	1.- Positive electrotaxis. 2.- Electrotetany. 3.- Electronarcosis 4.- Time recovery (3–5 s).	1.- Negative electrotaxis. 2.- Electrotetany. 3.- Electronarcosis. 4.- Time recovery (> 3 s).
< 50 hz	1.0 - 2.5	140.52 – 175.51	No effect	No effect

In this study, tadpoles exhibited a response with electric frequencies ranging from 40 to 48 hz, with a total recovery of the mobility in a period no longer than 5 s, and no external damages or injuries were found. We consider the electrofishing sampling a safe and effective method for the collection of *C. gayi* tadpoles and other amphibians, serving as a potential tool for conservation studies of the species. Nevertheless, it is necessary to understand and perform more studies of this sampling technique to discard potential damage over amphibians, since it is widely used in streams and rivers in Chile.

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