

## SHORT COMMUNICATION

# Cannibalism in *Telmatobius rubigo* (Anura: Telmatobiidae) and comments on seasonal variation of diet

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**Palabras claves:** Canibalismo, Especie amenazada, Lavado de estómago, Puna Andina Central, Rana Acuática Andina, Sobreposición de dieta.

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The knowledge on natural history of the Aquatic Andean Frogs of the genus *Telmatobius* was increased in the last decade (Catenazzi *et al.* 2013, Lobos *et al.* 2016, 2018, Brunetti *et al.* 2017, Acosta *et al.* 2020, Gastón 2022, Sáez *et al.* 2022), particularly about feeding habits, diet and trophic ecology (Barrionuevo 2016, Watson *et al.* 2017, Lobos *et al.* 2018, 2021, Akmentins and Gastón 2020, Muñoz-Saravia *et al.* 2020, Abdenur-A *et al.* 2022). One shared characteristic of most *Telmatobius* species is that these frogs inhabit high-altitude Andean lotic and lentic aquatic systems, characterized by their simplified food webs (Lujan *et al.* 2013). Precise information on feeding habits could have direct and indirect implications for conserving one of the world's most threatened amphibian taxa (IUCN 2022).

*Telmatobius rubigo* Barrionuevo and Baldo, 2009 is a fully aquatic frog inhabiting lotic endorheic systems between 3500 to 4300 m a.s.l. in the harsh arid environment of Central Andean Puna ecoregion of Jujuy province in northwestern Argentina (Barrionuevo and Abdala 2018, Gastón 2022). The Laguna de Los Pozuelos' Rusted Frog was assessed as vulnerable in the IUCN red list because it is threatened by the introduction of exotic predatory fishes (rainbow trout), mining, and poor water management (IUCN 2022).

In the present study, we report a case of cannibalism in *T. rubigo* and analyze the seasonal variation of the diet. Finally, we discussed the implications of our registers for the ecology and conservation of this threatened aquatic Andean frog.

Frog surveys were carried out once per month in August, September, and November 2021 in the locality of Santa Catalina, Argentina (21°56'58.2" S, 66°02'21.6" W; 3802 m a.s.l.), in

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coincidence with the breeding events of the species during the dry season (Gastón 2022). The methodology indicated by Akmentins and Gastón (2020) was followed. Briefly, individuals were located by active search by visual encounter survey (Crump and Scott 1994) and captured manually, immediately then the stomach contents were obtained *in situ* by stomach flushing (Solé *et al.* 2005). Each frog was sexed and measured its snout-vent length (SVL) with a digital dial caliper (Mitutoyo Absolute Digimatic) to the nearest 0.1 mm and weighed with a portable digital scale (OHAUS) to the nearest 0.1 g. After stomach flushing, the individuals were returned to the same capture site.

The stomach contents were analyzed under a stereomicroscope and were identified as the lower taxonomic category as possible. For each item (prey category), number ( $N$ ), volume ( $V$ ), and occurrences ( $F$ ) were calculated in percentage values. The volume for intact prey items was calculated according to the formula used by Dunham (1983) for a prolate spheroid:  $V = 4\pi/3(\text{prey length}/2)(\text{prey width}/2)^2$ .

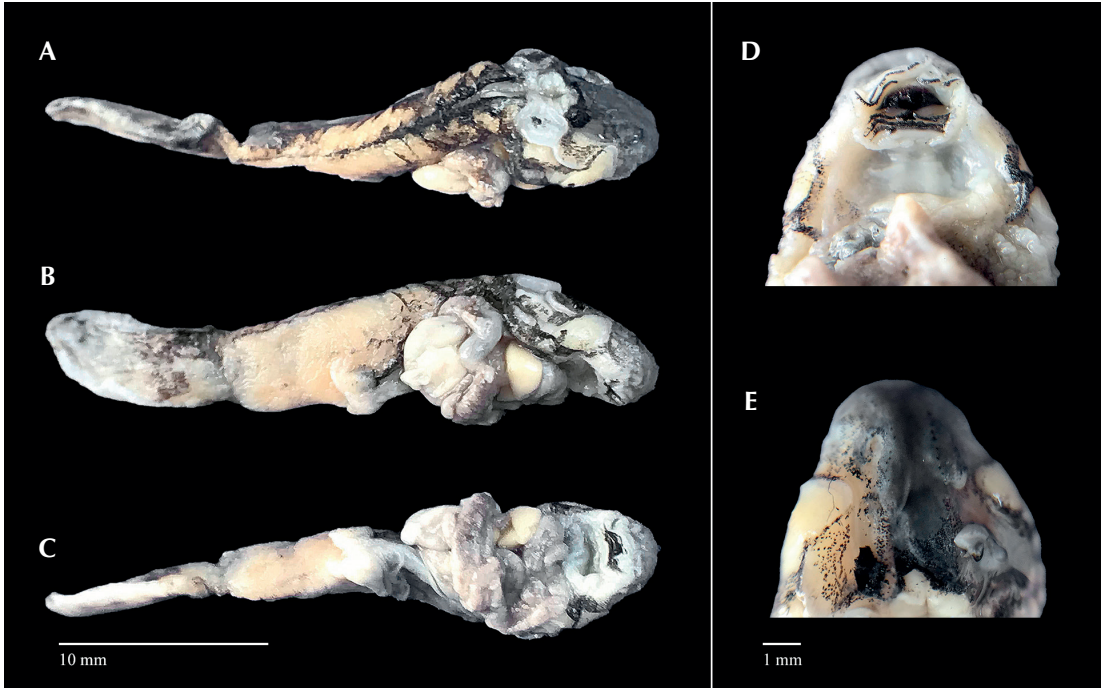
For comparison of seasonal variation of the diet of *T. rubigo*, the data on stomach contents obtained in the same locality during the wet season from January to March 2020 (Akmentins and Gastón 2020) were used. The importance value of main dietary items for pooled stomachs was calculated with the  $I_p$  index of Biavati *et al.* (2004). The trophic niche breadth in dry and wet seasons was estimated using Levin's standardized index (Krebs 1989), and breadth niche values were interpreted according to Novakowski *et al.* (2008) as high ( $> 0.6$ ), intermediate (0.4 to 0.6), or low ( $< 0.4$ ). The degree of diet overlap between seasons was determined with the Morisita-Horn Index (Horn 1966) and values greater than 0.60 were considered significant diet overlap (Zaret and Rand 1971).

A total of 32 diet samples from both seasons were analyzed, representing acceptable prey sampled completeness for the species (Akmentins and Gastón 2020). For the dry season, 17 diet samples were obtained from three females and

15 males. Females had a SVL of  $52.3 \pm 3.8$  mm (mean  $\pm$  SD) and weighed  $14.9 \pm 2.6$  g (mean  $\pm$  SD). Males had a SVL of  $46.8 \pm 2.5$  mm and weighed  $10.3 \pm 1.9$  g. In the pooled stomach contents were found 149 prey items and a mean number of preys per stomach of  $8.7 \pm 4.7$ . For the wet season, 15 diet samples obtained from five females and 10 males were analyzed. Females had a SVL of  $51.7 \pm 8.9$  mm and weighed  $11.5 \pm 7.4$  g. Males had a SVL of  $51.1 \pm 5.1$  mm and weighed  $12.2 \pm 4.7$  g. In the pooled stomach contents were found 71 prey items and a mean number of preys per stomach of  $4.7 \pm 5.7$ .

Two cases of anurophagy were detected in the dry season. One tadpole of *T. rubigo* in a Gosner (1960) stage circa 30 was preyed on by an adult female (SVL 55.08 mm; weight 15.6 g) (Figure 1), and one undetermined tadpole was preyed on by an adult male (SVL 46.43 mm; weight 10.36 g). The confirmation of the cannibalism event was made based on external characteristics of the preyed tadpole (Figure 1), such as mouth position, oral disc, and arrangement of lateral line neuromasts (Barrionuevo and Baldo 2009). These characteristics of the tadpole of *T. rubigo* differ from other tadpoles of sympatric species as *Rhinella altiperuviana* (Gallardo, 1961), *Boana riojana* (Koslowsky, 1895), and *Pleurodema cinereum* (Cope, 1878) (pers. obs.).

Cannibalism and anurophagy were reported for other *Telmatobius* species (Allen 1922, Valencia *et al.* 1982, Wiens 1993, Barrionuevo 2015, Muñoz-Saravia *et al.* 2020, Abdebur-A *et al.* 2022). One of the suggested causes for cannibalism in aquatic anurans is the high concentration of several cohorts in small water bodies (Barrionuevo 2015, Measey *et al.* 2015, Muñoz-Saravia *et al.* 2020). *Telmatobius rubigo* inhabits and breeds in shallow waters (Gastón 2022), although anurophagy and cannibalism were not observed in an extensive survey during the wet season (Akmentins and Gastón 2020). We suggest that this behavior occurs particularly during the dry season when the water deficit is



**Figure 1.** Detail of the stomach content of a female *Telmatobius rubigo* (SVL 55.08 mm; weight 15.6 g) with a cannibalism event of a tadpole in stage circa 30. (A) Dorsal, (B) lateral, and (C) ventral view; (D) oral disc detail; (E) lateral line neuromast detail.

more pronounced in the Central Andean Puna ecoregion (Garreaud *et al.* 2003, Santamans *et al.* 2021). It will be interesting to evaluate if extreme climate events associated with the global climate crisis (Urrutia and Vuille 2009) and the sustained trend of reduction of water bodies area reported in the region (Casagrande *et al.* 2019) could increase the frequency of the cannibalism in Aquatic Andean Frogs.

The trophic niche of *T. rubigo* in the dry season was mainly based on aquatic prey, with the anecdotic occurrence of one spider as an allochthonous (terrestrial) item (Table 1). In the wet season, *T. rubigo* consumed a wider range of prey that frequently includes allochthonous such as earthworms, adult dragonflies, and ants (Table 1). There is a noticeable variation in the importance of main consumed items, with

increased relevance of amphipod shrimps, coleopteran larvae, backswimmers (Notonectidae), and larvae and pupae of dipterans in the dry season (Table 1). This resulted in a narrower trophic niche of *T. rubigo* in the dry season with intermediate and non-significant diet overlaps between dry and wet seasons (Table 1). This result contrasts with the Chilean Altiplano species of *Telmatobius*, that have no or slight variation in its diet between wet and dry seasons (Lobos *et al.* 2018, 2021). This shift in food preferences could be related to a change in the environmental offer of allochthonous and aquatic prey items during the summer months in the Central Andean Puna ecoregion. However, a study on prey availability throughout the year in consecutive seasons is needed to confirm it.

**Table 1.** Summary of the identified prey items consumed by *Telmatobius rubigo* during dry and wet seasons, with the percentages of number (N), volume (V, in mm<sup>3</sup>), frequency of occurrence (F), and dietary importance value index (Ip). The development stages of the insect prey items are in parentheses. Categories with Ip-values above 10% are in bold. The two last rows show Levin's standardized index of trophic niche breadth for dry and wet seasons, and the Morisita-Horn index of seasonal diet overlap. \*Allochthonous prey items.

Prey item	Dry season (N = 17)				Wet season (N = 15)			
	N (%)	F (%)	V (%)	Ip	N (%)	F (%)	V (%)	Ip
Oligochaeta*	-	-	-	-	11.27	26.67	72.93	<b>36.96</b>
Ostracoda	1.34	11.76	0.03	4.38	1.41	6.67	0.02	2.70
Amphipoda	27.52	76.47	21.58	<b>41.86</b>	19.72	40.00	7.70	<b>22.47</b>
Araneae*	0.67	5.88	1.69	2.75	-	-	-	-
Odonata (nymph)	0.67	5.88	0.42	2.33	-	-	-	-
Odonata (adult)*	-	-	-	-	1.41	6.67	6.01	4.70
Ephemeroptera (nymph)	-	-	-	-	1.41	6.67	0.08	2.72
Diptera (larvae/pupae)	26.17	70.59	5.59	<b>34.12</b>	14.08	40.00	0.75	<b>18.28</b>
Coleoptera (larvae)	13.42	70.59	33.22	<b>39.08</b>	16.90	40.00	6.49	<b>21.13</b>
Coleoptera (adult)	1.34	11.76	0.11	4.40	29.58	40.00	5.53	<b>25.04</b>
Hemiptera	27.52	64.71	17.28	<b>36.50</b>	-	-	-	-
Formicidae*	-	-	-	-	4.23	20.00	0.48	8.24
Anura	1.34	11.76	20.08	<b>11.06</b>	-	-	-	-
Levin's standardized index	0.39				0.53			
Morisita-Horn index	0.55							

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