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NEW PREDATION RECORDS ON *THOROPA MILIARIS* (ANURA: CYCLORAMPHIDAE), WITH A REVIEW OF KNOWN PREDATORS

NUEVOS REGISTROS DE DEPREDACIÓN DE *THOROPA MILIARIS* (ANURA: CYCLORAMPHIDAE), CON UNA REVISIÓN DE LOS DEPREDADORES CONOCIDOS

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Resumen.– La rana de las piedras *Thoropa miliaris* (Cycloramphidae) es una especie saxícola endémica del Bosque Atlántico. La información sobre los posibles depredadores de esta especie es escasa en la literatura, un hecho posiblemente relacionado con la dificultad de registrar eventos de interacción entre predadores y presas. En este trabajo registramos diversos eventos predatorios oportunistas sobre *T. miliaris* por la serpiente *Chironius laevicollis* (Colubridae), por arañas del género *Ctenus* (Ctenidae) y por el ave *Furnarius rufus* (Furnariidae). Además, recopilamos los registros de depredación de las especies publicados hasta ahora.

Palabras claves.– déficit eltoniano, dieta, ecología trófica, Bosque Atlántico.

Abstract.– The rock river frog *Thoropa miliaris* (Cycloramphidae) is a saxicolous species endemic to the Atlantic Forest. There is scarce literature on potential predators of this species, which is likely related to the difficulty of recording its predatory interactions. In this paper, we report opportunistic records of predation on *T. miliaris* by the snake *Chironius laevicollis* (Colubridae), spiders of the genus *Ctenus* (Ctenidae), and the bird *Furnarius rufus* (Furnariidae). In addition, we compiled the reports of predation on *T. miliaris* from current published data.

Key words.– Atlantic Forest, diet, Eltonian shortfall, trophic ecology.

Data on predation are important to reduce the Eltonian shortfall— the lack of knowledge on biotic interactions (Hortal et al., 2015) —, but in nature, such data are recorded only occasionally (Menegucci et al., 2020). Anurans are an important part of the food web, as the prey of many vertebrate and invertebrate species (Toledo et al., 2007; Hocking & Babbitt, 2014). Brazil is the country with the greatest anuran diversity (Segalla et al., 2021; Frost, 2022), but the knowledge of biotic interactions of Brazilian anurans is deficient, even for common species like *Thoropa miliaris* (Spix, 1824), an endemic species to rocky environments in the Brazilian Atlantic Forest (Giaretta & Facure, 2004; Feio et al., 2006). In this work, we report opportunistic records of predation on *T. miliaris* by a snake, spiders, and a bird. We also compile the literature data on predators recorded for this species.

On 18 August 2014, at 20:04, CHON found a dead male snake *Chironius laevicollis* (Wied, 1824) (Colubridae) of 2.10 m snout-vent length at the Tombo D'água waterfall (Fig. 1A) (district of Mocotó do Imbé, municipality of Campo dos Goytacazes, state of Rio de Janeiro, Brazil; 21.81367° S, 41.75552° W, WGS84, 282 m a.s.l.). Dissection of the snake's abdomen revealed a partially digested *T. miliaris* (Fig. 1B). Predator and prey were not collected due to the degree of decomposition, but we were able to identify both species based on their overall morphology and color pattern (Dixon et al., 1993; Feio et al., 2006).

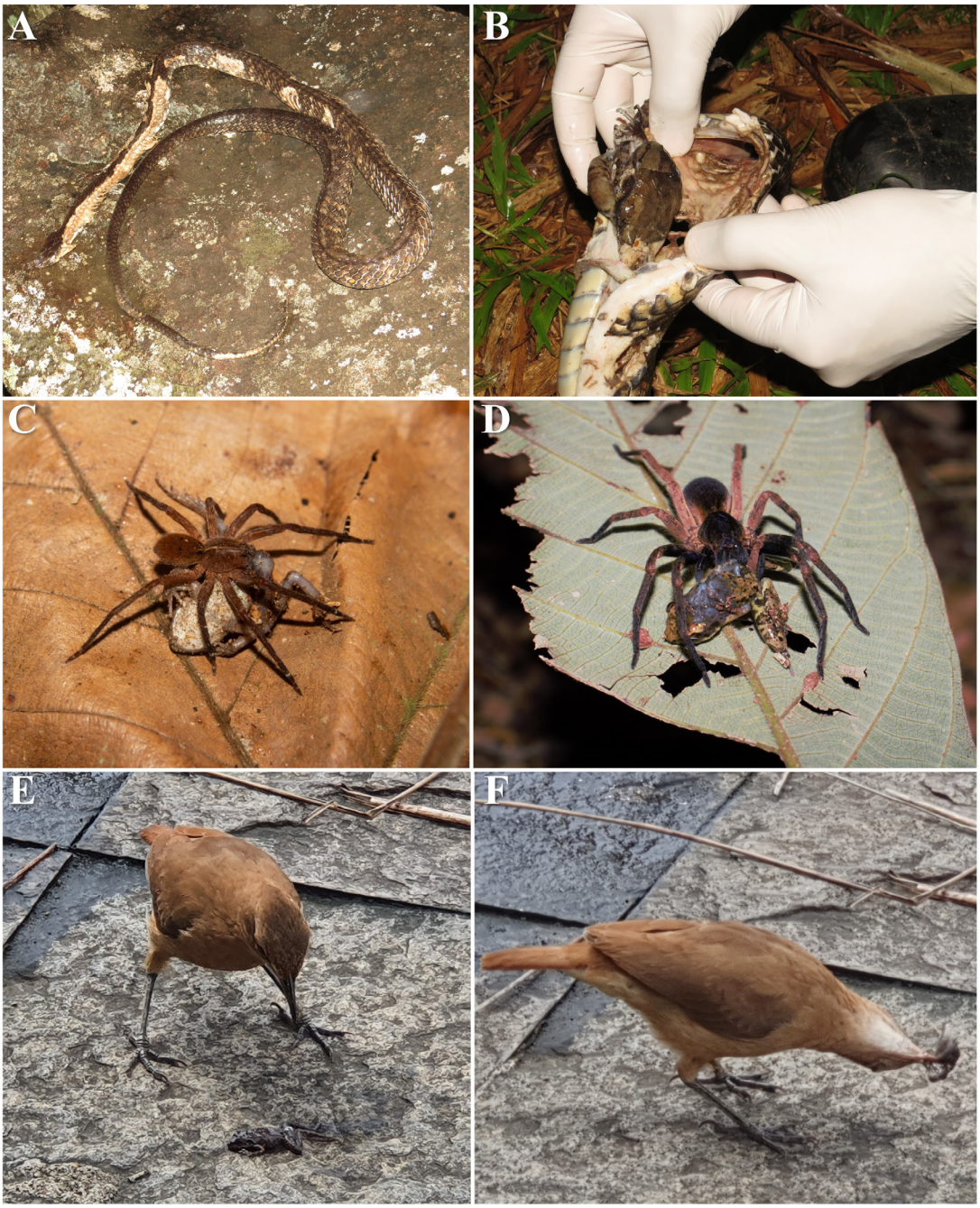

Figura 1. A) Individuo de *Chironius laevicollis* (Colubridae) encontrado muerto en el municipio de Campos dos Goytacazes, estado de Rio de Janeiro, Brasil. B) Individuo de *Thoropa miliaris* (Cycloramphidae) encontrado en el estómago de *C. laevicollis*, Campos dos Goytacazes, Rio de Janeiro, Brasil. Fotos de CHON. C) Individuo de *T. miliaris* siendo presa de una araña del género *Ctenus* sp. (Ctenidae) en Campos dos Goytacazes, Rio de Janeiro, Brasil. D) Individuo de *T. miliaris* siendo presa de una araña del género *Ctenus* cf. *medius* (Ctenidae) en Campos dos Goytacazes, Rio de Janeiro, Brasil. Fotos de CHON. E) y F) Individuo de *Furnarius rufus* (Furnariidae) predando un individuo de *T. miliaris* en el municipio de Juiz de Fora, estado de Minas Gerais, Brasil. Fotos de PSA.

Figure 1. A) Specimen of *Chironius laevicollis* (Colubridae) found dead in Campos dos Goytacazes, Rio de Janeiro, Brazil. B) *Thoropa miliaris* (Cycloramphidae) removed from the stomach of *C. laevicollis*. Photos by CHON. C) *Thoropa miliaris* being preyed upon by a *Ctenus* sp. (Ctenidae) spider in Campos dos Goytacazes, Rio de Janeiro, Brazil. D) *Thoropa miliaris* being preyed on by a *Ctenus* cf. *medius* (Ctenidae) in Campos dos Goytacazes, Rio de Janeiro, Brazil. Photos by CHON. E) and F) *Furnarius rufus* (Furnariidae) preying on *T. miliaris* in Juiz de Fora, Minas Gerais, Brazil. Photos by PSA.

At this same locality, CHON recorded two additional predation events on *T. miliaris* by spiders of the family Ctenidae: *Ctenus* sp. and *Ctenus* cf. *medius* Keyserling, 1891, identified by the spider taxonomist Leonardo Carvalho, Universidade Federal do Piauí, Brazil. The first record was on 19 February 2020, at 18:35 (21.82724° S, 41.74726° W; WGS84; 174 m a.s.l.; Fig. 1C), and the second on 16 June 2021, at 19:46 (21.81449° S, 41.75748° W; Fig. 1D). The *T. miliaris* individuals were collected and deposited in the Coleção Herpetológica do Norte Fluminense (CHNF 0897 and CHNF 0975, respectively).

On 21 February 2020, at 12:10, PSPA recorded a *T. miliaris* being preyed by a juvenile Rufous hornero, *Furnarius rufus* (Gmelin, 1788) (Furnariidae) in an urban environment near the hospital of the Universidade Federal de Juiz de Fora, municipality of Juiz de Fora, state of Minas Gerais, Brazil (21.78553° S, 43.36787° W, WGS84, 878 m a.s.l.; Fig. 1E). The *T. miliaris* was initially observed beside a paved road with little traffic, when the bird appeared and repeatedly pecked the frog on its dorsum, venter, and head. The frog attempted to escape several times, but the bird held it with its beak. The bird immobilized the frog and swallowed it alive (Fig. 1F). The bird was subsequently observed for approximately 40 minutes from a distance of 30 cm, but no regurgitation was recorded (see record video at https://doi.org/10.5281/zenodo.6954386). Prey identity was confirmed by

Tabla 1. Lista de depredadores de *Thoropa miliaris* (Anura: Cycloramphidae) basada en los datos propios de los autores y en una revisión de la literatura.
Table 1. List of predators of *Thoropa miliaris* (Anura: Cycloramphidae) based on the authors' data and literature review.

Predator identification	Life stage of prey	Environment	Source
Arachnida			
Cteniza sp. Latreille, 1829	Post-metamorphic	Forest	Pertel et al., 2010
Ctenus cf. *medius* Keyserling, 1891	Post-metamorphic	Forest	This study
Ctenus sp.	Post-metamorphic	Forest	This study
Trechalea sp.	Tadpole	Forest	Diniz et al., 2020
Anura			
Cycloramphus boraceiensis (Heyer, 1983)	Tadpole	Forest	Hartmann et al., 2003
Thoropa miliaris (Spix, 1824) (Tadpole)	Egg	Forest	Giaretta & Facure, 2004
Aves			
Furnarius rufus (Gmelin, 1788)	Post-metamorphic	Urban	This study
Insecta			
Tropisternus sp. (Larvae)	Tadpole	Forest	Siqueira et al., 2006
Squamata			
Bothrops jararaca (Wied, 1824)	Post-metamorphic	Forest	Sazima, 1992
Chironius bicarinatus (Wied, 1820)	Post-metamorphic	Forest	Roberto & Souza, 2020
Chironius flavolineatus (Jan, 1863)	Post-metamorphic	Not informed	Pinto et al., 2008; Roberto & Souza, 2020
Chironius fuscus (Linnaeus, 1758)	Post-metamorphic	Forest	Marques & Sazima, 2004; Hartmann, 2005; Roberto & Souza, 2020
Chironius laevicollis (Wied, 1824)	Post-metamorphic	Forest	This study
Erythrolamprus miliaris (Linnaeus, 1758)	Post-metamorphic	Forest	Albolea, 1998; Marques & Sazima, 2004; Mônico et al., 2016; Burg, 2020
Erythrolamprus poecilogyrus (Wied, 1825)	Post-metamorphic	Not informed	Pinto & Fernandes, 2004
Tropidurus torquatus (Wied, 1825)	Unknown - Museum specimen	Urban	Mônico & Mônico, 2022

Diego J. Santana (Universidade Federal do Mato Grosso do Sul, Brazil).

We reviewed literature records of predators of *T. miliaris* in Google Scholar on 28 April 2022, searching for the expression "predation OR predator OR prey AND *'Thoropa miliaris*'" in English, Spanish (depredación OR presa OR depredador), and Portuguese (predação OR presa OR predador), and found 267 results. Of these, only eight showed *T. miliaris* as the prey. We also searched issues of Herpetological Review from 1967-2022, finding four additional records. In addition, we searched the authors' pdf libraries. All reports are shown in Table 1.

Snakes are among the most important predators of post-metamorphic anurans (Toledo et al., 2007). Most reports of predation on *T. miliaris* were by *Chironius* spp., a genus of frog-eating species (Marques et al., 2016). Conversely, lizards are the least frequent vertebrate predators of frogs (Toledo et al., 2007). We found a single record of *T. miliaris* being preyed by a lizard (Mônico & Mônico, 2022): *Tropidurus torquatus*, a saxicolous species with a generalist diet (Gomides et al., 2013; Guimarães & Sbrek-Araujo, 2018). We also found two records of frogs preying on *T. miliaris*: i) tadpoles being preyed upon by *Cycloramphus boraceiensis* (Hartmann et al., 2003), and ii) egg cannibalism by conspecific tadpoles (Giaretta & Facure, 2004). Tadpoles were also preyed upon by larvae of the beetle *Tropisternus* sp., the only record of an insect preying on *T. miliaris*, despite Coleoptera being one of the most recorded invertebrate groups of anuran predators (Toledo, 2005). Arachnida is another frequently recorded invertebrate group of anuran predators (Toledo, 2005), although we found only two predation events, by a *Cteniza* sp. and *Trechalea* sp. (Pertel et al., 2010; Diniz et al., 2020).

Our records improve the information about the predation of post-metamorphic specimens of *T. miliaris* by the spider genus *Ctenus*, whose species often actively forage for anurans in leaf litter (Salvestrini & Gasnier, 2001; Menin et al., 2005). We also report the first avian predator of *T. miliaris*, the Rufous hornero, *Furnarius rufus*. Birds are common predators of post-metamorphic anurans (Toledo et al., 2007), but the absence of records for *T. miliaris* highlights the knowledge gaps on the biotic interactions of this relatively common, conspicuous, and abundant species.

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