ISSN 2413-337X

REVISTA NICARAGUENSE DE BIODIVERSIDAD

N° 119 Abril 2025

Review of the diet of *Leptodeira rhombifera* (Colubridae) and newly documented case of attempted predation of *Rhinella horribilis* (Bufonidae) in Nicaragua.

Lester Fonseca-González, Ariel Salinas & Ronier Francisco Rugama Montoya.

PUBLICACIÓN DEL MUSEO ENTOMOLÓGICO
LEÓN - - - NICARAGUA

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Review of the diet of *Leptodeira rhombifera* (colubridae) and newly documented case of attempted predation of *Rhinella horribilis* (Bufonidae) in Nicaragua.

Lester Fonseca-González[1], Ariel Salinas[2] & Ronier Francisco Rugama Montoya[3].

Resumen

Revisión de la dieta de *Leptodeira rhombifera* (Colubridae) y nuevo caso de intento de depredación de *Rhinella horribilis* (Bufonidae) en Nicaragua.

Las interacciones presa-depredador son importantes para comprender la dinámica de especies. En este estudio aportamos datos relevantes de la dieta de *Leptodeira rhombifera* a través de una exhaustiva revisión bibliográfica de su dieta. Conjuntamente reportamos por primera vez el intento de depredación de *Rhinella horribilis* por *Leptodeira rhombifera* en el pacifico de Nicaragua. Corroboramos que la dieta de *L. rhombifera* está dirigida principalmente hacia los anfibios; sin embargo, los reptiles y peces podrían ser parte sustancial de su alimentación, los reportes sugieren que los hábitos alimenticios de la especie están estrechamente relacionados con su historia natural. Por último, mencionamos que *R. horribilis* podría representar una alternativa en los hábitos alimenticios del género *Leptodeira*.

Palabras claves: Anfibios, Depredador, Dinámica ecológica, Presa, Serpientes.

DOI: 10.5281/zenodo.14611330

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Abstract

Prey-predator interactions are important to understand species dynamics. In this study, we provide relevant data on the diet of *Leptodeira rhombifera* through an exhaustive literature review of its diet. We also report for the first time the attempted predation of *Rhinella horribilis* by *L. rhombifera* in the Pacific region of Nicaragua. We corroborate that the diet of *L. rhombifera* primarily targets amphibians; however, reptiles and fish also could be a substantial part of its diet and reports suggest that the feeding habits of the species are closely related to its natural history. Finally, we argue that *R. horribilis* could represent an alternative in the feeding habits of the genus *Leptodeira*.

Keywords: Amphibians, Predator, Ecological dynamics, Prey, Snakes.

Introduction

Tropical habitats are characterized by high biodiversity and complex biotic interactions such as predation (Freestone *et al.*, 2011; Brown, 2014). Predation is an integral part of the ecological dynamics of living organisms and is based on the effort made by one animal to find and feed on another (Curio, 1976). Understanding predation is fundamental to better understand the ecology of living organisms (Rosenberg & Cooper, 1990), as documenting predation-prey interactions provides valuable information about the dynamics of structure and function within communities and ecosystems (Rosenberg & Cooper, 1990).

Anurans in particular are a crucial component in the trophic dynamics of communities and ecosystems (Whiles *et al.*, 2006); they are secondary consumers in the food chain, as they consume insects and other invertebrates, while also serving as prey for other species. Therefore, documenting biotic interactions in this group of animals is interesting in terms of ontogeny between prey and predators.

Cane toads are the most widely distributed and abundant new world amphibians around the world (Lever, 2001) and within this group there is *Rhinella horribilis*, which is naturally distributed from southern Texas to the central Amazon. This species is one of the most cosmopolitan anurans, inhabiting diverse types of ecosystems (Acevedo *et al.*, 2016; Bonett *et al.*, 2017). In Nicaragua, *R. horribilis* are present throughout the country, including urban areas, livestock areas and altered natural habitats (HerpetoNica, 2015). This species is terrestrial and nocturnal (Savage, 2002) however, arboreal behavior has been reported (Berra, 2020).

Rhinella horribilis toads have a generalist diet, essentially consuming different species they can capture in their mouths. They feed on a wide variety of invertebrates, small vertebrates and in some cases, plants (Botero-Trujillo, 2006; Escudero & Ortega, 2009; Sampedro-Marín *et al*., 2011), turn representing prey for other species.

In another order, *Leptodeira* is a genus of snakes that mostly consume amphibians and small lizards. Among this group is *Leptodeira rhombifera*, which has an established distribution from southern Mexico to Panama and is found in dry to humid lowland tropical environments (Barrio-Amorós, 2019). In Nicaragua, it is present in almost the entire national territory's, associated wetlands (HerpetoNica, 2015) and is primarily terrestrial and nocturnal, according to Leenders (2019) this species is more common in seasonally dry areas. They possess a certain amount of venom as well as enlarged, striated posterior, maxillary teeth that they use to immobilize their prey before consuming them (Leenders, 2019).

L. rhombifera feeds mainly consisting of adult or juvenile anurans (Duellman, 1958; Solórzano, 2004; Espinoza, 2021). However, this species has been documented feeding on other groups such as fish, birds and small mammals (Solórzano, 2004; Köhler 2008; Solórzano, 2022). Additionally, there are records that mention other important aspects of the species diet such as scavenging (Knight, 2016; Fuentes & Quiroz-Espinoza, 2024) and ophiophagy (Solórzano, 2004; Köhler 2008).

In this paper we describe a case attempted predations of *R. horribilis* by *L. rhombifera* in the pacific region of Nicaragua, and discuss relevant aspects of *L. rhombifera*'s diet.

Materials and Methods

The predation event occurred in the central Pacific region of Nicaragua, department of Managua, in "Natura" Reserve, located at the following coordinates: N. 11.86756º, W. 086.51387º. This zone corresponds to Central American dry forests and secondary regenerations were present locally.

Information Gathering

To document the *in-situ* observation and identification of both species involved, the organisms were photographed using a Sony Ciber-shot H-400 and Nikon 3400 camera. Photographs were taken from a distance of one meter so that the event would not be interrupted.

Subsequently, an exhaustive review of publications concerning *L. rhombifera* prey was conducted using the Google Scholar search engine and Scopus. We also reviewed the metadata of 15 specialized herpetology journals:

- Herpetological Review (https://ssarherps.org/publications/herpetologicalreview/)
- Herpetology Notes (https://www.biotaxa.org/hn)
- Herpetologica (https://bioone.org/journals/herpetologica)
- Reptiles & amphibians (https://journals.ku.edu/reptilesandamphibians)
- Mesoamerican Herpetology (https://mesoamericanherpetology.com/index.html)
- Bulletin of the Chicago Herpetological Society (https://chicagoherp.org/)
- Cuaderno de herpetologia (https://cuadernosdeherpetologia.com/index.php/CdH)
- Amphibia-Reptilia (https://brill.com/view/journals/amre/amre-overview.xml)
- The herpetological journal (https://www.thebhs.org/publications/the-herpetological-journal)
- British Herpetological Society Bulletin (https://www.thebhs.org/publications/the-herpetological-bulletin)
- Bristish Herpetological Society Report (https://www.thebhs.org/publications/british-herpetological-society-reports)
- Captive & Field Herpetology (https://www.captiveandfieldherpetology.com/)
- Journal of Herpetology (https://bioone.org/journals/journal-of-herpetology)
- Salamandra Journal (https://www.salamandra-journal.com/)
- Revista Latinoamérica de herpetologia (https://herpetologia.fciencias.unam.mx/index.php/revista).

Similarly, we reviewed the repository of CSUCA (Consejo superior de Universidades Centroamericanas) and other academic institutions, primarily in North America. During our publication review, we limited our search of *L. rhombifera* by employing field operators (Gómez, 2017) with the following key terms: Feeding / Diet / Predation / Note / *Leptodeira rhombifera* / *Rhinella horribilis* / Registration. We also searched key terms' Spanish equivalents when appropriate.

Compiled information was carefully reviewed and selected from its source and was organized chronologically and by taxonomic group. The scientific name is according to the latest published of the checklist of the herpetofauna in Nicaragua (Sunyer & Martinez-Fonseca, 2024) and Amphibians Web (2024) for species (prey) not distributed in Nicaragua.

Figure 1. The location where predation took place with macro and micro localization.

Results and Discussion

On August 20, 2024, during a night hike in the vicinity of the "Los Lagartos" reservoir, the rangers Ronald Bermudez, Francisco Flores, Junior Baltodano, Carlos Corea with Lester Fonseca, Ariel Salinas and Ronier Rugama observed a juvenile *Leptodeira rhombifera* on the side of the Guardabarranco Trail, feeding on a juvenile *Rhinella horribilis*, the event took place at 18:05 hours. Those present proceeded to photograph this predation event for approximately four minutes, during which the snake attempted to swallow the toad (Figure 2). At the time of the observation, the snake held its prey by the right flank, and the prey showed no signs of resistance.

Figure 2. Photos from the attempted predation of *R. horribilis* by *L. rhombifera* (photos © Lester Fonseca and Ariel Salinas).

After approximately four minutes, it was not feasible to remain at the site for more time, so we moved to other locations within the reserve.

Upon returning to the exact point of observation, we noticed that the snake abandoned its prey. The anuran exhibited lacerations on its shoulders as a result of the snake's subjugation and symptoms of having been poisoned (Figure 3).

We cannot assume that the colubrid did not consume the prey due to our presence or because it could not swallow it, as such cases have been previously recorded in snakes of the Colubridae family in which they do not complete their feeding for different reasons (Heinen & Hammond, 1997; Engeman & Engeman, 2015; Teles *et al*., 2018; Hernández & Guevara, 2022), such cases are related to the relative sizes of the predator, secretions from the toads' skin, or due to physical resistance on the part of the prey (Costa & Trevelin, 2020).

Figure 3. *Post mortem* state of *R. horribilis* (photos © Lester Fonseca and Ariel Salinas).

Both species were juveniles, the snake was about 27 centimeters long and the toad was about 4.5 centimeters. We emphasize that it is not clear whether the toad was not consumed because of the size of the prey relative to the snake, human presence, or some other factor.

R. horribilis has been documented as prey for other species of the genus *Leptodeira*, such as *L. maculata* (García-Mata *et al*., 2017), *L. splendida* (Gámez-Duarte *et al*., 2024) and *L. annulata* (McCranie, 2011). Additionally, other reptiles such *Ctenosauria similis* have been observed feeding on *R. horribilis* (Pasachnik & Corneil, 2011). There is also data provided by Pasachnik & Corneil (2011) and Okada-Aguiar & Costa-Campos (2018) specify that *R. horribilis* it is considered a feeding alternative for snakes even in its post-mortem state.

It is worth mentioning that according to HerpetoNica (2015), the Bufonidae family is considered the most common family of toads in the Pacific region of Nicaragua and is present throughout the country. Within the Bufonidae group, *R. horribilis* is the most frequently observed species. This statement is consistent with the relative abundance of *R. horribilis* in the Nature Reserve, as it tends to be the most commonly observed amphibian. Therefore, this species could represent an alternative resource in the diet of terrestrial snakes due to its common presence in the reserve.

The diet of *L. rhombifera* is well documented; however, records documenting its prey at the species level are rare. For example, a publication by Savage (2002) mentions that the snake consumes aquatic prey such as crabs and fish. Other authors also note lizards, amphibians, tree frog eggs, and small mammals as a part of the snake's diet without narrowing down the species (Duellman, 1958, Solórzano, 2004; Köhler, 2008). With this in mind, we compiled cases that specifically document the species (including some up to the family level) that are a part of the diet of *L. rhombifera*.

It should be note that in this analysis we only consider reports specifying the species *L. rhombifera* or the subspecies *L. rhombifera rhombifera*, since this species shows several taxonomic changes over time. For example, Duellman, 1958; Bocourt, 1884; Savage, 2002; Daza *et al*., 2009; Barrio-Amorós, 2019 and Sunyer & Martinez-Fonseca, 2024.

According our literary review, the diet of *L. rhombifera* is mostly made up of amphibian. This data suggests that the feeding habits by *L. rhombifera* are closely related to its natural history, as being a nocturnal and terrestrial species, it relies on prey that can be easily found on the ground or in not so high places. These characteristics may explain why there are almost no literary resources documenting the predation of birds or mammals by *L. rhombifera*.

Additionally, these particular characteristics of *L. rhombifera* could help explain the fact that this species has been reported to feed on fish and engage in scavenging behavior, which some believe it is likely to resort to more frequently than previously thought.

The consumption of dead prey by *L. rhombifera* is important, as it alludes to an ability of the species to select a broader diet when anurans are less abundant (Céspedes, & Abarca, 2014). Even with this, there have been no documented cases in which this species has been able to return to prey previously killed by them for food.

Of the 20 cases collected describing predation by *L. rhombifera* (Table 1), 60 percent correspond to amphibians, while 20 percent correspond to reptiles and 20 percent to fish.

Table 1. Compilation the diet (Prey) of *Leptodeira rhombifera*.

Documented prey of *Leptodeira rhombifera*				
Taxonomic group	**Prey**	**Documented attack**	**Country**	**Sources**
Amphibians	*Engystomops pustulosus*	Yes (Individuo)	Barra Colorado, Panama	Ryan (1985)
Amphibians	*Engystomops pustulosus*	Yes (Individuo)	Gamboa, Panama.	Dougherty & Lisondro (2023)
Amphibians	*Boana rosenbergi*	Yes (Individuo)	Panama	Kluge (1981)
Amphibians	*Boana rosenbergi*	Yes (Individuo)	Gamboa, Panama.	Dougherty & Lisondro (2023)
Amphibians	*Engystomops pustulosus*	Yes (Individuo)	Gamboa, Panama.	Dougherty & Lisondro (2023)
Amphibians	*Incilius coccifer*	Not (Individuo)	Guanacaste, Costa Rica	Área de Conservación de Guanacaste (2024)
Amphibians	*Lithobates vallianti*	Yes (Scavenging)	Guanacaste, Costa Rica	Mora-Benavides (1999)
Amphibians	*Rhinophrynus dorsalis*	Yes (Individuo)	Guanacaste, Costa Rica	Céspedes et al. (2018)
Amphibians	*Anaxyrus americanus*	Yes (Experiment)	Arrived in New York, EEUU	Skeha (1959)
Amphibians	*Lithobates pipiens**	Yes (Experiment)	Arrived in New York, EEUU	Skeha (1959)
Amphibians	*Pseudacris regilla*	Yes (Experiment)	EEUU	Busack (2018)

Amphibians	*Hylidae*	Yes (Scavenging)	Los Santos, Panama	Knight (2016)
Reptiles	*Leptodactylus labialis*	Yes (Scavenging)	Panama	Fuentes & Quiroz-Espinoza (2024)
Reptiles	*Lampropeltis triangulum*	Yes (Experiment)	Arrived in New York, EEUU	Skeha (1959)
Reptiles	*Anolis spp*	Yes (Experiment)	Arrived in New York, EEUU	Skeha (1959)
Reptiles	*Iguana rhinolopha*	Yes (Scavenging)	Panama	Fuentes & Quiroz-Espinoza (2024)
Fish	*Rhamdia guatemalensis*	Yes (2 Individuo)	Guanacaste, Costa Rica.	Rojas-Carranza & Anderson (2023)
Fish	*Rhamdia spp*	Yes (Individuo)	Alajuela, Costa Rica	Céspedes & Abarca (2014)
Fish	*Characidae*	Yes (Individuo)	Los santos, Panama	Knight & Shervette (2022)
Fish	*Rhamdia laticauda*	Yes (Individuo)	Francisco Morazán, Honduras	Solis & Guerrero (2016)

Note: * indicates an update in the scientific name of some documented species: *Rana pipiens*.

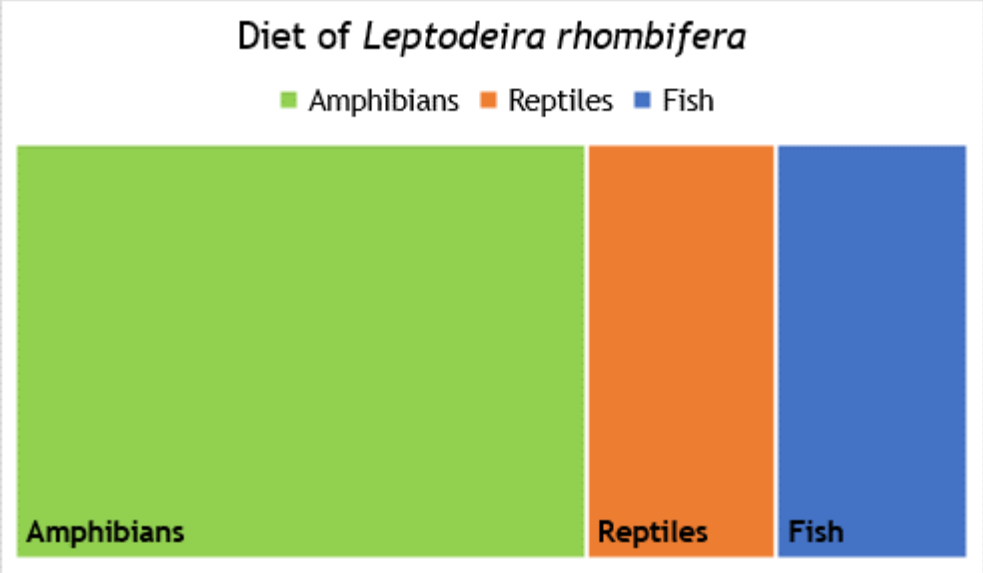

Figure 4. A representation of *L. rhombifera*'s diet.

It should be noted that five cases included in our compilation come from experiments, some of which were conducted outside of the natural habitat of the species. Additionally, four species included in our compilation were documented as cases of scavenging. Our prey data collection for *L. rhombifera* suggests a higher degree of plasticity than previously reported (Espinoza, 2021; Duellman, 1958; Solórzano, 2004; Dougherty & Lisondro, 2023). This includes prey such as reptils and fish in the diet of *L. rhombifera*. (Figure 4).

Conclusion

We believe that anurans are a main food source of *L. rhombifera*; however, this review suggests that fish and reptiles could be an essential part of its diet. This data suggests that the feeding habits by *L. rhombifera* are closely related to its natural history, as being a nocturnal and terrestrial species, it relies on prey that can be easily found on the ground or in not so high places. In addition, it is important to mention that this species exhibits some behaviors that are little known or sometimes overlooked, such as ophiophagy and scavenging.

Finally, we emphasize that due to the frequency and abundance of *R. horribilis*, this species could represent an alternative food source for many predators, including snakes of the genus *Leptodeira* and other terrestrial snakes. Further focal studies of *Rhinella horribilis* predators and a deeper analysis of their ecological role are needed.

Acknowledgments

The authors thank Reserva Natura for its management and sustainable development of the tropical dry forest, as well as for allowing research and generating knowledge about our biodiversity. We are also very grateful for the dedication of the park rangers, for their passion and dedication in the surveillance and protection of the area.

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