Literature Cited

Canseco-Márquez, L., and G. Gutiérrez-Mayén. 2006. Herpetofauna del Municipio de Cuetzalan del Progreso, Puebla. Pp. 180–196 *In* A. Ramírez-Bautista. L. Canseco-Márquez, and F. Mendoza-Quijano (Eds.), Inventarios Herpetofaunísticos de México: Avances en el Conocimiento de su Biodiversidad. Publicación Especial No. 3, Boletín de la Sociedad Herpetológica Mexicana, A.C., Mexico.

Cruz-Elizalde, R., U. Hernández-Salinas, A. Ramírez-Bautista, and O. Barrera-Hernández. 2011. Natural History Notes. *Bolitoglossa platydactyla* (Broad-footed Mushroom-tongued Salamander). Maximum elevation. Herpetological Review 42: 258.

Murrieta-Galindo, R., A. González-Romero, F. López-Barrera, and G. Parra-Olea. 2013. Coffee agrosystems: an important refuge for amphibians in central Veracruz, Mexico. Agroforest System 87: 767–779.

Parra-Olea, G., and D. Wake. 2008. *Bolitoglossa platydactyla*. The IUCN Red List of Threatened Species. (www.dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T59196A11885995.en; accessed 17 November 2015).

Ramírez-Bautista, A., U. Hernández-Salinas, R. Cruz-Elizalde, C. Berriozabal-Islas, D. Lara-Tufiño, I. Goyenechea-Mayer Goyenechea, and J. M. Castillo-Cerón. 2014. Los Anfibios y Reptiles del Estado de Hidalgo, México: Diversidad, Biogeografía y Conservación. Sociedad Herpetológica Mexicana, A.C., Mexico.

Ramírez-Bautista, A., F. Mendoza-Quijano, and M. C. Arizmendi. 2004. *Bolitoglossa platydactyla*. Estatus y conservación de algunos anfibios y reptiles de México. Facultad de Estudios Superiores Iztacala, Unidad de Biología, Tecnología y Prototipos. Universidad Nacional Autónoma de México. Bases de datos SNIB-CONABIO. Proyecto W043. México. D.F. (www.conabio.gob.mx/conocimiento/ise/fichasnom/Bolitoglossaplatydactyla00.pdf; accessed 17 November 2015).

Wake D. B., and J. F. Lynch. 1976. The distribution, ecology and evolutionary history of plethodontid salamanders in tropical America. Science Bulletin of Natural History Museum of Los Angeles County 25: 1–65.

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Predation of *Rhaebo haematiticus* (Anura: Bufonidae) by *Leptodeira septentrionalis* (Serpentes: Dipsadidae) in Costa Rica

The Truando Toad, *Rhaebo haematiticus* (Cope, 1862), is distributed from the Caribbean slopes of eastern Honduras to northern Colombia, and on the Pacific slopes from Costa Rica to central Ecuador (Savage, 2002). In Costa Rica, this species is widely distributed at elevations from near sea level to 1,300 m on the Caribbean and Pacific slopes and the Meseta Central (Savage, 2002). Although this toad is relatively abundant, little information is available on its ecology. *Rhaebo haematiticus* is known to inhabit the forest floor and to prey primarily on ants, and is an explosive breeder in small pools along streams from early to the middle of the wet season (Scott, 1983; Lieberman, 1986; Savage, 2002). Little else in know about the natural history of this species, including its potential predators.

Toads are known to have evolved a suite of chemical defenses that include dermal glands on their skin and greatly enlarged parotoid glands behind the head (Hayes, 1989; Denton and Beebee, 1991; Jared et al. 2009). These chemical defenses can be extremely toxic, and are capable of immobilizing or result in the death of such potential predators as snakes (Licht and Low, 1968; Phillips et al., 2003). The parotoid glands of *R. haematiticus* are elongated and especially large, and extend almost the length of the head (Savage, 2002), and thus can be an indicator of their relative toxicity (Phillips and Shine, 2005). Based on the size of these glands it can be inferred that *R.*

haematiticus has strong predator deterrent toxins, especially because to our knowledge there are no observed reports of predation on this species (e.g. Savage, 2002; Solórzano, 2004).

The Northern Cat-Eyed snake, *Leptodeira septentrionalis* (Kennicot, 1859), is distributed from extreme southern Texas, United States, southward to Peru, and its range overlaps extensively with that of *R. haematiticus* (Savage, 2002). In Costa Rica *L. septentrionalis* is an abundant species that occurs at elevations from near sea level to about 1,500 m, mostly in humid habitats on the Caribbean and Pacific slopes (Solórzano, 2004). Frogs and toads constitute most of diet of *L. septentrionalis*, but this species also is known to consume the eggs of treefrogs and dendrobatid frogs, and occasionally lizards (Duellman, 1958; Savage, 2002; Stynoski et al., 2014). The presence of toads in the diet of *L. septentrionalis* suggests a capability of consuming toxic prey items (Vargas-Salinas and Aponte-Gutiérrez, 2013). Considering the wide range of anuran species consumed by *L. septentrionalis* and its large distributional overlap with *R. haematiticus*, it is surprising that no reports of predation are available by this snake on this toad.

During an expedition to the Caribbean slopes of the Cordillera de Talamanca, Provincia de Limón, on 6 March 2015 we observed an adult female *L. septentrionalis* preying on an adult male *R. haematiticus* (Fig. 1) at the confluence of the Río Lari and the Río Pare (9°26'0.64"N, 83°2'55.21"W; WGS 84; elev. 390 m). We observed this event at 1810 h near a series of rocky pools located about 15 m from the western bank of the Río Lari. The snake was perched on a small shrub ca. 60 cm above the ground, and was holding the head of the toad in its mouth (Fig. 1a). We are not aware if the toad was captured on the ground or on low vegetation, but assume that it was captured while sleeping on low vegetation near the stream because this is a common behavior in this species (M. Ryan, unpublished), and it seems unlikely that the snake would have carried such a heavy prey item onto a higher perch. At 1900 h, 50 min after we started observing the event, the snake had ingested ca. 75% of the toad's body to near the groin (Fig. 1b), and after 118 min it finished swallowing the toad. At this point, we captured the snake to preserve it and document this rare event. Shortly after placing the snake in a collecting bag, however, it regurgitated the toad; we were uncertain if the regurgitation was caused by a reaction to the toad's toxins or because of the stress from capture. To rule out regurgitation from toxicity we left the toad and snake in the bag until morning, because snakes are known to re-ingest prey after regurgitation. The following morning we discovered that the snake had consumed the toad, and by that time it had advanced onto the snake's digestive tract. We then euthanized the snake and fixed it in formalin, and deposited it in the herpetological collection of Museo de Zoología, Universidad de Costa Rica (UCR 22313).

The *L. septentrionalis* was a gravid female that contained seven nearly completely developed eggs; it measured 975 mm in total length, which approached the maximum known total length of the species (1,055 mm; Savage, 2002). The snake and toad weighed 146.64 g, and without the toad the snake weighed 132.0 g. The toad measured 62.0 mm in body length and weighed 14.64 g, representing 11.1% of the snake's total mass. At the time of dissection the skin of the head and forelimbs of the toad were highly digested, and for this reason the remains of the toad were discarded.

The consumption of toxic prey can have important costs to the predator that include: a reduction of the predator's locomotion performance; more time handling and consuming prey; and lower energetic benefits compared to non-venomous frogs of equal size (Llewelyn et al., 2009). Because we did not observe the snake after it had ingested its prey, we are unaware if its locomotor performance was affected. Nonetheless, it took the snake nearly two hours (118 min) to consume the toad, and during this time it was exposed to increased risk from predation. The length of time it took the *L. septentrionali*s to swallow the *R. haematiticus* is similar that reported by Vargas-Salinas and Aponte-Gutiérrez (2013), who indicated that it took 113 min for a *L. septentrionali*s to swallow an individual of the toad *Rhinella humboldti*. This contrasts strongly with our unpublished observations of swallowing time of non-toxic anuran prey by *L. septentrionali*s, which includes similar-sized treefrogs (*Agalychnis callidryas* and *Smilisca phaeota*) at from 2 to 5 min. Like in most other snakes, non-toxic prey consumption by *L. septentrionalis* takes fewer than 2 min (e.g., see www.youtube.com/watch?v=XAYuV2KgBMs; accsessed 26 April 2015). Our observation supports that of Llewelyn et al. (2009), who found that the consumption of toxic prey can increase the consumption time. Whether the locomotor performance of *L. septentrionalis* is impaired after consuming *R. haematiticus* can be determined through laboratory feeding and locomotor trials.

Herein we report the first record of *L. septentrionalis* preying on *R. haematiticus*, and note that it took the snake a significant amount of time to consume such a toxic prey item. Considering the increased risk of predation to the snake during the swallowing process might explain why such an observation has not been reported. This observation is important because it suggests that *L. septentrionalis* has some ability to tolerate toad skin toxins, even at a cost of increased swallowing time. Such an event may be a rare occurrence and might happen when a snake's preferred prey items are not abundant, or this simply might have been an opportunistic feeding event.

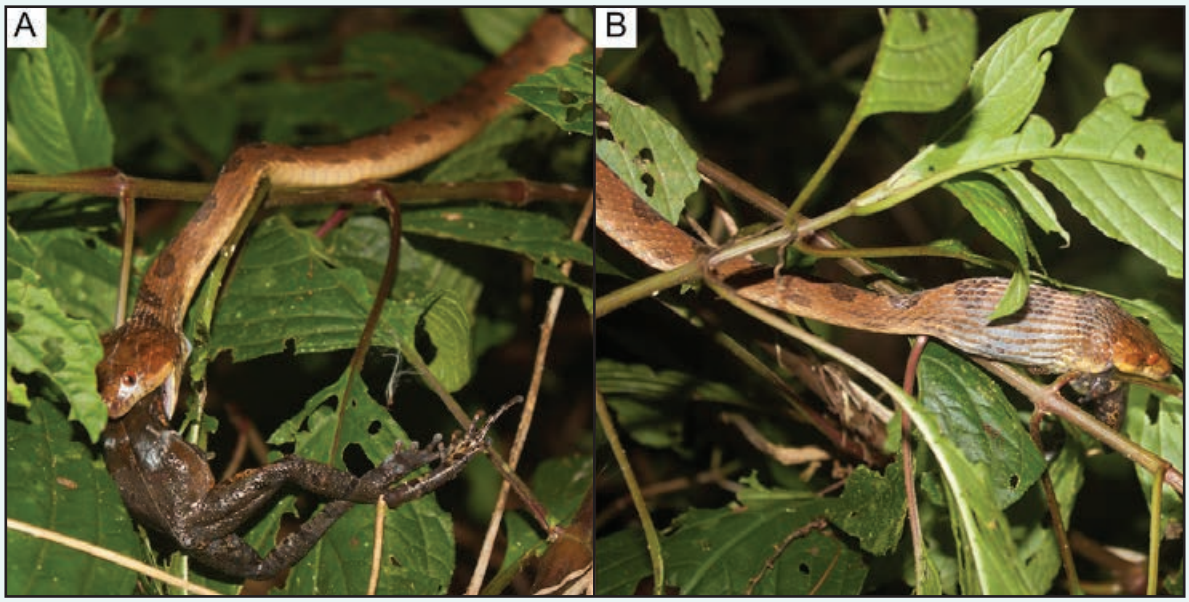

Fig. 1. An adult female *Leptodeira septentrionalis* feeding on an adult male *Rhaebo haematiticus*: (A) when it was first sighted; and (B) 50 minutes later. © Erick Arias

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Literature Cited

Denton, J., and T. J. C. Beebee. 1991. Palatability of anuran eggs and embryos. Amphibia-Reptilia 12: 111–114.

Duellman, W. E. 1958. A monographic study of the colubrid snake genus *Leptodeira*. Bulletin of the American Museum of Natual History 114: 1–152.

Hayes, F. E. 1989. Antipredator behavior of recently metamorphosed toads (*Bufo a. americanus*) during encounter with garter snakes (*Thamnophis s. sirtalis*). Copeia 1989: 1,011–1,015.

Jared, C., M. M. Antoniazzi, A. E. C. Jordão, J. R. M. C. Silva, H. Greven, and M. T. Rodrigues. 2009. Parotoid macroglands in toad (*Rhinella jimi*): their structure and functioning in passive defence. Toxicon 54: 197–207.

Licht, L. E., and B. Low. 1968. Cardiac response of snakes after ingestion of toad parotoid venom. Copeia, 1968: 547–551.

Lieberman, S. S. 1986. Ecology of the leaf litter herpetofauna of a Neotropical rain forest La Selva, Costa Rica. Acta Zoologica Mexicana Nueva Serie 15: 1–72.

Llewelyn, J. S., B. L. Phillips, and R. Shine. 2009.Sublethal costs associated with the consumption of toxic prey by snakes. Austral Ecology 34: 179–184.

Phillips, B., G. P. Brown, and R. Shine. 2003. Assessing the potential impact of Cane Toads (*Bufo marinus*) on Australian snakes. Conservation Biology 17: 1,738–1,747.

Phillips, B. L., and R. Shine. 2005. The morphology, and hence impact, of an invasive species (the Cane Toad, *Bufo marinus*): changes with time since colonization. Animal Conservation 8: 407–413.

Savage, J. M. 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna between Two Continents, between Two Seas. The University of Chicago Press, Chicago, Illinois, United States.

Scott, N. J., Jr. 1983. *Bufo haematiticus* (sapo, toad). Pp. 385 *In* D. H. Janzen, (Ed.), Costa Rican Natural History. The University of Chicago Press, Chicago, Illinois, United States.

Solórzano, A. 2004. Serpientes de Costa Rica: Distribución, Taxonomía e Historia Natural / Snakes of Costa Rica: Distribution, Taxonomy, and Natural History. Instituto Nacional de Biodiversidad (INBio), Santo Domingo de Heredia, Costa Rica.

Stynoski, J. L., G. Shelton, and P. Stynoski. 2014. Maternally derived chemical defences are an effective deterrent against some predators of poison frog tadpoles (*Oophaga pumilio*). Biology Letters doi: 10.1098/rsbl.2014.0187.

Vargas-Salinas, F., and A. Aponte-Gutierrez. 2013. A race for survivorship: failed predation on the toad *Rhinella humboldti* (Gallardo, 1965) by the cat-eyed snake *Leptodeira septentrionalis* (Kennicott, 1859). Herpetology Notes 6: 189–191.

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Crocodylus acutus in Panama: a status report

The American Crocodile, *Crocodylus acutus*, is the most widely distributed of the Neotropical crocodiles (Thorbjarnarson, 2010). Based on information provided by the International Union for the Conservation of Nature and Natural Resources (IUCN Red List; www.iucnredlist.org), this species is one of the three most threatened crocodilians in the Americas, and has been assessed as Vulnerable (Ponce-Campos et al., 2012). This species also is included in Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), except for Cuba where it is listed in Appendix II (CITES, 2012). At the country level, *C. acutus* is considered as Critically Endangered in Colombia (Rodríguez, 2002), Ecuador (Carvajal et al., 2005), and Peru (National Decree 034-2004-AG), and as Endangered in Panama (resolution No. AG–0051-2008), Venezuela (Rivas et al., 2012), and the United States (Mazzotti et al., 2007). In contrast, Mexico has listed this species under the category of Special Protection (NOM-059-SEMARNAT-2010), whereas in Cuba *C. acutus* is not listed in any of the threatened categories because the country harbors one of the largest and healthiest populations in its range (Larriera et al., 2008). Based on another conservation measure, the Environmental Vulnerabilty Score (EVS), Johnson et al. (2015) determined an EVS of 14 for *C. acutus* in Central America, placing this species at the lower end of the high vulnerability category.

Presently, the governments, national agencies, and researchers of only a few countries are providing support for conservation planning and management measures for *C. acutus* (Thorbjarnarson, 2010; Balaguera-Reina et al., 2015a; Venegas-Anaya, 2015a), which is of concern for the potential survival of at least some populations of this species. To determine where such problems might exist, clear strategies to assess each region's conservation plans must be made a priority. Our aim herein is to present an overview of the current status of *C. acutus* in Panama, including gaps in our knowledge of the biology of this species in the country, and to comment on research priorities based on a review of the literature.

Reports on the presence of *C. acutus* in Panama's bays and most rivers along the Pacific coast, in provinces from Panamá to Chiriquí, date back to the late 19th century; these reports also contained information on conflicts