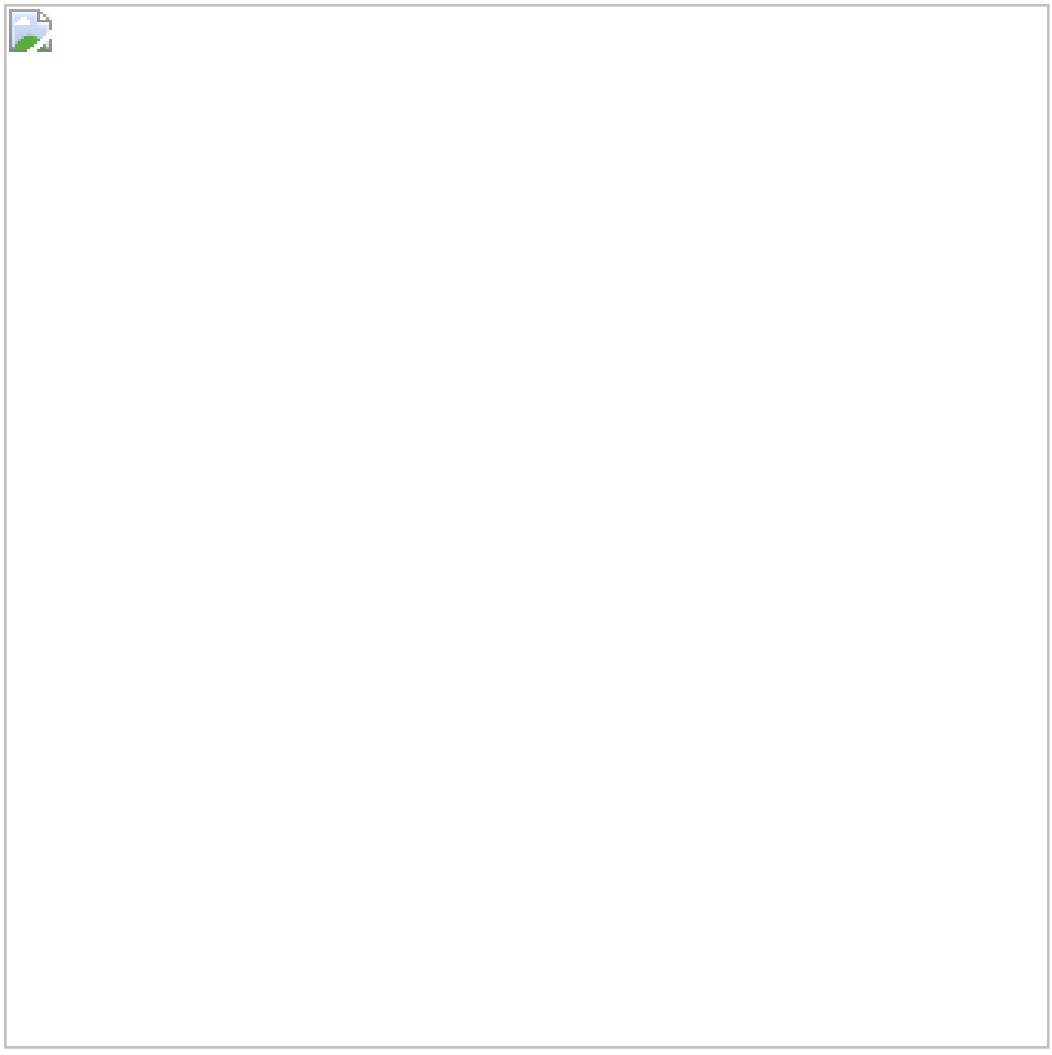

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Social Behavior in *Nototriton brodiei* in the Cloud Forest of Cusuco National Park, Honduras

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Abstract. The slender and elusive *Nototriton brodiei* is known only from a few specimens at two separate sites in the Sierra de Merendón, in Guatemala and Honduras. We present the first record of an aggregation of three adults of *N. brodiei* on a single leaf in the cloud forest of Cusuco National Park, Honduras. We observed two males and one female walking together at night, using one another as support to move across vegetation. This behavior is the first record of both sexes interacting for this species, and might represent courtship strategy or similar behavior. This observation is a contribution to the sparse natural history and ecology literature for this genus. Our observation highlights the need for herpetological research on little-known and imperiled species endemic to cloud forests in Central America.

Keywords. Aggregation; Animal behavior; Courtship; Herpetology; Salamander.

The diminutive, slender salamanders of the genus *Nototriton* Wake and Elias, 1983 are only known from a few specimens (Papenfuss and Wake, 1987; Townsend et al., 2010). In particular, reports of adults of the endangered species *Nototriton brodiei* (Campbell and Smith, 1998) are exceptionally rare, with fewer than 10 individuals observed to date from two localities in Guatemala and Honduras (Campbell and Smith, 1998; Kolby et al., 2009). Records of multiple active salamanders in nature are correspondingly scarce. Herein, we report an observation of three individuals of *N. brodiei* that were concurrently active on the same leaf, potentially a type of courtship or similar behavior. This observation provides insight into potential behavioral interactions related to the reproductive biology of this poorly understood salamander.

On 25 June 2017 at 20:34 in Guanales Camp (15°29′21.4″N, 88°14′11.0″W, 1,234 m elevation), Parque Nacional Cusuco, Cortés, Honduras, we witnessed three *Nototriton brodiei* individuals actively crawling on each other on the surface of a low broad-leaf (~1 m high) within cloud forest habitat. This aggregation was composed of two males and one female, determined by the presence of cirri, dorsal color, and body size. The salamanders were photographed *in situ* and measured using a digital caliper and spring scale. Male individuals were dark brown in coloration with a rusty sheen (mean measure of snout–vent length [SVL] = 32.5 mm, mean tail length = 42.5 mm, and mean mass = 0.6 g), whilst the female was considerably lighter in color and more brindled (SVL = 31 mm, tail length = 51 mm, mass = 0.9 g; Fig. 1A; see Table 1 for a summary of body measurements for the species). No eggs were observed in the female. Following measurements, we released the salamanders on the same leaf as they were found, where they walked facing the same direction, stepping on each other and using one another as a support to move across the leaves (Fig. 1B).

Given the few encounters in nature, relatively little is known about *Nototriton brodiei* life history, and observations involving interacting individuals have never before been documented. It is likely that this cryptic species hides underneath loose bark, mossy mats or decomposing logs similar to its congeneric "moss-salamanders" (Good and Wake, 1993). Some salamanders of the genus *Nototriton* are also well-adapted to occupying cloud forest bromeliads (Good and Wake, 1993) as they are small and slender with a long tail, short legs, and small feet (García-Paris and Wake, 2000).

Examples of previous literature found one individual of *Nototriton brodiei* at night walking across low vegetation in secondary growth forest (Vásquez-Almazán and Streicher, 2011) and crawling on rock banks at night (Campbell and Smith, 1998; Table 1); other members of the genus *Nototriton* are usually observed at night on vegetation about 1–2 m above the ground (Köhler, 2002). Our encounter, however, is the first record of an aggregation of multiple *N. brodiei* individuals climbing a plant. Aggregation behavior in plethodontids is scarcely recorded, beyond breeding migrations or when resources become limited (Spickler et al., 2006; Petranka, 2010). The function of climbing behavior in plethodontid sala-

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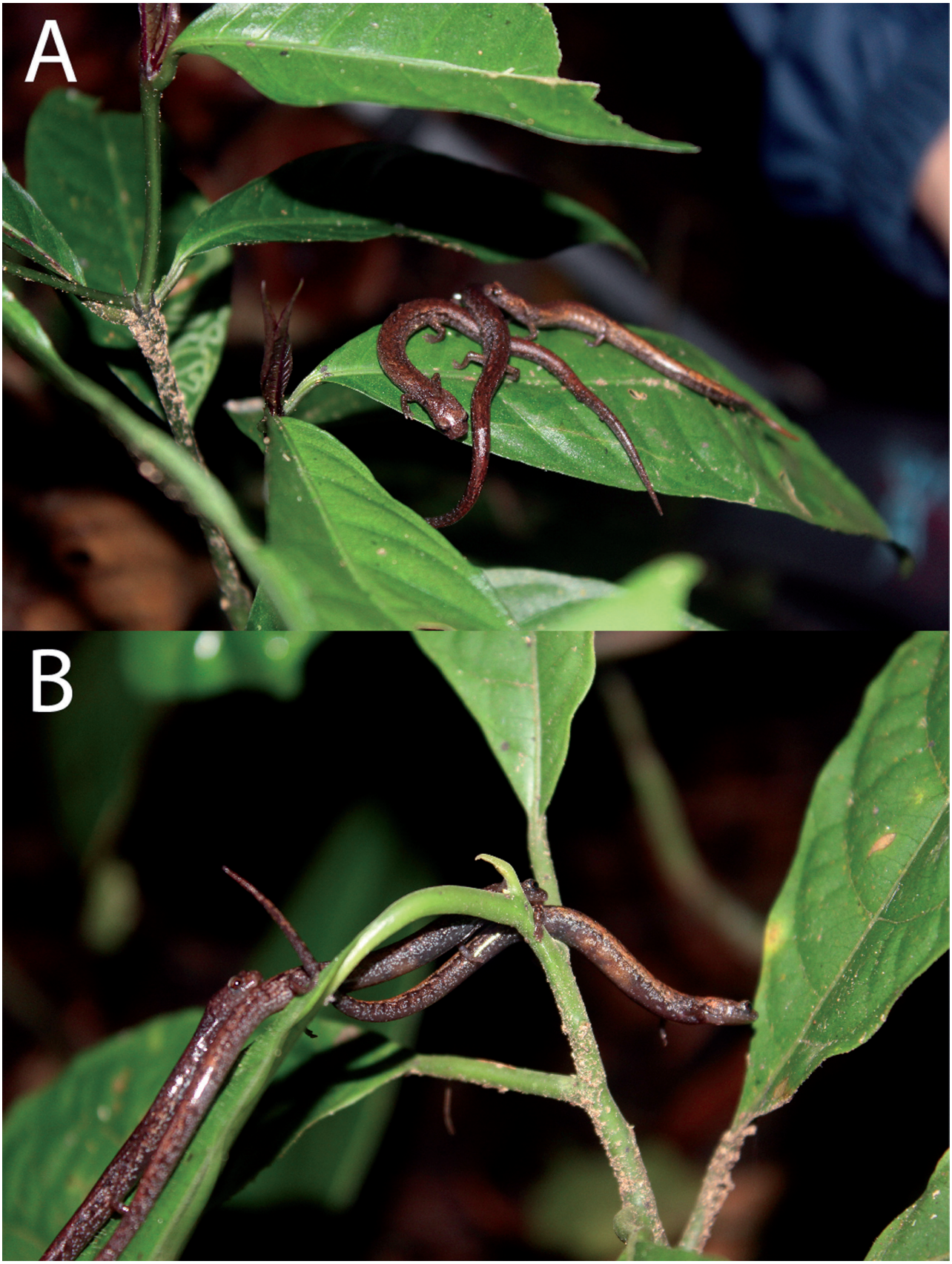

Figure 1. (A) Potential sexually-driven aggregation of three *Nototriton brodiei*. **(B)** *Nototriton brodiei* forming a bridge to allow a crossing over leaves. Photos by D.L. Gilroy.

Table 1. Summary of morphological and ecological data available for *Nototriton brodiei*. Abbreviations: SL, standard length; TL, tail length.

Source	Body Size	Weight	Sex (*n*)	Coloration	Location	Activity
Kolby et al. (2009)	-	-	-	-	Lower montane wet forest (1,540–1,590 m) at Parque Nacional Cusuco, Cortés, Honduras.	Inside pitfall trap.
Vásquez-Almazán and Streicher (2011)	-	-	-	-	Secondary growth forest (850 m), Sierra Caral, Izabal, Guatemala.	Walking across low-lying vegetation (21:00).
Campbell and Smith (1998)	SL 34.5 mm, TL 49.8 mm	-	Female (1)	Trunk dorsum is tan with a herringbone pattern of 13 brown dorsal chevrons, pointed posteriorly, between the level of the axilla and groin. Dark brown head and neck dorsum.	Cerro Pozo de Agua (1,125 m), Sierra de Caral, Municipio de Morales, Izabal, Guatemala.	Active on a broad green leaf ~10 cm above the forest floor (21:15, air temperature 20°C).
Campbell and Smith (1998)	SL 33.2–34.5 mm, TL 47.3–49.8 mm		Female (2)	Mahogany or rust-brown dorsal color with dark brown chevrons. Black or dark purplish brown venter and tail with cream flecks. Tail with irregular black or dark brown markings.	Sierra de Caral (875–1,140 m), Municipio de Morales, Izabal, Guatemala.	Beneath a pile of dead palm leaves in a small clearing (16:20 h, air temperature 24°C) and crawling on a rock bank near a small waterfall (01:10, air temperature 19°C).

manders is not well understood, but it may be to avoid predators, improve foraging, or to avoid competition with other salamanders (Jones et al., 2012; McEntire, 2016; Mezebish et al., 2018). However, most of these potential hypotheses are for individual salamanders. We observed multiple salamanders that were behaviorally interacting with one another, suggesting courtship as the most plausible explanation for the arboreal aggregation behavior.

Salamanders in general have diverse courtship and mating behaviors, including male-induced female receptivity by touching, conducing "tail-straddling" walk, or crawling under or on the female (Stebbins and Cohen, 1995). Following copulation and egg deposition, some species of plethodontids then guard or attend the clutch for a period of a few hours to days (Glime and Boelema, 2017). However, the congener *Nototriton barbouri* (Schmidt, 1936) lays eggs in clumps of bryophytes and abandons them, without any guarding or attendance (McCranie and Wilson, 1992). Our observations may well correspond to the mating behavior of two males courting the same female. Given our observations and the apparent absence of maternal care, there is a possibility that there is both multiple mating and multiple clutches in *N. brodiei*.

Honduras harbors unique amphibian fauna including 36 species of salamanders, which are endemic to Honduras (24 species; Solís et al., 2014) or restricted in distribution to Central America. Unfortunately, the amphibians of Honduran cloud forests are threatened by habitat degradation, which is fueled by deforestation (Wilson and McCranie, 2004) in favor of coffee plantations. Indeed, *Nototriton brodiei* is classified as an endangered species owing to only rare observations and limited distribution in two distinct locations (IUCN, 2014). Due to the few encounters in nature, virtually nothing is known about the population size or decline trends of *N. brodiei*. Across taxa, small geographic distributions are generally associated with high extinction risk (e.g., in frogs; Cooper et al., 2008). These threats, together with the lack of knowledge on *Nototriton* ecology, make our observations for this species of significant value and highlight the urgent need to improve conservation efforts on vulnerable cloud forests in Central America and their little-known inhabitants (Ponce-Reyes et al., 2013).

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