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Amphibian & Reptile Conservation
10(1) [General Section]: 1–6 (e112).

SHORT COMMUNICATION

Monitoring a population of *Cruziohyla craspedopus* (Funkhouser, 1957) using an artificial breeding habitat

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***Abstract.*—We report the detection of *Cruziohyla craspedopus* in Madre de Dios, Peru via use of an artificial breeding habitat: 1) giving us crucial information about the population, 2) contributing to the population by providing habitat, and 3) emphasizing the value of this method in detecting elusive species.**

Key words. Oviposition, primary forest, tree hole breeding, phytotelm breeding, canopy, frog, Peru, rare

Citation: Turrell C, Crnobrna B, Smith-Bessen M. 2016. Monitoring a population of *Cruziohyla craspedopus* (Funkhouser, 1957) using an artificial breeding habitat. *Amphibian & Reptile Conservation* 10(1) [General Section]: 1–6 (e112).

Received: 09 February 2015; **Accepted:** 29 June 2015; **Published:** 31 January 2016

For the more elusive and endangered anuran species in South America it can be difficult to get accurate representations of abundance and population size. Implementing different sampling techniques, including those focusing on aquatic larval stages, may bring population levels into clearer focus. Tadpoles are often restricted to well-defined water bodies where they can be easily caught for identification. Reproduction may depend on the availability and quality of these water bodies. The sparse literature addressing Amazonian tadpole identification is underdeveloped and often conflicting. Proper identification therefore represents a major hurdle in this type of investigation. We aimed to address problems with tadpole identification while measuring the effect of breeding habitat location via use of artificial breeding habitats (ABHabs) (Gascon 1994).

Adult amphibians with aquatic larvae often occupy drastically different environments from their tadpoles (Werner and Gilliam 1984). *Cruziohyla craspedopus* (Funkhouser, 1957) inhabit the high xeric environments of forest canopy, but are known to descend to the forest floor to breed (Rodriguez and Duellman 1994). Ranging from northern Ecuador to southern Peru (Faivovich et al. 2005), *C. craspedopus* has since been found throughout the Brazilian Amazon (Lima et al. 2003; Meneghelli et al. 2011; Venancio et al. 2014). While classified as Least Concern by the IUCN (Angulo et al. 2004), it is elusive and existing data does not adequately represent the population. In a comprehensive article, Hoogmoed and Cadle 1991 established the reproductive mode of *C. craspedopus*, with important updates by Block et al. (2003) and Rodrigues et al. (2011): phytotelm “tree hole” breeding involving logs, hollows, or depressions at ground level (pitfall buckets).

Resetarits and Wilbur (1989) mentioned the following factors influencing breeding habitat choice and oviposition site: species present at the pond, vegetation structure, pond age, temperature, and degree of permanence. Following Pearman (1993), who found varied responses to ABHabs across species in terms of area and depth, we used a variety of sizes, ranging from 0.5 L to as much as 400 L, to account for differing preferences. This was the approach of our pilot study at the Las Piedras Biodiversity Station (LPS), Tambopata Province, Madre De Dios Department, Peru (UTM 19 L 442465 8667117, 265 m asl, see Crnobrna et al., in prep. for site description). We placed five clusters of five plastic containers evenly across the primary terra firma forest landscape (Fig. 1). Clearing overhanging vegetation was often required, so we built makeshift oviposition sites

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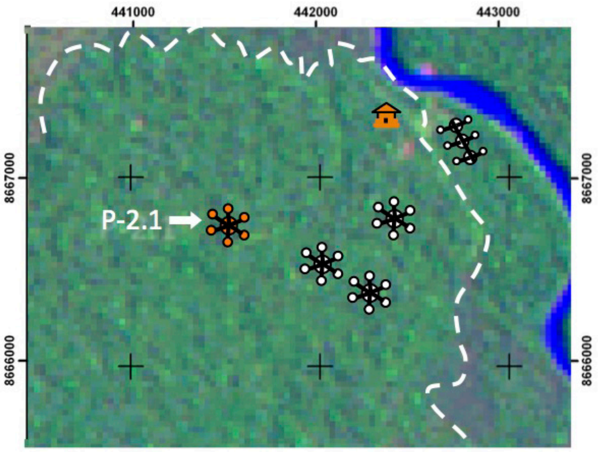

Fig. 1. Site map for ABHab points at LPS: dashed line is approximate separation of terra firma and flood plain forest.

from sticks and situated them over the larger ABHabs. We used tadpole descriptions by both Duellman (2005) and Hero (1990) to aid us in identification. Where the literature did not provide, or where the descriptions were not adequate, we kept individuals until metamorphosis and/or preserved specimens in 10% formalin (CORBIDI field # FF2222).

Our most successful ABHab (unique code P-2.1) was a blue cylindrical kiddie pool with a 25 cm plastic rim surrounding a 150 cm diameter plastic sheet. We left this particular ABHab in the "driest" forest available as expressed by its vicinity to water: all known permanent and ephemeral water sources were more than 250 m away. We drew water from a palm swamp 360 m away until the pool was approximately one half full (200 L), but subsequent rain filled it to its maximum capacity (more than 400 L). After set up on 28 August 2013 successive checks during the end of the dry season returned no observations of anuran breeding or tadpoles (Table 1). We left the site unattended between November 2013 and January 2014, during which time rain intensity was highest (160 cm, SENAMHI 2014). On 26 January 2014 we found approximately 20 *Cruziohyla craspedopus* tadpoles. *Phyllomedusa tomopterna* and *Dendropsophus* sp. tadpoles were simultaneously using the ABHab. This was the first positive check of P-2.1. In addition to the tadpoles found, there were also multiple aquatic insect species, and the remaining jelly of two empty egg masses present on our makeshift overhanging oviposition sites (Fig. 2A). While we cannot rule out *P. tomopterna* as the source, repetition of this protocol at other sites returned *Phyllomedusa* species. We could not, however, observe such persistent, low-viscosity masses at any other site (*n* = 25)—implying the original egg masses seen at P-2.1 were indeed laid by *C. craspedopus*.

On 26 January, we found live tadpoles in two Gosner stages: stage 28 and stage 45 (Gosner 1960). At stage 28, the *Cruziohyla craspedopus* tadpole (Fig. 2B) had a total length of 32 mm, a body length of 13 mm, width of six mm and height of two mm; the interorbital distance was five mm. The dorsum and tail were black. In some individuals there was a slight yellow tint to the tail, and in later stages small yellow specks on the dorsum. The venter was a translucent purple, then white at very late stages. The tail was pointed with a ventral fin equal in size to the caudal musculature, and a slightly smaller dorsal fin originating on the body. The greatest body width was halfway down the body, and largest body height was where the caudal musculature and the body meet. The nostrils were a quarter of the distance from the snout to the eyes. The eyes were yellow, situated dorsolaterally, and visible from below. The spiracle was ventrolateral and the oral disc bore a single row of marginal papillae ventrally and laterally. The labial tooth row formula (LTRF) observed was 2/2. However, both Duellman (2005) and Hoogmoed and Cadle (1991) recorded the LTRF to be 2/3, underscoring the difficulties in tadpole identification.

We continued to monitor the site throughout 2014, and in March another Gosner stage was observed (27). Throughout April and May *Cruziohyla craspedopus* tadpoles were present in the ABHab, presumably from at least one more breeding event, although specimens were not retrieved and "staged." However, we saw no diminishment in their numbers during this time, and no newly metamorphosed or adult individuals were seen. Delayed metamorphosis, to 100 days, could explain

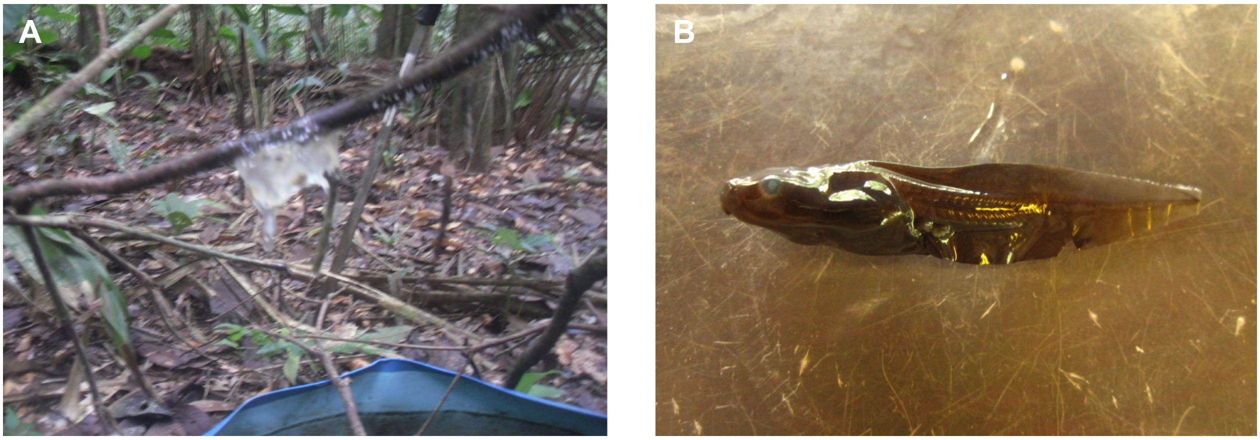

Fig. 2. A) ABHab P-2.1 with empty egg mass; B) Tadpole of *Cruziohyla craspedopus* (preserved).

Table 1. Timeline: P-2.1 ABHab at Las Piedras Biodiversity Station

Date	Activity	# coexistent size classes of *C. craspedopus* larva	Gosner stages observed
August 2013	Fauna Forever ABHab project starts at Piedras Sation		
28 August 2013	P-2.1 set up	0	n/a
September 2013	P-2.1 checked weekly	0	n/a
October 2013	final negative check, Fauna Forever relocates to other field sites	0	n/a
December 2013	heavy rains begin, ABHabs at max. volume	0	n/a
26 January 2014	First positive check, upwards of 20 tadpoles of 2 species, 2 emptied egg masses	2	28, 45
30 January 2014	Most advanced stage tadpole collected from P-2.1 metamorphoses in captivity	2	52
March 2014	positive check	2	27
May 2014	Fauna Forever relocates to Piedras Station, begins to monitor P-2.1 nightly	1	not collected
June 2014	Fauna Forever AHB project shuts down, maintenance and checking of ABHabs ceases		

these observations, but all documented metamorphosis has been less than 100 days (Hoogmoed and Cadle 1991), making it a distant possibility in a typically water-stressed species.

At P-2.1 we observed one breeding pair of *Cruziohyla craspedopus* actively breeding in December and January. Two details indicate that the number of individuals involved was greater than the minimum two: 1) Multiple egg masses as well as two distinct developmental and size classes persisted at once, indicating staggered, non-synchronous laying/hatching—a feat more easily achieved by more than one female (Yeager and Gibbons 2013); 2) In past observations of *C. craspedopus* each breeding habitat was attended by multiple individuals including multiple males (Block et al. 2003; Hoogmoed and Cadle 1991), which tended to congregate in typical amphibian style. Considering that smaller, earlier stage individuals were present in the ABHab into May of 2014, the evidence suggests that at least three independent breeding events took place involving many productive females. We collected one individual in Gosner stage 45 on 26 January 2014, and it metamorphosed in our captivity within four days (Fig. 3). Due to logistical constraints we were unable to monitor the site during this time, but according to the developmental scheme demonstrated, a subset of 10–20 individuals would have metamorphosed in late January. Asynchronous metamorphosis remains a possibility, but undoubtedly one well-placed artificial habitat contributed to the local population of *C. craspedopus*. In such an understudied species there is no way to know how much population growth this represents, i.e., the individuals surviving past metamorphosis weighed against naturally occurring habitats' size, hydroperiod, and predation.

Lamentably, even after repeated visits to P-2.1 at night, these tadpole observations represent the only evidence of a breeding *Cruziohyla craspedopus* population at LPS, regardless its productivity. Extensive effort to find amphibians at LPS included, but was not limited to, three years of coordinated surveys utilizing 100 m transects, call surveys, long opportunistic walks, and time constrained searches of breeding habitats (Crnobrna et al., in prep.). Despite this fact, only one adult individual of *C. craspedopus* has ever been seen at LPS, which was outside of herpetological fieldwork (a solo night hike of devoted enthusiast Paul Rosolie, pers. comm.). The well-documented difficulty in detecting the species, in Madre De Dios and elsewhere, is reflected in Duellman (2005), where almost 20 years of searching found no *C. craspedopus* until a suitable breeding habitat was discovered in 2000 (Block et al. 2003). Our results indicate that while artificial habitats contribute to local

Fig. 3. Newly metamorphosed juvenile *Cruziohyla craspedopus*.

populations of *C. craspedopus*, they also appear to be the only way to detect populations within logistical time constraints and with any degree of certainty. The dual advantage of this approach could be widely beneficial to future surveys attempting to find this charismatic and photogenic species.

It bears repeating that no natural habitat has been encountered at LPS, which implies that the majority of *Cruziohyla craspedopus* phytotelm breeding pools are themselves in the canopy (Crnobrna and Turrell, pers. obs.), and therefore can only be surveyed via canopy access—a costly, training intensive, and at times dangerous method. Similarly costly in training is recognizing the advertisement call, which could confirm the species on event of finding one near ground level. Call surveys for *C. craspedopus* would need to be extremely sensitive in picking up the soft and sporadic call (see Read and Ron 2011), which would often be relegated to anecdotal evidence.

The success of this ABHab was consistent with Marsh et al. (1999) that degree of pond isolation was more important than habitat quality. Although we spaced ABHab points evenly throughout the forest, they only numbered five and most were associated with available aquatic habitats that the ABHabs would share species with. P-2.1, however, was the only pool in unbroken terra firma with no direct influence from any known water body. We expected little to no amphibian occupancy on the assumption that the pool was not in the vicinity of any breeding sites visible from the ground. Yet even still the pool harboured both common and elusive species. This brings focus to the link between larval and adult environments, which when broken can contribute to the loss of amphibian diversity in imperilled ecoregions (Becker et al. 2007). Although *Cruziohyla craspedopus* populations are likely more abundant than indicated by published records (Faivovich et al. 2005; Lima et al. 2003; Meneghelli et al. 2011; Venancio et al. 2014), they are still subject to the specificity of their breeding habitats—their availability limiting population growth. It is worth noting that detection of *C. craspedopus* in this way confirms its presence in primary forest, and one could argue that this species can be used as a primary forest indicator (Gardner et al. 2007; von May et al. 2010). Other "tree hole" breeders have been implicated in deforestation and fragmentation studies (Zimmerman and Bierregaard 1986; Ernst and Rödel 2008) because of their perceived reliance on features of primary forests: phytotelm structures of large trees. Future studies should take into account oviposition parameters of *C. craspedopus* in the event that the species' absence in ideally placed artificial habitats (Tocher et al. 1997; Gagliardi 2008) and/or known naturally occurring habitats does in fact indicate degraded forests.

Acknowledgments.—The Fauna Forever ABHab project was the fruition of Chris Kirkby's idea. Justin Touchon generously donated the kiddie pools used. Erik Wild and Matthew Tibble reviewed early manuscripts. Volunteer research assistants directly involved included Chris Penker (Germany), Sarah Hrnyck (USA), Katrin Luder (Switzerland), Tom Heather (New Zealand), and Harry Turner (England). Special thanks to Andrew and Amy-Jane Peabody. The Las Piedras Biodiversity Station contributes to conservation efforts in Madre De Dios, and the people directly responsible are JJ Durand, Paul Rosolie, and Mohsin Kazmi.

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