



FIG. 1. An adult female *Litoria havina* (SVL ca. 37 mm) and *L. havina* eggs in the stomach of a *Tropidonophis* sp. (Keelback Snake) from near Tabubil in the Western Province of Papua New Guinea.

*statisticus*) occur in the general area where our observations were made (O'Shea 1996. A Guide to the Snakes of Papua New Guinea. Independent Publishing, Port Moresby, Papua New Guinea. 239 pp.).

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**PHYSALAEMUS PUSTULOSUS** (Túngara Frog). **SEXUAL COMMUNICATION.** At ca 1930 h on 14 June 2015 we made an interesting observation of sexual communication of a *Physalaemus pustulosus* in the Darien National Park in Darien (7.747°N, 77.536°W; WGS84), Panama.

Túngara Frogs produce mating calls (ca. 350 ms duration) that consist of a downward frequency sweep which can be produced alone or can be followed by 1–7 short, ca. 45 ms, bursts of sound called “chucks.” The call is accompanied by inflation and deflation of a relatively large vocal sac (Ryan 1985. The Túngara Frog, A Study in Sexual Selection and Communication. University of Chicago Press, Chicago, Illinois. 236 pp.). On this night we observed a small group of male Túngara Frogs, ca. 3–6, calling from a puddle on a trail. As chucks are typically always produced immediately after a whine, we were struck by what we thought was

a chuck produced in isolation. We then located the male producing the call in question. During ca. 5–10 min of observation, the male did indeed produce calls with only chucks. These chucks sounded similar to chucks typical of this species; although the amplitude seemed a bit lower than typical it was clearly audible. The male also produced whines in isolation and whines followed by chucks as is typical for this species, as well as what is best described as a “half-whine,” but he then returned to producing chucks in isolation. During this time we also observed the male inflating and deflating his vocal sac as if he were calling but without any audible call; this occurred several times. In all instances, whether or not accompanied by sound, the inflation-deflation of the vocal sac produced vibrations on the water's surface, which is merely an epiphenomenon of vibrating a structure on the water's surface. During all of these behaviors, chuck-only and half-whine calls, typical whine and whine-chuck calls, and muted vocal sac inflation-deflation, the male was alternating his display with neighboring calling males, as is typical for this species. Thus he was participating in the chorus in a typical manner even when producing an atypical signal.

One of us, MJR, has been studying this species for several decades (Ryan 1980. Science 209:523–525; Ryan 2011. In Losos [ed.], In Light of Evolution, Essays from the Laboratory and Field, pp. 185–203. Roberts and Company, Greenwood Village, Colorado) and only once previously did he observe a male producing a chuck-only. Examination of that male's larynx showed it was normal (MJR, unpubl. data; our current permits in the Darien did not allow collecting). Never, to our knowledge, has anyone observed a Túngara Frog inflating and deflating its vocal sac independent of sound production. The diurnal African frog *Phrynobatrachus krefftii* (Kreff's Puddle Frog) also shows this behavior which clearly is a communication signal (Hirschmann and Hödl 2006. Herpetologica 62:18–27). There are similar reports of muted vocal sac inflations for Bornean frogs in the genus *Staurois*, but their role in communication has not been investigated (Boeckle et al. 2009. Herpetologica 65:154–165). This observation is germane to the study of sexual communication in this species for several reasons. Female Túngara Frogs strongly prefer whines with chucks to whines-only (Gridi-Papp et al. 2006. Nature 441:38). Normally, males do not produce chucks without the preceding whine and females do not show phonotaxis to chucks-only. In addition, females do not accurately group whines and chucks to the same source (Ryan 1985, *op. cit.*). A chuck spatially displaced by 135° from a whine is perceptually bound to that whine by the female, (i.e., she perceives the two sounds as a single whine-chuck call), and she then approaches the chuck rather than the whine (Farris et al. 2002. Brain Behav. Evol. 60:181–188). Thus a male producing a chuck-only in a chorus could attract a female if his chuck follows the whine of another male calling within a 135° arc. We knew that; now we know that at least one male in the Darien can produce a chuck without a whine.

Vocal sacs recycle air between the lungs and the vocal sac, saving the male the effort of buccal pumping to fill the lungs between each call (Pauley et al. 2006. Comp. Physiol. Biochem. 79:708–719). In a number of frogs the inflation-deflation cycle of the vocal sac also serves as a visual cue (Starnberger et al. 2014. Anim. Behav. 97:281–288), and as mentioned above in *P. krefftii*, this is true even in the absence of accompanying sound. Our observations show that muted vocal sac inflation-deflation occurs in at least one Túngara Frog in the Darien. In Túngara Frogs the vocal sac inflation synchronous with a call enhances the attraction of the call (Taylor et al. 2008. Anim. Behav. 76:1089–1097), and typically



the vocal sac must be synchronous with the call to produce a salient bimodal display (Taylor et al. 2011. *J. Exp. Biol.* 214:815–820).

Finally, the movement of the vocal sac also produces water-surface ripples that enhance the saliency of a typical call (Halfwerk et al. 2014. *Science* 343:413–416). When the deviant male we observed inflated and deflated his vocal sac, not only was he producing a visual cue but vibrational cues as well. Although we have shown that the water-surface vibrations by themselves are not salient as a mating display, they do enhance the acoustically only component of the male Túngara Frog's display (Halfwerk et al. 2014, *op. cit.*).

The female Túngara Frog is permissive in responding to and sometimes preferring sexual signals that typically do not exist in nature (Ryan et al. 2010. *Curr. Zool.* 56:343–357), thus acting on signal variation as it arises. Our observations of this one male Túngara Frog in the Darien rainforest show that there is more standing phenotypic, and perhaps genetic, variation for sexual signaling in this frog than previously appreciated. Thus, we now have evidence of variation arising in both signal production and perception, providing the raw materials necessary for complex anuran signals to evolve.

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**PLECTROHYLA POKOMCHI (Rio Sananja Spikethumb Frog).**

**ALTITUDINAL DISTRIBUTION.** *Plectrohyla pokomchi* is a critically endangered species of stream-breeding frog endemic to Guatemala. An adult female specimen (SVL = ca. 4 cm) was found climbing on the leaves of a tree fern *Cyathea* sp. (Fig. 1) about 2 m above the ground at 2032 h on 15 March 2014 at Apaj River source within Biotopo Protegido Mario Dary Rivera para la Conservación del Quetzal, Purulha, Guatemala (15.2070°N, 90.2326°W, WGS84; 2120 m elev.). This record extends the upper known vertical distribution from the highest elevation reported of 1900 m by 220



FIG. 1. *Plectrohyla pokomchi* found at 2120 m elev. in Purulha, Guatemala.

m (Duellman and Campbell 1992. *Misc. Publ. Mus. Zool. Univ. Michigan* 181:1–32). This species is considered to be declining severely, especially in the location where we found it (Mendelson et al. 2004. *Rev. Biol. Trop.* 52:991–1000). This record also indicates that, as of 2014, the species is still extant within the confines of the protected area mentioned above. A photographic voucher of the specimen was deposited at Colecciones Biológicas de la Universidad del Valle de Guatemala, Guatemala (UVG-F-0004).

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**PRISTIMANTIS CERASINUS (Clay-colored Rain Frog). MORTALITY.**

*Pristimantis cerasinus* is a craugastorid frog found in humid lowland and premontane forests from Nicaragua to Panama (Savage 2002. *The Amphibians and Reptiles of Costa Rica. University of Chicago Press, Chicago, Illinois.* 934 pp.; Padial et al. 2014. *Zootaxa* 3825:1–132). At ca. 1100 h on 13 April 2013, an adult *P. cerasinus* was found in the web of a Golden Silk Orbweaver (*Nephila clavipes*, Araneidae) on the Lindero Sur trail at La Selva Biological Station, Costa Rica (10.4300°N, 84.0200°W; WGS 84). We identified the frog as *P. cerasinus* by the presence of heel tubercles, the absence of enlarged supraocular tubercles, the relative width and shape of finger toe pads, the dark brown coloration of the posterior thigh, paired suprascapular ridges shaped as inverted parentheses, and failure of the tip of toe V to reach the ultimate subarticular tubercle on toe IV (Savage 2002, *op. cit.*; Guyer and Donnelly 2005. *Amphibians and Reptiles of La Selva, Costa Rica, and the Caribbean Slope: A Comprehensive Guide.* University of California Press, Berkeley, California. 299 pp.). Although we did not verify that the frog was depredated by the spider, the frog was dead, its body was desiccated, and strands of spider web were wrapped tightly around the frog's left hind leg at three places.

To our knowledge, this is the first published record of death of a craugastorid frog due to *N. clavipes*. *Pristimantis cerasinus* is known to occupy arboreal perch sites in vegetation at night, and the individual may have jumped from a perch site to be ensnared in the web. *Nephila clavipes* webs are known to entrap hummingbirds (Graham 1997. *J. Field Ornithol.* 68:98–101), small songbirds (Cox and NeSmith 2007. *Florida Field Nat.* 35:46–48), and bats (Nyfeller and Knörnschild 2013. *PLOS ONE* 8:e58126). We are unaware of any records of *N. clavipes* consuming trapped vertebrates, although there are two records of *Nephila plumipes* feeding on unidentified anurans (McCormick and Polis 1992. *Biol. Rev.* 57:29–58).

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**PSEUDACRIS MACULATA (Boreal Chorus Frog). CALLING PHENOLOGY.**

*Pseudacris maculata* is a widespread hylid found