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Short Communication

Bamboo traps as refugia for *Pristimantis olivaceus* (Anura: Craugastoridae) and as breeding site for *Osteocephalus castaneicola* (Anura: Hylidae)

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Ecological and reproductive information on tropical amphibians remains sparse; particularly with respect to the use of phytotelm breeding sites (von May *et al.* 2009). Phytotelmatas, such as leaf axils, bromeliads, brazil-nut husks, tree cavities, and bamboo internodes are important breeding sites for several amphibians throughout the tropics (Caldwell 1993, Moravec *et al*. 2009). Bamboo internodes are one of the least documented of these, known only to be utilized in the Neotropics by *Ranitomeya sirensis, Fritziana ohausi, Nyctimantis rugiceps,* and *Aparasphenodon pomba* (Duellman and Grey 1983, Lehtinen *et al*. 2004, Waldram 2008, Assis *et al.* 2013). Here we provide new information about the use of bamboo internodes by *Pristimantis olivaceus* (Köhler, Morales, Lötters, Reichle, and Aparicio, 1998) and *Osteocephalus castaneicola* (Moravec, Aparicio, Guerrero-Reinhard, Calderón, Jungfer, and Gvoždík, 2009).

Osteocephalus castaneicola is a hylid treefrog classified as "Least Concern" by the International Union for Conservation of Nature (IUCN) Red List (IUCN 2013); little is known about its ecology (Moravec *et al*. 2009, AmphibiaWeb 2015). However, some congeners have been recorded utilising phytotelmata breeding sites (e.g., Ferreira *et al.* 2012). *Pristimantis olivaceus* is an arboreal member of Craugastoridae; currently, it is considered "Data Deficient" (von May *et al*. 2008, IUCN 2015) and information about its ecology is scarce (Duellman and Lehr 2009).

The Manu Learning Centre (MLC) is a research facility owned and operated by The Crees Foundation (www.crees-manu.org) on a reserve known locally as Fundo Mascoitania.

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The reserve is located on the Alto Madre de Díos River, situated in the Manu Biosphere Reserve in southeastern Peru (12º47'21.849" S, 71º23'28.06" W, 460 m a.s.l., ~ 643 ha). From 2011 to 2014, the average seasonal rainfall in the wet season (October–March) was 3098 mm but just 1557 mm in the dry season (April–September; weather data collected from the MLC). The reserve contains a patch of bamboo (*Guadua* sp.)–dominated forest of approximately 18.2 ha. The hollow, segmented internodes of the bamboo naturally collect rain water and are an ideal reproductive site for amphibians that are able to enter them through a breakage event in the bamboo or a hole made by another animal (Waldram 2008).

We initiated a pilot study from July to August 2012 to determine whether crafted pieces of bamboo attached to trees and filled with water, would attract amphibians. Traps were cut from cross sections of bamboo internodes and fashioned into lengths of 50 cm. We discovered two instances of tadpoles of *Osteocephalus castaneicola* in the traps, as well as three adult *Pristimantis olivaceus*. The latter were brought back to the MLC to be photographed and taken as specimens (Figure 1); stored at Universidad Nacional Mayor de San Marcos, Lima, Peru (MUSM numbers 31665, 31701, 31728).

We continued the study with a structured sampling design for a year beginning in mid-October 2012. The traps were designed with two different types of openings: (1) a large circular opening in the top of the bamboo made by removing the top, and (2) a 2 × 5-cm rectangular window cut in the side of the bamboo near the closed top. There were 14 sampling locations, each of which contained a total of four traps, as follow: a high open-top trap, a high closed-top trap, a low open-top trap and a low closed-top trap. Low traps were 60 cm and high traps 170 cm from the ground.

Traps were checked once every two weeks to ensure that a liter of water was present. If necessary, water was replenished from a nearby stream, because if the volume of water is too low, it is more difficult to determine the presence of frogs, tadpoles, or eggs (von May *et al*. 2009). In every check we recorded presence of frogs, tadpoles or eggs. Tadpoles of *Osteocephalus castaneicola* were brought back to the MLC research station and raised to verify their identification, photograph developmental stages and a single individual was taken as a specimen (Figure 2). Stored at Universidad Nacional Mayor de San Marcos, Lima, Peru. (MUSM number 31606).

A Mann Whitney-U test was conducted to determine if *Osteocephalus castaneicola* showed any preference for the height of the breeding site or the kind of opening (Hollander and Wolfe 1999). Thirty-two reproductive observations (froglets, tadpoles, or eggs) of *O. castaneicola* were made during the structured study period (total of 34 including occurrences from the pilot period). Seventeen reproductive observations were found within both closed and open-top traps, showing no preference between trap openings ($w = 112$, $p = 0.436$). Although more anurans were observed in the high traps than the low (21 and 13, respectively), the difference was not significant ($w = 88$, $p = 0.584$).

Osteocephalus castaneicola used the traps from mid-July through November; however, no observations were made from December to June (Figure 3). Reproductive activity (recorded as the presence of froglets, tadpoles, or eggs) in *O. castaneicola* seems to begin in the middle of the dry season (July) and reach a peak by the onset of the wet season (October). Subsequently, records drastically fall off as the wet season continues through to November, after which no activity is recorded. The onset of egg deposition in July may be correlated with the presence standing water from the previous wet season; such water may be characterized by a stable high nutrient content and abundance of potential food resources such as mosquito larvae (von May *et al*. 2009). The onset of the heavy wet season may disturb this stable high nutrient environment and limit the available resources for tadpoles of *O. castaneicola* to feed and develop.

Osteocephalus castaneicola has been documented to breed in water-filled husks of Brazil nuts (Moravec *et al*. 2009) and to avoid appropriate reproductive sites that had already been used by other species of anurans or by predacious insect larvae (Lehtinen *et al*. 2004, von May *et al*. 2009). At the MLC reserve, we also found *O. castaneicola* to breed in pitfall-traps partially filled with water. These occurrences, along with the lack of preference for open or closed-top bamboo traps, indicate that *O. castaneicola* opportunistically selects standing water sources for breeding. However, *O. castaneicola* does appear to use specific cues associated with seasonal rainfall patterns to initiate reproductive events (Figure 3).

Figure 1. Individual of *Pristimantis olivaceus* collected at the MLC study area (SVL = 24.1mm).

Pristimantis olivaceus only used bamboo internodes as refugia during the dry season to protect itself from increased heat and sun in a moist, secure environment (Glorioso and Waddle 2014). We also have observed a few *P. olivaceus* in bromeliads at the MLC reserve but firm conclusions cannot be made from these data about breeding sites. Nevertheless, both bamboo internodes and bromeliads likely are important microhabitats and refugia for this species. Other studies utilizing PVC traps have reported amphibians to use the traps as refugia, rather than as water-containing breeding sites (Glorioso and Waddle 2014, Trimble and Aarde 2014).

The use of naturally occurring bamboo internodes is a convenient, cost effective way to study phytotelmata breeding/dwelling species, especially because the traps can be made from bamboo naturally present within the study area. Von May *et al*. (2009) suggested that there is no

Figure 2. Stages of development of *Osteocephalus castaneicola* in the bamboo refugia from the MLC study area (average adult SVL = 52.5mm).

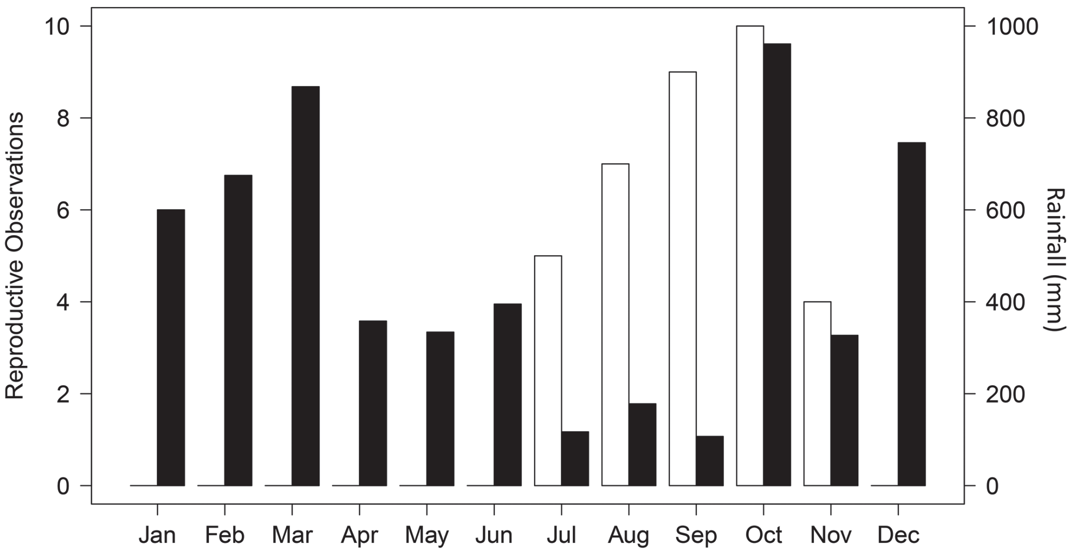

Figure 3. Presence of *Osteocephalus castaneicola* eggs, tadpoles or froglets each month (white bars) throughout the study period alongside total monthly rainfall.

significant difference between the use of naturally occurring bamboo and artificial PVC traps.

Although originally considered to be "uncharacteristic" of anurans, phytotelmata-breeding species now are thought to comprise of 154 species worldwide (Lannoo *et al*. 1987, Lehtinen *et al*. 2004, Moravec *et al*. 2009). In terms of future research, phytotelmata provide unique opportunities to study development, tadpole behavior, and predator/prey relationships of anurans. These microhabitats are natural laboratories in which to control environmental factors such as water level, prey/predator presence, and size-factors that cannot be controlled in larger bodies of water and fast-flowing streams (Lehtinen *et al*. 2004).

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