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OOPHAGY IN THE TREE-HOLE DWELLING TADPOLES OF *ECNOMIOHYLA SUKIA* (HYLIDAE) IN COSTA RICA

OOFAGIA EN RENACUAJOS DE *ECNOMIOHYLA SUKIA* (HYLIDAE) QUE VIVEN EN AGUJEROS DE ÁRBOLES EN COSTA RICA

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Resumen.– Se reporta la estrategia alimentaria de los renacuajos de la Rana Arbórea Voladora Shaman (*Ecnomiohyla sukia*), una rana endémica del dosel en Costa Rica. Se escaló un árbol para recolectar tres renacuajos en diferentes etapas, luego se analizó su contenido estomacal. Dos de los tres renacuajos recolectados tenían masas de huevos en sus intestinos; el análisis de los contenidos estomacales evidenció la presencia de alrededor de 200 huevos en un espécimen. Se confirma que los renacuajos de *E. sukia* son oofágicos y pueden sobrevivir alimentándose de huevos de su misma especie. Sugerimos que la oofagia también podría estar presente en otras especies del género *Ecnomiohyla*; podrían utilizar esta estrategia para complementar los limitados recursos alimentarios disponibles en sus microhábitats; sin embargo, se necesita más investigación para confirmarlo.

Palabras clave.– Comportamiento alimentario, estrategia de alimentación, huevos conespecíficos, rana de dosel.

Abstract.– The feeding strategy of the tadpoles of the Shaman Fringe-limbed Treefrog (*Ecnomiohyla sukia*), a canopy frog endemic to Costa Rica, is reported. A tree was climbed to collect three tadpoles at different stages, then the stomach contents were analyzed. Two of the three collected tadpoles had masses of eggs in their intestines. An analysis of stomach contents found evidence for the presence of around 200 eggs in one specimen. *Ecnomiohyla sukia* tadpoles are confirmed to be oophagous and can survive by feeding on conspecific eggs. We suggest that oophagy may also be present in other species of the genus *Ecnomiohyla*; they could use this strategy to supplement the limited food resources available in their microhabitats; however, more research is needed to confirm this.

Keywords.– Canopy frog, conspecific eggs, feeding behavior, feeding strategy.

Frogs of the genus *Ecnomiohyla* are inhabitants of the tropical forests ranging from Mexico to Colombia with 12 described species to date (Frost, 2023). Most of their natural history is unknown as they are canopy-dwelling species that are rarely seen; there is limited data pertaining to population size and conservation status of these species. The reproductive specialization of this genus in tree holes allows them to keep their eggs and larvae out of reach from most terrestrial predators. However, since food resources might be limited in these small microhabitats, use of other strategies are likely to adequately maintain their progeny and provide sufficient and suitable feeding options for the tadpoles (Caldwell & de Araujo, 2004).

Shaman Fringe-limbed Treefrog (*Ecnomiohyla sukia*) Savage & Kubicki, 2010 is a hylid frog endemic to Costa Rica, found in the Caribbean low and mid lands from 400 to 1300 meters in elevation (Savage & Kubicki, 2010). This species uses water-filled cavities in trees as sites for egg deposition where larvae eventually develop into tadpoles. Egg postures have been observed at 3 to 15 meters above ground level (Salazar et al., 2021a). Like other species that breed on tree trunks, feeding can be complex (Lehtinen et al., 2004). Due to the presence of conspecific eggs found in the holes where the tadpoles are found, it has been suggested that the genus (Savage, 2002) and specifically *E. sukia* (Hoffmann & Kubicki, 2011; Salazar et al., 2021a), can feed on infertile eggs

deposited by the mother. This claim has not been yet verified and one single experiment in captivity unsuccessfully tried feeding the specimens with glass frog eggs (Hoffmann & Kubicki, 2011). In this note we report the oophagy behavior in *E. sukia* tadpoles.

In December 2022, we visited a reproductive tree hole of *E. sukia* previously located at the Finca La Guacamaya, near Santa Clara, Sarapiquí (10.219° N, 83.949° W). For the collection of tadpoles, one of the researchers climbed up the tree with the help of specialized tree climbing equipment. Three tadpoles of *E. sukia* in stages 29, 39 and 41 (Gosner, 1960) were collected from a tree trunk located 7 meters above the ground. Tadpoles were collected and transported in plastic bags to the lab for stomach content analysis and photographic evidence. Stomach contents of each specimen were reviewed, the buccal structure and the presence of eggs were photo-documented and subsequently the individuals were preserved in 10% formalin and deposited in the Zoological Museum at the University of Costa Rica (tadpole stage 41: UCR24242 and tadpoles stages 29 and 39: UCR24243, permits: R-SINAC-SE-DT-PI-007-2022).

The tadpole in stage 41 (SVL: 37.3 mm) and stage 39 (SVL: 20. 7 mm) had egg masses in its intestines, which were clearly visible in ventral view (Figs. 1A, 1B and Fig. 2A) while the tadpoles in stage

Figura 1. Renacuajo de la Rana Arbórea Voladora Shaman (*Ecnomiohyla sukia*) en el estadio 41 de Gosner mostrando el estómago lleno de huevos de la misma especie. A) vista ventral, B) vista lateral. Foto: Calíope Rojas-Rodríguez.

Figure 1. Tadpole of the Shaman Fringe-limbed Treefrog (*Ecnomiohyla sukia*) in Gosner stage 41 showing the stomach full of conspecific eggs. A) ventral view, B) lateral view. Photo: Calíope Rojas-Rodríguez.

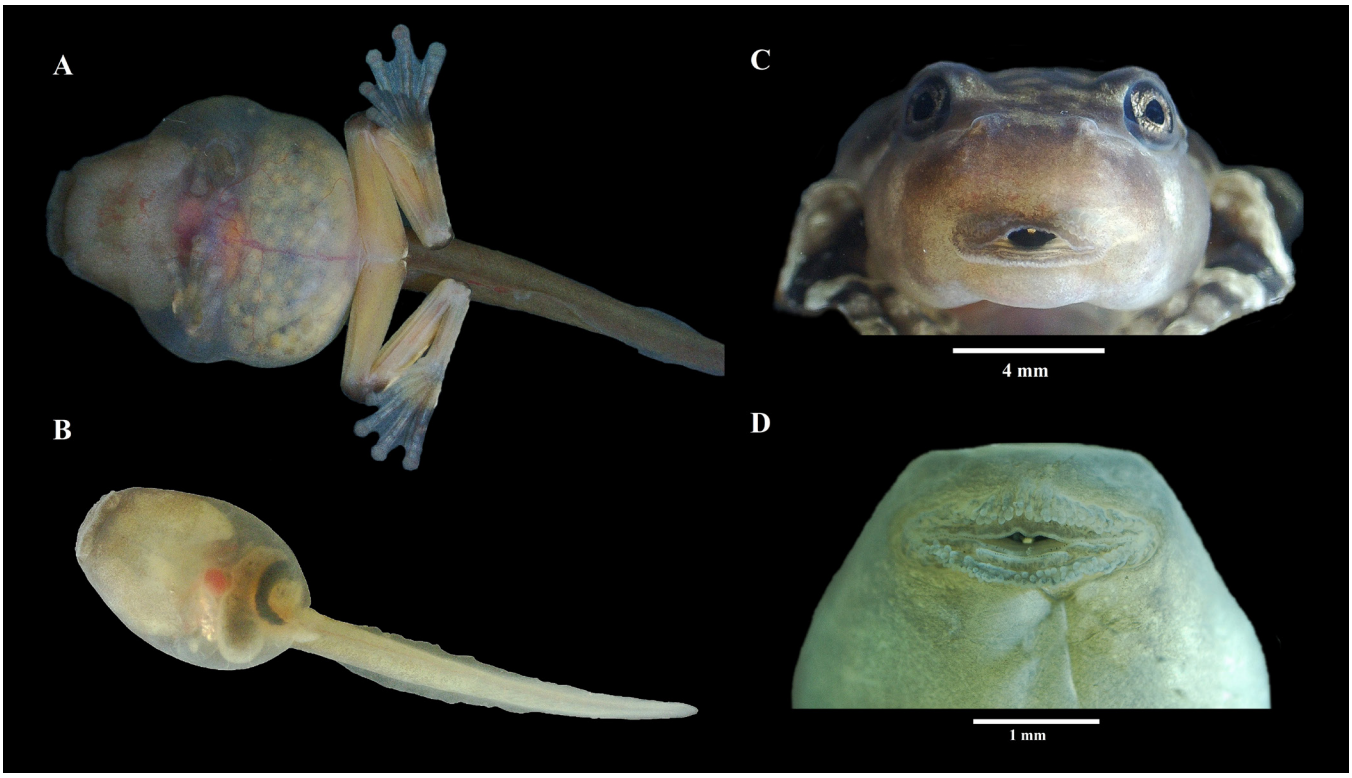

Figura 2. Vista ventral y frontal de los renacuajos de la Rana Arbórea Voladora Shaman (*Ecnomiohyla sukia*) en diferentes etapas. A) vista ventral del renacuajo en la etapa 39 mostrando la presencia de huevos, B) vista ventral del renacuajo en la etapa 29 sin huevos visibles, C) vista frontal del disco oral en la etapa 41, D) vista ventral del disco oral en la etapa 29. Foto: Juan G. Abarca.

Figure 2. Ventral and frontal view of the Shaman Fringe-limbed Treefrog (*Ecnomiohyla sukia*) tadpoles at different stages. A) ventral view of tadpole in stage 39 showing the presence of eggs, B) ventral view of tadpole in stage 29 with no visible eggs, C) frontal view of the oral disk at stage 41, D) ventral view of the oral disk at stage 29. Photo: Juan G. Abarca.

29 (SVL: 10.34 mm) had no visible eggs (Fig. 2B). The stomach content analysis of the tadpole in stage 39 had 200 eggs, of which 15 were measured between 1.09 and 1.8 mm (average 1.37 mm). The individual at stage 41 developed adequately in captivity into a juvenile frog, which was unsuccessfully fed with fruit fly and grasshopper prey.

Because Wilson et al. (1985) observed eggs in one of the breeding holes of *Ecnomiohyla salvaje* Wilson, McCranie & Williams, 1985, that could be conspecific trophic eggs, Savage (2002) proposed that the members of this species group could be oophagous and obligate egg eaters. Hoffmann & Kubicki (2011) in the description of the tadpole of *E. sukia*, suggested that it could feed on eggs. Here we report this feeding behavior of the larvae, which may be present in other species of the genus *Ecnomiohyla*. It is possible that all these frogs must complement the low availability of food present in the phytotelma with the development of oophagy and the consequent buccal structure of tadpoles as adaptations for this feeding behavior (Lehtinen et al., 2004).

Larvae of the genus *Ecnomiohyla*, like other tree-hole breeding species, have some modifications for feeding, including modifications for oophagy. As mentioned by Hoffmann & Kubicki (2011), the rows of teeth are weak, which was at first thought to be caused by captive breeding problems. However, individuals observed in nature also have widely scattered weak teeth, the denticles in rows A2 and P1 were almost negligible (Fig. 2D). These characteristics, in addition to the decrease in the rows of denticles, are somewhat consistent with the arboreal tadpole morphologies, Group 2 proposed by Lehtinen et al. (2004) for oophagous tadpoles in (i.e., shorter tadpoles with stout bodies and reduced or absent rows of teeth).

Some characteristics observed, like tadpole mouth shape, feeding tadpoles with conspecific frog eggs and living in similar habitat to other oophagous species can be related to some form of advanced parental care. One of the researchers (SS) observed mothers returning every 15 days to laying eggs. The continuous presence of females in the surroundings and the presence of

tadpoles at different stages in the same hole (Salazar et al., 2021b) may indicate that feeding may be constant and sufficient to sustain several individuals. Hoffmann & Kubicki (2011) indicated that the shape of the papillae of *E. sukia* could also allow this frog to adhere to and suck the body of an adult frog, but the few observations that have suggested this behavior have not been able to conclusively confirm it for this species (Salazar et al., 2021a), as was described in *E. rabborum*, where the submerged males feed the tadpoles with pieces of skin (Mendelson, 2008).

Also, it has not been ruled out that this paternal care in *E. sukia* could help in younger stages when the size of the mouth is not enough for swallowing eggs, due to the beak width at stage 25-29 measuring less than 1 mm (Fig. 2D) and egg size being greater than 1 mm. The youngest tadpoles could take advantage of the large beaks and umbellate papillae to adhere to the skin of their parents for feeding before participating in oophagy. Possible changes in the type of feeding relative to development could prevent feeding competition between siblings of different sizes and ages.

Tree frogs of the genus *Ecnomiohyla* are found mainly in primary or little-disturbed forests; tree trunks are extremely important for their reproduction. Therefore, habitat loss due to deforestation is one of the main threats that would affect this species and others with similar ecology. Fortunately, in Costa Rica much of the distribution of *E. sukia* occurs within public and private protected areas with large forest cover. It is necessary to increase protection efforts for areas of lowland forests and surrounding buffer zones from deforestation and other threats to aid the survival of *E. sukia*.

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