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Foam Nesting in a Hylid Frog (Amphibia, Anura)

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Foam nest construction has evolved in four anuran families: Leptodactylidae, Myobatrachidae, Rhacophoridae, and Hyperoliidae (Duellman and Trueb, 1986; Hödl, 1986). Foam nesting species have been associated with a developmental continuum from aquatic to terrestrial environments within leptodactylids (Heyer, 1969) and myobatrachids (Martin, 1970). The route to terrestriality in leptodactylids may have been through the evolution of a foam nest (Heyer, 1969), whose main function seems to be protecting eggs and larvae against desiccation (Hödl, 1986).

This paper reports the construction of a foam nest in a hylid frog identified as *Hyla* cf *rizibilis* Bokermann. Although the studied species is morphologically identical to *Hyla rizibilis*, Bokermann (1964, and pers. comm.) observed the typical hylid spawning pattern, without foam, for *H. rizibilis*. This raises at least two possibilities: these are two sibling species which may differ in breeding habits; or foam nest construction is a local phenomenon. In January 1988, at Ribeirão Branco, São Paulo, southeastern Brasil (ca. 24°13'S, 48°46'W), males of *Hyla* cf *rizibilis* were observed calling in dense aggregations in a sunny forest clearing during both day and night. Males perched on emergent branches in shallow water. In the field we observed two foam nests attributed to this species, each approximately 8 cm in diameter. Three amplectant pairs caught in the field were put inside plastic bags with a water depth of approximately 4 cm, and an upper air layer of approximately 15 cm. Each pair constructed a foam nest during the night. Nest construction was not observed because the pairs interrupted egg laying when illuminated by flashlight. Two of these nests were similar in appearance to those observed in the field. The third nest constructed contained little foam and was made by a pair whose female had a broken leg; this suggests that the female takes an active part in nest formation, probably beating the foam with her hindlimbs, as reported in rhacophorid frogs (Coe, 1974). Counts of the numbers of eggs in the three nests built in plastic bags are: 1114; 870; 961 ($\bar{x}$ = 981.7; SD = 123.3). Eggs were pigmented (Fig. 1). Eggs between stages 4 and 8 (Gosner, 1960) were measured submerged in water with an ocular micrometer; they were small ($\bar{x}$ = 1.09 mm diameter; SD = 0.05 mm; N = 40), with thin capsules ($\bar{x}$ = 1.14 mm diameter; SD = 0.06; N = 40), and embedded in the foam mass. The foam was white, contained large air bubbles (Fig. 1), and was of fragile consistency; the foam dissolved completely in 5% formalin after three months. Adults (ZUEC 6819–6822) and eggs of *Hyla* cf *rizibilis* from the study site are deposited in the Museu de Historia Natural, Universidade Estadual de Campinas, Campinas, São Paulo, Brasil.

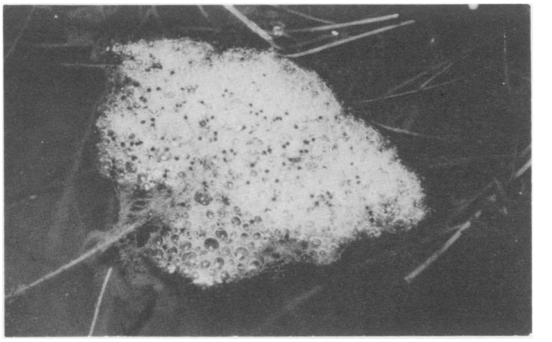

FIG. 1. Foam nest made by *Hyla* cf *rizibilis*. Note larger air bubbles and pigmented eggs.

The family Hylidae contains more than 600 species currently arranged in four subfamilies (Frost, 1985). In this large family the most common and apparently primitive condition of development is by an aquatic tadpole stage (but see Bogart, 1981, for a different interpretation), although several species have evolved a more terrestrial form of development (Duellman and Trueb, 1986). With such a large number of species and degrees of terrestriality, it is surprising that *Hyla* cf *rizibilis* is, to our knowledge, the only hylid frog reported to construct a foam nest.

Although Fouquette and Delahoussaye (1977) resurrected the genus *Ololygon* Fitzinger, which includes *H. rizibilis*, we adopt a conservative posture, maintaining *Hyla* cf *rizibilis* in the *Hyla catharinae* complex (*sensu* Lutz, 1973), for reasons presented by several authors (e.g., Almeida and Cardoso, 1985; Haddad and Pombal, 1987). Species in the *H. catharinae*

complex are forest-inhabiting (Almeida and Cardoso, 1985), and may protect their eggs against insolation by spawning in shaded places and laying aquatic eggs. However, *Hyla* cf *rizibilis* lays eggs in ponds located in forest clearings where sunlight may act as a significant source of mortality. Although the function of a white foam nest is controversial (Downie, 1988), two main functions may be postulated: protection against thermal damage, since white foam reflects heat (Gorzula, 1977); and protection against desiccation by the retention of humidity when the water level fluctuates or the water source dries up (Heyer, 1969; Duellman and Trueb, 1986). In light of this information, we suggest that the construction of foam nests in *Hyla* cf *rizibilis* has evolved mainly as protection against insolation and desiccation of the eggs and embryos.

Heyer (1969) states that preadaptations to foam nest construction are widespread among anurans, since many species are able to secrete mucus. Nevertheless, few species have evolved the beating behavior needed to transform this mucus into a foam nest. In order to test Heyer's (1969) suggestion, we manually beat the mucus present in the spawn of *Hyla hiemalis* Haddad and Pombal, and thereby obtained foam. The presence of mucus and absence of foam in the spawn of this species is suggestive because it is a forest-inhabiting frog closely related to *Hyla* cf *rizibilis* (Haddad and Pombal, 1987).

In *Hyla* cf *rizibilis*, the primary evolutionary change leading to a foam nesting habit was, apparently, behavioral (beating of the mucus secretion into a foam). This behavioral innovation is similar to changes observed within the family Leptodactylidae, changes which allowed the evolution of a terrestrial life promoted by the foam nest construction (Heyer, 1969). Furthermore, the clutch of *Hyla* cf *rizibilis* contains a relatively large number of small pigmented eggs, and thus resembles the first steps in the evolution of terrestrial spawning as observed for leptodactylid (Heyer, 1969; Hödl, 1986) and myobatrachid frogs (Martin, 1970). Foam nest construction in *Hyla* cf *rizibilis* probably evolved independently, and convergent evolution of this habit presumably accounts for the occurrence of foam nesting in five anuran families.

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Characteristics Distinguishing *Leptodactylus pentadactylus* and *L. knudseni* in the Central Amazon Rainforest

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In the central Amazon rainforest four species of the *Leptodactylus pentadactylus* "group" occur sympatrically: *L. pentadactylus*, *L. knudseni*, *L. rhodomystax*, and *L. stenodema*. There has been confusion concerning the characteristics distinguishing *L. pentadactylus* and *L. knudseni* (Heyer, 1972, 1979; Duellman, 1978; Zimmerman and Rodrigues, In press). These difficulties have been exacerbated by phenotypic variation in morphology and vocalization throughout the ranges of these species in South and Central America (Heyer, 1979). Here we present morphological, auditory, and