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Egg Clutch Characteristics of the Barking Treefrog, *Hyla gratiosa*, from North Carolina and Florida

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Information on the basic life histories of many species of amphibians is lacking in the literature. This deficiency can hinder comparative studies and contribute to a poor understanding of broad patterns of life-history variation. A striking example of this deficiency is the minimal amount of published information on egg clutch characteristics of *Hyla gratiosa*. Published data for this species consists of an estimate of 2084 eggs from a single clutch collected in 1921 in the Okefenokee Swamp in southern Georgia (Livezey and Wright 1947; Wright 1932). In addition, a study evaluating the influence of time spent in amplexus on oviposition behavior of *H. gratiosa* in northern Florida found an average clutch size of 867.2 (SD = 330.5, N = 11) for females in the longest amplecting group, which were allowed to remain in amplexus for 1.5 h prior to separation (Scarlata and Murphy 2003). Here we report characteristics of egg clutches for *Hyla gratiosa* in two areas in the southeastern United States: Scotland Co., North Carolina and Leon Co., Florida, and evaluate relationships between female body size and clutch size and geographic variation in clutch size. These data contribute to baseline reproductive information for this species and suggest some interesting questions for future studies.

Materials and Methods.—Seventeen clutches were collected from two localities in Leon Co., Florida (FL; 30.375°N, 84.37°W, elevation 7 m and 30.389°N, 84.329°W, elevation 9 m) from April through June 2003, and 13 clutches were collected from Grassy Pond in Scotland Co., North Carolina (NC; 35.009°N, 79.422°W, elevation 80 m, Travis 1983) in 1979. Amplexed pairs were collected, transported to the laboratory, and placed in separate covered buckets filled with well water (FL) or pond water (NC) for oviposition (as described in Gunzburger 2006). The following morning, adult size was measured using wet mass (g) in NC or tibio-fibula length (TFL, in mm) in FL. Number of eggs in each clutch was counted (NC) or photographed in a small container and eggs counted later from the photograph (FL). Diameter of the vitellus of 9–18 eggs from each clutch collected in NC was also measured using a dissecting microscope. Vitellus diameter data are presented, but no analysis was performed, because a small proportion of the eggs in each clutch were measured and variation in vitellus diameter may have arisen due to variation in development time. All analyses were performed for each population separately because the data for the two populations were collected at different time intervals separated by almost 30 years.

TABLE 1. Summary data (± SD, minimum – maximum in parentheses) of clutch characteristics and adult size [tibio-fibula length (TFL, mm) or mass (g)] from two populations of *Hyla gratiosa*. ND indicates no data was collected on that characteristic for that location.

Location	Sampling Interval	N	Clutch Size	Egg Diameter	Female TFL	Female Mass	Male TFL	Male Mass
Scotland Co., North Carolina	1979	13	2826 ± 842 (1825–4381)	1.39 ± 0.10 (1.19–1.55)	ND	14.72 ± 2.40 (11.01–17.28)	ND	15.71 ± 2.60 (13.50–20.28)
Leon Co., Florida	2003	17	1008 ± 249 (459–1492)	ND	22.63 ± 1.01 (21.5–25)	ND	24.00 ± 1.47 (22–26.4)	ND

Results.—Clutch size of *H. gratiosa* ranged from 459–4381, covering a two- to three-fold range even when considered among females from a single location (Table 1). Clutch size was significantly larger in NC than FL (t-test, t = -8.48, P < 0.001, Table 1). For the FL population, TFL of female *H. gratiosa* was significantly smaller than males (t-test, t = -3.13, P = 0.004, Table 1). Female TFL was not strongly correlated with the TFL of the male with which they were in amplexus (Pearson r = -0.08) or clutch size (r = 0.06, Fig. 1). For the NC population, mass was similar in males and females (t-test, t = -1.01, P = 0.32). Female mass was not strongly correlated with mass of the male with which they were in amplexus (Pearson r = -0.06). Larger females produced larger clutches (r = 0.59, Fig. 1). The diameters of individual eggs varied widely among the NC females, with the largest size being 30% larger than the smallest (Table 1).

Discussion.—Clutch size was larger for *H. gratiosa* in NC than in FL; this could be due to larger body sizes in NC (Travis, unpubl. data), temporal changes, or independent geographic variation, all of which are confounded in these collections. The published data on intraspecific geographic variation in body size in anurans suggests a trend toward larger sizes at higher latitude and elevation, but further study is needed to determine if this is the case for *H. gratiosa* (Ashton 2002; Berven 1982; Morrison and Hero 2003). *Hyla gratiosa* is the largest native hylid in the southeastern United States (Mount 1975), and in comparison to other closely-related hylids, has both a higher maximum and a greater range of variation in clutch size. In this study, *H. gratiosa* clutch size was found to range from 459 to 4381 eggs. In comparison, *H. cinerea* average clutch size ranges from 700 to 1472 (Garton and Brandon 1975; McAlpine 1993) and *H. squirella* average clutch size ranges from 957 to 1059 (Brugger 1984; Wright 1932). Limited evidence indicates that *Hyla gratiosa* females may oviposit more than one egg clutch each season (Perrill and Daniel 1983), so it is possible that some of the variation in clutch size for *H. gratiosa* is due to females ovipositing smaller second clutches.

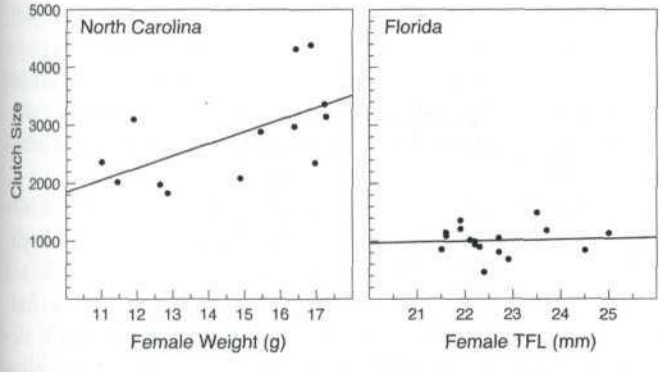

FIG. 1. Female body size and clutch size for *Hyla gratiosa* from the Florida population (N = 17) and North Carolina (N = 13).

Female size was more strongly correlated with clutch size for *H. gratiosa* from NC relative to FL. This could be due to differences in the measurement of adult size between the two data sets (mass and TFL, respectively) or differences between locations in the range of female body size. Future studies of reproductive ecology of this species should include both measurements of body size. Mean egg diameter was similar in this study in NC (Table 1) to that measured from a single clutch in the Okefenokee Swamp (mean = 1.37, SD = 0.19, N = 29, Wright 1932). The relationship between clutch size and egg size warrants further investigation as this study suggests that, at least in the NC population, larger females lay larger clutches of larger eggs. Although limited in scope, this study suggests there may be significant variation in reproductive characteristics of *H. gratiosa*.

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Herpetofauna of Mount Roraima, Guiana Shield Region, Northeastern South America

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The Guiana region of northeastern South America is an area of high biodiversity, and the varied habitats on the tepuis of the region support a significant portion of this diversity. The zoogeography of the pantepui region has been a recent topic of interest, with several sources of published data (Duellman 1999; Gorzula and Señaris 1999; Hollowell and Reynolds 2005a; Hoogmoed 1979a; McDiarmid and Donnelly 2005).

The herpetofaunal communities of several tepuis have been described (Donnelly and Myers 1991; Gorzula 1992; McDiarmid and Paolillo 1988; Myers 1997; Myers and Donnelly 1996, 1997, 2001). Mount Roraima, the most famous of these table mountains, has been explored extensively (McDiarmid and Donnelly 2005). Although numerous specimens have been collected on Roraima, these collections have never been summarized or analyzed.

Roraima (05°12'N, 060°44'W) is one of the highest points in northeastern South America, and it marks the boundary between Guyana, Venezuela, and Brazil. The summit plateau, from 2600 to 2810 m elevation, is some 34 km^2 in area. The plateau is known for its varied rock formations, and for its very sparse vegetation. The summit is at the top of steep walls which extend from below 2000 m up to 2600–2700 m; these walls are occasionally broken by more gradual slopes. At the bottom of the vertical walls, below about 2000 m, the tepui is surrounded by forested slopes. The forest is most extensive below 1500 m, with only a narrow band encircling the mountain above this elevation. Descriptions of the physical features and vegetation of Roraima are in Huber (1995a, b).

Herpetofaunas on tepui summits often differ in species composition from faunas on tepui slopes. Summit faunas are often more depauperate than slope faunas (Myers and Donnelly 2001). Both elevation and microhabitat can affect species distributions, and many species occur over a range of elevations (McDiarmid and Donnelly 2005). It is therefore worthwhile to have a compilation of slope and summit species, for comparison with faunas on other mountains.

The first aim of this paper is to compile a list of the known herpetofauna of Roraima, from both summit and slopes. The second aim is to compare the Roraima herpetofauna with those of other tepuis in the Guiana Shield (following Hollowell and Reynolds 2005b, p.1); this consists of 1) comparison using criteria developed by McDiarmid and Donnelly (2005), and 2) the hypotheses of tepui zoogeography of Myers and Donnelly (2001), who enumerated five general points about the composition of tepui herpetofaunas. Such comparisons can provide valuable insight about the zoogeography of the region.

Methods.—Information was taken from museum records or published literature. Amphibian taxonomy follows Faivovich et al. (2005), Frost et al. (2006) and Grant et al. (2006); reptile taxonomy follows Avila-Pires (2005). Institutional abbreviations follow Leviton et al. (1985), with the following additions: CSBD – Centre for the Study of Biological Diversity, University of Guyana, Georgetown, Guyana; MHNLS – Museo de Historia Natural La Salle, Caracas, Venezuela (formerly SCNLS); ULABG – Laboratorio de Biogeografia, Universidad de Los Andes, Mérida, Venezuela.

The aims of this study require that two points be defined. First, what are the boundaries of Roraima? Second, what are highland species? These questions were resolved as follows:

Roraima: We defined the boundaries of Roraima as that part of the mountain which is above 1500 m. Although some studies of the Guiana Shield region have used 1000 m as a minimum elevation (e.g., Hoogmoed 1979a), the use of this criterion at Roraima would necessitate the inclusion of the extensive surrounding uplands, and would increase the boundaries of Roraima to an unrealistic extent. We therefore adopted the 1500 m criterion, as have other studies of the Guiana fauna (Gorzula and Señaris 1999; McDiarmid and Donnelly 2005).

Because of the potentially great difference between faunas on tepui summits and faunas on forested tepui slopes, we have indicated the location from which each species was recorded, in order to determine whether each is part of the summit or slope faunal assemblages. The habitat on the slopes of Roraima is varied, ranging from steep rocky walls to more gently sloping forested areas (Huber 1995a, b).

Highland Species: Highland species are those which typically occur above 1500 m; any such species is here considered a highland species, although it may have been occasionally collected below 1500 m. McDiarmid and Donnelly (2005) followed a similar procedure. Although a highland species may occasionally occur at elevations below 1500 m, it will not be widespread below that elevation. Table 1 contains all species reported from above 1500 m, plus several highland species collected slightly below

Viperidae
Bothriopsis taeniata
Crotalus durissus
V
Slope
05° 09'
060° 47'
1550
MHNLS