FALL BREEDING OF THE SOUTHERN LEOPARD FROG (RANA SPENOCEPHALA) IN NORTHEASTERN ARKANSAS

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ABSTRACT -- We investigated the sporadic nature of winter breeding in the southern leopard frog from 1999-2002. Southern leopard frogs bred during heavy rains, fall 2002. Although we observed calling in other years, lack of rain seemed to suppress breeding activities despite the presence of flooded agronomic fields and ditches in the region. The fall number of eggs per mass was similar to that observed during the spring, but mass-per-egg was nearly half that observed in studies of spring breeding frogs. Clutch size may vary geographically and may be related to multiple clutching in this species.

INTRODUCTION

Most temperate zone anurans partake in a single breeding episode each year (Wright and Wright 1929). A number of isolated observations suggest that the southern leopard frog (*Rana sphenocephala*) may be an exception to this rule (Pechmann and Semlitsch 1986). Brief accounts of fall breeding in the southern leopard frog appear occasionally in North Carolina (Martoff et al. 1980), South Carolina (Martoff et al. 1980, Caldwell 1986), and Virginia (Martoff et al. 1980). Opportunistic breeding occurs throughout the summer and fall in Kansas (Collins 1993) and occasionally in Missouri (Caldwell 1986, Johnson 2000).

In early September Wright and Wright (1929) observed egg clutches in Richland County, Illinois. Phillips et al. (1999) made a brief mention of southern leopard frog breeding in the “southern counties of Illinois” and indicate egg masses vary (e.g., contained from 1,000 – 4,000 eggs). Petzing et al. (1999) supported these observations. They observed newly hatched tadpoles and egg masses in Pulaski County, Illinois during late September 1996. They also observed “hundreds of tadpoles and metamorphs” at the same location in early July 1997. They could not determine if these were from fall or spring choruses.

In Alabama most breeding occurs December – March when heavy rains accompany temperatures above 10° C (Mount 1975). The egg masses in Alabama contain < 1,000 eggs/mass, and the egg masses are smaller than reported in other regions (Brown 1956). In South Carolina eggs are laid communally in shallow water during cold weather, but they are laid in isolation during warm weather (Caldwell 1986). Pechmann and Semlitsch (1986) suggested that migrations to the oviposition site may reflect tradeoffs among predations risks, vision physiology, temperature, and moisture. Southern leopard frogs from Louisiana appear to call and oviposit throughout the year (Dundee and Rossman 1989). The most intensive breeding occurs December – February with temperatures between 7° and 26° C. These are plinth type (flattened) egg masses containing 1,000 – 1,500 eggs/mass (Dundee and Rossman 1989). In Missouri, egg masses contain < 5,000 eggs (Johnson 2000). Dixon (1987) makes no mention of fall breeding in Texas. Bragg (1944) observed > 200 egg masses from Oklahoma of which fewer than 10% contained fewer than 200 eggs. Whether these were *Rana sphenocephala* or *Rana blairi* is questionable.

Trauth (1989) characterized the reproductive traits of March breeding female southern leopard frogs from northeastern Arkansas. He observed 75 globular egg masses in a 3 m square area. Communal masses were deposited in heavily vegetated areas, whereas isolated masses were deposited in sparsely vegetated locations. This may partly support Caldwell’s (1986) observations of springtime communal oviposition in this species; however, the influence of temperature on this behavior that she identified was not investigated. The vegetation characteristics of oviposition sites provide additional information regarding oviposition site selection in this species. Necropsied females from Arkansas (n = 39) had peritoneal clutches averaging 2,958.7 eggs, whereas field collected clutches (n = 49) averaged 2,106.5 eggs. Formalin-fixed egg diameter averaged 1.76 mm. He also found positive correlations between mean ovum size and female snout-vent length as well as between clutch size and female snout-vent length. Negative correlations were observed between mean egg diameter and size of the egg mass as well as between mass per egg and the size of the egg mass. He suggested that larger, hence older females partitioned clutches while smaller, younger females refrained from this behavior.

Despite the wealth of information reviewed here, little is known about fall breeding in the southern leopard frog elsewhere throughout its range. Trauth (pers. obser.) has noted southern leopard frog tadpoles during the winter and spring in ponds and streams from northeastern Arkansas. The size of these tadpoles suggested that they originated from fall breeding choruses that he observed anecdotally. The purpose of our study was to document fall breeding by southern leopard frogs in northeast Arkansas.

METHODS

Agricultural ditches and flooded agronomic fields known in Craighead and Poinsette Counties, Arkansas and known to harbor southern leopard frogs were visited monthly from fall 1999 – fall 2002 to monitor the breeding activities of southern leopard frogs. In 2002 surveys included the Arkansas Post National Memorial (Arkansas County, Arkansas). County roads bordering fields were driven and periodic stops made to listen for calling frogs. North American Amphibian Monitoring Program (NAAMP) calling survey protocols were followed throughout the study. When calling was observed, the habitat was searched for egg masses, and later in the year for tadpoles. Egg masses were collected and transported to the Arkansas State University Museum of Zoology (ASUMZ) for examination. The egg masses were massed and their eggs counted. Individual egg clutches were calculated algebraically using the number of eggs/mass and the mass of the egg clutch. A sub-sample of 100 eggs was removed from each clutch and placed in separate plastic storage boxes, each containing 2 L of dechlorinated water. The remaining eggs were deposited in the ASUMZ herpetological collection. Testes from three adult male frogs were excised and submitted to histologic analysis. The status of spermatogenesis was characterized and photographed. The diameter of the largest spermatic cyst from each of 30-33 randomly selected histosections from each frog was measured. The mean diameter was calculated for each specimen and the group.

RESULTS

Fall 1999 – Choruses in agronomic fields and adjacent ditches were characterized by isolated calling males dispersed throughout these habitats from August - November. No egg masses or new tadpoles were observed.

Summer 2000 – Choruses could be heard in agronomic fields and adjacent ditches from March through August. They were not heard in streams or ponds from the region. No egg masses were observed during this period, although the thick vegetation in rice fields is not conducive to finding egg clutches. Males could be heard calling in isolation throughout agronomic fields at low (NAAMP Code I) levels. This calling period is continuous with the spring breeding chorus, but the activity is much less intensive.

Fall 2000 – Calling gradually declined from August through September when it ceased. No resurgence of calling was observed. Metamorphs were abundant.

Summer - Fall 2001 – Calling was observed in agronomic fields and adjacent ditches from March through August. No calling was observed in streams or ponds. Egg masses and new tadpoles were not observed. Males calling followed that observed in Summer 2000. Metamorphs were abundant throughout these periods.

Summer 2002 – Southern leopard frogs continued calling from the spring chorus through summer at the Arkansas Post at NAAMP code II. Calling surveys were not made at the Arkansas Post in Fall 2002. Calling in northeastern Arkansas continued after the spring chorus into the summer but ceased by mid-July during the peak of northern cricket frog (*Acris crepitans*) choruses. Calling was observed in agronomic fields and ditches, but was not identified in any ponds or streams from northeast Arkansas. No eggs or new tadpoles were observed during this period. Metamorphs were abundant.

Fall 2002 – Large choruses (NAAMP code III) were observed throughout all agronomic fields and adjacent agricultural ditches beginning 20 September

2002 immediately following a heavy rain. Three males and two females were collected and deposited in the ASUMZ herpetological collection. Eleven globular egg clutches were collected at Mallard Magic Hunting Club in Poinsette County (T11N, R2E, sec 29) on 21 September 2002. These were situated in two groups of three and one group of four masses. The characteristics of these egg masses are provided in Table 1. A hatch test using nine of the eleven clutches resulted in 880/900 eggs (97.8%) hatching (100%, 97%, 97%, 98%, 100%, 98%, 100%, 99%, 91%). Histologic examination of testes indicated that testes were spermiogenic (Fig. 1). Spermatozoa, spermatids, and spermatogonia were evident in nearly all spermatic cysts. The mean maximum spermatic cyst diameter was 61.24 :m (s = 0.0125), (ASUMZ 27273 = 59.9 :m, s = 0.009, n = 33; ASUMZ 27276 = 70.6 :m, s = 0.0122, n = 30; ASUMZ 27277 = 53.3 :m, s = 0.0098, n = 30). Spermatic cyst diameter was significantly different between specimens (ANOVA, F = 20.71, df = 92, p = 0.000). A Tukey's pairwise comaparisons test indicated all three specimens had significantly different spermatic cyst diameters (95% CI: ASUMZ 27276 x ASUMZ 27273 = - 0.0169, - 0.0043; ASUMZ 27276 x ASUMZ 27277 = 0.0108, 0.024; ASUMZ 27273 x ASUMZ 27277 = 0.0003, 0.0129).

DISCUSSION

It appears that southern leopard frogs call throughout the year in northeastern Arkansas. Despite this observation, breeding appears to be restricted to early spring during drought years, and to autumn in wetter years. Precipitation, but not the amount of standing water (such as in flooded rice fields), appears to stimulate fall breeding. Breeding was observed in rice fields that were flooded every year to control nuisance vegetation. This standing water should have been sufficient for breeding, but this was not observed. Unlike autumns from 1999-2001, in 2002 several rainstorms occurred. A particularly large storm occurred on 19 September 2002 that we believe stimulated fall breeding.

Breeding was not observed during the summer. Whether this reflects the capacity of females to gain sufficient energy resources for both hibernation and egg production is not known. Females may require the entire summer to build up these resources. If this is true, hypothetical summer-breeding females might either produce eggs with lower energy reserves, or reallocate body reserves to egg production reducing the animal's winter survivorship potential. Southern leopard frog tadpoles require 8-10 months to metamorphose. Breeding adults often migrate far from permanent water during the summer. During this migration they should encounter many temporary water bodies.

Why summer breeding does not occur is an interesting subject for discussions of life history evolution in this species. Females might derive lower reproductive capacity when breeding in these habitats during summer because the summer heat would frequently dry these ponds before the juveniles emerge. If fall storms are large, the resulting temporary pools are likely to last through the winter. This would provide enough time for tadpoles to metamorphose by early spring. If little rain comes in the fall, all ponds might be susceptible to desiccation. Consequently, breeding in autumn should only be adaptive during years with heavy fall rains, explaining the facultative breeding many researchers have observed.

The high hatching success suggests that if oviposition occurs in the fall, reproductive success can be quite high. The more eggs that hatch into tadpoles, the more tadpoles that should emerge as frogs. This would be especially true in years with timid winters. Spring hatched tadpoles are restricted to diets of detritus and are susceptible to highly anoxic conditions before their lungs develop. Fall-breeding frogs should find an advantage as their tadpoles avoid severe winter anoxia until their lungs have developed. They also should grow faster due to the warmer fall temperatures and abundance of algal food produced in the summer sun. This might place them at a selective advantage to spring tadpoles.

The number of eggs per egg mass was similar to that observed in spring breeding choruses (Trauth 1989), but we observed a much larger mean mass-per-egg (0 = 50.0 mg) than he observed (0 = 22.8 mg/egg). Larger eggs may represent larger egg-storehouses of resources for embryo development. This difference in mass may reflect physiologic trade-offs during aestivation. Females retaining eggs through the winter may reabsorb resources from the oviductal egg masses to meet added energy demands during aestivation. Eggs laid in the fall are not subjected to these hurdles, allowing females to invest maximum energy reserves in the survival of the eggs. It is unknown whether fall breeding females have time to restore body fat reserves to needed to produce an additional spring clutch.

The number of eggs per clutch fell at the low end of the range observed in Illinois (Phillips et al. 1999) and Missouri (Johnson 2000), similar to Louisiana (Dundee and Rossman 1989, Moore 1949), but was larger than observed in Alabama (Brown 1956). Based on these observations, clutch size may increase with latitude as a trade-off between the reproductive potential experienced with multiple breeding seasons in the south and a single annual breeding season in the north.

Further investigations are needed to evaluate these relationships. The potential for fall breeding females to breed again the following spring may reveal interesting repercussions to the evolutionary stability of fall breeding behavior. The allocation of resources between body reserves and eggs may reveal interesting information regarding the complex trade-offs between the drive for reproduction and survival. Unfortunately, the sporadic nature of fall breeding in southern leopard frogs makes it difficult to study these evolutionary quandaries except on a long-term scale.

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Table 1. Characteristics of egg masses from the fall 2002 southern leopard frog breeding chorus.

Egg Mass Number	1	2	3	4	5	6	7	8	9	10	11
Mass of 100 (g)	4.79	4.72	4.97	6.24	5.02	6	5.69	5.97	5.06	5.46	5.79
Total Egg Mass	92.14	55.33	110.04	106.94	91.62	114.79	82.97	100.03	101.05	133.72	102.02
Mass per egg (g)	0.0479	0.0472	0.0497	0.0624	0.0502	0.06	0.0569	0.0597	0.0506	0.0546	0.0579
Total eggs	1924	1172	2214	1714	1825	1913	1458	1676	1997	2449	1762

Mean Total Eggs	1828
Mean Total Mass (g)	99
Mean Mass/Egg (g)	0.05

Figure 1. Testicular condition of a southern leopard frog (ASUMZ 27276) collected during the Fall 2002 breeding chorus.