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REPRODUCTIVE PHENOPHASES AND CLUTCH CHARACTERISTICS OF SELECTED ARKANSAS AMPHIBIANS

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ABSTRACT
Seasonal reproductive phenomena in 13 species of salamanders and 16 species of anurans from Arkansas were investigated. Most specimens were collected during a span of 6 years (1985-1990). Clutch characteristics, including mensural and meristic data, were determined from gravid females. In some species, the size of egg masses was also documented. Among the plethodontid salamanders, average clutch size (in parentheses) greatest in Eurycea lucifuga (77.7) and smallest in Plethodon occidentalis (7.0). One of 2 ambystomatid salamanders (Ambystoma texanum) averaged 545.4 eggs per clutch; the other species (Ambystoma tigrinum) averaged 130.5. Siren intermedia netting (one of 3 salamanders examined) had the greatest mean clutch size (851.3). Among anurans, Rana catesbeiana had the largest clutch size and mass (43.073 eggs and 55.9 g), whereas clutches of Acris crepitans blancardi averaged the smallest (284.1 eggs and 0.1382 g). Multiple clutch production may be the rule in some anurans (e.g., Desmognathus brunneus, A. c. blanchardi, Pseudacris triseriata feriarum, and P. streckeri streckeri); however, partial clutch deposition remains a possibility in these species. By knowing the synchrony between male and female reproductive cycles, a clarification of the onset, timing, and duration of reproductive phenophases (e.g., courtship, breeding, egg laying, etc.) was documented in many species.

INTRODUCTION
Reproductive phenology is the study of the seasonality of reproductive events and represents a suite of life history phenomena often neglected during field studies on amphibians. For many species, the seasonal timing of reproduction is determined largely by and adjusted to fit within recurring climatic episodes; Dowling (1974) and Mitchell (1979) provided reviews on the subject of phenology and its application in herpetology. Comparative phenological data related to the annual and seasonal timing of amphibian reproductive phenophases (i.e., the timing and duration of courtship activities, mating, egg laying, hatching, and metamorphosis) are generally lacking in many geographic areas in the United States; this is especially true for Arkansas. Collecting phenophase data is perhaps the simplest of tasks related to field investigations on breeding anurans. Geographic variation in reproductive phenophases exists; yet, few studies have addressed this topic satisfactorily on a regional or statewide basis (for a notable exception, see Dundee and Rossman, 1989).

In many salamander species, a precise determination of the timing of mating activities can only be accomplished through the histological examination of the female spermatheca for the presence of spermatozoa (e.g., Ireland, 1976; Trauth, 1983, 1984); nevertheless, clutch characteristics (i.e., the presence of enlarged ovarian follicles or total mass of the ovaries) can also provide valuable information as to the onset and duration of the reproductive season as well as to information on clutch size. Nesting phenophases in salamanders yield data on oviposition, embryonic development, and hatchling success and can contribute a better assessment of overall fecundity in populations (Jutterbock, 1986). Other studies have shown that seasonal variation in anuran reproductive phenologies insures a competitive advantage in species that breed early (see Alford, 1989).

In the present study, we provide data on the reproductive phenologies of 29 species of amphibians from Arkansas. Although our survey does not include every possible reproductive phenomenon in each species, our primary objectives were to document poorly known species and to analyze clutch characteristics when gravid females were available.

MATERIALS AND METHODS
Most of the amphibians examined in this study were collected over a six-year period (1985-1990). One notable exception was a span of 10 years for Desmognathus brinleyorum (i.e., 1980-1989). Nearly all specimens were processed within 24 hr after capture. Snout-vent length (SVL) was measured to the nearest 0.1 mm. Individuals were killed in a 20% chloretone solution, fixed in 10% formalin, and preserved in 70% ethanol. Egg masses and egg clutches were placed directly into 10% formalin for storage. With few exceptions, quantitative data on clutch parameters were gathered following techniques discussed elsewhere (Trauth, 1989a). In general, clutch size was calculated by counting all yolked ovarian follicles in each female or by an estimation of clutch size (see Trauth, 1989a). Standard errors (± 2SE) are given along with sample means when the sample size was greater than 10. All clutch (including adults, larvae, eggs, and ovarian follicles) are deposited in the Arkansas State University Museum of Zoology. Standard common names and current scientific names follow, in most cases, Collins (1990).

RESULTS AND DISCUSSION
ORDER CAUDATA
Family Plethodontidae

Three species of dusky salamanders are known from Arkansas. The biology of the Ouachita dusky salamander, Desmognathus brinleyorum, was reviewed by Means (1974); yet, little has been published on its reproduction in Arkansas (for recent data, see Chaney, 1958; Health...
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Although the spotted dusky salamander, *D. fuscus conanti*, has been collected from spring seepages along the eastern slopes of Crowley's Ridge (Means, 1974; Nickerson et al., 1979; Smith, 1964), no individuals were collected during many attempts over the last 5 years. The reproductive biology of this species has not been determined in Arkansas populations.

The distribution of the cave salamander, *Eurycea lucifuga*, is restricted to the Ozark Mountains in Arkansas. The reproductive biology of this species is poorly known for Arkansas populations (Smith, 1964). Average clutch size was 77.7 (range 60-120) in 11 gravid females. Yolk deposition begins in February and continues into August. The smallest gravid female had a SVL of 54 mm (the largest, 67 mm). Most larvae of *E. lucifuga* metamorphose in less than 1 year (Rudolph, 1978); however, some populations require more than 1 year. For example, most larvae transform at around 25 mm SVL (Rudolph, 1978) sometime between July and October. We found larvae averaging 31.6 mm SVL (range 29-37) in late October and others averaging 37.2 mm SVL (range 30-40) in early January. The smallest transformed individual was collected in mid-February and measured 30 mm SVL; transformed individuals in late May were 36 mm SVL.

The graybellied salamander, *Eurycea multipilicata griseogaster*, inhabits aquatic habitats associated with caves and spring-fed streams within the Ozark Mountains of Arkansas (Ireland, 1976). Dunne (1965) pointed out that many populations of *E. m. griseogaster* within the Salem Plateau of northcentral and northeastern Arkansas are neotenic. A single neotenic population in Marion County was studied during the 1989-1990 calendar years. Two gravid neotenic females were collected from Chapman Spring (near Lakeview) on 3 September 1989; clutch size and average ovum diameter for one (36 mm SVL) were 8 and 1.93 mm and for the other (38 mm SVL), 13 and 2.15 mm. Upon returning to the spring on 21 October, all 7 adult females collected (31-41 mm SVL) were postreproductive. Three egg clutches of 8, 10, and 14 eggs were discovered beneath several layers of small rocks within the spring's flow just downstream from the spring's mouth. The gastrula embryos averaged 2.36 mm in diameter (2.01-2.61), whereas the average diameter of the total egg capsule was 5.80 mm (5.37-6.09). The jelly capsules were similar to those described by Spotila and Ireland (1970) for a non-neotenic population. Larvae were found at the spring on 16 March 1990 and averaged 15.0 in SVL. Average adult SVL in late Oc-

![Figure 1. Seasonal distribution of yolked ovarian follicles and their average ovum diameter in *Desmognathus brimleyorum*.](http://scholarworks.uark.edu/jaas/vol44/iss1/29)

![Figure 2. Relationship between clutch size and SVL in *Desmognathus brimleyorum*. Circles symbols represent two records; the regression equation is Y = -7.7860 + 0.4753X. Mean values for X and Y coordinates are shown.](http://scholarworks.uark.edu/jaas/vol44/iss1/29)
October was 36.4 mm (30-41; n = 14) and 33.8 mm (29-37; n = 11) in mid-March 1990.

Little life history information exists for the many-ribbed salamander. *E. m. multicolorata*, a species largely confined to the Ouachita Mountains in Arkansas. No gravid females were found in any of the samples collected from late December to mid-March. In contrast, all 3 populations of *E. m. griseogaster* studied by Ireland (1976) had females with enlarged ovarian follicles during this time of the year.

The Oklahoma salamander, *Eurycea tynerensis*, is a larval form species that is restricted to the western half of Benton County in extreme northwestern Arkansas (Cline et al., 1989). Reproduction in Arkansas populations has not been published. We found gravid females on 18 May and 12 November 1989. Clutch size in 3 females ranged from 11 to 11 eggs (X = 6.67). The presence of females with regressed ovaries in addition to females with enlarged ova in May suggests that oviposition occurs in the summer. The single gravid female collected in November possessed enlarged oviducts which indicates the possibility that multiple clutches are produced by this species.

Reproduction in the four-toed salamander, *Hemidactylium scutatum*, has not been published for Arkansas populations. Although known from the Ozark Mountains of Arkansas (Trauth and Caldwell, 1986), our samples primarily came from sites in Garland and Montgomery counties of the Ouachita Mountains. Road collecting was conducted at night during rainstorms and yielded a disproportionately large number of gravid females (38) compared to adult males (4). The relationship between clutch size and body size is shown in Fig. 3; average clutch size in 31 females was 42.4 ± 2.78 (27-57). Vitellogenic ova were present in females collected from October through mid-March. Several gravid females collected on 17 February 1990 were placed in an aquarium supplied with sphagnum moss; three females laid communal egg clutches by 21 February. Hatching began in 2 egg clutches 23 days later (16 March). Brooding behavior as described by Harris and Gill (1980) was observed.

The southern redback salamander, *Plethodon serratus*, is the smallest of 6 species of *Plethodon* that are known to occur in Arkansas. Reproduction in this species was examined from samples taken from Rich Mountain. Yolk deposition begins as early as January; ova reach a maximum diameter of approximately 3.0 mm by late May. The average clutch size of 7.04 ± 0.41 (5-9; n = 22) was greater than an average of 5.5 for this species in Georgia (Camp, 1988).

The reproductive biology of Arkansas populations of the groto salamander, *Typhlotriton sphenops*, a troglobitic species that inhabits caves and springs in the Ozark Mountains, has received little attention. The most detailed life history account was conducted by Brandon (1971) in Missouri. We examined clutch size, ovum diameter, and other reproductive traits from museum specimens in the ASUMZ collection and the Northeast Louisiana University collection. The largest ova (3 x 3.10 mm) were observed in a female collected in early June. Enlarged vitellogenic ova were present in most females from April through August. Smith (1960a) found egg clutches in January. We found larvae averaging 20.5 mm SVL (18.24; n = 10) in mid-April; others at this time were as large as 45 mm SVL and were nearing metamorphic size. This species requires over one year to transform (Rudolph, 1978; Smith, 1960a).

Family Ambystomatidae

Aspects of the reproductive biology of the smallmouth salamander, *Ambystoma texanum*, have been reported in this species throughout its range (Anderson, 1967). Plummer (1977) found that clutch size was correlated with SVL in Kansas specimens. In Arkansas specimens examined (n = 8), average clutch size was 545.38 (250-813); clutch size was negatively correlated (r = -0.05) with SVL. Smallmouth salamanders partition their clutches into many small egg clumps which they attach to vegetation in temporary pools of drainage ditches. Egg mass size averaged 12.62 ± 1.50 (5-22; n = 34); egg masses are generally laid from late January to mid-April.

Until recently, few locality records had been published for the eastern tiger salamander, *Ambystoma tigrinum tigrinum*, in Arkansas (Butterfield and Marks, 1989; Dowling, 1957; Trauth et al., 1987). Since March, 1987, a total of 16 adult salamanders has been collected from 4 sites in the northeastern Ozark Mountains (Fulton, Izard, and Randolph counties). Females with oviductal eggs were collected 6 January and 17 February, 1989. All females collected in March were postreproductive. On 4 February 1990, egg masses were discovered in a stock pond near Band Mill (Izard County); 2 egg masses of 96 and 165 eggs were recorded. Length of incubation of eggs (in 1990) was estimated to be 40 to 45 days. By mid-March, larvae had attained an average SVL of 18.0 mm; by mid-April, larvae averaged 33.25 mm SVL, and in mid-June, 1989, larvae had reached 55.0 mm SVL. All larvae had transformed by mid-July, 1989.

Family Amphiumidae

Reproduction in the three-toed amphiuma, *Amphiuma tridactylum*, has been studied little in Arkansas since the work of Hay (1888) in Pulaski County. Cagle (1948) found an average clutch size of 98.0 in 26 females from Louisiana. Only 2 gravid females were examined in our study; average clutch size was 103.5 (80 and 127). Vitellogenic ova in these 2 females collected 24 March 1989 (Crawford County) averaged 4.11 and 4.22 mm in diameter and were similar to the size range of 3.54-4.5 mm given by Cagle for March specimens.

Family Proteidae

The life history of the Red River mudpuppy, *Necturus maculosus louisianensis*, is best known from studies in Louisiana (Cagle, 1954; Shoop, 1965). A total of 9 gravid females from Arkansas yielded an average clutch size of 106.5 (48-174). The smallest female possessing yolked ovarian follicles was 156 mm SVL; the largest was 235 mm SVL. Shoop (1965) reported an average clutch size of 54.2 (31-91) in 48 females; in addition, the largest gravid female he examined was 180 mm SVL. In our sample, the largest ova ranged from 4.35-5.22 mm in diameter and were measured from females taken from the St. Francis River (Craighead County) in the Ouachita Mountains diameters in March specimens from the same site was 4.54-5.19 mm.

![Figure 3. Relationship between clutch size and SVL in *Hemidactylium scutatum*. Circles symbols represent two records; the regression equation is Y = -29.4500 + 2.0890X.](image-url)
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Family Sirenidae

The type locality for the western lesser siren, *Siren intermedia nettingi*, is near Imboden in Lawrence County (Goin, 1942). Egg laying was observed by Noble and Marshall (1932) near Imboden, and they presented drawings of larval development which showed stages from hatching to 51 days old. Noble and Marshall (op. cit.) also provided clutch sizes of 260, 289, and 555 eggs. Our data on clutch size shown in Fig. 4 are from specimens collected in Clay and Greene counties. Average clutch size was 851.37 (98±1506; n = 8). Ovulation was occurring in 1 female collected 31 March 1968; this individual had an average ovum diameter of 2.94 mm. Size-age class data indicate that females reproduce at 2 years of age. The smallest female to possess yolked ovarian follicles was 165 mm SVL. Older females (> 2 years) produce much larger clutches than younger females; clutch size is significantly correlated with SVL (Fig. 4).

ORDER ANURA
Family Bufonidae

Reproduction in the dwarf American toad, *Bufo americanus charlesmithii*, and Fowler’s toad, *B. woodhousei fowleri*, has not been studied in Arkansas. Breeding choruses of *B. a. charlesmithii* generally begin in early March, slightly before calling in *B. w. fowleri*. Breeding in both species reaches a peak from late April to early May. Clutch size in both species showed a significant positive correlation with SVL (Fig. 5). Average clutch size in *B. a. charlesmithii* (470.10 ± 2533.0; range = 1840-13,982; n = 103) is less than that of *B. w. fowleri* (8175.7 ± 1978.4; range = 3067-15,618; n = 14). Transforming *B. w. fowleri* were observed in Logan County on 7 June 1989; individuals had well-developed hind legs and an averaged SVL of 14.0 mm. Recently-hatched tadpoles of *B. a. charlesmithii* were found in Salado Creek (Independence County) on 26 July 1990; larvae at this time of the summer would indicate an extended breeding season or multiple clutch production in this species.

Family Hylidae

Members of the family Hylidae are among the earliest breeding anurans that occur in Arkansas. The northern cricket frog, *Acris crepitans crepitans*, is predominately found in the southeastern portion of the state, whereas Blanchard’s cricket frog, *A. c. blanchardi*, is mostly confined to the Interior Highlands. Both forms are active throughout the year, but the seasonal development of ova in *A. c. blanchardi* spans from mid-April to late July. Based upon the simultaneous presence of vitellogenic ova (in the absence of oviductal eggs) and the presence of ovarian scars (corpora lutea) in several females, it was concluded that female *A. c. blanchardi* may produce multiple clutches or may deposit partial clutches during a breeding season. Developing ova that contribute to additional clutches were found in females in May and July. Clutch characteristics for *A. c. blanchardi* include an average clutch size of 266.11 ± 54.83 (174-431; n = 9) and 127.0 ± 102 (120 and 134) for 2 specimens producing additional clutches. In *A. c. crepitans*, average clutch size was 258.0 ± 231 (298). Average ovarian mass in *A. c. blanchardi* was 0.0542 ± 0.0286 (0.1288). In early June, *A. c. blanchardi* tadpoles reach a maximum total length of 36 mm; transforming individuals were found at Morrilton (Conway County) in mid-July.

Of the 3 species of *Hyla* (treefrogs) examined during this study *H. versicolor*, the gray treefrog, began yolk deposition prior to entering overwintering retreats (Fig. 6; September specimen). Because of the lack of gravid females available for study, the timing of yolk deposition in the other species remains unknown. Clutch size in 6 gravid females of the green treefrog, *H. cinerea*, averaged 2152.0 ± 345.8X (1348-3946). This average appears somewhat inflated mainly because of the high number of ova in 1 specimen (55 mm SVL). By excluding this female, a revised mean of 1793.2 ± 1348 (2537) was calculated. Nevertheless, these averages for *H. cinerea* greatly exceed the estimated 500-1000 eggs reported for this species in southern Illinois (Garton and Brandon, 1975). In *H. versicolor*, calling males were observed as early as 12 March 1990 in the Russellville area (Pope County), on 8 May 1989 near Toad Suck Ferry Lock & Dam (Faulkner County), on 18 June 1989 near Bull Shoals Lake (Marion County), and on 27 June 1987 in Morrilton. Both *H. versicolor* and *H. chrysoscelis* (Cope’s gray treefrog) were heard calling syntopically 12.8 km W Mayflower (Faulkner County) on 1 June 1989. *Hyla chrysoscelis* was also heard calling on 17 July 1989 near Columbus (Heavener County) and on 2 September 1989 near Petit Jean State Park (Perry County). The latter calling episode for *H. chrysoscelis* occurred outside the normal reproductive season and, in this instance, is referred to as a “rain call.” Average clutch size in *H. versicolor* and *H. chrysoscelis* were 270.5 ± 2604; n = 10) and 3401.0 ± 2657; n = 4), respectively. Ritke et al. (1990) found an average clutch size of 2060 for *H. chrysoscelis* from western Tennessee; they also noted multiple clutch production in this species. Transforming *H. versicolor* tadpoles were observed on 14 June 1989 in Izard County; they averag-
ed 19.5 mm SVL (19-20), whereas the same species was transforming on 9 August 1989 in Morrilton at an average SVL of 17 mm. Transforming tadpoles of *H. chrysoscelis* were found in Drew County on 23 June 1989 and measured from 15 to 16 mm SVL (X = 15.4).

Within the genus *Pseudacris* (chorus frogs), breeding colonies may be heard as early as mid-January and extend to late April. Clutch size in the spring peeper, *P. crucifer* (formerly *Hyla crucifer*), is shown as a function of body size in Fig. 7. The correlation between these 2 variables was not significant. The average clutch size (n = 22) was 846.64 ± 58.38 (505-1201), and the average ovarian mass was 0.57 g ± 0.11 (0.22-1.52).

Reproductive activity in the uplands chorus frog, *P. triseriata feriarium*, also begins in mid-January. Duellman and Trueb (1986) indicated that *P. triseriata* can produce at least 2 egg clutches per breeding season. Our data (Fig. 8) support the possibility of multiple clutches; however, the deposition of partial clutches spread over the reproductive season cannot be excluded. Average clutch size in *P. t. feriarium* based solely upon enlarged vitellogenic ova in nonamplidant females with no oviducal eggs was 1002.5 ± 268.87 (445-1380) for February (n = 6), 857.5 ± 198.06 (555-1218) for March (n = 6), and 207 ova for a lone female in April. The grand mean clutch size for 13 specimens was 874.38 ± 188.5.

Strecker's chorus frog, *P. streckeri streckeri*, is largely restricted to sandy habitats along the Arkansas River from Faulkner to Sebastian County in Arkansas. Breeding choruses were recorded on 16 February 1990 near Morrilton, on 12 March 1990 at Dardanelle (Yell County), and again near Morrilton on 3 April 1988. Average clutch size in 3 gravid females collected 3 April 1988 was 440.67 (372-503). Buttonfield et al. (1989) found that clutch size in *P. s. illinoensis* in northeastern Arkansas ranged from 148 to 1012 (x = 467.56). The relatively low value for the upper range limit in *P. s. streckeri* may indicate the deposition of multiple and/or partial clutches. Average ovarian mass of the 3 specimens was 0.1923 g (0.1325-0.2211). Transforming *P. s. streckeri* were collected 9 May 1989 from Holla Bend National Wildlife Refuge (Pope County) with an average SVL of 17.3 mm (16-19; n = 6); at Dardanelle on 13 April 1990, transforming froglets averaged 24.0 mm SVL (22-25; n = 4).

### Family Ranidae

There are 6 species of ranid frogs currently found in Arkansas (Conant, 1975). Two of these (*Rana arenicola* and *R. clamitans*) are represented by 2 subspecies. Little reproductive information has been published on 4 of these species; however, the reproductive biology of *R. sphenocephala* (Trauth, 1989a) and *R. sylvatica* (Trauth et al., 1989b) has been investigated. The distribution of the northern crayfish frog, *R. a. circulosa*, is poorly known in Arkansas, although specimens are occasionally found in the Arkansas River Valley as well as in the northeastern corner of the state. A total of 11 specimens (9 males and 2 females) was available for study. Calling males have been observed from late February to early April. A clutch size of 2233 was counted from a gravid male 66.8 mm SVL.

The bullfrog, *R. catesbeiana*, is commonly found throughout Arkansas. The smallest female to contain vitellogenic ova was 113 mm SVL. This size is slightly smaller than that reported for Missouri specimens (see data in Bury and Whelan, 1984). Estimated clutch size ranged from 12,756 in the above specimen to 43,073 in the largest female (176 mm SVL). Average clutch size in 7 females was 22,944.28. Clutch mass varied greatly among 10 females; of the 7 with yolked ovarian follicles, over a ten-fold difference (4.86-55.91 g) in ovarian mass was noted. Bullfrog egg masses were observed in Lonoke County on 15 May 1990.

The bronze frog, *R. c. clamitans*, and the green frog, *R. c. melanota*, have an Arkansas distribution similar to cricket frogs (mentioned earlier) with *R. c. clamitans* found generally in the south and east and *R. c.
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_ melanota_ in the north and west (Conant, 1975). Average clutch size in 2 bronze frogs was 5327.0 (4924 and 5730) with SVL's of 73.8 and 72.7 mm, respectively. Only 1 gravid green frog (67.9 mm SVL) was examined; she contained 2851 ova.

Although found throughout most of Arkansas, the pickerel frog, _R. palustris_, is encountered infrequently; individuals are most commonly observed in or around caves and springs in the Ozark Mountains (McDaniel and Gardner, 1977). They are also found in abandoned mines in the Ouachita Mountains (Heath _et al._, 1986). Clutch size was found to significantly increase with SVL (Fig. 9); average clutch size in 14 females was 1759.59 ± 314.37 (960-2943). Calling males were observed on 8 March 1990 near Possum Grape (Jackson County). Transforming individuals were observed from 12 June to 24 June 1990 in ponds near Bethesda (Independence County).

![Image of relationship between clutch size and SVL](image)

Figure 9. Relationship between clutch size and SVL in _Rana palustris_. The regression equation is \[ Y = -1586.34 + 51.09X. \]

Family Pelobatidae

The annual breeding cycle of most species of spadefoot toads is largely seasonal and characteristically occurs during or following heavy rainfall. In northeastern Arkansas, breeding activity of the eastern spadefoot, _Scaphiopus holbrookii holbrookii_, was recorded on 14 March 1986 (Clay County), 28 March 1989 (Clay County), and 14 February 1990 (Craighead County). Clutch size averaged 3838.0 (3522-4469) in 3 females (64.3-65.9 mm SVL), and average ovarian mass was 3.78 g (2.93-4.89). In Hurter's spadefoot, _S. h. hurterii_, breeding may begin in mid-to-late March. Clutch characteristics of 8 gravid females (53.4-62.1 mm SVL) collected 1 April 1988 within the city limits of Dardanelle included an average clutch size of 2494.75 (1961-4847) and an average ovarian mass of 2.14 g (1.29-4.49). Larvae of _S. h. hurterii_ were observed at the above site on 8 April 1989 and at a site near Monnie Springs (Pulaski County) on the same date. A breeding colony was located near White Oak Lake (Craighhead County) on 3 June 1990.

The plains spadefoot, _Scaphiopus bombifrons_, is known from only 2 localities in Arkansas (Plummer and Turnipseed, 1982; Trauth _et al._, 1989a), and both are found within the Arkansas River Valley. Breeding activity has been recorded in the months of April (Trauth _et al._, 1989a), May (Trauth, 1989b), and June (Plummer and Turnipseed, 1982). Clutch size of a single gravid female collected near Morrilton on 8 May 1989 was 1697.

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