RESEARCH ARTICLE

Notes on Reproduction of Green Toads, *Anaxyrus debilis* (Anura: Bufonidae), from New Mexico

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Anaxyrus debilis (Girard, 1854) (Fig. 1) ranges from southeastern Colorado and southwestern Kansas south to Zacatecas, Mexico and southeast Arizona to eastern Texas (Stebbins and McGinnis 2018). *Anaxyrus debilis* is secretive and hides under surface litter and rocks (Lemos Espinal et al. 2018). Breeding choruses of *A. debilis* last 1 to 3 nights following summer rainstorms in Arizona–New Mexico (Sullivan 1984). The most detailed account of *A. debilis* reproduction is from Kansas by Taggart (1997). In this paper I provide information on reproduction of *A. debilis* from a histological examination of gonadal material from museum samples collected in July and August from New Mexico. The use of museum collections for obtaining reproductive data avoids removing additional animals from the wild.

Figure 1. Green Toad (*Anaxyrus debilis*), Cochise County, AZ. Photo by Jim Rorabaugh.

A sample of 31 *A. debilis insidior* (*sensu* Degenhardt et al. 1996) collected 1963 to 1993 from New Mexico (Appendix) consisting of 16 adult males (mean snout–vent length, SVL = 40.2 mm ± 2.9 SD, range = 35-45 mm), and 15 adult females (mean SVL = 45.3 mm ± 4.0 SD, range = 40-53 mm) was examined from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA.

A small incision was made in the lower part of the abdomen and the left testis was removed from males and a piece of the left ovary from females. Gonads were embedded in paraffin, sections were cut at 5 µm and stained with Harris hematoxylin followed by eosin counterstain (Presnell and Schreibman 1997). Histology slides were deposited in LACM. An unpaired t-test was used to test for differences between mean male and female SVLs (Instat, vers. 3.0b, Graphpad Software, San Diego, CA).

The testicular morphology of *A. debilis* is similar to that of other anurans as described in Ogielska and Bartmanska (2009a). Within the seminiferous tubules, spermatogenesis occurs in vesicles called cysts which remain closed until the late spermatid stage is reached; cysts then open and differentiating sperm reach the lumina of the seminiferous tubules (Ogielaska and Bartmanska 2009a). All 16 males in my sample (July n = 14, August n = 2) exhibited spermiogenesis. Sperm cysts had opened and packets of sperm were visible in the seminiferous tubules. In some cases intertwined sperm masses were present in the lumina of the seminiferous tubules. A ring of cysts containing germinal cells in various stages of development was present on the inner wall of the seminiferous tubule. The smallest reproductively active male in my sample (LACM 87681) measured 35 mm SVL and was from July. Wright and Wright (1949) reported adult male *A. debilis* ranged from 26 to 41 mm SVL.

The mean SVL of females was significantly larger than that of males (t = 4.1, df = 29, P = 0.0003). The ovaries of *A. debilis* are typical of other anurans in being paired organs lying on the ventral sides of the kidneys; in adults ovaries are filled with diplotene oocytes in various stages of development (Ogielska and Bartmanska 2009b). Mature oocytes are filled with yolk droplets; the layer of surrounding follicular cells is thinly stretched. Two stages were present in the ovarian cycle (Table 1); (1) (Stage 1) Spawning condition, yolk filled oocytes predominated. (2) Post-spawning, (Stage 2) few mature eggs were present. Both (Stage 2) females from July (LACM 87689, 132631) (Table 1) each contained postovulatory follicles from a recent spawning. Postovulatory follicles form when the ruptured follicle collapses after ovulation; the follicular lumen disappears and proliferating granulosa cells are surrounded by a fibrous capsule (Redshaw 1972). Postovulatory follicles are short-lived in most anuran species and are resorbed after a few weeks (Redshaw 1972). The smallest reproductively active females (spawning condition) both measured 40 mm SVL and

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were from July (LACM 184062) and August (LACM 140522). The size range of adult females given by Wright and Wright (1949) is 31-46 mm SVL.

Atresia is a widespread process occurring in the ovaries of all vertebrates (Uribe Aranzábal 2009). It is common in the amphibian ovary (Saidapur 1978) and is the spontaneous digestion of a diplotene oocyte by its own hypertrophied and phagocytic granulosa cells which invade the follicle and eventually degenerate after accumulating dark pigment (Ogielska and Bartmanska 2009b). See Saidapur and Nadkarni (1973) for a description of the stages of atresia in the frog ovary.

Moderate atresia was noted only in one ovary (LACM 87689) from July which contained numerous deteriorating unspawned follicles with yolk. Mild atresia (only occasional atretic follicles) were noted in LACM 132630 and LACM 184062 also from July and LACM 140540 from August.

Times of breeding for *A. debilis* through its range are given in Table 2. *Anaxyrus debilis* has longer activity and reproductive periods in states where activity is not dependent on summer monsoons. The time of breeding given as June to July in Degenhardt et al. (1996) should be extended to include August. (Table 1). As my samples from New Mexico were only from July and August, examination of *A. debilis* from earlier and later of the year are warranted to further elucidate the reproductive cycle of this species.

Acknowledgments—I thank Gregory B. Pauly (LACM) for permission to examine *A. debilis*.

Table 1. Two stages in the ovarian cycle of 15 *Anaxyrus debilis* adult females from New Mexico; * = postovulatory follicles present in LACM 87689, 132631.

Month	*n*	(1) Spawning Condition	(2) Post-spawning; few mature eggs
July	8	6	2*
August	7	7	0

Table 2. Times of breeding by state (U.S.A. and Mexico) for *Anaxyrus debilis*.

State	Time of Breeding	Source
Arizona	June through August	Brennan and Holycross 2009
Arizona	Late March to September	Murphy 2018
Coahuila	After heavy rains; no dates	Lemos–Espinal and Smith 2007
Colorado	Early June to mid–August	Hammerson 1999
Colorado	Late spring to August	Young 2011
Kansas	12 June to 2 September	Taggart 1997
Kansas	Early June to mid–August	Collins et al. 2010
New Mexico	August	Bogert 1962
New Mexico	June to July	Degenhardt et al. 1996
Nuevo León	Warm heavy rains; no dates	Lemos–Espinal et al. 2018.
Oklahoma	April to August (calling only)	Bragg and Smith 1942
Oklahoma	During or after rain; no dates	Sievert and Sievert 2011
San Luis Potosí	Warm heavy rains; no dates	Lemos–Espinal and Dixon 2013
Sonora	Late June or early July	Rorabaugh and Lemos–Espinal 2016
Texas	Late March to mid–June	Wright and Wright 1949
Texas	March until September	Tipton et al. 2012
Not given	April to August	Stebbins and McGinnis 2018

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Appendix: Thirty-one *Anaxyrus debilis* examined by county from New Mexico, borrowed from the herpetology collection of the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA.

Hidalgo LACM 87677, 87680, 87681, 87683, 87687, 87694, 123214, 171426, 184062, 184511, **Doña Ana** LACM 1106, 132630–132639, 140515, 140516, 140522, 140525, 140536, 140537, 140540, 140541; **Luna** LACM 87689, 87690.

RESEARCH ARTICLE

Diet of the Lacertid Lizard *Psammodromus algirus* in North Tunisia

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Abstract—The study of diet composition of *Psammodromus algirus* from north Tunisia allowed us to calculate the abundance and occurrence of each prey category. Thus, *P. algirus* demonstrated a generalist and an opportunistic behavior. The species consumed a large range of insects and invertebrates but the diet was mainly composed of Coleoptera (59.9%).

Keywords —Lacertidae; diet; Coleoptera; *Psammodromus algirus*; Mediterranean; north Africa.

Introduction

The lacertid lizard *Psammodromus algirus* is a species known for its large distribution from the Languedoc in France to the north east of Tunisia, Cap Bon Peninsula (Mamou 2016). In 2006 a population located on the northern side of the Mediterranean Sea was determined to be two separate species *Psammodromus jeanneae* and *P. manuelae* (Busack et al. 2006). This limited the distribution of *P. algirus* to the southern side of the Mediterranean Sea. Most of the dietary studies of the species were conducted on populations in Europe (Di Palma 1984, Díaz and Carrascal 1990, Díaz and Carrascal 1993) resulting in a lack of information about *P. algirus* diet from North Africa. Recently, a significant diet study was conducted in Algeria (Bouam et al. 2016) constituting great interest as Tunisia provides distribution continuity throughout the cost of North Africa. In this study, we study the northern Tunisia population as a model in order to have dietary composition insight of the species, its prey, and their availability.

Materials and Methods

Study area

The sampling was conducted from April to September 2017, in the north west and north east (Cap Bon Peninsula) of Tunisia (North Africa). Several habitats were visited in order to sample all the possibilities in