Female reproductive cycle of the snaked-eyed Lizard *Ophisops elegans* Ménétries, 1832 (Reptilia: Lacertidae) from Lebanon

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Received: 23 October 2019; returned for review: 25 November 2019; accepted: 11 December 2019.

We studied the female reproductive cycle of a population of Ophisops elegans lizard from the herpetology collection of the Natural History Museum of the Lebanese University. Females collected during spring and summer showed vitellogenesis in their ovaries with oviposition occurring from May to July followed by a subsequent quiescent period. They produced up to two clutches. Mean clutch size was 3.2 ± 1, range 2-5 eggs. Clutch size was independent of female body size. The smallest female attaining sexual maturity had a snout vent length of 45 mm. Sexual maturity can be attained within one year of age. We found no significant difference in body size between female and male adult lizards. Seasonal variations in the reproductive activity of females were well synchronized with those of males.

Key words: Clutch; ovary; oviparous; sexual maturity; vitellogenesis.

Reproduction is considered one of the most important aspects of life history of a species, besides growth and development. Studies on the reproductive pattern in lizards have shown general common features among species. However, each species has its own specific characteristics (Díaz *et al.*, 2012), such as the length of the reproductive period, snout vent length at sexual maturity, reproductive energy, determined by phylogenetic and physiological constraints or/and an adaptive response to its environmental conditions.

Lizards from temperate regions exhibit generally a seasonal reproductive cycle, while many species from tropical region exhibit often a continuous reproductive cycle throughout the year. Carretero (2006) reviewed the pattern of the reproductive cycles in Mediterranean lacertid lizards, their plasticity and their limits. The snake-eyed lizard, *Ophisops elegans* Ménétries, 1832 is an oviparous lacertid lizard, very common in Lebanon (Hraoui-Bloquet *et al.*, 2002). Different aspects of life history, and ecology of this species were reported. Environmental factors such as high winter precipitation, and intermediate levels of sunshine influence their distribution pattern (Oraie *et al.*, 2014). The longevity of *O. elegans* lizards does not exceed five to six years (Gharzi & Yari,

DOI: http://dx.doi.org/10.11160/bah.177

2013; TOK *et al.*, 2013), and most of their preys are larval forms of homoptera and other insects (AKKAYA & UGURTAS, 2006). We have previously showed that males of *O. elegans* from the same herpetological collection present vernal spermiogenesis (NASSAR *et al.*, 2017), as usually found in other species (CARRETERO & LLORENTE, 1997; AMAT *et al.*, 2000; ROIG *et al.*, 2000; CARRETERO 2006).

In this paper, we describe the female reproductive cycle, investigate the sexual dimorphism in body size, and discuss the species reproductive pattern.

Twenty-nine female reproductive organs (ovaries with attached oviducts) of *O. elegans* lizards collected out of the hibernation period, from April to October 1985 in Mahrouka (33°56′N, 35°50′E; at around 2000 m asl), Mount Sannine, Lebanon were analyzed. The area is predominantly rocky with sparse vegetation. During the winter season reaching spring, there is a snow cover. During the summer season, the land is dry. The mean annual air temperature was 14.9°C (Mean minimum air temperature 6.0°C in January - Mean maximum air temperature 23.4°C in August), and the total annual precipitation was 44.8 mm for the period of 1998-2008 (10 years mean). The corresponding values for the studied year (1985) were 14.7°C and 39.5 mm, respectively. The annual precipitation and temperature data were obtained from Tal Amara meteorological station (33°51′N, 35°59′E), located in the Beqaa Valley at about 18 km from the study area.

Snout-vent length (SVL) of each specimen was measured immediately after capture with a caliper to the nearest 0.01 mm. Sexual size dimorphism was assessed with 31 male specimens collected at the same date, and deposited at the Natural History Museum of the Lebanese University. Enlarged ovarian follicles and oviductal eggs were counted and measured, then the ovaries and the oviducts were stored in Bouin's solution. Later in the laboratory, they were subject to histological analysis. They were dehydrated in increasing concentrations of ethanol, and kept in butanol until paraffin embedding, using standard protocol (MARTOJA,1967). They were sectioned with a rotary microtome at 5 μm, and stained using hematoxylin and eosin. Ovary slides were examined for the presence of vitellogenic follicles and/or corpora lutea. Lizard oviducts were examined for the presence of sperm mixed to the epididymal secretory granules in the lumen of the oviduct and/or for the presence of sperm storage tubules.

Female reproductive characteristics were determined based on the presence and size of the ovarian follicles, the presence of eggs in the oviducts (Table 1). The smallest SVL of females containing enlarged vitellogenic ovarian follicles was considered the minimum size at sexual maturity.

We used SPSS 20.0® statistical software for data set analyses. An independent t-test was used to compare mean SVL (± 1 Standard Deviation SD) between males and females. Non parametric Spearman correlation was used in order to test for possible association between SVL and number of eggs.

The smallest reproductively active female measured 45 mm SVL, and was collected in May, therefore only females with an SVL ≥ 45 mm were considered to be adults. The mean

Table 1: Histological characteristics used to determine the different stages of the female reproductive cycle in the population of *Ophisops elegans* from Mount Sannine - Lebanon.

Characteristics	**Stages**
Ovarian follicles (< 5.5 mm) undergoing yolk deposition	Vitellogenesis
Ovarian follicles undergoing yolk deposition with the presence of enlarged follicles (≥ 5.5 mm)	First clutch
Ovarian follicles undergoing yolk deposition with the presence of oviductal	
Ovarian follicles undergoing yolk deposition with enlarged follicles for a subsequent clutch and the presence of oviductal eggs (or/and corpora lutea in the ovaries) from a previous clutch	Second clutch
Atresia in ovarian follicles	Atresia
Non vitellogenic follicles	Quiescent

SVL was 49.15 ± 2.68 mm, range 45-55 mm for adult females (N = 26), and 41.66 ± 1.53 mm range 40-43 mm for juvenile females (N = 3) collected in April. They can reach their sexual maturity in the current year if the physiological and environmental conditions permit it. According to the mean SVL for adult male specimens 48.87 ± 2.86 mm, range 43-54 (N = 31) (Nassar *et al.*, 2017), there was no significant difference between the mean SVL of adult males and females of *O. elegans* lizards ($t_{55} = 0.38$, $P > 0.05$).

Five stages were noted based on histological examination (Table 1). The four females examined in April exhibited vitellogenesis in their ovaries (Fig. 1). Vitellogenic follicles were observed in all the ovaries of active females from May until August. However, follicular atresia was frequently seen in some females examined in August, suggesting that vitellogenesis will not be completed during the current reproductive season for these females. Females of *O. elegans* laid their first clutch in May and June. The first enlarged follicles and the first oviductal eggs were seen in May. All females in June showed eggs in their oviducts. The three largest females from July exhibited enlarged follicles in their ovaries with the presence of oviductal eggs indicating that these females produced two clutches in that reproductive season. The presence of sperm mixed to secretory granules in the oviducts of these females indicates that a second mating preceded oviposition of the second clutch. No evidence was found for the presence of sperm storage tubules in the infundibulum or in the vagina in all examined lizards. Follicular atresia was frequently seen in females examined in August. All adult females collected in September and October were quiescent (Fig. 1).

We found no differences between the number of enlarged follicles and oviductal eggs with respect to female body size (ANCOVA, $F_{1,12} = 0.36$, $P = 0.56$). There-

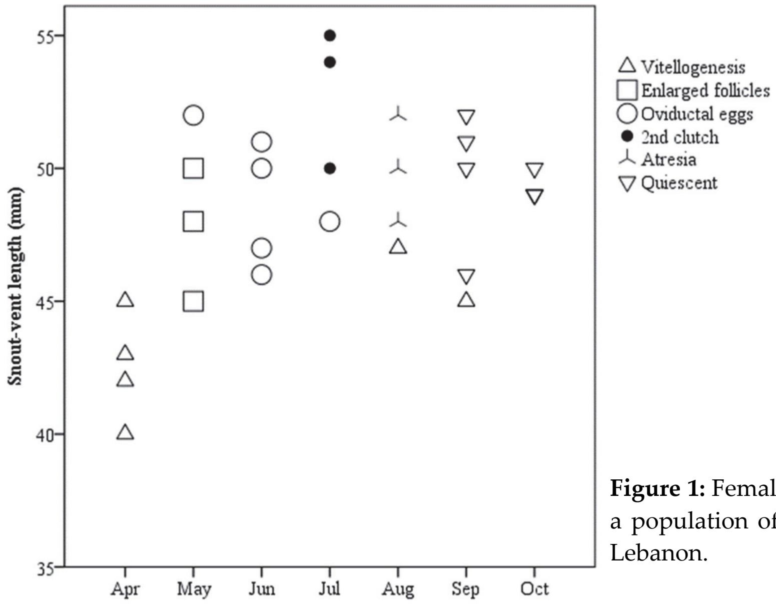

Figure 1: Female reproductive cycle of a population of *Ophisops elegans* from Lebanon.

fore, these data were pooled for estimating clutch size. Mean clutch size was 3.2 ± 1, range 2-5. Clutch sizes were not affected with female body size (R_S = 0.11, *P* = 0.67, N = 17).

Ophisops elegans are small-sized lizards. Sexual maturity can be attained when a lizard attains a minimum body size rather than a specific age (GALAN, 1996; CARRETERO, 2006). Males and females of *O. elegans* reach sexual maturity at 43 mm and 45 mm SVL, respectively. Sexual maturity of *O. elegans* can be attained within one year of age. Small body size lizards *Psammodromus hispanicus* may reach sexual maturity in less than three months, and they are capable to reproduce within less than one year of life span (CARRETERO & LLORENTE, 1997; CARRETERO, 2006). Members of the dwarf genus *Mesalina*, such as *Mesalina brevirostris* attains sexual maturity within one year (IN DEN BOSCH, 2001), and *Mesalina guttulata* reaches maturity at 36 mm (for males) and 43 mm (for females) SVL (GOLDBERG, 2012). However, the number of clutches varies among the different species. Females of *O. elegans* produce up to two clutches in the same reproductive season. Similar observation was reported in *P. hispanicus*, with a second clutch laid by the largest females (CARRETERO & LLORENTE, 1997). Multiple clutches (five clutches per year) were reported in *M. brevirostris* (IN DEN BOSCH, 2001), whereas no evidence of multiple clutches was reported in *M. guttulata* (GOLDBERG, 2012).

Sexual size dimorphism is a common trait in lizards. It reflects the presence of different selective forces which act differently on each sex (COX *et al.*, 2007). Males are larger than females in the majority of lizards, although females having larger body sizes than males is common and occurs in nearly every family (COX *et al.*, 2007; COX & KAHRL, 2015). In lacertid lizards, males are usually larger than females

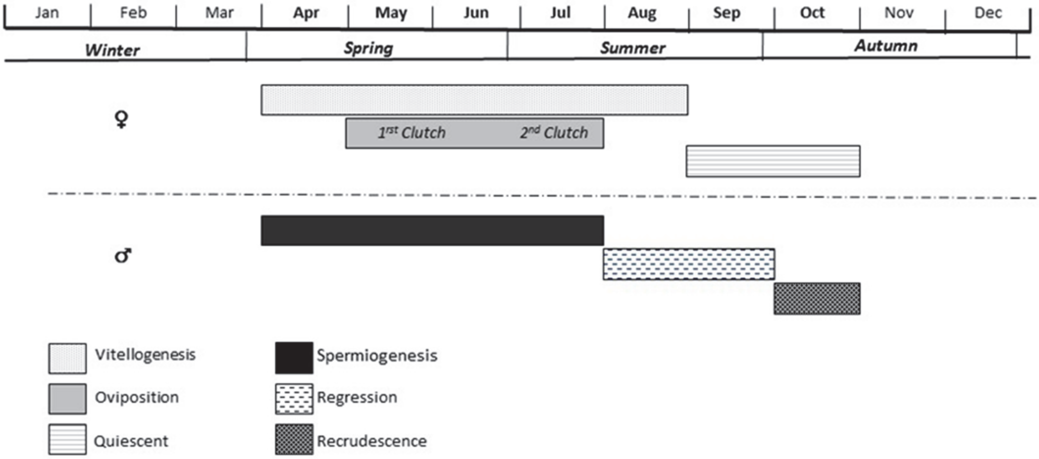

Figure 2: Reproductive pattern of *Ophisops elegans* lizards from Lebanon (male data from NASSAR *et al.*, 2017).

(COX & KAHRL, 2015; SUAREZ *et al.*, 2016). ORAIE *et al.* (2013) reported that males of *O. elegans* from western and north-western populations in Iran have a relatively longer snout-vent length than females. Our results showed no significant difference between male and female body sizes in the population of *O. elegans* from Mount Sannine. Similar observations, with no sexual dimorphism in body sizes was reported in a population of *O. elegans* from Kermanshah region in Iran (GHARZI & YARI, 2013).

Males and females of *Ophisops elegans* from Lebanon exhibited seasonal reproductive cycles. Females' reproductive cycle is well synchronized with that of males (Fig. 2). As males undergo spermiogenesis, females were in vitellogenesis. Mating and fertilization occurred in May. Two clutches were produced in that year (1985), which was characterized by a dry reproductive season that lasted from April to August. The first clutch was deposited from May until July, whereas the second clutch during July (Fig. 2).

Our studied population of *O. elegans* lizards follows a common reproductive pattern of reptiles from the temperate regions. Similar reproductive pattern was in fact described in a population of *O. elegans* lizards from Iran (TORKI, 2007). However, they differ in the beginning of the reproductive period. They emerge from hibernation one month before of those of Mount Sannine. Temperature and precipitation constitute a major cue for the reproductive activity in lizards. The beginning of reproduction depends on the spring temperature increase (CARRETERO & LLORENTE, 1997), and low precipitation appeared to constrain reproduction by influencing the relative abundance and the availability of food. However, no fundamental differences have been detected between the different reproductive patterns. Our results highlight the specific reproductive characteristics of females of *O. elegans* from Lebanon and contribute to a better knowledge of the reproductive biology of this species.

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