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The body size, age structure, and growth of Bosc's fringe-toed lizard, *Acanthodactylus boskianus* (Daudin, 1802)

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Abstract: Using skeletochronology, the age structure of a breeding population portion of *Acanthodactylus boskianus* (Daudin, 1802) from the southeast of Turkey was studied for the first time. A total of 21 preserved (9♂♂, 8♀♀, and 4 juveniles) specimens were used in this study. According to the analysis of the age structure based on counting lines of arrested growth, ages ranged from 6 to 9 years (mean: 7.44 ± 0.34 years) in males and from 5 to 7 years (mean: 6.13 ± 0.30 years) in females. Juveniles were from 3 to 4 years old. Age at maturity was estimated to be 4–5 years and the adult survival rates were estimated to be 0.62 for males and 0.56 for females. The mean snout–vent length was calculated as 79.09 ± 1.16 mm in males, 65.90 ± 2.02 in females, and 43.55 ± 2.02 mm in juveniles. The sexual dimorphism index was calculated as –0.20. The difference between the sexes in age and size was statistically significant.

Key words: Lacertidae, *Acanthodactylus boskianus*, age, size, sexual dimorphism, Turkey

1. Introduction

The genus *Acanthodactylus* is commonly referred to as the fringe-toed lacertids, owing to the presence of a series of scales on the fingers that provide traction for running over loose sand (Halliday and Adler, 2002; Pianka and Vitt, 2003). Bosc's fringe-toed lizard (*Acanthodactylus boskianus*) (Daudin, 1802) is one of the largest *Acanthodactylus* species (Schleich et al., 1996). It has a long, cylindrical body and well-developed legs, as is common with other lacertids (Pianka and Vitt, 2003). It excavates burrows in hard sand, some of which are equipped with multiple entrances to allow quick retreats (Schleich et al., 1996). The medium-sized lacertid species *A. boskianus* ranges widely throughout arid northern Africa and eastwards in Asia to western Iran and throughout the Arabian Peninsula (Seifan et al., 2009; Baran et al., 2012). According to Arnold (1983), *A. boskianus* inhabits more open areas. Rastegar-Pouyani (1999) mentioned that the habitat of *A. boskianus* in Iran has spiny bushes of *Astragalus*. The habitat of the species is the foothills of the Zagros Mountain, Iran, with dense vegetation (Fathnia et al., 2009). In Turkey, *A. boskianus* inhabits the sandy banks of the Euphrates River in Birecik, southeastern Anatolia (Baran et al., 2012). Its habitat consists of *Astragalus*. The total body length is up to 24 cm. The dorsal surface of the body is greenish brown-gray and spotless, and there are dark and light maculations on the ventral region. It hides in cracks and crevices and can also burrow. The female lays 2 clutches of between 3 and 7 eggs annually (Baran and Atatür, 1998; Baran et al., 2012).

Different studies have been carried out about *A. boskianus* to date: some of these studies concerned sexual dimorphism (Steifan et al., 2009), pheromones (Khannoon et al., 2010; Khannoon et al., 2011), environmental physiology (El-Masry and Hussein, 2001), biogeography (Harris and Arnold, 2000), and taxonomy (Rastegar-Pouyani, 1999). There are no data available about the life history traits, especially age structures, of this species.

Skeletochronology is a method for estimating age using the presence of growth layers in bone tissue and counting the lines of arrested growth (LAGs) (Castanet and Smirina, 1990). In amphibians and reptiles in which annual growth is cyclical, i.e. with alternating periods of rapid and slow growth, skeletochronology can be used to estimate the age of individuals (Castanet et al., 1993). This method has been successfully used for age determination of different lizard species to date [e.g., *Agama stellio*, El Mouden et al. (1999); *Darevskia* spp., Arakelyan (2002); *Lacerta agilis*, Roitberg and Smirina (2006); *Lacerta strigata*, Roitberg and Smirina (2006), Guarino et al. (2010); *Eremias argus*, Kim et al.

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(2010); *Dinarolacerta mosorensis*, Tomašević et al. (2010); *Plestiodon* (*Neoseps*) *reynoldsi*, McCoy et al. (2010)].

In the present study, we investigated the body size and age structure, as well as eventual intersexual differences, in terms of these characteristics of this species. We tested whether age estimation of museum samples is possible in order to use this information to characterize the age structure, sexual maturity, and longevity of *A. boskianus*.

2. Materials and methods

We used 21 preserved (9♂♂, 8♀♀, and 4 juveniles) *A. boskianus* specimens kept in the herpetological collection of the Dokuz Eylül University Department of Biology. The specimens were collected from Birecik/Şanlıurfa (37°03′N, 37°54′E) at an altitude of 445 m a.s.l. They were found in sandy areas with small amounts of shrubs and grasses. In this study, samples were captured by hand from under stones or on land. The feeding and breeding activities of *A. boskianus* generally start in April and end in October, according to the weather conditions.

The sex of each individual was determined according to the presence of a hemipenis in the cloacal opening. The distance between the tip of the snout and the posterior part of the vent of each individual was also measured using a dial caliper with 0.02 mm of precision in order to obtain the snout–vent length (SVL).

The sexual dimorphism index (SDI) was calculated according to the following formula introduced by Lovich and Gibbons (1992):

SDI = (mean length of the larger sex / mean length of the smaller sex) ± 1.

In this formula, +1 is used if males are larger than females and defined as negative, or –1 is used if females are larger than males and defined as positive arbitrarily.

Individual age was determined by applying the skeletochronological method on the longest finger of the forelimb. This analysis was also used successfully for the age determination of amphibian and reptile species in various studies (e.g., Castanet and Smirina, 1990; Olgun et al., 2005; Guarino et al., 2010; Tomašević et al., 2010). The skeletochronological analysis followed previous procedures (Castanet and Smirina, 1990) with some small changes according to the samples: preserved phalanges in 70% ethanol were dissected and the larger bone of the phalange was washed in tap water for 24 h, decalcified in 5% nitric acid for 2 h, and then washed again in tap water for about 12 h. The cross-sections (18 µm) from the diaphyseal region of the phalange were obtained using a freezing microtome and the sections were stained with Ehrlich's hematoxylin. The sections were placed in glycerin in order to be observed with a light microscope. Bone sections from each individual were photographed at the same magnification.

Age was determined by counting the LAGs in cross-sections, because each one corresponds to the annual number of period of arrested growth. We assessed the rate of endosteal resorption (how many LAGs are destroyed?) by comparing the diameters of eroded marrow cavities with the diameters of noneroded marrow cavities in sections from the juveniles.

Adult survival rate was calculated according to Robson and Chapman's (1961, in Krebs et al., 1969) formula:

$$Sr = T / \Sigma N + T - 1,$$

where Sr = average finite survival rate, i.e. a value of 0.75 means that on average 75% of the population survives from 1 year to the next; T = the sum of the coded ages times their frequencies when age is found by setting the youngest included age class to 0, the next age to 1 and so forth = $0N_x + 1N_{x+1} + 2N_{x+2} + \ldots + iN_{x+i}$; ΣN = number of animals from age class x to x + i = $N_x + N_{x+1} + N_{x+2} + \ldots + N_{x+i}$; and N_x = number of individuals in age class x.

Adult life expectancy (ESP), the expected total longevity of lizards that have reached maturity, was calculated according to Seber's (1973) formula:

$$ESP = [0.5 + 1 / (1 - Sr)],$$

where Sr = average finite survival rate of adults.

The age and body measurements (SVL) were normally distributed (Kolmogorov–Smirnov D-test, all $P > 0.05$), thus allowing comparisons using parametric tests (t-test). Pearson's correlation coefficient was computed to infer the pattern of relationships between SVL and age. The best regression model was selected according to R^2 values. All tests were processed with STATISTICA 7.0 (StatSoft Inc., USA) and Excel (Microsoft) and were interpreted at $\alpha = 0.05$.

3. Results

Lines of arrested growth were present in cross-sections of juvenile and adult phalanges. They appeared as thin and approximately concentric layers, more intensely stained than the rest of the cross-section. Endosteal resorption was observed in almost all cross-sections from adults and juveniles (Figures 1A and 1B). By comparing the diameters of eroded marrow cavities of adults with the diameters of noneroded marrow cavities of juveniles, we determined that endosteal resorption was not destroyed in the first LAG in 76% of the individuals, while the first LAG was completely eroded in 24% because of endosteal resorption. Endosteal bone deposition was also observed at certain points (Figures 1A and 1B). It was possible to estimate age for 100% (n = 21) of the available phalanges.

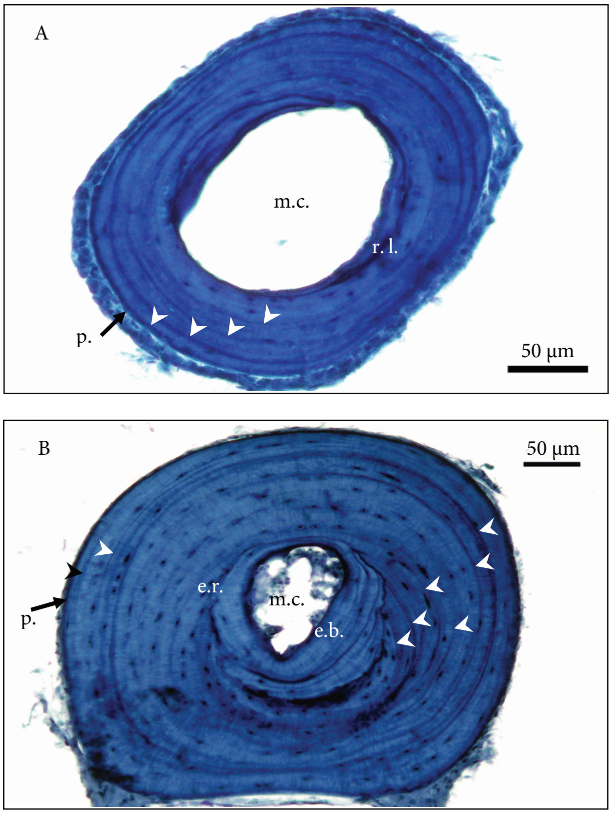

Figure 1. Cross-sections (18 µm thick) at the diaphysis level of a phalange of juvenile (A) and male (B) *Acanthodactylus boskianus*. A) Four-year-old juvenile, 45.14 mm body length. Four LAGs were observed in the periosteal bone. B) Eight-year-old male, 79.86 mm body length. Eight LAGs were observed in the periosteal bone (arrow heads). Endosteal resorption and endosteal bone were present. Periphery (black arrow) was not regarded as a LAG (m.c. = marrow cavity, r.l. = reversal line, e.r. = endosteal resorption, e.b. = endosteal bone).

Figure 2. Age distribution of male, female, and juvenile *Acanthodactylus boskianus*.

Descriptive statistics for SVL and age are shown in the Table. SVL of males was significantly larger than females (t = 8.654, df = 15, P = 0.000). SDI was calculated as –0.20, indicating a male bias. Minimum body length was 74.39 mm for reproductive males and 61.89 mm for females. The juvenile individuals had a mean SVL of 43.55 ± 2.02 mm (ranging from 37.74 to 47.06 mm).

Minimum ages were determined as 6 years for males and 5 years for females. Maximum ages were determined as 9 years for males and 7 years for females (Figure 2). The average ages of the males and females were calculated as 7.44 ± 0.34 and 6.13 ± 0.30 years, respectively (Table). Juveniles were from 3 to 4 years old. The difference in terms of age between the sexes was found statistically significant (t = 2.906, df = 15, P = 0.011). The youngest female was 5 years old, the youngest male was 6 years old, and the oldest juvenile was 4 years old. We thus estimated age at maturity to be 4–5 years. The adult survival rates were estimated to be 0.62 for males and 0.56 for females. ESP was 3.13 for males and 2.77 for females.

A significant positive correlation was found between age and SVL in males (r = 0.90, P < 0.01) and females (r = 0.97, P < 0.01). The best regression model was selected as an S-curve model according to R^2 values and the regression equations were SVL = 43.325Ln(age) – 8.3635 (R^2 = 0.940) for males and SVL = 35.337Ln(age) + 1.32 (R^2 = 0.925) for females (Figure 3).

4. Discussion

In this study, the first demographic data on the age structure of the *A. boskianus* population from southeastern Turkey are provided. The average ages of the males and females were calculated as 7.44 and 6.13 years, respectively, in this study (Table). The difference in age between the sexes was found to be statistically significant. The adult survival rates were estimated to be 0.62 for males and 0.56 for females. The adult survival rates were estimated to be 0.71 and

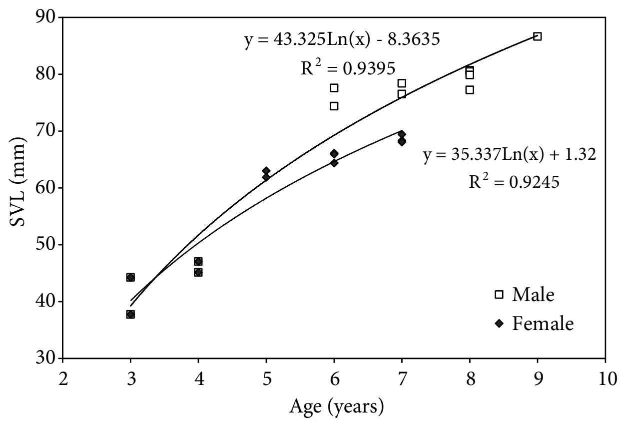

Figure 3. Relationship between SVL and age in male and female *Acanthodactylus boskianus*.

Table. Number of sampled individuals (n), SVL (mean ± SE), and range of *Acanthodactylus boskianus* population (min: minimum value, max: maximum value, SE: standard error of the mean).

	SVL (mm)			Age (years)		
	♂	♀	Juvenile	♂	♀	Juvenile
n	9	8	4	9	8	4
Min–max	74.39–86.66	61.89–69.45	37.74–47.06	6–9	5–7	3–4
Mean	79.09	65.90	43.55	7.44	6.13	3.50
Median	78.39	66.04	44.70	8	6	3.50
SE	1.16	0.95	2.02	0.34	0.30	0.29

0.75 for males and females, respectively, in *Dinarolacerta mosorensis* (Tomašević, 2010).

We found the maximum longevity to be 9 years for males and 7 years for females. Nouira (1987) reported a life span of around 4 years in nature for a population of *A. pardalis* from Tunisia. Guarino et al. (2010) found that age ranged from 2 to 4 years in males and from 2 to 3 years in females for a population of *Lacerta agilis* from Italy. However, in *L. agilis* living in Dagestan (Russia), the maximum longevity observed was 6–7 years for males and 5–6 years for females, depending upon altitudes (Roitberg and Smirina, 2006). For the same species living along the western coast of Sweden, maximum longevity was 11 years for males and 12 years for females (Olsson and Shine, 1996). Maximum observed longevity was also reported as 11 years and 8 years for *Eremias argus* females and males, respectively (Kim et al., 2010).

In our study, the mean SVL of males was significantly greater than that of females. Similar to our results, statistically significant differences between the sexes were also reported by Haenel and John-Alder (2002) for *Sceleporus undulates*, Liu et al. (2008) for *Lacerta vivipara*, and Ahmadzadeh et al. (2009) for *Eremias strauchi strauchi*, but in those cases the mean SVL of females was bigger than the males. No sexual size dimorphism in SVL was found between adult males and females in *Dinarolacerta mosorensis* (Tomašević et al., 2010). In contrast to our study, the mean SVL of females was bigger and did not differ significantly between sexes in the studies of *Eremias multiocellata* (Li et al., 2006), *Phymaturus patagonicus* (Piantoni et al., 2006), *Lacerta agilis* (Guarino et al., 2010), and *Eremias argus* (Kim et al., 2010).

In Bosc's fringe-toed lizard, the body size in both sexes significantly increased with age, which appears to be a general phenomenon in lizards that exhibit indeterminate growth (Bauwens, 1999). In this population, SVL of males was significantly greater than females and SDI was calculated as –0.20, indicating a male bias. Fitch (1981) also indicated that males are the larger sex in most lizards. This result is in agreement with the studies of *Agama impalearis* (El Mouden et al., 1999) and *Lacerta agilis boemica* (Roitberg and Smirina, 2006). However, no sexual dimorphism based on SVL was indicated between sexes in the studies of *Dinarolacerta mosorensis* (Tomašević et al., 2010) and *Eremias argus* (Kim et al., 2010). According to some studies, sexual size dimorphism in many adult lizards arises due to sexual differences in the growth rates, and the larger sex grows faster than the smaller sex (John-Adler and Cox, 2007; Tomašević et al., 2010). While some authors have suggested that sexual dimorphism has evolved as a result of competition between the sexes for a limited resource, such as food (Best and Gennaro, 1984), others have proposed that the primary cause of this dimorphism is sexual selection mediated by male–male competition for mates (Vitt and Cooper, 1985; Hews, 1990).

Consequently, we investigated some life history characteristics (i.e. body size, mean age, age at maturity, and longevity) of a breeding population portion of *A. boskianus* from southeastern Turkey. According to our results, the specimens reached sexual maturity at the age of 4 or 5, they had a lifespan of 7 to 9 years, and intersexual differences in body size were male-biased, which was also statistically significant. However, further studies are needed to obtain more comprehensive data about the life history characteristics of this species, especially for its populations in nature.

References

Ahmadzadeh F, Kami HJ, Hojjati V, Rezazadeh E (2009). Contribution to the knowledge of *Eremias strauchi strauchi* Kessler, 1878 (Sauria: Lacertidae) from Northwestern Iran. IJAB 5: 17–24.

Arakelyan M (2002). The study of age, growth, and longevity in the triploid hybrids of rock lizards of the genus *Darevskia* in Armenia. Russ J Herpet 9: 63–68.

Arnold EN (1983). Osteology, genitalia and the relationships of *Acanthodactylus* (Reptilia: Lacertidae). Bull Br Mus Nat Hist (Zool) 44: 291–339.

Baran İ, Atatür MK (1998). Türkiye Herpetofaunası (Kurbağa ve Sürüngenler), Ankara, Turkey: Çevre Bakanlığı (book in Turkish).

Baran İ, Ilgaz Ç, Avcı A, Kumlutaş Y, Olgun K (2012). Türkiye Amfibi ve Sürüngenleri. Ankara, Turkey: TÜBİTAK Popüler Bilim Kitapları (book in Turkish).

Bauwens D (1999). Life-history variations in lacertid lizards. Nat Croat 8: 239–252.

Best TL, Gennaro AL (1984). Feeding ecology of the lizard, *Uta stansburiana*, in southeastern Mexico. J Herpetol 18: 291–301.

Castanet J, Francillon-Vieillot H, Meunier FJ, De Ricgles A (1993). Bone and individual aging. In: Hall BK, editor. Bone. Vol. 7: Bone Growth. Boca Raton, FL, USA, pp. 245–283.

Castanet J, Smirina EM (1990). Introduction to the skeletochronological method in amphibians and reptiles. Ann Sci Nat Zool 11: 191–196.

El-Masry AA, Hussein HK (2001). Thermal relations, metabolism and winter dormancy of the sand lizard, *Acanthodactylus boskianus*. PJBS 4: 492–497.

El Mouden E, Znari M, Brown RP (1999). Skeletochronology and mark-recapture assessments of growth in the North African agamid lizard (*Agama impalearis*). J Zool Lond 249: 455–461.

Fathnia B, Rastegar-Pouyani N, Sampour M, Bahrami AM, Jaafari G (2009). The lizard fauna of Ilam province, southwestern Iran. IJAB 5: 65–79.

Fitch HS (1981). Sexual size differences in reptiles. Misc Publ Mus Nat Hist Univ Kans 70: 1–72.

Guarino FM, Giá ID, Sindaco R (2010). Age and growth of the sand lizards (*Lacerta agilis*) from a high Alpine population of north-western Italy. Acta Herpetol 5: 23–29.

Guarino FM, Lunardi S, Carlomagno M, Mazzotti S (2003). A skeletochronological study of growth, longevity, and age at sexual maturity in a population of *Rana latastei* (Amphibia, Anura). J Biosci 28: 775–782.

Haenel GJ, John-Alder HB (2002). Experimental and demographic analyses of growth rate and sexual size dimorphism in a lizard, *Sceloporus undulatus*. Oikos 96: 70–81.

Halliday T, Adler K (2002). The New Encyclopedia of Reptiles and Amphibians. Oxford, UK: Oxford University Press.

Harris DJ, Arnold EN (2000). Elucidation of the relationships of spiny-footed lizards, *Acanthodactylus* spp. (Reptilia: Lacertidae) using mitochondrial DNA sequence, with comments on their biogeography and evolution. J Zool 252: 351–362.

Hews DK (1990). Examining hypotheses generated by field measures of sexual selection on male lizards, *Uta palmeri*. Evolution 44: 1956–1966.

John-Alder HB, Cox RM (2007). The development of sexual size dimorphism in *Sceloporus* lizards: testosterone as a bipotential growth regulator. In: Fairbairn DJ, Blanckenhorn WU, Székely T, editors. Sex, Size and Gender Roles: Evolutionary Studies of Sexual Size Dimorphism. Oxford, UK: Oxford University Press, pp. 195–204.

Khannoon E, Breithaupt T, El-Gendy A, Hardege JD (2010). Sexual differences in behavioural response to femoral gland pheromones of *Acanthodactylus boskianus*. Herpetol J 20: 225–229.

Khannoon E, Flachsbarth B, El-Gendy A, Mazik K, Hardege JD, Schulz S (2011). New compounds, sexual differences, and age-related variations in the femoral gland secretions of the lacertid lizard *Acanthodactylus boskianus*. Biochem Syst Ecol 39: 95–101.

Kim JK, Song JY, Lee JH, Park D (2010). Physical characteristics and age structure of Mongolian racerunner (*Eremias argus*; Lacertidae). J Ecol Field Biol 33: 325–331.

Krebs CJ, Keller BL, Tamarin RH (1969). *Microtus* population demography: demographic changes in fluctuating populations of *Microtus ochrogaster* and *M. pennsylvanicus* in southern Indiana. Ecology 50: 587–607.

Li H, Ji X, Qu YF, Gao JF, Zhang L (2006). Sexual dimorphism and female reproduction in the multi-ocellated racerunner *Eremias multiocellata* (Lacertidae). Acta Zool Sinica 52: 250–255.

Liu P, Zhao WG, Liu ZT, Dong BJ, Chen H (2008). Sexual dimorphism and female reproduction in *Lacerta vivipara* in northeast China. Asiatic Herpetol Res 11: 98–104.

Lovich JE, Gibbons JW (1992). A review of techniques for quantifying sexual size dimorphism. Growth Develop Aging 56: 269–281.

McCoy ED, Mushinsky HR, Shockley WJ, Alvarez MR (2010). Skeletochronology of the threatened Florida sand skink, *Plestiodon (Neoseps) reynoldsi*. Copeia 2010: 38–40.

Nouira S (1987). Skeletochronological determination of age and demographic analysis of a population of *Acanthodactylus pardalis* (Lischenstein, 1823) of the Kerkennah islands (Tunisia). Arch Inst Pasteur Tunis 64: 351–362.

Olgun K, Üzüm N, Avcı A, Miaud C (2005). Age, size and growth of the southern crested newt *Triturus karelinii* (Strauch 1870) in a population from Bozdağ (western Turkey). Amphibia-Reptilia 26: 223–230.

Olsson M, Shine R (1996). Does reproductive success increase with age or with size species with indeterminate growth? A case study using sand lizards (*Lacerta agilis*). Oecologia 105: 175–178.

Pianka ER, Vitt LJ (2003). Lizards: Windows to the Evolution of Diversity. Berkeley, CA, USA: University of California Press.

Piantoni C, Ibargüengoytìa NR, Cussac VE (2006). Age and growth of the Patagonian lizard *Phymaturus patagonicus*. Amphibia-Reptilia 27: 385–392.

Rastegar-Pouyani N (1999). First record of the lacertid *Acanthodactylus boskianus* (Sauria: Lacertidae) for Iran. Asiat Herpetol Res 8: 85–89.

Robson DS, Chapman DG (1961). Catch curves and mortality rates. T Am Fish Soc 90: 181–189.

Roitberg ES, Smirina EM (2006). Adult body length and sexual size dimorphism in *Lacerta agilis boemica* (Reptilia, Lacertidae): between-year and interlocality variation. In: Corti C, Lo Cascio P, Biaggini M, editors. Mainland and Insular Lacertid Lizards: A Mediterranean Perspective. Florence, Italy: Firenze University Press, pp. 175–187.

Schleich HH, Kästle W, Kabisch K (1996). Amphibians and Reptiles of North Africa: Biology, Systematics, Field Guide. Königstein im Taunus, Germany: Koeltz Scientific Books.

Seber GAF (1973). The Estimation of Animal Abundance. New York, NY, USA: Hafner Press.

Seifan M, Gilad A, Klass K, Werner YL (2009). Ontogenetically stable dimorphism in a lacertid lizard (*Acanthodactylus boskianus*) with tests of methodology and comments on life-history. Biol J Linn Soc 97: 275–288.

Tomašević K, Ljubisavljević K, Polović L, Džukić G, Kalezić ML (2010). The body size, age structure and growth pattern of the endemic Balkan Mosor rock lizard (*Dinarolacerta mosorensis* Kolombatović, 1886). Acta Zool Acad Sci H 56: 55–71.

Vitt LJ, Cooper WE Jr (1985). The evolution of sexual dimorphism in the skink *Eumeces laticeps*: an example of sexual selection. Can J of Zool 63: 995–1002.