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AGE, ADULT SURVIVAL RATE, AND ADULT LIFE EXPECTANCY OF A *Podarcis tauricus* POPULATION (REPTILIA: LACERTIDAE) FROM SAROS BAY, TURKEY

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In this study, the age composition of a *Podarcis tauricus* population from Saros Bay (northwest Turkey) was determined by skeletochronology. 27 preserved adults (20♀♀, 5♂♂, 2 juveniles) were evaluated and the maximum observed lifespan was recorded to be 7 years in females and 6 years in males. The mean age was 5.2 ± 0.2 years in males and 5.0 ± 0.2 years in females; the mean snout-vent length (SVL) was 63.0 ± 0.7 mm (range: 60.4 – 64) in males and 61.3 ± 0.9 mm (range 52.4 – 68.5) in females. No significant differences were found between sexes in terms of body size, but the sexual dimorphism index (SDI), was determined as 0.03, indicating a weakly male-biased. Adult survival rate and adult life expectancy were estimated to be 0.51 and 2.54 for female individuals, respectively. The lizards reached sexual maturity between 2 and 3 years. No significant difference was found between the sexes in terms of age and head sizes. The age and SVL were correlated only in females. Additionally, a significant positive correlation was found among SVL, head length (HL), and width (HW) in females.

Keywords: age structure; sexual dimorphism; *Podarcis tauricus*; adult survival rate; adult life expectancy.

INTRODUCTION

Podarcis tauricus is a medium-sized lizard with a total length of up to 22 cm. It inhabits low and sparse vegetation with pebbly substrates or open places with sandy. Sometimes, it lives in a forest and feeds with insects. Its distribution can be up to 2350 m a.s.l. (IUCN, 2016).

Life-history data are crucial for providing answers to a great number of questions in evolution, ecology and conservation biology (Grimm et al., 2014). Knowing the age structure of a population provides important data about its demographic traits that have evolved in response to environmental factors (Sinsch et al., 2007). Some demographic parameters (i.e., lifespan, age at sexual maturity, the growth rate, fertility and reproduction timing) are related directly to an organism's condition (Tomašević et al., 2010).

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Skeletochronology, based on counting the lines of arrested growth (LAGs) in the bone tissue, has become a standard method for individual age estimation in many anurans (Leclair and Castanet, 1987; Miaud et al., 2007; Özdemir et al., 2012; Altunışık and Özdemir, 2015), urodelas (Verrell and Francillon, 1986; Olgun et al., 2001; Hasumi, 2010; Altunışık et al., 2014) and lizards (Tomašević et al., 2010; Altunışık et al., 2013; Gül et al., 2014; Yakin and Tok, 2015).

Although numerous demographic studies exist in the literature on the other lizard genera, there is little data (Barbault and Mou, 1988; Galán, 1999) available on life history characteristics like longevity, body size, age of sexual maturity, adult survival rate and adult life expectancy of *Podarcis* genus. This case encouraged us to investigate the age structure of the Balkan wall lizard, *Podarcis tauricus*, from a population located in northwest Turkey. So, the goal of this paper is to reveal the first data on the age, adult survival rate, adult life expectancy, maturity and sexual dimorphism on a *P. tauricus* population.

MATERIAL AND METHODS

Study site and sample collection

The 27 *P. tauricus* specimens (20♀♀, 5♂♂, and 2 juveniles) saved in the Zoological Collection of the Biology Department at Çanakkale Onsekiz Mart University, Turkey (collection number 137/2008) were used in this study. The samples were collected from Kavak Delta (Saros Bay), in the vicinity of Çanakkale (40°38′ N 26°50′ E; 7 m a.s.l.), Turkey.

Saros Bay was declared as "special environmental protection area" by the Ministry of Environment and Urban Planning of Turkey in 2010 for being an important wetland area for rich biodiversity. In this area, *Ophisops elegans*, *Lacerta trilineata*, *Pseudopus apodus*, *Malpolon monspessulanus*, and *Dolichophis caspius* were the other reptile species shared the same habitat with *P. tauricus* specimens.

Skeletochronological age estimation

We applied standard skeletochronology procedure that was described by Castanet and Smirina (1990) for laboratory protocols to assess the age structure. Firstly, we washed the phalanges kept in 70% ethanol in tap water then decalcified in nitric acid (5%) from 30 to 90 min depending on the bone structure. We prepared cross-sections (16 µm) of the phalangeal diaphysis by a freezing microtome (Shandon Cryostat, Germany) and stained them with Ehrlich hematoxylin. Cross-sections with the narrowest medullar cavity were examined for the presence of LAGs under a light microscope and they were independently assessed by two of the authors (A. Altunışık and T. Ergül Kalaycı) to provide precise age estimation.

Statistical analysis

We used Kolmogorov – Smirnov and Levene tests, for normality and homogeneity of variances for all variables, respectively. According to the Kolmogorov – Smirnov test, all data were normally distributed ($p > 0.05$), and therefore statistical significance was analyzed by using Student's *t*-test. The strength and direction of the relationship between age and body size (SVL, HL, and HW) were tested using Pearson's correlation coefficient. Regression analysis was performed by using the quadratic model, which has the highest R^2 value. All analyses were performed using SPSS 21 (IBM SPSS Statistics for Windows).

The snout-vent length (SVL), head width (HW), and head length (HL) of the specimens was measured using digital caliper. We calculated the sexual size dimorphism (SSD) according to a formula introduced by Ranta et al. (1994): Sexual Dimorphism Index (SDI) = 1 (mean body size of the larger sex/mean body size of the smaller sex).

We calculated adult survival rate from the age structure according to following formula (Miaud et al., 1999):

$$S_r = \frac{T}{\sum N} + T - 1,$$

where S_r is mean of finite survival rate estimate; T is the sum of the coded ages times their frequencies when age is found by arranging the youngest involved age class to 0, 1 and so forth

$$0N_x + 1N_{x+1} + 2N_{x+2} + ... + iN_{x+i};$$

$\sum N$ is the number of animals from x age class to $x + i$ class

$$N_x + N_{x+1} + N_{x+2} + ... + N_{x+i};$$

and N_x = number of individuals in age class x.

We calculated adult life expectancy (ESP) which is the expected life span of the lizards that have attained maturity by the formula of Seber (1973):

$$\mathrm{ESP} = 0.5 + \frac{1}{1 - S_r},$$

where S_r represents the survival rate. Since the number of males was inadequate ($n = 5$), we calculated S_r and ESP for only females.

RESULTS

Maximum age was determined as 7 years in a female *P. tauricus* specimen, and the cross-section of this individual was shown in Fig. 1. The mean age was determined as 5.2 ± 0.2 years in males and 5.0 ± 0.2 years in females. In Fig. 2, the age distribution of the population was given. The age of females was varied in the range between 4 and 7 years, whereas those of males were 5 and 6 years (Fig. 2). No significant difference was detected between the sexes with regard to mean age ($t = –0.46$, $df = 23$, $p > 0.05$).

Age at sexual maturity was designated using the distance between LAGs. Where we realized a significant decrease depending upon the thickness of the growth rings, we assumed it to sign the age when sexual maturity was attained (Ryser, 1988) and it was found as 2 and 3 years for both sexes in the studied population. S_r and ESP were calculated as 0.51 and 2.54 for female individuals, respectively.

Descriptive statistics of size parameters (SVL, HL, and HW) and age were given in Table 1. The mean SVL of the males was 63.0 ± 0.7 mm (range 60.4 – 64) and in females it was 61.3 ± 0.9 mm (range 52.4 – 68.5). Males were not significantly larger than females ($t = –0.956$, $df = 23$, $p > 0.05$), but SDI was computed as 0.03, mean-

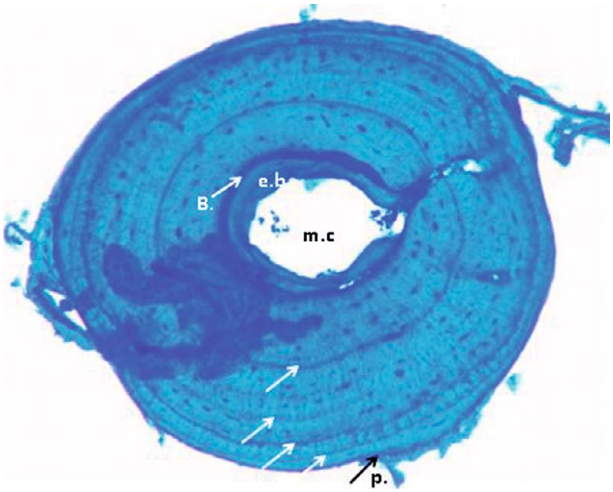

Fig. 1. Cross-section at the diaphysis level of a phalanx of a *P. tauricus* individual at the age of 5. Four LAGs were observed in the periosteal bone (white arrows). Periphery (black arrow) was regarded as a LAG (m.c., marrow cavity; B, border between periosteal and endosteal bone; e.b., endosteal bone; p, periphery).

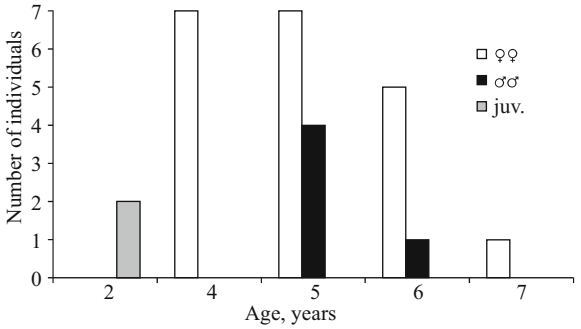

Fig. 2. Age distribution of *P. tauricus* individuals.

ing a weakly male-biased. SVLs of the juvenile individuals were measured as 36.3 and 36.9 mm.

The average HL was 15.2 mm (range 13.6 – 16.8) in males and it was 14.6 mm (range 12.7 – 16.9) in females. The mean HW of the males and females was 9.7 (range 8.6 – 10.2) and 9.0 mm (range 7.5 – 10.2), respectively. According to the results of Student's *t*-test, there was not statistically significant differences in terms of mean HL and HW between the sexes (HL: $t = -0.916$, $df = 23$; HW: $t = 1.828$, $df = 23$, $p > 0.05$).

According to Pearson's correlation coefficient, age and SVL were correlated only in females ($r = 0.68$, $p < 0.01$). However, there was not any relationship between age and head measurements (age-HL: $p > 0.05$; age-HW: $p > 0.05$) for both sexes. Additionally, there was a positive correlation among SVL, HL, and HW (SVL-HL: $r = 0.52$; SVL-HW: $r = 0.54$; HL-HW: $r = 0.72$, $p < 0.05$) in females.

DISCUSSION

We provided the first knowledge about the age composition of the *P. tauricus* population from northwest Turkey. In addition to this, we calculated sexual size dimorphism, ESP and S_r of the population.

Generally, lizards from low altitudes and southern latitudes live shorter than those in high altitudes and northern latitudes (Sears and Angilletta, 2004). We recorded longevity as 7 years for the studied *P. tauricus* population from Saros Bay which has low altitude (7 m a.s.l.). As well as similar conclusions, there are many different results comparing to our results in terms of altitude gradients. Barbault and Mou (1988) reported maximum lifespan as 5 years for the other *Podarcis* species, *P. muralis* (common wall lizard), from the mark-recapture study in Juillac, France (about 300 m a.s.l.). In another lizard species (*Dinarolacerta mosorensis*), which is endemic to Balkans (1350 m a.s.l.), the median age was found to be 6 years for females and 5 years for males, while the maximal lifespan was found as 9 years in both sexes (Tomašević et al., 2010). Maximum longevity was found to be 7 years in females and 9 years in males of *Acanthodactylus boskianus* from Birecik, Turkey (445 m a.s.l.) (Üzüm et al., 2014). However, in a population of *Anatololacerta anatolica* from northwest Turkey (low altitude, 10 – 30 m a.s.l.), the maximum age was detected as 10 years for a female individual (Yakın and Tok, 2015).

TABLE 1. Descriptive Statistics of Age, SVL, HL, and HW for the Studied Population

Sex	*N*	Age, years		SVL, mm		HL, mm		HW, mm	
		mean ± SE	range	mean ± SE	range	mean ± SE	range	mean ± SE	range
Males	5	5.2 ± 0.2	5 – 6	63.0 ± 0.7	60.4 – 64.0	15.1 ± 0.6	13.6 – 16.8	9.7 ± 0.3	8.6 – 10.2
Females	20	5.0 ± 0.2	4 – 7	61.3 ± 0.9	52.4 – 68.5	14.6 ± 0.3	12.7 – 16.9	9.0 ± 0.2	7.6 – 10.2
Juvenile	2	2	2	36.6	36.3 – 36.9	10.46	9.9 – 11.1	6.1	5.5 – 6.6

Age at maturity is an important life history parameter and it is associated with environmental conditions. Several authors suggested that lizards attain sexual maturity after having reached a certain minimum size but a variable age (Barbault and Mou, 1988; Adolp and Porter, 1996; Bauwens, 1999; Galan, 1999; Tomašević et al., 2010). In this study, both sexes reached sexual maturity at 2 or 3 years with a minimum size of 53 mm. Barbault and Mou (1988) recorded that the smallest sexually mature *P. muralis* female had 54 mm SVL and females did not mature until they were approximately 2 years old. According to Galan (1999), *P. bocagei* individuals matured at 1 or 2 years which was generally based on the birth time (early or late in the season) of the individual.

SSD and some morphological characteristics are well known in lizards (Altunışık et al., 2013) and according to some authors this phenomenon is generally resulted from sexual selection, especially for mating competition between the males (Vitt and Cooper, 1985; Shine, 1989; Hews, 1990; Vincent and Herrel, 2007). Whereas, Best and Gennaro (1984) pointed out natural selection as the reason of this dimorphism caused by the factors such as food competition. It is a general trend that most species of lacertid lizards are male-biased in terms of body size and head dimensions (Kaliontzopoulou et al., 2007). Consistent with this trend, in the population under study, Balkan wall lizard indicated a low male biased SSD (0.03) in adults depended upon the SVL, which was not statistically significant. Similar to our results, Roitberg and Smirina (2006) and Tomašević et al. (2010) reported a weakly male biased SSD for *Lacerta agilis* and *Dinarolacerta mosorensis* species, respectively. However, Üzüm et al. (2014) found that the body size of females were significantly smaller than the males and SSD was computed as –0.20, stating that a male bias for *Acanthodactylus boskianus* individuals.

Conforming with Asaccus barani study (Ergül Kalaycı et al., 2015), the current study found that the SVL, HL, and HW of *P. tauricus* did not differ statistically between the sexes. Since the body size and head measurements correlated with each other, it is usual that we did not found any differences between males and females with similar body size. However, in the studies of Kim et al. (2010) and Ramirez-Bautista et al. (2014), the head lengths (*Eremias argus*) and head size (*Sceloporus minor*: both head length and width) of the male lizards were found significantly greater than those of females. That male lizards have larger head may add an advantage in mating competitions between males.

In the present study, we calculated the adult survival rate and adult life expectancy as 0.51 and 2.54 for female individuals of Balkan Wall lizard, respectively. According to a mark-recapture study on *Podarcis bocagei* population from north-west Spain, Galan (1999) reported adult survivorship and estimated mean generation time as 7 and 2.09 years, respectively. In *Dinarolacerta mosorensis*, S_r was determined as 0.71 and 0.75 for males and females, respectively (Tomašević et al., 2010). Additionally, Üzüm et al. (2014) determined S_r as 0.62 for males and 0.56 for females in *Acanthodactylus boskianus*. Also, in the same study, adult life expectancy was declared as 3.13 for males and 2.77 for females.

In general, body size becomes larger with age in lizards that exhibit indeterminate growth (Bauwens, 1999). In the present study, the expected correlation between age and body size was statistically significant in only females. This case may be the result of low numbers of the males. However, we did not find any relationship between age and head measurements for both sexes.

This paper has given preliminary data for longevity, mean age, age at sexual maturity and body size of *P. tauricus* where these demographic parameters are poorly known. Although this research will serve as a base for future studies, more research is needed for improving our knowledge on demographic parameters of the Balkan wall lizard.

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