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Seasonal activity, sex ratio, and abundance in a population of *Lacerta agilis* LINNAEUS, 1758 from the Czech Republic

(Squamata: Lacertidae)

Dauer der jährlichen Aktivitätsperiode, Geschlechterverhältnis und Abundanz in einer Population von *Lacerta agilis* LINNAEUS, 1758 in der Tschechischen Republik

(Squamata: Lacertidae)

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KURZFASSUNG

Untersucht wurden die Dauer der jährlichen Aktivitätsperiode, das Geschlechterverhältnis und die Abundanz von *Lacerta agilis* LINNAEUS, 1758 aus dem Gebiet von Opava in der Tschechischen Republik. In Abhängigkeit von Geschlecht, Alter und Untersuchungsjahr waren die Eidechsen vier bis sechs Monate im Jahr aktiv. Die Männchen beendeten ihre Überwinterung vor den Weibchen. Das Geschlechterverhältnis adulter Individuen war zu verschiedenen Zeiten und insgesamt weitgehend ausgeglichen. Die mittlere Populationsdichte adulter und subadulter Tiere wurde auf 73 Individuen je Hektar geschätzt.

ABSTRACT

Length of the period of seasonal activity, sex ratio, and abundance were studied in a population of *Lacerta agilis* LINNAEUS, 1758 from near Opava in the Czech Republic. Lizards were active during four to six months of the year depending on sex, age, and year of observation. Males emerged earlier from hibernation than females. In adults, both total and operational sex ratios did not differ significantly from a balanced situation. The estimate of the average population density of adults and subadults was 73 individuals per hectare.

KEY WORDS

Reptilia: Squamata: Lacertidae: *Lacerta agilis*; population ecology, population size, sex ratio, activity period, phenology, Czech Republic

INTRODUCTION

Lacerta agilis LINNAEUS, 1758 is a small (total length about 200 mm in central Europe), diurnal, insectivorous lizard occurring in a substantial part of Europe and temperate Asia (BISCHOFF 1984). Females lay 6-12 eggs in June (RYKENA 1988). The lizards reach maturity in their third activity season (STRIJBOSCH & CREEMERS 1988).

Population ecology of *L. agilis* was extensively studied by several authors in various parts of the range (e.g., SHCHEPOTEV 1948; YABLOKOV 1976; RAHMEL & MEYER 1987, 1988; STRIJBOSCH & CREEMERS 1988). Available information reveals a considerable variation in many population characteristics, e.g., length of seasonal activity or population density (TERTYSHNIKOV 1976; NULAND & STRIJBOSCH 1981). On the other hand, some characteristics are similar among populations such as sex-dependent beginning of the seasonal activity (NULAND & STRIJBOSCH 1981; NICHOLSON & SPELLERBERG 1989) or female-biased sex ratio (OLSSON 1988; RAHMEL & MEYER 1988; STRIJBOSCH & CREEMERS 1988). However, with respect to the large size of its distribution area and the diversity of habitats occupied, published data still gives only limited information on the overall geographic variation of these parameters in *L. agilis*. Thus, more data is necessary for comparative studies, especially from populations in little studied parts of the species' range. The aim of this note is to provide comparative information on seasonal activity patterns, sex ratio, and population density in a population of *L. agilis* from the territory of the Czech Republic.

Table 1: Date and duration of field trips in the study area during the years 1993 and 1994. n. a. - not available.
Tab. 1: Begehungsdaten des Untersuchungsgebietes in den Jahren 1993 und 1994. n. v. - nicht verfügbar.

1993			1994		
Month / Monat	Day / Tag	Time of the Day/ Tageszeit	Month / Monat	Day / Tag	Time of the Day/ Tageszeit
March/März	25	n. a. / n. v.	March/März	19	n. a. / n. v.
April	4	11:00 - 14:00		31	12:00 - 15:00
	13	12:00 - 14:00		9	12:00 - 15:00
	17	12:00 - 15:00		15	13:00 - 14:00
	22	14:00 - 16:00		22	11:00 - 16:00
	25	12:00 - 16:00		28	12:00 - 14:00
May/Mai	1	11:00 - 15:00	May/Mai	8	10:00 - 13:00
	7	n. a. / n. v.		14	11:00 - 15:00
	30	n. a. / n. v.		31	13:00 - 16:00
July/Juli	20	14:00 - 17:00	June/Juni	10	13:00 - 15:00
August	2	14:00 - 16:00		15	14:00 - 17:00
	12	09:00 - 11:00		23	14:00 - 17:00
September	8	14:00 - 16:00	July/Juli	7	13:00 - 15:00
	9	12:00 - 14:00		31	09:00 - 17:00
	20	n. a. / n. v.	August	17	09:00 - 17:00
	27	n. a. / n. v.		29	n. a. / n. v.
October/Oktober	8	n. a. / n. v.	September	2	n. a. / n. v.
				12	n. a. / n. v.
				22	12:00 - 14:00
				26	13:00 - 15:00
			October/Oktober	3	n. a. / n. v.

MATERIALS AND METHODS

Data was gathered during two consecutive years (1993 and 1994) as a part of my MS thesis (GVOŽDÍK 1995, unpublished). The study area was a sand pit, 19,000 m^2 in size, situated 3.5 km NW of the town of Opava (17° 53' E, 49° 08' N, 280 m a.s.l.). The bottom of the sand pit was 8 - 10 m below the level of the ambient area and, thus, surrounded by steep walls except for a 4 m wide drive. Approximately one third of the area was covered by bare sand with little vegetation, one third was well covered by grass (*Calamagrostis epigeios*), various ruderal herbs (e.g., *Plantago* sp., *Equisetum* sp., *Urtica* sp.), and scattered birches (*Betula pendula*) and one third consisted of birch forest.

During sunny days I walked haphazardly across the study area and captured lizards by hand or by noosing (table 1). Each captured specimen was individually marked (WAICHMANN 1992) and the following data were recorded: date of capture, sex (based on secondary sexual characters), snout-vent length (SVL; to 0.1 mm with dial calipers) and body mass (BM; to 0.1 g with Pesola scales).

When captured for the first time, the lizards were assigned to one of three age groups by their SVL and BM (assignment based on data of individuals of known age from a previous capture-recapture study - GVOŽDÍK, unpublished); juveniles (1st calendar year of life; size range: 24.1 - 34.5 mm), subadults (2nd calendar year of life; size range: 26.5 - 66.4 mm), and adults (3rd calendar year of life and older; size range: 54.8 - 83.9 mm).

To assess the duration of the activity period in the population studied, I recorded the beginning and end of the activity period of males, females, and immatures (juveniles and subadults), in 1993 and 1994. The earliest monthly decade (i.e. ten-days-period) in which three specimens of a given sex were observed was considered as the beginning of the seasonal activity of this sex. Similarly, I defined the end of the seasonal activity as the monthly decade after which a maximum of three specimens was observed.

Operational (all mature individuals captured and recaptured within a given period) and total (all mature individuals cap-

tured) sex ratios were expressed as proportions of females (P_f) in a particular sample, with the standard error (SE) calculated after CAUGHLEY (1977):

$$SE_{P_f} = \sqrt{P_f(1-P_f)/n}$$

where n = number of males and females in the sample

Population size (N) was estimated on the basis of two samples (31 July and 17 August, 1994) using Bailey's modification (N_B) of the Petersen estimate (DONNELLY & GUYER 1994):

$$N_B = \frac{r(n+1)}{m+1}$$

where r = number of animals caught, marked, and released on day 1; n = total number of animals caught on day 2; m = total number of marked animals caught on day 2. Standard error of N_B was calculated as follows (DONNELLY & GUYER 1994):

$$SE_{N_B} = \left[\frac{r^2(n+1)(n-m)}{(m+1)^2(m+2)}\right]^{1/2}$$

I used Bailey's modification because it gives a more accurate estimation of the population size than the Petersen estimate when the number of recaptures is small. Only adults and subadults were used for estimation of population size. Since potential sex differences in activity during reproduction may result in unequal catchability of the sexes, population size was estimated after the end of the reproductive period. With respect to topographical characteristics of the study area, I assumed that emigration or immigration rates were negligible during the sampling period.

The numbers of males and females in particular samples were compared (H_0: equal numbers of males and females) using Fisher's exact test or G-test (SOKAL & ROHLF 1995) depending on sample size. A significance level of $P < 0.05$ was set for both tests. Statistical tests were performed using the JMP® statistical program (SAS® Institute 1995).

RESULTS

The length of the activity period varied from 4.3 (females) to 6.3 (immatures) months depending on sex/age category and year of observation (table 2). During two consecutive seasons, males emerged earlier from hibernation than females while the end of activity was the same in both sexes. Annual period of activity lasted one to four monthly decades longer in males than in females.

In total, 29 (16 males, 13 females) and 127 (68 males, 59 females) adult individuals were captured in 1993 and 1994 respectively. Total sex ratio (expressed as the proportion of females) did not deviate significantly from 0.5 in both years (1993: P_f = 0.45 ± 0.09, Fisher's exact test P = 0.80; 1994: P_f = 0.46 ± 0.04, G-test, df = 1, G = 0.33, P = 0.57). In 1994, the operational sex ratios ranged from 0 (March) to 0.58 (July) (table 3). Male-biased sex ratio is suggested by the raw data for March, April, and September. However, this imbalance was significant only for April which may be due to the small sample size. In March, the sample consisted solely of males.

The estimated population size ($N_B \pm SE_{N_B}$) was 138 ± 56 individuals which means that the average population density in the study area was about 73 individuals per hectare (r = 22; n = 24; m = 3).

DISCUSSION

The duration of the period of seasonal activity substantially varies among populations of *L. agilis* (compare TERTYSHNIKOV 1976; NULAND & STRIJBOSCH 1981; this study) which seems to be primarily a consequence of geographical variation in environmental temperatures (ADOLPH & PORTER 1993). However, comparison of the du-

Table 2: Beginning and end (decade / month) of the activity period in male, female and immature (juvenile and subadult) *Lacerta agilis* in two consecutive years.

Tab. 2: Beginn und Ende der Aktivitätsperiode (Dekade / Monat) bei Männchen, Weibchen und immaturen Individuen (Juvenile und Subadulte) von *Lacerta agilis* während zweier aufeinanderfolgender Untersuchungsjahre.

Category / Kategorie	Activity period / Aktivitätsperiode			
	Beginning / Beginn		End / Ende	
	1993	1994	1993	1994
Males / Männchen	2 / IV	3 / III	1 / IX	1 / IX
Females / Weibchen	3 / IV	1 / V	1 / IX	1 / IX
Immatures / Immature	2 / IV	3 / III	2 / IX	3 / IX

Table 3: Operational sex ratio. Variation of the proportion of females (P_f) among active adult *Lacerta agilis*, between March and September 1994. SE_{Pf} - Standard error; * - $P < 0.05$ (Fisher's exact test).

Tab. 3: Operationales Geschlechterverhältnis. Unterschiede im Anteil der Weibchen (P_f) unter den aktiven adulten Zauneidechsen in den Monaten März bis September des Jahres 1994. SE_{Pf} - Standardfehler; * - $P < 0.05$ (Fisher's exact test).

Month / Monat	Individuals captured / gefangene Individuen Females / Weibchen	Males / Männchen	Proportion of females (P_f) $\pm SE_{Pf}$ Weibchenanteil (P_f) $\pm SE_{Pf}$
March / März	0	4	0.00 ± 0.00
April	2	18	0.10 ± 0.07*
May / Mai	17	20	0.46 ± 0.08
June / Juni	16	13	0.55 ± 0.09
July / Juli	18	13	0.58 ± 0.09
August	14	11	0.56 ± 0.10
September	3	10	0.32 ± 0.12

ration of activity periods observed by different authors must be done with caution because of inconsistencies in the applied methods of recording the beginning and the end of the activity period. In the present study, males emerged earlier from hibernation than females which is consistent with observations from other populations of *L. agilis* (NULAND & STRIJBOSCH 1981; NICHOLSON & SPELLERBERG 1989; but see TERTYSHNIKOV 1976 for contrasting results). Why males are the first to emerge in *L. agilis* remains unknown. However, NICHOLSON & SPELLERBERG (1989) hypothesized that males probably emerge earlier from hibernation to elevate their body temperatures and thereby increase the rate of sperm development during spermatogenesis as it is also suggested for *Zootoca vivipara* (JACQUIN, 1787) by VAN DAMME et al. (1987).

The present result of a largely balanced total sex ratio in adults is surprising because most authors reported a female-biased sex ratio in *L. agilis* (SHCHEPOTEV 1948; YABLOKOV 1976; OLSSON 1988; RAHMEL & MEYER 1988; STRIJBOSCH & CREEMERS 1988) allegedly resulting from higher mortality rates in males (YABLOKOV 1976; STRIJBOSCH & CREEMERS 1988). Consequently, and assuming that the sex ratio of the hatchlings is balanced, similar numbers of adult males and females should suggest negligible differences in mortality rates between the sexes. Except for the beginning and end of the activity period, operational sex ratio also showed minor variation. Only in April, sex ratio was significantly male-biased caused by the later emergence of females from hibernation (table 2). Assuming equal catchability of the sexes, similar numbers of captured males and females may roughly indicate similar levels of surface activity in both sexes during the period of May to August. However, it must be stressed that under surface activity, the occurrence of lizards on the ground is understood here. This should not be confused with moving activity which is usually higher in males during the mating period (NICHOLSON & SPELLERBERG 1989).

In the present study, estimated population density was substantially below the density estimates on *L. agilis* from other

places in Central Europe (e.g., Hungary: 160 individuals/ha - KORSÓS 1984; Austria: 280 individuals/ha - RAHMEL & MEYER 1988). Among other factors this may be due to habitat heterogeneity (see Materials and Methods) resulting in a patchy distribution of lizards within the study area. Lizards were rarely (during mating period) observed in birch forest as well as on bare sand which both together constitute two thirds of the study area. Thus, the effective density should be, in fact, three times higher than the average density in the whole sand pit. Under the above provision, the effective density estimate, i.e., 219 individuals/ha, is comparable with data published elsewhere.

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