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Seasonal Diet Variations of the Sand Lizard (*Lacerta agilis*) (Lacertidae, Reptilia) in the Northern Lower-Volga Region

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The feeding of *Lacerta agilis* was studied by means of the content analysis of lizards' stomachs conducted in the vicinity of Saratov City from April till September 1983, 2003 and 2007. The maximum daily diet was characteristic in July and reached 2.5–2.7 g/day, while the minimum one was in April and September (1.1–1.2 g/day). The highest and lowest numbers of food objects were recorded in May and September, respectively. Insects are the basic food objects of *L. agilis*, their occurrence frequency being 100% during the whole active-life period. Coleoptera representatives predominated in the diet (25.4–40.5% by number, 43.5–70.9% by weight). The fractions of Lepidoptera, Hymenoptera, Diptera, etc. were somewhat lower. Well-flying and quickly-moving insects predominated in the food spectrum of *L. agilis*. Rather many invertebrates with cryptic colour, poisonous, stinging and badly smelt ones were frequently met among the nutrition objects. Moreover, vegetable remains (seeds, leaves, flower fragments etc.) and various small stones to act probably as gastrolites were found in many stomachs.

Keywords: *Lacerta agilis*, insects, daily diet, biomass, Saratov region.

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The sand lizard (*Lacerta agilis* (Linnaeus, 1758)) is a most studied representative of the *Lacerta* genus in the Russian herpetology. This is mainly due to its inclusion into the list of species for monographic description. The labour of many authors has resulted in the monograph “Sand lizard” (Yablokov, 1976) with a chapter to describe the composition

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of food, its specific features in various parts of the habitat, age, sexual and biotopical peculiarities, seasonal and perennial dynamics and other ecological aspects. However, the existing data are expedient to be supplemented with new ones. The study of trophic ecology is important for understanding the role of reptiles in ecosystems and the prospects for the development of their populations (Pincheira-Donoso, 2008). While examining the nutrition of *L. agilis* (as well as many other vertebrates) the utilized masses of various food groups have rarely been estimated (Shlyakhtin et al., 2006). Besides, the literature data on the amount of food and daily diet of *L. agilis* seem inconsistent and rather common (Schepotev, 1948, 1952; Lukina et al., 1976; Zavialov et al., 2000; Tertyshnikov, 2002; Shlyakhtin et al., 2006). This produces vague knowledge of the population dynamics of nutrition, the daily diet of lizards and its seasonal variations. We focused on these aspects of the nutrition ecology of *L. agilis* by conducting surveys in the population inhabiting a gully slope near Saratov City.

The nutrition of *Lacerta agilis* was studied by means of the content analysis of lizards' stomachs according to a bloodless technique (Legler, Sullivan, 1979; Shlyakhtin, Golikova, 1986). Collections were made from April till September in 1981, 2003 and 2007. Lizards were caught after 3–4 p.m. when their stomachs were full of food, marked and subjected to gastric content extraction. The nutrition behaviour of *L. agilis* was also observed in the nature. 245 samples were treated in total (Table 1). The abundance was estimated on a 2,000 × 3 m route band (Shlyakhtin, Golikova, 1986).

Table 1. Numbers of *Lacerta agilis* examined

Year	Month						Total
	April	May	June	July	August	September	
1981	–	10	–	25	–	–	35
2003	–	18	13	28	11	22	92
2007	7	17	12	40	15	27	118
Total	7	45	25	93	26	49	245

The normality of our sample distribution was determined by the Shapiro–Wilk criterion (*W*). All data with continuous variation (the mass of lizards and daily ration) were normally distributed ($p > 0.05$). Descriptive statistics were used for such data (mean – *M*, standard deviation – *SD*, variation range – *min–max*). For counting data (the number of preys), the median (*Me*) and interquartile range (25–75 percentiles) were calculated. Intra-annual and interannual differences in sexes according to the body weight of lizards and their daily diet were estimated using one-way ANOVA (*F*), and the Kruskal–Wallace test (*H*) was used for the number of preys at $p = 0.05$. Statistical data processing was performed by the PAST 2.17 software package (Hummer et al., 2001).

Sand lizards quickly bolt a petty prey as a whole. In case of a bigger prey, a lizard strongly squeezes it in its jaws and starts shaking its head from side to side, sometimes releasing the prey and snapping it again. Usually the lizard takes its prey with its jaws several times to direct it along the body axis and squeezes strongly to squash it for easier delivery through the gullet to the stomach (Shlyakhtin, 1987; Shlyakhtin et al., 2005).

The daily diet quantity changes within the active life period and varies strongly for different individuals. E.g., the daily diet quantity of *L. agilis* caught in July 1981, 2003 and 2007 (after the reproduction period) varied within wide limits, from 4 to 54 insects and from 0.73 to 6.52 g (Table 2).

Table 2. Lizard mass, number of preys and daily diet of *Lacerta agilis* (July 1981, 2003 and 2007)

Year	Sex	N	Lizard mass, g *	Number of preys **	Daily diet, g *
1981	Males	13	$\frac{15.1 \pm 2.06}{12.1-18.6}$	$\frac{19}{14-30}$	$\frac{2.64 \pm 1.43}{0.88-6.52}$
	Females	12	$\frac{15.0 \pm 2.03}{12.3-18.3}$	$\frac{16.5}{10-30}$	$\frac{2.56 \pm 1.42}{0.73-5.25}$
2003	Males	15	$\frac{15.2 \pm 2.07}{11.8-19.1}$	$\frac{22}{14-30}$	$\frac{2.80 \pm 1.63}{0.97-5.93}$
	Females	13	$\frac{14.9 \pm 1.46}{12.2-18.2}$	$\frac{19}{14-22.5}$	$\frac{2.49 \pm 1.23}{0.81-5.25}$
2007	Males	20	$\frac{15.0 \pm 2.17}{11.6-18.8}$	$\frac{17.5}{12.5-27.3}$	$\frac{2.52 \pm 1.391}{0.88-6.52}$
	Females	20	$\frac{15.0 \pm 2.10}{12.0-18.3}$	$\frac{15}{8.3-27.5}$	$\frac{2.30 \pm 1.289}{0.83-5.25}$

Note. * – the mean (*M*) and standard deviation (*SD*) in the numerator, the range of variation (*min* – *max*) in the denominator; ** – the median (*Me*) in the numerator, the interquartile range (25–75 percentil) in the denominator.

The survey has shown animals of masses within 50–200 mg and body lengths within 10–25 mm to be the most preferred prey. They constitute 73.9 and 85.7%, respectively, of the whole number of invertebrates caught. Such sizes of preys' bodies are obviously optimal for *L. agilis*. Of animals with big body lengths and masses sand lizards mainly catch invertebrates with soft integuments, namely, Oligochaeta, Myriapoda, and Lepidoptera. Most of the caught food objects had chitin integuments, they were found in 95.3% stomachs analyzed while 64.7% of all the samples comprised only chitin-covered insects.

There were no statistically significant ($p > 0.05$) differences between males and females by the quantity and volume of feed. However, a male stomach contained more food objects than a female one on the average (Table 3 and 4). Besides, the food composition of males was more diverse.

Table 3. Sex differences in the feeding of *Lacerta agilis*

Year	<i>W</i>	Number of preys	Daily diet
	$\frac{F}{p}$	$\frac{H}{p}$	$\frac{F}{p}$
1981	$\frac{0.009}{0.93}$	$\frac{0.39}{0.53}$	$\frac{0.02}{0.89}$
	$\frac{0.18}{0.67}$	$\frac{0.85}{0.35}$	$\frac{0.32}{0.58}$
2007	$\frac{<0.0001}{0.99}$	$\frac{1.09}{0.30}$	$\frac{0.27}{0.61}$

These distinctions are obviously due to bigger heads and teeth (Vorobiova, Chugunova, 1995), and their higher mobility (Chernomordikov, 1944).

Individual variations within certain limits are characteristic of the whole active-life period of *L. agilis*. At the same time, generalized data for each month show natural variations of the daily diet during the whole active period.

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On awakening (middle or late April) a sand lizard catches ca. 20 animals per day with their biomass of 1.2–1.3 g. In May the daily diet significantly increases by weight and reaches 2 g. A similar level is characteristic of June. July shows the highest daily diet (2.6 g in the population under survey). In August the daily diet reduces down to 2.2 g. In September, before growing torpid, it decreases significantly (down to 1.3 g). The average number of preys reduces as well. A similar daily diet and its seasonal changes were characteristic of this species on the slopes of the Ural (Galitsyn, 2014).

The daily diet dynamics is closely related to the biological cycles of *L. agilis* and ambient temperature. On spring awakening the air temperature is not high and rather unstable, so sand lizards hunt in the daytime only. At this time, mating begins and lizards eat less intensely. On mating (May–June) the daily diet increases sharply to reimburse the energy for reproduction and (for females) egg production (Shlyakhtin et al., 2006).

Significant differences in the size of the daily diet of lizards can be determined by the dynamics of the accessibility of food objects (Diaz, Carrascal, 1993) and their spatial distribution, as well as the level of vegetation development (Pitt, Ritchie, 2002). The increase in trophic activity that we found in the second half of July–August is apparently characteristic of the entire habitat of the sand lizard, due to an increase in the number of insects during this period and is associated with an intensive accumulation of energy reserves in the liver and fat bodies (Amat et al., 2000).

The highest ambient temperature is observed in July, so the active period extends and sand lizards take much food for their bodies to grow (Shlyakhtin et al., 2005). Since mid-August the temperature falls, the hunting time reduces, the diet in September becomes relatively poor with irregular eating.

Thus, insects form the nutrition basis of *L. agilis*. Their occurrence frequency in stomachs within the whole active-life period is 100%. Representatives of other classes, though of relatively little importance, are found more frequently than reported in the monograph (Yablokov, 1976).

Of insects, Coleoptera representatives predominate in the diet of *L. agilis* in all months (25.4–40.5% by number, 43.5–70.9% by weight). Lepidoptera, Hymenoptera, Diptera, Homoptera, Hemiptera, and Orthoptera have subdominant importance among insects in different months. The diet of *L. agilis* contains much more well-flying and quickly-moving animals in comparison with not so mobile ones. There are relatively many invertebrates with a cryptic colour, poisonous, stinging, and badly smelt ones. Vegetable remains (seeds, leaves, flower fragments) found in stomachs may have gotten into them by chance, i.e. have been seized together with insects. Moreover, various small stones were found in *L. agilis* stomachs, probably acting as gastrolytes.

Table 4. Interannual differences in the feeding of *Lacerta agilis* males and females

Sex	W	Number of preys	Daily diet
	$\frac{F}{p}$	$\frac{H}{p}$	$\frac{F}{p}$
Male	$\frac{0.06}{0.95}$	$\frac{0.89}{0.64}$	$\frac{0.16}{0.86}$
Female	$\frac{0.009}{0.99}$	$\frac{0.76}{0.68}$	$\frac{0.17}{0.84}$

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SEASONAL DIET VARIATIONS OF SAND LIZARDS

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СЕЗОННАЯ ДИНАМИКА РАЦИОНА ПРЫТКОЙ ЯЩЕРИЦЫ (*LACERTA AGILIS*) (LACERTIDAE, REPTILIA) НА СЕВЕРЕ НИЖНЕГО ПОВОЛЖЬЯ

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Изучение питания *Lacerta agilis* основано на анализе проб содержимого желудков, собранных в окрестностях г. Саратова с апреля по сентябрь в 1981, 2003, 2007 гг. Максимальные значения суточного рациона были характерны в июле и достигали 2.5 – 2.7 г/сут., минимальные – в апреле и сентябре – 1.1 – 1.2 г/сут. Наибольшее количество пищевых объектов отмечено в мае, наименьшее – в сентябре. Выявлено, что основу питания *L. agilis* составляют насекомые; их частота встреч на протяжении всего периода активной жизни составляет 100%. При этом в диете преобладали представители отряда Coleoptera (число экземпляров составляло 25.4 – 40.5%, а утилизованной биомассы – 43.5 – 70.9%). Несколько ниже доля среди насекомых занимали представители Lepidoptera, Hymenoptera, Diptera и др. Причем в пищевом спектре *L. agilis* преобладали насекомые, хорошо летающие и быстро передвигающиеся. Сравнительно много среди объектов питания беспозвоночных с криптической окраской, а также ядовитых, жалающих и с резким запахом. Кроме того, в содержимом многих желудков были встречены растительные остатки в виде семян, листьев, элементов цветка и т.п., а также различные небольшие камешки, возможно, выполняющие роль гастролитов.

Ключевые слова: *Lacerta agilis*, насекомые, суточный рацион, биомасса, Саратовская область.

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