THE STUDY OF THE ECOLOGICAL NICHE SEGREGATION FOR SYMPATRIC SPECIES OF LIZARDS *Lacerta agilis* AND *Zootoca vivipara*

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Sand and viviparous lizards, *Lacerta agilis* and *Zootoca vivipara* — the species of the Lacertidae family, are widely spread in the Palearctic zone. Due to the high number and ability to accumulate a considerable amount of biomass in the forest zone, lizards play an important role in the substance and energy transformation in biocenoses (Gasso, 1987). *L. agilis* and *Z. vivipara* within the bounds of their extensive natural habitat, that includes also the South of Western Siberia are represented both by allopatric and sympatric populations.

The information on the relationship between the sympatric species of reptiles, in particular Lacertidae is of fragmentary character (Strijbosch, 1986; Glandt, 1987). The analysis of the relationship among sympatriants is connected with the concept of “ecological niche” (Ananjeva, 1981; Pianka, 1981; Tuniyev and Beregovaya, 1986; Shenbrot, 1986). The aim of this work is to study the relation between the sympatric species *L. agilis* and *Z. vivipara* Southern boreal coniferous forest zone of Western Siberia.

**MATERIAL AND METHODS**

Researches and gathering of the material were carried out within the period from May through September of years 2002 – 2003 in the environs of Tomsk, on two experimental grounds (800 m² on the swath and 2100 m² in the pine forest). The first experimental ground was split into 464 squares, the second one into 319 squares (2 × 2 m each), respectively. In each square the numbers of individuals of *L. agilis* and *Z. vivipara* were calculated. Capturing of lizards was done by hands; marking was done by paint from molt to molt and by the amputation of digits (Kuranova et al., 1986). Activity was determined by the results of marking and recapturing, chronometry of behavioral acts was also used (Dinesman and Kaletskaya, 1952; Darevsky, 1987). 69 excursions and 8 daily registrations were held. 171 individuals of both sexes and different ages were marked. The analysis of diet ingredients was done on the basis of excrements and using the method of gastric lavage (Kuranova and Kolbintsev, 1983).

The following indexes were taken for the estimation of the ecological niche occupied by the species:

1. Width of the ecological niche was calculated with help of Simpson index:

\[ D = \frac{1}{\sum p_i^2} \]

where \( p_i \) — is a portion of a resource in the general range of resources used by an individual (Shenbrot, 1986).

2. Degree of overlapping of ecological niche was calculated as a probability of interspecific meetings (Pianka index — \( C_{ij} \)):

\[ C_{ij} = \frac{\sum p_{ih} p_{jh}}{\sqrt{\sum p_{ih}^2 \times \sum p_{jh}^2}} \]

where \( p_{ij} \) and \( p_{jh} \) — probability of the use of \( h \) resource by \( i \) and \( j \) species, respectively (Shenbrot, 1986).

3. Nutrition spectrum — set of food objects (%), consumed by an individual or a group of individuals (Darevsky, 1987).

Statistical data processing was done according to traditional methods (Rokitsky, 1967; Lakin, 1980), and using of application programs (Excel 7.0, STATISTICA 6.0). The difference between averages was made by a non-parametric criterion of Mann – Whitney (U-test), the degree of correlation in its turn was estimated by Spearman quotient (\( r_{sp} \)).

**RESULTS AND DISCUSSION**

**Spatial constituent of the ecological niche.** The cohabiting species of lizards differ in the way they use their territory. *L. agilis* has its own home range (an area restricted by the extreme points of the more or less frequent
visiting of the given individual — for the animals that have permanent or temporary individual ecotope (Reymers, 1990)), that is conditioned by the strongly expressed territorial behavior typical of this species. Home range of adults, especially males are rarely overlapped (Fig. 1A). Males are more active than females when mating. They can be more frequently met in the overlapping zone of their individual territory with the one of females (Fig. 1A).

These tendencies are marked in the works of different investigators (Dinesman and Kaletskaya, 1952). The average square of home range of $L. \text{agilis}$ adult males is $133.9 \pm 19.5 \text{ m}^2$ (limit $114.4 – 153.4 \text{ m}^2$), and of adult females is $56.9 \pm 28.5 \text{ m}^2$ (limit $36.9 – 76.9 \text{ m}^2$), respectively.

The size of home range varies during the whole active season. By the end of July – the beginning of August the length of home range [a maximum length between points of finding of the observed individual, this is a relative characteristic (Nerouchev and Kopoustina, 1983)] of adult males decreases to 10 – 15 m. The length of home range belonging to females increases to 3 – 5 m. Females consume much food after laying eggs. An increasing competition exists between $L. \text{agilis}$ and $Z. \text{vivipara}$. Viviparous lizards compete for food and territory because of their young of the current year.

Viviparous lizard is characterized by a group habit of life. That affects the whole active period adults individuals have overlapping home ranges during this period. The size of home range of $Z. \text{vivipara}$ is difficult to determine due to the lack of recurring marked species. According to the data extracted by Pilorge and Xavier (1981) the average size of a male individual home range of $Z. \text{vivipara}$ is about $540 \text{ m}^2$. The males are more active in warm days. They can move to 60 m and more. They are sure to come back by the end of the day (Buschinger and Verbeek, 1970). Lizards do not stay within the same home range, the size of which constantly varies (Buschinger and Verbeek, 1970; Pilorge and Xavier, 1981).

The average length of moving (a distance between the first and the second point of meeting) of adult $Z. \text{vivipara}$ is $1.5 – 2$ times higher than of $L. \text{agilis}$. It decrease during the active season (Table 1). Decreasing of this average is

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age group</th>
<th>$L. \text{agilis}$</th>
<th>$Z. \text{vivipara}$</th>
<th>$L. \text{agilis}$</th>
<th>$Z. \text{vivipara}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>Adults</td>
<td>$\bar{x} \pm m_{sx}$</td>
<td>17.4 ± 8.7</td>
<td>33.0 ± 18.7</td>
<td>11.4 ± 3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>limit</td>
<td>8.2 – 26.0</td>
<td>14.3 – 51.7</td>
<td>3.2 – 26.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$n$</td>
<td>5</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Females</td>
<td>Subadultus</td>
<td>$\bar{x} \pm m_{sx}$</td>
<td>6.0 ± 3.5</td>
<td>12.5 ± 5.1</td>
<td>5.1 ± 2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>limit</td>
<td>2.0 – 9.0</td>
<td>1.9 – 42.3</td>
<td>2.0 – 9.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$n$</td>
<td>3</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Males</td>
<td>Adults</td>
<td>$\bar{x} \pm m_{sx}$</td>
<td>7.5 ± 3.0</td>
<td>8.2 ± 3.7</td>
<td>5.0 ± 1.3</td>
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<tr>
<td></td>
<td></td>
<td>limit</td>
<td>4.0 – 11.0</td>
<td>3.0 – 16.0</td>
<td>1.2 – 11.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$n$</td>
<td>6</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Females</td>
<td>Subadultus</td>
<td>$\bar{x} \pm m_{sx}$</td>
<td>4.0 ± 2.8</td>
<td>4.6 ± 0.6</td>
<td>3.2 ± 1.6</td>
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<td></td>
<td></td>
<td>limit</td>
<td>3.0 – 5.0</td>
<td>4.0 – 5.3</td>
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<td></td>
<td></td>
<td>$n$</td>
<td>2</td>
<td>2</td>
<td>7</td>
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</tbody>
</table>

Note. $n$, sample number; limit, limits of values; $\bar{x} \pm m_{sx}$, average and its bias.
more typical of *L. agilis* because it possesses its individual home range and permanent shelters. The difference between the averages of subadultus of both species is slight (subadultus males \( U = 80, p = 0.44 \); subadultus females \( U = 55, p = 0.85 \)).

The spatial constituent of ecological niche of *L. agilis* in the year 2002 was 1.3 times higher than of *Z. vivipara*, in the year 2003 the constituent is 1.3 times lower, respectively (Table 2). In 2003 the observations were made on a different experimental ground \( (S = 2100 \text{ m}^2) \) where microclimatic conditions are better for the viviparous lizard, that is a lot of shelters inside of felled trees, and fallen leaves. This is supported by other authors’ data (Glandt, 1987; Zamolodchikov and Avilova, 1989).

**The temporary constituent of ecological niche.** Both lizards are characterized by day-light. The largest number of *L. agilis* was noticed from May till June on grounds under analysis. *Z. vivipara* in its turn was most active from May till July. The springtime activity is related to the mating season. The number of *Z. vivipara* increased sharply on the experimental ground in 2002 (beginning from July, 17) and in 2003 the increase was related to appearance of the young of the current year (starting from July, 3). The daily activity of *Z. vivipara* does not change in June – July and has two peaks of most intensity — 11 a.m. and 4 p.m. (Fig. 2). Sand lizard has 2 peaks of most intense activity (11 a.m and 4 p.m.) in June and only 1 in July which shifts to 2 p.m. It reduces the competition between the 2 species as the number of *Z. vivipara* rises considerably because of the young. By the end of the summer a day active time of both species shortens, August is the month of the young most activity.

The size of *L. agilis* is bigger \((L = 78.8 – 89.9 \text{ mm})\) and it gets warm and cools down slower that is the reason why it becomes active later and remains the same longer. *Z. vivipara* is smaller in size \((L = 48.8 – 72.4 \text{ mm})\), that is why it starts and ceases to be active earlier, this fact is also found in other authors’ data (Strijbosch, 1986).


<table>
<thead>
<tr>
<th>Terms of observations</th>
<th>Constituents of ecological niche</th>
<th>The width of constituent of ecological niche, ( D )</th>
<th>The overlapping of constituents, ( C_{ij} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td></td>
<td>( \text{Lacerta agilis} )</td>
<td>( \text{Zootoca vivipara} )</td>
</tr>
<tr>
<td>06/20/2002</td>
<td></td>
<td>6.84</td>
<td>8.94</td>
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<td>07/14/2002</td>
<td></td>
<td>3.57</td>
<td>2.67</td>
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<tr>
<td>07/24/2002</td>
<td></td>
<td>8.40</td>
<td>6.57</td>
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<td>06/25/2003</td>
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<td>4.57</td>
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<td>5.35</td>
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<tr>
<td>08/03/2003</td>
<td></td>
<td>4.48</td>
<td>6.53</td>
</tr>
<tr>
<td>08/24/2003</td>
<td></td>
<td>1.00</td>
<td>6.61</td>
</tr>
<tr>
<td>2002</td>
<td>Trophic constituents</td>
<td>7.07</td>
<td>6.78</td>
</tr>
</tbody>
</table>

Fig. 2. Chronogram of *Lacerta agilis* and *Zootoca vivipara* activity during the summer time (based on daily census data): A, June 20, 2002; B, July 27, 2002.
Temperature of air and soil, cloudiness, humidity and wind all influence the character and dynamic of seasonal and daily activity of Lacertidae (Yablokov, 1976; Nuland, Strijbosch, 1981; Kuranova, 1983; Damm et al., 1987). In June – July the fluctuations of temperature are slight, that is why the dependence of lizard activity on the air temperature is minimum. With the cloudiness and humidity rising the activity of the sand lizard goes down ($r_{sp} = -0.65, p \leq 0.005$; $r_{sp} = -0.52, p \leq 0.005$, respectively) and of the viviparous lizard one goes up ($r_{sp} = 0.65, r_{sp} \leq 0.005$; $r_{sp} = 0.52, p \leq 0.005$).

The width ($D$) of the temporary constituent of ecological niche of both species reduces during the activity season: in June the width of the temporary constituent of the sand lizard ecological niche is 1.2 – 1.3 times bigger than the one of the viviparous lizard. From July till August the width of the temporary constituent for $Z. vivipara$ is bigger than the one for $L. agilis$ (Fig. 3). The maximal overlapping of temporary constituents typical of sympatriants is observed in June (Table 2), when the peaks of their seasonal and daily activity concur (Fig. 2A).

The competition for food and territory goes down owing to the smaller overlapping ($C_{ij}$) of temporary niche during the season.

**Trophic constituent of ecological niche.** The trophic spectrum of $L. agilis$ is wider judging by the fact that no representative of Gastropoda class ($Mollusca$ phyum) and no adult individual of Lepidoptera (Insecta class, $Arthropoda$ phillum) were found in the $Z. vivipara$ gaster (Fig. 4). The viviparous lizard shows a certain selective type of eating habits. The width of trophic constituent of ecological niche typical of the sand lizard is not greatly bigger of the one typical of the viviparous lizard. According to Hutchinson rule the competition is lessened because of the smaller size of viviparous lizard jaws (big alimental objects consumed by sand lizards are not available) (Giller, 1988).

The maximal overlapping ($C_{ij}$) 0.85 is equal to the overlapping of temporary constituents of ecological niche, 0.75 is equal to the overlapping of trophic constituents (Strijbosch, 1986). The overlapping of spatial constituents is minimal and is 0.15 to 0.36 (Table 2).

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**Fig. 3.** Seasonal dynamic of width ($D$) of temporary constituents of $Lacerta agilis$ and $Zootoca vivipara$ ecological niche: $A$, 2002 year; $B$, 2003 year.

**Fig. 4.** The ratio of different groups of invertebrates in the diet $Lacerta agilis$ ($A$) and $Zootoca vivipara$ ($B$) (the environs of Tomsk, 2002).
To sum all up, differences in body size, strategy of multiplication and territory usage, species peculiarities of daily and seasonal activity, selectivity in the size of alimental objects all contribute to the coexistence and less tense competition of sympatriants *L. agilis* and *Z. vivipara*.

REFERENCES


