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Field observations on two lizard populations (Lacerta viridis Laur. and Lacerta agilis L.)*

By

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Abstract: Population dispersion of two sympatric lizard species, Lacerta viridis (Laur.) and L. agilis L., was calculated by MORISITA's index, indicating aggregated populations. Association values have been computed by three methods for the interrelationship between the two species, which has corroborated the distinctness between the lizard populations. Examining the relative growth of individuals, 2-variable discriminant analysis was performed for the quotients tail length to total length and the tail length data. Generalized distance (D^2) between the two populations was 0.4932. Of the various data collected in 1981, a morphological and a microclimatic variable group have been identified by principal component analysis. As a result of discriminant analysis performed for seven environmental variables, the measure of niche overlap between the two lizard species was found to be 34 percent.

Similarly to other branches of vertebrate zoology, the direction of herpetological research has changed in the past few years. While most of the invertebrates are still subject to faunistical and systematical studies opening unknown territories and describing taxonomical groups hitherto not known, vertebrate zoology deals with the problems of the origin and evolution of the taxa and the relationships between these animals and their environment on the basis of a thorough knowledge of the species. Considering the ecological investigations on reptiles, especially some American research should be mentioned (PIANKA 1966, BROOKS 1968, PARKER 1972), but there are remarkable results from European biologists as well (DAREVSKY 1960, PETERS 1970, BUSCHINGER & VERBEEK 1970). In most cases these studies were carried out in the appropriate departments of museums formerly dealing with taxonomy, thus holding the continuity of the work and taking advantage of the scientific collections already housed in these institutions.

Although observations on each lizard species are made in different ways in almost every study, there are some basically common aspect of the approach. The most frequent method for studying population dynamics is a capture-recapture experiment (LE CREN 1965), which however rises many difficulties from the herpetological point of view. There are several methods for trapping lizards (RODGERS 1939, BANTA 1957, HEATWOLE et al. 1964), but systematic, personal

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in-site capture is more efficient (EAKIN 1955, BUSTARD 1969, WITTEN 1974). Obtaining data about the animals is thus based on simple collection. From the demographic data, characteristics of a given population (age structure, survivorship, replacement rate, etc.) can be derived by means of so-called life-tables (CRENSHAW 1955, TINKLE 1972). TINKLE's team described interesting reproductive strategies by comparing the life histories of various species of lizards (TINKLE 1969, TINKLE et al. 1970). When examining the relationship between the animal and its environment, it is very important to describe the spatial distribution of the populations and to characterize the various environmental parameters. Niche segregation of different species may be clarified by a comparative analysis of the results of these investigations (MILSTEAD 1965, SCHOENER 1968, PIANKA & HUEY 1978).

The purpose of the study presented in this paper is to subject the populations of the two lizard species inhabiting the study area to a detailed ecological examination. Although this study is based on capture-recapture, descriptions of the temporal changes in population structure are not possible because of the low number of lizards captured. So far, it has been possible to clarify the dispersion patterns of the two lizard populations, and the relation between them by considering a number of environmental factors.

MATERIALS AND METHODS

The study area is situated in the field site of the Game Biology Research Station of the University of Agriculture, Gödöllő, about 33 km east of Budapest. The investigations were carried out in a young hillside plantation of Scotch pine (Pinus silvestris L.) with a southern exposure. At the lower section of this slope there is a rarely used track lined on both sides with black locust trees (Robinia pseudo-acacia L.), upwards from this the hillside is roughly homogeneous as regards the characters of the terrain and the vegetation. About 300 meters from the track there is a lake, which may play an important role by affecting moisture content of the soil, and therefore here the vegetation is somewhat more opulent, the grasses are taller on the edge of the site adjacent to the line of black locust trees. On the slope two species of lizards occur, namely the green lizard Lacerta viridis (Laur.) and the sand lizard Lacerta agilis L.

Collections were made in a 120 m by 50 portion of the hillside eight times in 1980 and eleven times in 1981 (from April to September), on the average at two weeks intervals. The exact time and location of capture of the lizards were noted. The x co-ordinate values of the location were given by the rows of seedlings planted by the forestry (33 rows = 50 m), the y co-ordinates by the number of steps along the line (160 steps = 120 m). Snout-vent length and total length of the animals were measured upon each capture. Before releasing the lizards, they were given individual marks by toe-clipping (WOODBURY 1956). Suitable combinations may give over 1200 different marks using three clipped toes only. The data recorded in the study area included not only the handled but the sighted and identified lizards as well.

In addition to the data recorded during the previous year, in 1981 I have also noted soil and air temperatures, the measure of light exposure, weights of the lizards and the vegetation density within a region two steps around the point of capture. Trees and shrubs were divided into four categories according to their sizes. In addition to these, speed of the wind was measured, arthropods suspected to be the prey of the lizards were captured in pitfall traps, extracted from soil samples and some representative stomach contents were collected systematically. From these numerous data I have decided to select ten variables, on which principal component and discriminant analyses have been performed on a CDC-3300 computer, using the Statistical Package for the Social Sciences (NIE et al. 1975).

RESULTS

After the first five months of sampling in 1980 I have exact location data on 43 L. viridis and 34 L. agilis. 27 L. viridis were captured, 3 of which (≅ 11%) were recaptures. The sex ratio of the adult specimens was 3 ♂♂ : 6 ♀♀, 15 juveniles were not sexed. 26 L. agilis were captured, 5 of these (≅ 19%) were recaptures; the 21 specimens included 6 ♂♂, 3 ♀♀ and 12 juveniles. In 1981 I collected location data on 38 L. viridis and 44 L. agilis. Of the green lizards, 18 were captured, 5 of them already were marked (≅ 28%). The 13 specimens included 6 ♂♂, 5 ♀♀ and 2 juveniles. 31 sand lizard were caught, 12 of these (≅ 38%) were recaptures; the 19 specimens included 6 ♂♂, 4 ♀♀ and 9 juveniles.

1. Dispersion analysis

The first part of the analysis was aimed at detecting the pattern of spatial distribution of the two lizard populations. The locations recorded in 1980 were not randomly distributed in the study area, as MORISITA's index of dispersion (MORISITA 1962) proved to be larger than one, indicating aggregated populations for both species. The value of the index for L. viridis was 1.75 (F-test, $P<0.05$), for the other species 2.2, which is statistically more significant (F-test, $P<0.01$). This cumulated, "contagious" population dispersion was more expressed in the case of Lacerta agilis than in the case of the other species, as shown by the k constant of the negative binomial distribution (SOUTHWOOD 1966) (L. viridis : $k_1 = 1.33$ and L. agilis : $k_2 = 0.83$). As this distribution approaches the Poisson, the constant tends to infinity.

The next question was: what kind of relationship exists between the cumulated populations of the two lizard species? I expected a negative association, i.e. one of the species forming groups consistently in exclusion from the other one. This relationship was quantified by three methods: the chi-square test, COLE's association measurement (COLE 1949) and the correlation coefficient (POOLE 1974). All three methods gave similar results, so the populations were independent of each other (Table 1). Accordingly, individuals of one species had no direct effect on the spatial distribution of the other one. However, the microhabitats of the two species could be different because of other factors. Before studying the problem of niche segregation, it was found necessary to compare certain morphological characters between the populations.

Table 1. Contingency table for Chi-square test ($X^2 = 0.031$), COLE's association measurement (C = 0.027 and correlation coefficient according to POOLE (V = 0.022)

		Lacerta viridis		Total
		present	absent	
Lacerta agilis	present	10	12	22
	absent	19	25	44
	Total	29	37	66

Table 2. Partitioning the D^2 generalized distance into the direct contributions of the variables and to the contribution of their combination

variable	contribution	
	absolute	relative
w_1^2	0.4645	0.9418
w_2^2	0.0182	0.0370
$2w_1w_2r_{12}$	0.0105	0.0212
D^2	0.4932	1.0000

Table 3. Factor matrix of character loading of the first three principal components on the original variables

variables	principal components 1	2	3
1. body weight	0.824*	0.138	0.312
2. snout-vent length	0.929*	0.161	0.131
3. total length	0.932*	0.176	0.162
4. soil temperature	0.847*	-0.196	-0.092
5. air temperature	0.850*	-0.282	-0.242
6. plant density	0.106	-0.515*	0.563*
7. time of capture	0.149	0.627*	0.457*
8. light exposure	0.679*	-0.199	-0.531*
9. x co-ordinate	0.122	0.730*	-0.320
10. y co-ordinate	-0.091	0.174	0.280

(*; correlation coefficients significant at 0.01 probability level)

Table 4. Unstandardized discriminant function coefficients of the environmental variables

variables	coefficients
soil temperature	-0.117
air temperature	0.086
plant density	-0.080
time of capture	-0.201
light exposure	0.001
x co-ordinate	-0.016
y co-ordinate	0.012
constant	2.225

Table 5. Classification results of discriminant analysis to interprete overlap in niche dimensions

actual group	number of cases	predicted group membership	
		group 1.	group 2.
group 1. Lacerta viridis	38	25 65.8%	13 34.2%
group 2. Lacerta agilis	44	15 34.1%	29 65.9%

percent of cases correctly classified = 65,85%
overlap = 34.15%

2. Morphometrical analysis

In this section the relative growth of tail length and total length of the lizards was examined, and also the differentiation of these length measurements. First, ontogenetic allometrical comparison (FÁBIÁN 1969) of the two lizard species was made. A log-log regression line was fitted to the total length versus tail length data (Fig. 1). The regression coefficients (0.95 for both species) showed a slight negative allometry, i.e. the elongation of the lizard tail

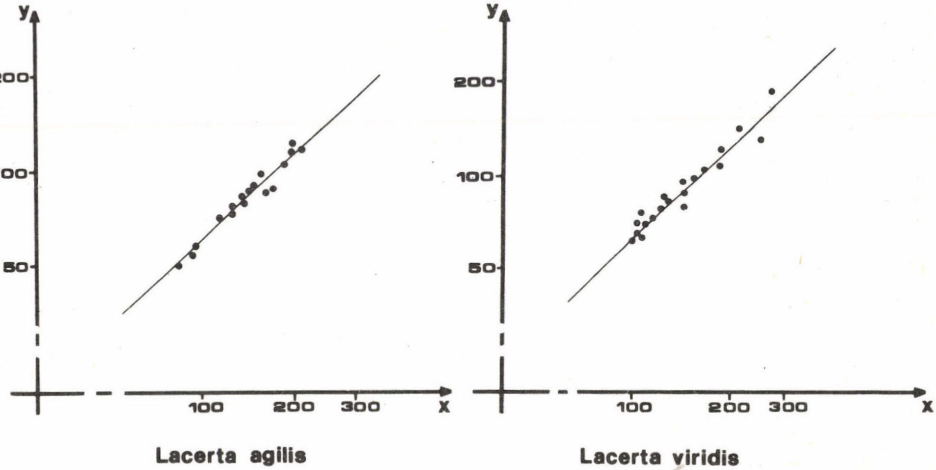

Fig. 1. Tail length (y) plotted against total length (x) in a log-log co-ordinate system (regression lines: Lacerta agilis lgy = -0.1073+0.95 lgx, Lacerta viridis lgy = -0.0875+0.95 lgx)

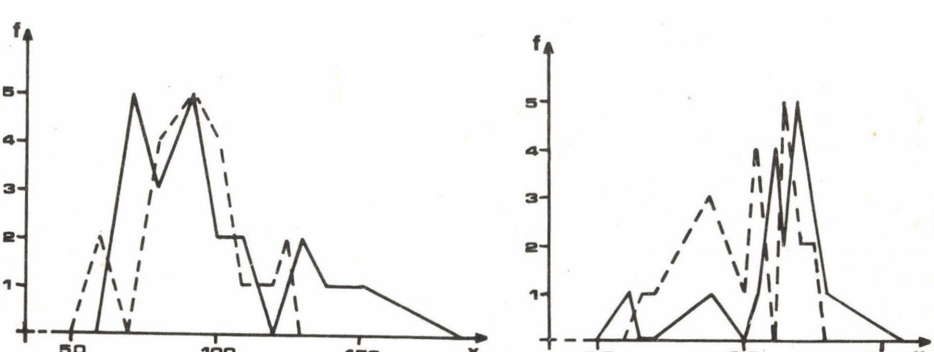

Fig. 2. Frequency distributions of tail length (x_1) and quotient of tail length to total length (x_2) (———— L. viridis , - - - - L. agilis)

had a somewhat slower rate of growth than that of the total length. However, these slightly parabolic curves showed only insignificant deviation from a straight line in a linear co-ordinate system, hence the growth of the lizards during ontogeny can be considered to be linear. For the sand lizard the isometric nature of postembryonic growth has already been verified by PLETICHA (1968). In this respect I did not find any differences between the two species in question. What is more characteristic for the two species is the quotient of tail length to entire body length, which was significantly different in the two samples (STUDENT's t-test, $P < 0.05$). Mean value of the quotients was 0.6343 for Lacerta viridis and 0.6095 for L. agilis. Nevertheless, there was great overlap in the frequency distribution of the actual data (Fig. 2). Therefore, discriminant analysis (SVÁB 1979) was performed for two variables: the quotients of tail length to total length and the tail lengths themselves. The frequency distributions of the discriminant scores computed for the two species had modes that were well segregated (Fig. 3). By calculating the difference between the means of the two samples a definite, numerically explicable degree of differentiation called MAHALANOBIS' generalized distance ($D^2 = 0.4932$) has been obtained for the two lizard populations. As it was expected, the results of the analysis showed that of the two variables the quotient of tail length to total length (w_1 in the Table 2) had more considerable effect on the generalized distance. The morphological differentiation outlined above may have influence over the habitat selection of the two lizard species. On the other hand, this difference may be the result of habitat segregation due to the effect of other factors.

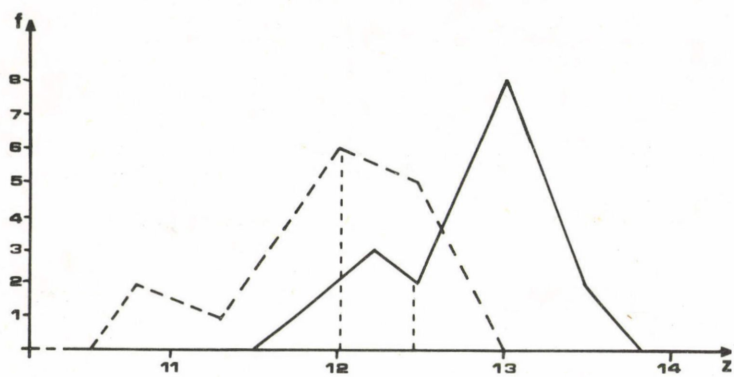

Fig.3. Frequency distribution of discriminant scores in a 2-variable discriminant analysis of morphological data. Centroids: 12.0031 and 12.4963 (——— L. viridis, - - - - L. agilis)

3. Niche segregation: a preliminary study

Of the data collected in 1981, ten variables (Table 3) were selected to study the niche segregation, on which principal component factoring was performed to find common background factors. Three components were extracted: the first principal component contained the morphological variables (body weight, snout-vent length, total length) and the microclimatic variables (soil and air temperatures, light exposure); the second principal component included the time of capture, the x co-ordinate value and the plant density around the point of capture. In the third principal component the same variables appeared with lower loadings (Table 3). In the co-ordinate system of the three components the variables formed definite groups (Fig. 4): a morphological and a microclimatic variable group could be identified and there was also a positive correlation between the x co-ordinates (number of the row at which the lizard was captured) and the time of capture. This is obvious, because the collection in most cases began from the lower edge of the slope.

Discriminant analysis of the two lizard populations was carried out considering seven environmental variables. Morphological variables were excluded from this analysis because of the ecological nature of the problem of niche segregation. The following axes of the seven dimensional

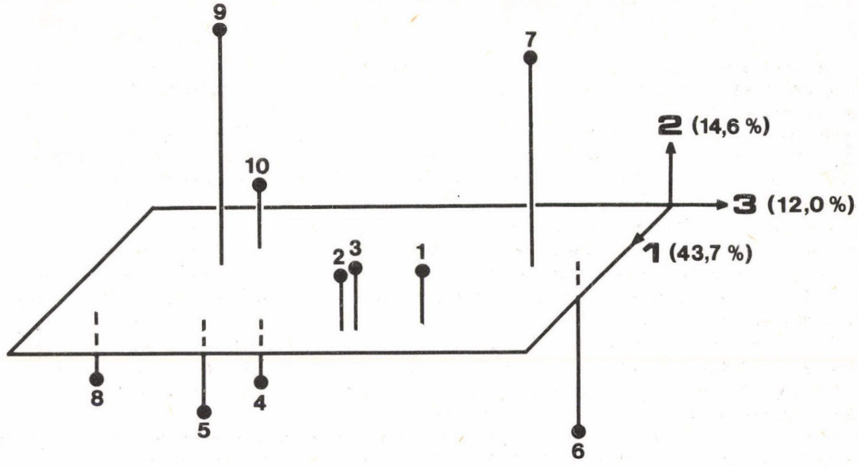

Fig. 4. Result on a principal component analysis on 10 morphological and environmental variables (1 = body weight; 2 = snout-vent length; 3 = total length; 4 = soil temperature; 5 = air temperature; 6 = plant density; 7 = time of capture; 8 = light exposure; 9 = x co-ordinate; 10 = y co-ordinate). The first three components accounted for 70.3% of total variance

hypervolume proved to be useful for segregating the environmental variables of the two species: soil and air temperatures and plant density (Table 4). The frequency distributions of discriminant scores had clearly segregated modal values (Fig. 5). Since the program package contained an option for reclassifying every case according to the classification function obtained in the analysis, I found that 34 percent of the cases were reclassified as belonging to the other group (Table 5). In other words, the probability of misclassification is 34 percent, which may also be considered as a measure of niche overlap (STEINHORST 1979). As far as the studied niche dimensions are concerned, the two lizard populations proved to be segregated to the extent of 66%.

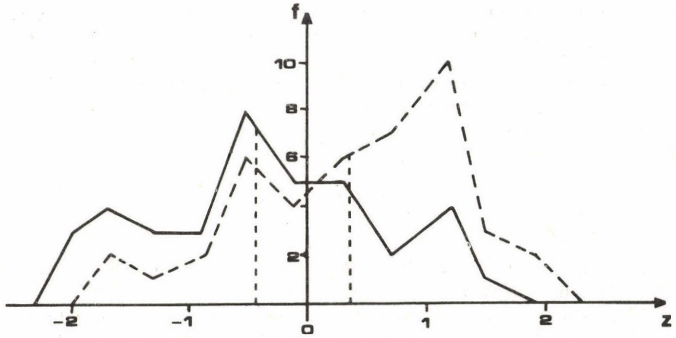

Fig. 5. Frequency distribution of discriminant scores in a 7-variable discriminant analysis of niche dimensions. Centroids: -0.4291 and 0.3705 (——— L. viridis, - - - - L. agilis)

DISCUSSION

Because Lacerta viridis more frequently hunts and climbs on trees and shrubs than the other species (VASVÁRI 1927), I hypothized that it would prefer microhabitats with dense woody and bushy vegetation. Very roughly this is true, since the green lizard occurs more frequently than the sand lizard in ecotones between fields and woods, and in thicket areas (ARNOLD et al 1978, DELY 1978). I thought that in a field site where both species occurred, divergent microhabitat selection would be detected between the two species by examining the distribution of the green lizard population corresponding to the mosaic-like pattern of the trees and shrubs. The dispersion analysis showed that the individuals were distributed according some kind of aggregation. Such a pattern might be the result of social behavior or simply of the cumulated distribution of the favourable environmental factors, but the clusters regarding the two species were independent of each other. This does not mean the lack of interspecific relationships considering either territoriality or competition for food. These background mechanisms cannot, however, be clarified by a statistical dispersion analysis, much broader comparative ethological study is required to do that. From the works of VERBEEK (1972) and others (WEBER 1957, SAINT GIRONS 1976) there is no doubt that within and between Lacerta lizard populations many behavioral interrelationships exist, which can be remarkable also from an ecological point of view.

Assuming that the adaptation to locomotion on branches and twigs in the case of L. viridis resulted in changes in morphology (VASVÁRI 1927), I examined the relative tail length vs. total body length as a typical character. The difference is in fact statistically significant between the green and the sand lizard. The study of the ontogenetic allometric growth was aimed at describing the change of this ratio during ontogeny: whether there was any difference between the species in this respect. The multivariate analysis showed the disconnection of the recorded morphological variables and the variables characterizing the life history (e.g. microclimatic data, plant density, etc.). Since the preference of the green lizard for woody habitats is not connected with the length of the tail, it was decided to treat the environmental variables instead of morphometrical ones. Using these, the separation of the two lizard species into distinct niches has become possible, but not on the basis of the plant density as shown above. Hence the distribution of individuals of L. viridis does not correspond to the mosaic-like pattern of the bushy vegetation in the study area. The microclimatic factors (soil and air temperatures and the measure of light exposure) are apparently much more important. Further studies need to be carried out in the direction of more exact descriptions of differences in microhabitat dimensions and trophic niches between the two species. I expect that an investigation on the latter aspect will assist in clarification of the issue of niche segregation.

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