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SYMPATRIC DISTRIBUTION OF SIX LACERTID LIZARDS

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Abstract: A sympatric distribution of six lacertid lizards, the highest in Bulgaria, is found in a very small area in the northeastern part of Rhodopi mountain. In the study area the lizards occurred in different species combinations. Niche segregation was obtained by studying species' habitat selection, ecological demands and the ethological differences between them. The data for the altitude preferences of *O. elegans* contrasts to the previously known one for country. *P.muralis* is found to be a typical forests dweller. *L. viridis* is presented by two subspecies with relatively broad contact zone.

Lacertid lizards are dominant family in the European herpetosocieties. The highest number of species can be found on the Balkan Peninsula and it numbers about twenty species [1]. In spite of this a sympatric occurrence of more than five species is very rare. Strijbosch, Helmer, Sholte [2] in the south of Evros province (Greece), Arnold [3] in Bosnia-Hercegovina near Gasko and Mayer, Beyerlein [4] in Peloponnse peninsula in the Arcadian Highlands describes a sympatry of seven species.

The study area of about 25 km^2 belongs to Haskovo district and covers the north-easternmost part of Rhodopi Mountain, the hill Gorata, between the villages of Mezek and Valce Pole. It is located in southwest to northeast direction, and situated between 150 m (Mezek village) and 704 m altitude (peak Sejnovec). It consists of agriculture lowlands in the surroundings of Mezek and Valce Pole villages. Open xerophylic oak forests dominate the rest of the area, especially at low altitude. Small sections of beech forests are situated at high altitude on the northern slopes, where the humidity is higher. Xero-mesophylic and mesophylic mixed deciduous forests dominate at the described kind of places, but xerophylic oak forests are also present. Small area of pine forest is situated above the village of Mezek.

MATERIALS AND METHODS

The study area was visited during May and June 2003.

For each captured specimen was collected data of the location, vegetation, substrate type, approximately altitude, size, sex and diurnal activity. Some test fields was applied: the distance to the nearest tree and to the same species specimen. Populations samples used in first test field test I came from five altitudes: 150 m – border area between the zone (2) and (4), 350 m – (4) and (7), 450 m - (4) and (7), 550 m – (4), (5) and (7) and 650 m - (4), (5) and (7). These from second test field (test II) include samples from all the study area. All the observations were recorded on a map 1:50000 scale.

In order all the necessary information about the density of the species to be obtained, the study area was divided into seven habitat zones that correspond to different habitats. The following zones are considered: agriculture lands, grass area, road sides covered whit different herbs (zone 1), area covered mainly by *Paliurus spina-cristi* (at lower altitude) or other shrubs (zone 2), pine forests and theirs surroundings (zone 3), xerophylic oak and *Carpinus orientalis* forests (zone 4), xero-mesophylic and mesophylic oak, and mixed deciduous forests (zone 5), beech forests (zone 6), stony areas whit thin vegetation, stony road sides (zone 7).

Local density was estimated in transects 100 m long and 5m wide. Three abundance score are established to represent the species density: rare (1 - 5 individuals at transect), uncommon (5 – 20 ind./tr.), common (20 – 100 ind./tr.) respectively. Density is called minimal because is calculated from the number of captured animals.

Statistical analyses performed in the study were based on the relative similarity or dissimilarity of data obtained from the test fields. Descriptive statistics comprise arithmetic mean, standard deviation, minimum and maximum. All statistical tests were performed with Microsoft Excel 97 and according to Fowler and Cohen [5]. P-value < 0.05 was considered as significant.

RESULTS AND DISCUSSION

Six different species could be recorded from different places of the study area. They are *Lacerta trilineata, L. viridis, Ophisops elegans, Podarcis erhardii, P. muralis* and *P. taurica. L. viridis* is presented by two subspecies. *L. v. viridis* and *L. v. meridionalis*. Table 1, show the specimen which are described. The total observations for *L. viridis and P. taurica* are approximately three times and for *L. trilineata* two times as much as given in this table. The highest number of species occurred in the contact area between the zones. Species richness is lowest inside the zones (Table 2). *L. viridis* and *P. taurica*

are the only species found in the monoculture pine and beech forests, and agriculture area in lowland respectively.

Table 1

Lacertid lizards of the study area, abbreviation used in the others tables (abb.), total number of specimen caught (n), number of transects for each species (tr.), number of animals used in the field test distance to the nearest tree (test I), number of animals used in the field test distance to the same species specimen (test II).

Species	abb.	n	tr.	test I	test II
Lacerta trilineata – balkan greene lizard	Lt	97	7	67	43
Lacerta viridis – green lizard	Lv	177	12	177	59
Ophisops elegans – snake-eyed lizard	Oe	41	5	23	41
Podarcis erhardii – Erhard's wall lizard	Pe	14	4	12	11
Podarcis muralis – common wall lizard	Pm	38	4	36	19
Podarcis taurica – balkan wall lizard	Pt	214	8	191	70

For more precise description of these six species this assemblage is divided into tree groups: *L. trilineata* and *L. viridis*, *O. elegans* and *P. taurica* and *P. erhardii* and *P. muralis*.

The first one comprises of the biggest species. In study area they are found mostly allopatric (Table 3 and 4). Small zone of sympatry occur in the ecotoms between the zones (1), (2) and (2), (3), (7).

Table 2

Species communities in different zones and contact zones. Species are listed by the decrease of their densities

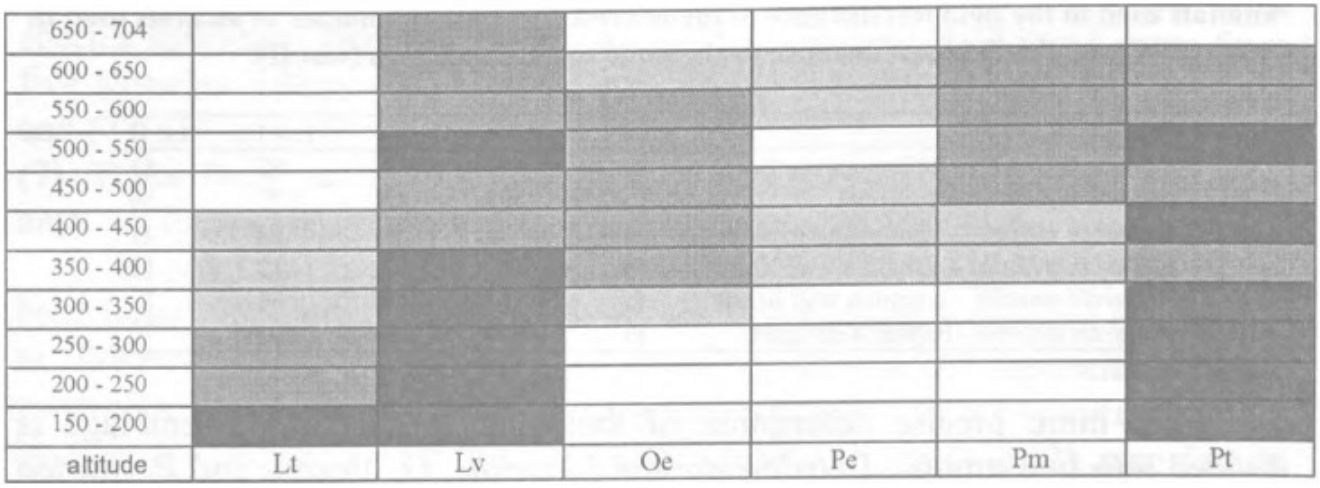
zone	1	2	3	4	5	6	7
1	Pt - Lt - Lv	Lt - Pt - Lv	Pt - Lv	Lv - Pt - Lt	Pt - Lv	Lv - Pt	Oe - Pt
2		Lt - Pt - Lv	Pt - Lt - Lv	Lv - Lt - Pt	Lv - Pt	Lv - Pt	Oe- Pt- Lv - Pe - Lt
3			Lv	Lv		Lv - Pt	Oe - Lv - Pe - Lt
4				Lv - Pt	Lv - Pm	Lv - Pt	Oe Pt - Lv - Pe - Lt
5					Pm - Lv		Lv - Pe - Pm
6						Lv	Lv
7							Oe - Pe

L. trilineata inhabit the northeastern lower part of the study area, with a few isolated locations situated to the south at higher altitude (up to 450 m, Table 3 and 4). Relatively more frequent on flat areas covered whit *Paliurus spina-cristi* or other shrub and thin tree layer, the species reaches its highest density (up to 24 ind./tr., mean 14 ind./tr.). *L. trilineata* predominate at lower altitude up to 200 m that corresponds to zone (2). In zone (1) are found only juveniles (94 %) and few subadults, which are entering this zone to avoid the competition whit the adults. Above this altitude species occurred on stony and pebbly area, roadsides and open oak forests (200 – 450 m) corresponding to zones (7) and (4). There it reaches its lowest values of frequency. At this altitude the species become rare or uncommon (Table 3 and table 4), as suitable habitats are not found or are isolated. *L. trilineata* is more frequent on sandy, pebbly or stony

soils (72 %). The results from test I are statistically significant. Due to the fact, that with the increase of the altitude the preferred habitats become more wooded the distance to the nearest tree decreases (Table 5).

Table 3

Altitude ranges distribution of lacertid lizard presence

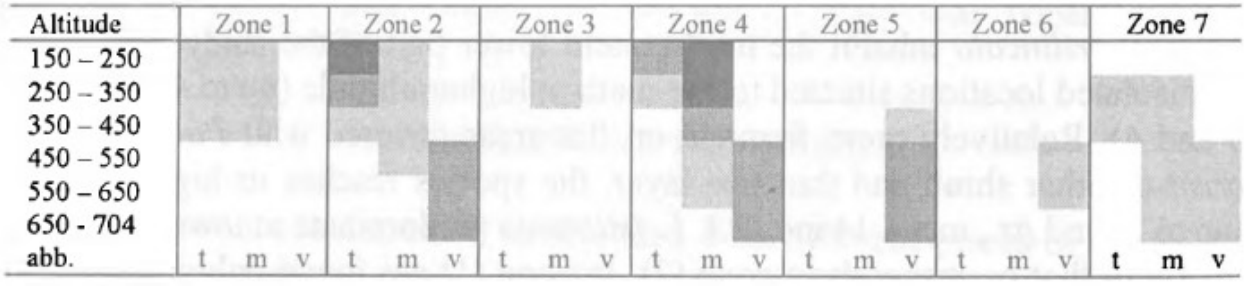


Presence: rare uncommon common

L. viridis range over the entire study area (Table 3 and 4). The species occur in the all habitats, it is presented by two subspecies *L. viridis meridionalis* and *L. viridis viridis*. The local densities are reported for *L. viridis*, not separately for its subspecies. Their contact zone covers the areas with altitude between 400 m and 650 m. *L. v. meridionalis* is common under 350 m in dry oak forests at low altitude.

Table 4

Presence of *Lacerta trilineata* (t), *Lacerta viridis meridionalis* (m) and *L. v. viridis* (v) according to altitude and habitat zone.



Presence: rare uncommon common

There it prefers areas without dense cover of shrubs and herbs where it reaches its highest local density values (up to 24 ind./tr., mean 16 ind./tr.). Above this altitude and up to about 450 m the subspecies become uncommon. It is rare above 450 m. *L. v. viridis* is found between 450 m and the highest point

of study area. It's local density reach up to 16 ind./tr. Nominate subspecies inhabit along the roadsides, clearing areas and near by large rocks. It is rare in large forest massifs. Specimens with intermediate traits inhabit the zone between 400 m and 650 m where both the subspecies are found. Which traits dominate depends on the habitat and the altitude. In dry habitats in the lower part of the contact zone predominate the traits of *L. v. meridionalis*, while in the higher and more humid parts predominate specimen with traits of *L. v. viridis*.

Table 5

Results of test field I. Mean distance (m) of lizards to the nearest tree in the five zones of sympatry.

Alt.	150		350		450		550		650		ANOVA
abb.	n	mean ± s	n	mean ± s	n	mean ± s	n	mean ± s	n	mean ± s	P
Lt	58	15.5 ± 9.7	5	6 ± 2.4	4	5 ± 1.6					0.01
Lv	79	5 ± 4.1	34	4 ± 1.7	24	3.8 ± 2.1	24	4 ± 1.9	16	3.8 ± 1.9	-
Oe			5	7.4 ± 2.9	15	5.7 ± 1.8	13	4.7 ± 1.8	5	5 ± 1.2	-
Pe					3	3 ± 1.5	5	3.8 ± 0.8	4	4.5 ± 1.3	-
Pm					5	2.2 ± 1.6	14	2.5 ± 1.6	17	2.9 ± 1.4	-
Pt	81	17.7 ± 9	37	6.8 ± 2.3	27	4.1 ± 2.4	27	4.1 ± 1.7	19	3.2 ± 1.7	-
ANOVA - P		-		-		< 0.05		< 0.05		0.07	

In mixed mesophylic deciduous forests pure populations of nominate subspecies are found in small area inhabiting the rocky sides of the roads, clearing areas and isolated rocks in the forests (Table 6). The nominate subspecies density reaches up to 16 ind./tr. (mean 11 ind./tr.). *L. viridis* is the only species capable of maintaining itself in pine forests and the periphery of beech forests. The differences in the results for male and female specimens shown by test II are very statistically significant (Table 7). Probably the reason for this is that the old male greene lizards do not tolerate another specimens in close vicinity.

Table 6

Descriptive statistic of the results from test field II. (n – sample size, mean – arithmetic mean, s – standard deviation, min – minimum, max – maximum)

	Male					Female					ANOVA
Abb.	n	mean	s	min	max	n	mean	s	min	max	P
Lt	16	8.8	4	2	18	27	7.1	3.8	4	20	-
Lv	23	10.3	3.3	5	16	36	8	3.3	2	17	> 0.001
Oe	19	6.2	3.8	2	13	22	8.6	3.1	2	12	-
Pe	6	12.2	5.1	5	19	5	10.2	2.9	6	13	-
Pm	5	14.6	7.2	7	25	14	11.9	7.9	5	29	-
Pt	36	8.6	3.8	4	15	38	5.5	2.4	2	11	> 0.05

The second group of representatives prefers grassy areas. Both species are found in sympatry (Table 8). *O. elegans* is more thermophylious and predominate in arid places. This species occurs in zone (7) but also penetrates in the adjacent zone (1), (2) and especially zone (4) (Table 2). It inhabits areas between 300 m and 650 m above the sea level (Table 3). *O. elegans* is only found on south faced slops. The species prefer sandy, pebbly and stony areas with thin herb cover, isolated shrubs and trees. In such areas it is more frequent (15 ind./tr., mean 8,2 ind./tr.) though it is not common anywhere. On the places where both *P. taurica* and *O. elegans* are found, *O. elegans* prefers the arid areas whit sparse herb and shrub cover on the southern slopes but it tends to inhabit against slopes. Conversely where *O. elegans* is both found with *P. erhardii,* it tends to inhabit flat areas covered whit herbs. Everywhere where all the three species are found together *O. elegans* is the uncommon one. According to test I this species occur least in the vicinity of trees.

Table 7

Principal ecological differences between *Lacerta viridis meridionalis* and *Lacerta viridis viridis*.

Lacerta viridis meridionalis (43 ind.)*	*Lacerta viridis viridis* (31ind.)*
- frequent in wooded areas and inside forests without large rocks and stones (79 % of the observations)	- relatively more frequent in forests whit large rocks and stones (62 %)
- prefer dry forests (78 %)	- prefer forest clearings, road sides (65 %)
- numerous on humous soil (82 %), rare on stony soil (13 %)	- prefer stony soil (54 %), less frequent on humous soil (38 %)
- more frequent on flat terrain (67 %)	- more frequent on against slopes (59 %)
- prefer dry microhabitats	- prefer more humid microhabitats
- more frequent under 550m especially under 350m	- found over 350m, more frequent over 450m

*In the table are included only specimens without intermediate traits.

P. taurica inhabit throughout the study area, from 150 m to 700 m above the sea level (Table3). The species is very common in areas with dense, well-developed herb layer that correspond to zones (1) and (2) and penetrates in the neighboring zones (3), (4), (5) and (7) (Table 2). Consequently it is more frequent on flat terrain. At higher altitude areas where suitable habitats are less frequent, it inhabits pebbly and sandy south, west or east faced roadsides in dry oak or mixed forests. Its wide distribution nowadays is a result of the deforestation and grazing. *P. taurica* both with *L. viridis* is the first species that colonized the clearing areas. *P. taurica* reaches local density of up to 44 ind./tr. and is the most numerous species – mean 27 ind/tr. Test I confirms the tendency of decrease in distance with the increase of altitude. In spite of the difference in the means of the five species this results are not statistically significant.

Table 8

Presence of *Podarcis taurica* and *Ophisops elegans* according to altitude and habitat zone.

Alt.	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Zone 6		Zone 7	
150 – 250														
250 – 350														
350 – 450														
450 – 550														
550 – 650														
650 – 704														
abb.	Pt	Oe	Pt	Oe	Pt	Oe	Pt	Oe	Pt	Oe	Pt	Oe	**Pt**	**Oe**

Presence: rare uncommon common

The third group species, *P. erhardii* and *P. muralis*, are divided by their habitat. The result of test I are the lowest for these two species, especially for *P. muralis* (Table 5). Conversely the result from test II are the highest. Low population density is the cause for that.

Table 9

Presence of *Podarcis erhardii* and *Podarcis muralis* according to altitude and habitat zone.

Alt.	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Zone 6		Zone 7	
150 – 250														
250 – 350														
350 – 450														
450 – 550														
550 – 650														
650 - 704														
abb.	Pe	Pm	Pe	Pm	Pe	Pm	Pe	Pm	Pe	Pm	Pe	Pm	**Pe**	**Pm**

Presence: rare uncommon common

The *P. erhardii* occurrence is restricted to the rocky sides of the roads. This species inhabits exclusively zone (7) (Table 2and 9). It is the most rare species in study area. It is found on places with altitude between 350 m and 650 m (Table 3). The study area is the northeastern limit of its distribution. The cause of its lowest density (up to 5 ind./tr.) is complex. The huge distance between the suitable habitats and the lack of them outside the rocky sides of the roads as well as their isolation can be the main reasons for its limited distribution.

P. muralis is found only in deciduous forests over 350 m and is restricted to zones (4) and (5) (Table 2,3 and 9). It lives in the vicinity of trees, roots, stubs, and rocks inside the forest and is extremely rare on the rocky sides of the roads (zone 7). Locally species density reaches 17 ind./tr. (mean 9 ind./tr).

The difference in the mean distance of lizards' communities shown by test I at 450 m and 550 m is statistically significant. This is a result of the niches segregation among the lizard species.

The described lacertid lizards' community is the richest for the country. It is a result of the mosaic distribution of great number of habitats. Competition among species is possible, considering species difference in size and niche preference. This competition is partly avoided by different habitat and microhabitat preferences, and difference in the diurnal activity and foraging strategy. Habitat preferences found in the study area correspond to the data presented by other authors [2, 4, 6]. The study area is the northwestern and northeastern limit for the distribution of *O. elegans* and *P.erhardii* [1, 2, 6, 7, 8]. The altitude distribution (300 – 650 m) of *O. elegans* is higher than the one previously known and is completely different than the data from the other regions in the country where the species is found [9, 10].

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