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BÖHME, W., BISCHOFF, W. & T. ZIEGLER (eds.): HERPETOLOGIA BONNENSIS, 1997: 265-271

Comparative ecology of two sympatric lizard species, *Lacerta graeca* and *Podarcis peloponnesiaca* endemic to Peloponnisos (Greece)

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Introduction

Peloponnisos is, regarding its herpetofauna, one of the most interesting areas in Greece, on the basis of the reptile diversity and their populations. Four endemic lizard species, three lacertids (*Algyroides moreoticus*, *Lacerta graeca* and *Podarcis peloponnesiaca*) and one anguid (*Anguis cephallonicus*) occur in this area. *L. graeca* and *P. peloponnesiaca* are distributed exclusively in Peloponnisos and probably are together the most numerous lizards in this region. However, even though we know many things on their systematics (BUCHHOLZ 1960, BÖHME 1984, BRINGSØE 1986, MAYER 1986) and distribution (BÖHME 1984, BRINGSØE 1986, BUTTLE 1987, 1988) little is known on their ecology and especially on the ecology of *L. graeca*. In an attempt to contribute to the better knowledge of the Greek lizards' ecology, we present in this work the first data on thermal and trophic ecology of these two lizard taxa.

Materials and methods

Both species have been observed at monthly intervals in a selected Peloponnisian biotope at Stymfalia lake (22° 20', 37° 50') and at seasonal visits in similar biotopes around Peloponnisos. The main characteristic of the Stymfalia area is the stony terrain with rock faces. The vegetation is mainly degraded maquis where *Quercus coccifera*, *Arbutus* sp., *Phlomis* sp. and several one-year plants are the dominant species. The climate of the area is Mediterranean with harsh winters (MAUROMATIS 1978). The data presented here are the first results of a project that started in 1991 as a study for a Ph.D. thesis of the first author.

Active lizards were caught by noose or by hand and for the maintenance of specimens the standard procedure was followed (PÉREZ-MELLADO 1992). In order to study their thermal ecology, body temperature (Tb) was taken using a cloacal (Schultheiss) thermometer as soon as possible after capture. Air and substrate temperatures (Ta and Ts respectively) were also taken at the point where the animal was first seen.

Both species are endemic to Peloponnisos and the populations of *L. graeca* are often scattered and isolated. Therefore for the study of their diet, the minimum number of the necessary animals has been collected. The digestive track contents of each specimen was examined for the presence of prey remnants. Prey items were grouped to taxonomic categories, generally dawn to ordinal level. Coleopteran, dipteran and lepidopteran larvae were grouped in one category as "insect larvae". The sympatricity of the species does not permit the study of their feeding ecology from their faecal pellets. The data presented here are from two seasons, spring and summer. The proportion of individuals of the examined species at the selected biotope was found 1 *L. graeca* : 4.5 *P. peloponnesiaca.*

For the statistical analysis of the results chi-square test, t-test, ANOVA, ANCOVA and regression analysis, were used as described by ZAR (1984). The Levins standard index was used in order to calculate the niche breadth ($B_s n$, $B_s f$) (KREBS 1979).

Results and Discussion

Thermal ecology: In both species there is not a significant difference between the body temperature values of the two sexes (*L. graeca*: $t = 0.23$, $df = 62$, $p > 0.05$; *P. peloponnesiaca*: $t = 0.17$, $df = 111$, $p > 0.05$). Average body and air temperatures of active animals for both species are given in Table 1. The mean body temperature is 30.68°C for *P. peloponnesiaca* and 32.12°C for *L. graeca*. No significant difference was found between the two species (ANCOVA, covariate:Ta, $F_{1,174} = 0.2$, $p > 0.05$). The mean Tb of both species is higher and statistically different from both Ta and Ts (Tb vs Ta: *L. graeca:* $t = 6.029$, $df = 128$, $p < 0.05$; *P. peloponnesiaca*: $t = 8.348$, $df = 222$, $p < 0.05$; Tb vs Ts: *L. graeca*: $t = 3.96$, $df = 128$, $p < 0.05$; *P. peloponnesiaca*: $t = 3.88$, $df = 222$, $p < 0.05$).

Species	N	Tb (°C)			Ta (°C)		
		x	SD	range	x	SD	range
P. peloponnesiaca	112	30.68	4.026	18.6 – 38.0	25.5	5.17	12.6 – 37.2
L. graeca	65	32.12	2.57	23.6 – 37.4	28.59	3.92	20.8 – 37.4

Tab. 1. Descriptive statistics for body (Tb) and air (Ta) temperatures of *P. peloponnesiaca* and *L. graeca*. N: sample size, x: mean value, SD: standard deviation.

ANCOVA test indicates that there are no significant differences in the body temperature of *L. graeca* through the year (tab. 2) (Tb, covariate: Ta, $F_{2.61} = 1.68$, $p > 0.01$). On the contrary *P. peloponnesiaca* has different mean body temperatures among the seasons (tab. 3) (Tb, covariate: Ta, $F_{2.108} = 4.14$, $P < 0.05$). In both cases the air temperature is different among the seasons (ANOVA, *L. graeca*, Ta: $F_{2.62} = 12.91$, $p < 0.05$; *P. peloponnesiaca*, Ta: $F_{2.109} = 58.06$, $P < 0.05$).

Concerning their annual activity pattern, *Podarcis peloponnesiaca* individuals appear in the beginning of March whereas those of *Lacerta graeca* do not emerge until late March or even early April. From late November to February no animal of either species has been observed.

For both species there is a positive linear correlation between body temperature and air temperature. Namely for *P. peloponnesiaca* we get the equation $Tb = 15.671 + 0.59\ Ta$ and

Tab. 2. Mean body (Tb) and mean air (Ta) temperatures of *L. graeca* among the seasons. N: sample size, x: mean value, SD: standard deviation.

Season	N	Tb (°C)		Ta (°C)	
		x	SD	x	SD
Spring	16	30.76	3.14	25.65	2.00
Summer	43	32.57	2.32	30.10	3.70
Autumn	6	32.60	2.81	25.63	3.91

Tab. 3. Mean body (Tb) and mean air (Ta) temperatures of *P. peloponnesiaca* among the seasons. N: sample size, x: mean value, SD: standard deviation.

Season	N	Tb (°C)		Ta (°C)	
		x	SD	x	SD
Spring	43	27.61	3.78	21.47	3.64
Summer	42	33.61	2.34	29.94	2.93
Autumn	27	30.98	2.81	25.01	4.49

for *L. graeca* the equation Tb = 22.225 + 0.35 Ta (fig. 1, 2). The slope values of the two species differ both from 1 and from 0. According to the model of HUEY & SLATKIN (1976), *L. graeca* seems to be a more efficient thermoregulator since its slope value is closer to zero, has a more restricted activity period, a smaller range of body temperature and the mean seasonal body temperatures are different from the corresponding air temperatures. On the other hand *P. peloponnesiaca* appears to have an intermediate attitude that gives it the ability to be active over a longer time period. We get a similar picture from other *Podarcis* species in Greece like *Podarcis erhardii* in the Aegean Sea area (VALAKOS 1990).

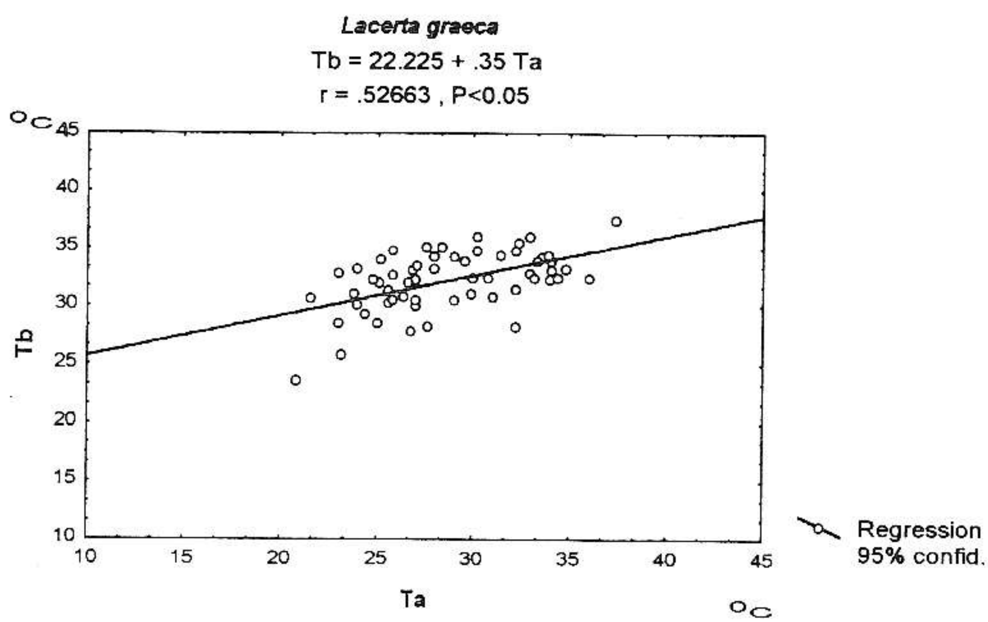


Fig. 1. Relationship between body temperature (Tb) and air temperature (Ta) in *Lacerta graeca*.

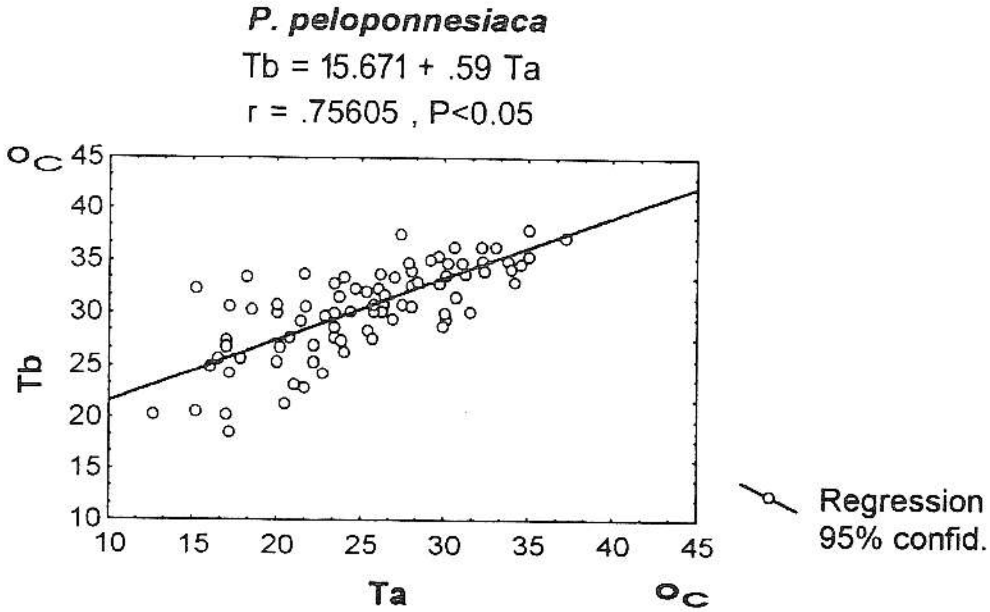
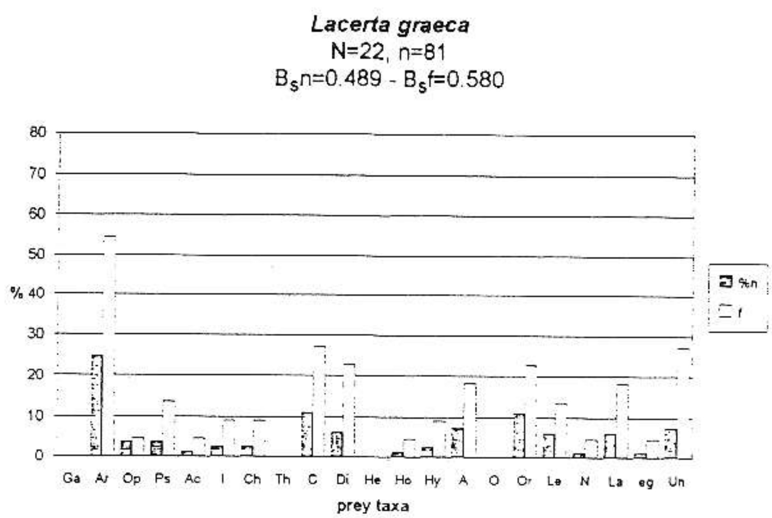


Fig. 2. Relationship between body temperature (Tb) and air temperature (Ta) in *Podarcis peloponnesiaca*.

Prey type	Spring *L. g.*	Spring *P. p.*	Summer *L. g.*	Summer *P. p.*
Gastropoda		1		
Araneae	12	8	8	7
Opiliones	3	0	0	1
Pseudoscorpions	2	0	1	0
Acarea	0	1	1	1
Isopoda	2	2	0	3
Chilopoda	0	0	2	0
Thysanura	0	1	0	0
Coleoptera	6	2	3	13
Diptera	4	2	1	2
Heteroptera	0	2	0	2
Homoptera	1	0	0	0
Hymenoptera	1	1	1	0
Ants	3	5	3	7
Odonata	0	0	0	2
Orthoptera	7	0	2	4
Lepidoptera	1	0	4	0
Neuroptera	0	0	1	0
Insect larvae	1	0	4	1
eggs	0	0	1	2
Undetermined	2	0	4	1
Total	45	25	36	46

Tab. 4. Trophic data of the two species for the two seasons examined (Numbers of prey items consumed). *L. g.* = *L. graeca*, *P. p.* = *P. peloponnesiaca*.

Trophic ecology: Both lizard species examined, feed mainly on arthropods (tab. 4). Also for both of them there is no difference in the percentage of the prey groups between the two seasons examined (*L. graeca* $x^2 = 21.24$, $df = 16$, $p > 0.05$, *P. peloponnesiaca* $x^2 = 18.033$, $df = 15$, $p > 0.05$), therefore we pooled the data. The two species feed on almost the same prey taxa but they show significant differences in the proportion of prey items consumed ($x^2 = 32.067$, $df = 19$, $p < 0.05$). Both species are euryphagous and it does not seem to exist differences between their niche breadth (fig. 3).



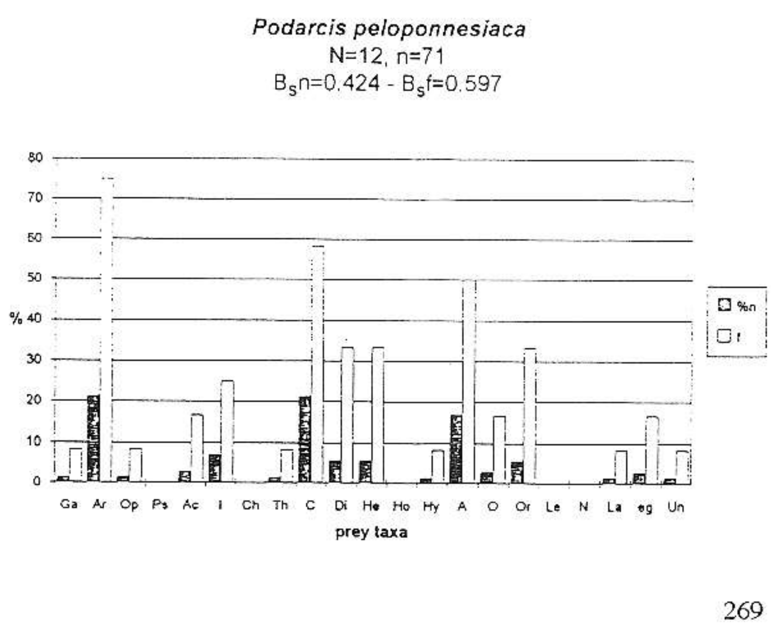


Fig. 3. Proportion of prey in the examined stomachs (% n) and proportion of specimens having eaten the same prey type (f). N: number of specimens, n: number of prey items. Ga: Gastropoda, Ar: Araneae, Op: Opiliones, Ps: Pseudoscorpionida, Ac: Acarea, I: Isopoda, Ch: Chilopoda, Th: Thysanoura, C: Coleoptera, Di: Diptera, He: Heteroptera, Ho: Homoptera, Hy: Hymenoptera, A: Ants, O: Odonata, Or: Orthoptera, Le: Lepidoptera, N: Neuroptera, La: Insect larvae, eg: eggs, Un: undetermined Arthropods.

In *P. peloponnesiaca*, the most frequently encountered prey groups in its diet are spiders, Coleoptera, Diptera and Orthoptera. These also constitute the greatest percentage of presence in the stomachs. The same prey groups with the exception of Diptera, have been also mentioned by BRINGSØE (1986) though not from stomach contents analysis. In the same paper ants are mentioned as a favorite prey but we did not come to similar findings.

L. graeca feeds mainly on spiders, Coleoptera, Orthoptera and frequently on Diptera. Some prey groups like pseudoscorpions, Lepidoptera and insect larvae are more frequently eaten by this species than by *P. peloponnesiaca*. No previous data from literature have been encountered.

The two species feed on the commonest prey taxa like spiders and Coleoptera. Although there is a big overlap in their diet there are also some differences that possibly reflect the differences in their habitat selection as *L. graeca*, when sympatric with *P. peloponnesiaca*, occupies more shaded and humid microhabitats (BUTTLE 1988).

Based on these first results we can say that the ecological requirements of the two examined species, although not extremely differentiated, are distinct enough to permit them to exist in sympatry.

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