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ANALYSIS AND COMPARISON OF SEXUAL SIZE DIMORPHISM IN TWO LACERTID SPECIES IN BULGARIA

A. P. GROZDANOV[1*] and N. D. TZANKOV[2]
[1] *Sofia University "St. Kliment Ohridski", BG – 1164 Sofia, Bulgaria*
[2] *Bulgarian Academy of Sciences, National Museum of Natural History, BG – 1000 Sofia, Bulgaria*

Abstract

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Sexual size dimorphism or SSD is widespread among many species of reptiles. The present research aims to analyze and compare the SSD in two lacertid lizards in Bulgaria – the Green lizard (*Lacerta viridis*) and the lowland subspecies of the Sand Lizard (*Lacerta agilis chersonensis*).

Ten experimental territories were selected in Sofia and Plovdiv plains and neighboring areas. A total of 68 sand lizards and 65 green lizards were analyzed. For every individual were measured or counted 8 metric traits (transformed in to 12 indexes) and 12 meristic traits. Data scores were analyzed by mean of uni- and multivariate statistical technique.

Investigating the meristic traits, we found statistically significant differences only in the number of horizontal lines of ventral shields between sexes in both species. Concerning the metric traits and indexes, we found statistically significant tendencies for larger absolute and relative head size in male sand lizards in comparison with females. In green lizard we stated similar significant tendency for larger head size and larger absolute and relative size of legs in male individuals. The presented results could be explained with the different roles of the sexes of those two species. SSD is more prominent in green lizard in comparison with sand lizard.

In conclusion all that factors lead to bigger morphological differences between sexes in green lizards.

Key words: Lacerta viridis, *Lacerta agilis*, morphology, dimorphism

Introduction

The differences between male and female individuals in the size of their body parts (generalized with the term "Sexual size dimorphism" – SSD) are widely distributed among reptiles (Roitberg and Smirina, 2006). During the last decades the SSD is object of some herpetological researches, dealing with morphological, evolutional and general ecology (Brana, 1996, Stamps et al., 1997; Wikelski and Trillmich, 1997; Butler et al., 2000). The main concepts for SSD expression are based on two statements: 1. bigger size of males, connected with advantages during territorial fights, 2. bigger size of females, connected with advantages for development of the eggs (Cox et al., 2003). The different species of lacertid lizards show large variations concerning the level and direction of SSD (Fitch 1981). However the published researches in this area are relatively rare (Brana, 1996; Molina-Borja and Rodríguez-Domínguez, 2004).

The aim of the present work is to analyze and to compare the SSD of the Green lizard (*Lacerta viridis*) and the lowland subspecies of the Sand lizard (*Lacerta agilis chersonensis*) in Bulgaria by usage of different metric and meristic traits and indexes based on them.

Material and Methods

For the present research a total of ten work polygons were selected. Five were situated in the Sofia plain, West-

**E-mail: zootribe@gmail.com*

ern Bulgaria, and five in Plovdiv plain. The polygons were visited between April and August 2010, April – July 2011 and May 2012, from 7:30 to 20:30 (GMT+2) as in all visits before and after that period no specimens were recorded. We attempted to catch by hand every lizard we spotted. Every individual's sex and age were identified by specific color pattern characteristics, stage development of the femoral pores in males and presence/absence of mating scars in females (presented in adults). A total of 68 individuals of Sand lizards and 65 individuals of Green lizards were captured. For every individual we took information for eight metric traits: body length – Lcor, tail length – Lcd, length of front leg – Pa, length of hind leg (from the fold to the base of the first finger) – Pp, length of hind legs step (from the tip of the longest to the base of the first finger) – Pp2, pileus length – Lpil, pileus width – Latpil, head width (at the widest point of the jugal bones) – Latcap, transformed into ten indices: Lpil/Lcor, Latcap/Lcor, Latpil/Lcor, Lcor/Lcd, Pa/Lcor, Pp/Lcor, Pp2/Lcor, Latcap/Lpil, Latpil/Lpil, Pa/Pp+Pp2. Additionally 12 meristic traits were stated, counting of different groups of scales, not described here as preliminary tests reviled statistically significant differences only in the number of horizontal lines of ventral shields. Standard measurements and scale count are following those in Terentiev and Chernov (1949), Funh and Vancea (1961) and Darevsky (1967).

The received data was processed with uni- and multivariate statistical methods – Analysis of variance (ANOVA) and Canonical discriminate analysis (CDA), which were performed with Statistica 7.0 (StatSoft 2004).

Results

During the separate statistical analysis of the SSD of the two species, we found similar differences between both sexes in only one meristic trait – the number of horizontal scale lines on abdominal side (V). More significant differences were found in the metric traits and indices, which generally showed tendencies for larger head size and longer limbs in males in both species. The first comparison of the researched species' SSD was based on the metric indices, analyzed trough ANOVA (Table 1). Statistically significant differences among sexes in *L. agilis* were found in four indices characterizing the proportions of the head, two indices connected with limbs and one tail index. In *L. viridis* statistically significant differences in SSD were better expressed in four indices characterizing the proportions of the head and three indices connected with limbs.

The comparison with ANOVA was followed by CDA with the raw data. Higher contribution had Latcap, Lcor, Pp, Pp2, Lpil and Lcd with different levels of statistical significance. The level of expression of SSD was compared by calculating of the squared Mahalanobis distance during the processing of data with CDA. The SSD was stated to be higher in Green lizard according to the higher value of the distance compared with the Sand lizard (Table 2).

Table 1

Statistically significant differences in indices between sexes of *Lacerta viridis* and *Lacerta agilis*

	Lacerta agilis	*Lacerta viridis*
Lpil/Lcor	***	***
Latcap/Lcor	***	***
Latpil/Lcor	***	***
Lcor/Lcd	**	
Pa/Lcor	*	**
Pp/Lcor		**
Pp2/Lcor	*	**
Latcap/Lpil	**	***

Legend: *P < 0.05, **P < 0.01 and ***P<0.001

Table 2

Values of squared Mahalanobis distance (with bold numbers) between sexes of *Lacerta viridis* and *Lacerta agilis*

вид, пол	*L. viridis* f	*L. viridis* m	*L. agilis* m	*L. agilis* f
L. viridis f	–	<0.001	<0.001	<0.001
L. viridis m	16.62	–	<0.001	<0.001
L. agilis m	52.70	41.45	–	<0.001
L. agilis f	45.32	60.96	11.45	–

Legend: f – female; m – male

The distribution of the sexes of *L. viridis* and *L. agilis* based on CDA is presented on Figure 1. The four groups are well separated in the multidimensional space. The percentages of correct classification among groups are very high (100% except for males *L. viridis* – 85.7%).

Discussion

The study of the meristic traits found significant differences between sexes of the two species in only one trait – the number of horizontal scale lines on abdominal side (V), which is higher in females. This situation is widespread among lacertids and is hypothetically connected with the development and hatching of the eggs (Darevsky, 1979).

The investigation of the metric traits of the two species showed common tendencies for larger head and longer limbs in males in comparison with females. The reasons for these results should be searched in the behavioral specifics of the two sexes. The larger head of male lizards is connected with the presence of larger jaw musculature (Herrel et al., 1996), which provides advantages during the territorial fights, fights for the female and for holding the female during copulation

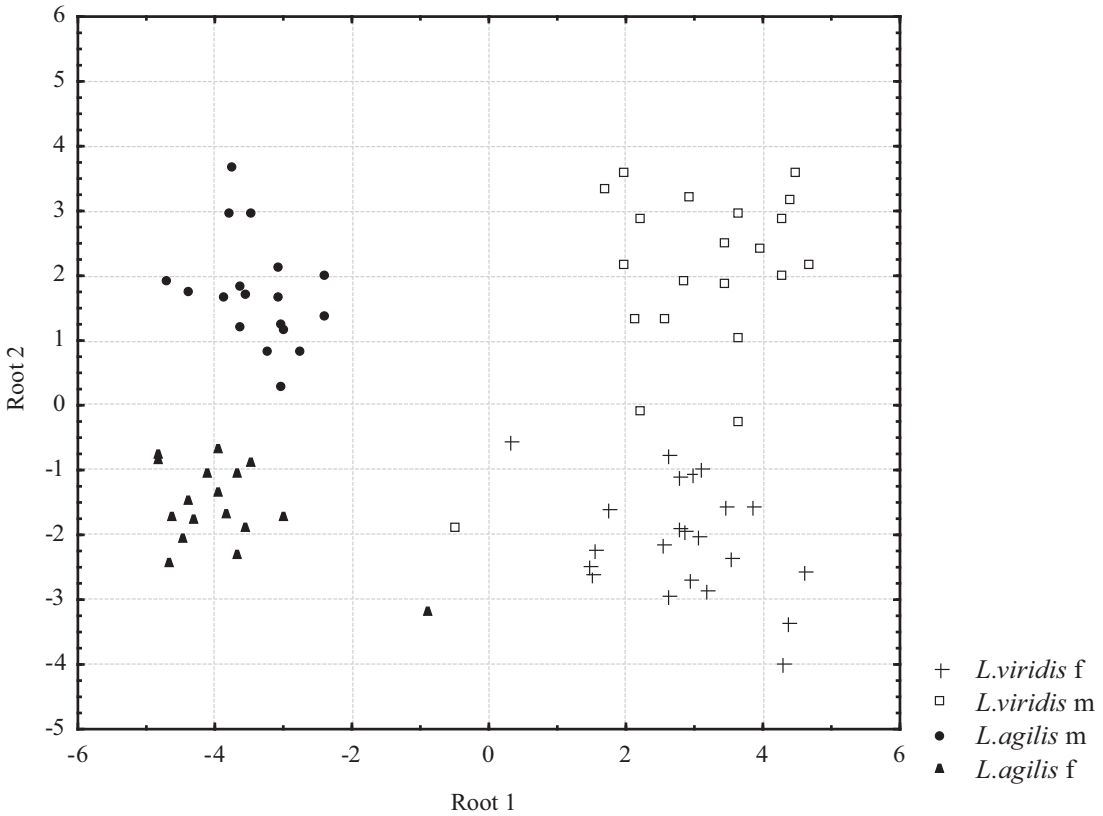

Fig. 1. Distribution of sexes of *Lacerta viridis* and *Lacerta agilis* in the multidimensional space obtained through CDA
Legend: **f – female; m – male**

(Verbeek, 1972; Heulin, 1988). The longer legs of the male lizards are connected with their higher mobility. The reasons for that could be found in their behavioral specifics like the guarding of the individual territory and the active chasing and guarding of females before copulation (Castilla and Labra, 1998; Cooper, 1999; Martín and López, 2001; Cooper and Vitt, 2002).

In detailed comparison of the single metric indexes of the two species, we found a tendency for relatively longer limbs and tail in Green lizards. That could be connected with the common use of climbing on shrubs and trees in that species compared with the Sand lizard. The climbing ability is also confirmed with the comparison of the microhabitats of the two species, which showed higher presence of shrubs and trees for the Green lizard (Stojanov et al., 2011).

The better expressed SSD in green lizards in general could be explained with the larger individual territories of the males (Korsos, 1986), which demand higher mobility for their protection. Additionally this species inhabits more variable microhabitats not only in horizontal but also in vertical scale which corresponds with his better ability for climbing. The facts mentioned above suggest higher differentiation between sexes in *L. viridis*, compared with *L. agilis*, which is visualized trough the squared Mahalanobis distance.

Conclusion

The Green lizard (*L. viridis*) and the Sand lizard (*L. agilis*) possess a well expressed SSD, confirmed mainly through metric traits and derived indices. In both species we found tendencies for larger head and longer limbs in males, which respond to their specific behavioral patterns. The level of expression of SSD is higher in *Lacerta viridis*, which is most probably connected with the larger individual territories of males, leading to their higher mobility and thus to higher morphological differences with the females. The present work analyzed and compared for the first time the SSD of the two taxa with large number of traits and indices, supported by statistical procedures.

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References

Brana, F., 1996. Sexual dimorphism in lacertid lizards: Male head increase vs female abdomen increase? *Oikos*, **75**: 511–523.

Butler, M. A., T. W. Schoener and J. B. Losos, 2000. The relationship between sexual size dimorphism and habitat use in Greater Antillean Anolis lizards. *Evolution*, **54**: 259–272.

Castilla, A. M. and A. Labra, 1998. Predation and spatial distribution of the lizard *Podarcis hispanica atrata*: an experimental approach. *Acta Oecologica*, **19**: 107–114.

Cooper, W. E. Jr. and L. J. Vitt, 2002. Increased predation risk while mate guarding as a cost of reproduction for male broadheaded skinks (*Eumeces laticeps*). *Acta Ethologica*, **5**: 19–23.

Cooper, W. E. Jr., 1999. Tradeoffs between courtship, fighting, and antipredatory behavior by a lizard, *Eumeces laticeps*. *Behavioural Ecology and Sociobiology*, **47**: 54–59.

Darevsky, I. S., 1967. Rock lizards of Caucasus. *Nauka*, Leningrad, 214 pp. (Ru).

Darevsky, I. S., 1979. Exploring the functional peculiarities traits of scaly cover of reptiles. In: *Status and prospects of morphology, Materials for the Union meeting, Nauka*, Moskva, 182–185 pp. (Ru).

Fuhn, I. and Ş. Vancea, 1961. The fauna of the People's Republic of Romania. Vol. XIV, fascicola II, Reptilia. *Editura Academiei R.P.R.*, Bucureşti, 352 pp. (Ro).

Herrel, A., R. Van Damme and F. De Vree, 1996. Sexual dimorphism of head size in *Podarcis hispanica atrata*: Testing the dietary divergence hypothesis by bite force analysis. *Netherlands Journal of Zoology*, **46**: 253–262.

Heulin, B., 1988. Observations sur l'organisation de la reproduction et sur les comportements sexuels et agonistiques chez *Lacerta vivipara*. *Vie & Milieu*, **38**: 177–187.

Korsós, Z., 1986. Ecological comparison of *Lacerta viridis* and *L. agilis*. In: Z. Roček, (Editor), *Studies in Herpetology*, *Proceedings of the European Herpetologieal Meeting, 3rd Ordinary General Meeting of the Societas Europaea Herpetologica August 19–23, 1985, Charles University*, Prague, 455–458 pp.

Martín, J. and P. López, 2001. Risk of predation may explain the absence of nuptial coloration in the wall lizard, *Podarcis muralis*. *Evolutionary Ecology Research*, **3**: 889–898.

Molina-Borja, M. and M. A. Rodríguez-Domínguez, 2004. Evolution of biometric and life-history traits in lizards *Gallotia* from the Canary Islands. *Journal of Systematic and Evolutionary Research*, **42**: 44–53.

Roitberg, E. S. and E. M. Smirina, 2006. Adult body length and sexual size dimorphism in *Lacerta agilis boemica* (Reptilia, Lacertidae): between-year and interlocality variation. In: C. Corti, P. Lo Cascio, M. Biaggini (Editors), *Mainland and insular lacertid lizards: a mediterranean perspective, Monografie Scienze, Firenze University Press*, **8**: 175–187.

Stamps, J. A., J. B. Losos, and R. M. Andrews, 1997. A comparative study of population density and sexual size dimorphism in lizards. *The American Naturalist*, **149**: 64–90.

StatSoft, Inc., 2004. STATISTICA (data analysis software system), version 7. www.statsoft.com.

Stoyanov, A., N. Tzankov and B. Naumov, 2011. Die Amphibien und Reptilien Bulgariens. *Chimaira*, Frankfurt am Main, 592 pp.

Terentiev, P. B. and S. A. Chernov, 1949. Field guide of reptiles and amphibians. *Sovetskaya nauka*, Moskva, 340 pp. (Ru).

Verbeek, B., 1972. Ethologische Untersuchungen an einigen europaischen Eidechsen. *Bonner zoologische Beiträge*, **23**: 122–151.

Wikelski, M. and F. Trillmich, 1997. Body size and sexual size dimorphism in marine iguanas fluctuate as a result of opposing natural and sexual selection: an island comparison. *Evolution*, **51**: 922–936.