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A COMPARISON OF SOCIAL BEHAVIOUR OF TWO LIZARD SPECIES – *ANGUIS COLCHICA* AND *ANGUIS FRAGILIS*

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Abstract: More and more studies proved a connection between behavioural characteristics and factors important to the adaptability of individuals. In this regard, the current research aims to study the behavioural strategies of *Anguis fragilis* and *Anguis colchica* to conspecifics in their intraspecific and interspecific interactions. The studies were conducted in laboratory conditions during the spring-summer period of 2017. A total of 9 dyadic encounters were held - 6 intraspecific and 3 interspecific encounters. Dyadic encounters were conducted in neutral glass terrarium for a period of 10 min. A total of 12 adult male lizards – 6 male *A. colchica* and 6 male *A. fragilis* were tested. The results showed that A. fragilis explored the environment longer time than A. colchica. During the interspecific encounters both species spent more time in searching for way out and less time in standing near to the partner. This gives a reason to believe that in nature the two legless lizard species probably avoid each other.

INTRODUCTION

The slow-worm *Anguis fragilis* (Linnaeus, 1758) is spread throughout continental Europe, including Britain and Scandinavia (Dely, 1981; Cabela, 1997; Salvador, 1998). Its populations reach Asia Minor. In Bulgaria, *A. fragilis* is found in the southwestern part of the country, mainly in the mountainous regions of Rila, Pirin, Rhodopes, West Stara Planina and Vitosha Mountain (Jablonski et al., 2016). The Eastern slow-worm, *Anguis colchica* (Nordmann, 1840) is found mainly in the southeastern Europe (Balkan Peninsula) and Western Asia. In Bulgaria the species is spread in the northern and eastern parts of the

country, mainly in the lower regions of Stara Planina, Strandzha, the Danube Plain and the Black Sea (Jablonski *et al.,* 2016). Anguidae are a group of reptiles, morphologically and functionally adapted to semi-subterranean lifestyle. The legless lizards prefer habitats with dense vegetation, where visibility is weak. So, they are often found under the bark of trees, flat stones or tiles. On this base, it is supposed that the legless lizards spend most of their active life underground or in the dense vegetation on the surface (Beebee and Griffiths, 2000).

The way that lizards use the physical and biological resources of habitats is an important aspect of their behavioural ecology. Various aspects of its behaviour, such as habitat selection, nutrition, protection from enemies, and others have been studied in various lizard species (Beck and Jenning, 2003; Reaney and Whiting, 2003, Quirt *et al.,* 2006; Schulte and Köhler, 2010), but their behaviour has been poorly studied. As a result of the observations on behaviour of male and female individuals of the common garden skink *Lupropholis guichenoti* in laboratory and semi-natural conditions, Torr and Shrine (2006) prepared an ethogram of observed behaviours. The authors described 45 behavioural events in individual and social context such as approaching, grooming, biting another individual, rolling, chasing, etc. According to the authors the most frequently observed behavioural events were connected to searching for food. At the same time, individuals rarely entered into contact. However, in natural conditions, aggressive interactions between two male *A. fragilis* individuals were reported by Malkmus (1995). Laboratory studies on the chemosensory reaction of *A. fragilis* to conspecifics of the same species are made by Gonzalo et al. (2004). Based on the results, it is assumed that the species is not territorial. In Bulgaria, the behavioural response of *A. fragilis* and *A. colchica* to their conspecifics is not studied yet. In this regard, the aim of the present work was to investigate their intra- and interspecific relationships during dyadic encounters in laboratory conditions. The knowledge of the character of interactions with conspecifics of their own and their closely related species will allow the understanding of the spatial relationships between them, arising from the spatial distribution and differences in their behavioural strategies. This knowledge can be integrated into different conservation and management practices (Wolf and Weissing, 2012). Both species of slow-worms are included in Annex III of the Bern Convention.

MATERIAL AND METHODS

For the study of the character of inter- and intraspecific relationships between two closely related slow-worms *A. fragilis* and *A. colchica* a total of 9 dyadic encounters were carried out - 6 intra- and 3 interspecific encounters. A total of 12 adult male lizards - 6 individuals of *A. colchica* and 6 adult male of *A. fragilis* were tested. The experiments were conducted in May and July of 2017. Encounters between individuals of the same species and between the two species

were carried out on neutral territory. For this purpose the lizards were moved from the terrariums in which they were reared in another, new terrarium. After 5 minutes of adaptation, their behaviour was observed for a period of 10 minutes. The following behavioural events were registered: Looking around (LO); Standing still (MN); Searching for Way out (WO); Approach to the partner (TO); Standing next to the partner (T); Retreat from the partner (R).

All behavioural experiments were recorded with a digital camera (Sony Cybershot DSC-HX60).

Duration of each behaviour, displayed by individuals in their intra- and interspecific encounters were compared using the $\chi 2$ test using MedCalc statistical software (https://www.medcalc.org/calc/comparison_of_proportions.php). In all tests performed for statistically significant differences, $P < 0.05$ was taken.

Ethic notes: Manipulations with the experimental objects were performed with the utmost precision to avoid injuries and any other disruption of animal viability. Upon completion of the experiments, the reptiles were released in the same places as they were previously captured.

RESULTS AND DISCUSSION

The results did not show a significant difference in the patterns of behaviour of both species in their intra- and interspecific relationships, except that in intraspecific dyadic encounters, *A. fragilis* significantly longer looked around compared to *A. colchica* - $\chi 2 = 5{,}1$, $P<0.02$ (Figs 1 and 2, Table 1).

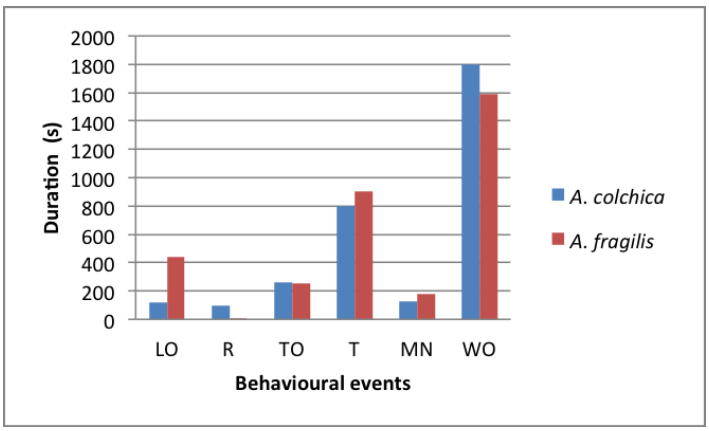

Fig. 1. Duration of observed behavioural events during intraspecific dyadic encounters in the two species of slow-worms - *A. colchica* and *A. fragilis.*
Legend: **LO** – looking around, **R** – retreat, **TO** - approaching to the partner, **T** - standing next to the partner, **MN** – standing still, **WO** – searching for Way Out

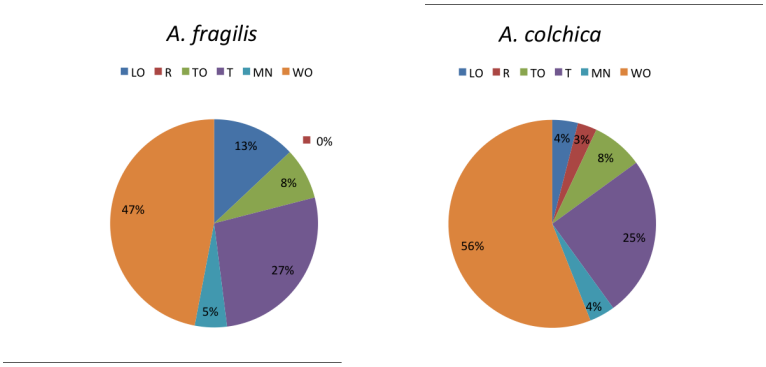

Fig. 2. Duration of behavioural events (in %) displayed by *A. fragilis* and *A. colchica* individuals in their intraspecific interactions.
Legend: **LO** – looking around, **R** – retreat, **TO** - approaching to the partner, **T** - standing next to the partner, **MN** – standing still, **WO** – searching for Way Out

Table 1. Comparison of the proportions of time of observed behavioural events in intraspecific dyadic encounters in *A. colchica* and *A. fragilis* by using of $\chi 2$ test. The statistically significant differences are in bold and marked with *.

Behavioural events	LO	R	TO	T	MN	WO
Difference	**9%**	3%	0%	2%	1%	9%
χ^2	**5,1**	3	0	0,1	0,1	1,6
DF	**1**	1	1	1	1	1
P	**0.02***	0,08	0	0,74	0,73	0,2

In interspecific encounters individuals of both species showed similar values in the duration of observed behavioural events. So, statistically significant difference between the two species in the proportion of time spent by the individuals in these activities was not established – Fig. 3, Table 2.

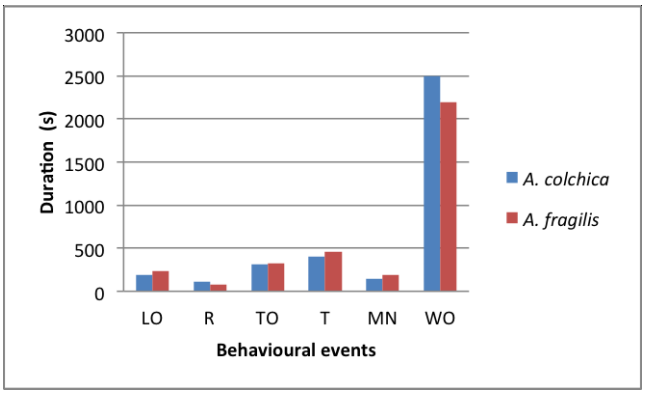

Fig. 3. Duration of observed behavioural events and their distribution in % in direct interspecific interactions in *A. colchica* and *A.fragilis*. *Legend:* **LO** – looking around, **R** – retreat, **TO** - approaching to the partner; **T** - standing next to the partner, **MN** - standing still, **WO** - searching for Way Out

Table 2. Comparison of the proportions of time of observed behavioural events in interspecific interactions in *A. colchica* and *A. fragilis* by using of $\chi 2$ test. The statistically significant differences are in bold and marked with *.

Behavioural events	LO	R	TO	T	MN	WO
Difference	2%	1%	0%	2%	2%	5%
χ^2	0,35	0,2	0	0,18	0,41	0,55
DF	1	1	1	1	1	1
P	0,55	0,65	1	0,66	0,51	0,45

However, when comparing the proportions time in which individuals displayed these behaviours with conspecifics of their own species (**Figure 2**) and in encounters with individuals of the other species (**Figure 4)**, it was found that individuals of both species showed higher values in search for Way Out and less time in standing near the partner in the interspecific encounters, compared to intraspecific ones - Table 3 and 4.

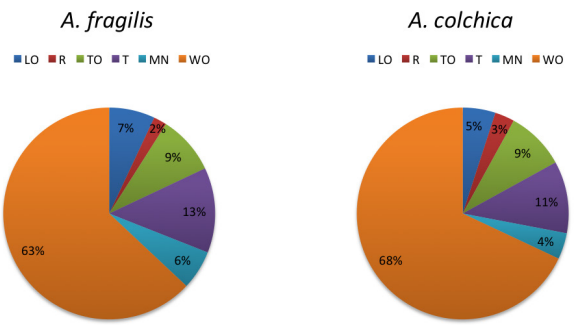

Fig. 2. Duration of behavioural events (in %) by *A. fragilis* in its direct interspecific interactions with *A. colchica* and vice versa - of *A. colchica* in its direct interspecific interactions with *A. fragilis*. *Legend:* **LO** – looking around, **R** – retreat, **TO** - approaching to the partner, **T** - standing next to the partner, **MN** – standing still, **WO** – searching for Way Out

Table 3. Comparison of the proportions of time of observed behavioural events in intra-and interspecific interactions in *A. colchica* by using of $\chi 2$ test. The statistically significant differences are in bold and marked with *

Behavioural events	LO	R	TO	T	MN	WO
Difference	1%	0%	1%	**14**	0%	12%
χ^2	0,1	0	0,06	**6,6**	0	3,04
DF	1	1	1	**1**	1	1
P	0,73	1	0,8	**0.01***	1	0,08

Table 4. Comparison of the proportions of time of observed behavioural events in intra- and interspecific interaction in *A. fragilis* by using of χ2 test. The statistically significant differences are in bold and marked with *

Behavioural events	LO	R	TO	T	MN	WO
Difference	6%	2%	1%	**14%**	1%	**16%**
χ^2	1,99	2	0,064	**6,09**	0,09	**5,1**
DF	1	1	1	**1**	1	**1**
P	0,15	0,15	0,8	**0.01***	0,75	**0.02***

The ability to receive information and to assess risk in a new environment is critical to the survival and adaptability of individuals in their natural habitats. Previous studies on the exploratory behaviour of the two lizard species *A. fragilis* and *A. colchica* (Telenchev, 2018) showed that *A. fragilis* displayed higher exploratory activity. In the intraspecific relationships, *A. fragilis* individuals looked around longer than *A. colchica,* which confirms its greater exploratory activity. In addition, in interspecific encounters, both species showed higher values of time in search for way out and less time standing close to the partner, similar to what found in other species of reptiles (Torr and Shine, 2006). This gives us the reason to believe that in nature the two species are probably avoiding each other.

Previous studies have shown that the Eastern slow-worm is much more adapted to the lower parts of the country (Telenchev, 2018). According to Telenchev (2018), at about 750 m there is a visible separation between the two species. Beshkov (1966) also mentioned that Eastern slow-worm is found more often below 500-600 m while the other species is found above this altitude. From the results related to bioclimatic factors of Telenchev (2018), it is also visible that the Eastern slow-worm is affected less by the humidity compared to *A. fragilis,* and the distribution and activity of *A. colchica* are much more dependent on the ambient temperature, than of *A. fragilis.* Thus, *A. fragilis* seems to be exposed to more and sharper climatic changes. The wider distribution and the lower dependence on the environmental factors of *A. fragilis* suggest that this species is much more adaptable and flexible than *A. colchica.* This flexibility of *A. fragilis* is probably the result of its evolutionally acquired behavioural strategies, including interactions with conspecifics. However, more data is necessary to insight into their intra- and interspecific interactions. According to Stojanov *et al.* (2011), cases of copulation between the two slow-worm species have been registered. In this regard, the spatial separation at altitude of the two species could contribute to reduce the possibilities for hybridization between them.

CONCLUSION

In the intraspecific dyadic encounters, *A. fragilis* looked around at the surrounding longer than *A. colchica,* which confirms its greater exploratory activity. In the interspecific encounters, both species spent more time in search for way out and less time in standing near the partner. This gives us a reason to suggest that in nature the two types of lizards avoid each other.

CONFLICT OF INTERESTS AND AUTHORSHIP CONTRIBUTION STATEMENTS

The authors declare that there is no conflict of interests regarding the publication of this article. D. S. planned the experiments, and I. T. carried out them. D.S. and V.S. wrote the manuscript with input from I.T., who contributed to the interpretation of the results. All authors provided critical feedback and helped shape the research, analysis and manuscript.

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