

## **A contribution to the knowledge of the trophic spectrum of the Slow Worm (*Anguis fragilis* L., 1758) (Reptilia: Anguidae) from Bulgaria**

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**Abstract.** During our study we identified 23 prey items in 12 prey categories in the trophic spectrum of *Anguis fragilis* with average number of prey items per stomach 2.87. The most important prey components are snails and slugs (Gastropoda) with 39.14% and beetles (Coleoptera) with 21.72%. The estimated trophic niche breadth is very high – 19.46. The Slow Worm forages primarily at dawn or twilight, and the feeding is most intensive in the summer season. It can be considered “swallowing” predator and a “polyphage” to some extent, capturing only slowly moving prey.

**Key words:** *Anguis fragilis*, diet, trophic spectrum, niche breadth, Bulgaria.

**Introduction.** The Slow Worm (*Anguis fragilis* L., 1758) is the one of the representatives from the Anguidae family, occurring in Bulgaria (Beshkov & Naney 2002) and its trophic spectrum is very poorly known. Partial data about the diet of the species in Bulgaria can be found in the works of Kovachev (1910, 1912), Peshev (1967), Peshev *et al.* (1984) and Beshkov & Naney (2002). Currently there is only one specialized study on the diet of the Slow Worm, conducted in Bulgaria (Angelov *et al.* 1966) and one unpublished MSc thesis (Voronov 1973).

The aim of the current study is to supplement the knowledge about the trophic spectrum and feeding ecology of the Slow Worm (*Anguis fragilis*) in Bulgaria.

**Material and Methods.** We examined 12 stomachs of adult specimens of the Slow Worm (*Anguis fragilis*), preserved in 70% alcohol and kept in the herpetological collection of the Department of Zoology at the University of Plovdiv, Bulgaria. The material was collected in 15.IV.1967 from the surroundings of Assenovgrad Town (UTM LG25) – 1 spec.; 18.V.1967 from the surroundings of Krastets Village (UTM LH83) in Stara Planina Mt. – 2 spec.; 26.V.1967 and 26.VI.1969 from the surroundings of “Zdravets” Hut in the Rhodopes Mts. (UTM LG05) – 6 spec. and the surroundings of Gramatikovo Village (UTM NG55) in Strandzha Mt. – 3 spec.

The stomachs were dissected in Petri dishes and the stomach contents were analyzed by means of binocular microscope. The prey taxa were identified to the lowest possible taxon, based on its degree of composition. The systematic of the identified invertebrate taxa follows “Fauna Europaea” (Fauna Europaea Web Service (2009). For convenience the Gastropods are divided in two biological groups – snails (Gastropoda terrestria) and slugs (Gastropoda terrestria nuda).

Sampling adequacy was determined using Lehner`s formula (Lehner 1996):

$$Q = 1 - \frac{N_1}{I},$$

rising from 0 to 1, where  $N_1$  is the number of the food components occurring only once, and  $I$  is the total number of the food components.

The diversity of the diet (niche breadth) was calculated, using the reciprocal value of the Simpson's diversity index (Magurran 1986):

$$S = \frac{1}{\sum p_i^2},$$

where:  $S$  – trophic niche breadth;  $P_i$  – proportion of food component  $i$ .

To determine the level of the food specialization we used the index of dominance of Berger-Parker ( $d$ ), calculated by the following formula (Magurran 1988):

$$d = \frac{n_i \max}{N},$$

where:  $N$  – the number of all recorded food components (taxa);  $n_i \max$  – the number of the specimens from taxon  $i$  (the most numerous taxon in the diet). The Berger-Parker index ( $d$ ) varies between  $1/N$  and 1. A value closer to 1 means a higher specialization in the choice of food; a value closer to  $1/N$  is typical for a species that is a general feeder (polyphage).

The results were statistically processed using descriptive statistics with the software package “Statistica 7.0” (StatSoft Inc. 2004). For the calculations of Simpson's diversity index and the Berger-Parker index we used the computer software “Bio-DAP” (Thomas & Clay 2000).

**Results and Discussion.** From the 12 collected stomachs, 4 were empty or with only digested remains. The analyzed stomach contents of total 8 stomachs contained 23 prey items, divided in 12 prey categories. The average number of prey items per stomach is 2.87 (SD=1.64). The sampling adequacy is considered sufficient – 0.75.

Table 1 presents the qualitative and quantitative proportion and frequency of occurrence of the trophic spectrum of *Anguis fragilis*. In the table are included the data from the study of Angelov et al. (1966) and unpublished data from the MSc thesis of Voronov (1973).

According to our data the predominated food type in the diet of the Slow Worm is Gastropoda – 39.14%, followed by Coleoptera – 21.72% (Table 1). The Insects in our study represent a low proportion of the trophic spectrum of *Anguis fragilis* (34.76%). Similar results were obtained by Angelov *et al.* (1966) – 33.34%, as the study of Vamporov (1973) showed a medium value – 57.12%.

The most important prey categories – the slugs and snails (Gastropoda) and the beetles (Coleoptera) seem to be consumed frequently by the Slow Worm. They are basic food component most probably due to the abundance of these animals and the wide range of habitats where they could be found. According to our results and the results by Angelov *et al.* (1966) and Vamporov (1973) *Anguis fragilis* doesn't show specific specialization in either group. The Berger-Parker index has considerably low value – 0.39.

The trophic niche breadth according to our data is quite high – 19.46. According to Vamporov's data it has significantly low value – 7.60. The trophic niche breadth calculated according to the data of Angelov et al. (1966) is 2.50, but this low value is due to the very small number of stomachs examined.

Some data about the seasonal feeding activity and feeding behavior of the Slow worm can be found in the work of Vamporov (1973). According the author the feeding intensity is higher in the summer (June and July) and partly the autumn. The foraging mainly occurs in

the morning or the evening hours. The Slow Worm's moving pattern differs from other active foraging lizard species, because it moves in continuous matter (Ghira *et al.* 1999). After identification and localization, the food object is slowly picked up in the mouth by the jaws. The prey is usually captured and swallowed with the long recurved teeth (Vamporov 1973). *Anguis fragilis* can be considered "swallowing" predator (Vorobyeva & Chugunova 1986), and a "polyphage" to some extent, capturing only slowly moving prey.

**Table 1.** Results from the food niche study of the diet of *Anguis fragilis* from the current study and comparison with literary data.

**Legend:** *n* – number of prey items; *n* % – numeric proportion (percentage proportion from the total number of prey items); *f* % – frequency of occurrence (percentage proportion of the frogs that consumed the prey taxon).

Prey taxa	Current study (n=8)			Angelov <i>et al.</i> (1966) (n=4)			Vamporov (1973) (n=63)		
	n	n %	f %	n	n %	f %	n	n %	f %
Gastropoda – undet.	—	—	—	4	66.66	80.00	—	—	—
Gastropoda (slugs)	2	8.70	1	—	—	—	13	11.61	12.70
Arionidae	3	13.04	2	—	—	—	—	—	—
Limacidae	2	8.70	2	—	—	—	—	—	—
Gastropoda (snails)	2	8.70	1	—	—	—	15	13.39	11.11
Arachnida (Aranei)	2	8.70	2	—	—	—	6	5.36	3.18
Lumbricidae	2	8.70	1	—	—	—	9	8.04	9.52
Crustacea (Isopoda)	2	8.70	2	—	—	—	3	2.68	3.18
Myriapoda, Chilopoda	—	—	—	—	—	—	2	1.78	3.18
Insecta - undet.	—	—	—	1	16.67	20.00	3	2.68	4.77
Insecta (larvae) – undet.	—	—	—	—	—	—	2	1.78	3.18
Dermaptera	—	—	—	—	—	—	3	2.68	3.18
Hemiptera	1	4.34	1	—	—	—	—	—	—
Hymenoptera	—	—	—	—	—	—	—	—	—
Formicidae	—	—	—	—	—	—	29	25.89	20.96
Coleoptera - undet.	—	—	—	—	—	—	—	—	—
Carabidae	1	4.34	1	—	—	—	—	—	—
Chrysomelidae	3	13.04	2	—	—	—	—	—	—
Cantharidae	1	4.34	1	—	—	—	—	—	—
Coleoptera (larvae)	—	—	—	—	—	—	13	11.61	12.70
Lepidoptera (larvae)	2	8.70	1	1	16.67	20.00	14	12.50	14.29
<b>Sampling adequacy</b>	<b>0.75</b>			<b>0.33</b>			<b>0.79</b>		
<b>Berger-Parker index</b>	<b>0.39<sup>1</sup></b>			<b>0.67</b>			<b>0.26</b>		
<b>1/Simpson</b>	<b>19.46</b>			<b>2.50</b>			<b>7.58</b>		

The other authors, who report only partial data about the trophic spectrum of the Slow Worm in Bulgaria, without any quantitative values are quite concordant with each other. According to Kovatchev (1910, 1912), *Anguis fragilis* feeds on "worms, caterpillars, centipedes and slugs". Peshev (1962) reported that the Slow Worm feeds on "slugs, worms, centipedes, etc" and Peshev *et al.* (1984) – "earth worms, snails and slugs, centipedes, insects and other slow-moving invertebrates". Beshkov & Naney (2002) reported that *Anguis fragilis* feeds on "small snails and slugs, Earth worms, centipedes, insects and their larvae".

In our opinion further studies on the trophic spectrum of *Anguis fragilis*, based on large number of studied specimens and conducted during several seasons, are needed in order to determine the variations in the diet, the food specialization of the species as well as its niche breadth.

<sup>1</sup> The Berger-Parker index (d) is calculated for the whole class Gastropoda.

### Conclusions.

1. During our study we identified 23 prey items in 12 prey categories in the trophic spectrum of *Anguis fragilis* with average number of prey items per stomach 2.87.
2. The most important prey components are snails and slugs (Gastropoda) with 39.14% and beetles (Coleoptera) with 21.72%.
3. The estimated trophic niche breadth is very high – 19.46.
4. The Slow Worm forages primarily at dawn or twilight, and the feeding is most intensive in the summer season. It can be considered “swallowing” predator and a “polyphage” to some extent, capturing only slowly moving prey.

**Acknowledgements.** The author would like to express his sincerest gratitude to Dr. Vasil Tomov for the given determined material, used in the current study, Dr. Georgi Popgeorgiev for the review of the manuscript and Prof. Dietrich Kranz for the support.

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