

## HELMINTH FAUNA OF *MUS MUSCULUS* LINNAEUS, 1758 FROM THE SUBURBAN AREA OF BELGRADE, SERBIA

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**Abstract** — The helminth fauna of the house mouse (*Mus musculus* Linnaeus, 1758) was studied on the basis of 429 host individuals from the suburban area of Belgrade. Eleven helminth species were recorded: three cestode species - *Catenotaenia pusilla*, *Rodentolepis fraterna*, and *Cysticercus* (= *Strobilocercus*) *fasciolaris* [larval stage of *Taenia taeniaeformis* (Batsch, 1821)]; and eight nematode species - *Heligmosomoides polygyrus*, *Syphacia* sp., *Aspiculuris tetraptera*, *Syphacia obvelata*, *Heterakis spumosa*, *Trichuris muris*, *Mastophorus muris*, and *Gongylonema* sp. Within the general helminth fauna, *H. polygyrus* was found to be the most prevalent species (39.2%) and caused the highest infection intensity. Prevalences of *A. tetraptera*, *C. pusilla*, and *S. obvelata* ranged from 12.8% to 6.1%, while the remaining species showed prevalences ranging from 4.9% (for *Syphacia* sp.) to 0.2% (for *Gongylonema* sp.). All the species found in males were also present in females, with the exceptions of *M. muris* and *Gongylonema* sp. No significant differences were found between males and females regarding prevalence (P%), mean infection intensity (MI), or mean abundance (MA).

**Key words:** *Mus musculus*, gastrointestinal helminths, suburban area of Belgrade, Serbia

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### INTRODUCTION

Rodents have a greater ability than most other animal species to harbor many zoonotic agents. Given their broad distribution and their close contact with different animals and humans, rodents play an important role as reservoir hosts for vector-borne disease agents (K l i m p e l et al., 2006). Parasites can have both direct and indirect effects on host reproduction; direct effects include abnormal growth, delayed sexual maturity, and shortening of the time period when the rodents are physiologically capable of reproducing (S c o t t, 1988). Most of the evidence for a key role of parasites in structuring communities is based on the concept of differential susceptibility of host species to infection and its consequences. Recent advances in community ecology suggest that life-history traits of free-living species can be an important determinant of their co-existence within communities. On the other

hand, parasites have the potential to indirectly alter life-history traits of their hosts, such as developmental time or dispersal (T h o m a s et al., 2000). The component structure of helminth communities in wild rodents in any geographical region is influenced by both extrinsic (year, season, site) and intrinsic (host sex, age, reproductive status) factors (H a u k i s a l m i et al., 1988; M o n t g o m e r y and M o n t g o m e r y, 1990; B e h n k e et al., 1999).

The helminths of the house mouse (*M. musculus*, Linnaeus 1758) have been studied in various parts of the world (M c K e n n a, 1997; F e l i u et al., 1997; P i s a n u et al., 2001; B e l l o c q et al., 2002; M a z e i k a et al., 2003; M o r o et al., 2003; M i l a z z o et al., 2003; P u l i d o - F l o r e s et al., 2005). M e s z a r o s et al. (1983) presented the first data on the helminth species of the house mouse and other rodents (*Apodemus agrarius*, *A. sylvaticus*,

*Microtus arvalis*, *Cricetus cricetus*) from the region of Vojvodina, Serbia. No studies of helminthic parasites of *M. musculus* in the suburban area of Belgrade have been carried out until the time of this research project.

The house mouse, which is cosmopolitan in its distribution, is primarily a burrowing species and is commonly found living near sources of food and water, such as refuse and drainage pits, streams, or sewers. The paucity of data on endoparasites of the house mouse might be explained by the fact that it is not common in natural habitats where wild rodents are usually caught.

The aims of the present study were: (1) to describe the species richness of gastrointestinal helminths of the house mouse from the suburban area of Belgrade, and (2) to investigate the effects of host-related (age, sex) and temporal factors on helminth prevalence and the number of parasite species per individual mouse.

#### MATERIAL AND METHODS

A total of 429 wild house mice (*M. musculus*, Linnaeus 1758) were collected from a site in the suburban area of Belgrade (village of Jabuka, 44° 55.921 N 20° 40.225 E, 15 km northeast of Belgrade).

Trapping of mice was carried out during the period from April 2004 to November 2005, using Sherman live traps (H.B. Sherman Traps Inc., Tallahassee, Florida, USA). The captured mice were euthanized and necropsied in our laboratory.

For each mouse examined, the data of trapping locality, body length (head and body), and sex were noted. Mice were separated into two age-weight groups: juveniles (< 9 to < 12 g) and adults (≥ 12 to > 15 g) (Krebs et al. 1995).

The material was analyzed using standard parasitological procedure. The stomach, small intestine, cecum, and colon were separated, opened longitudinally, and their contents rinsed out into individual Petri dishes with a 0.85% NaCl solution. The livers were examined for the presence of metacestodes. Larval capsules were opened through

a small slit to release the parasites. Helminthic parasites were recovered alive, counted, and identified under a stereoscopic microscope. The collected helminths were kept in 95% ethanol. For identification of helminths of house mouse we used Kruss and Olympus BO61 binoculars and Olympus CHC and Carl Zeiss microscopes. Identification of helminths was based on Key to Helminths of Rodents of the Fauna of the USSR (1978, 1979) and descriptions given by Genov (1984). The parasitological terminology and quantitative parameters are according to Buch et al. (1997).

Comparisons for age and sex were tested using the Mann-Whitney test (U). The ANOVA test was used to analyze differences in parasite abundance and body mass between groups of mice. The prevalence ratio was tested using Fisher's exact test. For parasite prevalence, helminth species were tested separately and combined. All other correlations were tested using Spearman's test. Overall homogeneity was tested by the Levine test and distribution by the normal distribution test. Statistical analyses were performed using the STATISTICA 5.0 statistical software package (StatSoft Inc., Tulsa, Oklahoma, USA).

#### RESULTS

The endoparasitic fauna of the house mouse in the suburban area of Belgrade is characterised by the presence of 11 species of helminths, namely: three cestode species - *Catenotaenia pusilla* (Goeze, 1782), *Rodentolepis fraterna* (Stilles, 1906), and *Cysticercus fasciolaris* [larval stage of *Taenia taeniiformis* (Batsch, 1786)]; and eight nematode species - *Heligmosomoides polygyrus* (Dujardin, 1845), *Syphacia* sp., *Aspiculuris tetraptera* (Nitsch, 1821), *Syphacia obvelata* (Rudolphi, 1802), *Heterakis spumosa* Schneider, 1866, *Trichuris muris* (Schrank, 1788), *Mastophorus muris* (Gmelin, 1790) and *Gongylonema* sp. (Table 1).

Of all house mice, 262 (61.1%) were infected with one or more intestinal helminth species. Of all adult mice, 50.2% of males and 40.4% of females were infected with one or more parasites. Of all juvenile mice, 33.4% of males and 31.3% of females were infected with one or more parasites.

**Table 1.** Quantitative indices of helminth infection of *Mus musculus*. Abbreviations: n - number of animals infected, N - total number of parasites, Range of the intensity /min-max/, M - median, P% prevalence, MI - mean intensity, MA ( $\pm$ SE) - mean abundance,  $p < 0.05$  ANOVA.

Helminth species	n	N	Min	Max	Total					Sex	
					M	P%	MI	MA	$\pm$ SE	p	
<i>Heligmosomoides polygyrus</i>	168	1470	1	75	6	39.2	8.7	3.42	0.49	0.73 ns	
<i>Aspicularis tetraptera</i>	55	966	1	88	7	12.8	17.6	2.25	1.13	0.08 ns	
<i>Catenotaenia pusilla</i>	31	174	1	40	3	7.2	5.6	0.40	0.41	0.76 ns	
<i>Syphacia obvelata</i>	26	209	1	48	3	6.1	8.0	0.48	0.57	0.96 ns	
<i>Syphacia</i> sp.	21	176	1	50	4	4.9	8.4	0.41	0.54	0.63 ns	
<i>Trichuris muris</i>	11	36	1	7	2	2.6	3.3	0.08	0.10	0.66 ns	
<i>T. taeniaeformis</i> larvae	6	7	1	2	1	1.4	1.2	0.02	0.02	0.37 ns	
<i>Rodentolepis fraterna</i>	5	25	1	13	4	1.2	5.0	0.05	0.24	0.54 ns	
<i>Heterakis spumosa</i>	3	17	1	12	4	0.7	5.7	0.04	0.27	0.49 ns	
<i>Mastophorus muris</i>	3	7	1	5	1	0.7	2.3	0.02	0.11	-	
<i>Gongylonema</i> sp.	1	3	3	3	3	0.2	3.0	0.01	-	-	

Male hosts (n = 213)										
Helminth species	n	N	Min	Max	M	P%	MI	MA	$\pm$ SE	
<i>Heligmosomoides polygyrus</i>	90	765	1	37	6	42.3	8.5	3.50	0.70	
<i>Aspicularis tetraptera</i>	28	344	1	60	6	13.1	12.3	1.61	1.05	
<i>Catenotaenia pusilla</i>	21	111	1	30	3	9.9	5.3	0.52	0.45	
<i>Syphacia obvelata</i>	15	122	1	48	3	7.0	8.1	0.57	0.85	
<i>Syphacia</i> sp.	9	63	1	20	4	4.2	7.0	0.29	0.45	
<i>Trichuris muris</i>	5	18	1	7	2	2.3	3.6	0.08	0.19	
<i>T. taeniaeformis</i> larvae	3	3	1	1	1	1.4	1.0	0.01	0.00	
<i>Rodentolepis fraterna</i>	2	14	1	13	7	0.9	7.0	0.06	0.58	
<i>Heterakis spumosa</i>	1	1	1	1	1	0.5	1.0	0	-	
<i>Mastophorus muris</i>	3	7	1	5	1	1.4	2.3	0.03	0.16	
<i>Gongylonema</i> sp.	-	-	-	-	-	-	-	-	-	

Female hosts (n = 216)										
Helminth species	n	N	Min	Max	M	P%	MI	MA	$\pm$ SE	
<i>Heligmosomoides polygyrus</i>	78	705	1	51	6	36.1	9.0	3.30	0.70	
<i>Aspicularis tetraptera</i>	27	622	1	88	10	12.5	23.0	2.88	1.96	
<i>Catenotaenia pusilla</i>	10	63	1	40	2	4.6	6.3	0.29	0.81	
<i>Syphacia obvelata</i>	11	87	1	40	3	5.1	7.9	0.40	0.80	
<i>Syphacia</i> sp.	12	113	1	50	4	5.6	9.4	0.52	0.95	
<i>Trichuris muris</i>	6	18	1	5	3	2.8	3.0	0.08	0.11	
<i>T. taeniaeformis</i> larvae	3	4	1	2	1	1.4	1.3	0.02	0.04	
<i>Rodentolepis fraterna</i>	3	11	1	6	4	1.4	3.7	0.05	0.17	
<i>Heterakis spumosa</i>	2	16	4	12	8	0.9	8.0	0.07	0.38	
<i>Mastophorus muris</i>	-	-	-	-	-	-	-	-	-	
<i>Gongylonema</i> sp.	1	3	3	3	3	0.5	3.0	0.01	-	

The nematodes *H. polygyrus* (39.2%) and *A. tetraptera* (12.8%), and cestode *C. pusilla* (7.2%) were the most prevalent helminths. Data on the prevalence, mean abundance and mean infection intensity of gastrointestinal nematodes and cestodes are presented in Table 1. In males, the prevalence of *H. polygyrus* (42.3%) is higher than in females (36.1%), but we found no significant difference linked with age of the animals.

The prevalence for juvenile individuals was 39.4%, while that for adults was 40.0% (Table 2). The values for mean abundance of *H. polygyrus* became higher with age.

The species *H. spumosa*, *Gongylonema* sp., *M. muris*, *T. muris*, and *Syphacia* sp. showed prevalence < 6% and were not taken into further statistical analysis

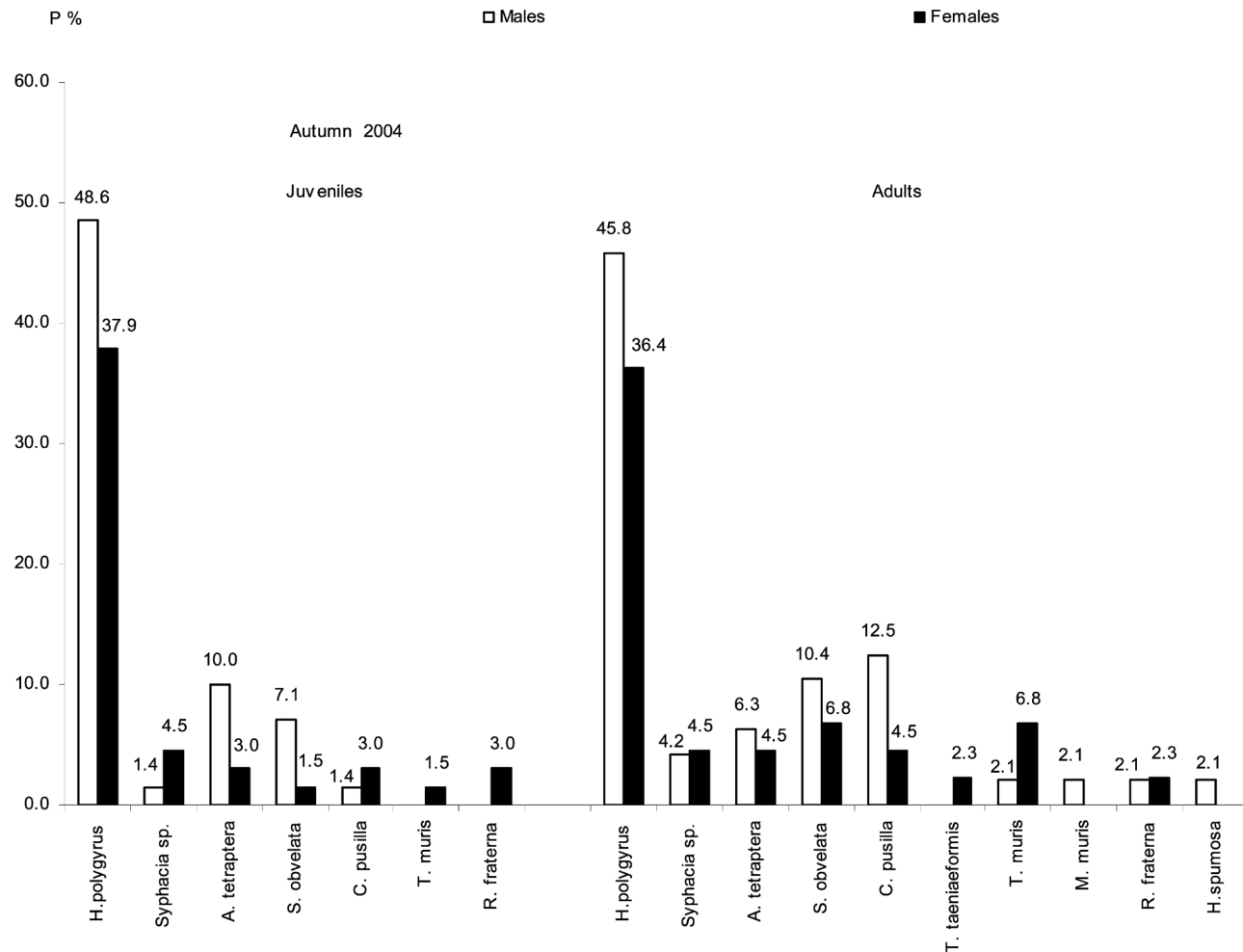


Fig. 1. Prevalence of *M. musculus* by host sex, age in autumn 2004.

of factors affecting the prevalence and abundance of infection.

Parasitism involving only one species was found in 79.0% (207/262) of the mice, two species in 17.1% (45/262), three species in 3.0% (8/262) and four species in 0.3% (1/262).

No significant differences in the prevalence, mean infection intensity, or mean parasite abundance were found for any of the helminth species (Table 1). For adults as for juveniles, there was no significant effect of sex and helminthic infection (each helminth species separately or combined) (Table 2).

The body weight of mice positively correlated with the abundance of *C. pusilla* ( $r_s = 0.57$ ,  $p < 0.003$ ) and *S. obvelata* ( $r_s = 0.58$ ,  $p < 0.030$ ). No relationships were found between abundance of any other species and mouse body weight.

With regard to season, seven helminth species were found among juveniles ( $n=136$ ) (Fig. 1) and 10 helminth species among adults ( $n=92$ ) in the autumn of 2004. We noted the appearance of six species of helminths in juveniles ( $n=77$ ) and nine species of helminths in adults ( $n=53$ ) during the autumn of 2005 (Fig. 2). The total prevalence of the dominant species, *H. polygyrus*, for juveniles during the autumn of 2004 was 43.3%, and that for adults

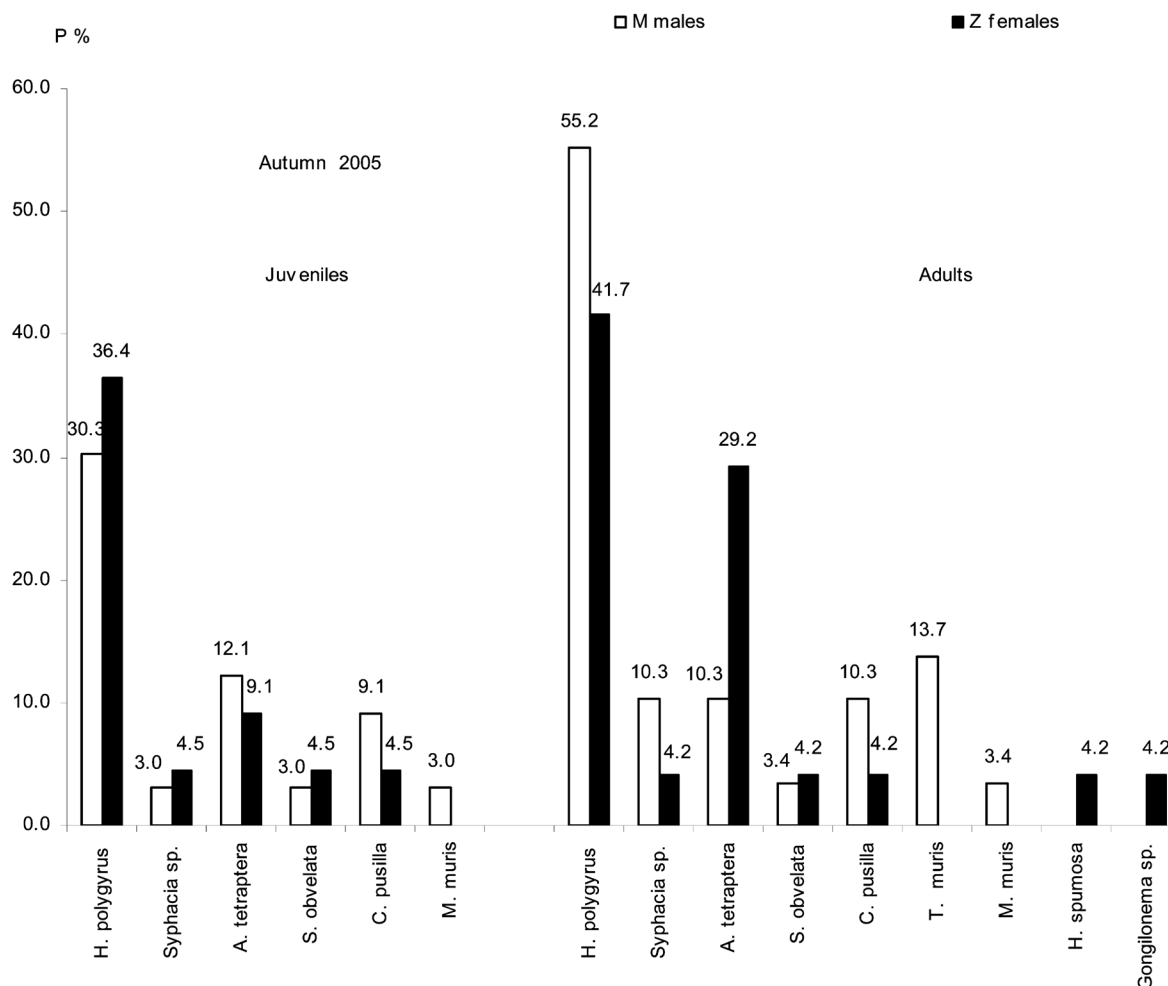


Fig. 2. Prevalence of *M. musculus* by host sex, age in autumn 2005.

41.3%. During the autumn of 2005, the total prevalence of *H. polygyrus* for juveniles was 33.7%, and that for adults 49.0%. We did not record any significant relationships between helminth species and age class during 2004 and 2005. Comparing the prevalence, we found significant differences for juvenile females in autumn 2004 and 2005 for all recorded helminth species ( $z = -1.97, p < 0.04$ ).

DISCUSSION

The results of this study showed that the house mouse from the suburban area of Belgrade is host to three cestode and eight nematode species. This is the first record of the species *Mastophorus muris*

in the house mouse on the territory of Serbia (Vukićević - Radić et al., 2007). Among the nematode species that we found, only four were previously recorded by Meszáros et al. (1983) in specimens of *M. musculus* on the territory of Vojvodina. These are: *H. polygyrus*, *A. tetraptera*, *S. obvelata*, and *Trichocephalus muris*. Feliu et al. (1997) found seven nematode, four cestode, and four trematode species in *M. musculus* on the Iberian Peninsula, among which are species recorded by us as well, viz. *Trichuris* (= *Trichocephalus*) *muris*, *H. spumosa*, *M. muris*, *H. polygyrus*, *S. obvelata*, *A. tetraptera*, *T. taeniaeformis*, *H. diminuta*, and *H.* (= *Rodentolepis*) *fraterna*. The observed

**Table 1.** Relationship between helminths dominant and host age classes. Abbreviations: P% prevalence, Range of the intensity/min-max/, MA ( $\pm$  SE) - mean abundance,  $p < 0.05$  ANOVA.

Helminth species		Age classes											
		Juveniles (n = 236)					Adults (n = 193)						
		P%	MA	$\pm$ SE	Min	Max	p	P%	MA	$\pm$ SE	Min	Max	p
<i>Heligmosomoides polygyrus</i>	Males	42.0	2.54	0.34	1	16		45.4	5.09	1.30	1	75	
	Females	37.0	2.12	0.37	1	19		33.0	4.52	1.40	1	51	
	Sexes combined	39.4	2.37	0.25	1	19	ns	40.0	4.81	1.00	1	75	ns
<i>Aspicularis tetraptera</i>	Males	12.5	1.25	1.15	1	37		14.1	2.05	1.80	1	60	
	Females	8.0	1.79	3.03	3	88		18.0	4.25	2.73	1	80	
	Sexes combined	10.1	1.53	1.54	1	88	ns	16.0	3.12	1.66	1	80	ns
<i>Syphacia obvelata</i>	Males	6.2	0.40	0.74	1	22		8.0	0.77	1.58	1	48	
	Females	4.8	0.52	1.39	1	40		5.3	0.23	0.39	1	9	
	Sexes combined	5.5	0.46	0.76	1	40	ns	6.7	0.51	0.90	1	48	ns
<i>Catenotaenia pusilla</i>	Males	5.3	0.23	0.39	1	12		12.1	0.78	0.81	1	30	
	Females	3.2	0.07	0.17	1	5		6.3	0.57	1.57	1	40	
	Sexes combined	4.2	0.14	0.22	1	12	ns	9.3	0.68	0.76	1	40	ns
<i>Syphacia sp.</i>	Males	1.7	0.07	0.00	4	4		7.0	0.55	0.74	1	20	
	Females	4.0	0.12	0.19	1	6		7.4	1.04	1.76	2	50	
	Sexes combined	3.0	0.09	0.11	1	6	ns	7.2	0.79	0.93	1	50	ns

higher prevalence of *A. tetraptera* and *S. obvelata* and lower prevalence of *Gongylonema sp.* in *M. musculus* specimens from the territory of Belgrade are in accordance with the results of Milazzo et al. (2003). Pulido-Flores et al. (2005) reported *M. musculus* as host to *A. tetraptera*, *S. obvelata*, *Trichuris muris*, *Gongylonema sp.*, and *Rodentolepis nana* (= *fraterna*), all with the same prevalence of 33%, at various localities in Mexico. Some of these species were also recorded in *M. musculus* specimens from the Belgrade area, but with significantly lower prevalence.

The results of our study showed that *H. polygyrus* was the dominant species, with a prevalence of 39.2%. One of the possible explanations for such high prevalence and abundance of this parasite species recorded in specimens of house mouse lies in the presence of *A. sylvaticus* in the area where the studied animals were caught. The prevalence of *H. polygyrus* in wood mouse specimens caught in this

area was 90% (our unpublished data). Other authors either did not find this parasite species, or found it with low prevalence in house mouse specimens. For example, Genov (1984) noted the prevalence of 1.3% for *H. polygyrus* for *M. musculus* from Bulgaria.

Our results show that the prevalence of almost all parasite species is higher for male than for female *M. musculus* individuals. To be specific, *H. polygyrus*, *S. obvelata*, and *C. pusilla* have a higher prevalence in males, while *A. tetraptera* has a higher prevalence (24.3%) in females. Higher prevalence of *S. obvelata* (4.8%) was noted in juvenile *M. musculus* females than in adult female specimens (3.8%), while for other helminth species the prevalence grew higher with the age of host individuals. Results indicating that house mouse males have a significantly higher parasite prevalence and intensity than females (Poulin, 1996; Schalk and Forbes, 1997; McCurdy et al., 1998; Moore and

Wilson, 2002) could be explained by the fact that the infected males have larger territories than uninfected males, and this could influence contact rates between infected males and susceptible hosts (Brown et al., 1994). Reproductive females show a stronger site-specific organization, which could explain low rates of transmission, whereas the home range of males tended to extensively overlap at high density and decrease at lower densities (Imms, 1987), which might account for higher rates of transmission. Numerous theories suggest that males are more susceptible to parasites than females, for many reasons (Ferrary et al., 2004). The male hormone testosterone is believed to have a negative effect on immune function (Grossman, 1989; Folstad et al., 1992), leading to the prediction that males will have higher parasite infection levels than females. Another hypothesis, a simpler one, assumes that, at least among mammals, the larger bodies of males could be easier targets for parasites (Arneberg, 2002). Whitaker (1970) and Behnke (1976) have shown seasonal and age dependence differences of parasite loads in feral mice.

No trematode species was found in our study. Fahmy et al. (1969) and Clark (1970) obtained similar results. Ribas (2005) carried out a seven-year study in the Pyrenees, where he detected 10 trematode species in nine rodents (among others in *M. domesticus*), while Milazzo et al. (2003), in a sample of 44 adult specimens of *M. musculus* from Sicily, found only one trematode species in one individual of this rodent.

Several studies have shown that the prevalence and abundance of intestinal parasites in wood mice peaks in late autumn, winter, and early spring (Kisielewska, 1970; Montgomery and Montgomery, 1988; Abu-Madi et al., 1998). These seasons may be periods of hardship for wild rodents, which, although not normally regarded as being commensal with humans, may at that time move into human habitats for shelter (Behnke et al., 2001). In our study, late autumn also turned out to be the time period when *M. musculus* had the heaviest infection with *H. polygyrus*. During the spring of 2004 and 2005, the dominant parasite species was *A. tetraptera*, while the mice

were most often also infected by *H. polygyrus* and *S. obvelata*. To be specific, during the autumn of 2004, we detected the presence of seven parasite species in juvenile and 10 parasite species in adult house mouse individuals. The most dominant species in juvenile individuals was *H. polygyrus*, and the second most dominant was *A. tetraptera*. The most dominant species in adult individuals was again *H. polygyrus*, while the second most dominant was *C. pusilla*. During the autumn of 2005, we detected the presence of six parasite species in juvenile and 9 parasite species in adult house mouse individuals. The most dominant species was *H. polygyrus*, both in juvenile and in adult individuals, and the second most dominant species was *A. tetraptera*.

Taking into consideration the life cycle, distribution, population density, and high mobility of the rodent species *M. musculus*, as well as the fact that individuals of this species cohabit with humans, we deem necessary to carry on and extend the study of endoparasitic species (and the parasitic fauna in general) of the house mouse and other synanthropic and hemi-synanthropic rodent species on the territory of Serbia.

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#### ФАУНА ХЕЛМИНАТА КУЋНОГ МИША (*MUS MUSCULUS* LINNAEUS, 1758) ИЗ СУБУРБАНОГ ПОДРУЧЈА БЕОГРАДА, СРБИЈА

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Хелминтофауна кућног миша (*Mus musculus*) истраживана је код 429 јединки изловљених са субурбаног подручја Београда (село Јабука, 15 км североисточно од Београда), а присуство 3 врсте пантљичара (Cestoda) и 8 врста ваљкастих црва (Nematoda) утврђено је у 262 јединке (61.1%). Од пантљичара су биле присутне *Catenotaena pusilla*, *Rodentolepis fraterna* и ларвени стадијум *Taenia taeni-aeformis* – *Cysticercus* (= *Strobilocercus*) *fasciolaris*, а од ваљкастих црва *Helygmosomoides polygirus*, *Syphacia* sp., *S. obvelata*, *Aspiculuris tetraptera*, *Heterakis spumosa*, *Trichuris muris*, *Mastophorus muris* и *Gongylonema*

sp. Доминантна врста била је *H. polygirus* са прева-ленцом од 39,2% и проузроковала је највиши интензитет инфекције. За *A. tetraptera*, *S. pusilla* и *S. obvelata* прева-ленце су износиле од 12,8 до 6,1%, а за остале врсте хелмината од 4,9 (за *Syphacia* sp.) до 0,2% (за *Gongylonema* sp.). Све врсте нађене у муж-јацима кућног миша биле су нађене и у женкама, изузимајући *M. muris* и *Gongylonema* sp. Нису нађе-не статистички значајне разлике између мужјака и женки кућног миша у погледу прева-ленце (P%) и средњих вредности интензитета инфекције (MI) и абунданције (MA).