



The striped field mouse (*Apodemus agrarius*) as a host of fleas (Siphonaptera) and tapeworms (Cestoda) in suburban environment of Lublin (eastern Poland)

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ABSTRACT

The striped field mouse, *Apodemus agrarius*, is one of the most abundant species among small rodents in Poland. It occurs commonly across the whole country inhabiting diverse ecological niches as meadows, farmlands, enclaves of natural habitats in cities. Wide range of ecological tolerance of this species makes it often the host, reservoir and vector of many pathogens: viruses, bacteria, protozoa, helminths and arthropods.

The aim of the present study was to carry out a qualitative and quantitative analysis of the fleas community and intestinal tapeworms of *A. agrarius* in suburban environment of Lublin (eastern Poland).

In studied population three species of Siphonaptera class i.e. *Ctenophthalmus agyrtes*, *Nosopsyllus fasciatus*, *Hystrichopsylla talpae* and one intestine Cestoda species *Hymenolepis diminuta* were identified. The results of our researches confirmed role of *A. agrarius* as the reservoir for tapeworms and host for fleas in urban environment. High level of the prevalence of fleas and tapeworms in rodents indicates the significant degree of contamination and can cause an epidemiological threat for human's health.

KEYWORDS: *Apodemus agrarius*, fleas, tapeworms

Introduction

The striped field mouse *Apodemus agrarius* is a small rodent measuring 7 to 12 cm and weighing 11 to 40 g with yellow-red fur and black longitudinal stripe on the back. This species has very wide range of distribution. In Europe it is found in the middle part of the continent up to northern Italy and southern coast of Scandinavia. In the south (Balkan

Peninsula and Turkey) there are numerous clumped populations of that species. In the east it is found in the European part of Russia up to southern Siberia and Kazakhstan. It occurs in the Russian Far East, China, Mongolia, Korean Peninsula and Taiwan. It prefers lowland areas or highlands up to 900 above sea level. It occupies humid

habitats, farmlands, pastures and is often appears in city parks and recreational areas (Babińska-Werka *et al.* 1979, Kefelioglu *et al.* 2003, Stanko 2014).

Wide range of ecological tolerance related to both occupied habitats and climatic conditions makes *A. agrarius* a common reservoir of pathogens and parasites threatening human and animals' health. Currently, because of epidemiological perspective striped field mouse plays an important role in the circulation and maintenance of tick-borne pathogens in nature. It is a vector of viruses belonging to Hantaviruses hazardous for humans – causative agents of haemorrhagic fever with renal syndrome (Vapalahti *et al.* 2003, Galfsky *et al.* 2019). *A. agrarius* is also a frequent host for ixodid ticks (e.g. *Ixodes ricinus*, *Dermacentor reticulatus*), fleas species (e.g. *Ctenophthalmus agyrtes*, *Nosopsyllus fasciatus*, *Hystrichopsylla talpae*) and parasitic helminths, including species potentially risky for humans, in Poland and bordering countries e.g. *Echinostoma* spp, *Plagiorchis elegans*, *Strigea falconis*; adult forms of tapeworms including *Hymenolepis diminuta*, *H. fraterna*,

Rodentolepis spp, larval forms of *Echinococcus multilocularis*, *Taenia taeniaeformis* and nematodes as *Heligmosomoides polygyrus*, *Heterakis spumosa*, *Syphacia agraria* (Shimalov 2002, Hildebrand *et al.* 2004, Kucia *et al.* 2006, Kowalski *et al.* 2014, Dwużnik *et al.* 2017).

The aim of our paper was to carry out a qualitative and quantitative analysis of the fleas community and intestinal tapeworms of *A. agrarius* rodents in suburban environment of Lublin (eastern Poland).

Material and methods

Rodents were captured in the Lublin area (eastern part of Poland) near to residential in the zone of abandoned field and pastures at different levels of ecological succession: meadows with islands of *Solidago virgaurea*, *Tanacetum vulgare* and *Fragaria vesca*; shrubs, mostly *Crataegus oxyacantha*, *Prunus spinosa* and trees *Betula* spp. (Figure 1).

Animals were captured in 2018 in two-week periods from June to October. In the area of research 40 wooden live traps were placed in one transect line in



Figure 1. Study area

distance of 50 cm each with two types of baits. Sunflower seeds were used as a bait for herbivores and pieces of animal-based food (larva of insects) for insectivorous species. Traps were checked every 4 hours during next 24 hours. Species of the caught rodents were identified. The protected species were immediately released at the place of caught. The rest of specimens were killed by cervical dislocation and placed in a plastic bag, then transport to the laboratory.

In laboratory, the captured animals of *A. agrarius*, were weighed with use of RadWag A110 with accuracy up 0.1 g and sexed. The bodies were surveyed to collect fleas specimens and autopsies were conducted to search intestinal tapeworms. From strobili of adult forms found in intestines of investigated animals microscopic slides were prepared according to method described by Rolbiecki (2007). From gravid proglottids smears of eggs were prepared. Species of tapeworms were identified with use of Olympus CX21 and identified according to Buczek (2005). Fleas were preserved, microscopic slides were prepared and then species were identified according to Skuratowicz (1967) key.

With Statistica ver. 13.3 software, statistical analyses were conducted to determine an impact of flea infestation on rodent's body weight. For analysis U Mann-Whitney test was used. Chi-square test was used for checking difference of *A. agrarius* body weight between males and females in studied population.

In all tests level of significance at 0.95 and probability at 0.05 were taken.

Trapping and handling procedures were approved by the Lublin Local Ethics Committee for Animal Experimentation (Permission No. 7/28/2018).

Results

The total number of 65 rodents were captured during research. Among them 57 were identified as *A. agrarius*. Another captured species were identified as *Microtus arvalis* – 4, *A. flavicolis* – 3, and *Myodes glareolus* – 1.

The most frequently occurring flea species was *C. agyrtes*, infesting 42.1% of males and 29.8% of females of *A. agrarius*. Other identified species were *N. fasciatus* and *H. talpae* (Table 1, Appendix Table A). 45 rodents (79%; 21 females and 24 males) were infested by at least one species of the fleas, while in 22 specimens 2 species of the fleas were revealed (49%; 13 females and 5 males).

In investigated rodents one intestinal tapeworm species was identified, i.e. *H. diminuta*. Infection with this species was confirmed in 4 specimens of *A. agrarius* (2 females and 2 males). The total prevalence of *H. diminuta* infection in investigated population was 6.9%.

The lack of correlation between body weight of *A. agrarius* and fleas' infestation was confirmed by statistical analysis ($Z = 1.833$, $p = 0.129$). The difference of body weight between males and females in studied population of rodents was not confirmed ($\chi^2 = 0.11$, $p = 1.42$).

Table 1. Infestation of *Apodemus agrarius* (n = 57) by fleas

Flea species	Number of collected fleas			Number of fleas per one rodent	Number of infested rodents	
	F	M	Total		F (%)	M (%)
<i>Ctenophthalmus agyrtes</i>	70	36	106	1.86	17 (29.8)	24 (42.1)
<i>Nosopsyllus fasciatus</i>	20	15	35	0.61	13 (22.8)	12 (21.1)
<i>Hystrihopsylla talpae</i>	2	0	2	0.01	2 (3.5)	0 (0.0)

F – females, M – males

Discussion

Tapeworm infections (caused by adult or larval forms) are important medical and epidemiological issue and can be considered as emerging infectious diseases although they are quite rarely diagnosed in comparison with another parasitic and infectious human diseases in Europe (Deplazes *et al.* 2017). Tapeworm infections that are the most frequently diagnosed and posing the highest risk for human's health are caused by larval forms of *E. multilocularis*, *E. granulosus* and *T. solium*. Also, humans may be definitive hosts for *T. saginata* and *Diphyllobothrium latum*. Infections that are the mostly related to children are caused by *Dipylidium caninum*, *H. nana*, *H. diminuta*. Morbidity of those diseases is environmentally based. The increase in the number of potential intermediate and definitive hosts for tapeworms can lead to newly diagnosed cases of humans' infections (Hofer *et al.* 2000, Schweiger *et al.* 2007).

The striped field mouse can be named as one of the preferred hosts of *H. diminuta* (Ondříková *et al.* 2010, Gubányi *et al.* 2015). It is result of biology and ecology of that species. *A. agrarius* can easily adapt to new or changed environmental conditions, has high reproductive ability (Yoon *et al.* 1997) and is an omnivorous rodent what can increase the probability of the infection with *H. diminuta* by eating insects (fleas). Prevalence of infection in rodents in area of our investigation (6.9%) is akin to results of another authors (Ondříková *et al.* 2010). *A. agrarius* is strongly adapted to urban environment. Specimens trapped in city parks have higher prevalence and mean abundance of helminths than other rodents captured in forests. This phenomenon may be explained by high local densities of rodents and range of parasite affecting this host (Dwużnik *et al.* 2017). It indicates that *A. agrarius* is an impor-

tant link in developmental cycle of that tapeworm in urban environment, however probability of human infestation is quite low. Most cases that had been described in literature concern infestation of children from Asian countries with hot and humid climate (Wiwanitkit 2004, Rohela *et al.* 2012). In Europe rare cases of infection by rat tapeworm are known from Italy (Marangi *et al.* 2003), Spain (Tena *et al.* 1998) and Turkey (Kılınçel *et al.* 2015). In Poland few cases of infection of humans by *H. diminuta* had been described in last 25 years (Kolodziej *et al.* 2014).

In the case of small rodents co-occurrence of infestation with endo- and ectoparasites is frequently found (Stanko 2014). In the investigated area presence of the *H. diminuta* tapeworms and *C. agyrtes* fleas was confirmed. This phenomenon plays a key role in the maintenance of tapeworms infections foci in nature and indirectly contributes to contamination of the environment by invasive forms of parasites. Moreover, identified species of fleas, i.e. *C. agyrtes*, *N. fasciatus*, *H. talpae* belong to the spectrum of ectoparasites of small rodents in environment of large agglomeration in Poland (Haitlinger 1989).

In the studied population of *A. agrarius* the most commonly collected flea species was *C. agyrtes* (Table 1, Appendix Table A). This is, next to *N. fasciatus*, one of the most frequently flea species identified on rodents in natural habitats in deferent parts of Poland (Kowalski *et al.* 2014) and confirmed in Lublin province by other authors (Haitlinger 2010). In our research, in Lublin area, *C. agyrtes* was found at 42.1% of males and 29.8% of females of the striped field mice (Table 1). One of the hypothesis explaining preponderance of infested males over females is larger home range of males (Vukićević-Radić *et al.* 2006). During

searching of that larger area *A. agrarius* males are more often exposed to fleas. Moreover, overall high level of infestation is favoured by communities living in large family groups that is specific for many small rodents species. In social animal communities close contact between specimens relevantly escalates fleas transfer between individuals (Krasnov *et al.* 2010). According to Kowalski *et al.* (2015) advantage of *A. agrarius* infested fleas is caused by male-biased parasitism with concurrent increasing level of infestation along with raising body mass but statistical analysis did not confirmed similar dependence in population studied in our research ($Z = -1.833$, $p = 0.129$), what can be caused by differences in sample size or ecological types of habitats where rodents were captured.

The results of our study show that enclaves of natural meadow ecosystems with vegetation patches of deciduous trees as a result of ecological succession create favourable conditions for sustaining stable population of *A. agrarius*. This type of habitat promotes increase in size of the fleas population in case of species that prefers rodents species living in deep burrows sheltered from the sun (Krasnov *et al.* 2006, 2010).

Identified species of fleas are characterized by high level of host specificity and feed mostly on small rodents and other small mammals. Epidemiological significance and threat to public health of *C. agyrtres* and *H. talpae* are limited to its role as a potential pathogens vector between small mammals communities in environment or being intermediate hosts for larval forms of tapeworms. *N. fasciatus* can occasionally attack human and be transferred into households by companion animals. This insect is confirmed as competent vector of *Yersinia pestis* (Kenis and Roques 2010). In temperate climate human is mostly exposed to fleas bites in autumn when their population

size reaches annual peak. Consequences of fleas' bites, that occur in natural environment, are pain and itching caused by their saliva. Syndrome of these symptoms is often called as "Flea Allergy Dermatitis – FAD" (Durden and Hinkle 2019).

Both, skin lesions after fleas' bites and non-specific symptoms in infections caused by *H. diminuta* can often occur and lead to problems in proper diagnosis and implementation of fast and efficient treatment. In case of infection of these parasites, next to symptoms, wide epidemiological interview should be considered. The question should concern the place of accommodation, ways and places of free time spending, physical activity and culinary habits. Answers for these questions and knowledge about environmental conditioning of infectious diseases – including hymenolepiasis and FAD.

Conclusions

The striped field mouse *Apodemus agrarius* is the preferred definitive host of *Hymenolpeis diminuta* tapeworm and flea species, i.e. *Ctenophthalmus agyrtres*, *Nosopsyllus fasciatus* and *Hystrichopsylla talpae*. The abundant population of this species in given area, especially in isolated urban environment can indirectly lead to an increase in contamination of environment by ecto- and endoparasites.

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Appendix

Table 1A. Fleas collected from *Apodemus agrarius* (n = 57)

Captured animal	Sex	Body weight [g]	Date of trapping	<i>Ctenophthalmus agyrtes</i>		<i>Nosopsyllus fasciatus</i>		<i>Hystrihopsylla talpae</i>	
				F	M	F	M	F	M
1	F	28.2	13.06	–	–	–	–	–	–
2	F	19.8		5	1	1	1	–	–
3	M	21.1	26.06	3	–	–	–	–	–
4	M	28.0	6.07	2	2	1	1	–	–
5	M	26.0		4	1	–	–	–	–
6	F	28.9		–	–	–	–	–	–
7	F	19.5	26.07	2	2	–	–	–	–
8	F	22.7		4	1	–	1	–	–
9	M	21.0	10.08	1	–	–	–	–	–
10	M	17.5		2	–	1	–	–	–
11	F	16.1		3	–	1	–	–	–
12	F	20.0		1	–	1	–	–	–
13	F	21.0		2	–	1	–	–	–
14	M	16.7	–	1	–	–	–	–	
15	M	13.5	21.08	2	3	–	–	–	–
16	F	15.7		2	1	–	2	–	–
17	M	15.4		3	2	–	–	–	–
18	M	15.2		–	1	–	–	–	–
19	F	13.4		3	1	–	–	–	–
20	F	15.9	–	1	1	1	–	–	
21	M	22.1	22.08	2	–	–	–	–	–
22	F	15.2		1	–	2	1	–	–
23	M	12.7		–	–	–	1	–	–
24	F	15.3		–	–	–	1	–	–
25	F	14.6	23.08	3	–	–	–	–	–
26	F	12.3		1	–	–	–	1	–
27	F	12.7		1	1	1	–	–	–
28	M	12.8		1	4	–	–	–	–
29	M	16.7		–	–	–	–	–	–
30	F	14.3	1	–	–	1	–	–	
31	M	12.5	19.09	–	–	–	–	–	–
32	M	12.7		2	2	–	–	–	–
33	F	13.0		–	–	–	–	–	–
34	M	27.5		1	–	1	–	–	–
35	M	24.5		1	–	–	–	–	–
36	M	10.7		1	–	1	–	–	–
37	F	27.5		–	–	–	–	–	–
38	M	24.7		1	–	1	–	–	–
39	M	30.9	20.09	2	2	–	–	–	–
40	M	19.1		–	1	–	–	–	–
41	F	11.5		–	–	–	1	1	–
42	M	24.7		–	–	2	–	–	–
43	M	14.6		–	1	–	–	–	–
44	M	16.6	3	3	1	–	–	–	
45	F	21.9	21.09	1	1	–	–	–	–
46	F	13.4		1	–	–	–	–	–

Captured animal	Sex	Body weight [g]	Date of trapping	<i>Ctenophthalmus agyrtes</i>		<i>Nosopsyllus fasciatus</i>		<i>Hystrichopsylla talpae</i>	
				F	M	F	M	F	M
47	M	19.2	2.10	–	–	1	1	–	–
48	M	15.2		–	1	1	–	–	–
49	F	15.8		1	–	–	1	–	–
50	M	15.0		3	–	–	–	–	–
51	F	13.7		–	–	–	–	–	–
52	F	12.9		–	–	1	–	–	–
53	M	14.0		3	1	1	1	–	–
54	M	15.8	3.10	–	1	–	–	–	–
55	M	15.7		1	1	–	1	–	–
56	F	14.9		–	–	–	–	–	–
57	F	13.6		–	–	–	–	–	–
			Total	70	36	20	15	2	0

F – females, M – males