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▣ ORIGINAL ARTICLE

Intestinal Helminthic Infections in Striped Field Mice, *Apodemus agrarius*, from Two Southern Regions of Korea

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Abstract: The present study was performed to know the infection status of intestinal helminths in a most common species of field mice, *Apodemus agrarius*, from 2 southern regions of Korea. Total 133 and 103 mice were collected by the mouse trap in Hapcheon-gun, Gyeongsangnam-do and Gurye-gun, Jeollanam-do, respectively, from July 2005 to June 2006. The small intestine of each mouse was resected and longitudinally opened with a pair of scissors. The intestinal contents were washed with 0.85% saline until the supernatant became clear. Helminths were collected with naked eyes or under a stereomicroscope from the sediment of the intestinal content. More than 11 species of helminths (4 nematode spp., 5 trematode spp., and 2 cestode spp.) were recovered. Among these, heligmosomoid nematodes (97.5%) was the most highly and heavily infected species. As the members of trematodes, *Plagiorchis muris*, *Brachylaima* sp., *Echinostoma hortense*, *Echinostoma cinetorchis*, and unidentified echinostome larvae were found in the small intestines of 35 (14.8%), 12 (5.1%), 6 (2.5%), 1 (0.4%), and 1 (0.4%) mice respectively. Two species of tapeworms, *Hymenolepis nana* and *Hymenolepis diminuta* were also detected in 79 (33.5%) and 21 (8.9%) mice, respectively. Conclusively, heligmosomoid nematodes were the most prevalent (dominant) species among more than 11 helminth species detected, and *Brachylaima* sp. fluke is newly added in the list of intestinal trematodes in Korea.

Key words: Intestinal helminth, striped field mouse, *Apodemus agrarius*, southern region of Korea

INTRODUCTION

Studies on rodent parasites of medical and veterinary importance have been performed to prevent transmission of diseases to humans and domestic animals. A variety of rodent species were investigated in various regions of the world [1-3]. The striped field mouse, *Apodemus agrarius*, is the most dominant species and the agricultural scourge in the Republic of Korea (=Korea). This mouse species is widely distributed in rural areas, agricultural fields, and forest in small mountains. It causes a great deal of economic loss in agricultural products and also acts as the natural transmitter for zoonotic parasites as well as pathogens like tularemia, leptospirosis, and hemorrhagic fever [4].

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Rodent parasites have been investigated by many workers in Korea. In the 1930's, *Cysticercus fasciolaris*, *Capillaria hepatica*, *Hymenolepis diminuta*, *Hymenolepis nana*, and *Echinostoma hortense* were reported [5-7]. Subsequently, a variety of helminth species were detected and described from various species of rodents in the 1960's [8-10]. Later, Seo et al. [11] found 6 trematode species in 170 house rats collected from 13 localities in Korea. In the 1990's, several species of helminths were also detected in rodent hosts from some localities including Gangwon-do through 3 additional surveys [12-14].

Recently, Chai et al. [15,16] reported the infection status of *Plagiorchis muris* and echinostomes in the striped field mice from the northern Gyeonggi-do near the demilitarized zone (DMZ). It was also reported that the striped field mouse is a new definitive host for *Neodiplostomum seoulense* [17]. Lee et al. [18] surveyed 56 wild rodents from northern Gangwon-do to examine the infection status of intestinal helminths. Most of these surveys on rodent parasites were done in the northern regions of Korea, and little data are available on the helminth diversity among rodents in southern regions of Korea. Therefore, the present study was performed to provide preliminary

data on the intestinal helminth fauna in striped field mice inhabiting 2 southern regions, Hapcheon-gun, Gyeongsangnam-do and Gurye-gun, Jeollanam-do, Korea.

MATERIALS AND METHODS

From July 2005 to June 2006, we collected the striped field mice, *A. agrarius*, once every month in the 2 southern regions, Hapcheon-gun and Gurye-gun. Sherman's rodent live traps were set at 11 outdoor places in the 2 southern regions afternoon and were collected at the early morning of the next day. The collected mice were anesthetized and killed after taking samples for preventive studies of febrile diseases in 2 laboratories of Gyeongsangnam-do and Jeollanam-do Institutes of Health and Environment, in Changwon-si and Gwangju-si, respectively, Korea. Intestines of each mouse were extracted from the abdominal cavity after dissection, preserved in a specimen bottle with 0.85% saline, and then transported to the laboratory in the Department of Parasitology and Tropical Medicine, Gyeongsang National University School of Medicine, Jinju, Korea.

The small intestine of each mouse was longitudinally opened with a pair of scissors. The intestinal contents were washed with 0.85% saline until the supernatant became clear. The helminthic worms were collected with naked eyes or under a stereomicroscope from the sediment of the intestinal content. After applying specific clearing and staining techniques, the collected helminths were identified using appropriate systematic keys, and each of them was counted to get hold of the infection rates and densities per mouse.

RESULTS

Infection rates of each helminth species

More than 4 species of nematodes, i.e., heligmosomids, *Syphacia* sp., ascarids, and hookworms were detected from 230 (97.5%), 12 (5.1%), 6 (2.5%), and 1 (0.4%) striped field mice, respectively. As the trematodes, *Plagiorchis muris*, *Brachylaima* sp., *Echinostoma hortense*, *Echinostoma cinetorchis*, and unidentified echinostome larvae were found in 35 (14.8%), 12 (5.1%), 6 (2.5%), 1 (0.4%), and 1 (0.4%) mice, respectively. *H. nana* and *H. diminuta* were detected from 79 (33.5%) and 21 (8.9) mice, respectively. Helminth species recovered and their infection rates by surveyed areas were presented in Table 1.

Table 1. Recovery rates of helminths in the small intestines of *Apodemus agrarius* from Hapcheon-gun, Gyeongsangnam-do and Gurye-gun, Jeollanam-do, Korea

Helminth	No. (%) of positive mice from		
	Hapcheon[a]	Gurye[b]	Total
Nematodes			
Heligmosomids	129 (97.0)	101 (98.1)	230 (97.5)
Syphacia obvelata	6 (4.5)	6 (5.8)	12 (5.1)
Ascarid	-	6 (5.8)	6 (2.5)
Hookworm	-	1 (1.0)	1 (0.4)
Trematodes			
Plagiorchis muris	26 (19.5)	9 (8.7)	35 (14.8)
Echinostoma hortense	5 (3.8)	1 (1.0)	6 (2.5)
Echinostoma cinetorchis	1 (0.8)	-	1 (0.4)
Unidentified echinostome larvae	1 (0.8)	-	1 (0.4)
Brachylaima sp.	-	12 (11.7)	12 (5.1)
Cestodes			
Hymenolepis nana	51 (38.3)	28 (27.2)	79 (33.5)
Hymenolepis diminuta	11 (8.3)	10 (9.7)	21 (8.9)

[a]133 and [b]103 mice were examined.

Infection status of heligmosomids by surveyed areas and months

Heligmosomid nematodes were recovered from 129 (97.0%) mice from Hapcheon-gun, Gyeongsangnam-do, and their average number was 97.5 per mouse infected. In mice from Gurye-gun, Jeollanam-do, heligmosomids were recovered from 101 (98.1.0%) mice, and their average number was 52.2 per infected mouse. The monthly results of heligmosomids recovery are shown in Tables 2 and 3.

Infection status of trematodes

P. muris were collected in the small intestines of 26 (19.5%) and 9 (8.7%) mice from Hapcheon-gun and Gurye-gun, respectively, and their worm burdens were 9.9 and 1.9, respectively, per infected mouse. *E. hortense* were detected in 5 (3.8%) mice from Hapcheon-gun, and their worm burdens were 5.0 per infected mouse. A total of 64 *Brachylaima* sp. flukes were found in 12 (11.7%) mice from Gurye-gun, and their worm burdens were 5.3 per infected mouse (Table 4).

Brief description of *Brachylaima* sp. (Digenea: Brachylaimidae)

Body elongate with spinose tegument and 4,422 by 1,000 in average size (all measurement unit is μm). Oral sucker subterminal and 299 by 354 in size. Prepharynx very short. Pharynx muscular and 176 by 236 in size. Esophagus absent. Intestinal ceca bifurcate directly at the pharynx and extend parallel

Table 2. Quantitative results of heligmosomids recovery in *Apodemus agrarius* from Hapcheon-gun, Gyeongsangnam-do, Korea

Year month	No. of mice examined	No. (%) of mice infected	No. of worms recovered		
			Total	Range	Average
2005					
July	17	16 (94.1)	983	12-236	61.4
August	10	10 (100)	1,207	25-258	120.7
September	11	11 (100)	1,435	7-316	130.5
October	20	20 (100)	3,813	19-618	190.7
November	9	9 (100)	648	25-259	72.0
2006					
January	12	11 (91.7)	533	1-135	48.5
February	13	12 (92.3)	637	20-220	53.1
March	7	6 (85.7)	280	13-75	46.7
April	6	6 (100)	396	17-116	66.0
May	5	5 (100)	452	19-208	90.4
June	23	23 (100)	2,190	4-447	95.2
Total	133	129 (97.0)	12,574	1-618	97.5

Table 3. Quantitative results of heligmosomids recovery in *Apodemus agrarius* from Gurye-gun, Jeollanam-do, Korea

Year month	No. of mice examined	No. (%) of mice infected	No. of worms recovered		
			Total	Range	Average
2005					
July	18	18 (100)	1,038	4-346	57.7
August	6	6 (100)	764	38-297	127.3
September	10	10 (100)	861	21-246	86.1
October	5	5 (100)	1,131	16-946	226.2
November	9	9 (100)	338	7-187	37.6
2006					
February	13	12 (92.3)	377	1-167	31.4
March	9	9 (100)	198	3-63	22.0
April	18	18 (100)	291	2-76	16.2
May	15	14 (93.3)	271	5-55	19.4
Total	103	101 (98.1)	5,269	1-946	52.2

Table 4. Quantitative results of trematode recovery in *Apodemus agrarius* from Hapcheon-gun, Gyeongsangnam-do and Gurye-gun, Jeollanam-do, Korea

Locality & Helminth	No. (%) of mice infected	No. of worms recovered		
		Total	Range	Average
Hapcheon-gun[a]				
Plagiorchis muris	26 (19.5)	258	1-71	9.9
Echinostoma hortense	5 (3.8)	25	1-18	5.0
Gurye-gun[b]				
Plagiorchis muris	9 (8.7)	17	1-3	1.9
Brachylaima sp.	12 (11.7)	64	1-23	5.3

[a]133 and [b]103 mice were examined in each area.

to lateral margins to nearly posterior end of the body forming undulations. Ventral sucker (417 by 427) slightly larger than oral sucker and located at about anterior 1/4 of body. Ovary transversely oval or elliptical, 212 by 315 in size, and located slightly dextral between 2 testes. Testes round to irregular in shape, with smooth or slightly lobulated margins, and the anterior one (380 by 423) slightly larger than the posterior one (331 by 380). Vitelline follicles distribute laterally or extracecally from the slightly lower level of pharynx to the level of anterior testis or ovary. Uterus consists of many loops with numerous eggs, and distributes intracecally from the level of pharynx to the level of anterior testis. Eggs small, operculate, and 24.8 by 14.1 in average size. The morphological characteristics will be described separately as a faunistic study in the near future.

DISCUSSION

In the present study, more than 11 species of helminths were recovered from 236 striped field mice examined. Among these, heligmosomid nematodes were most prevalent. Total 230 (97.5%) mice were infected with 77.6 heligmosomids in average. The prevalence rates were more or less similar in mice from 2 regions, but worm burdens were higher in mice from Hapcheon-gun, Gyeongsangnam-do. Unfortunately, we could not taxonomically define their generic and species names. On the other hand, Seo et al. [10] detected *Heligmosomum* sp. in the intestines of 7 wild rodent species and *Heligmosomoides* sp. in 3 specie from 4 northern regions, Cheolwon, Geumwha, Pocheon, and Paju, in Gangwon-do and Gyeonggi-do respectively [10]. They also described brief morphological characteristics of 2 heligmosomids, *Heligmosomum* sp. and *Heligmosomoides* sp., for the first time in Korea [10].

Seo et al. [10] recorded 7 rodent species, i.e., *A. agrarius*, *Rattus norvegicus*, *Rattus alexandrinus*, *Mus musculus yamashinai*, *Crocidura russula*, *Microtus fortis*, and *Cricetulus triton nester*, as the hosts of *Heligmosomum* sp. and they also listed 3 species, i.e., *A. agrarius*, *R. norvegicus* and *M. fortis*, as the hosts of *Heligmosomoides* sp. in Korea. Out of 300 rodents in 7 species examined, the striped field mouse, *A. agrarius*, was the dominant species (73.0%) and revealed 14.6% and 13.2% prevalence rates of *Heligmosomum* sp. and *Heligmosomoides* sp., respectively. The prevalence rate (97.5%) of heligmosomids in this study was much higher than that of Seo et al. [10]. The difference of infection rates with these nematodes may be closely related to

the inhabitation environment of rodent hosts. Survey areas in this study were 2 southern regions, Hapcheon-gun and Guryegun, whereas those in Seo et al. [10] were 5 northern regions, Cheolwon, Geumwha, Cheongpyeong, Pocheon, and Paju in Gangwon-do and Gyeonggi-do.

Seo et al. [10] found 8 species of nematodes, i.e., *Nippostrongylus muris Syphacia obvelata*, *Heterakis spumosa*, *Protospirura muris*, *Heligmosomum* sp., *Heligmosomoides* sp., *Rictularia* sp., and *Gongylonema* sp., in 219 *A. agrarius* from 5 northern regions of Korea [10]. Yong et al. [13] detected 3 species of nematodes, i.e., *N. muris*, *S. obvelata*, and *Gongylonema* sp., in 85 *A. agrarius* from Goyang-gun, Gyeonggi-do and Iri-si and Iksan-gun, Jeollabuk-do [13]. In aforementioned 2 studies, *N. muris* was the dominant species. However, in the present study, more than 4 nematode species, i.e., heligmosomids, *S. obvelata*, ascarids, and hookworms, were detected from 236 *A. agrarius*, and heligmosomids was the dominant one. Collectively, it is confirmed that various species of nematodes are inhabited in the gastrointestinal tract of striped field mice in Korea, and their infection rates and worm burdens are much higher than those of trematodes and cestodes.

As the trematodes inhabit in rodents, about 10 species, i.e., *E. hortense*, *E. cinetorchis*, *Echinostoma revolutum*, *Echinoparyphium recurvatum*, *Echinochasmus japonicus*, *Euparyphium murinum*, *P. muris*, *N. seoulense*, *Clonorchis sinensis*, and *Metagonimus yokogawai*, were reported in Korea [7-9,11-13,15-18]. Since *E. hortense* was reported for the first time in 1938 [7], *E. cinetorchis*, *E. murinum*, *P. muris*, and *N. seoulense* were added in the list of rodent trematodes by Seo et al. [8-9]. Seo et al. [11] detected 6 trematode species, i.e., *E. hortense*, *E. cinetorchis*, *P. muris*, *N. seoulense*, *C. sinensis*, and *M. yokogawai*, from 170 house rats. Lee et al. [12] also found 6 trematode species, i.e., *E. hortense*, *E. cinetorchis*, *E. revolutum*, *E. recurvatum*, *P. muris*, and *N. seoulense* in 2 house rats from Yangyang-gun, Gangwon-do [12]. Yong et al. [13] detected only 1 specimen of *E. japonicus* from a striped field mouse [13]. Recently, Chai et al. [15-17] reported the infection status of *P. muris*, *N. seoulense*, and echinostomes in 1,366 striped field mice from northern Gyeonggi-do near the demilitarized zone. When we analyzed the infection status of rodent trematodes reported previously, 4 species, i.e., *E. hortense*, *E. cinetorchis*, *P. muris*, and *N. seoulense*, are known to be widely distributed in Korea. However, *Brachylaima* sp. had not been reported in Korea before this study. Therefore, we will try to record this as a new trematode fauna of Korea in the near future.

Total 5 species of rodent tapeworms, i.e., *C. fasciolaris*, *H. diminuta*, *H. nana*, *Raillietina coreensis*, and *Paranoplocephala* sp., have been reported in Korea [5,6,10,13,14]. Since *C. fasciolaris* was reported for the first time as the rodent tapeworm by Nakamura and Kobayashi in Korea [5], *H. diminuta* and H. nana were listed by Ogura [6], and *R. coreensis* and *Paranoplocephala* sp., were added by Seo et al. [10]. Among 5 tapeworm species, *C. fasciolaris* was most frequently found from the rodent hosts [5,9,10,13,14]. However, this larval tapeworm was not detected in the present study, because we examined only the small intestines. If we examined the liver of mice as well, *C. fasciolaris* may have been recovered together with *H. diminuta* and *H. nana* in the present study.

Trematodes and cestodes inhabited in the rodent hosts can be, unlike nematodes, zoonotic pathogens. Especially, *E. hortense*, *P. muris*, *N. seoulense*, *H. diminuta*, and *H. nana*, widely prevalent among wild rodents in Korea, are commonly infected in humans also, and they are able to act as the reservoir host for human infections. However, among the nematodes, *Capillaria hepatica* is potentially a zoonotic pathogen to humans. Seo et al. [9] detected this nematode from 286 (88.0%) house rats, and a human (child) case by this zoonotic nematode infection was already reported in Korea [19]. Accordingly, we should pay attention to wild rodents acting as the reservoir host of trematode and cestode infections as well as hepatic capillariasis.

Conclusively, the fauna and infection status of helminths in the striped field mouse, *A. agrarius*, from 2 southern regions of Korea were partly revealed by the present study. The most prevalent (dominant) species, heligmosomoid nematodes, should be clarified in generic and species levels, and *Brachylaima* sp., newly added in the list of intestinal fluke, should also be named in the near future.

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CONFLICT OF INTEREST

We have no conflict of interest related to this study.

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