

Intestinal Parasites among Wild Rodents in Northern Gangwon-do, Korea

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Abstract: To determine geographical patterns of natural parasite infections among wild rodents, a total of 46 wild rodents from 3 different localities in northern Gangwon-do (Province), Korea were examined for intestinal parasite infections. Along with nematodes such as hookworms and *Syphacia* spp., *Plagiorchis muris* (2 specimens) (Trematoda) were collected from striped field mice, *Apodemus agrarius*. In a Korean wood mouse, *Apodemus peninsulae*, the overall nematode infections were similar to *A. agrarius*, but an adult worm of *Echinostoma hortense* (Trematoda) was collected. In addition, 2 species of cestodes, i.e., *Hymenolepis nana* and *Hymenolepis diminuta*, were collected from *A. agrarius*. Through this survey, *A. agrarius* and *A. peninsulae* were confirmed as the natural definite hosts for zoonotic intestinal helminths, i.e., *P. muris*, *E. hortense*, *H. nana*, and *H. diminuta*, in northern Gangwon-do, Korea. Considering increased leisure activities around these areas, seasonal and further comprehensive surveys on wild rodents seem to be needed to prevent zoonotic parasite infections.

Key words: *Plagiorchis muris*, *Echinostoma hortense*, *Apodemus agrarius*, *Apodemus peninsulae*, Gangwon-do

Since rodents can be natural final hosts of intestinal trematodes, several studies have been performed on parasitic infections among rodents. For example, *Neodiplostomum seoulense*, originally recovered from a house rat in 1964, was subsequently discovered in a man with epigastric pain, suggesting the role of rodents as a reservoir host for this trematode infection [1]. Moreover, echinostomes were reported in rats collected in Seoul, Yangyang-gun (Gangwon-do), Goyang-gun (Gyeonggi-do), Iksan-gun (Jeollabuk-do), and northern Gyeonggi-do near the demilitarized zone (DMZ), the Republic of Korea (= Korea) [2-5].

The prevalence of *Plagiorchis muris*, recently proved to be a human intestinal trematode, had also been surveyed in endemic areas. The adult worms of *P. muris* were discovered in rodents from Hadong-gun (Gyeongsangnam-do), Yongin-si (Gyeonggi-do), and Yangyang-gun (Gangwon-do), and 5.3% of *Apodemus agrarius* were infected with *P. muris* in northern Gyeonggi-do, near the demilitarized zone [3,6,7]. Outside of Korea, it

was reported that the overall prevalence of *P. muris* was 16.9% in the wood mouse of North Yorkshire, UK [8]. However, most Korean studies were performed on house rodents except for some studies performed from DMZ [5,7]. Considering the importance of sylvatic rodents as the reservoir host for intestinal flukes, more surveys should be performed on wild rodents in Korea. This study was initiated to determine the geographical patterns of natural parasite infections among small mammals and focused on the patterns and rates of intestinal parasite infections among the wild rodents from northern Gangwon-do (Province).

A total of 56 rodents were live-captured from 3 sites of northern Gangwon-do, i.e., Gaojak-2-ri, Nam-myon, Yanggu-gun (site 1), Jukgok-ri, Yanggu-eup, Yanggu-gun (site 2), and Gari, Inje-eup, Inje-gun (site 3) by using Sherman traps (3×3.5×9 folding traps; H.B. Sherman, Tallahassee, Florida, USA) baited with peanut butter between saltine crackers. The captured rodents included the striped-field mouse, *A. agrarius* (n=43), Korean wood mouse, *Apodemus peninsulae* (n=11), Red-backed vole, *Myodes regulus* (n=1), and squirrel (n=1). Animal trapping was performed during the summer season (July and August) of the year 2011. Captured animals were euthanized in accordance with the approved animal use protocol under biosafety level 3 (BSL-3) laboratory conditions. The

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whole intestine to the end of the rectum was removed and preserved in 70% alcohol till the time of examination. The gastrointestinal contents were opened in a Petri dish containing distilled water, and all helminths were collected under a dissecting microscope ($\times 10$). Finally, worms were examined under a light microscope for species identification.

In site 1 (Yanggu-gun, Gaojak-ri), 7 out of 9 (77.8%) captured *A. agrarius* were found to be infected with helminths. In site 2 (Yanggu-gun, Jukgok-ri), all captured 11 *A. agrarius* and 7 *A. peninsulae* were found to be infected with helminths. In site 3 (Inje-gun, Gaa-ri), 15 out of 23 (65.2%) *A. agrarius* were found to be infected with helminths. No parasite was recovered from the red-backed vole and the squirrel. The infection rates of each intestinal parasite in *A. agrarius* and *A. peninsulae* are summarized in Table 1. Briefly, 72.1% of *A. agrarius* and 63.6% of *A. peninsulae* were found to be infected with various species of intestinal parasites. In *A. agrarius*, hookworm infection rate (41.9%; 18/43) was the highest, followed by *Syphacia* spp. (14.0%) and ascarids (11.6%) among the nematodes. In case of trematodes, 2 specimens of *P. muris* were collected and no other species of trematodes were found (Fig. 1). In addition, 2 species of cestodes, i.e., *Hymenolepis nana* and *Hymenolepis diminuta*, were collected from *A. agrarius*. The species of 2 nematodes and 2 cestodes were unable to identify. In *A. peninsulae*, the overall nematode infection rate (63.6%) was similar to that of *A. agrarius* except the fact that the proportion of hookworms among the nematodes was relatively higher in *A. peninsulae* than in *A. agrarius* because of the absence of ascarids and small numbers of *Syphacia* spp. in *A. peninsulae*. Unlike *A.*

agrarius, only 1 *Echinostoma hortense* was collected as a trematode and no other species were found. Whereas *H. nana* was also collected from *A. agrarius*, *H. diminuta* was the only cestode found in *A. peninsulae*.



Fig. 1. (A) An adult worm of *Plagiorchis muris* recovered from a striped field mouse, *Apodemus agrarius*. Bar = 200 μ m. (B) An adult of *Echinostoma hortense* recovered from a Korean wood mouse, *Apodemus peninsulae*. Bar = 200 μ m. OS, oral sucker; VS, ventral sucker; O, ovary; T, testis; VT, vitellaria; HC, head crown.

Table 1. Infection rates of intestinal parasites in *Apodemus agrarius* and *Apodemus peninsulae* caught from 3 sites of Yanggu-gun and Inje-gun in northern Gangwon-do, Republic of Korea

Species of helminths	<i>A. agrarius</i> (n = 43) ^a		<i>A. peninsulae</i> (n = 11) ^b	
	No. positive (%)	No. worms	No. positive (%)	No. worms
Nematodes	22 (51.2)	713	7 (63.6)	516
<i>Ascaris</i> sp.	5 (11.6)	51	0 (0.0)	0
<i>Syphacia</i> sp.	6 (14.0)	160	2 (18.2)	4
Hookworms	18 (41.9)	502	7 (63.6)	512
Trematodes	2 (4.7)	2	1 (9.1)	1
<i>Plagiorchis muris</i>	2 (4.7)	2	0 (0.0)	0
<i>Echinostoma hortense</i>	0 (4.7)	0	1 (9.1)	1
Cestodes	16 (37.2)	49	6 (54.5)	14
<i>Hymenolepis nana</i>	4 (9.3)	19	0 (0.0)	0
<i>Hymenolepis diminuta</i>	12 (27.9)	30	6 (54.5)	14
Total ^c	31 (72.1)	764	7 (63.6)	531

^aParasite infections were identified from all 3 sites of Yanggu-gun (16) and Inje-gun (15).

^bParasite infections were identified from only 1 site of Inje-gun (7).

^c4 unknown helminths (2 nematodes and 2 cestodes) from *A. agrarius* were excluded from counting.

This is the first report on intestinal parasites among wild rodents in Gangwon-do, suggesting that wild rodents might play a role in maintaining the sylvatic cycle of some trematodes. Among them, *P. muris* is a small intestinal fluke (2.9-3.0 mm long) and there have been several reports on human infections [9,10]. According to a previous survey performed in a northern part of Korea, the majority (83.3%) of *A. agrarius* were infected with *P. muris* [2]. *A. agrarius* is still strongly suggested as an important reservoir of *P. muris* in northern parts of Korea [7] and in this survey, *P. muris* was also collected from *A. agrarius* although the infection rate was relatively low. In addition, an adult worm of *E. hortense* was recovered from *A. peninsulae*, proving the potential of *A. agrarius* as the natural definitive host in northern Gangwon-do.

H. nana, a dwarf tapeworm, is most common in temperate zone including the Korean peninsula. For a long time, it had been a relatively common cestode infection in Korea, especially in children. The nationwide survey in 1986 revealed that the egg positive rate of *H. nana* was 0.22%, but a review of zoonotic parasites in Korea also indicated very low prevalence of *H. nana* infection in comparison to other zoonotic cestodes like *Taenia* spp. [11,12]. However, the possibility of *H. nana* infection has still been present as seen in the case of a 40-year-old man [13], and symptoms can attend heavy worm burdens. Although *H. diminuta* is also known as a zoonotic cestode like *H. nana*, human infection cases by *H. diminuta* was almost absent in Korea after the first case report in 1966 [12,14]. However, in this survey, considerable infection rates of *H. diminuta* were shown in both *A. agrarius* (27.9%) and *A. peninsulae* (54.5%), still implying the possibilities of zoonotic infection by this cestode along with *H. nana*.

Taken together, the increased demands for leisure activities in northern Gangwon-do, Korea might provide the chance of opportunistic parasite infections around the areas of this survey. Furthermore, 2 major lakes (Paro-ho and Soyang-ho) which provide many attractive basins for freshwater fishing are located near from the survey sites. Therefore, seasonal and further comprehensive surveys on natural parasite infections in these areas are needed for an effective control of human infections by intestinal flukes and tapeworms.

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Conflict of interest

We have no conflict of interest related to this study.

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