

Echinostome Infections in the Striped-Field Mouse, *Apodemus agrarius*, and the Ussuri White-Toothed Shrew, *Crocidura lasiura*, Caught Near the Demilitarized Zone, Gyeonggi-do (Province), Republic of Korea

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Abstract: A total of 1,498 small mammals (rodents and insectivores), including *Apodemus agrarius* (n = 1,366), *Crocidura lasiura* (54), *Mus musculus* (32), *Micronyctus fortis* (28), *Eothenomys regulus* (9), *Micronys minutes* (6), and *Cricetulus triton* (3), were live-trapped in Gyeonggi-do (Province) (Paju-si, Pocheon-gun, and Yeoncheon-gun) near the demilitarized zone (DMZ) from December 2004 to September 2005. *A. agrarius* was found to be infected with 3 species of echinostomes (*Echinostoma hortense*, *Echinostoma cinetorchis*, and *Euparyphium murinum*), while *C. lasiura* was infected with 1 species (*Echinochasmus japonicus*) of echinostome. Other mammals were free from echinostome infections. Total 16 *E. hortense* were detected in 7 (0.5%) mice, 9 *E. cinetorchis* from 5 (0.4%), and 3 *E. murinum* from 2 (0.1%) out of 1,366 *A. agrarius* examined. *E. japonicus* was found only in 1 (1.9%; total 3 specimens) *C. lasiura*. These results demonstrate that *A. agrarius* and *C. lasiura*, inhabiting near the DMZ of Gyeonggi-do serve as the natural definitive hosts for several species of echinostomes, although their infection rates are low. This is the first record of natural infections of *A. agrarius* with *E. cinetorchis* and *C. lasiura* with *E. japonicus* in the Republic of Korea.

Key words: *Echinostoma hortense*, *Echinostoma cinetorchis*, *Euparyphium murinum*, *Echinochasmus japonicus*, striped field mouse, *Apodemus agrarius*, shrew, *Crocidura lasiura*, DMZ

Trematodes of the family Echinostomatidae, i.e., echinostomes, are intestinal parasites of animals, which can infect humans, are an important group of food-borne zoonotic parasites around the world [1]. A total of 20 species belonging to 9 genera are known to cause human infections, and among them, 7 species of *Echinostoma* and 5 species of *Echinochasmus* are the most common and important groups affecting humans and animals [1]. Natural definitive hosts for these echinostomes are known to be, in most cases, birds and mammals including rodents [1].

In the Republic of Korea (ROK), several studies have been performed on echinostome infections in rodents [2-6], cats [7, 8], and dogs [9]. Among rodent surveys, *Echinostoma hortense*, *Echinostoma cinetorchis*, and *Euparyphium murinum* infections were

reported from *Rattus norvegicus* (Norway rat), *Rattus rattus alexandrinus* (roof rat), *A. agrarius*, *Mus musculus yamashinai* (common field mouse), and *Microtus fortis pellceus* (reed vole), collected in Seoul and other localities in Korea [2-4]. In addition, *Echinostoma revolutum* and *Echinoparyphium recurvatum* were recovered from rats (probably *R. norvegicus*) captured in Yangyang-gun, Gangwon-do (province) [5], and *E. japonicus* from *A. agrarius* from Goyang-gun, Gyeonggi-do and Iksan-gun, Jeollabuk-do [6].

The demilitarized zone (DMZ) of Gyeonggi-do and Gangwon-do, ROK, is highly conserved and ecologically unique [10]. Many military field training sites are located near the DMZ, where civilian entry is prohibited. Echinostome infections had never been reported from this area. A comprehensive rodent surveillance program was conducted in 3 localities of northern Gyeonggi-do near the DMZ [11-13]. The present paper focused on the status of echinostome infections in field mice, *A. agrarius* and insectivores, *C. lasiura*, captured as a part of the rodent sur-

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veillance program.

A total of 1,498 small mammals (rodents and insectivores) were live-captured using Sherman traps ($3 \times 3.5 \times 9$ folding traps; H.B. Sherman, Tallahassee, Florida, USA) from military training sites at 3 areas in Gyeonggi-do, i.e., Paju-si (city), Pocheon-gun (township), and Yeoncheon-gun (township), located near the DMZ from December 2004 to September 2005. The captured mammals included the striped field mouse, *Apodemus agrarius* ($n = 1,366$), the Ussuri white-toothed shrew, *Crocidura lasiura* (54), *Mus musculus* (32), *Micronyctus fortis* (28), *Myodes* (= *Eothenomys*) *regulus* (9), *Micronys minutus* (6), and *Tscherckia* (= *Cricetulus*) *triton* (3). Seasonal trapping was conducted in December 2004, March 2005, June 2005, and September 2005. Captured specimens were euthanized in accordance with the approved animal use protocol under biosafety level 3 (BSL-3) laboratory conditions.

The stomach, small intestine, and large intestine to the end of the rectum were removed and preserved in 70% alcohol until examination. The gastrointestinal content was examined for intestinal helminths under a stereomicroscope [11,12]. Trematodes were removed and placed on a microscope slide with a coverslip, fixed with 70% alcohol, stained with Semichon's acetocarmine, and identified using a research microscope. Data on *Plagiorchis muris* [11] and *Neodiplostomum seoulense* infections [12] were already published, and those on nematodes and cestodes will be published separately.

A total of 15/1,420 (1.1%) *A. agrarius* and *C. lasiura* were found to be infected with several species of echinostomes (Table 1; Fig. 1). The echinostome species included *E. hortense* (Fig. 1A),

E. cinetorchis (Fig. 1B), *E. murinum* (Fig. 1C), and *E. japonicus* (Fig. 1D). The infection rate of *A. agrarius* for *E. hortense* was 0.5%, (7/1,366 mice examined), and total 16 *E. hortense* specimens were recovered (Table 1). The infection rate was higher in mice (1.8%; 6/325) captured in Yeoncheon-gun than the mice captured in Pocheon-gun (0.3%; 1/288) and Paju-si (0%; 0/753). A total of 5 *A. agrarius* were infected with *E. cinetorchis*, and a total of 9 specimens were recovered (Table 1). *E. cinetorchis* infections were found exclusively in mice captured in Paju-si (0.7%; 5/753). Three specimens of *E. murinum* were recovered from 2 *A. agrarius* captured in Paju-si (0.3%; 2/753). *E. japonicus* (3 specimens) were found only in 1 *C. lasiura* captured in Paju-si (8.3%; 1/12).

Small mammals, in particular, *A. agrarius* and *C. lasiura*, inhabiting near the DMZ of Gyeonggi-do have been found to serve as the natural definitive hosts for 4 species of echinostomes. Three

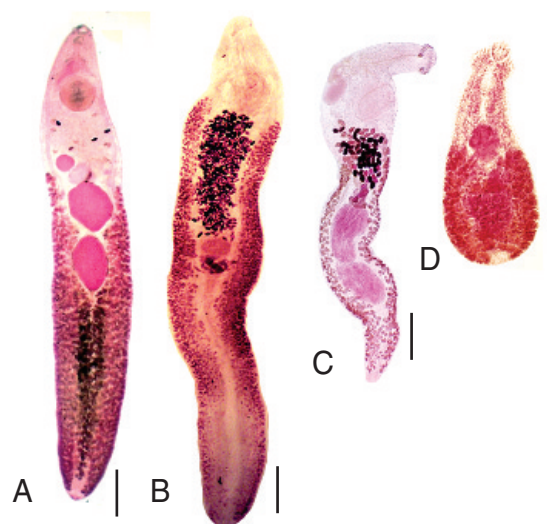


Fig. 1. (A) *Echinostoma hortense* adult recovered from a striped-field mouse, *Apodemus agrarius*, caught at Yeoncheon-gun, Gyeonggi-do. The characteristic features of this species include the presence of 27-28 collar spines on its head collar and a submedially located ovary. Scale bar = 1 mm. (B) *Echinostoma cinetorchis* adult recovered from *A. agrarius* caught at Paju-si, Gyeonggi-do. The characteristic features of this species include the presence of 37-38 collar spines on its head collar, abnormal location or disappearance of 1 or both testes, and a medially located ovary. Scale bar = 1 mm. (C) *Euparyphium murinum* adult recovered from *A. agrarius* caught at Paju-si, Gyeonggi-do. The characteristic features of this species include the presence of 45 collar spines on its head collar and a short uterine tubule. Scale bar = 0.5 mm. (D) *Echinochasmus japonicus* adult recovered from an insectivore, the Ussuri white-toothed shrew, *Crocidura lasiura*, caught at Paju-si, Gyeonggi-do. The characteristic features of this species include a short, plump body with the presence of 24 dorsally interrupted collar spines and 2 tandem arranged testes. Scale bar = 0.025 mm.

Table 1. Infection status of echinostomes in *Apodemus agrarius* and *Crocidura lasiura* collected near the DMZ of Gyeonggi-do (province), Republic of Korea

Species of echinostome	<i>A. agrarius</i> ($n = 1,366$)		<i>C. lasiura</i> ($n = 54$)	
	No. positive (%)	No. specimens	No. positive (%)	No. specimens
<i>Echinostoma hortense</i>	7 (0.5) ^a	16	0 (0.0)	0
<i>Echinostoma cinetorchis</i>	5 (0.4) ^b	9	0 (0.0)	0
<i>Euparyphium murinum</i>	2 (0.1) ^c	3	0 (0.0)	0
<i>Echinochasmus japonicus</i>	0 (0.0)	0	1 (1.9) ^d	3

^aSix of these 7 positive mice were caught in Yeoncheon-gun (positive rate; 1.8%, 6/325) and 1 mouse was captured in Pocheon-gun (0.3%, 1/288) of Gyeonggi-do.

^bAll 5 mice were caught in Paju-si (0.7%, 5/753).

^cBoth mice were caught in Paju-si (0.3%, 2/753).

^dThis infected insectivore was caught in Paju-si (8.3%, 1/12).

of the 4 species, *E. hortense*, *E. cinetorchis*, and *E. japonicus*, are zoonotic parasites capable of infecting humans, as human infections with these echinostome species have been reported in the ROK [14-17]. Infections of *A. agrarius* with *E. cinetorchis* and of *C. lasiura* with *E. japonicus* are reported for the first time in the ROK.

There was no difficulty in identifying the specimens of *E. hortense*, *E. cinetorchis*, and *E. japonicus*. However, there was difficulty in identifying *E. murinum* [18], because of the presence of several closely related species having 45 (43-47) collar spines. Such species included *Echinostoma macrorchis* [19], *Echinostoma gotoi* [19], *Euparyphium paramurinum* [20], and *Euparyphium albuferensis* [21]. The possibility of *E. macrorchis* for our specimens was excluded by the smaller body size, shorter and less coiled uterine tubule, and smaller egg size in our specimens. *E. gotoi* could be excluded because our specimens had globular testes, smaller sized eggs, and short uterus whereas *E. gotoi* has elongated elliptical or S-shaped testes, bigger sized eggs, and longer and more coiled uterus [19]. Two species of *Euparyphium* (*E. paramurinum* and *E. albuferensis*) were morphologically more similar to our specimens. However, the differential points between *E. murinum* and *E. paramurinum* given were minor [18,20], and these 2 species should be synonymous, so we excluded *E. paramurinum* for consideration. *E. albuferensis* was the most recently reared species of *Euparyphium*, which is similar to *E. murinum* [21]. However, the former differed from the latter in its larger body, larger suckers, more extensive distribution of vitelline follicles, and in the morphology of collar spines [21]. Our specimens were most similar to *E. murinum* in the body size and the distribution of vitelline follicles.

Infection rates of mice and insectivores with *E. cinetorchis* and *E. japonicus*, respectively, were higher in those captured at Paju-si compared with those captured at 2 other locations. Meanwhile, most of *E. hortense* infections were found in mice caught at Yeoncheon-gun. Whether this difference has any significant meaning is unclear at present. However, since all these 3 zoonotic echinostomes can infect humans through eating improperly cooked freshwater fish [1], attention should be paid to the possible presence of human infections with these echinostomes in these areas.

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