DIVERSITY OF GASTROINTESTINAL HELMINTHS AMONG MURID RODENTS FROM NORTHERN AND NORTHEASTERN THAILAND

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Abstract. The presence of gastrointestinal helminths (GI helminths) was investigated among 725 murid rodents, trapped in various habitats of Nan, Loei and Buri Ram Provinces, Thailand. The study revealed 17 species of rodents infected with 21 species or taxonomic groups of parasites (3 trematodes, 3 cestodes, 14 nematodes and 1 acanthocephalan). The overall prevalence of infection was 57.7% (418/725). Of the gastrointestinal (GI) helminths, the dominant parasitic group was members of the family Trichostrongylidae (24.3%), followed by the cestodes *Raillietina* sp (17.1%) and *Hymenolepis diminuta* (8.6%) and the nematode *Syphacia muris* (8.6%). The GI helminthic infection rates were highest in *Mus caroli* (81.8%), *Mus cervicolor* (76.5%), *Leopoldamys edwardsi* (75.0%), *Bandicota indica* (71.5%) and *Bandicota savilei* (71.4%). Highest rodent species richness (RSR) and helminth species richness (HSR) rates were found in Loei, followed by Nan and Buri Ram. The helminth prevalence rate was higher in rodents from Nan, followed by rodents from Loei and Buri Ram. Rodents from irrigated fields had the highest infection rates followed by rodents from upland or dry agricultural areas, forests and domestic habitats. *Raillietina* sp, *Rodentolepis nana* (syn. *Hymenolepis nana*), *Hymenolepis diminuta*, *Moniliformis moniliformis* and *Cyclodontostomum purvisi*, considered zoonotic parasites, were mainly found in rodents from domestic habitats and lowland irrigated fields.

Keywords: gastrointestinal helminths, rodents, habitat, Thailand

INTRODUCTION

Rodents are the most abundant group of mammals with more than 2,700 species worldwide (42% of mammalian species on earth) (Wilson and Reeder, 2005). They live in many environments throughout the world. Two-thirds of living rodent species belong to the family Muridae, which represents most of the rodents found in Asia (Aplin *et al*, 2003).

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Rodents are important carriers of disease to humans since they have adapted to human habitats and environmental changes (Carleton, 1984). They can contaminate food stores with their feces and urine, and transmit several pathogens to humans. Rodent-borne diseases are numerous and include bacterial diseases (*eg*, leptospirosis, plague, tularemia, salmonellosis and rickettsioses, such as scrub typhus and murine typhus), protozoal diseases (*eg*, leishmaniasis, babesiosis and cryptosporidiosis), and viral diseases (*eg*, hantaviral infections, arenaviral infections and rabies).

Helminths are also important zoonotic diseases. Helminth infections in rodents that are a potential risk to humans in Southeast Asia and the Pacific region include *Paragonimus* sp, *Schistosoma japonicum*, *Hymenolepis* sp, *Railletina* sp, *Angiostrongylus cantonensis*, *Capillaria hepatica*, *Gnathostoma spinigerum* and *Trichinella spiralis* (Maleewong *et al*, 1988; Aplin *et al*, 2003).

Although there have been several reports of helminth infections in rodents from other parts of the world (Warner, 1998; Behnke *et al*, 2000; Strojcevic *el al*, 2004; Paramasvaran *et al*, 2005; Singla *et al*, 2008), studies from Thailand are limited. Most surveys were done more than twenty years ago (Artchawakom, 1981; Chenchittikul *et al*, 1983; Kamiya *et al*, 1987; Namue and Wongsawad, 1997). Little data are available about helminth diversity among rodents in Thailand. Thus, the aim of this study was to conduct a preliminary survey of GI helminths among rodents in Thailand and to determine the risk to humans of zoonotic helminthiasis from different habitats which could help in the development of control programs.

MATERIALS AND METHODS

Three sampling locations were selected: one from northern (Nan) and two from northeastern (Loei and Buri Ram) Provinces of Thailand; the study was conducted from February 2008 to March 2010. These locations included areas with low human density and forest areas with high human density. Rodents were trapped from urban and rural areas: forest, upland areas (orchards, tree plantations and dry crops); lowland areas (irrigated rice fields and wetlands); and domestic areas (isolated houses and villages).

Live traps were used for trapping rodents. At each location 10 trap lines (composed of 10 traps each) were placed. The trap lines were moved every 4 days (3 times). Each trap line was located in a specific habitat. The rodents were anesthetized using chloroform, followed by carbon dioxide in order to cause the death of the rodents and potential ectoparasites (fleas, mites and ticks). Their GI tracts, stomachs, small intestines and large intestines were separately examined for helminths. Isolated helminths were preserved in 70% alcohol. Nematodes and acanthocephalans were cleared in lactophenol. Cestodes and trematodes were stained in Semichon's carmine, dehydrated in alcohol degradation and mounted in Canada Balsam. The prepared helminths were identified under a microscope followed by identification with keys (Yamaguti, 1958; Yorke and Maplestone, 1969; Skrjabin *et al*, 1970; Schmidt, 1986; Anderson, 2000). The protocols are described by Herbreteau *et al* (2011). Animal care and handling followed international standards (American Veterinary Medical Association Council on Research) and the protocols were approved during evaluation of the CERoPath project by the French ANR.

Table 1
Number of murid rodents captured in different locations and habitats.

Murid rodents	Total number	Locations			Habitats			
		Nan	Loei	Buri Ram	Forest	Upland	Lowland	Domestic
Bandicota indica	123	84	16	23	6	10	104	3
Bandicota savilei	21	-	21	-	5	1	15	-
Berylmys berdmorei	19	10	9	-	4	9	1	5
Berylmys bowersi	25	3	22	-	7	17	-	1
Chiropodomys gliroides	2	-	2	-	1	1	-	-
Hapalomys delacouri	1	-	1	-	1	-	-	-
Leopoldamys edwardsi	12	-	12	-	4	8	-	-
Leopoldamys neilli	1	-	1	-	1	-	-	-
Maxomys surifer	21	-	21	-	11	8	2	-
Mus caroli	33	6	27	-	-	12	21	-
Mus cervicolor	51	14	28	9	2	26	23	-
Mus cookie	69	22	47	-	6	51	11	1
Mus fragilicauda	1	-	1	-	1	-	-	-
Niviventer fulvescens	66		66	-	15	41	10	-
Rattus exulans	124	38	47	39	2	5	5	112
Rattus losea	88	-	88	-	12	16	60	-
Rattus tanezumi	68	20	35	13	6	17	25	20
Total	725	197	444	84	84	222	277	142

Rodent species richness (RSR), which is the number of rodent species found from each location, and helminth species richness (HSR), which is the number of helminth species found on each host species, were used to determine rodent and helminth diversity, respectively. We used univariate analysis to evaluate the relationship between individual helminth status (positive or negative); the four classified habitats were analyzed for variance by ANOVA. Significance was set at p = 0.05. Statistical analysis was performed using Statistica software. Specimens of each helminth species were preserved in alcohol and deposited at the Department of Helminthology (Faculty of Tropical Medicine, Mahidol University, Thailand) and the Laboratory of Parasitology (Faculty of Pharmacy, University of Barcelona, Spain). Original data and more specimen information can be found at the website of the CERoPath project (Community Ecology of Rodents and Their Pathogens in Southeast Asia; www.ceropath.org).

RESULTS

A total of 725 murid rodents belonging to 17 species from Nan (n=197), Loei (n=444) and Buri Ram (n=84) Provinces were captured from the four habitats: forest (n=84), upland area (n=222), lowland area (n=277) and domestic area (n=142) and examined for helminths (Table 1). Four hundred eighteen animals (57.7%) were infected with GI helminths. Twenty-one species of parasites or taxonomic

Table 2
Prevalence of gastrointestinal helminths in different species of murid rodents from Nan, Loei and Buri Ram (Thailand).

Rodent	Number with infection: Trematodes			Cestodes			Acantho	Nematodes													
	Noto (%)	*Leci* (%)	*Echi* (%)	*Rail* (%)	*H.dim* (%)	*R.nan* (%)	*M.mon* (%)	*T.mur* (%)	*Euco* (%)	*Aonc* (%)	*H.spu* (%)	*C.pur* (%)	*S.obv* (%)	*S.mur* (%)	*Phys* (%)	*Prot* (%)	*Mast* (%)	*Pter* (%)	*G.neo* (%)	*Tric* (%)	*Fila* (%)
B. ind	1(0.81)	-	-	75(60.9)	1(0.8)	-	-	9(7.3)	1(0.8)	3(2.4)	19(15.4)	1(0.8)	-	11(8.9)	9(7.3)	3(2.4)	3(2.4)	-	-	15(12.2)	-
B. sav	-	-	1(4.8)	4(19.1)	1(4.8)	-	-	1(4.8)	-	-	2(9.5)	-	-	9(42.8)	2(9.5)	-	-	-	1(4.8)	3(14.3)	-
B. ber	-	-	-	4(21.1)	3(15.8)	-	-	-	-	-	7(36.8)	-	-	2(10.5)	1(5.3)	2(10.5)	1(5.3)	-	-	-	-
B. bow	-	-	-	-	3(12.0)	-	-	-	-	-	5(20.0)	-	-	4(16.0)	-	1(4.0)	1(4.0)	-	-	-	-
C. gli	-	-	-	-	-	1(50.0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H. del	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L. edw	-	-	-	3(25.0)	5(41.7)	-	-	-	-	-	-	-	-	1(8.3)	-	-	-	-	-	3(25.0)	-
L. nei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M. sur	-	-	-	2(9.5)	1(4.8)	-	-	-	-	-	-	-	-	1(4.8)	-	-	-	-	1(4.8)	2(9.5)	-
M. car	-	-	-	-	-	6(18.2)	-	-	-	-	-	-	6(18.2)	-	1(3.0)	4(12.1)	-	-	-	24(72.7)	-
M. cer	-	-	-	2(3.9)	-	12(23.5)	-	-	3(5.9)	1(2.0)	-	-	6(11.8)	-	1(2.0)	7(13.7)	-	-	2(3.9)	27(52.9)	-
M. coo	-	1(1.5)	-	-	2(2.9)	14(20.3)	-	-	-	-	-	-	18(26.0)	-	-	8(11.6)	-	-	1(1.5)	30(43.5)	-
M. fra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N. ful	-	-	-	8(12.1)	22(33.3)	1(1.5)	-	-	-	-	-	-	-	1(1.5)	-	-	-	3(4.6)	1(1.5)	18(27.3)	1(1.5)
R. exu	-	-	-	2(1.6)	15(12.1)	-	2(1.6)	-	-	-	-	-	-	3(2.4)	-	2(1.6)	1(0.8)	-	1(0.8)	2(1.6)	-
R. los	8(9.1)	17(19.3)	1(1.1)	10(11.4)	1(1.1)	2(2.3)	-	1(1.1)	-	-	-	-	-	20(22.7)	10(11.4)	2(2.3)	-	-	1(1.1)	29(32.9)	-
R. tan	-	-	-	14(20.6)	8(11.8)	-	1(1.5)	1(1.5)	-	-	-	-	-	10(14.7)	-	1(1.5)	1(1.5)	4(5.9)	5(7.4)	23(33.8)	2(2.9)
Total	9	18	2	124	62	36	3	12	4	4	33	1	30	62	24	30	7	7	13	176	3
(725)	(1.2)	(2.5)	(0.3)	(17.1)	(8.6)	(5.0)	(0.4)	(1.7)	(0.6)	(0.6)	(4.6)	(0.1)	(4.1)	(8.6)	(3.3)	(4.1)	(1.0)	(1.0)	(1.8)	(24.3)	(0.4)

Rodent: *B. ind, Bandicota indica; B. sav, Bandicota savilei; B. ber, Berylmys berdmorei; B. bow, Berylmys bowersi; C. gli, Chiropodomys gliroides; H. del, Hapalomys delacouri; L. edw, Leopoldamys edwardsi; L. nei, Leopoldamys neilli; M. sur, Maxomys surifer; M. car, Mus caroli; M. cer, Mus cervicolor; M. coo, Mus cookii; M. fra, Mus fragilicauda; N. ful, Niviventer fulvescens; R. exu, Rattus exulans; R. los, Rattus losea; R. tan, Rattus tanezumi*

Helminth: *Noto, Notocotylus loeiensis; Leci, Licithodendriidae; Echi, Echinostoma* sp; *Rail, Raillietina* sp; *H. dim, Hymenolepis diminuta; R. nan, Rodentolepis nana; M.mon, Moniliformis moniliformis; T. mur, Trichuris muris; Euco, Eucoleus* sp; *Aonc, Aonchotheca sp; H. spu, Heterakis spumosa; C. pur, Cyclodontostomum purvisi; S. obv, Syphacia obvelata; S. mur, Syphacia muris; Phys, Physaloptera* sp; *Prot, Protospiura* sp; *Mast, Mastophorus sp; Pter, Pterygodermatites sp; G. neo, Gongylonema neoplasticum;Tric, Trichostrongyliidae; Fila, Filariidae*

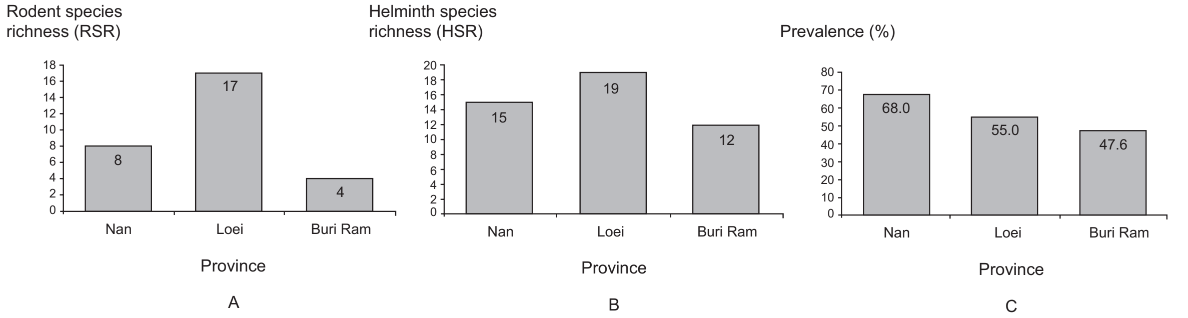

Fig 1–Rodent species richness (A), helminth species richness (B) and prevalence of helminth infection (C) in three localities.

groupings (in the case of Lecithodendriidae, Trichostringylidae and Filariidae) were identified. Three species of cestodes (*Raillietina* sp, *Hymenolepis diminuta* and *Rodentolepis nana*), three species of trematodes (*Notocotylus loeiensis*, Lecithodendriidae and *Echinostoma* sp) and 14 species of nematodes (*Trichuris muris*, *Eucoleus* sp, *Aonchotheca* sp, *Heterakis spumosa*, *Syphacia obvelata*, *Syphacia muris*, *Physaloptera* sp, *Protospiura* sp, *Mastophorus* sp, *Pterygodermatites* sp, *Gongylonema neoplasticum* and *Cyclodontostomum purvisi* and Trichostrongylidae) and Filariidae, including 1 species of acanthocephalan (*Moniliformis moniliformis*) were identified. The GI helminth infection rates in each rodent species were determined (Table 2).

The highest prevalence of helminth infection was found in *Mus caroli* (81.8%), followed by *M. cervicolor* (76.5%), *Leopoldamys edwardsi* (75.0%), *Bandicota indica* (71.5%) and *Bandicota savilei* (71.4%). The highest number of helminth species richness (HSR) was seen in *Bandicota indica* (13) followed by *Rattus losea* (12) and *Rattus tanezumi* (11). *Hapalomys delacouri*, *Leopoldamys neilli* and *Mus fragilicauda* were the three rodent species found to not be infected with any parasites. An unidentified nematode in the family Trichostrongylidae was the most common parasite (24.3%); other parasites frequently recovered were *Raillietina* sp (17.1%), *Hymenolepis diminuta* (8.6%), *Syphacia muris* (8.6%) and *Rodentolepis nana* (5.0%). Rodent species richness (RSR) and helminth species richness (HSR) had similar patterns of variation at the three study locations, with the highest diversity found in Loei, followed by Nan and Buri Ram. The highest GI helminth infection prevalence rate was found in Nan, followed by Loei and Buri Ram (Fig 1). The ANOVA evaluating individual helminth infections showed habitat had a significant effect ($F_{3,\ 721}$=13.036, p<0.0001), with rodents from domestic habitats having fewer helminth infections (Fig 2).

DISCUSSION

In this study, we found 21 helminth species (or taxonomic groups) in 17 species of rodents, indicating murid rodents from these parts of Thailand are infected by a great diversity of GI helminths. Some of these helminthes which have been found in previous studies from Thailand (Sinniah, 1979; Artchawakom, 1981; Chenchittikul *et al*, 1983; Namue and Wongsawad, 1997). Some helminth species in this study have not been reported among Thai rodents. We report the

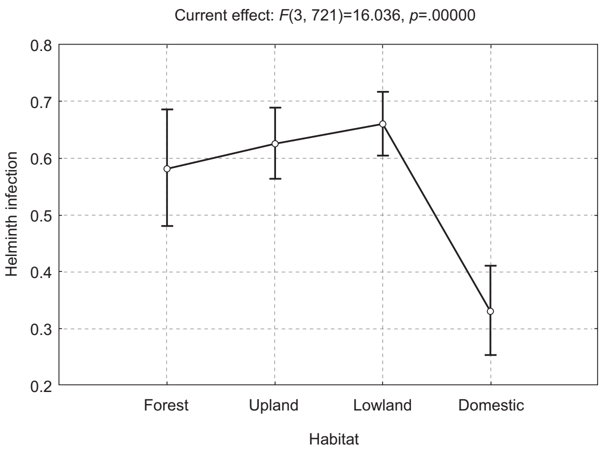

Fig 2–Helminth infections from four different habitats (ANOVA, $F_{3,721}=13.036$, $p<0.0001$).

first helminthological data for *Berylmys berdmorei*, *Berylmys bowersi*, *Chiropodomys gliroides*, *Leopoldamys edwardsi*, *Mus caroli*, *Mus cervicolor*, *Mus cookii*, *Niviventer fulvescens* and *Rattus losea* in Thailand. We report new helminth species from Thai rodents: the trematode *Notocotylus loeiensis* (Chaisiri *et al*, 2011) and three nematodes (*Eucoleus* sp, *Aonchotheca* sp and Filariidae).

Most rodent species live in restricted or specific habitats (Adler, 2009; Jittapalapong *et al*, 2009; Chaisiri *et al*, 2010). As a result, some helminth species can be found in the same habitat types such as *Notocotylus loeiensis, Trichuris muris* and *Physaloptera* sp, which were commonly found in lowland areas among: *Bandicota indica*, *Bandicota savilei*, *Mus caroli*, *Mus cervicolor* and *Rattus losea*. Acanthocephalan *Moniliformis moniliformis* was found only in domestic rodents, *Rattus exulans* and *Rattus tanezumi*, but some parasites were less restricted, being found in various rodents from domestic, upland and forest areas.

Rodents from lowland areas were highly infected, followed by rodents from upland areas and forest areas. Fewer helminth infections were found in domestic rodents (Fig 2). Several helminth species that potentially infect humans, such as *Raillietina* sp (Pradatsundarsar, 1968; Areekul and Radomyos, 1970), *Hymenolepis diminuta* (Sinniah, 1979; Chenchittikul *et al*, 1983), *Rodentolepis nana* (Kiettivuti *et al*, 1987), *Moniliformis moniliformis* (Walter, 1959; Moayedi *et al*, 1971) and *Cyclodontostomum purvisi* (Bhaibulaya and Indrangarm, 1975) were mainly found in domestic rodents and in rodents from lowland areas. This suggests in lowland and domestic humans and domestic animals are at risk for zoonotic helminths from murid rodents. People who hunt these rodents for food are particularly at the risk of being infected.

Some sylvatic rodent species, such as *Chiropodomys gliroides*, *Leopoldamys edwardsi*, *Maxomys surifer*, *Mus cookii* and *Niviventer fulvescens*, may act as reservoirs of helminths. Human activities that disturb ecosystems (*ie*, land use changes) where these rodents live play an important role in the epidemiology of zoonotic diseases (Ambu *et al*, 1996). Further studies should be carried out in other parts of Thailand in order obtain a more detailed picture of helminth diversity in the face of ongoing changes in country.

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