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ORIGINAL ARTICLE

Study of the endoparasitic fauna of commensal rats and shrews caught in traditional wet markets in Taichung City, Taiwan

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Background: Rats live in close proximity to human populations. Feral rodents are known to transmit diseases and act as reservoir hosts to many zoonotic parasites that pose health risks to humans. The aim of this study is to investigate endoparasitic infections in commensal rats and shrews caught in traditional wet markets in Taichung City, Taiwan.
Methods: A total of 51 commensal wild rodents and shrews were caught in traditional wet markets in Taichung City, including 32 *Rattus norvegicus*, 11 *R. rattus*, and eight *Suncus murinus*. All tissues, organs, and intestinal contents were carefully examined after euthanasia for the detection of parasites.
Results: The overall prevalence of infection was 94.1%, and the infection rates in *R. norvegicus*, *R. rattus*, and *S. murinus* were 93.8%, 90.9%, and 100.0%, respectively. Four cestodes (*Taenia taeniaeformis, Hymenolepis diminuta, H. nana,* and *Raillietina celebensis*), seven nematodes (*Angiostrongylus cantonensis, Capillaria hepatica, Heterakis spumosa, Nippostrongylus brasiliensis, Strongyloides ratti, Syphacia muris*, and *Trichosomoides crassicauda*), and one protozoan (*Sarcocystis* spp.) were detected.
Conclusion: Our findings indicate that commensal rodents and shrews found in the traditional wet markets of Taichung City are hosts to various zoonotic parasites and, therefore, pose a serious health risk to humans and domestic animals in Taiwan.

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Introduction

Rats survive and reproduce in households and agricultural and commercial areas that are commonly populated by human beings. More than 20 species of feral rodents have been categorized as pests in tropical and subtropical countries, and these species cause tremendous losses and damages to crops and food stocks.[1] Feral rodents are known to transmit diseases and act as reservoir hosts to many zoonotic parasites that pose health risks to humans, including *Angiostrongylus cantonesis*, *Capillaria hepatica*, *Hymenolepis diminuta*, *H. nana*, and *Taenia taeniaeformis*.[2–4] The development of control methods against zoonotic parasites depends on knowledge of their life cycles and transmission patterns in different zoogeographical regions. Therefore, it is important to survey the parasites that infect rodents in order to identify the sources of zoonotic infections.

Commensal rodents are generally found living in close proximity to humans and often dependent on human habitats for essential supplies such as food, water, shelter, and space.[5] Therefore, commensal rodents may play an important role in the transmission of zoonotic parasites. Although several studies on the endoparasites of feral rodents have been carried out in Taiwan,[6–9] limited information is available on endoparasitic infections in commensal rodents. The aim of this study is to investigate endoparasitic infections in commensal rats and shrews caught in traditional wet markets in Taichung City, Taiwan.

Materials and methods

Trapping and identification of rodents

Rodents were captured from three traditional wet markets in the central and south districts of Taichung City using food-baited traps. The trapped rodents were confined in wire cages and taken to a laboratory for further investigation. Keys and illustrations developed by Chen[10] and Wilson and Reeder[11] were used to identify the various species of rodents.

Examination for endoparasites

The rats and shrews were anesthetized by intraperitoneal administration of 40% chloral hydrate and then euthanized by cardiac puncture. After removing the skin, the body cavity was slit open from the throat to the anus, thereby revealing the esophagus, stomach, intestines, liver, and urinary bladder. Tissue samples for the examination of *Trichinella* spp. and *Sarcocystis* spp. were collected by pressing the tongue and diaphragm between two glass slides. The slides were then examined under both dissecting and light microscopes. The esophagus, stomach, intestines, liver, and urinary bladder of each animal were placed in individual Petri dishes containing 0.85% sodium chloride solution. The tubular organs, except for the liver which was examined for the presence of cysts/nodular structures, were flushed with phosphate-buffered saline (PBS) and/or slit open to facilitate the detection of parasites in the flushing solution as well as the organ itself. Small and large parasites isolated from the tubular organs were fixed in 70% methanol and 10% formalin, respectively. Tissue samples of the intestines, liver, and urinary bladder of the infected rats, as well as those of the tongue and diaphragm with cysts or cyst-like bodies, were fixed in 10% phosphate-buffered formalin and stained with hematoxylin and eosin. The parasites isolated from the skin and organs, and those observed in the tissue samples, were identified and documented by photomicroscopy.

Tapeworms and flukes were maintained in tap water and then fixed in 70% alcohol, pressed between two glass slides, stained with alum carmine, and mounted in permount. Nematode parasites were fixed in 10% formalin and cleared in lactophenol. Intestinal protozoa and helminth ova were detected by performing floatation of the rats' intestinal contents.

Statistical analysis

The Chi-square test was used to compare differences between groups. Probability values < 0.05 were considered significant.

Results

A total of 51 commensal wild rodents and shrews were collected, including 32 *Rattus norvegicus* (17 males and 15 females), 11 *R. rattus* (5 males and 6 females), and eight *Suncus murinus* (5 males and 3 females). Of the 51 rodents and shrews collected, 48 were found to host endoparasitic infections, indicating an overall prevalence of 94.1%. The infection rates for *R. norvegicus*, *R. rattus*, and *S. murinus* were 93.8%, 90.9%, and 100.0%, respectively (Table 1). No significant differences were observed between the different species and sexes of the rodents and shrews ($p > 0.05$).

The parasitic fauna are illustrated in Table 2. We identified four cestodes: *T. taeniaeformis*, *H. diminuta*, *H. nana*, and *Raillietina celebensis*. *T. taeniaeformis* was the most dominant parasite with an overall prevalence of 31.4%. *H. nana* was the dominant parasite in *S. murinus* with a prevalence of 87.5%.

Seven nematodes, including *A. cantonensis*, *C. hepatica*, *Heterakis spumosa*, *Nippostrongylus brasiliensis*, *Strongyloides ratti*, *Syphacia muris*, and *Trichosomoides crassicauda*, were identified in the various tissue and organ samples. Among these nematodes, *S. ratti* (84.3% overall

Table 1 Infection rates of endoparasites in commensal rodents and shrews trapped in traditional wet markets

Species	Number examined (♂/♀)	Number positive (♂/♀)	Infection rate (%)
Rattus norvegicus	32 (17/15)	30 (16/14)	93.8
Rattus rattus	11 (6/5)	10 (5/5)	90.9
Suncus murinus	8 (4/4)	8 (4/4)	100
Total	51 (27/24)	48 (25/23)	94.1

Table 2 Prevalence of endoparasites in commensal rodents and shrews trapped in traditional wet markets

Species	Prevalence (%)			
	R. norvegicus ($n = 32$)	*R. rattus* ($n = 11$)	*S. murinus* ($n = 8$)	Overall ($n = 51$)
Cestodes				
Taenia taeniaeformis	37.50 (12/32)	18.18 (2/11)	25.00 (2/8)	31.37 (16/51)
Hymenolepis diminuta	6.25 (2/32)	18.18 (2/11)	0	7.84 (4/51)
Hymenolepis nana	21.88 (7/32)	9.09 (1/11)	87.50 (7/8)	29.41 (15/51)
Raillietina celebensis	15.63 (5/32)	9.09 (1/11)	0	11.76 (6/51)
Nematodes				
Angiostrongylus cantonensis	18.75 (6/32)	9.09 (1/11)	12.50 (1/8)	15.69 (8/51)
Capillaria hepatica	62.50 (20/32)	18.18 (2/11)	0	43.14 (22/51)
Heterakis spumosa	15.63 (5/32)	0	0	9.80 (5/51)
Nippostrongylus brasiliensis	78.13 (25/32)	36.36 (4/11)	12.50 (1/8)	58.82 (30/51)
Strongyloides ratti	90.63 (29/32)	63.64 (7/11)	87.50 (7/8)	84.31 (43/51)
Syphacia muris	0	27.27 (3/11)	0	5.88 (3/51)
Trichosomoides crassicauda	40.63 (13/32)	9.09 (1/11)	25.00 (2/8)	31.37 (16/51)
Protozoa				
Sarcocystis spp.	28.13 (9/32)	9.09 (1/11)	0	19.61 (10/51)

prevalence) was the dominant species, followed by *N. brasiliensis* (58.8%), *T. crassicauda* (47.1%), *C. hepatica* (43.1%), and *A. cantonensis* (15.9%). *H. spumosa* was only found in *R. norvegicus* (9.8%). *S. muris* was only found in *R. rattus* (27.3%).

Only one protozoan was identified in the fauna of the commensal rodents. Thick-walled sarcocysts containing numerous zoites were found in tongue and diaphragm tissue samples of *R. norvegicus* and *R. rattus* with prevalence rates of 28.1% and 9.1%, respectively.

Discussion

Three species of commensal rodents and shrews were studied: *R. norvegicus*, *R. rattus*, and *S. murinus*. *R. norvegicus* was the most abundant species, accounting for approximately 62.7% of the total sample size. The high prevalence of parasitic infections (93.8% in *R. norvegicus*, 90.9% in *R. rattus*, and 100% in *S. murinus*) indicates that commensal rodents and shrews in traditional wet markets have a high degree of parasitic infections, including zoonotic species that are transmittable to humans.

A. cantonensis, the rat lungworm, is the major pathogen that causes eosinophilic meningitis in the Pacific Islands and Southeast Asia.[12–15] To date, more than 100 cases of eosinophilic meningitis have been recorded in Taiwan.[16,17] Rats serve as the primary host for this parasite.[18] Yang and Lu reported that 18.5% of field rodents are infected with *A. cantonesis*.[8] Tung et al reported that the overall prevalence of *A. cantonensis* is 16.8% in rodents and shrews on farms.[7] Here, the prevalence of *A. cantonensis* infection was found to be 15.9%. These findings indicate that the extensive distribution of *A. cantonensis* in central Taiwan is independent of the level of urbanization. Humans are at high risk of *A. cantonensis* infection, therefore special hygiene-related precautions should be exercised when eating raw or undercooked snails or contaminated vegetables.[12,16,19]

C. hepatica is a globally present parasite that inhabits the livers of a wide variety of mammals, including humans.[20] This parasite is widespread among rodents across Taiwan. Tung et al reported a 52.8% prevalence rate for *C. hepatica* in 89 farm rodents,[7] while we found a 51.2% prevalence rate in this study. These findings suggest that farms and wet markets are significantly contaminated with *C. hepatica*. The rate of infection in *R. norvegicus* was significantly higher than that of *R. rattus*. Underground drainage systems form a major reservoir for *R. norvegicus*. The workers on farms or wet markets might flush *C. hepatica* eggs into the drainage systems when cleaning the ground, thereby increasing the chances of *R. norvegicus* infection. *C. hepatica* elicits granuloma formation and fibrosis in the liver parenchyma of the host. Although a few human cases have been reported,[21–24] the high prevalence of *C. hepatica* in commensal rodents may increase the health risk to humans.

All four of the cestodes recovered from commensal rats and shrews (Table 2) can be transmitted to humans. *H. nana* infection was predominant in *S. murinus*, and similar findings have been reported in previous studies.[7,9] The habit of defecating and urinating in fixed sites increases the chances of *S. murinus* ingesting the infective cysticercoids of *H. nana*. Moreover, *H. nana* does not always need an intermediate host because the eggs hatch in the intestines of the host and grow into adult worms. This occurrence may cause severe pathological problems in the host.[4]

Tung et al reported that 38.9% of the rodents and shrews caught on farms were infected with *H.* diminuta.[7] However, in this study, the prevalence of *H. diminuta* infection was found to be 7.8%. Beetles, fleas, caterpillars, and other insects are hosts for the cysticercoid larvae of *H.* diminuta.[25] This tapeworm is commonly found in areas where large amounts of grain or other dry food products that are

preferred by rats are stored.[25] These two factors are responsible for the significantly higher prevalence of *H. diminuta* infections in rats caught on farms versus those caught in wet markets.

H. nana and *H. diminuta* can accidentally infect humans, causing diarrhea and abdominal pain in case of serious infection.[26–28] Transmission of these zoonotic parasites to humans is more frequent in areas with high temperatures and poor sanitary conditions.[4]

Adult *R. celebensis* were recovered from the small intestines of five *R. norvegicus* (15.6%) and one *R. rattus* (9.1%). A previous study conducted in Kaoshung indicated that 8.8% of *R. norvegicus* are infected with *R. celebensis*.[9] However, Tung et al reported that the prevalence rate was up to 45.3% in rodents and shrews caught on dairy farms.[7] This difference can be attributed to the fact that the rodents on farms can easily prey on beetles or ants that are hosts to infective cysticercoids. *R. celebensis* infections are uncommon in humans, however a few cases have been reported in Indonesia and the French Polynesian Islands.[29,30]

The diversity observed in the parasitic fauna indicates the adaptability and immense capability of rodents to support the growth and developmental needs of these parasites.[4] The high prevalence of individual infection and relatively high susceptibility to parasitic infections indicate that commensal rodents and shrews from wet markets are significantly infected with various parasites, and that they may play an important role in the transmission of certain zoonotic parasites to humans.

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