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Susceptibility of Some Rodents to *Taenia polyacantha* and Their Mortality along the Course of Infection

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Abstract

In the heavy infections, 100 and 1,000 eggs of *Taenia polyacantha* were orally administered to some rodents; namely, red-backed voles, wood mice, cotton rats, AKR/J and C57BL/KsJ mice, ICR mice, Mongolian gerbils, golden hamsters, and additionally to an insectivore; house musk shrews. The susceptibility of these hosts to the parasite, and mortality in the infection were examined. The red-backed voles, cotton rats and AKR/J mice were susceptible to *T. polyacantha* and high mortality in the early phase of infection was shown. Mature larvae were recovered from the Mongolian gerbils. Even in the mild infection of 10 to 50 egg-inoculation, almost all of the red-backed voles and the cotton rats were dead by 6 days post-infection (DPI) and 11 DPI, respectively. Ascites and hemorrhage into the peritoneal cavity and ecchymoses in the small intestine of these hosts were found as common lesions. Microscopically, the parasites were observed mainly in the hemorrhagic lesions of the wall of the small intestine, mesenteric lymph nodes and mesentery of the red-backed voles and cotton rats in the early phase of infection.

Key words: *Taenia polyacantha,* rodents, insectivora, susceptibility, larval development, pathogenicity

Introduction

Taenia polyacantha Leuckart, 1856 is widely distributed in the holarctic region and its life-cycle involves carnivores as definitive hosts and rodents of family Muridae, Cricetidae, Arvicolidae and Sciuridae as natural intermediate hosts (Abuladze, 1964; Šlais, 1973). The larvae multiply asexually and the metacestodes are found freely in the peritoneal and pleural cavity of the intermediate hosts (Murai, 1974; Prokopic and Hulinska, 1978; Rausch, 1959; Schiller, 1953; Tenora, 1963; Wiger *et al.*, 1974). As an exceptional case, Tenora *et al.* (1988) found the metacestodes under the liver serosa of an European rabbit (*Oryctolagus cuniculus*) in Czechoslovakia.

Most reports on this parasite deal with prevalence and morphological observations in the intermediate and definitive hosts. There are few reports on the development of the larval stage in the intermediate hosts. Recently, Rausch and Fay (1988a, b) reported postoncospheral developments in experimental infection of *T. polyacantha* eggs, and pathological changes in the natural intermediate hosts, *Microtus oeconomus* and *Lemmus sibiricus.*

In this investigation, we examined the susceptibility of various species of laboratory-reared rodents to *T. polyacantha* eggs, and mortality rates and pathological changes in those hosts.

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Materials and Methods

Parasite

Mature metacestodes were isolated from *Microtus oeconomus* in Savoonga, Alaska in 1988. These metacestodes were transplanted surgically into the peritoneal cavity of Mongolian gerbils for three months, and later orally administered to a mongrel dog. Gravid segments were collected daily after 62 days postinfection (DPI), washed with saline and stored at 4°C in saline containing penicillin, streptomycin and fungizon (Mitchell *et al.*, 1977; Williams *et al.*, 1981). Eggs from the gravid segments were used within one month of collection.

Animals

Red-backed voles, *Clethrionomys rufocanus bedfordiae,* (13 wks-old, ♂ 11, ♀ 8) and house musk shrews, *Suncus murinus,* (9 wks-old, ♂ 3, ♀ 5) were supplied from Central Institute for Experimental Animals, Kawasaki, Cotton rats, *Sigmodon hispidus,* (age not determined, ♂ 7, ♀ 13) came from Hokkaido Institute of Public Health, golden hamsters, *Mesocricetus auratus,* 17 wks-old, ♂ 11) from Hokkaido Experimental Animal Center, and ICR mice (15 wks-old, ♂ 11) from Nippon SLC Cooperation, Mongolian gerbils, *Meriones unguicuratus,* (6 wks-old, 16, ♂ 3), AKR/J mice (7 wks-old, ♂ 11) and C57BL/KsJ mice (5 wks-old, ♂ 10) were bred and maintained in our laboratory. Wood mice, *Apodemus speciosus,* (age not determined, ♂ 10), were trapped in a shelter-belt near Sapporo city, Hokkaido.

Infection and autopsy

Individual hosts were inoculated with 10 to 1,000 eggs by stomach tube under light ether anesthesia. Infected individual hosts were examined at appropriate intervals from 7 to 63 DPI, or when death occurred. A ventral median incision was made, and the peritoneal and thoracic cavities were washed with saline. The washings were examined for the parasite under a dissecting microscope. The recovered parasites were fixed in 10% formalin, and then mounted with glycerin jelly or stained with Schneider's aceto-carmine for morphological observation. Organs in the peritoneal and pleural cavities were also examined for gross lesions. When gross lesions were found, the organs were examined microscopically. Total numbers of parasites were not determined, as some of the parasites migrated into the host organs or attached to the host tissues, preventing accurate counting.

Results

Results of infection with 100 and 1,000 eggs of *T. polyacantha* in various animals are shown in Table 1. Among the 7 species inoculated with eggs, 4 species were susceptible; the red-backed voles, cotton rats, Mongolian gerbils, ICR and AKR/J mice. Most of the red-backed voles and the cotton rats, and half of the AKR/J mice died due to the effects of inoculation in the early phase of infection. No parasites or lesions were observed in the golden hamsters, wood mice, C57BL/KsJ mice and house musk shrews.

Red-backed voles

All 10 voles died by 9 DPI. From nine of them the parasites were observed either macroscopically in the peritoneal cavity or microscopically. At 5 and 6 DPI, common gross lesions were: the accumulation of blood-tinged ascitic fluid, and ecchymoses on the serosal surface of the small intestine, especially jejunum and ileum, mesenteric lymph node and mesentery (Fig. 1). Microscopically, parasites showing a central cavity, primary vesicles, were recovered mainly in the hemorrhagic lesions of the small intestines and mesenteric lymph nodes at 5 and 6 DPI. Extensive purulent inflammation and hemorrhage were observed surrounding the parasites (Fig. 2). In one dead vole, no parasites were found. Focal hemorrhages and degenerative changes were observed in the mesenteric lymph nodes, and a decrease in lymphocyte number occurred in the lymphatic organs. This may have been due to the hemorrhage and focal degenerative changes of lymph nodes.

Since all of the voles died by 9 DPI, mature larvae could not be recovered.

Table 1 Susceptibility of small mammals to *Taenia polyacantha*.

	Days postinfection					Total positive host* number/ Total number examined
	0–4	5–10	11–15	16–20	21–63	
Red-backed voles		(9/10)[†a,b‡]				9/10
Cotton rats		(5/6)[b]	(3/3)1/1[a]		1/1[a]	10/11
Golden hamsters				0/1[a]	0/10[a,b]	0/11
Mongolian gerbils				(1/1[a])	4/18[a,b]	5/19
Wood mice		0/1[b]	0/2[a,b]	0/1[a]	0/6[a,b]	0/10
Mice ICR			(1/1)[b]	0/1[a]	1/9[a,b]	2/11
AKR/J			(4/6)1/1[a,b]	(3/3)[a]	0/1[a]	8/11
C57BL/KsJ				0/2[a]	0/8[a,b]	0/10
House musk shrews			0/2[a,b]		0/6[a,b]	0/8

*; Positive host: Parasites were recovered macroscopically or microscopically.
†; Positive host number/number of sacrificed and examined: (Positive/number of dead and examined)
‡; Number of inoculated eggs: a; 100 eggs, b; 1,000 eggs.

Cotton rats

Nine of 10 infected rats died due to the effect of inoculation within 13 DPI. The rest of the rats were autopsied by 23 DPI. Parasites were found in the abdominal organs, e.g., the small intestinal wall and mesentery, and peritoneal cavity of 10 of the 11 rats. The parasites, secondary vesicles, at 12 DPI had formed an accumulation of nuclei at their distal end, and at 23 DPI almost all of the parasites were developing hooks and suckers. Microscopically, the same kind of lesions surrounding the parasites as in the red-backed vole, i.e., hemorrhage, extensive purulent inflammation and decrease in the number of lymphocytes were observed, but these lesions were milder than in the red-backed voles. All positive hosts died by 23 DPI, and mature larvae also could not be found in the cotton rats.

Mongolian gerbils

One of the 19 gerbils died at 18 DPI. In the peritoneal cavity of the dead gerbil, ascitic fluid with fibrin, and parasites with early developing hooks were found. The rest of the gerbils survived and were sacrificed. Morphologically mature larvae were recovered from 4 gerbils necropsied at 49 DPI (1 host) and 63 DPI (3 hosts). In the peritoneal cavity of these gerbils, there was a slight accumulation of yellowish brown ascitic fluid. The liver had adhesions to the diaphragm, and all of the abdominal organs were covered with organized connective tissue. Microscopically, lymphocytic hyperplasia was observed in the spleen of the gerbils.

ICR mice

Parasites were found in 2 of 11 mice, one was dead at 13 DPI and the other was necropsied at 48 DPI. The parasites, secondary vesicles, on both days had very thin bladder walls and accumulation of nuclei was not found at their distal ends. In a dead mouse at 13 DPI, turbid ascitic fluid had accumulated and the abdominal organs were covered with fibrin. The abdominal organs of a mouse at 48 DPI were completely adhered with organized connective tissue. Microscopically, lymphocytic hyperplasia was found in the spleen follicles of a mouse at 48 DPI. The rest of the 9 mice were not positive for the parasite and showed no pathological changes.

AKR/J mice

Nine of 11 AKR/J mice died between 11 and 20 DPI. Parasites were recovered from the peritoneal cavity of 8 mice, and a hematoma in the liver of a dead mouse at 13 DPI was observed. Parasites were found microscopically in this lesion. Most of the parasites at 16 and 17 DPI

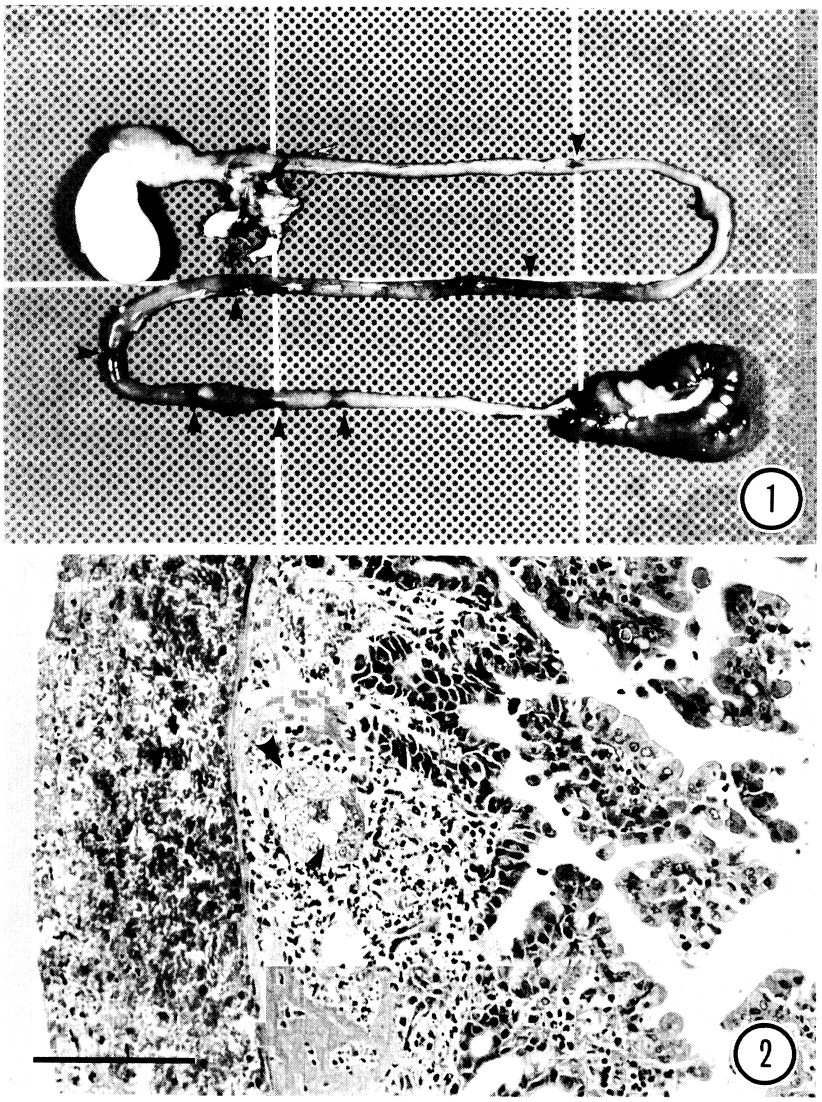

Fig. 1 Ecchymoses (arrowhead) on the small intestine and mesenteric lymph node (arrow) of a red-back vole, 5 DPI.

Fig. 2 Infiltration of numerous polynuclear cells and hemorrhage surrounding the parasite (arrowhead) which showed a central cavity (arrow) in the small intestine of a red-backed vole, 5 DPI. H-E stain. Bar = 100 μm.

had formed an invaginal canal and few parasites by 20 DPI had formed rosteller corns. Ecchymoses occurred in the wall of the small intestine and mesenteric lymph nodes, and pinkish or turbid ascitic fluid with fibrin was observed in the dead mice in the early phase of infection. In contrast to the red-backed voles and cotton rats however, parasites were not found in these hemorrhagic lesions. Since all positive animals died by 20 DPI, mature larvae were not recovered from this host species.

Other animals

All of 11 golden hamsters, 10 wood mice, 10

C57BL/KsJ mice and 8 house musk shrews were refractory to *T. polyacantha* infection. They survived and showed no pathological changes at necropsy.

Infection with a small number of eggs

Oral infection with more than 100 eggs caused high mortality in hosts, thus the number of eggs inoculated was reduced to 10–50 in the next experiment. Nine red-backed voles and 9 cotton rats were divided into 3 equal groups, and inoculated with 10, 30 and 50 eggs of *T. polyacantha*. Seven of the 9 voles died by 4 to 5 DPI. Two voles survived and were not positive for the parasite. All of the cotton rats were dead between 9 and 11 DPI. In these dead animals, the same gross lesions and microscopic changes as in the previous experiment were observed.

Discussion

Rausch (1957) and Rausch and Fay (1988b) reported on the life-cycle of *T. polyacantha*. In North America mainly arvicoline rodents, *Microtus oeconomus* and *Lemmus sibiricus* are reported as the intermediate hosts of *T. polyacantha*. Also in Europe, although a few reports note genus *Meriones, Mesocricetus, Apodemus,* etc. (Abuladze, 1964; Tenora, 1963; Tenora, 1965), the natural intermediate hosts of *T. polyacantha* are mainly arvicoline rodents, i.e., *Clethrionomys glareolus* and *Microtus arvalis* (Dorosz, 1968; Murai and Tenora, 1973; Murai, 1974; Wiger *et al.*, 1974). *Clethrionomys glareolus* and *C. glareolus helveticus,* which belong to the same genus as the red-backed vole, and *Meriones tanatiscinus, M. meridianus* and *M. erythrorus,* which belong to same genus as the Mongolian gerbil, were reported as natural intermediate hosts (Aduladze, 1964). In the present study, the red-backed voles, cotton rats and AKR/J mice were highly susceptible hosts, while Mongolian gerbils and ICR mice had low susceptibility. The golden hamster and wood mouse, *Apodemus speciosus,* were refractory to infection, although Kirshenblat (1940) reported mature metacestodes in the golden hamster, and there are a few reports of naturally infected *Apodemus flavicolis* and *A. sylvaticus.*

In the present study, mature larvae with fully developed hooks were recovered only from Mongolian gerbils, and this host species showed low susceptibility to infection with eggs. The parasite showed lower pathogenicity to the gerbils. In the red-backed voles, which showed high susceptibility and mortality, the passage time of the parasites from the internal organs to the peritoneal cavity was about the same as in *M. oeconomus* (Rausch and Fay, 1988a), but the parasites observed in the wall of the small intestine and mesenteric lymph nodes at 5 DPI, and recovered from the peritoneal cavities at 6 DPI were much more developed than ones reported on the northern voles (Rausch and Fay, 1988a). On the other hand, the development of parasites in the cotton rats at 12 and 23 DPI and Mongolian gerbils at 18 DPI was similar to the results of Rausch and Fay (1988a). In AKR/J and ICR mice, development was delayed, but a few parasites in AKR/J mice developed well. Thus AKR/J mouse may be a potential experimental intermediate host. Many hosts died due to the effect of inoculation, but no parasites were found in the few animals macroscopically and microscopically. This result may be due not to the absence of the parasites, but to overlooking the small parasites within the organs.

High mortality rates occurred in the red-backed voles and cotton rats even in the mild infection of 10 to 50 eggs. More than 10 eggs inoculation proved to be fatal to these hosts. Rausch and Fay (1988b) reported that infection with 5 eggs or more may be debilitating or even fatal in such rodents because of diffuse subcapsular hepatitis and peritonitis related to the migration of the parasites. However in the present study, in the many red-backed voles, cotton rats and AKR/J mice found dead in early phase of infection, extensive hemorrhage, purulent inflammation and focal necrosis of the small intestinal walls and mesenteric lymph nodes, were observed as common pathological changes. Rausch and Fay (1988a, b) reported that marked accumulation of inflammatory cells was observed in the liver of the northern voles. Thus the migration of parasites from the abdominal organs to

the peritoneal cavity was pathogenic to the host. Other pathological changes caused by *T. polyacantha* were adhesions in the abdominal organs, and splenic and adrenal hypertrophy. These changes were reported in naturally infected hosts (Rausch and Fay, 1988a; Tenora *et al.*, 1979; Wiger, 1973). The same lesions were also observed in the Mongolian gerbils at 49 and 63 DPI, and an ICR mouse at 48 DPI. The main cause of death of host animals remains unclear, and the migration route of the postoncospheral stage will be reported in detail elsewhere (Fujita *et al.*, submitted).

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