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Interspecific Competition Between *Spirometra erinacei* (Rudolphi, 1819) and *Dipylidium caninum* (Linnaeus, 1758) in Cats

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Abstract

An epidemiological survey of *Spirometra erinacei* and *Dipylidium caninum* in cats was done. Of the 226 cats examined, 89 (39%) were infected with *S. erinacei* and 33 (15%) were infected with *D. caninum*. Only one (0.4%) cat had both species of tapeworms at the same time. The prevalence of *S. erinacei* was higher in rural areas (22–55%) than in the urban area (0%) investigated, and this difference seemed to be related to the presence of more intermediate hosts such as amphibia and reptiles in the country. In the urban area, 58% of cats had *D. caninum,* and in the rural areas, this tapeworm was found significantly less often (8–14%) than *S. erinacei.* Infestation with fleas (*Ctenocephalides felis*), an intermediate host of *D. caninum,* was observed in 45% of the cats in rural areas. The lower frequency of *D. caninum* in the rural areas could not, therefore, be explained by the absence of its intermediate host in the country. To find out reasons for the lower frequency of *D. caninum,* we transplanted *S. erinacei, D. caninum,* or both into cats free of tapeworms on different schedules. The presence and growth of *D. caninum* were inhibited in the presence of *S. erinacei,* indicating that there was interspecific competition between them.

Key words: *Spirometra erinacei, Dipylidium caninum,* interspecific competition, transplantation

Introduction

Spirometra erinacei and *Dipylidium caninum* are found in the small intestines of dogs, cats, and rarely humans, throughout the world. They are widespread in Japan (Oishi and Kume, 1973; Iseki *et al.*, 1974; Asato *et al.*, 1986). According to a review article, the prevalence of *S. erinacei* in cats in Japan varied from 21% to 72% and that of *D. caninum* varied between 1% and 51%, with much local difference (Yamashita, 1972). The variation in the prevalence of these tapeworms is said to be related to the distribution (Oishi and Kume, 1973) and season of activity (Uchida *et al.*, 1982) of the intermediate hosts. Certain tapeworms have inter- and intraspecific competition at higher densities of infection, regulating the spatial distribution in the host gut (Muzzall, 1980; Pojmanska, 1982). During an earlier study (Uga *et al.*, 1983), we came to suspect that there was interspecific competition between *S. erinacei* and *D. caninum* because a mixed infection of both tapeworms in the same cat was never found, although the prevalence of *S. erinacei* was 39% and that of *D. caninum* was 13%.

The purpose of this study was to investigate infection by *S. erinacei* and *D. caninum* in cats captured in Hyogo Prefecture, and to use a transplantation experiment to check for intraspecific competition.

Materials and Methods

Period and area of survey

The study was done over a period of 20 months from May 1990 to December 1991 in parts of Hyogo Prefecture, Japan, excluding Kobe. The survey area was divided into six districts: Hanshin, an urban region; Higashi-

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harima and Nishiharima, agricultural regions with a warm climate throughout the year; Tanyu, a mountain region; Tajima, an agricultural region with heavy snowfall during the winter; and Awaji, an island. The human population density and the percentage of the total area of each district occupied by mountains, forests,, and fields were 2,609 and 34% in Hanshin, 825 and 47% in Higashiharima, 350 and 57% in Nishiharima, 133 and 60% in Tanyu, 98 and 51% in Tajima, and 280 and 40% in Awaji.

Survey method

Of the cats brought to the Animal Administration Office of Hyogo Prefecture, 226 cats (96 males and 130 females) estimated to be 1 to 10 years old judged by external appearance and the degree of dental development were chosen as subjects. The contents of the small intestines of the cats, which were killed with carbon dioxide, were scraped out together with the mucosa and washed several times in a beaker. A stereomicroscopic microscope was used to check for scolices of *S. erinacei* and *D. caninum*. We also looked for *Ctenocephalides felis,* an intermediate host of *D. caninum,* using another 181 cats in the Hanshin, Higashiharima, and Nishiharima districts. The cats, which were killed in the same way, were suspended at room temperature for 24 hours and the number of *C. felis* that fell from them was counted.

Transplantation

For the transplantation experiment, cats given praziquantel (Droncit tablet, Bayer) 7–10 days before were used as recipients. Six *S. erinacei* and six *D. caninum* scolices 1–4 cm long were recovered from donors and transplanted into these cats. The parasites suspended in 0.5–1 ml of physiological saline were injected through a 0.5–1 cm incision by a 1 ml disposable syringe in the upper part of the small intestine. Transplantation was done in one of three ways: simultaneous transplantation of both kinds of tapeworms, transplantation of *S. erinacei* followed by *D. caninum* 1 week later, and transplantation of *D. caninum* followed by *S. erinacei* 1 week later. The recipients were killed 7–30 days after the final transplantation and the presence and length of any parasites recovered were recorded.

Results

Of the 226 cats examined, 89 (39%) were infected with *S. erinacei* and 33 (15%) were infected with *D. caninum*. Only one cat had concurrent infection, which was significantly lower ($P<0.01$, by the χ^2 test) than the expected value of 13 (6%) calculated ($226\times0.39\times0.15$) on the assumption that these parasites are not mutually competitive. The mean number of parasites recovered from each cat was 21 for *S. erinacei* and 46 for *D. caninum*. In the cat with mixed infection (a male weighing 4 kg, captured in the Higashiharima district; estimated age, 10 years), three *S. erinacei* and two *D. caninum* were detected (Table 1). The incidence of *S. erinacei* and *D. caninum* did not differ by sex of the host. Some 42% of male cats and 37% of female cats were infected with *S. erinacei,* and 15% of male cats and 15% of female cats were infected with *D. caninum*. The incidence was not affected by the host's age, either (data not shown).

Table 2 shows detection rates of *S. erinacei* and *D. caninum* in the different districts. No *S. erinacei* infection was found in the urban Hanshin district, but the other five districts, all rural, had infection rates of 22–55%. The pattern was opposite for *D. caninum,* and the rural rates were all significantly lower than that for *S. erinacei* ($P<0.05$, by the χ^2 test).

The incidence of *C. felis* was 75% in cats from Hanshin and 45% in the Higashi- and Nishiharima districts combined. The mean number was higher in Hanshin than in the two other districts (Table 3). Of the 521 *C. felis* recovered from cats living in the Hanshin area, 67 were examined for cysticercoid. No positive *C. felis* was obtained indicating the prevalence of cysticercoid in *C. felis* was lower than 1.5%. Therefore, the prevalence between urban and rural areas was not compared.

In preliminary experiments, the recovery rates of *S. erinacei* and *D. caninum* after transplantation were 88% and 67%, respectively. The mean length of the parasites recovered 7–10 days after

Table 1 Infection with *Spirometra erinacei* and *Dipylidium caninum* in cats

Parasites detected	No. of cats examined	No. of cats infected	Infection rate (%)	No. parasites detected min.	max.	mean
S. erinacei	226	89	39	1	472	21
D. caninum	226	33	15	2	163	46
*S. e+D. c**	226	1	0.4	–	–	3+2†

**S. erinacei* and *D. caninum* were detected at the same time.
†Three *S. erinacei* and two *D. caninum* were recovered.

Table 2 *Spirometra erinacei* and *Dipylidium caninum* infections in different districts

Districts	No. of cats examined	*S. erinacei* no. cats*	*S. erinacei* %	*D. caninum* no. cats†	*D. caninum* %
Hanshin	19	0	0	11	58
Higashiharima	57	27	47	8	14
Nishiharima	58	26	45	6	10
Tanyu	44	24	55	4	9
Tajima	37	8	22	3	8
Awaji	11	4	36	1	9

*Number of cats infected with *S. erinacei*.
†Number of cats infected with *D. caninum*.

Table 3 Infestation of cats with *Ctenocephalides felis*

Districts	No. of cats examined	No. positive	Positive rate (%)	No. *C. felis* recovered min.	max.	mean	total
Hanshin	44	33	75	1	99	16	521
Higashiharima Nishiharima	137	61	45	1	41	7	436

transplantation was 78 cm for *S. erinacei* and 65 cm for *D. caninum*. The recovery rate of *D. caninum* dropped when transplantation of the two species was simultaneous, when *S. erinacei* was transplanted before *D. caninum*, and when *D. caninum* was transplanted before *S. erinacei*. Whatever the combination, the body lengths of the *D. caninum* recovered were less than 10 cm (Table 4).

Table 4 Recovery of *S. erinacei* and *D. caninum* after transplantation of both parasites to cats in different combinations

Combination*	No. of parasites transf.	Days after last transpl.	No. of parasites recovered (%)		Mean length† of parasites	
			S. e	*D. c*	*S. e*	*D. c*
S. e‡	5.3	7–10	4.7 (88)	–	78	–
D. c‡	6.0	7–10	–	4.0 (67)	–	65
	6 each	7	5 (83)	2 (33)	37	4
S. e+*D. c*	6 each	19	4 (67)	0 (0)	ND§	0
	6 each	21	5 (83)	1 (17)	87	5
	6 each	8	5 (83)	0 (0)	11	0
S. e→*D. c*	6 each	10	6 (100)	0 (0)	51	0
	6 each	21	6 (100)	3 (50)	142	5
	6 each	9	3 (50)	3 (50)	65	7
D. c→*S. e*	6 each	11	6 (100)	1 (17)	36	7
	6 each	30	5 (83)	0 (0)	68	0

* *S. e*+*D. c*, Both parasites were transferred at the same time.
S. e→*D. c*, *S. erinacei* was transplanted first, followed by *D. caninum* one week later.
D. c→*S. e*, *D. caninum* was transplanted first, followed by *S. erinacei* one week later.
† In centimeters.
‡ Preliminary single-transplant experiment, with six cats given *S. erinacei* and three cats given *D. caninum*.
§ ND, Not done.

Discussion

In another epidemiological study of parasitic helminths of cats done in Hyogo Prefecture (Uga *et al.*, 1983), the prevalence of *S. erinacei* was 39% and that of *D. caninum* was 13%, which our new results are in close agreement with. In that study, mixed infections of *S. erinacei* and *D. caninum* were not found, and in this study, only one cat had mixed infection; these findings suggested competition between these species of tapeworms.

Local differences in prevalence were found, with *S. erinacei* the dominant species in rural areas, probably because of the abundance of intermediate hosts such as snakes and frogs in such areas (Oishi and Kume, 1973; Uchida *et al.*, 1982). Contrary to this, *D. caninum* dominant in the urban area studied, in a pattern that we have named, "the urban-type infection" (Uga *et al.*, 1983). Such an infection pattern has been reported in other urban areas like Tokyo (Oishi and Kume, 1973), Osaka (Iseki *et al.*, 1974), and Kanagawa (Uchida *et al.*, 1982). In the past, it has been explained that *D. caninum* would not be much affected by the kind of place where its host lives because the intermediate host is the *C. felis*. However, this study showed low infection rates of *D. caninum* in rural areas in spite of the high infection rate in the urban area. The reason may not be the difference in frequency of *C. felis* infestation: its prevalence was 45% in rural areas and 75% in the urban area. Some, 45% of cats from rural areas were infested with *C. felis,* and mean number of fleas per cat was seven, which is a sufficient number of intermediate hosts, taking the infection threshold into consideration. Prevalence of cysticercoid in *C. felis* was low even

in the high prevalence area of *D. caninum*. This result made it impossible to carry out any infection experiment by using cysticercoid recovered from *C. felis*.

The results of transplantation in various patterns showed that the presence of *S. erinacei* reduced the rate of detection of *D. caninum* or slowed the growth of this parasite, although the presence of *D. caninum* did not affect either the numbers of *S. erinacei* detected or their size. *D. caninum* could be recovered on day 21 after the final transplantation, but it had grown little and seemed will have been exterminated in the course of time. Pojmanska (1982) examined three species of the genus *Diorchis* recovered from European coots and observed inter- and intraspecific competition at high densities of infection. This has been referred to as the crowding effect, found also in *Hymenolepis diminuta* (Roberts, 1961). Andersen (1972) observed that maturation of *Dipyllobothrium dendriticum* was postponed when a hamster was infected with eight plerocercoids of this cestodes at the same time, indicating the crowing effect. He also reported that the small intestine of the hamster was almost filled with cestodes. In our study, however, the cat was used as a recipient and this has higher "carrying capacity" than hamster (Andersen, 1972). Furthermore, the total number of parasites used in each transplantation experiment was 12. This number is not seemed to be high enough to introduce crowing effect because *S. erinacei* and *D. caninum* were naturally infected in cats with a mean number of 21, 46, respectively. Therefore, the phenomenon observed in this study cannot be explained by the crowing effect.

The effect of concurrent infection on the distribution of cestodes along the host gut was discussed by Olszewska (1975). She observed three species of genus *Diorchis* overlapped each other, and concluded that there was no competitive interaction among these species. Similar observation was done by Pojmanska (1982). The scolices of *S. erinacei* and *D. caninum* were found from the anterior part of the small intestine. Antagonism between these species was observed, although each of them concurrently harbored with *Taenia taeniaeformis* (data not shown). These observations suggest that *S. erinacei* and *D. caninum* are directly compete each other, which is not related with site of infection.

We concluded that the reason for the low rate of infection with *D. caninum* in rural areas was interspecific competition with *S. erinacei,* which was dominant in rural areas. The reason of interspecific competition observed between these tapeworms is not yet examined. We found 13 species of helminths in this study other than *S. erinacei* and *D. caninum,* but competitive relationships were not detected among them.

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