***Strongyloides planiceps* (Nematoda; Strongyloididae) in Some Wild Carnivores**

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ABSTRACT. We investigated 40 raccoon dogs (*Nyctereutes procyonoides viverrinus*), 5 Japanese weasels (*Mustela sibirica itatsi*), and 3 masked palm civets (*Paguma larvata*) in Kanagawa Prefecture, and 2 Japanese martens (*Martes melampus melampus*) in Niigata Prefecture, Japan, for *Strongyloides* species from October, 1982 to December, 1983. Nematodes of the genus *Strongyloides* were obtained from the small intestine of 26 raccoon dogs and 2 Japanese weasels. The number of worms ranged 3–127 in raccoon dogs and 2–12 in Japanese weasels. The *Strongyloides* species obtained was identified as *S. planiceps* by the morphological characteristics of their parasitic and free-living stages and of eggs and further by such ecological features as prepatent period, the form of parasite passed into the feces of hosts and susceptibility of dogs and domestic cats to infection with the parasite. Some species of wild carnivores, especially raccoon dogs, act as the reservoir host of *S. planiceps* and will play an important role in spreading *Strongyloides* infections among dogs and domestic cats.—**KEY WORDS:** *Mustela sibirica itatsi*, *Nyctereutes procyonoides viverrinus*, reservoir, *Strongyloides planiceps*.

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Strongyloides planiceps is a nematode parasitic in the small intestine of such carnivores as dogs, cats, and raccoon dogs. This nematode was first collected from a rusty tiger cat, *Felis planiceps*, in Malaya and was described as a new species, *S. cati* by Rogers in 1939 [19]. *S. cati* was then altered to *S. planiceps* by the same author in 1943 because *S. cati* was *nomen nudum* [20].

In Japan, Horie *et al.* (1974, 1980) [9, 10] obtained *Strongyloides* sp. from a dog, which was brought from Nagasaki Prefecture to Osaka Prefecture about 5 days before, and identified it as *S. planiceps* by detailed morphological and ecological examinations. Thereafter, *S. planiceps* was reported from a dog in Kyoto Prefecture [1], a domestic cat in Nara Prefecture and a raccoon dog in Osaka Prefecture [11]. *Strongyloides* species obtained from a dog [16], two domestic cats [17], and a red fox *Vulpes vulpes schrencki* [15] in Hokkaido is probably *planiceps*. In addition, we found this species from 4 of 420 dogs [6] and 4 of 105 domestic cats [4, 5] in

Kanagawa Prefecture.

From these reports, *S. planiceps* is thought to be widely distributed in Japan. However, existence of reservoirs other than dogs and domestic cats is presumed, because the incidence rate is low in these animals and neither intermediate nor paratenic host is required for the development of the nematode species. So, we surveyed the incidence of *S. planiceps* in some wild carnivores.

MATERIALS AND METHODS

We examined 40 raccoon dogs (*Nyctereutes procyonoides viverrinus*), 5 Japanese weasels (*Mustela sibirica itatsi*), and 3 masked palm civets (*Paguma larvata*) in Kanagawa Prefecture, and 2 Japanese martens (*Martes melampus melampus*) in Niigata Prefecture, Japan, from October, 1982 to December, 1983. Parasitic females of *Strongyloides* were collected by autopsy of the animals and examined morphologically.

Parasitic females from 2 raccoon dogs and

Table 1. Incidence rates of *Strongyloides* species in some wild carnivores

Mammals species examined	No. animals examined	No. animals infected	No. worms in an animal
Raccoon dog (<i>Nyctereutes procyonoides viverrinus</i>)	40	26	3–127
Japanese weasel (<i>Mustela sibirica itatsi</i>)	5	2	2–12
Masked palm civet (<i>Paguma larvata</i>)	3	0	—
Japanese marten (<i>Martes melampus melampus</i>)	2	0	—

1 Japanese weasel were measured. Rhabditiform free-living females and males and filariform larvae were obtained by cultivation of the rectal feces according to the method of Harada and Mori (1951) [7]. These adults, larvae, and eggs were also measured. Measurements were taken on body length, body width, distance from the anterior tip of worm to the beginning of intestine, tail length, distance from the anterior tip of worm to vulva (only of parasitic females and rhabditiform females), and spicule length (only of rhabditiform males). Esophageal length was measured as the distance from the anterior tip of worm to the beginning of intestine. Eggs were measured on length and width. Ratios were calculated between the above measurements of worms and eggs.

In the animals in which worms and eggs had been measured, the eggs in rectal feces were cultured. 10^3 filariform larvae obtained were each subcutaneously injected into a dog and two domestic cats. Then the feces of experimentally infected animals were cultured every day after infection by Harada and Mori's method [7] for determination of prepatent period. After starting of oviposition, the fresh feces was examined precisely to detect eggs or larvae by the direct smear method, flotation method with saturated NaCl solution, and MGL method.

RESULTS

Parasitic *Strongyloides* females were obtained from the small intestine of 26 of 40 raccoon dogs and 2 of 5 Japanese weasels, but not from the masked palm civets and Japanese martens. The number of worms ranged 3–127 in raccoon dogs and 2–12 in Japanese weasels (Table 1). The worms possessed the following morphological characteristics: Body very slender, about 3 mm in length and about 0.04 mm in width; esophagus filariform; ovary twisted; and tail abruptly tapered with rounded end. From the rectal feces, embryonated eggs were detected but not rhabditiform larvae.

Measurements of worms in each developmental stage and of eggs from 2 raccoon dogs and 1 Japanese weasel are shown in Table 2 to 4.

Experimental infections of a dog and domestic cats with infective larvae succeeded in all the three cases. Prepatent period was 9–11 days and only embryonated eggs were excreted into the fresh feces (Table 5).

DISCUSSION

The present *Strongyloides* species obtained from raccoon dogs and Japanese weasels well agreed with *S. planiceps* in the morphology

Table 2. Measurements (in mm) of various developmental stages of *Strongyloides* from a racoon dog (A)

	Rhabditiform female	Rhabditiform male	Filariform larva	Parasitic female	Embryonated egg
Body length or Egg length	1.108±0.125	0.861±0.189	0.577±0.030	3.205±0.267	0.060±0.004
Body width or Egg width	0.059±0.010	0.046±0.012	0.016±0.001	0.040±0.004	0.032±0.002
Esophageal length	0.165±0.016	0.130±0.008	0.261±0.011	0.928±0.187	—
Tail length	0.106±0.007	0.078±0.021	0.068±0.004	0.045±0.005	—
Anterior tip to vulva	0.556±0.061	—	—	2.029±0.183	—
Spicule length	—	0.043±0.005	—	—	—
Body length/Body width or Egg length/Egg width	19.11±2.31	18.76±2.45	36.72±2.49	82.04±14.58	1.88±0.18
Body length/Esophageal length	6.77±1.11	6.65±1.46	2.21±0.10	3.50±0.41	—
Body length/Tail length	10.45±1.03	11.56±2.85	8.49±0.56	72.70±12.06	—
Body length/Anterior tip to vulva	1.99±0.04	—	—	1.58±0.01	—
Body length/Spicule length	—	19.94±3.32	—	—	—

Table 3. Measurements (in mm) of various developmental stages of *Strongyloides* from a racoon dog (B)

	Rhabditiform female	Rhabditiform male	Filariform larva	Parasitic female	Embryonated egg
Body length or Egg length	1.215±0.121	0.827±0.108	0.564±0.053	2.917±0.138	0.062±0.005
Body width or Egg width	0.061±0.013	0.044±0.009	0.017±0.001	0.040±0.001	0.033±0.002
Esophageal length	0.154±0.010	0.131±0.010	0.249±0.023	0.775±0.041	—
Tail length	0.107±0.011	0.090±0.020	0.069±0.003	0.043±0.005	—
Anterior tip to vulva	0.613±0.063	—	—	1.892±0.094	—
Spicule length	—	0.040±0.009	—	—	—
Body length/Body width or Egg length/Egg width	20.50±2.86	19.09±3.27	34.02±3.18	72.51±4.15	1.91±0.24
Body length/Esophageal length	7.93±0.92	6.35±0.84	2.28±0.29	3.77±0.28	—
Body length/Tail length	11.48±1.79	9.55±1.97	8.13±0.77	68.24±8.42	—
Body length/Anterior tip to vulva	1.98±0.08	—	—	1.54±0.05	—
Body length/Spicule length	—	21.20±4.87	—	—	—

Table 4. Measurements (in mm) of various developmental stages of *Strongyloides* from a Japanese weasel

	Rhabditiform female	Rhabditiform male	Filariform larva	Parasitic female	Embryonated egg
Body length or Egg length	1.179±0.144	1.012±0.088	0.593±0.013	3.127±0.290	0.063±0.004
Body width or Egg width	0.064±0.009	0.052±0.008	0.016±0.001	0.039±0.003	0.031±0.002
Esophageal length	0.169±0.021	0.131±0.009	0.262±0.011	0.840±0.139	—
Tail length	0.099±0.006	0.089±0.006	0.071±0.004	0.044±0.005	—
Anterior tip to vulva	0.601±0.081	—	—	2.037±0.221	—
Spicule length	—	0.044±0.006	—	—	—
Body length/Body width or Egg length/Egg width	18.63±2.37	19.70±2.50	36.90±3.07	81.53±12.18	2.06±0.18
Body length/Esophageal length	7.02±0.79	7.72±0.73	2.25±0.07	3.82±0.68	—
Body length/Tail length	11.96±1.55	11.45±0.95	8.34±0.49	71.86±13.45	—
Body length/Anterior tip to vulva	1.97±0.05	—	—	1.54±0.07	—
Body length/Spicule length	—	23.37±2.95	—	—	—

Table 5. Experimental infection of a dog and domestic cats with *Strongyloides* species from raccoon dogs and a Japanese weasel

Animals infected	Origin of the parasite	Prepatent period	Form of parasite excreted into feces
Dog	Raccoon dog	11	Embryonated egg
Domestic cat	Raccoon dog	9	Embryonated egg
Domestic cat	Japanese weasel	10	Embryonated egg

of worms of each developmental stage, the form of parasite passed in the feces of hosts, and susceptibility of dogs and domestic cats [4, 6, 9–11, 19]; but it clearly differed from the other species of the genus reported from Canidae, Felidae, and Mustelidae as *S. erschowi*, *S. fülleborni*, *S. lutrae*, *S. papillosus*, *S. putorii*, *S. ramsomi*, *S. stercoralis*, *S. tumefaciens*, and *S. vulpis* in one or more of the following features as body length, the proportion of esophageal length to body length, and the morphology of ovary, tail and tail tip of parasitic females, the form passed in the feces of hosts, and habitat in hosts. *S. mustelorum* [3] and *S. martis* [18] have been also reported from Mustelidae, the latter of which was supposed synonymous with the

former by Little (1966) [14]. These two species agree with *S. planiceps* in body length and the proportion of esophageal to body length, but differ in body width, which is smaller in *planiceps* than in *mustelorum* and *martis*. Accordingly, we identified the present species as *S. planiceps* Rogers, 1943.

S. planiceps were reported from a rusty tiger cat in Malaya [19], dogs [1, 6, 9, 10], domestic cats [4, 5, 11], and a raccoon dog [11] in Japan. And further, the *Strongyloides* species from a dog, domestic cats, and a red fox in Hokkaido, Japan is probably *S. planiceps* [15–17]. The present investigation clarified that *S. planiceps* infested raccoon dogs and Japanese weasels in high incidence rate, so this species infects not only Canidae and

Felidae but also Mustelidae.

Kamiya and Ishigaki (1972) [12] reported *Strongyloides* sp. from a Japanese weasel in Hokkaido, Japan. Although the species was not identified, it clearly differs from *S. planiceps* in body length. Kamiya and Ohbayashi (1975) [13] further reported two species of *Strongyloides* from red foxes in Hokkaido, one of which resembles *S. planiceps* in body size. In addition, Arizono *et al.* (1977) [2] obtained *Strongyloides* sp., of which morphological description is not present, from raccoon dogs and Japanese weasels in Kyoto Prefecture. The *Strongyloides* spp. reported by Kamiya and Ohbayashi (1975) [13] and Arizono *et al.* (1977) [2] may include *S. planiceps*.

Raccoon dogs were revealed to be infected with *S. planiceps* in a high incidence rate in the present investigation. The high incidence rate is thought to be caused by a specific habit of the raccoon dog that raccoon dogs in an area defecate at definite sites called "latrines" [21, 22]. The infective larvae of *Strongyloides* infect hosts mainly through the skin, so the parasite will be easily transmitted among raccoon dogs at "latrines".

Incidence rate of *S. planiceps* does not appear so high in dogs and domestic cats in Japan from the investigations in Kanagawa Prefecture [5, 6,] and Hokkaido [16, 17]. But wild carnivores, especially raccoon dogs, are highly infected with the nematode and play an important role as reservoir hosts.

In new residential areas parasites have many opportunities to be transmitted between domestic and wild animals. The canine heartworm, *Dirofilaria immitis*, infects wild animals as the raccoon dog at the much lower rate than in the dog [8]. In this case the dog is thought to be a reservoir host and the raccoon dog may play a role in spreading the parasitic disease. In the case of *S. planiceps*, on the other hand, the raccoon dog will be a reservoir, and dogs and domestic cats that come in direct or indirect contact with the

wild animal may spread the distribution of the parasite.

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要 約

数種の野生食肉類にみられた猫糞線虫 *Strongyloides planiceps*: 深瀬 徹・茅根土郎・板垣 博 (麻布大学獣医学部寄生虫学教室) ——1982年10月から1983年12月までの期間に神奈川県産のタヌキ 40 頭, イタチ 5 頭, ハクビシン 3 頭, および新潟県産のテン 2 頭について, *Strongyloides* 属糞線虫の検索を行い, 一部の材料については, 犬, 猫への感染実験を実施した。タヌキ 26 頭, イタチ 2 頭の小腸からは *Strongyloides* 属の寄生世代雌虫が得られた。寄生虫体数は, タヌキで 3–127 隻, イタチで 2–12 隻であった。これらの虫体の形態的特徴は, 体長約 3 mm, 捻転走行する卵巣, 肛門位から急に細くなる尾部, 鈍な尾端などであった。また, 犬, 猫への実験感染における prepatent period は 9–11 日で, 宿主糞便中に幼虫形成卵として排出されることが確認された。寄生世代雌虫, 自由生活世代の各発育期虫体・虫卵の形態学, ならびに prepatent period および宿主糞便中の発育形態などから, 今回得られた *Strongyloides* 属糞線虫は猫糞線虫 *Strongyloides planiceps* Rogers, 1943 と同定され, タヌキなどの野生食肉類を保虫宿主として広く蔓延しているものと推察された。