

The Life Cycle of *Streptopharagus pigmentatus* (Nematoda,
Spiruroidea) from the Japanese Monkey¹⁾

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A spiruroid nematode, *Streptopharagus pigmentatus* (LINSTOW, 1897), occurs in the stomach and small intestine of the Old World monkeys, *Macaca*, *Papio*, *Cercopithecus*, *Colobus*, *Erythrocebus* and *Hylobates* (YAMAGUTI, 1961; YAMASHITA, 1963). It is very common in the Japanese monkey, *Macaca fuscata fuscata*, that is, the fecal examination showed the following infection rate: 80.0% (24/30; TANAKA and NIGI, 1964), 84.0% (105/125; KAGEI and HASEGAWA, 1974), 90.0% and 76.7% (45/50 in A troop and 23/30 in B troop; HORII, 1975, unpublished data) at Takasakiyama, Ôita Prefecture; 94.5% (69/73; MATSUBAYASHI, 1973, unpublished data) at Kôshima, Miyazaki Prefecture; 64.7% (22/34; HORII, 1975, unpublished data) at Toimisaki, Miyazaki Prefecture; 72.1% (88/122; MACHIDA and SANÔ, 1974) at Arashiyama, Kyoto Prefecture; 0% (0/81; NIGI *et al.*, 1975) at Shiga, Nagano Prefecture.

However, the life cycle of *S. pigmentatus* is not clarified, and the source of monkey infection remains unknown. To solve this problem, the following examinations

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were carried out: 1) Re-identification of adult *S. pigmentatus* from the monkey at Kôshima. Kôshima is an islet 3 km around and harbours about 100 individuals of the wild Japanese monkey. 2) Detection of larvae from coprophagous beetles at Kôshima. The beetles are presumed to play a part of intermediate host of *S. pigmentatus* on the analogy to those of related nematodes. 3) Experimental infection of a monkey with larvae and identification of the adult worms obtained.

Consequently, a monkey was orally infected with the larvae. An autopsy was performed 69 days later and preadults of *S. pigmentatus* were recovered from the small intestine. The result indicates that the coprophagous beetles serve as intermediate hosts of the nematode.

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Materials and Methods

1) Adult worms from the Japanese monkey, *Macaca fuscata fuscata*:— Some adult worms were obtained by the postmortem examination of a monkey named Sasa (7-IX-1973), others were excreted with monkey feces (12-X-1973) at Kôshima. The worms were preserved in 5% formalin and cleared in Gater's solution.

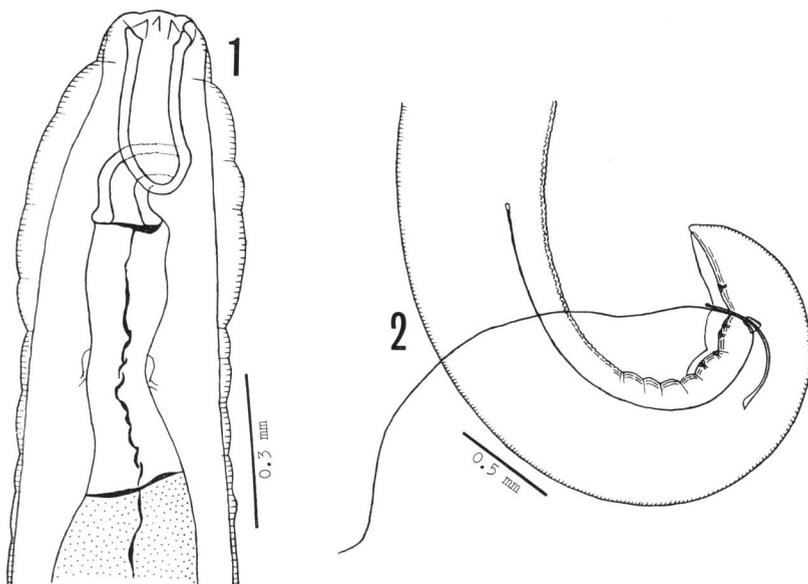
2) Larval worms from coprophagous beetles:— Four species of beetles, *Geotrupes laevistriatus*, *Onthophagus atripennis*, *O. ater* and *Aphodius (Paremadus) mizo*, which crowded on feces of monkeys were collected at Kôshima. Dissection of the insects was performed in 0.65% saline solution and showed the larvae encysting in the hemocoel of three species of beetles except for *A. mizo*. Some larvae were stored in 5% formalin for observation.

3) Experimental infection of a monkey with larvae from the beetles:— A crab-eating monkey, *Macaca fascicularis*, 2.5 years old and 2.1 kg in weight, which had been reared under worm-free conditions in the National Institute of Health, was orally infected with 400 encysted infective larvae mixed with honey. Monkey feces were examined for *Streptopharagus* eggs by the formalin-ether (MGL) method at 7-day intervals beginning 7 days after infection. The results were negative consistently for 63 days. On autopsy 69 days later, two preadult worms were recovered from the central part of the small intestine. The worms were fixed in hot 70% ethanol and cleared in glycerin-ethanol solution for observation.

Results

1) Morphology of adult worms from the Japanese monkey (Figs. 1-2):— Mouth hexagonal, with four submedian cephalic papillae and two lateral amphids.

Cervical alae present. Vestibule cylindrical, muscular, forming a half turn of a spiral just behind its middle. Esophagus divided into two portions; the anterior short and muscular, the posterior long and glandular. Nerve ring at mid-level of muscular esophagus. Cervical papillae asymmetrical; anterior one near junction of vestibule and muscular esophagus, posterior one some distance behind nerve ring. Cuticle finely striated transversely.



Figs. 1-2. Adult *Streptopharagus pigmentatus* from the wild Japanese monkey. — 1. The anterior end of a female. — 2. The posterior end of a male.

Male. Body 30.8–34.5 mm long and 0.75–0.94 mm wide. Vestibule 0.29–0.35 mm long. Muscular and glandular esophagus 0.30–0.45 mm and 6.4–7.3 mm long, respectively. Nerve ring and two cervical papillae about 0.60, 0.30 and 0.65 mm from head end, respectively. Five pairs of anal papillae pedunculate; of these four pairs are preanal, one pair postanal. Spicules unequal, dissimilar; right spicule short, round-pointed, 0.70–0.80 mm long, left spicule slender, sharp-pointed, 4.52–5.40 mm long. Gubernaculum broad, 0.071–0.082 mm long. Tail 0.40–0.47 mm long.

Female. Body 46.5–56.5 mm long and 1.20–1.33 mm wide. Vestibule 0.30–0.37 mm long. Muscular and glandular esophagus 0.35–0.51 mm and 7.6–8.9 mm long, respectively. Nerve ring and two cervical papillae about 0.60–0.70 mm, 0.40 and 0.65–0.80 mm from head end, respectively. Vulva opening 9.3–11.2 mm from head end, and divided body length in ratio of 1: 3.57–4.46. Tail 0.59–0.75 mm long. Eggs elliptical, thick-shelled, embryonated, 0.037–0.040 × 0.020–0.023 mm.

2) Larval worms from coprophagous beetles (Figs. 3–10):— Encysted larvae

were found free in the hemocoel of three species of the beetles, *Geotrupes laevistriatus*, *Onthophagus atripennis* and *O. ater*. For the infection rate and the number of larvae found, refer to *Annual Rept. of Primate Res. Inst., Kyoto Univ.*, vol. 6, p. 47.

Cyst is spherical, 0.75–1.25 mm in diameter, containing one coiled larva or occasionally two or three larvae. Several cysts sometimes stick to one another like a bunch of grapes.

Infective larva has transversely striated cuticle. Mouth with four submedian cephalic papillae and two lateral amphids. Vestibule subcylindrical. Esophagus slender, divided into two portions; the anterior short and muscular, the posterior long and glandular. Nerve ring at mid-level of muscular esophagus. Excretory pore just behind nerve ring. Sexes can be differentiated. Rectum short, surrounded by three rectal glands. Tail end bearing irregularly arranged minute spines.

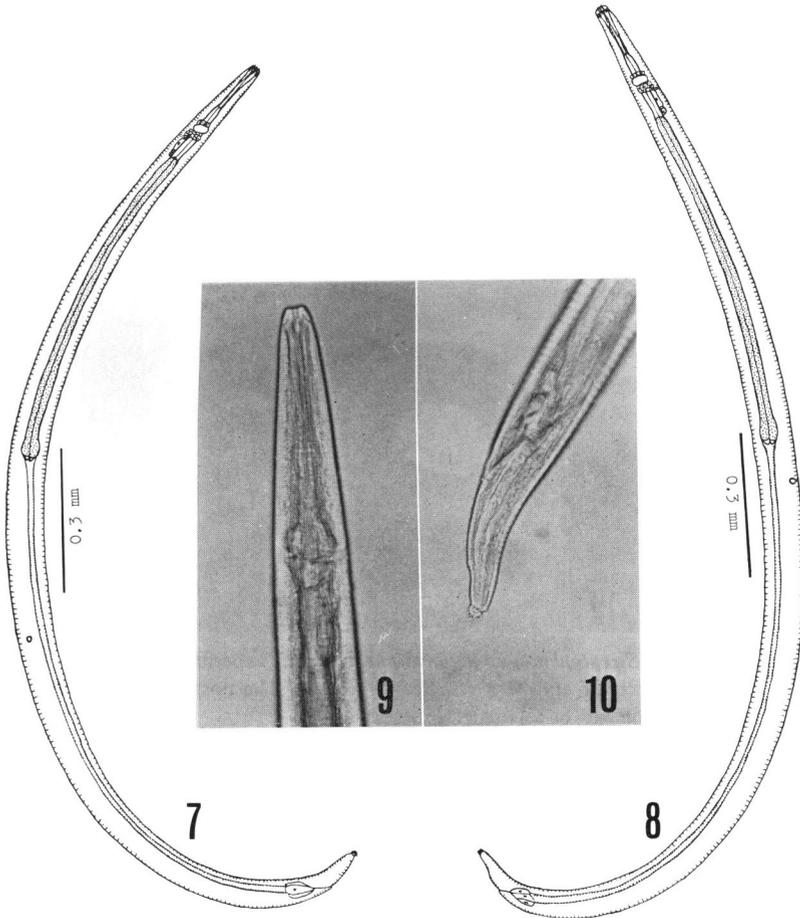
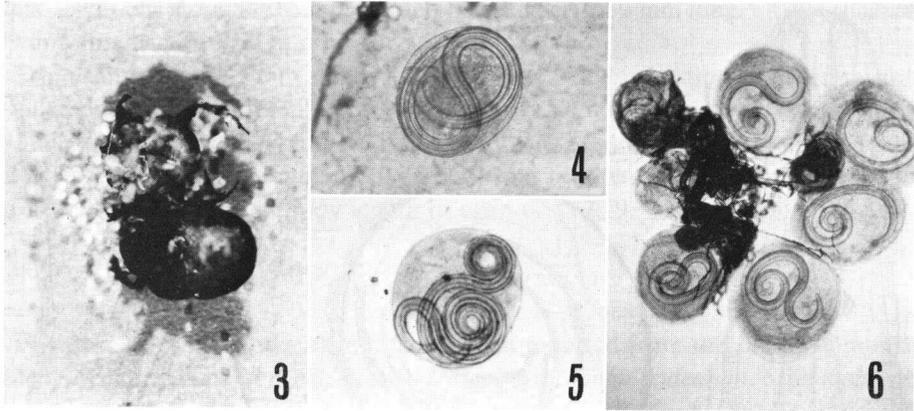
Male. Body a little smaller than female, 2.20–2.45 mm long and 0.070–0.085 mm wide. Vestibule 0.088–0.103 mm long. Muscular and glandular esophagus 0.121–0.139 mm and 0.65–0.75 mm long, respectively. Nerve ring and excretory pore 0.149–0.168 mm and 0.160–0.206 mm from head end, respectively. Genital primordium oval, 0.013–0.015 × 0.010–0.013 mm, situated at 1.23–1.47 mm from head end, some distance behind posterior end of esophagus, ventrally between body wall and intestine. Tail 0.084–0.093 mm long.

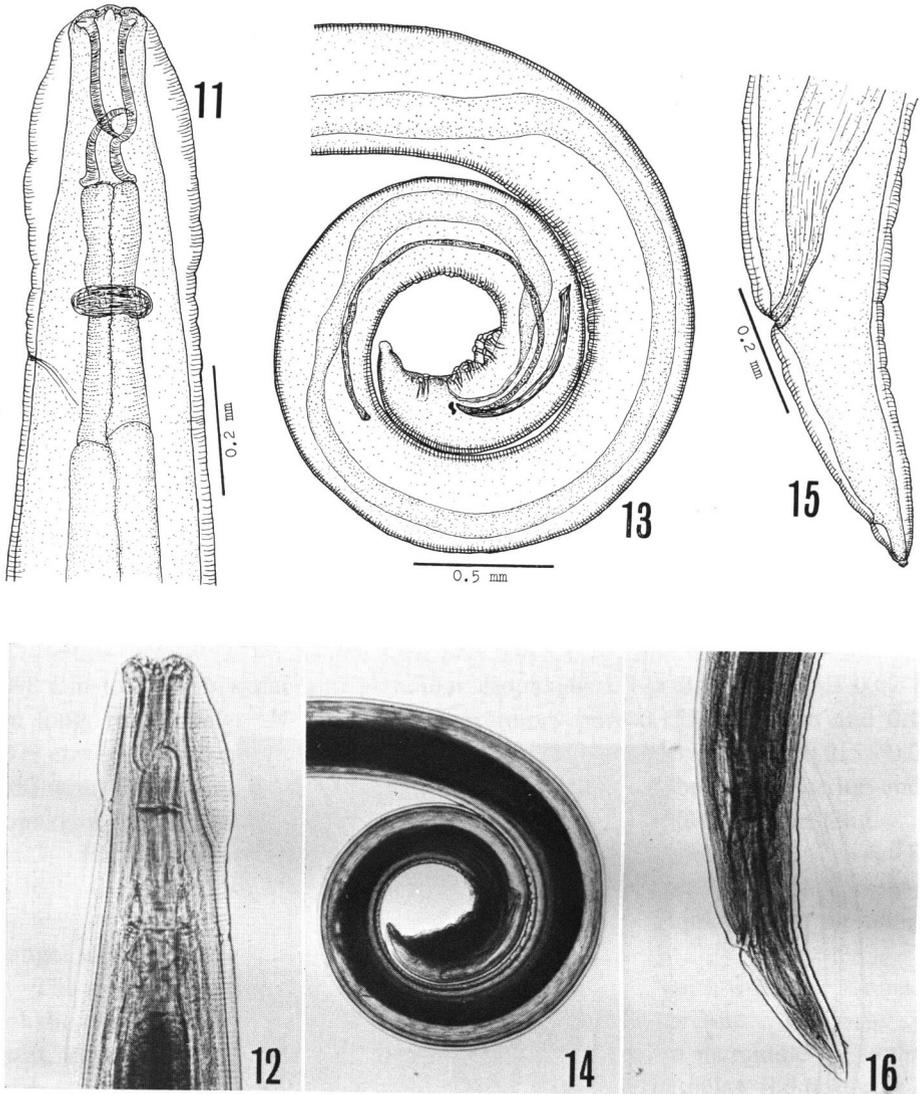
Female. Body 2.37–2.52 mm long and 0.075–0.101 mm wide. Vestibule 0.090–0.098 mm long. Muscular and glandular esophagus 0.126–0.152 mm and 0.67–0.81 mm long, respectively. Nerve ring and excretory pore 0.155–0.173 mm and 0.188–0.209 mm from head end, respectively. Genital primordium oval, 0.012–0.015 × 0.010–0.013 mm, situated at 0.98–1.17 mm from head end, just behind posterior end of esophagus, attached to ventral side of body wall. Tail 0.080–0.101 mm long.

3) Preadult worms from a monkey experimentally infected with larvae (Figs. 11–16):— On autopsy 69 days after infection, two preadult worms, one male and one female, were recovered from the small intestine of the monkey. No pathological changes were observed.

The worms have transverse striations on the cuticle. Mouth with four submedian cephalic papillae and two lateral amphids. Cervical alae present. Vestibule cylindrical, muscular, forming a half turn of a spiral just behind its middle. Esophagus slender, divided into two portions; the anterior short and muscular, the posterior long and glandular. Nerve ring at mid-level of muscular esophagus. Excretory pore just behind nerve ring. Cervical papillae asymmetrical; left one near junction of vestibule and muscular esophagus, right one just behind nerve ring. Tail bluntly pointed. No spermatozoa or eggs are observed.

Figs. 3–10. *Streptopharagus pigmentatus* from a coprophagous beetle; cysts (3–6) and infective larvae (7–10). — 3. Cysts from hemocoel of the coprophagous beetle, *Onthophagus ater*. — 4. A cyst containing one larva. — 5. A cyst containing two larvae. — 6. Several cysts stuck to one another. — 7. Male larva. — 8. Female larva. — 9. The anterior end of a larva. — 10. The posterior end of a larva.





Figs. 11-16. Preadult *Streptopharagus pigmentatus* from an experimentally infected monkey.
 — 11-12. The anterior end of a female. — 13-14. The posterior end of a male. —
 15-16. The posterior end of a female.

Male. Body 26.7 mm long and 0.51 mm wide. Vestibule 0.25 mm long. Muscular and glandular esophagus 0.35 mm and 6.0 mm long, respectively. Nerve ring and excretory pore 0.41 mm and 0.52 mm from head end, respectively. Cervical papillae asymmetrical, 0.25 mm and 0.46 mm from head end. Five pairs of anal papillae pedunculate; of these, four pairs are preanal, one pair postanal. Spicules

unequal, right one stout, 0.71 mm long, left one slender, 1.89 mm long. Gubernaculum 0.049 mm long. Tail 0.35 mm long.

Female. Body 26.5 mm long and 0.49 mm wide. Vestibule 0.26 mm long. Muscular and glandular esophagus 0.36 mm and 5.0 mm long, respectively. Nerve ring and excretory pore 0.44 mm and 0.54 mm from head end, respectively. Cervical papillae asymmetrical, 0.25 mm and 0.46 mm from head end. Vulva opening 7.0 mm from head end, and divided body length in ratio of 1: 2.79. Tail 0.42 mm long.

Discussion

Five species of helminths have hitherto been reported from the Japanese monkey, *Macaca fuscata fuscata*: *Bertiella studeri*, *Oesophagostomum sculeatum*, *Streptopharagus pigmentatus*, *Strongyloides fuelleborni* and *Trichuris trichiura* (YAMASHITA, 1963; HAYAMA and NIGI, 1963; etc.).

YAMAGUTI (1935) described the morphology of *S. pigmentatus* based on the material from the small intestine of the Japanese monkey in Nara Prefecture. Comparing his description with the present Kôshima specimen, there is little difference between the two, except somewhat larger gubernaculum in the present specimen (Table 1). The difference in gubernaculum may be only a variation, because ORTLEPP

Table 1. Dimensions of adult *Streptopharagus pigmentatus* from Japanese monkey (mm).

Author Locality	YAMAGUTI (1935) Nara Prefecture		Present authors Kôshima, Miyazaki Prefecture	
	Male	Female	Male	Female
Body length	26.45-31.55	34-57	30.8-34.5	46.5-56.5
Body width	0.5-0.7	0.65-1.4	0.75-0.94	1.20-1.33
Vestibule	0.23-0.31	0.25-0.37	0.29-0.35	0.30-0.37
Muscular esophagus	0.3-0.48	0.4-0.5	0.30-0.45	0.35-0.51
Glandular esophagus	4.95-6.5	5.9-7.5	6.4-7.3	7.6-8.9
Tail	0.46-0.53	0.5-0.63	0.40-0.47	0.59-0.75
Spicule (right)	0.65-0.82		0.70-0.80	
(left)	5.4-5.7		4.52-5.40	
Gubernaculum	0.060-0.066		0.071-0.082	
Vulva (from head end)		9.7 (1: 3.67)		9.3-11.2 (1: 3.57-4.46)
Eggs		0.036-0.044 × 0.018-0.021		0.037-0.040 × 0.020-0.023

(1925) mentioned it 0.070-0.078 mm long, very similar in measured value to ours. Besides, only one species of spiruroid nematode, *S. pigmentatus*, occurs in the Japanese monkey, *Macaca fuscata fuscata*. The adult worms which we found in the Japanese monkey were considered to be *S. pigmentatus* for the reasons mentioned above.

SANDGROUND (1933) stated that the gradation of spicule size is continuous from *S. armatus* through *S. intermedius* to *S. pigmentatus*. These species are not at all

distinguishable from each other by other morphological features. Consequently, both *S. armatus* and *S. intermedius* will have to be relegated to the synonyms of *S. pigmentatus* on the basis of the taxonomical rules of priority, unless new characters are discovered to support the distinction between them.

Though the intermediate host is revealed to be coprophagous beetles in other related spiruroid nematodes like *Ascarops strongylina*, *Gongylonema pulchrum*, etc., it is unknown in *S. pigmentatus*. Therefore, we expected that the larvae found in the coprophagous beetles in this study might be those of *S. pigmentatus*.

The larva has transverse striations on the cuticle. The vestibule is subcylindrical. The slender esophagus consists of a short muscular and a long glandular portion. Sexes can be distinguished, owing to the position of genital primordium. These features resemble one another among the spiruroid infective larvae such as *Ascarops strongylina*, *Gongylonema dupuisi*, *G. pulchrum*, *Physaloptera hispida* and *Physocephalus sexalatus* (ALICATA, 1935; WATANABE, 1949; SCHELL, 1952; QUENTIN, 1969; ZAJÍČEK and PÁV, 1972; etc.). In respect to irregularly arranged minute spines at the tail end, the present larva is also similar to that of *Physocephalus sexalatus* of ALICATA (1935) and *Ascarops strongylina* of ZAJÍČEK and PÁV (1972). These facts strongly suggest that the infective larvae are identical with those of *S. pigmentatus*.

The eggs may be excreted with the feces of the monkey and ingested by coprophagous beetles such as *Geotrupes laevistriatus*, *Onthophagus atripennis* and *O. ater*, in which the larvae develop.

The experiment showed that the coprophagous beetles may serve as an intermediate host of *S. pigmentatus*. However, there is no evidence that the wild monkey acquires the infection directly upon ingesting infected beetles in natural environment.

Two preadult worms were recovered on autopsy 69 days after infection from a crab-eating monkey ingested with the infective larvae. The structure of the worm, such as cervical alae, vestibule, esophagus, male anal papillae, etc., closely resembles that of the adult worm.

We may conclude from the facts described above, that the nematodes concerned in this investigation are *Streptopharagus pigmentatus*.

The development in the intermediate and definitive hosts remains still unknown. Further studies are necessary to draw a conclusion on the whole life cycle of this species.

The period for sexual maturation in the final host varies in different spiruroid nematodes. For example, *Streptopharagus kutassi* requires 38–40 days in *Meriones* and the white rat (GAFUROV, 1968), whereas *Physaloptera hispida* takes 73–90 days in cotton rats (SCHELL, 1952). *S. pigmentatus* seems to require a relatively long developmental period in the monkey.

Summary

A spiruroid nematode obtained from the Japanese monkey at Kôshima, Miyazaki

Prefecture, was identical with *Streptopharagus pigmentatus*. Meanwhile, unknown nematode larvae were found at the same place in the coprophagous beetles, *Geotrupes laevistriatus*, *Onthophagus atripennis* and *O. ater*. A crab-eating monkey was experimentally infected with the larvae. On autopsy 69 days later, preadults were recovered from the small intestine, and proved to be those of *S. pigmentatus*. This result showed that the coprophagous beetles serve as an intermediate host of the nematode.

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