

***Cardiostrongylus sika* n. gen., n. sp. (Molineoidea; Dictyocaulidae)**
from the Heart Muscle of Sika Deer in Japan

TSUKASA SAKAMOTO¹⁾ AND RAMIRO MALGOR²⁾

¹⁾Department of Parasitology, School of Veterinary Medicine,
Faculty of Agriculture, Iwate University, Morioka 020, Japan.

²⁾Institute of Hygiene, Faculty of Medicine, University of Republic, Montevideo, Uruguay.
(Accepted January 6, 1996)

Abstract

Cardiostrongylus sika n. gen., n. sp. (Nematoda: Molineoidea: Dictyocaulidae) was described based on six specimens from the heart muscle of sika deer, *Cervus nippon centralis*, captured at the foot of Mt. Goyo, Iwate Prefecture, Japan. The new genus resembles *Dictyocaulus* that is parasitic in the bronchi of artiodactyls, but is readily distinguished by having a cephalic swelling of cuticle in the anterior end, and by the site in host.

Key words: dictyocaulid nematode; *Cardiostrongylus sika* n. gen., n. sp.; sika deer; *Cervus nippon centralis*; heart muscle; morphology.

Introduction

As far as we know, there has been no report in regard to adult nematode of the order Strongylida parasitizing in the heart muscle of cervids. Recently, adult Strongylids were recovered from the heart muscle of sika deer captured at the foot of Mt. Goyo, Iwate Prefecture, Japan. In this paper a new nematode belonging to the family Dictyocaulidae is described.

Materials and Methods

Three sika deer captured at the foot of Mt. Goyo, Iwate Prefecture, Japan, were autopsied on June 15, 1993. All the organs were macroscopically examined. Especially the heart and lungs were carefully examined under the binocular microscope too. All of the organs from the deer were fixed in 10% formalin solution and processed for routine histologic preparations.

The contents of the alimentary tract dissected

were washed out with saline solution into a 100-mesh sieve. The residues on the sieve were carefully examined under the binocular microscope. Nematodes collected were fixed in 5% formalin solution and cleared in lacto-phenol solution for microscopy. Hand cut cross sections and *en face* preparations were made for examination of longitudinal cuticular ridges and papillae around mouth.

In the description, measurements in micrometer (μm) unless otherwise stated, are given for the holotype male and the allotype female, followed in parentheses by the range for paratype males and females. The specimens are deposited in the parasitological collection of the Museum of Veterinary Medicine, Faculty of Agriculture, Iwate University, Morioka, Japan.

Results

Considerable number of a nematode belonging to the family Dictyocaulidae (*Trichostrongylina*: Molineoidea) were found in the heart muscle of one of the deer (Fig. 1). Three males and 3 females of the worms were collected from it. A number of *Dicrocoelium* sp., and small number of *Trichostrongylus* sp. were found in the liver and small intestine, respectively. Considerable number of *Sarcocystis*

Correspondence: Tsukasa Sakamoto

坂本 司¹⁾, Malgor Ramiro²⁾ (岩手大学農学部獣医学科家畜寄生虫病学教室, ²⁾ウルグアイ共和国大学医学部衛生研究所)

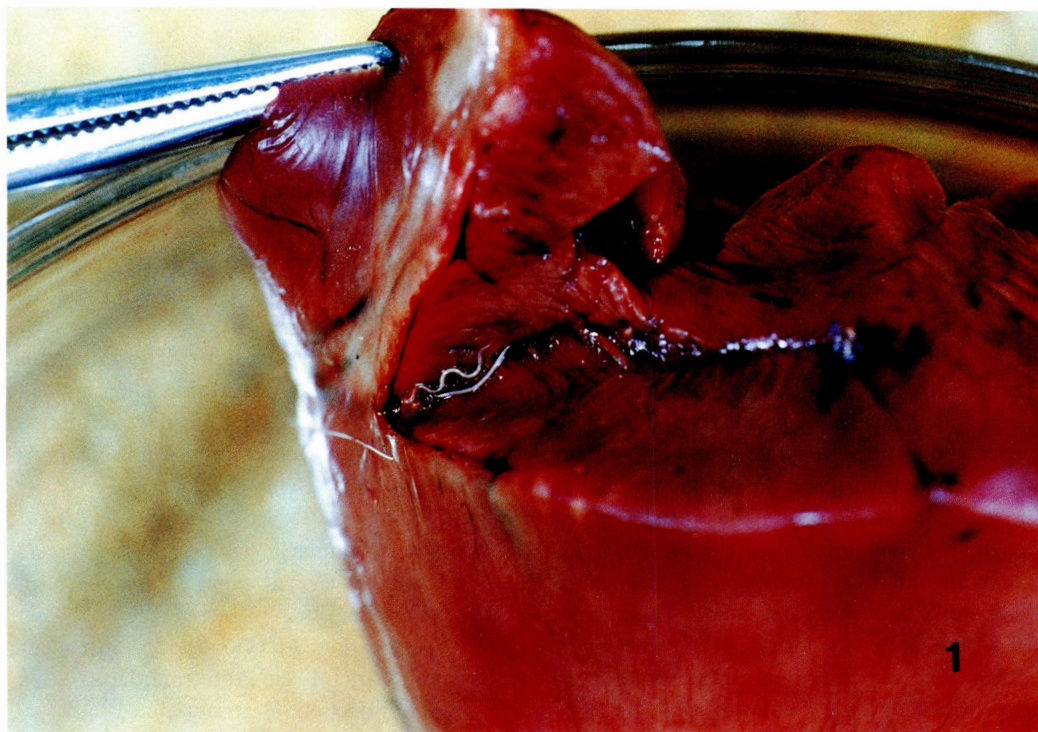


Fig. 1 *Cardiostrongylus sikaе* in the heart muscle of sika deer.

sp. were seen in the skeletal muscle and esophagus. But no worm was found in the other organs including the lungs.

Description

Cardiostrongylus n. gen.

Diagnosis: Trichostrongylina: Molineoidea: Dicyocaulidae.

Slender delicate nematode with cephalic vesicle. Cuticle delicate; with numerous longitudinal ridges of even height. Mouth without lips; oral opening circular to oval; buccal capsule wall not so prominent; without single tooth in a reduced esophageal funnel. Bursa without separate lobes; dorsal ray completely separated; complex spicules short, stout; gubernaculum present; opposed ovjectors; vulva opening near the middle of the body; tapering female tail without a terminal spine.

Type and only species: *Cardiostrongylus sikaе*

n. sp.

Cardiostrongylus sikaе n. gen., n. sp.

General: Long, filiform, whitish nematodes. Cuticle with numerous cuticular ridges, the intervals of ridges 2.5–3.5 in middle part of body. Body attenuated toward both extremities. Terminal mouth opening oval, without lips and with six papillae symmetrically arranged around it (Figs. 4, 12). Buccal cavity shallow and buccal capsule wall slightly thickened in its basal part (Figs. 3, 4, 12, 13). The body is covered with thin, fragile cuticular membrane. The cuticular membrane forms a cephalic vesicle, 126–148 in diameter, at anterior extremity (Figs. 2, 4, 9, 10). The delicate membrane is frequently torn or peeled (Figs. 12, 13, 20). Esophagus cylindrical, slightly widening posteriorly. Excretory gland well-developed. Excretory pore opens on the ventral surface behind the level of nerve ring (Figs. 2, 10).

Male (holotype and 2 paratype): Body length 17.7 (14.5–18.1) mm, maximal width 232 (228–232) in middle part of body, 190 (190–210) wide just anterior to bursa, head 80.2 (80.2–80.3) wide; nerve ring, excretory pore and cervical papillae 245 (211–253), 297 (297–301) and 338 (321–347) from anterior end, respectively. Esophagus 891 (808–922) long, 105 (93–106) in maximal width. Caudal part bent ventrally. Bursa almost round, 184 (170–190) in diameter. Bursal rays except externodorsal ray and anterolateral ray reaching bursal margin, ending with a small protuberance. Dorsal rays completely separate, each having a tiny lateral branch in middle part, ending with three tiny protuberances (Figs. 6, 15). Externodorsal ray separate, shorter than both adjacent rays, with a knoblike thickening at tip. Mediolateral and posterolateral rays fused over entire length, without bifurcation at tip (Figs. 5, 6, 15, 17). Anterolateral ray arising separately from base, with a knoblike thickening at distal tip. Ventral rays joined at base and divided for most of their length. Anteroventral ray slightly thinner and shorter than lateroventral. Spicules equal, thick, brown, proriferous structure, 168 (168–178) long, 35 (27–40) wide. Gubernaculum lighter than spicules, curved, 38 (37–40) in length.

Female (allotype and 2 paratype): Body length 15.4 (14.3–23.4) mm, width 85 (76–97) at head, 274 (230–349) at vulval region, 192 (183–211) at level of end of esophagus, and 78 (75–80) at level of anus. Esophagus 820 (790–920) long, 110 (85–112) in maximal width. Nerve ring, excretory pore and cervical papillae 230 (210–304), 270 (262–329) and 317 (300–368) from anterior end, respectively. Vulva in form of a transverse slit, lips of vulva slightly raised above body surface, and 8.1 (7.8–12.2) mm from anterior end, ratio to body length 52.1 (50.6–56.3)% (Figs. 8, 18). Vagina muscular and short. Ovipositor well-developed, combined length of op-

posed vestibles 570 (456–836), combined length of anterior sphincter and infundibulum 94 (55–128) and combined length of posterior sphincter and infundibulum 81 (72–85). Amphidelphic uteri containing numerous embryonated eggs, reversed at the end of excretory gland and at 350 (335–350) from caudal end. Anus 283 (235–330) from caudal end. Tail tapers sharply posterior to anus, phasmids 91 (84–126) from caudal end. Eggs in vestibule elliptical, with larva, 59–80×34–44 mm in size (Figs. 9, 21).

Histological observations: The inflammatory reaction around the parasites invading in the heart muscle was very slight. Considerable number of sarcocysts were found in the muscle layer of esophagus and skeletal muscle.

Taxonomic summary

Type host: *Cervus nippon centralis* Kishida, 1935 (Cervidae).

Type location: Mt. Goyo (1351 m elevation), Sanriku District, Iwate Prefecture, Japan.

Site of infection: Heart muscle

Date of collection: 15 June, 1993.

Etymology: The genus name is derived from the site of infection, cardiac muscle. The species name is derived from the generic name of type host, *Cervus* (=Sika).

Specimens deposited: MVMIU Pn-6907 (holotype and allotype); MVMIU Pn-6908 (2 male and 2 female paratypes).

Discussion

Five genera belonging to the family Protostrongylidae, i.e., *Protostrongylus*, *Orthostrongylus*, *Varestrongylus*, *Elaphostrongylus* and *Parelaphostrongylus*, have been hitherto reported from various cervids (Anderson, 1992, Dougherty and Goble,

Plate I.

Fig. 2 Anterior end of female, lateral view.

Fig. 3 Anterior end of female, lateral view.

Fig. 4 Anterior end of male, en face view.

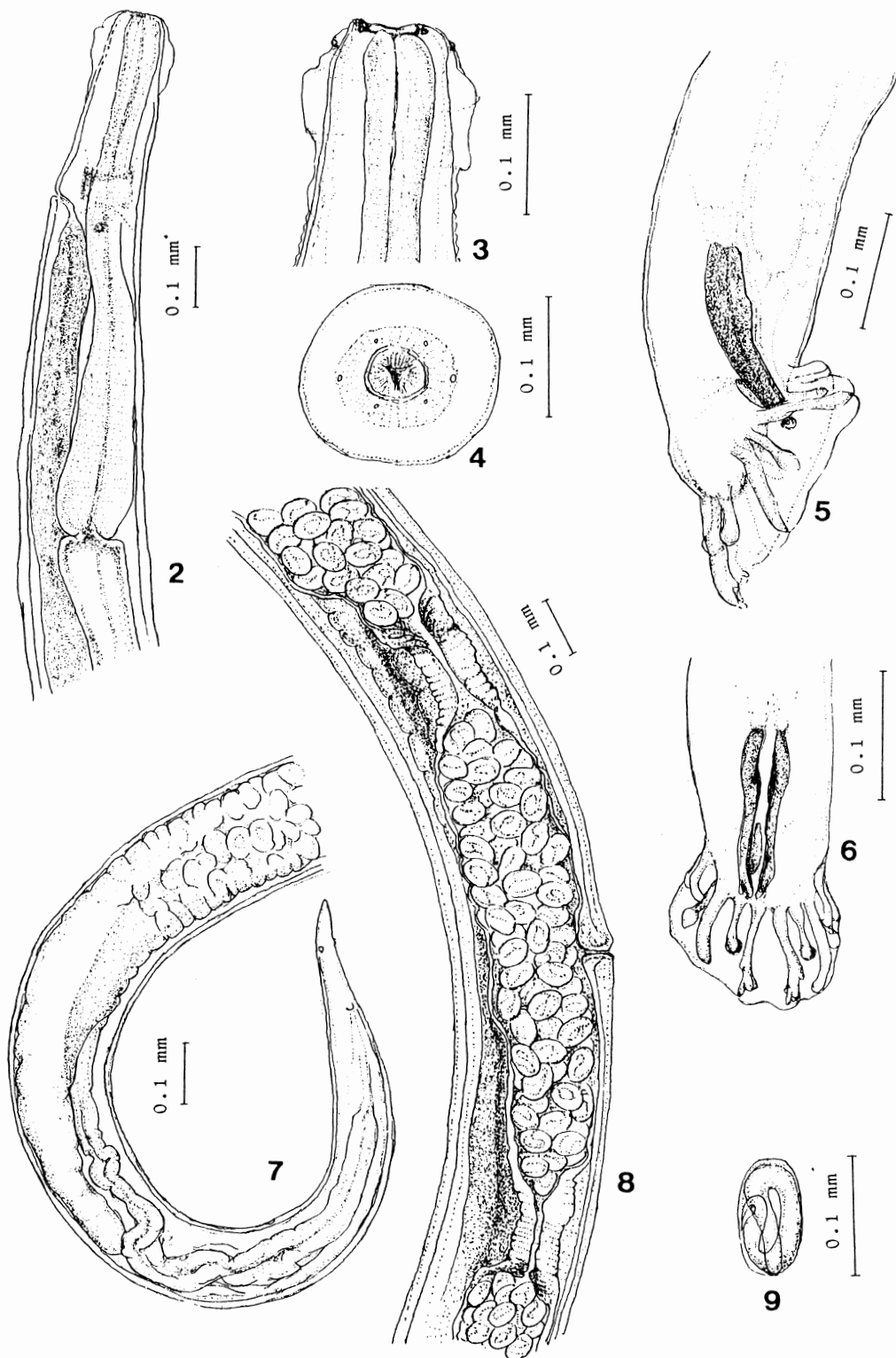
Fig. 5 Posterior end of male, lateral view.

Fig. 6 Posterior end of male, ventral view.

Fig. 7 Posterior end of female, lateral view.

Fig. 8 Vulval region of female, lateral view.

Fig. 9 Embryonated egg.



1946; Lankaster and Northcott, 1979; Preswood, 1972; Skrjabin *et al.*, 1952). The former three genera were found from the lungs and bronchi, but the latter two are parasitic nematodes associated with the central nervous system and thoracic musculature. Also, five species, *Dictyocaulus filaria*, *D. noerteri*, *D. eckerti*, *D. hadwenii* and *D. viviparus* belonging to the genus *Dictyocaulus* have been reported from the bronchi of cervids (Boev *et al.*, 1963; Chapin, 1925; Dougherty, 1964; Durette-Desset *et al.* (1988), Skrjabin and Schul'ts, 1934). Skrjabin *et al.* (1952) synonymized *D. hadwenii* with *D. eckerti*. Also, Durette-Desset *et al.* (1988) stated that *D. eckerti* must be synonymized with *D. noerteri*. As far as the authors know, however, there has been no report concerning a nematode found from the heart muscle of the cervids.

Gibbons (1984) and Gibbons and Khalil (1988) using light and scanning electron microscopes demonstrated the presence of longitudinal cuticular ridges in all the species belonging to the genus *Dictyocaulus*. In the present observation of the hand cut cross section, numerous longitudinal cuticular ridges of even height were recognized on body surface of the new nematode too. Gibbons and Khalil (1988) described that *D. filaria* and *D. arnfieldi* have buccal capsule with wall not so prominent, but *D. viviparus*, *D. eckerti* and *D. africanus* buccal capsule with thick wall. Durette-Desset *et al.* (1988) described that *D. noerteri* and *D. viviparus* are different in shape and thickness of the buccal ring corresponding to the thickened buccal wall. The buccal capsule with slightly thickened wall was observed in the new nematode. The new nematode is similar to the genus *Dictyocaulus* in the location of vulva and in the shape of spicules, but differs from it in the presence of cephalic vesicle, in the inflation of vulval cuticle, in the habitat, and in the absence of

two labia around its mouth. The new parasite differ from *Otostrongylus* in the double dorsal rays (Skrjabin *et al.*, 1952, 1954). Also, the new nematode is further differentiated from the above genera belonging to the family Protostrongylidae in the location of vulva and in the number of dorsal ray (Chabaud, 1965; Dougherty, 1951; Skrjabin *et al.*, 1952, 1954). Also, the new nematode is further differentiated from the above genera belonging to the family Protostrongylidae in the location of vulva and in the number of dorsal ray (Chabaud, 1965; Dougherty, 1951; Skrjabin *et al.*, 1952). From the findings as mentioned above, the new nematode is named *Cardiostrongylus sikae* n. gen., n. sp. Skrjabin established within the family Metastrongylidae in 1933, he elevated the subfamily Dictyocaulinae to the rank of family, and he transferred it from the superfamily Metastrongyloidea to the superfamily Trichostrongyloidea (Skrjabin *et al.*, 1952, 1954). Skrjabin's classification-system has been fundamentally succeeded by some investigators at present (Anderson 1978, 1992; Boev *et al.*, 1963). Thereafter the phylogenetic investigations of the Trichostrongylina have been carried out by Durette-Desset and Chabaud (1977, 1981) and Durette-Desset (1983, 1985). Durette-Desset (1994) reported that the Trichostrongylina is classified into three principal superfamilies, the Trichostrongyloides, the Molineoidea and the Heligmosomoidea, and that the Dictyocaulidae belongs to the Molineoidea. Based on the morphological characters consisting of cephalic structure, reproductive organs and longitudinal cuticular ridges, *Cardiostrongylus* is considered to belong to the family Dictyocaulidae of the superfamily Molineoidea. In principle, the suborder Metastrongylina is heteroxenous, but the Trichostrongylina is monoxenous (Anderson, 1992, Skrjabin *et al.*, 1954). Therefore, it is considered

Fig. 10 Anterior end of male, lateral view. $\times 140$.

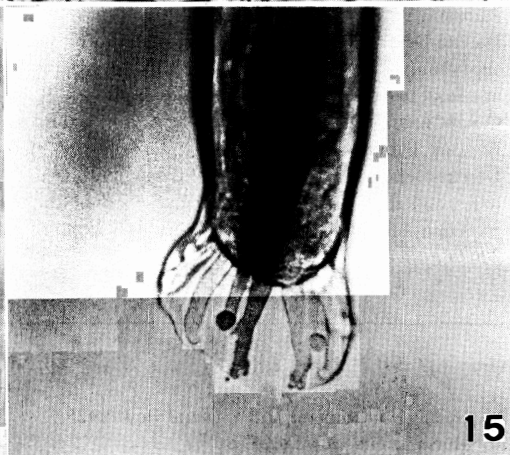
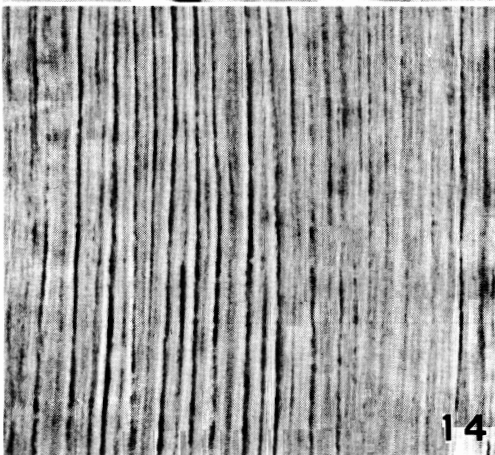
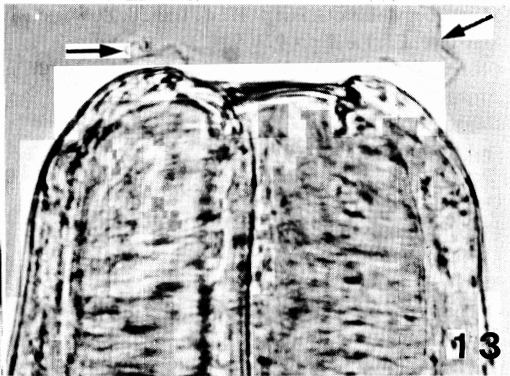
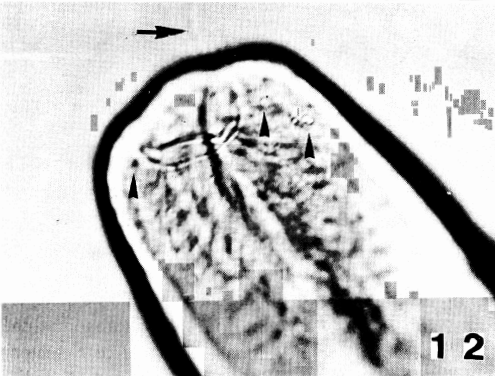
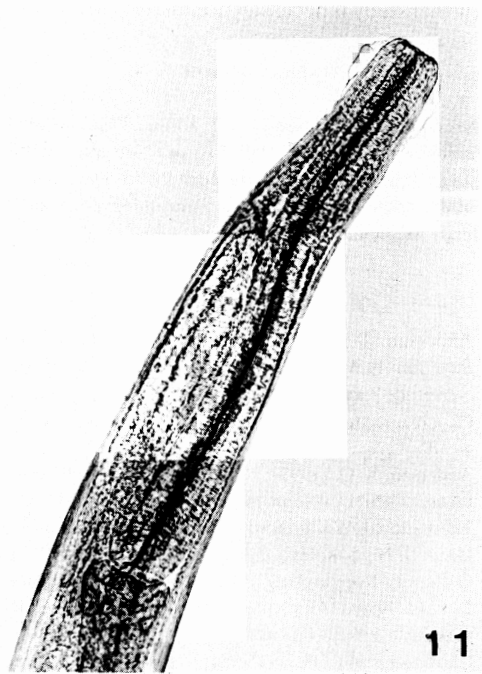
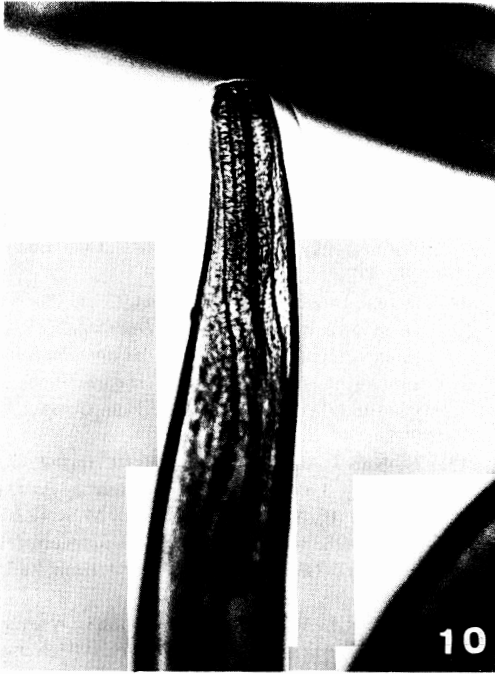
Fig. 11 Anterior end of female, lateral view. $\times 110$.

Fig. 12 Anterior end of male, oblique frontal view. $\times 425$. Arrow heads point papillae. Allow points outer cuticular membrane desquamated.

Fig. 13 Anterior end of female, lateral view. $\times 850$. Arrows point outer cuticular membrane desquamated.

Fig. 14 Longitudinal cuticular ridges in the middle part of body of female. $\times 850$.

Fig. 15 Posterior end of male, ventral view. $\times 110$.



that further study is necessary to clarify its life cycle.

Acknowledgment

The authors wish to thank Prof. T. Kifune, Department of Parasitology, School of Medicine, Fukuoka University for his kind advice. They are also acknowledge the technical assistance of the staffs of Department of Parasitology, School of Veterinary Medicine, Iwate University.

References

- 1) Anderson, R. C. (1978): Keys to Genera of the Superfamily Metastrongyloidea. In CIH Keys to the Nematode Parasites of Vertebrates. No. 5. Anderson, R. C., Chabaud, A. G. and Willmott, S. ed., Commonwealth Agriculture Bureaux, Farnham Royal, 40pp.
- 2) Anderson, R. C. (1992): Nematode Parasites of Vertebrates. Their Development and Transmission, C A B International, Wallingford, 587pp.
- 3) Boev, S. N., Sokolova, I. B. and Panin, V. Y. (1963): Gel'minty Kopytnykh Zhivotnykh Kazakhstana Tom. 2. Izdatelystvo Akademiya Nauk Kazakhskoj SSR, Alma-Ata 536pp (In Russian).
- 4) Chabaud, A. G. (1965): Superfamille des Metastrongyloidea. Grassé, P. P. ed., Traité de Zoologie, Masson et C^{ie}, Paris, pp. 921–931.
- 5) Chapin, E. A. (1925): New Nematodes from North American Mammals. J. Agric. Res., 30, 677–681.
- 6) Dougherty, E. C. (1951): A further revision in the classification of the family Metastrongylidae Leiper (Phylum Nematoda). Parasitology, 41, 91–96.
- 7) Dougherty, E. C. (1964): A brief survey of the genus *Dictyocaulus* Railliet and Henry 1907 (Nematoda: Trichostrongylidae). Proc. Helminthol. Soc. Wash., 13, 49–54.
- 8) Dougherty, E. C. and Goble, F. C. (1946): The genus *Protostrongylus* Kamenskii, 1905 (Nematoda: Metastrongylidae), and its relatives: preliminary note. J. Parasitol., 32, 7–16.
- 9) Durette-Desset, M. C. (1983): Keys to genera of the superfamily Trichostrongyloidea. In CIH keys to the nematode parasites of Vertebrates. No. 10. Anderson, R. C. and Chabaud, A. G. ed., Commonwealth Agricultural Bureaux, Farnham Royal, 86 pp.
- 10) Durette-Desset, M. C. (1985): Trichostrongyloid nematodes and their Vertebrate: Reconstruction of the phylogeny of a parasitic group. Adv. Parasitol., 24, 239–306.
- 11) Durette-Desset, M. C., Beveridge, I. and Spratt, D. M. (1994): The origins and evolutionary expansion of the Strongylida (Nematoda). Int. J. Parasitol., 24, 1139–1165.
- 12) Durette-Desset, M. C. and Chabaud, A. G. (1977): Essai de classification des nematodes Trichostrongyloides. Ann. Parasitol. Hum. Comp., 52, 539–558.
- 13) Durette-Desset, M. C. and Chabaud, A. G. (1981): Nouvel essai de classification des Nematodes Trichostrongyloidea. Ann. Parasitol. Hum. Comp., 56, 297–312.
- 14) Durette-Desset, M. C., Hugonnet, L. and Chabaud, A. G. (1988): Redescription de *Dictyocaulus noerneri* Railliet et Henry, 1907, parasite de *Capreolus capreolus* en europe. Comparaison avec *D. viviparus* (Bloch, 1782), parasite du betail. Ann. Parasitol. Hum. Comp., 63, 285–295.
- 15) Gibbons, L. M. (1984): The genus *Dictyocaulus* Railliet & Henry, 1907 (Nematoda: Trichostrongyloidea). In: Tumbay, E., Yasarol, S. and Ozel, M. A. (Eds). Abstracts of the 4th European Multicolloquium of Parasitology (EMOP IV), 14–19 Oct. 1984, Izmir, Turkey, p. 17.
- 16) Gibbons, L. M. and Khalil, L. F. (1988): A revision of genus *Dictyocaulus* Railliet & Henry, 1907 (Nematoda: Trichostrongyloidea) with the description of *D. africanus* n. sp. from African artidactylids. J. Afr. Zool., 102, 151–175.
- 17) Lankester, M. W. and Northcott, T. H. (1979): *Elaphostrongylus cervi* Cameron 1931 (Nematoda: Metastrongyloidea) in caribou (*Rangifer tarandus*) of Newfoundland. Can. J. Zool., 57, 1384–1389.
- 18) Prestwood, A. K. (1972): *Parelaphostrongylus andersoni* n. sp. (Metastrongyloidea: Protostrongylidae) from the musculature of white-tailed deer (*Odocoileus virginianus*). J. Parasitol., 58, 897–902.
- 19) Skrjabin, K. I., Shikhobalova, N. P. and Schul'ts, R. S. (1954): Dictyocaulidae, Heligmosomatidae and Ollulanidae of Animals. Essential of Nematodology. Vol. 4, Skrjabin, K. I. ed., Izdatel'stvo Akademii Nauk SSSR, Moskva, 316pp. (translated from Russian).
- 20) Skrjabin, K. I., Shikhobalova, N. P., Schul'ts, R. S., Popova, T. I., Boev, S. N. and Delyamure, S. L. (1952): Gel'mintologicheskaya laboratoriya, Strongylyay, Izdatel'stvo Akademii Nauk SSSR, Moskva.
- 21) Skrjabin, K. I. and Schul'ts, R. S. (1934): Les helminthiases pulmonaires des animaux. Bull. Off. Intern. Epizooty., 10, 1–50.

Plate II.

Fig. 16 Spicules with gubernaculum, lateral view. ×425.

Fig. 17 Bursa, lateral view. ×425.

Figs. 18, 19 Vulvar region of female, lateral view. ×110.

Fig. 20 Posterior end of female, lateral view. ×110.

Fig. 21 Eggs from vestibule. ×850.

