Title	A NEW NEMATODE, YATINEMA JAPONICUM GEN. ET SP. N. (HELIGMONELLIDAE : NEMATODA), FROM VOLES, EOTHENOMYS SMITHI THOMAS AND E. NIIGATAE (ANDERSON)
Author(s)	ASAKAWA, Mitsuhiko; OHBAYASHI, Masashi
Citation	Japanese Journal of Veterinary Research, 34(1), 7-23
Issue Date	1986-01-31
DOI	https://doi.org/10.14943/jjvr.34.1.7
Doc URL	https://hdl.handle.net/2115/4641
Type	departmental bulletin paper
File Information	KJ00002374357.pdf

Jpn. J. Vet. Res., **34**, 7–23 (1986)

A NEW NEMATODE, *YATINEMA JAPONICUM* GEN. ET SP. N. (HELIGMONELLIDAE : NEMATODA), FROM VOLES, *EOTHENOMYS SMITHI* THOMAS AND *E. NIIGATAE* (ANDERSON)

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(Received for publication November 22, 1985)

A new heligmonellid, *Yatinema japonicum* gen. et sp. n., from the small intestine of voles, *Eothenomys smithi* Thomas and *E. niigatae* (Anderson), was described. The hosts are found only in Japan. The similarity of the synlophe of *Y. japonicum* to Heligmonellinae suggested that it is inappropriate to place the nematode under the simplex dendrogram as proposed by Durette-Desset (1971), in which *Orientostrongylus* is the progenitor. Since *E. smithi* and *E. niigatae* are parasitized by a common parasite, *Yatinema japonicum*, we postulated that these two hosts are phylogenetically closely related.

Key words : *Yatinema japonicum* gen. et sp. n., *Eothenomys*, phylogenetic system, Heligmonellidae, Japan

Introduction

The phylogenetic system of parasites which occur specifically in small mammals (mainly, orders Rodentia and Insectivora) with regard to the host phylogenetic system in the Far East, including Southeast Asia and Japan, has been studied (Ohbayashi, 1979 ; Ohbayashi et al., 1979, 1980, 1983 ; Ow Yang et al., 1984 ; Asakawa et al., 1983, 1984 a, b, 1985 a, b ; Yokoyama et al., 1985).

Two hypotheses concerning the coevolution of parasites and their host have been put forward. One by Eichler (1940), which defines coevolution sensu stricto, states that the "host-parasite relationship evolved from their respective progenitors". The other by Durette-Desset (1971) states that "in the evolutionary process of the host speciation and/or zoogeographic migration, a mammalian host may be accidentally invaded by parasite which is specific to another phylogenically distinct host, and this

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will result in this parasite adapting itself to the new host and becoming isolated by population genetics to such an extent that it becomes varied morphologically to form a new taxon". Examples of such parasites are *Heligmosomoides* spp. in Muridae (Asakawa et al., 1985 b) and the present *Yatinema japonicum* gen. et sp. n.

To confirm to these two hypotheses, the parasites selected for our study were the "steno-host-range" type. For this investigation we defined "steno-host-range" as one parasite (at genus, species or subspecies level) which specifically parasitized one host (at genus or species level) in the Holocene Epoch, viz, the Present Age, such as the trichostrongylids, metastrongylids, oxyurids, the genus *Capillaria* etc.

The hosts were selected for observation on the basis of 1) the ease of collection, 2) the absence of zoogeographic movement due to human activity, and 3) advancements made in phylogenetic studies of the host itself.

In this paper we describe a trichostrongylid, *Yatinema japonicum* gen. et sp. n. (Heligmonellidae ; Nematoda), which parasitized the voles of Japanese endemic species, *Eothenomys smithi* Thomas and *E. niigatae* (Anderson), and also reviewed the trichostrongylid's phylogenetic position.

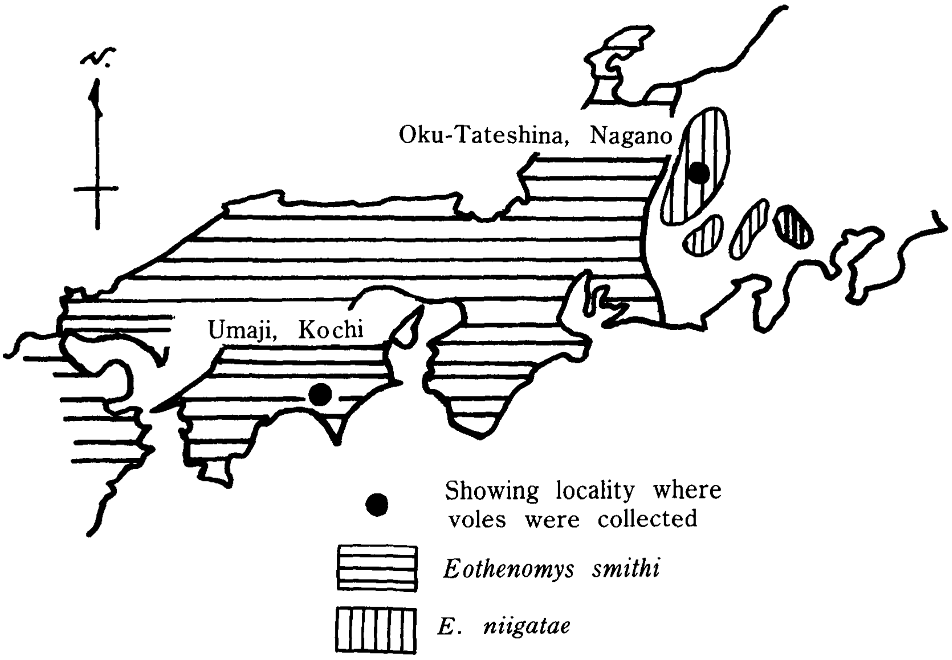

Figure 1 *Map showing localities where hosts were collected and geographical distribution of hosts*

MATERIALS AND METHODS

Trichostrongylid nematodes were obtained from the small intestine of Japanese voles, four *Eothenomys smithi* THOMAS collected in March, 1984, at Umaji Village, Kochi Prefecture (33° 30' N, 134° 5' E), and six *E. niigatae* (ANDERSON) collected in April, 1985, at Oku-Tateshina, Nagano Prefecture (36° 10' N, 138° 20' E), Japan (fig. 1).

The nematodes were fixed in 5% formalin, and for microscopic examination were cleared in lacto-phenol solution. Some of the specimens were embedded in paraffin, and the sections made were stained with haematoxylin-eosin for observing the ridges of the synlophe.

RESULTS

Yatinema gen. n.

Diagnosis

Heligmonellidae DURETTE-DESSET et CHABAUD, 1977,
Heligmonellinae DURETTE-DESSET, 1983

Small nematode. Number of ridges of synlophe usually less than 20. Inclination of axis of ridges from sagittal axis 37–64°. Bursa asymmetrical, right lobe larger than left; arrangement of rays type 2–2–1; postero-lateral rays short; dorsal lobe not separated. Spicule tips fused, curved like "L". Gubernaculum well-developed, boat-shaped. Tail of female lacking spine. Intestinal parasites of Oriental Cricetidae.

Type host: *Eothenomys smithi* THOMAS

Type species: *Yatinema japonicum* gen. et sp. n.

Remarks

The name *Yatinema* is derived from the Japanese *Yati* of "Yati-nezumi", meaning field-mouse, and *nema*.

Yatinema japonicum gen. et sp. n.

Host: Japanese voles, *Eothenomys smithi* THOMAS (Type host) and *E. niigatae* (ANDERSON) (= *Aschizomys niigatae* ANDERSON)

Habitat: small intestine

Localities: Umaji Village, Kochi Prefecture (Type locality), and Oku-Tateshina, Nagano Prefecture

Description (All measurements are in mm.)

Small nematode, body coiled and reddish when alive. Main measurements are shown in table 1. Synlophe and cervical papillae are shown in figures 3, 5–10, 12, 17–21, 29 and 32. Cuticle with continuous and longitudinal ridges (synlophe). Number of ridges and the axis inclination of orientation of ridges to the sagittal axis are shown in table 2. The maximal inclination of axis in mid-body, and the inclination

TABLE 1 *Measurement of Yatinema japonicum gen. et sp. n. (in mm.)*

NEMATODE	HOST	
	E. smithi	*E. niigatae*
Male	(N=9)	(N=10)
Cephalic vesicle		
length	0.048–0.054	0.044–0.055
width	0.019–0.038	0.028–0.032
Body		
length	2.42–3.05	1.95–3.25
width (mid-body)	0.076–0.113	0.074–0.117
Esophagus (length)	0.29–0.34	0.31–0.38
Excretory pore		
from head end	0.120–0.199	0.154–0.172
Spicules	0.452–0.549	0.395–0.483
Gubernaculum	0.035–0.051	0.037–0.048
Female	(N=5)	(N=7)
Cephalic vesicle		
length	0.046–0.055	0.043–0.055
width	0.027–0.033	0.024–0.033
Body		
length	2.29–3.24	2.29–3.28
width (at vulva)	0.083–0.094	0.088–0.106
Esophagus (length)	0.32–0.34	0.24–0.40
Excretory pore		
from head end	0.237–0.250	0.222–0.242
Nerve ring		
from head end	0.138–0.176	0.132–0.198
Tail (length)	0.048–0.064	0.022–0.046
Vulva		
from tail end	0.145–0.186	0.073–0.103
Egg	0.043–0.076 × 0.021–0.041	0.062–0.076 × 0.036–0.045

N : Number of specimens examined

TABLE 2 *Number of ridges and inclination of axis of orientation of ridges from sagittal axis in Yatinema japonicum gen. et sp.n.*

HOST	NO. OF RIDGES			INCLINATION (°)
Eothenomys smithi				
male (N=1)	15–18 1)	17 2)	16–18 3)	37–48
female (N=2)	15–16	18–21	15–18	53
E. niigatae				
male (N=3)	17–18	18	19	51–64
female (N=3)	16	17–19	12–14	46–64

N : Number of specimens examined
1) In anterior region
2) In mid-body
3) In posterior region

of axis and number of ridges decreasing anteriorly and posteriorly. Left and right ridges more developed than the adjacent ridges. Gradient in size of ridges is from left to right on the ventral side, and from right to left on the dorsal side (DURETTE-DESSET, 1983). In female, however, no such gradient in posterior region. Carene absent. Cervical papillae at level of excretory pore.

Genital organs are shown in figures 11–15, 22–26, 28 and 31. Male (one specimen from *E. smithi*) : Bursa, formula of bursal rays type 2–2–1 ; remarkably asymmetrical ; right lobe larger than left ; right ventral and lateral rays longer than those of left, externo-dorsal rays subequal, dorsal ray almost symmetric ; right lobe 0.229 wide and 0.205 long, left lobe 0.207 wide and 0.111 long ; dorsal lobe not separated. Right antero- and postero-ventral rays, right antero- and medio-laterals remarkably larger and longer than left ones. Length of rays : right antero-ventral 0.160, left one 0.136 ; right postero-ventral 0.224, left one 0.143mm ; right antero-lateral 0.192, left one 0.113 ; right medio-lateral 0.206, left one 0.130 ; postero-laterals considerably short, originated from base of medio-laterals, right 0.047 and left 0.033. Externo-dorsal and dorsal rays arising from thick common stem, right externo-dorsal diverged at 0.031 and left at 0.020 from base of stem ; length of right externo-dorsal 0.068 and left 0.059 ; length of dorsal ray 0.058 with two branches, each branch bidigitated. Prebursal papillae present. Spicules equal, yellow in color, enclosed by thin membrane ; spicule tips fused, shaped like letter "L" (figs. 11, 22 and

25) and blunt; gubernaculum well-developed and boat-shaped (figs. 11, 12, 22 and 23). Genital cone conical with a pair of minute papillae (fig. 25). Female (one specimen from *E. smithi*): Monodelphic; vestibule 0.019 and sphincter 0.047, both are completely surrounded by a muscular sheath; infundibulum bell-shaped, 0.038 long and 0.036 wide; uterine eggs in ovejector oval, 0.062–0.074 x 0.033–0.040, 4–6 cell stage.

Specimens are deposited in Department of Parasitology, Faculty of Veterinary Medicine, Hokkaido University, Japan.

DISCUSSION

The genus *Yatinema* belongs to the family Heligmonellidae DURETTE-DESSET & CHABAUD, 1977, because of the following key characteristics: 1) oblique axis of orientation of ridges, 2) female tail lacking spine, 3) bursa of type 2–2–1 (DURETTE-DESSET, 1983).

According to the inclination of axis of orientation of ridges from the sagittal axis, DURETTE-DESSET (1983) classified Heligmonellidae into four subfamilies as shown below.

1) Heligmonellinae; 0–45°, parasites of Talpidae, lagpmorphs and archaic rodents.
2) Nippostrongylinae; 45–67°, parasites of mainly "recent rodents" throughout the world and New World Cricetidae.
3) Pudicinae; 67–90°, parasites of New World Cricetidae and lagomorphs.
4) Brevistriatinae; 67–90°, parasites of Old World "archaic rodents" and Muridae.

The angle above-noted in *Yatinema* inclined 37–64°. This characteristic indicates an intermediate type between Nippostrongylinae and Heligmonellinae, however, gradient in size of ridges indicates the character of Heligmonellinae.

Among 15 genera of Nippostrongylinae and 6 genera of Heligmonellinae (DURETTE-DESSET, 1983; OW YANG et al., 1983), the asymmetrical bursa such as in *Yatinema* is known in genera of Nippostrongylinae: *Nippostrongylus* LANE, 1923 (parasites of Oriental and Australian Muridae and Oriental Dermoptera), *Heligmonina* BAYLIS, 1928 (Ethiopian Muridae), and *Stilestrongylus* FREITAS, LENT et ALMEIDA, 1937 (Neotropical Cricetidae). These genera, however, did not accord with *Yatinema*, because in *Yatinema* 1) synlophe shows character of Heligmonellinae, 2) postero-lateral rays remarkably short, 3) dorsal lobe not separated, 4) spicule tips fused, blunt and curved like letter "L", 5) gubernaculum well-developed and boat-shaped, and 6) host is Oriental Cricetidae (*Eothenomys*).

YAMAGUTI (1954) reported "*Longistriata wolgaensis* SCHULZ, 1926" from *Clethrionomys smithii* (= *Eothenomys smithi*?). Judging from the measurements, YAMAGUTI'S *L. wolgaensis* is considered as a synonym of *Yatinema japonicum*. DURETTE–DESSET (1971) created the dendrogram of Nippostrongylinae; she hypothe-

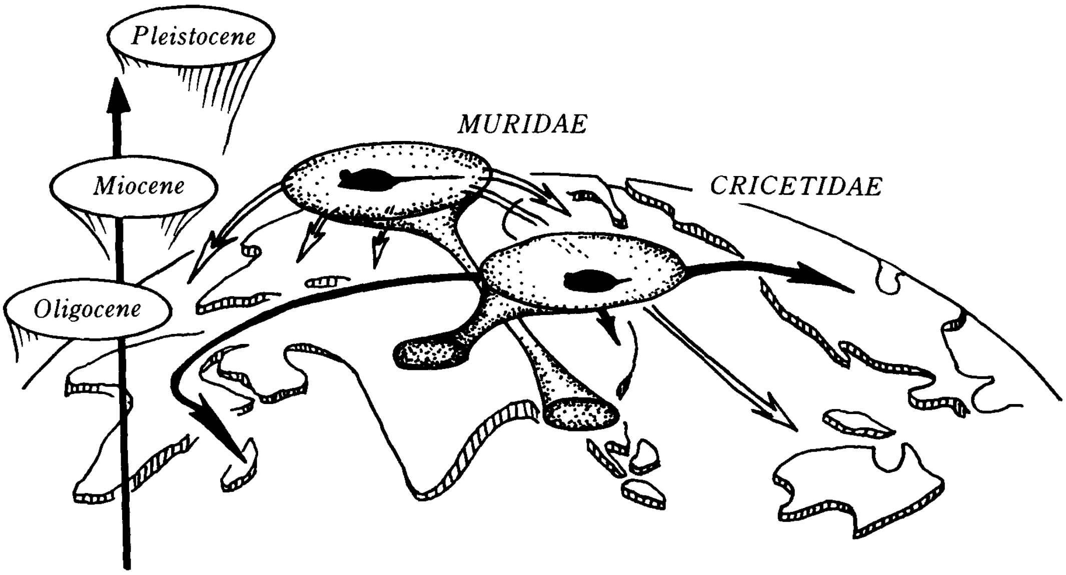

FIGURE 2 *Showing geologic epoch and zoogeographic localities of murids' and cricetids' speciation*

sized that a progenitor of the subfamily Nippostrongylinae is the genus *Orientostrongylus* DURETTE-DESSET, 1970, which originated from Heligmonellinae. She concluded that the speciation of the subfamily Nippostrongylinae occurred according to the explosive adaptive radiation of "recent rodents". There are two main groups in "recent rodents" : Muridae (Old World rats and mice) and Cricetidae (hamster, voles, lemmings, gerbils and New World rats and mice). These rodents, however, had distinct geologic epoch and zoogeographic localities (fig. 2) : Cricetidae ; central region of the Eurasian Continent in the Oligocene (3,600–2,500 x 10^4 years ago) and the Muridae ; Southeast Asia in the Miocene (2,500–1,200 x 10^4 years ago) (KURTEN, 1971 ; WALKER, 1975 ; KOBAYASHI, 1977 ; CORBET, 1978).

Therefore, we consider the placement of all nematodes of Heligmonellidae from voles of Cricetidae under the simplex dendrogram to be inappropriate. DURETTE-DESSET (1971) hypothesized that a common progenitor of Heligmonellidae from "recent rodents" was *Orientostrongylus* (parasites mainly of Muridae in the Present Age), and that it belonged to one subfamily, Nippostrongylinae DURETTE-DESSET, 1983.

Actually, the genus *Yatinema* manifests the character of the subfamily Heligmonellinae, which is best indicated by the morphological characteristics of the ridges of synlophe. And we thus concluded that *Yatinema* should not be placed under DURETTE-DESSET's dendrogram, in spite of the host, Oriental Cricetidae of "recent rodents", and its zoogeographic region.

We suggest that careful phylogenic and taxonomic consideration should also be given to some genera which are designated as belonging to Nippostrongylinae of Cricetidae ; *Carolinensis* (TRAVASSOS, 1937) ; *Hassalstrongylus* DURETTE-DESSET, 1971 ; *Stilestrongylus* FREITAS, LENT et ALMEIDA, 1937 and *Hypocristata* DURETTE-DESSET, 1971.

As to taxonomy of the Japanese cricetids, no definite conclusions have been made (MURAKAMI, 1981 ; TSUCHIYA, 1981 ; AIMI, 1981). TSUCHIYA (1981) made a taxonomic studies of the karyotypes of many Japanese mammals. On his results obtained the Japanese cricetids, *Clethrionomys* spp., *Aschizomys* spp. and *Eothenomys* spp, except for *Microtus*, they have a common chromosome number 2n = 56, morphology of these genera are similar each other, and these cricetids are closely related in phylogenic systems. AIMI (1981) classified these cricetids into two genera (*Clethrionomys*, which occurs in Hokkaido, and *Eothenomys*, which occurs throughout Japan except in Hokkaido) from the growth of the molars. We consider that because of the presence of a common species *Yatinema japonicum* from *Eothenomys smithi* THOMAS and *E. niigatae* (ANDERSON) (= *Aschizomys niigatae A.*), both hosts are closely related phylogenetically.

Trichostrongylids of *Clethrionomys* in Japan have been studied by CHABAUD et al. (1963), ISHIMOTO (1974) and ASAKAWA et al. (1983, 1984 a), and they have reported *Heligmosomum yamagutii* CHABAUD et al., 1963 (Heligmosomidae). On the other hand, nematodes of Heligmonellidae, *Mammanidula hokkaidensis* (OHBAYASHI et al., 1968) and *Heligmonoides speciosus* (KONNO, 1958) have been reported (*H. speciosus* of *Clethrionomys rufocanus bedfordiae* THOMAS is considered as an accidental parasite, since this species is a specific parasite of *Apodemus* spp. (Muridae)).

Although *Eothenomys* and *Clethrionomys* are closely related phylogenetically, the trichostrongylids found in them were different at the family level. One explanation for this is 1) the progenitor of *Eothenomys* or a primary *Eothenomys* (UDAGAWA (1974) supposed that *Eothenomys* originated in "the southern region of the Eurasian Continent" judging from the present distribution) encountered the ancestor of *Yatinema* (probably a parasite of "ancient rodents" or lagomorphs), the heligmonellid adapted to the vole and a new genus was established finally; and 2) *Clethrionomys*, which inhabited the northern region of the Old and New World, was not parasitized by Heligmonellidae.

HASEGAWA & OTSURU (1981) obtained *Heligmosomum* sp. from a vole, *Eothenomys* sp., in Niigata Prefecture, Japan. Since the number of voles is few in the present investigation, we are unable to obtain the genus *Heligmosomum*. We postulated that the Cricetidae (evolved *Clethrionomys*)- *Heligmosomum* relationship is essential, therefore, an ancestor of *Eothenomys* probably parasitized by *Heligmosomum*. We consider that some species of this genus should be reported from *Eothenomys* in a future study.

ACKNOWLEDGEMENTS

We wish to thank Dr. H. ABE, the Institute of Applied Zoology, Faculty of Agriculture, Hokkaido University, for his identification of hosts and useful advice. We are also grateful to Mr. H. TANAKA, Department of Veterinary Medicine, College of Dairying, for his kind assistance in the field.

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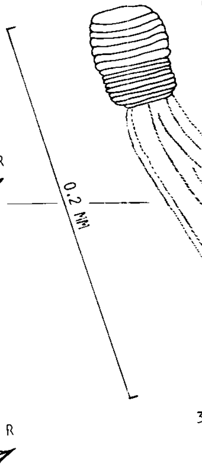
EXPLANATION OF PLATES

PLATE I *Yatinema japonicum* gen. et sp. n. from *Eothenomys smithi* THOMAS

Fig. 3	Anterior extremity of male, left-lateral view
Fig. 4	Anterior extremity of female, left-lateral view
Fig. 5	Cross section of anterior extremity of male: D, dorsal; V, ventral; L, left-lateral; R, right-lateral
Fig. 6	Cross section of mid-body of male
Fig. 7	Cross section of posterior extremity of male
Fig. 8	Cross section of anterior extremity of female
Fig. 9	Cross section of mid-body of female
Fig. 10	Cross section of posterior extremity of female
Fig. 11	Posterior extremity of male, ventral view
Fig. 12	Posterior extremity of male, ventral view
Fig. 13	Posterior extremity of male, left-lateral view
Fig. 14	Dorsal ray
Fig. 15	Posterior extremity of female, ventral view
Fig. 16	Egg



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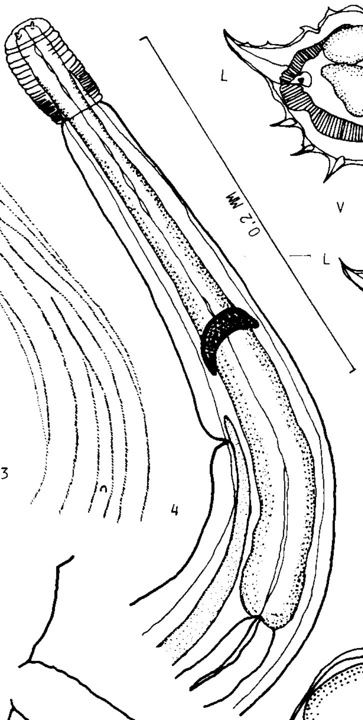

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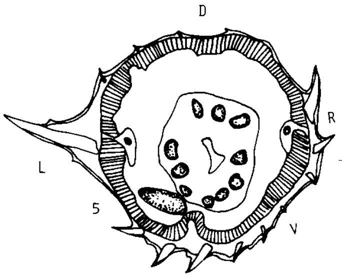

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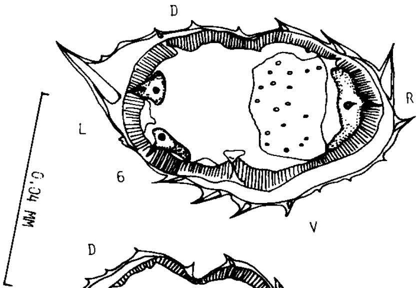

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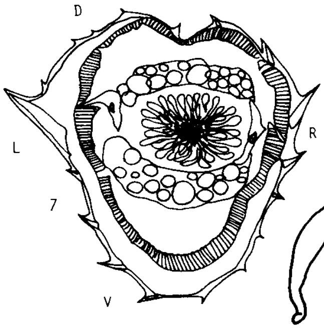

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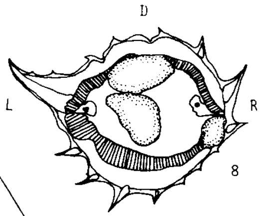

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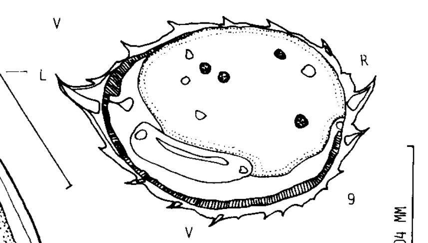

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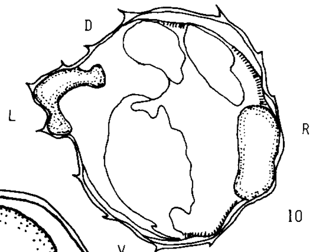

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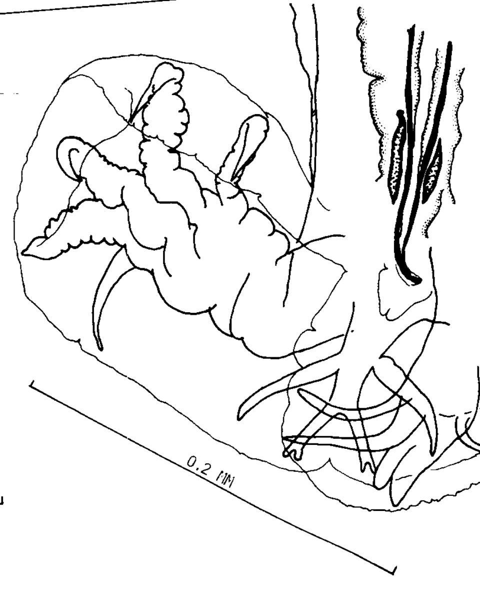

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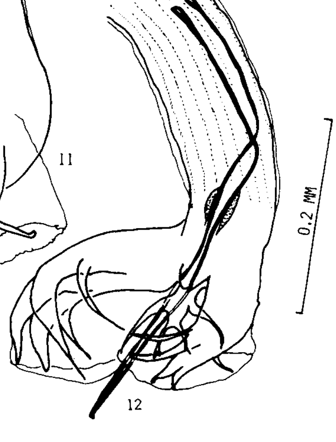

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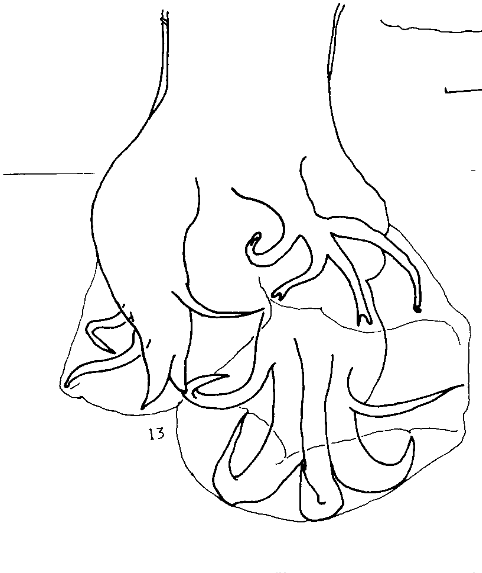

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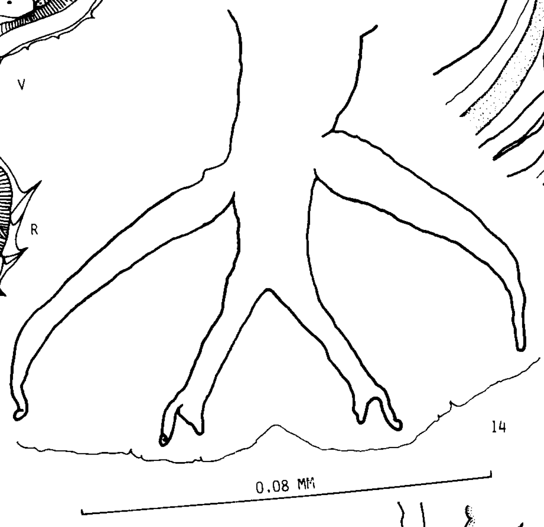

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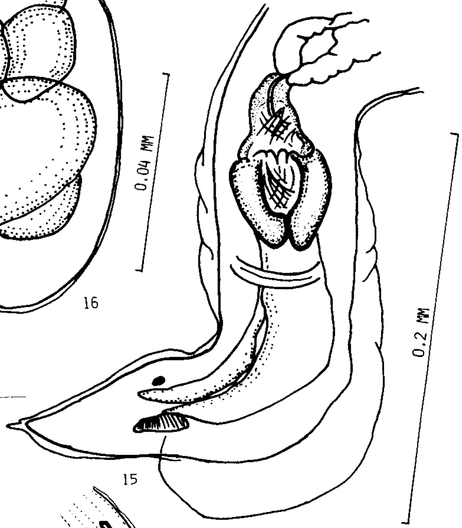

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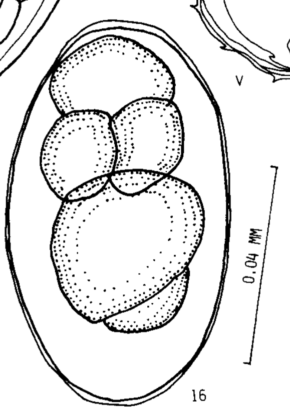

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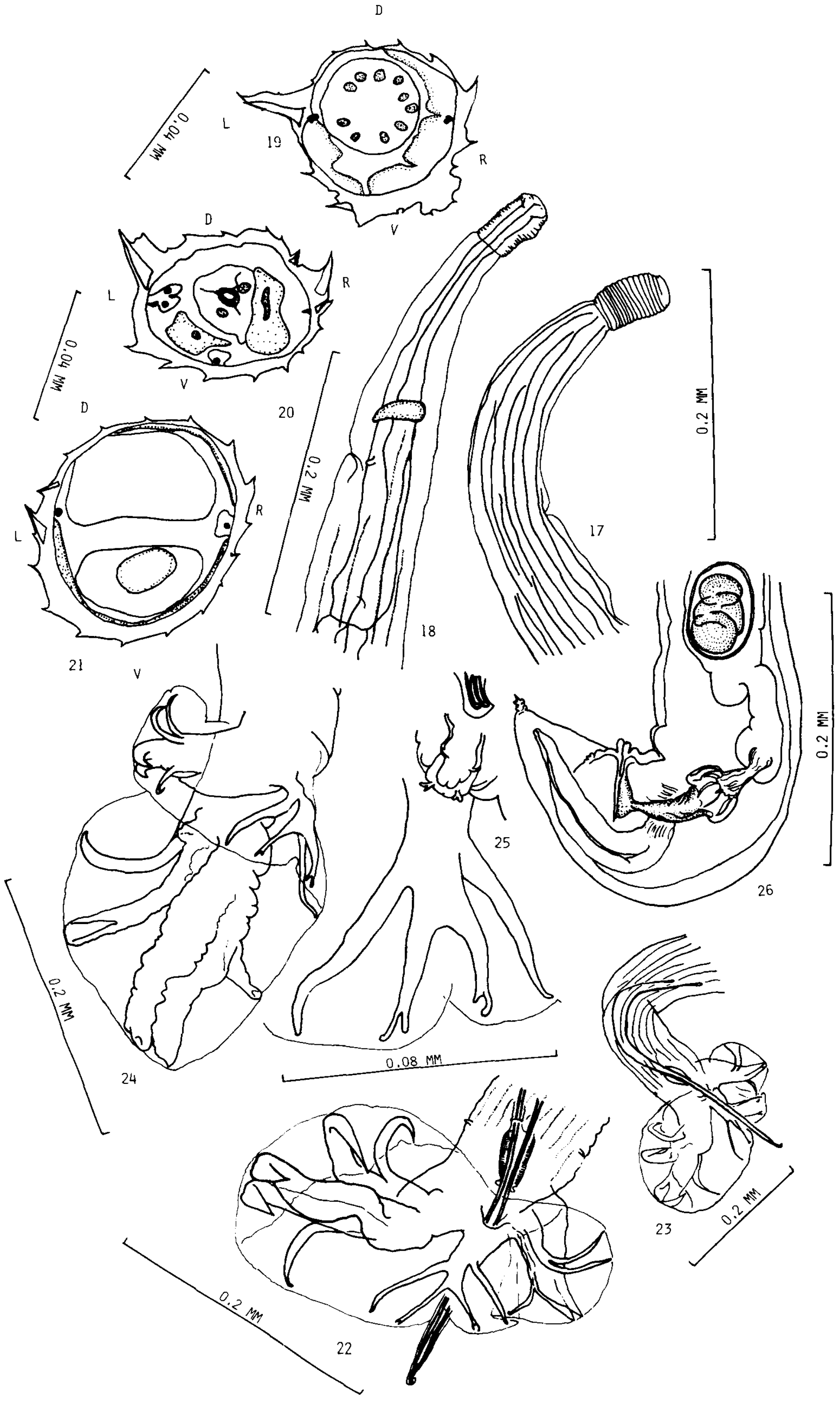
PLATE II *Yatinema japonicum* gen. et sp. n. from *Eothenomys niigatae* (ANDERSON)

Fig. 17 Anterior extremity of female, right-lateral view
Fig. 18 Anterior extremity of female, left-lateral view
Fig. 19 Cross section of anterior extremity of male
Fig. 20 Cross section of mid-body of female
Fig. 21 Cross section of posterior extremity of female
Fig. 22 Posterior extremity of male, ventral view
Fig. 23 Posterior extremity of male, ventral view
Fig. 24 Posterior extremity of male, left-lateral view
Fig. 25 Dorsal ray, genital cone and spicule tips
Fig. 26 Posterior extremity of female, left-lateral view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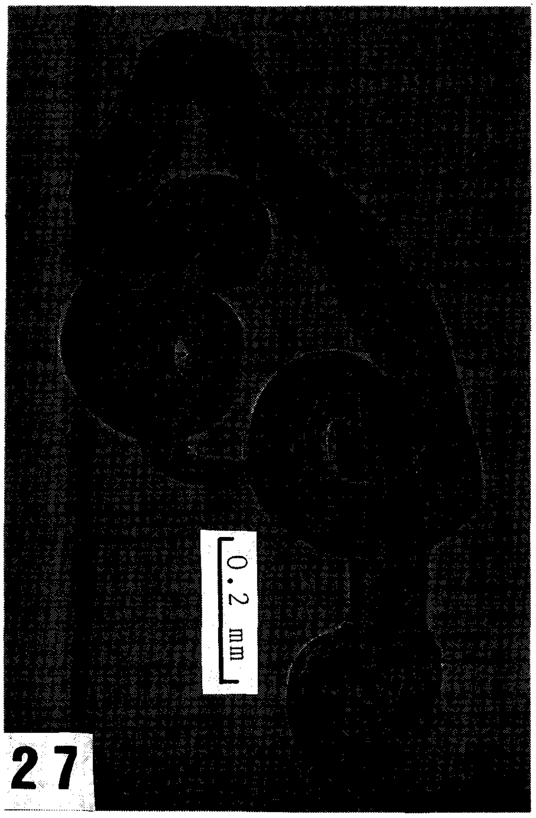
0.2 MM
17
0.2 MM
26
25
0.2 MM
24
0.08 MM
0.2 MM
23
0.2 MM
22

PLATE Ⅲ *Yatinema japonicum* gen. et sp. n.

Figs. 27–29 *Y. japonicum* gen. et sp. n. from *E. smithi*
Fig. 27 *Y. japonocum*
Fig. 28 Posterior extremity of male, ventral view
Fig. 29 Cross section of anterior extremity of female
Figs. 30–32 *Y. japonicum* from *E. niigatae*
Fig. 30 *Y. japonicum*
Fig. 31 Posterior extremity of male, left-lateral view
Fig. 32 Cross section of anterior extremity of female



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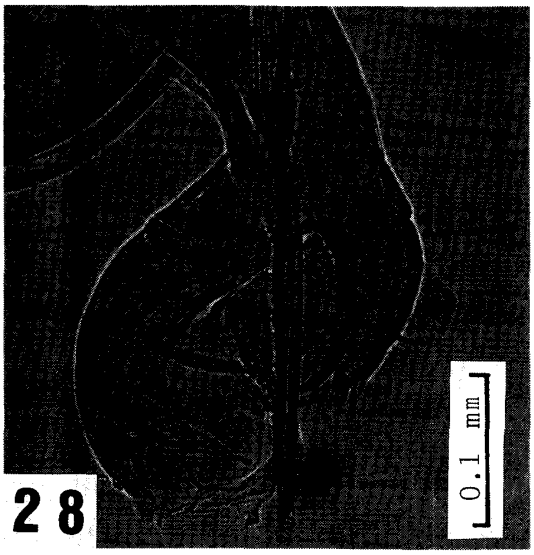

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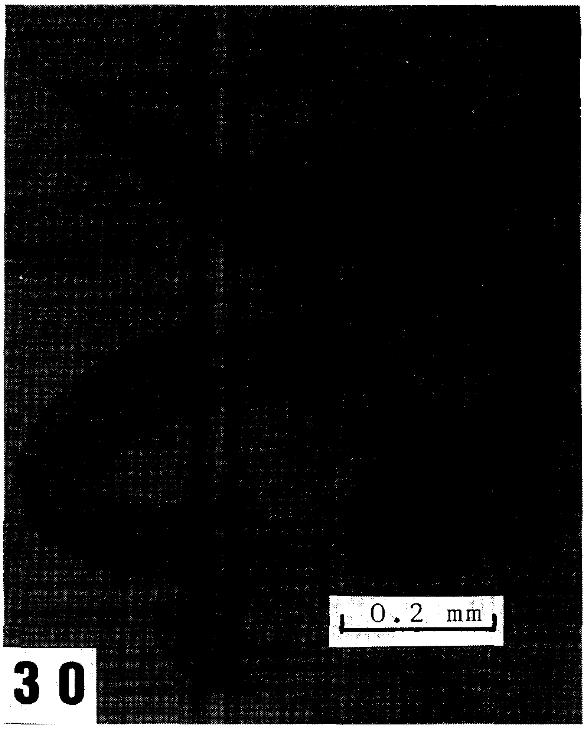

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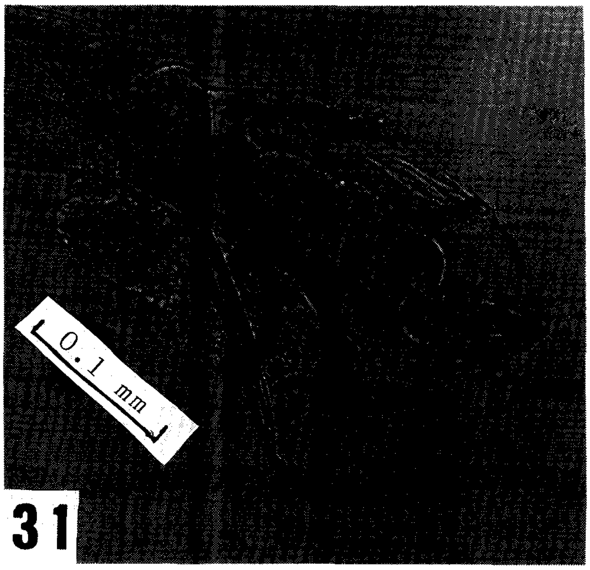

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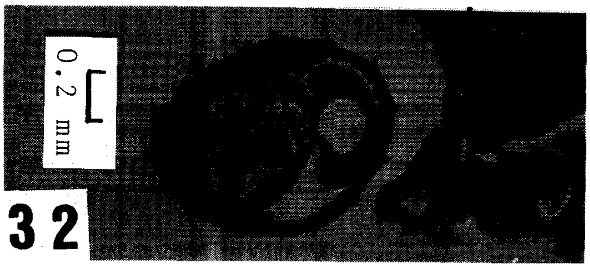

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