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REDESCRIPTION AND MULTIVARIATE MORPHOMETRICS OF *MOGURANEMA NIPPONICUM* YAMAGUTI, 1941

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Moguranema nipponicum was obtained from the Japanese larger shrew mole, *Urotrichus talpoides* and two species of the Japanese moles, *Mogera wogura* and *M. kobeae*, and redescribed. *U. talpoides* and *M. kobeae* are new hosts of this nematode. Principal component analysis was performed to study the intraspecific variations of the worms. The first and second principal components depended upon the size and shape of the worms, respectively and the former correlated to the body size of host.

Key words : *Moguranema nipponicum*, mole, Japan, multivariate morphometrics

INTRODUCTION

Moguranema nipponicum is a large-sized nematode in Trichostrongyloidea, discovered by YAMAGUTI (1941) from an intestine of a specimen of the Japanese mole, *Mogera wogura*, thus he proposed the new genus. MEYER and KUNTZ (1964) reported this species without morphological descriptions from the Formosan mole, *Talpa micrura insularis* in Taiwan. DURETTE-DESSET (1977) placed this genus in Molineinae, in Molineidae, but later she (1983) has removed this species to Haemonchinae, in Trichostrongylidae.

There are at least two species of shrew-moles and four species of moles in Japan (ABE, 1967, 1985). The present authors examined the intestinal parasite fauna of about 4 hundreds of these moles and shrew-moles collected at almost all distribution areas in Japan from 1958 to 1988, then obtained a series of *M. nipponicum* and analysed intraspecific variations of this nematode using principal component analysis (PCA), one kind of multivariate statistical techniques. In this paper, this species is redescribed and the results of the analysis are reported.

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MATERIALS AND METHODS

Two species of shrew-moles, 11 *Dymecodon pilirostris* and 171 *Urotrichus talpoides*, and 4 species of Japanese moles, 2 *Talpa mizura*, 129 *Mogera wogura*, 221 *M. kobeae* and 28 *M. tokudae* were collected from many areas of the Islands of Japan. Their localities, number and date of capture were shown in Table 1. Intestines of these moles were divided into upper, middle and lower portions for examination, but those of shrew-moles were not divided. Twenty three male and 42 female *Moguranema nipponicum* were obtained from the intestines of 3 *U. talpoides*, 9 *M. wogura* and 6 *M. kobeae*. The localities, sexes and head and body lengths of the hosts, and the numbers and sexes of the worms in each host animal are shown in Table 2. The parasite specimens were fixed in 10% formalin and cleared in lacto-phenol solution.

Twelve male and 17 gravid female worms with little destruction were selected and eight dimensions of them were measured for PCA (Table 4). The program package for PCA based on TANAKA et al. (1984) was used. Calculations were performed with a correlation matrix.

The present specimens are deposited in the collection of the Department of Parasitology, Faculty of Veterinary Medicine, Hokkaido University.

REDESCRIPTION

Host: *Urotrichus talpoides* (new host), *Mogera wogura, Mogera kobeae* (new host)
Habitat: Upper to lower portions of intestine
Locality: Hanaizumi and Maesawa, Iwate Pref.; Semine, Miyagi Pref.; Agematsu and Chiyo, Nagano Pref.; Togouchi and Hiroshima, Hiroshima Pref.; Kawashima, Tokushima Pref.; Hikosan and Zendoji, Fukuoka Pref.

Well-developed transverse striations exist from round cuticular vesicle of anterior end to tail end except bursa. Cuticular ridge absent. Corona radiata weakly developed, about 0.04 mm in diameter. Integument thick near anterior extremity, thin in other portion. Esophagus muscular, with column-shape anterior, relatively narrow medial and spherical posterior portion.

Bursa consisting of large lateral and indistinct dorsal lobes supported six pairs of symmetrical rays and dorsal ray divided into four branches, inner two short, outer two long. Exterodorsal ray small, independent of other rays with no contact to edge of bursa. Medio- and posterolateral rays and ventroventral ones small, divergent from large anterolateral and lateroventral rays, respectively. Spicules simple with equal length between right and left and with fine transverse marked membranes on inner edges of both spicules.

Female tail end tapering with blunt point. Didelphic. Vulva tend to anterior with posterior swelling cuticlar tegument. Eggs elliptical with thin shell.

Measurements based on all specimens obtained were in Table 3.

Results of PCA

All eigenvectors of the measurements (Table 4) had positive values in the first component, indicating that this component was acceptable as a size vector. The scores of this component were highly correlated to the spicule lengths (r=0.77, P< 0.01) on the male worms. These scores were also correlated to the head and body length of the hosts on both male (r=0.78, P<0.01) and female (r=0.76, P<0.01) worms. In the second component, body width and anterior, medial and posterior widths of esophagus had large negative values, whereas values of length of esophagus, length between oral end and nerve ring and length between oral end and excretory pore had positive ones in Table 4. This component indicates it is a shape vector, especially for slenderness, except for the total length with small negative value. The first component accounted for 74.1% of total factors and the second one for 9.4% of them.

Scatter diagram (Fig. 1) showed some intraspecific variations on both the first and second components. Male worms were smaller than females, and nematodes from *Urotrichus talpoides* were smaller than those from *Mogera wogura* and *M. kobeae* in each sex. There was no apparent difference between the worms from two host species of *Mogera* because of small number of positive hosts.

Variation in the second component in *U. talpoides* was smaller than in *Mogera* spp. and it was included in the range of variation of the latter. No other principal component showed any difference between worms from *U. talpoides* and *Mogera* spp.

Discussion

Yamaguti (1941) stated as the dorsal ray had three branches based on only one specimen, the identification of which was incorrect. Unfortunately, the type specimens were incomparable with the present specimens because of the loss of the type ones, but our findings were plausible because all the present specimens retained four branches.

Multivariate morphoanalysis has not been used by parasitic nematologists, who usually have analyzed variations of many worms with only a few kinds of measurements, such as spicule lengths (e.g., Lichtenfels et al. 1988). But it is usually difficult to represent the general characteristics of whole worm bodies and to discuss the relationships among the characters with a few measurements of them. Additionally, some deformations often occurring even on the spicule lengths (Ohbayashi, 1967) have made the analysis difficult. The high correlation of the first component score to the lengths of the spicules would partly show the validity of PCA for the variation analysis of some nematodes.

The first component showed that the size difference of the worms depended on that of the hosts, smaller shrew-moles and larger moles. The variations of the shape of the worms on the second component apparently depended on the differences among their habitats, e.g., from upper to lower intestines. Widths of these variations were larger in moles than in shrew-moles as well as the difference in the lengths of their intestines.

Host specificity of Trichostrongyloidea is generally high. The occurrence of the worms in *U. talpoides* may be an accidental case, because it was much lower in this host species (3 of 171 individuals, 1 of 29 localities) than in *Mogera wogura* (9 of 129 individuals, 4 of 17 localities) and *M. kobeae* (6 of 221 individuals, 5 of 27 localities). *M. nipponicum* has not been reported so far from Japanese shrew-moles (OHBAYASHI et al. 1972a, 1972b and 1973; OHBAYASHI, 1975; MACHIDA and UCHIDA 1982). *U. talpoides* and *M. kobeae* have often adjacent home ranges at mountain habitats, e.g., at Hikosan, where the nematode was obtained from *U. talpoides*, although none was found from one specimen of *M. kobeae* trapped at the same habitat. It must be easy for the eggs of this worm to be taken by shrew-moles, because their tunnel-systems are frequently adjacent to those of the moles (ABE, 1968).

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TABLE 1 . Host materials collected

Species	Locality	number	Date of capture
D. pilirostoris	Kamikouchi, Nagano Pref.	6	Jul., 14-18, 1959
	Sasa-Renbizan, Ehime Pref.	3	Apr., 10-12, 1959
	Niihama, Ditto	2	Aqr., 16, 1959
	Total	11	
U. talpoides	Hikosan, Fukuoka Pref.	17	Jun., 10-13, 1959
	Other localities (28)	154	Apr., 24, 1959-Jun., 11, '88
	Total	171	
T. mizura	Kitazawa, Nagano Pref.	2	Jul., 24, 1959
M. wogura	Hanaizumi, lwate Pref.	14	Jul., 22-23, 1960
	Maesawa, Ditto	1	Jul., 21, 1960
	Semine, Miyagi Pref.	18	Jul., 19-20, 1960
	Agematsu, Nagano Pref.	9	Aug., 8-14, 1959
	Other localities (13)	87	Aug., 14, 1959-Oct., 12, '69
	Total	129	
M. kobeae	Chiyo, Nagano Pref.	9	Jul., 26-27, 1959
	Togouchi, Hiroshima Pref.	17	Jun., 23-Jul., 1, 1959
	Hiroshima, Ditto	3	Jul., 1, 1959
	Kawashima, Tokushima Pref.	17	Jan., 1, 1958-Mar., 30, '62
	Zendoji, Fukuoka Pref.	9	Mar., 30-Jun., 7, 1959
	Hikosan, Ditto	1	Jun., 13, 1959
	Kagoshima, Kagoshima Pref.	11	Apr., 21-May, 27, 1959
	Other localities (20)	154	Nov., 13, 1958-Apr., 6 '88
	Total	221	
M. tokudae	Shibata, Niigata Pref.	7	Oct., 11-12, 1960
	Niitsu, Ditto	3	Jul., 10, 1960
	Kameda, Ditto	4	Jul., 14, 1960
	Ryozu, Sado ls., Ditto	14	Jul., 11-13, 1960
	Total	28	

TABLE 2. Data on each host individual with *Moguranema nipponicum*

Host species	No.[1]	Locality	Sex	HBL[2]	Portion of intestine parasitized	Nos. of worms male	Nos. of worms female
U. talpoides	1	Hikosan	♂	98	—	8	8
〃	2	〃	♀	96	—	1	2
〃	3	〃	♂	94	—	0	1
M. wogura	4	Hanaizumi	♀	139	upper	0	1
〃	5	〃	♂	142	middle	1	0
〃	6	Maesawa	♂	135	lower	0	1
〃	7	Semine	♀	144	upper	1	6
〃	8	〃	♂	153	middle	0	1
〃	9	〃	♀	unknown	upper-lower	0	5
〃	10	〃	♀	148	upper-middle	0	2
〃	11	〃	♂	150	upper-middle	0	3
〃	12	Agematsu	♀	128	upper	1	1
M. kobeae	13	Chiyo	♀	157	upper-middle	5	6
〃	14	Togouchi	♀	146	upper	1	1
〃	15	Hiroshima	♀	157	middle	2	2
〃	16	Kawashima	unknown	unknown	lower	1	0
〃	17	〃	unknown	unknown	lower	1	1
〃	18	Zendoji	♀	161	upper	1	1

([1] cf. Fig. 1, [2] Head and body length; mm)

TABLE 3. Measurements of *Moguranema nipponicum* based on all specimens

Measurements	*Mogera* spp.		*Urotrichus talpoides*	
	male	female	male	female
Total length	13.4-19.8	33.4-44.3	10.4-12.7	23.2-27.7
Maximum width	0.29-0.42	0.42-0.74	0.18-0.25	0.29-0.34
Esophagial length	0.56-0.70	0.63-0.87	0.49-0.54	0.52-0.62
Esophagial width				
Anterior portion*	69.8-91.2	91.2-119.1	59.2-64.0	72.8-91.2
Medial portion*	56.3-67.9	75.7-98.9	44.6-56.3	66.0-77.6
Posterior potion*	67.9-89.2	97.0-140.5	69.8-79.5	93.1-106.7
Oral end-Nerve ring	0.22-0.32	0.30-0.49	0.24-0.30	0.25-0.37
Oral end-Excretory pore	0.49-0.78	0.53-0.93	0.42-0.59	0.44-0.63
Spicule length	0.33-0.42	—	0.23-0.28	—
Eggs*	—	122.2-149.4 × 69.8-89.2	—	110.6-128.0 × 67.9-73.7
Anus-Tail end	—	0.25-0.45	—	0.14-0.19
Vulva-Tail end	—	6.26-7.98	—	3.91-5.09

(μm* or mm)

TABLE 4. Eigenvectors of each measurement of *Moguranema nipponicum*

Measurement	Principal component	
	first	second
Total length	0.39110	-0.12242
Maximum width	0.37831	-0.24205
Esophagial length	0.34191	0.37079
Esophagial width		
Anterior portion	0.38220	-0.19390
Medial portion	0.38090	-0.25480
Posterior potion	0.36239	-0.31169
Oral end-nerve ring	0.28129	0.68193
Oral end-Excretory pore	0.29225	0.35443

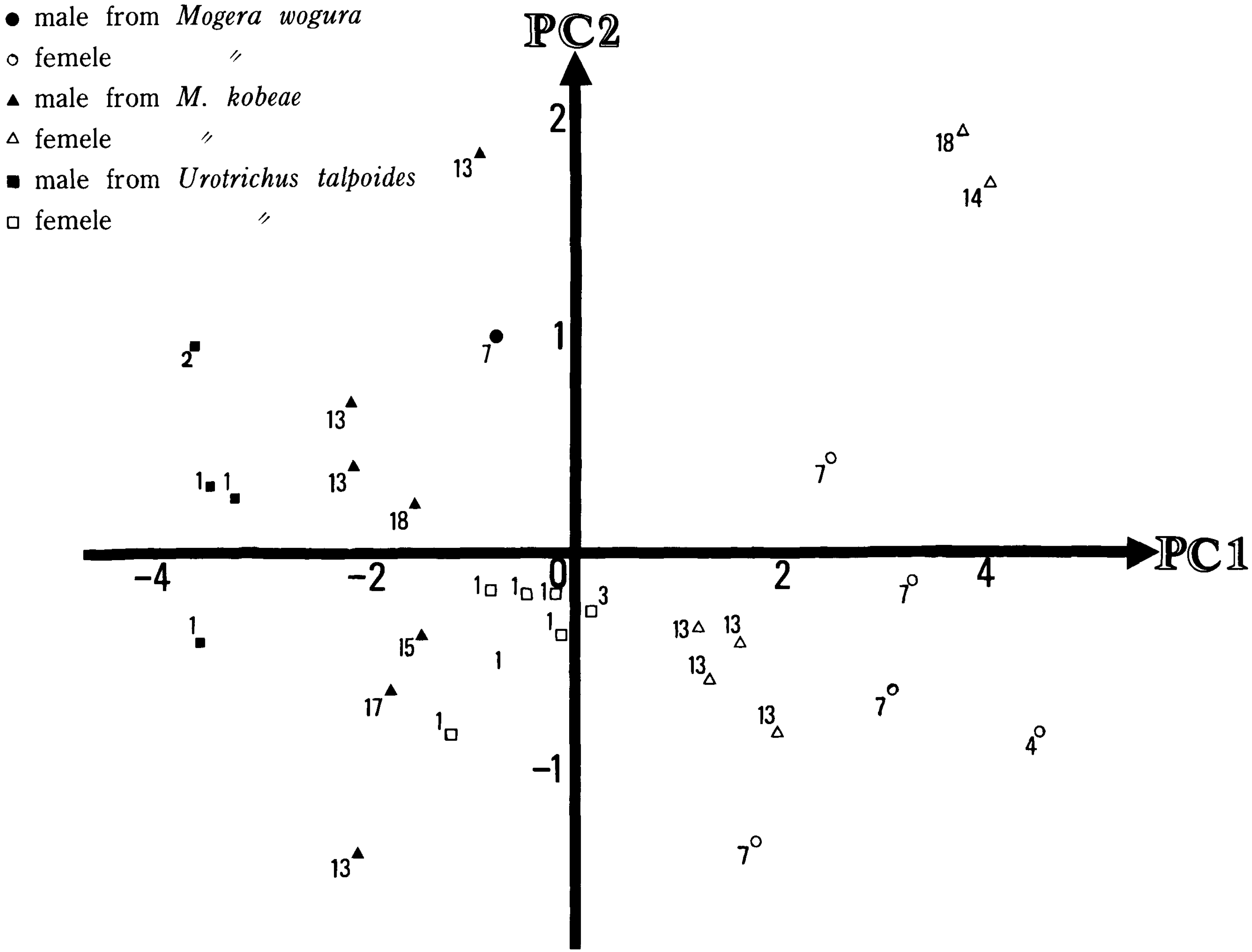
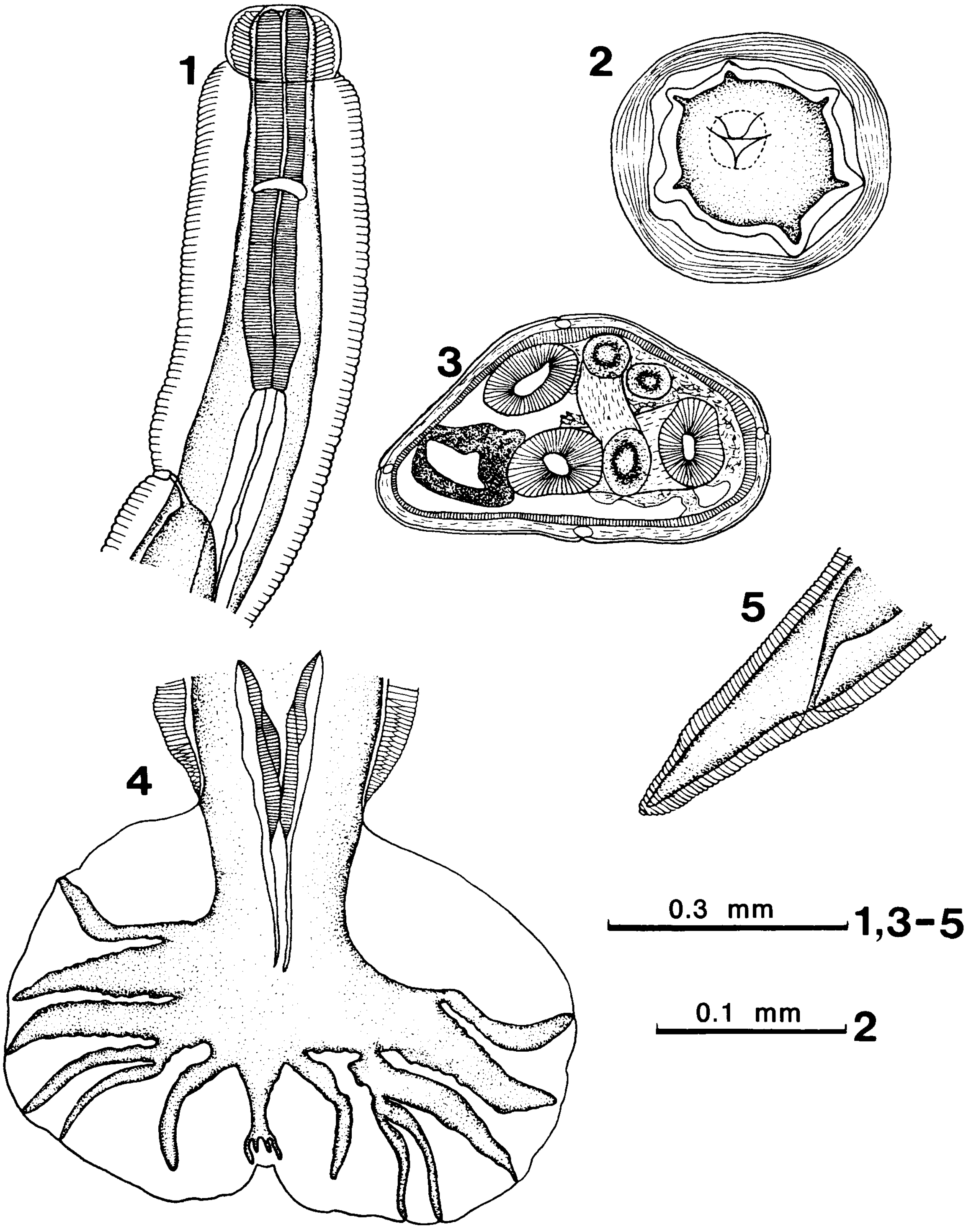


Fig. 1 *Scatter diagram of principal component I and II*

EXPLANATIONS OF FIGURES

PLATE I. *Moguranema nipponicum*

1. Anterior end of male, Lateral view
2. Anterior end of female, Apical view
3. Cross section of middle portion of female.
4. Posterior end of male, Ventral view
5. Posterior end of female, Lateral view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2
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