Treubia, 51(2): 125–140, December 2024
DOI: 10.14203/treubia.v51i2.4845
https://biologyjournal.brin.go.id/index.php/treubia

NEMATODE PARASITES OF RATS FROM KALIMANTAN

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Received: August 31, 2024; Accepted: November 15, 2024; Published: December 30, 2024

ABSTRACT

Rats can serve as a reservoir of diseases because the parasites within rats can be transmitted to humans and other animals. One of the parasites comes from the phylum Nematoda. This study aimed to identify the nematode species found in rats, determine their prevalence and intensity in Kalimantan Island. This study used 20 carcasses of rats from Kalimantan Island stored in the wet collection of MZB (Museum Zoologicum Bogoriense) BRIN Cibinong-Bogor. Identification was carried out by observing and measuring the nematodes found using a light microscope and Scanning Electron Microscope (SEM). The nematode species were then calculated for prevalence and intensity in each host. In this study, four species of nematodes, including *Subulura (Murisubulura) andersoni* (10% and 11-35)*, Subuluridae* gen. sp. (80% and 1-53)*, Mastophorus* sp. (25% and 1), and *Physocephalus* sp. (25% and 5), were found. Kalimantan Island is a new record area for *S (M.) andersoni*, *Mastophorus* sp. and *Physocephalus* sp. This needs further research to identify *Subuluridae* gen.sp. and its distribution area in Indonesia.

Key words: intensity, Kalimantan Island, nematodes, prevalence, rats

INTRODUCTION

Rats are often found living in close proximity to humans, where they compete for food and shelter. These animals are known as vectors and reservoirs for many parasites. One of these parasites is helminth. Rodent-borne helminthiases are neglected diseases that can impact human nutritional status (Gliga et al., 2020). One group of helminths that is interesting to study is nematode. Some study reported nematodes, which use rodents as definitive host, have zoonotic potential in human, including *Capillaria hepatica, Angiostrongylus cantonensis, Trichuris* spp., etc. (Cowie, 2013; Strand & Lundkvista, 2019; Tijjani et al., 2020).

Research on parasitic nematodes in rats have been widely conducted in Indonesia (Dewi & Purwaningsih, 2013; Purwaningsih et al. 2021). However, the data on nematodes in rats from Kalimantan Island are still very limited. So far, research on nematodes from Kalimantan Island has been conducted by Hasegawa & Syafruddin (1997) who described a new species of *Maxomystrongylus yasumai*. Furthermore, Purwaningsih (2003) recorded *Cyclodontostomum purvisi* from *Rattus exulans,* then Hasegawa & Dewi (2021) reported *Ascarops strongylina* in

the stomach of *Maxomys whiteheadi*. Recent publication on Kalimantan nematode was made by Hasegawa et al. (2022) who observed the morphology of *Physaloptera* species found from *M. whiteheadi* and *M. bartelsii.*

This study was conducted to reveal and identify the nematode species found in rats from Kalimantan Island and to provide data related to the species of nematodes, their prevalence and intensity. In addition, the data of the prevalence can also be used as a basic data in efforts to prevent and control diseases transmitted by rat nematodes. This study also presents a distribution map of nematodes in Indonesia for each nematode found. This data will add to the distribution area of nematode species in Indonesia.

MATERIALS AND METHODS

Twenty rats from the wet collection of the Museum Zoologicum Bogoriense (MZB) BRIN were dissected by removing their digestive organs. The rat species were *Leopoldamys sabanus, Maxomys whiteheadi*, *M. rajah*, and *Niviventer cremoriventer*. The parasitic worms found were stored in collection bottles filled with 70% ethanol. Nematodes were observed using a light microscope, and they were previously cleared using lactophenol until transparent. Their characteristics were then observed, measured, and photographed using an Olympus BX50 camera attached to the light microscope. Additionally, the nematode characteristics were observed using a JEOL IT-200 Scanning Electron Microscope (SEM). Prior to observation, the parasitic worms underwent a series of preparation processes, including fixation, dehydration through a series of ethanol (50%-100%), and fresh drying. Each prepared sample was then mounted on a specimen stub and coated with gold at 5–8 mA for 5 min using an ion coater, IB-2 (Eiko Co., Tokyo, Japan). Measurements were given in micrometres unless otherwise stated, and presented as the range and followed by the mean in parentheses. After identification process, the nematodes were counted for prevalence and intensity. Prevalence is the number of host infected with 1 or more individuals of a particular parasite species divided by the number of host examined for that parasite species. Intensity is the range of numbers found of each individual parasite species on each individual host (Bush et al., 1997).

RESULTS

This study found 4 species of nematodes, 3 genera, and 2 families. They were *Subulura (Murisubulura*) *andersoni* (Fam: Subuluridae), *Subuluridae* gen. sp. (Fam: Subuluridae), *Mastophorus* sp. (Fam: Spirocercidae), and *Phisocephalus* sp. (Fam: Spirocercidae). The identification of the four species of nematodes mentioned above is presented below.

Taxonomic Accounts

Class Chromadorea Inglis, 1983
Subclass Chromadoria Pearse, 1942
Order Rhabditida Chitwood, 1933
Suborder Ascaridina Inglis, 1983
Family Subuluridae Yorke and Maplestone, 1926
Genus *Subulura* Molin, 1860
Subgenus *Murisubulura* Quentin, 1969

***Subulura (Murisubulura) andersoni* (Cobbold, 1876)**

General: Medium-sized worm, anterior part curved ventrally. Cephalic end with 6 reduced lips, 6 internal labial papillae, one pair of amphid, and four large cephalic papillae (Figs. 1C, D). Buccal cavity longer than wide, thick-walled (Fig. 1A), with six large teeth on anterior margin. Cervical alae well developed, starting from base of cephalic plate and ending anterior to posterior bulb of esophagus. Esophagus consisting of pharynx, corpus, and bulb (Fig. 1B).

Male (n=10): Total body length 11.26–12.49 (11.76) mm, width at midbody 375–447 (419). Head width 42–44 (43). Total esophagus length 1.31 –1.47 (1.40), consisting of pharynx 46–49 (47.9) long, 45–52 (47) wide, corpus 1.11–1.28 (1.19) mm long, 125–155 (135) wide; bulbus 184–245 (211) long, 194–225 (211) wide. Nerve ring 270–310 (284) and excretory pore 387–446 (424) from anterior end. Ten pairs of papillae and one papilla at posterior parts, with following arrangement: one pair located lateral to precloacal sucker (1st); two pairs (2nd and 3rd) almost parallel in sequence between the precloacal sucker and cloaca; two pairs close together, located on antero-lateral cloaca; one on median part of cloaca, two pairs (6^{th} and 7^{th}) after the cloaca; one pair and two submedian papillae located close together at tip of tail. Tail tip with spike, 239–287 (266) (Fig. 1G). Precloacal suckers narrow, elongated, supported by radiating muscle fibers (Fig. 1H), 655–880 (763) long. Spicules equal, alate 1.08–1.18 (1.14) mm (Figs. 1G, H). Gubernaculum tongue-like shape, 143–174 (161) long.

Female (n=10): Body length 18.58–19.96 (19.46) mm, width at midbody 486–532 (513). Head width 52–59 (56). Total esophagus length 1.59–1.73 (1.67) mm; comprising pharyngeal length 57–70 (63), width 52.6–63.6 (57.9); corpus length 1.36–1.49 (1.41) mm, width 143.7–169.1 (158.7); and bulbus length 242–278 (262) and width 236–268 (255). Nerve ring 252–296 (270), excretory pore length 448–502 (475), and vulva 6.96–8.34 (7.49) mm from anterior end (Fig. 1D). Egg oval, thick—walled with coiled embryo, 59–65 x 48–55 (Fig. 1F). Tail pointed, 775–918 (846) (Fig. 1E).

Host: *Niviventer cremoriventer*
Site of infection: Caecum.
Locality: Nunukan Kalimantan, Indonesia.

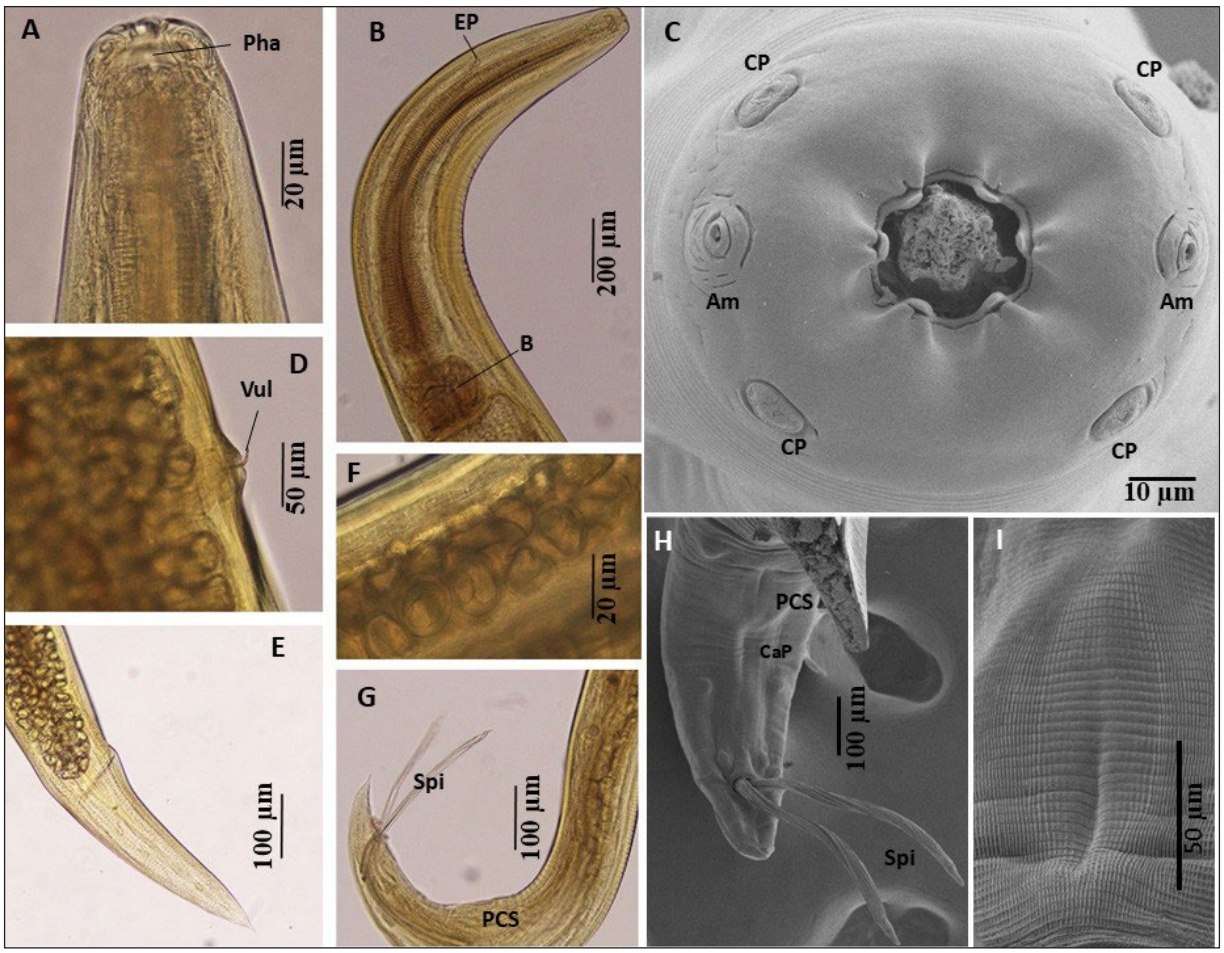


Figure 1. *Subulura* (*Murisubulura*) *andersoni* form *Niviventer cremoriventer* of Nunukan, South Kalimantan, Indonesia. A. Anterior end left lateral view; B. Anterior part including pharynx, corpus and bulbus; C. Apical view of cephalic end, D. Vulva; E. Posterior end of female; F. Eggs; G, H. Tail and spicule, I. Precloacal sucker.

Abbreviations: Pha: pharynx; EP: Excretory pore; B: Bulb; Am: Amphid; CP: Cephalic papilla; Vul: Vulva; PCS: PreCloacal Sucker; CaP: Caudal papilla; Spi: Spicule.

Remarks: the morphology and morphometrics of these specimens closely identical to the description of *S. (M.) andersoni* by Dewi et al. (2018). This includes the lengths of the body, esophagus, gubernaculum and spicules, the number and arrangement of the caudal papillae, the position of the vulva and the morphology and length of the tail.

Class Chromadorea Inglis, 1983
Subclass Chromadoria Pearse, 1942
Order Rhabditida Chitwood, 1933
Suborder Ascaridina Inglis, 1983
Family Subuluridae Yorke and Maplestone, 1926

***Subuluridae* gen. sp.**

General: Medium-sized worm. Cephalic end with 3 lips, one pair of amphid, and four large cephalic papillae (Fig. 2A). Anterior portion of pharynx twisted (Figs. 2B, C). Esophagus consisting of pharynx, corpus, and bulb (Fig. 2D).

Male (n=10): Body 8.75–14.60 (10.54) mm long, mid–body width 376–390 (388). Head width 42–44 (43). Total esophagus length 1.17–1.40 (1.28) mm, consisting of pharynx 45–46 (45.5) long, 42–44 (43) wide; corpus 1.01–1.18 (1.08) mm long, 114–117 (116) wide; and bulbus 147–189 (173) long, 180–202 (188) wide. Nerve ring 285–288 (286) and excretory pore 404–409 (406) from cephalic end (Fig. 2D). Tail length 376–398 (385). Spicule similar, alate, pointed at distal end, 874–956 (908) long (Fig. 2G). Gubernaculum length 149.2–153.1 (150.2). Ten pairs of papillae and one papilla at posterior parts, with arrangement similar to *S. (M.) andersoni.* Tail with long whip-appandage (Fig. 2G)

Female (n=10): Body length 16.79–19.82 (18.85) mm, width 384–496 (459). Head width 42.2–44.2 (43.3). Total lenght esophagus 1.30–1.46 (1.41) mm long, consisting of pharynx 52.4–57.1 (54.9) long, 42.2–44.2 (43.3) wide; corpus 1.12–1.31 (1.20) mm long, 125–162 (140) wide; and bulbus 198–236 (208) long, 197–241 (221) wide. Nerve ring length 301–310 (306), excretory pore 468–493 (478), and vulva 6.41–7.98 (6.76) mm long from anterior end. Vulva slit-shaped (Fig. 2J). Egg oval, thick-—walled, embryonated in uterus (Fig. 2I), 60–65 x 42–50. Tail long, tapered, 1.28–1.46 (1.35) mm long (Fig. 2H).

Host: *Maxomys whiteheadi, Lepoldamys sabanus*

Site of infection: Caecum.

Locality: Nunukan Kalimantan, Indonesia.

Remarks: Inglis (1958) conducted a comparative study on the structure of the head in the nematode family Subuluridae. His research has now formed the basis for a new classification within this family. In Indonesia, there are records of one genus and two species from the Subuluridae family: *S. (M.) andersoni* and *S. (M.) sipiroki*. The genus *Subulura* is typically characterized by having six lips (Inglis, 1958); however, the specimen we examined has three lips.

According to Hodda (2022), family Subuluridae consists 14 genera. Among them, *Subuluridae* gen. sp. shows similarities to *Leipoanema* Johnston & Mawson, 1942 and *Primasubulura* Inglis, 1958 by having three well developed lips at the cephalic end. However, the head of *Leipaonema* is separated from the body by a groove (Chabaud 2009). Additionally, the genus *Primasubulura*, established by Inglis, 1958, was created to accommodate the species within the family Subuluridae which occur in primate hosts. This genus now consists of ten species and all of them occurred in primate host. Therefore, we are still facing challenges in determining the genus to which this specimen belongs. Further molecular study needs to resolve this issue before we can ascertain whether this species fits into *Primasubulura* or should be classified as a new genus.

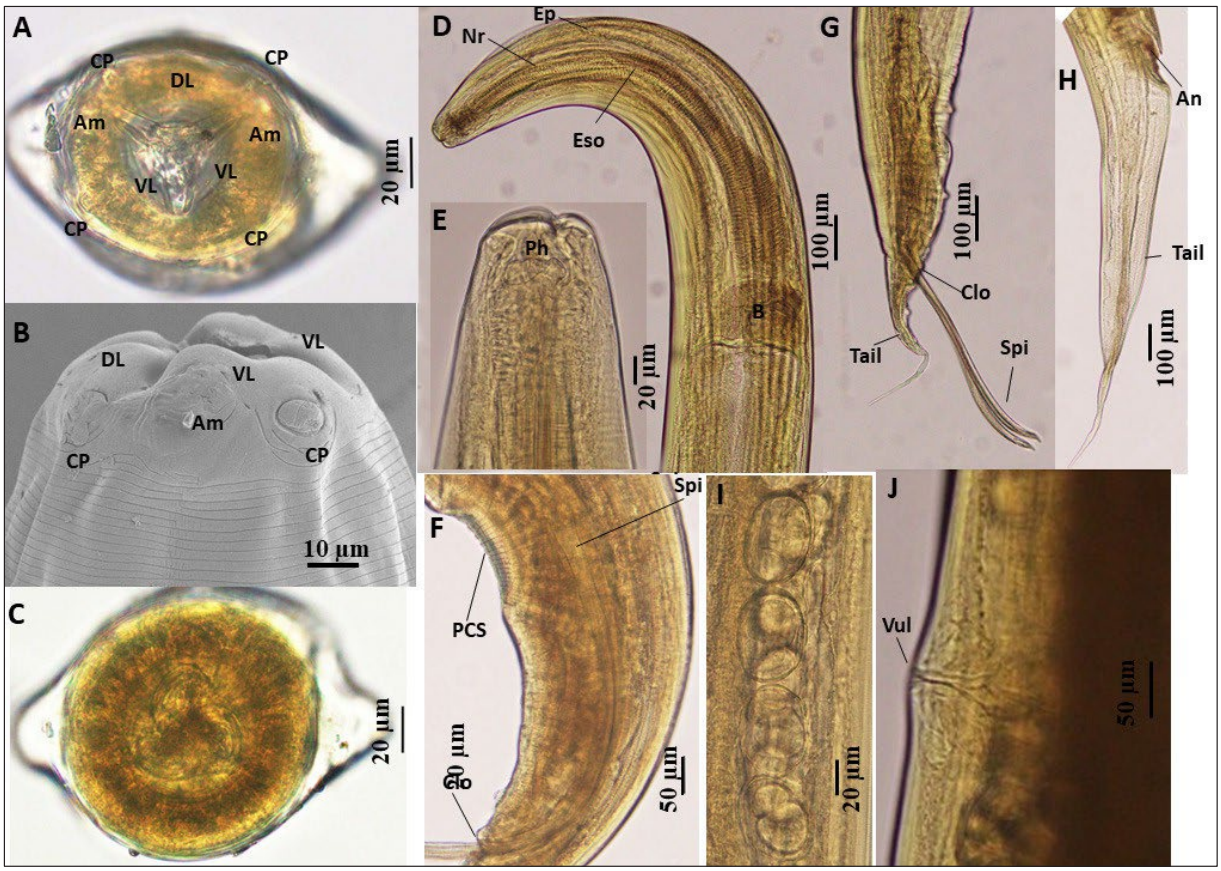


Figure 2. *Subuluridae* gen. sp. from *Maxomys whiteheadi* of Nunukan, South Kalimantan, Indonesia. A. Apical view; B. Anterior end (lateral view); C. Cross section through pharynx; D. Anterior portion; E. Anterior end, left lateral view; F. Pre-cloacal sucker; G. Posterior portion of male; left lateral view; H. Posterior end of female, left lateral view; I. Egg; J. Vulva, left lateral view.

Abbreviations: CP: Cephalic papillae; DL: Dorsal lip; VL: Ventral lip; Am: Amphid; Nr: Nerve ring; Ep: Excre- tory pore; Eso: Esophagus: Ph: Pharynx: B: bulb; Clo: Cloaca; Spi: Spicula; An: Anus; PCS: Pre-cloacal sucker; Vul: Vulva.

Class Chromadorea Inglis, 1983
Subclass Chromadoria Pearse, 1942
Order Rhabditida Chitwood, 1933
Suborder Spirurina Railliet & Henry, 1915
Family Spirocercidae Chitwood & Wehr, 1932
Subfamily Mastophorinae Quentin, 1970
Genus *Mastophorus* Diesing, 1853

***Mastophorus* sp.**

General: Body robust, decreasing to mid-body. Anterior end with two pseudo-lips, each pseudo-lip with well-developed one large lateral and two smaller sub-median lobes. Each lip lobe at the inner end with 4-7 teeth, central tooth largest (Figs. 3A, B). Anterior end with four large head papillae and one pair of amphid. Pharynx thick wall.

Male (n=1): Body 21.3 mm long, mid–body width 887. Total esophagus length 3.26 mm, consisting of pharynx 117 long, 100 wide; muscular esophagus 393 long, 171 wide; and glandular

esophagus 2.75 long, 302 wide. Nerve ring 410 from cephalic end. Spicules without alae, left spicule 731 and right spicule 1.97. Tail with alae and some papilla, length 487 (Fig. 3E).

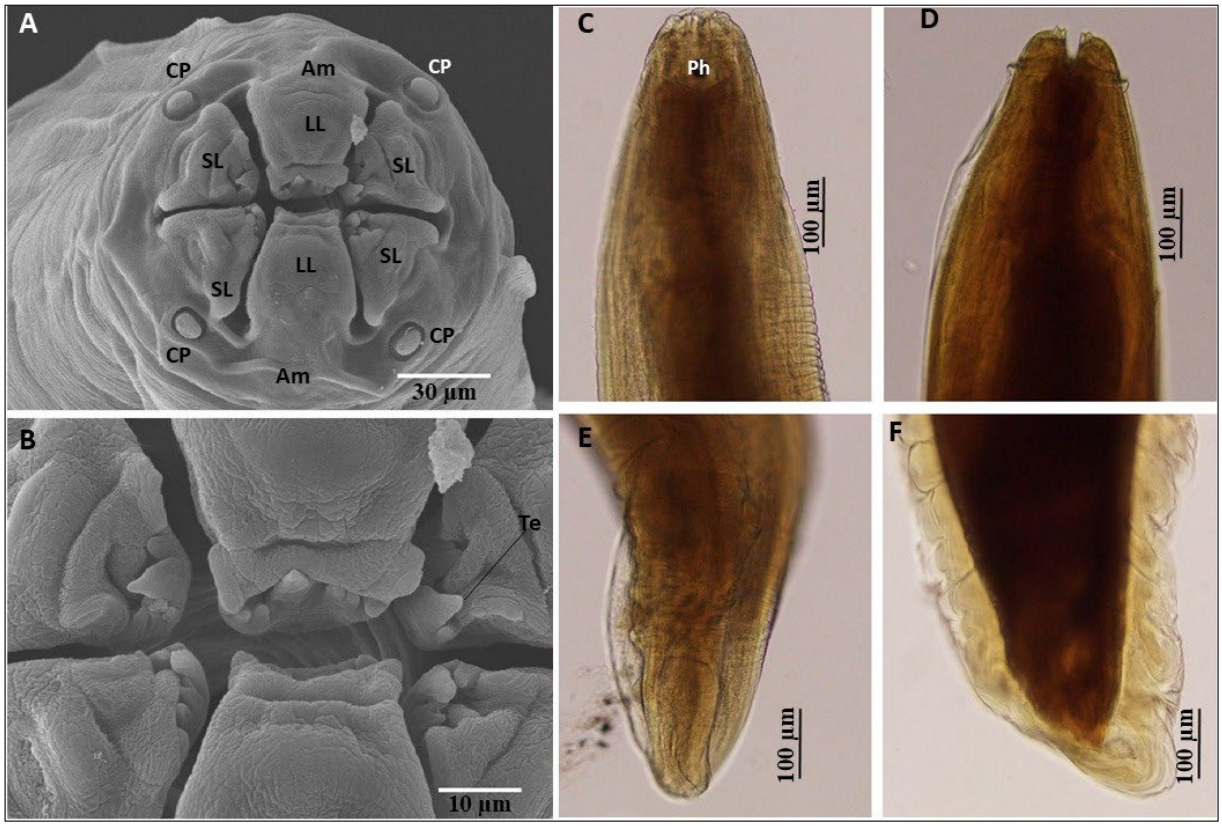
Female (n=1): Body length 16.4 mm, width 1,0 mm. Total lenght esophagus 2.77 mm long, consisting of pharynx 102 long, 96 wide; muscular esophagus 328 long, 144 wide; and glandular esophagus 2.34 mm long, 267 wide. Nerve ring 362 and vulva 2.17 mm from anterior end (Figs. 3G, H). Tail length 508 (Fig. 3F). Egg embryonated in uteri, 47–51 x 28–34 (Fig. 3I).

Host: *Maxomys whiteheadi*

Site of infection: Stomach.

Locality: Nunukan Kalimantan, Indonesia.

Remarks: In this study, the specimen was very thick and dark although it had been cleared in the Hoyer solution for one month. We stopped the clearing process because the Hoyer solution is corrosive to the specimen. The shape of spicules and the posterior papillae in male could not be observed. However, we still could identify the specimen up to genus level according to the observation on the anterior end by using an electron microscope. It is clear that the specimen obtained is *Mastophorus* but its species cannot be determined yet.



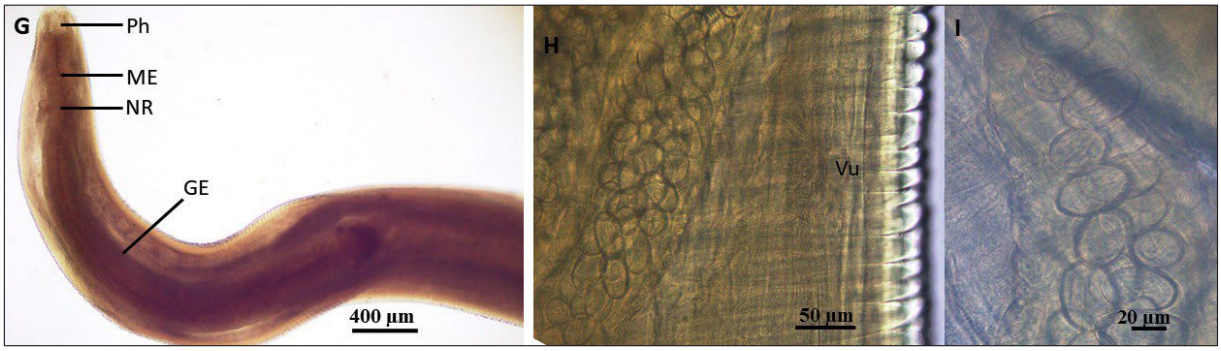


Figure 3. *Mastophorus* sp. A. Apical view; B. Lips; C, D. Anterior part (C. ventral view, D. lateral view); E. Posterior end of male, I. E. Posterior end of female; G. Anterior portion; H. Vulva; I. Egg.

Abbreviations: CP: Cephalic papillae; DL: Dorsal lip; VL: Ventral lip; Am: Amphid; Eso: Esophagus: Ph: Pharynx: Vu: Vulva; SL: Sub-median lobes; LL: Lateral lip; ME: Muscular esophagus; GE: Glandular esophagus.

Class Chromadorea Inglis, 1983
Subclass Chromadoria Pearse, 1942
Order Rhabditida Chitwood, 1933
Suborder Spirurina Railliet & Henry, 1915
Family Spirocercidae Chitwood & Wehr, 1932
Subfamily Ascaropsinae Alicata & McIntosh, 1933
Genus *Physocephalus* Diesing, 1861

***Physocephalus* sp.**

Medium-sized worm. Body elongated, tapering slightly anteriorly. Anterior end with two lips, each lip has three lobes, and each with one pair of large papillae and one amphid (Fig. 4C). Pharynx with spiral-shaped thickening (Figs. 4A, B). End of cervical papillae v-shaped. Lateral alae present on each lateral side, like two furrows side by side (Fig. 4D).

Female (n=5): Body length 12.8–13.66 (13.1) mm, midbody width 372.7–445.4 (397.1). Body tapers in 1/3 anterior, slowly to enlarge and reaches maximum before posterior end. Buccal capsule 122.7–151.0 (141.69) long, 31.1–35.1 (33.4) wide. Anterior esophagus 1.94–2.30 (2.06) mm long, 142.3–147.1 (144.3) wide. Nerve ring 140.9–147.9 (144.7) and vulva 5.07–8.19 (6.78) from anterior end. Tail rounded with cone-shaped appendage, 258–334 (290) length (Figs. 4E, G). Egg 52.5–62.2 (59.1) x 36.4–44.6 (41.2).

- No male worm was found.

Host: *Leopoldamys sabanus*

Site of infection: Small intestine

Locality: Nunukan Kalimantan, Indonesia.

Remarks: In Indonesia, there is only one record of *Physocephalus* that was also identified up to the genus level. *Physocephalus* sp. infected *Rattus tanezumi* from Banjarnegara, Central Java (Dewi and Purwaningsih, 2020). In this study, these specimens also could not be identified up to species level because there are only females. The genus *Physocephalus* is characterized by the mouth opening that is surrounded by two trilobed lateral lips followed by a pair of flat papillae on each side and pharynx with spiral-shaped thickening (Schuster et al., 2014).

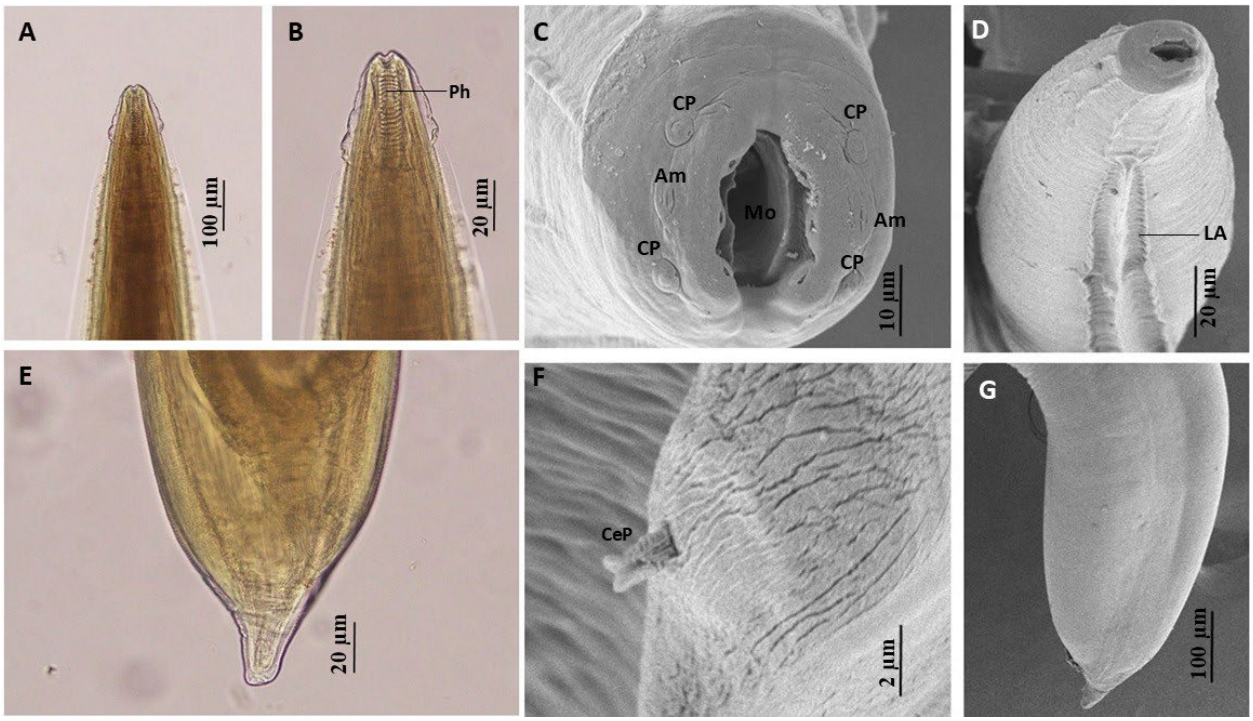


Figure 4. *Physocephalus* sp. A, B. Anterior part showing pharynx with spiral-shaped thickening; C. Apical view; D. Anterior part with lateral alae; E, G. Posterior end of female; F. Cervical papilla.

Abbreviations: Am: Amphid; CP: Cephalic papillae; Eso: Esophagus; LA: Lateral alae; Mo: Mouth; Ph: Pharynx.

Prevalence and Intensity of Nematodes found in Rats

In this study, among 20 observed rats, only two were found to be free of nematode infection, so the prevalence was 90%. The pattern of nematode parasite in the studied rats are presented in Table 1 and the number of male and female nematodes in each host can be seen in Table 2. Of four rat species observed, only *Maxomys rajah* was free from nematodes.

Table 1. Pattern of Nematodes Infection

Rodent species	No. positive	Percentage (%)	Nematode species	Site of infections
Single Infection	**12**	**60**		
Maxomys whiteheadi	10	45	*Subuluridae* gen. sp.	Caecum
Niviventer cremoriventer	2	10	*Subulura (M.) andersoni*	Caecum
Mixed infection	**6**	**30**		
Maxomys whiteheadi	4	20	*Subuluridae* gen. sp.+ *Mastophorus* sp.	Caecum Stomach
Leopoldamys sabanus	1	5	*Subuluridae* gen. sp. + *Mastophorus* sp.	Caecum Stomach
Leopoldamys sabanus	1	5	*Subuluridae* gen. sp. + *Physocephalus* sp.	Caecum Small intestine
Negative	2	10		
Maxomys rajah	2	10		
Total	20	100		

Among the four species of nematodes identified in the study, two were located in the caecum *Subuluridae* gen. sp. and *S. (M.) andersoni*), one species was found in the stomach (*Mastophorus* sp.), and one species was in the small intestine (*Physocephalus* sp.). The highest number of individuals recorded in this study was from *Subuluridae* gen. sp. (239), followed by *S. (M.) andersoni* (48). The lowest were *Mastophorus* sp. and *Physocephalus* sp., with each having only 5 individuals (Table 2).

Table 2. Intensity, prevalence and number of male and female nematodes per host

No MZB	Host	Nematode species							
		Subulura (M.) andersoni		***Subuluridae* gen. sp.**		***Mastophorus* sp.**		***Physocephalus* sp.**	
		♂	♀	♂	♀	♂	♀	♂	♀
34087	*Maxomys whiteheadi*	-	-	1	3	-	-	-	-
34088	*Maxomys whiteheadi*	-	-	2	3	-	-	-	-
34089	*Maxomys whiteheadi*	-	-	4	6	-	1	-	-
34090	*Maxomys whiteheadi*	-	-	11	9	-	-	-	-
34091	*Maxomys whiteheadi*	-	-	5	6	-	-	-	-
34092	*Maxomys whiteheadi*	-	-	8	14	-	1	-	-
34093	*Maxomys whiteheadi*	-	-	16	20	-	-	-	-
34094	*Maxomys whiteheadi*	-	-	7	11	-	1	-	-
33928	*Maxomys whiteheadi*	-	-	23	30	-	1	-	-
33929	*Maxomys whiteheadi*	-	-	2	4	-	-	-	-
33930	*Maxomys whiteheadi*	-	-	9	7	-	-	-	-
33931	*Maxomys whiteheadi*	-	-	2	4	-	-	-	-
33932	*Maxomys whiteheadi*	-	-	15	9	-	-	-	-
YS 586	*Maxomys whiteheadi*	-	-	1	3	-	-	-	-

No	Host	Nematode species							
		Subulura (M.) andersoni		***Subuluridae* gen. sp.**		***Mastophorus* sp.**		***Physocephalus* sp.**	
		♂	♀	♂	♀	♂	♀	♂	♀
34093	*Leopoldamys sabanus*	-	-	-	2	1	-	-	-
34098	*Leopoldamys sabanus*	-	-	1	-	-	-	-	5
34099	*Niviventer cremoriventer*	22	13	-	-	-	-	-	-
34100	*Niviventer cremoriventer*	6	5	-	-	-	-	-	-
	Total number	30	18	107	132	1	4	-	5
Prevalence		10%		80%		25%		5%	
Intensity		11-35		1-53		1		5	

Distribution map of four nematode species from the rats found in this study in Indonesia

This distribution map on the nematode recorded in this study is presented to know the locality where each species has been found in Indonesia before this research. Out of the four nematodes found, three of them have not been identified to the species level. Therefore, the distribution records used are the nematode genera in Indonesia, except for *Subulura*. All species of *Subulura* recorded in Indonesia have previously all been identified to the species level. In Indonesia there are two species of *Subulura*, namely *S. (M.) andersoni* and *S. (M.) sipiroki*, both of which have six lips (Dewi et al., 2013). *Subuluridae* gen. sp. has three lips which is only found in Kalimantan.

Data on the distribution of nematode species outside of Kalimantan were gathered from various previous publications (Wiroreno, 1978; Purwaningsih & Saim, 1997; Purwaningsih & Dewi, 2007; Dewi & Purwaningsih, 2013; Smales, 2016; Dewi et al., 2018; Dewi & Purwaningsih, 2020; Musyaffa et al., 2020, 2021; Purwaningsih et al., 2021). This information will help to expand the knowledge about the distribution areas of each species in Indonesia, especially outside of Kalimantan Island. Prior to this study, there were no records of these species and genera being discovered in Kalimantan, so Kalimantan is the new record location for the four nematodes.

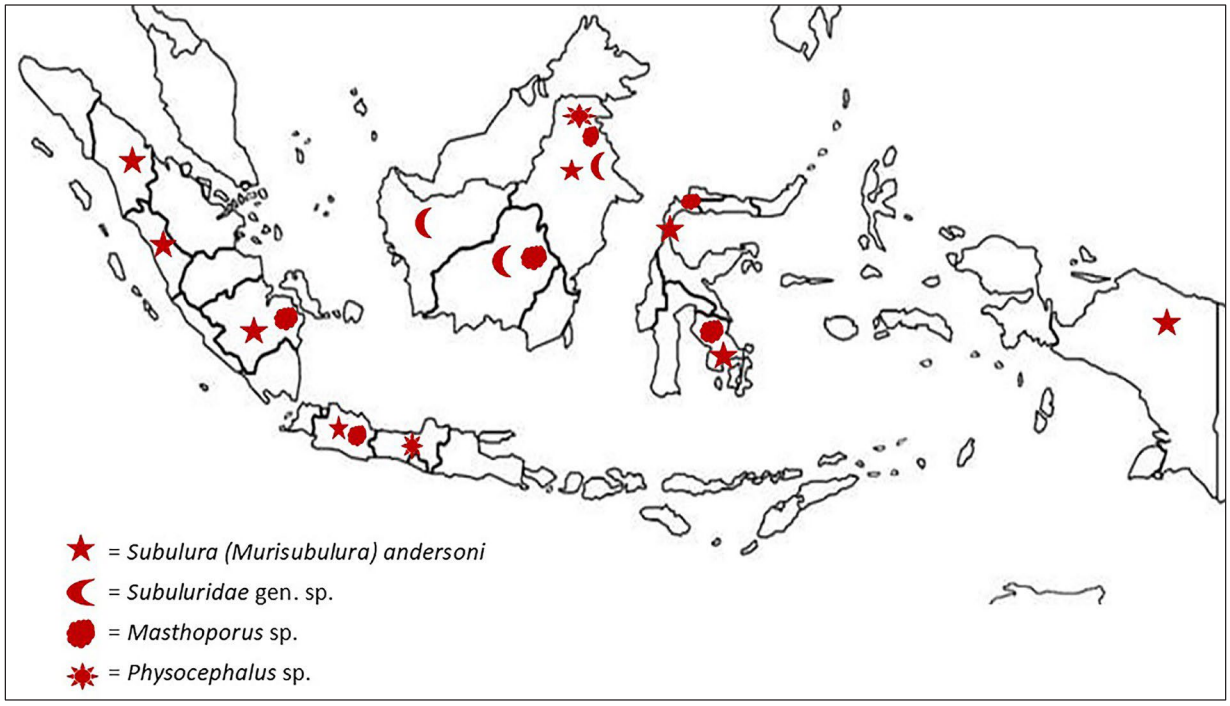


Figure 5. Distribution map of of four nematode species from the rats found in this study in Indonesia

DISCUSSION

This research found four nematode species, *Subulura (Murisubulura) andersoni, Subuluridae* gen. sp., *Mastophorus* sp., and *Physocephalus* sp (Table 1). In our study, we observed that 18 hosts (90%) were infected with nematodes, and only two individuals of rat (10%) were free. Of the infected hosts, 12 hosts (60%) had single infection and six hosts (30%) had mixed infections (Table 2). Mixed infection refers to when an individual host is infected with more than one species of nematode. The highest mixed infection was *Subuluridae* gen.sp. and *Mastophorus* sp. in four individulals of *M. whitheadi* (20%). In natural populations, the occurrence of co-infection of individual hosts by multiple parasite species is a pattern that is very commonly observed (Viney & Graham, 2013). The occurrence of mixed infection can be influenced by the interaction of rats with their environment. Rats can become infected with nematodes from sources such as water, soil, food, or direct contact with other infected rats.

Subulura (M.) andersoni has a wide distribution, ranging from India to Australia and infecting various host species, including murid rodents, sciurids, and squirrels (Dewi et al., 2018). The distribution record of this species in Indonesia are West Java, West and North Sumatra, Southeast Sulawesi, and Papua (Fig. 5). Previous studies in Indonesia have shown that this nematode infects murid rodents from the genera *Bunomys, Lepoldamys, Maxomys,* and *Rattus* (Wiroreno, 1978; Purwaningsih, 2003; Purwaningsih & Dewi, 2007; Smales, 2016; Musyaffa et al, 2021; Dewi et al., 2018). This study has added *Niviventer cremoriventer* as a new host record for *S. (M.) subulura.* The total number of *S. (M.) andersoni* found was 48, most of which were found in the caecum with the intensity of 2-35.

Subuluridae gen. sp. is the dominant species in this st udy, with a prevalence of up to 80%. The total number of *Subuluridae* gen. sp. found was 229, which were found in the caecum, with an intensity of 1–53 per individual host. This species was found infecting *M. whiteheadi* and *L. sabanus*. Of the 229 individuals recorded, there are only three individuals of *Subuluridae* gen. sp. parasitizing *L. sabanus*. This could be because the natural host of *Subuluridae* gen. sp. is *M. whitheadi*, while *L. sabanus* is only an accidental host.

The genus *Physocephalus* was proposed by Diesing (1861), with the type species being *P. sexalatus,* which was identified from a pig. *Physocephalus* is known to be parasitic in the stomach or intestine of mammals (Yamaguti, 1961). Currently, this genus consists of nine species (Hodda, 2022). In Indonesia, *Physocephalus* was reported to infect *Rattus tanezumi* in Banjarnegara, Central Jawa (Dewi & Purwaningsih, 2020). In this study, *Physocephalus* was found to parasitize *L. sabanus* at a low prevalence; out of 20 rat specimens examined, only one rat was infected (5%), comprising five female individuals.

The morphological of the genus *Mastophorus* is similar with the genus *Protospirura,* so the taxonomic status of both genera has been confusing for a long time. One of the differential characteristics between the two genera is the number of teeth in the pseudolabia (two or four in *Protospirura* vs. five, seven or nine in *Mastophorus*) (Miquel et al., 2023). *Mastophorus* sp. is found free living in the stomach of the host. In Indonesia, this worm has been found infecting *Niviventer lepturus, Sundamys muelleri, Rattus tiomanicus, R. mueleri, R. lepturus,* and *R. marmoxorus* (Dewi & Purwaningsih, 2020; Purwaningsih et al., 2021). Its distribution areas of this genus are Lampung, West Java, and Southeast Sulawesi (Purwaningsih et al., 2021). The hosts of *Mastophorus* sp. in this study was *Maxomys whiteheadi,* so this study added new species host to *Mastophorus.* The total number of *Mastophorus* sp. found was five, found in the stomach with the number of worms per individual host was one.

CONCLUSION

The species of nematodes found in rats from Kalimantan Island are *Subulura (Murisubulura) andersoni*, *Subuluridae* gen. sp., *Mastophorus* sp., and *Physocephalus* sp. The prevalence of nematodes in rats from Kalimantan was 90%. Out of 20 rats examined, 18 were infected with nematodes and only 2 rats were not infected. Specifically, *Subulura (M.) andersoni* exhibited a prevalence of 15% with an intensity range of 2–35, *Subuluridae* gen. sp. had a prevalence of 80% prevalence and an intensity range of 1–53, *Mastophorus* sp. showed a prevalence 25% with an intensity of 1, and *Physocephalus* sp. also had a prevalence of 25% but with an intensity of 5. In this study Kalimantan is a new record location for *S. (M.) andersoni, Physocephalus* sp., and *Mastophorus* sp. Furthermore, this study has also added *Niviventer cremoriventer* as a new host record for *S. (M.) subulura.*

ACKNOWLEDGMENTS

We are grateful to Prof. (Em.) Hideo Hasegawa, for the helpful suggestions and the references on *Subuluridae* gen. sp. This study is part of the "*Riset dan Inovasi Indonesia Maju (RIIM)"* project sponsored by Indonesia Endowment Fund for Education Agency (LPDP) year 2024 with contract numbers are B-1116/II.7.5/FR.06/3/2024 and B-949/III.5/FR.06.00/3/2024.

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