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HELMINTH PARASITES IN WILD RATS FROM PENINSULAR MALAYSIA OIL PALM PLANTATION

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ABSTRACT

The presence of wild rats in oil palm plantations not only causes significant losses in crop production but also poses a potential threat to human health through the transmission of zoonotic diseases such as helminthiasis. This study determines the prevalence of helminths among the rat population in an oil palm plantation at Sungai Ara, Johor. By setting 100 metal live traps with baits, a total of 74 individual wild rats consisting of 6 species were successfully caught. Rats were euthanized and necropsied to examine internal organs for the presence of helminths. This study has revealed an overall infection rate of 91.9 %, (n = 68) and recorded several species from two groups of helminths: nematodes (*Heterakis spumosa*, *Nippostrongylus brasiliensis*, *Syphacia muris*, *Hepatojarakus malayae*, *Angiostrongylus* spp., *Trichuris* sp., and *Capillaria hepatica*) and cestodes (Cyst. *Taenia taeniaeformis*, *Hymenolepis diminuta*, and *Hymenolepis nana)*. Among these helminths, several species have been identified as important zoonoses with the potential to infect humans such as taeniasis, hymenolepiasis and capillariasis.

Keywords: Agriculture, endoparasites, Muridae, Kota Tinggi, species diversity.

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INTRODUCTION

Rats and mice (Family Muridae) are widely distributed throughout the world, except Antarctica and are well-adapted with human activities, therefore called synanthropic rodents (Capizzi et al., 2014) It can be found in micro and macro-habitats such as urban, suburban, rural, modified forest, human settlements, and agricultural fields (Anders et al., 2019; Ortega Pérez, 2022). Overpopulated rats in countries can be considered pests to humans that can affect the economy, welfare, and public health (Shukor et al., 2018; Jurišić et al., 2022).

In Malaysia oil palm plantation, rat species decrease palm oil yield production estimated at RM100 million per annum (Puan et al., 2011) by damaging the bunches of fresh fruit, destroying shoots and saplings (Woittiez et al., 2016). *Rattus rattus diardii*, *Rattus argentiventer*, *Rattus tiomanicus*, *Rattus tanezumi*, *Rattus exulans*, *Rattus norvegicus*, *Maxomys whiteheadi*, *Sundamys muelleri*, and *Bandicota indica* are listed rat species that frequently infest oil palm plantations (Wooda & Fee, 2003; Rizuan & Noor Hisham, 2015; Nugroho & Santosa, 2018).

Several parasitic infections, including *Ascaris lumbricoides* Linnaeus, 1758; *Trichuris trichiura* Linnaeus, 1771; *Strongyloides stercoralis* Bavay, 1876; *Enterobius vermicularis* Linnaeus, 1758; *Hymenolepis nana* Bilharz, 1851; and *Hymenolepis diminuta* Rudolphi, 1819, have been reported to infect oil palm workers in Malaysia (Sinniah et al., 1978) *H. nana*, *H. diminuta*, and *T. trichiura* were also found in the internal organs of rats in Thailand and Indonesia (Chaisiri et al., 2012; Mamonto & Liu, 2020; Setiati et al., 2021), highlighting the role of rats as a pathogenic reservoir of these parasites. *Rattus* species reported to carry helminth infections such as taeniasis, hymenolepiasis, angiostrongyliasis, and capillariasis, that can be transmitted to humans (Paramasvaran et al., 2009; Ibrahim, 2020; Tijjani et al., 2020). Therefore, the presence of rats in oil palm plantations poses a significant zoonotic risk, especially to plantation workers and nearby residents, who are at higher risk of exposure to these diseases (Frederick & Abdul-Mawah, 2022).

However, there are still lacking studies being conducted on the rats and helminths associated with agricultural fields, mainly in oil palm plantations. Therefore, this study aims to determine the diversity of helminths related with host species of rat that might infect the local community in Sungai Ara, Kota Tinggi. This preliminary study in oil palm plantation might be considered pilot research to understand the potential zoonotic disease that can contribute to helminthiasis data to the Ministry of Health Malaysia.

MATERIALS AND METHODS

Ethical Approval

This study was reviewed and approved by the Institutional Biosafety and Biosecurity Committee Universiti Malaya (UM IBBC); UMIBBC/PA/R/FOS/ISB-025/2023. The animal handling and protocol were permitted by the Institutional Animal Care and Use Committee, Universiti Malaya, Malaysia (UM IACUC) with the ethics reference number S/29102024/31052024-01/R. The Department of Wildlife and National Parks (DWNP) Peninsular Malaysia authorized this study to collect wild samples with permit reference number: JPHLTN.600-6/1/4 JLD2 (194).

Study sites

This study was conducted at Sedili, Kota Tinggi specifically in an oil palm plantation of Sungai Ara, 2°0’35.27”N, 103°51’58.02”E (Fig. 1) which was covered with matured oil palm estimated age between 10-15 years old. This study site has 398 hectares and our trapping points have 4 blocks which are each block present with water bodies, mulches of palm fronds and loam to sandy type soil. Sungai Ara is about 40 km to Gunung Panti Recreational Forest and 46 km to the coastal area of Tanjung Sedili. Several oil palm plantations near Sungai Ara have been reported with serious issues related to rats’ infestation (Nasir et al., 2022). Our study area is near several secondary forests, and the

study blocks are considered a home range for various wildlife animals and are also frequently disturbed by elephants (Zafir & Magintan, 2016; Lim et al., 2017).

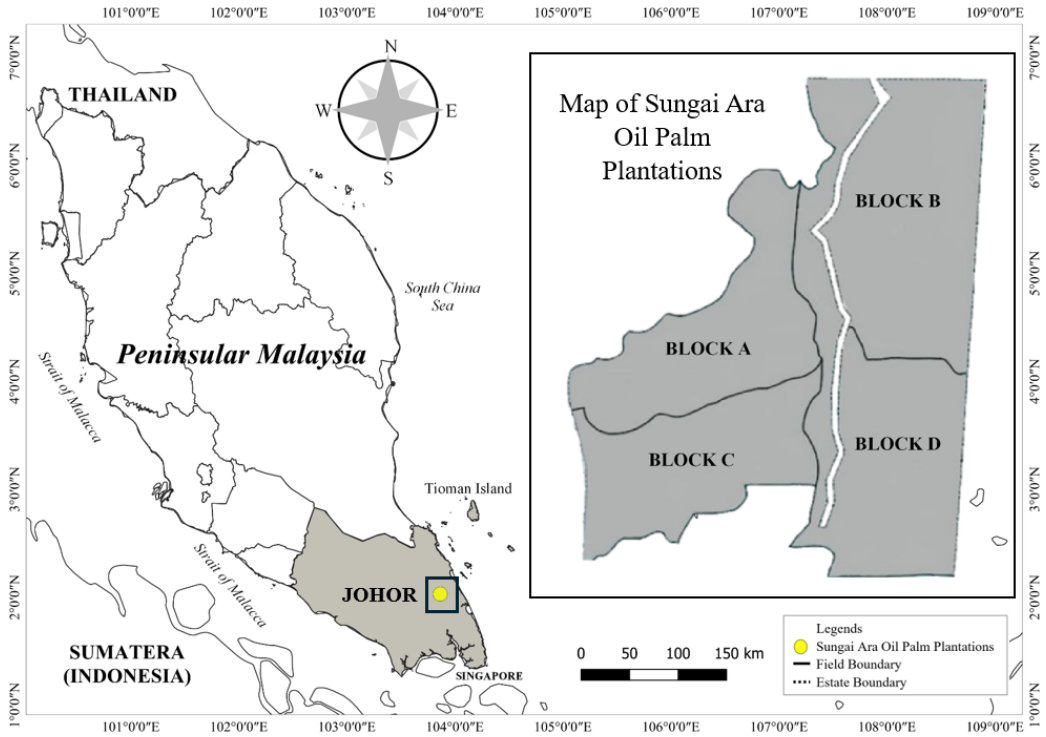

Figure 1. The study area of rats sampling in Sungai Ara oil palm plantation at Kota Tinggi, Johor

Collection and identification of rats

A total of 100 metal live traps sized 28 cm × 15 cm × 12 cm were randomly laid out for 7 days of trapping and the traps were baited with bananas, fresh palm fruit, fried chicken and salted fish. Traps were set up starting from the afternoon and left overnight to avoid any disturbance. The following day, all traps were checked around 10 a.m. and the successfully captured animals were transferred in a white pouch bag for species identification. All the captured rats were humanely euthanized using an Intramuscular (IM) injection of 0.04–0.1 mL Zooletil. The external measurements (in millimetres) such as the length of head to body, tail, hindfoot, forefoot, ear, and body weight (in grams) were measured and recorded (Herbreteau et al., 2011). In addition, videos and photos were captured from various angles such as dorsal, ventral, and lateral, arrangement of mammae, and ridges patterns on the hind foot were recorded for species identification (Francis, 2008; Pimsai et al., 2014).

Collection and identification of endoparasites

All rats' samples were placed on a white dissecting tray with the ventral side facing up. Using surgical scissors, the chest and peritoneal cavity were slit open to expose the heart, lung, kidney, spleen, stomach, small intestine, and large intestine. These organs were immersed separately into a petri dish consisting of 10% Phosphate Buffered Saline (PBS) to remove excess blood that might interfere with the vision during the endoparasite harvest (Herbreteau et al., 2011). The caudal and lateral lobe of the rat's liver were observed to check the presence of cysts the size from 2.0 mm to 8.0 mm and the color performed from white to greyish white. Each of the cysts will only have one larva with a length of about 6−20 centimetres (cm) (Sharma et al., 2017) and rostellum armed

with 19 hooks in the two alternating rows. Next, all stomach contents were gently removed under a dissecting microscope recovered endoparasites were put in 70% labelled ethanol vials and stored at -20 ^{o}C for further identification.

The endoparasite samples were brought back to the parasitology laboratory and temporary mount slides were prepared by dropping lactophenol on the endoparasite specimens for morphological examination. To obtain better observation under the light microscope, some helminth species were temporarily stained by modified Giemsa staining with a mixture of 1:9 of Giemsa solution and 10% PBS. Then, the helminths were immersed in 70% ethanol for 5 to 10 minutes and washed with distilled water. Helminths samples were dried before the mounting slides were prepared by dropping the microscopy lactophenol solution. Grenacher's alcoholic-borax-carmine staining was applied on the cestodes sample to observe the internal structure (Kennedy, 1979). The slides of the endoparasites were observed under a light microscope with magnification 4X, 10X, 100X, and 400X. Identification of cestode and nematode worms were referred to in the taxonomic key and description following Yamaguti (1959) and Yamaguti (1961).

Statistical analysis

We analysed diversity indices of rats and endoparasites such as Shannon-Weiner Equation (H), Simpson's Dominance (D), Evenness (E) and species richness (S) by using R-software (Package: Vegan). Then, Quantitative Parasitology 3.0 (QP3.0) software was used to determine the prevalence rate with 95% Confidence Level (CL) and the mean intensity ± standard error (SE), mean abundance of each host and endoparasite species. In addition, R-software (Package: Bipartite) was run to visualize bipartite graphs showing the relationships between host and protected endoparasite species. One-way Analysis of Variance (ANOVA) with $\alpha = 0.05$ was calculated to observe the significant differences between infection rate and the rat's sexes, ages, and species. Finally, we analysed the distribution of rat-parasite species based on intensity using Principal Component Analysis (PCA) visualized with R-software (Package: FactoMineR).

RESULTS

A total of 74 individual commensal rats were captured which comprised of 6 species from genus *Rattus*. The highest number of species recorded was *R. rattus* (n = 39, 52.7%) followed by *R. tiomanicus* (n = 10, 13.5%), *R. argentiventer* (n = 9, 12.2%), *R. tanezumi* (n=10, 13.5%), *R. exulans* (n = 5, 6.76%), and *R. norvegicus* (n = 1, 1.35%). These numbers account for slightly less male's rats 45.9% (n = 34), compared to female individuals which were 54.1% (n = 40). In terms of ages, adult rats (n = 58, 78.4%) recorded the highest number as compared to subadults (n = 11, 14.9%), and juveniles (n = 5, 6.8%).

The most successful rats trapping was in Block C (n = 24, 32.4%) followed by Block A (n = 22, 29.7%), Block B (n = 17, 22.9%), and Block D (n = 11, 14.9%). However, the diversity indices show that the highest value is in Block A (H' = 1.364, D = 0.732, E = 0.848), meanwhile Block B (H'= 1.149, D = 0.684, E = 0.829), Block C (H' = 0.961, D = 0.533, E = 0.693), and Block D (H'= 0.935, D = 0.636, E = 0.851). This is due to the occurrence of several rat species in this block namely *R. rattus*, *R. tiomanicus*, *R. argentiventer*, *R. tanezumi*, and *R. exulans*. A single species of *R. norvergicus* was recorded in Block D.

A high prevalence of endoparasite fauna infection was recorded (91.9 %, n = 68/74) in the rats' population originated from two phyla (Fig. 2) i.e., Nematode and Cestode. Overall, 1052 individual helminths were collected that comprised 9 genera and 10 species and showed the highest diversity in Block D as compared to other blocks (Fig. 3). Seven species belonging to the phylum Nematoda: *Heterakis spumosa* Schneider, 1886; *Nippostrongylus brasiliensis* Travassos, 1914; *Syphacia muris* Yamaguti, 1935; *Hepatojarakus malayae* Yeh, 1955; *Angiostrongylus* sp.; *Trichuris* sp.; and *Capillaria hepatica* Bancroft, 1893. While 3 Cestode species included Cyst. *Taenia*

taeniaeformis; *H. diminuta* Rudolphi, 1819; and *H. nana* Bilharz, 1851. No trematodes and acanthocephalan were found in this study. The prevalence and mean intensity for each helminth-infected rat species are presented in Table 1.

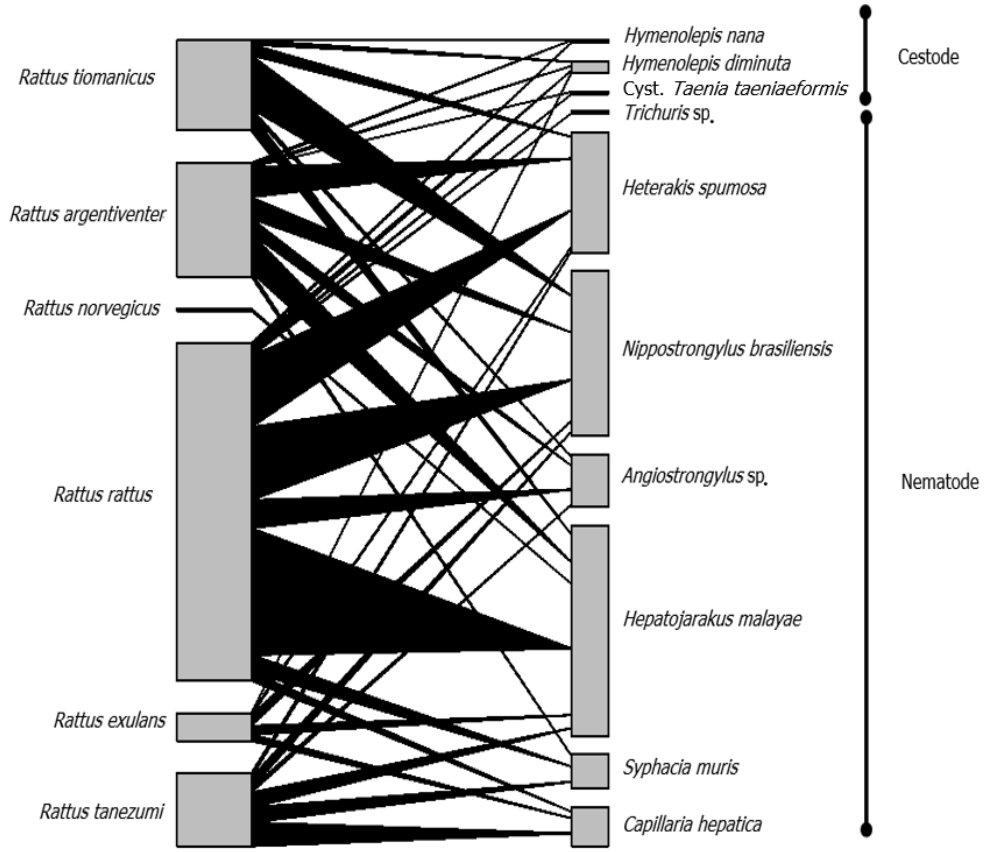

Figure 2. Bipartite graph the correlation between rats-helminths (black arrow) and their intensity (thickness of the box)

Table 1. Prevalence (95%CI), % and mean intensity ± standard error (SE) of helminth infection in each species of rats trapped

Rat species	Helminths Species/Numbers of rats infected (n)	Prevalence (95%Cl), %	Mean Intensity ± SE
Rattus rattus (n = 39)	NEMATODE		
	Heterakis spumosa (n = 15)	38.5 (0.234–0.554)	8.87 ± 2.12
	Capillaria hepatica (n = 4)	10.3 (0.029–0.242)	3.75 ± 1.49
	Angiostrongylus sp. (n = 6)	15.4 (0.059–0.305)	4.67 ± 1.05
	Trichuris sp. (n = 1)	2.6 (0.001–0.135)	2.00 ± 0.00
	Nippostrongylus brasiliensis (n = 9)	23.1 (0.111–0.393)	13.33 ± 1.84
	Syphacia muris (n = 3)	7.7 (0.016–0.209)	7.33 ± 3.38
	Hepatojarakus malayae (n = 28)	71.8 (0.551–0.850)	7.29 ± 1.05
	CESTODE		
	Hymenolepis nana (n = 2)	5.3 (0.006–0.178)	1.50 ± 0.50
	Hymenolepis diminuta (n = 5)	12.8 (0.043–0.274)	2.00 ± 0.32

Rat species	Helminths Species/Numbers of rats infected (n)	Prevalence (95%Cl), %	Mean Intensity ± SE
	Cyst. *Taenia taeniaeformis* (n = 5)	12.8 (0.052–0.267)	1.20 ± 0.20
Rattus tiomanicus (n = 10)	NEMATODE		
	Heterakis spumosa (n = 2)	20.0 (0.023–0.556)	8.50 ± 5.50
	Angiostrongylus sp.(n = 1)	10.0 (0.003–0.445)	2.00 ± 0.00
	Nippostrongylus brasiliensis (n = 4)	40.0 (0.122–0.738)	22.00 ± 7.95
	Hepatojarakus malayae (n = 7)	70.0 (0.381–0.913)	5.00 ± 1.75
	CESTODE		
	Hymenolepis nana (n = 1)	10.0 (0.003–0.445)	1.00 ± 0.00
Rattus argentiventer (n = 9)	NEMATODE		
	Heterakis spumosa (n = 2)	22.2 (0.041–0.558)	13.00 ± 2.00
	Angiostrongylus sp. (n = 4)	44.4 (0.169–0.749)	3.00 ± 1.00
	Nippostrongylus brasiliensis (n = 2)	22.2 (0.041–0.558)	16.50 ± 1.50
	Hepatojarakus malayae (n = 6)	66.7 (0.323–0.902)	10.67 ± 3.04
	CESTODE		
	Hymenolepis nana (n = 1)	11.1 (0.006–0.443)	1.00 ± 0.00
	Hymenolepis diminuta (n = 1)	11.1 (0.006–0.443)	1.00 ± 0.00
	Cyst. *Taenia taeniaeformis* (n = 1)	11.1 (0.006–0.443)	1.00 ± 0.00
Rattus exulans (n = 5)	NEMATODE		
	Hepatojarakus malayae (n = 3)	60.0 (0.189–0.924)	8.67 ± 4.10
	Heterakis spumosa (n = 1)	20.0 (0.010–0.657)	3.00 ± 0.00
	Capillaria hepatica (n = 1)	20.0 (0.010–0.657)	10.00 ± 0.00
	Nippostrongylus brasiliensis (n = 2)	40.0 (0.077–0.810)	9.00 ± 6.00
	CESTODE		
	Hymenolepis diminuta (n = 1)	20.0 (0.010–0.657)	1.00 ± 0.00
Rattus tanezumi (n = 10)	NEMATODE		
	Hepatojarakus malayae (n = 2)	20.0 (0.037–0.554)	7.50 ± 5.50
	Heterakis spumosa (n = 4)	40.0 (0.150–0.790)	3.50 ± 0.96
	Syphacia muris (n = 2)	20.0 (0.037–0.554)	11.50 ± 6.50
	Capillaria hepatica (n = 3)	30.0 (0.087–0.619)	13.33 ± 4.41
	Nippostrongylus brasiliensis (n = 2)	20.0 (0.037–0.554)	8.50 ± 1.50
	Angiostrongylus sp. (n = 1)	10.0 (0.005–0.446)	10.00 ± 0.00
Rattus norvegicus (n = 1)	NEMATODE		
	Hepatojarakus malayae (n = 1)	100.0 (0.05–1.00)	5.00 ± 0.00

In terms of sexes, the overall infection was slightly higher in female rats (n = 37, 53.6%) than male rats, (n = 32, 46.4%). However, there was no significant difference in infection rate between both sexes ($p = 1.062$, $p > 0.05$). In contrast, the ages of rats showed a significant difference in infection rate ($p = 0.00837$, $p < 0.05$) and Tukey-Kramer Post Hoc Analysis showed a significant difference in the adult individual.

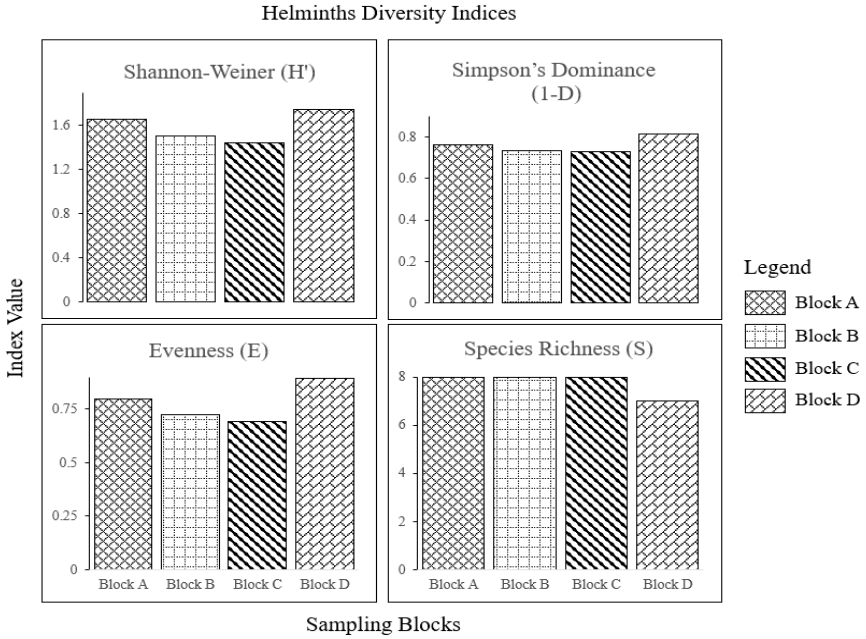

Figure 3. Diversity indices of the helminths infected rats for each block in an oil palm plantation at Sungai Ara

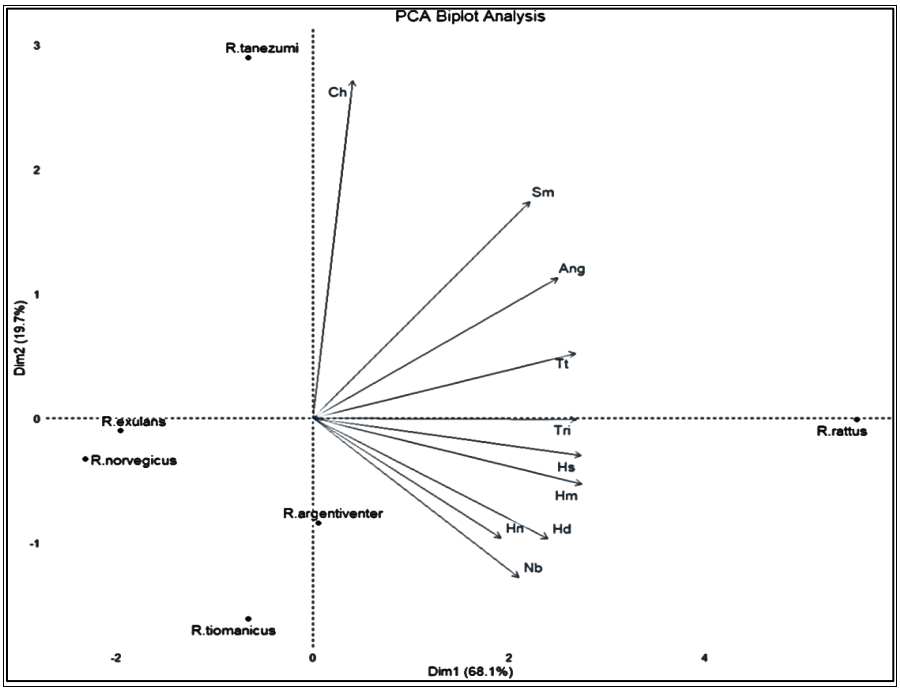

Figure 4. Principal components analysis (PCA) ordination showing parasite species distribution based on intensity among the rat species in Sungai Ara oil palm plantation. Ch: *Capilaria hepatica*, Ang: *Angiostrongylus* sp., Tt: Cyst. *Taenia taeniaeformis*, Tri: *Trichuris* sp., Hs: *Heterakis spumosa*, Hm: *Hepatojarakus malayae*, Hd: *Hymenolepis diminuta*, Hn: *Hymenolepis nana*, Nb: *Nippostrongylus brasiliensis*

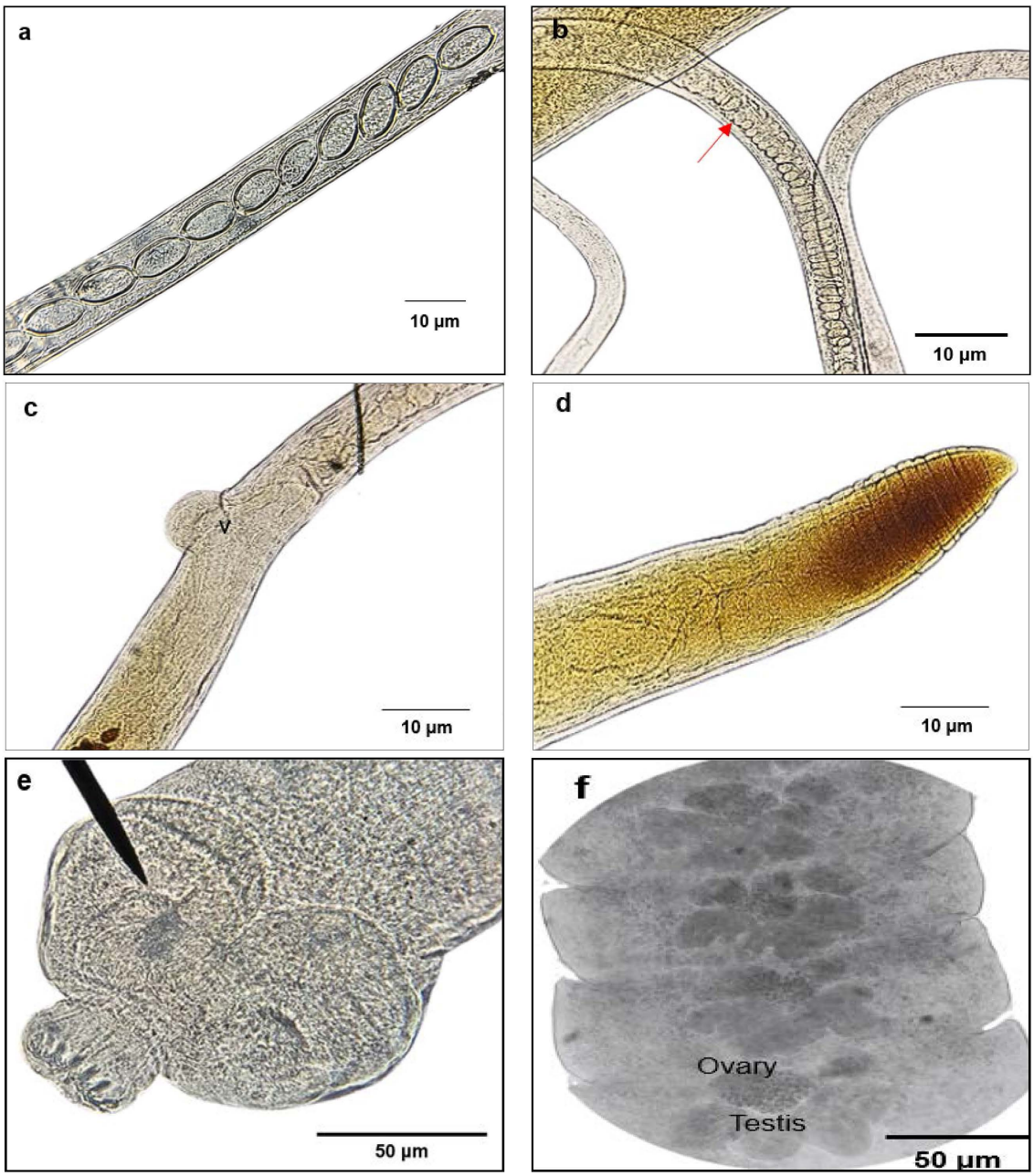

Figure 5. (a–d) *Trichuris* sp.; Female individual body embedded with eggs, Stichosome at the anterior end (red arrow), Vulva region (V), Posterior end with blunt tail; (e–f) *Hymenolepis nana*; Scolex region showing an armed rostellum and suckers, Proglottid with ovary and testis

Meanwhile, the dominant species, *R. rattus*, recorded the highest prevalence between 40.9% to 62.5% for each sampling block. It was also recorded to be infected with all species of helminths giving a total of 568 individuals. In our finding, female *Trichuris* sp. was only recovered from the *R. rattus* intestine. The PCA result of 68.1% (first axis) and 19.6% (second axis) showed *R. rattus*, *R. argentiventer*, and *R. tanezumi*

have a positive correlation with the first axis (Fig. 4). Meanwhile, a strong correlation between *R. tanezumi* and *C. hepatica* also *R. argentiventer* and *N. brasiliensis* as compared to *R. rattus* due to lower intensity was recorded.

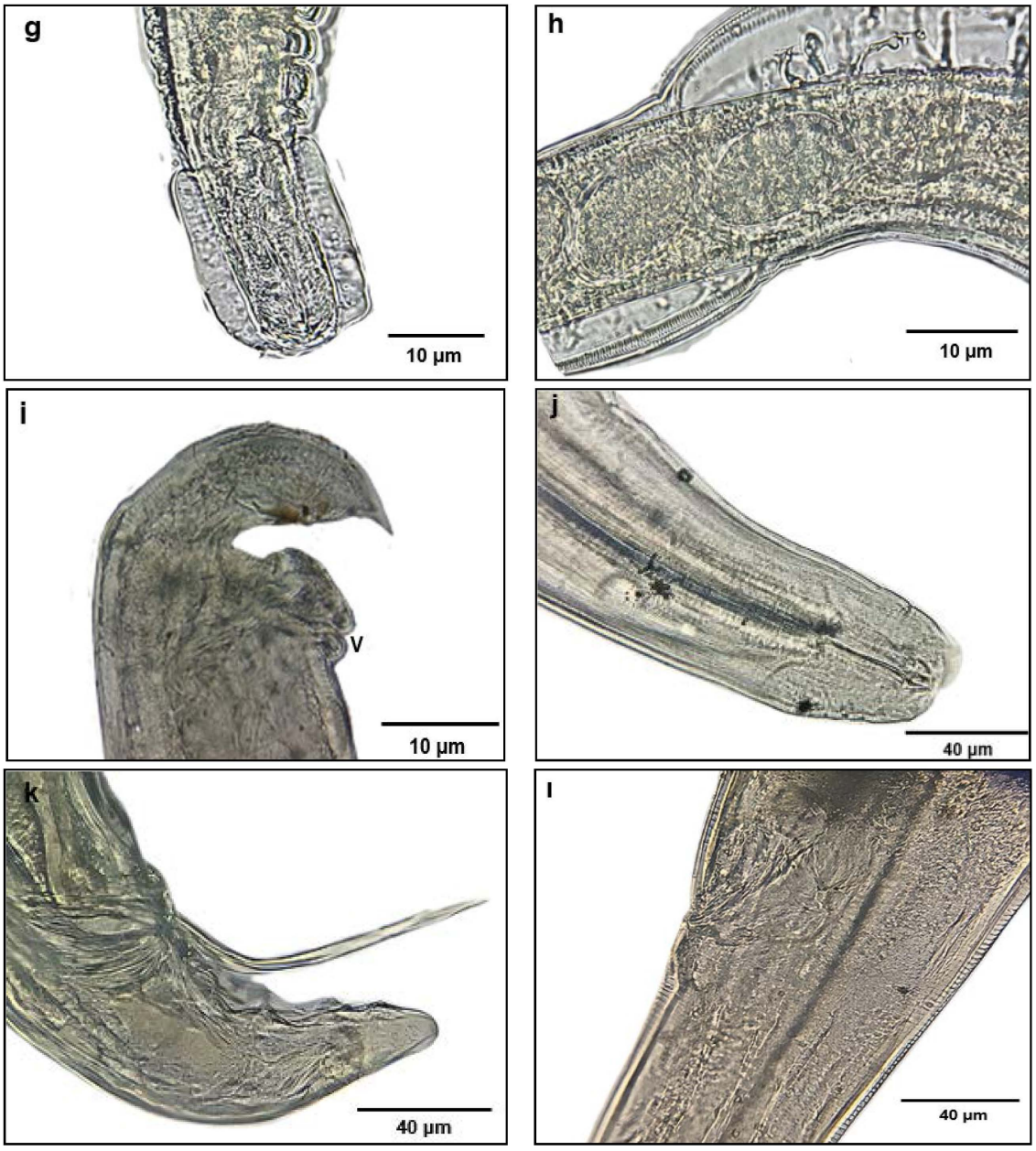

Figure 6. (g–i) *Nippostrongylus brasiliensis*; Head region with the cephalic expansion, Female individual body embedded with eggs, (V) Vulva region; (j–l) *Syphacia muris;* Head structure, Posterior end of male individual with the protruding spicule, Anus region of female individual

Although helminth infections were recorded from various internal organs such as the gastrointestinal tract, lungs, heart, and liver, however, most were also recovered

from the intestine which included *N. brasiliensis*, *H. spumosa*, *S. muris*, *H. diminuta*, and *H. nana*. Other helminths species such as *Angiostrongylus* sp., *H. malayae*, and *C. hepatica* were recovered from the liver, lungs, and heart. Cysts of *T. taeniaeformis* was found on the surface of the liver. However, there were lower intensity than helminths discovered from the stomach and caecum.

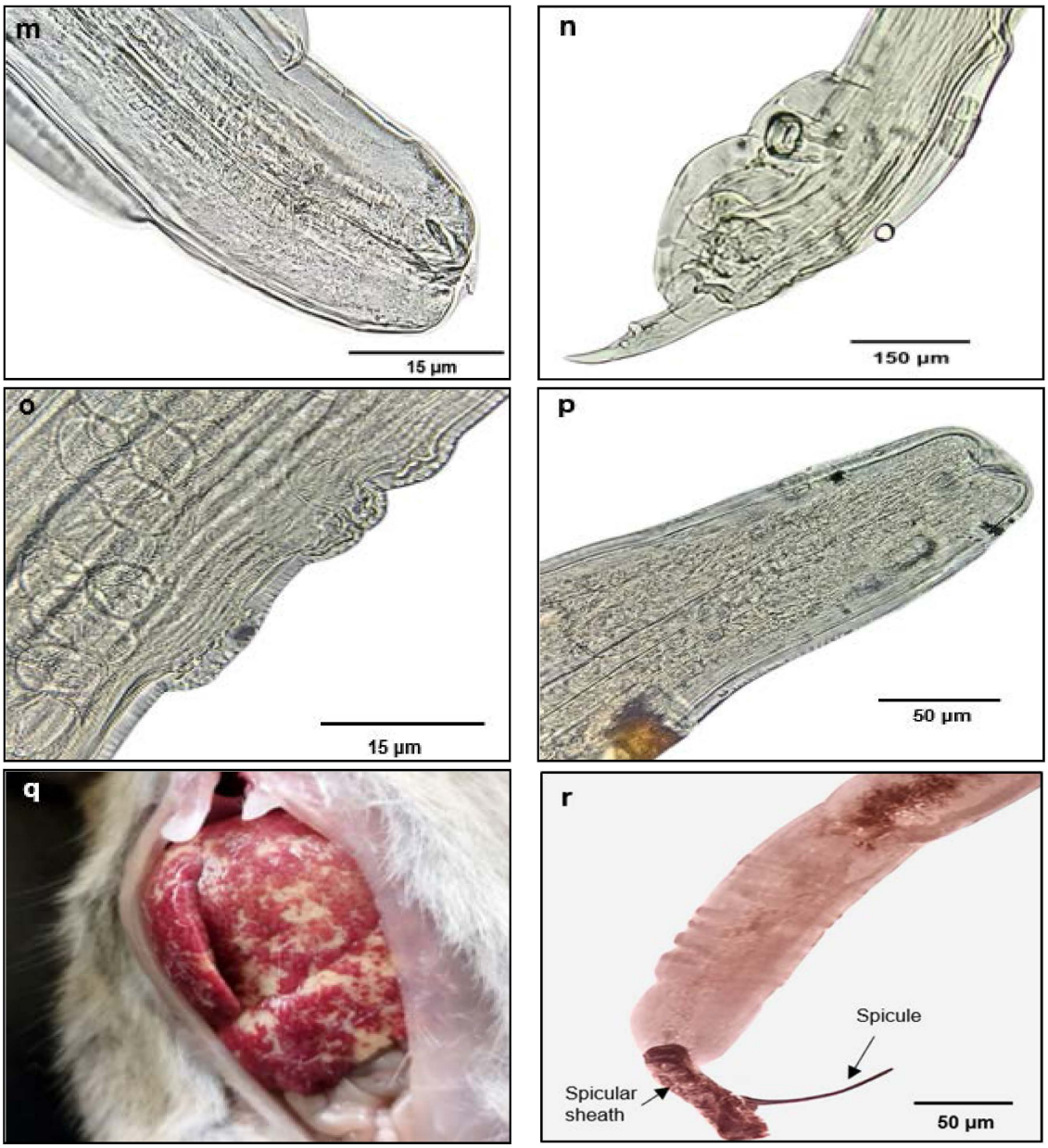

Figure 7. (m–o) *Heterakis spumosa*; Mouthpart, Lateral side of male end with preanal sucker and pairs of papillae, Vulva region; (p–r) *Capillaria hepatica*; Anterior end with simple mouthpart, Dissection of rat's liver revealed the *Capillaria hepatica* infection (yellow lesions on the parenchyma), Posterior male with spicule and specular sheath

H. malayae is the dominant species with an abundance of 5.00 (3.76–6.43) at a 66.2% prevalence rate. In contrast, some of the helminth species were recorded to have a low intensity and prevalence rate such as *Trichuris* sp., *Angiostrongylus* sp., *H. diminuta*, *H. nana*, and Cyst. *T. taeniaeformis*. Although the intensity of the *N. brasiliensis* and *H. spumosa* were the same, their prevalence rate was different. All the helminth morphology found in this study are shown in Figures 5–9.

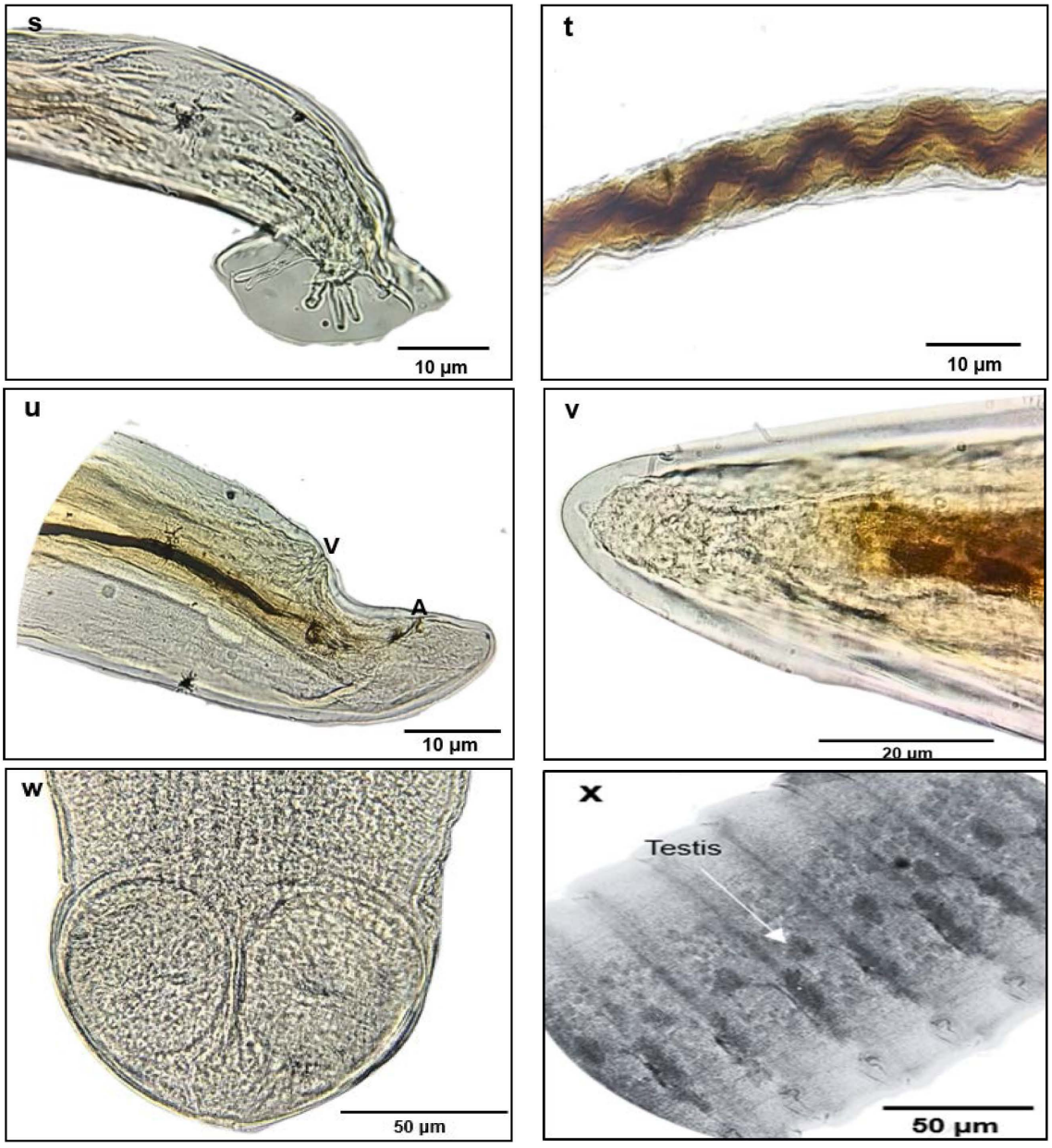

Figure 8. (s–v) *Angiostrongylus* sp.; Male bursa with the bursal rays, Barber-pole pattern along their body, Female tail with vulva (V) and anus (A) region; Female tail; (w–x) *Hymenolepis diminuta;* Scolex with hooks and sucker, proglottid showing testis

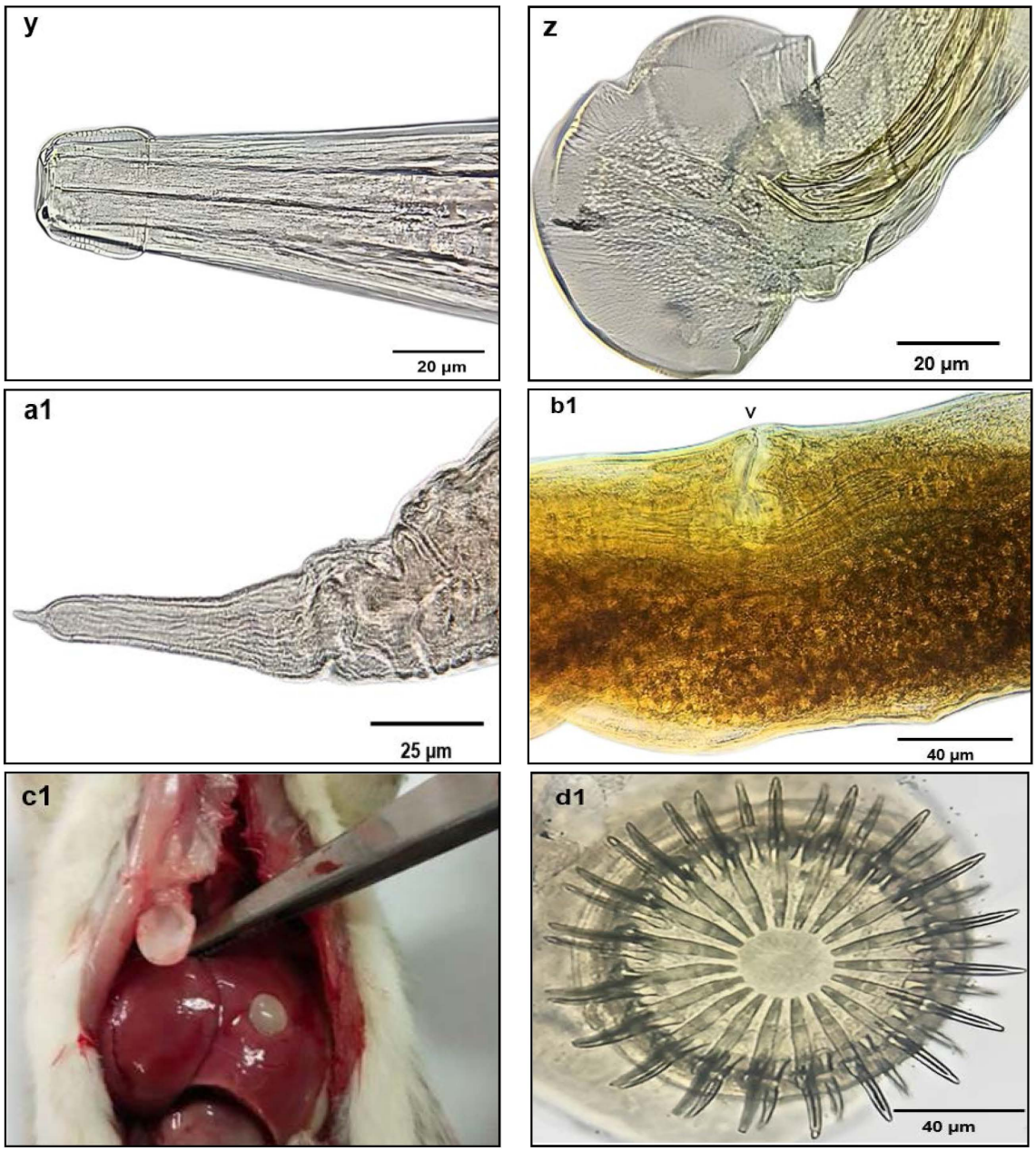

Figure 9. (y–b1) *Hepatojarakus malayae;* The anterior end shows cephalic expansion visible, the posterior end of the male shows the copulatory bursa with spicule present, the posterior end of the female shows an elongated conical tail with terminal spike (V) Vulva region at the posterior half of the body; (c1–d1) Cyst. *Taenia taeniaeformis;* Rostellum armed

DISCUSSION

In Southeast Asia, mainly Indonesia and Malaysia, *Rattus* species are predominantly pest in paddy fields, maize plantations, orchards, and oil palm plantations (Ikhsan et al., 2020; Nasir et al., 2022b; Puan et al., 2011). Apart from reducing crop productivity, rats play a significant role in helminthiasis transmission within the human population

through the infection of nematode, cestode, trematode, and acanthocephalan (Spickett et al., 2020). However, endoparasite in rats was not well-documented in oil palm plantations, even though several studies have been conducted in Malaysia (Lim & Muul, 1970; Ow-Yang, 1971; Krishnasamy et al., 1980; Nursyazana et al., 2013). Therefore, the epidemiology and etiology of particular disease carried by rats and its relationships to helminths in oil palm plantation is poorly understood.

The present study recorded *R. rattus* was the most infected by helminths due to non-selective feeding habits, which preferring to consume intermediate hosts such as beetles and cockroaches (Onyenwe et al., 2009; Ogolla et al., 2019). Therefore, their population is easily exposed to various types of endoparasites. The significant difference of prevalence rate in adult rats was related to their longer life span which increased the exposure duration of being infected. Our results showed nematodes and cestodes have a high prevalence that potentially causes infecting helminthiasis to the residents and workers in this study site. Helminths recovered from the study considered cosmopolitan species as this result also parallels with the endoparasite assessment from different microhabitats which were urban and forest areas by previous studies (Arnez & Mohd Zain, 2006; Mohd-Qawiem et al., 2022; Nursyazana et al., 2013b; Paramasvaran *et al*., 2005; Premaalatha *et al*., 2018). Trematodes and acanthocephalans were not found in this study in which possible their occurrence was influenced by environmental factors and host availability to complete their life cycle (Hancke et al., 2011).

Morphological identification of *Trichuris* sp. and *Angiostrongylus* sp. up to the species level is problematic and challenging. This contributes by the overlapping characteristics which lead to the misidentification. In *Angiostrongylus* sp., species identification is determined by female tail morphology, male spicule's length, and differences in their bursal rays (Yong et al., 2016). However, a recent study revealed that these morphological characteristics were not relevant for identification as molecular approaches are compulsory (Kaenkaew et al., 2024). Besides, there is a lack of morphological studies to compare the *Trichuris* sp. infection in rodents. This is because rats are the definitive host for *T. muris*, however, their population is also reported for *T. trichuria* infection (Upadhyay & Nanware, 2020). This epidemiology also contributes to the species identification uncertainty as the non-specific host is infected.

As the definitive host, humans can become infected with *Hymenolepis* spp. if consuming contaminated insects, water, or food. It is leading to the growth of the tapeworms within the small intestine and causing hymenolepiasis (Sulima-Celińska et al., 2022). The existence of open dumpsites at the study site also contribute to the adaptability of beetles and cockroaches as intermediate hosts to *Hymenolepis* spp. Taeniasis infectious agent, *T. taeniaeformis* was known to be zoonotic in nature (Miyazaki, 1991). Humans can be the accidental hosts through the close relation with domesticated animals such as cats and dogs as the intermediate host in the sampling area might predate on the infected *R. rattus.* Hence, it can cause human cysticercosis as documented in Cambodia (Garin et al., 2005), Sri Lanka and Argentina (Ekanayake et al., 1999). From this study, the workers and residents might be potentially affected by capillariasis through rats' carcasses or barefoot on the soil with their infective eggs. *C. hepatica* lays eggs in the liver of rats parenchyma which 100% of the infection rate is in *Rattus* sp. (Claveria et al., 2005) and to complete its life cycle, no intermediate host is involved. However, other animal wildlife including rats might be affected through cannibalism or predation (Min et al., 2013). Humans as the accidental host can be infected through a fecal-oral route of contaminated food, water, or soil with their embryonated eggs (Kazemi Aghdam et al., 2015).

H. malayae was not reported to be zoonotic in humans. However, it was recorded

as the most dominant species in each sampling block in the Sungai Ara oil palm plantation, probably due to the sandy, muddy and moist soil providing optimal conditions in this oil palm area suitable for hatching their eggs. Ow-Yang (1974) also mentioned that mice will be infected by *H. malayae* through ingestion of larvae on soil or vegetation and maturation occurs in their visceral organs. *H. spumosa, N. brasiliensis, S. muris,* are not reported to be zoonotic to humans.

CONCLUSION

Rats are known to be a serious threat to human health with the transmission of various zoonotic diseases. Therefore, it is recommended that every worker in oil palm plantations should undergo a health examination to check for possible infections other than viruses, fungi, bacteria and protozoa that often refer to rats as the cause of disease. Continuous monitoring (annual or seasonal) is important to identify rodent species as well as the prevalence of macro-parasites that can be carried in oil palm plantations. Further studies should be extended to other oil palm plantations for the development of an integrated pest management strategy. In future works, molecular and morphology studies are needed to identify some species of endoparasites that have the potential to carry diseases that need to be carried out so that the spread of infection can be controlled immediately.

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