HELMINTH INFECTIONS OF TWO ORDERS (RODENTIA AND SORICOMORPHA) OF SMALL MAMMALS FROM EDO STATE, NIGERIA

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OCTOBER, 2O25

CERTIFICATION

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PROF. (MRS). A.A. IMASUEN
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DEDICATION

This work is dedicated to God Almighty who has been my strength.

ACKNOWLEDGEMENT

I give glory to God for his immeasurable help and strength given to aid me throughout the program.

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ABSTRACT

Helminth infections remain an important public and veterinary health concern due to their impact on host populations, zoonotic potential and ecological significance. This study investigated the prevalence, diversity and mean intensity of helminths infecting small mammals (*Mastomys* sp, *Mus musculus*, *Sorex* sp, *Rattus rattus* and *Rattus norvegicus*) from two Local Government Areas of Edo State in order to determine the impact of helminths on host populations, zoonotic potential and ecological significance.

A total of 90 small mammals were captured using Rat Glue Board and Sherman traps baited with smoked fish. The captured small mammals were anesthetized by chloroform and the measurement of the total body length, tail length, hind foot length, head body length and ear length were taken using vernier caliper and recorded in centimeter (to the nearest 0.1cm). The sex of the animal was determined and the weight was also taken using weighing balance and recorded in grams (nearest 0.1g). Standard parasitological techniques were employed to recover, identify and quantify helminth parasites from gastrointestinal tracts, and morphological identification was carried out using established taxonomic keys.

Results show an overall helminth infection prevalence rate of 31.1% (28 out of 90 small mammals were infected). Members of the order Soricomorpha recorded a higher prevalence and mean intensity rates compared to Rodentia. A total of 10 helminth parasites belonging to two taxa: Cestoda and Trematoda were recovered from the small mammalian hosts. Two zoonotic helminthes (*Hymenolepis diminuta* and *Hymenolepis nana*) were recovered in commensal small mammals (*Sorex, Rattus rattus* and *Rattus norvegicus*). Statistical analysis revealed significant variation ($p<0.05$) in infection rates with respect to host species, sex and the two Local Government Areas.

The findings underscore the role of small mammals as important reservoirs of zoonotic helminths in Edo State, Nigeria. This highlights the need for continuous ecological surveillance, improved sanitation and public health education to mitigate potential transmission risks. This study provides essential baseline information for understanding the epidemiology of helminth infections among small mammal populations and their implications for human and animal health within the One Health framework.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Small mammals are a diverse group of warm-blooded vertebrates characterized by their relatively small size, body covering of fur or hair and the presence of mammary glands used to nourish their young. They include several taxonomic groups such as rodents (Rodentia), insectivores (Soricomorpha), bats (Chiroptera) and lagomorphs (Lagomorpha) (Wilson and Reeder 2005).

Small mammals constitute over half of all mammalian species (Walker *et al*., 2007; Napolitano *et al*., 2008). Their small body sizes (6–500 g) allow them to occupy diverse habitats such as caves, burrows and treetops (Akpan *et al.,* 2015). They reproduce rapidly and feed on a wide variety of foods (Reuben *et al*., 2013) contributing significantly to ecosystem balance as prey for many predators and as participants in energy flow within eccosystems.

Their diversity and distribution are influenced by vegetation, climate, predation and human activities (Vieira and de Moraes, 2006; Johnson and Horn, 2008). Among them, rodents (Order Rodentia) form the largest mammalian order with a global distribution, inhabiting habitats ranging from forests to deserts (Musser, 2020). They are identifiable by a pair of chisel-shaped incisors and absence of canines (Carleton, 1984). While they are ecologically important, many species compete with humans for food and damage crops and stored produce (Stenseth *et al*., 2003). Futhermore, rodents transmit several zoonotic pathogens such as *Leptospira*, *Yersinia pestis* and Lassa virus (Meerburg *et al*., 2009).

Helminth parasites are common among rodents and can be transmitted to humans via contact with contaminated food, water or vectors (Ismail *et al*., 2003). Major zoonotic helminths include cestodes (*Hymenolepis nana*), nematodes (*Trichuris trichiura*) and trematodes (*Schistosoma* spp.) (Krauss *et al*., 2003).

Shrews (*Sorex* spp.), due to their predominantly insectivorous diet, often harbor a rich diversity of helminth parasites (Christopher, 1992) compared to herbivorous or omnivorous small mammals. Rats (*Mastomys* spp, *Rattus norvegicus* and *Rattus rattus*) and mice (*Mus musculus*), however, are the most extensively implicated in zoonotic helminth transmission (Shimalov, 2017) due to their commensal behaviour and frequent contact with humans. Species such as *Hymenolepis nana* and *Hymenolepis diminuta* are frequently reported in rodents and are of significant public health concern because of their ability to infect humans (Jawdat and Mahmoud, 1980). Other helminths commonly reported in rodents further highlight the role of these animals as reservoirs and disseminators of parasitic infections.

1.2 AIM AND OBJECTIVES

The aim of the study was to investigate the helminth community and the patterns of infections in small mammals (*Mastomys* sp, *Mus musculus*, *Sorex* sp, *Rattus rattus* and *Rattus norvegicus*) in order to determine the role of rodents as potential reservoirs for zoonotic parasites.

The objectives of this study were to:

1. determine the prevalence and mean intensity of helminth parasite infections.
2. determine the prevalence of helminth parasite infection according to sex.
3. determine the prevalence of helminth parasite infection according to the host age class.
4. determine the prevalence of helminth parasite infection according to location.

1.3 JUSTIFICATION FOR THE STUDY

In Nigeria, studies on helminth infections of small mammals are relatively limited, with available information being scanty in many regions, including Edo State. (Akinboade *et al.,* 1981 Udonsi 1989; Ugbomoiko and Obiamiwe 1991; Mafiana *et al.,* 1997; Ajayi *et al.,* 2006; Clement *et al.,* 2018). Rapid population growth, urbanization and habitat fragmentation have increased human-animal interactions, thereby enhancing the potential for parasite transmission between wildlife, domestic animals and humans.

Therefore, this study is focused on comprehending the diversity and prevalence of helminths fauna of small mammals in two local government areas of Edo state.

CHAPTER TWO

LITERATURE REVIEW

2.1 BIODIVERSITY OF SMALL MAMMALS IN NIGERIA

Iyawe (1989), reported a total of 392 species of small mammal belonging to five families of rodent and four families of shrews in Ogba Forest Reserve in Nigeria. Similarly, Hutterer *et al.* (1992), studied small mammals from forest islands of Eastern Nigeria and adjacent Cameroon, where they encountered five species of Insectivora (Soricidae); *Sylvisorex megalura, Sylvisorex camerunensis, Sylvisorex ollula, Crocidura attila* and *Crocidura olivieri*, as well as ten species of Rodentia (Muridae); *Grammomys rutilans, Hylomyscus stella, Lemniscomys striatus, Lophuromys sikapusi, Mastomys sp., Mus musculoides, Mus setulosus, Otomys occidentalis, Praomys* cf. *jacksoni* and *Praomys hartwigi obscurus*.

Anadu (2006), conducted a preliminary survey of small mammals in the montane forest of Obudu plateau in Cross River State, Nigeria and reported that rodents accounted for 75% and shrews 22% of the total mammal population. Likewise, Akpan *et al.* (2015), surveyed the checklist and abundance of small mammals in Idu, Akwa Ibom State, Nigeria and reported seven (7) species of small mammals belonging to three (3) orders: Rodentia, Carnivora and Pholidota. The low abundance and diversity index were attributed to deforestation, habitat loss, hunting and other anthropogenic activities.

In a recent study, Omogbeme and Oke (2018) investigated the population dynamics of rodents and insectivores in the lowland tropical rainforest ecosystem of Okomu National Park, Edo state, Nigeria and recorded 737 individuals (680 rodents and 57 insectivores) across dry and wet seasons, comprising 17 rodent species and 3 insectivore species. Isaac *et al.* (2018), also surveyed the endoparasites of small mammals in Edo State, Nigeria along with their public health implications. Six genera of small mammals were recorded; *Apodemus* sp., *Crocidura* sp., *Mastomys natalensis, Mus musculus, Rattus* sp. and *Sorex* sp.

2.2 HELMINTH PARASITIC INFECTIONS OF SMALL MAMMALS

Several studies have investigated the helminth parasites of small mammals across different parts of the world, including Nigeria. Haukisalmi, V. (1989), examined the intestinal helminth communities of *Sorex* shrews (*S. araneus*, *S. caecutiens* and *S. minutus*) in Finland and reported 23 helminth species comprising 4 trematodes, 14 cestodes and 5 nematodes, with cestodes of *Hymenolepis* species being the dominant. Similarly, Mafiana *et al*. (1997) identified three cestode species (*Hymenolepis diminuta, Taenia taeniaeformis* (cyst) and *Raillietina* sp.), three nematodes (*Mastophorus muris, Trichuris muris* and *Syphacia* sp.) and one acanthocephalan (*Moniliformilis moniliformilis*) from 612 black rats in Abeokuta, South-West Nigeria.

Binkien, R. (2006), reported 34 species of helminths (5 trematodes, 15 cestodes and 14 nematodes) in two Sorex species (*S. araneus* and *S. minutus*) in Lithuania. In the USA, Kinsella, (2007) examined helminths of Vagrant shrews and identified 19 helminth species (1 trematode, 11 cestodes, 7 nematodes) from 45 *Sorex vagrans*. In this particular study was the first record of merocercoids of *Paruterina candelabraria* from a shrew (*Suncus etruscus*), and the first report of the genus *Paracrenosoma* in North America. Kinsella *et al*. (2008), later reported eight helminth species (6 cestodes, 2 nematodes) from 30 *Sorex cinereus*, including three new hosts records (*Lineolepis lineola*, *Staphylocystoides serrula*, *Soricinia pulchra*).

In Nigeria, Okoye and Obiezue (2008), identified six intestinal helminthes in rodents from Nsukka ecological zone and reported 2 cestode species (*Hymenolepis* sp. and *Raillietina* sp.), 3 nematode (*Trichuris muris*, *Ascaris* sp., *Cyathostomum* sp.), and one Acanthocephalan (*Moniliformis moniliformis*).

Similarly, studies in other regions revealed various species compositions: in Serbia, Kataranovski *et al*. (2011), reported seven helminths in *Rattus norvegicus*; in India, Sharma *et al*. (2012), found six species in *Rattus rattus* and *Mus musculus*; in Malaysia, Shafiyyah *et al*. (2012), recorded four intestinal helminths and one blood parasite among wild rats; in South-East Asian region, Pakdeenarong *et al.* (2014), recovered 19 species of parasites (2 trematode, 3 cestode and 14 nematode species) from 404 rodents noting that some (*Echinosoma malayanum, Raillietina* spp*, Hymenolepis diminuta* and *Hymenolepis nana*) have zoonotic importance while Meshkekar *et al*. (2014), reported five helminths in *Rattus rattus* and *Rattus norvegicus* in Tehran, Iran..

In Ile-Ife, Nigeria, Ogunniyi *et al.* (2014), recovered two ectoparasites (*Xenopsylla cheopis* and *Laelaptid mite*), five helminth genera (*Moniliformis, Hymenolepis, Taenia, Trichuris* and *Trichinella*) and seven protozoan genera (*Amoeba, Dientamoeba, Entamoeba, Retortamonas,* *Trichomonas, Chilomastix* and *Trypanosoma*) from house rats. Ayinmode *et al*. (2016), identified cestodes, nematodes and protozoans from 246 rodents in Ibadan while Paul *et al.* (2016), reported *H. diminuta* and two ectoparasites (*Ctenocephalides canis* and *Polypax spinulosa*) in domestic rats in Maiduguri.

Subsequent studies globally and locally have documented a wide range of helminths in small mammals. Shimalov (2017), recorded six species (1 trematode, 3 cestodes and 2 nematodes) in *R. norvegicus*; Rufai and Olagunju (2017), identified nine gastrointestinal parasites in *R. rattus* in Osogbo; and Tabu *et al.* (2017), reported 15 helminth taxa (3 trematodes, 11 nematodes and 1 cestode) from rodents and shrews in Congo and amongst them were six new host records (*Apophallus* spp., *Fasciola hepatica, Toxascaris* spp., *Physocephalus* spp., *Ancylostoma* spp., and *Syngamus* spp.). Arzamani *et al.* (2017), found 13 helminth species in rodents from Iran, while Fitte *et al.* (2017), recorded *Hymenolepis diminuta* and *Rodentolepis nana* in urban rodents in Argentina.

In Nigeria, Isaac *et al*. (2018), identified 12 helminth taxa from 502 small mammals in Edo State, with *Strongyloides* sp. and *Heterakis spumosa* being most prevalent. Houéménou *et al*. (2018), reported nine helminth species from Cotonou, Benin, with *Moniliformis moniliformis* and *Hymenolepis diminuta* dominant. Rahman *et al.* (2018), documented six helminth species in *Suncus murinus* in Bangladesh with the dominant being *Hymenolepis* spp. More recent studies (Ibrahim, 2020; Abdullahi and Tijjani, 2020; Tijjani *et al*., 2020; Islam *et al*., 2020; Mohtasebi *et al*., 2020) have further confirmed the diversity and zoonotic significance of helminths in rodents and shrews across regions, including *Hymenolepis nana, H. diminuta, Strongyloides* spp., *Capillaria* spp., *Trichuris* spp. and *Taenia taeniaeformis*.

Recent investigations also highlight regional variations: Abdullahi and Mamman (2021), recovered *Hymenolepis* sp. and *Plasmodium vivax* from African giant rats in North-Eastern Nigeria, while Sasaki *et al*. (2021) documented 10 cestode species (*Hymenolepis* sp.1, *Hymenolepis* sp.2, *Arostrilepis* sp., *Microsomacanthus* sp., *Catenotaenia* sp. *Raillietina* sp., Taenia *crassiceps, Hydatigera taeniaeformis* Larva, *Paranoplocephala kalelai* and *Echinococcus multilocularis*) in murid rodents from Japan, among which were three new locality records (*Arostrilepis tenuicirrosa*, *Paranoplocephala kalelai* and *Taenia crassiceps*). Benatti *et al.* (2021), listed 15 helminth species (*Rodentolepis akodontis, Angiostrongylus sp., Protospirura* *numidica criceticola, Trichuris navonae, Syphacia alata, Syphacia criceti, Syphacia evaginata, Trichofreitasia lenti, Stilestrongylus aculeata, Stilestrongylus eta, Stilestrongylus gracielae, Stilestrongylus franciscanus, Stilestrongylus moreli, Stilestrongylus* spp., and *Pentastomida gen*. spp.) from rodents in the Atlantic Forest of Brazil, with several representing new host and locality records. Mohd-Qawiem *et al.* (2022), Grandón-Ojeda *et al.* (2022), Khan *et al*. (2022), and Onah and Umeike (2022), also recorded diverse gastrointestinal helminths, particularly, *Hymenolepis diminuta*, *Hymenolepis nana*, *Trichuris muris* and *Taenia* spp., reinforcing the global and zoonotic significance of rodent and shrew helminth infections

2.3 MEDICALLY IMPORTANT TAPEWORM SPECIES FOUND IN SHREWS AND RATS

Among tapeworms belonging to the genus *Hymenolepis*, three species are medically relevant and globally distributed in regions where murid rodents occur: *Hymenolepis nana*, *Hymenolepis diminuta* and *Hymenolepis microstoma* (Dujardin, 1845; Blanchard, 1891; Cunningham and Olson, 2010; Meshkekar *et al.,* 2014).

Hymenolepis (= Rodentolepis) *microstoma*, the mouse bile duct tapeworm, has a wide range of hosts including mice (Hopkins *et al*., 1977), rats (Goodall, 1972), hamsters (Bogh *et al*., 1986), voles (Litchford, 1963), gerbils (Schmidt, 1986) and shrews (Jarošová 2020). It requires an intermediate insect host, usually a tenebrionid beetle such as *Tribolium* or *Tenebrio*, for cysticercoid development (Bogh *et al.,* 1986; Smyth and Wakelin, 1994). However, a direct life cycle has been demonstrated in immunodeficient mice (Andreassen *et al.,* 2004).

The zoonotic potential of this tapeworm (*Hymenolepis microstoma*) was highlighted by Macnish *et al*. (2003), who reported mixed infections of *Hymenolepis nana* and *Hymenolepis microstoma* in four humans in Western Australia. Similarly, *H. diminuta* infections have been documented in humans in Iran (Meshkeker *et al.,* 2014), particularly among children, where it sometimes causes gastrointestinal disorders.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Ethics Statement

Ethical clearance was obtained from the Faculty of Life Sciences, University of Benin, Nigeria (FLSRE-2023-017).

3.2 Study Area

The study was carried out from January 2022 to March 2023. The study area encompasses two Local Government Areas of Edo State which are both tropical biotopes; Ovia North East (Iguosa Housing Estate) with a coordinate of 6° 26'21" N and 5° 35'51" E and Uhunmwonde (Egba market) of 6° 35'48" N and 6° 0'40" E coordinates.

The average temperature in the 2,301 square kilometres Ovia North East Local Government Area (LGA) is 28°C with a humidity of 52%. There are two distinct seasons in the LGA: the rainy season and the dry season. Here, crops like maize, sugarcane, cassava, bananas, oil palm, and plantains are grown. This area is also home to banks, hotels, industries, and both privately and publicly owned establishments. Trade, lumbering, and craft production are some of the other significant economic activities that take place in this LGA.

Uhunmwonde Local Government Area (LGA) covers a total area of 2,033 square kilometres and has an average temperature of 27°C with a humidity of 52%. The LGA is well forested, has a number of streams and rivers and also, hosts the Egor Forest Reserve. Trade is an important economic activity in this area. This LGA also has a vibrant agricultural sector and is recognized for the cultivation of crops such as pineapples and plantains. Other economic activities here include lumbering, food processing and animal rearing.

3.3 Rationale for the Choice of Study Area

Ovia North East and Uhunmwode Local Government Areas of Edo State were selected as the study area based on their ecological revelance and suitability for investigating helminth infections in small mammals. These areas are characterized by diverse habitats, including secondary forests, farmlands and human settlements, which support rich populations of rodents and shrews known to serve as hosts for various helminth parasites. Both areas are also relatively accessible, ensuring ease of sampling and transportation of specimens, while maintaining adequate safety for field operations. Overall, the choice of Ovia North East and Uhunmwode Local Government Areas was informed by their ecological diversity, accessibility and relevance to the research objectives of assessing helminth parasitic infections among small mammals in Edo State, Nigeria.

3.4 Sampling Locations

A total of 10 sampling locations were utilized; 6 in Ovia North East and 4 in Uhunmwonde LGAs. The sampling locations were selected based on the presence of vegetation cover or nearness to refuse dump (both around human dwellings). Market places, houses and bushes close to human habitations were selected to be the points of rodent capture.

3.5 Rodent and Shrew Trapping

Animals were captured using Sherman traps baited with smoked fish and Rat Glue Board. A total of 90 small mammals were trapped and used in the study. The sample size was determined by the trapping success. Trapping of small mammals were carried out inside houses and in peri-domestic areas using Rat Glue Board and Sherman live traps respectively. The traps were positioned at the site of small mammals' activities (holes, runs, logs, etc.) and set up few meters away from each other and then checked in the mornings. The traps were set in the evenings to increase capture rates as the animals usually go out at that time to forage for food and were checked as early as possible in the morning between 5am and 7am to reduce the stress of capture (Mills *et al.,* 1995).

3.6 Sex Determination of Rodents

Carraway's standard guidelines were used to determine the sex of shrews (Carraway 2009). Males have a longer anogenital distance than females and in addition, sexually mature females have prominent nipples (mammae) which are arranged along the ventral surface (Happold, 2013).

3.7 Rodent and Shrew Collection

Small mammals (rodents and shrews) that had been captured were transported to the Laboratory of Parasitology in the Department of Animal and Environmental Biology (University of Benin), and were anesthetized by chloroform. Standard guidelines developed by Booth (1960), Rosevear (1969), Hutterer and Happold (1983), Happold (1987), and Kingdon (1997) were used for identification. Using a vernier calliper, the lengths of the head, tail, hind foot, ears, and entire body were measured and recorded in centimetres (to the nearest 0.1 cm). A weighing balance was also used to take the weight, which was then recorded in grammes (about 0.1 g).

Individuals were classified as either adults (≥70g) or sub-adults (≤70g females, ≤80g males; females, males weighing more than 80g) (Panti-May *et al*. 2012). Adults (≥70g females, ≥80g males) or sub-adults (≤70g females, ≤80g males) were the two classifications given to the individuals (Panti-May *et al*., 2012). Adults (≥70g females, ≥80g males) or sub-adults (≤70g females, ≤80g males) were the two classifications given to the individuals. Adults (≥70g females, ≥80g males) or sub-adults (≤70g females, ≤80g males) were the two categories into which the individuals were divided (Panti-May *et al*. 2012).

Black rat individuals were categorised as either sub-adults (females ≤70g, males ≤80g) or adults (females ≥70g, males ≥80g) (Panti-May *et al*., 2012). Individuals of Mastomys sp. were categorised as juveniles (>10g), sub-adults (13-19g), or adults (20g). Depending on whether secondary sexual traits were present or absent, shrews were classified as juveniles or adults.

3.8 Isolation of Parasites

Using scissors, the gastro-intestinal tract of each animal was removed, having opened the abdominal cavity. The tract was cut into different organs (stomach, small intestine, large intestine and rectum) and each part was dissected and put into petri-dishes containing 0.85 ml normal saline and dissected. The contents were thoroughly examined for the presence of helminth parasites under a dissecting microscope (the smallest tapeworms in shrews hardly reach 1mm in length). After a brief washing and relaxing, the isolated parasites were transferred to 5% formo-saline. The tapeworms and trematodes were stained by Acetocarmine technique as described by Georgiev *et al.* (1986), and were mounted in Canada balsam.

3.9 Identification of Parasites

The helminthes were identified to the level of genus and species using standard helminthological keys (Yamaguti 1961; Anderson *et al.,* 2009 and Jones *et al.,* 2005).

3.10 Staining of Parasites

Following conventional helminthological techniques, cestodes and trematodes were washed free of preservative (70% alcohol and 5% formol-saline respectively) in several changes of tap water and then stained overnight in dilute solution of acetocarmine. The stained specimens were dehydrated in alcohol series (50, 70, 90 and 100%), cleared in xylene and permanent mounts were made in Canada balsam (Aisien *et al.,* 2001, 2003) for identification and measurement

3.11 Statistical Analysis

The raw data was appropriately documented using SPSS and MS Excel 2013. The Chi-square (λ2) test was used to determine correlations between variables like sex, age, physical characteristics, and parasitisation. The threshold for statistical significance was $p<0.05$.

The arithmetic mean was used to determine the average values of various parameters such as the number of parasites per host, body weight of animals and the prevalence of infection across study sites. The Arithmetic Mean Formula is used to determine the mean or average of a given data set. The symbol used to denote the arithmetic mean is 'x̅' and is read as x bar. The arithmetic mean of the observations is calculated by taking the sum of all the observations and then dividing it by the total number of observations.

$$\overline{X} = \frac{\text{sum of all the observations}}{\text{number of observations}} \quad \overline{X} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

It can also be expressed as:

$$\overline{X} = \frac{\sum x}{n}$$

Opara and Fagbemi's (2008) formula was used to calculate the mean worm load. By dividing the total number of rodents in a given area that tested positive for that parasitic taxon by the number of worms for each taxon found in the rodents, the mean worm load for each taxon was calculated. The number of each worm taxonomic species discovered was divided by the total number of rodents analysed in a given region to calculate relative abundance. By dividing the total number of worms discovered in that region by the total number of rodents examined in that same region, the overall relative abundance was calculated.

The mean intensity of parasites and the prevalence (percentage) of infected hosts were calculated using the formulas outlined in Bush *et al*. (1997) and are provided below:

$$\text{Prevalence of hosts infected} = \frac{\text{Number of hosts infected}}{\text{Total number of hosts examined}} \times 100$$

$$\text{Mean intensity} = \frac{\text{Number of parasites (particular species)}}{\text{Number of hosts infected (particular host species)}}$$

CHAPTER FOUR

RESULTS

4.1 Small Mammals' Fauna

Ninety (90) specimens of small mammals belonging to the class Rodentia were captured, identified and examined for helminth parasites. The small mammals belonged to two (2) orders, two (2) families, four genera and five (5) species. The orders are Rodentia and Eulipotyphla. The families include Muridae and Soricidae (Table 4.1). Species representing these families are as follows: *Rattus norvegicus* (Plate 4.1), *Mus musculus* (Plate 4.2), *Sorex* sp (Plate 4.3), *Mastomys* sp (Plate 4.4) and *Rattus rattus* (Plate 4.5).

Of the total number of small mammals examined, 14 were *Rattus norvegicus* (Plate 4.1), 32 were *Mus musculus* (Plate 4.2), 19 were *Sorex* sp (Plate 4.3), 15 were *Mastomys* sp (Plate 4.4) and 10 were *Rattus rattus* (Plate 4.5).

4.2 Distribution and Diversity of Small Mammals Collected

The small mammals were collected from Ovia North-East and Uhunmwode Local Government Areas. The specimens from Ovia North-East LGA were mainly collected from bushes and within houses while those from Uhunmwode were caught from the Egba Junction market. The *Sorex* sp examined from Ovia North-East were caught from the bushes; none were found within houses while *Mastomys* sp and *Mus musculus* were found in houses inhabited by humans. The summary of information on the mammalian host, locality, number of males and females sampled is given in table 4.2.

4.3 Helminth Parasitic Infection of the Small Mammals Encountered at Ovia North East and Uhunmwode

This study showed that, out of 90 small mammals encountered and examined during the study period, 28 small mammals were infected with an overall prevalence of 31.11%. The prevalence of helminth parasites was higher in adults (39.7%) than in young small mammals (15.6%) (Table 4.3). Ten (10) helminth parasites belonging to two taxa; Cestoda and Trematoda were recovered from the small mammals.

Table 4.1: Mammalian Species Sampled from Ovia North East and Uhunmwode

Family/Genus	Species
Muridae	
Mus	*Mus musculus*
Mastomys	*Mastomys* sp.
Rattus	*Rattus rattus*
	Rattus norvegicus
Soricidae	
Sorex	*Sorex* sp.

FAMLY MURIDAE

Plate 4.1: *Rattus norvegicus* caught from Uhunmwode LGA (Egba junction market)

Scale Bar: 10 mm

Plate 4.2: *Rattus rattus* caught from Uhunmwode LGA (Egba junction market)

Scale Bar: 10 mm

Plate 4.3: *Mus musculus* caught from Uhunmwode LGA (Egba junction market)

Scale Bar: 10 mm

Plate 4.4: *Mastomys* sp. caught from Ovia North-East LGA (within houses)

Scale Bar: 10 mm

FAMILY SORICIDAE

Plate 4.5; *Sorex* sp. caught from Ovia North-East LGA (bush)

Scale Bar: 10 mm

Table 4.2: Mammalian Host, Locality, Number of Males and Females Caught during the Survey from Ovia North East and Uhunmwode

LGA	Host	Number of Male	Number of Female	Total
Ovia North-East				
Bush	*Sorex* sp	11	6	17
Within houses	*Mastomys* sp	12	3	15
	Mus musculus	16	6	22
Uhunmwode				
Market	*Mus musculus*	9	1	10
	Sorex sp	2	0	2
	Rattus rattus	7	3	10
	Rattus norvegicus	13	1	14
TOTAL		70	20	90

Table 4.3: Overall Prevalence of Gastrointestinal Helminths of Small Mammals Caught in Relation to Sex and Age from Ovia North East and Uhunmwode

Variable	Number Examined	Number Infected	P(MI±SD)	95% CI
Sex				
Male	72	22	30.6 (34.7 ± 50.5)	23 – 46.4
Female	18	6	33.3(139.5±300.3)	0.8 –278.2
Age				
Young	32	5	15.6 (39 ± 23.9)	30.7 – 47.3
Adult	58	23	39.7 (61.1 ±147.8)	40.8 – 81.4
Overall	**90**	**28**	**31.1**	

P = prevalence; MI= Mean intensity; SD = Standard deviation; CI = Confidence Limits

The helminth parasites recovered from these small mammals and their sites of infection are presented in Table 4.4. The parasites included one trematode; *Platynosomum concinnum* (Plate 4.16) and seven cestode species; *Hymenolepis diminuta* (Plate 4.6), *Hymenolepis nana* (Plate 4.7), *Hymenolepis* sp. 1 (Plate 4.8), *Hymenolepis* sp. 2 (Plate 4.9 and 4.10), *Taenia* sp. 1 (Plate 4.11), *Taenia* sp. 2 (Plate 4.12), *Taenia* sp. 3 (Plate 4.13), Undetermined specimen sp. 1 (Plate 4.14) and Undetermined specimen sp. 2 (Plate 4.15).

4.4 Distribution of Gastrointestinal Parasites amongst Small Mammals Examined from Ovia North East and Uhunmwode

The distribution of gastrointestinal parasites is shown in Table 4.5. *Mastomys* sp. examined, had 0% prevalence as none was found infected with any helminth species. *Sorex* sp. examined, had 100% (19/19) prevalence with 100% (19/19) positive for cestodes and 10.5% (2/19) positive for trematodes. *Mus musculus* had 3.13% (1/32) prevalence with 3.13% (1/32) positive for cestodes and none for trematodes (0.0%). In *Rattus rattus,* there was 40% (4/10) prevalence with 40% (4/10) positive for cestodes and none for trematodes (0.0%). *Rattus norvegicus* had 28.57% (4/14) prevalence with 28.57% (4/14) positive for cestodes and none for trematodes 0(0.0%).

The mean intensity of cestode infection was highest in *Sorex* sp. (81.95) while *R. rattus* is second highest with a mean intensity of 5.75, followed closely by *R. norvegicus* with mean intensity of 4.25, then *Mus musculus* has a mean intensity of 3.0. *Mastomys* sp. has zero mean intensity as no parasite was found in the *Mastomys* sp. dissected in the course of the research (Table 4.5). For trematode infection, the only mean infection recorded was that of *Sorex* sp. (190) as it was the only species infected with a trematode in this study (Table 4.5).

4.5 Morphometric Measurement of the Small Mammals Sampled at Ovia North-East and Uhunmwode LGAs

The overall means of body weight and other external morphometric observations are recorded in the Table below (Table 4.6). The ninety small mammals caught comprised of 15 *Mastomys* sp., 19 *Sorex* sp., 32 *Mus musculus*, 10 *Rattus rattus* and 14 *Rattus norvegicus.* The average body weight was variable among the five species (18.41 ± 13.2gm, 48.96 ± 11.26gm, 119.07 ± 58.81gm, 214.72 ± 80.85gm and 23.99 ± 8.95gm for *Mastomy*s sp., *Sorex* sp., *Mus musculus*

Table 4.4: Helminth Parasites Recovered from Small Mammals and their Predilection Sites Sampled from Ovia North East and Uhunmwode

Helminth Parasites	Host	Predilection Site
Hymenolepis diminuta	*Rattus norvegicus*	Small intestine
	Rattus rattus	"
Hymenolepis nana	*Rattus rattus*	Small intestine
	Sorex sp	"
Hymenolepis sp. 1	*Sorex* sp	Small intestine
Hymenolepis sp. 2	*Sorex* sp	Small intestine
Taenia sp. 1	*Rattus rattus*	Small intestine
	Rattus norvegicus	"
Taenia sp. 2	*Mus musculus*	Small intestine
	Rattus rattus	"
	Rattus norvegicus	"
Taenia sp. 3	*Rattus rattus*	Small intestine
	Rattus norvegicus	"
	Sorex sp	"
Platynosomum concinnum	*Sorex* sp	Liver
Undetermined specimen 1	*Sorex* sp	Small intestine
Undetermined specimen 2	*Sorex* sp	"

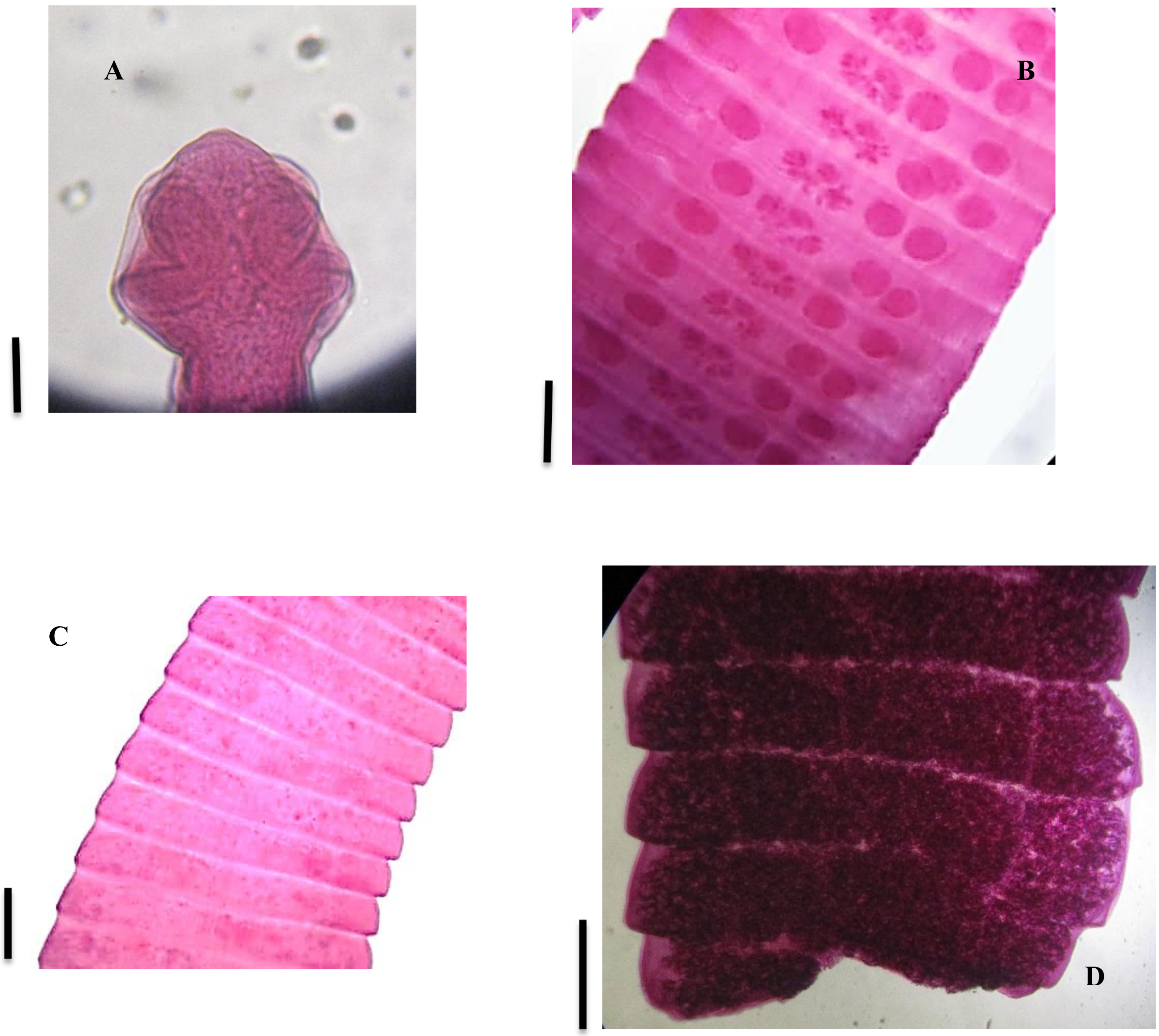

Plate 4.6: *Hymenolepis diminuta* infecting *Rattus norvegicus* from Uhunmwode LGA
A. Scolex; B. Mature Proglottid; C. Early gravid; D. Mid gravid.
Scale Bar: A = 0.05 mm; B= 0.2 mm, C = 0.5 mm, D = 0.05 mm

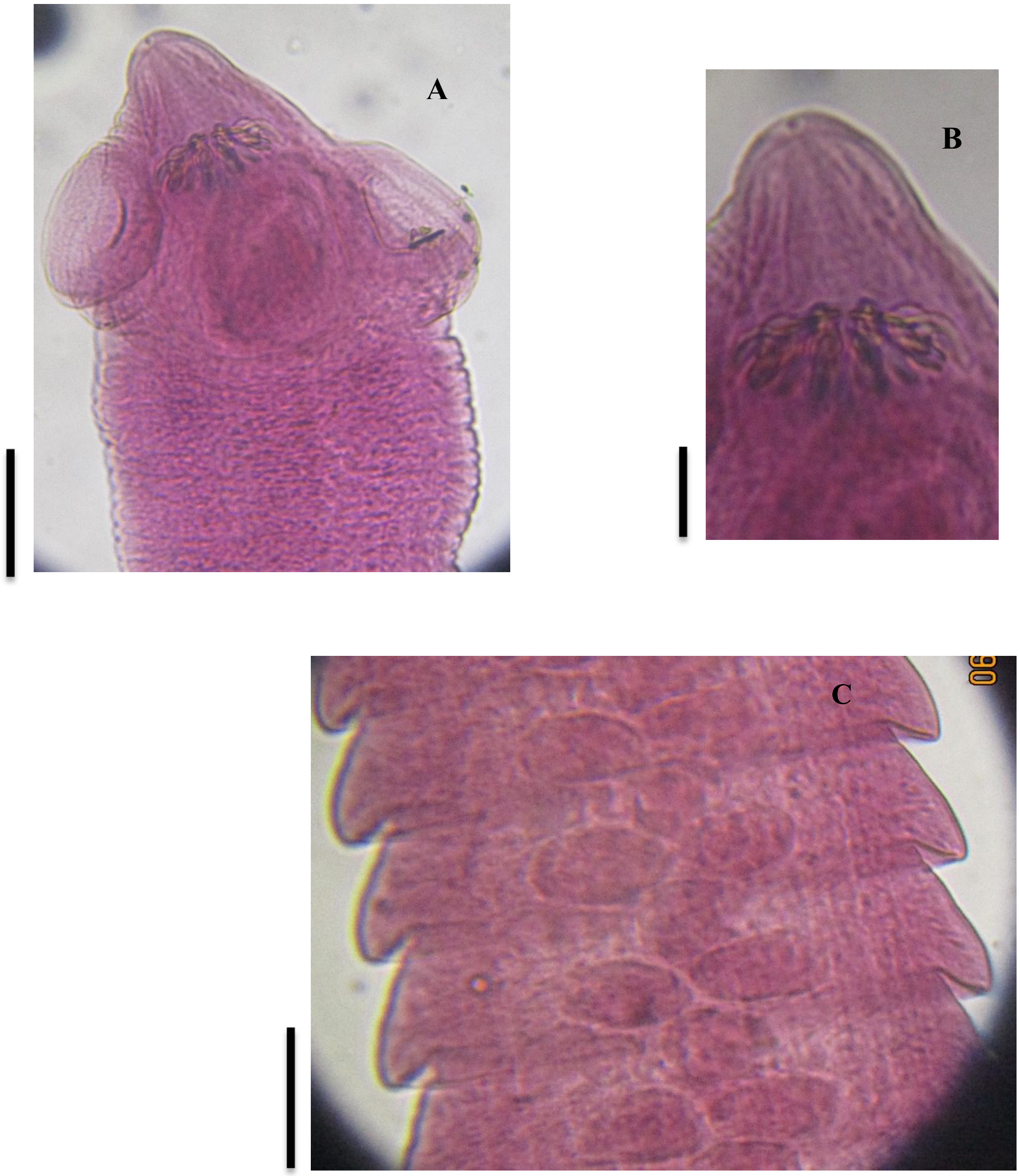

Plate 4.7: *Hymenolepis nana* infecting *Sorex* sp. from Ovia North East and Uhunmwode LGA
A. Scolex; **B**. Hooks; **C**. Mature proglottid
Scale Bar: **A** & **C** = 0.05 mm, **B** = 0.02 mm

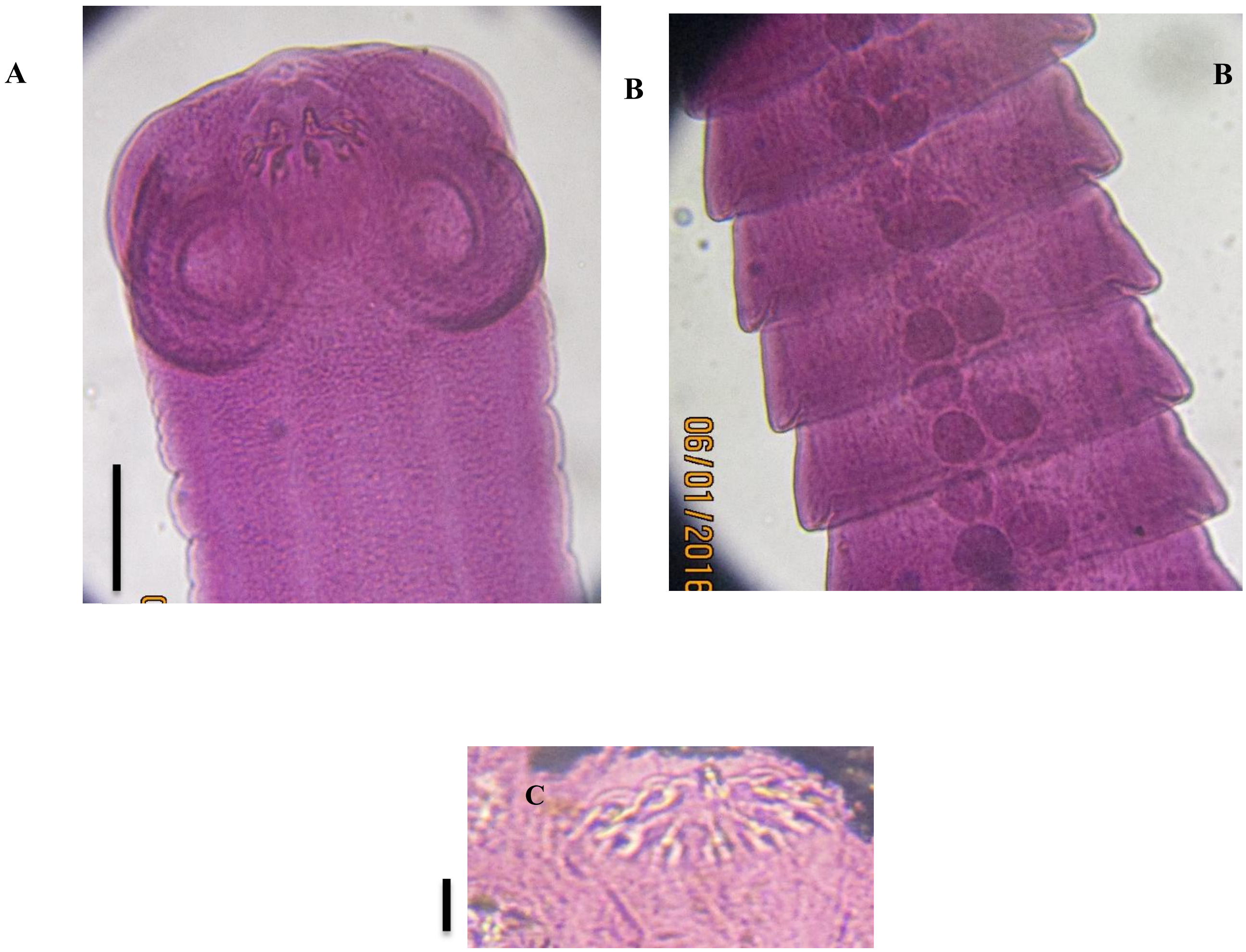

Plate 4.8: *Hymenolepis* sp.1 from Uhunmwode LGA
A. Scolex. **B**; Mature proglottid. **C**; Hooks
Scale Bar: A, B &C = 0.05 mm

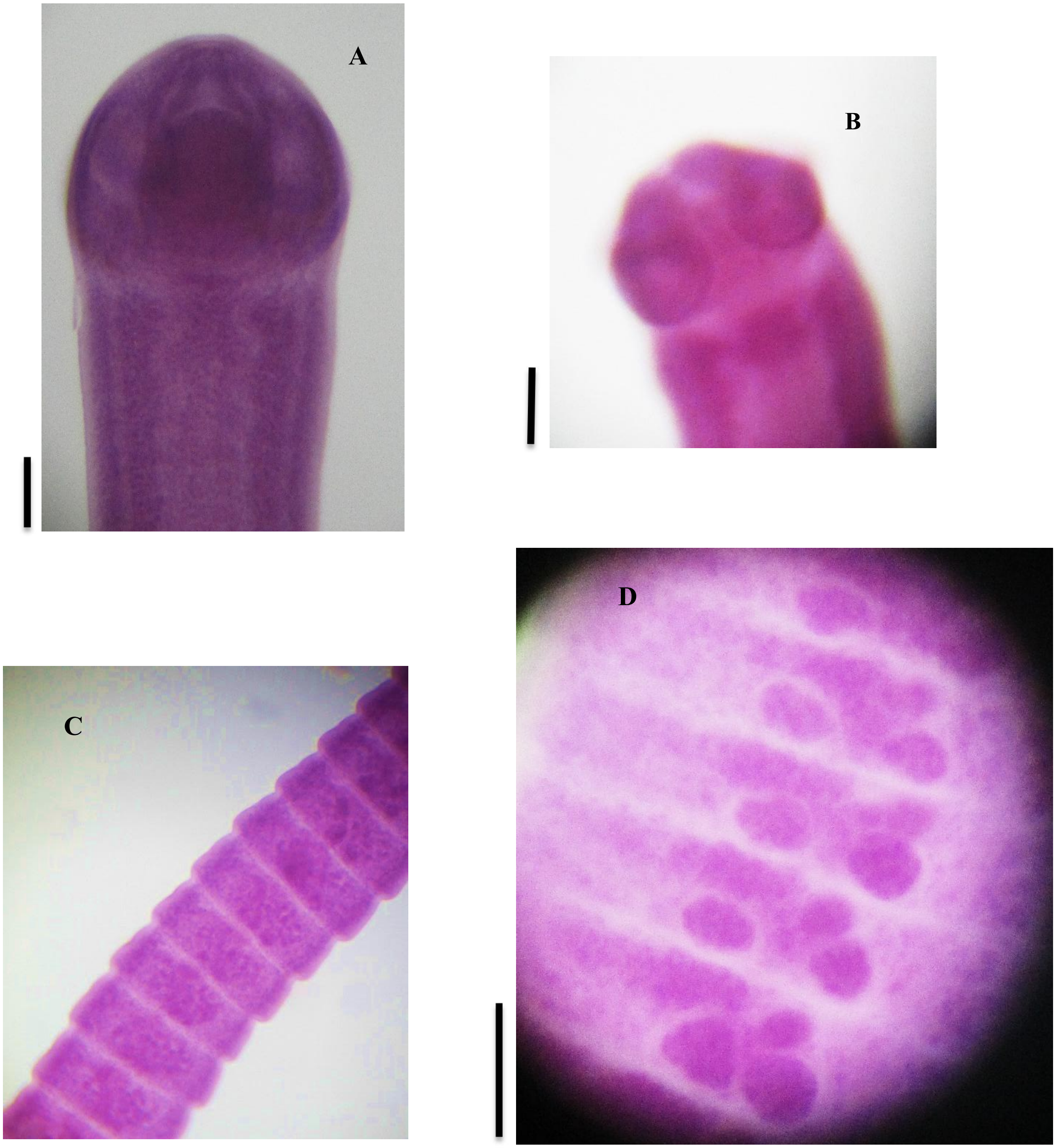

Plate 4.9: *Hymenolepis* sp. 2 infecting *Sorex* sp. from Ovia North East
A. Scolex**; B.** Another presentation of the scolex**; C.** Early mature proglottids**; D.** Mature proglottids
Scale bar: A & D = 0.05 mm; **B & C** = 0.10 mm

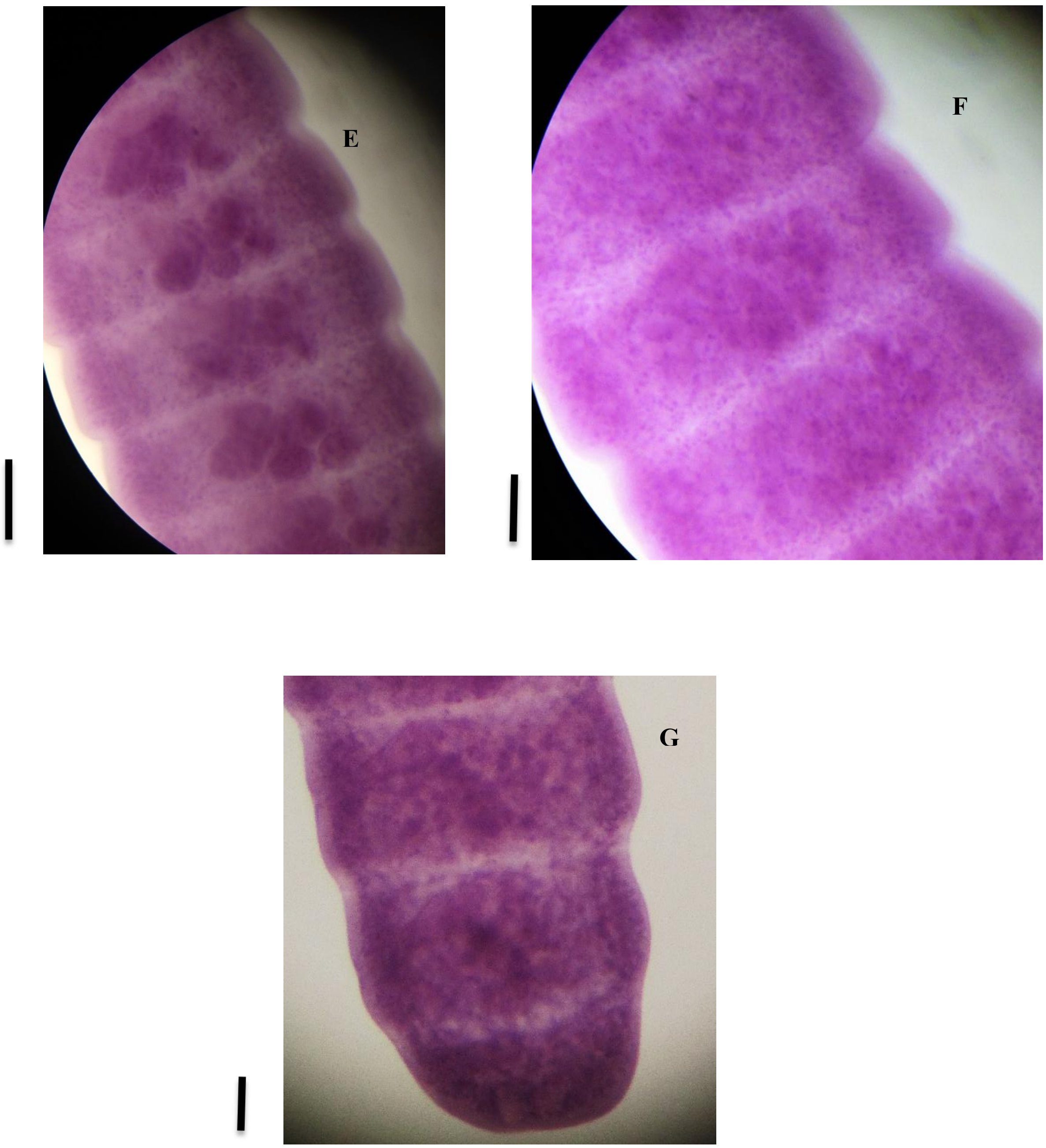

Plate 4.10; *Hymenolepis* sp. 2 infecting *Sorex* sp. from Ovia North East
E. Proglottid with indication of fertilization F. Early gravid G. Full gravid
Scale bar: A, B&C = 0.05 mm

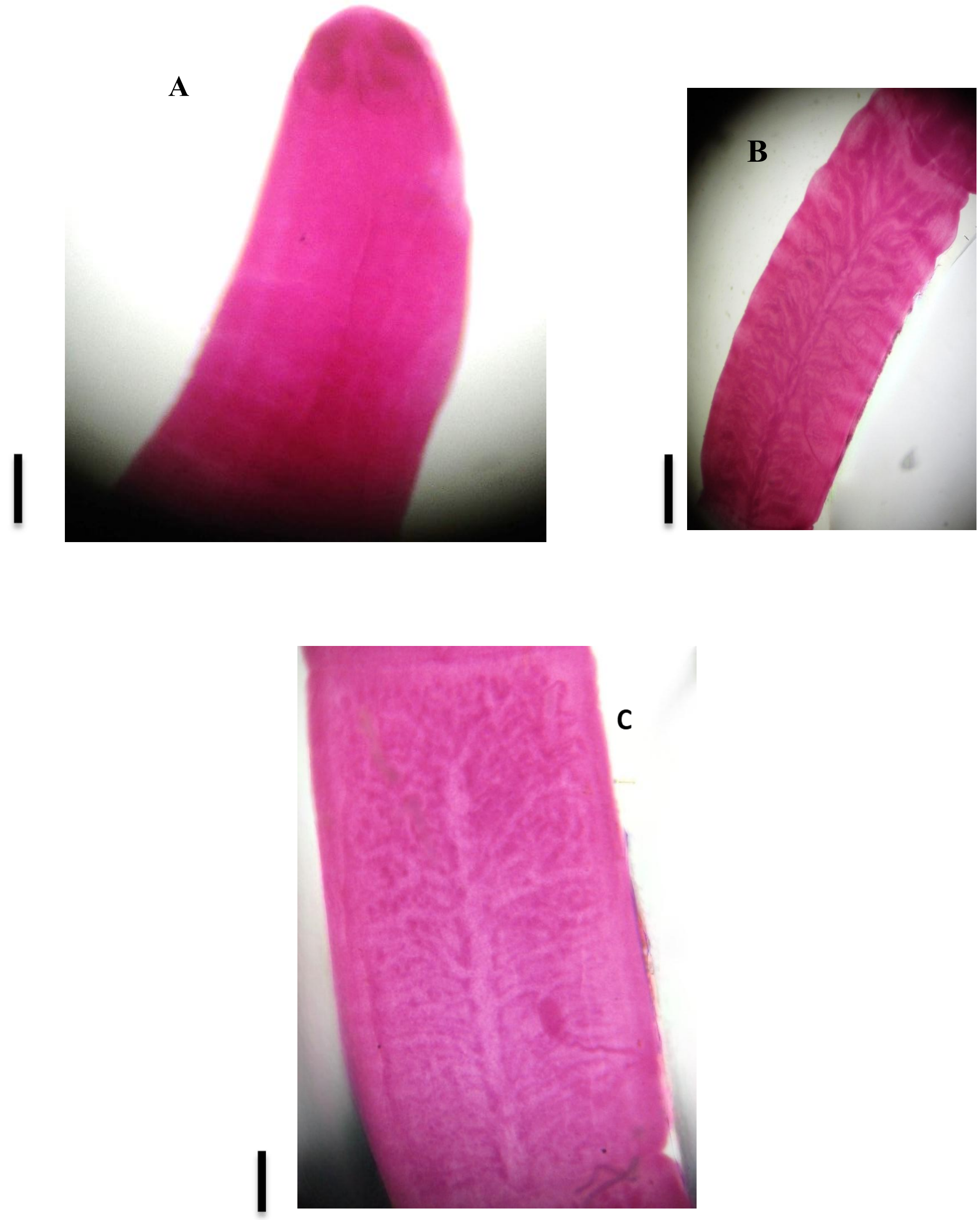

Plate 4.11; *Taenia* sp. 1 afffecting *Rattus rattus* from Uhunmwode LGA
A. Scolex; **B .** Immature proglottid**; C.** Mature Proglottid
Scale Bar: A = 0.5 mm**, B** = 0.1 mm, **C =**0.2 mm

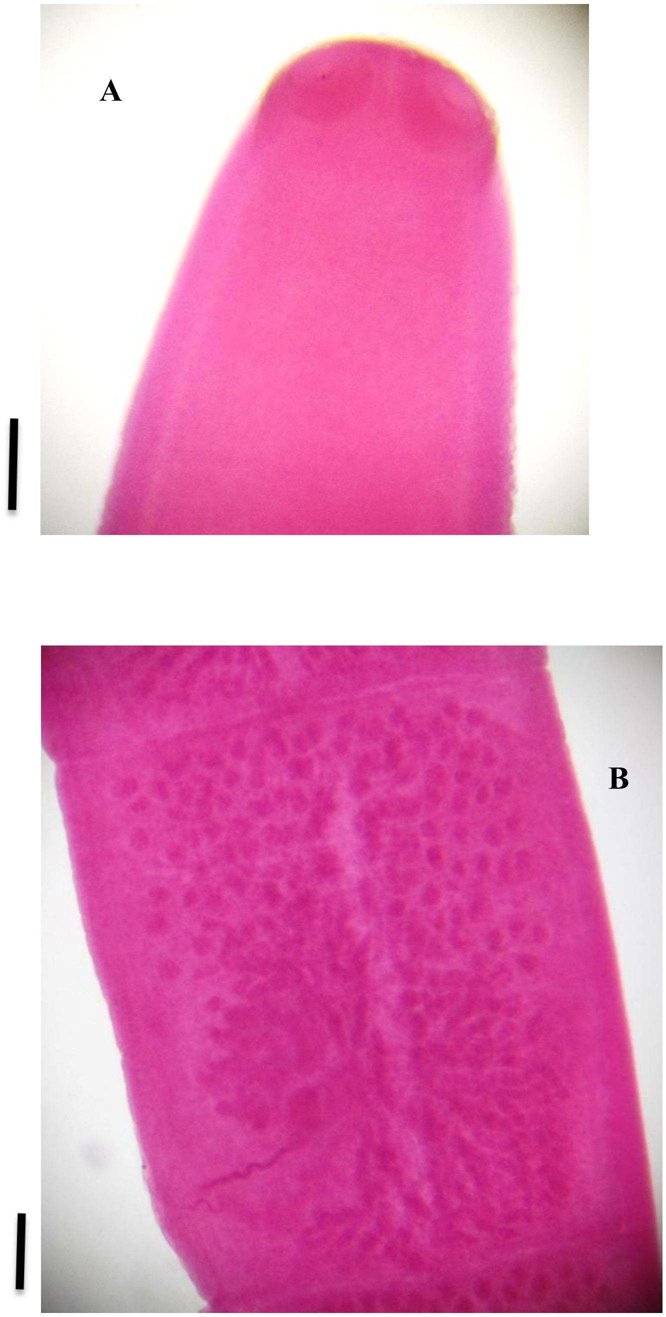

Plate 4.12: *Taenia* sp. 2 infecting *Rattus rattus* from Uhunmwode LGA
A. Scolex; **B.** Mature Proglottid
Scale Bar: **A** = 0.3 mm; **B** = 0.2 mm

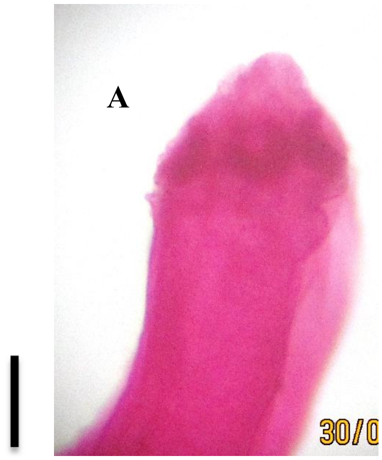

Plate 4.13: *Taenia* sp. 3 infecting *Rattus rattus* from Uhunmwode LGA
A. Scolex; **B.** Mature proglottid
Scale Bar: **A & B** = 0.1 mm

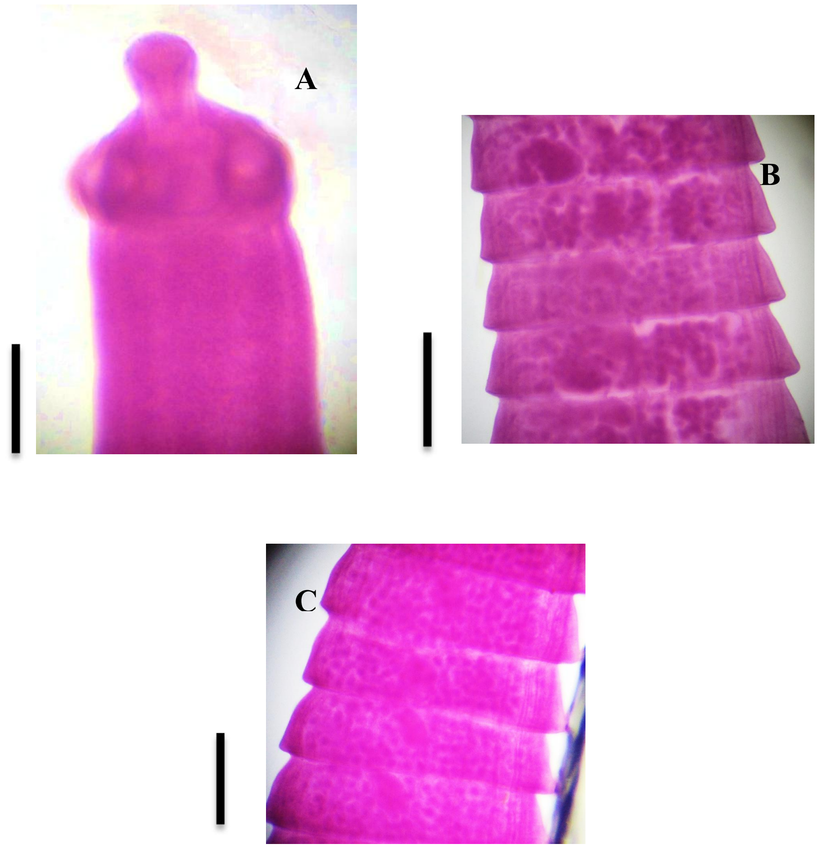

Plate 4.14; Undetermined specimen 1 affecting *Sorex* sp. from Ovia North East
A; Scolex. **B**; Early gravid **C**; Late gravid
Scale bar: A = 0.05 mm; B &C = 0.1 mm

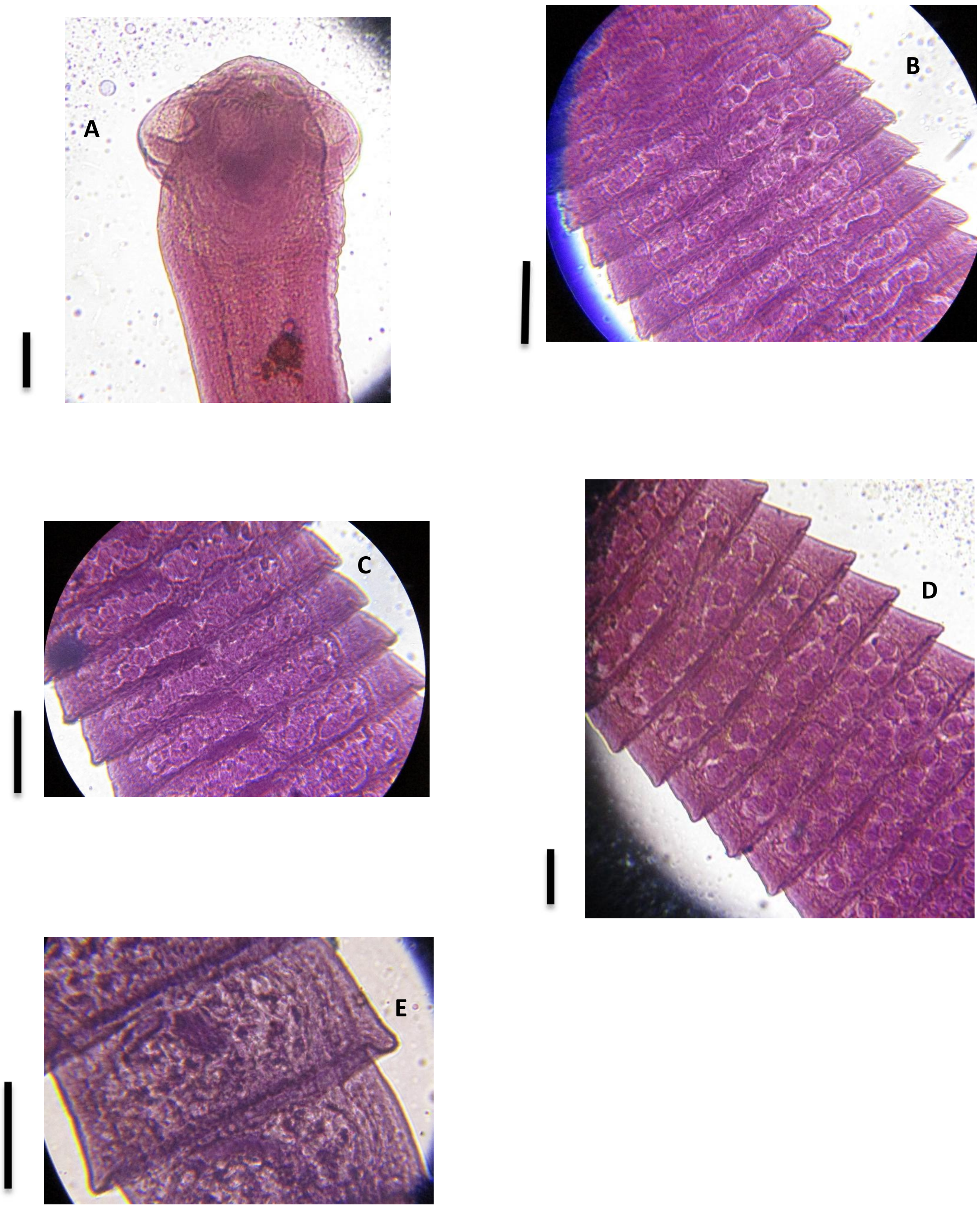

Plate 4.15; Undetermined specimen 2 affecting *Sorex* sp. from Ovia North East
A.Scolex; B. Mature proglottid; C. Early gravid proglottid; D. Gravid proglottid
Scale bar: A = 0.01 mm; B, C, D & E = 0.05 mm

Plate 4.16: *Platynosomum concinnum* infecting *Sorex* sp. from Ovia North East LGA
Scale Bar: 0.5 mm

Table 4.5: Prevalence of Helminth Parasites amongst Small Mammals Caught from Ovia North-East and Uhunmwode LGAs

Parasites	**Hosts**	**No. of Host Examined**	**No. of Infected Hosts**	**No. of Parasites Recovered**	**P(MI±SD)**	**95% CI**
Cestodes	*Mastomys* sp.	15	0	0	0	0
	Sorex sp.	19	19	1557	100(81.95 ± 105.79)	34.38 – 129.52
	Mus musculus	32	1	3	3.1(3 ± 0.55)	2.81 – 3.19
	Rattus rattus	10	4	23	40(5.75 ± 4.11)	3.2 – 8.3
	Rattus norvegicus	14	4	17	28.6(4.25 ± 3.6)	2.37 – 6.13
Trematodes	*Mastomys* sp.	15	0	0	0	0
	Sorex sp.	19	2	380	10.5(190 ± 226.27)	88.3 – 291.7
	Mus musculus	32	0	0	0	0
	Rattus rattus	10	0	0	0	0
	Rattus norvegicus	14	0	0	0	0

P = prevalence; MI= Mean intensity; SD = Standard deviation; CI = Confidence Limit

Table 4.6: External Body Measurements (Mean ± SD) of Small Mammals Sampled from Ovia North East and Uhunmwode

Parameters*	***Mastomys* sp. (n=15)**	***Sorex* sp. (n=19)**	***Rattus rattus* (n=10)**	***Rattus norvegicus* (n=14)**	***Mus musculus* (n=32)**
Body weight	18.41 ± 13.2	48.96 ± 11.26	119.07 ± 58.81	214.72 ± 80.85	23.99 ± 8.95
Head and Body Length	7.57 ± 1.98	12.95 ± 1.27	15.61 ± 2.53	20.05 ± 2.87	8.72 ± 1.27
Hind-Foot Length	1.51 ± 0.29	2.01 ± 0.21	3.28 ± 0.38	3.63 ± 0.35	2.04 ± 0.29
Ear Length	0.81 ± 0.28	1.30 ± 2.04	1.55 ± 0.38	1.3 ± 0.29	0.81 ± 0.15
Tail Length	8.33 ± 2.51	8.31 ± 0.79	19.36 ± 3.14	14.47 ± 3.80	9.23 ± 2.19

* Body weight was measured in grams and the rest of the parameters were measured in centimeter; n: Total observation, SD: Standard deviation of mean.

Rattus rattus and *Rattus norvegicus* respectively). The observed values were normally distributed as indicated by their skewness and kurtosis statistics. In general, the tail is longer than the length of the head and body of *M. musculus*, *Mastomys* sp. and *R. rattus*, which is the opposite in *R. norvegicus* and *Sorex* sp.

4.6 Morphological Characteristics of the Helminth Parasites in Small Mammals Encountered at Ovia North East and Uhunmwode LGAs

Hymenolepis nana (Plate 4.7) recovered displayed a small globular scolex of about 0.3-0.4mm and equipped with four muscular suckers. It also had a short retractable rostellum with a single row of 20-30 hooks. The three testes were arranged triangularly (one anterior, two posterior-lateral) with a single bilobed ovary centrally located within the proglottid.The vitelline gland was compact and lies posterior to the ovary. The uterus was sacular without branching.

Hymenolepis diminuta (Plate 4.6) recovered had a larger scolex than *Hymenolepis nana* with four prominent suckers and an unarmed rostellum. The three testes present were arranged in a straight pattern with a central single bilobed ovary. The vitellarium lies posteriorly to the ovary. The uterus formed a sac-like expansion in gravid segments.

Hymenolepis sp, 1(Plate 4.8) recovered had a small and rounded scolex bearing four muscular suckers with a retractile rostellum armed with hooks and similar to *H. nana*. The hooks appear arranged in a single row around the rostellum. In the mature proglotid, the internal arrangement showed the characteristic triad of testes, typically positioned one anterior aand two posterolateral, forming a traiangular configuration. The ovary was bilobed and centrally positioned in the posterior half of the segment. A compact vitelline gland was located posterior to the ovary. The uterus was sac-like, occupying much of the central portion of the mature segment. The presence of an armed rostellum, three testes and a saccular uterus suggests similarity to *Hymenolepis nana,* although species identity could not be confirmed and was therefore left as *Hymenolepis* sp, 1

Hymenolepis sp, 2 (Plate 4.9 and 4.10) recovered had a rounded scolex with four distinct suckers. The rostellum was unarmed lacking hooks. The rostellum was short and simple without visible hook structures. The mature proglottid displayed three testes, typical of the genus, arranged dorsally in a triangualar pattern. The ovary was bilobed and centrally placed, occupying the posterior region of the proglottid. A compact vitellarium lies behind the ovary. The uterus was simple and sac-like. The exact identification of the specie requires molecular confirmation and as such, it is therefore recorded as *Hymenolepis* sp, 2.

The *Taenia* species observed in Plates 4.11 – 4.13 displayed the typical taeniid cestode morphology, consisting of a distinct scolex, neck and a long chain of proglottids. The scolex was globular and possessed four strong suckers. In the specimens examined, the rostellum appeared armed with hooks arranged in a double row, although the exact hook pattern varied slightly among the three forms presented. This armature was characteristic of armed *Taenia* species.

The mature proglottids contained numerous testes (typically several hundreds) distributed dorsally throughout the segment. A single, bilobed ovary occupied the posterior half of the proglottid, with a compact vitelline gland situated posterior to the ovarian lobes. The uterus showed the characteristic taeniid pattern of lateral branching. Each gravid segment exhibited a central uterine stem from which multiple lateral branches extended, the number of which varied among the specimens.

Overall, the *Taenia* specimens demonstrated the key features associated with the genus (armed scolex, numerous dispersed testes, bilobed ovary, and a highly branched uterus) while subtle differences in scolex armature and uterine branching suggested thst more than one type of *Taenia* specimen was present in the samples examined.

The trematode *Platynosomum coccinum* (Plates 4.16) exhibited the characteristics flattened, leaf-like morphology typical of dicrocoeliid flukes. It possessed an anterior oral sucker and a ventral sucker (acetabulum) located slightly posterior to the oral opening. The body was elongated and dorsoventrally flattened, with smooth margins.

The reproductive organs displayed the typical trematode arrangement. Two rounded testes were located in the posterior half of the body and arranged in tandem, with one lying directly behind the other. A single small, oval-shaped ovary was situated anterior to the testes (pretesticular position). The vitelline glands were distributed laterally along both sides of the body, extending from the mid-body to the posterior region.

The uterus occupied much of the anterior two-thirds of the body and appeared long, coiled and convoluted. It contained numerous operculate eggs, indicating its gravid state. The digestive system consistem of an oral sucker, short pharynx, oesophagus and two bifurcating caeca that extended posteriorly along the body length.

Overall, *Platynosomum coccinum* in this study, displayed the typical features of dicrocoellid trematodes (absence of scolex, tandem testes, pretesticular ovary, extensive vitellaria and a long , coiled uterus) confirming its identity within the family Dicrocoeliidae.

4.6.1 Morphological Characteristics of the Undetermined Species Encountered at Ovia North East

The cestode specimen labelled as Undetermined sp. 1 (Plate 4.14) exhibited a small, rounded scolex equipped with four muscular suckers. The rostellum appeared present with an armed armature. The early gravid segment displayed a developing uterus occupying the central region of the proglottid, with reproductive structures still discernible. The testes were arranged dorsally, the ovary appeared compact and centrally located, with a small posterior vitelline gland.

In the late gravid segment, the uterus became markedly enlarged and sac-like, filling most of the internal cavity with numerous eggs. No lateral uterine branches were observed, suggesting a simple saccular uterus typical of hymenolepid cestodes rather tthan the branched uterus of *Taenia* species.

The cestode specimen labelled as Undetermined sp. 2 (Plate 4.15) possessed a rounded scolex with four prominent suckers. The rostellum was present with hooks. The scolex morphology suggested a small-bodied cyclophyllidean cestode.

The mature proglottid contained a well-developed reproductive system. The ovary was bilobed and situated posteriorly within the proglottid, accompanied by a compact vitelline mass just behind it. The uterus appeared sac-like and centralized, without evidence of external branching. These features aligned with the general pattern seen in *Hymenolepis* and related genera.

4.7 Prevalence and Mean Intensity of Helminth Parasites in Small Mammals Encountered at Ovia North East and Uhunmwode LGAs

4.7.1 Prevalence and Mean Intensity of Helminth Parasites in *Sorex* sp. Encountered at Ovia North East and Uhunmwode LGAs

The helminth parasites recovered from the 19 Sorex sp (17 *Sorex* sp. examined from the Ovia North East LGA and 2 *Sorex* sp. from Uhunmwode LGA) were *Hymenolepis nana*, *Hymenolepis* sp. 1, *Hymenolepis* sp. 2, *Taenia* sp. 3, Undetermined specimen 1, Undetermined specimen 2 and *Platynosomum concinnum* (Plates 4.6 - 4.16).

The prevalence and mean intensity of infection in *Sorex* sp in the two LGAs studied are presented in Table 4.7 and Table 4.8. *Hymenolepis nana* and *Taenia* sp. 3 were recorded in the two LGA studied. *Hymenolepis nana* had a prevalence of 100% in Uhunmwode LGA (Table 4.8) and a mean intensity of 60.0 while at Ovia North East LGA (Table 4.7), *Hymenolepis nana* had a prevalence of 35% and a mean intensity of 40.0. *Taenia* sp.3 had a prevalence of 5.9% and a mean intensity of 12.0 ± 2.9 at Ovia North East LGA (Table 4.7). *Hymenolepis* sp 1 and *Taenia* 3 both had a prevalence of 50% in Uhunmwode LGA (Table 4.8) with a mean intensity of 75.0 ± 24.7 and 75.0 ± 53.0 respectively. *Hymenolepis* sp 2, Undetermined specimen 1 and Undetermined specimen 2 were recorded only in Ovia North East LGA (Table 4.7) with a prevalence of 11.8%, 5.9% and 35.5% respectively and mean intensity of 29.5 ± 13.3, 55.0 ± 13.3 and 27.0 ± 20.8 parasites/infected host. *Platynosomum concinnum* was only recorded in Ovia North East LGA (Table 4.7) with a prevalence of 11.8 and a mean intensity of 178 parasites/infected host. The trematode infection was found only in two females (one of them adult, and the other being a juvenile) with the mean intensity of the infection higher in the adult than in the juvenile (Table 4.10).

The male and female prevalence range was from 53.8% to 7.7%, with the female having a prevalence of 16.6% in *H. nana*, *Hymenolepis* sp. 1, *Hymenolepis* sp. 2 and *Platynosomum concinnum* while the highest prevalence of 53.8% for *H. nana* was found in the male (Table 4.9). Also, the adults of *Sorex* sp. had prevalence range from 33.3% to 6.7% while the juveniles had prevalence range between 75% and 25% (Table 4.10).

Table 4.7: Prevalence and mean intensity of helminth parasites of small mammals encountered at Ovia North East LGA

Parasites	*Sorex* sp. n=17 P(MI ± SD)	*Mus musculus* n =22 P(MI ± SD)	*Mastomys* sp. N=15 P(MI ± SD)
Cestoda			
Hymenolepis diminuta	-	-	-
Hymenolepis nana	35.0(40.0 ± 28.7)	-	-
Hymenolepis sp 1	-	-	-
Hymenolepis sp 2,	11.8 (29.5 ± 13.3)	-	-
Taenia sp. 1	-	-	-
Taenia sp. 2	-	-	-
Taenia sp. 3	5.9 (12.0 ± 2.9)	-	-
Undetermined specimen 1	5.9 (55.03 ± 13.3)	-	-
Undetermined specimen 2	35.0 (27.0 ± 20.8)	-	-
Trematoda			
Platynosomum concinnum	11.8 (178.0 ± 78.9)	-	-

n = number of specimens; P = prevalence; MI = Mean intensity; SD = Standard deviation

Table 4.8: Prevalence and mean intensity of helminth parasites of small mammals encountered at Uhunmwode LGA

Parasites	*Sorex* sp n=2 P(MI ± SD)	*Mus musculus* n =10 P(MI ± SD)	*Rattus norvegicus* n=14 P(MI ± SD)	*Rattus rattus* n=10 P(MI ± SD)
Cestoda				
Hymenolepis diminuta	-	-	14.3 (1.5 ± 0.6)	10.0 (2.0 ± 0.6)
Hymenolepis nana	100.0 (60.0 ± 56.6)	-	-	-
Hymenolepis sp. 1	50.0 (75.0 ± 24.7)	-	-	-
Hymenolepis sp. 2	-	-	-	-
Taenia sp. 1	-	-	7.1 (3.0 ± 0.8)	20.0 (6.0 ± 2.6)
Taenia sp. 2	-	10.0 (3.0 ± 0.9)	14.3 (4.0 ± 1.5)	20.0 (4.5 ± 2.6)
Taenia sp. 3	50.0 (75.0 ± 53.0)	-	7.1 (3.0 ± 0.8)	-
Undetermined specimen 1	-	-	-	-
Undetermined specimen 2	-	-	-	-
Trematoda				
Platynosomum concinnum	-	-	-	-

n = number of specimens; P = prevalence; MI = Mean intensity; SD = Standard deviation

Table 4.9: Prevalence and Mean Intensity of Helminth Parasites in the Hosts according to Sex Sampled from Ovia North East and Uhunmwode

Parasites	Host	Male			Female		
		No. of hosts examined	No. of hosts infected	Prev. (%)	No. of hosts examined	No. of hosts infected	Prev. (%)
Cestoda							
Hymenolepis diminuta	*Rattus rattus*	7	1	14.3	3	0	0
	Rattus norvegicus	13	2	15.4	1	0	0
Hymenolepis nana	Sorex	13	7	53.8	6	1	16.6
Hymenolepis sp. 1	Sorex	13	0	0	6	1	16.6
Hymenolepis sp. 2	Sorex	13	2	15.4	6	1	16.6
Taenia sp. 1	*Rattus rattus*	7	1	14.3	3	1	33.3

	Rattus norvegicus	13	1	7.7	1	0	0
Taenia sp. 2	*Mus musculus*	25	0	0	7	1	14.3
	Rattus rattus	7	1	14.3	3	1	33.3
	Rattus norvegicus	13	2	15.4	1	0	0
Taenia sp. 3	*Rattus norvegicus*	13	1	7.7	1	0	0
Undetermined specimen 1	Sorex	13	1	7.7	6	1	16.6
Undetermined specimen 2	Sorex	13	5	38.5	6	1	16.6
Trematoda							
Platynosomum concinnum	Sorex	13	0	0	6	2	33.3

Table 4.10: Prevalence and Mean Intensity of Helminth Parasites according to Host Age Class (Juvenile/Adult) Sampled from Ovia North East and Uhunmwode

Parasites	Host	No. of host examined	No. of host infected	No. of host parasites	Prev. (%)	Mean intensity MI ± SD
Cestoda						
Hymenolepis diminuta	*Rattus rattus*	9^a1^b	1^a0^b	2^a0^b	33.3^a0^b	$2.0^a0^b \pm 0.7^a0^b$
	Rattus norvegicus	14^a0^b	2^a0^b	3^a0^b	14.3^a0^b	$1.5^a0^b \pm 0.6^a0^b$
Hymenolepis nana	*Sorex* sp.	15^a4^b	5^a3^b	249^a131^b	33.3^a75^b	$49.8^a43.7^b \pm 34.9^a29.9^b$
Hymenolepis sp. 1	*Sorex* sp.	15^a4^b	1^a0^b	35^a0^b	6.7^a0^b	$35^a0^b \pm 36.1^a0^b$
Hymenolepis sp. 2	*Sorex* sp.	15^a4^b	2^a0^b	59^a0^b	13.3^a0^b	$29.5^a0^b \pm 14.2^a0^b$
Taenia sp. 1	*Rattus rattus*	9^a1^b	2^a0^b	12^a0^b	22.2^a0^b	$6.0^a0^b \pm 2.7^a0^b$
	Rattus norvegicus	14^a0^b	1^a0^b	3^a0^b	7.1^a0^b	$3.0^a0^b \pm 0.8^a0^b$
Taenia sp. 2	*Mus musculus*	26^a6^b	1^a0^b	3^a0^b	11.5^a0^b	$3.0^a0^b \pm 0.6^a0^b$
	Rattus rattus	9^a1^b	1^a1^b	6^a3^b	11.1^a100^b	$6.0^a3^b \pm 2.0^a0^b$
	Rattus norvegicus	14^a0^b	2^a0^b	8^a0^b	14.3^a1^b	$4.0^a0^b \pm 1.5^a0^b$
Taenia sp 3	*Rattus norvegicus*	14^a0^b	1^a0^b	3^a0^b	7.1^a0^b	$3.0^a0^b \pm 0.8^a0^b$

Undetermined specimen 1	*Sorex* sp.	15^a4^b	1^a0^b	55^a0^b	6.7^a0^b	$55^a0^b \pm 14.2^a0^b$
Undetermined specimen 2	*Sorex* sp.	15^a4^b	5^a1b	125^a37^b	33.3^a25^b	$25^a37^b \pm 20.8^a18.5^b$
Trematoda						
Platynosomum concinnum	*Sorex* sp.	15^a4^b	1^a1b	400^a30^b	6.7^a25^b	$400^a30^b \pm 103.3^a15^b$

*Subscript a represent adult

*Subscript b represent juvenile

Table 4.10 (continued): Prevalence and Mean Intensity of Helminth Parasites according to Host Age Class (Juvenile/Adult) Sampled from Ovia North East and Uhunmwode

Parasites	**Host**	**No. of host examined**	**No. of host infected**	**No. of host parasites**	**Prev. (%)**	**Mean intensity MI ± SD**
	Rattus rattus	9^a1^b	1^a1^b	6^a3^b	11.1^a100^b	$6.0^a3^b \pm 2.0^a0^b$
	Rattus norvegicus	14^a0^b	2^a0^b	8^a0^b	14.3^a1^b	$4.0^a0^b \pm 1.5^a0^b$
Taenia sp 3	*Rattus norvegicus*	14^a0^b	1^a0^b	3^a0^b	7.1^a0^b	$3.0^a0^b \pm 0.8^a0^b$

*Subscript a represent adult

*Subscript b represent juvenile

4.7.2 Prevalence and Mean Intensity of Helminth Parasites in *Mastomys* sp. Encountered at Ovia North East LGA.

Mastomys sp**.** was only found in Ovia North East LGA and no parasites were recorded in all the specimens examined.

4.7.3: Prevalence and Mean Intensity of Helminth Parasites in *Mus musculus* Encountered at Ovia North East and Uhunmwode LGAs

No infection was found in the *Mus musculus* encountered at Ovia North East LGA. In Uhunmwode LGA, *Taenia* sp. 2 was the only parasite recorded in this host specie with a prevalence of 10.0% and a mean intensity of 3.0 parasites/infected host (Table 4.8). The parasite was recorded in a female host with a prevalence of 14.3% (Table 4.9) and according to host age class, the juveniles had a prevalence of 11.5% (Table 4.10).

4.7.4: Prevalence and Mean Intensity of Helminth Parasites in *Rattus norvegicus* Encountered at Uhunmwode LGA.

Rattus norvegicus was found only in Uhunmwode LGA. Four (4) species of helminth parasites were recovered in *Rattus norvegicus* namely; *Hymenolepis diminuta*, *Taenia* sp. 1, *Taenia* sp. 2 and *Taenia* sp. 3 had a prevalence of 14.3%, 7.1%, 14.3% and 7.1% each with a mean intensity of 1.5, 3.0, 4.0 and 3.0 parasites/infected host, respectively (Table 4.8).

The male and female prevalence range was from 15.4% to 7.1% with the highest prevalence of 15.4% recovered in a female host with a *Taenia* sp 2 infection (Table 4.9). The adults of *Rattus norvegicus* had the highest prevalence of 14.3% in *H. diminuta* (Table 4.10).

4.7.5: Prevalence and Mean Intensity of Helminth Parasites in *Rattus rattus* Encountered at Uhunmwode LGA.

Rattus rattus was found only in Uhunmwode LGA. Three (3) species of helminth parasites were recovered in *Rattus rattus* namely; *Hymenolepis diminuta*, *Taenia* sp. 1 and *Taenia* sp. 2 had a prevalence of 10%, 20% and 20% each with a mean intensity of 2.0, 6.0 and 4.5 parasites/infected host, respectively (Table 4.8).

The male and female prevalence range was from 33.3% to 14.3%. Only the males had infections with all three (3) helminth species with a prevalence of 14.3% while the females recorded an infection in *Taenia* sp. 2 with a prevalence of 33.3% (Table 4.9). The juveniles of *Rattus rattus* had the highest prevalence of 100% in *Taenia* sp. 2 while the adults had prevalence ranging from 33.3% to 22.2% in *H. diminuta* and *Taenia* sp. 1 respectively (Table 4.10).

CHAPTER FIVE

DISCUSSION

5.1.1 Small mammals encountered at Ovia North East and Uhunmwode Local Government Areas

Ninety specimens consisting of five species of small mammals were encountered in this study undertaken in the two Local Government Areas (LGAs) of Edo State, namely; Ovia North East and Uhunmwonde Local Government Areas.

The small mammals' populations sampled in this study are represented by *Rattus norvegicus* (n=14), *Mus musculus* (n=32), *Sorex* sp. (n=19), *Mastomys* sp. (n=15) and *Rattus rattus* (n=10). All the small mammals recorded in this study have previously been studied in different regions in Nigeria (Ugbomoiko and Obiamiwe, 1991; Akpan *et al*., 2015; Isaac *et al*., 2018).

Isaac *et al*. (2018) in their research work on endoparasites of small mammals in Edo State, Nigeria reported six genera (*Apodemus* sp., *Crocidura* sp., *Mastomys natalensis*, *Mus musculus*, *Rattus* sp., and *Sorex* sp) from major towns (Auchi, Benin, Ekpoma, and Uromi) and environs in Edo state, Nigeria while Omogbeme and Oke (2018) recorded seventeen species (14 species of rodents and 3 species of insectivores) of small mammals including *Rattus rattus*, *Mastomys natalensis* and *Mus musculoides* in the lowland tropical rainforest of Okomu National Park, Edo State, Nigeria when they researched the population dynamics of rodents and insectivores present in Okomu National Park. These small mammals (excluding *Apodemus* sp and *Crocidura* sp.) reported by these authors have been found in this present study, indicating that, Edo State is home to such rodent species.

Identical to the low diversity of small mammals observed in this study, Akpan *et al*. (2015), recorded a low abundance and diversity index of small mammals that were of three (3) orders and seven (7) families from Idu, Uruan L.G.A of Akwa Ibom State Nigeria, which could be attributed to deforestation, habitat loss, hunting and other anthropogenic activities in the study area.

Considering the fact that the habitats sampled were tropical areas, it is possible that there are still more species of small mammalian hosts present in the study areas which were not found in this study

5.1.2 Helminth parasitic infection of small mammals in Ovia North East and Uhunmwode Local Government Areas

The results obtained from this study indicate an overall prevalence of 31.1% for gastrointestinal helminth parasites (comprising nine species of cestodes and one trematode specie) recovered from the five species of small mammals sampled in two Local Government Areas of Edo State, Nigeria. The overall prevalence in this study corresponds to the findings of Abdullahi and Tijjani (2020) who reported 34.5% prevalence of parasitic helminthes in rodents that were infected with at least one or more intestinal parasites in Damaturu metropolis, Nigeria. Other studies report varying prevalence of parasitic helminthes in rodents: for example Okoye *et al.* (2008) reported an overall prevalence of 54.0% for helminth parasites in a survey of the gut parasites of rodents in Nsukka ecological zone; Paul *et al.* (2016) reported a very low prevalence of 8.2% for gastrointestinal helminthes in domestic rats trapped from residential areas within Maiduguri Municipality, Nigeria; Rahman *et al.* (2018) reported an overall prevalence of 77.9% for gastrointestinal helminthes parasitizing free-ranging Asian house shrew (*Suncus murinus*) in Bangladesh; Tijjani *et al.* (2020) reported a prevalence of 17.1% for intestinal helminth parasite in wild rats in Serdang, Selangor, Malaysia while Abdullahi and Mamman (2021) reported 100% prevalence of gastrointestinal helminthes in African giant rat (*Cricetomys gambianus*) in North Eastern Nigeria. Population size and survey techniques may have been responsible for these differences.

Of the 90 small mammals examined, none showed the prevalence of ectoparasite nor nematode parasitization and it could be due to lack of suitable environment for their survival (Abdullahi and Tijjani 2020; Ibrahim 2020). This represent about 0.0% infection and while it is in agreement with Abdullahi and Mamman (2021) who also reported zero incidence of ectoparasite on African giant rat (*Cricetomys gambianus*) in North Eastern Nigeria, it is in contrast to the findings reported by Ogunniyi *et al.* (2014), who reported an ectoparasite prevalence rate of 34% in *Rattus rattus*; Paul *et al.* (2016), in which an ectoparasite prevalence of 9.4% in rats from Maiduguri, Nigeria was reported and finally, Abdullahi and Tijjani (2020), who recovered ectoparasites; mites (*Laelap nuttalli* and *Ornithonyssus bacoti*), ticks (*Ixodes granulatus*), lice (*Polyplax spinulosa* and *Hoplopleura pacifica*) and fleas (*Xenosphylla cheopis*) from rodent species such as *Rattus rattus* and *Rattus norvegicus* in Damaturu.

Phylum Cestoda was the most prevalent taxon of helminth parasites of small mammals encountered in this study, which is consistent with the findings reported by Ayinmode *et al*. (2016), in gastrointestinal parasites of rodents in Ibadan, Nigeria and Rahman *et al.* (2018) in free-ranging Asian house shrew (*Suncus murinus*) in Bangladesh.

Four (4) species of *Hymenolepis* were encountered in this study namely: *Hymenolepis diminuta, Hymenolepis nana* and two undetermined species (*Hymenolepis* sp. 1 and *Hymenolepis* sp. 2) from *Sorex* sp., *Rattus norvegicus* and *Rattus rattus.*

All of the *Hymenolepis* spp. mentioned except *Hymenolepis diminuta* (that is, *Hymenolepis nana* and the two undetermined *Hymenolepis* spp.) were found in *Sorex* sp while *Hymenolepis diminuta* was the only *Hymenolepis* species found in both *Rattus norvegicus* and *Rattus rattus*. The *Hymenolepis* species encountered were found only in the small intestine of the host species. This contradicts with report of Onah and Umeike (2022) that reported *Hymenolepis diminuta* to be found in the duodenal-jejunal region, caecum, ileum and colon in *Cricetomys gambianus*.

In addition, various studies have reported *Hymenolepis* species in rodents. For example, Okoye *et al.* (2008), reported *Hymenolepis* sp. from rodents (*Xerus erythropus, Cricetomys sp.* and *Rattus rattus*) in Nsukka, Nigeria; Ogunniyi *et* al. (2014), reported *Hymenolepis diminuta* from peridomestic rats (*Rattus rattus*) in Ile-Ife, Nigeria; Ayinmode *et* al. (2016), reported *Hymenolepis nana* as the only cestode recovered from *Rattus norvegicus, Thryonomys swinderianus* and *Cricetomys gambianus* in Ibadan, Nigeria; Paul *et al.* (2016) reported *Hymenolepis diminuta* from rats in Maiduguri, Nigeria; Rufai and Olagunju (2017), reported *Hymenolepis diminuta* as the only species of tapeworm recovered from domestic rats in Osogbo; Tabu *et al.* (2017), reported *Hymenolepis nana* as the only cestode from small mammals (rodent and shrew) in an Island forest in the Republic of Congo; Rahman *et al*. (2018), reported *Hymenolepis* species from Asian house shrew (*Suncus murinus*) in Bangladesh; Houéménou *et al.* (2018), reported *Hymenolepis diminuta* (34.3%) and *Hymenolepis* spp. (1.5%) in rodents and shrews from Cotonou town, Benin; Isaac *et al*. (2018), reported both *Hymenolepis diminuta* and

Hymenolepis nana from small mammals in Edo State, Nigeria; Tijjani *et* al. (2020), reported both *Hymenolepis diminuta* and *Hymenolepis nana* from *Rattus rattus diardii* and *Rattus norvegicus* in Malysia and Abdullahi and Tijjani (2020) reported both *Hymenolepis diminuta* and *Hymenolepis nana* from rodents (*Rattus rattus* and *Rattus norvegicus*) in Damaturu, Nigeria.

Hymenolepis nana was the most prevalent cestode (53.8%) found in the males of *Sorex* sp. in this study (Table 4.9) and in both LGAs sampled (with 100% prevalence rate at Uhunmwode LGA and 35.5% at Ovia North East LGA) (Table 4.7 and Table 4.8). This finding corroborate with the report of Tabu *et al*. (2017) that investigated the gastrointestinal helminths of small mammals (rodent and shrew) in an island forest habitat of Lac de Ma Vallée, Kinshasa, Democratic Republic of Congo and reported *Hymenolepis nana* as the helminth that has the most parasitized small mammals with an infestation rate of 56.86%.

The *Hymenolepis* infection in *Sorex* sp. had high mean intensities ranging from 29.5 to 40.0 at Ovia North East LGA and 60.0 to 75.0 at Uhunmwode LGA (Table 4.7 and Table 4.8). The high number of cestodes of the genus *Hymenolepis* found in *Sorex* sp in this study is identical to what was reported by Vouge and Rausch, 1955. This could be attributed to their voracious manner of eating and feeding habits as insectivores, because many hymenolepid cestodes of terrestrial vertebrates require an insect or other invertebrate host (coleopteran beetle or fleas of *Xenopsylla* sp) (Vouge and Rausch, 1955). `

Three (3) species of *Taenia* (all adult stages) were encountered in this study but could not be identified to species level from *Sorex* sp., *Mus musculus*, *Rattus norvegicus* and *Rattus rattus.* They are *Taenia* sp. 1, *Taenia* sp. 2 and *Taenia* sp. 3.

Among these *Taenia* spp, the most prevalent was *Taenia* sp. 3 encountered at both Uhunmwode LGA (with a mean intensity of 75.0 and a prevalence of 50%) and Ovia North East LGA (but with a mean intensity of 12.0 and a prevalence rate of 5.9%) in *Sorex* sp., followed by both *Taenia* sp. 1 and *Taenia* sp. 2 in *Rattus rattus* (with a mean intensity of 6.0 and 4.5 respectively, and similar prevalence of 20%). At Ovia North East, *Taenia* sp. 3 was the only *Taenia* specie encountered with a prevalence of 5.9 and a mean intensity of 12.0.

Although, most studies (Ogunniyi *et al.,* 2014; Islam *et al.,* 2020; Tijjani *et al.,* 2020) report the larval stage of *Taenia taeniaeformis* being found in rodents (encysted in the liver), only Ibrahim

(2020), reported adult *Taenia taeniaformis* in rodents (rats and shrews) and it was recovered from the lung and small intestine in Kuala Terengganu, Malaysia.

The parasite, *Taenia taeniaeformis* is a known tissue parasite usually found in the liver of intermediate hosts and in particular, the larval stage has been reported in rodents, birds, insectivores, and even humans (Mino *et al*., 2013) while the adult stage is found in the small intestine of carnivores (cats) which are the definitive hosts. Infection is gotten through carnivory when cats predate on rodents (intermediate hosts) or by ingesting food or soil contaminated with cat faeces (Tijjani *et al.,* 2020).

Taenia taeniaeformis was not recorded in this study. In addition, the *Taenia* species reported in this study were all found in the small intestine which is in agreement with the reports of Onah and Umeike (2022) who reported *Taenia* sp. in African giant rat (*Cricetomys gambianus*) recovered from the ileum, caecum and colon while Ibrahim (2020) reported *Taenia taeniaformis* in the lung and small intestine of rats and shrews.

Platynosomum concinnum (a trematode) was recorded in this study from *Sorex* sp. and was recovered from the bile duct of two females (1 adult and 1 juvenile) at Ovia North East LGA with a prevalence rate of 11.8% and a mean intensity of 178.0 (Table 4.7). The mean intensity was higher in the adult female (400.0) than in the juvenile female (30.0) *Sorex* sp. (Table 4.10). There were only two individuals (of *Sorex* sp.) that were recorded with a trematode infection and that is because, Ovia North East where the infection was found is home to both the terrestrial mollusc (*Subulina octonona* which is the first intermediate host of *P. concinnum*) and the terrestrial isopod or a beetle (the second intermediate host of *P. concinnum*) which forms part of the diet of *Sorex* sp. The terrestrial isopod (pill bugs or sow bugs) carries the metacercariae (infective form) of *Platynosomum* sp.

The trematode, *Platynosomum* sp., has been described as a parasite of civet cat (Chantawong *et al*., 2024) and infection is by ingesting intermediate hosts (terrestrial isopods) or paratenic hosts (lizards, amphibians, and insects) containing metacercaria (Chantawong *et al*., 2024). Infection with this parasite can induce mottled liver, gall bladder distention, hepatitis, cholangiohepatitis, cholecytitis, periductal fibrosis, biliary cirrhosis and biliary obstruction (Nur-Amalina *et al.,* 2022). The species of the parasitic genus is represented as *P. fastosum* in the temperates and in the tropics, as *P. concinnum.* Previous records of *Platynosomum* in small mammals are few. It has been reported in marmosets (Olivera *et al*., 2023) and other species of mammals including non-human primates and birds (Basu and Charles, 2014; Pinto *et al*., 2017). It is a parasite of the bile duct and gallbladder and it is the first time it would be reported in *Sorex* sp. in the world.

Two undetermined specimens (of Class Cestoda) were also recovered from the *Sorex* sp. encountered at Ovia North East LGA. One had a high mean intensity of 55.03 while the other had a mean intensity of 27.0 (Table 4.7). These cestodes were not found at Uhunmwode LGA probably because of the low numbers of individuals of *Sorex* sp. sampled there or due to the absence of the intermediate host for this cestode, which is commonly beetle.

In accordance to what was observed by Vouge and Rausch, 1955, in this study, large bodied size tapeworms had fewer mean intensities as they occurred in smaller numbers while very small sized species occurred in larger numbers per individual and they had higher mean intensities as seen in *Hymenolepis nana* (small in size but with more mean intensity of 40.0) (Table 4.7) and *Hymenolepis diminuta* (large in size but with lesser mean intensity of 1.5 and 2.0) (Table 4.8)

The overall prevalence of helminth parasites of male and female small mammals was compared and the prevalence of parasitic infection in female (33.3%) was greater than that of the male (30.6%), and the difference was statistically significant ($p < 0.05$) suggesting that there is effect of host sex on helminth parasites infections. The overall prevalence of helminth parasitic infections in the two local government areas was also compared and it was statistically significant ($p < 0.05$). In adult, the prevalence of helminth parasitic infections was higher than the juvenile with statistical difference ($p < 0.05$).

5.2 Medically Important Helminth Infections

Hymenolepiais is a major zoonotic rodent cestode disease (Islam *et al*., 2020). Helminths infestation in rodents affects their own health and can subsequently alter the rodent-environment ecology to a considerable degree because they can serve as reservoir hosts. Moreover, rodent helminths are important for humans, livestock, and pet animal health (Islam *et al*., 2020). *Hymenolepis diminuta and H. nana* are both zoonotic helminth parasites (responsible for hymenolepiasis) (Isaac *et al.,* 2018), because humans can be affected when food contaminated with rodent faeces that is containing the parasitic eggs are ingested or*,* the intermediate host (coleopteran beetle or fleas of *Xenopsylla* sp) are ingested (Chatterjee 2012, Gárate *et al*., 2011, Dhaliwal and Juyal 2013, Kim *et al.,* 2014, Bhosale, 2022).

Hymenolepis nana is a known zoonotic parasite with several cases reported in various areas of the globe and majority of the patients being children (Sun, 1988b), persons with chronic infections and immuno-compromised individuals (Bhosale, 2022). Mild infections are usually asymptomatic. Severe infection may cause headache, dizziness, pruritis, diarrhoea, restlessness or even convulsion in man (Sun, 1988b). Worm antigens in 73.4% of children with *H. nana* infections induce necrotic ulceration of the conjunctiva and cornea (Bhosale, 2022).

Kim *et al.,* (2014) reported a case of human hymenolepiasis in which a 44-year-old Korean man suffered from heavy *Hymenolepis nana* infection. A large number of *H. nana* adult worms were found throughout the colon, as well as in the terminal ileum. In a recent article, Peralta *et al*. (2023), reported 3 cases of hymenolepiasis in children aged 9, 12 and 13, due to zoonotic transmission from rodents and presumably associated with the consumption of powdered milk contaminated with infective eggs of *Hymenolepis* nana.

Hymenolepis diminuta is also known to be a zoonotic helminth parasite. Although *H. diminuta* in humans is mostly innocuous, it can cause abdominal pain, anorexia, cutaneous itch, mild diarrhoea, low-grade fever, eosinophilia and anaemia in rare cases with heavy infections (Bhosale 2022).

5.3 Contribution to knowledge

The study has contributed to knowledge in the following ways;

1) This study has provided a detailed report on the parasites of *Mus musculus*, *Sorex* sp., *Rattus rattus* and *Rattus norvegicus.*

2) This study has reported a new host record for *Platynosomum concinnum* globally.

3) This study has reported the presence of *Hymenolepis diminuta* and *Hymenolepis nana* (Zoonotic helminthes) in *Sorex* sp., *Rattus rattus* and *Rattus norvegicus.*

4) This study has reported the presence of *Taenia* sp. (the adult) in *Mus musculus*, *Sorex* sp., *Rattus rattus* and *Rattus norvegicus.*

5.4 Conclusion and Recommendation

The public health importance of rodent-borne helminth parasites is not fully recognized (Islam *et al*., 2020). However, rodent population control should be the primary concentration by a One Health approach to control the spread of these helminths at the humans-animal-environmental interface. "One Health is a collaborative, multisectoral, and transdisciplinary approach - working at the local, regional, national, and global levels—with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment" (CDC 2024). Thus, One Health practice comes as a practical approach to control rodent-borne helminth prevalence (Kaplan *et al*., 2009). It is also recommended that a countrywide and more detailed studies be conducted on rodent-borne helminths along with their impact on public health in Edo State, Nigeria.

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APPENDIX 1

DATA ANALYSIS

Chi-Square Test

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Sex * Infection	2840	100.0%	0	0.0%	2840	100.0%

Sex * Infection Crosstabulation

Count

		Infection		Total
		-ve	+ve	
Sex	F	200	968	1168
	M	1040	632	1672
Total		1240	1600	2840

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	568.040[a]	1	.000		
Continuity Correction[b]	566.209	1	.000		
Likelihood Ratio	604.503	1	.000		
Fisher's Exact Test				.000	.000
N of Valid Cases	2840				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 509.97.

b. Computed only for a 2x2 table

Response: The difference between the male and female infection rate is significant ($p<0.05$)

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Maturity * Infection	2840	100.0%	0	0.0%	2840	100.0%

Maturity * Infection Crosstabulation

Count

		Infection		Total
		-ve	+ve	
Maturity	Adult	700	1405	2105
	Juvenile	540	195	735
Total		1240	1600	2840

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	358.177[a]	1	.000		
Continuity Correction[b]	356.544	1	.000		
Likelihood Ratio	363.466	1	.000		
Fisher's Exact Test				.000	.000
N of Valid Cases	2840				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 320.92.

b. Computed only for a 2x2 table

Response: The difference between the adult and juvenile infection rate is significant ($p<0.05$)

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
LGAS * Infection	2840	100.0%	0	0.0%	2840	100.0%

LGAS * Infection Crosstabulation

Count

		Infection		Total
		-ve	+ve	
LGAS	Ovia NE	740	1337	2077
	Uhunmwod	500	263	763
Total		1240	1600	2840

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	202.839[a]	1	.000		
Continuity Correction[b]	201.626	1	.000		
Likelihood Ratio	203.134	1	.000		
Fisher's Exact Test				.000	.000
N of Valid Cases	2840				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 333.14.

b. Computed only for a 2x2 table

Response: The difference between Ovia North East and Uhunmwode infection rate is significant ($p<0.05$)

FACULTY OF LIFE SCIENCES
UNIVERSITY OF BENIN, BENIN CITY

Research Ethics Committee

Date: 12-09-2024

Ogunmiji Modupe Agatha
Department of Animal & Environmental Biology,
Faculty of Life Sciences

Dear Agatha,

RESEARCH ETHICS APPROVAL LETTER

The Faculty of Life Science Research Ethics Committee (FLSREC) has recently reviewed your research proposal. Your proposal meets the requirements of the Faculty of Life Sciences' statement on ethical conduct and hereby grant you full ethical approval as outlined below:

Approval No.	**FLSRE-2023-017**
Project title	Helminthic parasitic infections of two families (Rodentia and Soricomorpha) of small animals in two LGAs of Edo State
Approval date	September 11, 2024
Expiry date	
FLSREC Decision	**Approved**

The standard conditions of this approval require you to conduct the research strictly in accordance with the proposal submitted and approved, including any amendments made to the proposal by the Faculty of Life Science Research Ethics Committee. Please take note that failure to comply with the conditions of approval may result in the withdrawal of approval for the project.

Best regards,

Professor N. P. Okolie
Chairman,
Faculty of Life Science Research Ethics Committee