Sahel Journal of Life Sciences FUDMA (SAJOLS)
December 2025 Vol. 3(4): 520-526
ISSN: 3027-0456 (Print)
ISSN: 1595-5915 (Online)
DOI: *https://doi.org/10.33003/sajols-2025-0304-48*

Research Article

Histological Impact of Intestinal Helminth Parasites of some Vertebrates sold in Select Markets, Rivers State, Nigeria

***Chidinma C. Amuzie, Chioma G. Osah-Eze and Favour I. George**

Laboratory of Entomology and Parasitology, Department of Animal and Environmental Biology, Rivers State University, Port Harcourt, Nigeria

****Corresponding Author's email*: ekeh.chidinma@ust.edu.ng; Phone: +2348036729346**

ABSTRACT

Intestinal helminth parasites impact on the health of their hosts in several ways, including altering the structure and function of host tissues. Histological impacts of three helminths from three vertebrate hosts are hereby reported. Intestinal helminth community of greater cane rats (*Thryonomys swinderianus*) of Omagwa Bush Meat Market, Rivers State, Nigeria, was sampled to compare with previous reports. Intestinal tracts of *T. swinderianus* (n=12) samples were obtained from the slaughterhouse at Omagwa Bush Meat Market. Fish specimens (*Bostrychus africanus* [n=24] and *Periophthalmus papilio* [n=17]) were obtained from fishers at Creek Road Market, Rivers State. Sampling lasted from June to August 2023. All hosts were examined for parasites by dissection and microscopic examination; histologic impacts were assessed using Hematoxylin and Eosin staining procedures. Hosts and parasites were appropriately identified using keys. *Thryonomys swinderianus* were infected by nematodes- *Trichuris* sp. (16.7%), *Oesophagostomum venulosum* (50%) and *Strongylus* sp. (25%). *Raphidascaroides africanus* (20.8%) and *Neoechinorhynchus* sp. (6%) infected *Bostrychus africanus* and *Periophthalmus papilio,* respectively. Histologic impacts observed were as follows: *T. swinderianus* infected with *Trichuris* sp. showed mild disintegration of tissues. *Raphidascaroides africanus* caused detachment of the connective tissue core and dispersed mucus-secreting cells in *B. africanus*; *Neoechinorhynchus* sp. resulted in loss of secretory cells associated with disruption of the intestinal epithelial lining in *P. papilio*. The study showed that parasites result in histological changes, including tissue disintegration and dispersal/loss of secretory cells, in vertebrate hosts, and helminths of *T. swinderianus* include *Trichuris* sp., *Oesophagostomum venulosum* and *Strongylus* sp.

Keywords: *Neoechinorhynchus* sp.; *Raphidascaroides africanus;* Tissue alteration; *Trichuris* sp.; Wildlife parasitology

Citation: Amuzie, C.C., Osah-Eze, C.G., & George, F.I. (2025). Histological Impact of Intestinal Helminth Parasites of some Vertebrates sold in Select Markets, Rivers State, Nigeria. *Sahel Journal of Life Sciences FUDMA*, 3(4): 520-526. DOI: *https://doi.org/10.33003/sajols-2025-0304-48*

INTRODUCTION

Studies on the helminth parasites of wildlife species contribute to understanding the stressors that these parasites pose to infected hosts (Bhat *et al*., 2022). These impacts could contribute to population declines in natural habitats while increasing the risk of zoonosis (Msoffe *et al*., 2025).

Omagwa Bush Meat Market, located in Rivers State - Nigeria, has been intensely visited by researchers as it offers an easy reference point for studies on local wildlife species (Nzeako *et al*., 2016; Ibiso *et al*., 2021; Amuzie *et al*., 2022). This market boasts of several species, including *Thyronomys swinderianus, Cercopithecus mona, Tragelaphus spekii, Centrochelys sulcata, Atherurus africanus* etc. Amuzie *et al.* (2022) had investigated the intestinal helminth parasites of *Thryonomys swinderianus* from this location. These authors reported the following

helminth parasites: *Oesophagostomum venulosum, Strongylus* sp., *Trichuris parvispicularis* and *Toxocara vitulorum*.

Reports on the histopathological impacts of helminth parasites are sparse. Omaimah (2016) examined the impact of nematode parasites (including, *Anisakis simplex* larvae, *Thynnascaris* larvae*, Procamallanus chetumalensis* and *Camallanus hypophthalmicthys*) on four species of fish, *Epinephelus* spp. She reported pathological changes such as "extensive vacuolization and destruction of most hepatocytes and blood vessels, accumulation of lipid droplets, congestion of blood sinusoids and focal hemmorage". Amuzie *et al*. (2020) reported that helminths (*Rhabdias africanus* and *Raillietiella* sp.) caused congested pulmonary vessels, abnormal vascular dilatation and pulmonary haemorrhage in amphibians. In pigeons (*Columba livia domestica*) infected with *Raillietina* sp. (cestodes) and *Ascaridia columbae* (nematode), Aldamigh *et al*. (2022) reported "atrophy and distortion of villi, infiltration of inflammatory lymphocytic cells, erosion, and loss of the intestine integrity, necrosis in villi, and blood vessels congestion." Howard (2025) observed an increase in the mass of the liver and spleen of small mammals infected with helminth parasites. These observations are based on deviations from the normal morphology of the hosts as a result of the activities of parasites.

This article reports on the histological impacts of three helminth parasites isolated from *T. swinderianus* and two fish species (*Bostrychus africanus* and *Periophthalmus papilio*). The intestinal helminth parasites of *T. swinderianus* from Omagwa Bush Meat Market were also assessed to compare with previous results.

MATERIALS AND METHODS

Study Area

Vertebrate samples used for this research were obtained from Omagwa Bush Meat Market (located between 4°58'5''N and 6°41'20''E at Ikwerre Local Government Area) and Creek Road Market (4°45'04.43''N, 7°00'14.08''E at Port Harcourt Local Government Area) both in Rivers State, Nigeria.

The climate at both locations is warm and humid tropical rainforest type with distinct wet (late April or early May to August, and September) and dry (from October to March) seasons. The major activities of the people are subsistence farming, trading, hunting and transportation business.

Sample collection

The gastrointestinal tract of twelve *T. swinderianus* samples were purchased from the slaughterhouse at Omagwa Bush Meat Market for this study. Twenty-four sleeper gobies (*Bostrychus africanus*) and seventeen mudskippers (*Periophthalmus papilio*) were purchased from fishers at the Creek Road Market. These were examined for the histological impacts of their intestinal helminth parasites.

Sampling protocol

Sample collection was done over the period of June and August, 2023. For the cane rats, the gastrointestinal tracts which were cut from freshly captured rats were purchased from butchers at the slaughterhouse and immediately transported to the Laboratory of Entomology and Parasitology, Department of Animal and Environmental Biology, Rivers State University, Port Harcourt. Whole fresh samples of both fish species were purchased from fishers. Sampling was random as the organisms used in this research were purchased based on their availability.

Fish samples were identified using standard keys by Schneider (1990). The wet body mass of each sample was obtained using an electronic weighing balance (Camry model EK5350) while the standard length was measured with a metre rule. Dissection was done under sterile conditions. Using of a pair of dissecting scissors, a longitudinal incision was made on the ventral surface from the anal pore of each sample exposing the internal organs. After the dissection, the gut and visceral organs of the fish were placed into Petri dishes containing physiological saline.

All samples were examined for parasites; intestinal sections of infected hosts were used for histological analysis.

Laboratory Examination

The intestinal samples of *T. swinderianus* were sectioned and incised longitudinally. Portions of the content were scooped into Petri dishes containing 0.9% normal saline solution. Parasites were extracted using forceps, cleared in lactophenol and observed under the microscope at ×10 and ×40 objectives. Parasite identification was accomplished using the morphological identification of nematodes by Yamaguti (1961) and Baker (2007).

The organs incised from the fish samples were carefully dissected to aid the emergence of parasitic helminths. Parasites were picked up using plastic pipettes, examined under the microscope (x10 and x40 objective) and later fixed in 70% ethanol solution. Parasite identification was aided with standard keys as follows: *Raphidascaroides africanus* by Khalil and Oyetayo (1988) and Moravec, 2019; *Neoechinorhynchus* sp. by Paperna (1996).

For histological examination, sections of infected intestines of fish and of *T. swinderianus* were used. These were fixed in 10% neutral buffered formalin at room temperature for 24 hours. After serial dehydration steps in ethanol, samples were then embedded in paraffin. The blocks of embedded tissue were sectioned at 5µm and sections were routinely stained with hematoxylin and eosin (HeE) within a period of about 12 minutes, and mounted on DPX. Images were acquired with a Leica DFC280 digital camera attached to a light microscope (Leica 6000B) at a magnification of x400.

Data Analysis

Results obtained from the parasitological examination of the host samples were used to compute the parasite ecological parameters of prevalence and mean intensity according to Bush *et al*. (1997) using Microsoft Excel 2010.

RESULTS

Helminth Parasites Isolated from Samples Exposed to Histological Analysis

Five (20.8%) of the 24 specimens of *Bostrychus africanus* were infected with *Raphidascaroides africanus* while of the seventeen specimens of *Periophthalmus papilio*, only one (6.0%) was infected with an acanthocephalan parasite, *Neoechinorhynchus* sp. The intestine of *Thryonomys swinderianus* used for histological analysis was infected with only *Trichuris* sp.

Histological Observations in the Intestines of *B. africanus*, *P. papilio* and *T. swinderianus*

Histological examinations of intestines of all three species of vertebrates infected with helminths presented varying degrees of degeneration of epithelium and depletion of cells.

It was observed that the intestinal tissues of *B. africanus* infected with *R. africanus* showed detachment of the connective tissue core and a dispersal of the mucus secreting cells lining the GIT epithelium (Plate 1). *In P. papilio* infected with *Neoechinorhynchus* sp., loss of secretory cells and disruption of the epithelial lining (Plate 2) were observed. On the other hand, mild disintegration of tissues (Plate 3) was observed in the intestinal tissues of *T. swinderianus* infected with *Trichuris* sp.

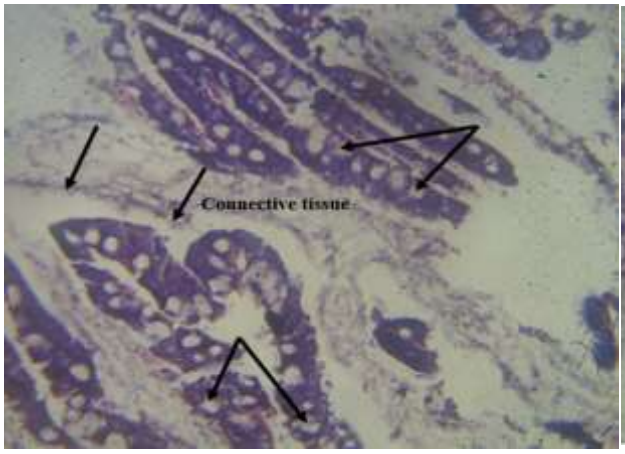

Plate 1. Photomicrograph (H&E X400) of the intestine of *Bostrychus africanus* infected with *Raphidascaroides africanus* showing detachment of the connective tissue core (single arrows); dispersed mucus secreting cells lining the GIT epithelium (joined arrows)

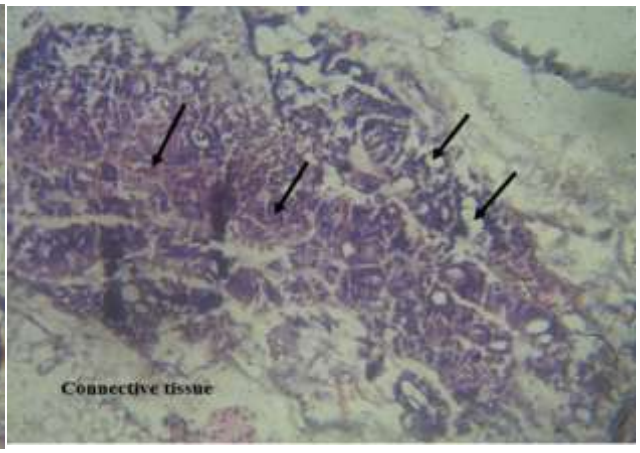

Plate 2. Photomicrograph (H&E X400) of the intestine of *Periophthalmus papilio* infected with an acanthocephalan parasite, *Neoechinorhynchus* sp., showing loss of secretory cells associated with disruption of the epithelial lining of the GIT

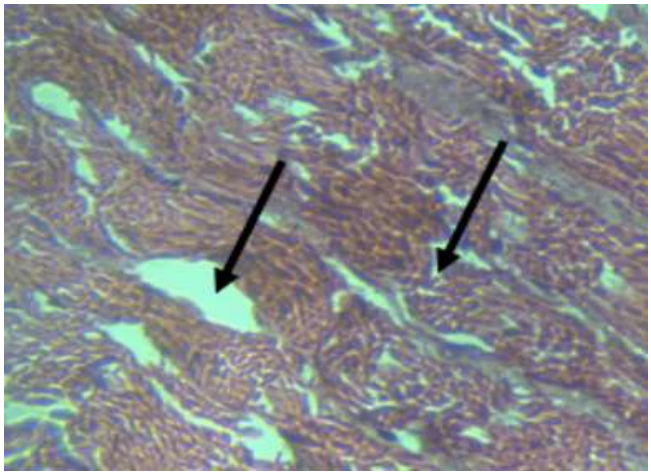

Plate 3. Photomicrograph (H&E x400) of the intestinal sample of Thryonomys swinderianus infected with Trichuris sp. showing mild disintegration of tissues

Helminth Parasites Isolated from Greater cane rats (*Thryonomys swinderianus*)

Three helminth parasites were isolated from *T. swinderianus* namely, *Trichuris* sp., *Oesophagostomum venulosum* and *Strongylus* sp. *Oesophagostomum venulosum* was the most prevalent of the three (50.0%) occurring in six of the samples. One hundred and six individuals of the parasite were isolated, hence, a mean intensity of about eighteen parasites per infected host (Table 1). *Strongylus* sp. infected four (25.0%) samples at a mean intensity of about one parasite per infected host. *Trichuris* sp. infected two hosts (16.7%). Seventeen parasites were isolated from the two hosts thus, a mean intensity of about nine parasites per infected host (Table 1).

A total of ten hosts were infected (83.3%), consisting of both single and co-infections. *Trichuris* sp. occurred alone in the hosts it infected. *Oesophagostomum venulosum*, on the other hand, singly infected four host samples and co-infected two other hosts with *Strongylus* sp. As already stated, *Strongylus* sp. co-infected two host samples with *O. venulosum*, and singly infected another two.

Table 1. Prevalence and mean intensity of parasite infection in grasscutters (*Thryonomys swinderianus*), Omagwa Bush Market, Rivers State, Nigeria

Parasite species	No. of Infected Hosts	Location in Host	Prevalence (%)	Mean intensity
Oesophagostomum venulosun	6	Large Intestine	50.0	17.7
Strongylus sp.	4	Small Intestine	25.0	1.3
Trichuris sp.	2	Small Intestine	16.67	8.5

DISCUSSION

Nematode parasites have been reported to cause histologic changes in host tissues. For instance, Amuzie *et al*. (2020) reported that lung nematodes, *Rhabdias africanus,* of amphibians caused congested pulmonary vessels and abnormal vascular dilatation in *Rhabdias*-infected lungs, and pulmonary haemorrhage in addition to the other pathologies in lungs co-infected by *Raillietiella* sp. Akinsanya (2021) reported moderate lymphocytic infiltration of the lamina propria in fish (*Rhinogobius ocellatus*) infected by *Raphidascaroides* sp. In the present study, *Bostrychus africanus* infected with the nematode parasite, *Raphidascaroides africanus*, showed massive detachment of the connective tissue core. This can be associated with the movement of the parasite through the epithelial cells, causing lesions. Such lesions trigger an inflammatory response from the fish immune system causing the release of inflammatory cell infiltrates. Thus, *Raphidascaroides* and other parasitic genera of nematodes can result to tissue damage in infected vertebrate hosts. The

damage they cause are generally linked to their migration within host tissues and organs, secretory fluids, attachment organs (where available) and their feeding patterns.

Histological examinations of the gastrointestinal tract of *Periophthalmus papilio* infected with *Neoechinorhynchus* sp. (acanthocephalan parasites) showed intense disruption of the intestinal epithelium and loss of secretory cells. Similarly, Jithendran and Kannappan (2010) observed that acanthocephalan parasites in Grey Mullets (*Mugil cephalus*) led to the distortion of the epithelial lining due to inflammatory infiltrates on the intestinal wall. Generally, acanthocephalan parasites are reported to result in severe histological damage (including destruction of the villi, thickening of the mucus layer, severe inflammation, hyperplasia etc) of the intestines of infected fish, especially owing to their possession of a spiny proboscis (de Matos *et al*., 2017; Palaq *et al*., 2017). Thus, the possession of a spiny proboscis is mainly responsible for the tissue alterations associated with acanthocephalan parasites.

Sections of the intestine of *Thryonomys swinderianus* infected with *Trichuris* sp. showed mild disintegration of the tissues. However, other researchers reported infiltrated lymphocytes, thickening of intestinal mucosa, ulceration and nodule formation, loss of blood at the point of insertion of the worm's anterior region into the intestinal mucosa (Tahmina and Wajihullah, 2016). Others reported ruptured and disorganized intestinal epithelium, significant increase in the counts of *Escherichia coli* and *Proteus* sp. as well as general imbalance in gut microbiota (Schachter *et al*., 2020), which were associated with *Trichuris* spp. infection. Damage due to *Trichuris* infection is worse at high infection intensity as the parasite is generally asymptomatic, lacking in organs of attachment (Amuzie *et al*., 2022).

The helminth community of greater cane rats, *T. swinderianus*, at Omagwa Bushmeat Market has been relatively unchanged over a two-year period. In earlier research, Amuzie *et al*. (2022) reported four gastrointestinal helminth parasites, namely, *Oesophagostomum venulosum, Strongylus* sp., *Trichuris parvispicularis* and *Toxocara vitulorum*, from same host species captured in 2020-2021 from same location. The present study isolated the same parasites from the previous study except *Toxocara vitulorum*. Prevalence of infections were generally higher in the earlier report (Amuzie *et al*., 2022) though *O. venulosum* maintained a prevalence of 50%; *Strongylus* sp. and *T. parvispicularis* recorded prevalence of 50% and 33.3% respectively in the earlier report against 25% and 16.7% respectively in the present report. The lower diversity of parasite species in the present study does not indicate a significant deviation because the difference involves one parasite which had the least prevalence (8.3%, infecting one host out of twelve examined) in the previous report. The parasite, *Toxocara vitulorum*, usually exhibits vertical transmission or directly through the ingestion of infective eggs from contaminated habitats. Infection prevalence is thus expected to be low in less contaminated situations.

Intensity of parasite infection differed slightly. In both reports, *O. venulosum* had the highest mean intensity of 12 parasites per infected host in Amuzie *et al*. (2022) and 17 parasites per infected host in the current research. The mean intensity of *Strongylus* sp. reduced from 6.7 (Amuzie *et al.,* 2022) to 1.3 in the current research, while that of *Trichuris* sp. increased from 1.8 (Amuzie *et al*., 2022) to 8.5 in the current research. Intensity of parasite infection can differ for several reasons, including host ecology and demographics, natural or human-induced habitat alterations and environmental factors, such as prevailing temperature values (Magdalek *et al*., 2022). The study of these factors was, however outside the scope of the present study.

In earlier research on *T. swinderianus* from the same location, however, Abara *et al*. (2021) reported more species, including *Ascaris* sp., *Strongyloides* sp., *Fasciola* sp., *Taenia* sp., *Moniliformis* sp. and hookworms from sixty samples. Similarly, Yeboah *et al.* (2024) reported more helminth species (*Ascaris* sp., hookworms, *Strongyloides* sp., *Fasciola* sp., *Trichuris* sp., *Taenia* sp. and *Hymenolepis* sp.) in rectal samples of fifty *T. swinderianus* of Atwemonom Bushmeat Market, Kumasi, Ghana. These disparities could be accounted for by the higher number of host samples examined and by the use of concentration and molecular biology techniques in the cited literature. Larger sample sizes generally increase the chances of encountering a higher diversity of parasite species (Yamada and Takemoto, 2017). Similarly, certain techniques, such as concentration and molecular diagnostic techniques, present higher

parasite diversity due to their ability to increase the number of parasites per sample and higher sensitivity making it easier to identify parasites that are present in low abundance (Alsharksi *et al*., 2024).

Multiple or mixed infection of helminth parasites is common in cane rats (*T. swinderianus*), as well as in African civets (*Civettictis civetta*) and antelopes (Yeboah *et al*., 2024). It has also been observed in ungulates (Bhat *et al*., 2022), consisting of five to more parasites in the same host, and in rats, *Rattus* sp. with up to six and seven helminth species (Paller *et al*., 2024). This is because the complexity of the vertebrate body provides several microhabitats for different parasites to establish infection.

CONCLUSIONS

Helminth parasites such as, *Raphidascaroides africanus, Neoechinorhynchus* sp. and *Trichuris* sp. were shown to cause histologic alterations in the gastrointestinal regions of fish and mammal hosts and may have deleterious effects on their overall health. Intestinal helminth parasites of greater cane rats (*Thryonomys swinderianus*) of Omagwa Bush Meat Market were found to consist of nematodes namely, *Trichuris* sp., *Oesophagostomum venulosum* and *Strongylus* sp.

Due to the observed gap existing on the histological impacts of helminth parasites, we recommend further research into the pathology of parasitic helminths. Also, regular examination of wildlife for parasites is essential for early detection of emerging zoonosis and is therefore encouraged.

Author Contributions: CCA designed the study; CCA, CGO and IFG were involved in sample collection and laboratory analyses. CCA drafted the manuscript; CGO and IFG reviewed it. All authors agree to the publication of the manuscript.

REFERENCES

Abara, P. N., Adjeroh, L. A., Nwachukwu , M. O., and Osinomumu, I. (2021). Preliminary survey of the intestinal helminths of grasscutter and antelope (Bush Meat) in Omagwa Rivers State. DOI: https://doi.org/10.55434/CBI.2021.9102. *Caribbean Journal of Sciences and Technology*, **9**(1), 1–6. https://doi.org/10.55434/CBI.2021.9102.

Akinsanya, B. (2021). Ultrastructure of the Anisakid nematode, *Raphidascaroides* sp. (Nematoda: Anisakidae) from the freshwater fish *Rhinogobius ocellatus* (Fowler, 1937) with attendant histopathological alterations in Lekki Lagoon, Lagos, Nigeria. *Scientific African*, **12**: e00725.

Aldamigh, M.A., Hassan, A.H. and Alahmadi, A.A. (2022). Histopathological changes in the intestine of infected pigeons (*Columba livia domestica*) by helminth parasites from Al-Qassim, Saudi Arabia. *Open Access Library Journal*, **9**: 1-9. doi: 10.4236/oalib.1108916.

Alsharksi, A.N., Sirekbasan, S., Gurkok-Tan, T. and Mustapha, A. (2024). From tradition to innovation: diverse molecular techniques in the fight against infectious diseases. *Diagnostics*, **14**: 2876. https://doi.org/10.3390/diagnostics14242876.

Amuzie, C. C., Nwafor, P., Robert, B. and Akani, G. C. (2022). Intestinal helminth parasites of greater cane rats (*Thryonomys swinderianus*) sold at Omagwa Bushmeat Market, Omagwa, Rivers State, Nigeria. *Annals of Parasitology*, **68**(3): 623–629.

Amuzie, C.C., Brown, F.C. and Daka, E.R. 2020. Histopathology of *Rhabdias* and *Raillietiella* infected lungs of *Sclerophrys maculata* (Hallowell's Toad), Port Harcourt, Nigeria. *Journal of Nature Studies*, **19**(2): 1-9.

Baker, D.G. (2007). Flynn's parasites of laboratory animals. 2nd Edition. Blackwell Publishing; Iowa. Parasites of rats and mice; pp. 303–397.

Bhat, R.A., Tak, H., Bhat, B.A., Dar, J.A. and Ahmad R. (2022). Gastrointestinal helminth parasites of wild ungulates in Hirpora Wildlife Sanctuary, Kashmir, India. *Journal of Parasitic Diseases*, **46**(3):804-810. doi: 10.1007/s12639-022-01493-3.

Bush, A.O., Lafferty K.D., Lotz J.M. and Shostak A.W. (1997). Parasitology meets ecology on its own terms: Margolis *et al*. revisited. *Journal of Parasitology,* **83**(4): 575–583. https://doi.org/10.2307/3284227.

de Matos, L.V., de Oliveira, M.I.B., Gomes, A.L.S. and da Silva,G.S. (2017). Morphological and histochemical changes associated with massive infection by *Neoechinorhynchus buttnerae* (Acanthocephala: Neoechinorhynchidae) in the farmed freshwater fish *Colossoma macropomum* Cuvier, 1818 from the Amazon State, Brazil. *Parasitology Research***,** 116(3); DOI:10.1007/s00436-017-5384-3.

Howard, G. (2025). Pathohistological effects of helminth parasites in small mammals. *Celebration of Scholarship*. 4.

https://digitalcommons.shawnee.edu/cos/2025/session8/4.

Ibiso, G., Akani, G.C., Nioking, A. and Onuegbu, G.C. (2021). Population abundance of antelopes based on prevalence in some selected markets in Rivers State, Nigeria. *African Journal of Environment and Natural Science Research (AJENSR),* **4**(3): 45-47.

Jithendran, K. P. and Kannappan, S. (2010). A short note on heavy infection of acanthocephalan worm (*Neoechinorhynchus agilis*) in grey mullet, *Mugil cephalus*. *Journal of Parasitic Diseases*, **34**(2): 99–101. DOI: 10.1007/s12639-010-0019-y .

Khalil, L. F. and Oyetayo, A. S. (1988) *Raphidascaroides africanus* sp. nov. (Nematoda: Anisakidae) from the fish *Bostrychus africanus* in Nigeria and a key to the species of the genus *Raphidascaroides* Yamaguti, 1914. *Journal of African Zoology*, **102**: 85–91.

Magdalek, J., Bourgoin, G. and Vadlejch, J. (2022). Non-native nematode *Ashworthius sidemi* currently dominates the abomasal parasite community of cervid hosts in the Czech Republic. *Frontiers in Veterinary Science*, **9**: 862092. Doi:10.3389/fvets.2022.862092.

Moravec, F. (2019). Parasitic nematodes of freshwater fishes of Africa. 1st edition. Czech Republic: Czech Academy of Sciences.

Msoffe, V.T., Thomas, C.A., Rija, A.A., Nzalawahe, J., Katakweba, A.S., Misinzo, G. and Mnyone, L.L. (2025). Gastrointestinal helminth infections and ectoparasitism in wild rodents along wildlife-human interfaces in Tanzania. *International Journal for Parasitology: Parasites and Wildlife*, 26, 101040, https://doi.org/10.1016/j.ijppaw.2025.101040.

Nzeako, S.O., Uche, A.O., Umoren, P., Ezeanwaka, C. and Nzeako, M.M. (2016). Inventory of harvested wildlife sold at the Omagwa bush meat market, Rivers State, Nigeria. *Annals of Biological Research,* **7** (6):12-19.

Omaimah, M. (2016). Histopathological effects of some helminthic parasites on the liver of Serranid fish. *Journal of Advances in Biology*, **9**(3): 1922-1926. DOI : 10.24297/jab.v9i3.795.

Palaq, P., Langer, S., Ahmad, F. and Nissa, N.U. (2017). Histopathological alterations in the intestines of c

Labeo rohita infected with acanthocephalan parasite *Neoechinorhynchus* sp. *Bioscience and Biotechnology Research Asia*, **14**(4). Available from: https://www.biotech-asia.org/?p=28399.

Paller, V.G.V., Fornesa, R.N., Fernandez, D.A.P. and Estaño, L.A. (2024). Rats and their helminth parasites: Potential zoonosis threats of land use change in the northeastern sub-watersheds of Mount Makiling, Laguna, Philippines. *Helminthologia*, **61**:30-39. doi: 10.2478/helm-2024-0005.

Paperna, I. (1996). Parasite, infestations and disease of fishes in Africa—An Update. *CIFA Technical Paper*, 31: 1-220.

Schachter, J., de Oliveira, D.A., da Silva, C.M., de Barros Alencar, A.C.M., Duarte, M., da Silva, M.M.P., Ignacio,A.C.P.R. and Lopes-Torres, E.J. (2020). Whipworm infection promotes bacterial invasion, intestinal microbiota imbalance, and cellular immunomodulation. *Infection and Immunity*, **88**(3): e00642-19. Doi:10.1128/IAI.00642-19.

Schneider, W. (1990). FAO species identification sheets for fishery purposes. Field guide to the commercial marine resources of the Gulf of Guinea, Food and Agricultural Organisation of the United Nations, Rome, Italy.

Tahmina, Z. and Wajihullah, K. (2016). Morphological and histopathological studies of *Trichuris ovis* in goat intestine. *Journal of Parasitic Diseases, Diagnosis and Therapy*, **1**: 1-7.

Yamada, F.H. and Takemoto, R.M. (2017). How does host ecology influence sampling effort in parasite diversity estimates? A case study using Neotropical freshwater fishes. *Acta Parasitologica*, **62**: 348-353. https:doi.org/10.1515/ap-2017-0042.

Yamaguti S. (1961). Systema helminthum. Vol. III. The nematodes of vertebrates. Parts 1 and 2. Interscience Publishers Inc., New York, USA.

Yeboah, J.A., Offih-Kyei, W., Danso-Coffie, C.K., Boafo, E., Banahene, P., Yeboah, R., Futagbi, G., Bimi, L.and Oduro, D. (2024). Assessment of enteric helminth parasites in bushmeat in Ghana. *International Journal for Parasitology: Parasites and Wildlife*, **25**: 101005, https://doi.org/10.1016/j.ijppaw.2024.101005.