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Communication

Prevalence and Seasonal Variation of *Trichuris* Worms Infection in *Mastomys natalensis* in Morogoro and Iringa Regions, Tanzania

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Abstract: Trichuriosis is a disease in mammals caused by the whipworms of the genus *Trichuris*. These worms are known for the high disease burden they cause in humans and domestic animals, especially in sub-Saharan Africa. In this study, we investigated the prevalence and seasonal variations of *Trichuris* worms in multimammate rats (*Mastomys natalensis*). The study was conducted between January and November 2021 in Tanzania, in two regions (Morogoro and Iringa) that differ in their eco-climatic conditions. Removal trapping was conducted using Sherman® live traps during the rainy and dry seasons. The gastrointestinal tracts of captured rodents were screened for the presence of *Trichuris* worms, which were identified using morphological keys. A total of 200 *M. natalensis* rats were collected from each of the regions, with 100 animals in each season. For Morogoro, the overall prevalence of *Trichuris* worms in *M. natalensis* was 36% (n = 72), of which 42% (n = 42) and 30% (n = 30) were for the rainy and dry seasons, respectively. For Iringa, the overall prevalence was 65% (n = 130), of which there were 80% (n = 80) and 50% (n = 50) for the rainy and dry seasons, respectively. *Trichuris* worm infections were significantly higher during the rainy season in Iringa than in Morogoro; however, no significant difference in infections between males and females was noted in either region or season. Other helminths detected were *Strongyloides* spp., *Capillaria* spp., *Hymenolepis* spp. and eggs of a helminth that has yet to be confirmed, possibly an Anoplocephalid species. Since *M. natalensis* is the most important pest species in sub-Saharan Africa, and is a carrier of several zoonotic helminths, there is a need for improved surveillance of helminths infections in the studied regions, in order to establish strategic control programs to reduce their adverse impacts on health.

Keywords: rodents; Trichuriosis; whipworm; zoonosis

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Citation: Thomas, C.; Msoffe, V.; Van Houtte, N.; Mhamphi, G.; Mariën, J.; Sabuni, C.; Makundi, I.; Nzalawahe, J.; Machang'u, R.; Leirs, H. Prevalence and Seasonal Variation of *Trichuris* Worms Infection in *Mastomys natalensis* in Morogoro and Iringa Regions, Tanzania. *Parasitologia* **2023**, *3*, 293–299. https://doi.org/10.3390/parasitologia3030030

Academic Editors: Maurizio Francesco Brivio and Theo de Waal

Received: 10 June 2023
Revised: 7 August 2023
Accepted: 13 August 2023
Published: 16 September 2023

1. Introduction

Trichuriosis is a disease of mammals caused by nematodes belonging to the genus *Trichuris* [1–3]. The disease has spread worldwide, and is most abundant in tropical regions of the world. Infections affect about one billion people around the globe, and more than a quarter of the world's population is predicted to be at risk. In 2020, the World Health Organization (WHO) considered sub-Saharan Africa as one of the regions most heavily affected by *Trichuris* worms infections. *Trichuris* worms and other intestinal parasites have received much worldwide attention in recent years due to the exponential increase in their infection rates in humans and animals [4,5].

Approximately 80 species of the worms are currently identified in the genus *Trichuris*, and most seem to have specific mammalian hosts. For instance, *Trichuris muris* is a rodent intestinal parasitic nematode that inhabits the large intestine of its host, and induces a strong immune response [5]. Indeed, rodents are reservoirs of many zoonotic pathogens, including *Trichuris* worms [1,6]. *Mastomys natalensis* is among the most abundant and dominant rodent species in sub-Saharan Africa, including Tanzania [7–9]. This rodent species is highly prolific, and has successfully exploited a wide variety of habitats and environments [7–9]. In addition, their populations are strongly seasonal, depending on the availability of rainfall and feed abundance [10].

Several studies suggested that differences in environmental conditions, such as temperature and rainfall, lack of access to potable water, poor hygiene and poverty, are major risks for trichuriosis infections [5–9]. It is also hypothesized that infections occur more often during the rainy season [11–15]. Consequently, little is known about the prevalence of *Trichuris* worms in climatically different environments in Tanzania. Therefore, this comparative study aimed to determine the prevalence and seasonality of *Trichuris* infections in two climatically different regions of Tanzania. The findings will help to determine the influence of season on infection, which can help organize worm control programs, including deworming of vulnerable communities.

2. Materials and Methods

2.1. Study Sites and Design

A cross sectional study was carried out in two climatically different regions of Tanzania, namely, Morogoro and Iringa, from January to November 2021. In Morogoro, the study was carried out in Choza village close to the Sokoine University of Agriculture main campus, and in Kiroka village (6°50′34.9794″ S; 37°38′8.232″ E). The villages experience a bimodal rainfall pattern that is characterized by short rains from November to January, and long rains from March to May. The drier season lasts for six months in Morogoro, from May to November [16] (Figure 1).

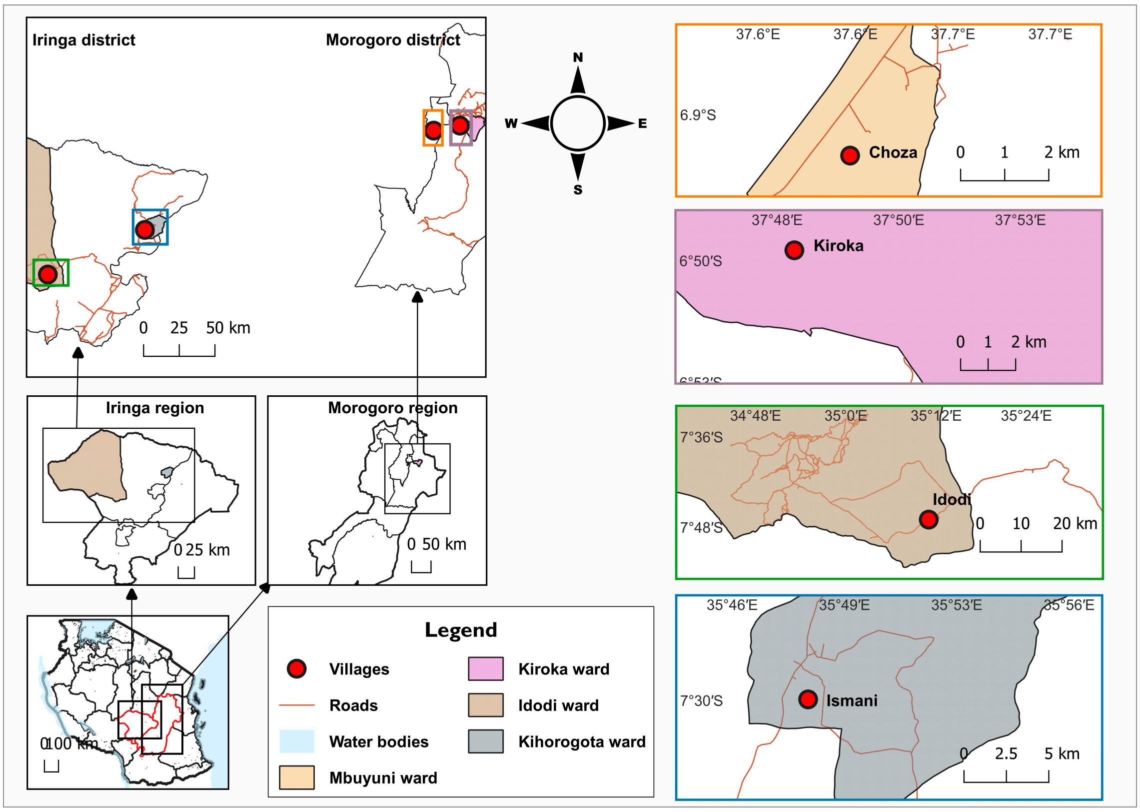

Figure 1. Map of selected study areas of Morogoro and Iringa regions, Tanzania.

For Iringa, Isimani and Idodi villages were selected (6°50′34.9794″ S; 37°38′8.232″ E), both with a unimodal rainfall pattern. The rainy and dry seasons are well distinguished, with rainfall starting late November or December and ending in April or May, followed by the dry season that starts in May or June and ends in October or November [17].

2.2. Climatic Conditions of Morogoro and Iringa

According to the world climate database, Morogoro has an average temperature of 21.9 °C during the coldest month of July, and 27.3 °C during the warmest month of January; the precipitation amounts to 890 mm per year [16].

In Iringa, the average temperature of the coldest month (July) is 19.0 °C, and that of warmest month (November) is 23.1 °C. The precipitation amounts to 740 mm per year [17,18].

2.3. Trapping of Rodents

The removal trapping procedure was conducted in both sites using Sherman® traps (standard medium size LFA: 7.6 × 8.9 × 23 cm). The trapping was conducted once per month from January to November 2021, during the rainy and dry seasons, for three consecutive nights, making a total of 32 trapping nights. The traps were set in the early evening, and left overnight and inspected the following morning. In each line, the traps were placed 10 m apart from in 10 lines. A total of 300 traps were used in each trapping session, and each trap was baited with peanut butter [19].

2.4. Animal Processing and Parasitological Screening for Trichuris Worms

The captured rodents were identified, sexed and weighed before being euthanatized and dissected, in order to obtain the gastrointestinal tract for the recovery of adult worms [20]. The intestines and fecal samples collected were preserved in bijou bottles containing 70% ethanol, before being transported to the Institute of Pest Management (IPMC) Laboratory for analysis.

The fecal samples for helminth egg examination were collected from the rectum and recovery of adult worms from the gut contents was carried out after dissecting the entire intestine. The isolation and measurements were conducted using a stereomicroscope mounted with a camera (model MB200, OPTA-TECH, Warsaw, Poland, Oswietienie; 3.3 V) at ×2 magnification [21].

Rodents were considered to be free of *Trichuris* spp., only after the entire intestinal section was scanned and no eggs or whipworms were seen. The isolated adult *Trichuris* worms were identified using published morphological keys [22].

Three to four fecal pellets were placed in a 3 mL test tube containing 2 mL of floatation solution (analytical sodium chloride), and once the pellets were softened, they were triturated to break up the pellets to facilitate the release of the helminth eggs. A volume of 1 mL floatation solution was then added to make up a total of 3 mL, followed by covering of the test tube with a coverslip for at least 15 min [23].

The fecal ova were examined at ×100 magnification using a light microscope with a mounted camera (Nikon digital camera DXM1200C). Samples were considered positive for *Trichuris* spp. when one or more eggs with the characteristic *Trichuris* "lemon" shape were found [23,24].

2.5. Data Analysis

The effects of the geographical region, season, and sex of the rodents on *Trichuris* worm infections were tested using a generalized linear model with a binomial function. Data entry was carried out using Excel (Microsoft). Data cleaning, statistics and plotting were done in R statistical software 4.1.3 [10].

3. Results

A total of 200 *M. natalensis* were collected from each region and screened for *Trichuris* infections. For each season, an equal number of 100 animals were screened. For the Morogoro region, 97 (49%) and 103 (51%) of the animals were males and females respectively. Overall, the prevalence of *Trichuris* worms infection for both seasons in Morogoro was 36% (n = 72), of which males accounted for 33% (n = 32) while females accounted for 39% (n = 40); moreover, incidences of 22% (n = 22) and 30% (n = 30) were recorded during the rainy and dry seasons, respectively.

For the rainy season, the prevalence were 12% (n = 12) in males and 10% (n = 10) in females, while for the dry season, the prevalence were 16% (n = 16) and 14% (n = 14) for males and females respectively.

For the Iringa region, 105 (53%) were males and 95 (47%) were females. The overall prevalence of infection was 65% (n = 130), of which 61% (n = 64) and 70% (n = 66) were in males and females for both seasons respectively. For the rainy season, the total number of males was 57% (57), while females was 43 (43%). The overall prevalence of infection was 80% (n = 80), of which males and females accounted for 44% (n = 44) and 36% (n = 36), respectively. For the dry season, the overall prevalence was 50% (n = 50), of which 20% (n = 20) were males and 30% (n = 30) were females (Figure 2). During the study, the prevalence of *Trichuris* worm infections varied significantly between the two regions and seasons; with the rainy season showing a higher prevalence than the dry season in both regions (Figure 2) (df = 1, χ^2 = 31.443, $p < 0.05$), with infection being significantly higher in the Iringa region than in the Morogoro region (df = 1, χ^2 = 16.438, p = 0.0001). The generalized linear model showed no significant difference between males and females in infection with *Trichuris* worms in either region or season (Figure 2) (df = 1, χ^2 = 1.3, p = 0.431). During the study, eggs and adult worms other than *Trichuris* spp. were observed via stereomicroscopy [23,25–28] (Tables 1 and 2).

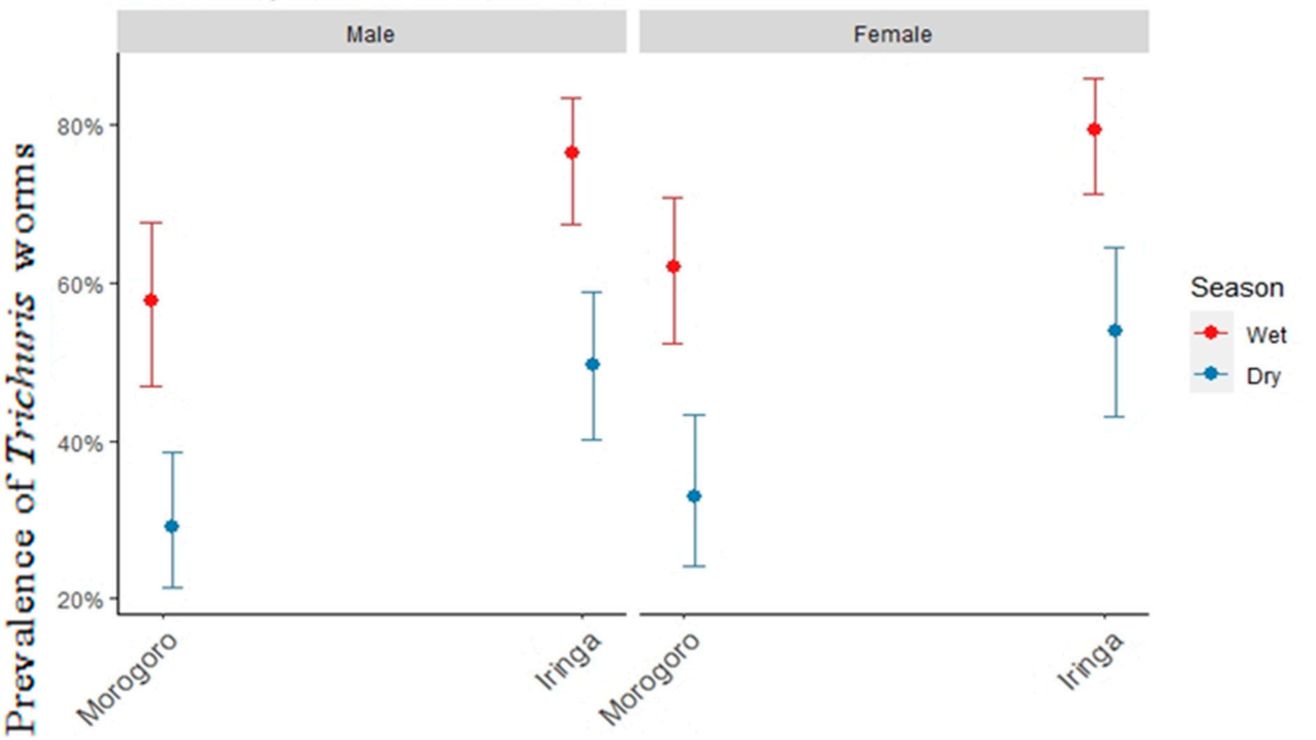

Figure 2. Plot showing the effect of season, location and sex of *Mastomys natalensis* on *Trichuris* worm infections in Morogoro and Iringa regions, Tanzania.

Table 1. Prevalences of helminth eggs detected during the screening of *Trichuris* worms in the fecal samples of *Mastomys natalensis* in the dry and rainy seasons in Morogoro region, Tanzania.

	Rainy Season			Dry Season		
Helminths Detected	**Total Prevalence (n = 100)**	**Male**	**Female**	**Total Prevalence (n = 100)**	**Male**	**Female**
Trichuris spp.	22%	12%	10%	30%	16%	14%
Anoplocephalid species. *	10%	4%	6%	22%	15%	7%
Strongyloides spp.	0%	0%	0%	50%	22%	28%
Capillaria spp.	0%	0%	0%	14%	6%	8%
Hymenolepis spp.	0%	0%	0%	55%	27%	28%

* Yet to be confirmed.

Table 2. Prevalences of helminth eggs detected during the screening of *Trichuris* worms in the fecal samples of *Mastomys natalensis* in the dry and rainy seasons in Iringa region, Tanzania.

	Rainy Season			Dry Season		
Helminths Detected	**Total Prevalence (n = 100)**	**Male**	**Female**	**Total Prevalence (n = 100)**	**Male**	**Female**
Trichuris spp.	80%	44%	36%	50%	20%	30%
Anoplocephalid species. *	20%	12%	8%	28%	15%	13%
Strongyloides spp.	90%	56%	34%	50%	39%	21%
Capillaria spp.	0%	0%	0%	16%	6%	10%
Hymenolepis spp.	0%	0%	0%	6%	2%	4%

* Yet to be confirmed.

4. Discussion

The current study aimed to determine the seasonal variations of *Trichuris* worm infections in *M. natalensis* in two regions of Tanzania (Morogoro and Iringa) that are climatically different. The study showed different infection levels according to the regions and seasons (Table 1, Figure 2). The prevalence of *Trichuris* worms and other helminths in both regions was higher during the rainy than the dry seasons. Moreover, the prevalence of *Trichuris* worm infections was higher in Iringa than in Morogoro.

The relatively high prevalence of *Trichuris* worms in *M. natalensis* has also been reported in other studies [1,9], with higher abundances during the rainy season compared to the dry season [7]. Our results also suggest that male and female rodents are equally infected. This result is in contrast to other studies that showed females to be more susceptible [27–29]. This finding calls for more studies to explain this disparity.

During the screening, ova and adult worms belonging to other species were also detected. During the rainy season, the eggs of an unconfirmed helminth, possibly Anoplocephalid species were also found in Morogoro and Iringa, while *Strongyloides* spp. were detected in Iringa. For the dry season, *Strongyloides* spp., *Capillaria* spp., Anoplocephalid species and *Hyemenolepis* spp. were found in rodents from both regions. This suggests that coinfection with worms of different species is common in rodents. These findings were similar to those of other studies conducted elsewhere, where helminthic infections in mice were screened [28,30].

Furthermore, during this study, the highest prevalence was noted during the rainy season in Iringa. This result agrees with those of previous studies on seasonal variations of *Trichuris* spp. and other intestinal helminth infections [7,29]. However, a study conducted in India by [15] conflicted with this study by showing that *Trichuris* worm infections were higher during the dry season than the rainy season.

Other studies have shown that *Trichuris* worm ova can adapt easily under different environmental conditions, thus enabling them to survive well even during dry seasons [29]. Various studies have shown that helminth infections in *M. natalensis* can adversely impair digestive function in a host, and consequently affect its efficiency in absorbing nutrients from the gut. Other reports showed that parasitic infections in *M. natalensis* can compromise an animal's health, adversely impacting its intestinal microbiota and digestive and immunoregulation [3].

Generally, the examined rodents were more infected with *Trichuris* worms, *Strongyloides* spp. and presumptive an Anoplocephalid species with a higher prevalence found in Iringa than in Morogoro. The differences in rainfall pattern, temperature and humidity could cause this variation in favor of the Iringa region. Iringa is located at a higher altitude (1564 masl) compared to Morogoro (254 masl), and has an overall higher rainfall abundance and lower average temperature than Morogoro. These factors may probably be favorable for the survival of the *Trichuris* ova deposited on the soils in Iringa, and hence a higher chance of infection than in Morogoro.

Based on the findings of this study and other studies [3,31], *M. natalensis* is shown to be involved in transmitting a series of helminths known to be potential pathogens to humans and animals. Therefore, human, animal and environmental health professionals (One Health) need strategic awareness on control programs to reduce their adverse impact. These programs shall include periodic screening of rodents for helminths, and management of the small mammal populations where there is imminent danger of them causing disease. Moreover, further studies to characterize the different species of *Trichuris* from different animal species at the molecular level are highly recommended.

Author Contributions: Data curation, formal analysis, investigation, methodology, validation, visualization, writing original draft and editing, C.T.; Data Curation, investigation and methodology, V.M., N.V.H. and G.M.; Data curation, investigation, methodology, writing, review, formal analysis and editing, J.M., J.N. and C.S.; Investigation, Methodology, writing, review, editing, conceptualization, methodology, I.M. and R.M.; Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, writing, review and editing, H.L. All authors have read and agreed to the published version of the manuscript.

Funding: This work was financially supported by the Research Foundation-Flanders (FWO) (G065720N) and the African Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development (ACE IRPM & BTD) ACE II-Credit number 5799–TZ of the Sokoine University of Agriculture, Morogoro, Tanzania.

Institutional Review Board Statement: Research ethical approval was sought from the ethical committee and decision board of the Sokoine University of Agriculture [SUA], Tanzania Wildlife Research Institute (TAWIRI) and Tanzania Commission for Science and Technology (COSTECH) with permit number 2022-401-NA-2021-084.

Data Availability Statement: Data can be obtained from the corresponding author upon a request.

Acknowledgments: The authors would like to thank the SUA staff, SFUCHAS staff, IHI scientists (molecular biology division), staff of UA-Evolutionary Ecology Group, SUA, Institute of Pest Management (IPM) field units and regional administrators of Morogoro and Iringa for their support and cooperation during the study.

Conflicts of Interest: The authors declare that they do not have competing interests.

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