Journal of Applied Veterinary Science and Technology
http://e-journal.unair.ac.id/javest

OPEN ACCESS

Research Reports

Prevalence of Ectoparasites and Hemoparasites in Rodents and Shrews in Ilemela District, Mwanza Region, Tanzania

Prevalensi Ektoparasit dan Hemoparasit pada Rodensia dan Celurut di Distrik Ilemela, Wilayah Mwanza, Tanzania

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ABSTRACT

Background: Rodents and shrews play an important role in the transmission and spreading of zoonotic diseases in Tanzania and worldwide. **Purpose:** This study aims to identify ectoparasites and hemoparasites in rodents and shrews captured in Ilemela District, Mwanza Region, Tanzania. **Methods:** Rodents and shrews were captured using Sherman live traps and modified wire cages, both of which were placed indoors, peri-domestically, and in agricultural fields. The animals were anaesthetized using diethyl ether, and blood samples were collected aseptically from the heart. Thin and thick smears were prepared for the identification of hemoparasites. **Results:** The overall prevalence of ectoparasites was 56.4%, with the following ectoparasites identified: *Laelaps echininus* (39.6%), *Polyplax spp.* (4.0%), *Xenopsylla cheopis* (2.7%), and *Haemaphysalis leachi* (0.7%). The highest prevalence of ectoparasites was observed in *Mastomys natalensis*. In terms of sex, male animals showed a higher prevalence of ectoparasites (59.0%) than female animals. Additionally, the prevalence of hemoparasites was 35.5%, with the following parasites identified: *Anaplasma spp.* (18.8%), *Trypanosoma lewisi* (0.7%), *Plasmodium spp.* (1.3%), Bipolar coccobacilli (2.7%), and *Bacillus spp.* (3.4%). *Anaplasma spp.* was identified in all infested rodent species, with the highest prevalence observed in *Mus musculus* (34.4%) and *Mastomys natalensis* (27.3%). However, *T. lewisi* was only identified in *Rattus rattus* (0.7%), whereas no hemoparasites was identified in *Crocidura spp.* **Conclusion:** This study provides baseline information on the prevalence of ectoparasites and hemoparasites in rodents and shrews in Ilemela district, Mwanza Region, Tanzania. Therefore, monitoring of these parasites is important for preparedness and early warning preparation for the control of rodent-borne diseases.

ARTICLE INFO

Received: 18 January 2024
Revised: 20 February 2024
Accepted: 24 April 2024
Online: 30 April 2024

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Keywords: Ectoparasite; Hemoparasite; Rodent; Shrew

ABSTRAK

Latar Belakang: Hewan pengerat dan tikus memainkan peran penting dalam penularan dan penyebaran penyakit zoonosis di Tanzania dan seluruh dunia. **Tujuan:** Penelitian ini bertujuan untuk mengidentifikasi ektoparasit dan hemoparasit pada hewan pengerat dan tikus yang ditangkap di Distrik Ilemela, Wilayah Mwanza, Tanzania. **Metode:** Tikus dan celurut ditangkap menggunakan perangkap hidup Sherman dan kandang kawat yang dimodifikasi, yang ditempatkan di dalam ruangan, di luar rumah, dan di lahan pertanian. Hewan-hewan tersebut dibius menggunakan dietil eter, dan sampel darah dikumpulkan secara aseptik dari jantung. Hapusan tipis dan tebal dibuat untuk mengidentifikasi hemoparasit. **Hasil:** Prevalensi ektoparasit secara keseluruhan adalah 56,4%, dengan ektoparasit yang teridentifikasi: *Laelaps echininus* (39,6%), *Polyplax spp.* (4,0%), *Xenopsylla cheopis* (2,7%), dan *Heamaphysalis leachi* (0,7%). Prevalensi ektoparasit tertinggi diamati pada *M. natalensis* sebesar 67,7%. Berdasarkan jenis kelamin, hewan jantan menunjukkan prevalensi ektoparasit yang lebih tinggi (59,0%) dibandingkan hewan betina. Selain itu, prevalensi hemoparasit adalah 35,5%, dengan parasit teridentifikasi: *Anaplasma spp.* (18,8%), *Trypanosoma lewisi* (0,7%), *Plasmodium spp.* (1,3%), Coccobacilli bipolar (2,7%), dan *Bacillus spp.* (3,4%). *Anaplasma spp.* diidentifikasi pada semua spesies hewan pengerat yang terinfestasi, dengan prevalensi tertinggi diamati pada *Mus. musculus* (34,4%) dan *Mastomys* (27,3%). Namun *T. lewisi* hanya teridentifikasi pada *Rattus rattus* (0,7%), sedangkan hemoparasit tidak teridentifikasi pada *Crocidura spp.* **Kesimpulan:** Penelitian ini memberikan informasi dasar mengenai prevalensi ektoparasit dan hemoparasit pada hewan pengerat dan tikus di distrik Ilemela, Wilayah Mwanza, Tanzania. Oleh karena itu, pemantauan terhadap parasit ini penting untuk kesiapsiagaan dan persiapan peringatan dini pengendalian penyakit yang ditularkan oleh hewan pengerat.

Cite This Article:
Deng, A.A., Lita, E.P., Ochi, E.B., Nzalawahe, J.S, Katakweba, A.A.S., 2024. ***Prevalence of Ectoparasites and Hemoparasites in Rodents and Shrews in Ilemela District, Mwanza Region, Tanzania.*** Journal of Applied Veterinary Science and Technology. 5(1): 72-77. https://doi.org/10.20473/javest.V5.I1.2024.72-77

Kata kunci: Celurut; Ektoparasit; Hemoparasite; Rodensia

INTRODUCTION

Rodents are mammals belonging to the Rodentia order. They are the most successful in terms of distribution, diversity, and abundance in Africa. They are characterized by the presence of a single pair of continuously growing incisors in each of the upper and lower jaws (Samuelson, 2021). In contrast, shrews are small mouse-sized mammals with elongated snouts, dense and uniform-colored fur, musky odor, small eyes, insectivorous teeth, and aggressive behavior. They are found throughout the Africa (Kirsten, 2010). Rodents and shrews are known to carry a number of ectoparasites, including fleas, mites, ticks, and lice. Some of these parasites have been identified as having public health implications (Dada, 2016). The ecological adaptability of rodents makes them a suitable host for a number of parasites (Babyesiza *et al.*, 2023). They contribute significantly to the risk of disease occurrence by carrying and acting as amplifying hosts for specific pathogens (Fenollar and Mediannikov, 2020). Other impacts of these small mammals include, but are not limited to, damaging field crops, causing post-harvest losses, and contaminating stored foods and water supplies (Frye *et al.*, 2015).

Arthropods such as fleas, mites, ticks, and lice are considered as significant vectors for the transmission of numerous diseases, including plague, leptospirosis, bartonellosis, and toxoplasmosis to both humans animals (Mhamphi *et al.*, 2023). A number of studies have been conducted on the prevalence of ectoparasites in rodents and shrews across the globe (Kia *et al.*, 2009; Thanee *et al.*, 2009; Babyesiza *et al.*, 2023). Previous studies on ectoparasites in rodents and shrews have reported the presence of different species, including *Mastomys natalensis, Aethomys spp., Rattus rattus, Lemniscomys rosalia, Lemniscomys striatus, Praomys spp., Arvicanthus spp., Lophuromys spp., Gerbiliscus spp., Crocidura sp.,* and *Nannomys sp.* (Mgode *et al.*, 2014; Shilereyo *et al.*, 2022; Mhamphi *et al.*, 2024). In Tanzania, studies on hemoparasites in rodents and shrews have received relatively little attention. This has resulted in a lack of knowledge and understanding of the significant role of rodents and shrews in the maintenance and transmission of diseases (Katakweba, 2018). However, Mgode *et al.*, (2014) have reported a prevalence of 25.8% and 2.17% of leptospirosis and toxoplasmosis, respectively. Katakweba *et al.*, (2012) reported the presence of *Trypanosoma lewisi, Bacillus spp., Borrelia spp.,* and bipolar coccobacilli in rodents and shrews captured in Tanzania, Namibia, and Swaziland. The study also affirms that zoonotic pathogens infecting humans are prevalent in these animals. Therefore, this study aims to identify ectoparasites and hemoparasites in rodents and shrews in selected villages in Ilemela District, Mwanza Region, Tanzania.

MATERIAL and METHOD

Study Area

This study was conducted in Ilemela District, Mwanza Region, Tanzania (**Figure 1**). Ilemela District is situated between the latitude of 2°15' and 2°31' to the south of the equator and the longitude of 32°45' and -33°2' to the east of Greenwich and approximately 1,140 meters above sea level. It is situated on the southern shores of Lake Victoria and divided into nineteen administrative wards. Two wards, namely Bugogwa and Sangabuye, which border Lake Victoria to the north, were purposively selected for this study due to their high population and agricultural activities. In Bugogwa Ward, five villages were included, namely Bugogwa, Kabangaja, Kayenze Ndogo, Kasamwa and Kisundi. In Sangabuye Ward, a village called Nyashimba was included.

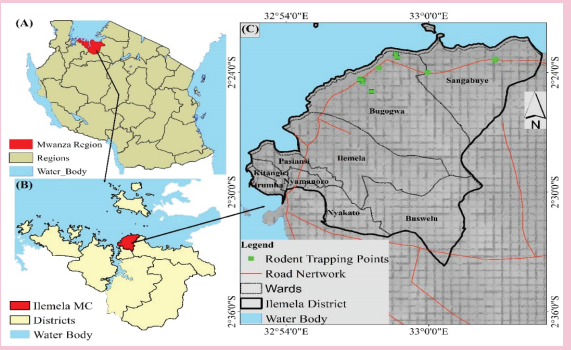

Figure 1. Map of The Study Area

Capturing and Identification of Species

Rodents and shrews were captured using Sherman live traps (LFA 7.5 x 9 x 23 cm) and modified wire cages, both of which were placed indoors, peri-domestically, and in agricultural fields. The traps were set at night and baited with a mixture of peanut butter and maize bran and covered with leaves and grasses (outdoor traps) to prevent captured rodents from adverse environmental conditions. The traps were checked and rebaited every morning. The captured small mammals were anaesthetized in a jar containing cotton wool soaked with diethyl ether. Each captured rodent and shrew was morphologically identified (Happold, 2013).

Collection and Identification of Ectoparasites

Each anesthetized animal was examined and its external body parts were brushed to recover the ectoparasites in a basin. The ectoparasites were collected using a camel hair brush and placed into a labelled microvial containing 70% ethanol and shipped to Sokoine University of Agriculture (SUA) for identification. Mites and ticks were identified directly based on their morphological appearance using an ordinary light microscope and a stereomicroscope.

Lice and fleas were kept in a 10% potassium hydroxide (KOH) solution for a day as an initial cleaning process. Subsequently, they were immersed in distilled water for 20 minutes and subjected to serial dehydration in an increasing grade of ethanol (70%, 80%, 95%, and absolute) for 30 minutes in each concentration. Following dehydration, the specimens were cleared with xylene for one hour and mounted on clean slides with dibutylphthalate polystyrene xylene (DPX) mountant and a coverslip was applied prior to microscopic examination (Mathison and Pritt, 2014).

Blood Collection and Identification of Hemoparasites

Immediately following the administration of anesthesia to captured rodents and shrews, blood samples were collected

aseptically after each animal was treated with methylated spirit. Thick and thin blood smears were prepared on separate microscopic slides. All smears were left to air dry, after which the thin smears were fixed with methanol for three minutes. Both smears were then stained with 10% Giemsa solution for 30 minutes, rinsed with tap water, and left to air dry. Finally, a microscopic examination was conducted to identify blood parasites objective lenses at 40x and 100x magnification to enhance visibility of suspected parasites (Zajac and Conboy, 2012).

Data Management and Analysis

The data were coded and computed using the Statistical Package for the Social Sciences (SPSS) version 20 software (IBM Corp., NY, USA, 2011). Descriptive statistics were run to obtain the prevalences and frequencies of the variables. Bivariate analysis using the Chi-squared test (X^2) was conducted to determine the correlations between variables (sex, species of small mammal, habitats, season, and villages) using a 95% confidence interval and a $p \leq 0.05$

RESULTS

Prevalence of Ectoparasites in Rodents and Shrews

A total of 149 small mammals were captured and identified, including 144 rodents belonging to four species, namely *Mastomys natalensis* (66.4%), *Mus musculus* (21.5%), *Rattus rattus* (7.4%), and *Aethomys spp.* (1.3%), with the remaining five being shrews belonging to the *Crocidura spp.* Species (3.4%). In addition, the following ectoparasite species were identified: *Laelaps echininus, Polyplax spp., Xenopsylla cheopis,* and *Haemaphysalis leachi,* belonging to mites, lice, fleas and ticks, respectively.

The overall prevalence of ectoparasite infestation was 56.4%, with the captured small mammals found to be infested with either a single or a co-infection of two or three ectoparasites. The single infection was found to be 47%, whereas the co-infection was 9.4%. The most prevalent ectoparasites identified were *Laelaps echininus* (39.6%), followed by *Polyplax spp.* (4.0%), *Xenopsylla cheopis* (2.7%), and *Haemaphysalis leachi* (0.7%).

A greater proportion of male animals were found to be infested (59.0%) than female animals (55.5%), although this difference was not statistically significant (p 0.618). However, a significant correlation was found between habitat, villages, captured species, and season with ectoparasite infection ($p < 0.01$), as shown in **Table 1.** *Mastomys natalensis* showed the highest prevalence of ectoparasite infection (67.7%).

Prevalence of Hemoparasites

A total of 149 blood samples were screened for the presence of hemoparasites, with 36.0% yielded positive results with either a single (27.0%) infection or a co-infection of two parasite species (9.0%). The following hemoparasites were identified from the infected hosts: *Anaplasma spp.* (18.8%), *Trypanosoma lewisi* (0.7%), bipolar coccobacilli (2.7%), *Plasmodium spp.* (1.3%) and *Bacillus spp.* (3.4%) in single infection as shown in **Table 2**.

Plasmodium spp. and bipolar coccobacilli (0.7%), *Anaplasma spp.* and *Plasmodium spp.* (6.7%) and *Anaplasma spp.* and *Bacillus spp.* (1.3%) were identified in co-infection. *Anaplasma spp.* was identified in all the infected rodent species, with the highest prevalence observed in *M. musculus* (34.4%), followed by *M. natalensis* (27.3%). *T. lewisi* was only identified in *R. rattus*, whereas no hemoparasites were identified in *Crocidura spp*.

DISCUSSION

Rodents and shrews play an important role in disease transmission, acting as hosts for ectoparasites and reservoirs for certain zoonotic diseases. This study identified four types of ectoparasites, including *Laelaps echininus, Polyplax spp., Xenopsylla cheopis,* and *Haemaphysalis leachi,* belonging to mites, lice, fleas, and ticks, respectively. The most prevalent ectoparasite identified in this study was the *Laelaps echininus* mite (39.6%). Mites are typically generalist parasites, exhibiting low host specificity. This finding is consistent with studies conducted by Gebrezgiher *et al.,* (2023) and Shilereyo *et al.,* (2022) in Tanzania.

The overall prevalence of ectoparasites in this study was 56.4 %, with male animals (59.0%) found to be more infested with ectoparasites. Several studies conducted within the African region on rodents and shrews have reported different prevalence of ectoparasites. Wale *et al.,* (2023) reported a prevalence of 73.0%, which was not consistent with another study in Ethiopia. Kasso (2023) reported a higher prevalence of mites in rodents and an overall prevalence of 73.53%, which was also higher than the findings of this study. Mawanda *et al.,* (2020), reported a prevalence of 35.3%, which was less than the prevalence reported in this study. These differences in prevalence could be attributed to several factors, including seasonal variations in climatic conditions and ecological requirements such as the nature and density of vegetation in a habitat (Shilereyo *et al.,* 2022). The higher prevalence of ectoparasites in male animals is consistent with the findings of Mfune *et al.,* (2013), who reported a higher prevalence offl eas in male animals (54.3%) than in female animals (34.6%) in Namibia. Additionally, Mustapha *et al.,* (2019) reported a higher prevalence of ectoparasites in male hosts (45.8%) compared to females hosts (30.8%) in Malaysia. The high prevalence in male animals could be attributed to their greater mobility, larger home range, and larger body size, which increase their likelihood of encountering parasites (Kowalski and Bogdziewicz, 2015). Moreover, a study conducted to assess hormonal effects in male rodents revealed that male rodents with high levels of testosterone showed increased locomotory activity and reduced innate and acquired resistance to tick feeding (Hughes and Randolph, 2001).

Furthermore, this study revealed a high prevalence of ectoparasites in *M. natalensis* (67.7%). *Mastomys natalensis* was the most abundant rodent species in the study site and were commonly observed in fallows and agricultural fields. Therefore, they are more susceptible to ectoparasite infestation. Moreover, these species are known to prefer densely

Table 1. Prevalence of Ectoparasites in Captured Small Mammals Based on Different Variables

Variable	Category	Number of Trapped Hosts	Number of Infested Hosts	Prevalence	X^2	Df	p-value
Habitat	Indoors	44	13	8.7%	33.210	5	<0.01
	Peri-domestic	16	04	2.7%			
	Agricultural fields	89	64	43%			
Villages	Bugogwa	37	20	13.4%	26.308	5	<0.01
	Kabangaja	21	18	12.1%			
	Kayenze Ndgo	54	21	14.1%			
	Nyashimba	16	15	10.1%			
	Kissundi	07	05	3.3%			
	Kasamwa	14	05	3.3%			
Species of small mammals	*Mastomys natalensis*	99	67	45%	18.67	4	0.01
	Rattus rattus	11	05	3.3%			
	Mus musculus	32	09	6.0%			
	Aethomys spp.	02	00	00%			
	Crocidura spp.	05	03	2.0%			
Sex	Male	61	36	24.1%	0.291	1	0.618
	Female	88	48	32.2%			
Season	Wet	86	24	41.6%	28.698	1	0.01
	Dry	63	22	14.8%			

Table 2. Prevalence of Hemoparasites in Blood Samples of Different Species of Rodents and Shrews

Rodent and Shrew Species	Total Captures	Single Infection			Co-Infection			Positive	
	N	N	%	Blood Parasite	N	%	Blood Parasite	N	%
Mastomys natalensis	99	17	17.2	*Anaplasma spp.*	1	1.0	*Plasmodium spp.*& Bipolar coccobacilli	37	37.4
		3	3.0	Bipolar coccobacilli	9	9.1	*Anaplasma spp.* & *Plasmodium spp.*		
		2	2.0	*Plasmodium spp.*	1	1.0	*Anaplasma spp.*& *Bacillus spp.*		
		4	4.0	*Bacillus spp.*					
Rattus rattus	11	1	9.1	*Anaplasma spp.*	0	0	-	2	18.2
		1	9.1	*T. lewisi*	0	0	-		
Mus musculus	32	9	28.1	*Anaplasma spp.*				13	40.6
		1	3.1	Bipolar coccobacilli	1	3.1	*Anaplasma spp.*& *Plasmodium spp.*		
		1	3.1	*Bacillus spp.*	1	3.1	*Anaplasma spp.* & *Bacillus spp.*		
Aethomys spp.	2	1	50	*Anaplasma spp.*	0	0	-	1	50.0
Crocidura spp.	5	0	0	-	0	0	-	0	0
Total	**149**	**40**	**26.9%**		**13**	**8.7**		**53**	**36%**

covered vegetation while also being able to survive in open areas of less vegetative coverage and lacking territoriality (Leirs *et al.,* 1996). Furthermore, *M. natalensis* are sexually active throughout the year, contributing to their high abundant (Mulungu *et al.,* 2013). The overall prevalence of hemoparasites was 35.5%, with the identified parasites including *Anaplasma spp.* (18.8%), *Trypanosoma lewisi* (0.7%), *Plasmodium spp.* (1.3%), bipolar coccobacilli (2.7%), and *Bacillus spp.* (3.4%) as single infections.

This finding is consistent with a study conducted by Katakweba *et al.,* (2012), who reported the presence of *Trypanosoma spp., Plasmodium spp.,* and *Bacillus spp.* in rodents and shrews as zoonotic infectious agents to humans. In addition, co-infections were identified between *Plasmodium spp.* and bipolar coccobacilli (0.7%), *Anaplasma spp.* and *Plasmodium spp.* (6.7%), and *Anaplasma spp.* and *Bacillus spp.* (1.3%). The co-infection of two hemoparasite species could be attributed to the presence of the vectors associated with these parasites in the study area. In this study, *Anaplasma spp.* was the most prevalent hemoparasite and predominantly identified in all captured rodent species. Additionally, its highest prevalence was observed in *M. natalensis* (51%). Several studies have reported similar high prevalence of mites and *Anaplasma spp.* in rodents (Thanee *et al.,* 2009; Islam *et al.,* 2020; Babyesiza *et al.,* 2023). These findings are consistent with the findings of this study, which revealed a high prevalence of *Anaplasma spp.* in the blood samles of captured rodents. Islam *et al.,*(2020) identified three hemoprotozoa in rodents in Bangladesh, with *Anaplasma spp.* being the most prevalent (7.5%). Thanee *et al.,* (2009) reported that mites and *Anaplasma spp.* were the most frequently observed ectoparasite and hemoparasite in most species of rodents captured in Thailand.

Furthermore, this study revealed the presence of *T. lewisi* in *R. rattus.* This finding is consistent with that of Katakweba *et al.,* (2012), who reported the presence of T. lewisi in a significant proportion of *R. rattus.* This finding is also consistent with a study of Archer *et al.,* (2018) in Durban, South Africa, which revealed a significant positive correlation between rats infected with fleas and trypanosomes. Interestingly, this study identified *T. lewisi* in *R. rattus* infested with *Xenopsylla cheopis,* or the black rat flea, which is considered as the primary vector of bubonic plague.

ACKNOWLEDGEMENT

The authors are indebted to Ilemela Municipal Council for granting permission for data collection and to the farmers for their active participation and cooperation. Moreover, the authors are very thankful to Mr. Ginethon Mhamphi for his assistance in data collection, as well as Mr. Salim Omary Bwata and Mr. Mabula Msabula Kashindye for the identification of the parasites in the laboratory.

CONFLICT of INTEREST

The authors declare that they have no conflicts of interest.

RESEARCH FUNDING

This study was supported by World Bank under Africa Center of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development (ACE II credit No.5799 TZ), Sokoine University of Agriculture-Tanzania

ETHICAL APPROVAL

The study protocol has been considered and approved by the Ethics Committee of the Department of Research and Publication at Sokoine University of Agriculture, Morogoro, Tanzania with a certificate number DPRTC/R/186 VOL IV. Trapping of rodents and shrews was performed with prior approval from the local authorities and the owners of the agricultural farms and houses in Ilemela District, Mwanza Region, Tanzania.

AUTHORS' CONTRIBUTIONS

AAD contributed to conception, data collection, analysis, interpretation, discussion, and drafting of this manuscript. EPL contributed to statistical analysis, discussion, and reviewing of this manuscript. EBO contributed to reviewing and editing of this manuscript. JSN and AAK contributed to conception, design, reviewing, editing, and supervision. All authors, AAD, EPL, EBO, JSN and AAK, made substantial contributions, read, and approved the final draft of this manuscript.

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