Prevalence of Hemoparasites in Rodents and Shrews and their Potential Zoonotic Risk in Arusha Municipal, Tanzania

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ABSTRACT

Rodents and shrews are important in public health as reservoirs of ectoparasites and zoonotic hemoparasites, which can threaten livestock and human health. This study aimed to assess the prevalence of hemoparasites in rodents and shrews in Arusha Municipal, Tanzania. A cross-sectional survey was conducted from March to May 2024, where rodents and shrews were captured using live traps in residential and peridomestic areas. Blood samples were collected and examined for hemoparasites through thick and thin smears. Data were analyzed using SPSS, and logistic regression was used to explore the relationship between prevalence and variables such as species, sex, and habitat. A total of 96 small mammals were captured, comprising 85 rodents and 11 shrews. *Anaplasma* spp. had the highest prevalence, infecting 24.7% of rodents and 36.4% of shrews, with co-infection of *Anaplasma* spp. and *Theileria* spp. detected in 4.7% of rodents and 27.3% of shrews. *Babesia* spp was detected at infection rate of 2.4% in rodents, and 9.1% in shrews. Logistic regression revealed that the odds of *Anaplasma* spp. infection were significantly higher in shrews compared to rodents ($p = 0.023$), and animals from peridomestic areas exhibited a higher prevalence ($p = 0.017$). The study highlights the high prevalence of hemoparasites in rodents and shrews, particularly in peridomestic areas, emphasizing the need for targeted interventions. Habitat management, vector control, and public health education are crucial for reducing zoonotic disease transmission. Future research should focus on ecological factors influencing hemoparasite transmission and their potential impacts on human and animal health.

Keywords: Prevalence, Hemoparasite, Zoonoses, Rodents, Shrews, Arusha

INTRODUCTION

Rodents and shrews represent the most diverse and abundant group of mammals, accounting for 42% of all mammalian species globally (Davies *et al*., 2020; Issae *et al*., 2023a). They display significant ecological, morphological, physiological, behavioral, and life history diversity, which enables them to adapt to a wide range of environments (Hoffmann *et al*., 2005). These small mammals play a dual role in public health, not only as reservoirs for ectoparasites

that transmit pathogens to humans but also as significant carriers of zoonotic hemoparasites (De Boni, L. 2017; Mwita *et al*., 2020; Issae *et al*., 2023b). Hemoparasites are blood-dwelling parasites that spend most of their life cycles within the vascular systems of vertebrates, including mammals (Kramer *et al*., 2007). Notable examples include *Babesia*, *Theileria*, *Borrelia*, *Trypanosomes*, *Bacilli*, and *Plasmodium* (Gratz, 1997; Battersby *et al*., 2002; Kawabuchi *et al*., 2005; Jittapalapong *et al*., 2008; Issae *et al*., 2023b). These parasites pose significant threats to livestock and other domestic animals, contributing to mortality, morbidity, and reduced animal productivity (Kim *et al*., 2018; Issae *et al*., 2023b).

The prevalence of hemoparasites in rodents and shrews can vary based on geographic location, species, and environmental factors. In Arusha Municipal, Tanzania, a high prevalence of hemoparasites has been observed in these small mammals. For instance, a study in 2015 found that 90% of rodents and shrews tested positive for at least one hemoparasite. Commonly identified hemoparasites in Arusha include protozoans such as *Theileria parva* (Chenyambuga *et al*., 2010) *Babesia*, *Anaplasma* (Fyumagwa *et al*., 2011) and *Trypanosomes* (Kimaro *et al*., 2018), which cause anemia, weight loss, and death in infected livestock. These parasites can also be transmitted to humans through ectoparasite (such as ticks, fleas) bites (Moraga-Fernandez *et al*., 2023).

Given the potential for zoonotic disease transmission from hemoparasites in rodents and shrews, it is critical to determine the prevalence of these parasites in Tanzania, particularly in Arusha Municipal. Understanding the types and prevalence of hemoparasites will provide valuable data for designing effective control and prevention strategies, ultimately reducing the risk of disease transmission between animals and humans. This study aims to fill the gap in knowledge regarding hemoparasite prevalence in the region and contribute to the development of public health Interventions.

MATERIALS AND METHODS

Study site and design

A cross-sectional study was carried out in Arusha Municipal, located in the Arusha region of northern Tanzania, from March 2024 to May 2024. Arusha Municipal lies at the coordinates 3.37°S and 36.68°E, at the intersection of latitude and longitude. It is bordered by Arumeru, Monduli, and Karatu districts to the north, south, east, and west, respectively (URT, 1997). Arusha Municipal, in particular, is divided into 25 wards. The population of the Arusha region is approximately 2,356,255 people, spread over an area of 37,576 km² (NBS, 2022). The major economic activities in the region include business, employment, agriculture, livestock keeping, and both small- and large-scale industrial production (NBS, 2012). The climate is generally mild, with warm and temperate conditions. The average annual temperature ranges from 7°C to 22°C, while the average annual rainfall is around 2,068 mm (TMA, 2021). For sample collection, four wards were selected: Kaloleni, Kimandolu, Kibaoni, and Ngarenaro.

Rodents and shrews trapping

Trapping was conducted using Sherman and locally made live traps baited with a mixture of peanut butter and maize bran (Issae *et al*., 2023a). The trapping sites were indoor and peri domestic areas. Three Sherman traps, four mouse traps, and four box traps were

strategically placed for five consecutive nights (Katakweba, 2018). Each morning, the traps were inspected to identify and record the captured animals. The trapping of animals was intentionally carried out in households that kept livestock, including cattle, sheep, and goats.

Blood sample collection and smear preparation

Before sample collection, rodents and shrews were anesthetized using cotton wool soaked in diethyl ether. Blood samples (20–25 µl) were drawn from the supraorbital veins using glass capillaries. Thick blood smears were prepared by placing one drop of whole blood on the center of a microscope slide and allowing it to air dry. Thin blood smears were also prepared by placing a small drop of blood near one end of a slide, spreading it thinly, air drying it, and fixing it with methanol for 3 minutes before allowing it to dry further (Katakweba, 2018). Thick smears were used for greater sensitivity in detecting low-level infections, while thin smears allowed detailed morphological study and quantification of parasites. The prepared slides were then transported to the College of Veterinary Medicine and Biomedical Sciences (CVMBS) for further laboratory analysis.

Data analysis

The collected data were analyzed using SPSS version 25 to calculate the percentage occurrence of blood parasites. A logistic regression analysis was conducted to evaluate the relationship between hemoparasite prevalence and factors such as animal species, sex, and habitats. In this analysis, p-values less than 0.05 were considered statistically significant.

RESULTS

Small mammal capture and distribution by habitat and sex

A total of 96 small mammals were captured, comprising 85 rodents and 11 shrews. The majority of rodents (53) and shrews (11) were captured in peri-domestic areas and 32 rodents were found indoor. The sample included a sex breakdown of 59 female rodents and 26 male rodents, along with 7 male and 4 female shrews.

Prevalence of hemoparasites in rodents

Anaplasma spp. had the highest prevalence, infecting 25% of rodents, followed by *Theileria* spp and lastly by *Babesia* spp. Co-infections was observed in *Anaplasma* spp. and *Theileria* spp. as demonstrated in Table 1. These findings underscore the importance of understanding local wildlife's role in the epidemiology of vector-borne diseases and suggest targeted interventions to reduce infection risks.

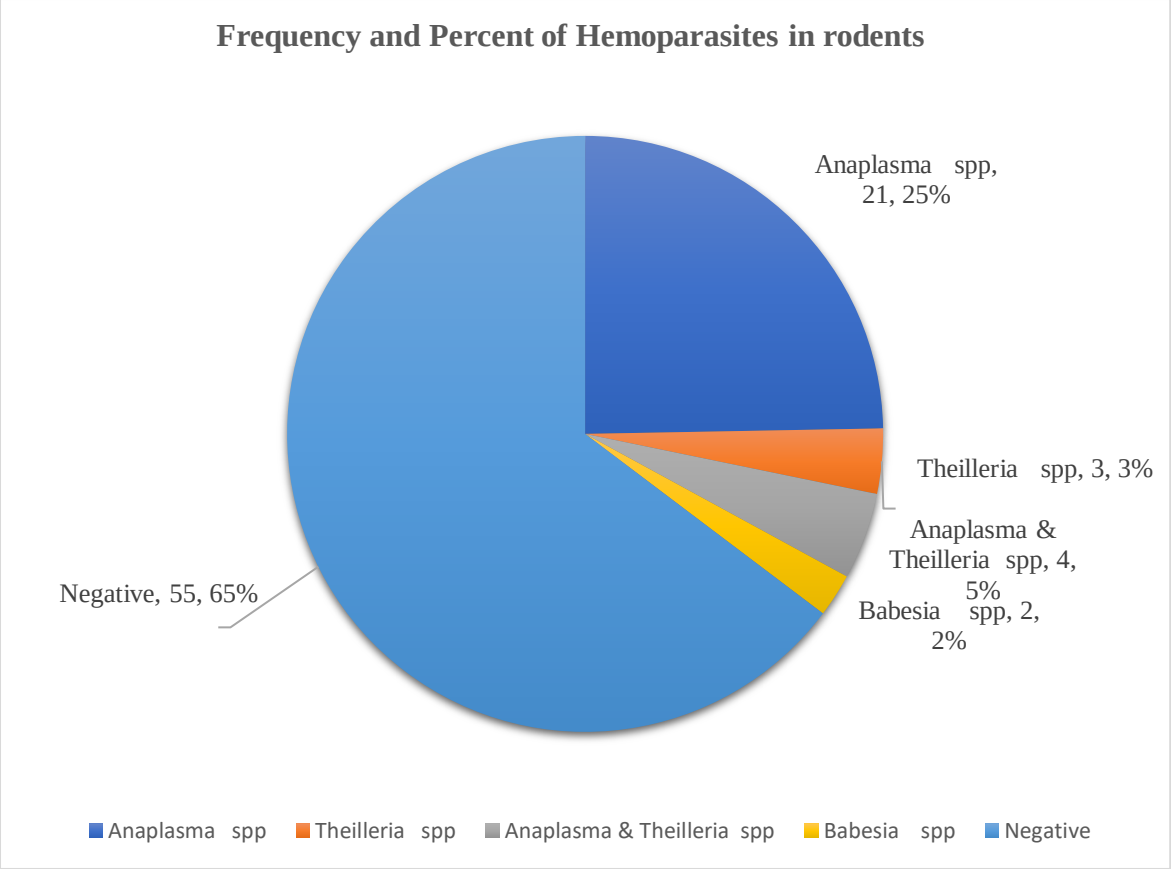

Figure 1: Frequency and prevalence of hemoparasites found in rodents

Prevalence of hemoparasites in shrews

In shrews, the prevalence of *Anaplasma* spp. was higher at 36.4%, while 18.2% were infected with *Theileria* spp. The high infection rates of *Anaplasma* spp indicate a widespread presence in local small mammal populations, which may serve as a reservoir for the pathogen. Co-infection of *Anaplasma* spp and *Theileria* spp was found in 27.3% of shrews, and *Babesia* spp. was detected in 9.1% of shrews (Fig.2).

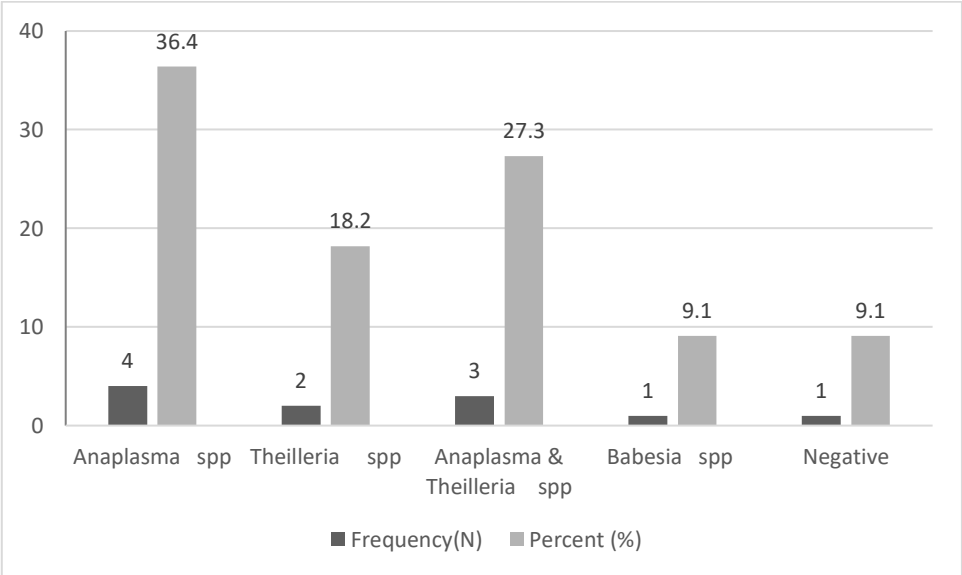

Figure 2: Frequency and prevalence of hemoparasites found in shrews

Logistic regression analysis

A logistic regression analysis was conducted to assess the relationship between hemoparasite prevalence and factors such as animal species, sex, and habitats (Table 1). The results showed that the odds of *Anaplasma* spp. infection were significantly higher in shrews compared to rodents (p = 0.023), suggesting a species-specific susceptibility to this hemoparasite. Regarding sex, no statistically significant difference in hemoparasite prevalence was observed between male and female rodents (p = 0.084), although female rodents had a slightly higher capture rate. Among shrews, sex was not a significant predictor of infection (p = 0.12). Habitat was found to play a crucial role, with hemoparasite prevalence significantly higher in animals captured in peridomestic areas compared to indoor areas (p = 0.017), indicating a greater risk of infection in these environments. These findings highlight the influence of both habitat and species on hemoparasite prevalence, with peridomestic areas and shrews presenting a higher risk of infection.

Table 1: Logistic regression analysis of factors influencing hemoparasite prevalence.

Variable	B	Std. Error	Wald	df	p-value	OR	95% CI
Species (Shrews vs Rodents)	1.235	0.565	4.786	1	0.023	3.442	1.173 - 10.178
Sex (Female vs Male)	0.307	0.292	1.163	1	0.084	1.359	0.839 - 2.193
Habitat (Indoor vs Peridomestic)	1.234	0.52	5.697	1	0.017	3.44	1.237 - 9.603

Note: B=Beta coefficient, **Std. Error**=Standard Error, **Wald**= Wald test, **df**=Degree of Freedom, **OR**=Odd Ratio, **CI**=Confidence Interval

DISCUSSION

This study investigated hemoparasite prevalence in rodents and shrews within Arusha Municipality, Tanzania, uncovering critical insights into the epidemiology of these pathogens in small mammals. Findings show an overall high prevalence of hemoparasites, particularly *Anaplasma spp.*, raising significant public health concerns due to the zoonotic potential of these organisms. Notably, 24.7% of captured rodents tested positive for *Anaplasma spp.*, supporting earlier studies that identify rodents as key reservoirs of this pathogen. Within Tanzania, comparable studies in Morogoro and Mwanza reported prevalence rates of 22.9% and 18.8%, respectively (Katakweba, 2018; Deng *et al*., 2024), indicating that hemoparasite infections may be a widespread issue in small mammals across the regions. In contrast, prior studies reported lower prevalence rates, 4.9% in Kenya (Mosha *et al*., 2024), 16.7% in China (Yang *et al*., 2013), and 7.5% in Bangladesh (Islam *et al*., 2020), suggesting that prevalence may vary based on geographic, ecological, and

methodological factors. By contrast, higher prevalence rates were documented in Brazil, with 56.04% of rodents testing positive (Calchi et al., 2020), emphasizing the complex interaction of ecological factors and host susceptibility. The notably high prevalence of *Anaplasma spp.* in shrews (36.4%) suggests a potential species-specific vulnerability that merits further study. This finding highlights the need for targeted surveillance, as shrews may serve as significant reservoirs for zoonotic pathogens, posing risks to animal and human health. Together, these results underscore the importance of ongoing research and region-specific surveillance to better understand hemoparasite epidemiology and to inform effective, locally adapted control strategies.

The detected concurrent infections of *Anaplasma* and *Theileria* highlights the potential for compound interactions between multiple hemoparasites. The socio-economic impacts of these hemoparasites are substantial, particularly in rodent populations living around human settlements. Hemoparasites like *Anaplasma* spp. and *Theileria* spp. pose a notable danger to the livestock sector by infecting cattle and other domestic animals, leading to productivity losses and increased veterinary costs. In addition to impacting livestock health, the pathogens present a risk to human health, especially for communities in close proximity to affected rodent populations. Infection with hemoparasites can reduce livestock productivity, which, in turn, can affect food security and the livelihoods of communities reliant on animal agriculture. The lower prevalence of *Theileria* spp. (3.5%) and Babesia spp. (2.4%) suggests that while these parasites are present, they may not be as dominant as *Anaplasma* spp. in this region. However, the presence of these pathogens in small mammal reservoirs close to human dwellings underscores the need for integrated public health strategies. Addressing these infections not only supports the health of livestock but also reduces the zoonotic spillover risk to humans, contributing to improved community health and resilience against vector-borne diseases.

Sex was not found to be a significant factor influencing hemoparasite prevalence among rodents and shrews in this study, although female rodents were captured slightly more frequently. This finding suggests that infection rates may not differ significantly between sexes in these species, which contrasts with other studies that report sexual dimorphism in susceptibility to certain pathogens. For instance, a study in Bangladesh found that female rodents exhibited higher infection rates of hemoparasites, potentially due to behavioral differences that increase exposure risk (Islam *et al.*, 2020). Similarly, research in Mwanza Tanzania indicated that male rodents were more likely to be infected with hemoparasites, possibly due to reproductive stressors affecting immune response (Deng *et al.*, 2024). In contrast, other studies, such as those conducted in Poland (BAJER *et al.*, 2001) and Kenya (Wanyonyi *et al.*, 2013), reported no significant differences in hemoparasite prevalence between sexes. These discrepancies highlight the need for further investigation into the role of sex in susceptibility to hemoparasites, as ecological and behavioral factors may significantly influence these outcomes across different environments.

The habitat significantly impacted hemoparasite prevalence, with a higher prevalence noted in peridomestic areas compared to indoor settings ($p = 0.017$). This result underscores the importance of habitat management in mitigating the risk of zoonotic infections. Peridomestic areas often provide optimal conditions for ectoparasites, such as

fleas and ticks, which transmit hemoparasites, highlighting the need for public health interventions focused on these environments. Similar findings have been reported in other regions, where peridomestic settings were associated with increased risks of infections (Islam *et al*., 2020). For instance, a study conducted in Bangladesh indicated that environmental factors, such as proximity to livestock and vegetation cover in peridomestic areas, contributed to elevated risks of hemoparasite transmission among small mammals (Islam *et al*., 2020). These studies emphasize the critical role of ecological factors in shaping disease dynamics and the need for targeted interventions in peridomestic habitats (sanitation and vector control measures) to reduce zoonotic disease transmission.

This study reveals a high prevalence of hemoparasites, particularly *Anaplasma* spp., in rodents and shrews within Arusha Municipality, underscoring their role as significant zoonotic reservoirs. The findings point to ecological and habitat-specific factors especially in peridomestic areas as key drivers of transmission risk. Despite no significant sex-based differences, the study highlights the importance of targeted surveillance and habitat management. These insights are critical for developing integrated, locally adapted strategies to protect both livestock and public health.

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