Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2022; 10(5): 221-225

Received: 02-07-2022
Accepted: 06-08-2022

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A survey on ectoparasites and endoparasites of African pygmy hedgehogs (*Atelerix albiventris*) in urban and suburban areas of Morogoro municipal, Tanzania

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DOI: https://doi.org/10.22271/j.ento.2022.v10.i5c.9065

Abstract
The aim of this study was to determine the prevalence of ectoparasites and endoparasites of the African pygmy hedgehogs in Morogoro municipality, Tanzania. A total of 20 African pygmy hedgehogs were captured during the study period, among the captured individuals twelve were females and eight were males. The ectoparasites and endoparasite prevalence was found to be 60% (12/20) and 45% (9/20) respectively. Ectoparasites found from the infested hedgehogs were exclusively hard ticks, composing the three species of hard ticks namely *Haemaphysalis leachi*, *Rhipicephalus* (*Boophilus*) sp. and *Rhipicephalus appendiculatus*. The endoparasite identified were helminthes from one genus of nematodes namely *Aspiculuris* and Stongyle nematode egg and a trematode egg. The results of the present study will contribute to the general knowledge of the parasites of African pygmy hedgehog (*Atelerix albiventris*) in Tanzania.

Keywords: Prevalence, ectoparasites, endoparasites, *Atelerix albiventris*, Tanzania

Introduction
Hedgehogs are nocturnal small mammals characterized by the presence of spine in their upper body parts and mostly available in areas close to human households. Their distinctive characteristics is the presence of short grooved, stiff, sharp and harder spines at the back and sides of their body [1, 2, 3, 4]. Hedgehogs mostly depends on beetles, slugs, centipedes, snakes, snails, earthworms, as well as insects and frogs for their feedings which make them participate in the natural ecosystem [3]. The name hedgehog came from the behavior of these animals during searching for food as they dig in the hedge to find arthropods like insects, beetles and centipedes, some amphibian such as frogs, some reptiles like lizards and snakes as well as some gastropods like snails and slugs.

African pygmy hedgehogs (*Atelerix albiventris*) are mostly found in areas with various climatic conditions both across Central, East, and West Africa [5, 6]. In East Africa hedgehogs are mostly found across village households, urban and suburban's areas, as these areas have soil and shelter which support insects and some amphibians for their dwelling.

Hedgehogs are natural hosts for most ectoparasites and endoparasites reported by most researchers due to their foraging habits during searching for food, attributing to the habit of being omnivorous in nature [7]. Endoparasites are parasites that live inside the body of living organisms which reside either in definitive hosts or intermediate hosts during their life cycle. The hedgehogs are amongst the natural hosts which harbor a variety of species of endoparasites. Several parasites have been reported to infect the hedgehogs including *Crenosoma streatum* and *Capillaria aerophila* which are among the endoparasites (nematodes) which reside in the respiratory system, causing problems in the lung functions [8, 9]. Additionally**,** *Capillaria erinacei*, *Brachylaemus erinacei* and *Physaloptera clausa* are amongst the reported helminthes which tends to infect the hedgehogs. Some protozoan parasites have also been reported causing infection to the hedgehogs including *Isospora rastegaiev* which is among the coccidian species which infects hedgehogs. *Eimeria* spp. and *Cryptosporidium* spp. also are protozoans which occasionally infect hedgehogs [9].

Ectoparasites, these are parasites which live outside the body surface of the Host [10].

They include the common groups which are Ticks, Fleas, Mites, Lice and some of the insects. Most of these ectoparasites can infest human beings and wild and/or domestic animals. Furthermore, ectoparasites are capable of affecting the health of the susceptible host by either direct damages like causing anemia, annoyance and biting worry or indirect by transmitting disease causing agents to the susceptible hosts like *Babesia*, *Theileria*, *Rickettsia*, *Borrelia*, *Crimean Congo Haemorrhagic fever* and *Anaplasma* to mention a few, which they can result into high mortality rate if not well managed [11-13].

Hedgehogs live very close to human dwellings, in fact are among the households small mammals which interact with humans as well as wild and/or domestic animals. Due to the interaction of these small mammals with humans and domesticated animals, there is a high chance of transmission of parasitic disease from hedgehogs to human or domestic or wild animals and vice versa [11, 14, 15]. Many researchers in other continents and Africa in general have investigate upon parasite infections in small mammals including hedgehogs, however, in Tanzania, to the best of our knowledge few and limited studies have been carried out on ectoparasites and endoparasites of the African pygmy hedgehogs. Therefore, we sought of investigate the ectoparasites and endoparasites of the African pygmy hedgehogs to determine their prevalence, with the view of contributing to the baseline information on the parasites of the African pygmy hedgehog.

Materials and Methods

Study area

The study was conducted at Morogoro municipal (Morogoro region) in urban and suburban areas, Tanzania. Morogoro region is located between 6°49'S and 37° 40'E and on the east is bordered by the Pwani and Lindi Regions, to the north by the Tanga region, to the south by the Ruvuma region and to the west by Iringa and Dodoma regions. The laboratory work was performed at Sokoine University of Agriculture (SUA) in the Department of Veterinary Microbiology, Parasitology and Biotechnology. The study was conducted from January, 2020 to May, 2020. Four different areas in which the hedgehogs were captured are summarized in the table 1 below.

Table 1: Sampling areas with their coordinates

Streets/Areas	Location
Misufini	S-6.833580 E37.654106
Chamwino	S-6.821153 E37.646935
SUA farm	S-6.842209 E37.658020
Mafiga	S-6.827764 E37.653339

Study design

The cross sectional study design was employed.

Sample collection and identification of endoparasites

The hedgehogs were captured alive in farm and roadsides during night, around selected urban and suburban areas of Morogoro municipal, using spotlights, upon spotted hedgehogs were picked up by hand with a protective gloves and transported in a well-ventilated plastic containers to the College of Veterinary Medicine and Biomedical sciences at Sokoine University of Agriculture for examination in Parasitology laboratory. The African pygmy hedgehogs were kept overnight in separate cages in the parasitology laboratory so as to collect fecal samples after hedgehog defecation for diagnosis of parasite eggs and protozoan oocysts. The sex of each individual were determine and recorded, the weight was also measured and recorded. Then the captured hedgehogs were released at the point of capture after the sample had been taken.

The following techniques were employed during the examination of the fecal samples.

Simple test tube flotation method

Flotation method was used for detection of nematode eggs, cestode eggs and oocysts of protozoans as described by Soulsby [16]. 3g of fecal sample was measured in calibrated weighing balance and placed in a plastic beaker containing 42ml of flotation fluid, saturated salt solution was poured into plastic beaker and thoroughly mixed using wooden tongue blade. The suspensions were filtered using a tea strainer into a plastic beaker and then the filtrate formed was poured into the test tube supported in a test tube rack until the convex meniscus formed at the top of the tube. Carefully the coverslip was placed on top of the test tube and left to stand for about 20 minutes. Then the coverslip was lifted off carefully together with the drop of fluid adhering to it and placed on a clean microscopic slide. Finally the slides were examined under a compound microscope for observing the presence of Helminths eggs and coccidian oocysts.

Sedimentation technique

Sedimentation technique was performed as described by Soulsby [16]. 3g of fecal sample measured was placed in a sieve coffee strainer or muslin cloth and then transferred into a 300ml conical flask filled with tap water. Fecal sample within muslin cloth was strained by using tap water and the fecal suspension in the conical flask was allowed to stand for about 30minutes. The supernatants were decanted and water was added so as to resuspend the sediment and the mixture was allowed to stand again for 30minutes. The procedure was repeated twice and finally the supernatant was decanted and aliquots of sediment examined on a microscope slide and petri dish for observing the trematode eggs.

Ectoparasite collection and Identification

For ectoparasite sampling, each hedgehog was anesthetized using a piece of cotton soaked in 98% diethyl ether for 3-5minutes and then carefully examined for ectoparasites. After thorough examination and collection of ectoparasites the collected ticks were immediately preserved in labeled glass vials containing 70% alcohol and examined microscopically by stereo microscope and identified to genus or species according to identification key described by Walker *et al.* [17].

Data analysis

Data collected were entered, cleaned and stored in the Microsoft Excel 2007. Descriptive statistics were used to summarize the data by the aid of SPSS. The weight was reported as Mean ± Standard Deviation (S.D). Prevalence of ectoparasites and endoparasites were established according to Bush *et al.* 1997 [18].

Results and discussion

African pygmy hedgehogs

We captured a total of 20 African pygmy hedgehogs, whereby 12 were females and the remaining 8 were the males. During the study period we captured more females than males, our findings are in disagreement with the findings from Kimbita, [10] where the researcher captured a relatively higher number

of males than females during a study that was conducted in Tanzania. These findings could be explained by the fact that disparity in movement usually occurs, whereby females tend to explore more habitats to get more food for themselves and nourishing the young ones, also to find the suitable males for mating. Most of the captured individuals came from farms near the households, this could be explained by the nature of the areas, in which some places are having grass habitats and a lot of source of food, as it was grossly evident. Moreover, the surroundings were in favor, perfect soil for nest buildings as well as high interaction with human activities could be the reason for their abundance.

In this study the females were observed to have slightly larger body size and higher body weight compared to males. Females were having a mean weight (g) of 271.23±51.70 while the males were having a mean weight (g) of 268.83±49.41. In contrast to study reports from Sykes & Durrant, [19] males have been recorded to have slightly larger body size than females. Indeed, the relatively larger body size of the captured female's hedgehogs in our study than the males could be due to plenty of food in the habitats, perfect climate, low competition and also low number of predators in the area.

Endoparasite prevalence

In here we report for the first time the helminthological data of African pygmy hedgehog (*A. Albiventris*) from Morogoro municipal, Tanzania. Among the 20 fecal samples of hedgehogs analyzed, 9 (45%) were found to harbor helminthes parasites as shown in table 3. Nematodes were found to be most ubiquitous with a total prevalence of 40% (8/20) while trematodes had a total prevalence of 5% (1/20). Moreover, amongst the nematodes the *Aspiculuris tetraptera* contributed a total prevalence of 30% (6/20) while Strongyle nematode species had a total prevalence of 10% (2/20) as shown in table 2. Interestingly, the higher prevalence of *A. tetraptera* was unexpected since the pin worm commonly infects rodents such as rats and mice. Furthermore, the most common nematodes reported by several studies that infect the hedgehogs are *Physaloptera dispar*, *Cappillaria* spp. and *Crenostoma striatum* and they are host specific to the hedgehogs [20].

The prevalence of *A. tetraptera* in African pygmy hedgehogs to the best of our knowledge has never been reported by other previous studies. Surprisingly, we found that the most prevalent helminth to be *A. tetraptera* in the African pygmy hedgehogs, this can be attributed by the fact that the rodents and hedgehogs share the same habitats. Moreover, the infective stage of the parasite is within the same habitats where the rodents and hedgehogs interact. Our study findings are in disagreement with the study conducted by [21], where by *Physaloptera dispar* was found to be the most prevalent nematode (24%) in African pygmy hedgehogs from Nigeria, whilst the study in Kenya *Physaloptera dispar* found to have the prevalence of 77% accounting for the most prevalent nematode [22]. Strongyle nematodes reported from this study had a very low prevalence, since the egg of most strongyle nematode species looks the same, we failed to identify the egg to the species level. Hedgehogs have been reported to harbor various strongyle nematode species.

The trematode egg was only observed in one African hedgehog giving out the prevalence of 5%. Indeed, the lowest prevalence of trematode could be due to a reduced number of intermediate hosts (snails) which carry the trematode infective stage during the sampling period. Furthermore, according to Svadzhyan, 1953 [23], the prevalence of trematode endoparasite could be higher in mollusks of mountain steppe areas, compared to those in the lowlands like the area we sampled the hedgehogs.

The endoparasites prevalence with respect to sex were as follows; females infected were 6 with the overall prevalence of 30% whereas the males infected were 3 with the overall prevalence of 15.00% as shown in table 3. Sex biased endoparasitism was seen in our study in which the females were more infected than the males. Apparently, our study is contradicting the male biased parasitisim, it is known that male's vertebrates are more susceptible to parasitic burdens compared to females [24]. In fact, males tends to explore more habitats, sex hormones (that have immunosuppressive effect) and also have large body size which predispose them to the infection with endoparasites. Furthermore, behavior and immune response of the individual of either sex of hedgehogs can have the effect on the occurrence of endoparasites.

Table 2: The endoparasites of hedgehogs and their prevalence

Endoparasites	No. of positive hedgehogs (n=20)	Prevalence (%)
Aspicular istetraptera	6(20)	30
Strongyle nematode	2(20)	10
Trematode	1(20)	5
Total	9	45

Table 3: Prevalence of endoparasites with respect to the sex of hedgehogs

Sex	Number of captured individuals	No. of positive	Prevalence (%)
Male	8	3	15.00%
Female	12	6	30.00%
Total	20	9	45.00%

Ectoparasite prevalence

Among the Twenty African pygmy hedgehogs sampled 12(60%) were infested with ticks as shown in table 5. A total of 29 ticks were collected from the infested hedgehogs. Infestation with ectoparasites in African pygmy hedgehogs is most common in our settings since they share habitats with other domesticated and wild animals which do harbor these ectoparasites, hence is inevitably to avoid these parasites. Three hard ticks were identified; *Haemaphysalis leachi*, *Rhiphicephalus* (*Boophilus*) sp. and *Rhipicephalus appendiculatus*. Our findings showed that individual prevalence of the ticks were, 55% (11/20) were infested by *H. leachi*, 15% (3/20) by *Rhiphicephalus* (*Boophilus*) sp. and 5% (1/20) by *R. appendiculatus* as shown in table 4. The mixed infestation prevalence with *H. leachi* and *Rhiphicephalus* (*Boophilus*) *sp*. was found to be 15% (3/20). The reported

ectoparasite prevalence in this study is slightly lower than the prevalence reported by Hajipour *et al.* [25] in Iran, which was 67.7%. In North Western Libya the study carried out by Hosni & Maghrbi, 2014 [26]. Showed the prevalence of tick infestation in hedgehogs was 20.5% which is very low compared to our findings. In our present study in urban and suburban areas of Morogoro municipal, Most of *H. leachi* was found on hedgehogs with prevalence of 55%. *H. leachi* was the most abundant and most prevalent tick in our study. Indeed, our results are in agreement with the studies that was done by Kimbita, [10] whereby *H. leachi* was the most predominant ectoparasite of African hedgehog in Tanzania. Moreover, the study conducted by Okaemi & Osakwe 1988 [27] in Nigeria concurs with our present findings whereby the H. Lechi was the most abundant and prevalent tick. However, Kimbita, [10] reported the prevalence of *H. leachi* to be 100% which is relatively higher compared to our study prevalence.

H. leachi infests and feeds on a wide range of animals from domesticated to wild [28], therefore due to this feeding habits it is expected to find them on African pygmy hedgehogs. Surprisingly, we found a mature stage of the tick on the infested African pygmy hedgehogs, whilst most studies have reported immature stages to be common in small mammals rather than adult stages [29]. According to Kimbita, [10] stages found from the study were both immature and adult stage, this is indeed contradicting our findings where we found out only the adult stage on infested African pygmy hedgehogs. Interestingly, most of the researches are showing that *Haemaphysalis* spp. ticks are less frequently collected on hedgehogs than other ticks during routine tick monitoring, simply because they are more difficult to detect due to their smaller sizes [30]. *H. leachi* can transmit different pathogenic agents to some hosts, for example is capable of transmitting *Babesia* spp and *Rickettsia* spp. Matter of fact, this implies a zoonotic potential, thus endangering public health, since the African pygmy hedgehogs are sympatric animals, and frequently interact with human beings.

Rhipicephalus appendiculatus prevalence was found to be 5.00% in the present study. *R. appendiculatus* has been reported in various domesticated animals such as Cattle, goats, sheep, horses, donkeys, pigs and dogs to mention a few. Kimbita, [10] also reported the presence of this tick of veterinary and medical importance in Africa, especially East Africa. Moreover, it was reported in Libya by Hosni, [31] and Hosni & Maghrbi [26] *R. appendiculatus* is the main vector of *Theileria parva*, a protozoan parasite which is responsible for causing a devastating febrile disease known as East Coast Fever, which has high mortality and morbidity in Cattle. Additionally, *R. appendiculatus* is known as the vector of *Babesia* spp., *Anaplasma* spp and *Ehrlichia* spp to mention a few.

Rhiphicephalus (*Boophilus*)) sp. prevalence was found to be 15% in the present study. The tick has been reported to infest a wide range of domestic and wild animals, it is also a major vector of *Babesia* spp. In Tanzania, to the best of our knowledge this is the first report of *Rhiphicephalus* (*Boophilus*)) sp infestation on the African pygmy hedgehogs.

Table 4: The ectoparasites of hedgehogs and their prevalence

Ectoparasites	No. of infested hedgehogs (n=20)	Prevalence (%)
Haemaphysalis leachi	11	55
Rhiphicephalus (*Boophilus*)) sp.	3	15
Riphicipelus appendiculatus	1	5
Haemaphysalis leachi and *Rhiphicephalus* (*Boophilus*)) sp. Mixed infestation	3	15

Table 5: The prevalence of ectoparasites with respect to sex

Sex	No. of captured individuals	No. of positive	Prevalence (%)
Male	8	2	10
Female	12	10	50
Total	20	12	60

Conclusion

The present study has shed some light on the ectoparasites as well as endoparasites that are found on and/or in the African pygmy hedgehogs (*Atelerix albiventris*) in Morogoro municipal, Tanzania. A number of important species of the hard ticks have been found as the solely ectoparasite of the hedgehogs whilst the nematodes were the predominant endoparasites found followed by trematodes. The study provides the baseline information that is crucial to understand the parasites of small mammals in Tanzania, taking into account the potential zoonotic importance of some parasites.

Acknowledgements

The authors wish to thank all the people that have participated in this study in one way or another to ensure the success of this work, their contributions are extremely appreciated.

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