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Research article

First report of *Rhipicephalus appendiculatus, Echidnophaga gallinacea* and *Ctenocephalides felis* on African pygmy hedgehogs (*Atelerix albiventris*) captured in Morogoro, Tanzania

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Abstract

A study was conducted to determine ectoparasites infesting the African pygmy hedgehog, *Atelerix albiventris* (Wagner, 1841; Erinaceomorpha; Erinaceidae). This species is widespread throughout Africa, and can be found in steppes, savannas, grasslands, bushy areas as well as around human premises. In human settlement, they are found in abandoned houses, livestock enclosures and other agricultural fields. In this study, 22 wild-collected hedgehogs from grassland and bush areas were examined for the presence of various ectoparasites. The hedgehogs were captured by using pitfall and intensive searching methods. Thorough examination in the laboratory revealed high infestation rates with *Haemaphysalis leachi* (100%), *Rhipicephalus appendiculatus* (27.3%), *Echidnophaga gallinacea* (31.8%), and *Ctenocephalides felis* (54.5%). The intensity of parasite infestation per animal was 19.1 for *Haemaphysalis leachi*, 13.4 for *Echidnophaga gallinacea* 3.5 for *Ctenocephalides felis* and 2.6 for *Rhipicephalus appendiculatus*. These findings added to the knowledge of parasites affecting the African pygmy hedgehog.

Keywords: African pygmy hedgehog; *Atelerix albiventris*; ticks; fleas; Tanzania

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Introduction

Ectoparasites are animals which live on the surface of their host. There are many types of ectoparasites including ticks, lice, mites, fleas, keds and this association favours the parasite, with the possibility of harming the host. The associations between ectoparasites and host have evolved over many years to the extent that is it considered that the ecologies of mammals and their external parasites are inseparable (Barnes, 1962). Ectoparasites are of great importance to the health of animals due their blood sucking behaviour and ability to transmit diseases (Wall, 2007). For example fleas are well known for transmission of plague, while ticks are associated with the transmission of protozoal, viral, rickettsial, spirochaetal and bacterial diseases (Van de Broek et al., 2003). Moreover, the bites of ectoparasites cause pain hence direct pathological effects to animals (Berriatua et al., 1999). Furthermore, the salivary and faecal antigens produced by ectoparasites as they feed can stimulate immune responses in some individuals leading to hypersensitivity (Van de Broek et al., 2003).

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Hedgehogs are small, solitary, and nocturnal mammals, which belong to order Erinaceomorpha under the Erinaceidae family (Bedford et al., 2000). They are characterized by the presence of spines on dorsal part and hair on ventral aspect as well as on the face. The skin colour varies considerably from brown to almost black and at sexual maturity they weigh 250 to 600 grams with an average weight of 450 grams (Kaikabo et al., 2007, Santana et al., 2010).

African pygmy hedgehogs (*Atelerix albiventris*) are widespread throughout Africa. Due to their wide range distribution and stable population in the wild, the species holds no particular conservation status. However, their survival is facing a great challenge, due to the fact that they are dying in significant number particularly through road kill. The hedgehogs inhabit a range of microhabitats around the premises of human being; among others include small burrows or nest of grass, leaf litters under shrubs, gardens, hollow logs and farmland (Feldhamer et al., 1999).

The African pygmy hedgehogs can also be found in the human premises and often are used as pets (Berriatua et al., 1999). As a consequence, there is an intimate contact between human and hedgehogs as well as its associated ectoparasites which may be of great importance. Despite the fact that there are great risks and uncertainties regarding these interactions, currently there is no report on the ectoparasites associated with hedgehogs in Tanzania. This study aimed to investigate and report the external parasites of hedgehogs captured in Morogoro, Tanzania.

Materials and Methods

Study Area Description

The study was carried out at the Sokoine University of Agriculture main campus located at latitude S 06° 50'55.3″ and longitude E 037° 39'15.6" at the foot of Uluguru Mountains. The study area covers approximately 53,774.34 m^2 of which 16,382 m^2 was bush land with natural vegetation, 23,707.34 m^2 was cultivated area and 13,682 m^2 was grassland. The climate was characterized by average annual precipitation of 935 mm with an annual highest temperature of 30°C and lowest temperature of 18.6°C. The study was confined to two sites namely bush land and grassland. The bush land, which was dominated by *Lantana Camara* at the edge and mixture of exotic and indigenous plants, is reserved for different studies including grazing of horses. Presence of different crops such as paddy and beans in experimental plots prevented establishment of pitfalls in the cultivated gardens. The grassland, dominated by short grasses was used for different sports such as golf and football. The experiment was conducted during the rainy season in March of 2015.

Trapping and capturing of Hedgehogs

Pitfall traps: The bush land was selected for pitfall trap setting. A total of 14 pitfall traps which were made from plastic bucket with a diameter of 20 cm X 25 cm, were systematically established on four transect lines located 50m apart. The GPS was used to locate the specific position of traps in the bush land. The distance between pitfall traps was set at 50 m. All pitfalls were inspected in the morning from 0700hrs to 0800hrs for ten days and a total of 5 hedgehogs were collected from pitfall traps.

Searching: Intensive, continuous searching of hedgehogs was conducted in grassland habitat for ten days, from 1900hrs to 2100hrs. Flashlights were used to detect the nocturnal animals. A total of 17 hedgehogs were collected using this method. Captured hedgehogs from the two methods were kept in different aerated buckets to ensure they had access to sufficient air. For each captured hedgehog, the sex and habitats were recorded.

Collection of ectoparasites from hedgehogs: Animals were taken from the field in aerated buckets to the laboratory. Each animal was anaesthetized by being placed in jars with cotton wool soaked with diethyl ether.

Anaesthetized hedgehogs were examined over the whole body for ectoparasites. The body was swabbed using cotton wool soaked with diethyl ether to anaesthetize the parasites, which were then removed by gentle combing. Ticks were picked with forceps while caution was taken not to damage mouth parts which are very useful in the identification of parasites. The anaesthesia jar was examined for remaining ectoparasites. The collected ectoparasites from each hedgehog were preserved in 70% ethanol in a numbered vial for identification. The hedgehogs were set free in their natural habitats after they had woken up from anaesthesia.

The collected ectoparasites were placed on a watch glass disc and examined under stereo microscope with side lamp. Ticks were identified as described elsewhere (Walker et al., 2003). The fleas were identified by keys developed by Hopkins and Rothschild (1953).

Data processing and analysis

The prevalence and intensity of infestation were calculated by methods described by Margolis et al. (1982). The T-test was used to determine statistical significance and the cut off was 5%.

Estimating species diversity

Simpson's Diversity Index (Simpson, 1949) was used to calculate degree of diversity for ectoparasites in each habitat.

Results

Hedgehogs and the identified ectoparasites

A total of 22 hedgehogs were captured in two major habitats (Bush land and Grassland) during the rainy season of March, 2015. Out of 22, 77.3% were captured in grassland while 5 hedgehogs (22.7%) were captured in bush land and the distribution by sex is shown in Figure 1.

The Simpson's Index showed that diversity of ectoparasites on hedgehogs captured in grassland was higher (0.266) than in bush land (0.593) (Table 1). A comparison between male and female hedgehogs found that males had more ectoparasites than females (Table 2). Moreover, T-test revealed a significant difference between ectoparasites found on male and female hedgehogs ($P<0.005$).

In total 572 individual external parasites were collected from 22 hedgehogs captured. Majority of the ectoparasites were collected from the ventral part and face, which are not covered with spines. The species of ectoparasites identified were *Haemaphysalis leachi*, *Rhipicephalus appendiculatus*, *Echidnophaga gallinacea* and *Ctenocephalides felis* (Fig. 2). All 22 hedgehogs examined had ixodid ticks as the major external parasites regardless of the habitat from which the animals were captured. Majority of ticks (96%) collected from hedgehogs were in the adult stage and the minority were nymphs.

In this study, *H. leachi* was the most abundant tick species found on hedgehogs (73.42%) and was considered to be important while *R. appendiculatus* was less abundant (2.8%). This might indicate that *H. leachi* was more widely distributed in the study area than other ectoparasite species identified in this study.

Prevalence and mean intensity

The prevalence of ectoparasites collected on hedgehogs is presented in figure 3.

The overall prevalence of ectoparasites (ticks and fleas) on hedgehogs irrespective of sex suggests that *H. leachi* was leading species with prevalence of 100%, followed by *C. felis* (54.55%), then *E. gallinacea* (31.88%) and the least prevalent was *R. appendiculatus* 27.3% (Fig. 3). This implies that all 22 hedgehogs examined in this study were infested with *H. leachi*, but only a few hedgehogs were infested with *R. appendiculatus*.

The mean intensity of infestation of *H. leachi* recorded on hedgehogs was 19.1 ticks per hedgehog (Fig. 4).

In contrast, *R. appendiculatus* was recorded at low prevalence of 27.3% (Fig. 3) as well as mean intensity of 2.66 (Fig. 4) compared to other ectoparasites. Apart from ticks, two species of fleas (*E. gallinacea* and *C. felis*) were also recorded on hedgehogs at prevalence

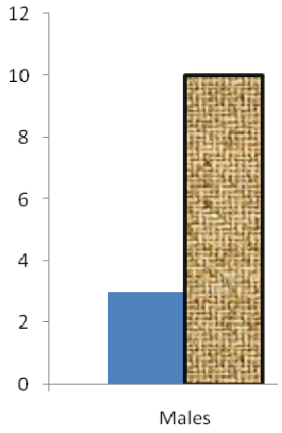

Fig. 1: Comparison of the number of hedgehogs captured in the grassland and bush land

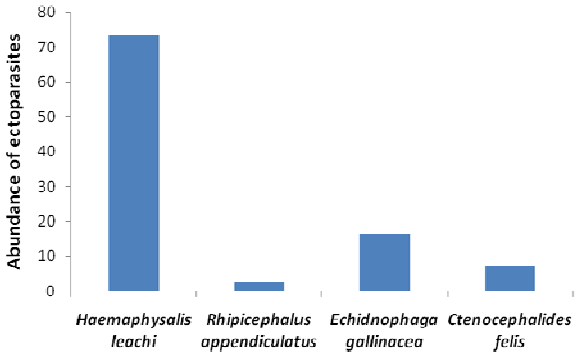

Fig. 2: Relative species abundance of ectoparasites on the African pygmy hedgehogs

rates of 31.88% and 54.55% respectively (Fig. 3). The mean intensity of *E. gallinacea* and *C. felis* were 13.43 and 3.5 respectively (Fig. 4). Using the T-test there was no significant difference in prevalence infestation between *E. gallinacea* and *C. felis*. However, there was a significant difference in mean intensity between the two species ($P<0.005$). This pattern suggests that numerous *Echidnophaga gallinacea* were collected from few hedgehogs while few *Ctenocephalides felis* were collected from larger number of hedgehogs. *Echidnophaga gallinacea* has a wide range of hosts including chickens and other bird species and is occasionally found on dogs and cats. It tends to attach and cluster on the skin of hosts especially around the eyes. In this study the same situation was observed in two hedgehogs among seven individuals infested with *Echidnophaga gallinacea*.

Discussion

In this study, more hedgehogs were captured in open grasslands than bush land. The major reason could be clear visibility in the grassland compared to poor

Table 1: Species diversity (Simpsons's Diversity Index) of ticks and fleas recovered from hedgehogs captured from the two habitats (grassland and bush land).

Ectoparasites	Habitat					
	Grassland			Bush land		
	Number of parasites	Number of infested hedgehogs	n(n-1)	Number of parasites	Number of infested hedgehogs	n(n-1)
Haemaphysalis leachi	384	17	120756	72	5	5112
Rhipicephalus appendiculatus	15	5	210	1	1	0
Echidnophaga gallinacea	10	6	90	84	3	6972
Ctenocephalides felis	24	9	552	18	2	306
Simpson's Index of diversity	0.226			0.593		

Table 2: The number of ectoparasites recovered according to sex of hedgehog

Parasite	Infested female	Number of parasites	Infested males	Number of parasites
Haemaphysalis leachi	9	121	13	299
Rhipicephalus appendiculatus	2	2	5	14
Echidnophaga gallinacea	2	83	5	11
Ctenocephalides felis	6	28	7	16

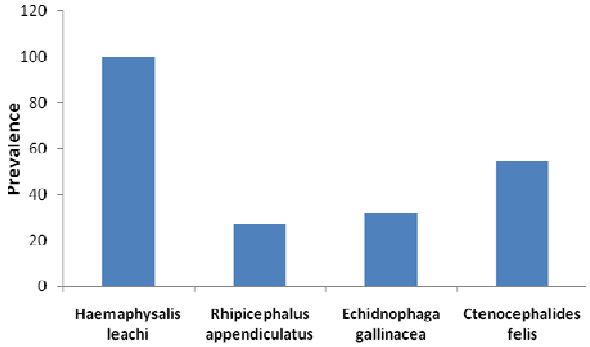

Fig. 3: The prevalence of ectoparasites collected on hedgehogs

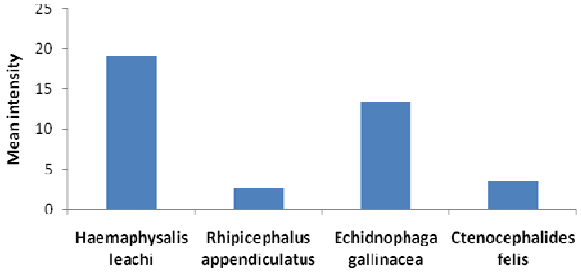

Fig. 4: Mean intensity of ectoparasite infestation on hedgehogs

visibility in the bush land particularly at night. However, it has been reported that hedgehogs feed on a variety of invertebrates including earthworms, slugs, insects and snails, eggs of ground-nesting birds, small mammals, frogs, reptiles, crabs, fungi, roots and groundnuts (Van de Broek et al., 2003), which were probably easily seen in the grasslands compared to bush land. A higher number (Berry, 1999) of male hedgehogs were captured compared to females in both habitats. This may be caused by disparity in movement between male and female hedgehogs; male hedgehogs travel longer distance at night wandering regardless of the availability of food. Furthermore, it has been reported that hedgehogs can travel up to 2.3 km within one night (Berry, 1999), which exposes them to the ectoparasites from other domesticated animals like dog and cat.

In this study, four species of external parasites *H. leachi*, *R. appendiculatus*, *E. gallinacea* and *C. felis* were collected from hedgehogs. The grassland and bushes from which the hedgehogs were captured are shared with domestic animals such as dogs, horses, cattle, goats and sheep. The above mentioned ectoparasites virtually play a vital role in various forms of parasitic relationship and consequently can serve as vectors transmitting infective stage of parasites to hosts. The four identified ectoparasites are also commonly found on domestic animals. Thus, there are possibilities for transmission of disease causing agents between domestic and wild animals through the identified ectoparasites. It could be speculated that disease causing agents for which the hedgehogs may act as reservoirs, could be transmitted by the ticks and fleas to domestic animals. At the same time viruses, bacteria, rickettsia and protozoa could be transmitted from domestic animals to wild animals through ticks and fleas. The ticks and fleas could also bite human beings and thereby transmit infectious agents of disease to humans. Generally, ticks have been recognized to transmit a variety of pathogenic microorganisms, protozoa, rickettsiae, spirochaetes and viruses, compared to other group of arthropods, and are amongst significant vectors of diseases affecting livestock, humans and companion animals (Jongejan, 2007).

Haemaphysalis leachi is highly adapted to feed on a wide range of animals (Horak et al., 1983). In this study *H. leachi* was the most abundant and prevalent tick identified from the African pygmy hedgehog, the result being similar to previous work by Okaeme and

Osakwe (2008) in Nigeria. *Haemaphysalis leachi* was capable to transmit rickettsia of tick typhus from dog to guinea pig; therefore, it is possible also for *H. leachi* to transmit any zoonotic diseases from hedgehogs to other animals including humans. *Haemaphysalis leachi* is an important vector of *Babesia canis* of dogs in South Africa (Lewis et al., 1996). Furthermore, *H. leachi* have been acknowledged in the transmission of *Babesia* of a wide range of domesticated and wild animals including endangered species such as black rhino (*Diceros bicornis*) (Zimmermann, 2009; Fyumagwa and Nyahongo, 2010). In another study, it was reported that adult *H. leachi* prefer animal species from the order carnivora including lion, leopard, domestic dogs, hunting dogs (*Lycaon pictus*), spotted hyaenas (*Crocuta crocuta*) and jackals, while larvae and nymphs prefer rodents (Horak et al., 1983). The 100% prevalence infestation of *H. leachi* on hedgehogs may indicate preference for this host in Tanzania. Previous studies reported that small mammals were good hosts for immature *H. leachi* and *R. Gertrudae* (Horak et al., 2005), which contrasts with the findings reported herein, because most *H. leachi* collected were engorged adults and very few were immature stages.

In contrast to *H. leachi*, only a few *R. appendiculatus* were recovered (16 individuals out 572 ectoparasites) from 6 hedgehogs. One could speculate reasons for this as being that adult *R. appendiculatus* prefers to feed on the ears while immature stages feed on the ears, head, and legs of the host (Dantas Torres, 2010). However, hedgehogs have very small ears which probably cannot accommodate a large number of *R. appendiculatus*. Nevertheless, the face, legs and the ventral aspect of hedgehogs are covered with hair, while the head and the dorsal part is protected with spines. Thus, in those body parts there was no space for a large number of *R. appendiculatus* to attach successfully.

Rhipicephalus appendiculatus infests a wide range of domestic and wild animals though most wild animals are considered highly resistant to diseases transmitted by *R. appendiculatus* and therefore can act as reservoir (Horak et al., 1983). *Rhipicephalus appendiculatus* is the most importance vector of *Theileria parva* which cause East Coast Fever (ECF) to cattle from Southern Sudan to Eastern and Southern Africa. Moreover, the presence of ticks on livestock leads to poor quality of hides and skins. Furthermore, through blood sucking, ticks cause anaemia particularly in juvenile mammals (Zewdie, 2010). In this study, *E. gallinacea* (stick tight flea) was collected from hedgehogs with 31.88% prevalence infestation and 13.43% mean intensity. *Echidnophaga gallinacea* is a common flea which mostly affects chickens, but also can infest different bird species, horses, rabbits, canidae and sometimes humans (Galloway et al., 2000). This parasite is usually found on hosts in a clustered form around the eye and is difficult to remove because its head is embedded in the skin. It has been reported that large populations of this flea may cause ulcers on the affected area, may transmit bubonic plague to humans and is the key vector in the spread of murine typhus from rat to humans (Wheeler et al., 1941). It has also been reported that *E. gallinacea* plays a vital role in the transmission of tularemia from cottontail rabbits to man (Lopez, 1982). *Ctenocephalides felis* is primarily a parasite of domestic cats, but can also be found on domesticated dogs (Gerhard and Martin, 2011). *Ctenocephalides felis* was found on many hedgehogs but the number of fleas on individual hedgehog was very low. This parasite is known to transmit the dog tapeworm *Dipylidium caninum* as well as causing flea dermatitis. Moreover, heavy infestation with cat fleas has been suspected to cause dehydration especially in small animals. Cat fleas can also transmit agents of plague and some authors consider humans as the most important group of mammals affected by *C. Felis* (Magesa et al., 2001). Other diseases such as bartonellaosis and murine typhus have been reported to be transmitted by cat fleas to humans, dogs, and cats.

This is the first report of *R. appendiculatus*, *E. gallinacea* and *C. felis* on the African pygmy (i.e. four toed) hedgehog, although other parasites have been reported in other places. For example in Southern Africa, ticks belonging to *H. colesbergensis*, *H. norvali* and *Amblyomma marmoreum* (Horak et al., 2005) have been reported on small mammals including other African hedgehogs. In Iran, *R. turanicus* has been recorded (Youssefi et al., 2011), while three species of fleas namely *Archaeop syllaerinacei*, *Ceratophyllus gallinae*, and *C. felis* have been recorded from European hedgehogs (Visser et al., 2001).

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