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Ectoparasite diversity in the eastern rock sengis (*Elephantulus myurus*): the effect of seasonality and host sex

Dina M Fagir[1], Ivan G Horak[2,3], Eddie A Ueckermann[4,5], Nigel C Bennett[1] and Heike Lutermann[1]*

[1] Mammal Research Institute, Department of Zoology and Entomology, University of Pretoria, Pretoria, South Africa
[2] Department of Veterinary Tropical Diseases, Faculty of Veterinary Science, University of Pretoria, Onderstepoort, South Africa
[3] Department of Zoology and Entomology, University of the Free State, Bloemfontein, South Africa
[4] Agricultural Research Council–Plant Protection Research Institute, Queenswood, Pretoria, South Africa
[5] Unit for Environmental Sciences and Management, North-West University, Potchefstroom Campus, Potchefstroom, South Africa
** Corresponding author, email: hlutermann@zoology.up.ac.za*

Globally small mammals are important hosts of ectoparasite vectors of pathogens of medical, veterinary and economic importance. Insectivores are currently understudied as hosts of pathogen vectors. However, data are needed on the diversity of such vectors before we can investigate the underlying factors affecting ectoparasite distribution. Abiotic (e.g. temperature and rainfall) and biotic (e.g. host sex) factors have been identified as the main determinants of host–parasite interactions. The present study describes the ectoparasite community of insectivorous eastern rock sengis (*Elephantulus myurus*) in a nature reserve in the Gauteng province, South Africa, and how it varies with season and host sex. A total of 81 sengis were examined for the presence of ticks, mites, fleas and lice between April 2010 and April 2011. The ectoparasite assemblage comprised 11 groups of tick species, a single mite family, one louse and two flea species, with ticks and mites being the most numerous ectoparasites recovered. The prevalence and/or abundance of two commonly collected ticks (*Ixodes* spp. and *Rhipicephalus warburtoni/arnoldi*) and chigger varied with season. In addition, female-biased tick burdens were apparent for one ectoparasite species possibly due to reproductive investment. The mechanisms causing the observed patterns should be addressed in future studies.

Keywords: ectoparasites, host sex, Macroscelididae, seasonality

Introduction

Small mammals are hosts to numerous ectoparasite species, some of which are vectors of pathogens such as *Borrelia*, *Babesia* and *Anaplasma* causing disease in both humans and livestock (Labuda and Nuttall 2004; Morand and Krasnov 2006).Understanding the factors that regulate the distribution of ectoparasites among host populations could provide management solutions for such diseases. It has frequently been observed that parasites exhibit aggregated or over-dispersed patterns on or within their hosts, i.e. the majority of parasites infest few host individuals, whereas most host individuals harbour only a few or no parasites (Wilson et al. 2001; Poulin 2007). Such aggregation patterns may be caused by a number of drivers that can be abiotic (e.g. climate) or biotic factors (e.g. host reproductive activity) acting on the parasite and/or the host (Wilson et al. 2001). Abiotic factors, such as temperature and rainfall, can result in seasonal variation in parasite burdens. For example, high temperatures can reduce developmental times for arthropod parasites but at the same time may increase the risk of desiccation and hence mortality when humidity is low (Marshall 1981; Needham and Teel 1991; Benoit and Denlinger 2010). For arthropod parasites such effects may be closely linked to the relationship between parasites and their hosts. Parasites such as ticks, which spend a substantial part of their life off-host, will be more strongly affected by climate factors than, for example, lice, which spend their entire life cycle on their hosts (Marshall 1981; Randolph 2004; Kim 2006).

Seasonal variation in temperature and rainfall can also influence a host's exposure and susceptibility to parasitic infection. For example, during cold seasons resources may be limited, while concurrently the energy demand for thermoregulation is high. If hosts have to increase their home range to cover their nutritional needs this may result in increased exposure to parasites during cold periods. Alternatively, but not mutually exclusive, hosts may have lower resistance to parasites during winter due to reduced resources available for parasite defence (Nelson et al. 2002; Martin et al. 2008). Parasite burdens may, however, also be increased during summer because the host diverts resources for parasite defences into reproductive activities (Altizer et al. 2006). Seasonal variation in ectoparasite burdens has been recorded by a number of studies carried out in different regions of Africa, including South Africa, and irrespective of whether those were carried out in summer or winter rainfall regions, rainfall patterns appeared to play

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Complex interactions within the ectoparasite community of the eastern rock sengi (*Elephantulus myurus*)

Heike Lutermann *, Dina M. Fagir, Nigel C. Bennett

Department of Zoology and Entomology, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa

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A B S T R A C T

Concomitant infection with more than one parasite species is the rule in nature. Since co-infecting parasites are exploiting the same host, interspecific interactions at the infracommunity level are likely. The nature of such interactions can be expected to affect the distribution of parasites within host populations. Intraspecific interactions within the infracommunity are not easily discernible from cross-sectional studies and the focus of most of these studies lies on relationships between endoparasitic micro- and macroparasites. In the current study of the ectoparasite community of wild eastern rock sengis (*Elephantulus myurus*) we experimentally reduced tick and flea infestations and monitored ectoparasite burdens over the course of three years. We found a number of within-taxon facilitating interactions between tick species that might be the result of decreasing immune responses with increasing tick burden. In contrast, inter-taxon relationships appeared to be dominated by antagonistic relationships likely to be linked to competition over feeding sites. Only one of the observed interspecific interactions was reciprocal. Our experimental manipulation revealed additional antagonistic relationships that cross-sectional studies would not have captured. In addition, we found substantial long-term changes in the sengi ectoparasite community as a result of our experimental manipulation suggesting carry-over effects of our treatment. This study is the first that evaluates interspecific interactions within the entire ectoparasite community exploiting a mammalian host in Africa and highlights the complexity of interspecific interactions within an ectoparasite community.

1. Introduction

The distribution of parasites across a host population tends to be highly skewed with a small proportion of the host population sustaining the majority of the parasite population (Woolhouse et al., 1997; Wilson et al., 2002; Poulin, 2007). Such asymmetries in parasite distribution are thought to be a result of individual differences between hosts in the exposure and susceptibility of hosts to parasites (Wilson et al., 2002). Abiotic factors such as seasonal variation in rainfall and temperature can affect developmental rates and survival of parasites in the environment but also the availability of resources for maintenance and reproduction of hosts and frequently results in seasonal variation in parasite burden (Altizer et al., 2006). Similarly, sex-specific strategies to maximize survival and reproductive output can result in differential resource allocation strategies into maintenance, reproduction and mate searches. Such differences can be expressed as dimorphism in body size or sexual ornaments, ranging behaviour and immune function, all of which have been linked to sex biases in parasite burden (Moore and Wilson, 2002; Rolff, 2002; Wilson et al., 2002; Klein, 2004).

Much research has been dedicated to exploring the contributions of these abiotic and biotic factors on parasite burden and the vast majority of these focussed on a single parasite species. However, hosts are usually infested with more than one parasite species (Petney and Andrews, 1998; Behnke et al., 2001; Cox, 2001). Parasite species exploiting the same host can be expected to interact with each other like species of other ecological communities. Such interactions may be either through direct interference or indirect such as via competition for host resources (bottom-up regulation) or immune mediated (top-down regulation) and may be facilitating or antagonistic (Pedersen and Fenton, 2007). The nature and outcome of such interspecific interactions can be expected to contribute to the distribution of parasites within a host population and should be considered when exploring parasite distributions.

Although the number of studies providing evidence for interspecific interactions in parasite communities is increasing, they are largely biased towards those investigating interactions between helminths and microparasites (Lello et al., 2004; Cattadori et al., 2008;

* Corresponding author. Department of Zoology and Entomology, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa. Tel.: +27 12 420 4872; fax: +27 12 362 5242.

E-mail addresses: hlutermann@zoology.up.ac.za (H. Lutermann).

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RESEARCH Open Access

The Namaqua rock mouse (*Micaelamys namaquensis*) as a potential reservoir and host of arthropod vectors of diseases of medical and veterinary importance in South Africa

Dina M Fagir[1], Eddie A Ueckermann[2,3,4], Ivan G Horak[4], Nigel C Bennett[1] and Heike Lutermann[1*]

Abstract

Background: The role of endemic murid rodents as hosts of arthropod vectors of diseases of medical and veterinary significance is well established in the northern hemisphere. In contrast, endemic murids are comparatively understudied as vector hosts in Africa, particularly in South Africa. Considering the great rodent diversity in South Africa, many of which may occur as human commensals, this is unwarranted.

Methods: In the current study we assessed the ectoparasite community of a widespread southern African endemic, the Namaqua rock mouse (*Micaelamys namaquensis*), that is known to carry *Bartonella* spp. and may attain pest status. We aimed to identify possible vectors of medical and/or veterinary importance which this species may harbour and explore the contributions of habitat type, season, host sex and body size on ectoparasite prevalence and abundance.

Results: Small mammal abundance was substantially lower in grasslands compared to rocky outcrops. Although the small mammal community comprised of different species in the two habitats, *M. namaquensis* was the most abundant species in both habitat types. From these 23 ectoparasite species from four taxa (fleas, ticks, mites and lice) were collected. However, only one flea (*Xenopsylla brasiliensis*) and one tick species (*Haemaphysalis elliptica*) have a high zoonotic potential and have been implicated as vectors for *Yersinia pestis* and *Bartonella* spp. and *Rickettsia conorii*, respectively. The disease status of the most commonly collected tick (*Rhipicephalus distinctus*) is currently unknown. Only flea burdens differed markedly between habitat types and increased with body size. With the exception of lice, all parasite taxa exhibited seasonal peaks in abundance during spring and summer.

Conclusion: *M. namaquensis* is the dominant small mammal species irrespective of habitat type. Despite the great ectoparasite diversity harboured by *M. namaquensis*, only a small number of these are known as vectors of diseases of medical and/or veterinary importance but occur at high prevalence and/or abundance. This raises concern regarding the potential of this host as an endemic reservoir for zoonotic diseases. Consequently, additional sampling throughout its distributional range and research addressing the role of *M. namaquensis* as a reservoir for zoonotic diseases in southern Africa is urgently needed.

Keywords: *Micaelamys namaquensis*, Flea, Tick, Vector, *Bartonella*, *Rickettsia*, Zoonotic disease

* Correspondence: hlutermann@zoology.up.ac.za
[1]Mammal Research Institute, Department of Zoology and Entomology, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa
Full list of author information is available at the end of the article

FUNCTIONAL MICROMORPHOLOGY OF *Demeillonia granti* FLEAS COLLECTED FROM EASTERN ROCK ELEPHANT SHREWS *Elephantulus myurus*

E.D. Green[1], C. Baker[2], A.A. Adebesin[1] and D.M. Fagir[3]

[1]Department of Anatomy and [2]Electron Microscope Unit, University of Limpopo, Box 232, Medunsa 0204, Pretoria; [3]Department of Zoology and Entomology, University of Pretoria, Private Bag x20, Hatfield, 0028, South Africa.

Demeillonia granti has been collected from elephant shrew species throughout the arid western half of southern Africa, as well as from the Namaqua rock mouse sharing their rocky habitat[1,2]. These fleas were collected from *Elephantulus myurus* trapped on the Ezemvelo Nature Reserve, Mpumalanga, which was a new host and distribution record. This investigation sought to confirm the taxonomic characteristics of *D. granti* as well as elucidating the functional micromorphology.

Fleas fixed in 70% ethanol were cleared and mounted for light microscopy for identification, while the remainder was routinely processed for SEM before being viewed in a Zeiss Supra 55 FE-SEM at 1 kV.

D. granti are elongated fleas with the males measuring less than 1.66 mm in total length and the females approximately 2.2 mm. The frons of the head was angular bearing fine setae anterior to the five prominent flattened spines forming the genal comb (Fig.1). The shape of each spine was characteristic, with the third spine greatly elongated and tapering to a point[1,2]. The spines were angled for hooking onto the hairs of the host as well as protecting the lateral antennae. The large eyes were situated anterio-dorsally and protected by the frons. The antennae were large and held in the deep antennal grooves by spatulate suckers in the male. This was similar to the spatulate setae shown in the related *Macroscelidopsylla* fleas[3]**.** The mouthparts composed of two serrated laciniae and a rodlike epipharynx for penetrating the skin, were housed in a pair of tube-like labial palps. The prominent pronotal comb consisted of stout round 12 apically flattened bristles in the male (Fig.1), and 16 to 18 in the female.

These pronotal spines were longitudinally ridged for hooking onto the hairs. The tibia of the hind legs showed stout spines arranged in 9 dorsal notches reminiscent of a comb, which is a characteristic of this species.[1] The tarsal claws with lateral plates were specialized with ventral grooves for attaching to the hairs of the host as suggested in the related *Macroscelidopsylla* fleas collected from the same elephant shrews species[3]. The spiracular plate openings on the abdominal tergites were elongated except for the large slit-like posterior spiracles on tergite VIII. The sensilium consisted of 28 long sensory sensilla which is the same number as for *Macroscelidopsylla*[3]. The external genitalia of both female and male fleas were also investigated. The male genitalia was shown to have unique specializations of the claspers, phallosome and nineth sternite (Fig.2) which would prevent interspecific cross-breeding. A number of functional micromorphological specializations of *D. granti* were elucidated in this SEM study.

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Figure1. Lateral view of the male head with angular frons with a genal comb of five distinctly shaped genal spines (GC), a large eye (*), and a well-developed antenna (A) in a deep fossa. The prominent pronotal comb (P) consists of six stout bristles on each side.

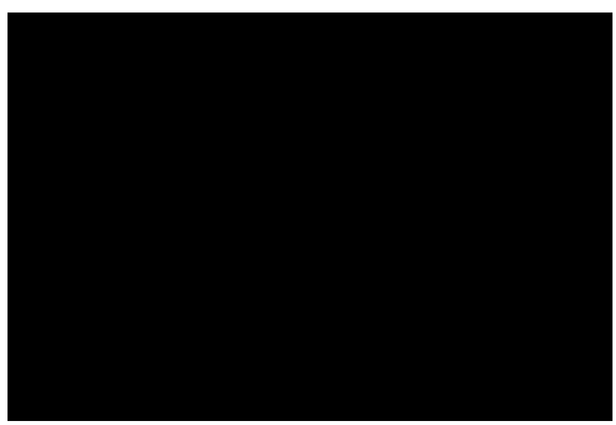

Figure 2. External male genitalia consisting of a sensilium (S), large dorsal clasper (CL), phallosome (Ph) with 2 apical teeth, and an elongated stylet-like nineth sternite (St).

Corresponding author: *Edward.Green@ul.ac.za*

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ORIGINAL ARTICLE

Parasites of the Nile rat in rural and urban regions of Sudan

Dina M. FAGIR and El-Amin EL-RAYAH

Department of Zoology, University of Khartoum, Khartoum, Sudan

Abstract

In this investigation on endoparasites (helminths) and ectoparasites of the Nile rat (*Arvicanthis niloticus* Desmarest, 1822), a total of 220 Nile rats were trapped from different regions of Sudan during the period January 2003–January 2006. Examination of different tissues, identification of parasites, effect of these parasites on the organs, the prevalence and intensity of infestation of the parasites and their relation to the habitat of the host, and sex-related infestations were considered. Results showed that the variation among helminth species was wide, especially in those that are transferred by arthropods. No protozoan parasites or distortion in the infected tissues were observed. No examination for *Toxoplasma gondii* was carried out. Two species of cestodes (*Hymenolepis nana*, *Hymenolepis diminuta*), two genera (*Raillietina* sp. I, *Raillietina* sp. II) and one unidentified Hymenolepididae were reported. The most prevalent species of cestodes was *Raillietina* sp. And for nematodes only one species and one genus were recovered (*Monanema nilotica* and *Streptopharagus* sp.). Investigation of skin revealed that 83.8% of rats were infested with one or more of ectoparasites; namely, insects and arachnids. This survey also revealed that fleas and lice were the most common ectoparasites that infested the Nile rat. Synanthropic rodents, particularly those living in close association with man, play a significant role in human health, welfare and economy. It has to be stressed that their arthropod ectoparasites are important vectors of pathogenic microorganisms and they can also be important reservoirs for parasitic zoonoses, like trichinellosis and capillariosis. No doubt, the increase in rodent populations could be followed by an increase in zoonotic diseases (Stojcevic *et al*. 2004, Durden *et al*. 2000). Rats and mice (commensal and wild) play an important role in public health, being carriers or reservoirs for infectious diseases that can be transmitted to humans (zoonoses). *Xenopsylla cheopis* is the most important vector of plague and the rickettsial infection murine typhus (Gratz 1999). Man can also acquire the infection through direct contact with infected animals' tissues (WHO 1987). *Arvicanthis niloticus*, *Mastomys natalensis* and *Rattus rattus* are probably the most important and widespread reservoirs of plague in Kenya: 10 percent of all *Rattus rattus* tested were found to be positive as compared to 12% of the *Arvicanthis niloticus* (Gratz 1999).

Key words: *Arvicanthis*, fleas, lice, mites, Nile rat, Sudan, ticks.

INTRODUCTION

The parasitic fauna of rodents have been widely studied as rodents often act as intermediate hosts and reservoirs of several helminthic and protozoan diseases (Smyth 1981). In Sudan, there is high risk from diseases spread by rats because of socioeconomic factors typical of developing countries. The unstriped Nile grass rat (*Arvicanthis niloticus*) is a common rodent species in Sudan and, in particular, the most common species detected along the cultivated banks of the Nile. This rodent is a herbivorous

Correspondence: Dina M. Fagir, Department of Zoology, University of Khartoum, Khartoum 11115, Sudan.
Email: d_fagir@hotmail.com