Endoparasites of the Spiny Mouse (*Acomys spinosissimus*) from South Africa

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ABSTRACT: The endoparasite fauna of the spiny mouse (*Acomys spinosissimus*) was studied for the first time from April 2007 until April 2009 in a population from the Limpopo Province of South Africa. In a total of 129 mice examined, only 6 endoparasite taxa were found, 2 nematode species (*Syphacia minuta*, *Monanema joopi*), 1 genus of cestodes (*Rodentolepis* spp.) and unidentified hymenolepidid fragments. In addition, 1 pentastomid species (*Armillifer grandis*) as well as unidentified porocephalid specimens were recovered. The overall prevalence was low with 15.5% and only 1 individual harbored more than 1 parasite species. With 12.4% *S.minuta* was the most prevalent parasite. Its prevalence and abundance were significantly higher during the dry and cooler season than during the wet and warm season while a female-biased burden was observed during the wet season only. For the remaining parasite species, low prevalence prevented meaningful statistical analyses. The observed parasite species richness, prevalence and abundance for *A. spinosissimus* was low compared to that reported for other *Acomys* spp. This may be linked to the lack of anthropogenic influences in the study population as well as the small size of *A. spinosissimus*.

The helminth communities of rodents from Europe have attracted a large number of studies and their ecology as well as the effects of host factors (e.g. sex and age) are well characterized for a number of species (Goüy de Bellocq et al., 2002 and references therein). In contrast, research exploring the helminth parasites of African rodents is still limited and often restricted to reports of a taxonomic nature or from sampling over a limited period and this is particularly true for the southern African subregion (De Graaff, 1981 and references therein, but see Froeschke et al., 2010). One group of rodents with a large distributional range, that spans the entire African continent with some species occurring on the Sinai Peninsula and several Mediterranean islands are spiny mice of the murid genus *Acomys* (De Graaff, 1981). Despite its main range being on the African continent, the geographical focus of taxonomic and ecological studies of the helminth communities of this genus has been the Middle East (Myers et al., 1962; Wertheim and Greenberg, 1970; Behnke et al., 2000, 2004). These studies report more than 20 helminth species for *A. dimidiatus* and *A. russatus* alone with geographical differences in community composition when sampled over short periods. In contrast, for 2 other *Acomys* spp. from the southernmost distribution of the genus (*A. subspinosus* and *A. spinosissimus*) no endoparasite data have ever been collected (De Graaff, 1981). With an average body mass of 20-22 g they also represent some of the smallest members of this genus. Given the large distributional range of *A. spinosissimus*, including parts of Tanzania, the Democratic Republic of Congo, Zambia, Malawi, Zimbabwe, Mozambique and the northeastern provinces of South Africa (De Graaff, 1981), the lack of parasitological information for this species is unmerited. Taking advantage of the opportunity created by a study on the reproductive biology of *A. spinosissimus*, we provide the first assessment of the endoparasite species richness sustained by *A. spinosissimus*, and evaluate the

influence of host sex on parasite richness, prevalence and abundance. As the current study constitutes the first long-term assessment of endoparasite burdens in the genus *Acomys*, our last objective was to explore the influence of climate on the parasite richness, prevalence and abundance in *A. spinosissimus*.

Spiny mice were collected from the Goro Game Reserve (22°58'S, 29°25'E) in the Limpopo Province, South Africa. Sherman live traps baited with oats, peanut butter and sardines were set out overnight on rocky outcrops. Trapping aimed to collect 5 individuals of each sex during monthly trips from April 2007 to August 2008. Additional trapping was carried out in October 2008 and April 2009. Each animal was sexed on capture and mice were kept in standard rodent cages with wood shaving as bedding and rodent pellets and water was available ad libitum. In addition, pieces of apple or carrot were offered daily. Only individuals above a body mass of 12g were sampled and post-mortem examination based on tooth wear confirmed that our sample did not contain sub-adults (Medger et al., 2010). Animals were killed within a maximum of 8 days of capture with an overdose of halothane. Three of the individuals caught in February 2008 were kept for up to 17 wk before euthanasia with the same method. The body cavity was opened by lateral incision, the gastrointestinal tract (GIT) removed, and stored in 70% ethanol. As part of an unrelated study, blood was collected from the heart for all animals examined, and an additional 7 individuals. Any parasites encountered during this procedure were stored as indicated below. For individuals infected with *Monanema joopi* (see Results section) additional searches of selected organs and ear pinnae were conducted as described in Junker et al. (2012). As parasite not populating the GIT were largely coincidental findings (see results) these counts were not included in our statistical analyses. The GIT was separated into stomach, small intestine, caecum and colon and each section examined separately. All parasites encountered were stored in 70% ethanol. For identification, helminths were cleared in lactophenol and pentastomids in Hoyer's medium. All were examined under a compound light microscope. Species richness (number of parasite species) was only calculated for gastrointestinal helminths due to the reasons provided above. Only a single female was infected with more than 1 gastrointestinal helminth species and we classified helminths as either being present or absent. The effects of host sex and season on the prevalence of helminths were evaluated employing a χ^2-test. As the number of animals caught per month was low for most months we classified months either as part of the dry (May-August, austral winter, n=39) or the wet season (September-April, austral summer, n=90) that also coincides with reproductive activity in the study species (Medger et al. 2010). Only 1 helminth species (see Results section) occurred in sufficient numbers to allow a more advanced statistical analysis. We used generalized linear models with a binomial distribution with a logit-link function and a negative binomial distribution with a log-link function to test for the effect of host sex and season on prevalence and abundance (Bush et al., 1997), respectively. For significant interactions post-hoc comparisons were carried out using the least significant difference (LSD). Results are reported as means ± SE. Confidence intervals (CIs) were calculated with the software package Quantitative Parasitology 3.0 (Rósza et al., 2000).

A total of 129 individuals (66 males, 63 females) were examined for intestinal helminths. Six taxa, comprising 2 nematode species, 1 genus of cestodes and 1 pentastomid species, as well as unidentified specimens of hymenolepidids and porocephalids, were recovered from the GIT, the heart, skin and the tissues of various organs (Table I). With regard to gastrointestinal helminths, the mean species richness was low (0.16±0.39, CI: 0.10-0.23), ranging from 0-2. Their overall prevalence was also low, reaching a mere 15.5% [CI: 9.9-22.62] and did not differ significantly with time (dry: 23.1%, CI: 12.3-38.4, wet: 12.2%, CI: 7.0-21.0, χ^2=2.472, df=1, p=0.114) or between the sexes (females: 15.9%, CI: 8.5-26.9, males: 15.2%, CI:

8.1-25.6, χ^2=0.052, df=1, p=0.820). Similarly, the interaction between season and sex was not significant (χ^2=0.019, df=1, p=0.891). Nematodes were the most common helminths, with *Syphacia minuta* having the greatest prevalence as well as abundance (Table I). The prevalence of *S. minuta* was significantly greater during the dry compared to the wet season (χ^2=4.694, df=1, p=0.030; Fig. 1). In contrast, it did not differ significantly between the sexes (females: 14.3%, CI: 7.4-25.2, males: 12.1%, CI: 5.7-22.6, χ^2=0.288, df=1, p=0.591) and the interaction between season and sex was not significant (χ^2=0.206, df=1, p=0.650). The abundance of *S. minuta* was significantly greater during the dry (1.66±4.24) compared to the wet season (0.81±4.68, χ^2=8.877, df=1, p=0.003). It was significantly greater for females (1.75±0.31) than for males (0.75±0.15, χ^2=10.188, df=1, p=0.001). Furthermore, the interaction between season and sex was significant (χ^2=4.927, df=1, p=0.026) and while *S. minuta* abundance did not vary temporally in females (LSD: p=0.587) it was significantly greater for males during the dry compared to the wet season (LSD: p=0.009; Fig. 2). As a consequence *S. minuta* abundance did differ significantly between the sexes during the wet (LSD: p<0.0001; Fig. 2) but not during the dry season (LSD: p=0.535). Ten of the mice examined were infected with *Monanema joopi* retrieved from the heart cavity at low abundances (Table I). Only 3 mice harbored hymenolepidid tapeworms. Two hosts harbored 2 and 3 specimens, respectively, of *Rodentolepis* spp., as evidenced by the number of scoleces, while from the remaining host unidentified hymenolepidid fragments were collected. In addition, 3 mice were infected with pentastomids. Two hosts harbored one unidentified porocephalid larva each (Table I), while the remaining pentastomids were retrieved from a single mouse and identified as *Armillifer grandis*.

The species richness and prevalence of endoparasites observed in the current study was extremely low compared to that reported for other rodent hosts (Behnke et al., 1999; Abu-Madi et al., 2000; Eira et al., 2006; Brouat et al.,

2007; Froeschke et al., 2010). This may be linked to the aridity of the habitat that the study species exploits (annual mean: 400 mm) as it has been suggested that survival of free-living helminth stages is greatly reduced in such habitats due to desiccation (Eira et al., 2006; Froeschke et al., 2010). However, the observed species richness and prevalence in *A. spinosissimus* was also markedly lower (6 vs. > 20) than that reported for other *Acomys* spp. that inhabit similarly arid habitats (Wertheim and Greenberg, 1970; Behnke et al., 2000, 2004). One explanation for this discrepancy may be the lack of anthropogenic influences in the study population as it is located in a Nature Reserve far from human habitation. The high availability of food resources around human habitation often results in increased population densities of rodents and may in turn increase intra- and interspecies transmission rates compared to natural habitats. This hypothesis is supported by findings of Wertheim and Greenberg (1970) who report considerably higher helminth prevalence in commensal *A. dimidiatus* populations compared to those in natural habitats. Similar effects have been suggested for other *A. dimidiatus* populations (Behnke et al., 2004). However, experimental evidence for this mechanism is currently lacking. Furthermore, helminth species richness often correlates with host body size (Poulin and Morand, 2004). Consequently, the considerably smaller body size of *A. spinosissimus* compared to other *Acomys* spp. studied may have limited the number of endoparasite species that it can support. Alternatively, the period of captivity during which animals received an artificial diet may have affected the parasite burden. However, with the exception of 3 individuals all animals were killed within days of capture and hence this effect is probably of minor importance.

The homoxenous oxyurid *S. minuta* was the most common helminth encountered in *A. spinosissimus*. This species has previously been recorded in several *Acomys* spp. (Greenberg, 1969; Wertheim and Greenberg, 1970; Behnke et al., 2000, 2004) but no other hosts,

suggesting that it might be specific for this host genus. Both the prevalence and the abundance of *S. minuta* varied temporally and were highest in the cooler dry season. Similar increases of other *Syphacia* spp. during the cooler period of the year have been observed in various rodent species and have been linked to the increased desiccation risk during hot periods (Abu-Madi et al., 2000; Eira et al., 2006; Froeschke et al., 2010). Alternatively, but not mutually exclusive, a greater proportion of juvenile individuals during the wet breeding season may explain the observed reduction of *S. minuta* burdens as a number of studies have reported an age-related accumulation of *Syphacia* sp. (Behnke et al., 1999; Eira et al., 2006; Brouat et al., 2007). Although we did not sample juveniles in our study, individuals of the youngest age class were almost exclusively observed during the wet season (Medger et al., 2010). As younger adults would not have accumulated as many parasites as older ones the temporal changes in burden could be related to temporal changes in age structure of the host population. The homoxenous life-cycle of *S. minuta* may also account for the female biased abundance observed during the wet but not dry season. Transmission of this parasite is often accomplished through eggs ingested during ano-genital grooming (Anderson, 2000). During the mating season, which coincides with the wet season in the study species, males searching for mates tend to spend less time grooming and consequently reduce transmission rates.

The second most common helminth was the filarial nematode *M. joopi*, recently described from *A. spinosissimus* (Junker et al., 2012). They occurred in low numbers and are likely transmitted by ixodid ticks of the *Rhipicephalus simus/follis* group (Junker et al., 2012) that infest *A. spinosissimus* at low abundances (Harrison et al., 2011). However, given that *Monanema* spp. adults are primarily lymphatic (Wanji et al., 1990), while the current study largely focused on the alimentary tract of the mice, the prevalence and/or abundance of this nematode may have been underestimated. In contrast, the prevalence and abundance of

Rodentolepis spp. found in the current study is comparable to the low burdens reported for *A. dimidiatus* from Egypt (Behnke et al., 2000, 2004). Furthermore, we provide the first record of a small mammal host for pentastomids from South Africa and *A. spinosissimus* constitutes a new host record for this pentastomid parasite. The final hosts of these pentastomids are snakes (Riley, 1986) that are abundant in the study area. In summary, the helminth species recorded have previously been reported for *Acomys* spp. from distant geographic locations. However, the parasite species richness and abundance observed for *A. spinosissimus* was comparatively low, possibly due to their smaller body size.

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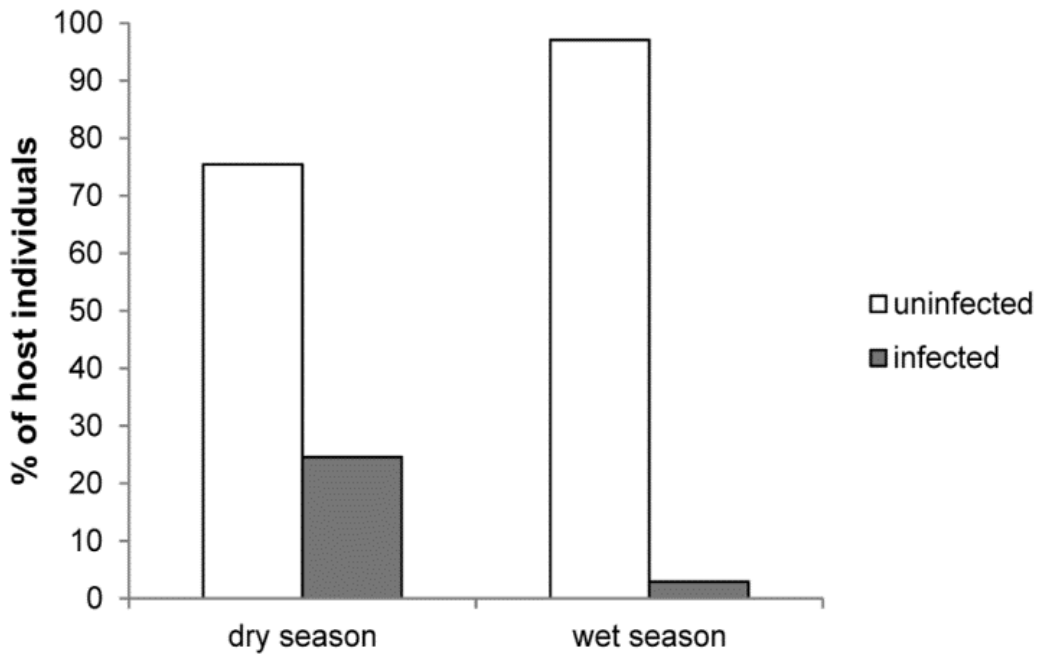
Fig. 1. Temporal variation in the prevalence of *Syphacia minuta* in *Acomys spinosissimus* from the Limpopo Province, South Africa.
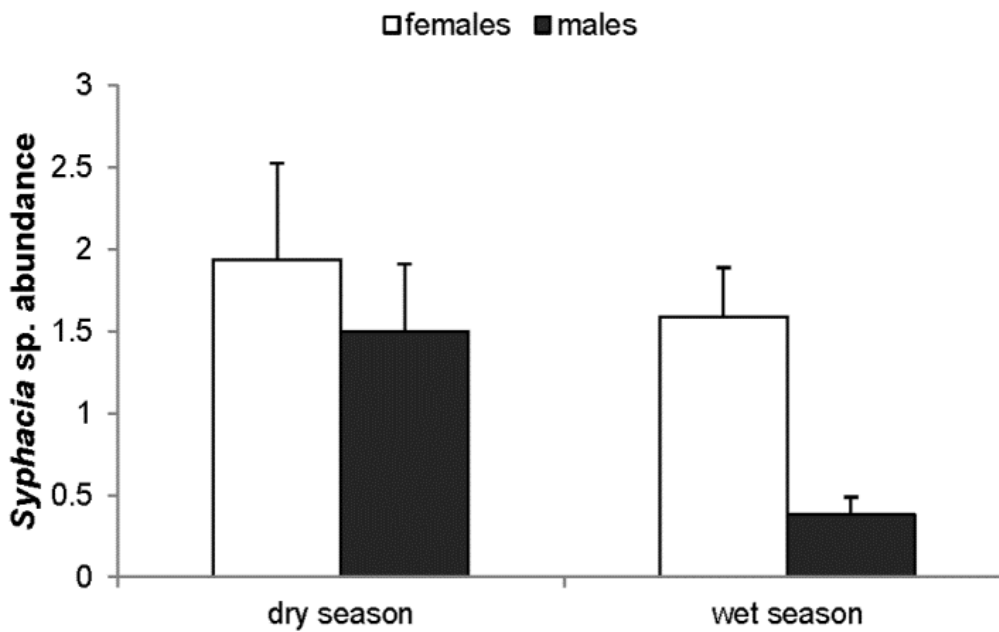

Fig. 2. Effect of host sex and rainfall on *Syphacia minuta* abundance in *Acomys spinosissimus* from the Limpopo Province, South Africa. Displayed are the means ± SE.

Table I Endoparasites recovered from *Acomys spinosissimus* in the Soutpansberg Mountains of the Limpopo Province, South Africa. The 95% confidence intervals are reported in parentheses. Range indicates the minimum and maximum numbers of parasites encountered.

Taxon	Site in host	No. of worms	No. of infected hosts	Prevalence (%)	Abundance (mean±SE)	Range
Nematoda						
Syphacia minuta	Caecum, colon	161	15	12.4	1.22±2.12	0-28
Monanema joopi[*]	Blood from heart	15	10	7.4	0.11±0.42	0-2
Cestoda						
Hymenolepididae gen. sp.	Small intestine	-	1	0.8		-
Rodentolepis sp.	Small intestine	5	2	1.6	0.04±0.0.08	0-3
Pentastomida						
Porocephalidae gen. sp[b]	Various tissues	2	2	1.6	0.01±0.03	0-1
Armillifer grandis[b]	Various tissues	7	1	0.8	0.05±0.10	0-7

*blood drawn from 136 hosts
†these parasites were incidental findings