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Ectoparasites (sucking lice, fleas and ticks) of small mammals in southeastern Kenya

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Abstract

During 1998–2000, at least 14 species (*n* = 309) of small mammals were live-trapped and examined for ectoparasites in moist forests of the Taita and Shimba Hills and drier savannah habitats of Nguruman, southeastern Kenya. Ectoparasites were recorded from 11 species of mammals. Five species of sucking lice [*Hoplopleura inexpectans* Johnson, *H. intermedia* Kellogg & Ferris, *Polyplax reclinata* (Nitzsch), *P. waterstoni* Bedford and *Schizophthirus graphiuri* Ferris], six species of fleas (*Ctenophthalmus leptodactylous* Hubbard*, Dinopsyllus grypurus* Jordan & Rothschild, *D. lypusus* Jordan & Rothschild, *Hypsophthalmus campestris* Jordan & Rothschild, *Listropsylla basilewskyi* Smit and *Xiphiopsylla lippa* Jordan) and at least six species of ticks (*Amblyomma* sp., *Haemaphysalis* sp., *Ixodes* sp., *I. alluaudi* Neumann, *I. cumulatimpunctatus* Schulze, *I. muniensis* Arthur & Burrow and *Rhipicephalus* sp.) were recorded from these hosts. Four of the five species of sucking lice were host specific whereas *P. reclinata* was recorded from two different species of white-toothed shrews, *Crocidura* spp. Although fleas and ticks were less host specific, *C. leptodactylous, D. grypurus* and *I. cumulatimpunctatus* were only recorded from the murid rodent *Praomys delectorum* (Thomas), *Amblyomma* sp. was only recorded from the nesomyid rodent *Beamys hindei* Thomas, *Rhipicephalus* sp. was only recorded from the murid *Lemniscomys striatus* (L.) and *I. muniensis* was only recorded from the dormouse *Graphiurus microtis* (Noack). More species of ectoparasites and significantly greater infestation prevalences were recorded from small mammals in moist habitats compared with those from the savannah habitat. At least one of the fleas recorded, *D. lypusus*, is a known vector of *Yersinia pestis* Lehmann & Neumann, the causative agent of plague, which is present in the region.

Keywords

Ectoparasites; fleas; small mammals; sucking lice; ticks; Kenya

Introduction

Few studies have addressed the associations between small mammals and their ectoparasites in Kenya (Oguge *et al.*, 1987), a country where some ectoparasites have medical

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significance as vectors of zoonotic pathogens such as *Yersinia pestis* Lehmann & Neumann, the causative agent of plague (Schwan, 1986, 1993). As part of an ecological study of moist forests and savannahs of southeastern Kenya, ectoparasites were collected, identified and analysed from live-trapped small mammals (shrews and rodents) between 1998 and 2000.

Materials and methods

The study area was the Taita Hills forest complex (03°20′S, 38°15′E) in southeastern Kenya, specifically moist forests of the Taita (seven sites) and Shimba Hills (one site) and savannah habitats of Nguruman (one site) within an elevational range of 1200–2200 m.

This forest complex forms the northernmost part of the Eastern Arc Mountains which were formed from 290 to 180 million years ago (Rogo & Oguge, 2000). Mammals were captured using 7.5 × 9 × 23 cm Sherman live-traps (H. B. Sherman Traps, Inc., Tallahassee, FL) baited with fried coconut cubes mixed with peanut butter and corn oil. Two hundred traps were set for 10 consecutive nights at each site for 2000 trap nights per site and a total of 18 000 trap nights for the entire study. Captured animals were treated ethically under an approved animal use protocol.

Ectoparasites were collected by gently brushing the fur of each captured mammal into individual 9 × 12 cm plastic bags. The ear pinnae and other hidden areas, such as under the tail, were also carefully examined. All ectoparasites from each animal were then stored in individually labelled vials containing 70% ethanol. Sucking lice and fleas were later cleared in potassium hydroxide, dehydrated in an ethanol series, further cleared in xylene and then slide-mounted in Canada balsam to aid in identification at high magnification (100–400×). Ticks were stored in ethanol and briefly allowed to surface-dry during identification usually at low magnification (10–40×). Voucher ectoparasites are deposited in the U.S. National Tick Collection (ticks), the General Ectoparasite Collections in the Department of Biology (sucking lice), both at Georgia Southern University, or at the Rocky Mountain Laboratories (fleas).

Results

A total of 309 mammals belonging to at least 14 species were live-trapped (Table 1) for a trapping success rate of 1.72%; two individual mammals could only be identified to genus (Table 1). The moist forests of Taita and Shimba Hills yielded 257 small mammals belonging to at least 11 species whereas the drier savannah habitat of Nguruman yielded 52 mammals belonging to 5 species (Table 1). Ectoparasites were recorded from 11 species of mammals (Tables 2–4). Sucking lice (five species) were collected from five species of mammals (Table 2). *Polyplax reclinata* (Nitzsch) was collected from two congeneric hosts but the other four species of sucking lice were each collected from just one host species. *Praomys delectorum* (Thomas) was parasitized by two species of sucking lice whereas the remaining four host species were each infested by one species of louse (Table 2). Fleas (six species) were collected from at least four species of mammals (Table 3). One host species, *P. delectorum*, was parasitized by five species of fleas, another host species, *Graphiurus microtis* (Noack), was parasitized by three species of fleas, and the remaining hosts identified to species were each parasitized by one species of flea (Table 3). At least six species of ticks were collected; immature stages of *Amblyomma, Haemaphysalis, Rhipicephalus* and some *Ixodes* spp. could not be identified to species. Ten species of mammals (four species of shrews, six species of rodents) were each parasitized by one to three species of ticks (Table 4).

Only two species of ectoparasites (*H. intermedia* Kellogg & Ferris and *Rhipicephalus* sp.) were recorded from the 52 small mammals examined for ectoparasites from savannah habitat (Nguruman), in contrast to 15 species of ectoparasites from the 257 mammals examined in moist habitats (Taiti and Shimba Hills). The two ectoparasite species and four of the six small mammal species recorded from savannah were unique to that habitat (Table 1). *Gerbillurus nigricaudus* and *Mus minutoides* were the only small mammal species shared by both habitats. Ectoparasite infestation prevalences (per cent of hosts infested; all ectoparasite species combined) were significantly higher ($\chi^2 = 42.69$, $p < 0.001$) for hosts in moist habitats (61.1%) compared with hosts in the savannah habitat (11.5%). If flea records are excluded (flea collections were not available from dry habitat hosts or from 41 of the moist habitat hosts), ectoparasite infestation prevalences remained significantly higher ($\chi^2 = 23.98$, $p < 0.001$) on moist habitat (48.2%) versus dry (savannah) habitat (11.5%) hosts.

Table 5 shows that co-infestations of the five most common ectoparasites on individuals of the most common host, *P. delectorum* ($n = 199$), were frequent. Sample sizes for other hosts were too small to reliably demonstrate coinfestation data.

Discussion

All five species of sucking lice recorded in this study have previously been documented from Kenya with the type locality for two of these species (*Hoplopleura inexpectans* Johnson and *Schizophthirus graphiuri* Ferris) being in this country (Kim & Emerson, 1968; Durden & Musser, 1994). All five of these species appear to be widely distributed in sub-Saharan Africa and *P. reclinata* is also widely distributed in much of the Old World as an ectoparasite of many species of shrews (Kim & Emerson, 1968; Durden & Musser, 1994). Nevertheless, both host species recorded here for *P. reclinata* [*Crocidura jacksoni* Thomas and *C. viaria* (Geoffroy)] are new host associations for this louse (Durden & Musser, 1994). With the exception of *P. reclinata*, the data show strict host specificity for sucking lice in the study area. However, in other parts of Africa, *H. inexpectans* has been recorded from three species of *Praomys* (including *P. delectorum*, its host in this study) as well as from *Myomys albipes* (Ruppell) (Durden, 1991; Durden & Musser, 1994). Similarly, *Hoplopleura intermedia* Kellogg & Ferris has previously been recorded from three species of *Mastomys* [including *M. natalensis* (Smith), its host in this study] and three species of *Praomys* (Durden, 1991; Durden & Musser, 1994). However, our records of *S. graphiuri* and *Polyplax waterstoni* Bedford from *G. microtis* and *P. delectorum*, respectively, are newly recorded host associations. Previously recorded hosts for *S. graphiuri* are *Graphiurus kelleni* (Reuvens) and *G. murinus* (Desmarest) whereas previously recorded hosts for *P. waterstoni* are *Mastomys coucha* (Smith), *M. natalensis, Myomys albipes, Praomys jacksoni* (de Winton) and *P. tullbergi* (Thomas) (Durden & Musser, 1994).

Five of the six species of fleas recorded in this study have previously been reported from Kenya and are, in general, widely distributed in the Afrotropical region (Hopkins & Rothschild, 1956, 1966; Schwan, 1986, 1993; Segerman, 1995; Beaucournu, 2004). However, *Ctenophthalmus leptodactylus* Hubbard was not reported from Kenya by Beaucournu (2004) who nevertheless recorded this flea from adjoining Tanzania. Additionally, Beaucournu (2004) treated *Listropsylla basilewskyi* Smit as *Listropsylla dolosa basilewskyi* Smit which he documented from the Democratic Republic of Congo, Malawi, Tanzania and Zambia but not Kenya; however, the author did record the nominate subspecies, *L. dolosa dolosa* Rothschild, from Kenya (and from Democratic Republic of Congo, Uganda and Tanzania). All six flea species recorded during this study are parasites of various Afrotropical rodents, especially murids (Beaucournu, 2004). Our flea records from Kenya generally conform to previously reported host associations although three species of fleas (*Dinopsyllus grypurus* Jordan & Rothschild, *Hypsophthalmus campestris*

Jordan & Rothschild and *L. basilewskyi*) were also recorded from shrews (Table 3). Therefore, little host specificity was evident in the host associations recorded for fleas in this study (Table 3).

Ixodes alluaudi Neumann and *I. cumulatimpunctatus* Schulze have previously been recorded from Kenya (Walker, 1974; Matthysse & Colbo, 1987). *Ixodes alluaudi* appears to preferentially parasitize shrews but it also infests rodents, lagomorphs and elephant shrews (Arthur, 1965; Walker, 1974). A similar situation was recorded during the current survey with this tick parasitizing two species of shrews and one species of rodent (Table 4). Extralimitally, *I. alluaudi* has been documented from several sub-Saharan African countries including Burundi, the Democratic Republic of the Congo, Rwanda, South Africa, Sudan and Tanzania (Arthur, 1965; Elbl & Anastos, 1966; Matthysse & Colbo, 1987). *Ixodes cumulatimpunctatus* Schulze parasitizes many mammalian hosts including humans, carnivores, ungulates, hyraxes, rodents and insectivores (Arthur, 1965; Matthysse & Colbo, 1987; Ntiamoa-Baidu *et al.*, 2005). *Ixodes cumulatimpunctatus* was rare in this study with just one female being recorded from one rodent host, *P. delectorum* (Table 4). Like *I. alluaudi*, this tick has previously been recorded from several sub-Saharan African nations including the Democratic Republic of the Congo (as Belgian Congo), Ghana, Kenya (as *I. pseudorasus*), Malawi (as *I. pseudorasus* from Nyasaland), Rwanda (as *I. pseudorasus*), Senegal, Tanzania, Uganda and Zimbabwe (as southern Rhodesia) (Arthur & Burrow, 1957; Walker, 1974; Matthysse & Colbo, 1987; Ntiamoa-Baidu *et al.*, 2005).

Three nymphs of *Ixodes muniensis* Arthur & Burrow collected from the dormouse, *G. microtis* in this study (Table 4), appear to be the first documentation of this tick from Kenya although it is widely distributed in Africa with previous records from Burundi, Cameroon, Côte d'Ivoire (Ivory Coast), the Democratic Republic of the Congo (as Belgian Congo), Equatorial Guinea (as Rio Muni), Ghana, Nigeria, Rwanda, Tanzania, Uganda and Zimbabwe (as Rhodesia) (Arthur, 1965; Elbl & Anastos, 1966; Matthysse & Colbo, 1987; Ntiamoa-Baidu *et al.*, 2005). In her monograph on the ixodid ticks of Kenya, Walker (1974) recorded *I. cumulatimpunctatus* (as *I. pseudorasus*) and *I. alluaudi*, but not *I. muniensis*, from that country. Ticks exhibited little host specificity in this study (Table 4). However, *I. cumulatimpunctatus* was only recorded from *P. delectorum*, *Amblyomma* sp. was only recorded from the nesomyid rodent *Beamys hindei* Thomas, *Rhipicephalus* sp. was only recorded from the murid *Lemniscomys striatus* (L.) and *I. muniensis* was only recorded from the dormouse *G. microtis*.

It is only possible to speculate as to the cause of the significantly lower infestation prevalence of ectoparasites infesting small mammals in the savannah habitat compared with the moist habitats. Perhaps off-host life-cycle stages for ticks and fleas are more susceptible to desiccation or these ectoparasites are less efficient at locating hosts in the drier habitat. However, this argument would not hold for sucking lice because their entire life-cycle is completed on the host. Nevertheless, some bird lice attached to their hosts are more prone to desiccation and reduced survival rates in dry habitats (Moyer *et al.*, 2003) so a similar situation may hold true for some sucking lice on their mammalian hosts. Other potential reasons for these differences in prevalences include the possibility that host population densities may be lower in the dry habitat which could reduce the likelihood of ectoparasite transfer between host individuals, that reproductive potentials of ectoparasites on dry habitat hosts could be lower, or that dry habitat hosts are more social and allogrooming is more frequent between them than for moist habitat hosts.

Coinfestations by different ectoparasite species were common on *P. delectorum* (Table 5). The occurrence of two species of sucking lice (*H. inexpectans* and *P. waterstoni*) on the same host at the same time (18 records) compared with *H. inexpectans* alone (16 records) and *P. waterstoni* alone (14 records) show that competition between these two species belonging to the same sub-order (Anoplura) is not a limiting factor for either of them. Similarly, the two common flea species on this host belong to the same family (Hystrichopsyllidae) but occurred on this host species at the same time (13 records) or without the other species (10 records for *D. grypurus*; 6 records for *L. basilewskyi*). All other coinfestation combinations between the five species of common ectoparasites on *P. delectorum* were also recorded, suggesting there is little or no significant inter-specific competition between these species on this host.

At least one of the ectoparasite species recorded in this survey has relevance with respect to vector-borne zoonotic disease in Kenya and adjacent countries. *Dinopsyllus lypusus* Jordan & Rothschild is an important enzootic vector of *Y. pestis*, the aetiologic agent of plague, in discrete foci in Kenya and adjoining countries (Schwan, 1986; Senzota, 1992; Laudisoit *et al.*, 2007). None of the sucking lice or ticks identified to species in this study are known vectors of zoonotic pathogens but they could be involved in the enzootic transmission of certain agents such as viruses or rickettsiae; further research is needed to investigate this possibility. However, Oguge *et al*. (1987) reported immature stages of the tropical bont tick, *Amblyomma variegatum* (Fabricius), and brown ear tick, *Rhipicephalus appendiculatus* Neumann, from Kenyan rodents; these ticks are vectors of the agents of heartwater fever and East Coast fever, respectively, to ungulates (Walker, 1974). Additional research should therefore be directed towards recording the ectoparasites of Kenyan mammals and their host associations.

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Table 1

Mammals examined for ectoparasites in southeastern Kenya (Taita Hills, Shimba Hills and Nguruman), 1998–2000[*].

Crocidura fuscomurina (Heuglin)–Bicoloured musk shrew–1 (0) M[†]
Crocidura hildegardiae Thomas–Hildegarde's shrew–6 (6) M
Crocidura jacksoni Thomas–Jackson's Shrew–9 (9) M
Crocidura viaria (Geoffroy)–Savanna Path Shrew–7 (0) M
Crocidura sp.–Unidentified shrew–1 (1) M
Arvicanthis nairobae Allen–East African Arvicanthis–14 (0) D
Beamys hindei Thomas–Hinde's Pouched Rat–3 (0) M
Gerbilliscus nigricaudus –Black-tailed gerbil–2 (1) D,M
Grammomys dolichurus (Smuts)–Common Grammomys–1 (0) M
Grammomys sp.–Unidentified Grammomys–1 (0) M
Graphiurus microtis (Noack)–Large Savanna African Dormouse–22 (21) M
Lemniscomys striatus (L.) –Typical Lemniscomys–1 (0) D
Mastomys natalensis (Smith)–Natal Mastomys–34 (0) D
Mus minutoides Smith–Southern African Pygmy Mouse–7 (3) D,M
Mus triton (Thomas)–Gray-bellied Mouse–1 (1) M
Praomys delectorum (Thomas)–East African Praomys–199 (175) M

[*] Mammal taxonomy and vernacular names follow Wilson & Reeder (2005).

[†] For each mammal species listed, the first number refers to the number of individuals examined for sucking lice and ticks whereas the second number (in parentheses) refers to the number of individuals examined for fleas. D designates mammal species trapped in the dry forest of Nguruman; M designates mammal species trapped in the moist forests of Taita and Shimba Hills.

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Table 2

Sucking louse (Phthiraptera: Anoplura) infestations of small mammals in southeastern Kenya (Taita Hills, Shimba Hills and Nguruman), 1998–2000.

	Hoplopleura inexpectans	**Hoplopleura intermedia**	**Polyplax reclinata**	**Polyplax waterstoni**	**Schizophthirus graphiuri**
Host species:					
Crocidura jacksoni	—	—	11%, 1.0, 1, 1N*	—	—
Crocidura viaria	—	—	29%, 3.0, 3, 2M, 4F*	—	—
Graphiurus microtis	—	—	—	—	14%, 1.7, 1–2, 1M, 3F, 1N
Mastomys natalensis	—	15%, 1.8, 1–3, 2M, 7F	—	—	—
Praomys delectorum	26%, 3.8, 1–15, 59M, 134F, 5N	—	—	20%, 3.0, 1–11, 28M, 68F, 22N	—

* Infestation data listed are prevalence (% of hosts infested), mean intensity (mean per infested host), infestation range (or a single number if there was no range) and numbers of each stage collected, respectively; M = Male(s), F = Female(s), N = Nymph(s).

Table 3

Flea (Siphonaptera) infestations of small mammals in southeastern Kenya (Taita Hills, Shimba Hills and Nguruman), 1998–2000.

	Ctenophthalmus leptodactylus	**Dinopsyllus grypurus**	**Dinopsyllus lypusus**	**Hypsophthalmus campestris**	**Listropsylla basilewskyi**	**Xiphiopsylla lippa**
Host species:						
Crocidura hildegardiae	—	—	—	—	17%, 1.0, 1, 1F*	—
Crocidura jacksoni	—	—	—	22%, 1.5, 1–2, 1M, 2F*	—	—
Crocidura sp.	—	100%, 5.0, 5, 1M, 4F	—	—	100%, 1.0, 1, 1M	—
Graphiurus microtis	—	—	5%, 1.0, 1, 1F	—	10%, 1.0, 1, 1M, 1F	10%, 1.0, 1, 1M, 1F
Praomys delectroum	2%, 1.7, 1–3, 2M, 3F	19%, 2.4, 1–8, 32M, 46F	1%, 2.0, 1–3, 2M, 2F	3%, 1.0, 1, 3M, 2F	17%, 1.2, 1–2, 21M, 14F	—

*Infestation data listed are prevalence (% of hosts infested), mean intensity (mean per infested host), infestation range (or a single number if there was no range) and numbers of each sex collected, respectively; M = Male(s), F = Female(s).

Table 4

Tick (Acari: Ixodoidea) infestations of small mammals in southeastern Kenya (Taita Hills, Shimba Hills and Nguruman), 1998–2000.

	Amblyomma sp.	Haemaphysalis sp.	Ixodes sp.	Ixodes alluaudi	Ixodes cumulatimpunctatus	Ixodes muniensis	Rhipicephalus sp.
Host species:							
Crocidura fuscomurina	—	—	100%, 1.0, 1, 1L	—	—	—	—
Crocidura hildegardiae	—	—	33%, 2.0, 1–3, 3N, 1L	33%, 1.0, 1, 2N	—	—	—
Crocidura jacksoni	—	—	11%, 1.0, 1, 1L	22%, 2.0, 1–3, 4L	—	—	—
Crocidura viaria	—	43%, 5.3, 1–14, 16L	14%, 1.0, 1, 1N	—	—	—	—
Graphiurus microtis	—	—	14%, 1.7, 1–2, 2N, 3L	—	—	9%, 1.5, 1–2, 3N	—
Beamys hindei	33%, 1.0, 1, 1N*	—	33%, 1.0, 1, 1N	—	—	—	—
Lemniscomys striatus	—	—	—	—	—	—	100%, 3.0, 3, 3L
Mus minutoides	—	14%, 3.0, 3, 3N	—	—	—	—	—
Mus triton	—	100%, 4.0, 4, 4L	—	—	—	—	—
Praomys delectorum	—	—	0.5%, 1.0, 1, 1N	19%, 1.5, 1–4, 9F, 28N, 18L	0.5%, 1.0, 1, 1F	—	—

*Infestation data listed are prevalence (% of hosts infested), mean intensity (mean per infested host), infestation range (or a single number if there was no range) and numbers of each stage collected, respectively; M = Male(s), F = Female(s), N = Nymph(s), L = Larva(e).

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Table 5

Coinfestations of the five most common ectoparasite species on *Praomys delectorum* ($n = 199$), southeastern Kenya, 1998–2000*.

	No other Species	With *H inexpectans.*	With *P. waterstoni*	With *D. grypurus*	With *L. basilewskyi*	With *I. alluaudi*
Hoplopleura inexpectans	16	X	17	4	11	15
Polyplax waterstoni	14	18	X	8	8	4
Dinopsyllus grypurus	10	4	8	X	13	8
Listropsylla basilewskyi	6	11	8	13	X	10
Ixodes alluaudi	13	15	4	9	10	X

*Totals of rows and columns are not equal because some individual hosts were parasitized by more than two ectoparasite species (up to four) at the same time.