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Original Article

Ectoparasites on Meso-carnivores in the Desert-steppe of Mongolia

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Abstract

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Studying flea community structure on wild carnivores is important for identifying flea vectors for potential infectious diseases and providing information needed to design programs for human and wildlife health. We collected ectoparasites from 4 species of meso-carnivores in an arid Desert-steppe ecosystem of Mongolia. We captured four meso-carnivore species, including corsac fox (*V. corsac*, n = 7), red fox (*Vulpes vulpes*, n = 4), Asian badger (*Meles leucurus*, n = 4), and Pallas's cat (*Otocolobus manul*, n = 4), and recorded 207 fleas representing 14 species from 7 genera of 4 families, and 2 ticks from 1 species. We collected 86 fleas (6 species) from corsac foxes, 89 fleas (6 species) from red foxes, 14 fleas (5 species) from badgers, and 18 fleas (8 species) from Pallas's cats. The flea community was dominated by two species (*Pulex irritans, Chaetopsylla homoeus*), which accounted for 72% of all ectoparasites collected. *Pulex irritans* was the most common species on corsac and red foxes, and *Paraceras melis* was the most common species on badgers. Three species were most commonly collected on Pallas's cats, including *Pulex irritans*, *Paraceras melis*, and *Chaetopsylla appropihquans*. Among fleas, 8 species occurred only on a single meso-carnivore species, 1 species occurred on two meso-carnivore species, and 5 species occurred on 3 meso-carnivore species. The tick, *Dermacentor nuttalli* only occurred on corsac fox and badger. Our results provide baseline information on the associations of fleas and ticks with wild carnivores that represent potential vectors of disease, which can inform disease management strategies in Mongolia.

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Introduction

In Mongolia, after more than a century of flea research, scientists have recorded 6 families, 37 genera, 101 species and 12 subspecies obtained from 53 species of host-mammals (Puntsagdulam & Altanchimeg, 2005). Bavaasan (1974) catalogued 130 flea species, and just 7 years later Kieffer *et al.* (1984) expanded the number of flea species and subspecies known from Mongolia to 159, based on their own collections. More recently, Kiefer *et al.* (2012) reported 162 species of fleas known to exist in Mongolia and the adjacent Tuva Republic of Russia.

Fleas are highly specialized ectoparasites with a wide range of hosts, including birds and mammals. Fleas alternate between periods of direct occurrence upon the host's body and in the substrate of their host's nest or den. The degree of host specificity of fleas varies greatly among species, ranging from highly host-specific to opportunistic (Marshal, 1981). In addition to their role as ectoparasites, fleas have relevance as vectors of pathogens that infect humans and animals (Dobler & Pfeffer, 2011).

Carnivores represent important mammalian hosts of fleas (Krasnov, 2008), and several studies have suggested that wild carnivores represent disease reservoirs or play a role in the transmission cycles of flea-borne infections, such as plague, bartonelloses, and rickettsioses. For instance, skunks (*Mephitis* spp.) and foxes (*Vulpes macrotis* and *Urocyon cinereoargenteus*) are suspected to be reservoirs of *Bartonella rochalimae* (Lopez-Perez *et al.,* 2017), which has been associated with bacteremia in humans (Eremeeva *et al.,* 2007). Also, researchers have identified wild canids as carriers of *Yersinia pestis* (the causal agent of plague) among prairie dog (*Cynomys* spp.) colonies (McGee *et al*., 2006). Many flea species that function as important vectors of flea-borne diseases (e.g., *Pulex* spp., *Oropsylla* spp., *and Ctenocephalides* spp.) have been recorded from mammalian carnivores, such as wild felids, canids, and mustelids (McGee *et al.,* 2006; Marquez *et al.,* 2009; Lopez-Perez *et al.,* 2017)

Knowledge on the spectrum of parasites carried by host species and determination of their ectoparasite infestation levels is essential for understanding the dynamics of relevant diseases and establishing control policies. Nevertheless, in the case of meso-carnivores, very few studies provide quantitative data on the level of infestation of external parasites, both in terms of prevalence and abundance. In this study, conducted as part of a research project on the ecology of meso-carnivore in Mongolia, we sampled a relatively large number of animals that we captured as part of a radio-collaring study. Our results contribute to filling our gap in knowledge of ectoparasites in meso-carnivores in this region.

Material and Methods

Study area. We captured and surveyed parasites from meso-carnivores in Ikh Nart Nature Reserve, which was established in 1996 to protect 66,592 km^2 (Maygmarsuren & Namkhai, 2012). Ikh Nart is located in north-western Dornogobi Aimag (45°43' N, 108°39' E) and lies on the northern edge of the Gobi Desert Ecosystem at the transition between steppe and desert habitats (referred to as desert-steppe; Reading *et al.,* 2011). More specifically, Ikh Nart contains sparse vegetation at the interface of dry steppe and semi-desert steppe ecotypes. Vegetation types include shrublands, tall grasslands, and open plains of short grasses, forbs, and semi-shrubs (Jackson *et al.,* 2006). Ikh Nart has an arid, continental climate characterized by relatively dry, hot summers (to 43°C), cold winters (to -40°C), and dry and windy springs with extremely low humidity. Most of the limited precipitation (~ 60 cm/yr) falls in summer as rain (Reading *et al.,* 2011).

In the mid-2000s, a research project began that focused on the ecology of meso-carnivores and their prey. The project focused primarily on the ecology of red foxes (*Vulpes vulpes*) and corsac foxes (*Vulpes corsac*), but that also included Pallas's cats (*Otocolobus manul*), Asian badgers (*Meles leucurus*), and wolves (*Canis lupus*) (Murdoch *et al.,* 2006, 2010, 2016; Munkhzul *et al.,* 2012, Davie *et al.,* 2014, Lkhagvasuren *et al.,* 2016). This study involved capturing and radio-collaring animals as part of a broader project on protected area management in the reserve (Reading *et al.,* 2016).

Methods. We live trapped four meso-carnivore species (red fox, corsac fox, Asian badger, and Pallas's cat) from 2004 to 2007, and collected fleas from captured animals. We trapped meso-carnivores using box traps (Tomahawk Live Trap Company, Tomahawk, Wisconsin, USA) and padded soft-catch leg-hold traps (Woodstream Corporation, Lititz, Pennsylvania, USA). We placed each captured corsac fox, red fox and Pallas's cat in a large cloth bag for handling without chemical restraint. We chemically immobilized badgers using an anaesthetic (Ketamine HCL). Handling followed protocols established for kit foxes (O'Farrell, 1987) and followed guidelines of the American Society of Mammalogists (Sikes, 2016).

For each animal, we recorded age, sex, health, and morphological measurements, collected hair and tissue samples, and inspected them for ectoparasites. Each animal was inspected systematically for fleas by combing for 5 min. We particularly focused areas around the ears and necks, body parts that proved to host higher numbers of ectoparasites. We placed fleas in a cryovial containing 70% ethanol and stored them in liquid nitrogen. To observe the structures required for identification, we placed the fleas in 2% saline with Tween 80 detergent (2 drops/liter). We placed fleas individually in single petri dishes for examination using a stereo microscope and identified morphologically using a taxonomic key (Loff *et al*., 1965; Smith, 1967, 1973; Bavaasan *et al.,* 1977).

Results

We captured and collected fleas and other ectoparsites from 7 corsac foxes, 4 red foxes, 4 badgers, and 4 Pallas's cats (Table 1). Among captured animals, we collected 207 fleas (Aphaniptera) representing 14 species belonging to 7 genera of 4 families, and 2 ticks from 1 species (*Dermacentor nuttalli*) (Table 1, Fig. 1). We collected 86 fleas (6 species) from corsac foxes, 89 fleas (6 species) from red foxes, 14 fleas (5 species) from badgers, and 18 fleas (8 species) from Pallas's cats (Table 1). Two species dominated the flea community: *Pulex irritans* and *Chaetopsylla homoeus* (Table 1). These species accounted for 72.2% of all ectoparasites collected. *Pulex irritans* was the most common species on corsac foxes (42.5%) and red foxes (79.8%), and *Paraceras melis* was the most common species on badgers (26.7%). Three species were most commonly collected on Pallas's cats, including *Pulex irritans*, *Paraceras melis*, and *Chaetopsylla appropihquans*. Among fleas, 8 species (57.1% of total) occurred only on a single meso-carnivore species, 1 species (7.1% of total) occurred on two meso-carnivore species, and 5 species (35.7% of total) occurred on three meso-carnivore species (Table 1). We collected 1 tick from a corsac fox and another from a badger.

Discussion

Our results revealed patterns of flea assemblages of wild meso-carnivores in Mongolia. Regarding

Table 1. Number of ectoparasites by species collected on corsac foxes (*Vulpes corsac*; n = 7), red foxes (*V. vulpes*; n = 4), Asian badgers (*Meles leucurus*; n = 4), and Pallas's cats (*Otocolobus manul*; n = 4) captured in Ikh Nart Nature Reserve, Dornogobi Aimag, Mongolia from 2004 to 2007.

Species	Corsac fox	Red fox	Badger	Pallas's cat
Aphaniptera				
Ceratophyllidae				
Ceratophyllus lunatus				2
Ceratophyllus paradoxus		2		
Ceratophyllus scaloni	3			
Ceratophyllus tesquorum				1
Paraceras melis			4	4
Leptopsyllidae				
Frontopsylla luculenta		6		
Mesopsylla hebes				1
Pulicidae				
Ctenocephalides canis	5	1	2	
Ctenocephalides felis				1
Pulex irritans	37	71		4
Vermipsyllidae				
Chaetopsylla appropihquans	1		2	4
Chaetopsylla globiceps	6	7		1
Chaetopsylla homoeus	34	2	3	
Chaetopsylla trichosa			3	
Parasitiformes				
Ixodidae				
Dermacentor nuttalli	1		1	

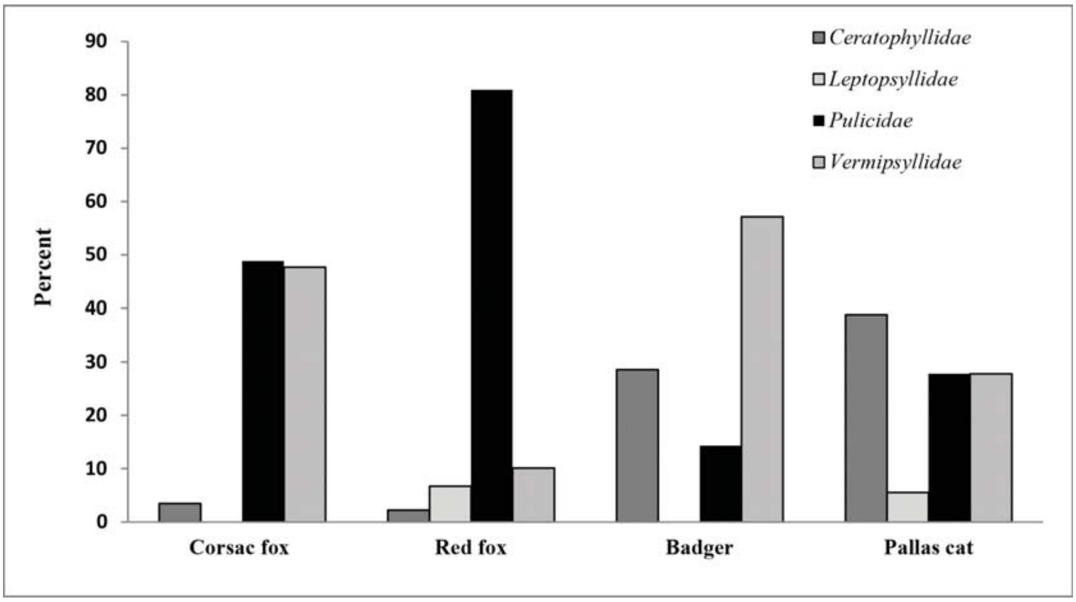

Figure 1. Percent of fleas by taxonomic family collected from four meso-carnivore species (corsac fox *Vulpes corsac*, red fox *V. vulpes*, Asian badger *Meles leucurus*, and Pallas's cat *Otocolobus manul*) in Ikh Nart Nature Reserve, Dornogobi Aimag, Mongolia from 2004 to 2007.

host identity, we can distinguish some trends of the flea assemblages. Of the 14 flea species collected from 4 meso-carnivore hosts, *Pulex irritans* and *Chaetopsylla homoeus* dominated. Several studies agree with our findings that fleas belonging to the genus *Pulex* are the most abundant and prevalent on wild canids (Harrison *et al.,* 2003). The *Pulex* genus comprises six species (Whithing *et al.,* 2008), but only two of them, *P. simulans* and *P. irritans*, are reported to infest wild carnivore hosts (Harrison *et al.,* 2003; McGee *et al.,* 2006; Salkeld *et al.,* 2007; Gabrel *et al.,* 2009; Dobler & Pfeffer, 2011). In concordance with our findings, *P. irritans* usually predominates and is often the most common flea on the genus *Vulpes*, while *P. simulans* is typically the most common flea on gray foxes (*Urocyon cinereoargenteus*) and coyotes (*Canis latrans*) (Harrison *et al.,* 2003; McGee *et al.,* 2006; Salkeld *et al.,* 2007; Gabrel *et al*., 2009; Dobler & Pfeffer, 2011). As might be expected, we found that *P. irritans* had a broader host distribution than other species.

We found fleas *Paraceras melis* and *Chaetopsylla trichosa* and a tick belonging to the family Ixodae (*Dermacentor nuttalli*), from badgers in Ikh Nart. In contrast, for European badgers (*Meles meles*) from western Europe, the main ectoparasites were the biting louse *Trichodectes melis*, *Paraceras melis*, a host-specific flea (*Siphonaptera*), and ticks belonging to the genus *Ixodes* (Butler & Roper, 1996; Neal & Cheeseman, 1996). *Paraceras melis* is an important vector in the transmission of trypanosomes (Pierce & Neal, 1974). In the case of the Asian badger and Pallas's cat, very few studies provide quantitative data relative to the level of infestation of the main external parasites. Knowledge of flea faunal composition and flea infestation rates of wild meso-carnivores not only identifies potential flea vectors, but also provides information needed to design and implement programs to manage flea-borne diseases for purposes of human and wildlife health.

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