Research Article

First Report on Ticks, Mites, and Other Ectoparasites Infesting Carnivorous Mammals in Uzbekistan

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Abstract | **Background:** Ectoparasites are known to transmit various pathogens that can cause numerous diseases in livestock, leading to detrimental effects such as skin damage, weight loss, anemia, reduced meat and milk production, and even mortality. **Aim:** This study aimed to investigate the species composition and prevalence of ectoparasites in domestic (dogs and cats) and wild predatory mammals (jackals, wolves, foxes, and reed cats) in Uzbekistan through regular parasite collections. **Materials and Methods:** A comprehensive surveillance was conducted to calculate the prevalence of ectoparasites in carnivorous mammals. Data on ectoparasite prevalence, including area, host, breed, species diversity, age, and seasonal infestation rate, were recorded and analyzed. This research represents the first investigation of ectoparasites in carnivorous mammals in Uzbekistan and encompassed 12 regions (Andijan, Namangan, Fergana, Samarkand, Jizzakh, Syrdarya, Bukhara, Kashkadarya, Surkhandarya, Navoi, Khorezm, and Tashkent regions). **Results:** The study identified a total of 23 ectoparasite species belonging to the classes Arachnida and Insecta, encompassing 758 carnivorous mammals. Among Arachnida, three families were represented: Ixodidae (12 species), Sarcoptidae (1 species), and Demodecidae (1 species), with the genera *Haemaphysalis* (3 species) and *Rhipicephalus* (4 species) being the most dominant among the ixodid ticks. Insects comprised nine species from five families: Trichodectidae (1 species), Linognathidae (1 species), Pulicidae (4 species), Culicidae (2 species), and Hippoboscidae (1 species). The domestic dog exhibited the highest ectoparasite species diversity, with 21 identified species, while domestic and jungle cats harbored only four species each. **Conclusions:** This study sheds light on the diversity, infestation rates, and various factors influencing ticks, mites, and other ectoparasites in dogs, cats, jackals, wolves, foxes, and reed cats across the 12 regions of Uzbekistan. Higher ectoparasite burdens and disease rates can significantly reduce animal production and productivity. Understanding the prevalence and distribution of ectoparasite species will aid in the development of informed control measures.

Keywords | Carnivorous mammals, ectoparasites, Arachnida, Insecta, domestic dogs, cats, distribution, infestation, diversity, Uzbekistan.

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INTRODUCTION

The investigation of the ectoparasites' species composition and how the parasitic system operates concerning certain groups of vertebrates in particular climatic zones is a crucial scientific field. Understanding the parasitological situation of predatory mammals in the "Ectoparasites - carnivorous animals" system in Uzbekistan's biogeocenoses is currently an urgent task for both fundamental and applied parasitology (Safarov et al., 2018).

Researchers in the fields of general biology, medicine, and veterinary sciences have been interested in ectoparasites' role as carriers of transmissible diseases of infectious and parasitic etiology for a long time (Dantas-Torres and Otranto 2016; Kluever et al., 2019). This interest is reflected in a considerable number of articles, fundamental monographs, guidelines, and extensive works published in various regions of the world (Morse 1995; Bengis et al., 2004; Colella et al., 2020; Muhammad et al., 2021).

The biogeocenoses of Uzbekistan have a significant population of predatory mammals belonging to the order Carnivora (Kashkarov et al., 2020). Researchers have documented the presence of representatives from 5 families in the region, namely Canidae, Ursidae, Mustelidae, Hyaenidae, and Felidae (Shernazarov et al., 2006; Kashkarov et al., 2020). Overall, there are approximately 40 species and subspecies of carnivorous mammals present in Uzbekistan (Kashkarov et al., 2020).

Carnivores, irrespective of their habitat, are susceptible to ectoparasite infections. However, no comprehensive studies have been conducted to determine the species composition of ectoparasites infesting both domestic and wild predatory mammals in the distinct regions of Uzbekistan (Safarov et al., 2018). The current available information mainly focuses on ixodid ticks of ungulates (Uzakov 1972), which is fragmentary and outdated and does not accurately reflect the current state of ectoparasite fauna of predatory animals in Uzbekistan.

The study of ectoparasites of domestic dogs in the Tashkent metropolis has been substantially enhanced by the study of Safarov et al. (2018). This report revealed that dogs were infested with ectoparasites, including ten tick species from the class Acarina and seven insect species from the class Insecta. The findings reported a total of 17 ectoparasites species infesting domestic dogs in Tashkent, some of which can also parasitize humans (Safarov et al., 2018). Unfortunately, information on ectoparasites of domestic and wild carnivorous mammals in Uzbekistan remains limited. Given the significance of this group of animals, there is a need for a comprehensive investigation of their current fauna taking into account the ecological characteristics of natural and urban areas in Uzbekistan (Safarov et al., 2022). Therefore, it is imperative to conduct further research in this area.

The aim of this study was to fill the knowledge gap in the ectoparasite fauna of carnivorous mammals in Uzbekistan. This report presents the findings of a comprehensive study conducted to investigate the diversity and prevalence of ectoparasites, including ticks, mites, lice, mosquitoes, flies and fleas, on predatory mammals in Uzbekistan.

MATERIALS AND METHODS

Investigated regions

Our research utilized our personal collection of ectoparasites obtained from carnivorous mammals inhabiting the biocenoses of Northwestern, (Khorazm), Central (Syrdarya, Jizzakh, Samarkand, Navoi, Bukhara), Southern (Surkhandarya, Kashkadarya), Northeastern (Tashkent, Namangan), and Eastern (Fergana, Andijan) regions of Uzbekistan (Fig. 1).

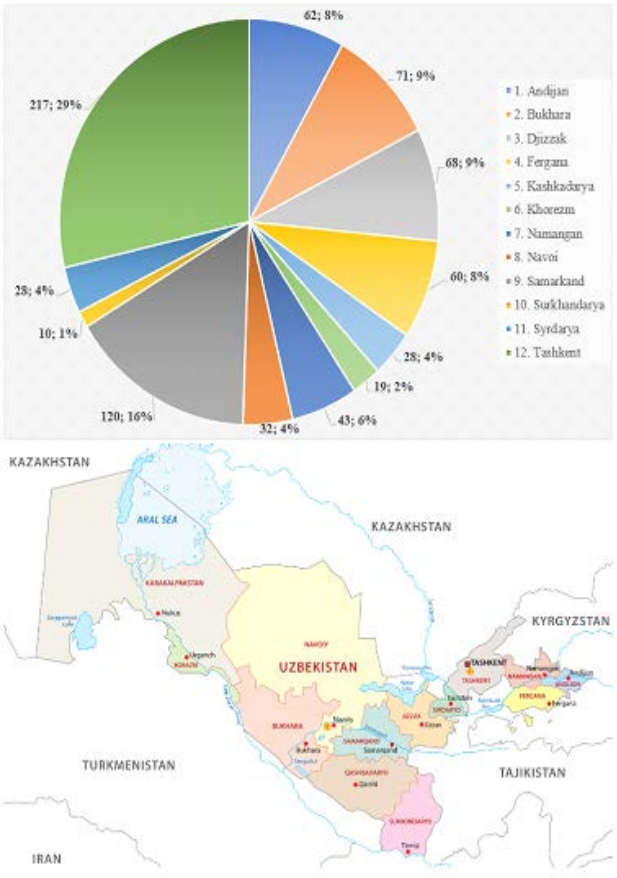

Figure 1: Ectoparasites' collection sites in Uzbekistan.

Ectoparasites' collection was carried out 12 regions of Uzbekistan between 2018 and 2022. The study was reviewed and approved by the center's ethics committee (approval

Table 1: Composition, number, and infestation rates with ectoparasites of studied carnivorous mammals from the investigated regions of Uzbekistan

Animal family	Animal species	Examined	Infested (rate, %±C.I.[1])	P value
Canidae	Golden jackal, *Canis aureus*	120	60 (50.0±0.090)	0.000*
	Grey wolf, *Canis lupus*	62	9 (14.5±0.088)	
	Domestic dog, *Canis lupus familiaris*	399	302 (75.9±0.041)	
	Red fox, *Vulpes vulpes*	68	34 (50.0±0.119)	
Felidae	Jungle cat, *Felis chaus*	43	5 (11.7±0.096)	
	Domestic cat, *Felis catus*	66	10 (16.4±0.086)	
Total		758	420 (55.4±0.035)	

Abbreviations: [1]: C.I.: 95% confidence interval, *: Statistically significant, p < 0.05.

code: No. 15 protocol on 18 October 2022).

Collected samples

A total of 758 domestic and wild mammals of the Carnivora order were examined (Table 1 and Figure 1). Wild animals were surveyed during the hunting seasons (autumn and winter) in five regions of the Republic, with the help of professional hunters. The animals included in the study were carefully inspected by combing and examining them under a magnifying glass. For larger animals, a thorough examination of the entire body surface was conducted to recover ticks, fleas, lice, and mites. These ectoparasites were then stored in sterile tubes containing 70% ethanol.

Ectoparasites' identification

Parasitological analysis was conducted in the General Parasitology laboratory at the Institute of Zoology of the Academy of Sciences of the Republic of Uzbekistan by using advanced equipment such as the Olympus CK2-TR microscope, Lomo research, binocular - ML - 2200, and trinocular microscope N-300 m Ningo Yongkin Optics. The extensiveness of invasion (EI, %) and intensity of invasion (II, ind.) were used to determine the quantitative characteristics of parasitocenoses of carnivorous mammals. The identification of the collected ectoparasites was carried out based on their morphometric characteristics. The keys provided by Beaucornu and Launay (1990) were used for flea identification, while tick identification was performed using the key developed by Estrada-Peña (2004). For mites, and fleas identification, the key provided by Domínguez-Peñafiel et al. (2011) was used as a reference.

Statistical analysis

Mean values, standard deviations, and standard errors were calculated using Microsoft Office Excel 2010.

The statistical analysis was performed using EpiInfo 7 software (CDC, USA). The prevalence and its 95% Confidence Interval (CI) were calculated, and differences among groups were assessed by chi squaretesting and considered significant for $p \leq 0.05$.

RESULTS

Ectoparasite infestation prevalence in studied carnivorous mammals

The present study investigated the infestation rates of ectoparasites on six species of carnivorous mammals in different regions of Uzbekistan. The study examined a total of 758 individuals, including Canidae and Felidae families. The infestation rates varied between species, with domestic dogs showing the highest infestation rate (75.9%1), followed by golden jackals (50.0%) and red foxes (50.0%). Grey wolves had the lowest infestation rate (14.5%), while domestic cats and jungle cats had infestation rates of 16.4% and 11.7%, respectively. The overall infestation rate across all studied species was 55.4%. The P-value obtained for the differences in infestation rates was highly significant ($P < 0.001$, Table 1).

In carnivorous mammals that harbored ectoparasites, several consistent clinical signs were observed. These included a significant decrease in body mass, fur shedding, the presence of red rashes on the skin, elevated body temperature, and alterations in the nervous system.

Ectoparasite species diversity and prevalence in overall

Infestation rates of different ectoparasite species in a total of 758 animals were showed in Table 2. The infestation rates were ranged from 2.2% to 26.7%, indicating that the prevalence of ectoparasites varies across species. Ticks were the most prevalent ectoparasite group, with *Hyalomma asiaticum* being the most common species infesting animals (26.7%). This is followed by *Ixodes persulcatus*, *Rhipicephalus sanguineus* sensu lato, *Haemaphysalis sulcata*, *Rhipicephalus turanicus*, *Hyalomma scupense*, *Dermacentor marginatus*, *Haemaphysalis numidiana*, *Rhipicephalus pumillo*, *Haemaphysalis punctata*, *Rhipicephalus bursa*, and *Dermacentor niveus*, in descending order of infestation rates ($p < 0.001$, Table 2).

Sarcoptes canis, a member of the Sarcoptidae family, was the

Table 2: Infestation rates of ectoparasite species for all investigated animals (n=758).

Type	Family	Species	Number of infested animals	Infestation rate (%±C.I.[1])	P value
Ticks	Ixodidae	*Hyalomma asiaticum*	203	26.7±0.031	0.000*
		Ixodes persulcatus	183	24.1±0.031	
		Rhipicephalus sanguineus sensu lato	178	23.4±0.029	
		Haemaphysalis sulcata	135	17.8±0.027	
		Rhipicephalus turanicus	110	14.5±0.025	
		Hyalomma scupense	97	12.7±0.023	
		Dermacentor marginatus	97	12.7±0.023	
		Haemaphysalis numidiana	89	11.7±0.023	
		Rhipicephalus pumillo	82	10.8±0.021	
		Haemaphysalis punctata	53	6.9±0.017	
		Rhipicephalus bursa	38	5.0±0.015	
		Dermacentor niveus	23	3.0±0.011	
Mites	Sarcoptidae	*Sarcoptes canis*	187	24.6±0.031	NA
	Demodecidae	*Demodex canis*	123	13.2±0.025	NA
Lice	Trichodectidae	*Trichodectes canis*	17	2.2±0.009	NA
	Linognathidae	*Linoglatus setotus*	34	4.4±0.015	NA
Fleas	Pulicidae	*Ctenocephalides canis*	61	8.0±0.019	0.000*
		Ctenocephalides orientis	53	6.9±0.017	
		Ctenocephalides felis	25	3.2±0.011	
		Pulex irritans	17	2.2±0.009	
Mosquitoes	Culicidae	*Culix pipiens*	202	26.6±0.031	0.045*
		Aedes caspius	169	22.2±0.029	
Louse flies	Hippoboscidae	*Hippobosca longipennis*	41	5.4±0.015	-

only mite species listed, with an infestation rate of 24.6% infesting investigated animals. *Demodex canis*, a member of the Demodecidae family, was also present, with an infestation rate of 13.2%. *Trichodectes canis* and *Linoglatus setotus*, members of the Trichodectidae and Linognathidae families, respectively, were the only two lice species present on studied animals. The infestation rates for both species were low, estimated at 2.2% and 4.4%, respectively. Fleas were represented by four species, namely *Ctenocephalides canis*, *Ctenocephalides orientis*, *Ctenocephalides felis*, and *Pulex irritans*. The infestation rates for *C. canis* and *C. orientis* were statistically the highest, at 8.0% and 6.9%, respectively ($p < 0.001$). The infestation rates for *C. felis* and *P. irritans* were much lower, at 3.2% and 2.2%, respectively. Two mosquito species, *Culix pipiens* and *Aedes caspius*, were identified, with infestation rates of 26.6% and 22.2%, respectively (Table 2).

Ectoparasite species diversity and prevalence in domestic carnivorous mammals

The results conducted on the diversity and infestation rates of ectoparasites' species in domestic carnivorous mammals from different regions of Uzbekistan are presented in Table 3. The study included 302 dogs and 66 domestic cats, and the infestation rates and diversity of ticks, mites, lice, fleas, mosquitoes, and louse flies were evaluated. The infestation rate of ticks in dogs was found to be very high, with *I. persulcatus* being statistically the most common tick species infesting 43.7% of dogs, followed by *Ha. sulcata* (37.4%) and *Hy. scupense* (29.1%). *D. marginatus* and *R. turanicus* had a lower infestation rate (11.9% and 6.2%, respectively) compared to other tick species ($p < 0.001$). However, domestic cats were less infested with ticks, and *Hy. asiaticum* (4.5%), *Ha. punctata* (9%), and *R. sanguineus* s.l. (25.7%) were the only tick species found in domestic cats ($p < 0.001$, Table 3).

The infestation rate of mites was also high in dogs, with *S. canis* infesting 61.9% of dogs, followed by *D. canis* (40.7%). No infestation was found in cats for these mite species. Similarly, the infestation rate of lice was low in both dogs and cats, with *T. canis* and *L. setotus* being found in dogs (3.6% and 10.2%, respectively) and only *L. setotus* being found in cats (4.5%). Fleas were found to infest both dogs

Table 3: Diversity and infestation rates of ectoparasites' species in studied domestic carnivorous mammals from investigated regions of Uzbekistan

Type	Family	Species	Number of infested animals (infestation rate, %±C.I.[1])			
			Dogs (n=302)	P value	Domestic cats (n=66)	P value
Ticks	Ixodidae	*Ixodes persulcatus*	132 (43.7±0.056)	0.000*	0 (0)	0.000*
		Hyalomma scupense	88 (29.1±0.050)		0 (0)	
		Hyalomma asiaticum	91 (30.1±0.050)		3 (4.5±0.050)	
		Dermacentor marginatus	36 (11.9±0.037)		0 (0)	
		Dermacentor niveus	0 (0)		0 (0)	
		Haemaphysalis numidiana	71 (23.5±0.047)		0 (0)	
		Haemaphysalis sulcata	113 (37.4±0.054)		0 (0)	
		Haemaphysalis punctata	47 (15.5±0.041)		6 (9.0±0.068)	
		Rhipicephalus bursa	29 (9.6±0.033)		0 (0)	
		Rhipicephalus pumillo	33 (10.9±0.035)		0 (0)	
		Rhipicephalus turanicus	19 (6.2±0.027)		0 (0)	
		Rhipicephalus sanguineus sensu lato	58 (19.2±0.045)		17 (25.7±0.105)	
Mites	Sarcoptidae	*Sarcoptes canis*	187 (61.9±0.054)	NA	0 (0)	NA
	Demodecidae	*Demodex canis*	123 (40.7±0.054)	NA	0 (0)	NA
Lice	Trichodectidae	*Trichodectes canis*	11 (3.6±0.021)	NA	0 (0)	NA
	Linognathidae	*Linoglatus setotus*	31 (10.2±0.033)	NA	3 (4.5±0.050)	NA
Fleas	Pulicidae	*Ctenocephalides canis*	43 (14.2±0.039)	0.000*	7 (10.6±0.074)	0.000*
		Ctenocephalides orientis	53 (17.5±0.043)		0 (0)	
		Ctenocephalides felis	0 (0)		18 (27.2±0.107)	
		Pulex irritans	14 (4.6±0.023)		0 (0)	
Mosquitoes	Culicidae	*Aedes caspius*	109 (36.0±0.054)	0.013*	0 (0)	NA
		Culix pipiens	139 (46.0±0.056)		0 (0)	
Louse flies	Hippoboscidae	*Hippobosca longipennis*	30 (9.9)		0 (0)	

Abbreviations: [1]: C.I.: 95% confidence interval, *: Statistically significant, p < 0.05, NA: Not applied.

Table 4: Diversity and infestation rates of ectoparasites' species in studied wild predatory mammals from investigated regions of Uzbekistan

Type	Family	Species	Number of infested animals (infestation rate, %±C.I.[1])							
			Jackals (n=120)	P value	Wolf (n=62)	P value	Foxes (n=68)	P value	Jungle cats (n=43)	P value
Ticks	Ixodidae	*Ixodes persulcatus*	33 (27.5±0.080)	0.000*	0 (0)	0.000*	18 (26.4±0.105)	0.000*	0 (0)	0.000*
		Hyalomma scupense	0 (0)		0 (0)		0 (0)		9 (20.9±0.121)	
		Hyalomma asiaticum	42 (35±0.086)		18 (29.0±0.113)		11 (16.1±0.088)		38 (88.3±0.096)	
		Dermacentor marginatus	53 (44.1±0.088)		0 (0)		0 (0)		8 (18.6±0.115)	
		Dermacentor niveus	0 (0)		0 (0)		23 (33.8±0.111)		0 (0)	
		Haemaphysalis numidiana	0 (0)		0 (0)		18 (26.4±0.105)		0 (0)	
		Haemaphysalis sulcata	0 (0)		0 (0)		22 (32.3±0.111)		0 (0)	
		Haemaphysalis punctata	0 (0)		0 (0)		0 (0)		0 (0)	
		Rhipicephalus bursa	0 (0)		9 (14.5±0.088)		0 (0)		0 (0)	
		Rhipicephalus pumillo	0 (0)		21 (33.8±0.117)		28 (41.1±0.117)		0 (0)	
		Rhipicephalus turanicus	43 (35.8±0.086)		6 (9.6±0.074)		31 (45.5±0.117)		11 (25.5±0.131)	
		Rhipicephalus sanguineus s.l.	51 (42.5±0.088)		11 (17.7±0.096)		41 (60.2±0.115)		0 (0)	
Mites	Sarcoptidae	*Sarcoptes canis*	0 (0)	NA	0 (0)	NA	0 (0)	NA	0 (0)	NA
	Demodecidae	*Demodex canis*	0 (0)	NA	0 (0)	NA	0 (0)	NA	0 (0)	NA
Lice	Trichodectidae	*Trichodectes canis*	6 (5.0±0.039)	NA	0 (0)	NA	0 (0)	NA	0 (0)	NA
	Linognathidae	*Linoglatus setotus*	0 (0)	NA	0 (0)	NA	0 (0)	NA	0 (0)	NA
Fleas	Pulicidae	*Ctenocephalides canis*	31 (25.8±0.078)	0.000*	6 (9.7±0.074)	0.000*	11(16.2±0.088)	0.000*	0 (0)	0.000*
		Ctenocephalides orientis	0 (0)		0 (0)		0 (0)		0 (0)	
		Ctenocephalides felis	0 (0)		0 (0)		0 (0)		7 (16.2±0.109)	
		Pulex irritans	3 (2.5±0.027)		0 (0)		0 (0)		0 (0)	
Mosquitoes	Culicidae	*Aedes caspius*	51 (42.5±0.088)	0.121	0 (0)	NA	0 (0)	NA	9 (20.9±0.121)	0.001*
		Culix pipiens	63 (52.5±0.090)		0 (0)		0 (0)		0 (0)	
Louse flies	Hippoboscidae	*Hippobosca longipennis*	11 (9.1±0.050)		0 (0)		0 (0)		0 (0)	

Abbreviations: [1]: C.I.: 95% confidence interval, *: Statistically significant, p < 0.05, NA: Not applied.

and cats, with *C. canis* and *C. orientis* being the most common species in dogs (14.2% and 17.5%, respectively) and *C. felis* being the only species found in cats (27.2%). The infestation rate of fleas was significantly higher in cats than in dogs. *P. irritans* infested only 4.6% of dogs, while no infestation was found in cats ($p < 0.001$, Table 3). Mosquitoes were found to infest dogs with a high infestation rate, and *A. caspius* and *C. pipiens* were the most common species found in this animal species (36.0% and 46.0%), respectively (Table 3).

Ectoparasite species diversity and prevalence in wild carnivorous mammals

The results revealed a high diversity of ectoparasites infesting wild predatory mammals in Uzbekistan. Ticks were found to be the most prevalent ectoparasites among the studied wild animals. The infestation rate of *I. persulcatus* was 27.5% in jackals, and 26.4% in foxes. *Hy. asiaticum* was found to have the infestation rate of 35% in jackals, 29% in wolves, 16.1% in foxes, and 88.3% in jungle cats. *D. marginatus* was also prevalent among the studied wild animals, with an infestation rate of 44.1% in jackals, and 18.6% in jungle cats. In addition, *R. turanicus*, and *R. sanguineus* s.l. were also prevalent among the studied wild animals especially in Jackals (35.8% and 42.5%, respectively), and Foxes (45.5% and 60.2%, respectively). Also, *Rhipicephalus pumillo* was found to have the infestation rate of 33.8% in wolves, and 41.1% in foxes. Moreover, *D. niveus*, *Ha. numidiana*, *Ha. sulcata*, *Ha. punctata*, and *R. bursa* were found to infest some of the studied animals ($p < 0.001$, Table 4).

Fleas were also common among the studied wild predatory mammals in Uzbekistan. *C. canis* was the most prevalent flea species, with an infestation rate of 25.8% in jackals, 9.7% in wolves, and 16.2% in foxes. *P. irritans* was found to infest only a few animals with an infestation rate of 2.5% in jackals ($p < 0.001$, Table 4). Mosquitoes were found to be prevalent among the studied animals, with an infestation rate of 42.5% for *A. caspius* in jackals and 20.9% for the same species in jungle cats. *C. pipiens* was also found to infest 52.5% of Jackals. Louse flies were the least prevalent ectoparasites among the studied animals. *H. longipennis* was found to infest 9.1% of the studied jackals (Table 4).

DISCUSSION

In recent years, there has been a growing interest in the study of ectoparasites in vertebrates due to their significant threat to agricultural and commercial animals as well as humans. These parasites are known to carry numerous arthropod-borne pathogens that can cause severe diseases in their hosts (Sahito et al., 2017). For example, ticks are capable of transmitting diseases such as Lyme disease, Rocky Mountain spotted fever, and tick-borne encephalitis (Sajid et al., 2008). Similarly, fleas can transmit diseases like plague, murine typhus, and Bartonellosis (Reeves et al., 2007). Besides being disease carriers, ectoparasites also serve as vectors for various vector-borne diseases in vertebrates. Mosquitoes, for instance, are known to transmit malaria, dengue fever, and Zika virus, while sandflies can transmit leishmaniasis (Depaquit et al., 2010; Chouin-Carneiro et al., 2016; Saraiva et al., 2016). Therefore, research on ectoparasites holds great importance in veterinary medicine, human health, and public health. The findings from these studies are extensively published and well-known among specialists, aiding in the development of new treatments and control strategies for the prevention of diseases transmitted by ectoparasites (Telleria, 2018).

The study of ectoparasites in Uzbekistan is still in its early stages, and there is limited available research on the fauna of ectoparasites infesting domestic dogs. Previous studies conducted by Uzakov (1972), Kuklina (1976), and Safarov et al. (2018) have contributed to this field. Safarov et al., (2018) identified 17 species of ectoparasites in domestic dogs in Tashkent, with mites and insects being the predominant groups.

The research by Safarov et al. (2018) also indicates that the distribution of ectoparasites in the dog population is influenced by the unique ecological characteristics of the urban environment in Tashkent. As dogs and their ectoparasites enter the city, they introduce mites, fleas, lice, and blood-sucking dipterans, which have the potential to parasitize humans. This finding aligns with the data presented by Halliwell Richard (2013).

It is important to highlight that the presence of ectoparasites in dogs and other mammals not only poses a risk to human health but also significantly impacts animal welfare. Therefore, further research on the ectoparasites of predatory mammals in Uzbekistan is crucial for understanding the magnitude of the issue and developing effective control and prevention strategies.

In this study, our objective was to investigate the ectoparasites infesting six predatory mammal species in Uzbekistan, including jackals, wolves, foxes, jungle cats, dogs, and cats. Among these species, four were wild animals, while two were domesticated. Our findings revealed the presence of ectoparasites in both domestic species, dogs and cats.

A total of 23 arthropod species belonging to two classes, Acarina and Insecta, were observed on the predatory mammals in Uzbekistan. The class Acarina comprised 14 species from three families: Ixodidae, Sarcoptidae, and Demodecidae. The most frequently encountered species were Ixodid ticks, with 12 species infesting a wide range

of hosts. Specifically, these ticks were found on jackals (five species), wolves (four species), foxes (eight species), jungle cats (four species), dogs (13 species), and cats (three species). The identified ticks included *Ixodes persulcatus*, which was found on jackals, foxes, and dogs; *Hyalomma scupense*, found exclusively on dogs and jungle cats; *Hyalomma asiaticum*, found on domestic dogs and cats, jackals, wolves, foxes, and jungle cats; *Demodex marginatus*, found on dogs, jackals, and jungle cats; *Demodex niveus*, found only on foxes; *Haemaphysalis numidiana* and *Haemaphysalis sulcata*, identified in dogs and foxes; *Haemaphysalis punctata*, found on domestic dogs and cats; Rhipicephalus bursa, exclusive to dogs and wolves; *Rhipicephalus pumillo*, detected in dogs, wolves, and foxes; *Rhipicephalus turanicus*, present in all investigated animal species except domestic cats; and *Rhipicephalus sanguineus* s.l., identified in all studied animal species except jungle cats.

The class Insecta comprised nine species from five families: Trichodectidae, Linognathidae, Pulicidae, Culicidae, and Hippoboscidae. This study identified several ectoparasites belonging to the class Insecta on the examined animals. Mites from the families Sarcoptidae and Demodecidae were found, with *Sarcoptes canis* being the most frequently observed mite species. Lice from the families Trichodectidae and Linognathidae were also found on the investigated animals, with Trichodectes canis being the predominant louse species. Fleas were identified as common ectoparasites, and several species were identified, including *Ctenocephalides canis*, *Ctenocephalides orientis*, *Ctenocephalides felis*, and *Pulex irritans*. Mosquitoes from the family Culicidae were found, with *Aedes caspius* and *Culex pipiens* being the most commonly observed species. Lastly, louse flies from the family Hippoboscidae were identified, with *Hippobosca longipennis* being the sole species observed on the analyzed animals. Overall, this study provides valuable insights into the diversity of ectoparasites infesting predatory mammals in Uzbekistan and emphasizes the importance of ongoing surveillance of these parasites in both domestic and wild animal populations.

In Uzbekistan, cases of *Hippobosca longipennis* infections in dogs have been documented. The first recorded case of *H. longipennis* infections in dogs was reported by Doszhanov in 2003, who found 93 females and 46 males of *H. longipennis* in dogs from the Tashkent and Samarkand regions between 1972 and 1974. A more recent study conducted by Safarov et al., in 2018 documented the second case of *H. longipennis* infections in dogs in Uzbekistan. *H. longipennis* is commonly found in stray dogs residing in both rural and urban areas of Uzbekistan and is prevalent in several countries in Africa, Asia, and Europe. During the autumn of 2021, researchers removed a total of 13 females and 7 males of *H. longipennis* from the inner surface of the auricle of three dogs in Tashkent and the Tashkent region, indicating that *H. longipennis* continues to pose a problem for dogs in Uzbekistan.

Apart from *H. longipennis*, other ectoparasites were also discovered in predatory animals in Uzbekistan. These parasites often exist as single invasions or coexist with parasitic mites and insects. The researchers observed that individual dogs had associations with 2 to 6 species of ectoparasites, along with various modifications, highlighting the necessity for effective ectoparasite control measures in animals. The predatory mammals in Uzbekistan exhibit a diverse fauna of ectoparasites, comprising a total of 23 species. Extensive research on the region's ecosystems has revealed the presence of parasitic communities across all habitats. Among these species, 14 belong to the tick family, including Ixodidae, Sarcoptidae, and Demodecidae, while the remaining 9 species fall under the insect category and are distributed across 5 families: Trichodectidae, Linognathidae, Pulicidae, Culicidae, and Hippoboscidae. The composition of these parasitic communities varies depending on the habitat of the carnivorous hosts, with each ecological zone exhibiting species that are characteristic of that specific region. Previous literature, as supported by Tulov (2013), emphasizes that the confinement of these species to particular biotopes is primarily influenced by landscape conditions favorable for ectoparasites and the availability of suitable host habitats.

Interestingly, the study did not find a direct ontogenetic effect of parasites on one another. Instead, the co-occurrence of various parasitic components in the examined animals suggests a positive correlation between parasite invasions. This correlation may be attributed to the similar environmental requirements of parasites belonging to different orders, as documented in previous literature by Povlovsky (1934).

The findings of this study indicate that the development of the present fauna of ectoparasites in predatory mammals of Uzbekistan has been influenced by multiple factors, including ecological zones and environmental conditions. These factors have played a significant role in shaping the composition and distribution of ectoparasitic communities in both natural and urbanized areas of the country. By shedding light on the intricate interactions between parasites and their hosts, this research provides valuable insights into the dynamics of these communities. Furthermore, it emphasizes the importance of comprehending the underlying ecological factors that contribute to the formation and maintenance of such parasite-host associations. Understanding these factors is crucial for effective management and control strategies aimed at mitigating the impact of ectoparasites on both wildlife and domestic

animals in Uzbekistan.

CONCLUSION

In conclusion, the study highlights the importance of research on ectoparasites in Uzbekistan, considering their significant threat to human health, animal welfare, and agricultural productivity. The findings emphasize the need for ongoing surveillance and monitoring programs to assess the prevalence, distribution, and impact of ectoparasites in both domestic and wild animal populations. Improved data availability and collaboration among researchers, veterinary professionals, and public health authorities are crucial for enhancing knowledge, developing targeted control strategies, and implementing effective preventive measures. Based on these insights, it is recommended to strengthen surveillance efforts, develop targeted control strategies, and promote collaboration among stakeholders. This will contribute to the management and prevention of ectoparasite-related diseases, safeguarding the health and well-being of humans and animals in Uzbekistan. Furthermore, continued research into the ecological factors influencing the formation and maintenance of ectoparasite communities will enhance our understanding of these complex interactions and support evidence-based approaches for ectoparasite control and management.

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CONFLICT OF INTEREST

The authors declare no competing interests.

NOVELTY STATEMENT

The fauna of ectoparasites of carnivorous mammals was comprehensively studied for the first time in Uzbekistan.

AUTHOR CONTRIBUTIONS

AS designed this study. AS collected samples and epidemiological data. AS performed the identification of ectoparasites. AS and MBS performed the statistical analysis and wrote the manuscript, and NN, FA, ShD, DA, JE and MBS edited and finalized it. All these authors approved the final version of the manuscript.

ETHICS APPROVAL

The study was reviewed and approved by the center's ethics committee (approval code: No. 15 protocol on 18 October 2022).

CONSENT FOR PUBLICATION

Authors are giving their consent to publisher to publish their manuscript upon acceptance.

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