Investigation and study on the fauna and epidemiology of rodent endoparasites in the desert of northwest China

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Abstract

Zoonoses are severe and have attracted wide attention in society. Many animal parasitic diseases can cause human infection, so it is necessary to study the host of parasites and their transmission routes. The sampling investigation in the inland arid desert area of northwestern China - Xinjiang, a total of 963 rodents belonging to 21 species, 15 genera, four families, and two *Lepus yarkandensis*, 17 *Crocidura leucodon* were captured in the arid desert region of Xinjiang. Among them, 33 species of endoparasite were detected, including 17 species of nematodes, 15 species of tapeworm, and one acanthocephalan species. A total of 127 positive specimens were detected. The infection rate of endoparasite was 13.19%, Nematode infection rate was 6.63%, and the tapeworm infection rate was 7.98%. Epidemiological studies were carried out, and the conclusions are as follows:

The infection rate of endoparasite in rodents in this area is not related to gender but is closely related to the host's age, distribution area, host species, cluster lifestyle, and season. The infection intensity is not related to the number of infected endoparasite species and the infection rate but is mainly related to specific parasite species and rodent species. With the succession of rodent communities, the infection intensity increases from desert to artificial forest, farmland, and residential area, indicating that the direction and route of parasite transmission from primitive desert to artificial environment have formed.

Introduction

With the development of the economy, the relationship between humans and nature is getting closer and closer. Some zoonoses had been discovered successively, especially the outbreak and spread of SARS in 2003, avian flu in 2004, swine flu in 2009, and novel coronavirus in 2020, which did great harm. Therefore, it is essential to know the host, foci, transmission route, and transmission mode of zoonotic diseases to prevent and control parasitic diseases. Currently, the study of animal parasites is more focused on the external parasites, and the object of study mainly concentrated on domestic animals (Fanyao Kong, 1997), pets (Ming Wang, 2004), and experimental animals (Ting-heng Wen et al., 1987 and Xinru Chen et al., 1996). Research reports on wild animals, especially wild rodents' endoparasites, are commonly found in West Asia (Asghar et al. 2018 and Nasser Hajipour et al., 2016) and Africa (Khalafalla R E et al., 2011 and Fredrick O. et al., (2019). However, few research reports in this field in China and data are relatively scarce (Zhengmei Huang et al., 1995 and Zilin Zhou et al., 1993). There are only sporadic investigations on the ecological characteristics and epidemiology of rodents' endoparasite in inland arid desert areas. (Wei Jiang et al., 1999, Wei Jiang et al., 2000 and Chinese Academy of Sciences, 1959). In this paper, the endoparasitic infections in different areas, different host, different genders, and ages in Xinjiang was investigated and analysed; the aim was to clarify the life history of endoparasites, the model, and way of transmission. Moreover, put forward the corresponding prevention measures. Investigation and research results were as follows:

Materials And Methods

Specimens Source

According to the zoogeographic regionalization of Xinjiang (Rongzhu Zhang, 1999), we chose five sampling points, which belong to three zoogeographic subregions respectively. The five sample plots are as follows: (1) Tarim Basin in southern Xinjiang, which belongs to the western desert subregion; (2) Mosuowan (a place name in Xinjiang) reclamation area, extending 60 kilometres to the hinterland of Junggar Basin, belongs to the western desert subregion; (3) Fukang Farm, located in the southern edge of Junggar, belongs to the western desert subregion; (4)

Mulei steppe belongs to the eastern steppe subregion;(5) Bole Mountain belongs to Tianshan Mountain subregion. A total of 963 rodents were examined in this necropsy, including 21 species of rodents. A total of 963 rodents belonging to 21 species, 15 genera, four families, and two *Lepus yarkandensis*17 *Crocidura leucodon* were captured. These rodents' specimens were examined, and the conclusions were as follows:

Inspection method

We referred to "Domestic Animal Parasitology" (Fanyao Kong,1997), "Clinical Parasitology and Experimental Guide to Parasitology" (Qingren Zeng, 2003), and "Human and zoonotic nematology" (Zhongzhang Tang, Chongti Tang, 1987)

Field inspection: The captured rodents were identified (Sibo Wang et al., 1983 and Yingxiang Wang, 2003), registered with male and female numbers, and measured body weight, body length, tail length, carcass weight, reproductive and developmental conditions. The captured rodents' stomach and intestines were cut off on the spot and stored in 10% neutral formaldehyde or 70% alcoholic semen.

Laboratory examination: Gastrointestinal body specimens were removed from the immersion solution, numbered, cut into sections, and rinsed with normal saline. Furthermore, specimens were examined by sections of the stomach, small intestine, cecum, and large intestine. Besides, endoparasites were collected by picking needles. The tapeworm was washed, pressed, stained with hydrochloric acid magenta, and examined under a microscope. The nematodes were rinsed, transparent with milk phenol, and classified and identified under the microscope.

Epidemiology and public health indicators

- (1) Infection rate
- (2) Infection intensity

Results

*Endoparasite fauna and species*see Table 1

Through three zoogeographic fauna and five sampling sites investigation in northwestern China's inland arid desert area - Xinjiang, 963 rodents belonging to 21 species, 15 genera, four families, and two *Lepus yarkandensis*17 *Crocidura leucodon* were captured in the arid desert region of Xinjiang. Among them, 33 species of endoparasite were detected, including 17 species of nematodes,15 species of tapeworm, and one acanthocephalan species. One hundred twenty-seven positive specimens were detected. The infection rate of endoparasite was 13.19%, Nematode infection rate was 6.63%, and the tapeworm infection rate was 7.98%. Due to the limited identification conditions and levels, only four nematodes of the 18 species were identified to genera and species, while the other 14 nematodes could only be identified to orders and families. Among the 15 species of tapeworm, only four tapeworm species were identified to genus and species, while the other 11 species could only be identified to order and family.

Table 1 Detection results of endophytic parasites

Parasite species	positive rat	mistletoe-site	host
Nematode			
1. <i>Trichurata</i> spp N1	9	cecum	<i>Meriones meridianus</i> ∅ <i>Rhombomys opimus</i>
2. <i>Spirurata</i> spp N2	3	intestine	<i>Apodemus sylvaticus</i>
3. <i>Trichurata</i> spp N3	1	cecum	<i>Brachiones przewalskii</i>
4. <i>Syphacia obvelata</i> N4	17	Cecum∅ intestine	<i>Meriones meridianus</i> ∅∅ <i>Rhombomys opimus</i> ∅ <i>Cricetulus migratorius</i> ∅ <i>Mus musculus</i> ∅ <i>Microtus norvegicus</i> ∅ <i>Lagurus lagurus</i> ∅ <i>Apodemus sylvaticus</i>
5. <i>Passalurus ambiguous</i> N5	2	cecum	<i>Lepus yarkandensis</i>
6. <i>Strongylata</i> spp N6	1	intestine	<i>Meriones tamariscinus</i>
7. <i>Trichurata</i> spp N7	1	cecum	<i>Meriones tamariscinus</i>
8. <i>Strongylata</i> spp N8	1	intestine	<i>Lagurus lagurus</i>
9. <i>Ascaridata</i> spp N9	3	intestine	<i>Cricetulus migratorius</i> ∅ <i>Mus musculus</i>
10. <i>Spirurata</i> spp N10	1	intestine	<i>Citellus undulates</i>
11. <i>Spirurata</i> spp N11	5	abdominal cavity	<i>Marmota sibirica</i> ∅ <i>Apodemus sylvaticus</i>
12. <i>Strongylata</i> spp N12	4	intestine	<i>Rhombomys opimus</i> ∅ <i>Meriones meridianus</i>
13. spp N13	2	intestine	<i>Rhombomys opimus</i> ∅ <i>Meriones meridianus</i>
14. <i>Strongylata</i> spp N14	6	Intestine∅ cecum	<i>Rhombomys opimus</i>
15. <i>Capillaria hepatica</i> N15	2	liver	<i>Rhombomys opimus</i> ∅ <i>Meriones meridianus</i>
16. spp N16	1	intestine	<i>Rhombomys opimus</i>
17. <i>Spirurata</i> spp N17	3	testis	<i>Microtus norvegicus</i> ∅ <i>Allactaga elate</i>
Acanthocephalan			
1.spp A1	2	intestine	<i>Mus musculus</i> ∅ <i>Rattus norvegicus</i>
Cestoda			
1. spp C1	8	intestine	<i>Meriones meridianus</i>

2. spp C2	1	intestine	<i>Apodemus sylvaticus</i>
3. spp C3	2	Stomach intestine	<i>Euchoreutes naso</i> <i>Cricetulus migratorius</i>
4. spp C4	1	intestine	<i>Euchoreutes naso</i>
5. <i>Gvosdevilepis fragmentata</i> C5	2	intestine	<i>Lepus yarkandensis</i>
6. <i>Hymenotepis nana</i> C6	20	intestine	<i>Meriones meridianus</i> <i>Meriones erythrourus</i> <i>Meriones tamariscinus</i> <i>Cricetulus migratorius</i>
7.spp C7	13	intestine	<i>Lagurus lagurus</i>
8.spp C8	1	intestine	<i>Mus musculus</i>
9.spp C9	3	intestine	<i>Cricetulus migratorius</i>
10.spp C10	3	intestine	<i>Microtus gregalis</i>
11. <i>Ctenotaenia caucasica</i> C11	13	intestine	<i>Citellus undulates</i>
12.spp C12	2	intestine	<i>Rhombomys opimus</i>
13. <i>Catenotaenia</i> sp. C13	6	intestine	<i>Meriones erythrourus</i> <i>Meriones tamariscinus</i> <i>Allactaga.elate</i>
14. spp C14	1	intestine	<i>Cricetulus migratorius</i>
15. spp C15	1	intestine	<i>Rattus norvegicus</i>

2.1.2 As can be seen from Table 1, among the nematodes, the infection rate of rat *Syphacia obvelata* was the highest, and there were seven host species and a wide distribution area, indicating that this nematode had a low specificity and was easy to spread. In contrast, most of the other nematodes were mainly distributed regionally and had strong specificity. Among them, *Rhombomys opimus* and *Meriones meridianus* were infected with more species: six species of *Rhombomys opimus* and five species of *Meriones meridianus*, which had not been reported before. Another type of *Spirurata* spp on the test is also reported for the first time; *Capillaria hepatica*

in *Rhombomys opimus* and *Meriones meridianus* was not reported. From the parasitic sites, mostly concentrated in the intestine, cecum.

2.1.3 The infection rates of No. 6, 7, 11, 1, and 13 among the tapeworms were high, in which No.6 (*Hymenotepis nana*) infected four hosts, distributed in the desert and Mulei steppe of northern Xinjiang, with low specificity and easy transmission. The hosts of these 5 species of tapeworm are all the local dominant rat species.

2.1.4 The number of infected endoparasite species in Junggar was up to 16, followed by 10 species in southern Xinjiang, 8 species in Mulei, and Bole had the fewest infected , only four, which was consistent with the number of host species.

Endoparasite infection of rodent in different regions (see Table 2)

Table 2 Endoparasite infection of rodent in different areas of Xinjiang

Area	Qty Inspected	Number of infections	total infection rate %	infection intensity	nematode		tapeworm	
					infection rate %	infection intensity	infection rate %	infection intensity
southern Xinjiang	133	20	15.04	4.5	6.77	1.9	9.02	6
Mosuowan	470	51	10.85	17	5.96	7	5.74	23
Fukang	106	4	3.78	2.5	1.89	2	1.89	3
Mulei	199	31	15.58	4	6.53	5	9.05	3
Bole	55	21	38.19	15	10.91	9	29.09	16
total	963	127	13.19	14	6.63	7	8.19	18

A total of 963 rodent samples from 21 species, 15 genera, four families were examined, and the total infection rate of endoparasites was 13.19%. The highest value was 38.19% in Bole Mountain District, and it is significantly higher than in other areas($p<0.05$), which may be related to the dominant species of marmots and *Citellus*. The value was 15.58% in Mulei, 15.04% in southern Xinjiang, 10.85% in Mosuowan, and 3.78% in Fukang. The number of parasite species in Mosuowan was 14 at most, followed by ten in south Xinjiang, eight in Mulei, four in Bole, and three in Fukang. The infection rate of nematode was higher than that of tapeworm in the Mosuowan area, but tapeworm was higher in other places. The infection intensity of tapeworm was higher than that of nematode in all regions. The highest infection intensity was 17 in Mosuowan, 15 in Bole, 4.5 in southern Xinjiang, four in Mulei, and 2.5 in Fukang.

Intracarasitic infection of rodents of different species (see Table 3)

Table 3 Endoparasite infection of rodent in different species of Xinjiang

Rodent species	Qty Inspected	Number of Infections (%)	infection intensity	nematode		tapeworm	
				infection rate %	infection intensity	infection rate %	infection intensity
<i>Meriones meridianus</i>	243	32(13.17)	4.6	5.35	1.5	9.05	5.7
<i>Rhombomys opimus</i>	48	10(20.83)	4.8	16.67	3.3	4.17	2.5
<i>Meriones erythraeus</i>	108	6(5.56)	15.0	0	0	5.56	15.0
<i>Meriones tamariscinus</i>	47	6(12.77)	67.0	4.26	2.0	8.51	100.0
<i>Apodemus sylvaticus</i>	73	6(8.22)	4.7	6.85	5.4	1.37	1.0
<i>Cricetulus migratorius</i>	70	9(12.86)	8.0	4.29	5.7	8.57	9.3
<i>Allactaga elate</i>	42	2(4.76)	5.0	2.38	6.0	2.38	4.0
<i>Mus musculus</i>	123	6(4.88)	3.3	4.07	3.6	0.81	2.0
<i>Rattus norvegicus</i>	12	1(8.33)	14.0	8.33	4.0	8.33	10.0
<i>Dipus sagitta</i>	18	0					
<i>Microtus norvegicus</i>	24	6(25.00)	25.0	25.00	25.0	0	0
<i>Alactagulus pygmaeus</i>	4	0					
<i>Lagurus lagurus</i>	86	20(23.26)	3.8	8.14	5.3	15.12	3.0
<i>Allactaga sibirica</i>	1	0					
<i>Citellus undulates</i>	26	13(50.00)	20.4	3.85	8.0	50.00	19.8
<i>Microtus gregalis</i>	18	3(16.67)	1.7	0	0	16.67	1.7
<i>Sicista tianschanica</i>	2	0					
<i>Sciurus vulgaris</i>	3	0					
<i>Marmota sibirica</i>	4	4(100.00)	10.0	100.00	10.0		
<i>Euchoreutes naso</i>	8	2(25.00)	1.5	0	0	25.00	1.5
<i>Brachiones</i>	3	1(33.33)	2	33.33	2.0	0	0

<i>przewalskii</i>							
<i>total</i>	963	127(13.19)	14	6.63	7	8.19	18

A total of 963 rodents belonging to four families and 15 genera 21 species were examined in five areas, among which 16 species of rodents were infected with endoparasites. A total of 31 species of endoparasites were detected, including 15 species of tapeworm and 16 species of nematode. As can be seen from Table 2, the infection rate of *Lagurus lagurus* was 23.26%, *Rhombomys opimus* was 20.83%, and *Microtus norvegicus* was 25%. These rodents all lived in colonies and were easy to spread within species, so the infection rate was high. The infection rate was 13.17% in *Meriones meridianus* and 12.86% in *Cricetulus migratorius*. These two species were solitary rodents with the little interspecific transmission, so the infection rate was not high. The infection rate of *Citellus undulatus* 50.0%, and *Marmota sibirica* was 100.0%, which was related to the region-specific distribution. Both rodents were distributed in mountainous areas and were the plague hosts. The parasite species of *Meriones meridianus* *Rhombomys opimus* *Cricetulus migratorius* were more than that of other rodents. The infection intensity of *Meriones tamariscinus* was the highest, up to 67, followed by *Citellus undulatus* (19) and *Microtus norvegicus* (25). The infection rate of *Meriones meridianus* was 12.77% (12/94) in southern Xinjiang and 13.42% (20/149) in northern Xinjiang. There was no significant difference ($P > 0.05$). However, the species of infected parasites varied greatly. *Meriones meridianus* were infected six species of parasites in northern Xinjiang and two in southern Xinjiang.

Parasite infection in rodents of different ages and sexes. (See Table 4)

Table 4 Endoparasite infection in rodents of different ages and sexes

	Number of rodents	Number of infections	Infection rate %
adult	352	45	12.78
juvenile	118	6	5.08
total	470	51	10.85
female	249	29	11.65
male	221	22	9.95
total	470	51	10.85

As shown in Table 3, according to the data of rodents in the Mosuowan area, 45 of 352 adult rodents were infected, the infection rate was 12.78%, and six of 118 juvenile rodents were infected; the infection rate was 5.08%. There was a significant difference between the two ($P < 0.05$); adult rodents' infection rate was significantly higher than that of juvenile rodents. In terms of sex, the infection rate was 11.65% (29/249) in females and 9.95% (22/221) in males, and there was no significant difference between the two ($p > 0.05$).

Endoparasite infection in different seasons see Table 5

Due to investigation time constraints, three consecutive seasons were not sampled from the same site. To eliminate the influence of climate and region, we analysed the results of several sample sites located in Junggar Basin in northern Xinjiang. As shown in Table 4, the endoparasite infection rate was 3.78% in spring in the Fukang area, 10.85% in summer in the Mosuowan area, and 15.58% in autumn in the Mulei area. According to the seasonal analysis of parasitic infection rates of the three groups, the seasonal parasite infection rates in spring were lower than those in summer and lower than those in autumn, with an increasing trend from 3.78% to 10.85% to 15.58%, which existed to significant differences ($P < 0.05$).

Table 5 Endoparasite infection of rodents in a different season

season	Number of rodents	Number of infections	Infection rate %
spring	106	4	3.78
summer	470	51	10.85
autumn	199	31	15.58

Parasite infection in different rodent communities (Table 6)

Table 6 Endoparasite infection of rodent in different rodent communities

community	Qty Inspected	number of infections %	infection intensity	parasite species	nematode		tapeworm	
					infection rate %	infection intensity	infection rate %	infection intensity
I	150	26(17.33)	4	9	10.67	4	8.0	5
II	120	8(6.67)	15	3	0.83	6	5.83	16
III	21	4(19.05)	30	3	4.76	14	14.29	35
IV	76	4(5.26)	76	3	2.63	3	2.63	150
V	86	7(8.14)	22	4	8.14	22	1.16	4
VI	17	2(11.76)	17	3	5.88	4	11.76	15

Cluster analysis showed that the rodents in the Mosuowan area could be divided into six communities with concentric circular distribution in general (Daming Zhang et al., 2005) (see Fig 1). From community Ⅰ to Ⅵ, from the peripheral desert the Haloxylon forest, to windbreaks to farmland, and eventually penetrated the central residential area, the rodent community evolved from desert gerbils to farmland then to domestic rodents. Ⅰ is the rodent community in the Haloxylon desert dominated by Rhombomys opimus+ Meriones meridianus; Ⅱ is the rodent community in the ecological windbreak forest dominated by Meriones erythrourus+Meriones meridianus+Allactaga. elate; Ⅲ is the rodent community in the cotton field dominated by Meriones tamariscinus+Meriones erythrourus; Ⅳ is a rodent community in grassland dominated by Mus musculus+Meriones tamariscinus+Apodemus sylvaticus; Ⅴ is a rodent community in a wheat field dominated by Mus musculus+Microtus norvegicus; Ⅵ is rodent community in the residential area dominated by Rattus norvegicus+Cricetulus migratorius+Mus musculus. As shown in Table 5,in comparison with the infection rate of endoparasite among different rodent communities, it showed that there were significant differences among community ($P < 0.05$), Ⅱ, Ⅲ, and Ⅳ community were significantly higher than the Ⅰ, Ⅱ, Ⅲ

community. ($P < 0.05$). The gerbil community and domestic rodent community's infection rate was higher than others, which might be related to the stable community and the camp cluster life. However, as for the intensity of infection, $\bar{x}$ was the lowest, s^2 and C_v was higher than the others. The number of parasites infected, the desert rodents were infected with nine species at most, and the other communities were three to four species.

Conclusion

Studies showed that:

1 The infection rate of endoparasite in rodents in this region is not related to gender but is closely related to the host's age, distribution area, host species, and season.

2 The rodents living in cluster life had a higher infection rate of endoparasites, especially infected with the same species, which indicated that their living habits facilitate the transmission of parasites within the population, thus having a more significant impact on the population quantity. In comparison, the rodents living in disperses had a lower infection rate and a smaller impact.

3 The infection intensity was not closely related to the species of infected endoparasites and the infection rate. It was mainly related to specific endoparasite species and rodent species.

Infection situation in different rodent communities indicated that: First, the species of endoparasite in the source host is the most comprehensive. During migration and community succession to the human settlement area, some of the parasites did not adapt to the host change and remained in the original host and native environment. However, some parasites with strong adaptability completed the migration from the desert native environment to the human settlement environment. Second, although primitive desert rodent communities had high infection rates and parasite species, the infection intensity was low. In contrast, the infection intensity and infection rate from the transition zone to the residential area was more significant, and the harm was more serious than others. Third, some parasite species were found in almost every rodent community and indicated that some parasite species with low specificity spread in the rodent population and spread among different rodent populations. With the migration and succession of rodents, there was a tendency to spread from the desert to the residential area, threatening to humanity. Fourth, the infection rate of the dominant rodent species in each community was high, which indicated that the parasites had the characteristics of seeking benefits and avoiding harm by selecting the dominant host. It is conducive to the parasite's reproduction.

In general, with the succession of rodent communities, the infection rate decreased from desert to artificial forest, farmland, and residential area. In contrast, the infection intensity increased, indicating that the direction and route of parasite transmission from primitive desert to artificial environment had been formed.

Due to the limited identification conditions and levels, only four nematodes of the 18 species were identified to genera and species, while the other 14 nematodes could only be identified to orders and families. Among the 15 species of tapeworm, only four species of tapeworm were identified to genus and species, while the other 11 species could only be identified to order and family.

Declarations

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Author Contribution

Xudong Zhou conceived and designed the study, conducted data gathering, performed statistical analyses, and wrote it. Wei Jiang provided some ideas for the identification of rodents and endoparasite species.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

Ethical Standards

Not applicable.

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Figures

Figure 1

Spatial configuration pattern of rodent community in Mosuowan reclamation area. Ⅵ is the rodent community in Haloxylon desert dominated; Ⅲ is the rodent community in the ecological windbreak forest; Ⅳ is the rodent community in the cotton field; Ⅴ is a rodent community in grassland; Ⅴ is a rodent community in a wheat field; Ⅱ is rodent community in the residential area.

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