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Taenia pisiformis Bloch, 1780 (Cestoda) as an endoparasite of mammals

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Abstract

Taenia pisiformis is a cosmopolitan cestode of considerable veterinary importance, circulating between carnivorous definitive hosts and lagomorph intermediate hosts. The present study investigated the occurrence, host range, and seasonal patterns of *T. pisiformis* infection among domestic and wild mammals in the Republic of Karakalpakstan, Uzbekistan. Mammals representing different host groups were examined using complete and incomplete helminthological necropsy, and cestodes were identified on the basis of morphological characters using standard parasitological methods. The infection was recorded in both definitive and intermediate hosts, indicating the active circulation of *T. pisiformis* in the studied ecosystems. Among intermediate hosts, the Tolai hare, *Lepus tolai*, was the most frequently infected species, confirming its important role in the life cycle of the parasite. Among definitive hosts, wild carnivores, particularly foxes and jackals, played a significant role in maintaining the transmission cycle. Seasonal differences were observed in the detection of infection; however, the data on larval stages in intermediate hosts should be interpreted with caution because metacestodes may persist in host tissues for extended periods. The findings demonstrate that *T. pisiformis* is widely

distributed among domestic and wild mammals in Karakalpakstan and emphasize the epidemiological importance of interactions between carnivores and lagomorphs. The results provide a scientific basis for further monitoring and for the development of targeted preventive measures against taeniid infections in domestic and wild animal populations.

Keywords
Metacestode, canines, lagomorphs, wild mammals, definitive and intermediate hosts, Karakalpakstan

Introduction

Tapeworms of the family Taeniidae are globally distributed and are among the most characteristic parasites of carnivorous mammals, occurring in a wide array of definitive hosts across diverse geographical regions of the world (Hoberg 2006). Scientific literature indicates that *Taenia pisiformis* Bloch, 1780 infects not only carnivores but also rabbits and other wild mammals (Schoeb et al. 2007). Infection with this parasite is primarily observed in lagomorph intermediate hosts, including domestic rabbits and hares; however, it can cause significant economic losses in rabbit farming worldwide. Since the metacestode stage of *T. pisiformis* usually does not produce distinct clinical signs, detection is difficult, and the infection is often diagnosed only during post-mortem examination. The metacestode stage of *T. pisiformis*, historically referred to as *Cysticercus pisiformis*, is one of the most common larval forms of taeniid cestodes, widely distributed worldwide and predominantly found in lagomorphs (Yang et al. 2013). Although infections are often subclinical, heavy parasite burdens in intermediate hosts can cause substantial hepatic damage, leading to hepatitis and, in chronic cases, cirrhosis (Loos-Frank 2000; Taylor et al. 2007). Historically, until the mid-nineteenth century, the larval and adult stages of *T. pisiformis* were considered separate parasitic species (Bowman 2009). This cestode species has a complex life cycle in which larvae develop in intermediate hosts, while adult forms develop in definitive hosts. Therefore, its ecological epidemiology, genetic diversity, and evolutionary dynamics have been extensively studied on a global scale (Yang et al. 2013; Mogalli 2020; Samorek-Pieróg et al. 2021; Ras et al. 2025; Piórkowski and Flis 2025). It has been emphasized that canids play a significant role in the transmission of *T. pisiformis*, and thus, further research on the detection of this parasite in definitive hosts is necessary (Zhang 2019). The occurrence of *T. pisiformis* in definitive hosts has often been reported in cases of co-infection with other parasitic species (Jenkins et al. 2014; Luong et al. 2018; Morandi et al. 2020).

In recent years, extensive studies have been conducted in Central Asia, including the CIS countries, on the morphological, molecular genetic, and ecological characteristics of *T. pisiformis* (Breslavtsev and Romashova 2018; Kamenov and Shinkarenko 2019; Striukov et al. 2022; Maslennikova 2023; Krivko et al. 2024). At the same time, the role of this parasite species in the veterinary healthcare system, its impact on animal health, and issues related to epidemiological surveillance are being systematically investigated.

Studies on the distribution of *T. pisiformis* under the conditions of our Republic, its life cycle, and its role in veterinary medicine have been conducted by Shakarboev, Berdibaev (2023) and Berdibaev et al. (2025).

The aim of this study was to determine the prevalence, host range, and seasonal patterns of detection of *T. pisiformis* infection in domestic and wild mammals.

Materials and methods

The study was conducted between 2022 and 2026 in various regions of the Republic of Karakalpakstan using both stationary and route-based survey methods. Field investigations were carried out in accordance with standard parasitological and zoological approaches. A total of 448 specimens of domestic and wild mammals were examined using complete and incomplete helminthological necropsy methods (Ivashkin et al. 1971; Anikanova et al. 2007; Shakarboev et al. 2025).

To ensure representative geographical coverage, investigations were performed across eight key localities encompassing the principal natural and ecological zones of Karakalpakstan. These included desert ecosystems, the dried seabed of the Aral Sea, river delta habitats, wetlands, and protected natural areas. The selected sampling sites and their geographical coordinates were as follows:

1. Ustyurt Plateau: 42°51′27.0″N, 58°41′17.0″E;
2. Dried Seabed of the Aral Sea, Uchsay area: 43°49′24.8″N, 58°53′31.0″E;
3. Lower Amu Darya State Biosphere Reserve: 42°00′19.0″N, 60°26′08.8″E;
4. Kyzylkum Desert: 42°54′51.5″N, 60°11′48.9″E;
5. Sudochie Lake, Muynak District: 43°25′02.2″N, 58°29′52.9″E;
6. Amu Darya Delta: 43°00′51.0″N, 59°10′27.8″E;
7. Dauitkul, Nukus District: 42°55′55.1″N, 59°24′08.5″E;
8. Nazarkhan, Amudarya District: 42°20′05.0″N, 59°59′34.4″E (Fig. 1).

These study sites were selected to represent the major landscape and ecological zones of the region, thereby enabling a comprehensive assessment of helminth diversity, host distribution, and parasite–host relationships under varying environmental conditions. Table 1 presents the examined mammalian species and the number of individuals studied for each species.

The species composition of cestodes was determined based on specimens stained with alum carmine and prepared as permanent slides. Identification of helminths was carried out using an SME-2 stereoscopic microscope (magnification ×10). Measurements of helminths were performed using a graduated ocular micrometer (Uspensky and Gorokhov 2012).

Species identification of adult cestodes, eggs, and metacestodes was performed using the taxonomic keys of Kozlov (1977) and Bowman (2009).

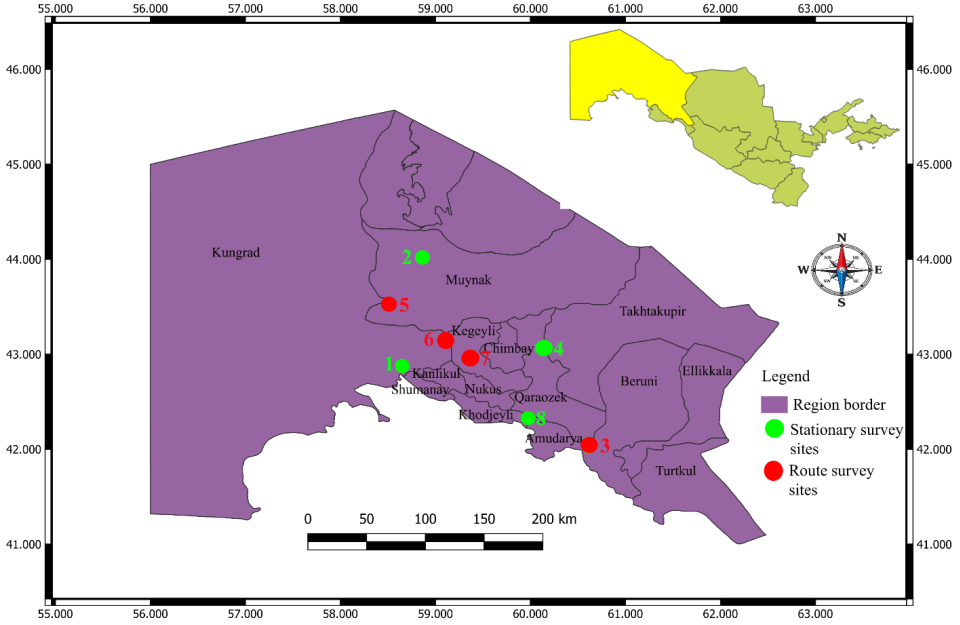

Figure 1. Sampling locations in Karakalpakstan.

Table 1. Species composition and number of examined animals

Animal species	Examined (n)
Definitive hosts	**369**
Domestic cat – *Felis domestica* Linnaeus, 1758	35
Dog – *Canis lupus familiaris* Linnaeus, 1758	43
Golden jackal – *Canis aureus* Linnaeus, 1758	91
Wolf – *Canis lupus* Linnaeus, 1758	41
Red fox – *Vulpes vulpes* (Linnaeus, 1758)	62
Badger – *Meles meles* (Linnaeus, 1758)	25
Jungle cat – *Felis chaus* Schreber, 1777	39
Wildcat– *Felis lybica* Forster, 1780	33
Intermediate hosts	**79**
Tolai hare – *Lepus tolai* Pallas, 1778	33
Domestic rabbit – *Oryctolagus cuniculus domesticus* (Linnaeus, 1758)	46

Quantitative indicators of infection of domestic and wild mammals with T. pisiformis, as well as the distribution of the parasite within the host organism, were calculated based on parasitological parameters such as prevalence (P), intensity of infection (I), and abundance (A) (Bush et al. 1997).

All numerical data were subjected to mathematical and statistical analysis. Certain statistical analyses were performed using Microsoft Excel and OriginPro 7.5 software (OriginLab Corporation, USA).

Results

T. pisiformis was detected in all ten examined mammalian species. Of the 448 domestic and wild mammals examined by complete and incomplete helminthological necropsy, 159 individuals were found to be infected, corresponding to an overall prevalence of 35.5%. Figure 2 shows an adult specimen of *T. pisiformis* collected from the intestine of a golden jackal, *Canis aureus*.

Figure 2. Adult specimen of *Taenia pisiformis* collected from the intestine of a golden jackal, *Canis aureus*.

Infection was recorded in both carnivorous definitive hosts and lagomorph intermediate hosts. Among the intermediate hosts, the highest prevalence was recorded in the Tolai hare, *Lepus tolai*, whereas among the definitive hosts, the highest prevalence was observed in the red fox, *Vulpes vulpes*. The highest intensity of infection was recorded in the golden jackal, *Canis aureus* (Table 2).

Table 2. Infection parameters of domestic and wild mammals with *T. pisiformis* under the conditions of Karakalpakstan

Animal species	Number of examined animals	Prevalence		Intensity of infection	
		n (individuals)	%	min-max	M±m
Felis domestica	35	7	20.0	1–4	2.6±0.1
Canis lupus familiaris	43	11	25.6	1–11	8.5±0.5
Canis aureus	91	35	38.5	2–27	12.4±1.2
Canis lupus	41	17	41.5	2–11	7.9±0.5
Vulpes vulpes	62	27	43.5	3–21	12.6±1.2
Meles meles	25	9	36.0	1–14	9.5±0.8
Felis chaus	39	15	38.5	2–21	11.7±1.1
Felis lybica	33	10	30.3	2–19	13.6±1.3
Lepus tolai	33	19	57.6	1–17	12.5±1.2
Oryctolagus cuniculus domesticus	46	9	19.6	1–6	3.6±0.2

The metacestode stage of *T. pisiformis* was detected in the liver of Tolai hares, Lepus tolai. Figure 3 shows larval cysts of *T. pisiformis* in the liver of a Tolai hare collected from the lower reaches of the Amu Darya River.

Figure 3. Larval cysts of *Taenia pisiformis* in the liver of a Tolai hare, *Lepus tolai*, from the lower reaches of the Amu Darya River.

During our study, 271 larval cysts of *T. pisiformis* were observed in the liver and peritoneal membranes of a single tolai hare specimen. When the larval cysts of *T. pisiformis* isolated from tolai hares were placed in Petri dishes and separated from their cystic membranes, it was observed that the larvae died after a certain period of time (Fig. 4).

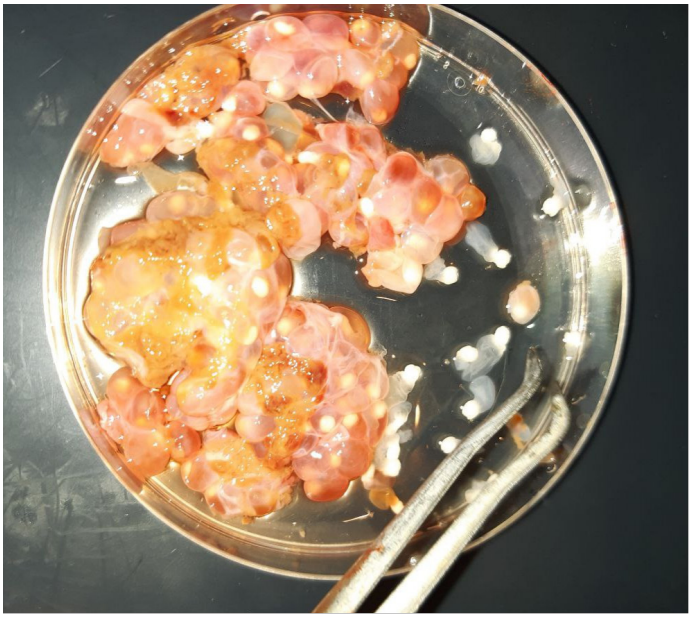

Figure 4. Larval cysts of *Taenia pisiformis* isolated from a tolai hare in the lower reaches of the Amu Darya River.

Seasonal patterns in the detection of *T. pisiformis* infection were analyzed in domestic and wild mammals. The results showed seasonal variation in the detection of infection among definitive and intermediate hosts (Table 3). However, the data for intermediate hosts should be interpreted with caution, as metacestodes may persist in host tissues for a long period and may not reflect recent seasonal infection.

Seasonal patterns in the detection of *T. pisiformis* infection were analyzed in domestic and wild mammals. The results showed seasonal variation in detection rates among definitive and intermediate hosts (Table 3). However, the data for intermediate hosts should be interpreted with caution, as metacestodes may persist in host tissues for a long period and may not reflect recent seasonal infection.

Among definitive hosts, the highest detection rates of *T. pisiformis* were recorded in spring (46.9%) and summer (40.0%), whereas lower rates were observed in winter (34.8%) and autumn (21.3%) (Fig. 5).

Among intermediate hosts, the metacestode stage of *T. pisiformis* was more frequently detected in winter (53.8%) and autumn (50.0%) than in summer (14.3%)

and spring (5.8%). However, these findings should be interpreted cautiously, because metacestodes may persist in host tissues for an extended period and may not reflect recent seasonal infection (Fig. 6).

Table 3. Seasonal patterns in the detection of *Taenia pisiformis* infection in definitive and intermediate hosts in Karakalpakstan

Animal species	Spring		Summer		Autumn		Winter	
	Examined	Infected	Examined	Infected	Examined	Infected	Examined	Infected
Definitive hosts	**98**	**(46.9%)**	**65**	**(40.0%)**	**94**	**(21.3%)**	**112**	**(34.8%)**
Felis domestica	10	(30.0%)	8	(37.5%)	8	–	9	(11.1%)
Canis lupus familiaris	11	(36.4%)	9	(22.2%)	11	(18.2%)	12	(25.0%)
Canis aureus	24	(54.2%)	13	(46.1%)	22	(22.7%)	32	(34.4%)
Canis lupus	11	(45.4%)	7	(42.8%)	11	(27.3%)	12	(50.0%)
Vulpes vulpes	15	(53.3%)	9	(44.4%)	15	(33.3%)	23	(43.5%)
Meles meles	7	(42.8%)	7	(42.8%)	9	(33.3%)	2	–
Felis chaus	11	(54.5%)	7	(42.8%)	10	(20.2%)	11	(36.4%)
Felis lybica	9	(44.4%)	5	(40.0%)	8	–	11	(36.4%)
Intermediate hosts	**17**	**(5.8%)**	**14**	**(14.3%)**	**22**	**(50.0%)**	**26**	**(53.8%)**
Lepus tolai	7	(14.3%)	6	(33.3%)	9	(77.8%)	11	(81.8%)
Oryctolagus cuniculus domesticus	10	–	8	–	13	(30.8%)	15	(33.3%)
Total	**115**	**(40.8%)**	**79**	**(35.4%)**	**116**	**(26.7%)**	**138**	**(38.4%)**

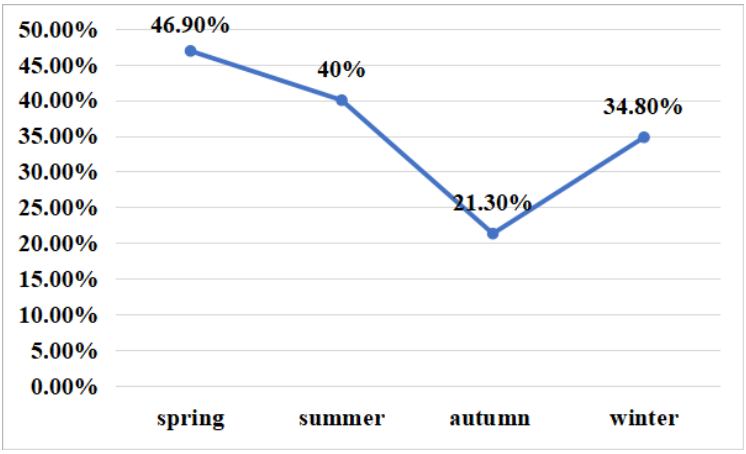

Figure 5. Seasonal detection rates of *Taenia pisiformis* infection in definitive hosts in Karakalpakstan.

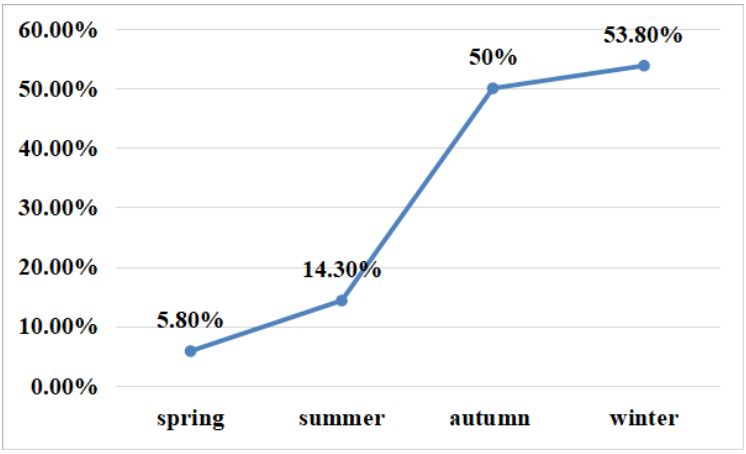

Figure 6. Seasonal detection patterns of the metacestode stage of *Taenia pisiformis* in intermediate hosts in Karakalpakstan.

Discussion

The results of the present study demonstrated that *Taenia pisiformis* is widely distributed among both domestic and wild mammals in Karakalpakstan, with an overall prevalence of 35.5%. This level of infection is generally consistent with findings reported in previous international studies, indicating the broad epidemiological distribution of this parasite across different ecological settings. In particular, studies conducted on rabbits have reported an overall infection prevalence of 21.3%, while in domestically reared rabbits the prevalence has been shown to reach up to 40.2% (Ras et al. 2025). In the present study, the infection rate detected in domestic rabbits (19.6%) confirms the active circulation of the larval stage of *T. pisiformis* within rabbit populations, highlighting their role as intermediate hosts in the parasite's life cycle. A similar pattern was reported by Mogalli (2020), who documented a markedly higher prevalence of infection in domestic rabbits (76.6%), with metacestodes predominantly localized in the liver and peritoneal cavity, thereby emphasizing the pathological significance of *T. pisiformis* infection. Likewise, studies conducted in Iraq revealed a prevalence of 23.33% for *T. pisiformis* infection in rabbits (Al-Khayat and Al-Azawi 2024), further supporting the widespread involvement of rabbits as key intermediate hosts.

Comprehensive morphological and molecular studies conducted on wild canids – including foxes, coyotes, and wolves – in Canada have demonstrated a high circulation of *Taenia* spp. within these host populations. The overall prevalence has been reported to range from 47% to 52%, with certain species, particularly forms closely related to *T. pisiformis*, occurring in foxes at rates of up to 27% (Bouchard 2021). These findings confirm that wild canids serve not only as definitive hosts for these

parasites but also as ecologically important paratenic hosts, ensuring their long-term persistence in natural ecosystems. The findings of our study in Karakalpakstan strongly support this ecological pattern. A consistently high prevalence of infection was recorded among wild carnivores, with infection rates of 43.5% in foxes, 41.5% in wolves, and 38.5% in jackals. These data underscore the pivotal role of wild carnivores in maintaining the natural transmission cycle of *T. pisiformis* in the region.

In domestic animals, particularly dogs (25.6%) and cats (20.0%), the comparatively lower prevalence of infection may be attributed to controlled husbandry practices and access to veterinary care. Nevertheless, dogs represent the principal definitive host of *T. pisiformis* and play a crucial role in the transmission cycle of this parasite. Infection typically occurs through the consumption of infected intermediate hosts, especially rabbits. Furthermore, contact between domestic animals and wildlife, as well as uncontrolled feeding behavior, can substantially increase the risk of infection (Rashed et al. 1991; Ras et al. 2025).

Among intermediate hosts, the infection prevalence observed in Tolai hare (*Lepus tolai*) populations (57.6%) indicates that this species serves as an important paratenic host in the biological cycle of *T. pisiformis*. This level of infection is considerably higher than those reported in many regions of Europe, including Spain (2.8–6.1%) (Remesar et al. 2021), Scotland (3%) (Boag 1985), and England (28%) (Allan et al. 1999). However, it is close to the prevalence recorded in wild rabbits from Mexico, where an infection rate of 67.7% has been documented (Domínguez-Roldán et al. 2018). Such geographical variation in prevalence suggests that the distribution of *T. pisiformis* metacestodes is likely associated with ecological conditions, the density of definitive hosts, predator–prey interactions, and the biological characteristics of lagomorph populations. Therefore, the high infection rate observed in the present study confirms the active natural circulation of *T. pisiformis* within the local ecosystem and highlights the Tolai hare (*L. tolai*) as an epidemiologically significant intermediate host.

In support of this ecological pattern, regional studies from the Rostov region have also reported the circulation of *C. pisiformis* in European brown hare (*Lepus europaeus*) populations, with an overall prevalence of 15.1%, where 4 out of 6 examined individuals were infected. Notably, infection levels varied significantly across different areas, ranging from 0% to 50%, which has been attributed to differences in the distribution and density of definitive hosts such as foxes, wolves, jackals, stray dogs, and hunting dogs (Krivko et al. 2024).

In the present study, the recovery of 271 metacestodes of *T. pisiformis* from a single host indicated a high intensity of infection. This finding reflects the parasite's strong reproductive potential and the widespread contamination of the environment with infective eggs. At the same time, pathological changes observed in infected rabbits have also been extensively described by other authors (Rabie et al. 2024; Pritt et al. 2012).

In definitive hosts, the seasonal dynamics of *T. pisiformis* infection showed higher prevalence during spring (46.9%) and summer (40.0%), whereas lower infec-

tion rates were recorded in winter (34.8%) and particularly in autumn (21.3%). This pattern indicates a 2.2-fold decrease in prevalence from spring to autumn. Such seasonality is closely associated with the parasite's biological cycle and ecological factors, including the feeding intensity of carnivores and the availability of intermediate hosts. A similar trend was reported by Rashed et al. (1991) in a study conducted in Cairo, where infection rates of 63.4% in winter and 70.8% in spring were documented, indicating a persistently high parasitic burden. The authors attributed this phenomenon to the consumption of infected rabbit tissues and the active transmission of the parasite through the trophic chain.

Modern studies have demonstrated that the investigation of the molecular genetic characteristics of *T. pisiformis*, particularly based on the cox1 and nad1 genes, plays an important role in determining its population structure (Ras et al. 2025; Samorek-Pieróg et al. 2021). Therefore, future molecular-level studies of *T. pisiformis* populations in the Karakalpakstan region represent a highly relevant and promising scientific direction.

Overall, the obtained results indicate that *T. pisiformis* is widely distributed in the study area, with active circulation between definitive and intermediate hosts and a clearly expressed seasonal dynamic. These findings provide a solid scientific basis for the development of effective preventive and control measures against this parasite.

Conclusion

The present study demonstrated that *Taenia pisiformis* circulates among both domestic and wild mammals in the Republic of Karakalpakstan. The parasite was recorded in carnivorous definitive hosts as well as in lagomorph intermediate hosts, indicating the stability of its transmission cycle in the studied ecosystems. Wild carnivores, particularly foxes, jackals, and wolves, play an important role in maintaining the adult stage of the parasite, whereas Tolai hares and domestic rabbits serve as important intermediate hosts for the metacestode stage.

The findings confirm that interactions between definitive and intermediate hosts are essential for the persistence of *T. pisiformis* in natural and anthropogenic ecosystems of Karakalpakstan. The detection of the parasite in both wild and domestic animals also indicates the need for regular parasitological monitoring and improved veterinary control measures.

Preventive measures should focus on routine deworming of domestic dogs and cats, veterinary supervision of domestic rabbits, prevention of access of carnivores to infected viscera, and proper disposal of organs containing metacestodes. For wild mammals, continued surveillance is recommended rather than direct anthelmintic treatment.

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