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Original article

STUDY OF THE PREVALENCE AND MORPHOLOGICAL FEATURES OF CESTODES IN FOXES (*VULPES VULPES*) IN THE TERRITORY OF KAZAKHSTAN

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ABSTRACT

This study aimed to examine the prevalence and morphological features of cestodes in foxes (*Vulpes vulpes*) in the territory of Kazakhstan. From 2020 to 2024, 53 foxes were analysed using the complete helminthological dissection method by Skrjabin K.I. The detected cestodes were preserved in 70% alcohol, after which their morphology was studied using microscopy and hematoxylin-eosin staining. It was found that 43.3% of the examined foxes were infected with cestodes, represented by three genera: *Taenia*, *Mesocestoides*, and *Dipylidium*. The most common species was *Mesocestoides* spp. (39.1%), followed by *Taenia crassiceps* (30.4%), *Taenia hydatigena* (21.7%), and *Dipylidium caninum* (8.8%). Morphological studies revealed structural features of the proglottids and reproductive organs in each cestode species. The obtained data allows for assessing the infection level of the fox population with cestodes, which is important for understanding the ecology of parasitic infections in Kazakhstan and developing control measures against them.

Keywords: foxes, cestodes, *Taenia*, *Mesocestoides*, *Dipylidium*, morphology, parasitic infections.

1. INTRODUCTION

C*estodiasis i*s one of the most common parasitic infections among wild animals, particularly foxes (Vulpes vulpes), and can *threat*en *animals and* humans [1]. Foxes serve as definitive hosts for many cestode species, such as Taenia, Mesocestoides, and *Dipylidium*, which can spread through food chains to other wild and domestic animals [2]. Cestodes affect the health of wild populations, impacting the entire ecosystem. Moreover, their presence indicates potential risks to agriculture and human health, as some of these parasites can be zoonotic, causing human diseases [3,4].

Cestodes such as *Mesocestoides* spp., *Taenia hydatigena*, *Taenia crassiceps*, and *Dipylidium caninum* play a significant role in fox parasitic infections worldwide. These parasite species are found in foxes across various regions, highlighting their wide geographical distribution and importance in veterinary and public health [5,6].

As predators, foxes often serve as definitive hosts for many cestode species, including *Mesocestoides* spp., which have been predominantly identified in European countries such as Poland and Italy, as well as in China and Mongolia. This species is characterised by a complex life cycle involving intermediate and definitive hosts, challenging its study and control. *Mesocestoides* spp infect various animals, including mammals and birds, leading to a wide range of diseases in wild and domestic animals [7,8].

Taenia hydatigena and *Taenia crassiceps* are other widespread cestode species commonly found in foxes across different regions. *T. hydatigena* frequently affects both domestic and wild animals, such as sheep and cattle, leading to significant economic losses in agriculture. In contrast, *T. crassiceps* can cause life-threatening infections in small mammals, such as rodents, which serve as intermediate hosts. This cestode species has been recorded in foxes in several regions, including Yakutia in Russia.

Dipylidium caninum, although less frequently associated with wild foxes, remains a parasite of concern for domestic animals such as dogs and cats and humans, particularly children. This cestode is globally distributed, with fleas acting as intermediate hosts in its life cycle.

International experience shows that studying and controlling the spread of cestodes in foxes is crucial for veterinary and public safety, given their ability to infect a wide range of animals and humans [9-13].

Few studies have been conducted in Kazakhstan on the prevalence and species composition of cestodes in wild foxes. Thus, the relevance of this study is due to the need to identify the main cestode species and assess their infection levels among fox populations in the region.

The goal of this study was to investigate the morphology and distribution of cestodes in foxes in the territory of Kazakhstan. To achieve this, 53 foxes were examined using the complete helminthological dissection method by Skrjabin K.I., allowing the identification of the main cestode species and determination of their infection rates.

2. MATERIALS AND METHODS

T*he helmintho*logical study of cestodes in foxes (Vulpes vulpes) was conducted in the parasitology laboratory of the

Faculty of Veterinary Medicine and approved by the Animal Ethics Committee of the S. Seifullin Kazakh Agrotechnical Research University (Protocol No. 1, July 24, 2019). From 2020 to 2024, 53 foxes were examined through complete helminthological dissection following the method of Skrjabin K.I.

The dissection was performed to extract intestinal helminths, with the carcasses being fixed on an anatomical table under sterile conditions. The abdominal cavity was opened using sterile instruments, and the gastrointestinal tract was then extracted. The tract was cut along its entire length, from the stomach to the rectum. The helminths found were collected with tweezers and fixed in 70% alcohol [14-16].

Samples were processed using the standard hematoxylin-eosin staining technique for microscopic identification. The staining procedure included the following steps: 1. Samples were incubated in hematoxylin for 10 minutes, 2. Differentiation in hydrochloric acid alcohol, 3. Differentiation in ammonia water until a blue tint appeared, 4. Staining with eosin for 2 minutes, 5. Dehydration with 70% alcohol [17].

The morphological identification of cestodes was carried out using the publication by Chelladurai, J. J. «Canine Tapeworms,» Today's Veterinary Practice, 2022, *as a reference* guide. The identification of Dipylidium caninum was based on characteristic features of the scolex and proglottids, as well as the presence of hermaphroditic organs. The proglottids contained egg capsules, which served as an additional criterion for species determination. Key features included the presence of a central trunk in the proglottids *and symmetrical* lateral branches in identifying Taenia hydatigena. These morphological charact*eristics enabled* precise species identification. Taenia crassiceps identification was based on the structure of the hermaphroditic proglottids, including the ovary, testes, *and reproduc*tive organs. The identification of Mesocestoides spp relied on the absence of hooks on the scolex and the symmetrical arrangement of reproductive organs [18]. Cestode morphology was studied using an inverted microscope MC 700 (I). Standard parasitological indices were used to assess the foxes' infestation with parasites: prevalence of infection (%) and helminth abundance index (AI).

3. RESULTS

During the complete helminthological dissection following Skrjabin's K.I. method, we examined the carcasses of 53 foxes, of which 43.3% were infected with cestodes (Figure 1 A), belonging to three genera: *Taenia*, *Mesocestoides* and *Dipylidium*. Microscopic examination revealed the following results: *Mesocestoides* spp. (39.1%), *Taenia crassiceps* (30.4%), *Taenia hydatigena* (21.7%), *Dipylidium caninum* (8.8%) (Figure 1 B).

The study analysed fox samples from three regions of Kazakhstan to assess the prevalence of cestode infections and the abundance index of helminths. The results showed that the Karaganda region had the highest level of fox cestode infections.

In the Akmola region, out of 16 foxes examined, 7 (43.8%) were infected with cestodes. The species found in this region included *Mesocestoides* spp., *Taenia hydatigena*, and *Taenia crassiceps*. These species' helminth abundance index (AI) was 22.3, 16.5, and 23.4 individuals, respectively. In the Karaganda region, out of 31 foxes, 13 (41.9%) were infected. In addition to *Mesocestoides* spp., *Taenia hydatigena*, and *Taenia crassiceps*, *Dipylidium caninum* was also identified, indicating a more diverse range of parasites. Abundance index was 28.9 for *Mesocestoides* spp., 18.7 for *Taenia hydatigena*, 21.3 for *Taenia crassiceps*, and 7.5 for *Dipylidium caninum*. The Kostanay region recorded the highest infection rate, with 3 out of 6 foxes (50%) infected with cestodes. The species found included *Mesocestoides* spp., *Taenia hydatigena*, and *Taenia crassiceps*, with helminth abundance indices of 24.1, 16.7, and 18.9, respectively.

The results demonstrated significant differences in the prevalence and species composition of cestode infections among foxes across different regions. The highest infection rate and cestode diversity were observed in the Karaganda region, which may be linked to differences in fox ecology, population density, diet, and environmental conditions.

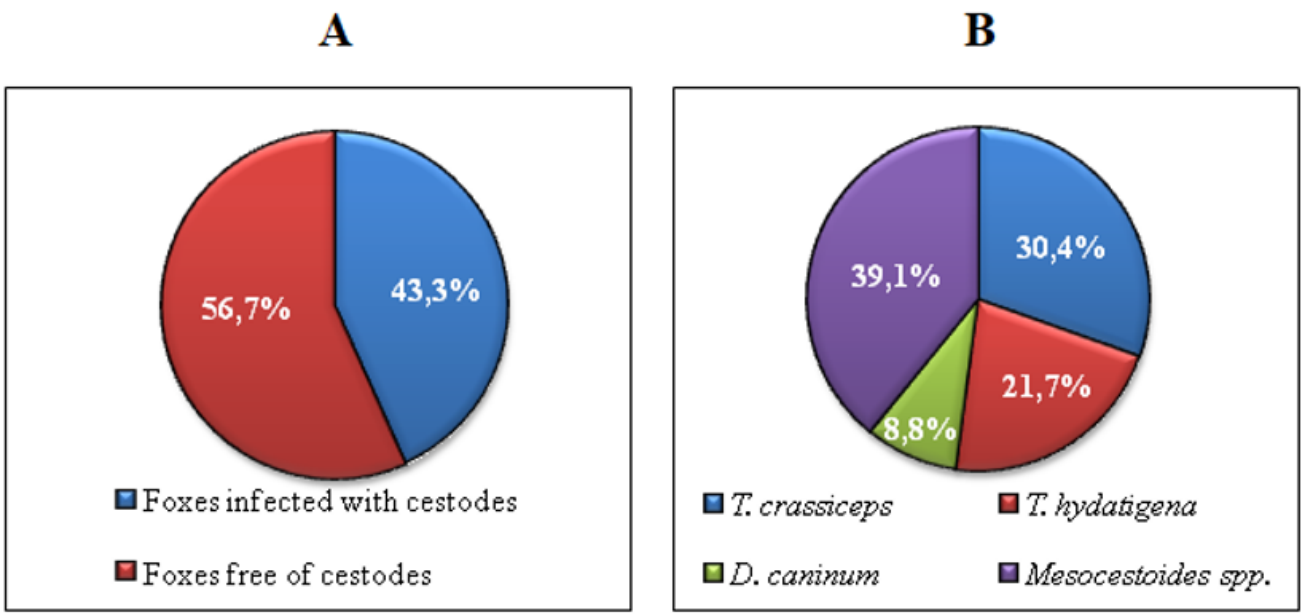

Figure 1 – Prevalence of Infection (%): (A) Examined foxes, (B) Infected foxes.

Table 1 – Prevalence of cestode infections and helminth abundance index in foxes from different regions of Kazakhstan.

Region	Number of foxes examined	Number of infected foxes	Species of cestodes	Helminth abundance index (AI)
Akmola Region	16	7	*Mesocestoides* spp.	22,3
			Taenia hydatigena	16,5
			Taenia crassiceps	23,4
			Dipylidium caninum	–
Karaganda Region	31	13	*Mesocestoides* spp.	28,9
			Taenia hydatigena	18,7
			Taenia crassiceps	21,3
			Dipylidium caninum	7,5
Kostanay Region	6	3	*Mesocestoides* spp.	24,1
			Taenia hydatigena	16,7
			Taenia crassiceps	18,9
			Dipylidium caninum	–

Dipylidium caninum displayed characteristic cestode morphology, starting with a narrow neck connecting the scolex to the main body. The neck is long and gradually widens, forming new proglottids. Initially, the proglottids are narrow and less differentiated, but as they progress along the strobila, they grow and develop their final form (Figure 1). These mature proglottids are rectangular and have a dense texture with clearly defined internal structures, including egg capsules. Each proglottid contains both male and female reproductive organs.

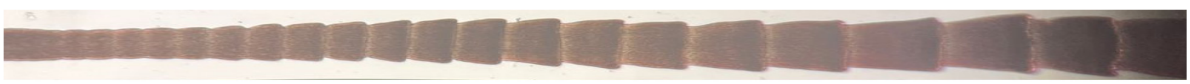

Figure 1 – Neck of *Dipylidium caninum* (×5).

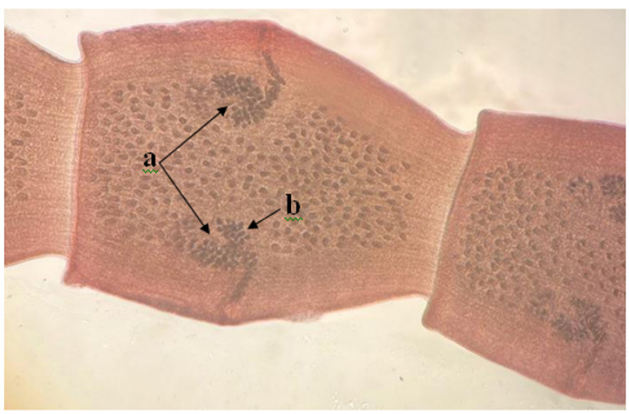

Figure 2 – Mature proglottids of *Dipylidium caninum* – (a) mature segments, (b) eggshell (×5).

A pair of mature proglottids (Figure 2 a) located in the central section is filled with numerous eggs (Figure 2 b). The colouration of the proglottids ranges from pinkish to brown, emphasising their internal structure. Together, these morphological features reflect the growth and development of *Dipylidium caninum*, from the formation of proglottids in the neck to their mature, reproductively active form.

Microscopic analysis showed the structure of the strobila of the helminth, likely belonging to *Taenia hydatigena*. In the micrograph of a mature *Taenia hydatigena* proglottid (Figure 3), the central trunk of the proglottid is visible, running along the entire length (Figure 3 a). The proglottid has a simple tubular structure with numerous lateral branches extending from the sides (Figure 3 b). These branches symmetrically fill most of the proglottid's area, which is typical for mature proglottids of the *Taenia* genus. The branches extend towards the lateral edges of the proglottid and are well differentiated, with 8 to 10 branches on each side.

The central trunk expands as it approaches the posterior edge of the proglottid, where egg formation begins. The micrograph confirms that a dense shell surrounds the eggs and features the characteristic *Taenia* oncosphere.

The muscle layers of the proglottid are located on the periphery, providing flexibility and mobility, while the parenchyma filling the internal space supports the organ's structure. The outer surface of the proglottid is covered with a cuticle, which allows the parasite to absorb nutrients and offers protection from the external environment.

In Figure 4, the hermaphroditic proglottid of *Taenia crassiceps* clearly shows well-developed reproductive organs, typical for this species. The proglottid has a rectangular shape with distinct borders between adjacent segments. The central part of the proglottid is occupied by a large, well-differentiated unilobular ovary located closer to the posterior section. The ovary is rounded and stands against the proglottid's parenchyma (Figure 4 a).

Above the ovary, a compact and well-visible vitellarium is located, consisting of a dense group of small vesicular formations. It is important to provide the eggs with the necessary nutrients (Figure 4 b). In the central part of the proglottid, a genital duct is also visible, connecting the hermaphroditic structures.

Numerous testes, presented as small round vesicles, are located on both sides of the proglottid. These structures are evenly distributed and produce sperm. The testes have clear boundaries and are well differentiated. The genital duct is con-

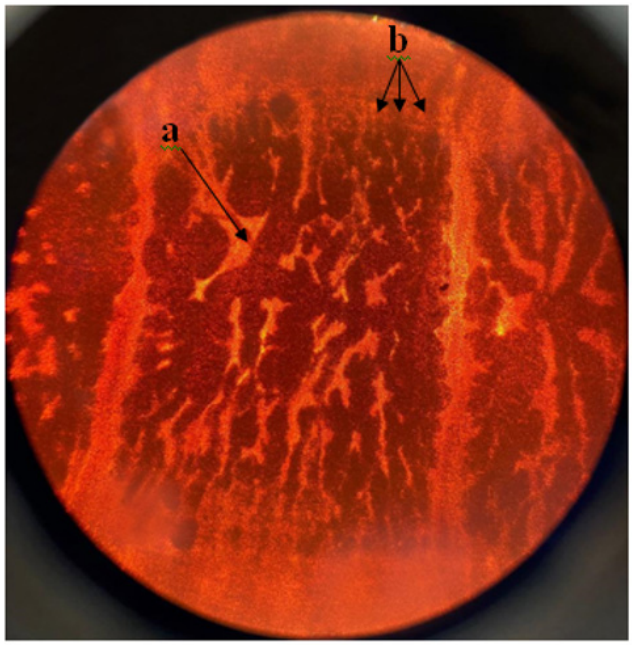

Figure 3 – Mature proglottid of *Taenia hydatigena* – (a) central stem of the segment, (b) lateral branches of the segment (×5).

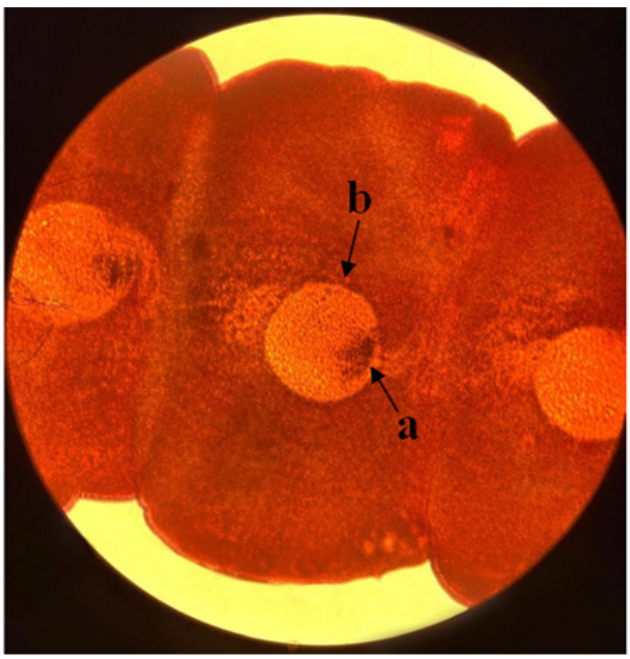

Figure 5 - Mature proglottid of *Mesocestoides* spp. – (a) mature segment, (b) seminal vesicles (×5).

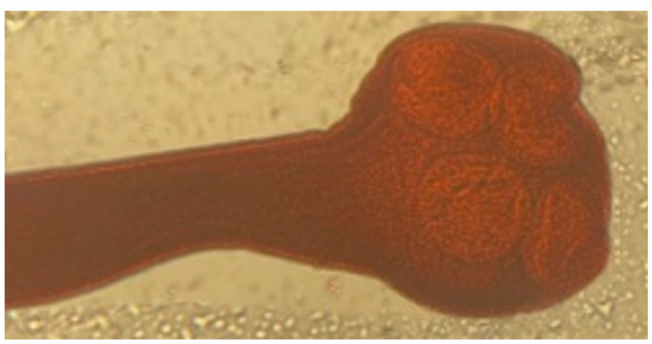

Figure 6 - Scolex of *Mesocestoides* spp. (×5).

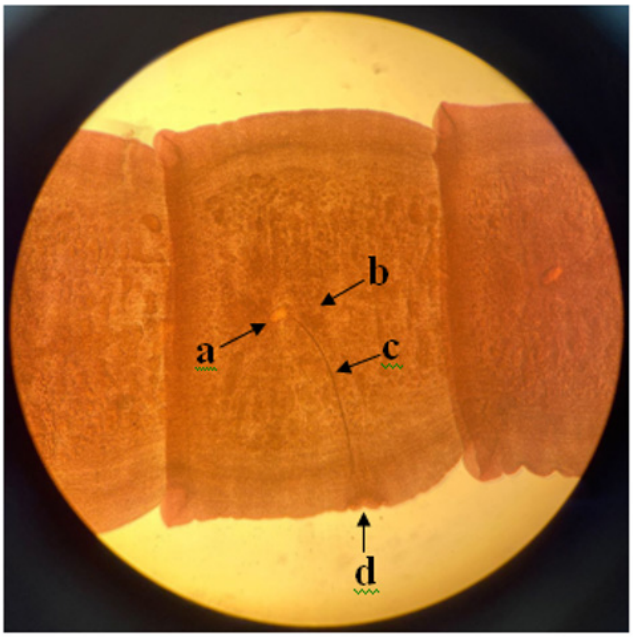

Figure 4 – Hermaphroditic proglottid of *Taenia crassiceps* – (a) ovary, (b) vitellaria, (c) genital pore, (d) genital duct (×5).

nected to the genital pore, which opens on the lateral surface of the proglottid and is visible in the micrograph (Figure 4 c, d).

The proglottid structure is supported by a parenchyma of dense tissue surrounding the reproductive organs and ensuring the structural stability of the segment. The outer surface is covered with a cuticle, providing protection and facilitating nutrient absorption.

Figure 5 demonstrates key morphological features of the *Mesocestoides* proglottid, enabling a more detailed analysis of their structure. A distinguishing feature is the elongated body with well-differentiated reproductive organs. Rounded structures inside the proglottid represent probable sections of the reproductive system, such as a mature segment and seminal vesicles (Figure 5 a, b). These structures are distinctly stained, with darker areas representing cell nuclei, and lighter areas showing the stained cytoplasm and intercellular substance.

The morphology of the mature segment confirms the genus *Mesocestoides* based on the symmetrical arrangement of reproductive organs. The visible reproductive structures indicate an active reproductive stage, typical of mature proglottids of this genus.

Figure 6 shows the scolex, the head section of the cestode. The *Mesocestoides* spp. scolex has four suckers symmetrically arranged around the head. Notably, the scolex lacks hooks, a characteristic feature of the *Mesocestoides* genus. This trait distinguishes these cestodes from other genera, where hooks often play a crucial role in parasite attachment in the host. The suckers serve as the primary means of fixation in the host's intestines.

Figures 5 and 6 confirm the classification of the presented samples as belonging to the *Mesocestoides* genus based on the absence of hooks and the presence of well-differentiated reproductive organs. The combination of morphological features, such as the structure of the scolex and mature segment, allows for confident identification of this genus, which is cru-

cial in epidemiological studies of parasites of this genus.

4. DISCUSSION

During this study, the morphological characteristics of four cestode species were thoroughly examined: *Dipylidium caninum*, *Taenia hydatigena*, *Taenia crassiceps*, and representatives of the genus *Mesocestoides*. For each species, key structural features of the proglottids and strobila morphology were described, allowing for their taxonomic classification and the identification of distinguishing traits. *Dipylidium caninum* stands out among the examined species due to its unique features, including two sets of reproductive organs in each proglottid and a distinctive neck structure. Meanwhile, *Taenia hydatigena* and *Taenia crassiceps* share morphological traits similar to those of other members of the genus, making their identification more challenging. The genus *Mesocestoides* also exhibits specific characteristics that differentiate it from *Taenia* species; however, structural similarities complicate their differentiation.

Microscopic examination of these cestodes was labor-intensive, requiring significant effort and time for accurate species identification. Despite its importance, morphological identification does not always provide 100% certainty, particularly when studying cestodes with similar features. It is difficult to differentiate closely related species, such as *Taenia hydatigena*, *Taenia crassiceps*, and *Mesocestoides* spp., where subtle differences may be easily overlooked or misinterpreted. Even *Dipylidium caninum*, despite its distinct morphological traits, can be difficult to identify in cases of poor sample preservation or insufficient expertise.

Given these challenges, genetic identification methods offer the most reliable solution for accurate cestode identification. Modern molecular techniques, such as PCR (polymerase chain reaction) and DNA sequencing, allow for highly precise species determination based on genetic material analysis. This is particularly valuable for species with similar morphology, where traditional methods may not be accurate enough. Genetic identification can significantly improve diagnostic accuracy, reduce research time, and minimise errors associated with morphological identification, providing more reliable and reproducible results in parasitological studies.

CONFLICT OF INTEREST

There are no conflicts of interest to declare.

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ИЗУЧЕНИЕ РАСПРОСТРАНЕННОСТИ И МОРФОЛОГИЧЕСКИХ ОСОБЕННОСТЕЙ ЦЕСТОД У ЛИСИЦ (*VULPES VULPES*) НА ТЕРРИТОРИИ КАЗАХСТАНА

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АБСТРАКТ

Целью данного исследования было изучение распространенности и морфологических особенностей цестод у лисиц (*Vulpes vulpes*) на территории Казахстана. В период с 2020 по 2024 год было исследовано 53 особи лисиц методом полного гельминтологического вскрытия по К.И. Скрябину. Обнаруженные цестоды были зафиксированы в 70%-ном спирте, после чего их морфология была изучена с использованием микроскопии и окраски гематоксилин-эозином. Было установлено, что 43,3% исследованных лисиц были заражены цестодами, представленными тремя родами: *Taenia*, *Mesocestoides* и *Dipylidium*. Наиболее распространенным видом оказался *Mesocestoides* spp. (39,1%), за ним следовали *Taenia crassiceps* (30,4%), *Taeina hydatigena* (21,7%) и *Dipylidium caninum* (8,8%). Морфологические исследования выявили особенности строения проглоттид и репродуктивных органов у каждого вида цестод. Полученные данные позволяют оценить степень зараженности популяции лисиц цестодами, что важно для понимания экологии паразитарных инфекций в Казахстане и разработки мер борьбы с ними.

Ключевые слова: лисицы, цестоды, *Taenia*, *Mesocestoides*, *Dipylidium*, морфология, паразитарные инфекции.

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ҚАЗАҚСТАН АУМАҒЫНДАҒЫ ТҮЛКІЛЕР (*VULPES VULPES*) ЦЕСТОДТАРДЫҢ ТАРАЛУЫ МЕН МОРФОЛОГИЯЛЫҚ ЕРЕКШЕЛІКТЕРІН ЗЕРТТЕУ

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АҢДАТПА

Бұл зерттеудің мақсаты Қазақстан аумағында түлкілер (*Vulpes vulpes*) цестодтарының таралуы мен морфологиялық ерекшеліктерін зерттеу болды. 2020-2024 жылдар аралығында 53 түлкі К.И. Скрябин бойынша толық гельминтологиялық сойып-ашу әдісімен зерттелді. Табылған цестодтар 70% спиртте тіркеліп, олардың морфологиясы микроскопия мен гематоксилин-эозин бояуы арқылы зерттелді. Зерттелген түлкілердің 43,3% - ы үш

тұқымдас түр цестодтарымен жұқтырылғаны анықталды, олар: *Taenia*, *Mesocestoides* және *Dipylidium*. Ең көп таралған түрі *Mesocestoides spp*. (39,1%) болып шықты, одан кейін *Taenia crassiceps* (30,4%), *Taeina hydatigena* (21,7%) және *Dipylidium caninum* (8,8%). Морфологиялық зерттеулер цестодтардың әр түріндегі проглоттидтер мен репродуктивті органдардың құрылымдық ерекшеліктерін анықтады. Алынған деректер Қазақстандағы паразиттік жұқпаларының экологиясын түсіну және олармен күресу шараларын әзірлеу үшін маңызды болып табылады, сонымен қатар түлкі популяциясының цестодтармен жұқтыру дәрежесін бағалауға мүмкіндік береді.

Түйінді сөздер: түлкілер, цестодтар, *Taenia*, *Mesocestoides*, *Dipylidium*, морфология, паразитарлық жұқпа.