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Yak thelaziasis in the Orenburg Oblast: *Musca autumnalis* (De Geer, 1776) as a vector and *Thelazia rhodesi* (Desmarest, 1827) as the causative agent of infestation

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ABSTRACT

Introduction. Thelaziasis remains a widespread vector-borne parasitic zoonosis both within the Russian Federation and globally. Thelaziasis in yaks remains insufficiently studied, with the available data being fragmentary. It is the first time a thelaziasis clinical case in yaks from the Orenburg Oblast is described and it is of significant interest to a broad range of specialists.

Objective. Analysis and clinical case description of thelaziasis in yaks from the Orenburg Oblast, including the study of its causative agent and vector.

Materials and methods. Studies conducted from 2021 to 2023 at the steppe field station of the Institute of Steppe of the Ural Branch of the Russian Academy of Sciences in the Belyayevsky Raion of the Orenburg Oblast included clinical examinations and assessment of pathological lesions and severity of inflammation in the eyes and conjunctiva of yaks. Parasitic secretophagous dipterans (flies) from the ocular region were collected and counted, and their abundance, species and sex ratios were determined. Helminthoscopy was performed, and the nematode species was determined morphologically.

Results. Clinically, thelaziasis in yaks manifested as profuse lacrimation and recurrent keratoconjunctivitis. The extent of invasion (EI) was 100%, and the intensity of invasion (II) was 5. The detected helminths belonged to *Thelazia rhodesi* species. The intermediate hosts and vectors of *Thelazia* were facultative hematophages, specifically *Musca autumnalis*, a synbovine fly species ubiquitous in the steppe landscapes of the Orenburg Oblast. The ratio of females to males collected from the head region of yaks was 83 and 17%, respectively, confirming the leading role of female *Musca autumnalis* as vectors of nematodes of the genus *Thelazia*.

Conclusion. Domestic yaks in the natural and climatic conditions of the Orenburg Oblast are susceptible to thelaziasis. The disease progress, its clinical manifestations, as well as extent and intensity of invasion are likely influenced by acclimatization of yaks, who are not indigenous to this region.

Keywords: ocular infection, thelaziasis, zoonosis, yaks, *Musca autumnalis*, *Thelazia rhodesi*

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Телязиоз яков в Оренбургской области: *Musca autumnalis* (De Geer, 1776) как переносчик и *Thelazia rhodesi* (Desmarest, 1827) как возбудитель инвазии

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РЕЗЮМЕ

Введение. Телязиоз остается широко распространенным трансмиссивным паразитарным зоонозом как на территории Российской Федерации, так и в мире. Заболевания телязиозом яков изучены недостаточно, имеющиеся сведения фрагментарны. Клинический случай телязиоза яков в Оренбургской области описывается впервые и представляет собой большой интерес для широкого круга специалистов.

Цель исследования. Анализ и описание клинического случая телязиоза яков в Оренбургской области, изучение возбудителя и переносчика данного инвазионного заболевания.

Материалы и методы. Исследования, проведенные в 2021–2023 гг. в степном стационаре Института степи Уральского отделения Российской академии наук в Беляевском районе Оренбургской области, включали клинический осмотр, оценку патологических процессов и степени воспалительных процессов глаз и конъюнктивы яков. Произведен отлов с области глаз и учет паразитических двукрылых мух-секретофагов, определены их количественные, видовые и половые характеристики. Проведена гельминтоскопия, видовая принадлежность обнаруженных нематод установлена морфологически.

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Результаты. Клинически телязиоз яков проявлялся в обильном слезотечении и рецидивирующем кератоконъюнктивите. Экстенсивность инвазии составила 100%, интенсивность инвазии равнялась 5. Обнаруженные гельминты принадлежали виду *Thelazia rhodesi.* Промежуточными хозяевами и переносчиками телязий являлись факультативные гематофаги, представители синбовинной фауны мухи *Musca autumnalis*, повсеместно распространенные в степных ландшафтах Оренбургской области. Соотношение самок и самцов, снятых в области головы яков, составило 83 и 17% соответственно, что подтверждает ведущую роль самок *Musca autumnalis* как вектора передачи нематод рода *Thelazia.*

Заключение. Домашние яки в природно-климатических условиях Оренбургской области подвержены телязиозу. Течение болезни, клинические проявления, экстенсивность и интенсивность инвазии, вероятно, обусловлены процессами акклиматизации яков, которые не являются аборигенными для данной местности.

Ключевые слова: глазная инвазия, телязиоз, зооноз, яки, *Musca autumnalis*, *Thelazia rhodesi*

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INTRODUCTION

Thelaziasis, caused by "eyeworms", is a seasonal parasitic keratoconjunctivitis spread across both Europe (England, Italy, Spain, France, Croatia, Serbia, Germany, Romania, Poland) and Asia (India, Korea, Taiwan, Thailand, Bangladesh, Mongolia, Indonesia, China, Myanmar, Japan) [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]. Sporadically, the invasion was noted in Africa, Australia, North and South America [2, 10].

According to the literature, bovine thelaziasis in the Russian Federation occurs in the Northwestern, Volga, West Siberian, and Far Eastern regions, as well as in the Middle and Southern Urals [11, 12, 13]. In the Orenburg Oblast, bovine thelaziasis is registered everywhere, the causative agent is *Thelazia rhodesi* (Desmarest, 1827) [1, 12, 14].

Currently, 16 *Thelazia* species have been described [10], the most common are:

– *Th. callipaeda* (Railliet et Henry, 1910) – oriental eye worm;
– *Th. californiensis* (Price, 1930) – California eye worm;
– *Th. gulosa* (Railiet et Henry, 1910) – cattle eye worm;
– *Th. lacrymalis* (Gurlt, 1831) – eyeworm in horses;
– *Th. rhodesi* (Desmarest, 1827) parasitic nematode of cattle;
– *Th. leesei* (Railliet et Henry, 1910);
– *Th. alfortensis* (Railliet et Henry, 1910);
– *Th. skrjabini* (Erschov, 1928);
– *Th. ershowi* (Oserskaja, 1931);
– *Th. bubalis* (Ramanujachari et Alwar, 1952);
– *Th. anolabiata* (Molin, 1860).

Nematodes of the genus *Thelazia* parasitize cattle, domestic horses, Przewalski's horses, donkeys, mules, and European bison [2, 3, 4, 6, 7, 8, 15]. The infection also affects small ruminants, pigs, cats, dogs, foxes, and rabbits [1, 5, 9]. Reports in the literature describe infection in deer, badgers, monkeys, and wolves [10]. Several cases of avian infestation have been described [1, 2, 16].

Thelaziasis in yaks has been confirmed in the Kabardino-Balkarian Republic. The extent of invasion (EI) was 2.7%, and the causative agent was *Thelazia gulosa* [17, 18]. There is evidence that *Th. skrjabini* can infest yaks [1].

In disadvantaged socioeconomic environments, humans can also become an accidental host of *Th. californiensis*, *Th. gulosa* or *Th. callipaeda*. Thus, thelaziasis is a parasitic zoonosis, which is consistent with the literature data [1, 10, 19, 20, 21].

The role of *Musca autumnalis* (De Geer, 1776) as an intermediate host for nematodes of the genus *Thelazia* has been extensively described in both Russian [11, 12, 16] and international literature [2, 3, 4, 10, 22].

The aim of this work was to study the vector *(Musca autumnalis)* and the causative agent (*Thelazia rhodesi*) of thelaziasis in yaks from the Orenburg Oblast. It is the first time a thelaziasis clinical case in yaks from the Orenburg Oblast is described and it is of significant interest to a broad range of specialists.

MATERIALS AND METHODS

The studies were carried out at the Orenburg Tarpania Steppe Field Station (Institute of Steppe of the Ural Branch of the Russian Academy of Sciences, Orenburg Federal Research Center of the Ural Branch of the Russian Academy of Sciences) in the Belyayevsky Raion of the Orenburg Oblast. This location is home to an assembled collection of ungulates: in addition to domestic yaks, the site supports populations of Przewalski's horses, Tibetan kiangs, Bactrian camels and wool goats.

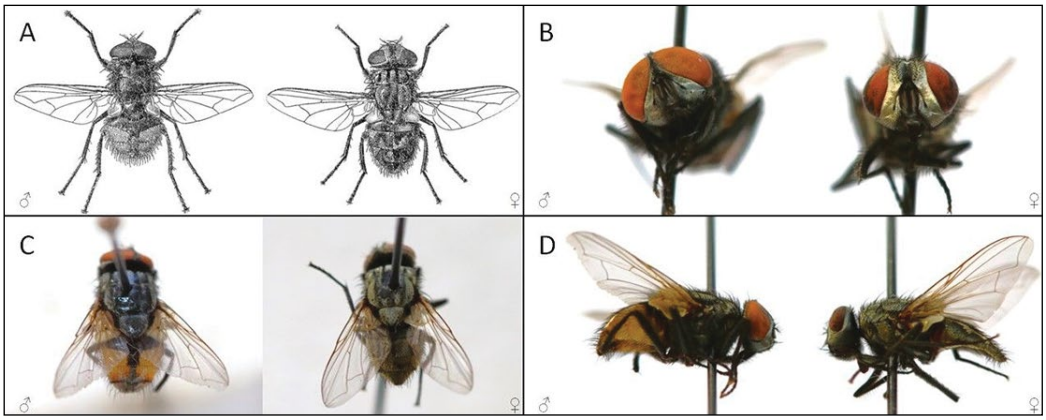

Fig. 1. M. autumnalis: A – dorsal view (adapted from A. A. Stackelberg, 1956, fig. 56, p. 75); B – head, illustrating holoptic eyes in the male and dichoptic eyes in the female; C – dorsal view; D – lateral view

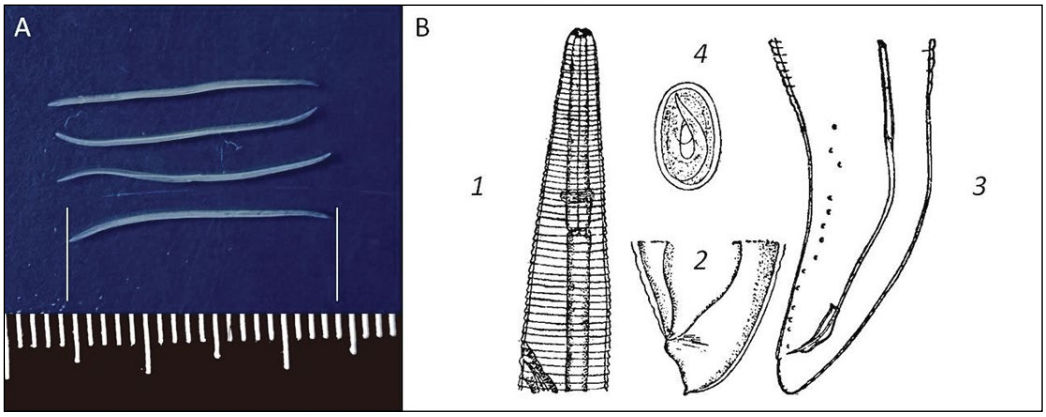

Fig. 2. Th. rhodesi: A – adult females from the yak conjunctival sac (external view and size); B – morphological details: 1 – anterior end, 2 – female posterior end, 3 – male posterior end, 4 – egg (adapted from K. I. Skryabin et al., 1934, fig. 277, p. 311)

In 2021–2023, yak were clinically examined to assess pathological lesions and inflammation degree in the eyes and conjunctiva.

Parasitic secretophagous dipterans (flies) from the ocular region were collected and counted, and their abundance, species and sex ratios were determined. Collection and counting of insects from the suborder *Brachycera Orthorrhapha* were carried out throughout the entire flight period of imago using an entomological sweep net directly on the animals, following standard methods for collecting *Diptera* [23]. Insects were identified using taxonomic keys [24, 25, 26].

Adult *Thelazia* nematodes were recovered by irrigating the conjunctival sacs of the yaks. The animal's head was secured, the eyelids were retracted, and the third eyelid and conjunctival cavity were flushed with a 3% boric acid solution. Strong jets of fluid were produced using a rubber bulb syringe to ensure thorough flushing. Next, contents of the conjunctival cavities were collected [16]. The nematode species were identified morphologically.

The study assessed both the extent of invasion, defined as the percentage of infected animals out of the total examined, and the intensity of invasion, defined as the number of parasite specimens recovered from an individual host.

Photographs were obtained using a Canon 760D camera (Japan) and a Nikon Eclipse E200 microscope (Japan).

RESULTS AND DISCUSSION

Musca autumnalis (the face fly) belongs to the family *Muscidae* (Latreille, 1802), which includes house flies and stable flies. It belongs to the superfamily *Muscoidea*, section *Calyptratae*, suborder *Brachycera (Cyclorrhapha)*, order *Diptera* [26]. *M. autumnalis* is widespread in the Palearctic region, throughout Western Europe (Sweden, Norway, Spain, Italy), the Caucasus and Central Asia. These flies inhabit steppe, semi-desert, forest-steppe, and forest landscapes, and are a component of pasture fauna [1].

Fifty-eight species of *Diptera – Brachycera* from the synbovine complex have been identified in the Orenburg Cis-Urals, 40 of which are capable of mechanically transmitting helminths of medical and veterinary importance (including pinworms, ascarids, whipworms, tapeworms, hookworms, *Drascheia megastoma*, *Habronema*, *Parabronema*, *Parafilaria*, *Setaria*, *Stephanofilaria*, and *Thelazia*) [27]. *M. autumnalis* was found to be active throughout the flight

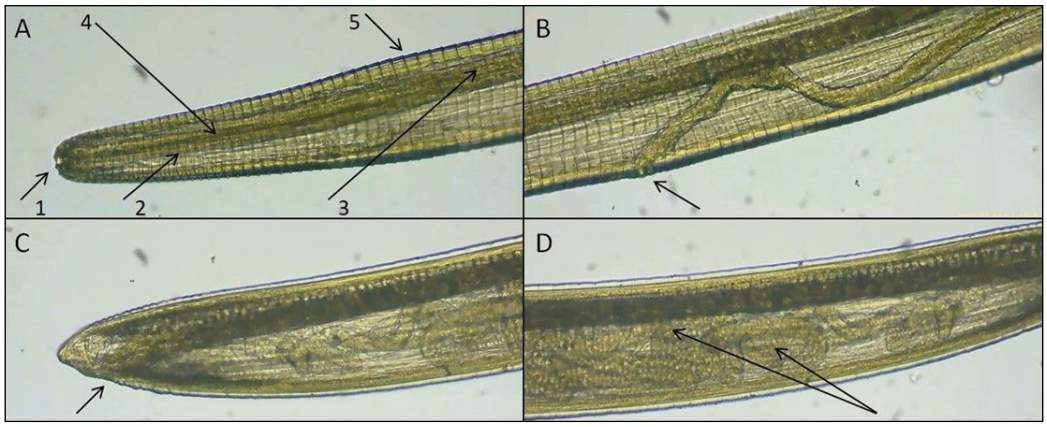

Fig. 3. Morphology of Th. rhodesi female. A – anterior end: 1 – oral opening (mouth), 2 – esophagus, 3 – intestinal tube, 4 – nerve ring, 5 – cuticular striations; B – vulva region, genital opening situated near the anterior end; C – posterior end, anal opening (anus); D – uterus containing eggs within the nematode body

period, from early spring to late autumn, confirming its status as a thermophilic species. Figure 1 shows the pronounced sexual dimorphism in eye color and structure between male and female flies. Holoptic eyes in males are adapted for swarming and mating in flight. The male exhibits symmetrical, translucent dark yellow spots located on the third and fourth abdominal tergites. The female has an abdomen entirely covered in a grayish bloom with iridescent spots; setae are developed on the first sternite [26].

Females constituted the overwhelming majority of the insects captured. The ratio of females to males collected from the head region was 83 and 17%, respectively, confirming the data of G. A. Kotelnikov [16] and F. Gregor et al. [22] regarding the leading role of females from an ecological and veterinary perspective. *M. autumnalis* serves as a transmission agent for various pathogens, particularly nematodes of the genus *Thelazia*.

Musca autumnalis is a typical representative of the synbovine, zoophilic fauna. In the imaginal stage, for example, members of the family *Muscidae* frequently feed on secretions from wounds and the ocular, nasal, and oral mucosa of grazing animals [26].

Nartshuk E. P. [26] and Ageeva T. Yu. [27] regard female *M. autumnalis* as facultative hematophages, a characterization that does not contradict the data obtained in the present study. *M. autumnalis* lacks a piercing proboscis capable of actively penetrating the skin of mammals. However, females possess prestomal teeth, with which they can damage healing wounds and mucous membranes, thereby sustaining inflammatory processes and obtaining nourishment.

Larvae of *M. autumnalis* are specialized saprophages that develop in and feed on vertebrate dung, exhibiting a coprophagous habit specific to the *Muscidae* [11, 26].

During the summer, the animals under study were kept together as a single herd, managed under semi-wild conditions on natural pasture. The general condition of the experimental animals was satisfactory; appetite and movement were normal. Water was provided from an open source, the Sazan stream. In winter, the animals were maintained under covered shelters. No antiparasitic drugs were administered to the animals.

Profuse lacrimation was recorded as one of the clinical signs of thelaziasis in the yaks. The animals presented with chronic recurrent keratoconjunctivitis and exhibited visual impairment, which is consistent with the findings of D. F. L. Djungu et al. [7].

Other clinical signs associated with thelaziasis are photophobia, blepharospasm, and ulcerative as well as non-ulcerative keratitis. Reported complications include granulomas and corneal perforations, inflammation of the lens, ectropion of the eyeball, corneal opacity (leukoma) resulting from nematode migration through the cornea, fibrohemorrhagic iridocyclitis, and blindness [1, 9, 10, 11]. The clinical course of thelaziasis is frequently complicated by secondary infections, further compromising the animals' health [10, 11, 12, 13, 14].

In the overwhelming majority of cases, thelaziasis-associated keratoconjunctivitis in yaks was observed to be bilateral. No age- or sex-related differences were observed, which contrasts with the findings of D. M. Tweedle et al. [8] that cattle aged 21 to 38 months were more commonly affected.

The intensity of invasion was determined to be 5, and the extent of invasion was 100%; this contrasts with the findings of A. K. Oshkhunov et al. [17]. In conclusion, yaks introduced into the natural and climatic conditions of the Orenburg steppes acquired the infection during the process of acclimatization.

Thelaziasis clinical signs were observed throughout the entire *M. autumnalis* flight period, thereby determining the disease seasonality. This finding is consistent with the data reported by D. M. Tweedle et al. [8], E. Kim et al. [9], and R. R. Kasarla et al. [10].

Nematodes were isolated from the conjunctival sacs of yaks during helminthoscopic examination by flushing, followed by collection and microscopic analysis. The parasites were identified as belonging to the species *Th. rhodesi*, and all nematodes recovered were female. Figure 2 illustrates that the females were approximately 20 mm long. They were highly motile, whitish in color, and barely visible to the naked eye within the conjunctival sac. The nematodes were most visible in the medial canthus (inner corner) of the yaks' eyes.

The species *Th. rhodesi* belongs to the genus *Thelazia*, the order *Spirurida*, the family *Thelaziidae*, the type *Nematoda*, nematodes, or roundworms. Microscopically, the

head end of *Th. rhodesi* has a cross-striations, as shown in Figure 3. The serrated cuticle of the nematodes inflicts mechanical damage to the corneal and conjunctival surfaces, resulting in inflammation.

Excessive lacrimation is a response to damage to the eye tissues. The blood-feeding fly *M. autumnalis*, acting as a facultative hematophage, induces profuse lacrimation in animals both through mechanical trauma to the cornea and by transmitting *Thelazia* infestation. In addition to the mechanical effects caused by the nematodes, there is also evidence (Glazunova L. A. et al. [1]) of their allergic and toxic pathological influence on the host. Khristianovsky P. I. et al. describe the phenomenon of parasite carriage by definitive hosts as a cause of annual infection in animals [12].

Larvae of *Thelazia* are excreted from the bodies of afflicted yaks through the lacrimal passages, namely from the lacrimal gland ducts, the conjunctival cavity, and the area under the third eyelid. *M. autumnalis* consumes the secretion of the lacrimal glands together with *Thelazia* larvae, thereby acting as a specific thelaziasis intermediate host. The nematodes reach the final stage of their development within the host organism over a period of approximately one month. Transmission of infective larvae to the definitive host occurs when flies ingest (take up) the larvae while feeding on yaks' tears and mucous secretions with their proboscises.

CONCLUSION

As a vector-borne parasitic zoonosis, thelaziasis continues to be of considerable importance in both human and veterinary medicine, necessitating continued research.

Thelaziasis in yaks is documented for the first time in the Belyayevsky Raion of the Orenburg Oblast, contributing both theoretical and practical value to the understanding of this disease.

The isolated nematodes were identified as *Th. rhodesi*. *M. autumnalis*, a species ubiquitous in the steppe ecosystems of Orenburg, served as the vector for *Thelazia* transmission. The chronic nature of the disease is linked to pathogen carriage over the winter stall period. Clinical manifestations and disease progression in yaks were driven by the mechanical, allergic, and toxic effects of *Th. rhodesi*, combined with a relatively low infestation intensity.

No distinct differences in clinical signs, diagnostic methods, prevention, or treatment were observed between thelaziasis in yaks and that in cattle. Preventive and therapeutic measures against thelaziasis in yaks should include seasonal applications of repellents and insecticides, as well as scheduled anthelmintic treatments. To control the incidence of thelaziasis, it is necessary to manage the population size of vector flies and maintain proper zoohygienic conditions on farms.

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