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Investigation of Pathomorphological Signs and Diagnostic Procedures for Saiga Coenurosis

Kaissar Kushaliyev *, Ulbolsyn Kuzhebayeva and Olesya Voloshina

[1]Institute of Veterinary and Agrotechnology, West Kazakhstan Agrarian and Technical University named after Zhangir Khan, Uralsk, Republic of Kazakhstan
***Corresponding author:** kushaliyevkaissar@gmail.com

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ABSTRACT

This study investigates coenurosis in the Ural population of saigas (*Saiga tatarica*), with a specific focus on its pathomorphological signs, diagnostic techniques, and implications for wildlife health. Coenurosis, caused by the larval stage of *Taenia serialis*, predominantly affects the central nervous system and is linked to high mortality among young saigas. Field research was conducted in Western Kazakhstan during 2020–2021 and 2024, involving post-mortem examinations of 350 animals. In all cases, parasitic cysts were localized in the left hemisphere of the brain, leading to severe neurological symptoms including motor dysfunction, body asymmetry, and vision loss. Histological examination revealed vascular congestion, focal hemorrhages, necrosis, and karyopyknosis, indicating widespread cerebral damage. Additionally, 82% of animals showed liver lesions, including protein and fatty degeneration, suggesting systemic metabolic disruption. Ophthalmological pathology was observed in 64% of cases, with retinal hemorrhages and hyperemia contributing to visual impairment. Trepanation and histology proved essential for accurate diagnosis. The study also analyzed seasonal migration patterns and ecological factors influencing parasite transmission, noting significant risk associated with interaction between wild and domestic animals. Preventive interventions, such as targeted deworming, migration route adjustments, and habitat monitoring, demonstrated effectiveness in reducing mortality rates.

Key words: Parasitology, Helminths, *Taenia serialis*, Cranial trepanation, Fülleborn method.

INTRODUCTION

Coenurosis, caused by the larval stage of the parasite *Taenia serialis*, poses a serious threat to the health of wildlife, especially saigas, which are central to the ecosystem of Kazakhstan. This disease predominantly affects the central nervous system (CNS) of different domestic and wild life ruminants, which lead to severe neurological signs and in many cases death can occur (Abbas et al. 2024). In 100% of observed cases, parasitic cysts are localized in the left hemisphere of the brain. This leads to severe neurological symptoms, including motor dysfunction, vision loss, and eventual death, particularly among young individuals (Bashir et al. 2020; Haq et al. 2024). The disease's systemic effects also extend to liver and ocular damage, compounding the threat to individual health and survival. As saigas play a key ecological role in their steppe habitats, the growing prevalence of coenurosis presents not only a conservation concern but also a broader ecological risk, emphasizing the urgent need for integrated prevention and surveillance strategies (Tas et al. 2023; Nzalawahe et al. 2024).

In the face of climate change and growing human pressure on natural habitats, parasitic infections are becoming more frequent and harder to manage (Serikbayeva et al. 2023; Umitzhanov et al. 2023; Tyrsynbayev et al. 2024). Studying such infections in wild animals is crucial for effective conservation (Ahn et al. 2021). An outbreak of coenurosis among Ural saigas in 2020–2021 caused high mortality, with 263 deaths, mostly among animals under three years old, highlighting their vulnerability to Taenia serialis (Varcasia et al. 2022; Kushaliyev et al. 2023). Nurushev et al. (2020) examined wild–domestic animal interactions and found that saiga migrations significantly influence parasite transmission. While the study offered general prevention guidelines, it lacked detail on pathogenesis and targeted measures for wild populations.

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Genetic predisposition to parasitic infections is a key aspect of coenurosis research (Krykbayev et al. 2024; Li et al. 2021). Begilov et al. (2023) identified genetic profiles that may increase susceptibility to parasitic infections, which is useful for developing targeted prevention strategies. However, the study overlooks the role of environmental and behavioural factors in the spread of coenurosis in saigas. The anthropogenic impact on Kazakhstan's ecosystems also contributes to the rise of parasitic infections (Mussayeva et al. 2023; Stigger et al. 2025). Nurushev and Nurusheva (2020) demonstrated that road construction and agricultural development create conditions favorable for disease spread among wild animals. While the study highlights the need for environmental monitoring and habitat protection, it lacks specific recommendations for preventing coenurosis amid increasing human intervention. An approach to the study of parasitic infections based on interdisciplinary interaction was proposed by Abdybekova et al. (2023) and Sapanov and Akhmedenov (2023). Their studies emphasise the need for veterinarians, ecologists, and geneticists to combine their efforts to create integrated strategies to control diseases such as coenurosis in wild animals. Although their work is theoretically significant it needs to be complemented by practical recommendations and specific studies aimed at developing effective measures to prevent and treat coenurosis in saigas.

The aim of the study was therefore to identify and analyse the pathogenesis of coenurosis in saigas from the Ural population in Kazakhstan, with a focus on its impact on animal health. To achieve this aim, the following objectives were set: to carry out a detailed analysis of the localisation and histological changes in the brain, to investigate systemic changes in other organs such as the liver and eyes, to assess the epizootological situation in the region and identify the main factors contributing to the spread of the disease, and to develop recommendations for the prevention and control of coenurosis based on the data obtained.

MATERIALS AND METHODS

Study area

The study was conducted in West Kazakhstan, specifically in the Kaztalovsky and Zhanibeksky districts, where the Ural saiga population resides. The research was carried out during 2020–2021, with some components completed in 2024. This region, being the natural habitat of saigas, provided the most representative data.

Study population and sampling

The study focused on saigas across different age groups: juveniles under one year, 1–3 years, 4–5 years, and 6–8 years. Data collection occurred in natural migratory conditions, enhancing data accuracy and relevance. A total of 350 saigas affected by mass mortality during migration were examined. Post-mortem examinations of the carcasses included detailed analysis of internal organs, including the brain, retinal capillaries and liver.

Clinical and surgical diagnosis

Coenurosis diagnosis began with a clinical examination of the animals, observing signs such as impaired coordination, body asymmetry, vision loss, serous haemorrhagic conjunctivitis, and lethargy. These symptoms prompted the identification of the disease. To confirm the diagnosis, skull trepanation was performed using the Aesculap GA720R neurosurgical drill to detect cerebral blisters. The procedure involved palpating the skull to find areas of bone softening, followed by an incision to expose the skull and separate the periosteum. The drilling process used a hand-held trepan with a lance-shaped cutter to control depth and prevent brain damage. A total of 5–6 holes were made and joined to access the brain lobes. The skull was then opened to visualize the cenotrophic bullae, if present.

Histological examination

Tissue and organ samples were fixed in 10% neutral formalin. Standard tissue processing, including paraffin embedding and sectioning (5–7 microns thick), was performed. The sections were stained with haematoxylin and eosin to reveal vascular changes, necrobiotic processes, erythrocyte aggregation, and endothelial cell alterations. Histological studies were conducted using a Nikon Eclipse E100 microscope and documented with a Micro Cam 5M camera.

Fülleborn method

The Fülleborn method was employed to diagnose helminth infestations in saigas and sheep. Faecal samples were collected quarterly from different age groups in natural habitats and migration areas (Zhigalova et al. 2024). The samples were mixed with a saturated salt solution, filtered, and examined under a microscope using a VIGIS 19J counting chamber. The number of eggs in multiple fields of view was counted to estimate infestation levels. This method proved effective for analyzing the epidemiological situation and developing preventive measures.

RESULTS & DISCUSSION

A study of coenurosis in saigas of the Ural population found that coenurosis, the larval stage of the *Taenia serialis* parasite, tends to be located in the left hemisphere of the brain. The study included 350 individuals subjected to cranial trepanation, which identified the presence of parasitic vesicles and conducted a detailed analysis of their distribution and impact on brain structures (Table 1).

Table 1: Age classification and main characteristics of coenurosis in saigas of the Ural population

Parameter	Overall result	Up to 1 year	1-3 years old	4-5	6-8
Total number of individuals studied	350	52	105	140	52
Length of the price ranges (cm)	3-4	3-4	3-4	3-4	3-4
Percentage of localisation in the left hemisphere			100%		
Percentage of cases with single price ranges	42%	40%	45%	43%	39%
Percentage of cases with multiple price ranges	18%	15%	20%	19%	16%
Percentage of cases with brain tissue atrophy	78%	75%	80%	79%	76%
Percentage of cases with severe neurological symptoms	100%	95%	98%	100%	97%

The tapeworms found in the brain had a characteristic oval and elongated shape, with a length of 3-4cm. It is important to emphasise that in 100% of cases of parasite detection, they were localised in the left hemisphere of the brain, which indicates a specific predisposition of this area to damage. Such a clear localisation may be due to the peculiarities of blood supply or anatomical characteristics of this part of the brain in saigas, which requires further study. However, at this stage, it can already be stated that the left hemisphere of the brain in saigas is the most vulnerable area for *Taenia serialis* infection (Fig. 1).

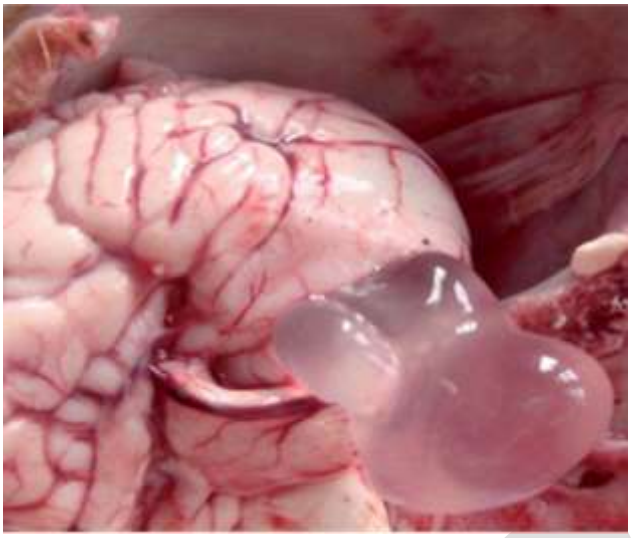

Fig. 1: Single cortices in the saiga brain.

Skull trepanation enabled precise detection of *Taenia serialis* in saigas, revealing cercariae in the left hemisphere in 42% of cases – indicating high prevalence. Parasite bladders caused pressure and tissue atrophy, found in 78% of infected animals. Neurological symptoms included body asymmetry, poor coordination, reduced activity, and vision loss. In all cases with multiple vesicles, severe symptoms such as circling, falls, nervous fever, and visual impairment were observed, showing rapid disease progression. Multiple cysts in 18% of cases led to severe motor and neurological deficits. Histological analysis confirmed the destructive impact of coenurosis on the central nervous system (Fig. 2).

Vascular haemorrhage, observed in all samples, indicated significant blood filling of vessels, pointing to inflammation and disturbed haemodynamics in the affected brain areas. This was seen in both large vessels and small capillaries, suggesting a systemic effect of the parasite on the brain's vascular network. Impaired blood flow leads to stagnation, creating conditions for further pathological changes like haemorrhages and oedema. Small-focal haemorrhages in the white and grey matter, detected in 78% of cases, revealed blood-brain barrier damage and vessel wall integrity loss. These haemorrhages cause inflammation and oedema, worsening the brain's condition and contributing to neurological symptoms such as seizures, coordination issues, and loss of consciousness, indicating severe tissue damage.

Analysis of the microcirculatory bed revealed severe damage to arterioles and capillaries in 85% of cases, including vascular wall injury, red blood cell aggregation, and clot formation – disrupting brain circulation and causing hypoxia, necrosis, and ischaemia. Endothelial swelling (90%) indicated vascular dysfunction and inflammation, while karyopyknosis (76%) reflected irreversible cell death. Oncosphere migration, present in all cases, caused brain tissue destruction and inflammation. These findings highlight the serious neurological impact of Taenia serialis infestation. Liver damage was found in 82% of cases, with granular protein dystrophy impairing hepatocyte function. Fatty liver dystrophy (67%) indicated lipid metabolism disorders, risking fibrosis or cirrhosis. Liver congestion (73%) led to increased size, mosaic colouration, and tissue degeneration. These changes severely impaired liver function, affecting metabolism, immunity, and detoxification (Fig. 3).

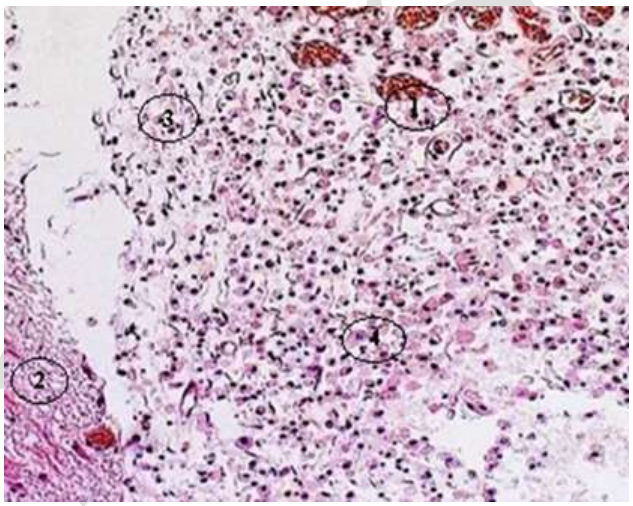

Fig. 2: Histological picture of the brain in a saiga infected with coenurosis; Note: 1 – full blood vessels; 2 – normal brain tissue; 3–necrosis zone (karyopyknosis of the nucleus); 4 – macrophages.

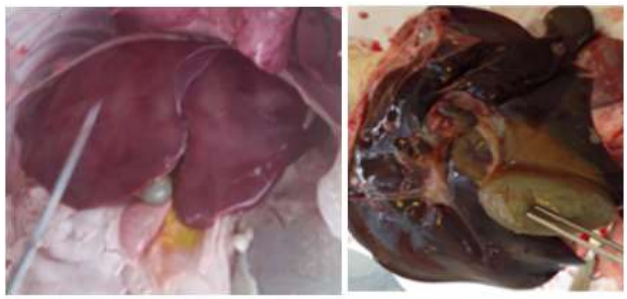

Fig. 3: Overflow of the gallbladder (a) and congestion (b) in the liver of a saiga.

Alongside liver damage, significant eye pathology in saigas pointed to systemic disease. Ocular hyperaemia was observed in 64% of cases, often with elevated intraocular pressure, risking glaucoma and vision loss. Retinal haemorrhages and eyeball discoloration occurred in 61%, causing visual impairment and potential retinal detachment. Similar rates of eye fundus congestion suggested microcirculation disorders, leading to oedema and inflammation. These findings reflect the severity of coenurosis, affecting multiple organs and reducing survival. Post-mortem exams confirmed coenurosis in 147 of 263 cases, with lab tests detecting brain cysts,

demonstrating the disease's high prevalence and impact on saiga health.

The results of this study of coenurosis in saigas in the Ural population indicate the serious consequences of parasitic infestation with *Taenia serialis* for animal health and the ecosystem. These results are highly relevant both for understanding the pathogenesis of the disease and for developing effective measures for its prevention and treatment. Notably, the data obtained confirms and complements the results previously obtained by other researchers, but also reveals several new aspects that require further study (Berezin et al. 2008; Haq et al. 2024). A key finding of the study was the high frequency of coenurosis localisation in the left hemisphere of the saiga brain. Previous studies, such as those by Umer et al. (2023) and Tas et al. (2023), reported similar localisation in sheep, though with less frequency. The data from Kazakhstan suggest that saigas may have anatomical or physiological traits that make the left hemisphere more vulnerable. This aligns with findings by Rey-Iglesia et al. (2022) and Stigger et al. (2025), who noted similar localisation in cattle, potentially linked to blood supply. This observation is novel for saigas and warrants further investigation to understand the underlying mechanisms.

Histological findings reveal the serious impact of coenurosis, with 78% of cases showing vascular congestion and focal brain haemorrhages, indicating major circulatory disruption. Similar changes were reported in sheep (Bashir et al. 2020; Gavet et al. 2023) and wild animals (Yang et al. 2022), though the Ural saiga population showed more severe signs, such as necrobiosis and erythrocyte aggregation, suggesting a more aggressive disease course. These differences may stem from saiga-specific immune or metabolic responses, warranting further study for targeted interventions. Liver lesions, including protein and fatty dystrophy in 82% of cases, confirm the systemic nature of the disease beyond the central nervous system.

Eye changes, including vascular hyperaemia and retinal haemorrhages in 64% of saigas, indicate systemic effects that may impair vision and survival. Similar lesions have been observed in cattle, with Gholami et al. (2022) linking such complications to parasitic infections, especially under stress. More severe eye damage in saigas may reflect a more aggressive disease or higher susceptibility (Li et al. 2021), highlighting the value of ophthalmological monitoring in coenurosis diagnosis and treatment. Systemic pathology in saigas resembles that in other species but also shows unique traits. Liver changes, including protein and fatty dystrophy, mirror findings in sheep (Nzalawahe et al. 2024) but appear more severe in saigas, suggesting metabolic or adaptive differences (Varcasia et al. 2022). This supports Majid et al. (2024), who reported intensified metabolic disturbances in stressed wild animals, such as during migration. These insights emphasize the need to consider environmental and physiological factors in saiga disease management.

The study also highlights significant concerns regarding the spread of coenurosis in saigas. The mass die-offs in 2020-2021 pose a serious threat, as noted by Dincel et al. (2023) in sheep outbreaks in Turkey. International studies, including those by Ahn et al. (2021) and Schöb et al. (2024), also emphasize the mass mortality caused by parasitic outbreaks in migratory wildlife. Notably, this study found that young saigas under three years of age are the most vulnerable, highlighting the need for targeted preventive measures, such as more frequent deworming and changes to housing conditions for this age group. These findings emphasise the importance of a comprehensive approach to the study and treatment of this disease, which should address both central and systemic effects of invasion.

Conclusion

The study highlighted significant health changes in the Ural population of saigas, particularly the high prevalence of coenurosis, with 100% of cases showing brain localisation in the left hemisphere. Histological changes, including vascular abnormalities and tissue necrosis, were observed in the majority of individuals. Additionally, 82% of saigas exhibited liver damage, and 64% had ophthalmological issues, which pose a serious threat to their survival. Epidemiological analysis confirmed 263 sick and dead animals, with young saigas being most vulnerable. Preventive measures, including deworming and migration route adjustments, effectively reduced mortality. The findings underline the need for timely diagnosis and comprehensive treatment of coenurosis, alongside further research to develop better preventive strategies. Limitations of the study include the potential influence of natural factors and the small sample size, necessitating further research to refine these results and enhance understanding of the disease.

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Ethical Approval of the Study: All procedures adhered to the European Convention for the Protection of Vertebrate Animals (1986) and the Universal Declaration on Animal Welfare (2007).

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