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ОШ МАМЛЕКЕТТИК УНИВЕРСИТЕТИНИН ЖАРЧЫСЫ.

АЙЫЛ ЧАРБА:

АГРОНОМИЯ. ВЕТЕРИНАРИЯ. ЗООТЕХНИЯ

ВЕСТНИК ОШСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА.

СЕЛЬСКОЕ ХОЗЯЙСТВО:

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**ОШ МАМЛЕКЕТТИК УНИВЕРСИТЕТИНИН ЖАРЧЫСЫ. АЙЫЛ ЧАРБА:
АГРОНОМИЯ, ВЕТЕРИНАРИЯ ЖАНА ЗООТЕХНИЯ**

Вестник Ошского государственного университета. Сельское хозяйство: агрономия,
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ЖУРНАЛ ЖӨНҮНДӨ [kg]

“Ош мамлекеттик университетинин Жарчысы. Айыл чарба: агрономия, ветеринария жана зоотехния” илимий журналы университеттин илимий журналдарынын импакт-факторун жогорулатуу жана келечекте эл аралык илимий базаларга киргизүү саясатын ишке ашыруу максатында ОшМУнун Окумуштуулар Кеңешинин чечиминин (2022-жылдын 20-апрелиндеги 7-протоколу) негизинде түзүлгөн.

“Ош мамлекеттик университетинин Жарчысы. Айыл чарба: агрономия, ветеринария жана зоотехния” илимий журналы Кыргыз Республикасынын Юстиция министрлигинен каттоодон өткөн. Каттоо номуру 10302, 22-июнь 2022-жыл.

Журнал үч тилде - **кыргыз, орус жана англис** тилдеринде макалаларды жарыялайт. Материалдар **акысыз** негизде кабыл алынат. Журнал макалаларды жөнөтүү, аларды кароо жана жарыялоо үчүн акы албайт. Автордук сый акы төлөнбөйт.

Журнал **жылына 4 жолу** чыгат (кошумча атайын чыгарылыштар болушу мүмкүн).

“Ош мамлекеттик университетинин Жарчысы. Айыл чарба: агрономия, ветеринария жана зоотехния” журналы өзүнүн расмий сайтына ачык кирүү мүмкүнчүлүгүн берет. Бул дүйнөлүк илимий коомчулукка журналга кеңири маалымат алуу мүмкүнчүлүгүн камсыз кылат.

Окурмандар жана авторлор журналдын веб-сайтынан журналдын учурдагы санынын электрондук версиясын жана мурунку басылмалардын архивдерин эркин көрүп жана жүктөп ала алышат. Creative Commons Attribution License (CC BY-NC 4.0) лицензиясынын шарттарына ылайык, журналдын баардык басылмалары электрондук түрдө бекер жана чектөөсүз таратылат.

“ОшМУнун Жарчысы. Айыл чарба: агрономия, ветеринария жана зоотехния” журналындагы макалалардын авторлору эмгектери менен бирге журналга басып чыгаруу укугун өткөрүп беришет, аны Creative Commons Attribution License (CC BY-NC 4.0) лицензиясы менен лицензиялаган болушат. Жарыяланган эмгектин автордук укук ээси болуп басып чыгаруучу Ош мамлекеттик университети эсептелет.

Журналдын материалдарынын электрондук версиялары <https://journal.oshsu.kg/index.php/agriculture/index> сайтында коомдук доменде жайгаштырылган.

CrossRef менен Ош мамлекеттик университетинин ортосунда түзүлгөн келишимге ылайык журналга 10.52754 нумурлуу DOI префикси ыйгарылган. Ушул келишимдин негизинде “ОшМУнун Жарчысы. Айыл чарба: агрономия, ветеринария жана зоотехния” журналына чыккан ар бир макалага DOI номуру берилет.

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О ЖУРНАЛЕ [ru]

Научный журнал “Вестник Ошского государственного университета. Сельское хозяйство: агрономия, ветеринария и зоотехния” был основан на основании решения Ученого совета ОшГУ (протокол №7 от 20 апреля 2022 года) в целях повышения импакт-фактора научных журналов университета и, в дальнейшем, реализации политики включения в международные научные базы данных.

22 июня 2022 года “Вестник Ошского государственного университета. Сельское хозяйство: агрономия, ветеринария и зоотехния” прошел регистрацию в Министерстве юстиции Кыргызской Республики под №10302.

Журнал публикует статьи на трех языках - **кыргызском, русском и английском**, принимает материалы к публикации на **безвозмездной** основе. Журнал не взимает плату за подачу статей, их рецензирование и их публикацию. Авторские гонорары не выплачиваются.

Периодичность издания: **4 выпуска в год** (возможны дополнительные специальные выпуски).

Журнал “Вестник Ошского государственного университета. Сельское хозяйство: агрономия, ветеринария и зоотехния” предоставляет открытый доступ к своему контенту на официальном сайте журнала. Это обеспечивает более широкий информационный доступ к журналу в масштабах мирового научного сообщества.

Читатели и авторы могут свободно просматривать и скачивать электронные версии текущего номера журнала и архивы за предыдущие периоды на сайте журнала. Все публикации журнала в электронном виде распространяются бесплатно и без ограничений на условиях лицензии Creative Commons Attribution License (CC BY-NC 4.0).

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По договору между CrossRef и Ошским государственным университетом журналу присвоен префикс DOI 10.52754. На основании этого договора каждой статье, опубликованной в журнале “Вестник Ошского государственного университета. Сельское хозяйство: агрономия, ветеринария и зоотехния” присваивается номер DOI.

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ABOUT THE JOURNAL [en]

The scientific journal “Journal of Osh State University. Agriculture: Agronomy, Veterinary and Zootechnics” was founded on the basis of the 7th Protocol of the Academic Council of Osh State University dated April 20, 2022 in order to increase the impact factor of scientific journals of the university and further implement the policy of inclusion in international scientific databases.

In June 22, 2022 the journal “Journal of Osh State University. Agriculture: Agronomy, Veterinary and Zootechnics” was registered with the Ministry of Justice of the Kyrgyz Republic under No. 10302.

The journal publishes articles in three languages – **Kyrgyz, Russian and English**, accepts materials for publication **free of charge**. The journal does not charge for the submission of articles, their review and publication. Author’s royalties are not paid.

Publication frequency: **4 issues per year** (additional special issues are possible).

The “Journal of Osh State University. Agriculture: Agronomy, Veterinary and Zootechnics” provides open access to its content on the official website of the journal. This provides greater information access to the journal throughout the global scientific community.

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Electronic versions of the journal materials are placed on the website <https://journal.oshsu.kg/index.php/agriculture/index> in the public domain.

Under an agreement between CrossRef and Osh State University, the journal was assigned the prefix DOI 10.52754. On the basis of this agreement, each article published in the “Journal of Osh State University. Agriculture: Agronomy, Veterinary and Zootechnics” is assigned a DOI number.

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РЕДАКЦИЯ [kg]

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АГРОНОМИЯ, ВЕТЕРИНАРИЯ ЖАНА ЗООТЕХНИЯ**

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**MAIN HELMINTHIASES OF IN CHICKENS AND THEIR CONTROL IN THE
CENTRAL GEOGRAPHICAL AND CLIMATIC REGIONS OF UZBEKISTAN**

ОСНОВНЫЕ ГЕЛЬМИНТОЗЫ КУР И БОРЬБА С НИМИ В ЦЕНТРАЛЬНЫХ
ГЕОГРАФИЧЕСКИХ И КЛИМАТИЧЕСКИХ РЕГИОНАХ УЗБЕКИСТАНА

ЎЗБЕКСТАНДЫН БОРБОРДУК ГЕОГРАФИЯЛЫК ЖАНА КЛИМАТТЫК
АЙМАКТАРЫНДАГЫ ТООКТОРДУН НЕГИЗГИ ГЕЛЬМИНТОЗДОРУ ЖАНА АЛАП
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MAIN HELMINTHIASES OF IN CHICKENS AND THEIR CONTROL IN THE CENTRAL GEOGRAPHICAL AND CLIMATIC REGIONS OF UZBEKISTAN

Abstract

Helminthiasis in farm poultry remains one of the most significant veterinary problems in households in the central regions of Uzbekistan, where poultry farming plays an important role in food security and sustainable development of the agricultural sector. The aim purpose of this study was to determine the prevalence of the main types of intestinal nematodes in chickens in three key regions of the country – Jizzakh, Syrdarya, and Samarkand provinces – and to evaluate the effectiveness of antiparasitic therapy using tetramisole-based drugs. Between 2022 and 2024, 747 chickens were examined, with helminthological and coprological analyses of faecal samples showing that the overall infection rate was 52.07%. The distribution of infected birds by region revealed significant variability: the lowest level of infestation was recorded in the Jizzakh region (41.9%) and the Syrdarya region (50.6%), and the highest in the Samarkand region, where 58.57% of birds were infected. The main nematodes identified were ascariidosis with an infection rate of 32.8%, heterakidosis with 32.53%, and capillariosis with 37.48%. Such a high prevalence indicates a wide range and pronounced endemicity of helminthiasis in these regions. Antiparasitic therapy with a tetramisole-based drug demonstrated high efficacy: 92.86% after the first course of treatment and 100% elimination of parasites after repeated use. The results of the study emphasised the need to adapt veterinary preventive measures to regional characteristics, which will reduce economic losses in poultry farming and improve poultry health indicators in households. The practical significance of the work study lies in the formation development of scientifically based recommendations for optimising helminthiasis control and prevention programmes, which is an important factor in increasing productivity and biosafety in the agricultural regions of Uzbekistan

Keywords: ascariasis; capillariosis; Helminth fauna; *Ascaridia galli*; *Heteraks gallinarum*; *Capillaria obsignata*; *C.bursata*

Основные гельминтозы кур и борьба с ними в центральных географических и климатических регионах Узбекистана

Ўзбекстандын борбордук географиялык жана климаттык аймактарындагы тооктордун негизги гельминтоздору жана алар менен күрөшүү

Аннотация

Гельминтозы у сельскохозяйственной птицы остаются одной из наиболее значимых ветеринарных проблем в домашних хозяйствах центральных регионов Узбекистана, где птицеводство играет важную роль в продовольственной безопасности и устойчивом развитии аграрного сектора. Целью настоящего исследования являлось выявление распространённости основных видов кишечных нематод у кур в трёх ключевых регионах страны – Джизакской, Сырдарьинской и Самаркандской областях, а также оценка эффективности противопаразитарной терапии с использованием препаратов на основе тетраемизола. В период 2022-2024 годов было обследовано 747 кур, при этом гельминтологический и копрологический анализы фекальных проб показали, что общий уровень заражённости составил 52,07 %. Распределение заражённых птиц по регионам выявило значительную вариабельность: минимальная степень инвазии зарегистрирована в Джизакской области – 41,9 %, в Сырдарьинской области – 50,6 %, и максимальная – в Самаркандской области, где заражено 58,57 % птиц. Основными выявленными нематодами оказались аскаридии с уровнем инфицирования 32,8 %, гетеракисы – 32,53 %, и капиллярии – 37,48 %. Такая высокая распространённость свидетельствует о широком ареале и выраженной эндемичности гельминтозов в данных регионах. Противопаразитарная терапия препаратом на основе тетраемизола продемонстрировала высокую эффективность: 92,86 % после первого курса лечения и 100 % элиминацию паразитов после повторного применения. Результаты исследования подчёркивают необходимость адаптации ветеринарных профилактических мероприятий с учётом региональных особенностей, что позволит снизить экономические потери в птицеводстве и улучшить показатели здоровья птицы в домашних хозяйствах. Практическая значимость работы заключается в формировании научно обоснованных рекомендаций для оптимизации программ контроля и профилактики гельминтозов, что является важным фактором повышения продуктивности и биобезопасности в аграрных регионах Узбекистана

Ключевые слова: аскаридоз; капилляриоз; гельминтофауна; *Ascaridia galli*; *Heteraks gallinarum*; *Capillaria obsignata*; *C. bursata*

Аннотация

Айыл чарба тоокторундагы гельминтоздор Ўзбекистандын борбордук аймактарындагы ўй чарбаларында эң маанилүү ветеринардык кўйгўйлўрдўн бири бойдон калууда. Бул аймактарда тоок чарбасы азык-тўлўк коопсуздугунда жана айыл чарбасын туруктуу ўнўктўрўўдў маанилўў ролду ойнойт. Бул изилдўўнўн максаты – ўлкўнўн ўч негизги аймагында – Джизак, Сырдарыя жана Самарканд облустарында тооктордўн ичегисиндеги негизги нематоддордўн жайылышын аныктоо жана тетраемизол негизиндеги каражаттарды колдонуу менен паразиттерге каршы терапиянын натыйжалуулугун баалоо болду. 2022-2024-жылдар аралыгында 747 тоок текшерилип, гельминтологиялык жана копрологиялык анализдердин жыйынтыгы боюнча жалпы инфекция деңгўэли 52,07 % тўзгўн. Аймактар боюнча инфекциянын таралышы маанилўў ўзгўрўўлўрдў кўрсўттў: Джизак облусунда – 41,9 %, Сырдарыя облусунда – 50,6 %, ал эми Самарканд облусунда эң жогорку кўрсўткўч – 58,57 % аныкталган. Негизги аныкталган нематоддорго аскариддер – 32,8 %, гетеракистер – 32,53 %, жана капилляриялар – 37,48 % кирет. Бул жогорку таралышы гельминтоздордўн кўңири аймакка жайылгандыгын жана эндемик экендигин кўрсўтўт. Тетраемизолго негизделген каражат менен паразиттерге каршы терапия биринчи дарылоодон кийин 92,86 % натыйжалуулукту, экинчи курстўн жыйынтыгында болсо 100 % паразиттердин жоголушўн камсыздаган. Изилдўўнўн натыйжалары ветеринардык алдын алуу чараларын региондук ўзгўчўлўктўрдў эске алуу менен адаптациялоонун зарылдыгын баса белгилейт, бул тоок чарбасындагы экономикалык чыгымдарды азайтууга жана ўй чарбаларындагы тооктордўн ден соолугуна оң таасирин тийгизет. Практикалык мааниси – гельминтоздорду кўзўмўлдўў жана алдын алуу программаларын оптималдаштыруу боюнча илимий негизделген сўнуштарды тўзўў, бул Ўзбекистандын айыл чарба аймактарында ўндўрўмдўўлўктў жана биобезопасыкты жогорулатууда маанилўў фактор болуп саналат

Ачкыч сўздўр: аскаридоз; капилляриоз; гельминтофауна; *Ascaridia galli*; *Heteraks gallinarum*; *Capillaria obsignata*; *C. bursata*

Introduction

Poultry farming is one of the leading sectors in the livestock industry, providing the population with valuable food products – meat and eggs – and supplying light industry with by-products of processing. In the Republic of Uzbekistan, the state pays special attention to the development of this sector, with an emphasis on the introduction of modern international standards. One of the priority tasks in this context is the development and implementation of effective measures to combat infectious, invasive, and non-contagious poultry diseases, which is of key importance for preventing economic losses and reducing risks to human health.

A systematic review and meta-analysis by A. Shifaw et al. (2021) covered more than 190 studies published between 1942 and 2019 to assess the global and regional prevalence of helminthiasis in chickens. According to the summarised data, the most prevalent were *Ascaridia galli* (35.9%), *Heterakis gallinarum* (28.5%), *Capillaria* spp. (5.9%), and *Raillietina* spp. (19.0%). The overall prevalence rate was 79.4%. It was noted that birds kept in free-range conditions and on smallholdings were significantly more likely to be infected with helminths than chickens raised in cage systems, which highlights the need to strengthen preventive measures in extensive forms of husbandry.

S. Rabbimov (2024) presented a comprehensive study of helminthiasis in domestic chickens in the north-eastern regions of Uzbekistan, including the Tashkent, Syrdarya, and Jizzakh regions. The researcher examined 927 domestic and wild birds and identified about 30 species of helminths, the most dangerous of which were representatives of the families Davaineidae, Ascarididae, Heterakidae and Capillariidae. The study highlighted the high degree of infestation in birds, especially during warm seasons, and the need to consider the bioecological characteristics of parasites when developing preventive measures. However, the study did not consider the effectiveness of antiparasitic therapy and does not address the clinical aspects of the course of infestations, which will be further investigated in this study with a focus on anti-nematode drugs in domestic settings.

S.N. Ritu et al. (2024) investigated the epidemiology, pathogenesis, and sensitivity of *Ascaridia galli* in semi-domesticated chickens in Bangladesh. The researchers found a high prevalence of infection (45.6%) and demonstrated the efficacy of levamisole and ivermectin, while albendazole, mebendazole, and piperazine showed no antiparasitic activity. Despite the valuable data, the study covered only one species of nematode and did not consider regional distribution patterns, which requires further study in other climatic conditions.

In a study by D.B. Fayzieva (2020), a systematic analysis of the helminth fauna of domestic birds – chickens, ducks, and geese – was conducted. A total of 38 species of helminths were identified: 9 trematodes, 12 cestodes, and 17 nematodes. The greatest diversity of parasites was found in chickens – 32 species, including representatives of the families Echinostomatidae, Cyclophyllidae, Trichocephalidae, Ascarididae, etc. Twelve species of helminths were found in ducks and four species in geese. The study described the taxonomic composition of the identified helminths by class, genus, family, and species, but did not consider the clinical manifestations of parasitic diseases or evaluate the effectiveness of antiparasitic therapy.

The development and evaluation of the action of anthelmintic drugs in poultry farming is given special attention, since the choice of an effective treatment method directly affects the

productivity and biosafety of farms. An experimental study by T. Feyera et al. (2021) included a comparative evaluation of the effectiveness of three anthelmintic drugs – levamisole, piperazine, and fenbendazole – in the treatment of artificial *Ascaridia galli* infestation in chickens, using both oral administration and addition to drinking water. It was found that individual oral administration of drugs provides higher efficacy than group treatment through water. Levamisole, piperazine and their combination showed over 96% reduction in helminths when administered orally, and fenbendazole in bolus form was significantly more effective than when administered in water.

Thus, the high prevalence of helminthiasis in chickens, its impact on health, productivity, and product quality, especially in extensive farming, requires regular monitoring and the use of effective antiparasitic measures. However, there is still a lack of relevant data on the structure of helminth fauna and the clinical efficacy of drugs in the central regions of Uzbekistan. In this regard, the purpose of the study was to identify the prevalence of intestinal nematodes in chickens in households in the Samarkand, Jizzakh, and Syrdarya regions and to evaluate the effectiveness of therapy using tetramisole.

Materials and Methods:

Geography and conditions of the study. The study was conducted in three central regions of the Republic of Uzbekistan – Samarkand, Jizzakh, and Syrdarya provinces – between 2022 and 2024. These regions are characterised by a continental climate with hot, dry summers and cold winters. Average temperatures during the study period ranged from +15°C to +32°C, with relative humidity of 40-60%. The research was conducted in households, mainly private farms with free-range chickens, where sanitary conditions were assessed as average, with factors contributing to the spread of parasitic diseases.

Objects of research. The study focused on domestic chickens of various meat and egg breeds and local breeds. A total of 747 birds were examined: 167 in the Jizzakh Region, 259 in the Syrdarya Region, and 321 in the Samarkand Region (Akramov, 2023). The conditions of keeping included free-range grazing, feeding with compound feed and grain mixtures, without strict control of sanitary standards..

Methods for selecting and analysing biomaterial. The material for the study consisted of faeces and intestinal contents of birds, taken in pure form directly from farms or after autopsy of dead individuals. Helminths were diagnosed using the Fulleborn method (Bench Aids for the diagnosis of intestinal parasites, 1994) to detect nematode eggs in faeces and the sequential washing method to isolate adult parasites from intestinal contents (Techniques for parasite assays and identification in faecal samples, n.d.). In some cases, the Baerman method was also used to detect larvae (Hansen & Perry, 1994). Microscopic analysis was performed using a LOMO ML-2200 light microscope (Russia) with morphological identification of parasites.

Identification and classification of helminths. The identification of helminth species was based on the morphological characteristics of adult specimens and eggs. *Ascaridia galli*, *Heterakis gallinarum*, *Capillaria obsignata* and other common nematodes were considered key species. The classification was in accordance with modern taxonomic guidelines. (Despommier et al., 2019).

Investigation of regional and seasonal dynamics. The studies were conducted systematically, considering seasonal fluctuations, which allowed identifying differences in the intensity of invasions depending on the region and time of year (Akramov, 2024). Samples were

collected in each area during different seasons to compare the level of infestation with climatic conditions..

Application of control and prevention methods. For deworming, the drug "Tetramizol 10%" in powder form was used, which was added to feed or drinking water (Lavrenova, 2018). The dose was 200 mg per 1 kg of live bird weight. The treatment was repeated after 14 days. The effectiveness of the drug was assessed based on the reduction in the level of helminth eggs in faeces and the decrease in the number of parasites during autopsy.

Ethical standards. The study was conducted in accordance with the principles of humane treatment of animals and veterinary bioethics. All samples were obtained with the consent of the bird owners, without causing harm to live specimens. No interventions requiring separate ethical approval were performed.

Results

Analysis of the data obtained showed that the level of nematode infection in chickens varies significantly depending on the region and district, reflecting differences in housing conditions, sanitary practices and access to veterinary care. The results presented below allow identifying the epizootiological characteristics of the spread of helminthiasis, and to establish the predominant species of nematodes and the frequency of their combination.

Regional distribution of nematode infections in chickens in certain areas of the Jizzakh, Syrdarya, and Samarkand regions. In the Jizzakh Region, 167 chickens from three districts – Pakhtakor, Sharof Rashidov, and Forish – were examined. The overall level of nematode infection was 41.9% (70 chickens). The distribution of helminth species and the level of infestation by district is shown in Table 1.

Table 1. Extent of nematode infections in chickens from different districts of Jizzakh Region

District	Total number of chickens examined	Number of infected chickens	Infection rate (EZ)	Types of nematode infections
Forish District	52	31	59.6%	40.4% ascaridiosis, 32.7% heterakidosis, 51.9% capillariasis
Pakhtakor District	77	34	44.2%	3.89% ascaridiosis, 11.7% heterakidosis, 42.9% capillariasis
Sharof Rashidov District	38	5	13.2%	7.89% ascaridiosis, 2.63% heterakidosis, 7.89% capillariasis

Note: the total number of infections by type may exceed the total number of infected chickens, as some birds have been found to have mixed infestations with two or more types of nematodes

Source: developed by the authors

The highest level of infection was recorded in the Forish District (59.6%). High rates of all three types of nematode infections were observed simultaneously, especially capillariasis (51.9%), which may be related to environmental conditions (moisture, constant contact of birds with the soil) and limited access to veterinary drugs in remote rural areas. In the Pakhtakor District, the infection rate was 44.2%, with capillariasis predominating (42.9%), and the proportion of ascariasis being low – only 3.89%. This distribution may indicate the chronic presence of capillariasis pathogens in the environment, particularly in litter, and inadequate sanitation of premises. Mixed infestations were detected in 44.2% of infected chickens, indicating a high intensity of parasite circulation. The

Sharof Rashidov District showed the lowest infection rates (13.2%), which may be explained by lower bird density, better sanitary conditions, or the seasonality of sampling. However, even in this district, cases of all three types of nematodosis were detected, indicating the endemicity of the parasitic load.

As part of the comprehensive helminthological survey, additional investigations were carried out in Syrdarya Region, where climatic and ecological conditions differ from those in the previously studied Jizzakh Region. In Syrdarya Region, a total of 259 chickens were examined using faecal samples, which were collected in a clean state and subjected to helminthoscopy. The study revealed that Ascaridiosis, Heterakidosis, and Capillariasis are also widespread among chickens in Syrdarya Region. The research results showed that 50.58% (131 chickens) were infected with nematodes. Specifically, 74 chickens (28.57%) had Ascaridiosis, 79 chickens (30.5%) had Heterakidosis, and 79 chickens (30.5%) were infected with Capillariasis eggs (Table 2).

Table 2. Extent of nematode infections in chickens from different districts of Syrdarya Region

District	Total number of chickens examined	Number of infected chickens	Infection rate (EZ)	Types of nematode infections
Mirzaabad District	54	13	24.1%	12.9% ascaridiosis, 7.4% heterakidosis, 20.4% capillariasis
Guliston District	55	31	56.4%	41.8% ascaridiosis, 38.2% heterakidosis, 29.1% capillariasis
Boyovut District	47	34	72.3%	29.8% ascaridiosis, 34.0% heterakidosis, 55.3% capillariasis
Xovos District	50	27	54%	38% ascaridiosis, 32% heterakidosis, 26% capillariasis
Sardoba District	53	26	49.1%	20.7% ascaridiosis, 41.5% heterakidosis, 30.2% capillariasis

Note: the total number of infections by type may exceed the total number of infected chickens, as some birds have been found to have mixed infestations with two or more types of nematodes

Source: developed by the authors

The level of nematode infection in chickens in the districts of the Syrdarya Region varied from moderate to high, which may be related to both the ecological characteristics of the region and differences in poultry husbandry conditions and preventive measures. The highest prevalence of nematode infections was recorded in the Boyovut (72.3%) and Guliston (56.4%) districts, which probably reflects unfavourable sanitary conditions, crowded housing of birds and insufficient frequency of deworming. Particularly high rates of capillariasis were observed in the Boyovut district (55.3%), which may indicate long-term contamination of the environment with parasite eggs and the pathogen's resistance to external influences. In contrast, the Mirzaabad district had the lowest infection rate (24.1%), which may be due to either a more favourable epizootological situation or lower livestock density on farms. The widespread combination of three types of nematodes (Ascaridiosis, Heterakidosis and Capillariasis) indicates widespread circulation of parasite eggs in the environment and insufficient biosafety in most farms. The variation in infection

rates between districts highlights the need for a differentiated approach to prevention, considering local risk factors.

In Bulung'ur district District of Samarkand regionRegion, 51 chickens, in Tayloq district 96 chickens, in Ishtixon district 82 chickens, in Jomboy district 44 chickens, and in Pastdarg'om district 48 chickens were examined, totalingtotalling 321 chickens from households raising egg-laying chickens. Faecal samples were collected from these chickens and were subjected to helminthological examination (Table 3). As a result of the study of chickens in the Samarkand regionRegion, 188 out of 321 were found to be infected.

Table 3. Extent of nematode infections in chickens from different districts of Samarkand Region

District	Total number of chickens examined	Number of infected chickens	Infection rate (EZ)	Types of nematode infections
Bulung'ur District	51	35	68.6%	68.6% ascaridiosis, 54.9% heterakidosis, 43.1% capillariasis
Tayloq District	96	44	45.8%	36.5% ascaridiosis, 22.9% heterakidosis, 39.6% capillariasis
Ishtixon District	82	63	76.8%	39.0% ascaridiosis, 64.6% heterakidosis, 41.5% capillariasis
Jomboy District	44	21	47.7%	43.2% ascaridiosis, 38.6% heterakidosis, 47.7% capillariasis
Pastdarg'om District	48	25	52.1%	47.9% ascaridiosis, 37.5% heterakidosis, 43.8% capillariasis

Note: the total number of infections by type may exceed the total number of infected chickens, as some birds have been found to have mixed infestations with two or more types of nematodes

Source: developed by the authors

In the Samarkand Region, the results of the study indicate a significant prevalence of nematode infections in chickens, especially in densely populated areas and areas where poultry is traditionally kept on private farms. The highest infection rates were recorded in the Ishtixon and Bulung'ur Bulung'ur districts, which is probably due to a combination of high poultry density, inadequate sanitary control and possible resistance of parasites to the drugs used. The proportion of heterakidosis is particularly high in the Ishtixon District, which may indicate a long-term presence of the infestation and untimely preventive measures.

In districts with less pronounced indicators, such as Tayloq and Jomboy, the infection rate also remains significant, indicating widespread circulation of nematode eggs in the environment and potentially insufficient awareness of biosafety measures among farm owners. The widespread combination of three types of nematodes in the samples – *Ascaris*, *Heterakis* and *Capillaria* – indicates the simultaneous presence of several parasite development cycles, which complicates diagnosis and treatment.

The absence of singamosis in all districts of the Samarkand Region is consistent with data from other regions and may be due to both climatic characteristics and the biology of the parasite itself, which is less resistant to current poultry farming conditions. The cumulative infection rate (58.6%) in the region highlights the need for a systematic approach to helminthiasis control,

including routine testing, educational work among owners, and regular deworming, considering regional epizootic characteristics.

Comparative assessment of nematode infection in chickens across three regions. For a comprehensive assessment of the epizootic situation regarding nematode infections in chickens in the central climatic zone of Uzbekistan, data from studies conducted in three administrative regions were summarized: Jizzakh, Syrdarya, and Samarkand regions. A total of 747 chickens kept on private subsidiary and small farms were examined between 2022 and 2024. Diagnosis was carried out using the Fulleborn method and sequential washing. The results are presented in Table 4, which shows the levels of infection and prevalence of the main types of intestinal nematodes: ascariasis, heterakidosis, and capillariasis.

Table 4. Extent of nematode infections in chickens in Jizzakh, Sirdarya, and Samarkand Regions based on helminthological and coprological examinations

Region	Number of chickens examined	Number of infected chickens	Infection rate (%)	Ascaridiosis (%)	Heterakidosis (%)	Capillariosis (%)
Jizzakh	167	70	41.92	16.17	15.57	37.13
Sirdarya	259	131	50.6	28.57	30.5	31.66
Samarkand	321	188	58.57	44.86	42.99	42.37
Total	747	389	52.07	32.80	32.53	37.48

Source: developed by the authors

The comparative analysis of nematode infections in chickens across the Jizzakh, Syrdarya, and Samarkand regions, based on the summarised data in Table 4, demonstrates noticeable regional differences in both the prevalence and structure of parasitic infestations. Among the three regions, Samarkand recorded the highest overall infection rate, with 188 out of 321 chickens (58.57%) infected. This elevated prevalence is closely associated with the dominant presence of ascaridiosis (44.86%), heterakidosis (42.99%), and capillariosis (42.37%), all showing nearly equal distribution. The high co-occurrence of these three types of nematodes suggests that complex mixed infections are widespread in this region. This pattern aligns with field observations indicating that backyard poultry in Samarkand is often raised in semi-extensive systems with limited biosecurity measures, promoting continuous exposure to contaminated environments.

In the Syrdarya Region, 50.58% of the examined chickens were infected, with heterakidosis (30.50%) slightly more prevalent than capillariosis (31.66%), and ascaridiosis (28.57%). These figures indicate a relatively even distribution of nematode species and a moderate level of infection compared to Samarkand. The presence of all three helminth types also points to polyparasitism, though not as intense as in Samarkand. Factors such as climatic conditions and similar management practices, including the lack of regular deworming and outdoor access to contaminated feed and soil, likely contribute to maintaining persistent parasitic circulation.

In Jizzakh, the overall infection rate was the lowest, at 41.92%, with a notably high proportion of capillariosis cases (37.13%) compared to ascaridiosis (16.17%), and heterakidosis (15.57%). This may reflect the ecological specificity of the area and the resilience of *Capillaria* eggs in the local environment, particularly in moist soil and litter where these nematodes are known to thrive. While the total infestation level is lower, the high rate of *Capillaria* infection still poses a significant health risk due to the pathogenic nature of these parasites, especially in young or immunocompromised birds.

In total, across all three regions and 747 chickens, the study found 389 infected birds, representing an overall infection rate of 52.07%. The dominant nematode infections were capillariosis (37.48%), followed by ascaridiosis (32.80%) and heterakidosis (32.53%). This relatively even distribution confirms the complex parasitological landscape in the central climatic zone of Uzbekistan and underscores the importance of regional epidemiological monitoring and targeted helminth control strategies.

The climate of central Uzbekistan is characterised as continental, with hot, dry summers and mild winters, which, according to literature data, creates optimal conditions for the survival of intestinal nematode eggs and larvae in the environment due to moderate humidity and temperatures favourable for their encrustation and development (Shifaw et al., 2021). Factors related to the bird's environment in free-range systems (backyard and free-range systems) play a key role, as they provide constant contact with soil, infected feces, intermediate hosts (such as earthworms, beetles), and plant biomass, which significantly increases the risk of nematode infection.

A separate study by F. Sadeghi et al. (2024) confirmed that in free-range conditions, the prevalence of *Ascaridia galli*, *Heterakis gallinarum*, and *Capillaria* spp. reaches 80-90% in chicken populations, regardless of organic or conventional farming methods. Moreover, the link between housing conditions (overcrowding, lack of pasture rotation, contaminated litter) and high intensity of helminthiasis has been repeatedly confirmed by survey data in different climatic zones, including similar climatic zones (Sherwin et al., 2013).

Thus, the continental climate of the region, free-range poultry farming, contact with a contaminated environment, and the lack of regular preventive measures have been confirmed as contributing factors to the widespread distribution of three key species of intestinal nematodes in the central zone of Uzbekistan.

Investigation of the effectiveness of an antihelminthic drug in farm conditions. In the final stage of the study, a therapeutic intervention was carried out using the anthelmintic agent Tetramizol 10%, a broad-spectrum nematodicidal preparation widely recognized in veterinary parasitology. The drug was administered in powdered form, mixed either with feed or diluted in drinking water, at a standardised dosage of 200 mg per 1 kg of live body weight, in accordance with veterinary pharmacological guidelines.

The choice of Tetramizol 10% was based on prior clinical evidence of its efficacy against the most prevalent nematode species affecting poultry, including *Ascaridia galli*, *Heterakis gallinarum*, and *Capillaria* spp. – all of which were identified during the present research. The active substance, levamisole hydrochloride, acts by inducing spastic paralysis in nematodes via nicotinic acetylcholine receptor stimulation, which facilitates expulsion of parasites from the host's digestive tract.

To quantitatively assess the therapeutic efficacy, faecal egg count reduction (FECR) was monitored post-treatment using standardised flotation and sedimentation techniques. Results showed that after the first administration, the prevalence of helminth eggs dropped by 92.86%, and complete elimination (100%) was achieved following a second application, administered 7 days after the initial dose. No adverse reactions were observed in the treated chickens, supporting the safety profile of the drug.

These findings affirm the suitability of Tetramizol 10% for the control of nematode infections in backyard poultry systems under the agroecological conditions of Uzbekistan's central climatic regions. The successful reduction in parasite load highlights its potential role in regional helminthiasis prevention programmes, especially in private farming settings where uncontrolled infections remain prevalent.

Discussion

The lack of systematic deworming, low levels of veterinary education among owners of smallholdings, and a tendency to independently use ineffective antiparasitic agents create favourable conditions for the preservation of parasitic cycles and stable species associations of helminths. These factors are confirmed by a study conducted by M.H. Radfar et al. (2012) conducted in the Sistan Region of eastern Iran, where 93.2% of free-range chickens were found to have mixed infestations involving *Ascaridia galli*, *Heterakis gallinarum*, *Subulura brumpti*, and several species of tapeworms and ectoparasites. A similar epizootic situation was observed in a number of farms in Central Uzbekistan, which indicates the need to introduce educational programmes and regular preventive treatments to break the epidemiological chains.

K. Wongrak et al. (2014) conducted a long-term study on free-range farms in Germany, observing the dynamics of nematode infection in chickens over two production cycles. By the end of the second period, the prevalence of *Heterakis gallinarum* reached 98.5%, *Ascaridia galli* – 96.2%, and *Capillaria* spp. reached 86.1%. In contrast to the data obtained (maximum prevalence of 58.6% in Samarkand), K. Wongrak et al. noted almost universal infestation with high parasitic pressure. This difference is conditioned by more intensive monitoring, post-mortem diagnosis and climatic conditions conducive to egg accumulation. However, both studies emphasised the key role of free-range systems in maintaining infectious cycles. F. Kaufmann et al. (2011) also took an interest in German farms. A study of 55 organic farms recorded a prevalence of *Ascaridia galli* at 88%, *Heterakis gallinarum* at 98%, and *Capillaria* spp. at 75.3%, with an average parasite burden of 218 worms per bird. Despite more favourable housing conditions and modern infrastructure, prevalence remains extremely high. This is consistent with the high resistance of helminths and the importance of seasonality and sanitation. In Uzbekistan, prevalence is lower, but the environmental risks are similar, especially with weak veterinary control.

The study by J.T. da Silva et al. (2022) on chickens in the Brazilian semi-arid region recorded a prevalence of endoparasites of 62.6%, with nematodes accounting for 40.5%. The key risk factors were unsanitary conditions, feeding from the ground, and heat, which inhibits the development of immunity. The result was subclinical infections, increased susceptibility to other pathogens, and a drop in productivity, which was fully consistent with the identified effects of reduced egg production and weight gain in infected birds in the central regions of Uzbekistan.

In a cross-sectional study by K. Wuthijaree et al. (2017) of free-range chickens in South Tyrol (Italy), the prevalence was almost 99.3%; *Heterakis gallinarum* (95.7%), *Capillaria* spp. (66.8%), and *Ascaridia galli* (63.6%) predominated. The intensity of infestation was significantly higher in organic farms compared to traditional ones (318.9 vs 112.0 worms/animal). The results correlate with data on mixed infections in the central regions of Uzbekistan, but chickens in Italia had a much higher infection rate, especially in winter, pointing to the strategic need for regional monitoring and individual preventive measures.

According to summary data on helminthiasis in poultry, the greatest threat to chickens is posed by nematodes of the genera *Ascaridia*, *Heterakis* and *Capillaria*, which are highly resistant and widespread in floor-based and especially free-range housing systems. It was noted that these housing systems contribute to an increased risk of infection due to contact with contaminated soil, faeces and intermediate hosts – earthworms and insects (Poultry Diseases, n.d.). This information is fully consistent with the results of the present study, where an increase in infection was observed in all regions where birds had free access to outdoor areas.

The epidemiological study conducted by T. Ferdusly et al. (2016) in Narsingdi District (Bangladesh) revealed a high prevalence of gastrointestinal helminths in free-range chickens, highlighting the high risk of parasitic infestations in free-range conditions. The study, which covered 150 individuals from three villages, found that the most common cestode was *Raillietina* spp. (86-92%), while *Ascaridia galli* (70-86%) and *Heterakis gallinarum* (70-76%) were the most common nematodes. Some individuals showed characteristic pathological changes, such as petechial haemorrhages on the walls of the small intestine in cases of *A. galli* infection and small white nodules in the caecum in cases of *H. gallinarum* infestation. It is noteworthy that most chickens were infected with several species of parasites at once, which indicates favourable conditions for the preservation and transmission of helminths in rural environments, and the insufficient effectiveness of current preventive measures in such housing systems.

Thus, the results obtained are generally consistent with data presented in studies conducted in various countries, including Germany, Iran, Italy, Bangladesh, and Brazil, despite varying levels of infection. Everywhere, the high prevalence of nematodes among free-range chickens and the stable circulation of the main helminth species, primarily *Ascaridia galli*, *Heterakis gallinarum* and *Capillaria* spp. Differences in infection levels are conditioned by both climatic conditions and the intensity of monitoring, veterinary services and the sanitary conditions of farms. Nevertheless, the overall epidemiological picture confirms the significance of helminthiasis as a constant threat to poultry farming in extensive farming systems. These data form the basis for the development of effective preventive strategies.

Conclusion

The study established the epizootological situation regarding intestinal nematodes in chickens kept on individual farms in three key regions of central Uzbekistan: Samarkand, Jizzakh, and Kashkadarya regions. Of the 747 biomaterial samples examined, 386 were found to be infected, accounting for 52.07% of the total, confirming the high prevalence of helminthiasis in farm poultry. Among the identified pathogens, the most significant were nematodes of the species *Ascaridia galli*, *Heterakis gallinarum* and representatives of the genus *Capillaria*, which dominated in all regions surveyed. Their presence, and the frequent combination of several species in one sample, indicate the active circulation of parasitic agents in conditions of free range and limited veterinary control.

The results obtained are fully consistent with data from epizootic observations conducted in other countries, such as Iran, Italy, Germany, Bangladesh, and Brazil. Despite differences in climate, veterinary care, and diagnostic methods, a high degree of vulnerability of poultry to nematode infestations was observed in systems close to extensive farming. This highlights the universality of the problem and the need for transnational exchange of knowledge and control methods.

Particular attention was paid to evaluating the effectiveness of antiparasitic therapy. It was found that the use of Tetramizol 10% provided a pronounced antiparasitic effect in mixed infestations, achieving an effectiveness of 92.86% to 100%. This makes the drug a reliable tool in the fight against helminthiasis in poultry and allows it to be recommended for use in private and farm households. The high effectiveness of the drug is especially significant in conditions of limited access to laboratory diagnostics and professional veterinary services.

The study identified the leading types of helminths, determined the level of infection in chickens, and confirmed the effectiveness of the therapeutic approach, which indicates that the set goals have been achieved. The practical significance of the study lies in the possibility of using the data obtained to plan regional strategies for the prevention and control of helminthiasis, adapted to the conditions of the private sector. In the future, further research should focus on investigating the seasonal dynamics of infection, monitoring the possible resistance of pathogens to various groups of anthelmintics, and comprehensively assessing the environmental factors and sanitary and hygienic conditions that contribute to the maintenance of parasitic cycles. This would enable the development of more sustainable and scientifically sound biosafety measures in poultry farming.

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**EFFECT OF THE PROBIOTIC “MAXILAC” ON THE BLOOD INDICATORS OF
YOUNG KARAKUL SHEEP**

**ВЛИЯНИЕ ПРОБИОТИКА “МАХИЛАС” НА ПОКАЗАТЕЛИ КРОВИ МОЛОДНЯКА
КАРАКУЛЬСКИХ ОВЕЦ**

**ПРОБИОТИК “МАХИЛАС”ТИН КАРАКУЛ КОЙЛОРУНУН КОЗУЛАРЫНЫН КАНЫНЫН
КӨРСӨТКҮЧТӨРҮНӨ ТИЙГИЗГЕН ТААСИРИ**

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EFFECT OF THE PROBIOTIC “MAXILAC” ON THE BLOOD INDICATORS OF YOUNG KARAKUL SHEEP

Abstract

The relevance of the study is determined by the need to increase the resistance and adaptability of young Karakul sheep in conditions of a sharply continental climate and intensive livestock farming, which requires the search for safe metabolic stimulants. The use of probiotics in the early postnatal period is considered a promising way to improve haematological and metabolic parameters in farm animals. The aim of this study was to investigate the effect of the probiotic “Maxilac” on the morphological and biochemical parameters of blood in Karakul lambs aged two and four months. To achieve this goal, an experiment was conducted on 20 clinically healthy lambs, evenly divided into control and experimental groups. The probiotic under investigation was added to the drinking water of the experimental group at a rate of 1 g per 100 l. The dynamics of growth were assessed by evaluating the erythrocyte and leukocyte formulas, haemoglobin levels, and blood metabolites. It was found that the lambs in the experimental group had a significantly higher number of erythrocytes (up to 10.48 million/ μ l) and haemoglobin level (up to 11.82 g/l) compared to the control group, as well as a physiological decrease in the number of leukocytes. Biochemical indicators showed an increase in the concentrations of glucose, urea, total bilirubin, and cholesterol, which may indicate the activation of metabolic processes. At the same time, a moderate decrease in the levels of total protein, chlorides, calcium, and phosphorus was observed. These changes persisted at both control points – at 2 and 4 months. Thus, the use of the probiotic under study had a positive effect on metabolic and haematological parameters, which allows it to be recommended for the prevention of alimentary disorders and the optimisation of the development of young Karakul sheep

Keywords: Karakul sheep breeding; erythrocytes; leukocytes; haemoglobin; total protein; glucose; urea

Влияние пробиотика “maxilac” на показатели крови молодняка каракульских овец

Аннотация

Актуальность исследования обусловлена необходимостью повышения резистентности и адаптивности молодняка каракульских овец в условиях резко континентального климата и интенсивного животноводства, что требует поиска безопасных стимуляторов обмена веществ. Применение пробиотиков в раннем постнатальном периоде рассматривается как перспективный путь повышения гематологических и метаболических показателей у сельскохозяйственных животных. Целью настоящей работы являлось изучение влияния пробиотика «Maxilac» на морфологические и биохимические показатели крови у каракульских ягнят в возрасте двух и четырёх месяцев. Для достижения цели проведён эксперимент на 20 клинически здоровых ягнятах, равномерно разделённых на контрольную и опытную группы. Исследуемый пробиотик добавлялся в питьевую воду опытной группе из расчёта 1 г на 100 л. В динамике роста оценивались показатели эритроцитарной и лейкоцитарной формул, уровень гемоглобина, а также метаболиты крови. Установлено, что у ягнят опытной группы по сравнению с контрольной достоверно повысились количество эритроцитов (до 10,48 млн/мкл), уровень гемоглобина (до 11,82 г/л), а также отмечено

Пробиотик “maxilac” тин каракул койлорунун козуларынын канынын көрсөткүчтөрүнө тийгизген таасири

Аннотация

Изилдөөнүн актуалдуулугу курч континенталдык климат шарттарында жана интенсивдүү мал чарбачылыгында каракул жүндүү койлордун жастарынын туруктуулугун жана адаптациясын жогорулатуу зарылдыгынан келип чыгат. Бул болсо организмдин алмашуу процессин стимулдаштыруу үчүн коопсуз препараттарды издөө талап кылынат. Пробиотиктерди туулган соңку эрте мезгилде колдонуу айыл чарба жаныбарларынын гематологиялык жана метаболикалык көрсөткүчтөрүн жогорулатуу боюнча перспективдүү жол катары каралууда. Бул иштин максаты – эки жана төрт айлык каракул жылкаларда “Maxilac” пробиотигинин кан морфологиялык жана биохимиялык көрсөткүчтөрүнө тийгизген таасирин изилдөө болду. Максатка жетүү үчүн 20 клиникалык ден соолугу чың жылкаларда эксперимент жүргүзүлүп, алар тең бөлүнүп көзөмөл жана тажрыйба топторуна бөлүндү. Изилденген пробиотик тажрыйба тобунун ичүүчү суусуна 100 литрге 1 грамм өлчөмүндө кошулду. Өсүү динамикасында эритроцитардык жана лейкоцитардык формулалар, гемоглобин деңгээли жана кан метаболиттери бааланды. Натыйжада, тажрыйба тобунда көзөмөлгө салыштырмалуу эритроциттердин саны (10,48 млн/мкл чейин), гемоглобин деңгээли (11,82 г/л чейин) статистикалык мааниде жогорулап,

физиологическое снижение количества лейкоцитов. В биохимических показателях зафиксировано увеличение концентраций глюкозы, мочевины, общего билирубина и холестерина, что может свидетельствовать об активации обменных процессов. Одновременно наблюдалось умеренное снижение уровня общего белка, хлоридов, кальция и фосфора. Эти изменения сохранялись в обе контрольные точки – в 2 и 4 месяца. Таким образом, применение исследуемого пробиотика оказало положительное влияние на показатели обмена и гематологических параметров, что позволяет рекомендовать его для профилактики алиментарных нарушений и оптимизации развития молодняка каракульской породы

лейкоциттердин саны физиологиялык жактан төмөндөгөнү аныкталды. Биохимиялык көрсөткүчтөрдө глюкоза, мочевина, жалпы билирубин жана холестериндин концентрациясы жогорулаганы байкалган, бул алмашуу процесстеринин активдешүүсүн көрсөтөт. Ошол эле учурда жалпы белок, хлориддер, кальций жана фосфор деңгээли орточо төмөндөдү. Бул өзгөрүүлөр 2 жана 4 айдагы көзөмөл чекиттеринде сакталды. Демек, изилденген пробиотик алмашуу жана гематологиялык параметрлерге оң таасирин тийгизип, аны азык алмашуунун бузулушун алдын алуу жана каракул тукумундагы жастардын өнүгүүсүн оптималдаштыруу үчүн колдонуу сунушталат

Ключевые слова: каракулеводство; эритроциты; лейкоциты; гемоглобин; общий белок; глюкоза; карбамид

Ачкыч сөздөр: каракул кой; эритроциттер; лейкоциттер; гемоглобин; жалпы белок; глюкоза; мочевина

Introduction

Livestock farming is one of the key sectors of agriculture in Uzbekistan, particularly important for desert and semi-desert regions. Karakul sheep farming occupies a special place in this sector, providing the population not only with food but also with a stable source of income. One of the pressing tasks for the industry remains increasing the productivity of young animals, strengthening their immunity and reducing mortality. With the ban on the use of feed antibiotics since 2020, there has been increased attention to biologically safe methods of growth stimulation, in particular probiotics. However, the effect of probiotic supplements on the physiological and biochemical parameters of Karakul lambs' blood has not been sufficiently studied, which determines the need for comprehensive research.

The relevance of the topic was confirmed by a study by T. Liu et al. (2022), which evaluated the effect of *Lactiplantibacillus plantarum* on the physiological condition of Sunit sheep. A significant decrease in blood lipid levels, increased expression of genes involved in lipid metabolism, and an increase in the content of beneficial metabolites and aromatic compounds in adipose tissue were observed. The authors concluded that probiotics have a complex effect on metabolic processes, contribute to improving product quality, and can be effectively used in sheep breeding, which makes this approach promising for karakul breeding as well.

In order to increase the survival rate of Karakul lambs, the use of probiotic preparations in the lambs' diet, along with milk, has shown high efficiency. Due to their biological properties, probiotics are widely used in animal husbandry and veterinary practice. This is proven by the work of S. Saha et al. (2023), which examines the effect of probiotics on the meat quality of small ruminants. The authors found that probiotics contribute to improving carcass weight, colour, aroma, tenderness, muscle fibre structure and the content of beneficial fatty acids. However, the results of various studies were inconsistent, which can be explained by different strains, dosages, housing conditions, and the physiological state of the animals. The need for standardisation of approaches and further research to identify optimal regimes for the use of probiotics in small animal husbandry was noted.

The biological mechanism of action of probiotics, which participate in the digestive and metabolic processes of the body and promote the synthesis and absorption of proteins and other biologically active substances, makes this research even more relevant. This explains the positive effects demonstrated in a number of studies, including those by L. Wang et al. (2024) and M.M. Shoukry et al. (2023), where probiotics showed the ability to strengthen immunity, improve weight gain and feed conversion. It is also known that Karakul lambs experience a decrease in blood protein starting at two months of age, especially in individuals separated from their mothers, which leads to slower growth. The use of probiotic supplements in such cases can compensate for protein deficiency by digesting dead microbial cells and stimulating the biosynthesis of protein structures, thereby supporting the growth and development of young animals in difficult grazing conditions.

A study by R. Wójcik et al. (2024) evaluated the effect of a multi-strain probiotic complex on the phagocytic activity and oxidative metabolism of granulocytes and monocytes in the peripheral blood of lambs. The experiment was conducted on 16 lambs divided into control and experimental groups. Lambs from the experimental group were administered a probiotic supplement containing *Lactobacillus plantarum* (AMT14, AMT4, AMT15) and *Bifidobacterium animalis* (AMT30) strains for 30 days, while the control group did not receive probiotics. The analysis showed that lambs

receiving probiotic support had significantly increased phagocytic activity and fluorescence intensity of granulocytes and monocytes, indicating enhanced immune function. Similarly, an improvement in the oxidative metabolism of cells was observed after stimulation with *Escherichia coli* bacteria and PMA. The authors concluded that this probiotic complex can positively affect the immune status of lambs, which may be important for increasing the resistance of animals to infectious diseases.

Despite numerous studies confirming the positive effect of probiotics on the immune status of lambs, data on the use of probiotics in the specific conditions of Uzbekistan and on the population of Karakul lambs remain limited and insufficiently studied. In this regard, the relevance of studying the probiotic “Maxilac” in the context of morphological and biochemical blood parameters of Karakul lambs is of particular importance. The aim of the study was to investigate the effect of the probiotic “Maxilac” on the morphological and biochemical blood parameters of Karakul lambs.

Materials and methods

The research was conducted on young Karakul sheep raised on Karakul sheep farms located in the desert-steppe zone of the Mubarek district of the Kashkadarya region (Uzbekistan). Twenty Karakul lambs from the second lambing were selected for the experiment on the principle of “similar pairs”, taking into account their live weight at birth, which ensured the homogeneity of the groups in terms of physiological and biometric parameters.

The study used lambs aged 2 and 4 months. The animals were kept under standard conditions on Karakul farms in the region, with adequate feeding and drinking water. The climatic zone is desert-steppe, characterised by dryness and seasonal temperature fluctuations. Stocking density and ventilation complied with veterinary standards, which ruled out the influence of stress factors on blood parameters. All lambs were divided into two groups of 10 animals each:

- control group (group I) – without probiotic supplementation;
- experimental group (group II) – with the addition of the probiotic under study.

The division into groups was carried out on the principle of paired selection, taking into account live weight at birth to minimise intergroup differences.

The probiotic under study was administered orally by dissolving 1 g of the preparation in 100 litres of drinking water, which was given to the animals daily throughout the study period. The preparation was used to assess its effect on the morphological and biochemical parameters of the lambs' blood.

Blood was collected from the jugular vein of the lambs at three key points: before the start of the experiment (baseline values), on the 15th and 30th days after the start of probiotic administration. The volume of blood collected was 5 ml, and the tubes contained an anticoagulant to prevent clotting. Blood morphology parameters were determined using a BIOBASE BK6190 automatic haematology analyser, which ensured the accuracy and reproducibility of the results. The main parameters were the number of erythrocytes, leukocytes and haemoglobin level (Kaneko et al., 2008). Biochemical blood parameters were examined using standard laboratory methods accepted in veterinary clinical biochemistry (State standards, Beyerstein methods, etc.) (Walker, 2002; Cooper, 2013). The concentrations of total protein, glucose, urea, total bilirubin, magnesium, cholesterol, chlorides, calcium, and phosphorus were determined. Reagents from leading

manufacturers were used, and the equipment was regularly calibrated to ensure the reliability of the results.

The data obtained were processed using statistical software (e.g., SPSS, Statistica). The results are presented as the mean value and standard error ($M \pm m$). To determine the statistical significance of the differences between the groups, Student's t-test was used, with a significance level of $p \leq 0.05$.

All experimental procedures complied with international and national standards for the ethical treatment of animals, as confirmed by permits from the relevant veterinary services (Directive 2010/63/EU, 2010). Control of housing conditions and exclusion of infectious diseases minimised the influence of external factors on the studied indicators (Decree No. UP-5995, 2020).

Results

Given the importance of blood parameters as a sensitive indicator of an animal's physiological condition, particular attention was paid to assessing changes in the number of erythrocytes, leukocytes and haemoglobin levels under the influence of this biological preparation. The studies were conducted on Karakul lambs aged two and four months, which were given the probiotic under study in the form of an aqueous solution at a dosage of 1 g per 100 l of drinking water for a certain period. The experimental group of lambs (group II) received the preparation according to the protocol, while the control group (group I) was kept under standard conditions without the administration of the probiotic. The analysis of morphological indicators revealed differences between the animals in the control and experimental groups in the dynamics of maturation, which indicates the physiological response of the body to the action of the probiotic. The summarised results of the morphological analysis of blood are presented in Table 1.

Table 1. Effect of the probiotic under study on the morphological parameters of blood in Karakul lambs ($M \pm m$)

Morphological parameters of blood	Unit of measurement	2 weeks old		4 weeks old	
		Group I	Group II	Group I	Group II
Erythrocytes	million	8.49 ± 5.7	9.74 ± 7.8	8.20 ± 4.5	10.48 ± 9.5
Leukocytes	thousand	7.46 ± 1.2	7.21 ± 0.24	7.81 ± 0.65	7.24 ± 0.86
Haemoglobin	g/l	9.69 ± 2.75	11.4 ± 3.02	10.72 ± 2.36	11.82 ± 2.4

Source: created by the authors

Analysis of the data presented in Table 1 demonstrates the effect of the probiotic under study on the morphological parameters of the blood of Karakul lambs aged two and four months. The results obtained allow to establish reliable differences between the control and experimental groups, indicating the biological activity of the probiotic and its ability to modulate physiological processes in the body of young animals.

Two-month-old lambs that were administered the probiotic showed an increase in the number of red blood cells compared to the control group. In particular, in the experimental group, this indicator was 1.25 million/mm³, which indicates stimulation of erythropoiesis and, possibly, improvement in the oxygen-carrying function of the blood. At the same time, there was an increase in haemoglobin concentration of 2.71 g/l compared to the same age group in the control group, which also confirms the positive effect of the drug on blood function. At the same time, the total number of leukocytes in the experimental animals was 0.25 thousand/mm³ lower, which is probably

due to the normalising effect of the probiotic on the immune system and a reduction in physiological stress.

A similar trend was observed in four-month-old lambs. The number of erythrocytes in animals receiving the probiotic reached 2.28 million/mm³, which clearly demonstrates the cumulative effect of the probiotic with prolonged use. An increase in haemoglobin levels by 1.10 g/l also indicates a sustained improvement in metabolic processes and blood transport functions. At the same time, a decrease in leukocyte levels by 0.57 thousand/mm³ relative to the control group can be interpreted as a reflection of more stable homeostasis and the absence of inflammatory reactions in the body. Such morphological changes in the blood with systematic administration of the probiotic confirm its adaptogenic and immunomodulatory effects. Thus, a comprehensive analysis of Table 1 allows to conclude that there is a positive trend in haematological parameters against the background of the use of the probiotic under study in Karakul lambs. The data presented illustrate a tendency towards improvement in the oxygen-transporting and protective functions of the blood, as well as a reduction in stress reactions, which may be important in the practice of early rearing of young animals.

At the next stage of the study, an attempt was made to characterise the effect of the probiotic preparation on the biochemical parameters of blood, reflecting the intensity of metabolic processes and the general physiological state of the organism. The blood biochemical parameters obtained in the control group before the administration of the probiotic indicate the baseline level of metabolic activity in Karakul lambs: total protein concentration was 45.6 g/l, glucose level was 3.04 mmol/l, urea – 4.79 mmol/l, total bilirubin – 1.32 mmol/l, magnesium – 0.59 mmol/l, cholesterol – 6.06 mmol/l, chloride – 95.6 mmol/l, calcium – 1.44 mmol/l, and phosphorus – 3.71 mmol/l. These indicators were recorded and presented in Table 2, which served as the basis for further comparative analysis after the use of the probiotic.

Table 2. Biochemical indicators ($r \geq 0.05$) in the blood of young Karakul lambs before administration of the probiotic under study ($M \pm m$).

Blood serum index	Units of measurement	Control	Experimental
		Group I	Group II
Total protein	g/L	45.6±3.35	51.6±40.4
Glucose	mmol/L	3.04±0.40	4.12±0.64
Urea	mmol/L	4.79±0.29	5.77±0.68
Total bilirubin	mmol/L	1.32±0.39	1.56±0.36
Magnesium	mmol/L	0.59±0.16	0.52±0.1
Cholesterol	mmol/L	6.06±0.46	4.14±0.7
Chlorides	mmol/L	95.6±4.36	82±1.05
Calcium	mmol/L	1.44±0.63	1.22±0.2
Phosphorus	mmol/L	3.71±0.28	3.49±0.2

Source: created by the authors

According to the data presented in Table 2, the biochemical composition of the blood of Karakul lambs before the use of the probiotic “Maxilac” shows certain differences between the control (I) and experimental (II) groups of animals, which indicates the initial physiological characteristics of the young animals at the start of the study. First of all, the level of total protein in the blood serum is noteworthy, which in the control group was 45.6 g/l, while in the experimental group this indicator was higher and reached 51.6 g/l. Such an increase may indicate better protein

metabolism in lambs in group II, possibly due to more intensive synthesis of proteins, including albumins and globulins, in the liver and immune system. Elevated protein levels at the initial stage of the experiment may serve as a favourable prognostic indicator for the adaptive capabilities of the organism.

The glucose content in animals from group II was also higher (4.12 mmol/l) than in the control group (3.04 mmol/l). This may be due to differences in energy metabolism, enzyme system activity, and carbohydrate metabolism. Elevated glucose concentrations may indicate more active metabolism or better feed digestibility, but in the absence of additional data, this indicator should be considered background for now. The concentration of urea in the blood serum of lambs from the experimental group was 5.77 mmol/l, which is 0.98 mmol/l higher than in the control group (4.79 mmol/l). The increase in this indicator may be associated with enhanced protein catabolism or changes in kidney function, but the values remain within the physiological norm for animals of this age. This indicates the absence of pathological disorders and the continued functional capacity of the excretory system.

Total bilirubin levels also showed a slight increase in animals in group II (1.56 mmol/L versus 1.32 mmol/L in the control group). This pigment is formed as a result of haemoglobin breakdown, and its concentration may reflect the condition of the liver and erythropoiesis processes. A slight increase in bilirubin levels indicates a possible increase in blood formation, which is also consistent with the previously recorded higher haemoglobin and erythrocyte levels in the experimental group. Against the background of these increases, there is a decrease in serum magnesium levels in the experimental group – 0.52 mmol/l versus 0.59 mmol/l in the control group. Given that magnesium plays an important role in enzymatic activity and energy metabolism, its decrease may indicate its more intensive use in metabolic processes, especially during periods of rapid growth and development.

A significant difference between the groups was found in cholesterol levels. In the experimental group, its concentration was 4.14 mmol/l, while in the control group it reached 6.06 mmol/l. This may indicate a decrease in lipid synthesis or their more active use in metabolic processes. A decrease in cholesterol levels can be considered a positive factor, indicating good lipid metabolism. A similar trend was observed with regard to chloride content: in the blood of lambs in the experimental group, the level was 82 mmol/l, which is lower than in the control group (95.6 mmol/l). Chlorides play a key role in regulating acid-base balance and osmotic pressure, so a decrease in their concentration may indicate certain changes in water-salt balance and electrolyte metabolism.

The calcium content in the blood of the experimental animals was 1.22 mmol/l, which is lower than that of the control animals (1.44 mmol/l). Calcium is an important element for bone formation and is also involved in nerve and muscle conduction processes. A slight decrease in its level may be associated with active skeletal formation in growing animals and more intensive consumption from the bloodstream. Phosphorus, which also plays an important role in mineral metabolism and bone formation, showed a slight decrease in the experimental group compared to the control group: 3.49 mmol/L versus 3.71 mmol/L, respectively. This indicates a possible activation of growth and mineralisation processes, accompanied by increased consumption of this element.

Thus, Table 2 illustrates the biochemical characteristics of Karakul lambs before the start of the study probiotic and demonstrates certain differences between the control and experimental groups, which is an important background for the subsequent analysis of the dynamics of changes under the influence of the probiotic preparation. Based on the data obtained, it can be assumed that in the organisms of the lambs in group II, metabolic processes were already activated at the initial stage, which was reflected in the indicators of protein, carbohydrate, lipid and mineral metabolism. These initial differences must be taken into account when interpreting the subsequent results and evaluating the effectiveness of the probiotic, the data on which are presented in the following graph and Table 3.

Table 3. Biochemical indicators ($r \geq 0.05$) in the blood of Karakul lambs after administration of the probiotic under study ($M \pm m$)

Blood serum index	Units of measurement	2 weeks old		4 weeks old	
		Group I	Group II	Group I	Group II
Total protein	g/L	44.8 $\pm$ 3.95	40.0 $\pm$ 10.1	56.2 $\pm$ 4.73	43 $\pm$ 3.4
Glucose	mmol/L	2.71 $\pm$ 0.44	3.77 $\pm$ 0.22	3.3 $\pm$ 0.777	3.4 $\pm$ 0.5
Urea	mmol/L	5.1 $\pm$ 0.27	6.9 $\pm$ 0.6	5.3 $\pm$ 0.6	6.81 $\pm$ 0.5
Total bilirubin	mmol/L	0.12 $\pm$ 0.04	1.6 $\pm$ 0.3	0.2 $\pm$ 0.5	1.13 $\pm$ 0.5
Magnesium	mmol/L	0.36 $\pm$ 0.02	0.44 $\pm$ 0.10	0.52 $\pm$ 0.11	0.37 $\pm$ 0.05
Cholesterol	mmol/L	3.89 $\pm$ 0.82	5.97 $\pm$ 0.44	3.32 $\pm$ 0.51	6.26 $\pm$ 0.47
Chlorides	mmol/L	106.6 $\pm$ 5.44	97.0 $\pm$ 5.3	130 $\pm$ 10.7	90.0 $\pm$ 3.3
Calcium	mmol/L	2.29 $\pm$ 0.68	3.68 $\pm$ 0.50	2.92 $\pm$ 0.24	2.48 $\pm$ 0.21
Phosphorus	mmol/L	4.65 $\pm$ 0.50	3.78 $\pm$ 0.27	3.5 $\pm$ 0.2	2.78 $\pm$ 0.24

Source: created by the authors

Table 3 shows the biochemical parameters of the blood serum of Karakul lambs in the second and fourth weeks after administration of the probiotic under study. Analysis of the dynamics of changes in these parameters allows important conclusions to be drawn about the physiological effect of the probiotic on metabolic processes in young animals. In the second week of the experiment, the total protein content in the control group was 44.8 g/l, while in the experimental group this indicator was lower – 40.0 g/l. This decrease may be associated with the increased use of proteins against the background of intensified growth and development in lambs receiving the probiotic. In the fourth week, the differences became even more pronounced: in the control group, the protein level was 56.2 g/l, while in the experimental group it was 43 g/l. This trend may indicate a redistribution of protein metabolism towards plastic processes, accompanied by a temporary decrease in serum protein, which does not necessarily indicate a deficiency, but rather reflects its active use in tissue synthesis.

The glucose level in the second week was higher in the experimental group (3.77 mmol/l) than in the control group (2.71 mmol/l), which may indicate improved carbohydrate absorption and increased energy metabolism under the influence of the probiotic. In the fourth week, the glucose content in both groups approached 3.3 mmol/l in the control group and 3.4 mmol/l in the experimental animals, demonstrating stabilisation of carbohydrate metabolism with a slight advantage in the group receiving the supplement. Urea levels were consistently higher in the experimental group in both weeks: 6.9 mmol/l versus 5.1 mmol/l (second week) and 6.81 mmol/l versus 5.3 mmol/l (fourth week). This indicates an intensification of protein metabolism and, possibly, more active protein breakdown, or an increase in detoxification and excretory processes

mediated by the kidneys. It is important to emphasise that the values remain within the physiological norm.

A significant difference between the groups was observed in terms of total bilirubin concentration. In the experimental group, it was 1.6 mmol/L in the second week, while in the control group it was only 0.12 mmol/L. In the fourth week, the bilirubin level in the experimental group decreased slightly to 1.13 mmol/l, but remained significantly higher than in the control group (0.2 mmol/l). These values may reflect increased destruction of erythrocytes or adaptive changes in the hepatobiliary system caused by the action of probiotic microorganisms.

Magnesium content also varied: in the second week, it was 0.44 mmol/L in the experimental group (compared to 0.36 mmol/L in the control group), and by the fourth week, it had decreased to 0.37 mmol/L, while in the control group it increased to 0.52 mmol/l. This dynamic may indicate a more intensive involvement of magnesium in enzymatic and energy reactions activated by the probiotic. Cholesterol levels in the experimental animals were higher than in the control animals in both weeks: 5.97 mmol/L and 6.26 mmol/L, respectively, compared to 3.89 mmol/L and 3.32 mmol/L. This may indicate changes in lipid metabolism, including lipoprotein synthesis and transport, and may be a consequence of the body's adaptation to growth, with an increased need for structural lipids.

The chloride content in the control group increased progressively from 106.6 mmol/l to 130 mmol/l, while in the experimental group there was a decrease from 97.0 mmol/l to 90.0 mmol/l. Lower values may indicate increased chloride consumption in metabolic processes or a change in water-salt balance. Such dynamics deserve attention, especially in hot climates, where electrolyte loss can be significant. Calcium and phosphorus levels in the experimental group were lower than in the control group. Thus, in the fourth week, the calcium level was 2.48 mmol/l versus 2.92 mmol/l, and the phosphorus level was 2.78 mmol/l versus 3.5 mmol/l. These elements are actively used in the formation of bone tissue and ensuring neuromuscular conduction. Their reduced content may be a temporary consequence of intensive growth and mineralisation of the skeleton.

A comparative analysis of the data presented allows us to draw general conclusions about the dynamics of biochemical indicators under the influence of the probiotic "Maxilac". For most parameters, there is a marked difference between the control and experimental groups, which indicates a systemic effect of the probiotic on metabolic processes in the body of Karakul lambs. Based on the results obtained, it can be said that the probiotic supplement contributes to the activation of energy and protein metabolism, as well as affecting mineral and lipid metabolism. These changes can be considered adaptively significant and physiologically appropriate in the conditions of rearing young animals in an arid climate. Thus, after analysing Tables 1, 2 and 3, a positive trend in the change in morphological and biochemical blood parameters under the influence of the probiotic "Maxilac" becomes apparent.

Discussion

Scientists are actively researching ways to improve the efficiency of feeding ruminants with probiotics, seeking to improve metabolism, digestion and the body's adaptive abilities. In an experiment by V.N. Romanov (2022), the effect of a combination of probiotic strains included in the diet of sheep in loose and granulated form was studied. An improvement in feed digestibility, an increase in the level of volatile fatty acids in the rumen, an increase in the population of beneficial

microflora and positive dynamics of haematological indicators were established, which indicates metabolic stabilisation. The results obtained in this study are consistent with the conclusions of V.N. Romanov, confirming increased microbiological activity and improved metabolic indicators. However, unlike the experiment, this study focuses not on the form of probiotic administration, but on the combination of specific phytobiotic additives, which made it possible to identify additional effects related to live weight gain and feed conversion efficiency.

The study by V.A. Pleshkov & S.N. Belova (2022) found positive changes in productivity indicators and haematological parameters in lambs against the background of the use of the probiotic feed supplement “Mucinol Extra”. An increase in absolute weight gain of 20.5%, average daily weight gain of 20.3%, and relative weight gain of 50.0% was noted, accompanied by an increase in haemoglobin and erythrocyte count by 11.2% and 14.1%, respectively. At the same time, an increase in the concentration of total protein, calcium, and phosphorus in blood serum was observed, with a decrease in glucose levels by 4.0% and urea by 12.5%. In contrast to the results obtained in this study using the probiotic under investigation, no decrease in glucose and urea levels was recorded; on the contrary, both indicators were higher in the experimental group compared to the control group, which may indicate a difference in the metabolic action of the probiotic strains used. In addition, while the experiment with “Mucinol Extra” showed an increase in total protein, the use of “Maxilac” showed a tendency towards a decrease, probably due to more intensive plastic use of proteins against the background of active growth. Despite these differences, both studies demonstrated the beneficial effect of probiotics on haematological and biochemical parameters, which emphasises the general advisability of including them in the diets of young sheep to stimulate metabolic processes and increase the adaptive resistance of the body.

A study by A. Estrada-Angulo et al. (2021) showed that the use of probiotics, prebiotics and their combination in lambs in a subtropical climate improved the energy efficiency of the diet and some productive indicators, with the combination of additives having a more pronounced effect. In the present study, conducted in a desert-steppe climate zone, the probiotic under investigation caused significant changes in the biochemical parameters of the blood of Karakul lambs, such as an increase in glucose and urea and a decrease in total protein, calcium and phosphorus, reflecting adaptive metabolic processes. Thus, despite differences in climate and research focus, both experiments confirm the effect of probiotics on the metabolism and physiological condition of young sheep.

Current research highlights the multifaceted effect of probiotics in sheep farming, aimed not only at improving animal growth and health, but also at reducing environmental impact, including reducing methane emissions. A review by A.S.A. Saleem et al. (2025) points to the ability of probiotics to stimulate beneficial rumen microflora, improve fermentation processes and increase nutrient absorption, which contributes to increased productivity and strengthened immunity. At the same time, the authors note the need to optimise the composition, dosage and methods of administration of probiotics for maximum effectiveness.

H. Chen et al. (2021) evaluated the effects of probiotics and polysaccharides of traditional Chinese medicine (PTCM) on growth, blood biochemistry, and rumen microbiota in lambs. Probiotics increased glucose and immunoglobulin G levels, enhanced rumen microbial protein, and lowered rumen fluid pH. PTCM increased average daily gain, improved immune indicators, and reduced the feed conversion ratio. Microbiota analysis showed changes in the relative abundance of

key bacteria affecting fermentation. The results confirm the positive effects of probiotics and PTCM on metabolism and immunity, with improved productivity via rumen microbiota modulation.

In a study by H. Mao et al. (2023) studied the effect of probiotics on growth, blood biochemistry, and rumen microbiota in 24 Hu lambs aged 50 days, including 8 healthy lambs (13.2 ± 1.17 kg) and 16 lambs with slow growth (9.46 ± 0.81 kg). The probiotic increased average daily gain and dry matter intake ($p < 0.05$), increased superoxide dismutase and glutathione peroxidase activity, and increased growth hormone and immunoglobulin G levels. Lambs without probiotics had higher concentrations of IL-6, interferon-gamma, and tumour necrosis factor alpha ($p < 0.05$). The probiotic also increased the content of volatile fatty acids and acetate ($p < 0.05$), and the microbiota showed an increase in the genera *Ruminococcus*, *Succiniclaticum*, and *Acidaminococcus*.

Unlike most studies aimed at assessing the effect of probiotics on animal growth and health, the work of O. Machuskyi (2023) focused on the development of a technology for the production of the probiotic “Sporo-lex”. The study compared two production options: in a liquid and in a solid nutrient medium. It was found that production on a solid medium provides faster (by 24 hours) and more cost-effective fermentation, with fewer intermediate control stages and the formation of more mature spores, which increases the stability of the preparation during storage. While most studies focus on the biological effect of probiotics, this work concentrates on the technological aspects that affect the quality and stability of probiotic preparations, which is important for ensuring their effective use in animal husbandry.

In a study by O. Shkromada et al. (2024) evaluated the effect of an enzyme-probiotic complex on the productivity and health of rabbits during the stressful period of weaning. The use of the complex contributed to an increase in live weight of up to 18.7%, an improvement in average daily gain and feed conversion, as well as a reduction in the incidence of gastrointestinal disorders. Biochemical indicators showed an increase in erythrocytes, haemoglobin, and leukocytes, as well as an improvement in lipid and protein metabolism and mineral balance (in particular, calcium). The results demonstrate the effectiveness of enzyme-probiotic supplements as alternative growth stimulants and means of supporting the immunity of young animals.

In another study, O. Shkromada et al. (2023) focused on the effect of probiotic feed supplements on the restoration of lactation in females after calving. The use of *Bacillus subtilis* AX 20 and *Bacillus licheniformis* EA 22 contributed to an increase in milk productivity in cows by 12.9-21.35% during the period from 7 to 21 days of the experiment compared to the control. In sows with hypogalactia, the use of *Bacillus megaterium* NCH 55 improved lactation and contributed to an increase in piglet live weight by 18.5-31.91% at different periods after birth. There was also a significant increase in the content of total protein, globulins and cholesterol in the blood serum of animals in the experimental groups, which confirms the improvement in metabolic processes and immune status. These results indicate the practical value of probiotics for increasing milk productivity and adapting the female organism after calving.

In a study by S.T. Qureshi et al. (2020), the effect of adding probiotics and crude protein levels (18% and 20%) to the diet of Salt Range lambs on growth parameters was evaluated. The experiment was conducted on 16 lambs aged about 30 days, divided into four groups with different diets. The results showed that increasing protein to 20% significantly improved average daily gain and feed conversion ($p < 0.05$), while probiotics had no significant effect on growth and blood

biochemistry. The main factor in improving productivity was related to protein levels, and probiotics did not increase growth efficiency under these conditions.

The study by V. Vosooghi-poostindoz et al. (2014) assessed the effect of different protein levels and probiotic supplementation on growth, blood parameters and rumen fermentation in lambs before and after weaning. In the pre-weaning experiment, increasing the protein content from 16% to 18% increased weaning weight and feed intake, while probiotics promoted increased feeding and reduced stress (low cortisol levels) but did not affect feed conversion and weight gain. In the post-weaning period, differences in protein levels (14.5% and 16.5%) and the addition of probiotics did not significantly affect lamb productivity. Thus, increased protein levels in the diet before weaning improved growth and consumption, and probiotics reduced stress but did not increase overall productivity.

M.O. Machado et al. (2024) evaluated the effect of probiotics on lambs of Texel and Ile-de-France breeds. The animals were divided into groups: control (without probiotics) and experimental with the addition of 1 g and 5 g of probiotics per day. Over 84 days of observation, no weight gain was recorded, but the GP1 group had higher silage and dry matter intake ($p < 0.001$). The control lambs showed thickening of the keratinised rumen epithelium ($p < 0.001$), while the probiotic groups showed greater diversity of the rumen and faecal microbiome. For example, in GP5, the proportion of *Azoarcus*, *Dialister*, *Treponema* and *Fibrobacter* increased, while *Anaeroplasm* predominated in the control group ($p < 0.05$). This confirms the protective role of probiotics for the microbiome and rumen morphology, despite the lack of effect on productivity.

Overall, a review of the scientific literature confirmed the high level of research activity in the field of probiotic use in animal husbandry. The diversity of subjects (from lambs of different breeds to other farm animals), methods and dosages underscores the relevance of the topic. Probiotics are considered not only as growth stimulants, but also as a means of improving the condition of the microbiome, digestion and immune functions. This indicates the great potential of this area as a sustainable alternative to antibiotics and hormonal stimulants in modern animal husbandry systems.

Conclusions

Based on the experiment and analysis of haematological and biochemical indicators of Karakul lambs raised in a desert-steppe climate zone, the following general conclusions can be drawn. It has been established that the use of the probiotic under study has a positive effect on the physiological condition of young animals. Two- and four-month-old lambs in the experimental group (receiving the probiotic) showed increased levels of total protein, erythrocytes and haemoglobin compared to the control group, indicating improved protein metabolism and haematopoietic function. At the same time, the control group had higher number of leukocytes, which may indicate increased antigenic load or stress without probiotic support.

Biochemical blood analysis showed significant shifts under the influence of probiotics. In two-month-old lambs in the experimental group, there was a decrease in the concentration of total protein, chlorides, and phosphorus, with a simultaneous increase in glucose, urea, bilirubin, magnesium, calcium, and cholesterol. The picture was similar in four-month-old lambs, except for a decrease in magnesium and calcium, which is probably due to age-related changes in metabolic processes. Such biochemical shifts indicate the activation of metabolic adaptation processes,

improved digestion and metabolism due to the normalisation of the intestinal microflora achieved by the use of probiotics.

Thus, in a desert-steppe climate, the probiotic under study has been found to be highly effective in establishing the physiologically complete status of Karakul lambs in the early stages of rearing. The stable haematological and biochemical shifts recorded during the experiment reflect not only the activation of metabolic processes, but also the potential of the probiotic in question as a safe and promising means of increasing the productivity of young animals in antibiotic-free feeding systems. The results obtained can serve as a basis for the introduction of this technology into sheep farming practice in arid zones. In the future, it is necessary to expand the scope of research, including the assessment of productivity, immune status and gastrointestinal microbiota during long-term use of probiotics in lambs of different ages and genotypes.

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**STUDY OF THE EPIZOOTOLOGY OF SHEEP BRUCELLOSIS IN SOME REGIONS OF
UZBEKISTAN AND THE RESULTS OF DIAGNOSTIC STUDIES**

ИЗУЧЕНИЕ ЭПИЗООТОЛОГИИ БРАДЗОТА ОВЕЦ В НЕКОТОРЫХ РЕГИОНАХ
УЗБЕКИСТАНА И РЕЗУЛЬТАТЫ ДИАГНОСТИЧЕСКИХ ИССЛЕДОВАНИЙ

ЎЗБЕКСТАНДЫН АЙРЫМ АЙМАКТАРЫНДА КОЙЛОРДУН БРАДЗОТУНУН
ЭПИЗООТОЛОГИЯСЫН ИЗИЛДӨӨ ЖАНА ДИАГНОСТИКАЛЫК ИЗИЛДӨӨЛӨРДҮН
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STUDY OF THE EPIZOOTOLOGY OF SHEEP BRUCELLOSIS IN SOME REGIONS OF UZBEKISTAN AND THE RESULTS OF DIAGNOSTIC STUDIES

Abstract

The development of sheep breeding as one of the leading areas of animal husbandry in Uzbekistan requires a systematic approach to the prevention of particularly dangerous infectious diseases, including sheep botulism caused by *Clostridium oedematiens*. The relevance of this study is due to the need for timely detection and prevention of outbreaks of this infection, which leads to significant economic losses and the death of productive animals. The aim of the study was to establish the epizootic situation regarding sheep botulism in the Kashkadarya, Samarkand and Jizzakh regions, as well as to conduct a comprehensive diagnosis of the disease, followed by the isolation and study of the biological properties of the pathogen. To achieve this goal, visits were organised to disadvantaged private and karakul sheep farms, where pathological material was collected from dead animals. Diagnostics included bacteriological studies using Kitt-Tarozzi medium, Gram staining, microscopy, and biological testing on laboratory animals. It was established that brucellosis in these regions was mainly recorded during the cold season – autumn, winter and early spring. The disease mainly affects sedentary and well-fed sheep, especially when grazing in conditions of high humidity. The isolated strains of *Cl. septicum* demonstrated characteristic growth with clouding of the medium and the formation of gas bubbles. Laboratory animals infected with the isolated culture showed typical clinical and pathological changes, confirming the high pathogenicity of the pathogen. The diagnosis was based on a combination of epizootological data, laboratory tests and bioassays. The results of the study are of practical importance for determining vaccination schedules, planning anti-epizootic measures and preventing economic losses in sheep breeding

Keywords: pathogen; *Cl. septicum*; bacillus; spore; anaerobe; Kitt-Tarozzi; sheep breeding

Изучение эпизоотологии браздота овец в некоторых регионах Узбекистана и результаты диагностических исследований

Аннотация

Развитие овцеводства как одного из ведущих направлений животноводства Узбекистана требует системного подхода к профилактике особо опасных инфекционных заболеваний, в числе которых браздот овец, вызываемый *Clostridium oedematiens*. Актуальность настоящего исследования обусловлена необходимостью своевременного выявления и предупреждения вспышек данной инфекции, приводящей к значительным экономическим потерям и падежу продуктивных животных. Целью работы являлось установление эпизоотической обстановки по браздоту овец в Кашкадарьинской, Самаркандской и Джизакской областях, а также проведение комплексной диагностики заболевания с последующим выделением и изучением биологических свойств возбудителя. Для достижения цели были организованы выезды в неблагополучные частные и каракулеводческие хозяйства, где от павших животных отбирался патологический материал. Диагностика включала бактериологические исследования с использованием среды Китта-Тароцци, окраску мазков по Граму, микроскопию, а также биологическую пробу на лабораторных животных. Установлено, что браздот в указанных регионах регистрировался преимущественно в холодное время года – осенью,

Ўзбекистандын айрым аймактарында койлордун браздотунун эпизоотологиясын изилдөө жана диагностикалык изилдөөлөрдүн жыйынтыктары

Аннотация

Ўзбекистандагы мал чарбачылыгынын негизги багыттарынын бири болгон кой чарбачылыгынын өнүгүшү өзгөчө коркунучтуу инфекциялык оорулардын алдын алуу боюнча системалуу мамиленин зарылдыгын туудурат. Алардын катарында *Clostridium oedematiens* бактериясынын түрткү болгон койлордун браздоту бар. Учурдагы изилдөөнүн актуалдуулугу – аталган инфекциянын кырдаалдарын өз убагында аныктоо жана алдын алуу зарылдыгында, анткени бул оорулуу экономикалык чыгымдарды көбөйтүп, продуктивдүү малдардын өлүмүнө алып келет. Изилдөөнүн максаты – Кашкадария, Самарканд жана Джизак облустарында койлордун браздотунун эпизоотологиялык абалын аныктоо, ооруну комплекстүү диагностикалоо, оорунун козгогучун бөлүп алуу жана анын биологиялык касиеттерин изилдөө болду. Максатка жетүү үчүн көйгөйлүү жеке жана каракул чарбаларына барышып, каза болгон малдардан патологиялык материал алынды. Диагностика Китт-Тароцци чөйрөсүндө бактериологиялык изилдөөлөрдү, Грамга боёну, микроскопияны жана лабораториялык жаныбарларда биологиялык сыноону камтыды. Аймактарда браздот негизинен суук мезгил – күз, кыш жана эрте жаз айларында катталган. Ооруга негизинен аз кыймылдуу жана жакшы салмак алган койлор

зимой и ранней весной. Заболеванию подвержены, главным образом, малоподвижные и хорошо упитанные овцы, особенно при пастьбе в условиях повышенной влажности. Выделенные штаммы *Cl. septicum* продемонстрировали характерный рост с помутнением среды и образованием газовых пузырьков. У лабораторных животных, инфицированных выделенной культурой, наблюдались типичные клинические и патологоанатомические изменения, подтверждающие высокую патогенность возбудителя. Диагноз устанавливался на основе совокупности эпизоотологических данных, лабораторных тестов и биопробы. Результаты исследования имеют практическое значение для обоснования сроков вакцинации, планирования противоэпизоотических мероприятий и предотвращения экономических потерь в овцеводстве

сезгентилген, айрыкча жогорку нымдуулуктагы жайыттарда. Бөлүнүп алынган *Clostridium septicum* штамдары өзгөчө өсүү менен, чөйрөнүн булануусу жана газ көбүкчөлөрүнүн пайда болушу менен мүнөздөлдү. Лабораториялык жаныбарларда бөлүнгөн культура менен жугузулган учурда типтүү клиникалык жана патологоанатомиялык өзгөрүүлөр байкалган, бул козгогучтун жогорку патогендигин тастыктады. Диагноз эпизоотологиялык маалыматтардын, лабораториялык тесттердин жана биологиялык сыноонун комплексинин негизинде коюлду. Изилдөөнүн жыйынтыктары эмдөөнүн мөөнөттөрүн белгилөөдө, эпизоотияга каршы чараларды пландаштырууда жана кой чарбачылыгындагы экономикалык жоготуулардын алдын алууда практикалык мааниге ээ

Ключевые слова: возбудитель; *Cl. septicum*; бацилла; спора; анаэроб; Китт-Тароцци; овцеводческое хозяйство

Ачкыч сөздөр: козгогуч; *Cl. septicum*; бацилла; спора; анаэроб; Китт-Тароцци; кой чарбасы

Introduction

Sheep brucellosis remains one of the serious factors limiting the development of karakul sheep farms and private households in the Republic of Uzbekistan. In this regard, the development of resource-efficient and import-independent preventive measures to combat infectious animal diseases is particularly relevant. Since 2018, large-scale measures have been implemented in the republic to prevent and control anaerobic infections affecting large and small ruminants. Among the key tasks in the field of animal husbandry, the priorities remain increasing livestock numbers, improving productivity, ensuring full reproduction, proper animal care and the prevention of dangerous diseases.

In order to ensure the sustainable development of karakul sheep breeding, increase the number of karakul sheep, expand production and processing, improve breeding work and social support for industry specialists, a set of regulatory and legal acts regulating state support for the sector was adopted. In particular, Decree of the President of the Republic of Uzbekistan No. DP-60 (2022), Resolution of the President of the Republic of Uzbekistan No. RP-3603 (2018), and Decree of the President of the Republic of Uzbekistan No. PP-224 (2022) are aimed at addressing the above-mentioned tasks.

However, despite the creation of additional opportunities and conditions, the problem of developing and increasing the productivity of sheep breeding remains widespread. The study by H. Esmaeili et al. (2025) examines the clinical and laboratory aspects of malignant oedema in sheep caused by *Clostridium septicum*, a pathogenic anaerobe similar in characteristics to the causative agent of brucellosis. Based on the study of clinical cases in imported sheep breeds (Il-de-France and Roman) in three farms in Iran, the authors conducted a comprehensive diagnosis, including bacteriological studies, Gram staining and PCR identification of the pathogen. The high pathogenicity of *C. septicum* and the need for early diagnosis of the disease were established, as its course is rapid and leads to death. It was noted that despite the availability of vaccines, the disease remains insufficiently studied and covered in veterinary practice.

A. Mussayeva et al. (2024) analysed outbreaks of brucellosis and anaerobic enterotoxemia in sheep in various regions of Kazakhstan in 2021-2022. Pathological material was examined using Kitt-Tarozzi medium, glucose-blood agar, microscopy and bioassays on guinea pigs. The cultural and morphological properties of *Clostridium perfringens* (types A, B, SVT, D), *Cl. septicum* and *Cl. oedematiens* were characterised. Over the decade, 15 cases of botulism and 44 cases of enterotoxemia were identified, with the majority occurring in the Zhambyl region. The authors attribute the low incidence to systematic vaccination, emphasising the importance of prevention and its potential as a model for other countries.

The article by R.M. Uraqova & H.S. Salimov (2021) presents experimental data on the determination of 50% and 100% lethal doses (LD_{50} and LD_{100}) of the causative agent of brucellosis – *Clostridium oedematiens* in guinea pigs. The bacteria were isolated from pathological material from sheep that had died from brucellosis and cultured in Kitt-Tarozzi medium. The authors emphasised that the most important predisposing factors for the development of the disease are winter and early spring grazing of sheep in high humidity, helminth infection, and deficiency of proteins, vitamins, and minerals, which leads to a decrease in the overall resistance of the organism. It has been established that *Cl. oedematiens* is a motile anaerobic microorganism capable of sporulation in the body of a dead animal. Infection occurs through feed, water, soil and manure. The

results of laboratory determination of lethal doses are important for understanding the pathogenesis and toxicity of isolated local strains, as well as for the development of effective preventive and diagnostic measures against brucellosis in sheep.

P. Thomas et al. (2021) presented the first complete genomic sequence of the *C. septicum* DSM 7534T strain and performed a comparative analysis of five genomes of this species. The data revealed a stable phylogenetic position of *C. septicum*, significant variability in prophages, CRISPR elements, and restriction-modification systems, as well as the presence of an extensive pool of virulence genes, including sialidase, collagenase, haemolysin, and leukocidin homologue genes. These results shed light for the first time on the genetic plasticity and pathogenicity of *C. septicum*, expanding understanding of its role as a dangerous zoonotic pathogen.

To develop effective measures to combat brucellosis, it is necessary to study its epizootiology and improve methods for diagnosing and preventing the disease. Of particular importance in this regard was the isolation of local strains of the pathogen from pathological material taken from sheep in farms affected by brucellosis and the study of their cultural, morphological and biological characteristics. The aim of the study was to isolate the pathogen from pathological material from sick and dead animals, to study its cultural-morphological, tinctorial, biochemical and biological properties in order to substantiate the diagnosis and develop preventive measures.

Materials and methods

The study was conducted in 12 sheep farms located in the Kashkadarya, Samarkand and Jizzakh regions of the Republic of Uzbekistan. The total number of sheep in the surveyed farms was about 8,000, which corresponds to the number of sheep in focal flocks with an increased incidence of brucellosis. At the same time, the total number of sheep in the three regions is about 50-70 thousand. For bacteriological studies, pathological material (75 samples) was collected from dead animals (Fig. 1): pieces of liver, heart, kidneys, tubular bones and muscle tissue from the affected areas (Fig. 2). Samples were collected in accordance with the rules of asepsis and antisepsis.



Figure 1. Sheep dead from brucellosis

Source: photos taken by the authors



Figure 2. Damaged internal organs

Source: photos taken by the authors

In the immunology and biotechnology laboratory of the Veterinary Research Institute (Tashkent, Uzbekistan), pathological material was subjected to bacteriological examination. For microscopic analysis, smears were prepared on microscope slides from the organs under investigation. The smears were air-dried and fixed over the flame of an alcohol lamp, which ensured their sterility and prevented bacterial growth during subsequent staining and microscopy. After fixation, the smears were stained according to Gram, which allowed microorganisms to be differentiated into Gram-positive and Gram-negative. The staining technique included the sequential application of carbolic acid solution of gentian violet (1-2 minutes), treatment with Lugol's solution (1 minute), decolorisation with alcohol (about 30 seconds), additional staining with an alcohol-water solution of fuchsin (1-2 minutes), after which the preparation was washed with water and dried (Eleusizova, 2018). To isolate bacteria, the surface of the organs was burned with a heated scalpel, then tissue fluid was collected from the tissues using a Pasteur pipette and seeded into test tubes with Kitt-Tarozzi medium (Litusov, 2015). The test tubes were incubated in a thermostat at 37-38 °C for the growth of microorganisms.

To confirm the pathogen and make a diagnosis, biological tests were carried out on laboratory animals (guinea pigs), which were infected with a daily culture of the isolated pathogen, *Clostridium septicum*. Clinical signs, pathological changes and the results of bacteriological studies were observed. Epizootological data were collected during business trips to the farms under study, together with local veterinary specialists, where information on the spread of the disease, the conditions of keeping and the nature of the affected animals was recorded.

To prevent and control brucellosis, sheep were vaccinated twice 35-40 days before being taken to pasture, with an interval of 12-14 days. The vaccine doses were: 2 and 3 ml for adult sheep, 1 and 1.5 ml for lambs up to 6 months old, respectively, administered intramuscularly into the inner

hairless surface of the hind limb. Immunity developed 10-12 days after the second dose (Dunlop & Malbert, 2004).

When the disease was detected on a farm, restrictions were imposed: a ban on the import and export of animals, and on the movement or transport of healthy unvaccinated sheep. Sanitary measures were carried out – destruction of carcasses, manure and feed residues by burning, disinfection of the territory with solutions of chlorinated lime (3%), formaldehyde (5%) and caustic soda (5%) with re-treatment after one hour.

During the research, all applicable ethical standards and requirements governing the use of animals for scientific purposes were observed. All manipulations with animals were carried out in strict accordance with the regulatory documents of the Republic of Uzbekistan and international standards for the treatment of laboratory and farm animals (International Standards for the Care..., 2019). Biological tests on guinea pigs were carried out using the minimum number of animals necessary to achieve reliable results. Before the start of the research, a positive review (permission) was obtained from the ethics committee of the Research Institute of Veterinary Medicine.

Results

The disease was recorded in various pastures, pens and subsidiary farms, mainly during sudden changes in weather conditions and violations of sanitary and hygienic standards for animal husbandry. Among the sheep examined in individual flocks, a high incidence of brucellosis was detected – in some cases it reached about 30%, while the mortality rate among those affected remained extremely high – 90-100%. The incidence rate among the total sheep population in the regions studied was estimated at approximately 1-1.5%. The highest number of cases was recorded in the Shakhrisabz district of the Kashkadarya region, the Payaryk district of the Samarkand region and the Gallyaarl district of the Jizzakh region, as shown in Figure 3.

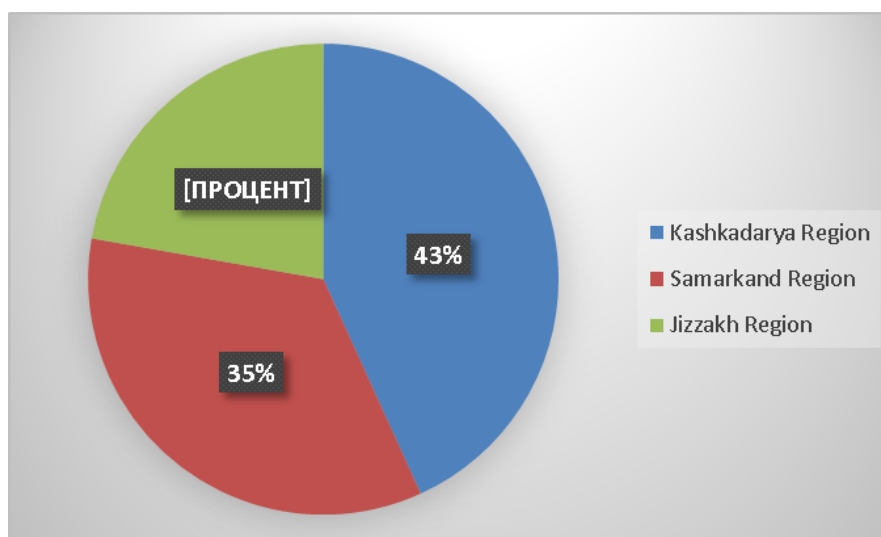


Figure 3. Prevalence of brucellosis by region (number of sheep affected)

Source: compiled by the authors

Based on the data presented in Figure 3, the highest epizootic intensity was observed in the Shakhrisabz district of the Kashkadarya region, where approximately 350 sheep were reported to be infected. A significant number of cases were also detected in the Payaryk district of the Samarkand region (approximately 280 animals) and the Gallyaarl district of the Jizzakh region (approximately

180 animals). This distribution indicates a probable dependence of the spread of brucellosis on environmental and economic-organisational factors. The disease was particularly intense in areas with a high density of sheep farms and inadequate sanitary control over housing conditions. Increased susceptibility of animals was observed during spring and summer fluctuations in temperature and humidity, which apparently contributed to the activation of the pathogen and the occurrence of acute outbreaks.

The studies established that sedentary and well-nourished sheep were highly susceptible to the disease, becoming infected mainly when grazing on pastures, whereas lambs contracted the infection in pens or household conditions. Despite the absence of a pronounced seasonal dependence, brucellosis in sheep is more often recorded between October and March. The main predisposing factors are winter and early spring grazing in pastures with high air humidity – the presence of dew, frost and precipitation, which creates favourable conditions for the contamination of feed and pastures with the pathogen.

An additional risk factor is a decrease in the overall resistance of the body caused by helminthiasis and disturbances in protein, vitamin and mineral metabolism. Immunodeficiency states contribute to the penetration of *Clostridium septicum* into the digestive organs and the accelerated development of the pathological process. Thus, temperature and humidity conditions, combined with the physiological weakening of sheep, create a favourable background for the development of brucellosis and high mortality among affected animals.

To confirm the diagnosis and clarify the aetiology of the disease, laboratory tests were carried out on pathological material taken from dead and clinically ill animals in outbreak areas. The material under investigation was sent to the Laboratory of Immunology and Biotechnology of the Research Institute of Veterinary Medicine, where bacterioscopic and bacteriological analyses were performed. Particular attention was paid to the isolation of a pure culture of the pathogen and the determination of its morphological and cultural properties. Figure 4 shows the growth of the causative agent of brucellosis in anaerobic conditions, accompanied by clouding of the nutrient medium and the formation of gas bubbles under petroleum jelly oil.



Figure 4. Growth of the causative agent of blight with clouding of the culture medium and formation of air bubbles under petroleum jelly oil

Source: compiled by the authors

The figure shows test tubes with meat-peptone broth inoculated with pathological material taken from dead sheep in areas suspected of having brucellosis. Incubation was carried out under anaerobic conditions at a temperature of 37°C for 24-48 hours. Characteristic signs of obligate anaerobic growth are visually observed: clouding of the medium, flaky sediment and the formation of gas bubbles under a layer of petroleum jelly oil, indicating active metabolic activity of the pathogen. The change in the colour of the medium from light yellow to dark brown may be due to the formation of metabolites and protein breakdown products accompanying the vital activity of clostridia and confirms the reproduction of the pathogen and its interaction with the components of the culture medium. However, the colour of the medium is not a specific diagnostic feature. Thus, the results of bacteriological culture confirm the presence of *Clostridium septicum* in the test material and indicate a typical course of blackleg in sheep, accompanied by massive intoxication, gas formation and high mortality. A microscopic image of Gram-positive bacteria of the causative agent of brucellosis is shown in Figure 5.



Figure 5. Microscopic image of the causative agent of brucellosis, stained according to Gram

Source: compiled by the authors

Microscopic examination of stained preparations prepared from pathological material revealed characteristic morphological features of the pathogen. Figure 5 shows Gram-positive rod-shaped bacteria, located mainly singly or in pairs, with clear contours and a characteristic purple colour, indicating the resistance of the cell wall to the action of alcohol during Gram staining. The bacteria ranged in size from 10 to 30 μm in length, with uneven thickness and a moderately pronounced capsule structure (Ferreira Alves et al., 2021). The microscopic data obtained indicate that the microorganisms belong to the genus *Clostridium*, and the combination of morphological features confirms the identification as *Clostridium septicum*, the causative agent of malignant oedema and brucellosis in sheep.

For final verification of the diagnosis, a biological test was performed: laboratory guinea pigs were injected with a daily culture isolated from pathological material obtained from dead sheep.

Characteristic clinical manifestations, pathological changes, and the results of subsequent bacteriological examination of infected animals confirmed the presence of *Cl. septicum* and served as the basis for the final diagnosis. After laboratory confirmation of the diagnosis, measures were promptly taken to treat and prevent the disease in the focus of infection. Sheep are vaccinated 35-40 days before the flock is put out to pasture. Immunisation is carried out twice at intervals of 12-14 days using a specific vaccine against brucellosis. Recommended dosages: adult animals – 2 ml for the first injection and 3 ml for the second; lambs up to 6 months of age – 1 ml and 1.5 ml, respectively. The vaccine is administered intramuscularly into the inner hairless surface of the hind limb. Immunity develops 10-12 days after the second injection.

If a case of brucellosis is confirmed on a farm, quarantine restrictions are imposed: the import and export of animals, as well as the movement and transport of unvaccinated sheep on the farm, are prohibited. All dead animals, feed residues and manure must be destroyed by burning. The territory is subjected to sanitary cleaning, and then disinfected twice, at intervals of one hour, with a 3% solution of bleach, a 5% solution of formaldehyde or a 5% solution of caustic soda.

Thus, comprehensive epizootological, laboratory and pathological studies have reliably established that *Clostridium septicum* is the causative agent of the reported cases of disease in sheep in a number of regions of Uzbekistan. Microscopic, bacteriological and biological methods, used in combination, ensured a high degree of diagnostic accuracy. The established seasonal patterns, clinical and anatomical picture and laboratory test results made it possible to formulate scientifically sound recommendations for the prevention, localisation and elimination of infection foci.

Discussion

The presence of *Clostridium septicum* in abomasal samples, despite its low detection rate, was confirmed by data from H. Kalender et al. (2023), who identified *C. septicum* among a number of clostridia in Turkey, albeit with a low prevalence rate, which was associated with mass vaccination of cows. In the conditions of the study in Uzbekistan, clinical foci were characterised by a high density of infection and the absence of large-scale prevention, which, apparently, led to a higher proportion of infected animals. Thus, the results showed that vaccination significantly reduced the frequency of *C. septicum* detection in the abomasum, which correlated with observations on the need for preventive measures.

The textbook by A.A. Shevchenko et al. (2013) was devoted to the study of anaerobic enterotoxemia in sheep and goats caused by *Clostridium perfringens* types C and D. The authors summarised a large amount of data on the pathogenesis, prevalence and methods of combating the disease. The work examined the historical development of the study of the disease, its economic damage, the resistance of the pathogen, as well as clinical and pathological signs. Particular attention was paid to diagnostic methods, including bacteriological studies, differential diagnosis, and laboratory confirmation. Based on the data obtained, recommendations were made for treatment, vaccination, and sanitary and preventive measures in affected farms.

A study by S. Moustafa et al. (2022) in Egypt showed that typical toxin-producing strains of *C. perfringens* were more prevalent in haemorrhagic abomasitis, while *C. septicum* was significantly less common. These data allowed a clear distinction to be made between brucellosis and abomasal enteritis, emphasising that the toxigenicity of *C. septicum* was mainly manifested in

other clinical forms, such as malignant oedema and brucellosis, which was confirmed by observations in Uzbekistan. The results obtained complemented the understanding of the pathogenetic differences between clostridia and clarified the specificity of *C. septicum* in various forms of the disease.

W.-X. Tan et al. (2025) reported a high prevalence of *C. perfringens* among sheep in the Asian region (~38.8%) and demonstrated the effectiveness of vaccination in reducing morbidity. This was consistent with the idea of the key role of preventive measures in enterotoxemia. Despite the difference in the aetiological agent – *C. perfringens* versus *C. septicum* – both pathogens were activated under the influence of stress factors associated with feeding and climatic changes. Consequently, the conclusion about seasonal outbreaks caused by humidity and temperature was confirmed in a broader regional context.

The review by Y.K. Prabhakar et al. (2025) presented modern molecular biological aspects of the epidemiology, pathogenesis, immunobiology, genomics, and proteomics of brucellosis pathogens in cattle. The authors described in detail the mechanism of severe inflammatory changes in the reproductive organs of animals, confirmed by the detection of vasculitis, fibrosis, and necrosis. Of particular importance was the consideration of the immune mechanisms by which the pathogen evades the host response, as well as the use of proteomics to search for biomarkers and potential therapeutic targets. Unlike the present study, which focused on sheep brucellosis, this review demonstrated a more comprehensive molecular approach to characterising the infection, including genomic sequencing and drug resistance analysis.

A detailed analysis of the clinical and pathological course of brucellosis in sheep was presented by J.F. Prescott et al. (2017), who considered the disease to be a form of clostridial abomasitis caused by *Clostridium septicum*. Characteristic macroscopic and microscopic changes were described, including oedema, gas formation in the abomasal wall, pronounced necrosis and vascular thrombosis, which fully coincided with the results recorded during outbreaks in Uzbekistan. The role of cold climate and damage to the mucous membrane as factors contributing to the development of infection was also emphasised. Particular attention was paid to rapid mortality, diagnostic difficulties in post-mortem isolation of the pathogen, and the limited effectiveness of antibiotic therapy, which coincided with conclusions about the need for vaccination and strict sanitary control. Unlike the present study, the presented work focused on experimental data on modelling the pathogenesis and international spread of the disease.

A study by S. Ting et al. (2025) conducted in Timor-Leste revealed low levels of awareness among farmers about brucellosis, but high willingness to vaccinate and use personal protective equipment. The authors pointed out that domestic and traditional practices, such as grazing on common pastures and leaving the placenta in the field, significantly increased the risk of spreading the infection to both animals and humans. These data correlated with the findings of the present study on the role of sanitary violations and pasture conditions in the spread of brucellosis. Despite the difference in aetiology – *Brucella* spp. in Timor and *Clostridium septicum* in this study – both works emphasised the key role of animal hygiene and epizootiological literacy in disease prevention.

R.M. Ortiz Flores et al. (2024) demonstrated that partially purified protein fractions secreted by *Clostridium septicum* induced macrophage death through the activation of autophagy and apoptosis. It was found that proteins with a molecular weight ≥ 100 kDa caused pronounced

inflammation, morphological changes in cells, and increased levels of IL-10 and TNF- α , indicating an attempt by the pathogen to evade the immune response at the site of infection. The data obtained confirmed the pathogenic potential of *C. septicum* as a highly virulent pathogen, which was fully consistent with the high mortality and rapid progression of brachitis in sheep observed in the present study. In contrast to the clinical focus of the current work, the article by R.M. Ortiz Flores et al. provided a molecular explanation for the pathogen's ability to cause massive tissue damage and immune dysfunction, expanding the understanding of the mechanisms of *C. septicum* virulence.

Scientists Z. Kirmbayeva et al. (2023) conducted epizootic monitoring of bacterial infections in animals in the southern regions of Kazakhstan, with a particular focus on clostridiosis, including emphysematous carbuncle. The study noted that these diseases mainly occurred during the grazing period, which correlated with the findings of the present study on outbreaks of brucellosis in sheep under similar conditions. In both cases, the role of weather factors, pasture structure and stocking density in the spread of infection was emphasised. Despite the low level of positive soil samples for clostridia (less than 1%), the authors pointed to the need for further research into the influence of the environment on morbidity. The difference was in the broader coverage of pathogens (including *Listeria* spp.) and the use of government monitoring data, whereas the present study relied on laboratory and field epizootiological methods.

Thus, a summary of the results of various independent studies conducted in Turkey, Kazakhstan, Brazil, and Egypt confirmed the key findings of this study: climatic conditions (humidity, temperature), poor sanitation, immunodeficiency, and lack of vaccination were the main predisposing factors for the development of brucellosis in sheep. The similarity of the data obtained with the results of other studies strengthened the evidence base, confirming the key factors in the development of the disease. At the same time, geographical and pathogenetic differences only emphasised the regional specificity of the pathology and the need to develop adapted prevention strategies.

Conclusions

The study found that brucellosis was recorded among sheep mainly in farms with foci of infection in certain areas of the Kashkadarya, Samarkand and Jizzakh regions of the Republic of Uzbekistan. In some of the flocks examined, the proportion of infected animals reached 30%, indicating the high intensity and focal nature of the disease. The mortality rate among infected sheep was 90-100%, reflecting the severity and acute course of the disease.

The overall prevalence of brucellosis in the regional sheep population, taking into account all the farms surveyed, is estimated at 1-1.5%. These figures are based on epizootological monitoring and a comprehensive analysis of clinical and laboratory studies. The difference between the high incidence in foci and the relatively low prevalence overall is explained by the localisation of infection foci and the effectiveness of preventive measures in most farms.

The highest number of cases was registered in areas with a high density of sheep farms and insufficient sanitary and hygienic control, which indicates the significant role of economic, organisational and environmental factors in the pathogenesis and spread of brucellosis. Sudden changes in climatic conditions, in particular temperature fluctuations and increased humidity in the spring and summer, contributed to the activation of the pathogen and the development of outbreaks

of the disease. Additional risk factors were a decrease in the immune status of animals due to helminthiasis and metabolic disorders.

The results of the study substantiated the need for a comprehensive approach to the diagnosis and prevention of brucellosis, including timely laboratory confirmation of the diagnosis, differentiation from similar diseases, and the implementation of vaccination programmes taking into account the specifics of regional epizootic conditions. An important element of anti-epizootic measures is also the sanitary treatment of infection foci and the introduction of quarantine restrictions to prevent the spread of the disease. In the future, it is advisable to deepen the study of the molecular-genetic characteristics of the pathogen and the factors affecting its virulence, as well as to monitor the effectiveness of existing vaccines in different climatic zones. Particular attention should be paid to the development of integrated epizootic control systems and improving farmers' knowledge of animal hygiene, which will help to reduce morbidity and economic losses in sheep breeding.

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THE MORPHOLOGICAL AND GENETIC CHARACTERISTICS OF KYRGYZ HORSES

**МОРФОЛОГИЧЕСКИЕ И ГЕНЕТИЧЕСКИЕ ХАРАКТЕРИСТИКИ КЫРГЫЗСКИХ
ЛОШАДЕЙ**

**КЫРГЫЗ АТТАРЫНЫН МОРФОЛОГИЯЛЫК ЖАНА ГЕНЕТИКАЛЫК
МҮНӨЗДӨМӨЛӨРҮ**

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THE MORPHOLOGICAL AND GENETIC CHARACTERISTICS OF KYRGYZ HORSES

Abstract

The relevance of this study lies in the necessity to preserve and selectively improve the indigenous Kyrgyz horse – a rare and unique breed group adapted to the extreme conditions of high-mountain environments. The genetic characteristics of this population have previously been studied to a very limited extent, which hinders effective management of its gene pool. The purpose of this study was to determine the intrapopulation genetic structure of Kyrgyz horses from the north-eastern region of the Kyrgyz Republic using single nucleotide polymorphisms (SNPs) and morphological traits. To achieve this, SNP genotyping was carried out using the Equine80k array (Illumina), alongside morphometric assessment of exterior traits, cluster and correlation analyses (UPGMA, PCoA, Dice, Mantel tests), and binary coding of phenotypic data. According to SNP analysis, the population was divided into two genetic clusters: the first comprised 22 horses with a genetically homogeneous structure, while the second included 3 individuals (KIR8, KIR18, KIR20) displaying higher genetic distance. Based on morphological traits, two clusters were also identified: the first group consisted predominantly of dark-coated horses (92%) with body measurements below average breed standards (up to 136 cm at the withers in 83% of cases); the second group comprised light-coloured horses (chestnut, grey, buckskin – 83%) with more developed conformation features (height at withers >136 cm, chest girth >158 cm – 92%, cannon bone girth >18 cm – 100%). However, results of the variation analysis and Mantel test ($r = -0.07396$; $p = 0.0499$) indicated no statistically significant correlation between morphological traits and SNP data, suggesting that traditional exterior features are independent of the molecular markers used. The practical significance of this study lies in establishing a foundation for future selective breeding and DNA-based certification of Kyrgyz horses, and in the development of scientifically grounded programmes for conserving native populations under mountain livestock systems

Keywords: conformation; SNP genotyping; markers; polymorphism; statistical analysis; cluster analysis

Морфологические и генетические характеристики кыргызских лошадей

Аннотация

Актуальность исследования обусловлена необходимостью сохранения и селекционного совершенствования аборигенной кыргызской лошади – редкой и уникальной породной группы, приспособленной к экстремальным условиям высокогорья. При этом генетические характеристики данной популяции ранее были изучены крайне ограниченно, что затрудняет эффективное управление её генофондом. Целью настоящей работы было установление внутрипопуляционной генетической структуры кыргызских лошадей северо-восточного региона Кыргызской Республики с использованием однонуклеотидных полиморфизмов (SNP) и морфологических показателей. Для достижения цели использовались методы SNP-генотипирования с применением массива Equine80k (Illumina), морфометрические измерения экстерьера, кластерный и корреляционный анализы (UPGMA, PCoA, Dice, Mantel), а также бинарное кодирование фенотипических данных. По данным SNP-анализа вся выборка была разделена на два кластера: в первом – 22 лошади с генетически однородной структурой, во втором – 3 особи (KIR8, KIR18, KIR20) с повышенной генетической дистанцией. По морфологическим признакам также выделены два

Кыргыз аттарынын морфологиялык жана генетикалык мүнөздөмөлөрү

Аннотация

Изилдөөнүн актуалдуулугу – кыргыздын жергиликтүү аттарын сактоо жана селекциялык жакшыртуу зарылчылыгынан келип чыгат. Бул аттар – сейрек жана уникалдуу тукумдук топ болуп, тоо тектүү катаал шарттарга ылайыкташкан. Бирок бул популяциянын генетикалык өзгөчөлүктөрү мурунку изилдөөлөрдө абдан чектелип каралган, бул анын генофондун эффективдүү башкарылышын кыйындатат. Учурдагы изилдөөнүн максаты – Кыргыз Республикасынын түндүк-чыгыш аймагындагы кыргыз аттарынын популяция ичиндеги генетикалык структурасын бир нуклеотиддик полиморфизмдер (SNP) жана морфологиялык көрсөткүчтөр аркылуу аныктоо. Максатка жетүү үчүн Equine80k (Illumina) массивин колдонуу менен SNP-генотипирлөө ыкмалары, экстерьерди морфометриялык өлчөө, кластердик жана корреляциялык анализдер (UPGMA, PCoA, Dice, Mantel), ошондой эле фенотиптик маалыматтарды бинардык коддоо колдонулду. SNP-аналитика боюнча толук тандоо эки кластерге бөлүндү: биринчи кластерде – 22 аттар, генетикалык жактан бирдей структурага ээ, экинчи кластерде – 3 жаныбар (KIR8, KIR18, KIR20), генетикалык аралык жогору. Морфологиялык белгилер боюнча да эки кластер аныкталды: биринчи кластерде негизинен кара түстөгү аттар (92 %) жана орто стандарттардан

кластера: первый включал особей преимущественно тёмных мастей (92 %) с телосложением ниже средних стандартов (до 136 см в холке у 83 %), второй – особей светлых мастей (рыжая, серая, игреневая, 83 %) с развитыми экстерьерными показателями (высота в холке >136 см, грудь >158 см – у 92 %, пясть >18 см – у 100 %). Однако результаты вариационного анализа и теста Мантэля ($r = -0,07396$; $p = 0,0499$) показали отсутствие статистически значимой связи между морфологическими признаками и SNP-данными. Это свидетельствует о независимости традиционных экстерьерных характеристик от используемых молекулярных маркеров. Практическое значение исследования заключается в формировании базы для будущей селекционной работы и DNA-паспортизации кыргызских лошадей, а также в разработке генетически обоснованных программ по сохранению аборигенных популяций в условиях горного животноводства

төмөн дене түзүлүшү (83 % үчүн холка бийиктиги 136 см чейин), экинчи кластерде – жеңил түстөгү аттар (чоң боро, күрөң, игрене, 83 %) жана өнүккөн экстерьердик көрсөткүчтөр (холка бийиктиги >136 см, көкүрөк >158 см – 92 %, пясть >18 см – 100 %). Бирок вариациялык анализдин жана Мантел тестинин ($r = -0,07396$; $p = 0,0499$) жыйынтыктары морфологиялык белгилер менен SNP-даноонун ортосунда статистикалык маанилүү байланыш жоктугун көрсөткөн. Бул традициялык экстерьердик өзгөчөлүктөрдүн колдонулган молекулярдык маркерлерден көз карандысыз экенин билдирет. Изилдөөнүн практикалык мааниси – кыргыз аттарынын келечектеги селекциялык иштери үчүн база түзүүдө, DNA-паспортторун жасоодо жана тоо шартындагы мал чарбачылыгында жергиликтүү популяцияларды сактоо боюнча генетикалык негизделген программаларды иштеп чыгууда.

Ключевые слова: экстерьер; SNP-генотипирование; маркеры; полиморфизм; статистический анализ; кластерный анализ

Ачкыч сөздөр: экстерьер; SNP-генотипирлөө; маркерлер; полиморфизм; статистикалык анализ; кластердик анализ

Introduction

The development of highland animal husbandry is impossible without sustainable, ecologically adapted breeds capable of ensuring productivity in extreme climatic conditions. In the Kyrgyz Republic, where more than 75% of the territory is occupied by mountains, the indigenous Kyrgyz horse is a strategically important genetic resource. This population was formed under the influence of natural selection, herd maintenance, and folk breeding. However, in recent decades, the increased introduction of improved breeds, spontaneous interbreeding, and the weakening of breeding control pose a threat of genetic erosion. Under these conditions, the importance of molecular genetic approaches is particularly increasing, which help to objectively assess the intrapopulation structure, identify unique lineages, and lay the foundation for the targeted conservation and reproduction of the indigenous gene pool.

In the Republic of Kyrgyzstan, horses of their own selection, well adapted to local natural and climatic conditions, are traditionally bred. The direction of horse breeding in the republic is mainly productive, with a herd-based method of maintenance. To a lesser extent – sports, working horses, and horse breeding. Horse breeding is aimed at meeting the needs of farmers in draft power and horseback riding, the production of horse meat and koumiss, and equestrian games. The main body of horse stock consists of the local Kyrgyz improved horse, its crossbreeds, the Novokyrgyz breed and a small group of indigenous Kyrgyz horses. According to S.D. Omurzakov (2011) there are 6 main breeds of horses bred in the republic: Novokyrgyz, which occupies 55% of the total population (195-200 thousand units); the second largest – local Kyrgyz improved – 40% (150-200 thousand units); then trotting horses – 3-4% (10-12 thousand units); representatives of the Don breed – 1-1.5% (3-3.5 thousand units); English thoroughbred horse breed – 0.5-1% (1 thousand units) and crossbreeds of different breeds – 1%.

Since the early 2020s, several significant studies have been conducted to assess the genetic diversity of traditional horse breeds using high-density SNP chips. The study by A. Pozharskiy et al. (2023) conducted the first GWAS (Genome-Wide Association Studies) analysis and SNP typing of indigenous Kazakh horses, identifying 60 significant polymorphisms associated with body size and weight, which highlights the high breeding value of such populations. The researchers noted a weak intra-breed structure, which was also observed in the populations of Kyrgyz horses, despite pronounced external differences.

Similar work was also carried out in the neighbouring regions of Central Asia. Thus, D. Kabyzbekova et al. (2023) performed a molecular genetic evaluation of Kazakh horses of the Zhab and Adai types using SNP analyses of the LCORL and PRKAG3 loci associated with meat productivity. The researchers revealed a high level of homozygosity in the studied groups and limited polymorphism, especially in horses from the Zhetysu and Mangystau regions. Despite this, it has been found that certain genotypes correlate with muscle development, chest volume, and growth rate, which confirms the possibility of using these SNP markers as tools for the genetic assessment of productive qualities in traditional horse breeding. However, the internal structure and degree of divergence between regional groups have not been sufficiently disclosed, which underscores the need for broader genomic research involving high-density SNP chips.

Reproductive traits play an important role in the development of effective breeding programmes. The study by M.D. Gomez et al. (2020), based on an analysis of more than 696,000 pedigree records of eight Spanish horse populations, has shown that the age of the first foaling, the

intervals between foaling, and the duration of reproductive life have a moderate to high heritability (up to 0.42 in mares and 0.28 in stallions). Particularly high values were recorded for sports breeds. The data obtained confirmed the importance of including these traits in genetic selection models, which is also relevant for traditional breeds in need of sustainable breeding strategies.

The role of the mutation in the DMRT3 gene, also known as the Gait Keeper mutation, was examined in detail in the study by T. Kristjansson et al. (2014), where it was found to be directly related to the quality and types of gaits in Icelandic horses. The AA genotype enhanced lateral gaits, while carriers of the CA genotype showed better performance in diagonal gaits (trot, gallop). These data highlight the influence of individual genes on movement coordination and exterior characteristics, but it should be emphasised that systematic studies of similar mutations in Central Asian indigenous breeds are still insufficient.

E.T. Todd et al. (2020) identified potential lethal haplotypes in the breed of purebred riding horses, focusing on the consequences of inbreeding and breeding without considering the genetic stability of populations. It was found that mutations in the LY49B gene are associated with foetal mortality, despite the high frequency of heterozygotes. This highlights the importance of including genetic monitoring in breeding programmes, especially when working with confined or native populations where latent lethal alleles can negatively affect abundance and reproduction.

Thus, the current scientific situation requires an integrated approach to the study of the gene pool of the Kyrgyz aboriginal horse using modern molecular genetic methods and parallel analysis of exterior features. The purpose of this study was to identify the intrapopulation genetic structure of Kyrgyz horses in the north-eastern region based on high-density SNP typing using an Equine80k microchip, and to analyse the morphometric characteristics of individuals.

Materials and Methods

Location and dates of research. The field stage of sampling and morphometric measurements was conducted in June 2024 at the Laboratory of Animal Genetics of the National Academy of Sciences of the Kyrgyz Republic (Bishkek) with a trip to the mountainous upper valley of the Tonsky district of the Issyk Kul region. Laboratory processing and data analysis were performed in the period from July to October 2024.

Objects of research and ethics. The study involved 25 animals of indigenous Kyrgyz horse breeds from private farms in the villages of Temir-Kanat (6 units), Kok-Sai (5), Zher-Uy (4), Tuura-Suu (5), and Toguz-Bulak (5). The animals were identified using a unique marking code with the prefix KIR (Kyrgyz breed). All procedures complied with the European Convention for the Protection of Vertebral Animals Used for Scientific Purposes (ETS No. 123, 1986) and the recommendations of the World Organisation for Animal Health (OIE) (2021) on bioethics. Biomaterial sampling was carried out painlessly, without sedation, and did not cause stress in the animals.

Sampling and morphometry. For genetic analysis, hair follicles were selected by DNA genotyping: at least 20 hairs with roots from the withers, manually. The samples were stored in paper envelopes at a temperature of +4°C until DNA isolation. The selection was carried out according to the requirements of ISAG (International Society for Animal Genetics, 2017). External measurements in horses were carried out before sampling according to generally accepted zootechnical standards using measuring tape and compasses. The main external indicators included

height at the withers (1), oblique body length (2), chest circumference (3), and metacarpal circumference (4) (Fig. 1).



Figure 1. Main indicators of the exterior

Source: created by the authors

SNP genotyping. It was performed using a set of Equine 80k HTS biochips and reagents manufactured by Illumina Inc. (USA) using the iScan genetic system for 145 SNP markers recommended by the International Society of Animal Genetics (ISAG) and approved by the Eurasian Economic Commission, Collegium (2020) (Isakova et al., 2018; 2021).

Data processing and analysis. The allelic data obtained during SNP genotyping, and the external morphological features of Kyrgyz horses, were encoded in binary form: the value “1” corresponded to the presence or severity of the trait, and “0” – to its absence. This encoding method allowed unifying heterogeneous data for statistical and cluster analyses. The following methods were used to identify the population structure and assess the degree of correspondence between molecular and phenotypic traits:

- The UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method, implemented through the SAHN algorithm, was used to build dendrograms and identify clusters based on the level of genetic similarity between individuals. The method is widely used in population genetics due to its simplicity of interpretation and visual visualisation of groupings.
- The Dice coefficient (Dice, 1945) was used to calculate the degree of similarity of binary matrices, which is especially important when comparing data of different origins (morphological and genetic). It allows objectively assessing the overlap of features between two objects.
- Principal Coordinates Analysis (PCoA) was applied to visualise the intrapopulation structure based on the distance matrix. This method helped to reflect the genetic differences between individuals in the form of a two- or three-dimensional scheme, which is convenient for subsequent interpretative analysis.
- The Mantel test (1967) was used to determine the degree of statistical dependence between two distance matrices based on morphological and SNP data. This helped to determine whether there is a correlation between phenotypic and genetic diversity in the study population.

All data processing and mathematical calculations were performed in the NTSYSpc software, version 2.2 (Rohlf, 1998). To assess the reliability of the obtained clusters, bootstrap analysis with

1,000 repeated samples was used, implemented in the FreeTree software suite (Pavliček et al., 1999). Visualisation of dendrograms was performed using the TreeView programme (Page, 1996).

Results

The study analysed the population of indigenous Kyrgyz horses, distributed mainly in the mountainous regions of Naryn, Issyk-Kul, and Osh regions. The population is estimated at about 50 thousand animal units. Comprehensive studies of phenotypic and genotypic characteristics conducted by scientists of the National Academy of Sciences of the Kyrgyz Republic have allowed identifying the Kyrgyz horse as a separate breed group. This paper presents the results of the phenotypic and molecular analysis of this population.

DNA polymorphism is so great that any two organisms, no matter what kind, reproducing sexually, will always carry differences in their DNA, which can be identified in one way or another. Analysing a large number of SNPs at once allows determining a population feature and provides more valuable information, including the genealogy of individuals and their traits that may be useful in breeding.

To identify potential SNPs related to colour and exterior characteristics, horses were sampled and grouped according to the main morphological characteristics – colour, height at the withers, oblique body length, chest circumference, and pastern circumference. According to these indicators, the horses were divided into several groups, as shown in Table 1. This distribution allowed identifying variability within the population in key external characteristics.

Table 1. Grouping by morphological characteristics of the horse phenotype

No.	Morphological indicators	Groups	Number of animals
1	Coat (5 groups)	chestnut	10
		black	4
		grey	7
		red	3
		liver-chestnut	1
2	Height at the withers (4 groups)	up to 135cm	4
		from 135 to 136cm	4
		from 136 to 139cm	4
		over 139cm	5
3	Oblique body length (3 groups)	up to 142cm	11
		from 142 to 145cm	7
		over 145cm	7
4	Chest circumference (3 groups)	up to 158cm	9
		from 158 to 165cm	8
		over 165cm	8
5	Metacarpal girth (3 groups)	up to 17.5cm	6
		18cm	13
		18.5cm	6

Source: compiled by the authors

An analysis of the data in Table 1 shows that within the studied population of Kyrgyz horses there is significant variability in key morphological features. By colour, the most numerous group is the chestnut (10 units), followed by the grey (7) and black (4) coats, which reflects the diversity of coat colour in the population. The distribution of height at the withers, oblique body length, chest circumference, and metacarpal circumference also demonstrates heterogeneity: the number of individuals is almost evenly distributed among the selected groups, indicating the presence of diversity in exterior parameters. This indicates the preservation of phenotypic diversity within the

population, which is an important factor for maintaining its adaptive and breeding qualities. Thus, grouping by morphological features helped to identify several morphological subgroups within the population, which was used to compare with genetic data and identify potential SNPs associated with external characteristics.

Genotyping and analysis of the genetic structure. A two-level cluster analysis, biplot analysis, was used to visually display information about both samples and variables of the Kyrgyz horse data matrix (Fig. 2).

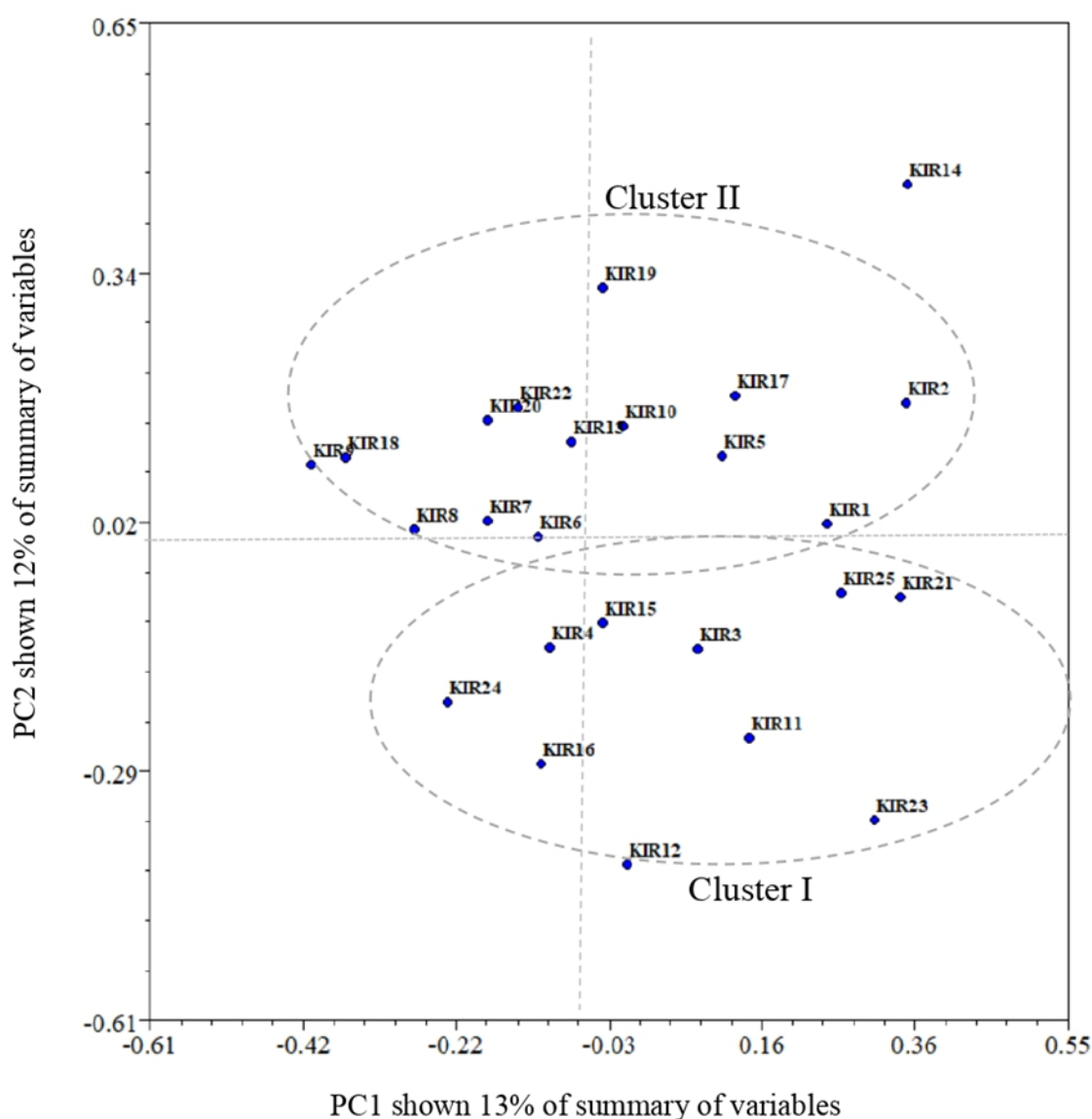


Figure 2. Biplot (principle of main coordinates)

Source: compiled by the authors

The figure shows a biplot based on SNP data, which displays the distribution of 25 Kyrgyz horses in a two-dimensional space defined by two main coordinates (PC1 and PC2). The first main coordinate (PC1) explains 13% of the variation, and the second (PC2) explains 12% of the variation in the overall variability of the features. The analysis showed the division of the studied population into two main clusters: Cluster 1 and Cluster 2. The Cluster 1 contains 22 individuals united by close genetic similarity, and the Cluster 2 includes 3 animals that differ from the main group.

This separation may be conditioned by differences in the allelic frequencies of SNP markers, reflecting the genetic structure and variability within the population. The division into two clusters indicates the presence of genetic differentiation, which may occur due to geographical isolation, breeding processes, or historical genetic differences between subgroups of horses. The reasons for the differences between clusters can be both phenotypic features (for example, colour or exterior parameters) and genetic variations due to hereditary factors. Given that PC1 and PC2 together account for about 25% of the total variation, most of the genetic diversity remains outside the two-dimensional representation, which is typical for complex biological systems with many features.

This division is important for understanding the intrapopulation structure and can be used for further analysis of associations between genotype and phenotype, and for optimising breeding work and preserving the genetic diversity of Kyrgyz horses. To visualise the genetic differentiation of the studied horses based on SNP marker data, a cluster tree was constructed using the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method based on the standard Nei distance. The reliability of clustering was assessed using bootstrap analysis. The results are shown in Figure 3.

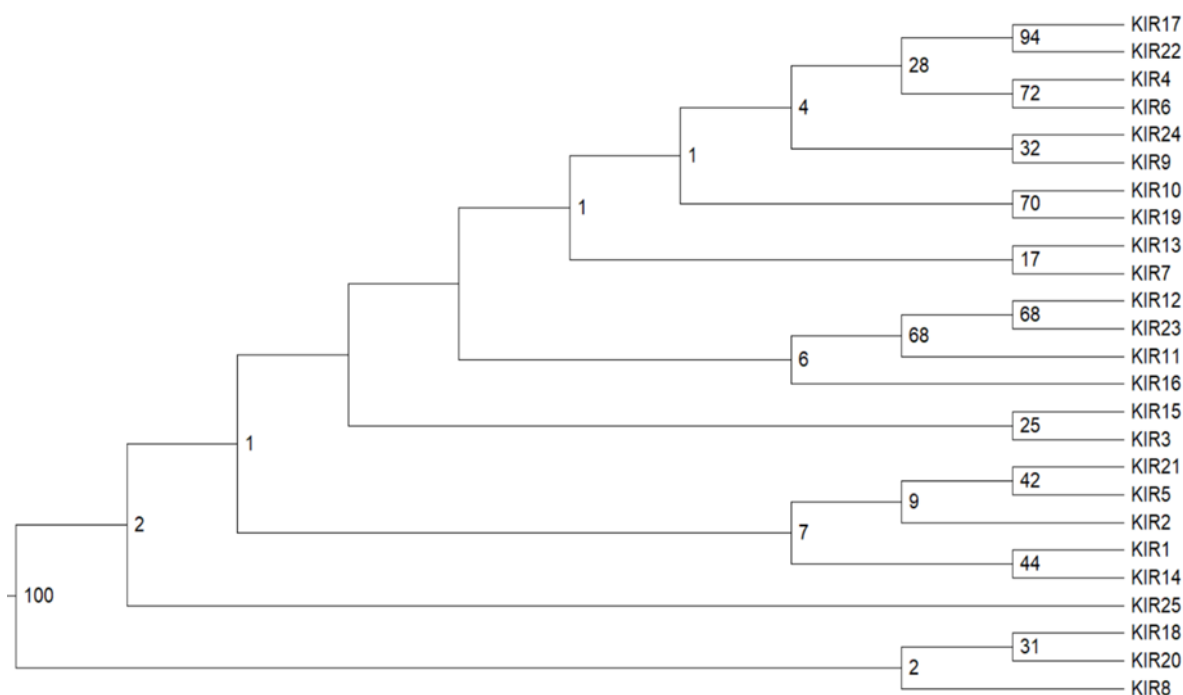


Figure 3. UPGMA of the standard Nei distance according to SNP markers

Source: created by the authors

The dendrogram (Fig. 3) shows that the studied population of Kyrgyz horses was divided into two main clusters. The numbers indicated between the branches are bootstrap values reflecting the reliability of the established clusters. The higher this value, the more stable the cluster is when generating samples multiple times using the Monte Carlo method. The analysis shows that most individuals form stable and genetically homogeneous subgroups, which indicates the presence of a certain intrapopulation structure. This is especially evident in the cluster combining samples KIR17, KIR22, KIR4, KIR6, and KIR24, which has high bootstrap values (94 and 72), which indicates a high reliability of their genetic proximity.

The first main group is of interest, in which the KIR8, KIR18, and KIR20 samples form a separate branch. Despite the relatively low bootstrap scores (maximum 31), their association into one cluster may indicate the presence of a common genetic feature that distinguishes them from other groups. To compare the results of the genetic analysis with the external features, clustering based on morphometric data was performed, based on the Nei and Li/Dice similarity coefficient. The reliability of clustering was also assessed by bootstrap analysis. The results are shown in Figure 4.

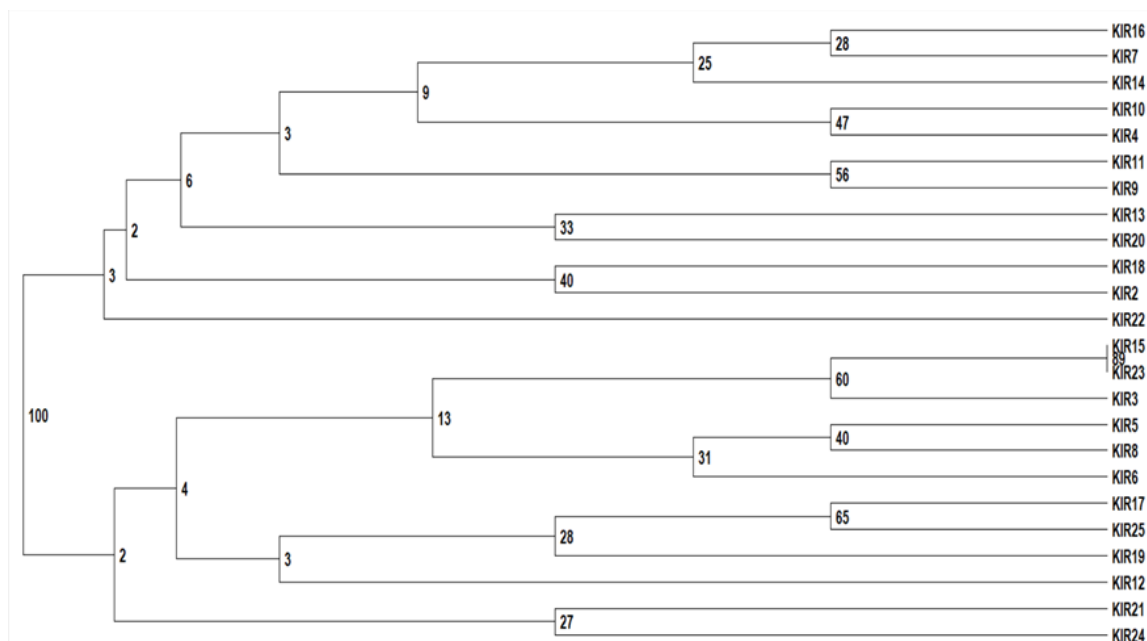


Figure 4. The dendrogram is constructed according to morphological features, the coefficient of Nei and Li/Dice

Source: created by the authors

According to the results of cluster analysis (Fig. 4), a group of Kyrgyz horses in the amount of 25 units was divided into two main clusters. The numbers located between the branches reflect bootstrap values indicating the degree of reliability of combining individuals into the corresponding subgroups. The Cluster 1 includes 12 animals with similarities in a number of morphological features. The majority of animals in this group have dark coats (chestnut and black colours) – 92% (11 animals). According to the main measurements of the exterior: height at the withers up to 136 cm was observed in 83% (10 animals), oblique body length up to 145 cm – in 83% (10 animals), chest circumference up to 165 cm – in 92% (11 animals), and metacarpal circumference up to 18 cm – in 75% (9 animals). Thus, the first cluster unites individuals with a relatively compact physique while maintaining breed standards, as well as predominantly dark colour.

The Cluster 2 includes the remaining 13 animals, which are characterised by opposite characteristics. 83% of the animals (10 animals) have a predominant light colour (red, grey, liver-chestnut). Morphometric data also show differences: height at the withers exceeds 136 cm, oblique body length exceeds 145 cm, chest circumference exceeds 165 cm – these signs are characteristic of 92% (11 animals); metacarpal circumference of more than 18 cm is observed in all 12 horses in the second cluster (100%). These data indicate that the second cluster contains animals with a more massive and elongated physique, exceeding the standard breed indicators, and a light colour.

The marked differentiation of morphological features (Fig. 3 and 4) may indicate the presence of inbred variability due to both genetic and breeding-climatic factors. The performed grouping of animals by phenotypic characteristics (Table 1) and subsequent cluster analysis based on morphological characteristics using the Nei and Li/Dice coefficients (Fig. 4) revealed two distinct clusters within the population of Kyrgyz horses under study.

The first cluster unites animals with predominantly dark hair colour and smaller exterior measurements, while the second cluster is characterised by a predominance of light colours and larger body measurements. Thus, visualisation based on morphological features demonstrated the degree of proximity of individual individuals grouped by appearance and colour within the population, and also allowed tracing stable differences within the breed. Additionally, to confirm and detail the results obtained, a grouping by morphological features based on SNP data was performed (Table 2). The obtained genotypic data correspond to the identified morphological clusters and confirm the existence of two stable phenotypic subgroups in the population of Kyrgyz horses.

Table 2. Grouping by morphological features based on SNP data

Groups	Source of the variation	Degrees of freedom	Components of variation	Variation (%)
(A) Samples without grouping	Between populations	24	Va = 42.27006	100.00 ***
	Within the population	27	Vb = 0.00000	0.00 **
	Total	51	42.27006	
(B) Data grouped by the place where it was collected	Between collection points	4	Va = 4.67276	11.03 NS
	Within the population	45	Vb = 37.70185	88.97 NS
	Total	49	42.37461	
(C) Samples were grouped by coat	Between groups	4	Va = -0.68679	-1.66***
	Between groups within a population	20	Vb = 42.08095	101.66***
	Within the population	91	Vc = 0	0 NS
	Total	115	41.39416	
(D) Samples grouped according to the oblique length of the trunk	Between groups	2	Va = 0.16994	0.40 NS
	Between populations within a group	22	Vb = 42.14168	99.60 NS
	Within the population	25	Vc = 0	0 *
	Total	49	42.31161	
(E) Samples grouped by chest circumference	Between groups	2	Va = 0.40752	0.96 NS
	Between populations within a group	22	Vb = 41.97412	99.04 NS
	Within the population	25	Vc = 0	0 *
	Total	49	42.38164	
(F) Samples grouped according to the pastern circumference	Between groups	2	Va = 0.19344	0.46 NS
	Between populations within a group	22	Vb = 42.13287	99.54 NS
	Within the population	25	Vc = 0	0 *
	Total	49		

Note: (A) samples without grouping, (B) grouping by collection location, (C) grouping by coat, (D) grouping by oblique body length, (E) grouping by chest circumference, (F) grouping by metacarpal circumference. NS – no significant difference; *p-value >0.5; ** p-value >0.1; *** p-value >0.01

Source: created by the authors

Table 2 is a comparative analysis of the contribution of morphological groupings to the overall genetic variance by SNP markers. Option (A), where the analysis was performed without preliminary grouping, shows the maximum possible level of genetic variation between populations

(100%), which indicates the presence of pronounced differences in the studied material in the absence of a priori classifications. However, already at the first level of grouping – at the sampling site (Option B) – the proportion of intergroup variation sharply decreases to 11.03% and turns out to be statistically non-significant (NS), which indicates the absence of a significant spatial structure of the population at the level of SNP profiles.

The most interesting results are observed when grouped by phenotypic traits. In the case of the colour of the suit (Variant B), a negative value of variation between the groups is found ($V_a = -0.68679$), which may indicate the artificiality or conventionality of this division and its inconsistency with the genetic structure. The intragroup variation is more than 100%, which also confirms the lack of genetic validity of the age differences. Similar results were obtained in the analysis of external indicators: oblique body length (D), chest circumference (E), and metacarpal circumference (F), where the contribution of intergroup variation ranges from 0.40-0.96% and is not statistically significant.

Thus, none of the analysed morphological features explains a significant part of the molecular variation. This indicates that the studied SNP markers are not directly associated with the selected morphological characteristics or exterior parameters. This result is typical for markers located outside the coding regions or not involved in the regulation of traits that are subject to polygenic heredity and strong environmental influences. Additionally, the Mantel test, comparing the matrices of genetic and morphological distances, showed a low and negative degree of correlation ($r = -0.07396$, $p = 0.0499$), which confirms the lack of congruence between the morphological and molecular genetic structure. This may be due to both the complex nature of phenotypic traits and the limited number of markers used in the analysis. In general, the data obtained indicate the need for an integrated approach to assessing the inbred structure, including expanding the set of SNP markers, in-depth morphometric analysis, and consideration of environmental and breeding factors when interpreting the results.

A comparable study was conducted by J. Yun et al. (2022), where the genetic structure of Mongolian horses from four geographically isolated regions was analysed using 14 microsatellite markers. The researchers revealed a high level of polymorphism and significant interpopulation differentiation, especially between the southern and northern groups. The use of PCoA and FCA helped to visualise a clear genetic separation, and cluster analysis confirmed the existence of two main genetic clusters. These results correlate with the data of the present study, which also shows structural heterogeneity within traditional populations, despite morphological proximity. The study demonstrates that in the absence of phenotypic differences, molecular markers can reveal a hidden population structure caused by spatial isolation and genetic drift.

A similar approach was implemented in the study of traditional Kazakh horses (Genetic structure and genome-wide..., n.d.), where, based on PCA, ADMIXTURE data and distance analysis, it was shown that intrapopulation differences between regional groups do not reach statistical significance. The genetic homogeneity helped to consider the studied animals as a single breed, which contrasts with the results obtained in the analysis of Kyrgyz horses, where pronounced structuring and the presence of several genetic clusters were established. Additionally, a GWAS analysis was performed in the Kazakh study, which helped to identify markers associated with the development of bone and nervous systems, whereas in the Kyrgyz sample, the main focus was on population structure and morphometry. Thus, in both cases, the high breeding value of Central

Asian horses was confirmed, but the differences revealed emphasise the influence of local breeding practices on the development of a genetic profile.

An additional perspective was provided by J. Metzger et al. (2014), based on genome-wide sequencing of both purebred and mixed-breed horses. The researchers identified more than 10 million SNPs and over a million indels, of which a significant part had not been previously described. It was found that mixed-breed animals were dominated by unique mutations associated with metabolic and morphogenetic processes, whereas purebred animals were dominated by muscle activity and neurodevelopment. Although the current study also used high-density SNP analysis, the focus was on inbred structure rather than differences between types of ancestry. Nevertheless, both approaches demonstrate the value of large-scale genotyping for identifying signs of selective breeding and studying adaptations.

V. Rossokha et al. (2022) evaluated the informative value of individual SNPs and polymorphisms of the LY49B, EDNRB, and CSN3 genes in three horse breeds using PCR-RFLP. The researchers found the presence of a lethal LWFS mutation in the Ukrainian horse breed and showed that the analysis of individual genes can serve as a diagnostic tool in breeding. In contrast to the focused methodology used in research, the current study was based on the analysis of thousands of markers within the Equine80k platform, which revealed a more complete picture of intra-breed differentiation. Thus, mass SNP genotyping demonstrated a higher resolution than targeted study of individual loci.

Another example of an applied molecular approach is presented in the paper by M.A. Ayala-Valdovinos et al. (2016), where mutagen-specific PCR (MS-PCR) was developed for genotyping a mutation in the EDNRB gene associated with lethal white foal syndrome. The proposed method helped to quickly and accurately identify carriers, replacing more time-consuming diagnostic methods. Despite the fact that the research had a narrow applied focus, it emphasised the importance of integrating genetic tests into the breeding system. In contrast, the Kyrgyz study focused on population structure and a comprehensive analysis of morphometric and genetic traits, which demonstrates a broader assessment of the genetic potential of the population.

A study of eight native Japanese horse breeds and Japanese thoroughbred mounts using SNP genotyping by T. Tozaki et al. (2019) revealed relatively low genetic diversity in most local breeds, except Hokkaido. Cluster and phylogenetic analyses have shown that the genetic relationships between the breeds generally correspond to their geographical distribution. Japanese thoroughbred horses differed from both local Japanese breeds and foreign thoroughbreds, demonstrating unique genetic characteristics. The study confirmed the origin of Japanese horses from Mongolian ancestors who migrated through the Korean Peninsula.

Thus, a comparison with the results of other researchers demonstrated a steady trend: morphological parameters often do not reflect real genetic diversity, especially in populations with open reproduction and without targeted breeding based on external characteristics. The inclusion of high-density SNP analysis and in-depth morphometry in a single methodology helps to more accurately assess the inter-breed structure, identify hidden clusters, and develop sound strategies for preserving the genetic resource. The totality of the data presented highlights the need for an integrated approach to the study of traditional horse breeds, considering both molecular and phenotypic aspects, and the socio-cultural conditions of their breeding.

Conclusions

As a result of a comprehensive analysis of the genetic and morphological structure of indigenous Kyrgyz horses, the presence of a certain genetic diversity within the population was established, which was confirmed by the results of cluster and statistical analysis of SNP marker data. The study revealed two main genetic clusters reflecting the inter-breed structure, while the phenotypic variation in the main morphological features was significant and heterogeneous.

The SNP markers used did not correlate with morphological parameters, which indicated the complex nature of the inheritance of phenotypic traits and the significant influence of non-genetic factors such as housing conditions and habitat. This pointed to the limitations of traditional morphological criteria in assessing the genetic structure of the breed and emphasised the importance of the integrated application of both classical morphometric methods and advanced biotechnologies.

To increase the efficiency of breeding work, it was recommended to develop and implement DNA markers linked to key morphological and productive traits, which would speed up the selection process and improve the quality of breed characteristics. The obtained data on the genetic structure and intra-breed variability could become the basis for the creation of adapted breeding programmes and strategies for preserving the genetic resource of Kyrgyz horses.

In the future, it was recommended to expand the sample of the studied animals and increase the density of SNP genotyping, which would allow for a deeper study of the relationship between genotype and phenotype, and consider the influence of environmental and breeding factors. Additional study of morphological features using modern methods of morphometry and statistical analysis would contribute to a more accurate assessment of breed characteristics and adaptive potential.

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PRODUCTIVITY OF KUIBYSHEV SHEEP OF DIFFERENT INTRA-BREED TYPES

**ПРОДУКТИВНОСТЬ ОВЕЦ КУЙБЫШЕВСКОЙ ПОРОДЫ РАЗНЫХ ВНУТРИПОРОДНЫХ
ТИПОВ**

**КУЙБЫШЕВ ТУКУМУНДАГЫ АР КАНДАЙ ИЧИ ТУКУМДУК ТИПТЕГИ КОЙЛОРДУН
ӨНДҮРҮМДҮҮЛҮГҮ**

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PRODUCTIVITY OF KUIBYSHEV SHEEP OF DIFFERENT INTRA-BREED TYPES

Abstract

The authors studied the productivity of Kuibyshev sheep in the Saratov region during intrabreed breeding to identify promising intrabreed types of animals with improved productive qualities. The purpose of the research was to study and substantiate the methods of improving Kuibyshev sheep using intrabreed selection in the Saratov region of the Volga region. The studies were conducted taking into account generally accepted methods. When mating Kuibyshev sheep, animals deviating to a certain intrabreed type were conditionally selected – ewes were of the meat and wool type, rams belonged to the meat type. The offspring obtained after mating were selected into groups: I – meat and wool intrabreed productive type; II – meat. When evaluating the productivity, an advantage of meat and wool type young animals over meat ones was revealed. The live weight of the meat-type ewe lambs was 5.0% higher than that of the meat-and-wool type peers, while the meat-and-wool type offspring exceeded their meat peers in dirty wool yield by 2.50% ($P \geq 0.99$). The meat-and-wool type young animals exceeded the meat individuals in pure fiber yield by 4.08%, and in pure wool yield – by 10.47% ($P \geq 0.999$). The wool fiber of the ewe lambs of both intra-breed productive types corresponded to quality 50 (29.1-31.0 μm). Thus, the best uniformity of wool fineness was characterised by the meat-and-wool type offspring, in comparison with the meat type analogues. The natural wool length of the meat-and-wool type ewe lambs was 1.29 cm higher, in comparison with their meat peers ($P \geq 0.999$). The young animals of the meat productive type had rarer wool, lower fleece density, which contained 1.85% more mechanical impurities, and less sweat. Thus, mating of ewes of the meat-wool intrabreed type with meat producers can be considered an improving selection method not only for live weight, but also for wool parameters necessary for further selection work with Kuibyshev sheep of the Saratov region of the Volga region

Keywords: ewes; intrabreed breeding; live weight; wool clip; wool yield

Продуктивность овец куйбышевской породы разных внутрипородных типов

Аннотация

Авторами была изучена продуктивность овец куйбышевской породы в Саратовской области при внутрипородном разведении для выявления перспективных внутрипородных типов животных с улучшенными продуктивными качествами. Цель исследований заключалась в изучении, обосновании приемов улучшения овец куйбышевской породы с использованием внутрипородного подбора в Саратовской области Поволжья. Исследования проводились, с учетом общепринятых методик. При спаривании овец куйбышевской породы условно отбирались животные, уклонявшиеся к определенному внутрипородному типу – овцематки были мясо-шерстного типа, бараны относились к мясному. Полученное после спаривания потомство, отбирали в группы: I – мясо-шерстного внутрипородного продуктивного типа; II – мясного. При оценке продуктивности было выявлено преимущество молодняка мясо-шерстного типа над мясным. Яркие мясного типа обладали на 5,0 % более высокой живой массой, чем сверстницы мясо-шерстного типа, при этом, потомство мясо-шерстного типа по настригу грязной шерсти преобладало на 2,50 % над сверстницами мясного ($P \geq 0,99$). Молодняк мясо-шерстного типа превосходил особей мясного по выходу чистого

Куйбышев тукумундагы ар кандай ичи тукумдук типтеги койлордун өндүрүмдүүлүгү

Аннотация

Авторлор продуктуу сапаттары жакшырган малдын перспективдүү породанын ичиндеги түрлөрүн аныктоо учун Саратов областындагы Куйбышев койлорунун продуктуулугун асылдандырууну изилдешкен. Изилдөөнүн максаты – Поволжьеинин Саратов областында порода ичиндеги селекциясын колдонуу менен Куйбышев койлорун жакшыртуунун ыкмаларын изилдөө жана негиздөө. Изилдөөлөр жалпы кабыл алынган ыкмаларды эске алуу менен жүргүзүлгөн. Куйбышев койлорун жупташтырууда белгилүү порода ичиндеги типке четтеген малдар шарттуу тандалып алынган – койлор эт-жүндүү, кочкорлор эт тибине кирген. Жупташкандан кийин алынган төлдөр төмөнкүдөй топторго тандалып алынган: I – эт жана жүн тукумундагы продуктуу түрү; II – эт. Кунардуулугун баалоодо эт жана жүн тибиндеги жаш малдын этке караганда артыкчылыгы аныкталды. Эт багытындагы койлордун тирүүлөй салмагы эт-жүн тибиндегилерге караганда 5,0 %га жогору, ал эми эт-жүн тибиндеги төлдөр кир жүн алуу боюнча этке салыштырганда 2,50 % ашып кеткен ($P \geq 0,99$). Эт-жүн тибиндеги жаш малдар этке караганда таза булалуулугу боюнча 4,08 %га, жүндөн 10,47 %га ($P \geq 0,999$) көп. Эки тукумдагы продуктуу түрдөгү койлордун жүн буласы 50 (29,1-31,0 мкм) сапатка туура келген. Ошентип, эт тибиндеги

волокна на 4,08 %, а по настригу чистой шерсти – на 10,47 % ($P \geq 0,999$). У ярокчек обоих внутрипородных продуктивных типов шерстное волокно соответствовало 50 качеству (29,1-31,0 мкм). Так, лучшей уравниенностью шерсти по тонине характеризовались потомки мясо-шерстного типа, в сравнении с аналогами мясного типа. У ярокчек мясо-шерстного типа естественная длина шерсти оказалась выше на 1,29 см, по сравнению со сверстницами мясного ($P \geq 0,999$). Молодняк мясного продуктивного типа, имел более редкую шерсть, меньшую плотность руна, в котором было больше на 1,85 % механических примесей, меньше жиропота. Таким образом, спаривание овцематок мясо-шерстного внутрипородного типа с производителями мясного можно считать улучшающим селекционным приемом не только по живой массе, но и шерстным параметрам, необходимым для дальнейшей селекционной работы с овцами куйбышевской породы Саратовской области зоны Поволжья

аналогдорго салыштырмалуу жүн уяңдыгынын эн жакшы бирдейлиги эт-жүн тибиндеги тукуму менен мүнөздөлгөн. Эт-жүн тибиндеги койлордун табигый жүнүнүн узундугу эт багытындагыларга салыштырмалуу 1,29 см көп болгон ($P \geq 0,999$). Эт продуктуу тибиндеги жаш малдын жүнү сейрек, жүнүнүн тыгыздыгы төмөн, анын курамында механикалык аралашмалар 1,85 % көп, тер азыраак болгон. Эт-жүндү туудурган тибиндеги койлорду эт өндүрүүчүлөр менен жупташтырууну жакшыртуучу селекциялык метод деп эсептөөгө болот Ошентип, Поволжьедеги Саратов областынын Куйбышев койлору менен мындан аркы селекциялык иштерди жүргүзүү учун тирүүлөй салмак боюнча гана эмес, жундун параметрлери боюнча да селекция жүргүзүү талап ылайык.

Ключевые слова: ярка, внутрипородное разведение, живая масса, настриг шерсти, выход шерсти

Ачкыч сөздөр: койлор, интригация, тирүүлөй салмак, жүн кыркмасы, жүн продуктуулугу

Introduction

The Kuibyshev sheep breed remains one of the few semi-fine-wool breeds in the Volga region that has retained its breeding value and prospects for further breeding. On farms specialising in breeding this breed, in particular at the “Shirokoye” closed joint-stock company (CJSC) in the Saratov district of the Saratov region, two productive intra-breed types have been clearly identified as a result of long-term selection work: “meat-wool” and “meat”. These types differ in the level of expression of economically useful traits and require comprehensive morphological, productive and genetic characterisation. The need for a detailed scientific justification of the differences between intraspecific types, an assessment of their breeding and economic value, and an analysis of their adaptability to the requirements of modern animal husbandry makes this study highly relevant.

According to Yu.A. Kolosov & V.V. Aboneev (2024), the Kuibyshev breed was developed in 1936-1948 in the Samara region under the leadership of A.V. Vasilyev by crossing local Cherkasy sheep with English Romney Marsh rams imported from England. The descendants inherited a strong constitution, large size, high wool yield, and adaptability to breeding conditions from the Cherkasy sheep, but had some disadvantages, such as uneven wool and insufficient meat conformation. The sheep were able to adapt to the conditions of the Volga steppes and tolerate heat and cold. Researchers I.E. Grekova & A.N. Rudak (2023) concluded that in order to obtain high-quality sheep products, semi-fine-wool breeds must meet modern requirements and be resistant to the conditions of breeding in sheep farms.

According to researcher E.I. Anisimova (2020), intra-breed breeding is an important resource for effective sheep farming, ensuring genetic diversity in flocks and improving the breed population. Scientists N.I. Efimova & S.N. Shumaenko (2023) concluded in their work that in the Stavropol Krai, intra-breed breeding resulted in the development of the Russian meat merino breed for meat and wool production with six intra-breed lines of varying productivity. The authors proved that such breeding is an important method of improving sheep, allowing the use of animals with outstanding productivity, creating a genetic population for systematic selection and matching of parent pairs to obtain highly productive individuals. The scientists developed a scheme for combining parent pairs for sheep farms. It was found that linear ewes were inferior to crossbred ewes in terms of washed wool yield, dirty wool yield, and live weight.

Scientists A.Ch. Gagloev et al. (2021) proved that the use of intra-breed selection of Prekos sheep – ewes of different intra-breed types – in purebred breeding and crossbreeding with rams of semi-fine-wool breeds (Romney-Marsh, Kuibyshev) improved the biological value of meat in offspring. According to the results of studies investigating the effect of different mating options for ewes and rams on the composition and quality of lamb meat, it was found that the water content in the meat of crossbred young animals was lower compared to purebred individuals. In terms of protein content in meat, rams from purebred breeding and crossbreeding prevailed over individuals from wool-meat type ewes. The lamb meat of meat-wool ewes was significantly higher in essential amino acids than that of wool-meat ewes.

According to O.N. Onishchenko et al. (2022), it was determined that the use of intra-breed selection in the Stavropol Krai region contributed to the creation of an effective intra-breed type of Soviet Merino fine-wool sheep. The authors noted that three groups of ewes were selected from the Soviet Merino sheep breed of the Stavropol population, the main difference between them being the number of folds on the animal's body. The first group belonged to the usual intra-breed type in

terms of skin folds, the second to the medium-front type, and the third to the full-front type. These ewes were inseminated with typical rams for each group of ewes. The scientists noted that at 14 months of age, ewes of the medium-front type outperformed their peers of the typical type and full-front type in terms of exterior indicators (compactness index) by 136.7-140.3% and 140-142.3%. In terms of other indicators, medium-front type animals, compared to young animals of the usual intra-breed type, in terms of skin folds and full-front type, surpassed them in terms of chest index and long-legged index. Sheep of the Soviet Merino breed of Stavropol, to a greater extent, deviated towards the medium-front type; Merinos of this intra-breed type are in demand and profitable.

The aim of the research was to study and justify methods for improving the productive qualities of Kuibyshev sheep through the rational use of intra-breed selection in the Saratov region of the Volga zone. In connection with the set goal, the main task was to analyse the productive qualities of Kuybyshev sheep of the local population of different intra-breed productive types.

The scientific novelty was that, for the first time in the Saratov region, the productive parameters of Kuybyshev sheep of different intra-breed types were studied. The live weight, quantitative and qualitative indicators of wool in intra-breed breeding were assessed, optimal options for the selection and matching of paternal and maternal forms of different intra-breed types were substantiated, and reasoned recommendations for the rational use of such parental pairs for mating semi-fine-wool sheep in the Volga region were developed.

Materials and methods

The research was conducted at “Shirokoye” CJSC in the Saratov District of the Saratov Region from April 2023 to July 2024. Purebred Kuibyshev sheep were used as the source material for the experiment. Three rams were selected for insemination of 50 ewes. After fertilisation, offspring were obtained from mating pairs of different intra-breed types, formed into two experimental groups (n=20 heads in each). Productivity was assessed in young animals at 14 months of age. The productive and physiological characteristics of the sheep were studied using standard methods:

1. The live weight of sheep (ewes) was determined by weighing during bonitation on special platform scales: with an accuracy of 0.5 kg according to State Standard 25955-83 (1984).
2. The physical and technological indicators of wool – the yield of unwashed wool was determined by weighing during shearing on special platform scales with an accuracy of 0.1 kg individually; the yield of washed wool was assessed after washing and removing all impurities (dust, coarse feed residues, particles of pasture vegetation seeds, faeces) by weighing using C-200 analytical scales with an accuracy of 0.1 kg individually.

Primary processing of unwashed (physical) wool fibre was carried out, including the separation of plant (straw, leaves, parts of branches and plant stems) and mineral (sand, clay) impurities, as well as loosening the wool for better penetration of the washing solution. Contaminated wool was washed with detergent solutions of surface-active substances at a temperature of 40-60 °C. Clean (washed) wool was evaluated using a method based on determining the yield of clean fibre (the ratio of the mass of washed fibre to the weight of unwashed wool in percent) using C-200 analytical scales, TS-53A devices, GPO-2M devices, and AK-2 conditioning apparatus (“Metrotek” and “Ivmashpribor”, Ivanovo, Russia). Assessment stages: selection of

samples weighing at least one kilogram; preparation of wool for soaking in a soda solution for 40 minutes, then washing and drying. The yield of clean wool was calculated using the formula:

$$P = U \times (100 + C) / A, \quad (1)$$

where P – the percentage yield of clean wool; U – the constant dry weight of the sample; A – the initial weight of dirty wool; C – the conditioning moisture content (for homogeneous wool – 17%, for heterogeneous wool – 15%).

All wool tests were conducted in accordance with Methodological recommendations for the study of wool quality (ARRISGB) (1985) in accordance with Methodological recommendations on the procedure and conditions... (2020) and in accordance with Order of the Ministry of Agriculture of the Russian Federation No. 860 (2021). The natural length of wool (accurate to 0.5 cm) was measured during individual grading of sheep on a barrel. Wool density was determined by the counting and weighing method, using a special fork for taking samples and torsion scales. Wool fineness (in micrometres) was determined on a lanameter (in qualities) during individual grading of sheep on a barrel. Wool tensile strength was measured on a DSH-3M dynamometer using torsion scales. True length and crimp were determined on a “Metrimpex” type 4-10-12 device (“Automatika” Trading House, Smolensk).

The physical and chemical composition of wool and the quality of fat were studied in ewes using the methods of the ARRISGB (All-Russian Research Institute of Sheep and Goat Breeding) (1985): wool fat (wax) content – by extraction in a Soxhlet apparatus; sweat content; mechanical impurity content – by the difference in mass of constantly dry samples before and after washing; nitrogen content – by the Kjeldahl method; sulphur content – by the Benedict-Denis method; melting point of wool grease (wax); iodine number of wool grease (wax) – by the Ganus method; the colour of the fat was determined visually in all animals during individual grading; an expert zootechnical description of the fleece was carried out in accordance with the ARRISGB (1985) methodology on wool samples taken from the main topographical areas of the fleece. For mating Kuibyshev sheep, animals belonging to a specific intra-breed productive type were conditionally selected, with ewes being typical of this breed’s meat-wool type and rams leaning towards the meat type. A visual assessment of the level of wool and meat productivity was used, which was refined according to productive indicators: live weight, wool yield and their ratio (Study book of the Kuibyshev breed..., 2021).

Ewes had an average live weight of 60-65 kg and an unwashed wool yield of 5-6 kg. Ram producers had an average live weight of 120 kg and a physical wool yield of 9-11 kg. As a result of mating parent pairs, the offspring were divided into conditional types: I – meat and wool; II – meat. The offspring were monitored for productive performance from birth to 14 months of age. All experimental groups of animals were kept under the same feeding and housing conditions. The sheep were mainly kept on pasture and in stalls. The animals were grazed from the beginning of April until mid-November, and in winters with little snow, until December (the grazing period lasted about 8 months).

The feeding rations for all age and gender groups of sheep were based on the nutritional value of the farm’s feed, according to recommended and detailed feed and feeding standards (Kalashnikov et al., 2003). In addition to winter pasture feed, hay, straw, haylage and concentrates

were used in the daily rations for sheep. Table salt was regularly used as a mineral supplement, both in loose form and in the form of a lick.

The diet of pregnant ewes in the first half of pregnancy consisted of cereal and mixed grass hay – 1.0 kg; legume hay – 1.0 kg; spring straw – 0.5 kg; silage – 2.8 kg; barley bran – 0.4 kg; concentrates (barley, oats, bran, peas) – 0.5 kg; table salt – 15.0 g; beetroot – 1.0 kg; sulphuric acid copper – 50.0 mg; feed phosphate – 10.0 mg; elemental sulphur – 1.0 g, and for ewes in the second half of lactation, respectively – 0.8 kg; 1 kg; 0.4 kg; 2.6 kg; 0.2 kg; 0.3 kg; 10.0 g; 0.8 kg; 40.0 mg; 8.0 g; 0.8 g. During the suckling period, the diet of ewes consisted of the highest quality feed. In the first half of lactation, they were given: cereal-legume hay – 1.3 kg; haylage – 3.0 kg; barley bran – 0.6 kg; elemental sulphur – 19.0 g, and in the second half of lactation, respectively – 1.1 kg; 3.0 kg; 0.40 kg; 15.0 g.

The diet of young stock (ewes) during weaning from their mothers at 4 months of age consisted of alfalfa hay – 0.5 kg; cereal hay – 0.5 kg; barley straw – 0.5 kg; haylage – 0.5 kg; barley bran – 0.4 kg. The rearing of young stock from 8 to 14 months of age took place during the stall period. In winter, the daily feed ration consisted of hay (cereal, legume) – 0.8-1.0 kg; haylage – 2.0-2.5 kg and concentrates – 200-300 g. The balanced feed rations for sheep fully provided them with adequate nutrition. In order to make rational use of natural feeding grounds and reduce feed transportation costs, the sheep population was dispersed throughout the farms in small flocks and kept at so-called “points”.

During the period of scientific research (2022-2023), this sheep farm was considered favourable in terms of maximum permissible veterinary and sanitary standards. Sheep mortality due to disease ranged from 3% to 8% on average. The main reasons for the insignificant mortality of sheep were non-contagious diseases, injuries, as well as invasive diseases, pneumonia and gastroenteritis at an early age, arising in connection with gas contamination, excessive crowding of sheep, dampness, draughts in rooms or hypothermia if weather conditions on the pasture deteriorated. Lambs were affected by invasive diseases primarily on pasture due to the prolonged use of the same areas. Drinking from stagnant water bodies also contributed to the infection of sheep with helminths, so the means of combating infestations was grazing with a change of pasture areas and sheepfold locations every 10-12 days. The farm's sheep sometimes suffered from pylorobezoar disease – eating wool, which blocked the stomach – as well as inflammation of the mucous membrane of the eyes due to a lack of vitamins in their diet, particularly vitamin D.

At the same time, CJSC “Shirokoye” implemented a set of preventive measures to prevent the occurrence of diseases: annual preventive vaccinations of animals; avoiding contact between sheep and other farms; taking measures against wolves, which cause great damage to the farm on the pasture; timely repair of premises, especially those intended for lambing; annual cleaning of sheepfolds and bases from manure; observance of pasture rotation when grazing sheep; prevention of cuts during shearing, followed by annual preventive shearing or treatment of each sheep; equipping all departments and shepherd stations with cattle burial grounds; carrying out preventive work to prevent diseases such as scabies, vibriosis, epididymitis, and brucellosis, while avoiding contact between sheep and animals from other farms, especially those bordering Kazakhstan. The main scientific data obtained during the research were processed biometrically (Merkuryeva, 1977), and standard software for personal computers, Microsoft Word and Excel, was used for calculations and graphical techniques in the research process.

Results

When purebred sires and dams were mated, heterosis resulted in changes in the productive performance of the offspring: live weight, pure wool yield, wool clip, and the physical, technological, and physical-chemical properties of the wool fibre. Productivity was assessed in young animals at 14 months of age (Table 1).

Table 1. Productivity of ewe lambs of different intrabreed types

Indicator	Group / intrabreed type	
	I – meat-wool	II – meat
Live weight, kg	60.00±0.10	63.00±0.06
Dirty (physical) wool yield, kg	4.10±0.08**	4.00±0.07
Pure wool yield, %	56.58±0.38	52.50±0.32
Wool clip, kg	2.32±0.05***	2.10±0.03

Note: ** – differences significant at $P > 0.99$; *** – differences significant at $P \geq 0.999$

Source: author's own development

Table 1 shows that in the offspring of group II (meat type), compared to group I (meat-wool type), there was an increase in live weight of 3.0 kg or 5.0%, while the young animals of group I (meat-wool type) exceeded their peers of group II (meat type) in terms of dirty (physical) wool yield by 0.1 kg or 2.50% ($P \geq 0.99$). Given the superiority of young animals of the meat-wool type over meat-type individuals in terms of clean fibre yield (by 4.08%), which closely correlated with the intra-breed type (combined meat-wool), their predominance in terms of pure wool yield over meat counterparts was 10.47% ($P \geq 0.999$). This provided the basis for assessing that mating meat-wool intra-breed ewes with meat producers was considered an improving selection technique not only in terms of live weight but also wool parameters.

The physical and mechanical properties of wool were assessed in young animals obtained by selecting parent pairs – ewes of the meat-wool type x rams of the meat type. When evaluating the young stock, it was found that the wool of both intra-breed productive types of the Kuibyshev breed corresponded mainly to 50 quality or 29.1-31.0 microns. At the same time, in terms of wool uniformity in terms of fineness, animals of the meat-wool type of group I surpassed their meat-type counterparts of group II by 3%. In terms of natural wool length, lambs of the meat-wool type prevailed over their meat-type peers by 1.29 cm ($P \geq 0.999$). In terms of wool crimp, the meat-wool type offspring were 16.8% superior to the meat type animals ($P \geq 0.999$).

It should be noted that for breed and pedigree evaluation, virtually all physical and technological parameters are significant and important, as they affect sheep productivity, wool quality and its suitability for processing. The wool of the experimental ewes of the Kuibyshev breed of both intrabred types was strong and complied with State Standard 30702-2000 (2000). Wool properties such as fineness, length, density and crimp were inherited as polymers, i.e. each of them was determined by a number of genes, which opened up prospects for the successful selection of animals of both intraspecific types, even for one of the parameters. Analysis of the physical and chemical properties of wool and the quality of fat in the offspring, with specified mating of parent pairs, showed that young animals of the meat-productive type had sparse wool, low fleece density, exceeding their meat-wool peers in the amount of mechanical impurities by 1.85%, and inferior in the amount of grease (Table 2).

Table 2. Colour of suint and properties of wool grease of ewe lambs in different intra-breed types

Group/	Grease content, %	Wool grease
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intra-breed type	Light cream	Cream	Melting point, °C	Iodine number, g
I – meat-and-wool	26.40	1.90	42.95±0.14	16.51±0.14
II – meat	23.53	3.92	42.64±0.18	16.71±0.13

Source: author's own development

In terms of the ratio of grease to sweat, sheep of both experimental groups (intra-breed types) showed fairly similar values, corresponding to the optimal level for domestic semi-finewool breeds – 1.03:1.0. It should be noted that the chemical composition of suint and its physical properties are not constant, depending on changes in nutrition and the physiological state of the organism. Considering the management conditions of the experimental ewe lambs of both groups, it was established that there were no significant differences between the intrabreed types in the content of sulphur and nitrogen in the wool: sulphur ranged from 3.36-3.41%, nitrogen from 14.86-14.90%. The colour of wool grease also influenced the technological properties of the fibre. According to Table 2, in ewe lambs of the meat-wool intrabreed type the proportion of animals with the desirable light cream wool grease was 26.40%, whereas among the meat-type young stock, the proportion of animals with cream-coloured grease was 3.92%.

The analysis of physico-chemical properties of the ewe lambs of both groups revealed certain differences between them, which may have been determined by hereditary information received from the maternal and paternal animals in the matings. In both groups, the melting point of wool grease was sufficient (42.64-42.95 °C), which provides grounds to consider them well adapted for breeding under the conditions of Saratov Region. At 14 months of age, all experimental ewe lambs underwent individual grading, which demonstrated the breeding class of the animals. The criteria for grading of breeding and productive qualities included live weight, wool quality, and productivity. In the overall assessment, the ewe lambs of Group I (meat-wool type) stood out compared with the meat-type young animals, since the proportion of animals rated as “elite” and Class I amounted to 88.2% (17 head) and 90.5% (19 head), respectively, of the total numbers in the groups. The Group I animals mainly had one drawback – insufficient live weight. However, compared with Group II, they had denser fleeces combined with excellent wool grease quality.

The number of rejected ewe lambs in both groups was small, within 2–3 animals. All animals of the experimental groups had correct body conformation, strong constitution, good live weight, dense closed fleeces, and wool of appropriate fineness and crimp, characteristic of semi-finewool breeds. The grading results of the experimental ewe lambs of both intrabreed types showed that all animals possessed good productive traits, representing high genetic and breeding value for Kuibyshev semi-finewool sheep.

Discussion

Modern industrial technology has always played a leading role in the scientific and technical process of sheep breeding, and specialised semi-fine-wool sheep breeds have been an integral part of this process. The decisive factor in increasing efficiency is the improvement of existing domestic semi-fine breeds, as well as the creation of new, more productive types and lines based on interbreeding and intrabreeding. In the sheep breeding industry, namely in semi-finewool sheep breeding, it is only possible to obtain high-quality products if highly productive animals are available. According to A.A. Velmatov et al. (2020), providing the country's population with high-quality agricultural products is the main and integral task of the agro-industrial complex. Scientist A.A. Gerasimov (2022) confirmed that the Kuibyshev breed of sheep has genetic and productive

potential, which was demonstrated during its breeding and use in the climatic and feed conditions of the Volga region.

L.I. Kibkalo & A.S. Glushenko (2024) concluded in their work that in order to solve the agro-industrial problem, it is necessary to accelerate the development of livestock breeding, which is one of the promising strategic directions for increasing the production of high-quality products. The semi-fine-wool Kuibyshev sheep breed, bred in the Saratov region and adapted to the ecological, climatic and feed conditions of the Volga region, consistently outperformed other local breeds with the same productive orientation in terms of high meat and wool productivity. In order to improve the productive and breeding qualities of the local Kuybyshev sheep population in the region, selection was carried out using purebred breeding with strict selection and selection, avoiding close-kin mating, to obtain animals of the meat-wool type characteristic of the breed.

According to scientists A.Ch. Gagloev et al. (2023), Kuybyshev sheep, due to their historical origin, are well adapted to any climatic and feeding conditions. Thanks to their mobility and endurance, these animals were able to make good use of pastures and were capable of making long journeys over long distances. A distinctive feature of these animals is their semi-fine, homogeneous wool of good quality and, at the same time, high live weight, early maturity and meat qualities. When entered in the stud book, the breed was defined as a combined meat-wool breed. Selection and breeding work with sheep of this breed made it possible to obtain animals not only of the meat-wool type, but also of the meat type and, sometimes, with strict selection, of the wool type.

Many scientists have studied the intraspecific selection of parent pairs to create intraspecific types and lines in sheep breeding. Thus, Z. Seitmusaeva & A. Gaziev (2023) presented studies of intra-breed homogeneous and heterogeneous selection of Karakul sheep of the Karakalpak sur of the Republic of Karakalpakstan with the aim of improving their productive qualities. The data obtained during the studies showed the influence of parent selection types on the uniformity of colouring in the offspring. In this case, a high yield of lambs with uniform colouring was noted from the homogeneous (uniform) selection of animals “steel x steel” ($75.0 \pm 5.09\%$), compared to the heterogeneous selection “candle flame x steel” ($56.2 \pm 7.15\%$). At the same time, it should be noted that the superiority of homogeneous selection in terms of this indicator was statistically significant compared to heterogeneous selection. In addition, with homogeneous selection, there was a decrease in the yield of lambs with insufficiently uniform and non-uniform colouring. The reason for these results was a certain incompatibility of mated sheep with “candle flame x steel” colouring; this combination led to a slight decrease in the yield of lambs with balanced colouring, which had to be taken into account in the selection work with sheep of the Karakalpak breed type. Lambs from heterogeneous mating exceeded their peers from heterogeneous mating in live weight by 1.6-2 kg or 4.64-0.6%, respectively. During the milk period, lambs from heterogeneous mating developed better than young animals from heterogeneous mating of parent pairs, and the wool of such animals was of uniform colour. At the same time, with the use of heterogeneous selection of parent pairs of Karakul sheep, the wool colouring indicators were 38 and 42%, respectively. The wool of these animals was not uniform. During the research, it was found that the offspring of different intra-breed selection inherited productive characteristics from their parents.

According to researchers E.A. Lakota & O.A. Vorontsova (2023), studies were conducted on intra-breed selection of Stavropol sheep in the Volga region with the aim of improving their productive qualities. After mating parent pairs: strong-type ewes x strong-type rams; fine-type ewes

x strong-type rams; loose-type ewes x strong-type rams, the productivity of the offspring was assessed. The assessment of productive parameters showed that in terms of live weight, the loose x strong young stock had an advantage over the fine x strong young stock by 11.93%, and the strong x strong young stock by 3.58%. In terms of wool yield, strong x strong sheep prevailed over tender x strong and loose x strong by 5.04% and 4.34%. In terms of exterior, the offspring of the loose x strong type outperformed the strong x strong type and the fine x strong type. In the process, it was noted that young animals of different intra-breed types developed well, inheriting exterior and productive qualities from their parents, but acquiring their individual characteristics in the phenotypic environment.

L.D. Milchevsky (2021) noted that within the semi-fine-wooled Tsigai breed, through purebred selection, a new intrabreed meat-wool type called “Solnechny” was created in the breeding farm “Solnechny” of Rostov region. It was developed by crossing local Tsigai sheep (wool–meat type) with rams of the meat-wool Azov-type rams from the Rosa Luxemburg breeding farm, which differs from the Azov type bred at the “Orlovsky” state breeding farm in the Rostov region the Black Sea type in Crimea and the Trans-Volga type in the Saratov Region, in that sheep of the Solnechny type produced white semi-fine wool and good-quality meat, while also being highly milk-productive. In Tsigai sheep of this intrabreed meat-wool type, the wool is semi-fine, homogeneous, strongly crimped, resembling coarse Merino, but with a relatively low amount of suint and grease.

According to researcher N.A. Rezun (2024), depending on their linear affiliation and the crosses obtained when selecting lines, animals of the fine-wool Russian meat merino breed had the ability to show unequal productivity, so the author recommended using the maternal line AS-30 and the paternal line MB-50 at the genetic-molecular level. Analysing the scientific conclusions obtained on intraspecific types in the Kuibyshev breed of sheep of the Volga population and comparing them with the scientific conclusions of scientist N.A. Rezun, the author’s opinion was confirmed, and the need for further in-depth study of the semi-fine-wool Kuibyshev breed in terms of intra-breed types at the genetic level was noted.

Thus, the results obtained in the course of the research showed that the economically useful productive traits of Kuibyshev sheep of different intra-breed types were influenced by the compatibility of parent pairs. At the same time, indicators of live weight and wool quality depending on the selection and pairing of Kuybyshev sheep of different intra-breed types have not been sufficiently studied, and it was necessary to make full use of the potential of animals of already tested intraspecific types in the breed by mating animals of different conditional types, which could result in the manifestation of conditional heterosis.

Conclusions

Mating sheep of the Kuibyshev meat-wool type with meat rams resulted in the selection of two intra-breed types: “meat-wool” and “meat”. An assessment of the productive qualities of the offspring of different types showed that meat-type ewes, unlike meat-wool-type animals, had an advantage in live weight, while meat-wool-type ewes prevailed over meat-type offspring in terms of dirty (physical) wool yield. When assessing the physical and mechanical properties of wool, it was noted that meat-wool type animals had wool of homogeneous thickness compared to meat type counterparts. Meat-wool type lambs had longer wool compared to meat type ewe lambs of the same age.

Analysis of the physical and chemical properties of the wool revealed that young animals of the meat type had sparse wool, low fleece density, more mechanical impurities and less grease in the wool, in contrast to young animals of the meat-wool type. The grease-to-sweat ratio in sheep of both intra-breed types was the same and amounted to 1.03:1.0. Ewes of the meat-wool intra-breed type were characterised by light cream-coloured grease sweat, while young animals of the meat type had cream-coloured grease sweat. Individual grading at 14 months of age showed that, based on a comprehensive assessment (live weight, wool quality, productivity), ewes of the meat-wool type, when compared with meat-type individuals, had an elite and first-class rating of 88.2% and 90.5%, respectively.

All animals were characterised by correct body parameters, strong constitution, good live weight, and dense closed fleece, which were characteristic of semi-fine-wool breeds. Considering the productive indicators of meat-wool intra-breed ewes compared to meat ewes, it was possible to testify to the potential genetic possibilities of such a rational selection of parent pairs during mating, and therefore, recommendations were made for the targeted use of this approach to improve the productive qualities of semi-fine-wool sheep flocks in the Volga region. Thus, the goal set at the beginning of the research and the task of studying and analysing the productive qualities of Kuibyshev sheep of the local population of different intra-breed productive types were achieved. In order to identify a desirable and promising intraspecific type in the Kuibyshev sheep breed, it is necessary to conduct an in-depth study of productivity indicators in terms of intraspecific types at the gene-molecular level.

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**SEASONAL PHENOLOGY OF ECTOPARASITES IN ZOOBIOCOENOSES OF
KARAKALPAKSTAN**

**СЕЗОННАЯ ФЕНОЛОГИЯ ЭКТОПАРАЗИТОВ В ЗООБИОЦЕНОЗАХ
КАРАКАЛПАКСТАНА**

**КАРАКАЛПАКСТАН ЗООБИОЦЕНОЗДОРУНДАГЫ ЭКТОПАРАЗИТТЕРДИН
СЕЗОНДУК ФЕНОЛОГИЯСИ**

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SEASONAL PHENOLOGY OF ECTOPARASITES IN ZOOBIOCOENOSES OF KARAKALPAKSTAN

Abstract

In 2023-2024, a study of the seasonal activity of ectoparasites parasitising cattle and sheep was conducted in the Nukus and Karauzak districts of the Republic of Karakalpakstan. The relevance of the study is conditioned by to the need for epizootic monitoring in an arid climate that promotes the conservation and spread of ectoparasitic forms that affect the productivity of farm animals. The purpose of the study was to determine the species composition of ectoparasites, their prevalence and seasonal phenology in the northwestern region of Uzbekistan. The methodological basis included a field collection of parasitic arthropods, followed by morphological identification using generally accepted definitions. The sample size was 3,648 animals examined in farms and private holdings. The presence of 12 ectoparasite species, mainly from the families Ixodidae, Hippoboscidae, and Trichodectidae, parasitising cattle and sheep, has been established. As a result of monitoring in 2023, species of mites of the genera Hyalomma (H. anatolicum, H. plumbeum, H. detritum, H. scupense), Rhipicephalus (Rh. bursa, Rh. turanicus), Haemaphysalis (H. sulcata, H. punctata), Dermacentor marginatus, Ixodes ricinus, and chewing lice of the genera Bovicola (B. ovis, B. bovis). The largest number of ixodid ticks was recorded from the middle of spring to the end of summer, especially in June and July, with a gradual decrease in autumn. The species Bovicola ovis demonstrated year-round activity, mainly in sheep, whereas B. bovis was more common in cattle. Seasonal dynamics indicated endemic migration of parasites, depending on temperature rise and microclimatic conditions. In addition, the relationship between the intensity of invasion and the density of livestock, the sanitary condition of the premises and the degree of anthropogenic stress on pasture ecotopes has been established. The results obtained are of practical importance for the development of seasonal schemes of antiparasitic treatments, increasing the stability of livestock and preventing vector-borne diseases in the steppe and semi-arid pastures of Karakalpakstan

Keywords: cattle breeding; sheep breeding; ixodid tick; chewing lice; bovicola; zoophilous insect

*Сезонная фенология эктопаразитов в зообиоценозах
Каракалпакстана*

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Аннотация

В 2023-2024 годах в Нукусском и Караузакском районах Республики Каракалпакстан было проведено исследование сезонной активности эктопаразитов, паразитирующих на крупном рогатом скоте и овцах. Актуальность работы обусловлена необходимостью эпизоотического мониторинга в условиях аридного климата, способствующего сохранению и распространению эктопаразитарных форм, влияющих на продуктивность сельскохозяйственных животных. Целью исследования являлось определение видового состава эктопаразитов, их распространённости и сезонной фенологии в условиях северо-западного региона Узбекистана. Методологическая основа включала полевую сбор паразитирующих членистоногих с последующей морфологической идентификацией по общепринятым определителям. Объём выборки составил 3648 животных, обследованных в фермерских и частных хозяйствах. Установлено наличие 12 видов эктопаразитов, преимущественно из семейств Ixodidae, Hippoboscidae и Trichodectidae, паразитирующих на крупном рогатом скоте и овцах. В результате мониторинга в 2023 г. были выявлены виды клещей родов *Hyalomma* (*H. anatolicum*, *H. plumbeum*, *H. detritum*, *H. scupense*), *Rhipicephalus* (*Rh. bursa*, *Rh. turanicus*), *Haemaphysalis* (*H. sulcata*, *H. punctata*), *Dermacentor marginatus*, *Ixodes ricinus*, а также волосоедов родов *Bovicola* (*B. ovis*, *B. bovis*). Наибольшая численность иксодовых клещей регистрировалась с середины весны до конца лета, особенно в июне-июле, с постепенным снижением осенью. Вид *Bovicola ovis* демонстрировал круглогодичную активность, преимущественно у овец, тогда как *B. bovis* чаще встречался у крупного рогатого скота. Сезонная динамика указывала на эндемичную миграцию паразитов, зависящую от повышения температуры и микроклиматических условий. Кроме того, установлена взаимосвязь интенсивности инвазии с плотностью поголовья, санитарным состоянием помещений и степенью антропогенной нагрузки на пастбищные экотопы. Полученные результаты имеют практическую значимость для разработки сезонных схем противопаразитарных обработок, повышения устойчивости поголовья и профилактики трансмиссивных заболеваний в зоне степных и полупустынных пастбищ Каракалпакстана

Ключевые слова: скотоводство; овцеводство; иксодовый клещ; шерстеед; *bovicola*; зоофильное насекомое

Аннотация

2023-2024-жылдары Каракалпакстандын Нукус жана Караузак райондорунда уй жана койлордо кездешкен эктопаразиттердин сезондук активдүүлүгү изилденди. Изилдөөнүн актуалдуулугу – аймактын кургакчыл климаты эктопаразиттердин сакталып, кеңири таралышын шарттап, айыл чарба малдарынын продуктивдүүлүгүнө терс таасирин тийгизеринен улам эпизоотологиялык мониторингдин зарылдыгына байланыштуу болду. Изилдөөнүн максаты – түндүк-батыш Өзбекстан шартында эктопаразиттердин түрдүк курамын, таралышын жана сезондук фенологиясын аныктоо. Методологиялык негиз – талаа шартында паразиттик муунтуп буттуулардын чогултулуп, аларды классикалык морфологиялык идентификациялоо ыкмалары менен аныктоо болду. Жалпысынан 3648 баш мал фермердик жана жеке чарбаларда изилдөөгө тартылды. Изилдөөдө Ixodidae, Hippoboscidae жана Trichodectidae тукумундагы 12 түр эктопаразиттер аныкталды. 2023-жылкы байкоолордо төмөнкү кенелер катталды: *Hyalomma anatolicum*, *H. plumbeum*, *H. detritum*, *H. scupense*; *Rhipicephalus bursa*, *Rh. turanicus*; *Haemaphysalis sulcata*, *H. punctata*; *Dermacentor marginatus*; *Ixodes ricinus*, ошондой эле шерстееддер – *Bovicola ovis* жана *B. bovis*. Иксод кенелеринин эң жогорку активдүүлүгү жаздын ортосунан жайдын аягына чейин, өзгөчө июнь-июль айларында байкалды. *Bovicola ovis* жыл бою активдүү болуп, негизинен койлордон табылды, ал эми *B. bovis* көбүнчө уйлордо кездешти. Сезондук динамика паразиттердин климаттык факторлорго байланыштуу локалдык миграциясын көрсөттү. Ошондой эле инвазиянын интенсивдүүлүгү малдын тыгыздыгына, сарайлардын санитардык абалына жана жайыттарга болгон антропогендик жүктөмгө байланыштуу экени аныкталды. Изилдөөнүн жыйынтыктары Каракалпакстандын талаа жана жарым-чөл жайыт аймактарында трансмиссивдик оорулардын алдын алуу жана малдын туруктуулугун жогорулатуу максатында сезондук дарылоо схемаларын иштеп чыгууда практикалык мааниге ээ

Ачкыч сөздөр: мал чарба; кой чарба; иксод кенеси; шерстеед; *Bovicola*; зоофилдүү курт-кумурскалар

Introduction

The constant growth in demand for livestock products, including meat, milk, wool and leather raw materials, requires a stable and sustainable level of productivity of farm animals. One of the key factors negatively affecting the health and productivity of cattle and sheep is parasitic diseases caused by ectoparasites. In the arid climate typical of a number of regions of Uzbekistan, including Karakalpakstan, favourable conditions are created for the survival and spread of ixodid ticks and zoophilous insects. These parasites reduce body weight gain, degrade the quality of livestock products, and contribute to the spread of vector-borne infections. In this regard, there is a need for a systematic study of the seasonal activity of ectoparasites, which would allow timely prediction of epizootic outbreaks and the development of effective preventive measures.

Research by K.T. Sultankulova et al. (2022) analysed the species of ticks that parasitise cattle, sheep, and horses in various regions of Kazakhstan. The researchers established the prevalence of *Dermacentor marginatus*, *Hyalomma anatolicum*, and *Hyalomma scupense*, and also identified the presence of pathogens of slaughter and leather animals. Despite the revealed high degree of infection of ticks with vector-borne pathogens, the study did not analyse the seasonal dynamics of parasitisation, which limits the possibility of predicting peak periods of invasion.

Similar aspects of ectoparasite infestation in an arid climate were considered in studies conducted in Pakistan. The study by S. Shahid et al. (2022), conducted in Quetta district, analysed the infection of sheep and goats with ixodid ticks. The total invasion was 12.26%, with species *Hyalomma*, *Rhipicephalus*, and *Ixodae* dominating. The greatest activity of ticks was observed in summer, especially in females and animals aged 1-2 years. N. Hussain et al. (2023) covered a wider range of animals in various agroecological areas of Pakistan, including cattle, camels, horses, and dogs. 11 species of ticks were identified, and the infection rate reached 14.3%. The dominant tick genera varied depending on the host species. Both studies emphasised the seasonal activity of ectoparasites and the importance of climatic factors, but the study by N. Hussain et al. had a wider interspecific and spatial coverage. Despite similar climatic conditions, such comprehensive data on the distribution and seasonal phenology of ectoparasites on farm animals in Karakalpakstan remain limited.

Y. Li et al. (2020) conducted a comprehensive assessment of the prevalence of ticks and their pathogens in domestic animals in the Xinjiang Uygur Autonomous Region of China. The researchers identified 5,822 ticks collected from cattle, sheep, goats, camels, and horses, and identified 12 species primarily from the genera *Dermacentor*, *Hyalomma*, and *Rhipicephalus*. Using molecular methods, pathogens *Rickettsia raoultii*, *Brucella* spp., *Anaplasma ovis*, *Babesia caballi*, *Theileria equi*, and *Theileria ovis* were detected, with tick infection reaching 36.8%. The data obtained emphasise the importance of monitoring ectoparasites as vectors of vector-borne diseases and demonstrate significant species and pathogenic diversity comparable to the risks in regions with an arid climate, such as Karakalpakstan.

The study by K. Altay et al. (2024) was aimed at the molecular identification of tick-borne pathogens in grazing horses in Kyrgyzstan. Of the 311 animals examined, 7.4% were infected with *Theileria equi*, with a predominance of genotypes A and E. No other pathogens have been identified. The study highlighted the importance of species-specific monitoring of tick-borne pathogens for the control of parasitic diseases in horses in Central Asia.

Thus, given the lack of comprehensive data on the species composition, distribution, and seasonal dynamics of ectoparasites in Karakalpakstan, the need for investigating the distribution and seasonal phenology of ectoparasites in cattle and sheep farms in this region was emphasised. The purpose of this study was to identify the main types of ectoparasites, assess their seasonal activity, and analyse the influence of climatic factors on the dynamics of infestation of farm animals.

Materials and Methods

The study was conducted on the territory of the Nukus and Karauzak districts of the Republic of Karakalpakstan, characterised by an arid climate with dry, hot summers (the average temperature in July reaches +38°C) and cool winters (down to -5°C), low air humidity, and a predominance of semi-desert and desert vegetation. Coordinates of the studied areas: Nukus district – 42.4532°N, 59.6022°E; Karauzak district – 41.7300°N, 60.7500°E.

Field surveys and material collection were conducted from March to November 2023, covering the spring, summer, and autumn seasons. The objects of the study were cattle (mainly Kazakh white-headed cows and local breeds) and small cattle (sheep and goats) kept in farms (Dami-ata, Nur Tilek Karauzek) and private farms in the Kuibak and Samanbai mahallas. In total, more than 1,200 cattle and over 2,400 sheep and goats were examined. The animals varied in age (from 6 months to 6 years) and sex. All examinations were conducted with the consent of the animal owners.

Ectoparasites were collected manually and by combing using sterile tweezers and brushes. Each animal was visually examined for ectoparasites, with an emphasis on the areas of the head, neck, withers, underbelly, groin, and tail base (Catalano, 2024). The examinations were carried out twice a month in the morning, when the parasites were most active. The collection was carried out by veterinary specialists who had been trained and had experience in parasitological examinations. Special attention was paid to the presence of ticks and chewing lice in different phases of development (larvae, nymphs, imago).

Each collected sample was placed in an individual tube with 70% ethanol. The test tubes were provided with a waterproof label indicating the sample code, the number of the farm, the date and place of collection, the type and age of the animal, and the affected body part. All data was recorded in the accounting log, eliminating the possibility of cross-contamination and losses. The samples were stored at a temperature of +4°C in the laboratory of Arachnoentomology and Acarology of the Nukus Branch of the Samarkand State University of Veterinary Medicine, Animal Husbandry, and Biotechnology.

The identification of the collected ectoparasites was carried out using classical determinants: "Atlas of Ixodid Ticks" (Ganiev & Aliverdiev, 1968), and other specialised manuals (Tsapko, 2020). Specific diagnostics was performed under an MBS-10 binocular microscope (LOMO–Leningrad Optical and Mechanical Association, USSR) and a Carl Zeiss microscope (Germany) with magnification up to 400×. Identification was carried out to the level of genus and species, considering morphological features at various stages of development.

To analyse the seasonal dynamics of infestation, a quantitative assessment was used: the number of parasites per animal, their stage of development, and frequency of occurrence. Observations were carried out monthly to identify peaks in ectoparasite activity. Generally accepted

indicators were used to assess infection: the degree of invasion (percentage of infected animals), the intensity of invasion (average number of parasites per infected animal). The data was processed using descriptive statistics with the calculation of averages, ranges, and standard deviations (Nikanorova, 2020).

All procedures were carried out in accordance with the ethical standards for the treatment of animals in force in the Republic of Uzbekistan, and in compliance with sanitary and hygienic requirements for the collection, transportation, and storage of parasitological material. The animals were not harmed, and the collection of material was carried out with minimal stress to the body.

Results and Discussion

Seasonal activation and movement of ectoparasites in the natural conditions of the Nukus and Karauzak districts began in the second ten days of April, which coincided with a steady increase in the average daily air temperature. As part of field studies conducted on farms and in private farms in these areas (including the Dami-ata farm, Samanbai mahalla, Nur Tilek Karauzek farm, and Kuibak mahalla), the species composition of ectoparasites infecting cattle and sheep was determined.

Representatives of ixodid ticks of the genera *Hyalomma* (*H. anatolicum*, *H. plumbeum*, *H. detritum*, *H. scupense*), *Rhipicephalus* (*Rh. bursa*, *Rh. turanicus*), *Haemaphysalis* (*H. sulcata*, *H. punctata*), *Dermacentor marginatus*, and *Ixodes ricinus* had the greatest epizootological significance. These species were active throughout the growing season, with peak numbers during the warmer months. Ticks of the genera *Hyalomma* and *Rhipicephalus* dominated among them, which indicates their high adaptability to the climatic conditions of the region.

Additionally, ectoparasites of the genus *Bovicola*, *B. ovis* in sheep (Fig. 1a) and *B. bovis* in cattle (Fig. 1b), were recorded in all surveyed farms. Unlike ixodid ticks, these parasites demonstrated year-round activity, which is due to the conditions of animal husbandry, especially in winter, when a warm and enclosed indoor environment promotes their reproduction. The presence of these species in all seasons indicates stable invasions that require systemic control as part of the prevention of pediculosis.



Figure 1. Larval and imago forms of *Bovicola ovis* (a) and *Bovicola bovis* (b)

Source: photo by the authors

Figure 1 shows the stages of development of two species of chewing lice typical of farm animals in Karakalpakstan. *Bovicola ovis*, which parasitises sheep, and *Bovicola bovis*, which infects cattle, are permanent inhabitants of the skin and hair of animals. Their year-round presence confirms the stable circulation of these parasites in the livestock farms of the region. Especially

high numbers are recorded in the autumn-winter period, which is associated with a denser crowding of animals and favourable indoor temperatures.

Bovicola ovis is an obligate ectoparasite of sheep, a representative of the chewing lice group, feeding on the surface layers of the skin and epidermal scales. According to the study by A. Eshetu et al. (2017), conducted in the Vogera region (Northern Gondera zone, Ethiopia), *B. ovis* infection was recorded in 12.07% of the examined animals. It was found that the degree of infection significantly varied depending on the sex and physical condition of the sheep: in animals with an unsatisfactory (52.9%) and average (38.2%) body index, infection was significantly higher than in sheep with a good physique (25%). It was also noted that rams were more likely to be infected with *B. ovis* compared to ewes (46.5% versus 33%). Despite the fact that age did not have a statistically significant effect on infection with this type of parasite, *B. ovis* was often detected in mixed infestations together with *Melophagus ovinus*.

Pediculosis in cattle caused by lice of the genus *Bovicola bovis* is a serious veterinary problem affecting the health and productivity of animals. The study by F. McKiernan et al. (2021) revealed a high level of lice infestation in beef cattle herds in Ireland, with resistance to deltamethrin, one of the widely used pyrethroid insecticides, being reported for the first time. The researchers noted that such resistance reduces the effectiveness of traditional control measures, exacerbating stress and skin damage in animals, which negatively affects productivity and well-being. These data confirm the importance of monitoring resistance and finding new methods to control ectoparasites, which is especially important in the conditions of cattle grazing similar to the region under study. The results obtained complement the knowledge about the biology and epidemiology of *Bovicola bovis*, which must be considered when developing strategies for the prevention and treatment of pediculosis in different climatic zones. Summary data on the species composition, distribution, and seasonal activity of ectoparasites are presented in Table 1.

Table 1. Ectoparasite species found in the territory of the Nukus and Karauzak districts of the Republic of Karakalpakstan

No.	Types of ectoparasites	Infected animal species	Seasons
1.	<i>Hyalomma anatolicum</i>	bovine cattle	in the warmer months in winter
2.	<i>Hyalomma detritum</i>		
3.	<i>Hyalomma plumbeum</i>	bovine cattle	in the warmer months nymph
4.	<i>Hyalomma scupense</i>	bovine cattle	in the warmer months
5.	<i>Dermacentor marginatus</i>	bovine cattle	in the warmer months
6.	<i>Rhipicephalus bursa</i>	bovine cattle	In all seasons, larva and nymph in winter
7.	<i>Rhipicephalus turanicus</i>		
8.	<i>Haemaphysalis sulcata</i>	bovine cattle	In the warmer months
9.	<i>Haemaphysalis punctata</i>	bovine cattle	In the warmer months
10.	<i>Hyalomma anatolicum</i>	sheep	In the warmer months
11.	<i>Bovicola ovis</i>	sheep	In all seasons
12.	<i>Bovicola bovis</i>	bovine cattle	In all seasons

Source: compiled by the authors

Based on the data presented in Table 1, it can be concluded about the pronounced seasonal activity of most ectoparasite species found in the Nukus and Karauzak districts of Karakalpakstan. The predominance of ixodid mites of the genus *Rhipicephalus* (Fig. 2) and *Hyalomma* (Fig. 3) in the warm season indicates a high dependence of these species on climatic factors, in particular, temperature and humidity, which create favourable conditions for their active development, mating,

and attacking their hosts. Ectoparasites were detected in cattle individually, in late March and early April. And in June and July, the process of their reproduction accelerated. Special attention should be paid to the species *Rhipicephalus bursa*, which, unlike most other species, remains active in all seasons, including winter, which indicates its high adaptability to the extreme conditions of the region and the presence of stable larval and nymph stages. The constant presence in the populations of *Bovicola ovis* (Fig. 1a) and *Bovicola bovis* (Fig. 1b), recorded in sheep and bovine cattle, respectively, throughout the year is explained by the conditions of animal husbandry – crowding, poor ventilation, and the presence of wool, which promotes the reproduction and shelter of these parasites. Such year-round circulation leads to chronic skin lesions, decreased productivity and overall stability of animals, and increases the risk of secondary bacterial infections. Thus, the established structure and seasonal dynamics of infection indicate the need for timely and differentiated antiparasitic treatment of animals, considering the species-specific features of ectoparasites.



Figure 2. Dorsal and abdominal mite species of the genus *Rhipicephalus*

Source: photo by the authors



Figure 3. Morphological features of ixodid mites of the genus *Hyalomma* identified in farm animals

Source: materials from free online sources

The morphological features of ixodid mites, shown in Figures 2 and 3, allow for a more detailed understanding of the adaptation mechanisms of these species to a parasitic lifestyle. The visible differences in the structure of the shield, chelicerae, and legs reflect the specifics of the mites' fixation on the host's body and penetration into the skin. The presence of dense chitinous

integument in representatives of the genus *Hyalomma* and a pronounced oral apparatus in *Rhipicephalus* indicates a high degree of adaptability to blood-sucking in the conditions of pastoral cattle breeding typical for the region. Such morphological features contribute to long-term attachment to the host, which increases the likelihood of transmission of vector-borne diseases. The visual representation of the parasite structure supports the results of field observations and highlights the need to take biological characteristics into consideration when developing regional schemes for the prevention and control of ectoparasites.

As a result of the analysis of the seasonal dynamics of ectoparasite infection in sheep and goats in the farms of the population of the Kuibak mahallas of Karauzak district and Samanbai of Nukus district, it was found that the level of infection of sheep in winter is at an average seasonal level, peaking in spring and summer, and decreasing to minimum values in the autumn months. These data reflect the pronounced seasonal activity of ectoparasites, which is determined both by the climatic conditions of the region and by the biological characteristics of the parasitic species. The greatest intensity of infection is observed in the warm season, which coincides with peak numbers of ticks and other parasites, while in the cold season their activity decreases significantly, with the exception of some species adapted to winter conditions. The obtained results emphasise the need for comprehensive monitoring and application of differentiated measures for the prevention of parasitic diseases in farms of Karakalpakstan.

The data obtained on the seasonal phenology of ectoparasites of cattle and sheep in the districts of Karakalpakstan are consistent with the results presented in the study by S.I. Mavlanov et al. (2025), who also studied the seasonal activity and infection rate of animals with ticks. Both studies confirmed that tick activity peaks in the summer months, with *Hyalomma* and *Rhipicephalus* being the dominant genera. If the study by S.I. Mavlanov et al. reported an invasion rate of 70-80% in cattle and 80-82% in small cattle, whereas the present study found a slightly lower infection rate in a number of age groups, which may be conditioned by differences in animal treatment methods, microclimatic conditions, or the level of veterinary control on individual farms.

K.C. Kim (1985) emphasised the importance of adaptive mechanisms that ensure the stable coexistence of parasites and hosts, and the development of specific biological bonds. Special attention was paid to obligate parasites, including ixodid mites and lice, which allowed for a deeper understanding of their role in epizootic processes. These provisions correlate well with the results of this study of ectoparasites in Karakalpakstan, where the adaptation of ticks of the genera *Hyalomma* and *Rhipicephalus* to local climatic conditions and host biology was revealed. The concepts of coevolution presented in the book have confirmed the need to consider the evolutionary and ecological characteristics of parasites when developing effective control and prevention measures, which is especially important for arid regions with intensive pasture farming.

Ixodid mites (Ixodidae) are among the most epidemiologically significant ectoparasites affecting farm animals in various regions. L. Fedonyuk et al. (2023) showed that pronounced seasonal ixodid activity is observed in Western Ukraine, with peaks in May-June and August-September, which is directly related to temperature, humidity, and host density. The researchers also emphasised the role of climate change in prolonging the period of tick activity and increasing epizootic danger. These data confirm the need for similar regional studies in other climatic zones, including arid regions of Uzbekistan, where the epidemiological risk persists in conditions of high temperatures and grazing animals.

A. Kamalova (2023) presented an important contribution to the study of bovine ixodidosis under experimental modelling conditions. The researcher noted that with the increase in the number of imported livestock and the expansion of livestock farms in Uzbekistan, the risk of the spread of ixodid ticks increases, especially in household farms and new ecotopes. In an experiment conducted on 10 cows, it was shown that infection with ixodidosis leads to a decrease in milk yields by an average of 300 g, which highlights the economic losses associated with the parasitic load. The study highlighted not only the productive, but also the clinical consequences of infection (itching, anxiety, decreased general condition), thereby confirming the need for preventive monitoring and the development of new means to combat ixodidosis in agricultural regions.

N. Choubdar et al. (2021) conducted a comprehensive assessment of the microbiota of the *Hyalomma anatolicum* mite using a new generation of culture and sequencing. A high species diversity of bacteria was revealed, differing in stages of development, sex, and organs of ticks. *Bacillus subtilis* dominated at all stages, which indicates possible transovarial transmission, and its presence on both ticks and livestock skin indicates a cutaneous origin. The NGS (Next Generation Sequencing) method showed the predominance of *Francisella* spp. and possible inhibition of *Rickettsia*, which is important for assessing the vector role of the tick.

The study by P. Biglari et al. (2018), conducted in the central part of Iran, found that *Hyalomma anatolicum* is the dominant tick species (38.83%) in cattle, sheep, and goats. The total infection rate of the animals was 18.53%, and the species composition included six species of ixodid ticks. These results are comparable to the data obtained in Karakalpakstan (2023-2024) in this study, where the predominance of *H. anatolicum* was also noted, but a greater species diversity (12 species) was revealed and a clear seasonal trend was traced. Thus, both studies confirmed the importance of *H. anatolicum* as a key ectoparasite, but the research in Karakalpakstan provides a more comprehensive picture of ecological and epizootic features.

A review by B. Kumar et al. (2020) examined the epidemiological significance of ticks of the genus *Hyalomma* as vectors of *Theileria annulata* in animals and Crimean Congo haemorrhagic fever virus in humans, and other pathogens, including *Babesia*, *Rickettsia*, and various viruses. The researchers noted difficulties in controlling populations of these ticks due to their multi-host nature and pointed to the limited effectiveness of conventional acaricides. The study analysed alternative control methods, including the development of *Hyalomma* vaccines by analogy with anti-*Rhipicephalus microplus* vaccines, and the use of plant-based acaricides and other environmentally sustainable approaches. The review highlighted the need to move towards comprehensive management strategies to reduce the spread of ticks and their transmitted infections.

During the three-year study by L.P. Phipps et al. (2022), conducted in Southern England, the potential for disease transmission by ticks of the species *Haemaphysalis punctata*, whose numbers and range are increasing in Northern Europe, was investigated. 302 individuals collected at eight different locations were analysed by polymerase chain reaction (PCR). The samples revealed two types of *Babesia* associated with diseases in farm animals (*Babesia major* and *Babesia motasi*), and the causative agent of borreliosis in humans, *Borrelia miyamotoi*. The highest concentration of infected ticks was recorded in Sussex County. The data obtained indicate the potential threat of the expanding *H. punctata* population to the health of humans and farm animals in the region.

M.S. Sajid et al. (2009) evaluated the efficacy of ivermectin and cypermethrin against the mite *Hyalomma anatolicum* both in vitro and in vivo. Both drugs showed high efficacy in the laboratory, while cypermethrin completely destroyed ticks even at the highest concentrations, and ivermectin significantly reduced survival. In the field, cypermethrin ensured the complete destruction of ticks for 20 days after treatment, while ivermectin only ensured destruction for 15 days. However, incorrect use of acaricides and excessive use of ivermectin, identified among farmers, could reduce the effectiveness of the drug in practice. Comparing these data with the results of this study, which revealed the high activity of *Hyalomma* ticks and their significant impact on the health and productivity of cattle in Karakalpakstan, the need to introduce more effective and sustainable ectoparasite control strategies becomes obvious. The findings of M.S. Sajid et al. confirmed that chemicals, especially cypermethrin, can be effective, but their rational use and proper organisation of animal treatment are key to long-term success.

Summarising, the integration of data on the seasonal activity of ticks, the microbiological characteristics of their populations and the effectiveness of acaricides emphasises the importance of an integrated approach to combating ectoparasites. The introduction of systematic monitoring, the rational use of acaricides and alternative control methods will reduce the burden of ticks and related diseases, increase livestock productivity, and improve the epizootic situation in the region.

Conclusions

The conducted research established that in the conditions of the Republic of Karakalpakstan, farm animals, in particular bovine cattle and sheep, are under constant threat of infection with a wide range of ectoparasites. Parasitisation of 12 species was recorded, including representatives of the genera *Hyalomma*, *Rhipicephalus*, *Haemaphysalis*, *Dermacentor*, *Ixodes*, and lice of the genus *Bovicola*, which indicates a high species diversity and adaptability of ectoparasites to local climatic and zootechnical conditions. These data confirm the importance of regular monitoring of ectoparasite populations on livestock farms and the need for timely preventive measures.

The analysis of seasonal phenology showed that the activation of ticks begins in the second decade of April, reaches a peak in June-July, and then gradually decreases. This distribution is related to the temperature and humidity conditions of the region, which favour the reproduction and distribution of arthropods during the warm season. Unlike ticks, the insects that cause entomoses, especially *Bovicola bovis* and *B. ovis*, were most common in the winter and spring period, which may be conditioned by a decrease in the immune status of animals during the cold season, increased crowding of livestock indoors, and less active control of parasites during this period.

The results obtained confirm that the tasks set – determining the species composition of ectoparasites, studying the seasonal dynamics of their activity and identifying periods of greatest danger – have been successfully solved. In the future, in-depth studies of the biology and resistance of the discovered species to chemical agents are required, and an assessment of the effectiveness of alternative control methods, including biological and phytotherapeutic approaches, considering the specifics of the region and the characteristics of farm animals.

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**THE STATE, ACHIEVEMENTS, AND PROSPECTS FOR THE DEVELOPMENT OF
SHEEP BREEDING IN UZBEKISTAN**

**СОСТОЯНИЕ, ДОСТИЖЕНИЯ И ПЕРСПЕКТИВЫ РАЗВИТИЯ ОВЦЕВОДСТВА В
УЗБЕКИСТАНЕ**

**ЎЗБЕКСТАНДАГЫ КОЙ ЧАРБАЧЫЛЫГЫНЫН АБАЛЫ, ЖЕТИШКЕНДИКТЕРИ ЖАНА
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THE STATE, ACHIEVEMENTS, AND PROSPECTS FOR THE DEVELOPMENT OF SHEEP BREEDING IN UZBEKISTAN

Abstract

Sheep breeding in Uzbekistan occupies one of the leading positions in the agricultural sector and is an important source of livestock products – mutton, wool, and sheepskins. In conditions of limited forage resources and the predominance of desert and semi-desert pastures (more than 21 million hectares), and the need to increase the productivity of local breeds, the task of breeding livestock renewal becomes especially urgent. Considering the climatic characteristics of the country and market requirements, the creation of new, more productive and sustainable sheep breeds is of strategic importance. The purpose of this study was to comprehensively analyse the state of sheep breeding in Uzbekistan and generalise data on breeding work to create a new factory type of fat-tailed sheep of meat and fat production, obtained by crossing the Jaydari and Hissar breeds. In the course of the study, methods of targeted factory crossing, selection and breeding, and a comprehensive assessment of zootechnical indicators were used. Breeding work was carried out in 2009-2022 in conditions of farms and scientific institutions of mountainous and foothill regions. As a result, a new type of sheep was described – “Akchasai”, officially registered in 2024 (patent No. ZAP 34). Animals of this type demonstrate consistently high rates: the live weight of breeding rams reaches 120-140 kg, ewes – up to 100 kg, which is 20-25% higher than the parameters of the original breed. High viability, early maturity, resistance to climatic stress, and stability of inherited traits make this type a valuable breeding resource. By 2022, a breeding core of 5,100 animals had been formed. The practical significance of the research lies in expanding the genetic potential of domestic sheep breeding and forming a scientific base for its sustainable development in Uzbekistan

Keywords: breeding; breed; sheep; productivity; sheepskin; type

Состояние, достижения и перспективы развития овцеводства в Узбекистане

Аннотация

Овцеводство в Узбекистане занимает одно из ведущих мест в аграрном секторе и является важным источником продукции животноводства – баранины, шерсти и смушек. В условиях ограниченных кормовых ресурсов и преобладания пустынных и полупустынных пастбищ (более 21 млн га), а также необходимости повышения продуктивности местных пород особенно актуальной становится задача селекционного обновления поголовья. С учётом климатических особенностей страны и рыночных требований создание новых, более продуктивных и устойчивых пород овец приобретает стратегическое значение. Целью настоящего исследования являлся всесторонний анализ состояния овцеводства в Узбекистане, а также обобщение данных о селекционной работе по созданию нового заводского типа курдючных овец мясо-сального направления продуктивности, полученного путём скрещивания джайдаринской и гиссарской пород. В ходе исследования были использованы методы направленного заводского скрещивания, отбора и подбора, а также комплексной оценки зоотехнических показателей. Селекционная работа проводилась в 2009-2022 гг. в условиях фермерских хозяйств и научных учреждений горных и предгорных регионов. В результате описан новый тип овец – «Акчасай», официально

Ўзбекистандаги кой чарбачилигынын абалы, жетишикендиктери жана өнүгүү көрүнүшү

Аннотация

Ўзбекистанда кой чарбачилигы агрардык сектордо алдыңкы орундардын бирин ээлейт жана мал чарбачилигынын маанилүү булагы болуп саналат – эт (кой эти), жүн жана каракул өндүрүү. Чектелген тоют ресурстары, ошондой эле 21 млн гектардан ашык чөл жана жарым чөл жайыттардын үстөмдүгү шартында, жергиликтүү породадардын продуктивдүүлүгүн жогорулатуу зарылчылыгы туулат. Өлкөнүн климаттык өзгөчөлүктөрүн жана базардын талаптарын эске алуу менен, жаңы, жогорку өндүрүмдүү жана туруктуу кой породадарын түзүү стратегиялык мааниге ээ. Бул изилдөөнүн максаты – Ўзбекистандагы кой чарбачилигынын абалын ар тараптуу талдоо жана эт-салоо багытындагы жаңы заводдук курдючтук кой порода тибин түзүүгө багытталган селекциялык иштердин жыйынтыктарын жалпылоо болуп саналат. Изилдөөдө заводдук багытталган аргындаштыруу, тандоо жана курактоо ыкмалары, ошондой эле зоотехникалык көрсөткүчтөрдү комплекстүү баалоо колдонулган. Селекциялык иштер 2009-2022-жылдары тоолуу жана тоо этектери аймактарындагы фермердик чарбаларда жана илимий мекемелерде жүргүзүлгөн. Натыйжада 2024-жылы расмий түрдө катталган (патент № ZAP 34) “Акчасай” аттуу жаңы кой тибин сүрөттөлгөн. Бул типтеги малдар туруктуу жогорку көрсөткүчтөрдү көрсөтөт: асыл тукум кочкорлордун тирүү салмагы 120-140 кг, кочкорлордуку 100 кг га

зарегистрированный в 2024 году (патент № ZAP 34). Животные этого типа демонстрируют устойчиво высокие показатели: живая масса племенных баранов достигает 120-140 кг, овцематок – до 100 кг, что на 20-25 % превышает параметры исходной породы. Высокая жизнеспособность, скороспелость, устойчивость к климатическим нагрузкам и стабильность наследуемых признаков делают данный тип ценным селекционным ресурсом. К 2022 году было сформировано племенное ядро численностью 5100 голов. Практическая значимость исследования заключается в расширении генетического потенциала отечественного овцеводства и формировании научной базы для его устойчивого развития в условиях Узбекистана

чейин жетет, бул көрсөткүчтөр баштапкы породадан 20-25% жогору. Жогорку жашоого жөндөмдүүлүк, эрте жетилүү, климаттык катаалдыктарга туруктуулук жана тукум кайталоочу белгилердин сакталышы – бул типти баалуу селекциялык ресурс кылат. 2022-жылга карата бул породадын асыл тукум ядросу 5100 башка жетти. Изилдөөнүн практикалык мааниси – улуттук кой чарбачылыгынын генетикалык потенциалын кеңейтүү жана Өзбекстандын шартында туруктуу өнүктүрүү үчүн илимий база түзүү

Ключевые слова: селекция; порода; овцы; продуктивность; смушка; тип

Ачкыч сөздөр: селекция; порода; койлор; продуктивдүүлүк; каракул; тип

Introduction

In the context of the transformation of Uzbekistan's agricultural sector, the development of sheep farming as a sustainable source of meat and wool products is of particular importance. The limited productivity of traditional breeds, unstable forage supply, and climatic vulnerability of pastures require a revision of approaches to breed development. The need to create specialised genotypes capable of ensuring stable economic performance in extreme conditions determines the scientific and practical importance of conducting a comprehensive analysis of the state and breeding achievements of the industry.

The study by A.K. Abdurasulov et al. (2024) reviewed the situation with the conservation and use of the gene pool of farm animals in the Kyrgyz Republic. The researchers noted that after the sovereignisation of the country, livestock numbers significantly decreased, feeding and maintenance conditions worsened, and breeding work weakened. Despite the presence of more than 20 breeds and populations with valuable adaptive qualities, effective conservation measures have been extremely limited. The researchers emphasised that the issues of breeding work in the conditions of pasture husbandry have been studied in fragments, and the adaptive potential of existing breeds has not been sufficiently disclosed. The present study aims to fill these gaps by analysing breeding strategies and evaluating a new type of fat-tailed sheep created in Uzbekistan.

The study by N.R. Ruzibaev et al. (2023) analysed the effectiveness of using frozen seed from breeding rams in artificial insemination. The results showed that the lambs produced by this method significantly outperformed their peers in terms of body weight at various stages of growth – from birth to 1.5 years of age. It was also revealed that winter cattle provides higher live weight indicators compared to spring. The researchers confirmed the high efficiency of using the gene pool of valuable producers and emphasised the importance of optimising the timing of insemination and lambing to increase the economic productivity of meat and wool sheep.

V. Fedorov et al. (2025) presented an assessment of the meat productivity of mongrel rams obtained by crossing the Texel meat breed with Soviet Merino and Edilbay ewes. A significant increase in slaughter weight, pulp yield, and meat yield ratio was found in crossbred animals compared with purebred counterparts. There was also an improvement in the fatty acid composition of meat, which indicates a high biological quality of the products. The researchers emphasised the effectiveness of hybridisation as a method of increasing sheep meat productivity and focus on the prospects for its introduction into production practice. This study confirmed the feasibility of developing and using new genotypes capable of ensuring sustainable production of high-quality mutton in the context of the transformation of the agricultural sector.

N. Bobokulov et al. (2021) analysed the meat productivity of Karakul and pasture sheep of various ethological types. The researchers noted their ability to maintain high productivity in hot climates, sparse vegetation, and limited access to green fodder. The presented data on live weight, slaughter yield, chemical composition of meat and diet confirmed the high biological value of these breeds. The study highlighted the importance of preserving and using the local gene pool in sheep farming sustainable development programmes.

A similar institutional and economic situation was considered by B.A. Akhmedov (2024), focusing not so much on productive qualities as on the institutional and economic aspects of the development of sheep farming in Uzbekistan. The researcher noted that due to reforms,

privatisation and the creation of farms, the country has made significant progress in the production of karakul products and strengthening the export potential of the industry. The existing problems were highlighted, including lack of resources, weak infrastructure, and unstable water supply to pastures. Thus, if the study by N. Bobokulov et al. focused on the biological and technological characteristics of the breeds, B.A. Akhmedov revealed the macroeconomic and managerial context of the industry's development, emphasising the need for government support and sustainable institutional mechanisms.

In 2020, Uzbekistan initiated a state programme for the development of the karakul industry based on the cluster model. According to the Presidential Decree of September 2, 2020, specialised clusters were created in the pasture areas of the country from 2020 to 2021, focused on breeding small cattle, forming a feed base, and organising a full production cycle – from slaughter to the release of finished products (A cluster for the development of karakul breeding..., 2020). Cooperation with research institutes, subsidisation of infrastructure modernisation, and drilling costs, and measures to stimulate employment were envisaged. This programme is aimed at the efficient use of natural resources, increasing the productivity of Karakul sheep and strengthening the economic sustainability of the sheep industry. However, despite some successful examples of selective breeding and the results of hybridisation, the following unresolved problems have been noted in the literature: the lack of systematised and nationally recognised adaptive meat and fat breeds, the lack of long-term studies of genotype stability, and the gap between government programmes and their practical implementation.

The purpose of this study was a comprehensive critical analysis of the current state of sheep breeding in Uzbekistan and the systematisation of data on breeding activities for the development of an adapted meat and fat type of sheep. The objectives of the study were the following:

- to analyse government initiatives and their impact on the industry;
- to characterise contemporary preferred breeds and pasture farming conditions;
- to synthesise information about the productive, exterior and reproductive characteristics of a new type of sheep obtained by crossing the Jaydari and Hissar breeds and identify gaps in existing breeding practice.

Materials and Methods

Research subjects. The present study was conducted on the territory of the Republic of Uzbekistan, covering various natural and climatic zones, including Tashkent, Namangan, Kashkadarya, and Surkhandarya regions. The main focus was on the mountainous and foothill areas of the Tashkent region, in particular, on farms and breeding enterprises of the Akhangaran region. These territories are characterised by a temperate continental climate with pronounced seasonality: cold winters, warm summers, and variable humidity significantly affect the productivity of farm animals. The main sheep breeds bred in the republic were included in the study.

- The Jaydari breed is a local breed, created under conditions of folk breeding, is highly resistant to extreme climatic conditions and retains productivity with year-round grazing.
- The Hissar breed is a large meat and fat breed known for its high precocity, slaughter yield, and endurance.

- The Akchasoi type is a new population obtained by crossing the Hissar and Jaydari breeds. It has improved indicators of meat and fat productivity and adaptation to the conditions of Uzbekistan.

- The study also included separate groups of Karakul, semi-fine-fleeced meat-wool, and Edilbai sheep breeds.

Farms of various forms of ownership were considered as objects of research: private farms, state-owned breeding enterprises, and personal farmsteads. This choice ensured the representativeness of the sample and allowed considering the specifics of sheep farming in different regions of the country.

The period and conditions of the study. Field and laboratory studies covered the time period from 2009 to 2023, which provided an opportunity to assess long-term trends and the impact of seasonal factors on sheep productivity. The studies were conducted year-round, considering seasonal changes in feeding, housing, and the physiological condition of the animals.

The climatic conditions of the mountainous and foothill zones are characterised by significant temperature fluctuations, an average annual temperature of +10...+15°C, dry summers and cold winters, which have a direct impact on fattening, reproduction, and wool productivity. In desert and semi-desert areas (breeding of the Karakul breed), low humidity, poor food supply, and extreme temperatures were observed, requiring high adaptability of animals.

Methods of data collection and analysis. The following methods were used to comprehensively cover all aspects of productivity and breeding work:

- Analysis of official statistics – data from the Agency of Statistics under the President of the Republic of Uzbekistan (National Statistics Committee..., n.d.), Ministry of Agriculture of the Republic of Uzbekistan (n.d.), and farm reporting forms, in particular, Form 1-FH “Report on the activities of a farming enterprise” (2023).

- Field observations – visual inspection of the herds was carried out, assessment of the conditions of keeping, feeding structure, and general condition of the animals.

- Documentary analysis – stud charts, veterinary records, and production reports were studied. Additional information about breeding work and the state of the industry was obtained based on reporting materials from the Akhangaran Department of the Scientific Research Institute of Animal Husbandry and Poultry (Ruziboyev, 2024).

Assessment of animal productivity. Sheep productivity was assessed in the following areas: body weight was measured using certified scales, and the body mass index was additionally calculated to characterise fatness and physical condition. Wool productivity was determined by annual shearing, subsequent sorting, and quality assessment in accordance with state standards. Meat productivity – slaughter yield, fattening coefficients, weight gain per feed unit were calculated. Sheepskin productivity was assessed by the structure, density, and quality of the sheepskins in accordance with commodity standards.

Methods of breeding work. Breeding activities were based on the principles of selection and selection of breeding animals based on the following characteristics: body weight, growth rate, fur quality, fertility (Kolosov et al., 2020). Interbreeding schemes were used, including the development of a new type of Akchasoi sheep based on the Jaydari and Hissar breeds, which

allowed obtaining genotypes with improved meat and fat productivity and adaptation. The genetic potential was assessed by analysing the heritability of economically useful traits and comparing generations by exterior and productive parameters.

Ethical norms and standardisation. All stages of the study were carried out in accordance with the current legislation of the Republic of Uzbekistan in the field of veterinary medicine and animal protection, and with international standards for the humane treatment of animals. Special attention was paid to minimising stress in animals during manipulation and ensuring proper conditions of maintenance in experimental farms. The products and parameters of the animals were evaluated in accordance with national meat and wool quality standards (Decree No. UP-5995, 2020).

Results

The current state and genetic structure of sheep breeding in Uzbekistan. According to the Agency of Statistics of the Republic of Uzbekistan for 2025, in all categories of farms in the country, there were over 14.3 million units of cattle, 24.5 million units of sheep and goats, and approximately 106 million units of poultry. Animal husbandry in Uzbekistan is based primarily on a pasture system covering 21.1 million hectares of natural land, of which 4.4 million hectares (21%) are in mountainous and foothill areas, and 16.6 million hectares (79%) are in desert and semi-desert plains. There are 15.8 million hectares of pastures at the disposal of territorial pasture farms subordinate to the Committee for the Development of Veterinary Medicine and Animal Husbandry, the remaining 7.2 million hectares are under the jurisdiction of the forest fund and other organisations. The republic breeds the Jaydari, Karakul, Hissar, semi-fine wool meat breed, and partially Edilbai sheep breeds. The breeding of fat-tailed meat breeds is carried out mainly in mountainous, foothill and semi-desert regions, while the Karakul breed dominates in desert and semi-desert zones.

The Government of Uzbekistan has provided incentives for the import of farm animals from abroad and their cultivation, the creation of a solid feed base, and the production of livestock products (Recent agricultural growth in Uzbekistan: Assessment and forecast, 2020). This allowed developing a stable Uzbek breeding base, improving the economic benefits of existing breeds through the introduction of the latest technologies in genetics, breeding and reproduction, and creating new types and breeds resistant to local climatic conditions, reducing dependence on imported breeding products.

The Jaydari (in Persian – local) sheep breed was created in Uzbekistan for several thousand years in folk breeding, is well adapted to breeding in mountainous and foothill regions of the republic and is considered one of the leading breeds in terms of the number of animal units (Fig. 1).



Figure 1. Sheep of the Jaydari breed

Source: N.R. Ruziboyev et al. (2019)

Jaydari sheep differ from other sheep breeds in that they are well adapted to environmental conditions (rainy, snowy, and wet cold) and have the potential of their high genetic potential for productivity in year-round pasture conditions. In terms of meat and fat productivity, they are inferior to the Hissar breeds. A distinctive feature of this breed of sheep is their short legs and elongated body. Most sheep are hawk-nosed, have a long head and long ears. The predominant colour is black, but brown, red, and grey sheep are also found. Live weight of ewes is approximately 75 kg, rams – 100 kg, wool yield from ewes – 2.0-3.0 kg, from rams – 3.0-4.0 kg, coarse wool, used for making coarse cloth, felt, etc.

The Hissar sheep breed is one of the leading meat and fat breeds peasant farms in Tajikistan and widely distributed in the republics of Central Asia, including Uzbekistan (especially in the Surkhandarya and Kashkadarya regions). The breed is well adapted to mountainous and foothill areas, which allows it to be kept in pasture conditions all year round due to the high digestibility of feed by lambs and the rapid growth of young animals (Fig. 2).



Figure 2. Sheep of the Hissar breed

Source: N.R. Ruziboyev et al. (2019)

Hissar rams are distinguished by their large live weight – adults weigh an average of 130-140 kg, and record specimens reach 170-188 kg. Ewes weigh about 80-85 kg, while productive animals reach 90-95 kg. The weight of the fat tail varies from 18 to 20 kg, and in some individuals reaches 30 kg or more. The live weight of rams at the age of 1.5 years is approximately 96 kg, and ewes – 49 kg. Externally, Hissar sheep are characterised by a powerful, strong physique with well-developed muscles and bones. The average height at the withers in rams reaches 87 cm, in ewes – 79 cm. The body length is 85 cm and 75 cm, respectively, and the chest depth is about 35 cm. The body is strong, with a wide back and a straight line along the top, a wide croup, and a deep chest. Due to their strong limbs and well-developed muscles, Hissar sheep are perfectly adapted for long-distance transitions between pastures. Thus, the Hissar breed is a large and productive meat and fat

breed with high adaptation to mountainous conditions and extensive pasture management, which makes it an important resource for animal husbandry in the region.

The Karakul sheep breed was created in Uzbekistan as a result of long-term folk breeding aimed at adapting animals to local climatic and economic conditions. There are several colour types in the breed, among which black, sur, and blue colours dominate (Fig. 3). Of particular importance is the sur colour, which is characterised by high quality wool and is highly valued on the market. In addition, the breed includes several regional types, such as the Karakalpak, Bukhara, and Surkhandarya, each of which is characterised by certain morphological and productive features reflecting adaptation to the conditions of specific areas.



Figure 3. Karakul sheep breed

Source: N.R. Ruziboyev et al. (2019)

The period of effective use of black sheep in economic conditions is on average 6-7 years, however, if high standards of care and feeding are observed, individuals can be exploited for up to 12 years. The biological maturity of Karakul sheep occurs at the age of approximately 1.5 years. The breeding herd was characterised by high fecundity – there were an average of 110-120 lambs for every 100 animals, which indicates the effective reproductive ability of the breed. The most productive period of black sheep is between the ages of 3 and 6 years.

Adult Karakul rams had an average live weight in the range of 60-75 kg, while the weight of ewes was 42-50 kg. Newborn lambs were characterised by a weight of 4.0-4.5 kg in females and 4.5-5.0 kg in males. Black sheep accounted for 75-80% of the livestock, blue – 13-17%, sur-coloured sheep – 5-7%, and other colours – approximately 3%, reflecting the genetic and phenotypic variability within the breed (Khatamov, 2021).

In 1976, researchers from the Scientific Research Institute of Animal Husbandry and Poultry Breeding created the Uzbek meat and wool breed group (Fig. 4). This breed group is characterised by a set of economically useful traits, among which are precocity, large body size, high frost resistance, and a uniformly high appetite and the ability to effectively digest large amounts of feed. These features ensure a high degree of conversion of feed into products, which is an important factor in the economic efficiency of animal husbandry.



Figure 4. Meat and wool sheep

Source: N.R. Ruziboyev et al. (2019)

According to the measurements, the live weight of lambs at birth averaged 4.93 kg for rams and 4.10 kg for ewe lambs. At the age of 4-4.5 months, the weight of the ram lambs reached 30.5 kg, and the ewe lambs – 28.4 kg. Adult breeding rams were characterised by a live weight in the range of 80-100 kg, while the weight of female ewes was 50-55 kg. The obtained indicators show a good potential of the breed group in terms of meat productivity while maintaining satisfactory wool quality, which is conditioned by a balanced genotype and adaptation to the climatic conditions of the region.

Breeding work on the creation of a new type of fat-tailed sheep “Akchasai”. After describing the sheep breeds existing in Uzbekistan, it should be noted that in the period from 2009 to 2024, significant scientific and practical successes in the field of sheep breeding were achieved in the republic. As part of a focused 15-year breeding work carried out by specialists from research institutions and breeding farms, new inbred types and populations of sheep have been developed, adapted to the conditions of pasture keeping in arid and mountainous regions. One of these achievements was the creation of a new type of fat-tailed sheep, “Akchasai”, characterised by improved meat and fat productivity, high viability, resistance to temperature fluctuations, and effective use of feed in conditions of extensive maintenance. Since 1991, the following significant results have been achieved in Uzbekistan in the field of agriculture and animal husbandry:

1. 13 factory types of Karakul sheep have been created at the Scientific Research Institute of Karakul Breeding and Ecological Deserts.
2. On the basis of the Akhangaran branch of the institute, an educational and experimental farm has been established, provided with pasture and rain-fed lands.
3. Artificial insemination of Uzbek semi-fine-wool meat-wool ewes using frozen ram semen imported from abroad was introduced for the first time.
4. A new type of “Fargona-Rishton-Dasht” was created and patented to increase the productivity of fat-tailed sheep.
5. In order to preserve the gene pool and increase productive qualities, Angora goats from Turkey, downy goats from Russia, and Bayad sheep from Mongolia were imported into the country in 2024.

6. Based on the crossing of local breeds with Hissar sheep and long-term breeding, a new factory type of meat-fat sheep, “Akchasai”, was bred. In 2023, a patent application was filed for the new type, and in 2024 it was officially approved by the Board of the Ministry of Justice of the Republic of Uzbekistan (No. ZAP 34 dated April 4, 2024).

The stages of creation of the Akchasai factory type. The initial stage (2009-2013). Breeding work began in 2009 with the import of Hissar rams from the Surkhandarya region. The research was conducted in the farms “Kyzyl Bour” and “Kholturaev Oybek KHM” in the Akhangaran district of the Tashkent region. Two rams were used as progenitors: No. 04207 – was characterised by early maturity and satisfactory indicators of meat and fat productivity; No. 10455 – was characterised by a high level of meat and fat productivity. The initial factory crossbreeding was carried out with local Jaydari ewes. The offspring of the first generation (F1) were repeatedly crossed with purebred Hissar rams (Rakhimov, 2023).

Development of the line (2014-2017). The offspring of the second generation (F2), obtained as a result of selection and breeding of desirable individuals, were bred “inbreed”. The development of flocks with up to $\frac{3}{4}$ Hissar blood was ensured. The main selection criteria were meat and fat characteristics, viability, and exterior features.

Completion of breeding (2018-2021). The breeding work carried out helped to stabilise the characteristics and create breeding herds of a new factory type with a high degree of consistency. Individual selection and breeding allowed consolidating inherited qualities. Further work was aimed at expanding the number of animals with pronounced genetic potential.

By 2022, the number of breeding stock of a new type of fat-tailed sheep has reached 5,100 units. Of these, 105 were breeding rams involved in the development of the next generation and the consolidation of target productive traits. In addition, there were 235 breeding rams in the herd, designed to replace producers and maintain the genetic potential of the population. The breeding stock consisted of 3,160 ewes, which ensured sustainable reproduction. A significant part was also made up of 1,600 breeding yearlings, selected for further breeding and improvement of the breeding core. These data reflect the achieved level of breeding and the scale of breeding work to create a new type of sheep (Table 1). The productivity, exterior, and reproductive properties of this new type of livestock, including viability, remain unchanged even after many years.

Table 1. Live weight of sheep of the new Akchasai type and Jaydari breeds

No.	Indicators	Akchasai type		Jaydari, kg	Difference, kg
		Average kg	Record holder, kg		
1	Breeding rams	90-120	140-180	70-90	20-30
2	Ewes	60-75	80-100	50-55	10-20
3	Breeding rams (1.5 years old) for the replacement stock	70-80	80-110	55-60	15-20
4	Breeding ewes (1.5 years old) for the replacement stock	45-60	65-75	35-45	10-15
5	5-month-old ram lambs	40-50	50-60	35-40	5-10
6	5-month-old ewe lambs	35-45	45-55	30-35	5-10
7	Ram lambs at birth	5.5-6.0	7.0-9.0	5.0-5.5	0.5
8	Ewe lambs at birth	5.0-5.5	6.0-7.0	4.5-5.0	0.5

Source: created by the authors

Based on the data presented in Table 1, it can be concluded that the new Akchasai type of sheep has a significant advantage over the Jaydari breed in terms of live weight in all sex and age

groups. This gap is especially pronounced in adult animals: the live weight of breeding rams of a new type varies between 90-120 kg, and in record holders it reaches 140-180 kg, while in Jaydari analogues it is only 70-90 kg. The difference in the average weight of breeding rams reaches 20-30 kg, which indicates significant breeding progress in increasing live weight.

A similar trend is observed among ewes, where the live weight of the new type of animals is 60-75 kg, with record values up to 100 kg, while the Jaydari breed is only 50-55 kg. The young animals also have significant advantages. For example, 1.5-year-old breeding rams had an average weight gain of 15-20 kg compared to Jaydari sheep, and 10-15 kg for ewes. There was also a positive trend in young animals at the age of 5 months. The new type of ram lambs weighs 5-10 kg more than the Jaydari ones, and the ewe lambs weigh – 5-10 kg more. Even at birth, the weight of rams and ewes of the Akchasai type was 0.5 kg higher than that of their counterparts.

Thus, it can be argued that the development and introduction of a new type of fat-tailed sheep “Akchasai” (Fig. 5) allowed obtaining more highly productive animals with not only increased live weight, but also better genetic potential. A 20-25% increase in weight compared to the base breed demonstrates the effectiveness of the breeding work carried out and the substantiation for breeding a new type in Uzbekistan.



Figure 5. Breeding rams and ewes of the Akchasai type

Source: obtained by the authors

The presented data clearly demonstrate that the new Akchasai type of fat-tailed sheep is significantly superior to the Jaydari breed in all key indicators of live weight, which is confirmed by both tabular materials and visual characteristics in the figure. Breeding measures implemented within the framework of interbreeding using the Hissar gene pool helped to obtain a highly productive type with pronounced meat and fat characteristics, good adaptation to pasture conditions, and stable reproductive ability. However, along with the results achieved, certain gaps remain in the system of selection and evaluation of breeding material, in particular, insufficient digitalisation of breeding records, limited genomic assessment of breeding value, and weak integration of local data into national databases. Using the genetic potential of the Hissar and Jaidari breeds to create highly productive lines requires further scientific development of methods to increase the heritability of productive traits, improve selection technology, and formalise breeding programmes. Thus, the results of the analysis not only confirm the prospects of the new type of sheep, but also indicate the areas of further scientific research and institutional improvements in the industry.

Discussion

The conducted research devoted to the characteristics of a new type of sheep, obtained on the basis of the Hissar and Jaydari breeds, allowed systematising information about the breeding

process, the conditions of pasture maintenance, and the productive features of the crossed livestock. However, a full scientific assessment of the results requires their comparison with similar studies conducted by other researchers in the field of genetics, animal husbandry, and sheep breeding.

A.A. Urimbetov & G.K. Amanova (2021) examined the ethological and biological features of Karakalpak sur Karakul sheep bred in the new northern territories of Karakalpakstan, considering the influence of local environmental conditions on the productivity of animals and their offspring. The researchers found that adaptation to natural and climatic factors, such as aridity and sudden temperature fluctuations, plays a key role in the development of high productive qualities and stability of the herd. These conclusions coincide with the results of the study of a new type of fat-tailed sheep “Akchasai”, which was created in conditions of extreme pasture ecosystems. In both cases, the importance of behavioural adaptation and resilience as an important selection criterion is emphasised. However, unlike the Karakul breed, where the main focus was on fur quality and survival, the Akchasai study shifted its focus to meat and fat productivity and reproduction, reflecting differences in breeding priorities due to economic tasks.

R.U. Turgunbaev & Y.F. Sultanov (2021) investigated the growth rates of fat-tailed sheep of various breeds, including Jaydari and Hissar, in Karakalpakstan. Significant fluctuations in the live weight gain of lambs were revealed depending on age, feeding level, and external factors. Special attention was paid to the lambs of the Hissar breed, which demonstrated the highest rates of both absolute and average daily growth. The data obtained confirmed the high productivity of the Hissar breed with extensive maintenance on pastures. These conclusions are consistent with the results of the present study, where selection based on growth rates and meat productivity played a key role in the development of a new breeding type, emphasising the importance of monitoring gains at early stages and adapting feeding to the genetic potential.

The study by Sh.T. Rakhimov (2023) analysed the growth rates of fat-tailed sheep, including the Jaydari and Hissar breeds and their hybrids, raised in Karakalpakstan. It was noted that against the background of a decrease in global demand for wool, interest in the meat and milk sector is increasing, which increases the importance of breeds with intensive and stable growth. The analysis of the average daily and absolute increments confirmed the advantage of the Hissar breed lambs. The results are similar to the conclusions of R.U. Turgunbaev & Y.F. Sultanov (2021), however, this study emphasised the large variability of growth depending on feeding, which indicates the importance of technological conditions along with genetics in breeding new types of sheep.

The study by S. Robinson (2020) on livestock production in Central Asia highlighted the impact of sector fragmentation, winter feed shortages, and limited access to pastures on production efficiency, especially in Uzbekistan. These conclusions are confirmed by the data on the creation of a new type of sheep “Akchasai”, the breeding of which was aimed at improving adaptive and productive qualities in conditions of limited feed resources. The need to move from extensive to more organised and sustainable animal husbandry, noted by S. Robinson, is consistent with the objectives of this study, where the emphasis is on genetic stability, early maturity and high meat productivity, increasing economic efficiency with a lack of external support.

The results presented by B.Y. Ataybekov et al. (2024) confirmed the high meat productivity of the Hissar breed in southeastern Kazakhstan, where a slaughter weight of 17.5 kg and a carcass yield of 78.3% were recorded during the slaughter of 4-month-old lambs. These data emphasise the

breeding value of the Hissar breed and strengthen the scientific substantiation for its use as a parent breed in the development of a new sheep breeding type “Akchasai”. Thus, the indicators serve as an empirical confirmation of the productive advantages of the Hissar breed and are consistent with the purpose of the study.

The study by K.T. Basitov et al. (2024) applied objective statistical methods, including analysis of variance, to assess the heritability of key productive traits of meat breeds of sheep, such as body weight and wool yield. The results obtained confirmed the significant genotypic conditionality of these traits, which is consistent with the methodological approach of this study. Despite the fact that the paper mainly deals with Merino breeds, the proposed approach to the analysis of the heritability and breeding value of traits is universal and can be applied to the breeds of the Hissar group and the new type of fat-tailed sheep “Akchasai”. In addition, the geographical region of the study, the south-east of Kazakhstan, has similar climatic and pasture conditions with the regions of Central Asia, which increases the relevance and practical significance of these results for the studied sheep population.

Thus, a comparison of the data obtained with the results of similar studies helped to objectively assess the breeding significance of the new type of Akchasai sheep in comparison with the original breeds. The high productive potential and adaptive qualities inherited from the Hissar and Jaydari breeds have been confirmed, which ensures the prospects for further breeding of a new type in the conditions of pastoral animal husbandry in Central Asia.

Conclusions

The purpose of the study was to create a new type of fat-tailed sheep of meat and fat production, combining the best qualities of the Hissar and Jaydari breeds. As part of the work, methods of in-breed selection, crossbreeding, evaluation of productive indicators, and analysis of the adaptive abilities of animals in conditions of pasture keeping in Uzbekistan were used. The parameters of growth, reproduction, meat productivity, and adaptation were studied, which allowed a reasonable approach to breeding a new type of sheep.

As a result of many years of breeding work, a new highly productive type of fat-tailed sheep, Akchasai, has been created, characterised by high growth rates, good meat and fat productivity and resistance to extreme climatic conditions. As part of the breeding, special attention was paid to preserving desirable genetic traits, accelerating ontogenesis, and increasing the reproduction rate. The materials submitted to the Agency of Intellectual Property attest to the completion of the primary breeding stage and the readiness to consolidate the new type as an innovative genetic resource. The development of an electronic breeding data accounting system and proven selection and selection methods ensure the sustainable development of a new trend in sheep breeding.

The results obtained confirm the achievement of all the tasks set and the validity of the chosen breeding strategy. Breeding a new type of sheep opens up prospects for increasing the productivity of the industry, reducing dependence on imported genetic material, and improving the food security of the region. In the future, an in-depth study of the biological features of Akchasai at the interregional level is required, including monitoring the sustainability of productive traits in the next generations, which will provide a reliable scientific and practical basis for the expanded introduction of a new type in Uzbek farms.

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