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Acclimatization influence on the formation of the maral, *Cervus elaphus Linnaeus*, 1758 parasites fauna in the Northern Tien Shan, Kazakhstan

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ABSTRACT

Analysis of the literature and own research have shown that 53 species of parasites are parasitized in marals living in Kazakhstan: 6 species of protozoa, 3 trematodes, 5 cestodes, 36 nematodes and 3 ectoparasites; in Altai marals 50 species including 6 protozoa, 3 trematodes, 5 cestodes, 34 nematodes and 3 ectoparasites; in Alatau marals 15 species including 4 protozoa, 2 trematodes, 2 cestodes, 6 nematodes and 3 ectoparasites; in North Tien Shan marals 7 species including 1 trematode, 1 cestode, and 5 nematodes. During acclimatization, marals lost 25 species of helminths (*Acanthospiculum cervipedis*, *A. flexuosa*, *Ashworthius sidemi*, *A. gagarini*, *Bicaulus sagittatus*, *B. tuvae*, *Dictyocaulus eckarti*, *Elaphostrongylus cervi*, *Nematodirus oiratianus*, *Oesophagostomum radiatum*, *Ostertagia gruhneri*, *O. ostertagi*, *O. antipini*, *Ostertagiella circumcincta*, *Schulzinema miroljubovi*, *Skrjabinema ovis*, *Chavertia ovina*, *Spiculopteragia schulzi*, *S. spiculoptera*, *Trichocephalus capreoli*, *T. ovis*, *Trichostrongylus axei*, *T. colubriformis*, *Spiculopteragia asymmetrica* and *Strongyloides papillosus*) and acquired 2 species of helminths (*Bunostomum phlebotomum* and *Haemonchus contortus*). Common to all marals are 3 species of protozoa (*Eimeria cervi*, E. *gallivalerioi* and *E. robusta*), 4 species of helminths (*Paramphistomum cervi*, *Capillaria bovis*, *Nematodirus spathiger* and *Trichocephalus skrjabini*) and 3 species of ectoparasites (*Lipoptena cervi*, *Hypoderma diana* and *Booponus borealis*). Five species of helminths are common to marals of Altai and Northern-Tien Shan. Acclimatizers can be involved in the circulation of these helminths. Since they are familiar with these parasites at native land and in a new habitat.

Keywords: Maral, Eimeria, Trematode, Cestode, Nematode, Ectoparasites

INTRODUCTION

In accordance with the research work "Development of the Northern Tien Shan fauna inventory to preserve its genetic diversity", information on the fauna of the studied region is provided. Wild ungulates of the Northern Tien Shan include: wild boar (*Sus scrofa nigripes*), Siberian roe deer (*Capreolus pygargus tianschanicus*), Siberian mountain goat (*Capra sibirica alaiana*), maral (*Cervus elaphus sibiricus*), argali (*Ovis ammon polli*), sheep (*Ovis aries*), goat (*Capra hircus*), cattle (*Bos taurus*), horse (*Equus caballus*), camel (*Camelus bactrianus* and *Camelus dromedarius*; McCarthy *et al.* 2010).

There are two types of marals: Altai maral living in western Siberia and Altai and the Tien Shan maral living in the Tien Shan mountains in Kazakhstan and Kyrgyzstan. Both species are still found in the wild, but most of them have been bred for many years in special maral farms. Maral breeding is most widely spread in Altai. In addition, the optimal height above sea level of these places and the large reserves of forage just suitable for maral have

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become fundamental factors for the creation of maral breeding farms here. In the Almaty region, work on the acclimatization of the Altai maral began in 2000. The first 60 marals were brought to the Kaskelen Gorge from the Katon-Karagay district of the East Kazakhstan region in 2001. Adult males (N = 30), females (N = 30) were imported. The second batch was imported in 2002 in the amount of 40 animals. This batch included 20 young male and 20 female marals. From 2001 to 2011, the number of Altai marals in the maral breeding farm "Alatau marals" tripled and increased to 240 individuals and the average annual increase in the herd was 48.7%.

The average values of the resulting offspring over the years ranged from 30 to 35%, which is inferior to those of some Altai maral breeding farms, where this figure reaches 90%. However, on some farms this figure is 8-12%. It can be considered that, in general, the adaptation of Altai marals in the conditions of the Kaskelen Gorge can be assessed as positive (Belenkaya *et al.* 2020).

Here, male and female marals have been fed since November. At this time, they were given 5-7 kg of hay per animal per day (alfalfa from Bakanas, Balkhash district of Almaty region), silage 4 kg and barley 0.5 kg. Since the beginning of April, silage and mixed fodder have been somewhat reduced, but the feeding with combined fodder has increased to 1.5 kg.

Here, on the territory of about 300 hectares, except for marals, other animals do not graze. However, during the feeding period, feed is brought in from other areas. One of the serious reasons hindering the development of maral breeding and negatively affecting their number is a group of diseases caused by parasites. Parasitosis not only reduces the productivity of marals, but often causes animals waste. As a result of the wide spread of parasitosis, it loses up to 400 kg of antlers. A very tangible "pressure of parasites" on the population of marals is observed in natural conditions. It can be expressed in the clinical manifestation of the disease, the waste of animals, the loss of their weight, fatness, and trophy qualities. Parasites, as well as other biological factors (predators, fodder capacity of land, etc.), are involved in the regulation of the number of marals. By the acclimatization of marals, it is possible that their parasite fauna will change. In all likelihood, they will acquire new species, and some of their existing ones may be lost.

According to E.I. Pryadko (Pryadko 1976), 89 species of helminths are known in marals in the world: trematodes include *Fasciola hepatica, Fascioloides magna, Parafasciolopsis fasciolaemorpha; Dicrocoelium lanceatum, Paramphistomum microbothrium, Paramphistomum* sp. and *Fischoederius skrjabini*; cestodes include *Moniezia expansa, M. benedeni; Thysanosoma actiniodes, Thysanieziz giardi; Taenia cervi* larvae; *T. hydatigena*, larvae; *T. krabbei* larvae; *T. parenchimatosa* larvae; *Taeniarhynchus saginatus* larvae and *Echinococcus granulosus* larvae; nematodes include *Capillaria bovis, Trichocephalus alcocki, T. gazellae, T. ovis, T. skrjabini, Pygarginema skrjabini, Parabronema skrjabini, Thelazia rhodesi, Gongylonema pulchrum, Wehrdikmansia flexuosa, W. cervipedis, W. jakutensis, Alcefilaria abramovi, Elaeophora schneideri, Cutifilaria wenki, Onchocerca skrjabini, Parafilaria antipini, Setaria cervi, S. labiato-papillosa, Strongyloides papillosus, Chabertia ovina, Bunostomum trigonocephalum, B. phlebotomum, Oesophagostomum radiatum, O. sikae, O. venulosum, O. cervi, O. indicum, O. columbianum, Schulzinema miroljubovi, Metastrongylus elongatus, Protostrongylus rufescens, Muellerium capillaris, Cystocaulus* sp., *Orthostrongylus macrotis, Verestrongylus sagittatus, V. tuvae, Elaphostrongylus cervi, Parelaphostrongylus tenius, Trichostrongylus askivali, T. axei, T. colubriformis, T. capricola, T. ostertagiaformis, T. vitrinus, T. ventricosus, Ostertagia ostertagi, O. gruhneri, O. antipini, O. leptospicularis, Marshallagia marshalli, Teladorsagia trifurcata, T. circumcincta, Skrjabinagia kolchida, S. arctica, S. lyrata, Apteragia quadrispiculata, Spiculopteragia spiculoptera, S. asymmetrrica, S. schulzi, Rinadia quadrifurcata, R. mathevossiani, Cooperia curticei, C. pectinata, Haemonchus contortus, Ashworthius sidemi, A. gagarini, Nematodirus filicollis, N. oiratianus, N. roscidus, N. spathiger, Nematodirella longissimespiculata, Dictyocaulus filaria, D. viviparus, D. eckerti* and *Skrjabinema ovis*.

On the territory of Kazakhstan, 18 species of helminths are registered (Pryadko 1976): *Dicrocoelium lanceatum, Moniezia expansa, M. benedeni, Taenia hydatigena* larvae, *Capillaria bovis, Trichocephalus alcocki, T. skrjabini, Wehrdikmansia flexuosa, Setaria cervi, Chabertia ovina, Oesophagostomum radiatum, O. venulosum, Verestrongylus sagittatus, Elaphostrongylus cervi, Trichostrongylus axei, Spiculopteragia spiculoptera, S. schulzi* and *Dictyocaulus eckerti.*

According to S.N. Boev (Sokolova *et al*. 1953), I.B. Sokolov (Lubimov 1945) and M.P. Lubimov (Lubimov 1945), the helminth fauna of the maral from the Northern Tien Shan is represented by 8 species: *Dicrocoelium lanceatum, Moniezia benedeni, Dictyocaulus eckerti, Elaphostrongylus panticola, Oesophagostomun venulosum, Parabronema skrjabini* and *Setaria altaica* (Table 1).

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The helminth fauna of the Altai marals in the places of their breeding in the Katon-Karagay district of the East Kazakhstan region was studied in 1950 by M.P. Lubimov (Lubimov 1950). He published 26 species of helminths in maral: *Dicrocoelium lanceatun* Stiles et Hassall 1896; *Echinococcus granulosus* (Batsch 1786) larvae; *Moniezia benedeni* (Moniez, 1879) Blanchard, 1891; *Taenia hydatigena* (Pallas 1776) larvae; *Acanthospiculum cervipedis* (Wehr et Dickmans 1935); *A. flexuosa* (Wedl 1856); *Ashworthius sidemi* Schulz 1933; *Bicaulus sagittatus* (Mueller 1891) Boev 1952; *Capillaria bovis* (Schnyder 1906) Ransom 1911; *Dictyocaulus eckarti* Skrjabin 1931; *Elaphostrongylus panticola* Lubimov 1945; *Elaphostrongylus cervi* Cameron 1931; *Nematodirus oiratianus* Rajevskaja 1929; *N. spathiger* (Railliet 1896) Railliet et Henry 1909; *Oesophagostomum radiatum* (Rudolphi 1803) Railliet 1898; *O. venulosum* (Rudolphi 1809) Railliet et Henry 1913; *Ostertagia gruhneri* Skrjabin 1929; *Ostertagiella circumcincta* (Stadelmann 1894) Andreeva 1957; Parabronema skrjabini Rassowska 1924; *Schulzinema miroljubovi* Krastin 1937; *Setaria altaica* Rajevskaja 1928; *Spiculopteragia asymmetrica* (Ware 1925) Andreeva 1957; *S. spiculoptera* (Guschanskaja 1931) Orloff 1933; *Trichocephalus skrjabini* (Baskakov 1924); *Trichostrongylus axei* (Cobbold 1879) Railliet et Henry 1909; and *T. colubriformis* (Giles 1892; Table 1).

S.T. Dyusembayev (Dyusembayev 1991) after 40 years conducted research on marals in this area and confirmed the presence of 25 parasites, out of the above 26 parasites. He did not find *Elaphostrongylus panticola* Lubimov, 1945. In addition, he added 13 more species to the helminth fauna of marals: *Paramphistomatidae* gen.sp., *Multiceps multiceps*, larvae (Leske 1780), *Moniezia expansa* (Rudolphi 1810) Blanchard 1891, *Ostertagia ostertagi* (Stiles 1892) Ransom 1907, *O. antipini* Matschulski 1950, *Spiculopteragia schulzi* (Rajevskaja 1930) Orloff 1933, *Ashwortius gagarini* Kostjaew 1969, *Nematodirella longissimespiculata* (Romanowitsch 1915) Skrjabin et Schikhobalova 1952, *Chavertia ovina* (Fabricius 1788), Railliet et Henry 1909, *Dictyocaulus filaria* (Rudolphi 1809) Railliet et Henry 1907, *Bicaulus tuvae* (Boev et Sulimov 1963) Boev 1968, *Skrjabinema ovis* (Skrjabin 1915) Werestschagin 1926, *Trichocephalus capreoli* Artjuch 1948, *T. ovis* Abildgaard 1795, *Strongyloides papillosus* (Wedl 1856).

The eimeriofauna of the Altai marals in the places of their breeding in the Katon-Karagay district of the East Kazakhstan region was studied in 1979 by S.K. Svanbayev (Svanbayev *et al.* 1976). For the first time, he discovered 3 species of *Eimeria* in marals: *Eimeria cervi* Galli-Valerio 1927; *E. gallivalerioi* Rastegaieff 1930; and *E. robusta* Supperer et Kutzer 1961 (Table 1).

S.T. Dyusembayev (Dyusembayev 1991) identified 5 species of Eimeria in Altai marals, of which 3 species were discovered by S.K. Svanbayev and 2 new species: *Eimeria catoni* Dyusembayev 1991 and *E. uscameni* Dyusembayev 1991.

Table 1. List of parasites recorded in marals in breeding and acclimatization areas.

№	Parasites	Altai marals	Alatau marals	North Tien Shan marals
1	*Eimeria cervi* Galli-Valerio 1927	6,7	8, 9,+	-
2	*E.gallivalerioi* Rastegaieff 1930	6,7	8, 9,+	-
3	*E.robusta* Supperer et Kutzer 1961	6,7	8, 9,+	-
4	*Eimeria catoni* Dyusembayev 1991	6	-	-
5	*E.uscameni* Dyusembayev 1991	6	-	-
6	*Sarcocystis grueneri* Yakimov et Sokolov 1934	11	+	-
7	*Fasciola hepatica* Linnaeus 1758	-	+	-
8	*Dicrocoelium lanceatun* Stiles et Hassall 1896	5,6	-	2,3,4
9	*Paramphistomum cervi* (Zeder 1901)	6	+	-
10	*Echinococcus granulosus* (Batsch 1786) larvae	5,6	-	-
11	*Moniezia expansa* (Rudolphi 1810) Blanchard 1891	6	8,9	-

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12	*Moniezia benedeni* (Moniez 1879) Blanchard 1891	5,6	8,9,+	2,3,4
13	*Taenia hydatigena* (Pallas 1776) larvae	5,6	-	-
14	*Multiceps multiceps*, larvae (Leske 1780)	6	-	-
15	*Acanthospiculum cervipedis* (Wehr et Dickmans 1935)	5,6	-	-
16	*A.flexuosa* (Wedl 1856)	5,6	-	-
17	*Ashworthius sidemi* Schulz 1933	5,6	-	-
18	*Ashworthius gagarini* Kostjaew 1969	6	-	-
19	*Bicaulus sagittatus* (Mueller 1891) Boev 1952	5,6	-	-
20	*Bicaulus tuvae* (Boev et Sulimov 1963) Boev 1968	6	-	-
21	*Capillaria bovis* (Schnyder 1906) Ransom 1911	5,6	8,9	-
22	*Dictyocaulus eckarti* Skrjabin 1931	5,6	-	2,3,4
23	*Dictyocaulus filaria* (Rudolphi 1809) Railliet et Henry 1907	6	-	-
24	*Elaphostrongylus panticola* Lubimov 1945	5	-	2,3,4
25	*Elaphostrongylus cervi* Cameron 1931	5,6	-	-
26	*Nematodirus oiratianus* Rajevskaja 1929	5,6	-	-
27	*N.spathiger* (Railliet 1896) Railliet et Henry 1909	5,6	8,9,+	-
28	*Nematodirella longissimespiculata* (Romanowitsch 1915) Skrjabin et Schikhobalova 1952	6	-	-
29	*Oesophagostomum radiatum* (Rudolphi 1803) Railliet 1898	5,6	-	-
30	*O. venulosum* (Rudolphi 1809) Railliet et Henry 1913	5,6	8,9	2,3,4
31	*Ostertagia gruhneri* Skrjabin 1929	5,6	-	-
32	*O. ostertagi* (Stiles 1892) Ransom 1907	6	-	-
33	*O. antipini* Matschulski 1950	6	-	-
34	*Ostertagiella circumcincta* (Stadelmann 1894) Andreeva 1957	5,6	-	-
35	*Parabronema skrjabini* Rassowska 1924	5,6	-	2,3,4
36	*Schulzinema miroljubovi* Krastin 1937	5,6	-	-
37	*Skrjabinema ovis* (Skrjabin 1915) Werestschagin 1926	6	-	-
38	*Chavertia ovina* (Fabricius 1788) Railliet et Henry 1909	6	-	-
39	*Setaria altaica* Rajevskaja 1928	5,6	-	2,3,4
40	*Spiculopteragia asymmetrica* (Ware 1925) Andreeva 1957	5,6	-	-
41	*S. schulzi* (Rajevskaja 1930) Orloff 1933	6	-	-
42	*S.spiculoptera* (Guschanskaja 1931) Orloff 1933	5,6	-	-
43	*Trichocephalus skrjabini* (Baskakov 1924)	5,6	8, 9,+	-
44	*T. capreoli* Artjuch 1948	6	-	-
45	*T. ovis* Abilgaard 1795	6	-	-
46	*Trichostrongylus axei* (Cobbold 1879) Railliet et Henry 1909	5,6	-	-
47	*T.colubriformis* (Giles 1892)	5,6	-	-

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48	*Bunostomum phlebotomum* (Railliet 1900)	-	8,9	-
49	*Haemonchus contortus* (Rudolphi 1803) Cobbold 1898	-	8,9,+	-
50	*Strongyloides papillosus* (Wedl 1856)	6	-	-
51	*Lipoptena cervi* Linnaeus 1758	10	8,9	-
52	*Hypoderma diana* Brauer 1897	10	8,9	-
53	*Booponus borealis* Rohdendorf 1959	10	8,9	-
	Total:	50	15	7

The parasitofauna of the Alatau marals in the places of their acclimatization in the Kaskelen Gorge of the Almaty region was studied in 2015 by employees of the Kazakh Research Veterinary Institute, the Kazakh National Agrarian University and the University of Zurich (Abdybekova *et al.* 2017; Zhaxylykova *et al.* 2015). They found 3 species of *Eimeria* in the maral: *Eimeria cervi, E.gallivalerioi* and *E. robusta* (Table 1), 6 species of nematodes: *Bunostomum phlebotomum, Capillaria bovis, Nematodirus spathiger, Haemonchus contortus, Oesophagostomum venulosum* and *Trichocephalus skrjabini*, 2 species of cestodes: *Moniezia expansa* and *Moniezia beneden*, deer bloodsucker: *Lipoptena cervi*, subcutaneous gadfly: *Hypoderma diana* and antler fly: *Booponus borealis.*

P.N. Merlich (Merlich 2012) identified deer bloodsucker, subcutaneous gadfly and antler fly in Altai maral and carried out measures to combat them.

N.G. Levchenko (Levchenko 1964) in 1964 found *Sarcocystis grueneri* Yakimov et Sokolov 1934 in the muscles of the Altai marals. Later, A.P. Polomoshnov (Polomoshnov *et al.* 1984) 20 years later found the same sarcosporium of marals.

The territory of the maral-breeding farm "Alatau Marals" used to be a place for summer grazing of animals from the farms of the Karasai and Zhambyl districts of the Almaty region. In 1939 Academician S.N. Boev (Boev, 1939), studied the helminths of sheep grazing in these places. He discovered 49 species of helminths: 7 species of trematodes including *Fasciola hepatica* Linnaeus 1758; *F. gigantica* (Coobbold 1855); *Dicrocoelium lanceatum* Stiles et Hassall, 1896; *Eurytrema pancreaticum* (Janson 1889); *E. coelomaticum* (Giard et Billet 1892); *Hasstilesia ovis* (Orloff, Erschoff et Badanin 1934) Gvosdev et Soboleva 1983; and *Ornithobilharzia turkestanica* (Skrjabin 1913); 8 species of cestodes including *Taenia hydatigena* larvae (Pallas 1766); *Multiceps multiceps*, larvae (Leske 1780); *M. skrjabini*, larvae Popov 1937; *Echinococcus granulosus* larvae (Batsch 1786); *Moniezia expansa* (Rudolphi 1810) Blanchard 1891; *M. alba* (Peroncito 1879); *M. benedeni* (Moniez 1879) Blanchard 1891 and *Thysaniezia giardi* (Moniez 1879) and 34 species of nematodes including *Parabronema skrjabini* Rassowska 1924; *Gongylonema pulchrum* Molin 1857; *G. verrucosum* (Giles 1892); *Filaria* sp. Mueller 1787; *Setaria labiato-papillosa* (Alessandrini 1838); *Skrjabinema ovis* (Skrjabin 1915) Werestschagin 1926; *Ascaris* sp. Linnaeus 1758; *Chabertia ovina* (Fabricius 1788); *Bunostomum trigonocephalum* (Rudolphi 1802); *Oesophagastomum columbianum* (Curtice 1890) Stossich 1899; *O. venulosum* (Rudolphi 1809); *Trichostrongylus axei* (Cobbold 1879) Railliet et Hernry 1909; *T. colubriformis* (Giles 1822) Ransom 1911; *T. probolurus* (Railliet, 1896) Looss, 1905; *Ostertagiella occidentalis* (Ransom, 1907) Andreeva 1957; *O. circumcincta* (Stadelmann 1894) Andreeva 1957; *O. trifurcata* (Ransom 1907) Andreeva 1957; *Marshallagia marshalli* (Ransom 1907) Orloff 1933; *Haemonchus contortus* (Rudolphi 1803) Coobbold 1898; *H. longistipes* Railliet et Henry 1909; *Nematodirus filicollis* (Rudolphi 1802) Ransom 1907; *N. oiratianus* Rajewskaja 1929; *N. spathiger* (Railliet 1896) Railliet et Henry 1909; *Nematodirella longissimespiculata* (Rajewskaja et Badanin 1933) Skrjabin et Schikhobalova 1952; *Dictyocaulus filaria* (Rudolphi 1809) Railliet et Henry 1907; *Protostrongylus hobmaieri* (Schulz, Orlow et Kutass 1933) Cameron 1934; *P. skrjabini* (Boev 1936) Dikmans, 1945; *P. raillieti* (Schulz Orlow et Kutass 1933) Cameron 1934; *Muellerius capillaris* (Mueller 1889) Cameron 1927; *Cystocaulus ocreatus* (Railliet et Henry 1907) Mikacic 1939; *Bicaulus schulzi* (Boev et Wolf 1938) Schulz et Boev 1940; *Strongyloides papillosus* (Wedl 1856); *Trichocephalus ovis* Abildgaard 1795; and *T. skrjabini* (Baskakow 1924).

The aim of this research is to study the fauna of protozoa and helminths of marals living on the territory of the maral breeding farm "Alatau marals" in the Almaty region. To achieve this goal, the following tasks were set: to establish the species composition of the fauna of protozoa and helminths of marals living in this farm.

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MATERIALS AND METHODS

The collection of material was carried out in 2022 from 19 marals in the maral breeding farm "Alatau marals" in the Almaty region. The material was collected by the method of complete and incomplete helminthological autopsies and intravital studies (Fülleborn and Berkinbay methods).

The matrices obtained by complete helminthological dissection were placed into cotton bags, labeled and preserved in a common jar with Barbagallo liquid.

Live parasitological studies of sheep were carried out according to the method of O. Berkinbay (Berkinbay, 2018). Fecal samples (3 g) were taken from the same animals. Feces were placed in paper bags and processed on site or placed in penicillin vials and preserved with 2.5% potassium dichromate solution for further processing in the university laboratory. The feces were carefully ground in a porcelain cup with 15-20 mL water. The suspension was filtered through a metal sieve and centrifuged for 5 minutes at 1000-1500 rpm. Then the upper liquid layer was poured off, and solutions of zinc chloride with a specific gravity of 1.598 were added to the precipitate. The precipitate was thoroughly mixed and again centrifuged for 1 minute at 1000 rpm. Then, the upper film was removed from the liquid with a wire loop, applied to a glass slide, drops of distilled water were added, covered with a coverslip, and examined by microscope.

The species affiliation of Eimeria was established on the basis of morphological features of oocysts (shape, size, color, thickness and structure of the shell, the presence of micropyle, polar cap, residual body and refractive bodies), sporocysts (shape, size, presence of residual body and stem bodies), sporozoites (shape, size, presence of refractive bodies) and time of oocyst sporulation. At the same time, the data of L.P. Pellerdy (Pellerdy, 1947) were also taken into account.

When determining helminth eggs, the shape, size, color, thickness and structure of the shells were taken into account; the presence of caps on one of the poles, miracidia or eggs with a yolk gland, a tubercle or spike, filaments in trematodes; pear-shaped apparatus with an oncosphere in cestodes; plugs at the poles, crushing balls or larvae in the center of nematodes.

The intensity of infection was determined by counting the number of oocysts of Eimeria and helminth eggs in 20 fields of view of the microscope.

A study on sarcocysts in sheep was performed by muscle biopsy using a Popov needle. The sampling site was preliminarily treated with tincture of iodine, then pieces of the femoral muscles were taken with a needle, placed between two glass slides or in a compressor, crushed and examined by microscope. In total, 1270 sheep were studied by the abovementioned method.

For histological examination of sarcocysts during a complete helminthological dissection of the animals, muscle samples were taken from the thigh, diaphragm and heart. Muscles were fixed in 10% formalin solution. Further processing of the material consisted of passing it through alcohols of increasing strength and preparing paraffin blocks. Sections 4–6 μm thick were prepared on a sledge microtome, stained with hematoxylin-eosin, and examined under a light microscope. The area of each section was 0.5-0.7 cm². The intensity of infection was determined by the number of sarcocysts in one section.

Collected cestodes and trematodes were fixed in 70^0-alcohol, nematodes and acanthocephalus were fixed in Barbagallo liquid. During subsequent processing, total preparations were prepared from trematodes and cestodes. For this purpose, flatworms were stained with alum carmine and dehydrated by passing through alcohols of increasing strength from 50^0 to absolute according to generally accepted methods. Then the cestodes and trematodes were clarified in hydrochloric alcohol or a mixture of dimethyl phthalate with 96^0 alcohol, after which they were placed in Canadian balsam.

Nematodes and acanthocephalans were studied on temporary total preparations in the transmitted light mode of a BIOLAR polarization-interference microscope at a magnification of 120-140 times. For their enlightenment, a mixture of 10-50% glycerol or lactic acid and distilled water in equal proportions was used. In this mixture, helminths were kept from several hours to three days. Male nematodes were identified to species, while females to genus.

The species belonging of helminths was established by morphological features using identification tables with the correctness check for the diagnosis of suborders and families, then according to the table of genera, for which monographs were used (Boev *et al.* 1962; Boev *et al.* 1963).

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RESULTS AND DISCUSSION

In the Kaskelen Gorge of the Almaty region, work on the acclimatization of the Altai maral began in 2000. A total of 100 marals were brought from the Katon-Karagay district of the East Kazakhstan region. From 2001 to 2011, the number of Altai marals in the maral breeding farm "Alatau Marals" tripled and increased to 240 individuals and the average annual increase in the herd was 48.7%. The territory of the maral breeding farm "Alatau marals" used to be a place for summer grazing of animals from the farms of the Karasai and Zhambyl districts of the Almaty region. Below is a list of parasites compiled according to our own and literature data (Table 1).

Table 1 shows that "Alatau marals" appeared in a new biocenosis for them when sheep and goats were already grazing there, in which protozoa, trematodes, cestodes, and nematodes were registered, i.e., a certain focus of a number of parasites already existed. Now it is important to trace the origin of the parasites mentioned in this list.

Previously, 5 species of *Eimeria* were registered in Altai deer: *Eimeria cervi, E. gallivalerioi, E. robusta, E. catoni, E. uscameni*. Of these, we found 3 species of *Eimeria* in Alatau deer including *Eimeria cervi, E. gallivalerioi, E. robusta*. Eimeria have strict host specificity, i.e., animals can only become infected with specific types of *Eimeria*. This is evidenced by the results of experiments conducted by domestic scientists (Tsygankov *et al.* 1963).

According to their data, the oocysts of each species of sheep *Eimeria* are morphologically similar to the corresponding oocysts of coccidia of goats, saigas, argali, Central Asian goats, roe deer, and goitered gazelles. However, despite the complete morphological identity of oocysts, they differ physiologically: some are capable of developing only in sheep, others in goats, and others in saigas. Consequently, the source of invasion for Alatau deer could only be Altai deer, and the transmission factors were grass and water contaminated with *Eimeria* oocysts. Altai deer brought *Eimeria* with them and spread them here. We did not find the species of Eimeria identified by S.T. Dyusembayev in Altai deer: *Eimeria catoni* and *E. uscameni*.

Earlier 5 species of Eimeria were registered in Altai marals: *Eimeria cervi, E. gallivalerioi, E. robusta, E. catoni, E. uscameni*. Of these, we found 3 species of Eimeria in Alatau marals: *Eimeria cervi, E. gallivalerioi, E. robusta*. *Eimeria* have strict host specificity, i.e., animals can become infected only with certain species of *Eimeria*. This is evidenced by the results of experiments conducted by domestic scientists (Tsygankov *et al.* 1963). According to their data, the oocysts of each species of sheep Eimeria are morphologically similar to the corresponding oocysts of coccidia of goats, saigas, argali, Central Asian goats, roe deer, goitered gazelles. However, with complete morphological identity of oocysts, they differ physiologically: some are able to develop only in sheep, the second in goats, and the third in saigas. Consequently, only Altai marals could be the source of invasion for the Alatau marals, and the transmission factors could be grass and water contaminated with Eimeria oocysts. Altai marals brought Eimeria with themseves and distributed here. Eimeria species identified by S.T. Dyusembayev in the Altai marals including *Eimeria catoni* and *E. uscameni* were not find in the Alatau marals.

In the Alatau marals, we recorded *Sarcocystis grueneri* for the first time (Levchenko 1964; Polomoshnov *et al.* 1984). This is a two-host parasite: the intermediate host is the maral, the definitive host is the dog, fox, corsac. The parasite has strict host specificity. So, gametogony and sporogony occur only in the body of predators from the canine family, and schizogony in the body of a maral. How did the foci of sarcocystosis of marals form? Altai marals brought with them sarcocysts in their bodies. The fallen marals and the organs of the shot marals were left to nature. Dogs, wolves and corsacs ate dead animals and their organs, hence became infected with sarcocysts and cysts developed in their bodies. Consequently, the main source of invasion for the Alatau marals are priotary dogs, wolves, corsacs living in this biocenosis, excreting sporulated sporocysts and oocysts of sarcosporidia with feces.

In the Altai and North Tien Shan marals (Lubimov 1945; Lubimov 1950; Dyusembayev 1991), 1 species of dicrocelia, *Dicrocoelium lanceatum* was found, while in the Alatau marals it was not found. Sheep grazing earlier in these places were recorded *Dicrocoelium*. Alatau marals in the future may become infected with this invasion. The source of invasion for Alatau marals could be sheep, reservoirs or transmission factors. Intermediate hosts include terrestrial mollusks *Ponadenia semenovi, Bradybena phaeozona, Bradybena plectotropic, Angiomphalia regeliana, Pseudotrichia rubiginosa* and ants of the genus *Formica* that live in this biocenosis.

According to the literature (Svanbayev *et al.* 1979; Zhaxylykova *et al.* 2015; Abdybekova *et al.* 2017) and our own data, there are 10 species of parasites found in Altai and Alatau marals: 3 species of Eimeria (*Eimeria cervi, E. gallivalerioi* and *E. robusta*), 4 species of helminths (*Paramphistomum cervi, Capillaria bovis, Nematodirus spathiger* and *Trichocephalus skrjabini*), 3 species of ectoparasites (*Lipoptena cervi, Hypoderma diana* and *Booponus borealis*).

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In Altai marals *Echinococcus granulosus* larvae; *Multiceps multiceps* larvae and *Taenia hydatigena* larvae were found (Lubimov 1950), but they are not recorded in Alatau marals. Echinococci, coenurs and taenias of sheep grazing earlier in these places were recorded. Alatau marals in the future may become infected with this invasion. The source of invasion for the Alatau marals could be predatory dogs, wolves and foxes, excreting cestode eggs with faeces.

In marals, anoplocephalids are represented by 2 species, *Moniezia expansa* and *M. benedeni* (Zhaxylykova *et al.* 2015; Abdybekova *et al.* 2017). Altai marals brought it with themselves. In addition, there was previously a focus of this invasion. The sources of invasion for marals are the marals themselves, the transmission factors are soil mites of the superfamily *Cribatoidea.*

Altai marals have *Acanthospiculum cervipedis, A. flexuosa, Ashworthius sidemi, A. gagarini, Bicaulus sagittatus, B. tuvae, Dictyocaulus eckarti, Elaphostrongylus cervi, Nematodirus oiratianus, Oesophagostomum radiatum, Ostertagia gruhneri, O. ostertagi, O. antipini, Ostertagiella circumcincta, Schulzinema miroljubovi, Skrjabinema ovis, Chavertia ovina, Spiculopteragia schulzi, S. spiculoptera, Trichocephalus capreoli, T. ovis, Trichostrongylus axei, T. colubriformis, Spiculopteragia asymmetrica, Strongyloides papillosus* (Lubimov 1950; Dyusembayev 1991), while in the North Tien Shan and Alatau marals they are not recorded.

Oesophagostomum venulosum and *Moniezia benedeni* were simultaneously recorded in Altai, North Tien Shan and Alatau marals (Lubimov 1950; Dyusembayev 1991; Zhaxylykova *et al.* 2015; Abdybekova *et al.* 2017).

Dicrocoelium lanceatum, Dictyocaulus filaria, Elaphostrongylus panticola, Parabronema skrjabini, and *Setaria altaica* have been simultaneously recorded in Altai and North Tien Shan marals (Boev 1939; Sokolova 1953). Perhaps in the future we will find these parasites in Alatau marals. Since they are familiar with this parasite at native land and in a new habitat. *Bunostomum phlebotomum* and *Haemonchus contortus* (Zhaxylykova *et al.* 2015; Abdybekova *et al.* 2017) were recorded only in Alatau marals.

It is likely that in the coming years a number of new parasite species will be registered in Alatau marals, since their new habitats used to be foci of the following helminths (Boev 1939): *Fasciola gigantica* (Coobbold 1855); *Eurytrema pancreaticum* (Janson 1889); *E. coelomaticum* (Giard et Billet 1892); *Hasstilesia ovis* (Orloff, Erschoff et Badanin 1934) Gvosdev et Soboleva 1983; *Ornithobilharzia turkestanica* (Skrjabin 1913), *Multiceps skrjabini*, larvae Popov, 1937; *Moniezia alba* (Peroncito 1879); *Thysaniezia giardi* (Moniez 1879), *Gongylonema pulchrum* Molin 1857; *G. verrucosum* (Giles 1892); *Filaria* sp. Mueller 1787; *Setaria labiato-papillosa* (Alessandrini 1838); *Ascaris* sp. Linnaeus, 1758; *Chabertia ovina* (Fabricius 1788); *Bunostomum trigonocephalum* (Rudolphi 1802); *Oesophagastomum columbianum* (Curtice 1890) Stossich, 1899; *Trichostrongylus probolurus* (Railliet, 1896) Looss, 1905; *Ostertagiella occidentalis* (Ransom, 1907) Andreeva, 1957; *O. circumcincta* (Stadelmann, 1894) Andreeva, 1957; *O. trifurcata* (Ransom 1907) Andreeva 1957; *Marshallagia marshalli* (Ransom 1907) Orloff 1933; *Haemonchus longistipes* Railliet et Henry 1909; *Nematodirus filicollis* (Rudolphi 1802) Ransom 1907; *N. oiratianus* Rajewskaja 1929; *Protostrongylus hobmaieri* (Schulz, Orlow et Kutass, 1933) Cameron, 1934; *P. skrjabini* (Boev 1936) Dikmans 1945; *P. raillieti* (Schulz Orlow et Kutass 1933) Cameron 1934; *Muellerius capillaris* (Mueller 1889) Cameron 1927; *Cystocaulus ocreatus* (Railliet et Henry 1907) Mikacic 1939; *Bicaulus schulzi* (Boev et Wolf 1938) Schulz et Boev 1940; *Trichocephalus ovis* Abildgaard 1795; *T. skrjabini* (Baskakow 1924).

CONCLUSION

Thus, the analysis of the literature and own research have shown that 53 species of parasites are parasitized in marals living in Kazakhstan: 6 species of protozoa, 3 trematodes, 5 cestodes, 36 nematodes and 3 ectoparasites; in Altai marals 50 species including 6 protozoa, 3 trematodes, 5 cestodes, 34 nematodes and 3 ectoparasites; in Alatau marals 15 species including 4 protozoa, 2 trematodes, 2 cestodes, 6 nematodes and 3 ectoparasites; in North Tien Shan marals 7 species including 1 trematode, 1 cestode, and 5 nematodes. During acclimatization, the marals lost 25- and acquired 2- species of helminths. Common to all marals are 3 species of protozoa, 4 helminths and 3 ectoparasites. Five species of helminths are common for marals of Altai and Northern Tien Shan. Acclimatizers can be involved in the circulation of these helminths. Since they are familiar with this parasite at native land and in a new habitat.

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