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Original Article

Saiga (*Saiga tatarica*) conservation strategy in Kazakhstan

Saiga (*Saiga tatarica*): uma estratégia de conservação no Cazaquistão

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Abstract

The saiga antelope (*Saiga tatarica*) is a living symbol of the Eurasian steppes. Even in the recent past, its total number exceeded a million heads. As a commercial species, it was a source of inexpensive meat and skins for suede. The natural world range of saiga in Eurasia covers the steppe and desert ecosystems of Kazakhstan, Uzbekistan, Turkmenistan, Mongolia, as well as Kalmykia and the Astrakhan region in the Russian Federation. It is divided into two subspecies: (*Saiga tatarica tatarica*) the nominal subspecies and (*S.t.mongolica*) the Mongolian saiga, which is found only in Mongolia. In 2002, the International Union for the Conservation of Nature (UICN) classified saiga as CR-critically endangered. The purpose of this work is to analyze the saiga population dynamics on the territory of Kazakhstan and characterize possible anthropogenic, genetic and environmental factors affecting their numbers, with the rationale for approaches to conserving these animals' population in Kazakhstan. The article highlights the saiga dynamics of number and distribution over the past decade, the reasons for decline in its number, also discusses specific measures to conserve the saiga in modern conditions, because the current critical situation with saiga in Kazakhstan requires implementing a strategy for its conservation as a species of mammals fauna of the republic.

Keywords: *Saiga tatarica*, mass death, ecosystem, epizootics of pasteurellosis, anthropogenic factors.

Resumo

O antílope saiga (*Saiga tatarica*) é um símbolo vivo das estepes da Eurásia. Mesmo no passado recente, seu número total ultrapassou um milhão de cabeças. Como espécie comercial, era uma fonte barata de carne e peles para camurça. A gama mundial natural de saiga na Eurásia abrange os ecossistemas de estepe e deserto do Cazaquistão, Uzbequistão, Turquemenistão, Mongólia, bem como a Calmúquia e a região de Astrakhan na Federação Russa. É dividido em duas subespécies: (*Saiga tatarica tatarica*) a subespécie nominal e (*Saiga tatarica mongolica*) a saiga mongol, encontrada apenas na Mongólia. Em 2002, a União Internacional para a Conservação da Natureza (UICN) classificou a saiga como uma espécie criticamente ameaçada (CR). O objetivo deste trabalho foi analisar a dinâmica populacional de saiga no território do Cazaquistão e caracterizar possíveis fatores antropogênicos, genéticos e ambientais que afetam seus números, com a justificativa de abordagens para conservar a população desses animais no Cazaquistão. O artigo destaca a dinâmica de número e distribuição da saiga na última década, as razões para o declínio em seu número, também discute medidas específicas para conservar a saiga em condições modernas, porque a atual situação crítica com a saiga no Cazaquistão requer a implementação de uma estratégia para sua conservação como espécie da fauna de mamíferos da república.

Palavras-chave: *Saiga tatarica*, morte em massa, ecossistema, epizootias de pasteurelose, fatores antrópicos.

1. Introduction

The natural world range of the saiga in Eurasia covers the steppe and desert ecosystems of Kalmykia, Astrakhan region in the Russian Federation, as well as Kazakhstan, Uzbekistan, Turkmenistan and Mongolia. The species is divided into two subspecies: (*Saiga tatarica tatarica*) nominal subspecies and (*S.t.mongolica*) - Mongolian saiga. In 2002, the International Union for Conservation of Nature (UICN) categorized the saiga as CR-critically

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endangered (European Union, 2019). The southern part of the Altai-Sayan ecoregion in Mongolia is the last refuge for the Mongolian saiga (*Saiga borealis mongolica*), which is an endemic subspecies of saiga (*Saiga borealis*). Saiga was listed by the IUCN in the category of "very rare" species, and is also marked in the Red Book of Mongolia.

About 290 years ago, the distribution of saigas was wider. They lived in the steppes of Ukraine, Trans-Volga, Urals, Northern Kazakhstan, as well as in the Baraba lowland (Western Siberia). Minoransky and Dankov (2016) concluded that under the influence of anthropogenic factors, the range has sharply decreased.

Currently, three geographic populations live in Kazakhstan: the Volga-Ural, Betpakdala and Ustyurt (Figure 1).

Until recently, the saiga in Kazakhstan was a background species of ungulates in the steppes, the number of which exceeded 1.0 million heads, and literally before our eyes, its populations collapsed, which can be interpreted by Serikbayeva et al. (2015a) as an ecological catastrophe. According to the "Beasts of Kazakhstan" at the end of the 40s of the last century in Central Kazakhstan it was possible to meet herds of saigas, numbering no more than several hundred heads in each. Only one herd was noted, in which there were more than 1000 individuals (IUCN, 2023). Therefore, in general, it should be summarized that no more than 2-3 thousand saigas lived in the republic at that time.

However, in subsequent years, thanks to the measures taken to protect, reproduce and rationally use the resources of this species, for 40 years (1958-1998) the saiga became the most numerous ungulate with a population of 1 million animals (Danilkin, 2005).

But, since 1999, there has been a sharp decline in their numbers:

1999-2000 years - 148500 - 34800
2001-2003 years - 21200 - 79300
2004-2006 years - 30700 - 47400
2007-2009 years - 54800 - 81000
2010-2012 years - 85500 - 137500

The most critical year was 2003, when only 21,200 heads were counted. From 2004 to 2013 the number of animals slowly but steadily began to increase. And in 2013, it reached 187,000 heads according to Huntingzooindustry.

The Betpakdala population of saigas is thinning mainly from the epizootics of pasteurellosis, which began to destroy them since 1981. Then several hundred thousand antelopes died at once. Then, in 1988, the death of about 0.5 million heads was registered (Zuter, 2012). And according to the Ministry of Agriculture of the Republic of Kazakhstan infotmed that, since 2010, in 2011, 2012, 2013, 11920, 441, 3000 and 1500 heads, respectively, died. According to other scientists, the root cause of mass diseases and the death of saigas in May 2015 in three regions of Kazakhstan should be considered teileriosis and tick-borne paralysis caused by the bite of pasture ticks on the migration routes of saigas in the spring (Baimanov, 2015). The last catastrophic epizootic in its scale was noted in May 2015 on the territory of three regions at once. The first cases of finds of 117 dead saigas were registered on May 11 in the Zholaba tract of the Zhangeldy district of the Kostanay region. By May 18, their number increased to 10,000 on an area of 16,000 hectares, and by May 22, 85,000 head. At the same time, dead animals were found in the Aktobe and Akmola regions. In total, as of June 22, 2015, 148,800 saiga carcasses had been disposed of. 127775 of these in Kostanay region, 10358 in Aktobe and 10667 in Akmola (Figure 2).

About 50.4% of the total number of saigas in Kazakhstan or 61.4% of these ungulates of the Betpakdala population died. To date, the remaining animals are dispersed in small groups over a large area, which significantly complicates monitoring and operational protection.

There is no doubt that the most important reason for the decline in the number of saigas was a sharp increase in poaching in the 1990s throughout the range and in all seasons of the year (Baitanayev and Serikbayeva, 2014). First of all, males were subjected to extermination, due to the high demand for their horns in the international market. In addition, adult saigas are shot for meat, which is prepared for the winter. According to scientists, saigas belong to those species of artiodactyls whose meat is considered halal (Serikbayeva et al., 2015b). However, in order to recognize saiga meat suitable for mass consumption, it is necessary to require confirmation of its compliance according to technical regulations as described in the study by Nurgaliyeva et al. (2017).

1.1. On the causes of saigas' mass deaths

The Biodiversity Project of the United Nations Development Program in Kazakhstan conducted an analysis

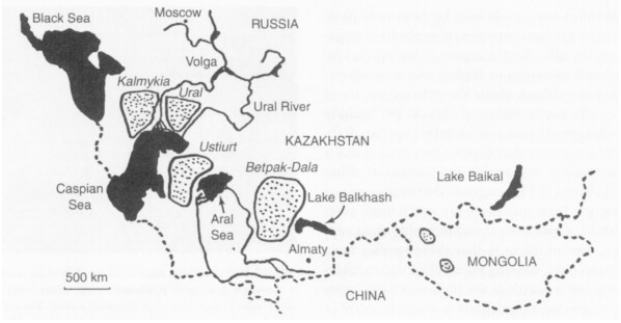

Figure 1. Distribution areas of saigas in Kazakhstan (Milner-Gulland and Woodroffe, 2001).

Figure 2. Dead saigas in Kostanay region (May 2016).

to ensure the systematic nature of the extinction of saiga antelopes in Kazakhstan over a certain period of time. Some sources say that mass deaths of this size were observed as early as the 19th century. There is even evidence that the extinction of saigas occurred in the 20th century with even greater frequency than in 19th century (Sludsky, 1955).

The main threats that reduce the number of saiga are: anthropogenic factor - poaching and bioecological - mass epizootics of infectious diseases. Moreover, the latter factor begins to prevail sharply and in future threatens with the extinction of saigas, the disappearance of the species in the fauna of mammals not only in Kazakhstan but also in the world as a whole.

Now many hypotheses have appeared that aim to interpret the causes of the occurrence of almost annual mass deaths of the saiga. Most of the versions have the right to exist until the true cause of this catastrophic natural phenomenon is revealed (Grachev and Bekenov, 2011; Karimova et al., 2021; Leontiev, 2017; Fereidouni et al., 2019; Kok et al., 2012; Zuter, 2012; Orynbayev et al., 2019).

The most common versions are: tympania of the saiga cicatricial stomach, when it swells due to fermentation in it when digesting green grass, anaerobic enterotoxemia, which also occurs when animals eat juicy green grass, moistened with heavy precipitation (Nurushev and Baitanayev, 2018). Fermentation of food in digestive system of saigas provokes the rapid reproduction of the corresponding bacteria that release toxins that penetrate through the blood vessels into all internal organs, affecting the nervous system as well. A group of versions that try to explain the cases of saiga from infectious (bacteria and viruses) and parasitic diseases.

This is intestinal clostridium; hemolytic septicemia; epizootic hemorrhagic disease of a viral nature transmitted by blood-sucking mosquitoes; theileriosis, caused by protozoan blood parasites, the carriers of which are ixodid ticks of the genus Hyalomma; viral infection unknown to science; hemorrhagic septicemia or pasteurellosis (Baitanayev et al., 2017; Costanza, 2021). The heptyl hypothesis, according to which the death of saigas occurs as a result of poisoning by rocket fuel with heptyl containing toxic components during rocket launches from the Baikonur cosmodrome and other test sites (Altynbayev, 2018).

Most of the above hypotheses, however, are currently rejected by researchers as not being confirmed and simply far-fetched. For example, the last accident of the Proton-M launch vehicle occurred on May 16, while the first cases of saiga deaths were noted earlier, on May 11, 2015. So far, only pure cultures of Pasteurella have been reliably isolated from bacteria and protozoa. In particular, according to the Russian Agricultural Supervision, in the reference laboratory for especially dangerous diseases, as a result of analyzes of pathological material from saigas from Akmola, Aktobe and Kostanay regions conducted on June 1-2, 2015, Pasteurella multocida type B, the causative agent of hemorrhagic septicemia or pasteurellosis, was found in all samples (Aikimbaev et al., 1984; Kock et al., 2018) came to the conclusion that this disease was the cause of the mass death of saigas in Kazakhstan. And, finally, for some reason, farm animals grazing near saigas did not die in large numbers from tympania of the stomach scar and anaerobic enterotoxemia.

The periodic mass death of saigas, which can be caused by a weakening of immunity against viral and bacteriological infections, due to the bottleneck effect, as well as anthropogenic and bioecological factors, actualizes the issue of preserving the saiga as an endangered species of mammals in Kazakhstan. The reason for the decline in the viability of saigas in Kazakhstan is seen as a sharp depletion of their genetic diversity caused by the "bottleneck" effect. The concept of the "bottleneck" effect in population genetics reflects a sharp decrease in the genetic diversity or gene pool of an animal population, which occurs between the two nearest cycles of population dynamics (critical decline and rise) (Sokolov, 1979).

According to the research of scientists (Serikbayeva et al., 2022), it was also noted that among the Mongolian saigas, a small ruminant plague (PPR) has recently been observed, so their number has significantly decreased and as of January 2020 amounted to 5,000 individuals. According to the results of studies by Rey-Iglesia et al. (2022), the Mongolian saiga has very low genetic diversity at the mitochondrial, as well as at the autosomal level, and most loci have low heterozygosity and a low number of alleles per locus (Steppe Bulletin, 2017).

2. Materials and Methods of Research

Saiga eat only 12-23 kg/ha of vegetation per year (about 1.5-2% of the crop), while domestic animals use 100 or more kg/ha (12-18%). This indicates a weak load on

pastures. According to calculations, the forage capacity of the pastures of the republic in full abundance can provide an annual diet of 1 to 3 million saigas without harming the environment (Orynbayev et al., 2019; Nurushev and Baitanayev, 2018). Thanks to their hooves, many rare plants endemic to the steppe are pollinated.

Generally accepted zoological methods of collecting material were used when studying the saiga population dynamics of three different populations inhabiting the territory of Kazakhstan, including visual observations (through binoculars, spotting scope), photography, satellite tracking, collection and analysis of food (when studying food), labeling of young and adult animals (Novikov, 1953). There are studies where GIS technologies were used to study hunting farms and fauna biodiversity (Serikbayeva and Akimzhanov, 2022).

To determine the abundance of saigas, a method of ground counting using motor vehicles (for small areas) and a method of aerial visual counting using light aircraft and helicopters have been developed (Sludsky and Shubin, 1963). They were also guided by the "Methodological guidelines for aerial survey of saigas in Kazakhstan", approved by order of the Committee for Forestry and Hunting of the Ministry of Agriculture of the Republic of Kazakhstan No. 191 dated August 23, 2005, and developed by the Institute of Zoology of the Ministry of Education and Science of the Republic of Kazakhstan, the Kazakhstan Association for the Conservation of Biodiversity and the State Enterprise "PO "Huntingzooindustry" and "Methodological recommendations for aerial survey of saigas in Kazakhstan", approved by the decision of the Scientific and Technical Council of the Committee for Forestry and Wildlife of the Ministry of Agriculture of the Republic of Kazakhstan dated March 17, 2014. Aerial surveys were carried out in the spring (in April) annually. Accounting was carried out on parallel routes, laid mainly through 10 km. The flight height is 120 m, the width of the registration strip is 1600 m (800 m in each direction). The survey routes cover the entire area occupied by saigas at the time of the survey. Animal population density is calculated separately for each survey route. The number of saigas was determined by extrapolating the accounting data to the territory occupied by the animals during this period.

Summer monitoring was regularly carried out on the territory of all three saiga populations, in their key habitats. At the request or when new information appeared, special visits were carried out jointly with the inspectors of the State Enterprise "PO Huntingzooindustry". During the monitoring period, the total route was 10,000 km.

The study of migration, in addition to observations in the spring, summer and autumn periods, was carried out throughout the year using data received from satellite transmitters

Ground accounts. Ground-based monitoring of saigas of the Betpak-Dala, Ural and Ustyurt populations was carried out in accordance with the Methodological Guidelines for Conducting a Survey of Individual Species of Wild Animals, approved by Order No. 191 of the Ministry of Agriculture of the Republic of Kazakhstan dated August 23, 2005, and the use of motor vehicles, approved by the order of the Committee for the Prevention of Agriculture of the Ministry of Agriculture of the Republic of Kazakhstan No. 81 dated 09.04.2003.

Saiga sightings were recorded using GPS Garmin. In all monitoring work, 10x and 8x binoculars were used, as well as 30x-60x spotting scopes, and when taking into account the rutting clusters, a Mavic Pro II quadcopter was also used.

3. Results and Discussion

According to the annual censuses of the Ural, Ustyurt and Betpakdala saiga populations over the past 11 years, their numbers are as follows (Figure 3). their absolute number began to increase markedly.

Figure 3 shows that, starting from 2010, the absolute number of saigas began to noticeably increase. So if in 2002 - 2009. their abundance was in the range from 30,000 to 8,100; by 2015, 295,470 heads were already counted, i.e. 3.6 times more. In the context of populations, the exponential growth of the Ural and Betpak-Dala groups and the minimal growth of the Ustyurt group should be noted. Compared to 1999, their abundance decreased by 3.4 times by 2010, and by 15.7 times in 2015. The main factor limiting the number of saigas in Ustyurt is anthropogenic, significant hunting during the winter, both in the Kazakh and Uzbek parts of the plateau.

After 2016, there has been an increase in saiga numbers in all three populations. The size of the Ural saiga population after 2003 (the minimum level) gradually increased until May 2010, when there was a mass death of animals from pasteurellosis (12 thousand died). In 2011, there was a second epizootic outbreak that caused the death of saigas, but in a small number (440 individuals). The number has decreased, but since 2012 there has been a steady increase to 545 thousand in 2022, that is, above the level at which it was previously hunted.

According to Figure 4, in 2022, the number of saigas of the Ural and Betpakdala populations is continuously increasing. The saiga is characterized by an intensive increase in its population. With favorable environmental and anthropogenic factors, annual growth increases from 5.5 to 37.3%, and on average by 24.7%. Approximately every 3-4 years, their total number can more than double.

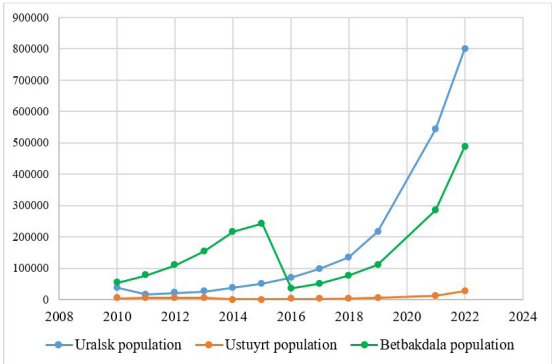

Figure 3. Dynamics of the number of saigas for 2010-2023.

The dynamics of the number of saigas in the Ural, Ustyurt and Betpakdala populations over the past 3 years has been consistently positive, with an increase above the average in the past year. To date, the largest population in the country is the Urals (Table 1).

In recent years, there has been a steady increase in Ural population. This year the growth was 47.0%. due to the pandemic, no counts were made in 2020 and the 2021 figure is based on two years. It should be noted that the state of protection of the Ural population seems to be the best, due to the peculiarities of its location - it is not as scattered over the territory as the Betpakdala population with its gigantic spaces, and its high-quality constant control is possible. Such control is carried out year-round by local groups of PO Huntingzooindustry reinforcement from other regions during lambing and rutting periods. All this led to an extremely high increase in the Ural population.

Compared to 2021, the Ustyurt saiga population, according to extrapolation data, increased by 133.3%. Such an increase in the number can be explained by the fact that, with a low number, underestimation in previous years was possible.

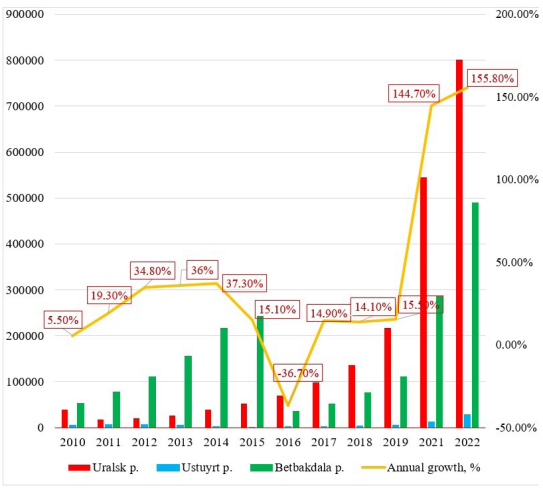

Figure 4. Relative dynamics of the number of saigas for 2010-2022.

Saiga saigas of the Ustyurt population currently stay all year round in the area north of the Saksaulsky-Beineu railway in a limited area, north of the railway, without moving south and into Uzbekistan for wintering. This facilitates their protection and also reduces mortality, increasing growth, which, along with other reasons, can explain its high value. But, at the same time, in the event of a severe winter, there is a very high risk of death in this group if it does not continue winter migrations. Therefore, it is necessary to take measures to improve the possibilities of crossing the railway, since the existing crossings of the saigas are obviously intimidating and are practically not used by them.

The total number of saigas in the country in 2022, according to aerial surveys and ground surveys of the "eastern" group, is 1,318,000 individuals, with an increase of more than 56% compared to 2021. Very favorable food and weather conditions of the past two years contributed to the high increase. and quite effective security, which also improved markedly during this period.

As mentioned above, saigas live mainly in three relatively isolated geographical groups or populations - Ural, Betpakdala, Ustyurt. In addition, extremely few, even isolated cases of their registration are known, for example, in Mangyshlak, Northern and Southern Balkhash, Semirechye, etc.

The total area of the surveyed territories, and separately for each site are shown in Table 2.

The Ural population is divided into 4 blocks, the Ustyurt population is divided into 3 blocks, and the largest of all three populations, the Betpakdala population, consists of 5 blocks. The proportion of the territories of each population is shown in Figure 5.

As can be seen from Figure 1, half (56%) of the total area is occupied by the Betpakdala population, that is, 65,079 km^2. The remaining 20% of the territory is occupied by the Ural population - 23786 km2, and 24% - by the Ustyurt population, that is, 28491 km^2.

The population density of the Ural population in 2022 is 76 heads per km^2, the Ustyurt population is only 0.2 heads

Table 1. Number of saigas in Kazakhstan in 2016-2022.

Year	Population size and growth (percentage)							
	Betbakdala		Ustyurt		Uralsk		Total	
	Population	%	Population	%	Population	%	Population	%
2016	70 200	+35,8	1 900	+49,6	36 200	-85,1	108 300	-63,3
2017	98 200	+39,9	2 700	+42,1	51 700	+42,8	152 600	+40,9
2018	135 000	+37,5	3 700	+37,0	76 400	+47,8	215 100	+41,0
2019	217 000	+60,7	5 900	+59,5	111 500*	+45,9	334 400	+55,5
2020	-	-	-	-	-	-	-	-
2021	285 000	+151,2	12 000	+103,4	545 000	+160,1	842 000	+153,3
2022	489 000*	+71,6	28 000	+133,3	801 000	+47,0	1 318 000*	+56,5

*Taking into account the "eastern" grouping, which was not included in aeral count.

or 1 head per every 5 km, the Betpakdala population is less than 2 heads per km^2.

In these antelopes, the phenomenon of seasonality of habitats is observed. With the onset of winter cold, they migrate to the south, where they experience adverse weather and climatic conditions. With the onset of spring warmth, they move to the northwest, where the females bring offspring. And by the summer they migrate even further northwest to the so-called letovki and are distributed in the semi-desert and steppe zone. In autumn, saigas gradually return to the south.

Our map in GIS format shows the main types of saiga habitats and the area they occupy (Figure 6).

All habitats or land types characteristic of saigas are divided into 2, 3, and 4 quality classes for three population which reflect the quality of land in terms of fodder, protective and nesting (places of lambing) properties. They differ respectively, as is known, into good average and poor quality (Table 3). The total area of saiga lands amounted to a little over 82 million hectares. Of these, the Betpakdala population of the saiga occupies more than 50 million hectares, the Ustyurt - 24.2 and the Urals 7.6 million hectares. It should be noted that the habitats of the Ustyurt population of antelopes are now almost empty due to the well-known sharp decline in their numbers. The saigas in the Betpakdala population (about 10 million ha) have the largest wintering area, and the Urals have the smallest. This is due to the overall small habitat area of the entire Ural population, although their numbers are by far the highest in Kazakhstan. A high population size in a relatively small area threatens to overcrowd, which can cause a mass epizootic of pasteurellosis or foot and mouth disease.

It should also be noted that for the Ustyurt saiga population, the most optimal is the hilly-argillaceous desert of the Priembenskaya Plain, covered with feather grass-wheatgrass-wormwood vegetation, and the worst is the loamy-limestone desert in combination with hilly-ridged sands on the Ustyurt plateau. Nevertheless, the most favorable habitats for the saiga are the fescue-feather grass and tyrsovo-feather grass steppes of Central Kazakhstan. In the recent past, their numbers were the highest here. It is the steppe vegetation that is most suitable for feeding saigas.

The obtained data on saiga lands distribution according to their quality ratings make it possible to calculate the allowable or optimal number of antelopes, in which

Table 2. Area of territories surveyed during aerial survey in 2022.

Parts	Uralsk population (km^2)	Ustyurt population (km^2)	Betbakdala population (km^2)
A	6 222	20 221	35 850
B	6 595	5 939	2,751
C	8 989	2 331	15,969
D	1 980	-	7,277
E			3,232
Total area	**23 786**	**28 491**	**65 079**

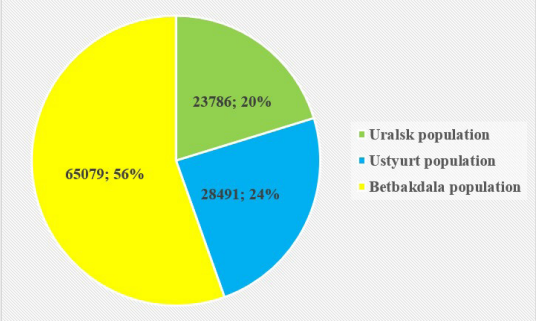

Figure 5. The share of territory surveyed when taking into account saigas, %.

Table 3. Habitat composition of saiga populations.

Population	Habitats (lands): 2 - good, 3 - average, 4 - bad, by quality classes	Area, ha
Ural	2: Wormwood and grass-feather grass semi-desert with thickets of bushes.	3084000
	3: Clay and sandy desert with sagebrush and - couch grass - fescue cover with thickets of tamarisk and calligonum	2855000
	4: Ridge-hilly fixed and weakly fixed sands with sagebrush-kochia-leimus vegetation	1673000
	Average quality class – II.8 Total:	7612000
Ustyurt	2: Hilly-argillaceous desert with sor depressions: feather grass-wheatgrass-sagebrush and sagebrush-biyurgun vegetation	9896000
	3: Wavy sandy-clayey desert with wormwood- poaceae and anabasys vegetation	10760000
	4 Loamy-limestone desert with massifs of ridge-hummocky sands with anabasys - salsola and sandy vegetation.	351400
	Average quality class – II.7 Total:	24170000
Betpakdala	2: Fescue-feather grass, stipa-feather grass with thickets of caragana steppe.	243200000
	3: Anabasys-sand with calligonum desert	16180000
	4: Rubble and sandy-loamy-clayey desert with small hilly areas with sagebrush-saltwort and haloxylonl vegetation	9723000
	Average quality class – II.6 Total:	50223000
	Total	**82005000**

habitats are used most productively (Table 2). Maintaining optimal number of saigas is possible by controlling their populations, limiting the impact of anthropogenic factors, exterminating predators, and, most importantly, strengthening the fight against poaching.

However, life does not stand still and the habitat of saigas, especially in the north, is already subject to intensive socio-economic development. Significant areas of the steppe are involved in agricultural production for arable land and livestock grazing. Saiga antelopes migrate together with their young to the north of their species range and end up on agricultural lands. And this causes dissatisfaction with farmers who complain about saigas causing economic damage to them. According to media reports, antelope trample crops, and eat all the vegetation in pastures, preventing hay for the winter. Such phenomena take place in the West Kazakhstan and Akmola regions.

Saiga have now come into conflict with agriculture. If earlier their numbers were regulated by fishing, now hunting is prohibited. And every year this situation will only get worse. Scientific justification that the number of saiga has not reached its maximum is clearly outdated, the antelope is recovering relatively quickly and further growth in numbers is already becoming undesirable.

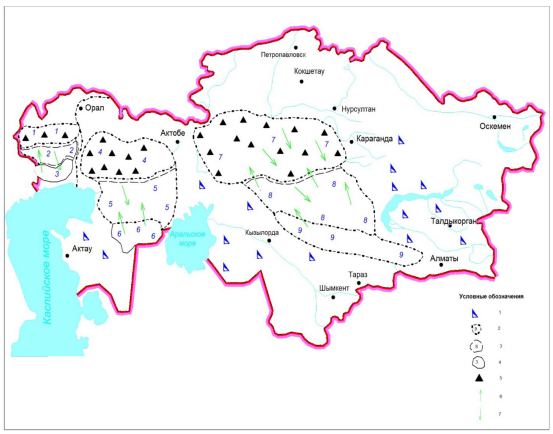

Figure 6. Spatial distribution of saiga populations in Kazakhstan. (1) separate visits; (2) year habitats; (3) spring habitats; (4) wintering place; (5) Saiga sightings in summer; (6) direction of spring migrations; (7) autumn migrations; (8) spring migrations; (9) unaffected areas.

From the point of view of hunting science, there is a need to regulate the number of saigas to optimal values. Then the harm to agriculture will be reduced to a minimum, and the state of their populations will not cause concern on the part of the scientific world and the public. The introduction of a moratorium on the use of saiga and their derivatives throughout Kazakhstan ends in 2023.

For practical purposes, it is sufficient to determine the approximate level of optimal abundance based on experience, taking into account productivity trends and dynamics of groups and habitat conditions. The most important landmarks are the existing population density of animals in specially protected natural areas and in the best hunting farms of the region, as well as the known density at which the reproductive abilities and quality of populations decrease, and the damage to forests and agriculture becomes tangible or intolerable. Of course, due to the different quality of the habitat and different economic goals, the levels of the optimal abundance cannot be the same in different countries, regions and hunting farms. Nevertheless, the order of recommended values is all the same (Danilkin, 2014; Serikbayeva et al., 2021; Baitanayev and Serikbayeva, 2021; Serikbayeva, 2020).

The results of calculating the optimal number of saigas show (Table 4) that already in 2017 the abundance of the Ural population began to exceed the permissible level. And in 2021, it already exceeds it by almost 10 times. As for the Ustyurt population, in fact, the very low number of antelopes is still far from optimal in many respects. And the Betbakdala population can reach its optimal size in 1-2 years. In general, the total number of saiga this year has already exceeded the allowable number by 198 thousand heads, due to the Ural population.

In our opinion, the size of the Ural population should be reduced in the next 3-4 years to about 60-80 thousand heads and constantly adhere to this level. Hunting tourism should be organized, including intour hunting for saiga. Make appropriate legal and regulatory decisions. Otherwise, antelopes will cause significant economic damage to the region's agriculture. We especially note that here in the near future mass epizootics of zoonotic infections may arise from overcrowding of the population.

As a result, the allowable or optimal number of the Ural saiga population should practically not exceed 75,000, the Betpakdala - 450,000 heads. And the number of the catastrophically low Ustyurt population must be brought up to 180,000 heads in the coming years.

Table 4. Calculation of the optimal number of saigas in Kazakhstan.

Total area inhabited by populations thousand ha	Include by bonitation				Optimum density per 1000 ha				Permissible population per total area according to boniteta				Total
	I	II	III	IV	I	II	III	IV	I	II	III	IV	
Uralsk 7612,0	-	3084,0	2855,0	1673,0	20	12	6	2	-	37008	17130	3346	57484
Ustyurt 24170,0	-	9896,0	10760,0	3514,0	20	12	6	2	-	118752	64560	7028	190340
Betbakdala 50223,0	-	23320,0	16180,0	9723,0	20	12	6	2	-	279840	97080	19446	396336
Total:	**-**	**36300,0**	**29795,0**	**14510,0**	**20**	**12**	**6**	**2**	**-**	**435600**	**178770**	**29820**	**644190**

Note: Optimum density per 1000 ha (Serikbayeva et al., 2021).

The total optimal number of saigas in Kazakhstan should be no more than 750,000 head. Only in this way can large-scale epizootics and economic damage to agriculture be avoided.

3.1. On urgent measures for the saiga conservation

Annually May, characterized by a rapid alternation of warm and cold periods of weather, presents a constant threat of mass epizootics of pasteurellosis to saigas endowed with depleted genetic diversity. Therefore, the most important problem arises - how to avoid a new death of antelopes, preserve and sustainably restore the population, and what, in this regard, needs to be done. We consider it possible to propose the implementation of the following urgent measures:

1. To develop a method of field vaccination of antelopes against pasteurellosis. Vaccination is the most effective way to prevent the epizootic of infectious diseases. However, some scientists consider it almost impossible to prevent hemorrhagic septicemia in saigas. Because aerosol spraying of the vaccine from a helicopter can cause severe stress in animals with more severe consequences.

In our opinion, it is possible to use agricultural drones or drones that are used to spray fields with solutions of fertilizers and herbicides. One of the acceptable ones can be the Agres MG-1S model UAV with a payload capacity of up to 10 kg. It is equipped with a CBR ground-scanning radar to maintain the required distance to the spray object with a sufficient amount of liquid. Speed up to 8 m/sec. Can be used in automatic, semi-automatic and manual control modes.

Drone tanks can be filled with an aqueous solution of pasteurellosis vaccine and test the technology of spraying saiga grazing areas using UAVs flying at an altitude of about 100 m. The device is silent and does not cause disturbance to animals. Preliminarily in April, a wide reconnaissance of saiga lands is necessary to determine the places of their greatest accumulation. And then immediately carry out field vaccination by spraying herbaceous vegetation using a UAV. Saiga saigas will receive an anti-pasteurellosis vaccine along with food. Thus, it will be possible to avoid their mass death at least in the next 1-2 years. And then repeat the vaccination of saigas every 2 years.

2. Conduct laboratory experiments on infection of saiga with Pasteurella in the experiment and in the norm, followed by their hypothermia when bathing in cold water to study the infectious process (pathogenesis) in these ungulates.
3. To confirm or refute the genetic syndrome, carry out studies of the population genetics of saigas from different parts of the range.
4. Implement a strategy for restoring the genetic diversity of the saiga by interbreeding between the Kazakh (S.t. tatarica) Mongolian (S.t. mongolica) subspecies. It is advisable to "blood flow" in small volumes, about 100-200 Mongolian saigas to replenish the depleted gene pool. In the future, they will simply be absorbed by the nominal subspecies and the original subspecies will remain unchanged.

In conclusion, it should be stated that the current critical situation with the saiga in Kazakhstan requires the implementation of a strategy for its conservation, as a species of mammalian fauna of the republic.

4. Conclusion

Thus, three factors remain that have the greatest influence on population dynamics: weather conditions, mass diseases, reduction and fragmentation of habitats. All of them are capable of causing very sharp fluctuations in abundance, which can occur at any time (especially at high population density), regardless of the presence of protective measures.

The saiga in Kazakhstan is one of the key components of biological diversity. And, of course, requires special attention for its sustainable conservation. On the one hand, in the biological aspect, it is an intensively breeding species, capable of increasing its numbers in a short time. And, on the other hand, in conditions of high numbers, mass epizootics of natural focal infections occur, causing the death of antelopes. Also, with a high abundance of saigas, they cause significant harm to agriculture in the steppe zone of the republic. They compete with small and large cattle on pastures, go to arable land, eating and trampling farmers' crops. The economic damage from saiga herds amounts to considerable amounts.

It can be concluded that in the biological aspect, the saiga is a relatively intensively breeding species. In modern conditions, its maximum number becomes undesirable and causes problems. The main one is the damage to agriculture and the mass epizootic of pasteurellosis and other zoonoses. Moreover, epizootics are natural regulators of the saiga population.

Currently, there is a need to manage saiga populations in Kazakhstan. It has become in demand to bring their numbers to optimal or acceptable limits. Therefore, the authors of this publication, for the first time in the republic, carried out the required research and developed practical solutions for the norms of the optimal number of the Ural, Betpakdala and Ustyurt saiga populations. For the Urals - 75000, Betpakdala - 450000 and Ustyurt (in the future) - 180000 heads. In total, this is no more than 750,000 saigas. This will allow the antelope to optimally exist as the most important representative of the fauna of Kazakhstan.

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