T.Yu. Karimova, A.A. Lushchekina, V.V. Rozhnov

SAIGA MANAGEMENT AT ZOOS AND BREEDING CENTRES:

making effective use of the lessons learnt for the restoration of wild saiga populations

Moscow – 2018

A.N. SEVERTSOV INSTITUTE OF ECOLOGY AND EVOLUTION
OF THE RUSSIAN ACADEMY OF SCIENCES

PERMANENT EXPEDITION OF RUSSIAN ACADEMY OF SCIENCES FOR STUDY OF RUSSIAN
RED DATA BOOK ANIMALS AND OTHER KEY ANIMALS OF RUSSIAN FAUNA

T.Yu. Karimova, A.A. Lushchekina, V.V. Rozhnov

SAIGA MANAGEMENT AT ZOOS AND BREEDING CENTRES:

making effective use of the lessons learnt for the restoration of wild saiga populations

KMK Scientific Press Ltd.

Moscow – 2018

Karimova T.Yu., Lushchekina A.A., Rozhnov V.V. Saiga management at zoos and breeding centres: making effective use of the lessons learnt for the restoration of wild saiga populations. Moscow: KMK Scientific Press. 2018. 117 pp.

Reviewers:
M.V. Kholodova, Doctor of Biology
V.M. Neronov, PhD, Geographi

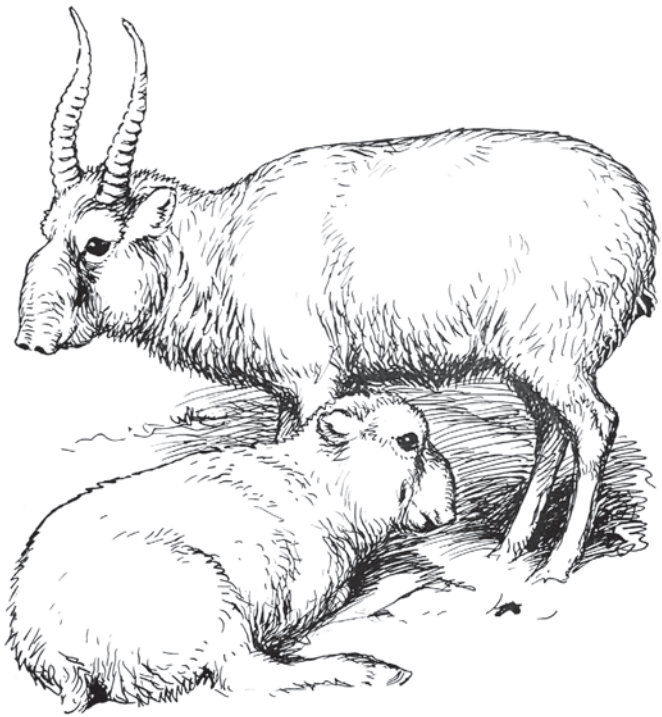
Translated by Tanya Arzhanova

Photographs
Cover: Checking the operation of the satellite transmitter before the release of saiga into nature (Photo by A.V. Khludnev)
Page 3 and Back cover: Photographs from the Archive of the Centre for Wild Animals of the Republic of Kalmykia
Page 4: Picture "Saigas" by V.M. Smirin from the collection of V.V. Rozhnov

The publication has been founded by the Program of the fundamental reserches of the Presidium of the Russian Academy of Sciences: "Biodiversity of Natural Systems and Biological Resources of Russia"

ISBN 978-5-907099-85-2

Dedicated to the memory of
Boris Ivanovich Petrishchev and to all colleagues
who have been involved in the noble cause
of the saiga conservation and reintroduction into the wild.



Contents

Introduction

Despite the efforts of general public and many specialists in the area of the study and conservation of nature, no progress has been achieved in reducing the rate of biodiversity loss in the period since the signing of the Convention on Biological Diversity (1995). Critical state of key natural resources and significant degradation of ecosystem services remain a major concern all over the world. The results of the "Millennium Ecosystem Assessment" international project (2001–2005) have shown that unless addressed, the problems of biodiversity conservation and sustainable development that are facing various countries can not be resolved.

Captive breeding programs and subsequent releases of animals into the wild have been increasingly used for conservation and restoration of threatened species worldwide. Convention on Biological Diversity (1995) and National Strategy of Biodiversity Conservation of the Russian Federation (2001) state that measures for *ex-situ* conservation should be used to complement *in-situ* activities for the purpose of biodiversity conservation. Given the high likelihood of future degradation and reduction of natural habitats, as well as extinction of wild populations of many animal species, it has to be concluded that a wider use of captive breeding programs for species restoration would be an appropriate approach to the conservation of target species.

Considerable experience in conservation and restoration of endangered and rare species was acquired at the times of the Soviet Union. The requirement for the development of practices of artificial breeding of rare species was stipulated in the USSR Law on Protection and Use of Animal World and included in the guidelines of the USSR Red Data Book (1983), while the requirement for the development of captive breeding techniques for game species was specified in a number of governmental regulations. *The USSR State Program on Environmental Protection and Sustainable Use of Natural Resources for 1991/1995 until 2005* (published in 1990) provided for "*continuing the development of methods of captive breeding of the most important animal species for the subsequent reintroduction of animals into the wild and implementing activities aimed at the practical use of such methods as one of the measures of the conservation of sustainable dynamic balance of natural ecosystems and creation of appropriate living and breeding conditions for wild animals in the whole range of species, subspecies and population diversity, as well as for enhancing efficiency of the use of animal world for economic, scientific, recreational and other purposes*". Regretfully, most results of this work were lost in the early 1990s (Pereladova, 2005).

Examples of successful implementation of the programs for conservation and restoration of rare animal species include ungulate conservation projects that were car-

ried out in some Central Asian Republics of the former USSR, such as programs on reintroduction and restoration of the wild populations of the Bukhara deer and kulan, and creation of breeding centres for the goitered gazelle, markhor, kulan, and Przewalski's horse. Since 1999, projects on the restoration of some ungulate species (Bukhara deer, kulan, and Przewalski's horse) have been carried out in the region with the support of the World Wildlife Fund (WWF). Long-time expert knowledge was summarized and systematized in a wide range of publications (e.g., Bannikov, Flint, 1982; Flint, 2000; Pereladova, 2005; Marmazinskaya, 2012; Pereladova, 2016).

In Russia, such activities are underway for large carnivores, such as brown bear (Pazhetnov *et al*., 1996, 1999), Amur tiger, and Far Eastern leopard (Rozhnov, 2015; Miquelle *et al*., 2016). Given the importance of the work aimed at rehabilitation and reintroduction of large carnivorous mammals, A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences (RAS) and RAS Theriology Society hosted the International Workshop on Rehabilitation and Reintroduction of Large Carnivores (Moscow, 2015) for summarizing experience of the projects that had been implemented around the world (Proceedings of the International Workshop on Rehabilitation and Reintroduction of Large Carnivores, 2015).

Prominent among reintroduction efforts is a study focused on the restoration of the wild population of the Przewalski's horse (Rozhnov *et al*., 2011). Przewalski's horses have been kept and bred in captivity for over 100 years, and the experience in the management of this species in semi-wild and captive environment proved to be successful. In 1980s, techniques for the reintroduction of the species in the wild habitats were developed (Przewalski's Horse and Restoration of the Wild Populations of the Species in Mongolia, 1988; Bouman, 1995; Flint, 2000). Since 1985, eleven major breeding and reintroduction centres for the Przewalski's horse have been established; four in Europe (France, Hungary, the Netherlands, and Ukraine), two in Middle Asia (Uzbekistan and Kazakhstan), and five in Central Asia (two in China and three in Mongolia). Some populations are managed under free-ranging conditions, while others are kept within fenced territories with the areas varying from several hundreds to several thousands hectares (Zharkikh, Yasinetskaya, 2005). Previous studies have shown that reintroduction of the Przewalski's horse and re-establishing wild population of this species can be also successful in Russia, in particular, in the remaining steppe territories in Orenburg region, located within historical range of the Przewalski's horse. The Program on the Restoration of Przewalski's Horse in Orenburg Region (Rozhnov *et al*., 2009) was developed by A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences (RAS), Zoological Museum of the M.V. Lomonosov Moscow State University, Institute of Steppe of the Ural Branch of the Russian Academy of Sciences, and Orenburg regional public fund "Revival of Orenburg Steppes" under the subprogram "Conservation of Rare and Endangered Species of Animals and Plants" of the "Ecology and Natural Resources of Russia" Federal Program (2002–2012) and "Biological Diversity" program of the fundamental research of the Presidium of RAS. In 2013, this Program was supported by the Russian Geographical Society. As a result, a plot of land "Orenburg Steppe" measuring 16.5 thousand hectares was integrated into the Federal State Budgetary Institution

"State Nature Reserves Orenburg" in 2015 and given a name "Pre-Ural Steppe" (Bakirova, Gorbunov, 2016). The Orenburg regional government and Institute of Steppe of RAS have also established a breeding centre for steppe animals and are planning to build enclosures for the bisons, camels, saiga antelopes, red deer, and other steppe animals (https://ria.ru/eco/20130919/964364452.htm).

International experience demonstrates that despite certain restrictions, this approach to biodiversity conservation can be used for many endangered animal species. Positive results have been achieved in the restoration of the Arabian oryx (*Oryx leucoryx*) in Jordan and Oman where the animals from the breeding centres of the USA and Western Europe were successfully used for reintroduction (Ostapenko, 2013). The programs for conservation and restoration of the wild populations of the European bison (*Bison bonasus*) and Père David's deer (*Elaphurus davidianus*) are some of the well-known examples of the restoration of threatened species through captive breeding (Pererva *et al*., 2002).

Captive breeding of animals under artificial conditions is one of the strategies suggested as a mean of species conservation by the Conservation Breeding Specialist Group (SBSG) of the IUCN Species Survival Commission (SSC/IUCN). The use of captive breeding methods ensures the conservation of the gene pool of wild animal species; this measure is an important tool of conservation, as there is a fine line between common and rare species in the contemporary world where human economic activity results in rapid and dramatic changes of natural ecosystems (Flint *et al*., 2002).

Saiga antelope (*Saiga tatarica*) is a keystone species of the Eurasian arid steppe ecosystems. Catastrophic decline in numbers that saiga populations have experienced across the species range, with the population having reduced from 1.6 millions in the 1950s to 55 thousands in the middle 1990s (Arylova, 2009), prompted the decision to include the saiga antelope in the Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1995), *Critically Endangered* category of the IUCN Red List of Threatened Species (2004), and Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) (2004). Currently, the saiga antelope is listed among the species suggested for the inclusion in the new edition of the Red Data Book of the Russian Federation.

At the International Conference on Saiga Conservation held in Elista in 2002, a draft of the Action Plan Concerning Conservation, Restoration and Sustainable Use of the Saiga Antelope was developed. Apart from the actions needed for the protection of the saiga and its natural habitats, monitoring and other conservation activities, the plan highlighted the importance of captive breeding as one of the alternative conservation methods of the conservation of the saiga, and foremost, of the species genetic diversity. At the joined initiative of CMS and CITES, a Memorandum of Understanding concerning Conservation, Restoration and Sustainable Use of the Saiga Antelope was drafted, based on the Action Plan prepared at the Conference in Elista. The MoU was signed by all range states in the course of relevant meetings held in the period from 2006 through 2009. Clause 2 of the MoU states that the signing Parties should implement the provisions of the Action Plan that forms an integral part of the MoU and a basis for conservation of saiga populations.

At each meeting of the representatives of the saiga range states that have signed the MoU, the participants adopt a Medium Term International Work Programme (MTIWP) for five years to support implementation of the MoU. The last MTIWP (2015–2020) was adopted at the Third Meeting of the Parties (Tashkent, Uzbekistan, 2015). Special attention in the MoU is paid to captive breeding of saiga as a potential mechanism of the restoration of the wild populations of the species. It should be noted that despite certain problems associated with captive breeding of saiga antelopes, this species can be kept within restricted area and the sizes of captive populations can increase (Arylova, 2009). However, the fundamental prerequisite for successful breeding of saiga antelopes in captivity is the necessity to meet biological needs of these gregarious, migratory animals.

The late B.I. Petrishchev, Candidate of Biological Sciences, the colleague from the A.N. Severtsov Institute of Ecology and Evolution of RAS, was an active participant in the process of establishing breeding centres in Russia at its early stages. It is largely through his recommendations that the area for the construction of the Yashkul Captive Breeding Station was selected, construction works were carried out to build animal enclosures at various breeding centres, and animals were captured in the wild and transported to the breeding centres. B.I. Petrishchev advised specialists on the methods of hand-rearing of saiga calves and their transition to fully solid diet; he also supported many other aspects of captive breeding activities.

We do not elaborate on the issues related to the enclosure design, capture and transportation of wild animals or feeding of adult and juvenile saiga antelopes, etc., as all these aspects have been described in detail in a number of publications (see Sokolov, Kholodova, 1996; Kholodova, Neronov, 1996; Arylova, 2009; Minoransky, Tolcheeva, 2010; Minoransky, Dankov, 2016).

This book presents an analysis of almost all available literature body on the history of husbandry and breeding of the saiga antelope (*Saiga tatarica*) under various conditions (zoos, breeding centres with semi-natural environment, and small captive breeding facilities) and the attempts aimed at the release of captive-bred saigas into the wild. We would also like to mention that there was no intent to assess husbandry practices used at various breeding centres or suggest our recommendations. However, we deem it important to commend the work carried out by Marc Enderby, hoof stock keeper at the RZSS Highland Wildlife Park of the Royal Zoological Society of Scotland, UK. A report drafted by Marc Enderby for Saiga Conservation Alliance (that provided support for this work) presents an analysis of information that was collected in the course of the visits to the Yashkul Captive Breeding Station of the Centre for Wild Animals of the Republic of Kalmykia, Centre of Rare Animals of European Steppes of the “Wild Nature of the Steppe” Association in Rostov region, and Centre for Wildlife and Conservation of Biodiversity of the West Kazakhstan Agricultural and Technical University named after Dzhangir Khan, and provides a number of useful recommendations (http://saiga-conservation.org/wp-content/ uploads/2017/03/ Saiga-Antelope-Captive-Husbandry-Project-RUS_Final.pdf).

The authors gratefully acknowledge the assistance provided by many Russian experts, including Yu.N. Arylov, N.I. Byzikina, Ye.A. Erofeeva, S.A. Kalashnikov, L.Ya. Kurilovich, A.V. Mekhovsky, V.A. Minoransky, V.M. Neronov, Ye. V. Pugacheva, N.Yu. Purvenova, S.V. Sidorov, N.A. Franov. We would also like to thank our colleagues in other countries, particularly V.S. Gavrilenko (Ukraine), B.B. Sarsenova (Kazakhstan), E.A. Bykova and N.V. Soldatova (Uzbekistan), Aili Kang, Fenglian Li and Zhigang Jiang (China), and D. Beetem and R. Rieches (United States) who provided us with information and illustrative materials. We highly appreciate the efforts of many colleagues, who contributed to the process of data collection over the past years.

This work has been implemented under the Program of fundamental research of the Russian Academy of Sciences (RAS): “Biodiversity of Natural Systems. Biological Resources of Russia: Status Assessment and Fundamental Basis for Monitoring”.

Status of the wild populations of saiga in Russia and other regions

The saiga antelope *(Saiga tatarica)* belongs to the order of even-toed ungulates (Artiodactyla) and is one of the most evolutionary distant members of the family Bovidae, the hollow horned ruminants. Taxonomic relations between the saiga antelope and other ungulates are still debated. For a long time, the saiga has been classified as an antelope and included in the Antilopinae subfamily. Some researchers classify the saiga under the subfamily Caprinae, while others suggest that the species should be included in a separate subfamily Saiginae. Under traditional concept, the saiga antelope is the sole extant member of the *Saiga* genus (Baryshnikov *et al*., 1998; Tikhonov, 1999; Hassanin, Douzery, 1999; Kuznetsova *et al*., 2002) that until recently included two subspecies: nominative *Saiga tatarica tatarica* (Linnaeus, 1766) found throughout the vast plains of Central Asia and North-West Pre-Caspian region and *Saiga tatarica mongolica* Bannikov, 1946, distributed in a relatively small area in Mongolia. In the latest (the third) edition of the «Mammal Species of the World» (Wilson, Reeder, 2005), these two subspecies are considered as separate species, and the Mongolian subspecies is given a Latin name *S. borealis* (Tschersky, 1876).

In 2010, this approach was reflected in the lists of Appendix II of CMS and CITES that stated that there are two separate species of the saiga antelope distributed in Eurasia, *S. tatarica* è *S. borealis.* However, it should be noted that the Latin name *S. borealis* has not been cited in either CMS (http://www.cms.int/en/meeting/ third-meeting-signatories-saiga-mou-mos3) or any papers of Mongolian experts (Chimeddorj *et al*., 2016, etc.), and there has been a debate in academic literature regarding the classification of the Mongolian subspecies of saiga antelope as a species. Although the Mongolian saiga differs from the animals of nominative subspecies in its smaller size, less bulbous nose, and thin short horns in the males, the study based on the use of modern techniques of molecular genetics and morphology (Kholodova, 2006) does not support its taxonomic ranking at a species level.

Five populations of the saiga remain in the wild to date, including four populations of *S. t. tatarica* (North-West Pre-Caspian region population – Russia; Ural population – Kazakhstan and Russia; Ustyurt population – Kazakhstan, Uzbekistan, and Turkmenistan; Betpak-Dala population – Kazakhstan and Russia), and one Mongolian population of *S. t. mongolica (=S. borealis)* found in western Mongolia (Fig. 1). One more population of *S. t. tatarica* that was distributed in the north-west of China and south-west of Mongolia went extinct in the 1960s.

The largest range and relatively high numbers of saigas have been recorded in the Republic of Kazakhstan. Aerial survey carried out in 2016 indicated that the total

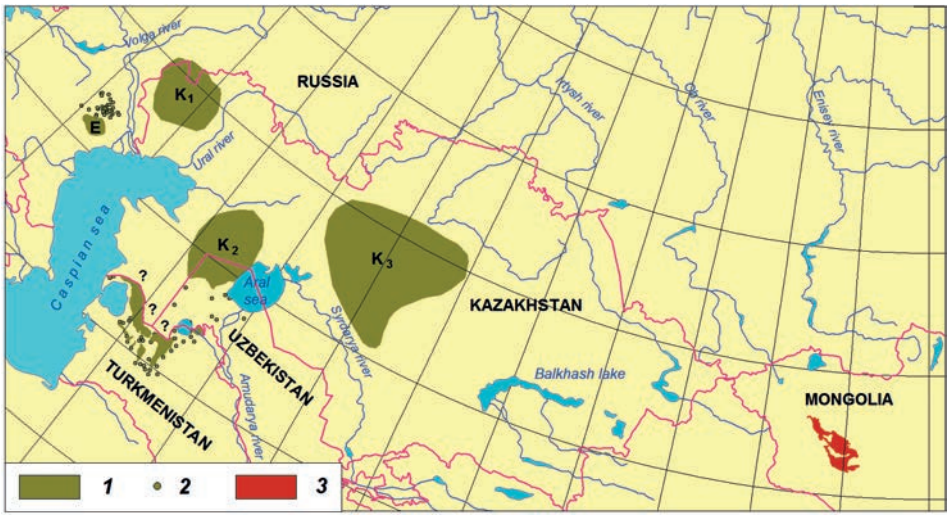


Figure 1. Range of *S. t. tatarica* (1) (Populations: Å – North-West Pre-Caspian; K_1 – Ural; K_2 – Istyurt; Êç – Betpak-Dala) and sites of sightings of *S. t. tatarica* in the recent years (2); range of *S. t. mongolica (=S. borealis)* (3) (adapted from Lushchekina, Struchkov, 2001, with amendments).

numbers of saigas reached 108,300 individuals, with Ural population comprising 70,200 individuals, Betpak-Dala population, 36,200 saigas, and Ustyurt population, 1,900 individuals (Zuther, Salemgareev, 2016). These data suggest the growth of the Ustyurt and Ural populations. In 2010, the latter decreased by more than 12,000 animals (about 30%) after the outbreak of pasteurellosis (Grachev, Bekenov, 2010). At the same time, a reduction is observed in the Betpak-Dala population that has not yet recovered after the mass die-off of saigas in 2015 when over 200,000 saigas died of pasteurellosis (http://www.cms.int/sites/default/files/document/Saiga%20MOS3_ Overview_Report_ of_Conservation _Status_Rus.pdf). It should be mentioned that the events of mass mortality in saigas, resulting from pasteurellosis were registered also in the past; in 1981 (ca. 100.000 deaths), 1984 (over 100.000 deaths), and 1988 (ca. 270,000 deaths) (Martynevsky, Aikimbaev, 2001). But aerial survey carried out in 2018 indicated that the total numbers of saigas reached 215,100 individuals, with Ural population comprising 135,000 heads, Betpak-Dala population – 76,400 saigas, and Ustyurt population – 3,700 individuals (http://acbk.kz/animals/default/view?id=51) and showed an increase in the number of all populations.

The Ural population is found in the northwest of Kazakhstan (West Kazakhstan region) in Volga-Ural interfluve. This population is transboundary between Kazakhstan and Russia, occurring in Astrakhan, Volgograd, and Saratov regions. Saigas of the Ustyurt population are found to the west of the Aral Sea (Aktobe and Mangistau regions); this is also a transboundary population of the species. Most animals of this population occur within the territory of Kazakhstan almost throughout the year, migrating to Uzbekistan (Karakalpakstan Autonomous Region) in winter. In the past, some animals migrated further to the south, passing through Uzbekistan and reaching

Turkmenistan. The historical distribution of the saiga embraced significant areas in Central Kazakhstan, from the Muyunkum Desert and the Chu River (Jambyl and South Kazakhstan regions) in the south to Lake Tengiz and Karaganda and Akmola regions in the north (*Zveri Kazakhstana*, 1993).

The government of Kazakhstan, as well as international non-governmental organisations and intergovernmental agencies have invested significant finances into creation of the net of strictly protected areas. Many projects are currently underway, including research, anti-poaching activities, education, and public awareness campaigns. Every year, land monitoring and aerial surveys of saigas, as well as satellite tracking of individual animals are carried out in Kazakhstan. Strictly protected areas cover significant proportion of saiga range (particularly Altyn Dala and Irgiz Turgay State Nature Reserves), and the first ecological corridor connecting key strictly protected areas has been established in the country in 2014 (Bragina, 2015; http://www.cms.int/sites/default/files/document/Saiga%20MOS3_Overview _Report_of _Conservation_Status_Rus.pdf). Improved efficiency in anti-poaching work in the recent decade has allowed to reduce the pressure of poaching and created conditions for rapid growth of the saiga population.

A small population of the saiga consisting of ca. 1,000 animals exists in Uzbekistan. These animals inhabit Vozrozhdeniye peninsula and adjacent areas along the costal zone of the Aral Sea (Nuridjanov, 2009).

According to the National Report submitted to the CMS by the Ministry of Nature Protection of Turkmenistan in 2015 (http://www.cms.int/en/meeting/third-meeting-signatories-saiga-mou-mos3), just sporadic cases of saiga sightings in secluded areas in the north of the country have been registered.

The Mongolian saiga *S. t. mongolica* (=*S. borealis*) inhabits Shargijn and Huyseiin Gobi in western Mongolia and Dorgon steppe, forming subpopulations. Major threats for the Mongolian saiga are presented by the expansion of agricultural lands, increase in livestock numbers (resulting in the increased competition for food), and harsh winters following dry summers. However, the Mongolian population has increased due to the strengthened measures of protection and favourable climatic conditions. In 2015, the size of the Mongolian saiga population was estimated at 15,000 individuals (Chimeddorj *et al*., 2016). In early January of 2017, mass die-off of saigas was observed in western Mongolia, caused by the breakout of highly contagious viral disease known as *Peste des petits ruminants*, or "goat plague" (PPR). Data from various online resources and information obtained from the experts of the Wildlife Conservation Society-Mongolia (WCS-Ì î í ãî ëèÿ), World Wildlife Fund (WWF-Mongolia) and Departments of Environment of Gobi-Altai and Khovd aimags suggest that the survey carried out in March 13–20, 2017, showed that only 4,961 saigas remained in the natural habitats (http://mongolia.panda.org/en/news/?296930/545-percent-of-theMongolian-Saiga-population-is-lost-due-to-disease-outbreak). It was noted that young animals born in 2016 comprised 70% of all died saigas, adult males, 28.7%, and adult females, 1.3%. Researchers believe that this disease that originates from the livestock may threaten the entire population of the Mongolian saigas. Animal carcasses have been burnt to contain the spread of PPR virus, and livestock animals are

vaccinated in the affected areas (https://informburo.kz/novosti/v-mongolii-vsledza-kazahstanom-massovo-gibnet-sayga.html). The survey of the saiga populations was performed by WWF-Mongolia in April 2018 in order to identify the current population size and compare it to those in the previous year, in addition to assessing their mortality rates. The team used a transect method for the survey within the saiga distribution range and counted about 3,000 saiga individuals, resulting in a 40 percent reduction from the March 2017 data (https://www.worldwildlife.org/press-releases/critically-endangered-mongolian-saiga-antelope-population-drops-by-40-percent-wwf-survey-shows).

In the past, saigas *(S. t. tatarica)* occurred in Xinjiang in Djungarian Gobi in the northwest of China, but the species disappeared in the country by the 1960s. Later, there were a number of sightings of saigas in these areas, but recorded animals were likely to be individuals migrating from Kazakhstan (Qian Huang *et al.*, 2014).

In Russia, an independent population of the saiga occurs in North-West Pre-Caspian region that covers western parts of the Republic of Kalmykia and southwest of Astrakhan region ("Cnernye Zemli" Ecoregion). The range of the Ural population overlaps the range of the North-West Pre-Caspian population at the boarder territory between Russia and Kazakhstan in the left-bank areas of Astrakhan, Volgograd and Saratov

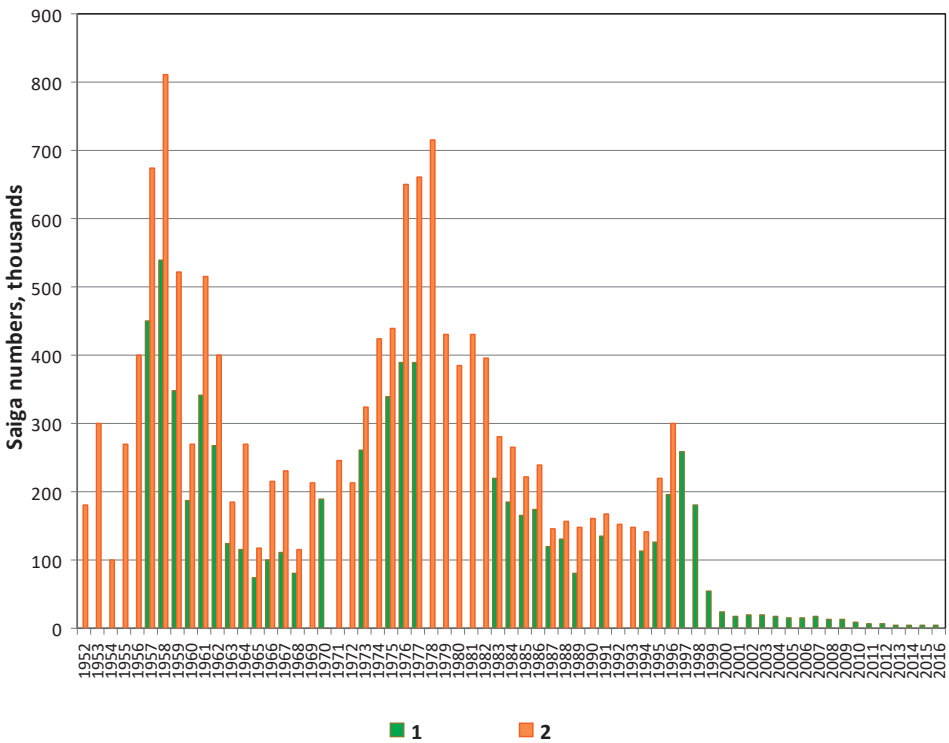


Figure 2. Long-term dynamics of the North-West Pre-Caspian population of the saiga; 1 – May; 2 – August (Retrieved from: Arylova, 2009; Neronov *et al.*, 2013, with amendments).

regions (Neronov *et al*., 2013). In recent years, transient saigas from Betpak-Dala population have been observed in Orenburg region (Levykin, 2015).

While in the 1950–60s the numbers of saigas in North-West Pre-Caspian region reached almost 800 thousand individuals and the outcomes of regulated hunting ensured significant profit at the state level, the local population of saigas rapidly decreased in the last decades (Fig. 2).

Despite many measures (hunting ban that was put in effect in 1998; Year of the Saiga campaign carried out in 2010, etc.), it has not been possible yet to reverse this dangerous trend. By the spring of 2012, the state of the North-West Pre-Caspian population became even more alarming; information presented at the meeting that was held at the Russian Ministry of Natural Resources and Environment on August 15, 2012, indicated that the maximum size of the regional population was estimated at 5,000 saigas. It was also stressed that "*this indicator implies that we are on the edge of the complete loss of the unique European population of this species*" (http://www.mnr.gov.ru/news/detail.php?ID=129113). The number of saiga in the North-West Pre-Caspian region (according to the expert assessment of specialists of the "Chernye Zemli" Nature Reserve) is estimated at about 7000 heads (B. Ubushaev, pers. comm.) that confirms our population assessment that in the recent years the numbers of saigas in this region have been stable but extremely low. Our estimates show that in the recent five years, the numbers of saigas in this region have been stable but extremely low.

Various measures of the conservation of saiga antelopes and their habitats have been taken at different levels (from local to federal) in the territory of the North-West Pre-Caspian region, including saiga monitoring, outreach activities, and some other conservation actions, such as inclusion of the saiga antelope in the list of animals and biological water resources of particular importance, included in the Red Data Book of the Russian Federation and/or protected under international treaties signed by the Russian Federation with the purposes of making this species a subject to liability under Articles 226.1 and 258.1 of the Criminal Code of the Russian Federation. All these measures should eventually promote the restoration of the wild population.

In general, similar negative factors affect the numbers of saigas across the species range; they include *poaching*, and in the first place, commercially motivated removal of mature males from the wild, resulting in the imbalance in the population sex ratio and age structure and a drastic reduction in the reproductive potential; *predation* pressure (by wolves, foxes, jackals, and large birds of prey); *anthropogenic transformation of natural landscapes*, such as land clearing in steppe territories, overgrazing, and extensive development of linear infrastructure projects that have an impact on the migrations of animals; *climatic and weather factors*, e.g. long periods of drought in the growing seasons and heavy snowfalls or thaws in winter, followed by severe frosts and causing dzhuts that lead to high mortality in saiga population (up to 50–70% of male saigas that participate in the rut may die during severe winter); and *diseases*, including foot-and-mouth disease, pasteurellesis, etc., which may cause deaths of thousands and even dozens of thousands of saigas.

Breeding centres that differ in their sizes and purposes have been established in Ukraine, Uzbekistan, Kazakhstan and China for preserving the gene pool of the saiga.

Three breeding centres were built in Russia: Yashkul Captive Breeding Station of the Centre for Wild Animals of the Republic of Kalmykia (currently closed); the "Saiga" Captive Breeding Centre of the Ilmeno-Bugrovoy Sanctuary (former Astrakhanskoye State Experimental and Hunting Enterprise) in Astrakhan Region, created in 2003; and the Centre of Rare Animals of European Steppes of the "Wild Nature of the Steppe" Association in Rostov Region. After the Crimea was incorporated into the Russian territory, one more breeding centre for saigas with semi-wild husbandry conditions, the Tarkhankut National Park, joined the net of the saiga captive breeding facilities in Russia. All these centres are involved in the study of behavioural and biological characteristics of the saiga, as well as in veterinary experimental works including artificial insemination, and in breeding and rearing saigas for their release into the wild.

It would not be possible to have these breeding centres built and functioning without experience gained by zoos and other zoological institutions that kept saigas under captive or semi-wild conditions. A brief review of the history of captive husbandry of saigas is presented in the next chapter.

History of saiga antelopes in zoos

The saiga antelope is one of the most difficult wild ungulate species in terms of captive breeding, which fact is supported by the history of maintaining this species in zoos. Almost all zoos, even those with a great experience in captive breeding of rare animal species, faced a number of challenges in the captive husbandry of saigas because of the specific ecology and behaviour of these animals (Sokolov, Kholodova, 1996).

The first attempt to establish saigas in captivity was made at *the Moscow Zoo* in the last half of the 19th century when this species appeared in the zoo exhibit in 1864; in the same year, one male was donated to the London Zoological Society (Mohr, 1943/1944). In 1879–1880, one male saiga was kept at the Moscow Zoo where he lived for 7 months (Bogdanov, 1889). These animals most likely originated from Volga basin region, as there is evidence that in the middle 19th century zoologist K. Galych hand-reared saiga calves for their transportation to Moscow (Tzaplyuk, 1982). Two shipments of saigas, one from from Uzbekistan (Narynsky district, Namangan region) in 1924 and one from Alma-Ata Zoo in 1939, were received at the Moscow Zoo (http://www.zootierliste.de/en?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2). The number of those saigas and their further fate are unknown.

After almost half a century, the Moscow Zoo made a renewed attempt to keep saigas in captivity; in 1981, it obtained two-year-old animals (one male and two females) that were wild caught as newborns in Kalmykia and raised at the Djanybek Station of the Laboratory of Forestry of the USSR Academy of Sciences (Petrishchev, Kholodova, 1980). However, these animals survived for less than three years.

The next attempt was made on the basis of the *Moscow Zoo's Breeding Centre for Reproduction of Rare Animal Species* (Volokolamsky District, Moscow Region) where many ungulate species, including goitered gazelle, Siberian ibex, bharal, Marco Polo sheep, Sichuan takin, kiang, alpaca, and many others, have been successfully kept and bred since 1994 (Ostapenko, Kuprikova, 2013).

In August of 2000, 24 saiga calves (7 males and 17 females) aged three months were brought to the Moscow Zoo's Breeding Centre. The calves were wild caught as newborns in the North-West Pre-Caspian region (Republic of Kalmykia) and hand-raised at the Captive Breeding Station of the Centre for Wild Animals of the Republic of Kalmykia in Khar-Buluk village (Kholodova *et al*., 2005). In February of 2001, another group of saigas arrived to the Breeding Centre from Kalmykia, which consisted of 35 wild caught animals (10 males and

25 females, most of which were already pregnant by the time of arrival). In 2003, one adult male from this group was sent to the "Saiga" Captive Breeding Centre of the Ilmeno-Bugrovoy Sanctuary (former Astrakhanskoye State Experimental and

Hunting Enterprise) in Astrakhan region to be introduced into a saiga group for participating in the rut. In 2005, when no mature males remained at the Moscow Zoo's Breeding Centre, this male saiga was returned to the Centre for breeding; besides, a new male was shipped to the Moscow Zoo's Breeding Centre and a new female arrived there in October of the same year. In October of 2007, four more females were shipped from Kalmykia to supplement the stock kept at the Breeding Centre.

Despite all efforts, no progress was made in establishing a viable group of saigas at the Moscow Zoo's Breeding Centre; the last female died in August of 2012 (Ostapenko, Kuprikova, 2013). In total, 65 saigas were brought to the Moscow Zoo's Breeding Centre in 13 years (18 males, one of which was brought in on two occasions, in 2000 and 2005, and 47 females), and 106 saiga calves were born at the Centre (53 males, 48 females, and 5 calves of unknown sex) (Table 1).

Average lifespan of saigas at the Moscow Zoo's Breeding Centre was 3.1 yeas for the wild caught females and 3.56 years for the males; average lifespan for the sexes combined was 3.2 years (Ostapenko, Kuprikova, 2013).

It should be noted that the saigas kept at the Moscow Zoo's Breeding Centre bred on regular basis, but the numbers of produced offspring varied depending on the year from 34 in 2002 to one in 2009 (Table 2). Average survival rate of the saigas born at the Breeding Centre was 5.04 months, with the females living longer than the males (6.1 and 4.5 months, respectively). Fewer than 10% of the saiga calves born at the Centre survived to the age of one year, while the maximum survival rate of these saigas was 5.6 years for females and 7.1 years for males).

Females with young calves were kept on the natural substrate in the enclosure located next to the pond and measuring 1.5 ha (Kashinin *et al*., 2005). The only shelter was presented by a sun shed installed over an asphalted area with the size of about 50 m^2; the feeders were settled in this area. A pen with the area of 300 m^2 adjacent to

Table 1. Status of the saigas at the Moscow Zoo's Breeding Centre in the period 2000–2012 (from the data of L.Ya. Kurilovich, pers. comm.)

Year	Arrivals	Deaths of adults	Births	Deaths of produced offspring	Total as of December 31
2000	24	2			22
2001	35	19	31	26	43
2002		19	34	34	24
2003		12	11	9	13
2004		6	7	6	9
2005	3	4	4	4	8
2006		5	4	2	5
2007	4	2	3	3	7
2008		4	3	3	3
2009			1	1	3
2010			4	2	5
2011		3	4	4	2
2012		2			0

Table 2. Survival rates of saiga calves born at the Moscow Zoo's Breeding Centre (from the data of L.Ya. Kurilovich, pers. comm.)

Year	Births, Total (♂.♀.unk*)	Survival rates (in days)							
		0	1–3	4–10	11–30	31–92	93–182	183–365	>365
2001	31 (17.12.2)	6.3.1	3.1		3.1.1	1.1	2.2	0.1	2.3
2002	34 (16.18)	3.7	9.6	2.1			2.4		
2003	11 (8.3)		2.0	1.0	0.1	2.0	2.1	1.0	0.1
2004	7 (4.3)	0.1	1.0	1.0	0.1		1.1		1.0
2005	4 (0.2.2)	0.0.1	0.0.1			0.2			
2006	4 (2.2)	1.1							1.1
2007	3 (1.2)		0.2				1.0		
2008	3 (1.2)					1.2			
2009	1 (1.0)	1.0							
2010	4 (1.3)						1.1	0.1	0.1
2011	4 (2.1.1)	0.0.1	1.0		0.1	1.0			
Total	106 (53.48.5)	11.12.3	16.9.1	4.1	3.4.1	5.5	9.9	1.2	4.6

*Note – sex is unknown.

the first enclosure was also asphalted (for reducing the risk of infectious diseases) and fenced with a wall. The pen was used for saiga calving and females with calves were kept there until the calves reached the age of three months. Because of the high aggressiveness of adult males, each of the males was kept in a separated enclosure with the area of 24 m^2; these enclosures were also asphalted. In the rutting period, each of the males in turn was given access to the females' enclosure, which helped to prevent animal traumas.

The saigas were fed on pellets, barley, hay or grass (depending on the season), browse of deciduous species, and grated carrot (Kashinin *et al*., 2005; Gorval, 2009). Salt-lick remained in the feeders permanently, and the saigas willingly licked it. Besides, in summer time the animals were offered small amounts of clay and charcoal. In winter, the diet of saigas was supplemented by vitamins (Gorval, 2009). The keepers sought to make the diet more diverse by offering saigas various plants growing in territory of the Centre and surrounded areas, which included mugwort, goose-foot, clover, and sea buckthorn browse (Kashinin *et al*., 2005).

In the first years, the survival rate of the calves born at the Moscow Zoo's Breeding Centre was extremelly low (see Table 1), which was attributed to the climatic differences between Moscow and North-West Pre-Caspian regions. Since the spring in the south arrives a month earlier (it may be quite cold and humid in Moscow in May), it was decided to artificially change the time of mating and introduce males to females in January; as a result, the mortality rate of the newborn calves had significantly decreased (Ostapenko, Kuprikova, 2013). However, just few individuals survived to the adult age.

Curators and keepers of the Moscow Zoo's Breeding Centre believe that keeping saigas in captivity imposes many challenges (L.Ya. Kurilovich, pers. comm.). It has been noted that high mortality level was associated with stress, insufficient sizes of

enclosures, and, to some extent, inadequate keeping conditions (higher humidity in Moscow region, and differences between the natural and captive diets of animals). The causes of animal deaths included pasteurellosis, tympanitis, bronchopneumonia, dictyocauloses, candidiasis, sero-plastic pericarditis, myocardosis, necrotic hepatitis, etc. (Kashinin *et al*., 2005).

Apart from the Moscow Zoo and its Breeding Centre that are most experienced in the work with saigas, many zoos of the former USSR were keeping animals of this species during different periods.

The Leningrad Zoo received saigas on four occasions, in 1937 (two males and one female), 1938 (one male and one female from Kalmykia), 1957 (one male and two females from Astrakhan Region), and 1958 (six males and five females from Kalmykia). Totally, 19 saigas were brought to Leningrad Zoo, and two calves were born at the Zoo in 1960; regretfully, both calves died at the age of five months from unknown causes (Sokolov, Kholodova, 1996). The lifespan of saigas in captivity was quite short; only 7 of 19 animals survived for over a year. Two of these seven saigas were sent to other zoological institutions, and the rest of the animals died after living at the zoo from 1.3 to 3.5 years (Sokolov, Kholodova, 1996).

A pair of saigas (a male and a female) that arrived to *Tallinn Zoo* from Kyzylorda Region (Kazakhstan) in 1963 survived for less than one year (3 and 7 months, respectively) (Sokolov, Kholodova, 1996).

Saiga antelopes were kept at *Novosibirsk Zoo* in 1965, 1968, 1969, 1972, and 1974 (International Zoo Yearbook, 1966; 1969; 1970; 1973; 1975). There is virtually no information about these animals. Four saigas that were obtained from Frunzenskoye Zooobjedineniye (Frunze Zoo Trade Company) in 1972 are known to die of various causes within three years (Sokolov, Kholodova, 1996).

Chymkent Zoo kept 41 saiga antelopes in the years 1981–1989 (Sokolov, Kholodova, 1996); these animals were brought to the Zoo from different areas of Kazakhstan. Eleven saiga calves from Soukhaz district of Chymkent region arrived to the Zoo in 1981 and 24 more saiga calves, in 1984; one saiga calf from Kyzylorda Region was brought to the Zoo in 1986. In 1984 and 1985, local residents handed adult saigas over to the Zoo; those animals survived for various periods (maximum three years), but the mortality levels were very high among young saigas. No information is available about saiga breeding at Chymkent Zoo.

At *Rostov-on-Don Zoo*, saigas were exhibited in 1969, 1972–1973, 1976, and 1988–1989 (International Zoo Yearbook, 1970; 1973; 1974; 1977; 1989; 1990). In June of 1988, six saiga antelopes (three males and three females) wild caught near the city of Karaganda (Kazakhstan) were brought to the Rostov-on-Don Zoo, but no one of these animals survived to the age of one year; the last male and female died in January and March of 1989, respectively (Sokolov, Kholodova, 1996).

Saiga antelopes were known to be kept at *Alma-Ata Zoo* in 1972 and 1973 (International Zoo Yearbook, 1973; 1974). Eight newborn saigas (four males and four females) wild caught in Jezkazgan Region of Kazakhstan were brought to the Zoo in 1992; five of these animals survived for less than six months, and the other three died in 1993 at the age of 1.3–1.5 years (Sokolov, Kholodova, 1996). In September 2015,

two hand-reared saigas, a male and a female, each aged two years, were brought to Almaty Zoo (former Alma-Ata Zoo) from the Scientific Research Institute for Biological Safety Problems of the Committee for Control of Education and Science of the Ministry of Education and Science of Kazakhstan. In the spring of 2016, two calves (male and female) were born to this pair (https://www.caravan.kz/news/dvasajjgakarodilis-v-almatinskom-zooparke-377494/), but the breeding female died in July of the same year (http://bnews.kz/ru/news/obshchestvo/v_rezultate_neschastnogo_sluchaya_v_almatinskom_zooparke_pogib_saigak-2016_07_15-1281548). In May 2016, the Centre for Wildlife and Conservation of Biodiversity (Kazakhstan) sent three newborn female saigas to Almaty Zoo (B.B. Sarsenova, pers. comm.). As of April 2017, four one-year-old females and two males born in 2013 and 2016 were kept at the Zoo (Fig. 3) (B.B. Sarsenova, pers. comm.).

Some other zoos had saiga antelopes in their collections during the times of the USSR; those animals were kept in the zoos of *Tbilisi* (1972), *Dushanbe* (1972–1973), *Odessa* (1973), and *Karaganda* (1976) (International Zoo Yearbook, 1973; 1974; 1977). V.A. Minoransky and S.V. Tolcheeva (2010) mention that saigas were kept also in Yerevan (Armenia) but do not provide any details.

The earliest data about saiga antelopes in the *zoos abroad* refer to the last half of the 19th century. Several saiga antelopes were kept at London Zoo in 1864–1865 and in 1866–1869 (Mohr, 1943/1944; http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2). In 1972–1875, Berlin Zoo exhibited a male that was kept at the Zoo during three years and a female that died in the second year of life. Saigas were also kept at the zoos of Cologne (1874), Hamburg (1876–1877), Antwerp (1878) and Bremen (1889) (Dolan, 1977; Pagel, Spieb, 2011). In the early 20th century saigas were kept in the private collection of Duke of Bedford (England, Woburn); all animals from the first group that arrived in 1902 died in the first year of life, while 19 specimens acquired in 1906 produced offspring in the first

Figure 3. Saiga antelopes at Almaty Zoo (Photo by A.S. Chimiruk).

year though no individuals survived to the age of two years (Dolan, 1977). In the 1930s, six to eight saiga antelopes were kept at the zoos of Berlin (1934), Hamburg (1938, 1939, and 1941) and Hannover (two saigas in 1936) (Mohr, 1943/1944).

J.M. Dolan (1977) notes that at that period a German animal trade company belonging to Ruhe family imported saigas for their further transportation to the USA. For instance, the National Zoological Park in Washington purchased a pair of saigas in 1934 and one female saiga in 1935; New York Zoological Society imported one female in 1936 and one female in 1937, and Saint Louis Zoo received one male and two females in 1937. In all cases, the saigas did not live long, but death causes have not been described (Dolan, 1977).

The attempts to keep saiga antelopes in zoos were renewed only in 1949 when Wassenaar Zoo (the Netherlands) imported several saigas from the USSR (Jones, 1996). In 1950, the first two pairs of saigas were exhibited at Prague Zoo (Dolan, 1977). In total, 52 males, 84 females and 12 saigas of unknown sex arrived to Prague Zoo in the period November 1950 – October 1972. All saigas were imported from the Soviet Union, and about 50% of them (29 males, 43 females and 4 saigas of unknown sex) did not survive to the time of their planned shipment to other zoos. An important role in the animal trade between the East and the West belonged to Tierpark Berlin (GDR) where 332 arrivals of saigas were recorded in the period from 1958 to 1982 (Pohle, 1974; 1987). All these animals were imported from the USSR at the age of 3–14 month, with the greater proportion being presented by the calves at the age of six months.

In the following years, saiga antelopes were kept in many zoos in Europe, Asia and North America, and some of these zoos managed to create adequate breeding conditions for this species. In 1960–1970, saigas born in USA zoos were used as founders in the groups of this species in Assinboine Park Zoo (Winnipeg, Canada), Edmonton's Polar Park/Alberta Game Farm (Canada) and San Diego Wild Animal Park (USA) (Dolan, 1977).

San Diego Wild Animal Park was most successful among the zoos of the USA in captive husbandry of saigas; in total, 34 males and 63 females of the saiga antelope were kept there in the period from 1970 through 2003 (Randy G. Rieches, pers. comm.). In various years, from one to 28 individuals lived in the enclosure with the size of 1,115 m^2 (Rubin, Michelson, 1994). Mean lifespan of saigas was 1,520 days for the females (N=58) and 1,084 days for the males (N=32), and some saigas (two males and four females) survived for almost 9 years. Ninety six saiga calves were born at San Diego Wild Animal Park in the period 1975–1994 (43 males and 53 females) (International Zoo Yearbook, 1962–2013).

The story of the most successful husbandry and breeding of saigas in Europe is presented in the paper of Vera Rduch and her colleagues (Rduch *et al.*, 2016). The paper provides a detailed description of the long-time work with these animals at the Cologne Zoo (Germany). Within a period from 1976 to 2009, a total of 99 (51 males and 48 females) saigas lived in Cologne (the last male died in October 2009). Each year, from one to 10 animals were kept in the enclosure of 640 m^2. Average lifespan in the females was 1,584 days (N=35), which is almost twice as long as the average

lifespan in the males, that reached 934 days (N=40). The oldest female died at the age of 10 years, while the oldest male lived at Cologne Zoo for almost 7 years and 5 months. A total of 79 saigas were born in Cologne, 43 males and 36 females.

Using available literature and Internet sources, we have compiled a database containing information (city, country, periods of holding saigas, births, and references) about all 92 zoological institutions that have kept saiga antelopes since 1864 (see Appendix).

Based on the data from the International Zoo Yearbook (1962–2013), we have found the trends in the numbers of saigas that were kept in various zoos from 1949 to 2017 (Fig. 4). Attempts to keep saigas were made in that period in 67 zoos of 29 countries (taking into account the Republics of the former USSR, GDR and Slovakia). The average number of saigas kept by one zoo was 4.98±3.74 specimens per year. Saigas were most widely presented at the zoos in the period 1971–1973 (15 to 26 zoos), and the largest number of saigas in zoos was registered in 1985. Clearly, the reduction in saiga numbers in zoo collections occurred in 1986, at the beginning of the "*perestroika*" (reformation) period in the USSR.

Analysis of available data has shown that there were 29 zoos where saigas produced offspring (International Zoo Yearbook, 1962–2013; Informational Issue of Eurasian Regional Association of Zoos and Aquariums, 2005–2016), with the total number of born calves exceeding 565 specimens. Captive born saigas bred successfully at least in eight zoos including the Moscow Zoo's Breeding Centre, Russia; zoos of Nuremberg and Cologne, Germany; Plancendael Zoo and Antwerp Zoo, Belgium; Emirates Park Zoo, UAE; and Oklahoma City Zoo and San Diego Wild Animal Park,

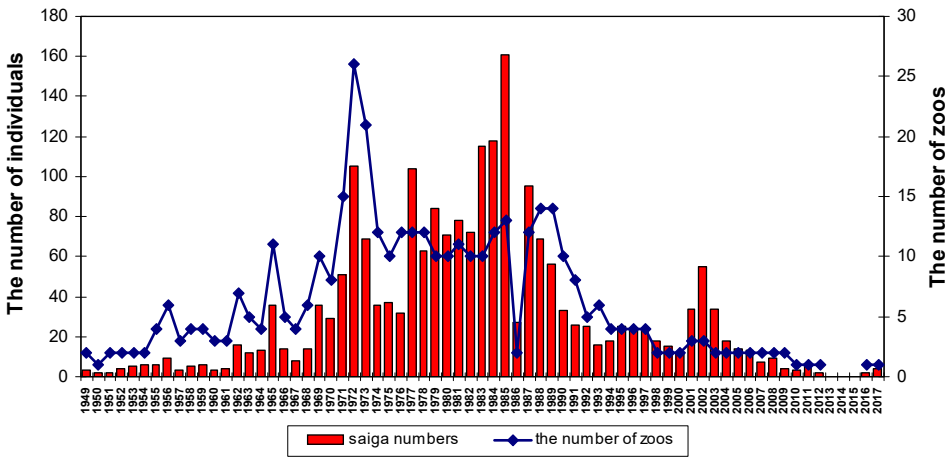


Figure 4. The numbers of saigas in the world zoos in the period from 1949 to 2017 (as of the 1st of January of the current year; International Zoo Yearbook, 1962–2013, Informational Issue of Eurasian Regional Association of Zoos and Aquariums. 2005–2016, etc.). Data on the saigas kept in the Askania Nova Biosphere Reserve were not included in the calculation of the total number of animals in the period from 1980, because the animals in Askania Nova were moved to a large enclosure and data for 1986 are incomplete.

USA (International Zoo Yearbook, 1962–2013). Data of M.L. Jones (1996) indicate that singles were born twice as often as twins and that there has been only one case of the birth of triplet, which was most likely associated with the female's age. 61 females of the total of 135 died after the first parturition and 30 females died after their second parturition. Only four females produced 5 litters, two females produced 6 litters, and one female, 7 litters. Maximum lifespan of the breeding females was 9 years and 8 months for wild born saigas and 8 years and 3 months for captive born females. Only one of the males that participated in the rut survived to the age of 6 years and 7 months, while a "bachelor" male lived 9 years. 24 male saigas of the total of 47 participated in the rut only once, 10 males, two times, 5 males, three times, and 8 males, four times.

Over the years of the captive husbandry of saiga antelopes, zoos have gained a great experience and knowledge in the areas of enclosure design, nutrition, breeding and veterinary control of diseases; this experience has been summarized in the paper of M.V. Kholodova and V.M. Neronov (1996). However, so far no zoo has been able to achieve a goal of establishing a viable group of saigas in captivity. The lifespan of saigas kept at the zoos of Russia and former USSR generally did not exceed three years. Most animals died before reaching the age of one year, and mortality rate of the young was particularly high in the first months of life (Sokolov, Kholodova, 1996). Similar situation was observed in most of the foreign zoos where very few saigas survived to the age of 9 or 10 years (Kholodova, Neronov, 1996; Jones, 1996). The causes of death were similar in different zoos; they included various traumas (mainly, of the legs), hemorrhagic pneumonia, acute gastroenteritis, endocarditis, nutritional myopathy, metabolic disorder, heart failure, gastrointestinal diseases, abscesses, helminthiases, etc. It has been noted that in most cases captive adult saigas and especially young animals suffer strong stress, which may lead to the listed diseases.

To reiterate, despite all efforts and long-time attempts to raise saigas in captivity, currently this unique species is kept only in one zoo in the world, the zoo of Almaty, Kazakhstan (https://tengrinews.kz/strange_news/krasnoknijnyie-saygaki-poyavilis-v-zooparke-almatyi-280610/). However, specialists remain hopeful that this antelope will appear in their collections. For instance, in the spring of 2013, administration of Calgary Zoo, Canada, published the Master Plan of the Zoo development for the period of twenty years, where it was stated that saiga antelopes will be exhibited at the zoo after the completion of the renovation process (http://www.calgaryzoo.com/masterplan/the-island.html#shadows).

Husbandry and breeding of saigas under artificial conditions

Conservation of the genetic diversity of rapidly declining animal species and populations is one of the critical tasks in the activities aimed at maintaining viable populations of wild animals (Altukhov, 2003; Speilman *et al.*, 2004). This task is implemented by various institutions and particularly by modern zoos that have gone well beyond the role of purely educational organizations and transformed into the last resort for many animal species that have been eliminated or displaced from their natural habitats by humans. However, while creating favourable husbandry conditions for the animals in their care and achieving successful breeding of many species, the zoos are not able to provide wild animals with a fulfilling life (lack of space, artificial social structures of animal groups, etc.) (Spasskaya *et al*., 2005). To this end, a central role should be played by breeding centres focused on the conservation of gene pool of rare and endangered species through establishing and maintaining sustainable and genetically viable groups of animals in enclosures or under semi-wild conditions (Flint *et al*., 2002). Additionally, breeding centres are supposed to implement many other important tasks, including development of animal husbandry and breeding methods, genetic management and studbook keeping, scientific studies, maintenance of the reserve populations for reintroduction programs and, to some extent, for commercial use, and ecological education.

All these tasks are successfully implemented by seven existing saiga breeding centres, three in saiga range states (Ukraine, Kazakhstan, and China) and four in Russia (Fig. 5).

The experience gained by the zoos in keeping saigas shows that successful breeding of this species in captivity can be achieved by creating conditions that fulfil biological requirements of saigas; these animals should be kept in spacious enclosures and their captive diet should include plants that are preferred by wild saigas. Such conditions have been created at three breeding centres: Askania Nova Biosphere Reserve (Ukraine), Breeding Centre in Gansu Province (China), and Breeding Centre in Tarkhankut National Park (Crimea, Russia). In the listed centres, saiga antelopes are kept in the pens together with other ungulate species, and successful breeding of saigas has been achieved in all of these centres.

Foreign countries

Currently, three special centres for saiga antelopes are active outside Russia, including Askania Nova Biosphere Reserve (Kherson Region, Ukraine), Centre for Wildlife and Conservation of Biodiversity (Kazakhstan), and Endangered Wildlife Breeding Centre in Gansu Province (China). Besides, attempts to breed saiga antelopes were made in Uzbekistan (the “Djeiran” Ecocenter) and Mongolia.

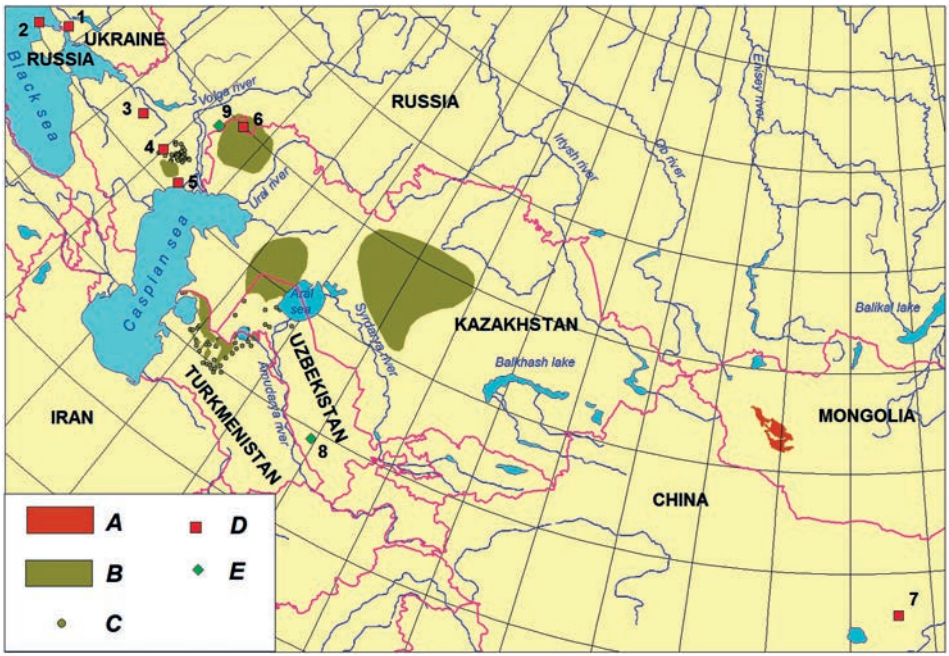


Figure 5. Current distribution of the saiga antelope and existing saiga breeding centres. *À* – distribution of *S. t. mongolica (=S. borealis*); *B* – distribution of *S. t. tatarica*; *C* – sites where siga individuals were recorded in recent years; *D* – centres where saiga antelopes are currently kept: 1 – Askania Nova Biosphere Reserve (Kherson Region, Ukraine); 2 – Tarkhankut National Park (Crimea, Russia); 3 – Centre of Rare Animals of European Steppes (Rostov Region, Russia); 4 – Yashkul Captive Breeding Station of the Centre for Wild Animals of the Republic of Kalmykia (Republic of Kalmykia, Russia); 5 – "Saiga" Captive Breeding Centre (Astrakhan Region, Russia); 6 – Centre for Wildlife and Conservation of Biodiversity (Kazakhstan); 7 – Gansu Endangered Wildlife Breeding Centre (Gansu Province, China); *E* – centres where saiga antelops were kept in the past: 8 – "Djeiran" Ecocenter (Bukhara Region, Uzbekistan); 9 – Djanybek Breeding Station (Russia).

Ukraine: Askania Nova Biosphere Reserve

Askania Nova Biosphere Reserve (Kherson Region, Ukraine) has the richest and longest history of keeping saiga antelopes in captivity. The saiga (just one specimen) was the first ungulate species brought by Baron Friedrich Jacob Falz-Fein to his newly founded zoo, "Askania Nova", in 1887. Located within the Black Sea Lowland, Askania Nova Biosphere Reserve covers a small part of the watershed between Dnepr and Molochnaya rives, the territory presented by a flat, closed river basin with a slight gradient in the direction northeast-southwest (absolute heights – 19 and 34 m above sea level) and saucer-shaped depressions.

The climate of the territory is temperate continental with hot long summers and short bleak winters with frequent thaws that lead to rapid melting of snow cover, which usually has a depth of no more than 10 cm. Frosts with the temperature drop-

ping down to -34°C C occur from time to time, and strong winds and storms are quite common in this region. Average monthly temperature is -3.6 °C for January and +23.4 °C for July. Precipitation is relatively low (about 400 mm per year).

509 higher plant species of 265 genera and 63 families are found in the alkaline black and chestnut soils of the virgin fescue and feather-grass steppe (Zavadovsky, 1924). The most common plant families include Asteraceae (82 species, or 16.1% of all plant species), Poaceae (61, or 12.0%), Fabaceae (39, or 7.7%), Brassicaceae (32 и 6.3%), and Lamiaceae (26, or 5.1%) (Shapoval, 2012). Saiga antelopes in Askania Nova feed on more than 90 plant species (Treus *et al*., 2002).

1,304 species of anthropods, three amphibian species, and 6 species of reptiles occur in the reserve (Semenov, Reut, 1989; Gavrilenko *et al*., 2010). The reserve serves as a stop-over for 226 species of migratory birds, with 107 of them nesting in the virgin steppe. Most numerous birds are larks, wheatears, quails, tawny pipit, and grey partridge; rare birds include the great bustard, little bustard, and steppe eagle. Rodents, such as voles, European hamster, striped field mouse, and birch mice, are most common among 41 species of mammals (Semenov, Reut, 1989; Gavrilenko *et al*., 2010).

There are 42 species of wild ungulates kept in the enclosures of the Askania Nova Biosphere Reserve, including Przewalski's horses, zebras, common elands, wildebeests, buffaloes, bisons, Barbary sheep, Siberian ibex, and markhors. From April through November all ungulates are grazing in the fenced areas of the enclosures built in the steppe (Yasinetskaya, 2006).

Six important periods related to saiga antelopes can be identified in the history of the Askania Nova Biosphere Reserve (Steklenjov, Smagol, 2011).

In the period from 1887 to 1921, one to 24 saigas were kept at a time in the zoo that in 1921 was given a status of nature reserve (Salgansky *et al*., 1963). Although the saigas did not start breeding until 1893 (Falz-Fein, 1930), the captive population was growing, mainly due to new arrivals: nine shipments with saigas were received at the Zoo during that period (Zavadovsky, 1924; Kasyanov, 1933; Falz-Fein, 1997). The saigas were kept on the natural substrate in the enclosure with the size of 60 "tithes" (ca. 65 ha). Attempts to keep saigas alive failed, which was attributed to the lack of knowledge of biological requirements of the species, traumas, and epizootic diseases (anthrax, pasteurellosis, tuberculosis, pneumonia, etc.) (Zavadovsky, 1924; Kasyanov, 1933; Falz-Fein, 1997).

Patchy information is available about the second period (1925–1941). It is believed that four shipments with saiga antelopes totally numbering 34 individuals were received at the reserve in the period 1925–1931 (Salgansky *et al*., 1963; Treus, 1968; Steklenjov, Smagol, 2011). In the pre-war time (before 1941), main causes of animal deaths were various gastrointestinal, lung and infectious diseases, as well as traumas (Steklenjov, Smagol, 2011). By the time of the occupation of Ukraine (August 1941), twenty saigas were held at the Askania Nova Biosphere Reserve (Steklenjov, Smagol, 2011), and all those antelopes were killed in the years of the Great Patriotic War (Krutyporokh, Treus, 1967).

In the beginning of the third period, in 1947, a new group of animals was brought from Alma-Ata, consisting of 15 saiga antelopes (8 males and 7 females); these animals

were introduced in the small enclosures built in the reserve (Steklenjov, Smagol, 2011). Although 15 saiga calves (13, according to other reports) were born in 1948–1949, the numbers of saigas steadily reduced, and by the year 1951, only two females remained in the Askania Nova Biosphere Reserve (Salgansky *et al*., 1963; Steklenjov, Smagol, 2011). Another attempt to increase the size of captive population was made in September 1951 when five individuals (two males and three females) were brought to the reserve and, together with the remaining two females, released into the enclosure with the size of 100 ha. However, in spite of all efforts, no offspring was produced by the saigas, and all animals died in the period 1951–1956 (Steklenjov, Smagol, 2011).

Reports about new arrivals during the fourth period (1957–1962) are controversial. Some authors (Salgansky *et al*., 1963; Treus, 1968; Steklenjov, Smagol, 2011) indicate that in 1957–1958, saigas (30 to 41 individuals) were brought to the reserve from Astrakhan Gospromkhoz (State Hunting Enterprise). All animals were kept in a small enclosure with the area of one hectare, which resulted in the deaths of 14 adult saigas in the period from January to March of 1958 (Steklenjov, Smagol, 2011). In March 1958, 20 saigas were released in the unfenced area on the Biryuchyi Peninsula, but this measure did not produce positive results as all saigas dispersed and were eventually killed by poachers or stray dogs (Babich, Kaminetsky, 2008). Only one male was found on the peninsula but he died shortly. In 1958, five saigas (two males and three females) that were still living in the reserve were moved to the large pen measuring 100 ha where ungulates of different species were kept. Saiga females bred successfully in the enclosure for three years (Salgansky *et al*., 1963), but no saiga survived to 1962, and, importantly, 80% of all saigas died from traumas inflicted by ungulates of other species.

The fifth period started in 1971 with the arrival of 21 saigas (6 males and 15 females) from Astrakhan Gospromkhoz. The animals were released into the pen with the size 80 ha and chain link fence. However, the husbandry conditions were not appropriate for the saigas, and many animals died (Steklenjov, Smagol, 2011). Although eight offspring were born in 1971–1978, only one male of all animals survived to 1979. Main causes of saiga mortality were attacks of stray dogs, traumas inflicted by ungulates of other species, gastrointestinal diseases, etc (Steklenjov, Smagol, 2011)

The last and most successful stage started in 1979 after the arrival of 72 saigas (with most of them being at the age of three months) from Kalmykia. About 40% saiga calves died from stress and other reasons associated with capturing and transportation (Steklenjov, 2002), while 37 remaining animals were released into the large enclosure and formed the core of the group that is currently kept at the reserve.

Currently, saiga antelopes are kept in two enclosures (with the sizes 1,200 and 680 ha) built in the Great Chapelsky Pod section of Askania Nova, a unique depression with a flat relief and vegetation cover mostly presented by fescue and feather grasses (Gavrilenko, 2009). Saiga husbandry regimes used at the Askania Nova Biosphere Reserve (that in 1985 was included in the UNESCO World Network of Biosphere Reserves (WNBR) and given a status of Biosphere Reserve) differ significantly from typical zoo regimes. First, the animals feed on natural vegetation the year round; even in the snowy winters with glazed frost they prefer digging snow in the areas with vehicle

tracks, ignoring the hay brought in by the staff of the reserve. Second, there are no any shelters in saiga enclosures, that would protect the animals from adverse weather (winds, rain), though, as was mentioned above, the climate of this region is characterized by extreme daily temperature variations, frequent thaws, rains, snow cover, and sleets in winters and long drought periods, storms and other extreme weather conditions in summers (Gavrilenko *et al*., 2009). Yet, despite unfavorable conditions, the numbers of saiga antelopes in the reserve have increased steadily for the recent several dozens of years (Fig. 6). An average growth rate of the "Askania Nova" saiga population in the period 1979–2015 was 9.84%, which is half the growth rate of the North-West Pre-Caspian wild population of this species (Zhirnov, 1982). According to data of V.O. Smagol, (2015), the highest number of saigas (650 individuals) was registered in July 2015, though data from EARAZA materials (Informational Issue of Eurasian Regional Association of Zoos and Aquariums, 2016) indicate that as of 01.01.2016, there were only 551 saigas at the Askania Nova Biosphere Reserve.

In the opinion of V.O. Smagol (2015), fluctuations in the growth rate of saiga population kept in Askania Nova under semi-wild conditions are attributable mainly to climate factors. In favorable years, after mild winters characterized by small amounts of snow, the growth rate may reach 55.4%, while harsh and snowy winters result in the death rates exceeding the birth rates (negative growth rate: -39.6%). Removal of saiga calves for hand-rearing also has a negative effect on the growth rates (over 40% of calves were hand-reared in some years) (Smagol, 2015). For the period from 1984 through 2006, 110 calves have been hand-reared, and 35 of them were transferred to various zoos (http://zoobusiness.kiev.ua/animals/wild/sajgak-unikalnoe-yavlenie-stepnoj-prirody.html).

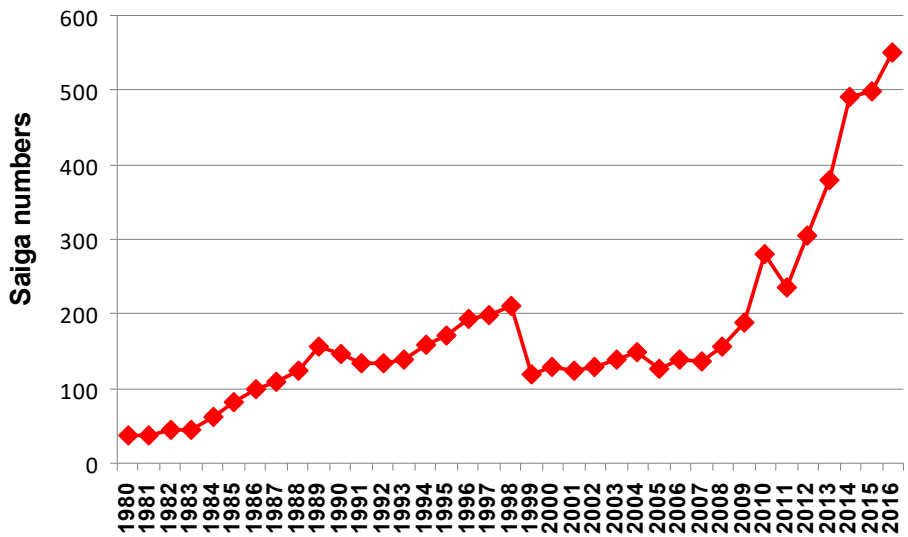


Figure 6. Numbers of saigas in the Askania Nova Biosphere Reserve in the period 1980–2016 (based on the data from: IZY, 1981–1998; Informational Issue of Eurasian Regional Association of Zoos and Aquariums, 2005–2016; Gavrilenko *et al*., 2009; Steklenev, Smagol, 2013 and others).

Predation is another factor limiting the growth of the population size (Gavrilenko, 2009; Gavrilenko *et al*., 2009). Young animals are especially susceptible to the predation. The main cause of the mortality in young saigas is predator attacks (foxes – 10.2%, stray dogs – 11.5%, gulls – 2.9%) and traumas (9.9%) (Treus, Zvegintsova, 2000). The calving period in saigas usually coincides with the time when foxes leave their dens, and the remains of saigas can be seen near almost all fox dens. Losses to birds (crows, Caspian gulls, golden eagles, and white-tailed eagles) match the losses caused by foxes. While crows and Caspian gulls usually attack newborn calves, golden eagles and white-tailed eagles hunt adult debilitated saigas in winter. In the last two years, birds of these two species regularly wintered in the reserve. Crows also have become common in the steppe of the reserve: seven to nine crow pairs nest in the spring time on power line poles, with each of the pairs raising a brood of 3–5 chicks. Six crows were seen attacking a female's first newborn calve, while the female saiga was giving birth to her second young 1.5 meters away; in the beginning, this bird group attacked the female, driving her away from the calve (Gavrilenko, 2009). The loss to bird predation is particularly significant in the periods of droughts since saiga calves are easy to detect in low grasses. Another risk factor is presented by household dogs; in some years the dogs even entered the saiga enclosures (Dumenko, Treus, 2000). Particularly, during 1995–1999 dogs killed 67 most vulnerable saigas, including males, which grew weak after the rutting period, and females with young, especially in calving seasons. Opinions differ, however, over the effects of wolf predation. For instance, V.S. Gavrilenko (2009) believes that wolves that have occurred in the steppe of the reserve since 1996 do not have any impact on the saigas kept within the pens, as wolves mostly kill hares and small rodents, sometimes raiding sheepcotes. On the other hand, it was shown that six wolves living in the reserve killed six saigas just in 2000 and 2001 but never attacked any other ungulates (Dumentko, 2002).

Predators are not the only threat to saigas. Results of the years of observations have demonstrated that members of Equidae family may show aggression towards smaller species of even-toed ungulates, when kept in the same enclosure (Treus, 1968; Smagol, 2015). Particularly, there have been cases when stallions of Przewalski's horse and Turkmenian kulan attacked pregnant female saigas and newborn saiga calves. Mortality of adult saigas may be caused by many reasons, including various diseases (6.2%), unsuccessful births (1.9%), death of males after the breeding season (8.9%), old age (4.8%), etc. (Treus, Zvegintsova, 2000)

Rut in saigas occurs in December, at temperatures below zero (Smagol, 2014b). Calving season in the saigas living in Askania Nova Biosphere Reserve is more extended than that in the wild saigas, lasting from late April to July (Treus *et al*., 2002), though the length of the mass calving is six to nine days (Smagol, 2014b) (Fig. 7). Twins are most common among newborns (Smagol, 2014b). Study of saiga breeding in Askania Nova Biosphere Reserve has shown that fluctuations in the timing of breeding activity, mating and calving depend on weather conditions and availability of fresh food (Steklenjov, 2002).

Lifelong body mass indexes for the male and female saigas kept in the enclosure of the Askania Nova Biosphere Reserve are lower than those for the saigas from the

North-West Pre-Caspian population (Smagol, 2014a). For instance, the average weight of newborn males is lower by 12.5% and average weight of newborn females, by 6.9%; these indicators in adult saigas are 14.1% and 16.5%, respectively. V.O. Smagol (2014a) presumes that this effect is associated with captive conditions and inbreeding resulting from the small number of the founders of the captive population.

Long-term health monitoring of saigas in Askania Nova Biosphere Reserve has revealed three species of Cestoda and 13 species of Nematoda, with the prevalence of Strongylida order members (Zvegintsova, 2011).

The longevity of the male saigas kept in spacious enclosures reaches 5–6 years, while females typically live longer (Treus *et al*., 2002). In the absence of anthropogenic pressure, adult males comprise a significant proportion of all animals in the herds (average 23.4%) (Steklenev, Smagol, 2013), which is much higher than the proportion of adult males in the wild, registered in the recent years (Neronov *et al*., 2013).

Study of herding behaviour of the saigas kept in the enclosures of the Askania Nova Biosphere Reserve has shown that behavioural patterns of captive saigas are similar to that of free ranging animals (Kokshunova *et al*., 2005). During the rutting period males attempt to gather together a small group of females into a harem and compete for receptive females. According to data obtained in the recent years (2011–2014), a harem of one sexually active male consists on average of 2.7±0.3 females, though harems of 15–23 females have also been observed (Smagol, 2014b). In calving season, a saiga herd does not move, staying within "calving grounds" that are usually confined to the feather grass stands in the interfluve plats (Kokshunova *et al*.,

Figure 7. Newborn saiga calve (Photo by V.S. Gavrilenko).

Figure 8. Saigas and kulans in the steppe of the Askania Nova Biosphere Reserve (Photo by V.S. Gavrilenko).

2005). Calving occurs in the areas with low vegetations or on bare ground (Smagol, 2014b). By late May, most saigas with their young keep moving around their enclosures. From middle summer till the onset of rutting (December) the composition of saiga herds and the numbers of saigas in the herds constantly change. Observations carried out in the reserve suggest that saiga navigate effectively in their habitat; they are aware of the system of trails and holes in the fences, sites where they can cross the irrigation ditch to come to the waterhole in the centre of the Great Chapelsky Pod, etc. Even when kept in spacious enclosures, saigas are well adapted to the presence of humans; the animals don't get frightened and do not flee, when people watch them from a car or horse drawn wagon from a distance of 50–80 metres.

In the Askania Nova Biosphere Reserve saigas are kept in the enclosures together with animals of other species (bisons, Przewalski's horses, Turkmenian kulans, nilgais, Cape buffaloes, sika deer and other deer species) (Gavrilenko, 2009) (Fig. 8). This practice proves that saigas can live in the multi-species communities not only in captivity but also in the wild, which is important for the programs of wild population restoration and development of livestock husbandry in arid zones.

Large numbers and high growth rate of the captive population (i.e., by the end of December 2012, there were 380 saigas in the Askania Nova Biosphere Reserve, while in the summer of 2013 saiga numbers reached 487) has led to overgrazing of the restricted area of the virgin steppe. To address this problem and optimize ungulate population size, 82 saigas (52 newborn calves, 13 four-month-old saigas and 17 adult animals) were removed from the herd in 2014 (Smagol, 2015). Besides, the issue of hand-rearing of calves is becoming increasingly urgent as saigas are in great demand. There are plans to sell more than a hundred of these antelopes to zoos and breeding

centres both internally and abroad – to China and other countries, where saigas were extirpated and attempts are made to restore wild populations of this species (http://khersonline.net/2013/09/10/zapovednik-askaniya-nova-vygodno-prodast-partiyu-lishnih-saygakov-v-krym-ikitay.html). Implementation of this plan would help raise necessary funds to maintain unique wild animal collection. Preference will be given to Ukrainian customers interested in the conservation of Ukrainian fauna. In September 2013, the Ukrainians had to pay only 6,000 hryvnias (or US $720, based on the exchange rate of that time) for a young saiga antelope, while for foreign nationals, the cost was US $2,000 per animal.

In 1984, kulans, sika deer, and sigas (8 specimens) were released into the fenced area of 70 ha in the "Elanetskaya Steppe" Sanctuary, protected area that was created by the scientists from Askania Nova and that later received a status of the reserve (Treus *et al*., 2002). However, the attempt to move saigas from the enclosures of Askania Nova Biosphere Reserve to the steppe has failed. According to V.S. Gavrilenko, Director of the Askania Nova Biosphere Reserve (pers. comm.), in 1991 there were no saigas in "Elanetskaya Steppe".

In summer 2013, administration of the Askania Nova Biosphere Reserve signed an agreement on the transfer of ten saigas and five kulans raised at the Reserve to the "Charvina Gavan" (Beautiful Harbor) National Park (currently Tarkhankut National Park, Russia). In October 2013, ungulates of the species that were distributed in Crimea several centuries ago and became extinct in the region due to human activity were released into the fenced area with the size of about 100 ha (http://itogi.ua/society/8960-2013-10-04-11-49-08.html).

In November 2016, six saigas and two kulans were brought from Askania Nova Biosphere Reserve to Odessa Region for keeping in spacious enclosures built specifically for these species in the "Tarutinskaya Steppe" Landscape Wildlife Refuge. It was the first group of the even-toed ungulates typical of steppe ecosystems of Southern Ukraine that will be used for the restoration of the wild populations of ungulates in the well-preserved Tarutinskaya steppe (former military training grounds), which plan will be implemented under the project "Promoting sustainable development of rural communities in remote regions through sustainable use of natural resources and historical and cultural heritage". This activity is carried out by the "Centre for Regional Studies" non-governmental organization with the support of the Republic of Lithuania. Experts from Askania Nova Biosphere Reserve and "Frumushika Nova" Centre for Ethnographic, Green and Rural Tourism provide assistance in the creation of the Landscape Wildlife Refuge (http://www.slovo.odessa.ua/news/15695-saygaki-ikulany-obzhivayut-tarutinskuyu-step.html#ixzz4Wahy8SBl).

Based on his many years of experience, Director of the Askania Nova Biosphere Reserve V.S. Gavrilenko assumes that saiga husbandry implies many more challenges than breeding (and acclimatization) of African and Indian antelopes that have been never distributed in Ukraine (Gavrilenko, 2009).

But the process of establishing saiga breeding centres in Ukraine attains a greater pace despite all odds. In 2018, for example, a Chinese company Shi Zhen Tan Pharmaceutical leased 97 ha (so far, for a term of seven years) of land located near Kamysh

village (Kherson region) for the construction of a spacious enclosure complex for saiga breeding (https://newday.kherson.ua/na-hersonshhine-kitajskie-biznesmeny-i-ukrainskie-uchenye-obedinili-usilija-dlja-razvedenija-sajgakov/). The construction of the complex has been implemented with the support from employees of the Askania Nova Biosphere Reserve who believe that this initiative can prove to be an interesting pilot project and a good opportunity to refine saiga raising and disease prevention methods, and develop better approaches to the conservation of this rare animal species so that these methods could be used in other Ukrainian regions that have appropriate conditions and resources.

The newly created centre has been provided with necessary infrastructure and the highest level of security. An electric wiring is in-built in a high fence for scaring off predators. The complex is provided with security cameras and surrounded by fire-break. Energy is supplied by solar panels. As of the end of November 2018, there were 23 saigas kept in the enclosure complex; the animals were purchased by the Chinese owners of the breeding centre from Askania Nova Biosphere Reserve. All animals have been trained through hand-raising that started from their birth.

However, considering an ongoing demand for saiga horns in the traditional Chinese medicine where saiga derivates together with other substances are successfully used as antipyretics in febrile children and indispensable ingredients of many preparations for the treatment of dozens (!) of diseases and even for improving men's sexual health, it can be assumed that the project of the Chinese company is commercially focused. There are plans to export saiga hides and horns to China, and alive animals are likely to become included in the list of exported goods in the future.

China: Endangered Wildlife Breeding Centre in Gansu Province

The Wuwai Endangered Wildlife Breeding Centre (now Gansu Endangered Wildlife Breeding Centre) was built in 1987 in the area between the northern extensions of Qilian Mountains and southeastern margins of the Tengger Desert, at elevation of 1,766 m above sea level. This area featuring many sand dunes is characterized by a temperate, moderately dry climate, with avarage annual temperature of ca. +7°Ñ (-35 °Ñ in January and +38.5 °Ñ in July) and average annual precipitation of about 76.0 mm. 116 plant species are found in this territory, mostly belonging to the families Poaceae, Fabaceae, and Chenopî diaceae (Liu, 1996) (Fig. 9).

Alfalfa crops cover significant proportion of the fenced territory of the Centre and serve the main food resource for grazing animals (Fig. 10).

The area of about 170,000 ha is a home for the animals of 45 species, including Przewalski's horse, kulan, wild camel, etc. (Kang, Zenian, 2005).

The first four saigas were brought to the Centre from Kalmykia in 1987; later, in 1988 and 1991, 11 individuals were obtained from Tierpark Berlin, Germany, and San Diego Zoo, USA, and 15 saigas, from Kazkhsytan (Kang, 2004). In 1997, the Centre received 14 four-month-old saiga calves raised at the Kalmykian centre for the study and sustainable use of the Kalmykian population of the saiga (ceased to exist by now) (Yu.N. Arylov, pers. comm.).

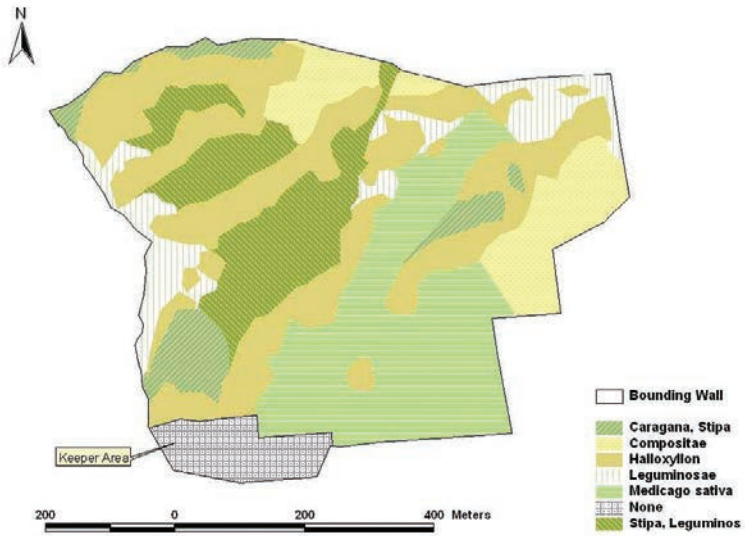


Figure 9. Plan of the saiga enclosure at the Gansu Endangered Wildlife Breeding Centre (Adapted from: Kang, 2004).

Figure 10. Male saiga in alfalfa field (Photo by Aili Kang).

Before 1992, saigas were kept in the enclosure with the sizes 20 m × 30 m, which was later expanded to 27 ha. By the year 2000, the number of saigas reduced by 77%, with only nine individuals remaining in the enclosure (Shaopeng Cui *et al*., 2017), but beginning from 2003 the size of captive population steadily increased. In winter of 2004, there were already 29 saigas at the Centre, and after the birth of 16 calves in May 2005 (Kang, 2004) the total size of the group exceeded 40 individuals. In May 2007, 11 offspring (seven males and four females) were born, and the number of saigas reached 50 (Kang, 2007). Another 24 calves were born in 2009, with the total size of the group coming to 65 individuals (http://www.china.org.cn/environment/news/2009-06/05/content_17894591.htm). The population grew even larger when 49 calves were born at the Centre in 2012 and the total number of saigas reached 129, and the birth of 70 calves in 2013 led to the increase in the population size to 170 individuals (Fenglian Li, pers. comm.). In the following years the population was declining (Fig. 11). Shaopeng Cui and colleagues (Shaopeng Cui *et al*., 2017) believe that founder events, bottlenecks and inbreeding have resulted in low genetic diversity in this captive population, which, together with harsh winter conditions and severe disease outbreaks, has led to large fluctuations in population size.

While saigas were kept in the enclosure with the size of 30 ha, several lethal accidents were registered when males injured or even killed females or each other in the course of chasing or fighting. Such problems do not exist now, and Chinese colleagues aim to increase the number of saigas for their release into the wild within the area of a special saiga reserve. To this end, it is planned to use the existing Xia'erxili Nature Reserve and expand its area to 314 km^2; this reserve is situated within the

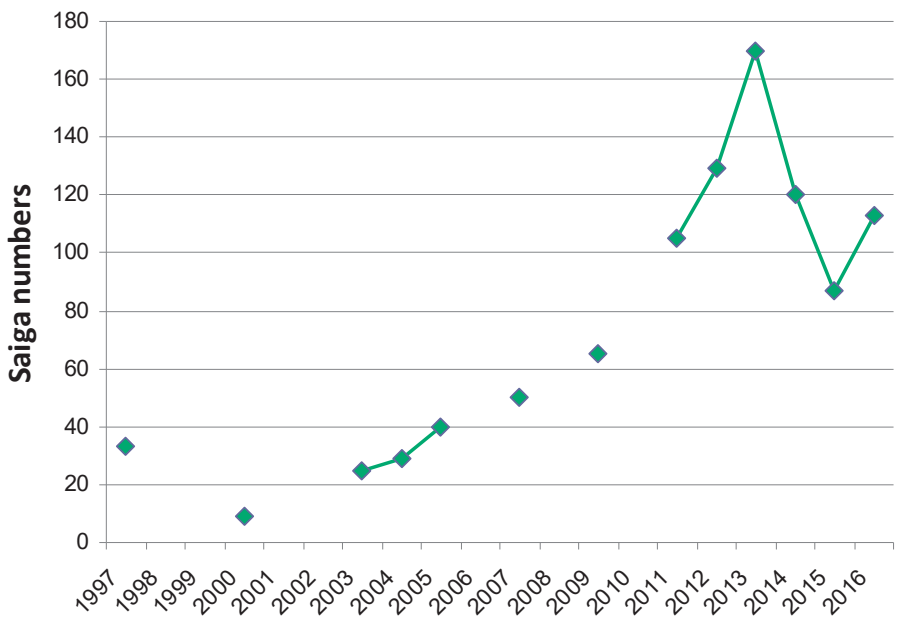


Figure 11. The numbers of saiga antelopes at the Gansu Endangered Wildlife Breeding Centre; 1997–2016.

Figure 12. Saiga antelopes at the Gansu Endangered Wildlife Breeding Centre (Photo by Aili Kang).

historical range of the saiga antelope and the vegetation of the reserve includes many species of sagebrush and feather grasses (Lishu, 2006).

Although recent comprehensive studies have demonstrated that the Gansu Endangered Wildlife Breeding Centre is located outside the historical range of the saiga and current conditions in the habitat are not ideal for these animals (Shaopeng Cui *et al*., 2017), valuable scientific experience has been gained by the Centre for 30 year of its existence. For instance, a number of studies have been carried out, which helped improving husbandry methods and protocols for supplemental feeding of animals (mostly pertaining to the inclusion of potato and carrot pieces into saiga diets) that is usually necessary in the period from November through March (Kang, 2004). Priority areas of the Centre concerning captive breeding include the increase of the size of existing group, genetic monitoring, and study of breeding characteristics of captive bred saigas. So far, no attempts have been made to reintroduce saiga antelopes into the wild.

Kazakhstan: Centre for Wildlife and Conservation of Biodiversity

The Centre for Wildlife and Conservation of Biodiversity was established in 2012 in West Kazakhstan Region on the basis of the Educational research and production centre for biodiversity conservation, with the support of the Ministry of Education and Science of the Republic of Kazakhstan and West Kazakhstan Agricultural and

Technical University named after Dzhangir Khan (http://khabar.kz/ru/news/obshchestvo/item/ 26496-kazakhstanskie-uchenye-namereny-sozdat-geneticheskij-bank-dannykhsajgakov). Initially, the Centre was located in Kaztalovsky district, in the flat territory characterized by dry continental climate and light chestnut soils. The prevailing plant formations are presented by the communities of diverse cereal grasses *(Poa bulbosa, Festuca valesiaca – Tanacetum millefolium)*, Poaceae species with co-dominance of Artemisia (*Poa bulbosa – Artemisia pauciflora),* Kochia and Artemisia species *(Artemisia pauciflora – Kochia prostrata)* and feather grasses with co-dominance of Artemisia *(Stipa capillata – Artemisia austriaca)* (Sarsenova *et al*., 2013, 2014). An enclosure with the sizes 10 × 12 m and height of two meters was built in this area. The enclosure was fenced with chain mesh lined with dried rushes from inside to reduce the risk of injury and provide some protection against winds. Additionally, there were six individual enclosures fenced with asbestos sheeting, and a quarantine facility (Sarsenova *et al*., 2014).

On May 14–15, 2013, in the period of mass calving of saigas, 10 calves (four males and six females) were caught in the wild, 10–15 km from Karaoba village (Kaztalovsky district, West Kazakhstan Region). During some time after their capture, the saigas were kept in the indoor room with the area of 6 m × 8 m and the walls lined with wood fibreboard to smoothen the angles; the room had a wooden floor preventing young saigas from eating soil, which could result in their deaths (Fig. 13).

Saiga calves were fed on whole cow's milk with the addition of fish oil (3 ml per individual) until 2.5 months of age (Fig. 14); later their diet was supplemented with hay, fresh grasses, and grains. Saiga diet always included water and licking salt

Figure 13. Saiga calves in a heated facility (Photo by B.B. Sarsenova).

Figure 14. Supplemental feeding of saiga calves with whole cow's milk and added fish oil (Photo by of B.B. Sarsenova).

Figure 15. Saiga antelopes stay calm in the presence of humans (Photo by B.B. Sarsenova).

(Sarsenova *et al*., 2014). In 2014, a new hand-rearing method was tested; when saiga calves reached the age of one month, whole cow's milk was replaced by the formula based on milk powder, with the rest of the diet remaining unchanged (Sarsenova *et al*., 2015b).

After the introduction of calves into the large enclosure, at first, they were scared by noises and any movements around them but after a while, started demonstrating calmer responses to disturbances (Fig. 15), which may indicate that these animals easily adapt to changes in their environment (B.B. Sarsenova, pers. comm.).

By November 2013, only six saiga calves (four males and two female) remained at the Centre. Three females died from traumas and one from hypothermia (B.B. Sarsenova, pers. comm.).

In May 2014, ten more saiga calves (three males and seven females) were caught in the wild for their transportation to the Breeding Centre. Due to operational needs, in early summer the Centre was transferred to a new place in Taskala Region (150 km from the city of Uralsk). A complex consisting of seven enclosures with the sizes of 150 m^2 was constructed in the area of 1.05 ha (Fig. 16) (Sarsenova *et al*., 2015b). The complex has a compact structure providing convenient conditions for the work with small groups of animals. All enclosures have gates (Fig. 16, *9)* that allow to move animals between different enclosures and a separate door from central enclosure (Fig. 16, *8*) used by the staff at the times of feeding. Each enclosure has its own shelter (Fig. 16, *3)* that the animals use for protection against adverse weather and other negative factors. Initially, the central enclosure was used for training the animals to feeding in the same place, while other enclosures served as resting areas. At the later stages, the same enclosure was used for pregnant females during calving period. Feeding calves in this area (Fig. 16, *6*) proved to be practical and efficient, especially when there were many young and only one staff member had to bottle-feed the calves. When necessary, the central enclosure was used for moving the animals between different enclosures. A heated indoor facility has been built for newborn calves (Fig. 16, 1) and wild caught saiga calves during the first 1–2 weeks after their removal from the wild (depending on weather conditions); in other times, they are kept in the outdoor enclosures.

In 2015, in view of the planned increase in saiga numbers, four additional enclosures were built: a larger paddock with the size 2 ha; medium-size enclosure with the area 500 m^2 and two separate enclosures (200 m^2 each) for males (B.B. Sarsenova, pers. comm.).

In contrast to the situation in Kaztalovsky district, saiga young did not forage in the enclosures of the new Centre after feeding. It could be associated with the composition of natural vegetation presented largely by grassland plants *(Calamagrostis* sp., *Alopecurus pratensis*, *Juncus* sp.*)* and Limonium communities *(Limonium gmelinii)* that dominate among the vegetation of grassland chestnut soils characterized by pronounced secondary salinization and growth of Salsola clumps; these plants are less preferred components of saigas' natural diet. (Sarsenova *et al*., 2015b). In the opinion of B.B. Sarsenova (pers. comm.), keeping saiga antelopes within restricted area where the vegetation is presented by the plants less preferable by saigas creates an imbal-

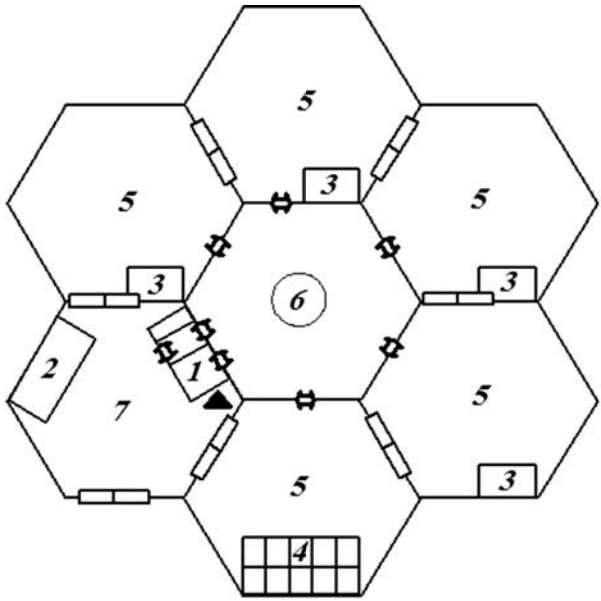


Figure 16. Plan of the enclosures at the Centre for Wildlife and Conservation of Biodiversity (from the data of B. B. Sarsenova, pers. comm.). *1* – roofed heated facility for newborn saigas, consisting of three compartments (12 × 5 m); *2* – hay shed made of asbestos sheeting (10 × 5 m); *3* – shelter of asbestos sheeting designed to protect animals from wind and rain (10 × 2.5 m); *4* – individual enclosures (5 × 6 m) made of asbestos sheeting, with a shelter in each enclosure; *5* –paddocks with chain mesh fencing for older saiga calves; *6* – feeding area with a chain mesh fence lined with dried rushes or wood fibreboards; *7* – staff zone. Symbol: ⇔ – doors between enclosures and rooms; ▭▭ – gates (2.5 m); ▲ – watch tower (height – 5 m).

ance in saiga diet, which can be compensated for by supplemental feeding of saigas with grains (Fig. 17) and hay with the prevalence of steppe-desert plants.

Table 3. Status of the saiga antelope stock at the Centre for Wildlife and Conservation of Biodiversity (from the data of B.B. Sarsenova, pers. comm.)

Description	**2013**	**2014**	**2015**	**2016**
Numbers at the beginning of the year (♂.♀)		6 (4.2)	8 (2.6)	14 (5.9)
Births (♂.♀)			7 (4.3)	12 (3.9)
Arrivals from the wild (♂.♀)	10 (4.6)	10 (2.8)		
Deaths (♂.♀)	4 (0.4)	(4.4)	1 (1.0)	7 (4.3)
Transfers or releases (♂.♀)				3 (0.3)*
Mortality rate (%)	40.0	50.0	6.7	27
Numbers at the end of the year (♂.♀)	6 (4.2)	8 (2.6)	14 (5.9)	16 (4.12)

*Transferred to Almaty Zoo.

Figure 17. Saigas feeding on grains (Photo by B.B. Sarsenova).

Figure 18. Fitting a young male saiga with a collar; December 2015 (Photo by B.B. Sarsenova).

Table 3 provides data on the numbers of saigas at the Centre for Wildlife and Conservation of Biodiversity. Successful work of the Centre is reflected in the fact that 19 saiga calves were born here in 2015 and 2016.

Although the Centre was founded only in 2013 and has a small staff (five full-time employees), it has carried out extensive research that has allowed to develop captive diets and two types of saiga enclosure design, test new methods of saiga transportation and immobilization, study animal behaviours, and investigate physiological characteristics of the species, with special focus placed on the study of the diseases of saigas in captivity (Sarsenova *et al*., 2013; 2014; 2015a; 2015b; 2016). Future plans of the Centre include development and implementation of techniques for the release of saigas into the wild. For this purpose, three young males are now trained to get used to the collars (Fig. 18) that will be later equipped with GPS-transmitters; it will provide an opportunity to collect more information about migrations of the Ural population of the saiga (http://ibirzha.kz/spasti-sajgu/).

Besides, calve raising is practised at the Centre for subsequent transfers of saigas to other breeding centres or zoos, particularly, to Almaty Zoo (see Table 3).

Uzbekistan: "Djeiran Ecocenter"

In 1978, four saiga antelopes of different ages and sexes were brought to the "Djeitran" Ecocenter and released in the main territory. Saigas had bred successfully until 1984; the maximum number of saigas was 17 individuals (http://www.ecocenter.uz/animals). After that time, the work on saiga breeding was not carried out, and no saigas remained at the Center by 1990 (Zimmermann, 2005). In 2016, a Chinese company addressed the State Biological Control of the State Committee for Nature Protection of the Republic of Uzbekistan with the offer of funding for the construction of saiga breeding centre. The staff of the "Djeitran" Ecocenter have developed a scheme of the necessary buildings and a business plan for the year 2017, but so far, no progress has been made on this project (E.A. Bykova, pers. comm.).

Mongolia

Attempts to establish a captive breeding centre for saiga antelopes in Mongolia made in the 1970s proved unsuccessful (http://www.cms.int/species/saiga/post_session/ru/Annex_05_Revised_Overview_Report_R.pdf). The literature evidences of captive breeding of saigas in Mongolia refer only to the facts of keeping saigas under semi-household conditions (Tsevegmid, Dashdorj, 1974). In 2006, a feasibility study for the creation of the saiga captive breeding centre in the northern part of the Great Lakes Basin was carried, but this project had been postponed indefinitely due to the lack of funding (Jungius, 2007).

Russia

In Russia, the early attempts at the captive management of saiga antelopes included the works carried out in the late 1970s at the Djanybek Station of the Laboratory of Forestry of the USSR Academy of Sciences (now Institute of Forest Science of the Russian Academy of Sciences) by the staff of the A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences (at that time, Severtsov Institute of Evolutionary Animal Morphology and Ecology of the USSR Academy of Sciences). Saigas had to be tamed for studying the processes of food consumption and digestibility in this species. The staff of the station had developed key methods of the capture, transportation, husbandry, rearing and artificial feeding of saigas (Petrishchev, Kholodova, 1980; Petrishchev, 1997), which allowed to use tame animals for studying nutrition in adult saigas under captive conditions (Abaturov, Kholodova, 1989; Subbotin, 2001; Larionov, 2008).

Detailed information on the specifics of saiga husbandry at the Djanybek Station has not been published. All we know is that saigas were sent to the Djanybek Station in 1978, since in August of that year, experiments for the study of the consumption and digestibility of forage in saigas were started on a group of three-month-old saiga calves (one male and five females) (Abaturov *et al*., 1982). Until the end of 1980, the male and three females were permanently kept in the enclosure built in a steppe area, and these animals even produced offspring. The study was renewed on two saigas (a male and a female) in 1995 (Abaturov *et al*., 1997) and continued on the two-year-old female in 1996 (Abaturov, Petrishchev, 1998). In 2003, a study of saiga nutrition was carried out at the Station on one tame saiga (Abaturov *et al*., 2005).

In the 1970–80s, "Kalmytsky" Gospromkhoz (State Hunting Enterprise) regularly captured newborn saiga calves in the wild and raised them until the age of two months; then, the calves were introduced into the specially constructed enclosures and kept there until they reached the age of 3 to 4 months. Afterwards, they were sent to Zooobjedineniye in Moscow (Zoo Trade Company) for their subsequent transfer to Russian and foreign zoos. Captive saigas were being tamed at the "Kalmytsky" Gospromkhoz, but a high mortality was observed in young saigas, which was attributed to a high frequency of injuries, permanent stress, and infectious diseases, including helminthiases. In 1987, after a series of unsuccessful experiments, "Kalmytsky" Gospromkhoz ceased its works on captive rearing of saigas (Kholodova *et al*., 2005).

The activities focused on captive breeding of saigas were renewed in Kalmykia more than ten years later at the Centre for the study and sustainable use of the Kalmykian population of saiga, which was created in 1997. Forty newborn saiga calves were caught in the wild and raised to the age of four months. In August 1997, the animals were shipped to the Gansu Endangered Wildlife Breeding Centre (see above); the saigas successfully adapted to the new environment and produced offspring in 1998 (Kholodova *et al*., 2005).

In 2000, captive breeding of wild caught saiga calves was continued in the "Chernye Zemli" State Nature Biosphere Reserve. A group of saigas raised at the

Reserve was sent to the Moscow Zoo's Breeding Centre (Volokolamsky District, Moscow Region; see above).

Since 2000, in the context of catastrophic decline in saiga numbers in North-West Pre-Caspian region, captive breeding centres for the saiga antelope have been created in Russia with the main purpose of maintaining genetic diversity of this unique species. Totally, three breeding centres were established: one in 2000 (Yashkul Captive Breeding Station of the Centre for Wild Animals of the Republic of Kalmykia), and two in 2003: "Saiga" Captive Breeding Centre of the Astrakhanskoye State Experimental and Hunting Enterprise (now, Ilmenno-Bugrovoy Sanctuary) in Astrakhan Region and Centre of Rare Animals of European Steppes of the "Wild Nature of the Steppe" Association in Rostov Region (Fig. 19). After in 2014 the Crimea was incorporated into the Russian territory, one more breeding centre for saigas with semi-wild husbandry conditions, the Tarkhankut National Nature Park, joined the net of the saiga captive breeding facilities in Russia.

Despite the differences in the locations, sources and scales of funding, sizes and infrastructures, these captive breeding centres share the same feature: they used wild caught saigas at the first stages of establishing the founder stock. In all years, employees of almost the same organizations were engaged in the processes of capturing of saigas in "Chernye Zemli" Ecoregion during calving season and transportation of the caught animals to the breeding centres (these organizations were former Hunting Management Department of the Republic of Kalmykia, Federal State Budgetary Institution "Central Hunting Control", and Centre for Wild Animals of the Republic of Kalmykia), using a unified procedure developed by B.I. Petrishchev. Untimely death

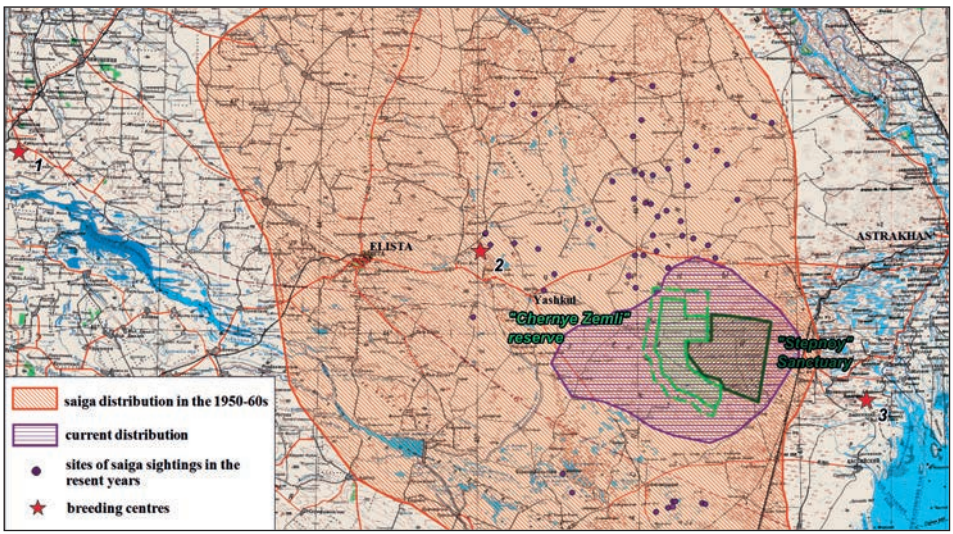


Figure 19. Saiga breeding centres located in Russia (with the exception of Tarkhankut National Park that is shown in Fig. 5): 1 – Centre of Rare Animals of European Steppes, Rostov Region; 2 – Yashkul Captive Breeding Station, Republic of Kalmykia; 3 – "Saiga" Captive Breeding Centre, Astrakhan Region.

did not allow B.I. Petrishchev to publish a full description of this procedure or results of other scientific works and recommendations on captive husbandry and breeding of saigas, but this procedure has been described in detail in the book of V.A. Minoransky and S.V. Tolcheeva (2010).

For the removal of saiga calves from the wild, a relevant permit from an authorized federal or regional body was required, which was granted based on the results of ecological assessment. With this permit, specialists could start their work on the calving sites. A field camp was usually set up near the calving grounds, with all necessary equipment and materials for both animals and people being available in the camp.

Selection of animals from the wild herds for establishing founder stock at each of the breeding centres was carried out according to recommendations of B.I. Petrishchev. Experiments in captive breeding of saigas have shown that the survival rate of the animals depends on the selection of newborn saiga calves in the calving grounds, based on the predisposition of the newborns to hand-rearing (Abaturov, 1978; Petrishchev *et al*., 1982, 1998; Petrishchev, 1986, 1987). Newborn saiga calves can be grouped in three categories related to the type of inherited defensive behaviour that is manifested by the defensive reaction to humans. The type I reaction takes the form of the behaviour of avoidance, type II is characterized by a very poor reaction or an absence of reaction, and type III, by a passive avoidance reaction that is usually demonstrated after feeding. Experiments have shown that under captive conditions, the calves with the second type of behaviour quickly adapt to artificial feeding and successfully reach maturity, while the calves belonging to types I and III die. These features of the behaviour of newborn calves on the sites of birth are particularly evident, if the calves have not been yet nursed by their mothers. Such calves can be identified by the wetness of placenta and calf wet

Figure 20. Saiga calve is calm when held in the man's arms (Photo by S.V. Khludnev).

Figure 21. Capture and marking of saiga calves in the steppe in calving season (Photo by I. Shpilenok).

hairs, often smeared with dirt (Petrishchev, 1982, 1998). Newborn calves with the behaviour of type II were selected for the breeding centres, i.e. the calves that did not bellow or try to escape while being held by humans (Fig. 20).

Additionally, following recommendations of B.I. Petrishchev (1982; 1998), newborn calves were weighed and only the calves that weighed no less than 2.6–3.3 kg were selected. Besides, the sucking reflex in newborn calves was checked; with this purpose, a calf was placed between the operator's knees and stomach, with the calf's head supported by one hand, while the operator put a baby's dummy onto the calf's mouth with the other hand. Only those calves were selected that suckled the baby's dummy, while all other calves were returned to their birth sites.

Capturing of saiga calves was carried out in the middle of the day, in dry, warm weather (Fig. 21), as the capture of calves in a rainy or wet weather could lead to hypothermia and diseases in most of the animals.

As the calves are timid and can be easily excited, it was extremely important to reduce the stress to minimum during the processes of selecting calves on their birth sites and their transportation, and maintain comfortable conditions during the first stages of their stay in captive facilities (Petrishchev *et al*., 1982).

After the capture, selected calves were housed in the temporary facility in the field camp, presented by a round area with the diameter of 3 m, fenced with small-sized cotton mesh (1 × 1 cm) attached to the poles with the length of 1.0–1.5 m. The enclosure was covered on top with the tissue or other material at hand so that the

calves could see a barrier and did not try to come through. Up to 15 newborn saiga calves could be housed in such temporary enclosure where they were every 4–5 hours fed with fresh whole cow's milk or a milk formula warmed up to the temperature of +35 to +40°C (no more than 30–50 ml).

It was critically important to catch all calves in one day and not leave them in the enclosure for the night time because night frosts may occur in the steppe in calving period (early May).

Transportation of newborn saiga calves triggers their agitation leading to a high motor activity, which may increase the risk of traumas; in addition, it causes tachypnoea, hyperthermia and severe stress (Petrishchev, 1986; Petrishchev *et al*., 1998). In order to avoid harmful consequences of the transportation, cardboard boxes (50 × 50 × 50 cm) with a soft grass litter and ventilation holes in the walls were used for the transportation of newborn saigas, with two calves being placed in each box. Boxes with calves were put on a truck (GAZelle trucks were most often used for this purpose) and fixed in a stable position to reduce vibrations.

Yashkul Captive Breeding Station of the Centre for Wild Animals, the Republic of Kalmykia

The first and the largest Russian captive breeding facility for saiga antelopes was the Centre for Wild Animals of the Republic of Kalmykia established in 2000 by the Decree of the President of the Republic of Kalmykia. Main aims of the Centre included the development of saiga husbandry and breeding techniques, scientific research, creation of the source population of saiga for further reintroduction, and ecological education.

The works on captive breeding of saigas at the Centre for Wild Animals were started with the construction of two rather small enclosures (with the total area of 0.2 ha) in the outskirts of Khar Buluk village located in Tselinnyi Region. The enclosures were fenced with asbestos sheeting with a height of two meters and contained hay mangers, racks for grains, and water troughs, as well as sheds where saigas could hide in a bad weather. A special facility was built for artificial feeding of newborn animals and wild caught calves or calves abandoned by their mothers. The Centre had a watch-tower and light poles used for night-time lighting.

The first saigas (17 wild caught newborn females) that became the founders of the breeding stock were brought to the enclosures in May 2000, and an adult male that was earlier kept in the paddock of the "Chernye Zemli" Nature Reserve arrived to the Centre in the autumn of the same year.

The breeding station in Khar Buluk existed for almost three years. Following recommendations of the International Workshop on Saiga Conservation (Elista, Kalmykia, 2002), the Government of the Republic of Kalmykia had allocated an area with the size of 800 ha in Yashkul district for the creation of captive conditions that would simulate the natural habitat of the species. The selection of this area was based on both favourable natural conditions and its remoteness from human settlements, which provided a secured and quiet environment for saigas.

The Yashkul Captive Breeding Station is located in the Priergeninskaya plain, a gently rolling area with a salt marsh depression in the east (Dzhapova *et al*., 2013). This region is characterized by sharply continental climate with hot, dry summers and temperatures sometimes reaching +45°Ñ. Thaws often occur in winter times, whith the temperature rising to +5 or +6°Ñ. The highest temperatures are usually registered in July and August (+24.2 to +26.9°C), and the lowest temperatures are typically observed in February (-0.2°Ñ). Average annual temperature is +9°Ñ. On average, the difference in the mean monthly temperatures between the coldest and warmest months is +31°Ñ. Distribution of monthly precipitation (only about 270 mm per year) is uneven, with most intense rainfalls with thunders occurring in the warm season and less intense snowfalls or prolonged drizzles, in autumn and winter. Soil water reserves necessary for plant growth are accumulated due to the spring and autumn rains. The contributing factors are lower evaporability and moderate temperatures in these seasons. Snow cover is not deep and sometimes even absent, with strong winds causing the changes in the snow cover pattern.

Vegetation cover is presented by the cenoses of cereals and woodworms, Artemisia species, bluegrasses and Artemisa species, and bluegrasses and woodworm communities growing on light loamy and sub-sand chestnut semi-desert salty soils, and by sedges and Artemisia, sedges with the dominance of Artemisia, and Artemisia species cenoses, and bluegrasses and Artemisa communities on the light and moderately loamy salty grounds (Dzhapova *et al*., 2013). Desert wheatgrass *Agropyron desertorum* is dominant among cereal grasses. Totally, 57 plant species are found in the area of the Breeding Station, which belong to 45 genera of 18 families (Dzhapova *et al*., 2013).

Three enclosures measuring 3 ha each and one enclosure with the size of 62 ha were constructed in the territory of the Breeding Station; each of the enclosures has a shelter (Fig. 22).

The enclosures are bordered by the hay storage; a grain storage facility and a maintenance unit are located nearby. A watchtower used for observations of animals is set next to the enclosures (Fig. 23). A fence around the perimeter is equipped with night lamps.

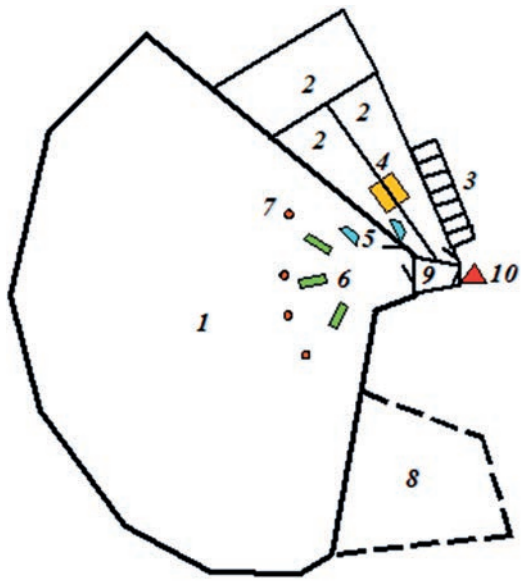


Figure 22. Plan of the Yashkul Breeding Station (from the data of Yu.N. Arylov, pers. comm.). *1* – main enclosure, 62 ha; *2* – enclosures with the sizes of 3 ha; *3* – experimental enclosures for individual animals; *4* – shelter for saigas; *5* – water troughs; *6* – hay mangers; *7* – racks for grains and feeding additives; *8* – projected enclosure with the area 20 ha; *9* – hay storage; *10* – watchtower.

Figure 23. Watchtower in the Yashkul Captive Breeding Station (Photo by T.Yu. Karimova).

To protect saigas and scare the carnivores off (wolves, foxes, and stray dogs), 15 red LED light bulbs, 11 scarecrows, reflective tapes, bells and other sound-signalling devices have been set up along the outside perimeter of the fence, and an electric fence was installed in 2012.

Apart from the spacious enclosures, there are ten enclosures for individual animals, measuring 4 × 6 m each (Fig. 24); these enclosures were designed for saigas used for research (study of animal hormonal status, experiments in AI, etc.) and as quarantine facilities for sick animals.

Special indoor facilities have been built for the wild caught calves that have to be hand-reared and the calves abandoned by the mothers (Fig. 25).

The Rozhnovski water tower (with the tank volume of 20 м^3) has been assembled for the water supply for watering plants and saigas, with water ab-

Figure 24. Enclosures for individual animals decorated with the help of the children from the Yashkul secondary school (Photo by T.Yu. Karimova).

straction from an artificial water reservoir.

Some other facilities have been built in the territory of the Yashkul Captive Breeding Station, including three-unit multi-family house for animal keepers, researchers and guests, field laboratory, visit-centre, and summer pavilion used for the lessons for school children (Fig. 27). Electricity supply to the Breeding Station is provided partially by renewable sources of energy that include a wind turbine with the power 4 kW and solar batteries (2.5 kW).

Management and feeding of saiga calves of the age under five months. After arrival of saiga calves to the Breeding Station, they were for one or two days kept in the "field conditions" in the crates measuring 1 × 1 m, with fresh grasses so that the calves could recover after the transportation and adapt to the new environment, while staff members could assess physical condition of the animals. Then, the calves were moved into the permanent enclosures. Based on the previous experience in saiga husbandry (Korneev *et al*., 1986; Petrishchev *et al*., 1998; Kholodova, Neronov, 1996), the enclosures of the minimal sizes were used for saiga calves of the age under four months, i.e. in the period before weaning; besides, the enclosures were designed to reduce a risk of injuries to a minimum. The enclosure for 8–10 young calves had the sizes 4 × 4 m and a rounded shape; the walls

Figure 25. Special indoor facility for feeding of saigas and bottle-feeding of calves in the Yashkul Captive Breeding Station (Photo by Yu.N. Arylov).

Figure 26. Installation of the Rozhnovski water tower in the Yashkul Captive Breeding Station (Photo by Yu.N. Arylov).

Figure 27. Residential complex and enclosures of the Yashkul Captive Breeding Station (Photo by Yu.N. Arylov).

were made of the fibre boards with the height of 1.7 m. For maintaining the desirable temperature (from +18 to +23°Ñ), hay and grass were put on the floor in each enclosure and an infrared bulb was turned on when necessary. Each saiga calf was fitted with a tag with an individual number.

The highest mortality rate is registered in saiga calves in the period of their dependence upon milk (Petrishchev, Kholodova, 1980; Petrishchev *et al*., 1998), therefore in addition to the use of traditional formulas (the whole cow's milk substitutes), a substantially new feeding method was tested, with saiga calves being fed on the saiga's milk replacement (SMR) (Arylov, 2002). Experiments showed that formula ZMR-3 had the composition that proved to be the best for hand-rearing of saiga calves as this method provided the largest daily weight gain and the highest body mass indices of the young (Arylov, Arylova, 2005). The composition of this formula is given in the Tables 4 and 5.

Table 4. Composition of the whole saiga's milk replacement
(from: Arylov, Arylova, 2005)

Nutrients	**%**
Cow's milk	92.0
Coocking oil	3.0
Phosphatidic concentrate	2.0
Chiken egg	2.0
Premixes*	1.0
Total:	*100.0*

*The list of premixes is provided in Table 5.

Table 5. Composition of vitamine premix per 1 kg of dry mass of the milk formula
(from: Arylov, Arylova, 2005)

Preparations, units of measure	**Quantity**
Vitamin A preparation, ml	0.06
Vitamin D preparation, ml	0.01
Vitamin E preparation, ml	0.10
Chlorotetracycline hydrochloride (crystalline), g	0.30
Cobalt chloride, g	0.07
Copper sulfate, g	0.20
Potassium iodide, g	0.01

Immediately before feeding, the powder mix (SMR) was dissolved in water (100 g of the powder per 1 L of water) in two steps. First, the required quantity of SMR was weighed and poured into a special reservoir. Then, about one third of the required volume of water warmed to the temperature +50 to +60°C was added to SMR. The mixture was stirred thoroughly until the mix fully dissolved and looked as a homogeneous substance with the consistency close to that of the sour cream. Then the rest of the water was poured in and the mixture was stirred to the consistency of milk. The resulting milk formula was then cooled down to the temperature of +38 to +40°C and fed to the calves from glass bottles (with the volume 250 ml) with rubber nipples. In some cases, the whole cow's milk was fed to orphaned calves or young saigas abandoned by their mothers.

For ensuring sterile conditions and preventing the spread of infections, individual bottles and disposable nipples were used for feeding. The bottles and all kitchen utensils were thoroughly washed, rinsed, steamed, and dried.

The feeding protocol for the calves fed on both SMR and cow's milk is presented in Table 6 (Arylov, Arylova, 2005). The volume of a single portion in the period of bottle-feeding ranged from 30 ml to 500 ml. Night feeding was used during the first 14 days to prevent hypothermia in the calves.

Vitamins were provided through supplementing the diets of calves with chicken eggs or fish oil (one egg per two calves or 3 ml of fish oil per individual). Health and

Table 6. Volumes and daily numbers of feedings for saiga calves fed on the replacement of saiga's milk (from: Arylov, Arylova, 2005)

Saiga calf age	Volume per feeding, ml	The number of feedings per 24 h
1–5 days	30–50	7
6–13 days	50–100	4
14–20 days	100–220	3
21–30 days	220–300	2
2 months	300–500	2
3–3.5 months	500	1
3.6–4 months	500, with reducing the volume by 50 ml daily	1
5 months	0	0

physical condition of the calves have been closely observed since the first days of artificial feeding. The digestibility was assessed based on the state of faeces that should have an appearance of dark, hard droppings in case of good digestibility.

By the end of the third month of age, saiga diets were gradually supplemented with crudely crashed barley and concentrate feed (100 g per individual). The staff of the Breeding Station closely monitored physical condition of the animals, registering all data (weight, body measurements, etc.) and keeping records in an observation diary. The calves were fed by hand, i.e., the keepers always contacted the calves at the feeding times. This method helped to reduce the defensive reaction in the calves and promoted their adaptation to the presence of humans. Thus, the described holistic approach to hand-rearing of saiga calves has reduced the mortality during calves' milk dependance period.

Management and feeding of saiga calves of the age of 5–7 months. At the age of 5 months the animals were entirely weaned to be fed on natural vegetation. At the same time, young saigas were moved from the small enclosures to a large one (with the area of 0.5 ha).

Railroad ties driven 0.5 m into the ground three meters apart were used as the support of the fencing. A chain mesh with the cell size of 7 × 7 cm was attached to the railroad ties from the outside, and asbestos sheets with the height of 2 meters were used for lining the fence from the inside. Wooden mangers for grass and hay and racks for concentrate feeds were set in the enclosure, as well as water troughs that were always attached to the fence. The enclosures were bordered by the residential house and well-lighted during the night time. A watchtower was built next to the enclosures, therefore the animals were constantly monitored by the staff of the Breeding Station.

The period from 5 to 7 months of age is the time of the quick growth and development of saiga calves. This is the period when the animal organism is being prepared for wintering and female saigas reach sexual maturity (Bannikov *et al.*, 1961). Therefore, the saiga diet for this period was developed with the aim to maximize the consumption of various nutrients. The saigas were provided with diverse steppe herbs, green pasture herbs, crudely crashed barley (or concentrate feed), mineral supplements (licking salt, charcoal, and bone flour) and vitamins ("Tetravit" complex) (Arylov,

2002). According to recommendations of B.I. Petrishchev and colleagues (1998), the grass was put into the wooden mangers in such a way that saigas could select preferable grass species (Fig. 28).

Calves were offered concentrate feeds at 200 g per an individual; then, beginning from November, the amount of concentrates was gradually increased to 400 g and left unchanged in the following months. During the autumn/winter season saiga diet predominantly consisted of alfalfa hay, small-leaf Sudan grass *(Sorghum sudanense)* and herbal hay with the dominance of sagebrush (comprising up to 70%) (Fig. 29).

Roughage was given to saigas two times a day, at 9:00 and 18:00, and grains, at 20:00. Previous observations have shown that saigas kept in the enclosure drink large amounts of water, therefore in summer period, the animals were provided with 300 L of water daily, based on the estimated volume of 4–6 L per an individual. In winter time, the amount of water was reduced to 200 L, since in this period the saigas also consumed rainwater and snow.

For establishing relashionships of trust between saigas and humans, the keepers followed recommendations of B.I. Petrishchev and co-authors (1998), staying in the enclosure for some time after the delivery of foods and communicating with the animals verbally while cleaning their enclosure.

The implementation of this husbandry protocol ensured a normal growth and development of the saigas; by November, the males reached the weight of 15–16 kg and the females, 12–13 kg. The females reached sexual maturity by the age of 7–8 months and were moved to the larger enclosure where adult saigas were held. The males were

Figure 28. The place for supplemental feeding of saigas at the Yashkul Captive Breeding Station (Photo by Yu.N. Arylov)

Figure 29. Supplemental feeding of saigas at the Yashkul Captive Breeding Station in the harsh winter of 2010 (Photo by Yu.N. Arylov).

kept separately until the age of 1.5 years, after which they were moved to the large enclosure.

Management of adult saigas (females older than 7 months, males older than 1.5 years). Groups of adult animals were established based on the sex ratio 7:3, as was recommended by B.I. Petrishchev and colleagues (1998), and moved to the large enclosure (62 ha) that was designed similar to the enclosure for young saigas. To prevent inbreeding depression, only "new" males that did not breed in the past were kept together with the females in the rutting period. "Old" (breeding) males were separated from the herd and moved to individual enclosures. The selection of males for breeding was based on morphological characteristics of the animals (Pronyaev & Fadeev, 1998).

The management of adult saigas was carried out with the view of the need to preserve the natural behavioural patterns of the animals and at the same time, promote their quiet behaviour in the presence of humans. The diet of adult saigas included both natural forage and supplemental feeds; seasonal specifics, sex and age structure of the herd and physiological status of saigas were considered in the development of the diet composition. Some authors (Ubushaev, 2017) suppose that saigas kept in enclosures and fed on standard diets develop and grow better, if they are fed on grasses and herbs, while growth rates in the animals fed on hay decrease with age. Feeding on herbal foods stimulates digestibility of the main nutrients, such as proteins (by 1.7%) and fat (by 1.2%). Diets based on grasses and herbs also help to intensify the metabo-

lism of proteins due to the increase in the digestibility of nitrogen by 3.1% and sulphur by 12.9%.

Comparative analysis of plants growing in saiga enclosures (Dzhapova *et al*., 2013) and plant species comprising a natural diet of the saiga in the wild (Adolf, 1950, 1954; Bakeev, Formozov, 1955; Lebedeva, 1959, 1960; Abaturov, 1984; Abaturov *et al*., 1982, 1998; Abaturov, Petrishchev, 1998; Bliznyuk, Baktasheva, 2001; Rozenfeld, Larionov, 2008; Larionov *et al*., 2008) has suggested that saigas kept in the enclosures can feed on the plants belonging to 37 species of 12 families. Composition of supplemental feeds for adult saigas did not differ significantly from the diet of one-year old calves (see above), but adult animals were additionally offered grain forage. The main rule of the animal feeding that was always followed by the staff was offering the animals such amount of food that only a small proportion of the forage remained in the enclosure after feeding.

Helminths found in saigas included nematodes *(Scrjabinoderma saiga, S. ovis, Trichostrongylus axci, T. colubriformis, T. probolurus, Ostertagia occidentalis, Marshallagia marshalli, Nematodirus spathiger)* and cestodes *(Moniezia expansa, Thysaniezia giardi, Multiceps multiceps* and others) (Bannikov *et al*., 1961). Prophylaxis against helminth infection was carried out by mixing Albendazole (suspension: 2 ml/10 kg BW) into the grains; the treatment was repeated after 30 days (Arylova, 2009). Results of express-analysis (Monahan, 2006) implemented in 2008 demonstrated the absence of helminths in faecal samples, which could be attributed to the lack of contacts between saigas and domestic animals (Arylova, 2009).

The holistic approach developed at the Yashkul Captive Breeding Station enabled the creation of regularly breeding captive population of the saiga. The experience of the Breeding Station has proved that saigas can successfully breed in captivity, even when the number of founders is not high (1 male and 17 females) (Table 7). There were only two other cases in the history of the Breeding Station when saigas were obtained from the wild, in 2005 (28 specimens) and 2007 (10 specimens).

Successful management and breeding of saigas made it possible for the Yashkul Captive Breeding Station to transfer animals to other breeding facilities and release adult saigas into the wild. In 2004, at first, 10 (5 males and 5 females) newborn saiga calves were transferred to the breeding centre newly established in Rostov Region and an adult male was sent to the centre in the autumn of the same year. In December 2004, four adult males fitted with GSP-collars were released into the wild. In December of 2005, 32 saigas (13 males and 19 females) escaped from the enclosure through the hole with the size of 70 × 90 cm after finding “a weak link” in the fencing and “unweaving” the chain mesh using their horns (Yu. N. Arylov, pers. comm.). Experiments on the monitoring of released saigas were continued in the following years; two males and one female fitted with GSP-collars were released into the wild in 2009 and five more males, in 2012. Obtaining the permits necessary for the removal of saiga antelopes from the wild was impossible in the last years, therefore in 2014 the administrations of the new breeding centre in Rostov Region and Yashkul Captive Breeding Station agreed on the transfer of 11 newborn saiga calves (6 males and 5 females) from Yashkul to the Rostov Breeding Centre.

Table 7. Numbers of saiga antelopes at the Yashkul Captive Breeding Station in the period 2000–2016 (from the data of Yu.N. Arylov, pers. comm.)

Description	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Numbers at the beginning of the year (♂.♀)		14 (1.13)	23 (8.15)	38 (13.25)	49 (16.33)	43 (12.31)	37 (15.22)	37 (15.22)	53 (19.34)	56 (17.39)	58 (17.41)	79 (30.49)	97 (39.58)	116 (47.69)	153 (63.90)	4 (1.3)	3 (1.2)	4 (2.2)
Births (♂.♀)		14 (8.6)	22 (10.12)	26 (13.13)	24 (12.12)	18 (10.8)	9 (4.5)	17 (6.11)	16 (8.8)	14 (7.7)	30 (15.15)	23 (13.10)	41 (21.20)	43 (20.23)	75 (39.36)	2 (1.1)	2 (1.1)	
Arrivals from the wild (♂.♀)	18 (1.17)					28 (16.22)		10 (5.5)										
Deaths (♂.♀)	4 (0.4)	5 (1.4)	7 (5.2)	15 (10.5)	15 (6.9)	20 (10.10)	9 (4.5)	11 (7.4)	13 (10.3)	9 (5.4)	9 (2.7)	5 (4.1)	17 (8.9)	6 (4.2)	213 (95.118)	3 (1.2)	1 (0.1)	
Transfers or releases (♂.♀)					15 (10.5)	32 (13.19)				3 (2.1)			5 (5.0)		11 (6.5)			
Mortality rate (%)	22.2	17.9	15.6	23.4	20.5	22.5	19.6	17.2	18.8	12.9	10.2	4.9	12.3	3.8	93.4	50.0	20.0	

Table 7 shows that the saiga mortality rate decreased with time (from 22.2% in 2000 to 3.8 in 2013), with the mean mortality value of 15.8±6.5%. Relatively high mortality rate in 2012 (12.3%) was associated with the severe drought. Shortage of natural vegetation led to the situation when these cautious animals could stay at a distance of only three to five meters from humans during feeding (Fig. 30).

In December 2013, 150 (62 males and 88 females) saiga antelopes were held in the large enclosure of the Yashkul Captive Breeding Station. Besides, one female born 2013 was kept in an individual enclosure with research purposes and two more animals (a male and a female) were held in a separate enclosure where they were moved to for rutting period (Yu. N. Arylov, pers. comm.). The pasture of the enclosure (62 ha) could not carry so many saigas because the vegetation was not given enough time to restore. In this regard, the decision was made to construct a new enclosure with the size of 20 ha as a temporary holding area for most of the animals. With this purpose, necessary materials were purchased and preparation works started.

75 saiga calves (39 males and 36 females) were born at the Breeding Station in May of 2014, and in June, a mass die-off of the saigas began. Despite numerous investigations of the veterinary services, the causes of this catastrophe have never been revealed. According to the procedures recognized in the Russian Federation, all saiga carcasses were utilized. Only four animals (one male and three females) that were kept in separate enclosures remained at the Breeding Station by the end of 2014.

Figure 30. Feeding of saigas at the Yashkul Breeding Station; June 2012 (Photo by T.Yu. Karimova).

In view of the critical situation at the Breeding Station and financial problems in the economy of the Republic of Kalmykia, the Government of Kalmykia made a decision to close the Yashkul Captive Breeding Station (Order N205-r of 01.10.2014). The functioning of the Breeding Station continued only due to the volunteer efforts of the former staff of the Breeding Station and support from the Saiga Conservation Alliance (SCA). As of April 2017, four saiga antelopes (two males and two females) were kept in the large enclosure of the Yashkil Breeding Station.

Data from the Veterinary Laboratory of the Republic of Kalmykia show that the causes of saiga deaths (with the exception of the mass deaths of 2014) mainly included extremity fractures (52% of all cases), gastrointestinal diseases and digestive disorders (30%), and respiratory diseases (18%). The most common causes of deaths in the females were presented by gastrointestinal diseases (41.4%), traumas (24.2%), respiratory diseases (24%), and abnormal labours (10.4%) (Arylova, 2009).

The experience of the Yashkul Captive Breeding Station in the management and breeding of saiga antelopes has shown that saigas born and raised in captivity almost do not differ from wild saigas in the body weight and sizes, general development, physiological characteristics, and behavioural responses (Arylova, 2005; Arylova *et al*., 2006; Arylov, Arylova, 2009). Males comprised 31.0±16.1% of the captive population, which is similar to this indicator for the wild population that was found in North-West Pre-Caspian region in the second half of the last century (Arylova, 2008) but much higher than what was typical for the wild population in the recent years when the males comprised less than 3% of the population by the end of rutting period (Neronov *et al*., 2013). This value is very close to that for the captive population at the Askania Nova Biosphere Reserve (ca. 32%) (Gavrilenko *et al.*, 2009), which may reflect a situation of the optimal sex ratio in the captive populations.

One of the important indicators of the population status is the annual number of offspring per a female (Fig. 31). A mean value of this indicator for the Yashkul Captive Breeding Station was 0.75±0.29, varying depending on environmental conditions. It is much lower than the estimated values for the wild population related to the second half of the 20th century, that ranged from 1.38 in 1958 to 1.4–1.83 in the late 1990s (Bannikov *et al*., 1961; Bliznyuk, Bukreeva, 2000), but close to the values related to the period of the low population size in the years 2001, 2002, and 2003 (0.26, 1.12, and 0.6, respectively) (Bukreeva, Kravchuk, 2004). A possible explanation is that the large numbers of saigas aggregate within a restricted area (in the enclosure measuring 62 ha) during rutting period, and all resources of the males are mostly directed at the fights for harems and less efforts are spent to mate females (Yu.N. Arylov, pers. comm.). As a result, most females remain unfertilized and males die in the fight for the dominance.

The Centre for Wild Animals of the Republic of Kalmykia presents a unique ground for comprehensive study of the saiga antelope (in the first place, of behavioural characteristics of the species) and diverse experimental work. It was the place where the satellite telemetry and medications for saiga immobilization were tested, artificial insemination experiments took place, physiology of thermoregulation in the saiga and its role in the adaptation strategy of the species were studied, and non-invasive monitoring methods were validated, including hormonal and phytolith analysis meth-

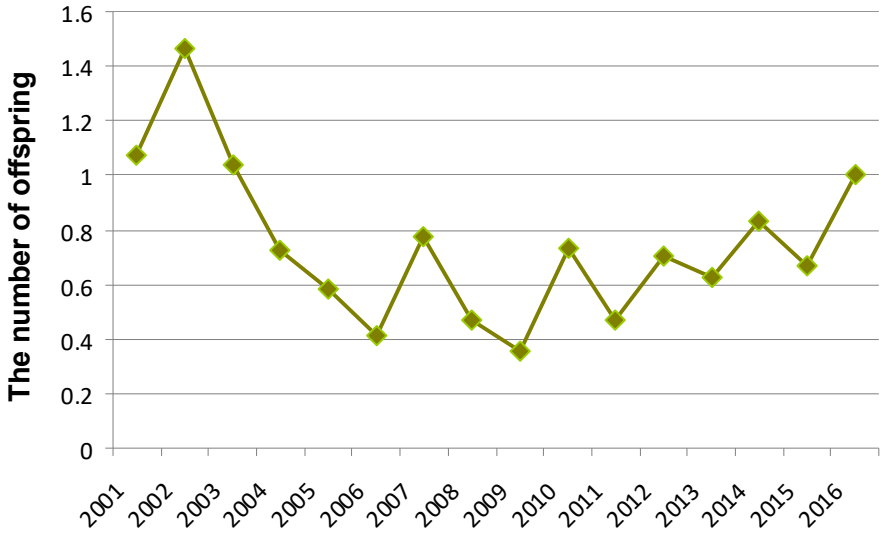


Figure 31. The number of offspring per a female at the Yashkul Captive Breeding Station.

ods. The Centre closely cooperated with many leading research institutes and conservation organizations, including the A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences (Moscow), L. K. Ernst All-Union Research Institute for Animal Husbandry (Moscow), All-Russia Williams Fodder Research Institute of the Russian Academy of Agricultural Science (Moscow Region), A.N. Kostikov All-Russia Research Institute of Hydraulic Engineering and Melioration of the Russian Academy of Agricultural Science (Moscow), and others. Students of the Biology and Agrarian Departments of the Kalmyk State University, Stavropol Agrarian State University and Moscow Timiryazev Agricultural Academy used the Centre as a base for preparing three course works and two diploma theses on the behaviour and physiology of the saiga. Materials collected at the Centre by the colleagues from various scientific institutions formed the basis of two theses for Doctor Degree and four theses for Candidate Degree. In addition to the works on the study and conservation of the saiga, the Centre was actively involved in the activities aimed at the restoration of the natural pastures of the species. The most important forage species *(Kochia prostrata, Salsola orientalis, Artemisia lercheana, A. halophila, Agropyron desertorum, A. cristatum, Festuca valesiaca,* and *Poa bulbosa)* were sown in the experimental plots in the territory of the Breeding Station with the purpose of increasing the productivity of degraded pastures of North-West Pre-Caspian region, and first seeds have already been obtained for growing these species in the wild.

Since apart from the low standards of living, the poor public awareness of the status of the North-West Pre-Caspian population of the saiga is one of the main factors that contribute to rising of the level of poaching, the Centre paid a lot of attention to ecological education of local people (primarily, of young generation), encouraging respect to nature and sustainable use of natural resources, which is very important for

the implementation of the strategy of sustainable development of the Republic of Kalmykia. Guided tours and training courses were regularly conducted at the Breeding Station that also implemented various projects of conservation education.

The positive experience of the Yashkul Captive Breeding Station has shown that the most important factors of the successful breeding of saigas include:

1) justified selection of the location of the breeding centre, i.e., such centre should be built in the area similar to the natural pastures of the saiga (lowland territory with low vegetation and mild depressions where the animals can hide);

2) feeding adult saigas on balanced diets, with supplementing natural forage with additional foods that would meet foraging and nutritional requirements of the species;

3) availability of sufficiently large enclosures designed with the view of the saiga defensive behaviour; and

4) creating conditions that would ensure maximum safety for saigas (fences without protruding surfaces, sharp angles, etc., which is especially important in the feeding and watering sites).

The experience in successful saiga breeding gained at the Yashkul Captive Breeding Station has been used by the other two breeding centres established in Astrakhan and Rostov regions. These centres have further developed some aspects of the management and breeding of saigas under captive conditions (enclosure design, veterinary services, management of breeding for avoiding inbreeding, etc.), and their knowledge can be successfully used in the future.

"Saiga" Captive Breeding Centre of the Ilmeno-Bugrovoy Sanctuary Astrakhan Region

Captive breeding of the saiga antelope in Ilmeno-Bugrovoy area of the former Astrakhanskoye State Experimental and Hunting Enterprise (currently Ilmenno-Bugrovoy Sanctuary) situated on the bank of the Beshenyi duct was started in 2003, following the decision of the Department of Protection and Rational Use of Hunting Resources (Hunting Department) of the Ministry of Agriculture of the Russian Federation. Based on the literature review and analysis of positive experience gained by other saiga breeding facilities (Askania Nova Biosphere Reserve, the Center for Wild Animals of the Republic of Kalmykia, etc.), the Biodiversity Conservation Center of the Russian Academy of Natural Sciences has developed a design of the "Saiga" Breeding Centre. Experts from A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences, Federal State Budgetary Institution "Central Hunting Control", Russian State Agrarian University (Moscow Timiryazev Agricultural Academy), Astrakhan State University, and other academic institutions were involved in the development of the project and further research that was implemented on the base of the Breeding Centre.

Creation of the "Saiga" Breeding Center (as well as of the Breeding Station of the Centre for Wild Animals of the Republic of Kalmykia) was aimed primarily at the conservation of the genetic diversity of the saiga antelope through captive breeding. It was supposed to achieve a purpose of establishing sustainable breeding population of

the saiga at the Breeding Centre and implement the releases of groups of male and female saigas into the wild for maintaining the size of the wild populations of the species. However, due to unforeseen difficulties that arose during the work of the Centre, it did not manage to increase the number of animals as soon as it was planned (Franov, Gagarin, 1209).

At the first stages, the Breeding Centre had an area of 4 ha, surrounded by the fence of asbestos sheeting and chain link with the height of 2.8 m. Eighty individual enclosures were built along the western and northern sides of this area, which measured 2.5 (w) × 10 (l) × 1.7 (h) m each and formed blocks that were separated from the large paddock with a corridor used for capturing and moving saigas around the enclosures. The large paddock with the sizes 180 × 180 m served as the holding area for females with their young; it was also used for saigas during rutting and calving periods. Individual enclosures were used for housing males, ill animals, and young saigas removed from the wild (Fig. 32).

After a testing period of two years, it was decided to renovate the existing facility by replacing building materials (wooden support posts with metal poles; asbestos sheeting with galvanized steel profiled sheeting), expanding the area, and building additional enclosures and passage corridors. A number of changes were made in the internal design of the enclosures, which improved their technological effectiveness and animal husbandry conditions

At present, the Breeding Station has an area of 21 ha (300 × 700 m). The Centre (Fig. 33) consists of a large paddock (*7*) with the area of 15 ha for keeping the bachelor group of saigas; smaller pen (*2*) measuring 3.5 ha that is used for saigas in the rutting period or for the entire group of females with their offspring; one family group

Figure 32. Top view of the enclosures in the “Saiga” Breeding Centre (Photo by A.A. Lushchekina).

pen (*3*) with the size 1 ha, used for saigas in rutting and calving periods; two family group pens (*4*, *5*) with the area of 0.5 ha each, used in rutting and calving periods; 17 individual enclosures (*6*) measuring 5 × 8 m, with the sheds made of sun bricks for young and ill animals; 10 individual enclosures *(7)* measuring 10 × 9 m, with the shelters for reserve males or the males that do not participate in the rut.

The vegetation in the enclosures is presented by the communities with the dominance of subshrubs, the saltworts *Salsola dendroidea* and *Salsola altissima*; vegetation associations including Syrian bean-caper *(Zygophyllum fabago)* and bulbous meadow-grass *(Poa bulbosa)* are also found in this area. Despite a sufficiently high level of the projective cover (up to 60%) and large biomass (up to 39 quintals per one hectare), the plant diversity of this area is poor, numbering only 13 species (Habitat quality…, 2011).

The initial saiga stock was formed in the Breeding Centre in 2003 of 50 newborn saiga calves that were removed from the wild in the Republic of Kalmykia in the period of mass calving (May) and two adult males born at the Moscow Zoo's Breeding Centre. The second group of saigas (35 newborn calves) was brought to the Centre in 2007 (Franov, Gagarin, 2009). The data on the numbers of offspring per a female are presented on the Figure 34, and general information on the numbers of saigas that were kept at the Breeding Centre in different years is given in Table 8.

In January 2017, 31 saigas were kept at the Breeding Centre (S.A. Kalashnikov, pers. comm.). The growth of the population in 14 years of the functioning of the Breeding Centre was insignificant and the mortality rate was very high, averaging 38.1±15.3%. Mortality rate was extremely high in 2007 (the year when the newborn saigas were brought to the Centre) when it reached 57.4%.

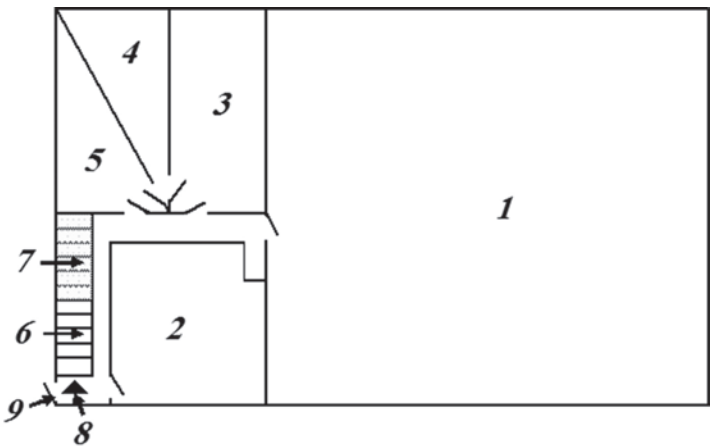


Figure 33. Plan of the "Saiga" Breeding Centre (from: Franov, Gagarin, 2009). *1* – large paddock; *2* – smaller pen; *3, 4, 5* – family group pens; *6* – individual enclosures with the sizes 5 × 8 m and sheds of sun bricks; *7* – individual enclosures with the sizes 10 × 9 m, without shelters; *8* – watchtower; *9* – gates and doors.

Table 8. Numbers of saiga antelopes at the "Saiga" Breeding Centre of the Astrakhanskoye State Experimental and Hunting Enterprise in the period 2003-2017 (Adapted from: http://www.ecoexpertcenter.ru/info/razrabotka_telmologiy_razvedeniya_cennyh_vidov_zliivotnyh_132.html; Franov, Gagarin, 2009, 2010; http://centrohotkontrol.ru/ 32.html and from the data of S. A. Kalashnikov, pers. comm.).

Description	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Numbers at the begi-nning of the year (♂.♀)		34 (14.20)	21 (9.12)	24 (10.14)	34 (15.19)	40 (22.18)	37 (19.18)	35 (13.22)	34 (12.22)	27 (10.17)	36 (12.24)	33 (12.21)	19 (9.10)	18 (5.13)	31 (14.17)
Births (♂.♀)		7 (1.6)	14 (6.8)	17 (10.7)	25 (14.11)	25 (12.13)	21 (9.12)	24 (12.12)	9 (3.6)	21 (10.11)	31 (17.14)	26 (10.16)	11 (6.5)	18 (12.6)	
Arrivals from the wild (♂.♀)	50 (16.34)				45 (18.27)							2 (2.0)			
Other arrivals (♂.♀)	2 (2.0)														
Deaths (♂.♀)	18 (4.14)	18 (6.12)	8 (3.5)	7 (5.2)	60 (25.35)	28 (15.13)	21 (13.8)	25 (13.12)	16 (5.11)	12 (8.3)	34 (17.17)	40 (13.27)	12 (10.2)	5 (3.2)	
Transfers or releases (♂.♀)		2 (0.2)	3 (2.1)		4 (0.4)		2 (2.0)					2 (2.0)			
Mortality rate (%)	36.0	43.9	22.9	17.1	57.7	43.1	36.2	42.4	37.2	25.0	50.7	65.6	40.0	13.9	

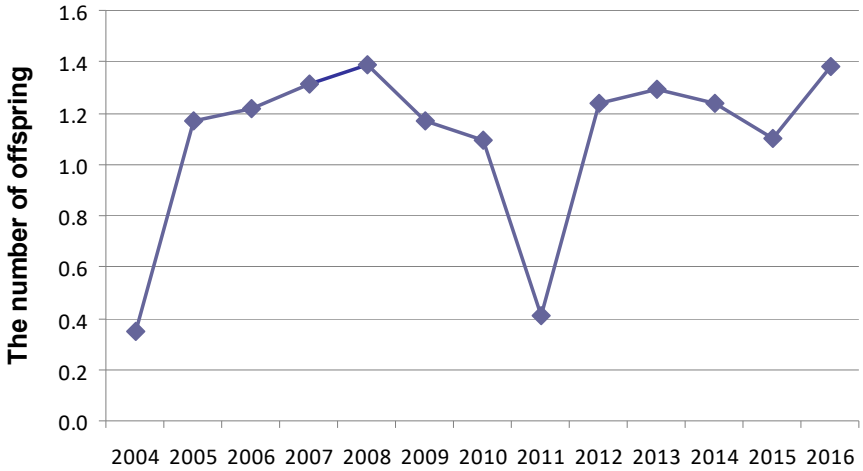


Figure 34. The number of offspring per a female at the "Saiga" Breeding Centre (from the data of S.A. Kalashnikov, pers. comm.).

Based on the gained experience, the following system of saiga husbandry was developed by the Breeding Centre: from the age of 4–5 months, all males are kept in the large paddock in a bachelor group throughout the year (Fig. 35), and in October or November the males selected for breeding are captured and moved to individual enclosures (Defining maximum sizes of saiga groups…, 2011).

At the same time, females with their offspring are captured in the smaller pen and divided into four groups, with each of the group being moved to the enclosure used for saigas in the rutting and calving periods. Young males are moved to the large paddock for establishing a bachelor group. In December, before the rutting period, selected males are introduced into the groups of females, and in February, the males are recaptured and moved to individual enclosures for recovering (until the end of the vegetation growth period), after which they are introduced to the bachelor group.

Calving occurs in the same enclosures that are used during the rutting period. Immediately after the birth of the last calves, all four groups of females were combined into a single group and held in the small pen. The procedure is carried out through step-by-step moves of the animals with the use of the corridor system. All the enclosures but individual ones are equipped with feeder traps that make it possible to capture selected saigas. During capturing procedure, every saiga is weighed and necessary veterinary treatment is carried out (Franov, Gagarin, 2009) (Fig. 36).

The diet of the wild caught newborn saigas was based on the fresh whole cow's milk with the addition of vitamins and mineral supplements. Fodder plants were introduced in the diet gradually, depending on the condition of individual saigas.

The percentages of natural pasture vegetation and supplemental plant feeds in saiga diet are 57.2% and 42.8%, respectively (Habitat quality…, 2011). During several years, the feeds used as supplements included alfalfa hay, diverse fresh-cut herbs, crashed barley, fresh fodder, and mineral supplements. For reducing expenses for the management of saigas, an experiment on the exclusion of lash feeds (carrots, beetroots,

Figure 35. Saiga antelopes in the enclosures of the “Saiga” Breeding Centre (Photo by V.V. Gagarin and A.A. Lushchekina).

Figure 36. Each animal at the "Saiga" Breeding Centre is marked with an individual tag (Photo by V.V. Gagarin).

and pumpkins) from the saiga diet was conducted, which did not reveal any changes in the health or behaviour of the animals (Feeding saiga antelopes…, 2011). Currently, each saiga is daily provided with 1 kg of barley and 2.5 kg of hay. In summer, a part of the hay is replaced with fresh-cut grass. Water for drinking is collected in the nearby river (Franov, Gagarin, 2009).

Main causes of saiga deaths at the Breeding Centre include gastrointestinal diseases in hand-reared saiga calves, traumas, and pasteurellosis in adult animals (Fig. 37). Prophylaxis and treatment of dyspepsia and colibacteriosis in young saigas were carried out through both changes in the quantity and quality of diet components and medical treatment. Design of the facilities and husbandry methods were and are being improved for the prevention of traumas.

Currently, the major veterinary problem facing the Breeding Centre is presented by periodical outbreaks of pasteurellosis that may have an acute or extra-acute form when the death occurs in a few hours after the onset of clinical disease and it is not possible to timely detect the symptoms, not least to treat the infection. Post mortem examination of died saigas revealed *Pasterella multocida* Types B and D (Franov, Gagarin, 2009). It is to be noted, that only Type D was isolated from the samples of young saigas aged 3–4 months, while samples collected from the adult saigas had both types of *P. multocida*. Bacterial agents have not been isolated from the samples of nasal smears from 19 alive saigas of different ages.

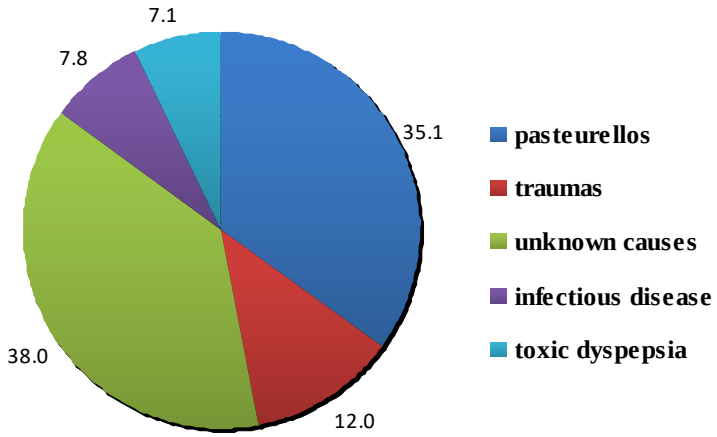


Figure 37. Causes of saiga deaths at the "Saiga" Breeding Centre in the period 2003–2016 (from the data of S.A. Kalashnikov, pers. comm.).

It has been suggested that although saigas can be the carriers of pasteurellosis, sick wild saigas fall behind their herd and do not infect other animals. Under captive conditions, the pathogen transmission rate increases manifold, probably as well as the pathogen virulence: pasteurellosis mortality rate in captive saigas is 100%. Specific prophylaxis of pasteurellosis through the use of the vaccine against pasteurellosis developed for livestock did not produce positive results (the incidence of pasteurellosis did not reduce). In view of these results and the fact that the vaccination requires capturing of animals, which often causes severe stress in saigas and leads to traumas, it was decided to suspend the practice of vaccination (Franov, Gagarin, 2009).

At the same time, the Breeding Centre is working on this issue in close cooperation with a number of research veterinary institutes. An action plan of the prevention of pasteurellosis has been developed. The plan of disease control and prevention also includes prophylactic measures against endoparasites and ectoparasites. The treatment of saigas with antihelminthics "Alben" and "Univerm" has proved to be successful. Staff of the Breeding Centre have developed and use a recipe of the repellent consisting of hypodermin, creolin and solar. This solution is effectively used for the treatment of saigas' coats and surfaces of the facilities at the peak of abundance of blood-sucking insects. Rat-extermination measures are not taken in the area of the Breeding Centre because local rodents that are potential carriers of infections migrate from neighbouring areas, quickly replacing killed rats (http://www.ecoexpertcenter.ru/info/razrabotka_tehnologiy_razvedeniya_cennyh_ vidov_zhivotnyh_132.html).

Now, when the "Saiga" Breeding Centre has an appropriate experience gained in the 14 years of its existence, its mission and objectives are clearer and more focused. These objectives include: further development of husbandry and breeding methods for the saiga antelope; development of science-based diets for saigas of different age classes; development of the effective system of veterinary measures for disease prevention and control; increasing the size of the captive population without removal of

saigas from the wild; and implementation of conservation programs and public ecological education for people living in Astrakhan Region (http://www.ecoexpertcenter.ru/info/razrabotka_tehnologiy_razvedeniya_cennyh_vidov_zhivotnyh_132.html).

Centre of Rare Animals of European Steppes of the "Wild Nature of the Steppe" Association, Rostov Region

In 2003, the "Wild Nature of the Steppe" Association was founded due to the joint effort of legislative and executive bodies, scientific, commercial, and public organizations, and other conservation oriented structures, with the support of the Administration of Rostov Region and Bashneft Group. The creation of the Association was aimed at the conservation and restoration of natural biodiversity of the European steppes in Rostov Region. The Centre for Rare Animals of European Steppes was established with the same purpose in the Kundruchensky farm and Manychsky station in Manych village (Orlovsky district of Rostov Region). The work of the Centre is aimed at the conservation and supplementation of the wild populations of endangered and rare steppe species through breeding of animals under captive and semi-wild conditions and releases of some of the animals into the wild. The Centre maintains captive populations of the Demoiselle crane *(Antropoides virgo)*, the great bustard *(Otis tarda)*, the mute swan *(Cygnus olor)*, the greater white-fronted goose *(Anser albifrons)*, the mallard *(Anas platyrhynchos)*, the kulan *(Equus hemionus)*, the bobak marmot *(Marmota bobak)*, and many other species (Minoransky *et al*., 2009).

Saiga breeding is one of the priorities of the Centre of Rare Animals of European Steppes (or Rostov Breeding Centre). The Centre is located in the south-east of Rostov Region. In the past, saigas from the Republic of Kalmykia were often found in this area, but in the last decades they were barely seen here, though in 1999, 2006, and 2009, isolated saiga groups were sighted in the territory of Rostovsky Nature Reserve (Minoransky *et al*., 2016). This fact suggests that the soil, vegetation, climatic and other natural conditions of Orlovsky district provide suitable habitat for the saiga antelope (Minoransky *et al*., 2009; Minoransky, Tolcheeva, 2010).

The main objectives of the Centre included the study of biological characteristics of the species; creation of optimal conditions for captive husbandry of saigas; development of successful methods of captive husbandry, based on dietary and other natural requirements of the saiga and transfers of captive bred animals to other breeding centres or zoos; preservation of the genetic pool of the saiga antelope through captive breeding with the purpose of the conservation of declining wild populations of the species; releases of saigas into the wild, provided that captive breeding produces sufficient numbers of available animals; conservation education and outreach activities (Minoransky, Tolcheeva, 2010).

The development of captive breeding techniques has become one of the priorities of the Centre. To this end, the experience of the world and Russian zoos in captive breeding of saigas was studied by the staff of the Centre at the initial stages of their work; besides, advice and expertise were provided by experts from the Centre for Wild Animals of the Republic of Kalmykia, A.N. Severtsov Institute of Ecology and

Evolution of RAS, and Federal State Budgetary Institution “Central Hunting Control”.

In 2004, the first three enclosures, each measuring 15 × 25 m, were constructed at the Centre. The enclosures are fenced with 2-meter high profiled asbestos sheeting that protects saigas from negative effects of various stimuli located outside the enclosures (other animals and humans). For reducing the incidence of traumas, all sharp edges of the fencing have been rounded. Shelters are built along one of the sides in two enclosures and the animals regularly use them for resting in the shadow. The third enclosure has an indoor facility instead of a shelter, which is used by the animals for resting; besides, the saigas can be locked there for capturing or carrying out other husbandry procedures (Fig. 38).

Feeders, water troughs, and licking salt are set near the shelters or indoor facility, and a closed three-level watchtower with observation windows is located on the opposite side outside the enclosures (Fig. 39).

The enclosures have natural vegetation that serves a food source for the saigas, but excessive density of the animals (15–20 individuals per an enclosure) leads to the compaction of soil surface and rapid deterioration of vegetation cover, as well as to the increased incidence of traumas. This situation promoted the need for the construction of additional enclosures, therefore one enclosure with the size of 15 × 25 m and three enclosures measuring 4 × 8 m each were built at the breeding centre (Minoransky,

Figure 38. Enclosures in the Rostov Breeding Centre (Photo by A.A. Lushchekina).

Figure 39. Watchtower in the Rostov Breeding Centre (Photo by A.A. Lushchekina).

Tolcheeva, 2010). In view of the plan to move some animals to the Manychsky Station (Manych village), an enclosure with the size of 10 × 15 m was constructed at the Manychsky Station, and aggressive males were moved to that enclosure. Additional seven small enclosures (3 × 5 m) built in 2007 provided conditions for moving males, females, and young saigas to different enclosures and allowed to significantly reduce the risk posed by aggressive males to other saigas, thus, reducing the incidence of traumas to a minimum. Periodical moves of the animals between different enclosures facilitate the growth of the plants in "resting" enclosures. The soil surface in the enclosures is warmed up by the sun throughout the year, which eliminates bacterial agents and helps to reduce the level of animal morbidity. Besides, keepers periodically clean the enclosures, removing animals' excrements, and local veterinarians examine the saigas on regular basis. A special enclosure (4 × 6 m) with a stone barn, fenced with profiled asbestos sheeting is used for housing the calves abandoned by their mothers and wild caught calves for a period of 1.5 months, when they are still fed on milk. Totally, 17 enclosures have been built in the Kundruchensky farm by 2013, including one enclosure with the sizes of 21 × 25 m, one enclosure of 21 × 21 m, four enclosures of 15 × 25 m, one enclosure measuring 10 × 15 m, three enclosures with the areas 4 × 8 m, and seven enclosures with the sizes 3 × 5 m (Minoransky, Dankov, 2015).

Back in 2006, S.V. Sidorov and O.M. Bukreeva developed a "Plan of captive breeding of saigas in enclosures" (Minoransky, Tolcheeva, 2010). In the light of the recommendations presented in the Plan, a paddock with the area of 63 ha was constructed at the field station of the "Wild Nature of the Steppe" Association, located nearby Manych village where animals of many other species are also kept, including

bisons, camels, llamas, Przewalski's horses, kulans, Père David's deer, wild yaks, buffaloes, etc. Additionally, an artesian well was drilled and a small reservoir with fresh water was built in the area of the field station. Thirty two saigas raised at the Breeding Centre of the Kundruchensky farm were transported to this place and released into the large enclosure in the period from August 2015 through February 2017 (V.A. Minoransky, pers. comm.).

The first saigas (five males and five females at the age of four months) were brought to the Centre of Rare Animals of European Steppes from the Centre for Wild Animals of the Republic of Kalmykia in September 2004, and in October of the same year, an adult male originating from the same facility arrived at the Centre of Rare Animals. In the following years, small groups of newborn calves (19 in 2005; 18 in 2006; 19 in 2007; and 10 in 2013) were caught on the calving grounds of the saiga in North-West Pre-Caspian Region ("Chernye Zemli" Ecoregion) and brought to the Centre for supplementing the existing stock and maintaining genetic diversity of the captive herd. In 2014, the Ministry of Natural Resources and Environment of the Republic of Kalmykia withheld the permission for the removal of saiga antelopes from the wild but proposed to bring in 11 saiga calves from the Yashkul Captive Breeding Station; the calves were transported to the Centre of Rare Animals in June of 2014.

Until 2010, females of all ages participated in the rut, including the calves under one year of age. The numbers of saigas grew, which caused the necessity to build new enclosures every year. Currently, only the females at the age of two or more years are used for breeding, while the females under one year of age are separated from the males (Minoransky *et al*., 2012). Saigas breed at the Centre every year; the mean mortality rate is 21.1±13.1% (Table 9).

The composition of the diet varies depending on the season, condition of vegetation, saiga group age structure, and physiological status of individual animals (Minoransky, Tolcheeva, 2010; Minoransky *et al*., 2012). The diet of adult saigas mainly consists of high-volume feeds (hay and grass) that are permanently available in the enclosure so that the animals can consume them *ad libitum*. The diet also includes barley or wheat (300 g per an animal). During plant growing season, about 15 kilograms of fresh-cut grass (genera Koelέria, Artemisia, Elytrigia, Bromus, Medicágo, Salvia, Tanacetum, etc.) are placed in the enclosures on a daily basis. In the autumn and winter, apart from hay, the animals are given root crops, fruit, cucumbers, melons, pumpkins, and other lash feeds. Periodically, the saigas are provided with bone flour and vitamin, mineral and other supplements. Grass growing in the enclosures is less important for the saigas because of the high density of animals. At the same time, the availability of spare enclosures allows to keep some of the enclosures empty for a long time, carry out sanitary procedures, sow seeds, and move saigas to the clean, green enclosures.

Newborn saigas and calves abandoned by mothers were bottle-fed on the replacement of saiga's milk as was recommended by Yu.N. Arylov (2002) or on the whole cow's milk with added chicken eggs and fish oil. The amounts of milk and feeding regime depended on the calf age and health condition. From the day 14, the dose of the milk formula should be gradually increased with simultaneous reduction in the

Table 9. Numbers of saigas kept at the Centre of Rare Animals of European Steppes (from: Uzdenov *et al.*, 2013; from the data of V.A. Minoransky, pers. comm.)

Year	Arrivals	Births	Maximum numbers during the year	Numbers as of December 31	Mortality rate (%)
2004	11		11	10	9.1
2005	19		32	18	43.8
2006	18		39	25	35.9
2007	19		49	35	28.6
2008			56	49	12.5
2009			81	70	13.6
2010			63	51	19.0
2011			51	48	5.9
2012			48	43	10.4
2013	10			50	
2014	11			?	
2015		18		52/11*	
2016		9/5		30/22	32.5

* x/y = numbers of saigas kept at the breeding centre in the Kundruchensky farm/numbers of saigas kept at the Manychsky station.

daily number of feeding; this process is carried out according to individual characteristics of the calves. The condition of the calves is assessed based on the intake of milk and condition of excrements. Plant feeds (cut grass, fresh hay, and vitamins) are added to the diet gradually, depending on the condition of individual animals. The calves are weaned after they reach the age of 3.5–4 months; at that period they are fed cut grass, hay and grains, with periodical addition of vegetables, fruits, root crops, and other supplements (Minoransky, Tolcheeva, 2010).

Maintaining the health of saigas is the basis of successful husbandry and breeding of these animals. Main causes of saiga deaths are presented by traumas and diseases associated with husbandry conditions. The factors dramatically affecting newborn and young saiga calves include high humidity, draughts, and low temperatures that induce cold-related diseases and pneumonia. Helminthological control and dehelminthization of the enclosures are carried out at the Centre on the regular basis. Measures aimed at the prophylaxis of infectious diseases are taken periodically. Newly arriving animals are kept in the quarantine enclosures, where they are subjected to close monitoring, rehabilitation and necessary treatment. Saigas demonstrating signs of diseases are moved to a special isolated enclosure (Minoransky *et al.*, 2012; Minoransky, Tolcheeva, 2010).

The Centre is carrying out important activities in the area of ecological education. It is annually visited by schoolchildren, university students, colleagues from conservation organizations, and many people living in Rostov Region. Visitors can see saigas, bustards, and some animals that were common in this area in the past and served as important game species. The Centre organizes international and regional conserva-

tion meetings and conferences, regularly publishes popular books, booklets, calendars and postcards depicting rare and endangered species of animals, and arranges shooting of documentaries (Minoransky, Tolcheeva, 2010).

Tarkhankut National Nature Park, the Republic of Crimea

In 2014, after the integration of the Republic of Crimea into Russia, one more organization involved in captive breeding of saigas, the Tarkhankut National Nature Park ("Charvina Gavan" (Beautiful Harbor) until 2014), joined the net of saiga breeding facilities. The approach of the Tarkhankut National Park to saiga husbandry differs from that exercised by the breeding centres in Kalmykia and Astrakhan and Rostov regions. The husbandry system adopted by the Tarkhankut National Park is rather similar to the system of the Askania Nova Biosphere Reserve. In summer of 2013, the administration of Askania Nova Reserve concluded an agreement on the transfer of ten saigas and five kulans raised at the Reserve to the Tarkhankut Natural Park (http://itogi.ua/society/8960-2013-10-04-11-49-08.html).

This nature park was created on the Tarkhankut peninsula in Crimea in 2009. Its area is 10,900 ha. Main types of the vegetation of this geographical zone are presented by steppe fescue and feather grasses or fescue, feather grass and diverse grass communities with the dominance of *Stipa lessingiana, S. capillata, Festuca sulcata, F. rupicola* and *F valesiaca.* Communities of Petrofitum species are formed on the natural outcrops (limestone) with the prevalence of the fescue, feather grass and Bromus species, fescue, thyme and feather grasses, and sagebrush, fescue and Bromus species (Mykhailov, 2015; Report of the Department…, 2016). There are 449 species of higher plants and 32 Bryophita species found in the Park. The fauna includes 37 species of

Figure 40. Landscapes of the Tarkhankut National Nature Park (Photo by N.I. Bysikina).

Figure 41. Saiga antelopes in natural habitats (Photo by G. Prokopov).

mammals, 219 bird species (52 of which nest in the territory of the Tarkhankut National Park), 2 amphibian species, 4 species of reptiles, and 758 species of invertebrates. Many of the species of flora and fauna belong to rare and endangered categories, and 135 species are included in either the IUCN Red List of Threatened Species or Red Data Books of the Russian Federation and Republic of Crimea (Prokopov, 2016).

Two enclosures were built in the Nature Park for housing saigas and kulans: a large enclosure (100 ha) and a small quarantine enclosure (2 ha). The enclosures are situated in a gulch complex with the slopes of different expositions and steepness and small watersheds. Galches occupy about 70% of the area, and their scrubby slopes and bottoms provide shelters for the animals (Fig. 40). Saigas spend most of the time on the flat open part of the territory, covered with steppe vegetation. The vegetation in the enclosure is mainly presented by steppe cereals, including needle grasses (*Stipa capillata* and *S. lessingiana*) and Keng yellow bluestem (*Bothriochloa ischaemum*); fescue grasses (*Festuca rupicola*), field sagewort *Artemisia lercheana* and Moldovan thymus *Thymus moldavicus* are less common. Low abandance of pulses (Romanian alfalfa *Medicago romanica* and yellow alfalfa *M. falcata*) that should be common in this area suggests that the animals eat them first (N.I. Bysikina, pers. comm.).

Ten saigas (five males and five females) were brought to the Park from the Askania Nova Biosphere Reserve in October of 2013. Since then, the animals have lived in semi-wild conditions, feeding on natural vegetation (Fig. 41).

Table 10 shows the numbers of saigas kept at the Park in different years. In general, the population is stable and two cases of breeding have already been registered.

Table 10. Numbers of saiga antelopes kept in the Tarkhankut National Nature Park in 2013–2017 (from the data of N.I. Bysikina, pers. comm.)

	2013	2014	2015	2016	2017
Numbers at the beginning of the year (♂.♀)		10 (5.5)	10 (5.5)	11 (4.7)	12 (4.8)
Births (♂.♀)			6 (3.3)	5 (2.3)	
Arrivals from the wild (♂.♀)					
Other arrivals (♂.♀)	10 (5.5)				
Deaths (♂.♀)			5 (4.1)	4 (2.2)	
Transfers and releases into the wild (♂.♀)		10 (5.5)			
Mortality rate (%)		0.0	31.3	25.0	

In January 2017, there were 12 saiga antelopes (four males and eight females) in the Tarkhankut National Park.

Deaths of saigas in the National Park are caused primarily by traumas; the staff of the Park believe that it could be associated with the rocky and irregular relief of the area (N.I. Bysikina, pers. comm.).

Staff members of the Tarkhankut Park together with specialists from other organizations are involved in the analysis of food plants available for the kulans and saigas in their enclosures, as well as in the monitoring of the current parasitological situation (Report of the Department…, 2016).

* * *

Positive dynamics of the numbers of animals may serve an indicator of the success of the activity aimed at the captive breeding of saiga antelopes. The numbers of saigas that were kept in different years in the listed breeding facilities are shown in Fig. 42. As can be seen from the Figure, the most successful husbandry and breeding of saigas was achieved by the Yashkul Captive Breeding Station where the stock increased to 220 individuals in the period of 15 years (2000–2014), with only 56 saigas originating from the wild. Despite unfavourable natural conditions of the "Saiga' Captive Breeding Centre that contribute to frequent outbreaks of pasteurellosis, well established husbandry procedures and veterinary control allow to maintain the numbers of saigas at the level of 30–40 individuals and even carry out trial releases of male saigas into the wild. In the last years, the Centre of Rare Animals of European Steppes (Rostov Region) claimed to be the unique and most successful saiga captive breeding facility in Russia (Minoransky, Dankov, 2015, 2016). However, the numbers of saigas were decreasing in the period 2010–2013 when wild caught animals were not brought to the Centre. The employees of the Centre attribute it to the shortage of space and effects of inbreeding (Uzdenov *et al*., 2013), but saiga calves from the wild and from the Yashkul Captive Breeding Station did arrive to the Centre in 2013 and 2014, regardless of insufficient enclosure sizes (see Table 9). Apparently, large sizes of enclosures providing a lot of space for saiga movements are prerequisite for successful

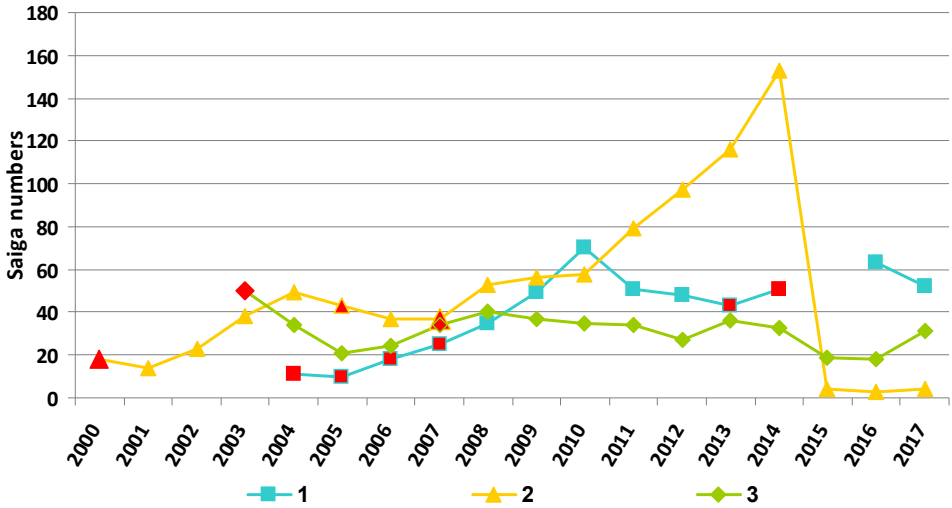


Figure 42. Numbers of saiga antelopes kept at the breeding facilities of Russia at the beginning of different years (red marks indicate the years of the arrival of saigas from the wild or from other breeding centres): 1 – Centre of Rare Animals of European Steppes, Rostov Region; 2 – Yashkul Captive Breeding Station, the Republic of Kalmykia; 3 – "Saiga" Captive Breeding Centre, Astrakhan Region.

husbandry and breeding of saiga antelopes. This is supported by the experience of the Askania Nova Biosphere Reserve, Yashkul Captive Breeding Station, and Endangered Wildlife Breeding Centre in Gansu Province, which all have large saiga enclosures where a manifold increase in the numbers of saigas was achieved in a relatively short time. The saiga stock of the Centre of Rare Animals of European Steppes can be increased through the transfer of the animals to a new spacious enclosure built nearby Manych village. With regard to the inbreeding, it should be noted that other breeding centres do not face this problem, though the number of wild born animals that these centre have obtained is almost the same as the number of wild caught saigas obtained by the Centre of Rare Animals of European Steppes: 56 wild caught individuals were obtained by the Yashkul Captive Breeding Station, 97 by the "Saiga" Breeding Centre and 88 by the Centre of Rare Animals of European Steppes.

Releases of saiga antelopes into the wild

As was shown in previous sections, specialized breeding centres have developed specific techniques for husbandry and breeding of saiga antelopes. As a result, there was a real opportunity to release captive bred saigas into the species natural habitats for the restoration of wild populations of the saiga. This is particularly relevant today, at the time when the sex ratio in the North-West Pre-Caspian population is skewed by selective poaching for male saigas (driven by the demand for saiga horns on the traditional Chinese medicine market): by the end of 2012, adult males comprised only 1.43% of the wild population (see report submitted by Russian experts to CMS Secretariat: http://www.cms.int/sites/default/files/document/Saiga%20MOS3_Compilation%20of%20Project%20Reports_Ronly.pdf). Even the growth of the proportion of males to 4–5 % in 2015–2016 (V.G. Kalmykov, pers. comm.) does not yet provide justification of the increase in reproduction level. Sustainable growth of the population size may probably become a reality, if the long-term average growth rate reaches 20%, as was the case in the years of saiga abundance (Zhirnov, 1982). For this to happen, it is necessary to accomplish releases of captive bred male saigas into the wild in rutting period.

Captive breeding is one of important tools in the conservation and restoration of rare and endangered species of animals and plants that suffer a disturbance of reproductive processes. Long-term international experience shows that *in situ* (in enclosures of breeding centres of zoos) breeding of the remaining individuals carrying genes of vanishing species and subsequent reintroduction of captive bred animals is the last hope for saving wild species that are on the verge of extinction (Flint *et al*., 2002). Creation of the first breeding centres was the outset of the transition from the passive wildlife conservation (protection of wild areas) to active measures aimed at saving of endangered species. V.Ye. Flint and colleagues (2002) called the releases of captive bred animals into the wild “repatriation”, defining repatriation as a process aiming at the restoration of extinct species populations, supplementation of vanishing populations, and establishing new populations of endangered species of animals.

Some authors (Danilkin, 2011) criticize such approach to the restoration of endangered species with respect to the saiga antelope, since they believe that releases of captive bred animals are bound to fail, because such saigas are more likely to be killed by wolves, stray dogs, or poachers than wild born animals. In support of their arguments, the authors site the results of previous releases of saigas into the wild (Kolosov, Lavrov, 1968): despite the evidence of saiga breeding and dispersal, the releases of saigas implemented in the past (1949 – on Bulla Island (20 and 58 saigas) and Glinyanyi Island (53 individuals) of Baku Archipelago in Caspian Sea; 1957 – in the Shirvan steppe (35 individuals); 1961 – in Sugatinskaya Valley in Trans-Ili Alatau

(7 males and 31 females) and Kyzyl-Agach Nature Reserve in Azerbaijan (9 young saigas)) did not produce desirable results. The restoration of the saiga population on Barsa-Kelmes Island (local population size was assessed at 1,705 individuals, based on the results of the survey carried out in 1963) became possible due to the extermination of wolves and foxes (Kolosov, Lavrov, 1968) and assigning the protection status to this territory. However, the saigas on this island were exterminated in the following years when they were caught for the trade to zoos and hunted for their meat (Sludsky, Afanasyev, 1964). In the opinion of A.A. Danilkin (2010), it will be impossible to save the saiga through "farming" without elimination of the main causes of the current population decline, and large-scale and expensive captive breeding and reintroduction project is unlikely to be needed, if the numbers of predators sharply decrease and there is an effective protection of saigas and their wild habitats in place.

Research into the prospects for the release of saiga antelopes into the wild was one of the priorities of the Yashkul Captive Breeding Station of the Republic of Kalmykia at the first stages of its activity, and later other breeding facilities started participating in this process. Apart from the development of the captive husbandry and breeding methods for saigas, it was necessary to develop monitoring techniques that would allow for assessing the outcomes of the releases. The use of GPS-collars for obtaining information about saigas' locations, movements over short distances, and long migrations have been considered in the paper of S. Cavenagh (Cavenagh, 2011/2012).

Trial releases of saigas raised at the Yashkul Captive Breeding Station (Republic of Kalmykia) and "Saiga" Breeding Centre (Astrakhan Region) became possible due to the negotiations and approval of the Ministry of Natural Resources and Environment of Russia and coordinated actions of the staff of the Centre for Wild Animals and Ministry of Natural Resources and Environment of the Republic of Kalmykia, Federal State Institution Astrakhanskoye State Experimental and Hunting Enterprise (now, Ilmenno-Bugrovoy Sanctuary), "Stepnoy" Sanctuary, and the Service for the Supervision and Use of Natural Resources of Astrakhan Region. Specialists of the A.N. Severtsov Institute of Ecology and Evolution of RAS coordinated the activities focused on the releases of saigas into the wild and carried out satellite-based monitoring of the released animals. The financial support of some stages of the project was provided by the Russian Office of the International Fund for Animal Welfare (IFAW).

The first experiments in the satellite telemetry of saigas for obtaining information on saiga movements and assessing the capability of captive raised animals to adapt to natural environment were undertaken in 2004 and 2009 by the specialists of the Centre for Wild Animals of the Republic of Kalmykia and A.N. Severtsov Institute of Ecology and Evolution of RAS together with the staff of the "Stepnoy" Sanctuary of Astrakhan Region. The works were carried out with the assistance of experts from the University of Wisconsin-Madison and Chicago Zoological Society.

In November/December of 2004, three male saigas fitted with Telonics ST-20/3210 satellite collars and one male marked with bright red paint were released from the enclosure of the Yashkul Captive Breeding Station into the territory of the "Stepnoy" Sanctuary (Fig. 43). Signals of the satellite transmitters at predetermined intervals were received by Argos satellite system, which allowed to determine animal locations

Figure 43. Male saiga fitted with satellite collar at the Yashkul Captive Breeding Station before the release into the area of "Stepnoy" Sanctuary (Photo by A.A. Lushchekina).

(Dubinin, 2009). Monitoring process showed that further improvement of the transmitters and monitoring methods were required for increasing the capacity of batteries and accuracy of measurements.

However, released saigas (Fig. 44) successfully integrated into the wild herds, which events were observed by the staff of the "Stepnoy" Sanctuary. Supposedly, these saigas participated in the rut (Arylova, 2009): a signal received from one of the transmitters a month after the release allowed to find the remains of the saiga killed by a wolf, and given that saiga males are usually become weakened by the rut, their killing by wolves is a common phenomenon, if the wolf population density is high. Nothing is known about the other saigas released from the Yashkul Captive Breeding Station because their transmitters stopped generating signals in three months after their activation, which was probably associated with the low battery capacity.

Therefore, satellite collars enable the researchers to obtain information about locations and movements of saigas within the study area (Arylova, 2009).

Trial releases were continued in December 2009 when two males fitted with Telonics ST-20/3210 satellite collars and one female marked with bright red paint were released into the wild. Signals of satellite transmitter allowed to trace the move-

Figure 44. Release of the male saiga fitted with satellite collar; 2004 (Photo by A.V. Khludnev).

ments of one of the saigas during two weeks (Fig. 45), until it was killed by a wolf (Figures 46 and 47).

Under the partneship agreement between the Federal State Institution "Central Hunting Control" and Federal State Institution Astrakhanskoye State Experimental and Hunting Enterprise, testing of the new model of GPS/GPRS transmitter was carried out in May 2010. A saiga male kept separately in the individual enclosure of the "Saiga" Breeding Centre was fitted with the collar with installed basic model of the "Sputnik GPS/GPRS tracker" transmitter (Figures 48 and 49) (Habitat quality..., 2011); the male moved only within the enclosure during the entire testing period.

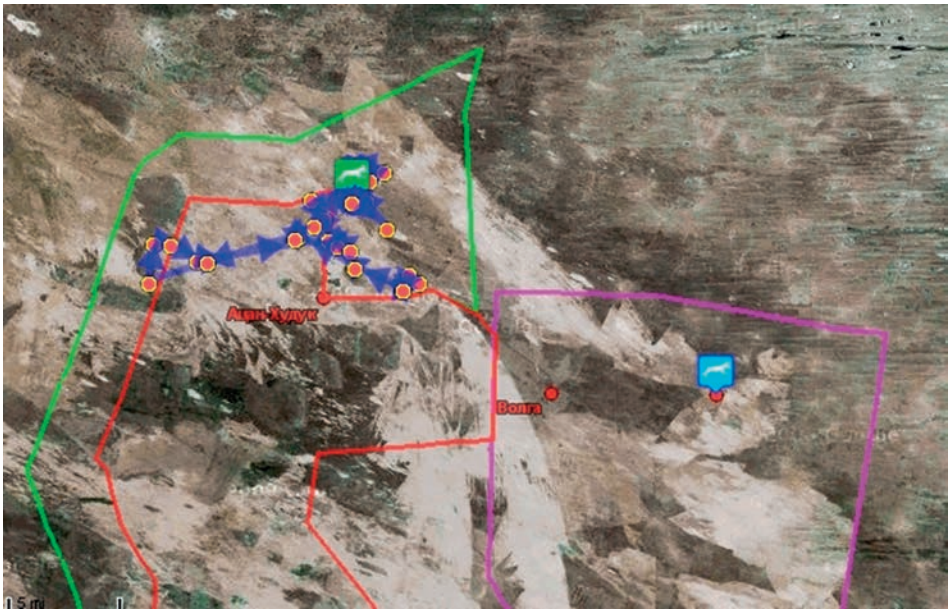


Figure 45. Information obtained by satellite monitoring of the released saigas in 2009 (Adapted from: http://gis-lab.info/projects/saiga-telemetry/saigal.html).

Figure 46. Remains of the eaten by a wolf radio-collared saiga found in the steppe (Photo by Yu.N. Arylov).

Figure 47. GSP-collar bitten by a wolf (Photo by Yu.N. Arylov).

Figure 48. GPS/GPRS-collar "Sputnik" (Habitat quality..., 2011).

Figure 49. Saiga fitted with GPS/GPRS-collar in the "Saiga" Breeding Centre (Habitat quality..., 2011).

The transmitter functioned in a normal regime during the whole testing period. The movements of the male were monitored with the use of the computer located in the Moscow office of the Federal State Institution "Central Hunting Control". Eighty three signals of the transmitter identifying the coordinates of its location were received in the testing period, with coordinates being displayed on the electronic version of the map of Astrakhan Region. This study showed that the basic model of the transmitter needed significant improvements for its use for the monitoring of released saigas (Habitat quality..., 2011).

In the beginning of December 2012, satellite monitoring of saiga males was renewed with the use of new satellite-based transmitters "Pulsar" (manufactured by ZAO "S-PAS") of GPS/Argos system; similar transmitter were earlier successfully used for monitoring other mammals, including Amur tigers, Far Eastern leopards, European bisons, and wolves (Duplaa *et al*., 2011; Kirilyuk, Rozhnov, 2011; Rozhnov, Salman, 2011). Three saiga males fitted with such transmitters were released into the wild from the Yashkul Captive Breeding Station (Fig. 50).

In addition to collared males, two other saigas marked with bright red paint were released into the wild and it was possible to monitor them visually for the short time (Fig. 51).

Figure 50. "Pulsar" radio transmitter (manufactured by ZAO "S-PAS") (Photo by A.L. Salman).

On December 7, 2012, saigas in transport crates were transported from the Yashkul Captive Breeding Station to the release site located 2 km north-west of the "Chernye Zemli" Nature Reserve boarder. The procedure of fitting all thee collars with GPS-transmitters to saigas took 30 minutes (Fig. 52). Before the release, the performance of the transmitters was controlled through the use of the portable receiver of Argos signals. When the preparation was completed, all three animals were released into the wild.

The first signals identifying saiga locations were received from all three transmitters in a few minutes after the release. The strength of the signals stayed at a high level during the entire period of the transmitter performance, which demonstrated the high quality of the transmitter and correct Argos antenna pattern. Information about saigas' movements obtained via satellite data is presented below (Rozhnov *et al*., 2013).

Radio transmitter ID 126210 functioned for three days, during which 83 signals were obtained. After the processing of the received information, 73 GPS locations and 24 Doppler locations were identified. During the first few hours following the release, the saiga intensely moved to the south, in the direction of the "Chernye Zemli" Nature Reserve. It covered about 23 kilometres in the first 12 hours and then slowed

Figure 51. Saigas marked with bright red paint (Photo by A.V. Khludnev).

Figure 52. Male saiga fitted with the collar equipped with “Pulsar” transmitter immediately before the release into the wild (Photo by A.V. Khludnev).

down, gradually shifting to the east. All signals from the transmitter received in the following 18 hours indicated that the animal stayed within the area with the radius of 120 m. Besides, an unprogrammed signal received from the transmitter was an indi-

rect evidence of its bad positioning (the electronic block could be screened from the satellite by the animal body or the collar could be located in a shelter).

Thirty five signals were obtained from the radio transmitter ID 126209 in the same period; their processing produced 30 GPS locations and 9 Doppler locations. Similar to the first saiga, this male was moving actively to the south during the first hours after the release, in the direction of the "Chernye Zemli" Nature Reserve. He covered at least 17.5 km in the first 6.5 hours and then the GPS receiver failed to timely detect coordinates of the transmitter (signals were not detected during 15 minutes). The last signals of the transmitter ID 126209 received on December 10, 2012, identified the coordinates of the animal (46°4'N 46°18'E) that correlated with the location of the Atsan-Kuduk cordon in the "Chernye Zemli" Nature Reserve. Apparently, the collar was located in one of the buildings of the cordon, as some time later the staff of the Reserve brought the collar to the Centre for Wild Animals of the Republic of Kalmykia.

Radio transmitter ID 126211 sent 72 signals in three days; their processing identified 65 GPS locations and 19 Doppler locations of the animal. After the release, the male headed to the west and started slowly moving around the herder station, trying to avoid it. In the first 18 hours, the saiga walked along the semicircle trajectory with the length of 15 km. Similar movement pattern was also registered later, but then the animal started moving toward the Elista–Astrakhan motorway. The last signal was received at 16:28 on December 9, 2012, when the male was located at a distance of 4 km from the motorway.

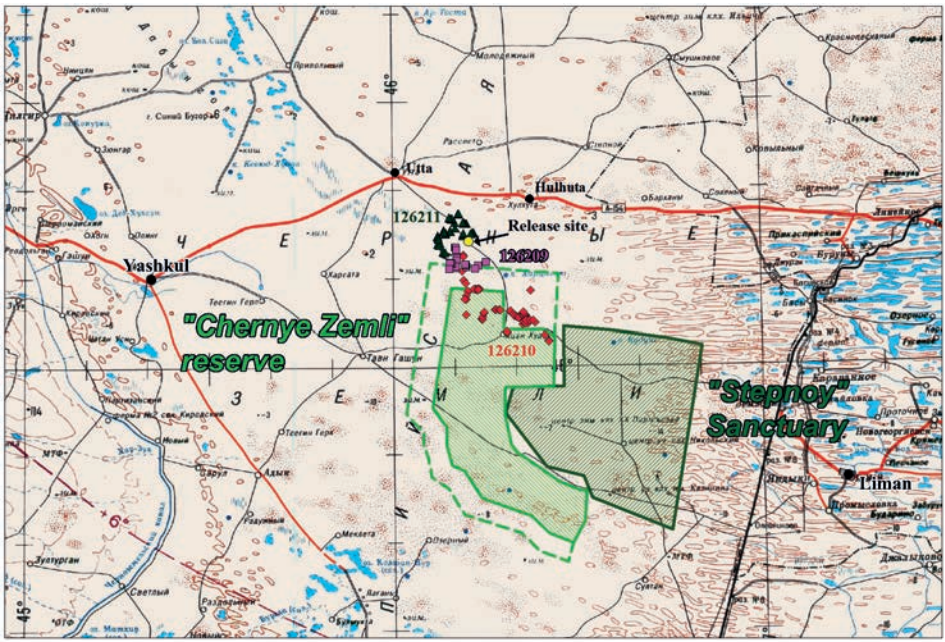


Figure 53. Sites of the registered locations of the saigas that were released in 2012 in the area of the "Chernye Zemli" Nature Reserve (from: Rozhnov *et al*., 2013).

Saiga movement trajectories are shown in Fig. 53. Collected data suggested that the released males were killed by wolves, which was further supported by the information provided by the Director of the "Chernye Zemli" Nature Reserve: two saigas fitted with satellite transmitters (ID 126209 и ID 126210) were killed by wolves and their GPS-collars were collected by the staff of the Reserve and for some time kept in the facilities of the Atsan-Kuduk cordon.

In January 2014, two male saigas (born in 2012 and 2013) raised at the "Saiga" Breeding Centre were released from the "Saiga" Breeding Centre of the Federal State Institution Astrakhanskoye State Experimental and Hunting Enterprise into the territory of the "Stepnoy" Sanctuary. The release was implemented in the frames of the regional "Programme on repatriation of males of the saiga (*Saiga tatarica tatarica*)". Monitoring of the released animals was carried out with the use of the collars equipped with "Pulsar" transmitters of GPS/Argos satellite system; transmitters and software used for monitoring were the same as those used in 2012.

Saigas were transported to the release site in the "Stepnoy" Sanctuary in specially designed individual crates loaded on the vehicle with closed body covered by tent fabric. The condition of the animals was assessed as satisfactory; the saigas did not have any injuries and had a good body and coat condition (Fig. 54). On January 4, 2014, the saigas were released in the area of the "Stepnoy" Sanctuary, near the location of a wild female herd numbering about 50 individuals (Franov *et al*., 2014).

Figure 54. Saiga antelopes in the "Saiga" Breeding Centre before the release into the area of "Stepnoy" Sanctuary (Photo by N.A. Franov).

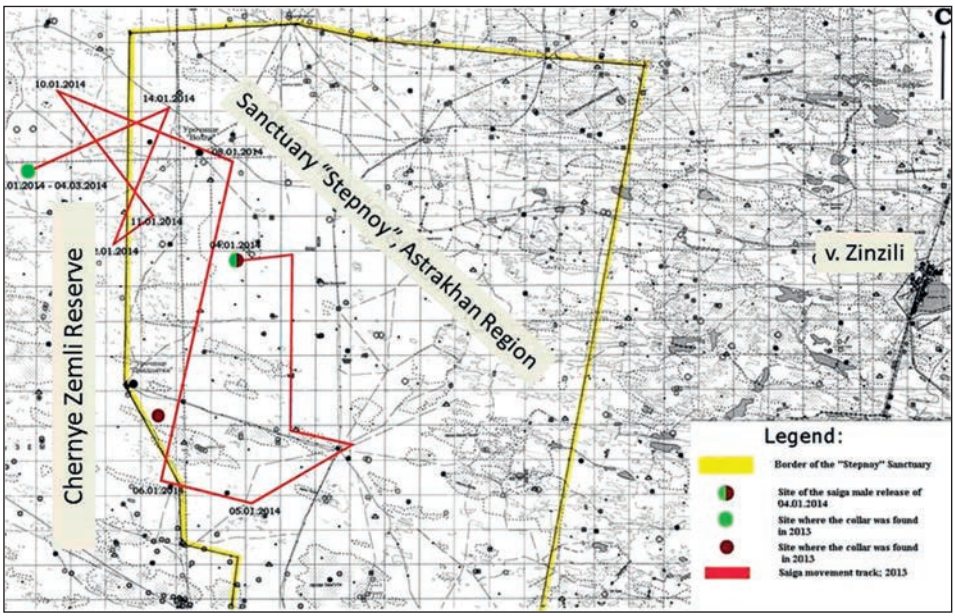


Figure 55. Release sites, movement tracks, and sites where radio-collars were found (Adapted with changes from: Franov *et al*., 2014).

The first data on the movements of the male born in 2013 were received in a week after the release, on January 10; the male was constantly moving, probably, together with the animals of one of the wild herds. Mapping of movement tracks (Fig. 55) demonstrated that the saigas averagely travelled up to 13 km per day.

This male was later observed via binoculars in a herd consisting of about 70 saigas, but on February 23, 2014, the transmitter stopped emitting signals, and on March 4, the collar was found in the area of the "Chernye Zemli" Nature Reserve, six kilometres west of its eastern border. The collar was torn (Fig. 56) and saiga fur and bone fragments were found nearby, so it could be concluded that the saiga was killed by wolves.

Figure 56. The collar torn by a wolf (Photo by N.A. Franov).

The transmitter of the male born in 2012 malfunctioned, emitting signals extremely irregularly. The collar was found in the area of the "Stepnoy" Sanctuary (in "Dvadtzatka" farm settlement). The collar was intact, and

no signs of fight or saiga remains were found around that site. Obviously, the saiga died in a different place, and the collar was brought to this site by humans.

Thus, based on visual observations and satellite tracking data, the male born in 2013 joined a wild saiga herd and actively moved with other members of the herd but was eventually killed by some predators (presumably, wolves). It is not known what happened to the male born in 2012 (Franov *et al*., 2014).

* * *

Results of the trial releases of captive born saigas show that released animals die quiet soon, mostly becoming killed by predators. Inadequate physical condition and inability to escape predators are the most probable causes of the deaths of the released saigas.

The task of the supplementation of the wild saiga population with captive bred males requires the creation of appropriate husbandry conditions: the animals should be kept in spacious enclosures where they could develop physically and run around like they do in the wild and their captive diet should be as close to the wild ration as possible. Saigas kept in small enclosures should undergo an "adaptation" process prior to their release into the wild, which could be achieved by their move to a large enclosure located in the natural habitat of the species. This issue was discussed at the International conference "Husbandry and Breeding of the Saiga Antelope (*Saiga tatarica* L.) in Artificial Environment" (May 28–30, 2013, Rostov Region, Russia) and has

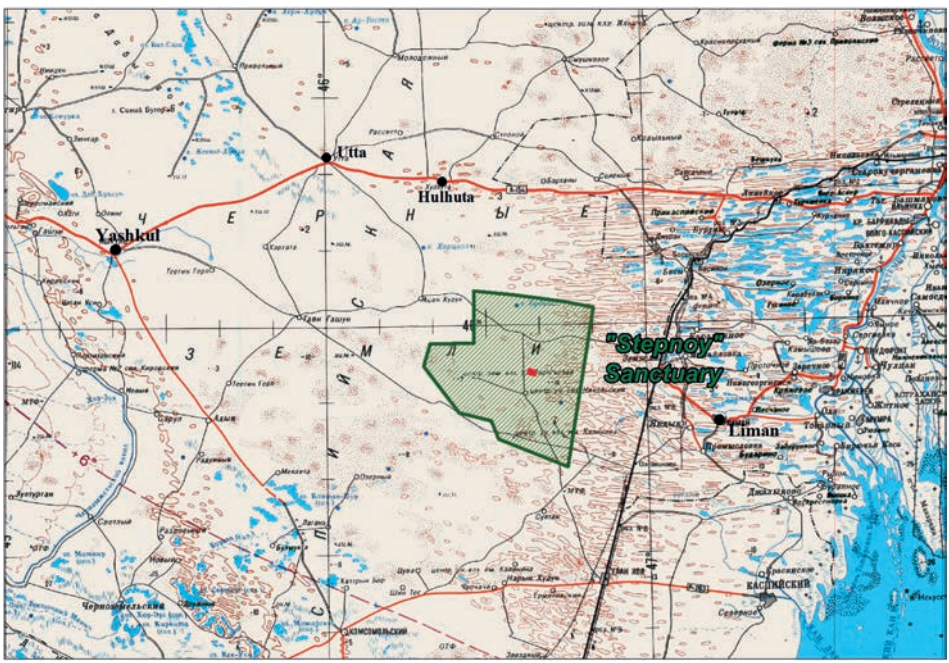


Figure 57. Projected location of the adaptation enclosure in the "Stepnoy" Sanctuary (Astrakhan Region).

been reflected in the Resolution of the Conference: "*To recommend the Ministry of Natural Resources and Environment of the Russian Federation to consider the possibility for establishing rehabilitation centre within the current distribution of the wild population of the saiga for the adaptation of captive raised saigas to natural environment*". The "Strategy for the preservation of rare and endangered species of animals and plants and development of the wildlife management industry in the Russian Federation until 2030" (http://www.mnr.gov.ru/online/detail.php?ID =129711) emphasizes the role of captive breeding in the conservation of wild populations of endangered species, and apart from the establishment of a number of new strictly protected areas, the Ministry of Natural Resources and Environment of Russia has incorporated the creation of new captive breeding centres for endangered animals, including the saiga, into the plan for 2017 (http://tass.ru/obschestvo/3914265).

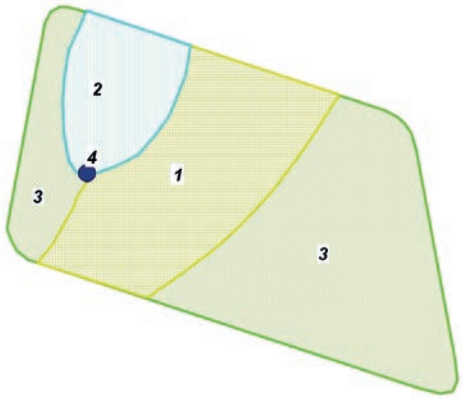


Figure 58. Structure of vegetation communities in the adaptation enclosure in the "Stepnoy" Sanctuary; Astrakhan Region: 1 – sagebrush communities; 2 – alkaline soil plant communities; 3 – feather grass communities; 4 – artesian well.

Feasibility study and engineering works were carries out in the "Stepnoy" Sanctuary and resulted in the selection of an area with the size of 1.5 km^2 (Fig. 57), which provides favourable natural conditions for saigas throughout a year (natural watering hole, various vegetation communities, and relatively diverse relief) (Fig. 58).

The development of the methods of the adaptation of captive raised saigas to the life in the wild will require further study of the behaviour and physiology of these animals.

Conclusion

The status of the saiga antelope is seriously compromised throughout the range of the species, though the reasons of the decline differ in different range states. It should be noted that the efforts made in some of the range states in the last 25 years by many governmental and non-governmental organizations have proved remarkably successful in increasing the numbers of these ungulates.

Although the saiga antelope is not included in the national Red Data Book of the Republic of Kazakhstan and has been widely hunted for centuries, the government of Kazakhstan invests a lot of money to support anti-poaching activities, saiga population surveys, and public education. The government of Kazakhstan have introduced a ban for hunting saiga antelopes and for the use of and trade in its parts and derivates across the entire territory of the Republic of Kazakhstan until 2020 by its Order of 25.07.2012; under this Order, low-breakers should pay a penalty of 200 monthly calculation indices (396,400 KZT, or 75,000 RUB) for each saiga individual or are punished by imprisonment for up to five years. All these measures have yielded significant increase in saiga numbers in Kazakhstan: the population had grown from 21,000 individuals in 2003 to 108,300 individuals in 2016. The numbers of saigas could be higher, but the outbreak of pasteurellosis in 2015 resulted in the deaths of over 200 thousands of animals (http://www.cms.int/sites/default/files/document/Saiga%20MOS3_Overview_Report_of_Conservation_Status_Rus.pdf). Aerial survey carried out in 2018 indicated that the total numbers of saigas reached 215,100 individuals (http://acbk.kz/animals/default/view?id=51) and showed an increase in the number of all populations. Scientific research, including satellite collaring of saigas, contributes to the effectiveness of the activities aimed at the saiga conservation in Kazakhstan. From 2009 through 2016, satellite transmitters were fitted to 95 saigas (70 saigas from Betpak-Dala population, 15 animals from Ustyurt population, and 10 saigas from Ural population). These transmitters daily send data that are used for mapping locations of the collared saigas. This information was also used in projecting the Altyn Dala State Nature Reserve for determining the borders of the ecological corridor in Central Kazakhstan and for justifying the expansion of the area of the Irgiz-Turgai State Nature Reserve by almost 410,000 ha (Ito *et al*., 2010; Salemgareev *et al*., 2011; Salemgareev, 2013; Michel, 2015; http://www.acbk.kz/ru/news/562/; http://www.acbk.kz/ru/news/556/; http:// www.acbk.kz/ru/news/436/; http://www. acbk.kz/ru/news/1978/; http://www.acbk.kz/ ru/pages/755.html, and others). Another example of the use of satellite monitoring of the migrations of this steppe antelope is presented by the development of guidelines on the construction of passages for saigas in projecting Zhezkazgan–Beineu railroad. (Salemgareev, 2013, 2014).

Much has been done in Mongolia to maintain the saiga population and increase the numbers of animals. The saiga antelope is listed in the second edition of the Mongolian Red Book; the government of the country and several NGOs invest significant resources in anti-poaching work, monitoring of saigas in different parts of the species range, and activities aimed at the engagement of local communities in the conservation of this unique species of West Mongolia. The saiga is protected under the Mongolian Law on Environmental Protection and Mongolian Law on Hunting, and the Criminal Code provides for a penalty of up to three months imprisonment or to a fine of 20,000–50,000 of the minimum wage for individuals and of 50,000–250,000 of the minimum wage for legal entities for people involved in illegal hunting of rare animals, including the saiga antelope. These measures had led to the increase in saiga numbers from 3,000 individuals in 2006 to 15,000 individuals in 2015 (http://www.cms.int/sites/default/files/document/Saiga%20MOS3_Overview_Report_of_Conservation_Status_Rus.pdf). The Mongolian saiga population was expected to further increase in size, but in January 2017, over 3,000 saigas were killed by the outbreak of peste-des-petits ruminants (sheep and goat plague) virus (http://web.unep.org/stories/ru/story). Data recently presented by WWF-Mongolia shows that although the prevalence of the disease has ceased the continued drought and food shortages in 2017 and 2018 causes decrease in Mongolian saiga population (http://wwf.panda.org/wwf_news/?335730/Horsemen-participation-in-Mongolian-saiga-conservation). Data recently presented by WWF-Mongolia shows that although the prevalence of the disease has ceased the continued drought and food shortages in 2017 and 2018 causes decrease in Mongolian saiga population (http://wwf.panda.org/wwf_news/?335730/Horsemen-participation-in-Mongolian-saiga-conservation). However, large-scale research activities are ongoing in Mongolia, including satellite monitoring of saigas for developing guidelines on the improvement of animal protection (Berger, Berger, 2006/2007; Berger *et al*., 2007/2008, 2010; Young *et al*., 2008/2009; Buuveibaatar *et al*., 2010/2011). For instance, saiga collaring and monitoring carried out in 2015–2016 within the area of the reconstruction of the 263-km long motorway connecting the territories of Gobi-Altai and Khovd provinces have indicated that human disturbance primarily associated with road construction works "negatively influenced saiga distributions by causing them to use areas farther from the road" (Chimeddorj *et al*., 2016).

In Uzbekistan, the saiga is listed in the Red Data Book as vulnerable species that suffers a habitat loss and decline in population size. Hunting of saigas was prohibited in the country by the Decree N290 of the Cabinet of Ministers of the Republic of Uzbekistan of 20.10.2014. In the event of illegal hunting of saigas, a fine of 50 minimal wages (5.9 million UZS, or US$ 2,278) is applicable to citizens of Uzbekistan and a fine of $US 5,000, for foreign nationals, and administrative and criminal liability can be applied to such cases. However, so far, the measures taken, including the assistance of international NGOs, fail to stabilize saiga numbers in the Ustyurt part of the species range. The primary reasons are high level of poaching and presence of various types of liner infrastructure that greatly affect the migrations of the transboundary population found in this region. A new "Saigachyi" Sanctuary with the

area of 7,000 km^2 was established in Uzbekistan in 2016 with the purpose to protect saiga antelopes and other unique wildlife and provide safety corridor for saigas migrating to Kazakhstan.

Certain measures for the restoration of the wild population of the saiga are also taken in China. For instance, researchers of the Institute of Zoology of the Chinese Academy of Sciences in cooperation with scientists from the University of Oxford have undertaken a literature review and developed a prediction model to define the borders of the saiga historical range and select appropriate habitats for saiga reintroduction (Shaopeng Cui *et al*., 2017). The authors note that in contrast to other regions of Central Asia, little or no work on the saiga reintroduction was earlier done in China. In addition, until present, no attempts have been made to study the patterns of the historical saiga migrations in this region and find out whether the current natural conditions in the potential saiga habitat meet biological requirements of breeding saigas. The authors of the study recommend implementing the reintroduction project in the protected areas located within the part of the historical range of the saiga in the north of Xinjiang Uyghur Autonomous Region and consider it necessary to develop a national action plan for identifying the main areas of the work aimed at the restoration of the saiga population in China.

Despite the critical status of the North-West Pre-Caspian population of the saiga, the issue of captive breeding and its funding, as well as of the activities on the protection of the wild population is currently not adequately addressed at the state level in Russia, and Article 49 ("Husbandry and breeding of game resources in semi-wild conditions and artificial environment") of the Federal Law of the Russian Federation "About hunting and about preserving hunting resources and about modification of separate legal acts of the Russian Federation" (2009) can not be taken into account in view of the upcoming inclusion of the saiga antelope in the Red Data Book of the Russian Federation. However, the adaptation of the "Strategy for the preservation of rare and endangered species of animals and plants and development of the wildlife management industry in the Russian Federation until 2030" (2012) where the role of captive breeding in the conservation of wild populations of endangered species is given a special attention and plans of the Ministry of Natural Resources and Environment of the Russian Federation to establish some new captive breeding centres, including captive breeding centres for the saiga (http://www.mnr.gov.ru/upload/iblock/3ee/1082.pdf), in the Year of Ecology (2017), give hope for future improvements in the area of saiga conservation.

Attempts at the saiga conservation made by saiga range states and cooperation under the Memorandum of Understanding *(*MoU) Concerning Conservation, Restoration and Sustainable Use of the Saiga Antelope and bilateral Agreements on the protection of transboundary populations of the saiga (between Russia and Kazakhstan, and between Kazakhstan and Uzbekistan), as well as exchange of the experience and knowledge between the range states show great promise for the conservation of this unique species across its entire range through all available means, including captive breeding, though as was noted earlier, range countries do not have special legislation that would regulate the works in this area. Based on the current situation, future ac-

tivities should be built upon the Medium Term International Work Programme for the Saiga Antelope (2016-2020) that is an integral part of the MoU. Point 9 ("Captive breeding") of the Programme listed under proposed measures states that it is necessary to: determine the role of captive breeding and other *ex situ* methods for genetic preservation or reintroduction and set guidelines on best practice, including approved facilities and reintroductions; maintain a central database or studbook for all captive populations and create structures and leadership for the database; promote the exchange of expertise in captive breeding, including study tours between captive breeding centres and research into existing issues and best practices; and establish captive breeding facilities in Mongolia, Uzbekistan and other parts of the saiga range where appropriate, and support existing facilities in the Russian Federation, Kazakhstan and China (http://www.cms.int/sites/default/files/document/unep-cms_saiga%20mos3_mr_annex%205_mtiwp2016-2020_rev_eng_0.pdf).

Tragic mass deaths of saigas in Kazakhstan in 2015 and in Mongolia in 2017, when mass die-offs of saigas caused by infectious diseases have almost reversed an impressive growth that saiga populations showed in the preceding years, clearly demonstrate the vulnerability of this species. This tragedy highlighted the importance of the fact that all saiga populations should be sufficiently large and sustainable to resist potential catastrophic events. In that regard, captive breeding of saigas can play an important role in achieving the goals of saiga conservation.

Captive breeding programs and subsequent releases of animals into the wild have been increasingly used for conservation and restoration of threatened species worldwide. Given the high likelihood of future degradation and reduction of natural habitats and extinction of wild populations of many species, it has to be concluded that a wider use of captive breeding programs for species restoration would be an appropriate approach to the conservation of target species.

The saiga antelope is one of the most difficult wild ungulate species in terms of captive breeding, which fact has been supported by the history of maintaining this species in zoos. Almost all zoos, even those with a great experience in captive breeding of rare animal species, faced a number of challenges in the captive husbandry of saigas, which was associated with specific ecology and behaviour of these animals. Although zoos have gained rich and unique experience in the enclosure design and husbandry, breeding and veterinary care of the saiga, no zoo has been able to establish a viable group of saigas under captive conditions. Moreover, despite the long-time efforts to manage and breed saigas in zoo environment, currently only one zoo in the world (Almaty Zoo in Kazakhstan) has this unique species in its animal collection.

The situation is different, however, when it comes to the specialized saiga breeding centres. Such centres have gained an extensive experience in husbandry, breeding and feeding of saigas. Despite the differences in the locations, sources and scales of funding, sizes and infrastructures, these captive breeding centres share the same feature: they used wild caught saigas at the first stages of establishing the founder stock. In Russia, all works on the capturing of saigas in "Chernye Zemli " Ecoregion during calving season and transportation of the caught animals to the breeding centres were carried out with the use of the unified techniques. The holistic approach devel-

oped at the breeding centres enabled the creation of sustainable and regularly breeding captive population of the saiga. The experience of the breeding centres suggests that saigas can successfully breed in captivity, even if the number of founders is not high. The most important factors of the successful breeding of saigas include justified selection of the location of the breeding centre (lowland area with low vegetation and mild depressions where the animals can hide), feeding adult saigas on balanced diets, with supplementing natural forage with additional foods that would meet foraging and nutritional requirements of the species, availability of sufficiently large enclosures, and creating conditions that would ensure maximum safety for saigas.

In order to improve reproduction of saigas from the wild populations through the increase of the numbers of mature males, captive bred males can be used for the releases into the wild; such males could originate from the breeding facilities, such as Askania Nova Biosphere Reserve (Ukraine), Endangered Wildlife Breeding Centre in Gansu Province (China), or Yashkul Captive Breeding Station of the Centre for Wild Animals of the Republic of Kalmykia (Russia) where appropriate conditions have been created for saigas and males comprised 30% to 60% of the captive stock (including both adult males and males under one year of age), depending on the year (Kokshunova, 2003; Kang, 2004; Gavrilenko *et al*., 2009; Minoransky, Tolcheeva, 2010). It should be noted that the removal of captive males for the releases (that should be implemented several months prior to the rutting period) will not affect the populations of the breeding centres.

The use of saiga breeding centres may benefit the activities aimed at the restoration of the wild populations, but experiments in the releases of saigas into the wild have demonstrated the need in developing methods of saiga preparation for the releases, which will improve the resilience of the released animals. Recent analysis suggests that the creation of saiga breeding centres for the subsequent use of captive bred animals for releases aimed at the restoration of the wild populations seems very promising, provided that a number of conditions are met, with sufficient long-term funding being one of the most important factors of success. Other prerequisites for successful captive breeding include science-based selection of the location of both breeding centre (in the area of natural pastures of the saiga) and rehabilitation enclosure where the animals would adapt to their wild environment; conformance of the enclosure sizes to the features of saiga behaviour (particularly, the enclosures should provide enough space for active movements of saigas); availability of professional and motivated staff; and adoption of the legislation clearly regulating various aspects of the activities aimed at captive breeding and releases of saigas into the wild.

It is important to stress again that any attempts at the reinforcement of the wild populations of saigas through the releases of captive-raised animals will fail in the absence of effective measures of the protection of animals in their wild habitats, which can be planned with the use of data on the locations, short movements and long migrations of the saiga; such information can be obtained via satellite monitoring of the saigas fitted with GPS-collars, and saigas raised in semi-wild conditions and adapted to the natural environment can be used as subjects to such type of monitoring.

Experiments in satellite monitoring of saigas have shown that releases of the animals raised at captive breeding centres can not only increase the reproductive success of some wild populations but also serve as a non-invasive, reliable method of obtaining information about movements of wild saigas. It will allow to develop and circulate recommendations on the practical measures of mitigating impacts of various barriers (cross-border constructions, roads, oil and gas pipeline, canals, etc.) to saiga migrations, as well as to improve the effectiveness of saiga protection.

Supplementation of the wild saiga herds with captive bred males will help to restore the normal sex ratio in the wild populations and increase their reproductive potential, but activities of the captive breeding centres may also contribute to reducing the pressure of poaching, since saigas may be bred in captivity for the production of horns and meat, which may have some economic effect.

The experience in husbandry and breeding of saigas in captivity, gained in the recent years in different countries may be utilized not only for species conservation but also with the aim of promoting local economic development. A good example is the practice of the wild and semi-captive management of game species, initiated in 1960 by the creation of the ranch for wild ungulates in Southern Rhodesia (now Zimbabwe) (Gabuzov, 1982; Neronov *et al*., 1986). Main advantages of such approach to the management of wild ungulates include better adaptations of animals to their natural environment, lesser impact on wild ecosystems, reduced water supply requirements, increased mobility and unrestricted foraging behaviour, and availability of a wide range of plants (including plants that are rarely eaten or not consumed by livestock) at various stages of growth (Gabuzov, 1982; Neronov *et al*., 1986), creating the situation when the numbers of wild animals supported by a certain natural area are 3–4 times higher than the numbers of livestock using the same area, and total amount of the plant biomass consumed by wild animals does not exceed 30–40% (at the tolerable level of grazing of 40–50%). Movement patterns and foraging and social behaviour of wild ungulates make the large aggregation of animals in some areas of the habitat extremely unlikely, which helps to reduce grazing pressure and minimize soil erosion and degradation of vegetation cover. It is to be noted that the net amount of meat products obtained from wild animals is 10–20% larger than that obtained from farm animals of the same weight. Meat of game animals contains 20–25% of proteins and only 1–5% of fat and is almost free of hormones, insecticides, and medications, which are usually given to livestock kept at modern farms. Wild animals are characterized by rapid growth and development, require little care, and are less susceptible to diseases. Expenses incurred in the creation and maintenance of wild animal farms comprise only 20% of the total income, while the expenses of the livestock farms reach at least 70% of the income (Mossman, Mossman, 1976), which is in important factor in the evaluation of their economic effectiveness (Dasmann, 1982; Ledger, 1983).

In many countries, multi-purpose captive breeding of wild ungulates has developed rapidly in recent decades for producing dietic meat products and row materials for medical industry, captive hunts or releases of animals into the wild ”under the gun”, and demonstrations of animals to visitors in “open” zoos or safari-parks where visitors usually ride in cars or electro-mobiles. The demand for such services shows

Table 11. Amino acid content of saiga's meat and lamb
(from: Shakhbaev, 1998)

Amino acid	**Content in 100 g of the product (in grams)**	
	Saiga's meat	Lamb
Valine	1.74	0.82
Isoleucine	–	0.754
Leucine	1.55	1.116
Lyzine	1.91	1.235
Methionine	1.4	0.356
Threonin	0.72	0.688
Tryptophane	0.16	0.198
Phenylalanine	1.33	0.611
Alanine	1.01	1.021
Arginine	2.15	0.993
Aspartic acid	2.63	1.442
Histidine	2.07	0.48
Glycine	2.92	0.865
Glutamic acid	2.55	2.459
Oxyproline	–	0.295
Proline	–	0.741
Serine	1.77	0.657
Tyrosine	0.88	0.524
Cysteine	–	0.205
Total	**27.79**	**15.46**

continuous growth, increasing the incomes of the companies owning these businesses, which, in turn, facilitates the expansion of businesses and growth of ungulate stocks (Danilkin, 2010).

Similar farms could be established for saigas. Saiga's meat is known to have quite high taste quality, therefore the expansion of the activities in saiga captive breeding could well lead to the production and even export of high quality meat. Comparative data on the content of organic matter in saiga's meat and lamb are given below (Table 11). As shown in Table 11, amino acid content is significantly higher in saiga's meat than in lamb.

Under contemporary conditions, saiga farms may generate income through direct sales of not only raw meat and meat products produced to special recipes but also skins (saiga skins are valued in manufacturing suede items), horns for medical purposes and as souvenirs, and live animals for zoos and other farms; in addition, the income can be generated due to ecotourism.

Saiga horns are particularly in demand, especially in the domestic market of China where they are sold for US$ 5,000 per 1 kg or over US$ 1,600 per a pair (Vaisman, 2015). Special study is required to assess the value of saiga horns with regard to the manufacture of medications and biologically active additives. Should their efficiency be proved, saiga breeding may bring profit that could be used for both protection of

wild populations and further development of saiga farms and breeding centres, which will improve the well-being of local communities and significantly reduce poaching.

Thus, captive breeding of saigas along with the management of livestock may become one of the priority areas of agriculture in the regions located within the natural range of this unique and valuable species. However, such plans are just a distant prospect that may become a reality only if there are a strong legal framework and strict control of relevant state bodies in place. Besides, a wide awareness campaign is necessary to inform local farmers about economic benefits of this innovative approach and its conservation aspects, as well as the governmental support of the initiatives aimed at establishing such farms.

Currently, there is no legislation in Russia (like in other saiga range states) that would directly regulate legal relations in the area of captive breeding (in the farms or in enclosures) of game animals (Danilkin, 2011). This type of relations is vaguely worded in the Federal Laws of the Russian Federation "On the Animal World" (1995) and "About hunting and about preserving hunting resources and about modification of separate legal acts of the Russian Federation" (2009), and in the Forest Code, Land Code, and Tax Code. These relations are stipulated for in the Article 49 ("Husbandry and breeding of game resources in semi-wild conditions and artificial environment") of the Federal Law of the Russian Federation "About hunting and about preserving hunting resources…", but specific items of this Article are unclear, and "farmers" have many questions and issues when applying for the licenses to operate business in the area of husbandry and breeding of game animals under captive conditions or in artificial environment (Danilkin, 2011). The basic Federal Laws ("On the Animal World" and "About hunting…") lack definitions of the "breeding under semi-captive conditions" and "artificial environment" concepts, and their interpretations differ widely, which leads to the emergence of corruption in the process of obtaining necessary permits (Danilkin, 2011). In the opinion of A.A. Danilkin (2010, 2011), the licensing system in the area of animal captive breeding should be legally eliminated to be replaced with a notification system.

Recent actions of the Government of the Russian Federation offer hope that saiga antelopes will not disappear from the Russian steppes. Recently, a new provision, Article 258.1, was introduced in the Russian Federal Law N150-FZ of 2.07.2013 "On Amendments to Certain Legislative Acts of the Russian Federation in Connection with the Improvement of the Division of Powers", which provides for criminal liability (imprisonment for up to 7 years and a fine of 2 million roubles) "for illegal hunting, possession, purchasing, storage, transportation, shipping (trafficking) and selling of especially valuable wild animal and aquatic biological resources and their parts and derivates belonging to the species included into the Russian Red Data Book and/or protected by international treaties to which Russia is a Party". Under the Ministerial Decree No. 978 validating the list of particularly valuable wild fauna species, saiga is included in the list of "particularly valuable" species as the species included in the Appendix of the CITES, of which Russia is a signatory party. Additionally, the saiga antelope has been included in the list of species proposed for the inclusion in the updated version of the Red Data Book of the Russian Federation.

However, it should be noted that management decision-making should be supported by the results of the comprehensive study of the biology and ecology of the saiga. In this regard, breeding centres can play a role of field laboratories that may be used for important, unique studies that would be difficult, if not impossible, to carry out on the wild saigas but that are essential for understanding biological and ecological characteristics of these animals and conservation of their wild populations.

Such studies include, inter alia, the development of non-invasive methods for monitoring reproductive status of female saigas; this research was implemented on the base of the Yashkul Captive Breeding Station through the measurement of the levels of the excretion of hormones or their metabolites in urine and faeces. The use of this non-invasive method allows for the evaluation of animal health not only without stressful procedures (capture, restrain, collection of blood samples) but even without the presence of the animals, which is extremely important from both technical and conservation perspective (Arylova, 2009).

Samples of fur, faeces, bones, and other tissues of saigas collected at the Yashkul Captive Breeding Station at the first stage of the research were used for the assessment of genetic diversity of the saiga antelope through the analysis of mitochondrial and nuclear DNA polymorphism, including microsatellite loci and class II genes of the major histocompatibility complex (MHC) (Kholodova *et al*., 2006). This research provided information for the assessment of the genetic diversity of the North-West Pre-Caspian population of the saiga and identification of main trends in the diversity of the population over the period of the decline of its numbers, which allowed to evaluate the potential viability of the population.

Palaeographic, faunistic, and ecological data suggest that energy metabolism and thermoregulation of the saiga are important, if not critical, parameters that had a noticeable impact on the evolution of this species. They are heavily interconnected with all aspects of the saiga biology and may be determinates of the species future. Saiga is well-known for its extremely distinctive appearance with an enlarged nasal cavity, with the soft tissues of the nasal vestibulum forming a pronounced trunk-like structure (Lodyzhenskaya, 1952; Frey, Hofmann, 1997; Clifford, Witmer, 2004; Frey *et al*., 2007), but the functional role of the unique saiga nose is not very clear. Existing hypotheses do not focus on the possible role of the saiga nose in thermoregulation, though its highly branched network of blood vessels can make it possible to use the nose as a “thermal window” to dissipate surplus heat, when necessary, for preventing hyperthermia. Thermography of the body surface of the saigas kept at the Yashkul Captive Breeding Station, that was carried out in summer/autumn and winter periods with the use of thermal imaging techniques, has shown that in general, given the similar conditions, the dynamics of the temperature of the saiga nose in relation to ambient temperature correlates with the temperature dynamics of the thermal windows in other mammals (Yu.F. Ivlev, pers. comm.).

Wildlife population management would not be possible without the monitoring of the numbers of animals. Surveys of saigas and data processing were conducted in various years and are still carried out with the use of different methods (aerial surveys from a low flying Antonov-2 aircraft or a helicopter), based on the techniques devel-

oped by various experts at relevant institutions (Federal State Budgetary Institution "Central Hunting Control", Federal State Budgetary Research Institution "Prof. B. M. Zhitkov All-Russia game management and fur farming research institute"). All these methods rely on visual observations of the animals, and annual surveys provide important information on the trends in population growth, but a "human factor", as well as methods of data processing that are usually characterized by a high rate of errors, strongly affect the results of such surveys. An alternative approach to the estimation of saiga numbers within a certain area has been developed recently, which utilizes satellite images of high resolution for the evaluation of ecosystem status and detection of relatively small objects, including saigas (Rozhnov *et al*., 2015; 2015).

In conclusion, it is necessary to emphasize the importance of saiga breeding facilities as the centres that may play a key role in the conservation of saiga genetic pool, maintenance of reserve populations of the saiga for future restoration of the wild populations of the species, outreach activities, and scientific experiments and research aimed at developing measures of the conservation and restoration of saiga populations throughout the entire range of this unique species.

References

Abaturov B.D. 1984. Mammals as a component of the ecosystem. Moscow: Nauka. 285 pp. (in Russian).

Abaturov B.D., Kholodova M.V. 1989. Variability and optimization of the nutrient and energy consumption and energy levels in herbivorous mammals. Zool. Jour. 68(1): 111-123 (in Russian).

Abaturov B.D., Kholodova M.V., Subbotin A.E. 1982. Intensity of food consumption and digestibility in saiga antelope *(Saiga tatarica)*. Zool. Jour. 6(12): 1870-1881 (in Russian).

Abaturov B.D., Kolesnikov M.P., Likhnova O.P., Petrishchev B.I., Nikonova O.A. 1997. Use of plant forage lignin and silica as digestibility indicators for a quantitative estimation of food consumption in free-ranging saigas. Zool. Jour. 76(1): 104-113 (in Russian).

Abaturov B.D., Larionov K.O., Kolesnikova M.P., Nikonova O.A. 2005. Nutrition status and food security of the saiga *(Saiga tatarica)* foraging on the pastures with different vegetation types. Zool. Jour. 84(3): 377-390 (in Russian).

Abaturov B.D., Petrishchev B.I. 1998. Comparative assessment of the diet of the free ranging saiga *(Saiga tatarica)* through microscopic analysis of fecal plant residuals and estimation of the quantities of consumed plants based on observations. Zool. Jour. 77(2): 964-970 (in Russian).

Abaturov B.D., Petrishchev B.I., Kolesnikov M.P., Subbotin A.E. 1998. Seasonal dynamics of forage resources and nutrition of saiga in natural semidesert pasture. Uspekhi sovremennoy biologii. 118(5): 564-584 (in Russian).

Abaturov B.D., Petrishchev B.I., Magomedov M.P. 1978. Experience in keeping saigas in enclosures. In: Acclimatization of game animals in the USSR. Minsk: Urozhai. 166-167 (in Russian).

Adolf T.A. 1950. The saiga in the Astrakhan steppe in the right-bank area of the Volga River basin. Okhrana Prirody. 10: 73-82 (in Russian).

Adolf T.A. 1954. Some Data on the Biology of Saiga in the Astrakhan Steppe, 1954. Uch. Zap. Mosk. Gos. Ped. Inst. 28(2): 247-256 (in Russian).

Altukhov Yu.P. 2003. Genetic processes in populations. Moscow. Academkniga. 431 pp. (in Russian).

Arylov Yu.N. 2002. Scientific aspects of nutrition and development of saigas in captivity. Thesis for the Doctor degree in biological sciences. Dubrovitzy. 352 pp. (in Russian).

Arylov Yu.N., Arylova N.Yu. 2005. Biological characteristics of saiga antelopes in terms of breeding under artificial conditions. In: Ecology and natural environment of Kalmykia. Elista. 97-99 (in Russian).

Arylov Yu.N., Arylova N.Yu. 2009. Captive breeding of the saiga for the conservation of the species gene pool and restoration of saiga populations in the wild. In: Proceedings of the 29th International Congress of biologists and game managers. 238-239 (in Russian).

Arylov Yu.N., Voznesenskaya V.V., Medhzidov R.A., Milner-Gulland E.J., Ubushaev B.S. 2006. International Projects on the Study and Conservation of the Saiga in Kalmykia. Steppe Bulletin. 21-22: 11-14 (in Russian).

Arylova N.Yu. 2005. Behaviour of the European saiga antelopes in captivity during the period of rut. In: Proceedings of the All-Russia scientific conference of students, doctoral candidates, and young scientists. Nalchik. 75-77 (in Russian).

Arylova N.Yu. 2008. Reproduction of the saiga antelope (*Saiga tatarica tatarica* L.) in the Republic of Kalmykia under conditions of small population size. Ecological Magazine of Volga Region. 2: 136-142 (in Russian).

Arylova N.Yu. 2009. Ecology of the saiga antelope *(Saiga tatarica tatarica* L., 1766) in the Northwest Pre-Caspian region: population under pressure (on the model of "Chernye Zemli" region). Abstract of the thesis for the Candidate degree in biological sciences. Rostov-on-Don. 26 pp. (in Russian).

Arylova N.Yu., Lushchekina A.A., Voznesenskaya V.V. 2006/2007. A new approach to studying saiga reproduction in the North-Western Caspian Sea. Saiga News. 4: 8-9.

Babich O.G., Kaminetskyi V.K. 2008. Formuvannya populyatsyi chiselnosti kopytnykh v natsionalnomu prirodnomu parku "Azovo-Sivasky". Naukovi dopovidi NAU. 2(10): 56-74 (in Ukrainian).

Bakeev N.N., Formozov A.N. 1955. Distribution and some ecological characteristics of the saiga antelope in the western part of Pre-Caspian basin. In: Materials on biogeography of the USSR. Volume 2. Moscow: Academy of Sciences of the USSR. 208-240 (in Russian).

Bakirova R.T., Gorbunov S.V. 2016. Przewalski's horses have come back to the steppe. Troitskyi variant. 199: 8 (in Russian).

Bannikov A.G., Flint V.Ye. 1982. We must save them. Moscow: Publ. House Mysl. 174 pp. (in Russian).

Bannikov A.G., Zhirnov L.V., Lebedeva L.S., Fandeev A.A. 1961. Biology of the Saiga Antelope. Moscow: Publishing House for agricultural literature, magazines and posters. 336 pp. (in Russian).

Baryshnikov G.F., Dmitrieva Ye.L., Krakhmalnaya T.V., Sher A.V. 1998. Origin, Evolution and Systematics of Saiga Antelope. In: Saiga: Phylogeny, Systematics, Ecology, Protection, and Use. Moscow: Print-shop of the State Agricultural Academy. 9-20 (in Russian).

Berger K., Berger J. 2006/2007. Mongolian Saiga: A summary of WCS field work and radio-collaring efforts. Saiga News. 4: P. 6.

Berger J., Murray-Berger K., Young J., Buuveibaatar B. 2007/2008. Research on population estimates and movements of Mongolian saiga, 2006-07. Saiga News. 6: 11.

Berger J., Murray K., Buuveibaatar B., Dunbar M., Lkhagvasuren B. 2010. Capture of ungulate s in Central Asia using drive nets: advantages and pitfalls illustrated by the Endangered Mongolian saiga *Saiga tatarica mongolica*. Oryx. 44(4): 512-515.

Bliznyuk A.I., Baktasheva N.M. 2001. Spring feeding of saiga antelopes (*Saiga tatarica*) from Kalmykia population. Zool. Jour. 80(6): 743-748 (in Russian).

Bliznyuk A.I., Bukreeva O.M. 2000. Current Fecundity and Calving in Saiga, *Saiga tatarica*, of the Kalmyk Population. Zool. Jour. 79(9): 1124-1132 (in Russian).

Bogdanov A.P. 1889. Longevity of Animals in Zoological Gardens. Vestnik of the Russian Emperor Society for Acclimatization of Animals and Plants. V. 5. Moscow. 132-138 (in Russian).

Bouman I. 1995. Re-introduction of Przewalski horses in Hustain Nuruu. Przewalski horse. 36: 16-29.

Bragina T.M. 2015. Saiga migratory routes in Kazakhstan are taken under protection. Saiga News. 19: 3-4.

Bukreeva O.M., Kravchuk O.A. 2004. Some disturbances in monocyclic pattern of breeding in European population of the saiga. In: Mammals as a component of arid ecosystems (resources, fauna, ecology, medical importance, and protection). Saratov. 23-24 (in Russian).

Buuveibaatar B., Young J., Lhagvasuren B., Berger J., Fine A.E. 2010/2011. Mongolian saiga calf survival: an update. Saiga News. 10: 11.

Cavenagh S. 2011/2012. Avenues for future research into the migration of the saiga antelope. Saiga News. 14: 16-17.

Chimeddorj B., Sergelen E., Buuveibaatar B. 2016. Effects of human disturbance on the distribution and movements of saiga antelopes in western Mongolia. Saiga News. 21: 35-37.

Clifford A.B., Witmer L.M. 2004. Case studies in novel narial anatomy: 3. Structure and function of the nasal cavity of saiga (Artiodactyla: Bovidae: *Saiga tatarica)*. J. Zool. 264(3): 217-230.

Convention on Biological Diversity (CBD). 1992. Secretariat of the Convention on Biological Diversity. Geneva, Switzerland.

Crandall L.S. 1964. The Management of Wild Animals in Captivity. Chicago: University of Chicago Press. 97 pp.

Curtis L., Turner L. 1977. Survey – Saiga antelope in captivity. Zool. J. 4(1): 3-12.
Danilkin A.A. 2010. Game farming industry. Moscow: KMK Scientific Press Ltd. 150 pp. (in Russian).
Danilkin A.A. 2011. Captive breeding of animals in enclosures: legislation as the basis of iniquity and corruption. Hunting – National Hunting Jour. 2: 2-7 (in Russian).
Dasman R.F.1982. Wildlife biology. Santa Cruz: Wiley eastern limited. 194 pp.
Defining maximum sizes of saiga groups in captivity during periods of rut, calving and young rearing and when keeping young saigas together with adult individuals (Astrakhanskoye State Experimental and Hunting Enterprise). 2011. In: Main areas and results of experimental works in the state experimental hunting enterprises of the Ministry of Natural Resources and Ecology of Russia (analytical review). Moscow: Physicheskaya cultura. 115-122 (in Russian).
Dolan J.M. 1977. The saiga, *Saiga tatarica:* a review as a model for the management of endangered species. Int. Zoo Yearbook. 17: 25-32.
Dubinin M.Yu., Lushchekina A.A., Radeloff F.K. 2009. Experience of saiga satellite telemetry in the Northwest Precaspian region. Saiga News. 6: 11-12.
Dumenko V.P. 2002. Wolf (*Canis lupus*) in the region of the Biosphere Reserve "Ascania-Nova".Visnik Luganskogo derzhavnogo pedagogichnogo universitetu imeni Tarasa Shevchenko. 1(45): 171-173 (in Russian).
Dumenko V.P., Treus M.Yu. 2000. Stray and feral dogs in the Askania Nova Biosphere Reserve. In: Steppes of Northern Eurasia: Strategy of conservation of natural diversity and use of steppe resources in the 21-th century. Orenburg: IPK "Gazprom-pechat". 153-155 (in Russian).
Duplaa A., Rozhnov V.V., Salman A.L. 2011. The use of the Argos radio-transmitters for remote monitoring of wild animals. In: The use of remote monitoring methods in zoological studies. Moscow: KMK Scientific Press Ltd. 24 (in Russian).
Dzhapova R.R., Ausheva E.Ch., Bembeeva O.G. 2013. Vegetation cover on the territory of the State Institution "The Centre for Wild Animals of the Republic of Kalmykia". In: Ecology and Natural Environment of Kalmykia. Elista: ZAO NPP Dzhangar. 21-27 (in Russian).
Falz-Fein W. 1930. Askania Nova. Berlin. 324 pp.
Falz-Fein V.E. 1997. Askania Nova. Kiev: Agrarnaya Nauka. 348 pp. (in Russian).
Feeding saiga antelopes without including fresh forage in their diets (Astrakhanskoye State Experimental and Hunting Enterprise). 2011. In: Main areas and results of experimental works in the state experimental hunting enterprises of the Ministry of Natural Resources and Ecology of Russia (analytical review). Moscow: Physicheskaya cultura. 123-125 (in Russian).
Flint V.Ye. 2000. Strategy for conservation of endangered wildlife species in Russia. Moscow. 328 pp. (in Russian).
Flint V.Ye., Smirnova O.V., Zaugolnova L.B., Khanina L.G., Bobrovsky M.V., Toropova N.A., Melekhova O.P., Sorokin A.G. 2002. Conservation and Restoration of Biodiversity. Moscow: Scientific, Education and Methodical Centre. 286 pp. (in Russian).Franov N.A., Gagarin V.V. 2009. Experience of captive breeding of saigas at the Astrakhanskoye State Experimental and Hunting Enterprise of the Hunting Department of the Ministry of Agriculture of the Russian Federation. In: Proceedings of the 29th International Congress of biologists and game managers. 20-21 (in Russian).
Franov N., Gagarin V. 2010. Saiga breeding at the Astrakhan State Hunting Research Station. Saiga News. 11: 11-12.
Franov N.A., Gagarin V.V., Shilenko M.V. 2014. Release of saiga males into the wild during the rutting period in Astrakhan province. Saiga News. 18: 16-17.
Frey R., Hofmann R.R. 1997. Skull, proboscis musculature and preorbital gland in the saiga antelope and Guenther's dikdik (Mammalia, Artiodactyla, Bovidae). Zool. Anz. 235: 183-199.
Frey R., Volodin I., Volodina E. 2007. A nose that roars: anatomical specializations and behavioural features of rutting male saiga. Journal of Anatomy. 211(6): 717-736.
Gabuzov O.S. 1982. Role and objectives of artificial breeding of game animals in promoting a greater productivity of hunting grounds. In: Game breeding in hunting industry. Moscow. 6-40 (in Russian).

Gabuzov O.S. 1992. The basis of artificial breeding of game animals and captive breeding of rare species. Abstract of the thesis for the Doctor degree in biological sciences. Moscow. 52 pp. (in Russian).
Gavrilenko V. 2009. Askania Nova, a semi-natural Saiga captive breeding centre. Saiga News. 9:14-15.
Gavrilenko V.S., Dumenko V.P., Smagol V.A. 2009. Current status of the saiga population in Askania Nova Biosphere Reserve and main factors affecting population growth. In: Proceedings of the 29th International Congress of Biologists and Game Managers. Moscow. 18-19 (in Russian).
Gavrilenko V.S., Listopadskyi M.A., Polishuk I.K., Dumenko V.P. 2010. Konspect fauni hrebetnykh Biosphernogo zapovidnika "Askania Nova". Askania Nova. 120 pp. (in Ukrainian).
Gorval V.N. 2009. Book of Diets. Animal feeding standards of the Moscow Zoo. Moscow: Moscow Zoo. 398 pp. (in Russian).
Grachev Yu.A., Bekenov A.B. 2010. On the case of mass die-off of saigas in Volga-Ural interfluve. Steppe Bulletin. 30. 35-36 (in Russian).
Habitat quality as a factor influencing numbers and distribution of the European population of the saiga antelope in Northwest Pre-Caspian region on the model of the pasture area of the "Saiga" Captive Breeding Centre (Astrakhanskoye State Experimental and Hunting Enterprise). 2011. In: Main areas and results of experimental works in the state experimental hunting enterprises of the Ministry of Natural Resources and Ecology of Russia (analytical review). Moscow: Physicheskaya cultura. 107-114 (in Russian).
Hassanin A., Douzery E. 1999. The tribal radiation of the family Bovidae (Artiodactyla) and the evolution of the mitochondrial cytochrome b gene. Mol. Phylogenet. Evol. 13: 227-243.
Informational issue of the Eurasian Regional Association of Zoos and Aquariums. 2005-2016. [URL: http://earaza.ru/?page_id=31] (in Russian).
International Zoo Yearbook. 1962-2013.
Ito T.Y., Masato Shinoda M., Esipov A.V., Grachev Yu.A., Singh N., Milner-Gulland E.J. 2010. Satellite tracking of saigas starts in Ustyurt. Saiga News. 10: 10-11.
Jones M.L. 1996. History of the Saiga *(Saiga tatarica)* in captivity. Gnusletter. 16(2): 10-12.
Jungius H. 2006/2007. Recommendations for the restoration of the Mongolian saiga in the Great Lakes basin. Saiga News. 4: 5-9.
Kang A. 2004. Behavioral research of the SaigaAntelope, *Saiga tatarica*, in its main reproductive seasons in semi-natural conditions. Abstract of PhD (biology) dissertation. College of Life Sciences East China Normal University. Harbin. 117 pp.
Kang A. 2007. New generation in Gansu Wuwei Wildlife Breeding and Research Centre. Saiga news. 5: 3.
Kang A., Zenian X. 2005. Saiga antelopes at the Gansu Endangered Wildlife Breeding Centre, China. Saiga news. 2: 6.
Kashinin V.V., Kuprikova Ye.A., Egorov D.N., Khudhzanov K.R. 2005. Management and breeding of saiga antelopes at the Moscow Zoo's Breeding Centre. In: Ungulates in Zoos and Breeding Stations. Moscow: Moscow Zoo. 160-165 (in Russian).
Kasyanov N.I. 1933. Infectious disease in acclimatized wild animals in Askania Nova (Veterinary and sanitary review for 1839–1932). In: Proceedings of the Institute of Agricultural Hybridization and Acclimatization of Animals in Askania Nova. Moscow/Leningrad: Gosudarstvennoe Izdaniye kolkhoznoi I sovkhoznoi literatury. V.1. 275-283 (in Russian).
Kholodova M.V. 2006. Genetic diversity and phylogenetic evolution of even-toed mammals (Artiodactyla, Ruminantia). Thesis for the Doctor degree in biological sciences. Moscow. 256 pp. (in Russian).
Kholodova M.V., Arylov Yu.N., Lushchekina A.A. 2005. Breeding saiga (Saiga tatarica L.) in captivity as an alternative way to maintain genetic diversity of the species. In: Ungulates in Zoos and Breeding Stations. Moscow: Moscow Zoo. 134-141 (in Russian).
Kholodova M.V., Milner-Gulland E.J., Easton A.J., Amgalan L., Arylov Yu.N., Bekenov A., Grachev Yu.A., Lushchekina A.A., Ryder O. 2006. Mitochondrial DNA variation and population structure of the critically endangered SAIGA antelope *Saiga tatarica*. Oryx. 40: 103-107 [http://

www.saigaresourcecentre.com/literature/mitochondrial-dna-variation-and-populationstructure-ofthe-critically-endangered-saiga-antelope-saiga-tatarica].
Kholodova M.V., Neronov V.M. 1996. Saiga Antelopes in Zoos of the World. Report 1. In: Experience in captive husbandry of saiga antelopes in the zoos abroad. N6. Moscow. 223-253 pp. (in Russian).
Kirilyuk V.E., Rozhnov V.V. 2011. On the experience in the release of captive raised wolves into the wild. In: Theriofauna of Russia and neighbouring regions. Proceedings of International Meeting (IX Congress of the Theriology Society). Moscow: KMK Scientific Press Ltd. 217 (in Russian).
Kokshunova L.E. 2003. Hierarchy in saiga bachelor group in captivity. In: Theriofauna of Russia and neighbouring regions. Moscow: A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences. 169-170 (in Russian).
Kokshunova L.E., Gavrilenko V.S., Treus M.Yu., Smagol V.A. 2005. Interrelations of saiga (*Saiga tatarica tatarica*) with wild and domestic ungulates. Journal of Evolutionary Biochemistry and Physiology. 41(6): 569-571 (in Russian).
Kolosov A.M., Lavrov N.P. 1968. Game fauna enrichment in the USSR. Moscow: Forest Industry Press Ltd. 256 pp. (in Russian).
Korneev G.A., Kukin V.M., Karpov A.A., Putyatin V.V. 1986. Experience in captive husbandry and feeding of saiga calves. In: The Fourth Congress of the All-Union Theriology Society. V.3. Moscow. 152-153 (in Russian).
Krutyporokh F.I., Treus V.D. 1967. Askania Nova. Kiev: Urozhai. 36 pp. (in Russian).
Kuznetsova M.V., Kholodova M.V., Lushchekina A.A. 2002. Phylogenetic analysis of sequences of the 12S and 16S rRNA mitochondrial genes in the family Bovidae: new evidence**.** Genetika. 38(8): 1115-1124 (in Russian).
Larionov K.O. 2008. Nutrition and food security of the saiga *(Saiga tatarica)*, depending on the vegetation cover on pasture areas. Abstract of the thesis for the Candidate degree in biological sciences. Moscow. 29 pp. (in Russian).
Larionov K.O., Dzhapova R.R., Rozenfeld S.L., Abaturov B.D. 2008. Feeding of the saiga *(Saiga tatarica)* on the pastures of the Kalmykian Chernye Zemli under conditions of restoration shift in vegetation patterns and steppe expansion. Zool. Jour. 87(10): 1259-1269 (in Russian).
Lebedeva L.S. 1959. Feeding of the saiga in the right-bank area of the Volga River. Bulletin of the Moscow Society of Naturalists. Biology Series. 64(5): 27-35 (in Russian).
Lebedeva L.S. 1960. Materials to the study of spring foods and pastures of the saiga in the rightbank area of the Volga River. Zool. Jour. 39(9): 1438-1442 (in Russian).
Ledger H.P. 1983. The rational use of wild animals. Domestication, conservation and use of animal resources. World animal science. V. A1. Amsterdam: Elsevier Science Publishers. 125 pp.
Levykin S.V., Kazachkov G.V., Yakovlev I.G., Grudinin D.A. 2015. Saiga antelope in Orenburg Region: history, legends, and the prospect for restoration. Izvestiya of the Samara Scientific Centre of RAS. 17(4): 174-178 (in Russian).
Lishu L. 2006. A potential reserve in China for saiga restoration. Saiga News. 3: 4-5.
Liu R.T. 1996. The vegetation characteristics in the introduction area of *Saiga tatarica*. I. evaluation of characteristics and suitability of plant flora. Acta Ecologica Sinica. 16(1): 65-70.
Lodyzhenskaya V.I. 1952. To the Morphology of the Upper Respiratory Tract in the Saiga Antelope (*Saiga tatarica)*. Uchenye zapiski Karelo-Finskogo Universiteta. 4(3): 17-41 (in Russian).
Lushchekina A., Struchkov A. 2001. The saiga antelope in Europe: once again on the brink? The open country. 3: 11-24.
Mammal Species of the World: A Taxonomic and Geographic Reference. 2005. Baltimore, Maryland: The Johns Hopkins University Press. V. 1 and 2. 2142 pp.
Marmazinskaya N.V. 2012. Methodical guidelines on the breeding and reintroduction of the Bukhara Deer into the natural habitats. Moscow: Skorost Zveta. 88 pp. (in Russian).
Martynevsky I.L., Aikimbaev A.M. 2001. On the causes of the mass die-off of saiga antelopes. In: The 2nd International Intergovernmental Conference on the cooperation of the states of the CIS in the area of sanitary protection. Almaty. 143-146 (in Russian).

Mikhel S. 2015. Guidelines on the use of the remote telemetry systems for identification of wild mammals. FLERMONECA. 16 pp. (in Russian).
Minoransky V.A. 2016. Saiga antelopes in Pontic Steppes. Donskoy Vremennik. 25: 142-147 [http://www.donvrem.dspl.ru/Files/article/m9/0/art.aspx?art_id=1526] (in Russian).
Minoransky V.A., Dankov V.I. 2015. Conservation of the saiga antelope *(Saiga tatarica tatarica* L.) in Russia. In: Proceedings of the International Ecological Forum (Krasnaya Polyana, Krasnodar Region, October 2-5 2015). Rostov-on-Don: Published by the "Wild Nature of the Steppe" Association. 110-121 (in Russian).
Minoransky V.A., Dankov V.I. 2016. Saiga antelope *(Saiga tatarica* L.): the Species Disappearing in Russia. South of Russia: ecology and development (ecology of animals series). 11(1): 88-103 (in Russian).
Minoransky V.A., Dankov V.I., Dolzhikov A.N. 2009. Management and breeding of saigas in the enclosures in the Centre of Rare Animals of European Steppes of the "Wild Nature of the Steppe" Association. In: Proceedings of the 29th International Congress of Biologists and Game Managers. Moscow. 250-251 (in Russian).
Minoransky V.A., Dankov V.I., Tolcheeva S.V., Dobrovolsky O.P. 2012. Technique of breeding saiga antelope *(Saiga tatarica* L.) in enclosures. In: Steppes of Northern Eurasia: Proceedings of the 6th Symposium. Orenburg: IPK "Gazprompechat" OOO "Orenburggaspromservice". 503-504 (in Russian).
Minoransky V.A., Tolcheeva S.V. 2010. Keeping saiga antelopes *(Saiga tatarica* L.) in enclosures. Rostov-on-Don: "Kovcheg" Publishing House. 288 pp. (in Russian).
Miquelle D.G., Arenas R., Jimenez-Perez I.I., Fernandez L., Garrote G., Lopez-Parra M., Rey T.D., Ruiz G., Garcia-Tardio M., Lopez G., Onorato D., Criffield M., Rozhnov V.V., Blidchenko E.Y., Hernandez-Blanco J.A., Naidenko S.V., Sorokin P.A., Yachmennikova A.A., Boixader J., Simon M.A. 2016. Rescue and rehabilitation centers and reintroduction to the wild. In: Snow Leopards: Biodiversity of the World: Conservation from Genes to Landscapes. Academic Press. 323-342.
Mohr E. 1943/44. Einiges uber die Saiga, *Saiga tatarica* L. Der Zoologische Garten. 15(5/6): 175-185.
Monahan C. 2006. Diagnostic techniques for veterinary parasitology. PhD. Department of Veterinary Preventive Medicine. OSU College of Veterinary Medicine. 230 pp.
Mossman S.L., Mossman A.S. 1976. Wild life utilization and game ranching Morges. Switzerland. IUCN Occ. N17. 99 pp.
Mykhailov V.A. 2015. Modern variety of steppes of the Crimean Peninsula. Steppes of Northern Eurasia. In: Proceedings of the 7th International Symposium. Orenburg: PD "Dymur". 531-533 (in Russian).
Neronov V.M., Arylova N.Yu., Dubinin M.Yu., Karimova T.Yu., Lushchekina A.A. 2013. Current status and prospects of conservation of the saiga antelope in the Northwest Pre-Caspian region. Arid ecosystems. 19(2): 5-14 (in Russian).
Neronov V.M., Kudoyarova I.A., Lushchekina A.A. 1986. Ecological and economic basis for breeding game animals under wild and semi-wild conditions: International experience. In: The First All-Union Meeting on the Problems of Zooculture. Part 1. Moscow. 59-61 (in Russian).
Nuridjanov A. 2009. Saigas in Vozrozhdenie Island, Uzbekistan. Saiga News. 9: 12-13.
Ostapenko V.A. 2013. Specifics of biology and breeding of various oryx species. Vestnik of the People's Friendship University of Russia (RUDN). Series: Ecology and Life Safety. 2: 25-33 (in Russian).
Ostapenko V.A., Kuprikova Ye.A. 2013. Results of captive breeding of saiga antelope in the Moscow Zoo's Breeding Centre. In: Management and breeding of the saiga *(Saiga tatarica* L.) in artificial environment. Rostov-on-Don. 59-65 (in Russian).
Our human planet: summary for decision-makers. Millennium ecosystem assessment. 2005. Washington D.C. USA: Island press. 109 pp.
Pagel T., Spieß W. 2011. Der Zoologische Garten in Coln eroffnet am 22. Juli 1860 – 150 Jahre Wildtierhaltung und –zucht. Der Zoologische Garten. 80(2-3): 117-202.

Pazhetnov V.S., Pazhetnov S.V., Bestman M., Chispiyakov R.E., Malev A.V. 1996. Return of the zoo born brown bear cubs into the wild. In: Scientific Research in Zoological Parks. N2. Kharkov. 25-29 (in Russian).

Pazhetnov V.S., Pazhetnov S.V., Pazhetnova S.I. 1999. Techniques of rearing orphaned bear cubs for their release into the wild. Tver. 47 pp. (in Russian).

Pereladova O.B. 2005. The state of affair in the area of captive breeding of ungulates for the restoration of the wild populations in the countries of Central Asia: WWF Central Asia programs: 1999-2004. In: Ungulates in Zoos and Breeding Stations. Moscow: Moscow Zoo. 15-27 (in Russian).

Pereladova O.B. 2016. Scientific basis of the works on the restoration of wild populations of large mammals in Central Asia: Effectiveness of WWF projects for 15 year period. In: Theriofauna of Russia and neighbouring regions. Moscow: KMK Scientific Press Ltd. 320 (in Russian).

Pererva V.I., Pererva A.V., Treboganova N.V., Verizhnikov Yu.A. 2002. Economic mechanisms of the captive breeding of wild animals. Moscow: Biodiversity Conservation GEF Project – Institute of Economics of Environmental Management – ZAO "Okaecos". 52 pp. (in Russian).

Petrishchev B.I. 1986. Principles of keeping saiga antelopes in captivity within restricted area. In: The Fourth Congress of Theriology Society. V. 3. Moscow. 159-162 (in Russian).

Petrishchev B.I. 1987. The desert needs saigas. Moscow: "Mysl". 127 pp. (in Russian).

Petrishchev B.I. 1997. Characteristics of saiga *(Saiga tatarica)* embryogenesis and offspring health assessment. Zool. Jour. 76(2): 234-242 (in Russian).

Petrishchev B.I., Kholodova M.V. 1980. Rearing of saigas in the field. In: Ungulates of the USSR fauna. Ecology, Morphology, Use, and Protection. Moscow: Science. 250-252 (in Russian).

Petrishchev B.I., Maksymuk A.V., Abaturov B.D. 1998. Captive husbandry and breeding of saiga antelope. Techniques of young saiga capture and husbandry. In: Saiga: Phylogeny, Systematics, Ecology, Protection, and Use. Moscow: Print-shop of the State Agricultural Academy. 281-289 (in Russian).

Petrishchev B.I., Maksymuk A.V., Abaturov B.D., Kholodova M.V. 1982. Capturing and keeping saiga antelopes in captivity. In: Increasing productivity of animal husbandry and game fauna. Moscow. 101-108 (in Russian).

Pohle C. 1974. Haltung und Zucht der Saiga-Antilope *(Saiga tatarica)* im Tierpark Berlin. Der Zoologischen Garten. 44: 387-409.

Pohle C. 1987. Experiences of keeping and breeding Saiga antilope at Tierpark, Berlin. In: The Biology and Management of Capricornis and Related Mountain Antelopes. London-New- York-Sydney: Croom Helm. 191-204.

Proceedings of the International Workshop on Rehabilitation and Reintroduction of Large Carnivores (Moscow, November 25-27, 2015). 2015. Moscow: KMK Scientific Press Ltd. 160 pp.

Prokopov G.A. 2016. Main statistics on the flora and fauna of the Tarkhankut National Park and neighbouring territories (as of 01.01.2016) [http://parktarhankut.ru/index.php/en/documents] (in Russian).

Pronyaev A.V., Fadeev A.A. 1998. Postnatal ontogenesis: Growth, development, and age-specific variability of the skull and other organs and systems. In: Saiga: Phylogeny, Systematics, Ecology, Protection, and Use. Moscow: Print-shop of the State Agricultural Academy. 202-205 (in Russian).

Przewalski's Horse and Restoration of the Wild Populations of the Species in Mongolia. 1988. Moscow: Centre of International Projects of the State Committee for Science and Technology. 247 pp. (in Russian).

Qian Huang, Aili Kang, Fenglian Li. 2014. The traditional medicine market for saiga products in China. Saiga News. 18: 14-15.

Rduch V., Zimmermann W., Vogel K.-H., Ladener H., Sliwa A. 2016. Saiga-Antilopen *(Saiga tatarica)* im Kolner Zoo: tiergartnerische Erfahrungen und Beobachtungen. Zeitschrift des Kolner Zoos. 59(3): 135-149.

Report of the Department of Ecological Education and Research of the Tarkhankut National Park for the IV quarter of 2016. 2016. Main results of the past year. [http://parktarhankut.ru/index.php/en/documents] (in Russian).

Rozenfeld S.B., Larionov K.O. 2006. Implementation of cuticular coprological analysis for study of forage composition of hoofed animals in Kalmykia and Mongolia. In: Current Problems of Ecology and Evolution in Research Works of Young Scientists"). Moscow: A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences. 249-254 (in Russian).

Rozhnov V.V. 2015. Reintroduction of Large Carnivores. In: Proceedings of the International Workshop on Rehabilitation and Reintroduction of Large Carnivores. (Moscow, November 25-27, 2015). Moscow: KMK Scientific Press Ltd. 8 (in Russian).

Rozhnov V.V., Lushchekina A.A., Yachmennikova A.A., Dobrynin D.V. 2015. Counting Saigas from Outer Space. Astrachanskiy vestnik ecologicheskogo obrazovaniya. 1: 23-33 (in Russian).

Rozhnov V., Orlov V., Paklina N., Spasskaya N. 2011. Comeback of the Przewalski's Horse. Science in Russia. 4(184): 32-37 (in Russian).

Rozhnov V.V., Salman A.L. 2011. Experience in the use of Argos and GPS/Argos radio-transmitters for studying Behaviours and Ecology of mammals. In: Theriofauna of Russia and neighboring regions. Moscow: KMK Scientific Press Ltd. 401 (in Russian).

Rozhnov V.V., Salman A.L., Arylov Yu.N., Lushchekina A.A. 2013. On the experimental release into the wild of saiga antelope males from the breeding centre. In: Management and breeding of the saiga *(Saiga tatarica* L.) in artificial environment. Rostov-on-Don. 66-71 (in Russian).

Rozhnov V.V., Spasskaya N.N., Chybilev A.A., Levykin S.V., Orlov V.N., Paklina N.V., Pozdnyakova M.K., Petrishchev B.I. 2009. The Program on the Restoration of Przewalski's Horse in Orenburg Region. Moscow: KMK Scientific Press Ltd. 32 pp. (in Russian).

Rozhnov V.V., Yachmennikova A.A., Dobrynin D.V. 2014. On the opportunity to detect saiga antelope (*Saiga tatarica*) individuals with the use of high-resolution satellite images. Reports of the Academy of Sciences. 459(6): 769-773 (in Russian).

Rubin E.S., Michelson K.J. 1994. Nursing behavior in dam-reared Russian Saiga *(Saiga tatarica tatarica)* in the San Diego Wild Animal Park. Zoo Biology. 13: 309-314.

Salemgareev A. 2013. Saiga collaring for research and conservation in Ustyurt. Saiga News. 16: 14-16.

Salgansky A.A., Sles I.S., Treus V.D., Uspenskiy T.A. 1963. Zoopark "Askaniya-Nova". Kiev: Gosselkhozizdat USSR. 305 pp. (in Russian).

Salemgareev A.A. 2014. Sixteen female saigas help biologists to study the endangered species – satellite telemetry in marking of wild animals. News of ACBK: e-bulletin of the Regional Public Organization "Association for the Conservation of Biodiversity of Kazakhstan". 16: 9 (in Russian).

Salemgareev A., Shaimukhanbetov O., Zuther S., Sklyarenko S. 2011. Results of the satellite collaring programme in Betpak-dala, 2009/10. Saiga News. 12: 11-12.

Sarsenova B.B., Sergaliev N.H., Usenov Zh.T., Baktygereeva Sh.R. 2013. Planning and construction of the saiga breeding centre in Kazakhstan. In: Management and breeding of the saiga *(Saiga tatarica* L.) in artificial environment. Rostov-on-Don. 72-76 (in Russian).

Sarsenova B.B., Sydikhov B.M., Usenov Zh.T., Shonyraev M.Zh. 2015a. Body mass indices in saiga calves of Ural population in captivity. Novosti Nauki Kazakhstana. 1(123): 99-106 (in Russian).

Sarsenova B.B., Sydikhov B.M., Usenov Zh.T., Shonyraev M.Zh., Azhgereev B.A. 2014. Experience of captive breeding of saigas of Ural population. In: Contemporary challenges in game management in Kazakhstan and neighbouring countries (Almaty, March 11-12, 2014). Almaty. 557-562 (in Russian).

Sarsenova B.B., Usenov Zh.T., Kazanova G.B. 2016. Some features of the behaviour of saigas in captivity. Contemporary research and innovations. N4 [http://web.snauka.ru/issues/2016/04/66316] (in Russian).

Sarsenova B.B., Usenov Zh.T., Shonyraev M.Zh. 2015b. Specifics of the captive husbandry of saiga antelope. In: Steppes of Northern Eurasia. Proceedings of the 7th International Symposium. Orenburg: PD "Dymur". 746-749 (in Russian).

Semenov N.N., Reut Yu.A. 1989. Fauna of mammals and birds in the Biosphere Reserve "Askania Nova". Scientific and technical bulletin of UNIIZh "Askania Nova" Kherson. 1: 43-47 (in Russian).

Shakhbaev Sh.A. 1998. Development of sustainable methods of production and processing of saiga meat. Thesis for the Candidate degree in engineering sciences. Voronezh. 209 pp. (in Russian).
Shaopeng Cui, Milner-Gulland E.J., Navinder J. Singh, Hongjun Chu, Chunwang Li, Jing Chen, Zhigang Jiang. 2017. Historical range, extirpation and prospects for reintroduction of saigas in China. Sci. Rep. **7**: 1-11. doi: 10.1038/srep44200 [https://www.nature.com/srep44200].
Shapoval V.V. 2012. BR Askania Nova named after F. J. Falz-Fein. In: Fytoriznomanittya zapovidnikiv I natzionalnykh prirodnikh parkiv Ukraini. Part 1. Biosphere reserves. Nature Reserves. Kiev: Fitosorsiocentr. 13-30 (in Ukrainian).
Smagol V.O. 2014a. Morphological features of the saiga *Saiga tatarica* from the population of Askania Nova. Visti Biosphernogo Zapovednika Askania Nova. 16: 56-64 (in Ukrainian).
Smagol V.O. 2014b. Characteristics of breeding activity of saiga antelope *Saiga tatarica* from the population of Askania Nova. Visti Biosphernogo Zapovednika Askania Nova. 16: 65-71 (in Ukrainian).
Smagol V.O. 2015. Dynamics of the population size of the saiga *Saiga tatarica* L. in Askania Nova Reserve. Visti Biosphernogo Zapovednika Askania Nova. 17: 77-81 (in Ukrainian).
Sokolov V.Ye., Kholodova M.V. 1996. Saiga Antelopes in Zoos of the World. Report 2. In: Experience in captive husbandry of saiga antelopes in the zoos of Russia and former Republics of the USSR. Scientific Research in Zoological Parks. N6. Moscow. 254-272 (in Russian).
Sludsky A.A., Afanasyev Yu.G. 1964. Acclimatization of game animals in Kazakhstan: results and horizons. In: Commercial and harmful mammals of Kazakhstan. Alma-Ata: Published by Academy of Sciences of KSSR. 119-200 (in Russian).
Spasskaya N.N., Paklina N.V., Pozdnyakova M.K. 2005. General criteria for the selection of animals for reintroduction projects (on the model of Przewalski's horse). In: Ungulates in Zoos and Breeding Stations. Moscow: Moscow Zoo. 27-32 (in Russian).
Spielman D., Brook B.W., Frankham R. 2004. Most species are not driven to extinction before genetic factors impact them. Proc. of Nat. Acad. Sci. USA. 101(42): 15261-15264.
Steklenev E.P., Smagol V.A. 2013. Current status of the subpopulation of saiga in the Biosphere Reserve "Askania Nova". In: Proceedings of the International scientific and practical conference "Management and breeding of the saiga (*Saiga tatarica L*) under artificial conditions". Rostov-na-Donu. 90-96 (in Russian).
Steklenjov E.P. 2002. Physilogichny osoblivosti razmnozhennya saigi *(Saiga tatarica)* pri napivvilnomu utrimanni na pivdni Ukraini. Vestnik zoologii. 36(2): 55-60 (in Ukrainian).
Steklenjov E.P., Smagol V.O. 2011. Formuvannya subpopulyatzii saigi *(Saiga tatarica L.)* v zapovedniku "Askania Nova". Naukoviy visnik NUBiP Ukraini. 160(1) (in Ukranian). [http://elibrary.nubip.edu.ua/8667/1/sep.pdf].
Subbotin A.E. 2001. An experimental study of the saiga *(Saiga tatarica)* nutrition related to the food resources. Abstract of the thesis for the Candidate degree in biological sciences. Moscow. 25 pp. (in Russian).
The USSR State Program on Environmental Protection and Sustainable Use of Natural Resources for 1991/1995 until 2005. 1990. Economy and life. 41: 15 (in Russian).
Tikhonov A.N. 1999. Systematics of bovids of the subfamily Caprinae (Artiodactyla, Bovidae). Abstract of the thesis for the Candidate degree in biological sciences. St. Petersburg. 22 pp. (in Russian).
Treus V.D. 1968. Acclimatization and hybridization of animals in Askania Nova. 80 year of experience in cultural exploitation of wild ungulates and birds. Kiev: Urozhai. 316 pp. (in Russian).
Treus M.Yu., Zvegintsova N.S. 2000. Saiga antelope's comeback to the steppes of Ukraine. In: Steppes of Northern Eurasia: the strategy of conservation of natural diversity and steppe exploitation in the 21st century. Orenburg. 378-379 (in Russian).
Treus M.Yu., Zvegintsova N.S., Smagol V.A. 2002. Saiga in the south of Ukraine. In: Strictly protected areas in the 21st century: objectives and goals. Smolensk. 163-166 (in Russian).

Tsevegmid D., Dashdorj A. 1974. Wild horses and other endangered wildlife in Mongolia. Oryx. 12(3): 361-370.
Tzaplyuk O.E. 1982. Renaissance of the Saiga antelope. Almaty: Kainar. 108 pp. (in Russian).
Vaisman A. 2015. Saiga Story: Medical history as a draft obituary. Russian hunting magazine. September: 42-44 (in Russian).
Ubushaev B.S. 2017. Keeping saiga antelope *(Saiga tatarica)* in enclosures with the use of typical diets. International Research Journal. 3(45). Part 3: 133-137 (in Russian).
Uzdenov A.M., Minoransky V.A., Dankov V.I., Dolzhikov A.N., Tolcheeva S.V. 2013. Management of the saiga *(Saiga tatarica* L.) in artificial conditions at the Centre of Rare Animals of European Steppes of the "Wild Nature of the Steppe" Association. In: Management and breeding of the saiga *(Saiga tatarica* L.) in artificial environment. Rostov-on-Don. 103-108 (in Russian).
Yasinetskaya N. 2006. Animal Collection of the Askania Nova Zoo – National Treasure of Ukraine. Kherson: Naddnipryanochka. 32 pp. (in Russian).
Young J., Buuveibaatar B., Fine A.E., Lhagvasuren B., Berger J. 2008. Mongolian Saiga Calves Captured and Collared. Saiga News. 8: 8.
Zavadovsky M.M. 1924. Genra; review and history of the development of Askania Nova. In: Askania Nova – steppe reserve of Ukraine. Moscow: GOSIZDAT. 1-60 (in Russian).
Zharkikh T.L., Yasinetskaya N.I. 2005. Review of some projects for reintroduction of the Przewalski's Horse *(Equus przewalskii)* and recommendations on establishing wild populations. In: Ungulates in Zoos and Breeding Stations. Moscow: Moscow Zoo. 33-60 (in Russian).
Zhirnov L.V. 1982. Returned to Life (Ecology, Protection, and Use of saigas). Moscow: Lesnaya Promyshlennost. 224 pp. (in Russian).
Zimmermann W. 2005. Przewalski's horses on the track to reintroduction - various projects compared. Zeitschrift des Kolner Zoo. 48(4): 183-209.
Zvegintsova N.S. 2011. Diagnostic of parasitoses and rehabilitation of the saiga through hand-rearing. Techniques of the conservation of rare animal species. Moscow: KMK Scientific Press Ltd. 15 (in Russian).
Zveri Kazakhstana [Animals of Kazakhstan]. 1993. Alma-Ata: Publishing House of the Academy of Sciences of the Soviet Socialist Republic of Kazakhstan. 502 pp. (in Russian).
Zuther S. 2009/2010. Tracking saigas in Kazakhstan. Saiga News. 10: 9-10.
Zuther S., Salemgareev A. 2016. The results of the aerial survey of saiga populations in Kazakhstan in 2016. Saiga News. 21: 38-39.

Appendix: Information about saiga antelopes at the zoos of the world

N	Country	City	Institution	Period	Off-spring	References
1	Armenia	Yerevan	Yerevan Zoo	?		1. Minoransky & Tolcheeva, 2010
2	Belgium	Antwerp	Antwerp Zoo	1878, 1983, 1972-1984	Yes	1.Dolan, 1977; 2.International Zoo Yearbook, 1962-2016
3	Belgium	Mechelen	Planckendael Animal Park	1971-1972, 1980-1990	Yes	1. International Zoo Yearbook, 1962-2016; 2. http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2
4	Canada	Edmonton	Edmonton's Polar Park (Alberta Game Farm)	1971, 1974?		1. Dolan, 1977
5	Canada	Penticton	Penticton Zoo	1973		1. International Zoo Yearbook, 1962-2016
6	Canada	Winnipeg	Assinboine Park Zoo	The 1960s-1970s?, 1974, 1987-1991	Yes	1. Dolan, 1977; 2. International Zoo Yearbook, 1962-2016
7	China	Beijing	Beijing Zoo	1953-1954?	Yes	1. http://www.zoochat.com/9/history-saiga-captivity-249984/index4.html
8	China	Chengde (?)	Chenade Zoo	?	Yes	1. Kholodova & Neronov, 1996
9	Czech Republic	Chomutov	Chomutov Zoo	1998-2004		1. http://www.zootierliste.de/en/?klasse=l&ordnung=l16& familie=11609&art=l160921&subhaltungen=2
10	Czechoslo-vakia	Bojnice	Zoo Bojnice	1971-1972, 1985-1987	Yes	1. International Zoo Yearbook, 1962-2016
11	Czechoslo-vakia	Brno	Brno Zoo	The 1950s?		1.http://www.zoobmo.cz/img/old/en/more-about-us/zoo-report/zoo-report/files/joumal-zooreport-profi-3-003-pdf.pdf
12	Czechoslo-vakia	Liberec	Zoo Liberec	1965		1.International Zoo Yearbook, 1962-2016; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=11609&art=l160921&subhaltungen=2
13	Czechoslo-vakia	Ostrava	Ostrava Zoo	1965		1.International Zoo Yearbook, 1962-2016; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=11609&art=l160921&subhaltungen=2
14	Czechoslo-vakia	Plzen	Plzen Zoo	1959-1964, 1972		1. http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=11609&art=l160921&subhaltungen=2

15	Czechoslo-vakia	Prague	Prague Zoo	1950-1973...	Yes	1.Dolan, 1977; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=11609&art=l160921&subhaltungen=2
16	Denmark	Aalborg	Aalborg Zoo	1969-1971		1.International Zoo Yearbook, 1962-2016; 2.http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
17	Denmark	Copen-hagen	Copenhagen Zoo	1953-1956		1. International Zoo Yearbook, 1962-2016
18	Estonia	Tallinn	Tallinn Zoo	1963, 1965		1. Sokolov & Kholodova, 1996
19	Finland	Helsinki	Helsinki Zoo	1972-1977	Yes	1.International Zoo Yearbook, 1962-2016; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=11609&art=l160921&subhaltungen=2
20	France	Paris	Museum National d'Histoire Naturelle	1959,1965	Yes	1. Curtis, Turner, 1977
21	France	Paris	Paris Zoo	1972		1. International Zoo Yearbook, 1962-2016
22	France	Thoiry	Safari Zoo de Thoiry	The 1970s?		1. -http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
23	Germany	Alfeld	Zoo & Tierpark Alfeld	?		1. Kholodova & Neronov, 1996
24	Germany (GDR)	Berlin	Tierpark Berlin	1958-1989	Yes	1.Dolan, 1977; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
25	Germany (FRG)	Berlin	Zoologischer Garten	1872-1875, 1883, 1901-1903, 1933-1935, 1973-1974		1. http://www.zootierhste.de/en/?klasse= l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
26	Germany	Bremen	Bremen Zoo	1889		1. Dolan, 1977
27	Germany	Cologne	Cologne Zoo	1874-..., 1976-2009	Yes	1. http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2
28	Germany	Dortmund	Dortmund Zoo	...-1986		1. http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2
29	Germany	Dresden	Dresden Zoo	?		1. http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2

N	Country	City	Institution	Period	Off-spring	References
30	Germany	Frankfurt	Frankfurt Zoo	1903-1905		1. http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2
31	Germany	Halle	Halle Zoo	1954		1. http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2
32	Germany	Hamburg	Hamburg Zoo until 1930	1872, 1876-1877		1.Dolan, 1977 2.http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2
33	Germany	Hamburg	Tierpark Hagenbeck	1912-1913, 1938, 1939, 1941		1.Mohr, 1943/1944; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l 160921&subhaltungen=2
34	Germany	Hannover	Hannover Zoo	1936, ...-1945, 1954-..., 1957, 1964	Yes	1.Mohr, 1943/1944; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
35	Germany	Leipzig	Leipzig Zoo	1971		1.International Zoo Yearbook, 1962-2016; 2.http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
36	Germany	Neumuenster	Neumuenster Zoo	1996		1. International Zoo Yearbook, 1962-2016
37	Germany	Nuremberg	Nuremberg Zoo	1977-1991	Yes	1. International Zoo Yearbook, 1962-2016
38	Hungary	Budapest	Budapest Zoo	1977-1979, 1987-1989	Yes	1. International Zoo Yearbook, 1962-2016
39	Italy	Naples	Naples Zoo	1961		1. International Zoo Yearbook, 1962-2016
40	Japan	Goraisho	Zoo	1984-1991	Yes	1. International Zoo Yearbook, 1962-2016
41	Kazakhstan	Alma-Ata (Almaty)	Almaty Zoo	1939, 1972-1973, 1992-1993, 2015-current time	Yes	1.Sokolov & Kholodova, 1996; 2.Informational issue of the Eurasian Regional Association of Zoos and Aquariums. 2005-2016; 3.International Zoo Yearbook, 1962-2016; 4.http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
42	Poland	Warsaw	Warsaw Zoo	1996-1997		1.International Zoo Yearbook, 1962-2016 2.http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
43	Poland (Germany)	Wroclaw (Breslau)	Wroslaw (Breslau) Zoo	1888-1889		1. http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2

44	Poland	Plock	Zoo Plock	1965		1. International Zoo Yearbook, 1962-2016
45	Poland	Poznan	Poznan Zoo	1973		1. International Zoo Yearbook, 1962-2016
46	Republic of Korea	Seoul	Seoul Zoo	1985		1. International Zoo Yearbook, 1962-2016
47	Romania	Bucharest	Bucharest Zoo	1973-1976	Yes	1. International Zoo Yearbook, 1962-2016
48	Russia	Moscow	Moscow Zoo's Breeding Centre	2000-2012	Yes	1. Ostapenko, Kuprikova, 2013
49	Spain	Barcelona	Barcelona Zoo	1972		1. International Zoo Yearbook, 1962-2016
50	Spain	Madrid	Madrid Zoo	1974		1. Curtis, Turner, 1977
51	Switzerland	Basel	Zoo Basel	1949-1953		1. http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=11609&art=l160921&subhaltungen=2
52	Switzerland	Bern	Tierpark-Bern	1974		1. Curtis, Turner, 1977
53	The Netherlands	Amsterdam	Artis Royal Zoo	1985-1991	Yes	1. http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
54	The Netherlands	Arnhem	Burgers' Zoo	1977-1978	Yes	1. International Zoo Yearbook, 1962-2016; 2. http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
55	The Netherlands	Rotterdam	Rotterdam Zoo	1951, 1954-1960, 1975-1977	Yes	1.International Zoo Yearbook, 1962-2016; 2.http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
56	The Netherlands	Valkenburg	Klant's Dierentuin	1949		1. http://www.zoochat.com/9/history-saiga-captivity-249984/index4.html
57	The Netherlands	Wassenaar	Wassenaar Zoo until 1985	1949, 1954-1955		1. http://www.zootierhste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
58	UAE	Abu Dhabi	Abu Dhabi Zoo	1977-1985	Yes	1. International Zoo Yearbook, 1962-2016
59	Ukraine	Askania Nova	Askania Nova Biosphere Reserve	1888-1921, 1925-1941?, 1947-1963, 1971-current time	Yes	1.Steklenjov, E.P., Smagol, V.O. 2011. 2.International Zoo Yearbook, 1962-2016
60	UK	Edinburgh	Edinburgh Zoo	1977		1. International Zoo Yearbook, 1962-2016
61	UK	Kingussie	Highland Wildlife Park	1974-1978	Yes	1.International Zoo Yearbook, 1962-2016; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
62	UK	London	London Zoo	1864-1869, 1956, 1964-1968	Yes	1.Mohr, 1943/1944 2.http://www.zootierliste.de/en/?klasse=1&ordnung=116&familie=11609&art=1160921&subhaltungen=2

N	Country	City	Institution	Period	Off-spring	References
63	UK	Woburn	Woburn Safari Park	1902-1907, 1970	Yes	1.Dolan, 1977; 2.http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
64	USA	Albuquer-que	Albuquerque BioPark	1969-1971-...	Yes	1. Dolan, 1977
65	USA	Browns-ville	Gladis Porter Zoo	?		1. Curtis, Turner, 1977
66	USA	Chicago	Lincoln Park Zoo	1958-...		1. Dolan, 1977
67	USA	Dallas	Dallas Zoo	1959-1967, 1969-1972, 1978-1985	Yes	1.Dolan, 1977; 2.International Zoo Yearbook, 1962-2016
68	USA	Houston	Houston Zoo	?		1. Kholodova & Neronov, 1996
69	USA	Los Angeles	Los Angeles Zoo	1989-1992	Yes	1. International Zoo Yearbook, 1962-2016
70	USA	Monroe	Louisiana Pur-chase Gardens & Zoo	1972-1973		1. International Zoo Yearbook, 1962-2016
71	USA	New York	Central Park Zoo	1936-1937, 1956		1. Dolan, 1977
72	USA	New York	Bronx Zoo	1936, 1956-1958		1. Curtis, Turner, 1977
73	USA	Oklahoma	Oklahoma Zoo	1969-1975-..., 1978-1990	Yes	1.Dolan, 1977; 2.International Zoo Yearbook, 1962-2016
74	USA	Omaha	Omaha Zoo	1969, 1971	Yes	1. Dolan, 1977
75	USA	Philadelphia	Philadelphia Zoo	1960-1963		1. Dolan, 1977
76	USA	Saint-Louis	Saint Louis Zoo	1934-1945	Yes	1. Dolan, 1977
77	USA	San Diego	San Diego Wild Animal Park	1970-2003	Yes	1.Dolan, 1977; 2.International Zoo Yearbook, 1962-2016
78	USA	San Diego	San Diego Zoo	1962-1963, 1989		1. International Zoo Yearbook, 1962-2016
79	USA	San Francisco	San Francisco Zoo	1962-1974	Yes	1. Dolan, 1977
80	USA	Toledo	Toledo Zoo	1962		1. Dolan, 1977

81	USA	Washington	Zoo	1934-1935		1. Dolan, 1977
82	USA	Washington	Smithsonian's National Zoo	1937, 1955-1959		1.Crandall, 1964; 2.http://archive.org/stream/reportofsecretarl937smit/reportofsecretarl937sm.it djvu.txt
83	USA	West Orange	Turtle Back Zoo	The 1970s?		1. Kholodova & Neronov, 1996
84	USSR (Georgia)	Tbilisi	Tbilisi Zoo	1972		1. International Zoo Yearbook, 1962-2016
85	USSR (Kazakhstan)	Karaganda	Karaganda Zoo	1976		1. International Zoo Yearbook, 1962-2016
86	USSR, (Kazakhstan)	Chimkent	Chimkent Zoo	1981-1989		1. Sokolov & Kholodova, 1996
87	USSR (Russia)	Leningrad (St. Petersburg)	Leningrad Zoo	1937-1938, 1957-1958	Yes	1. Sokolov & Kholodova, 1996
88	USSR (Russia)	Moscow	Moscow Zoo	1864, 1869, 1879-1880, 1924, 1939, 1981		5. Sokolov & Kholodova, 1996; 6. http://www.zootierliste.de/en/?klasse=l&ordnung=l16&familie=l1609&art=l160921&subhaltungen=2
89	USSR (Russia)	Novosibirsk	Novosibirsk Zoo	1965, 1968-1969, 1972-1974		1.Sokolov & Kholodova, 1996; 2.International Zoo Yearbook, 1962-2016
90	USSR (Russia)	Rostov-on-Don	Rostov-on-Don Zoo	1969, 1972-1973, 1976, 1988-1989		1. Sokolov & Kholodova, 1996; 2. International Zoo Yearbook, 1962-2016
91	USSR, (Tajikistan)	Dushanbe	Dushanbe Zoo	1972-1973		1. International Zoo Yearbook, 1962-2016
92	USSR (Ukraine)	Odessa	Odessa Zoo	1973		1. International Zoo Yearbook, 1962-2016

T.Yu. Karimova, A.A. Lushchekina, V.V. Rozhnov

SAIGA MANAGEMENT AT ZOOS AND BREEDING CENTRES:
making effective use of the lessons learnt for the restoration of wild saiga populations

Ì .: KMK Scientific Press, 2018. 117 pp.
Printed by “Galleia-Print”