Changes in the complex of rare and endangered mammals (Mammalia) in present-day Rostov Nature Reserve since the middle of the twentieth century

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Abstract. Under the influence of various factors, the ecosystems of dry steppes of Russia have undergone profound changes since the middle of the twentieth century. In the work dedicated to the territory occupied by the present-day Rostov Nature Reserve, the changes in mammals included in regional, federal and international Red Books (lists) and causes of these changes are reviewed. Until the 1950s, human use of steppes was limited due to scarcity of fresh water, which assured the preservation of natural xerophytic vegetation and associated fauna. Irrigation of steppes contributed to the intensive development of animal husbandry, restructuring of ecosystems with their biodiversity and the formation of anthropogenic deserts. To restore natural ecosystems, the Rostov Nature Reserve was created in 1996, and its activities made preservation of natural biodiversity possible. As a result of the deep restructuring of ecosystems, the modified biogeocenosis was very different from that in the mid-1950s of the XX century. Mammals typical for dry steppes in the past under the influence of various anthropogenic and natural causes considered in the article have become rare and endangered in present-day ecosystems. Intensification of economic activity in the twenty-first century and climate warming increase the negative impact on steppe ecosystems and rare mammals. Possibilities for the conservation of rare and endangered mammals in the reserve are discussed.

1. Introduction
The biodiversity of the Rostov region (hereinafter RR), located in the South-East of Europe, has undergone profound changes since the mid twentieth century under the influence of anthropogenic and natural factors. For its preservation, the Rostov Nature Reserve was founded in 1995. Thanks to intense activity over the previous 10-15 years, natural ecosystems have been restored on lands desertificated by human activities. In 2008, the reserve was included in the World Network of Biosphere Reserves, which are reference areas that preserve natural biodiversity and allow to verify the degree of disturbance of territories under anthropogenic and natural influence. Important areas of their activities include monitoring ecosystems, identifying changes taking place in them, clarifying the reasons for these changes, developing recommendations for optimizing the relationship of people with nature. Convenient objects for this work are rare and endangered species of animals that are included in the regional, federal and international Red Books (lists) [1, 2, 3, 4]. They respond most acutely and demonstrably to the transformations in ecosystems. The purpose of this work is to find out changes in
the complex of rare and endangered mammals in the territory of the present-day Rostov Nature Reserve in the 20th-21st centuries and their causes.

2. Location and methods of work

The Rostov Nature Reserve was created on December 27, 1995, on the right bank of Lake Manych-Gudilo (hereinafter lake M.-G.). It covers an area of 9531.5 hectares, its buffer (guard) zone, organized on November 4, 2000 in the Orlovsky district, is of 74 350 hectares. This territory is further called the reserve. In the middle of the twentieth century this area was characterized by a hot arid climate, lack of fresh water, dark chestnut and chestnut soils with varying degrees of salinity, grassy vegetation of desert steppes [5]. Collection of material on fauna, including mammals, has been carried out in this area since the mid-twentieth century [6]. The authors investigated it in the scope of the Wetlands International, Russian Bird Conservation Union, various regional and federal environmental structures programs [1, 7, 8, 9, 10, others]. In recent decades, regular itinerary observations are conducted by specialists of the reserve and the Wild Nature of the Steppe Association (hereinafter the Association), employees and students of Rostov State University (RSU, since 2006 Southern Federal University — SFU), the Southern Scientific Center of the Russian Academy of Sciences (UNC RAS), Moscow University, other scientific structures. All this allowed to accumulate information about the situation with mammals in the area under consideration in various years.

In the present article, various authors' researches since 1959, publications on the state of ecosystems and mammals in different periods, observations of reserve employees, Association and hunting organizations, chronicles of nature of the Rostov Nature Reserve were analyzed. Many generally accepted methods of mammal counting were used during field research (route accounting of burrows and animals, installing traps, live collection traps, catching cylinders and others). Given the complexities of comparing the material obtained by many specialists using different research methods over a period of 60 years, Table 1 provides relative information on the number of individual species. Mammals included in regional, federal and international Red Books (lists) [1, 2, 3, 4, 23] were used for analysis. The list included also Mesocricetus raddei Nehr., which went extinct during the period under review.

3. Results

The area presently occupied by the reserve, until the mid-twentieth century was characterized by hot arid conditions with an acute shortage of fresh water. The present-day water level in lake M.-G. was established by 1954 after filling it with water from the Kuban River. However, it remained saline and in the area in question in 1952 water mineralization was 24 g/l, in 1953 — 11, in 1959 — 15 g/l [11]. Domestic animals, including sheep, did not drink this water. They were supplied with fresh water from several wells on Lysaya Mountain, a few dozen kilometers away. An acute shortage of fresh water constrained the development of agriculture and, above all, sheep farming.

Steppe ecosystems retained the natural biodiversity characteristic of arid steppes. The mechanisms of natural homeostasis formed over the centuries continued to operate. The steppe had complete complexes of rare and endangered mammals, comprising all trophic elements of wildlife. Artiodactyla herbivores were represented by Saiga tatarica L., various Rodentia species and other organisms; Carnivora — Vulpes corsac L., Mustela eversmanii Les. and other Mammalia, as well as Aquila nipalensis Hodg., Buteo rufinus Cretz., Falco naumanni Fleis., other predatory species of Aves; Saiga tatarica L. in the warm period wandered into the territory from neighboring Kalmykia, where its population in 1958-1959 was 810-522 thousand heads [12]. Its herds from 18-20 to 500-3000 were regularly observed in May-July [6, 13] grazing in the steppe and coming to drink water with increased salinity in the bays of M.-G. lake. In some years in the territory under consideration, their number reached 5-10 thousand and more. By regularly changing feeding sites, they played an important role in keeping the grass in normal condition and the stability of these ecosystems.

Common in the steppe were Hemiechinus auritus Gmel., Vulpes corsac L., Mustela eversmanii Les., Allactaga major Kerr, Pygeretmus pumilio Kerr. Among other frequently occurring Mammalia...
species, in some sites *Citellus pygmaeus* Pall. and *Microtus socialis* Pall. were numerous. Widespread species included *Mesocestus raddei* Nehr. and *Cricetus cricetus* L. *Sicista subtilis* Pall. and *Stylodipustelum Licht.* were encountered in separate sites. Hunters have taken *Mustela erminea* L. and *Vormela peregusna* Güld. *Lagurus lagurus* Pall. was observed in the pellets of the eagle owl.

Steppe ecosystems began to undergo deep restructuring after the adoption by the Government of the USSR on October 20, 1948 the Resolution “On the plan of field protection forest plantations, implementation of grassland crop rotations, construction of ponds and reservoirs to ensure high and sustainable harvests in steppe regions of the European parts of the USSR.” Its execution led to great changes in the biodiversity of the entire region. The construction of main and distribution channels, supplying eastern regions with water from the Kuban and Don rivers, the creation of new reservoirs and ponds in the 60-70s provided water to arid steppes. This created favorable conditions for the development of animal husbandry and crops of forage plants, the influx of population to the region. At the same time, the steppe was covered by a network of field-protection forest bands, parks, gardens, other arboreal plantings began to appear in settlements. The period of strong anthropogenic influence on steppe ecosystems spanned many years, which led to gradual changes in the structure of biocenoses. Conditions uncharacteristic for arid landscapes began to form, creating favorable habitats for dendrophils and limnothiles, eurybionts and other ecologically plastic species (ubiquists, synanthropes, others). This contributed to the penetration, settlement and increase in the number of *Erinaceus rounanicus* Barr.-Ham. (a species living in the area under consideration by some authors is termed *Erinaceus concolor* Martin and *Er. Roumanicus* Barr.-Ham.), *Vulpes vulpes* L. and a number of other eurybionic species. Their number and role in biocenoses increased over the years, and the role of many non-competitive xerophilic stenobionts decreased.

In the 70-80s of the twentieth century, influenced by the increase in sheep numbers, the desolation of pastures, permission of poorly regulated hunting of *Saiga tatarica* L., increased demand for its horns, intense poaching and other factors, the number of *Saiga tatarica* L. decreased in the 70s to hundreds or tens, and in the 80s it practically disappeared from the territory under consideration. The number of *Erinaceus rounanicus* Barr-Ham and *Vulpes vulpes* L. was increasing. At some sites *Hemiechinus sauritus* Gmel., *Pyget muspumilio* Kerr and *Vulpes corsac* L. remained common, at some sites numerous, *Mustela eversmanii* Les. and *Allactaga major* Kerr. were uncommon, but widespread in the steppe. *Sicista subtilis* Pall., *Stylodipustelum Licht.*, *Mustela erminea* L., *Vormela peregusna* Güld. [9] have been observed. *Citellus pygmaeus* Pall. and *Microtus socialis* Pall were common among other species of Mammalia, and in certain places they were even numerous, *Cricetus cricetus* L. occurred, and *Canus aureus* L. appeared. *Lagurus lagurus* Pall. disappeared, *Mesocestus raddei* Nehr. became rare.

Intensification of animal husbandry and land unraveling began from the 60s of the 20th century, but especially strongly affected the ecosystems of the steppes in the 80-90s. At the Orlovsky State Breeding center, on the territory of which the prevailing part of the reserve was created, in the 1980s the number of sheep reached 56 000. Strong increase in the number of sheep and ignoring the norms of grazing led in the 80-90s years to steppe overgrazing, anthropogenic desertification of large areas in Kalmykia and RR [8, 14]. In the 90s, the number of sheep at the Orlovsky State Breeding center decreased to 1 thousand. This led to a profound transformation of steppe biocenoses. The social, economic and other changes in the country in the 1980s and 1990s exacerbated the nature protection situation. In the year of reserve creation *Lagurus lagurus* Pall. and *Mesocestus raddei* Nehr. were no longer encountered. Their disappearance over extensive areas is attributed by many researchers to climate changes, an increase in the number of birds of prey and other factors. However, in our opinion, these assumptions require additional studies, and human activity remains the leading cause. The degradation of the resources of steppe vegetation, impoverishment of the population, poaching caused a sharp drop in the population of *Saiga tatarica* L. [12, 13, 14] Kalmyk population. *Citellus pygmaeus* Pall. and some other animals, beside the reasons noted above, have been negatively affected by the intensive rodent extermination campaign employing zoocides over a number of decades. The decrease in the number of *Citellus pygmaeus* Pall. affected the number of *Mustela eversmanii* Les. and some
other predators (among Aves Aquila nipalensis Hodg., Buteo rufinus Cretz. were no longer breeding). The numbers of Pygoret muspumilio Kerr, Stylodipustelum Licht., some other rodents declined. This, as well as competition with the multiplying and invading Vulpes vulpes L. adversely affected the number of Vulpes corsac L. The ratio of their numbers already in the 90s of the 20th century began to change in favor of Vulpes vulpes L. (1:1 or 2:3). The invading and multiplying Erinaceus roumanicus Barr. -Ham. supplanted Hemiechinus auratus Gmel. Mustela erminea L. became very rarely observed, Sicista subtilis Pall was observed.

In the first years of creation of the Rostov Nature Reserve and later its buffer zone, great attention was paid to organizational issues, creation of a reserve regime of protection, regulation of wolf numbers. Succession processes began and the restoration of steppe grass vegetation was recorded. Herds and groups of Saiga tatarica L. were observed only occasionally and not annually (around 1,000 individuals entered in May, 1999, and 4 and 17 individuals in summer). Pygoret muspumilio Kerr was preserved and in separate areas (the vicinity of Volochaevsky, Runny) it still remained common. Stylodipustelum Licht. and Vormela peregusna Güld. were very rare, Mustela eversmanii Les. – rare. The numbers of Erinaceus roumanicus Barr.-Ham. and Vulpes vulpes L. increased. The first species exceeded Hemiechinus auratus Gmel. in numbers (at a 5:1 ratio) over a large part of the reserve, although in several locations these difference were small (3:2) or even negligible.

In the first decade of the 21st century, steppe grass vegetation was restored in the reserve, biodiversity increased, the number of Carabushun garicusmingenius Quen., C. bessarabicus Fisch.- Wald., Libelloides macaronius Scop., Tetrax tetrax L. and many other rare and endangered animals increased [1, 2, 15]. However, the steppe grass vegetation was qualitatively different from that of the mid-twentieth century. The lack of regular Saiga tatarica L. presence, irrigation and forestation of the steppes beginning in the 60-70s, the cessation of grazing created favorable conditions for mesophytes and changes in the composition of grass vegetation, increase in its density and height (in many areas the estimated covering was 80-100%). This contributed to the accumulation of dead plants litter on the soil surface, increasing humidity and reducing temperatures on the surface and topsoil. In the first decade of the 21st century number of Vulpes corsac L. in the presence of multiplying Vulpes vulpes L. and the change of grass vegetation became low. A similar situation developed in the ratio of the number of Hemiechinus auratus Gmel. and Erinaceus roumanicus Barr.-Ham., equaling 1:4-5 (in a number of sections of the reserve territory – 1:7). As a result of changes in grass vegetation and ratios in animal complexes, Citellus pygmaeus Pall., Pygoret muspumilio Kerr., Allactaga major Pall., Mustela eversmanii Les. became rare. This group includes Sicista subtilis Pall. and Vormela peregusna Güld.

The population size of Saiga tatarica L. in the southeast has declined dramatically [12], and it has been very rarely observed in the reserve. Around the Lopukhovaty lake, in August 24, 2006 26 individuals were encountered [13]; they were sometimes noted in the Starikovsky section (April 17, 2009, etc.) and, according to Inspector A. Sushkov, single individuals on this site are observed annually [16, 17]. For the conservation and study of this species, in 2004 the Association brought 11 individuals from Kalmykia to the Center of Rare Animals of European Steppes in Kundryuchensky settlement. By 2009, there were already 70 individuals [13].

Over the past decade, economic activity has been intensifying in the south-east of the European part of Russia, including in the area of the reserve (growing population of cattle and grazing effects, plowing areas of the steppe, the use of chemical rodents control measures, etc.), which complicates compliance with the environmental regime. In the territory of the Orlovsky State Breeding center, the number of sheep increased to 6,000, and cattle (cows) to 7,000. While the protection regime is strictly observed in the reserve protected areas, violations are noted in the buffer zone. In the Remontenskoy district, where the Krasnopartisan and Tsagan-Khag reserve areas are located, there is no buffer zone, and in the zone of reserve cooperation and the area district the regime of optimal nature management is not always maintained. All this produces a negative impact on biodiversity and bio-resources.

In the 21st century, the ecological situation in the south is exacerbated by climate aridization [18, 19]. Notable changes in weather conditions began to manifest since 2007, when in the reserve from
April to September at high positive temperatures precipitation was almost absent, and many bodies of water dried up since spring. The grass remained low, yellowed before September, and its feed value was extremely low. This weather anomaly negatively affected the resources of usually abundant in the steppe herbivore insects (Insecta) (Acridoidae, Cicadinea, Aphidinea, Diptera, Lepidoptera, etc.), their entomophages (Aranei, Carabidae, etc.), which in turn negatively affected the number and distribution of many species of Aves and Mammalia, which negatively affected many animals [20]. Further the Krutik, Bubashovsky, Chekina and other ponds dried up completely, many bodies of water underwent drastic level decrease (Manych-Gudilo lake, Kurnikov and Gorky estuaries, Kruglyi, Kolesnikova, etc.). Recent years also passed with hot and dry summer months, warm winters. These climatic changes coincided with the intensification of economic activity. Areas of degraded land are already found in the areas of the reserve, where vegetation is completely or mostly destroyed by sheep, cattle, horses. Climate aridization and ignoring environmental legislation negatively affect steppe ecosystems. Ratios of number of Vulpes corsac L. and Vulpes vulpes L. in 2014-2017 was 1 to 5 and more, with Hemiechinus auratus Gmel. and Erinaceus roumanicus Barr.-Ham., — 1 to 8-10 individuals. In 2019-2020, this ratio in the first two was 1:10, and Hemiechinus auratus Gmel. is very rare. Sicista subtilis Pall was noted at some sites (on Lysaya Mountain). In 2013, 4 individuals of Equus przewalskii Poljakov were brought to the Association from Askania-Nova. Since 2016-2017 they live in a breeding ground with an area of 512 hectares, where in recent years they reached a number of 11-14 individuals. Research of the influence of horses on the steppe grass vegetation [21, 22] is underway. The same breeding ground is home to 70 individuals of Saiga tatarica L., which are objects of scientific research. Such very rare species as Pygeret muspumilio Kerr, Allactaga major Pall., Citellus pygmaeus Pall., Mustela eversmanii Les., Vormela peregusna Güld can be found occasionally in the steppe.

The situation with the transformation of the considered mammalian complex in the territory occupied by the Rostov Nature Reserve is summarized in table 1.

Table 1. Rare and endangered mammals inhabiting the Rostov Nature Reserve in various years.

| №  | Species                          | Years 1959-1963 | 1970-1980 | 1990-1996 | 2004-2008 | 2016-2020 |
|----|---------------------------------|----------------|-----------|-----------|-----------|-----------|
| 1. | Hemiechinus auratus Gmel.       | ++++           | +++       | ++        | +         | +         |
| 2. | Pygeret muspumilio Kerr         | ++++           | +++       | ++        | +         | +         |
| 3. | Stylodipus telum Lich.          | +++            | +++       | +         | ?         |           |
| 4. | Sicista subtilis Pall.          | +++            | +++       | ++        | +         | +         |
| 5. | Lagurus lagurus Pall.           | +             |           |           |           |           |
| 6. | Mesocricetus raddei Nehr.       | +++            | ++        | +?        |           |           |
| 7. | Vulpes corsac L.                | ++++           | +++       | +++       | ++        | ++        |
| 8. | Mustela erminea L              | +             | +         |           |           | +         |
| 9. | Mustela eversmanii Les.         | ++++           | +++       | ++        | +         | +         |
| 10. | Vormela peregusna Güld        | ++             | ++        | +         | +?        |           |
| 11. | Equus przewalskii Poljakov     | +             |           |           |           | +         |
| 12. | Saiga tatarica L.              | ++++           | +         | +         | +         | +         |

Symbols: + — very rare, ++ — rare, +++ — unusual, ++++ — usual, in places numerous, ? — no data available.

4. Conclusion. Until the middle of the twentieth century, arid steppes in the area of the future Rostov Nature Reserve due to the shortage of fresh water were moderately used by humans, their ecosystems preserved natural biocenoses. Irrigation and forestation of steppes, intensification of economic and other activities of people in the second half of the century caused a deep restructuring of ecosystems and their biota. Wild ungulates (Saiga tatarica L.) began to disappear, a number of species associated with woody vegetation, reservoirs, human structures began to invade and multiply. A great harm to steppe ecosystems and their biodiversity was caused by an uncontrolled increase in the number of...
sheep. The creation of the reserve has a positive impact on the restoration and conservation of bioresources and biodiversity. Transformation of vegetation, penetration of euribiotic species, change of hydrothermal, trophic and other factors in ecosystems and their biota before the organization of the reserve and during its existence led to the formation of other biocenoses. For a number of mammal species and most notably xerophilic stenobionts (*Hemiechinus auratus* Gmel., *Pygeret muspumilio* Kerr, *Stylopidpastelum* Licht., *Vulpes corsac* L., etc.), different hydrothermal, trophic and other conditions have developed in the new biocenoses. The reserve did not stop the decline in their numbers, although it was slowed down in a number of cases. This group includes *Allacta gamajor* Pall., *Citellus pygmaeus* Pall. and some other species whose numbers and distribution were also reduced, and which merit consideration for inclusion into regional Red Books. In recent decades, the situation has been exacerbated by climate aridization, which together with increased economic activity is causing a synergic effect, increases their negative effects on ecosystems.

Problems of conservation of biodiversity and bioresources in present day conditions require increased attention, the use of scientifically-based systems of agriculture and nature protection. A deterrent to conservation and restoration of ungulate and a number of other terrestrial animals (*Aquila nipalensis* Hodg., *Otis tarda* L. and others) population is the insufficiently small area of the reserve. It consists of their 4 widely spaced sections (4591 ha, 2182.5, 1768 and 990 ha), stretched as a chain at a distance of 5-25 km in two districts of the RR and situated in locations of intensive economic activity. It is necessary to expand the territory of the reserve by joining to it a number of naturally valuable and so far little-used by humans territories, where *Hemiechinus auratus* Gmel., *Vulpes corsac* L., *Buteo rufinus* Cretz., *Haliaeetus albicilla* L., *Otis tarda* L., *TetraX tetraX* L., *Anthropoides virgo* L., and other rare animals breed; create a buffer zone in the Remontmensky district of RR, where two sections of the reserve are located. It is advisable to consider allocating in the reserve or in the buffer zone a territory by means of a fence or other form of isolation, and organizing a sustainable biocenosis with participation of ungulates in it under the supervision of specialists of the organization. Orenburg reserve specialists demonstrate valuable experience in creating a semi-domesticated population of *Equus przewalskii* Poljakov. The Association obtained a group of *Saiga tatarica* L., individuals, kept and successfully breeding in enclosures and large pens [13]. In recent years, they have been transferred to a breeding ground with an area of 512 hectares, inhabited by 60-80 individuals. There were 14 individuals of *Equus przewalskii* Poljakov in this breeding ground area in 2019. Employees of the Association and Reserve V. D. Kazmin and colleagues study the issues of influence of these animals on the steppe grass vegetation. These and other achievements of specialists, if implemented, will allow to preserve most rare and endangered mammals and a number of other terrestrial vertebrates within the buffer zone of the reserve.

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