Institute of General and Experimental Biology, Mongolian Academy of Sciences;
Ministry of Nature, Environment, and Tourism of Mongolia;
Ministry of Education, Culture, Science, and Sports of Mongolia;
Commission on Marmot Investigation of the Theriological Society at the Russian Academy of Sciences
Mammalian Ecological Society of Mongolia;
Joint Russian–Mongolian Complex Biological Expedition of RAS and MAS

PROCEEDINGS of the 7th International Conference on the Genus *Marmota*

Marmots of the Old and New World

13–17, August, **2018** Ulaanbaatar, Mongolia

PROCEEDINGS of the 7th international conference on the genus Marmota "Marmots of the Old and New World" 13-17 August, 2018. Ulaanbaatar Mongolia. Narud Design LLC. 336 pp.

Editors: Adiya Yansanjav, Oleg Brandler, Lkhagvasuren Badamjav, Gantulga Gankhuyag, Hannah Davie, Batdorj Sodnompil, Undrakhbayar Enkhbat

Printing layout: Ts.Naranbat

Conference organizers:

Institute of General and Experimental Biology, Mongolian Academy of Sciences

Ministry of Nature, Environment, and Tourism of Mongolia

Ministry of Education, Culture, Science, and Sports of Mongolia

Commission on Marmot Investigation of the Theriological Society at the Russian Academy of Sciences

Mammalian Ecological Society of Mongolia

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A HISTORY OF THE INTRODUCTION AND ADAPTATION OF BOBAK (*MARMOTA BOBAK* MÜLL.) AND THEIR MODERN DISTRIBUTION IN THE UDMURT REPUBLIC OF RUSSIA

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Abstract

The territory of the Udmurt Republic is located in the forest zone in the east of the East European Plain. As a result of agricultural development of natural landscapes, in the south of the Republic open areas with meadow vegetation have been created. These areas are potentially suitable habitat for bobak *(Marmota bobak)*. The first 94 individuals, who were caught in the Starokulatkinsky district of the Ulyanovsk Oblast, were introduced to the area in July, 1986 in the valley of the Bolshaya Emasha near the village of Cheganda, in the Karakulinsky district (N55°55 'E53°29'). Bobak became well established here and formed a main colony within the ravine system. Their family plots were primarily located on xerothermal slopes with southern exposure, occupied by steppe meadows and used as pastures for livestock. In the middle of the 1990s, new colonies began to appear.

Introduction activities in the Republic were continued in 2001 through 2003. Bobaks were released into the ravine system near the village of Sokolovka in the Sarapulsky district (N56°17 'E54°03'). There the northernmost viable population of bobak beyond their natural range was formed.

Currently, we have documented about 25 spatial groupings of bobak in the southeast of the Udmurtia: Fifteen colonies and 10 isolated families in the Karakulinsky (12 colonies and five isolated families), Sarapulsky (three colonies and four isolated families), and Kiyasovsky (one isolated family) districts. According to our estimates, the total number of the "Udmurt" population of the bobak is about 550 to 600 individuals.

The Udmurt Republic is one of the federal subjects of the Russia, located in the Eastern part of the Russian Plain,in the Western Suburals, between the large rivers of Kama and Vyatka. The coordinates of Udmurtia are N 55°12'-58°38', E 51°10'-54°26'. etc. (Udmurt Republic, 2000).

Two ecozones occur within the territory of the Republic; the taiga (boreal zone) and the subtaiga (boreal-subboreal) (Rysin,2009). Suitable habitat for bobak is found in the ravine networks in the southern region of the Republic. A lot of ravines are used for pastures and hayfields. Land use contributes to their deforestation and vegetation of these areas has features similar to northern steppe meadows. Moderate and intensive grazing of livestock prevents overgrowth of high grass, which creates conditions highly favorable to marmots.

Bobak (also known as steppe marmot) were introduced to the territory of the Udmurt Republic in the 1980s. Today, they have spread across the territory of the southeast of the Republic. Colonies in Udmurtia represent some of the northernmost in the bobak's range, so study of individuals at the site will improve our understanding of the adaptive potential of the species.

Systematic scientific studies of the bobak of Udmurtia have been conducted since the mid-1990s. Researchers involved include the employees and students of UdSU (Doskovskaya et al, 1999; V. Kapitonov & K. Kapitonov, 2001; Kapitonov et al.); Lobachevsky University (Samkharadze, 2003), and the Peoples' Friendship University of Russia (Matveev, 2006), as well as researchers from the Russian Research Institute of Game Management and Fur Farming (Kolesnikov, 2002) and the Fauna Protection Department of Udmurtia (Kapitonov & Ukraintseva, 1997). The purpose of this study was to document the spread and current stat of bobak in Udmurtia.

Materials and methods

The history of the introduction and establishment of bobak in Udmurtia was investigated using the archival materials of the Department of Fauna Protection of the Udmurt Republic, data from published literature, and surveys of and interviews with participants in the introduction of bobak to the republic.

Field research was conducted during the snowless period at bobak colonies in the Karakulinsky, Kiyasovsky, and Sarapulsky districts. During non-hibernation periods, from April to September, visual counts of bobak numbers and age composition were made. Counts were usually conducted in the morning and evening hours, when the animals were most active. Observations were made with 10x field binoculars. We also recorded observed social relationships between individuals and the spatial distribution of burrows and the trails between them.

During later surveys, we used a quadcopter with an optical system for photo and video to study the spatial distribution of bobak colonies.

After the beginning of hibernation, surveys and mapping of bobak wintering grounds were carried out with the help of a Garmin GPS-navigator with the goal of determining the number of families in each colony. Wintering holes were identified by the presence of a characteristic plug from the clumps of earth at the entrance (Ismagilov, 1961; Bibikov, 1989; Soroka; 2000; Tokarskiy 2008, Mashkin et al., 2010).

Statistical analysis was carried out using the MS Excel 2007 data analysis package.

The history of bobak introduction to Udmurtia

Bobak introductions to Udmurtia began in July, 1986 with the release of 94 individuals near the village Cheganda in the Karakulinsky district (N55°55' E53°29'). The translocated bobak were caught in the Starokulatkinsky district of the Ulyanovsk Oblast (Popov, 1987, 1990; Kapitonov & Ukraintseva, 1997). Note that the Starokulatinsky district was one of the donors of bobak for introduction to the European part of Russia. Bobak caught in Starokulatinsky were released in the districts of the Ulyanovsk Oblast, in the Samara and Nizhny Novgorod Oblasts; and Mordovia and Chuvashia (Abrakhina & Dimitriev, 1999).

Individuals were released into pre-prepared holes in the ravine network formed by the river Emasha. Post-release, 90 bobak were kept there in July 1987. In 1987 through 1989, bobak were released near the village of Kolesnikovo in the Karakulinsky district (N55°59' E53°34') and in the Uvinsky district of Udmurtia (near N56°49' E52°18'). In the 1980s, 472 bobak were released in Udmurtia (Zagumenov, 2014).

In 2001, translocation efforts were continued. Individuals were collected from colonies in the Voronezh and Ulyanovsk Oblasts and the colonies of the Karakulinsky district of Udmurtia, and were released near the village of Sokolovka (N56°17' E54°03') in the Sarapulsky district of the Republic. In total, 186 individuals were released in the Sarapul district of Udmurtia near the village of Sokolovka (Zagumenov, 2014).

Archival data indicate a large proportion of the bobak released (59.3% in 2001) were young (Zagumenov, 2014). According to the methodological guidelines for the translocation of marmots (Mashkin et al., 2010), a high proportion of yearlings in introduced groups of marmots negatively affects their survival. In the Sokolovsky colony, introduced bobak established themselves but, according to the archival data of the Fauna Protection Department of Udmurtia, there was high individual mortality following their initial release.

At the same time that bobak were released in the Sarapulsky district, small groups were also released in the previously established colonies in the Karakulinsky district.

In the Uvinsky district, the introduction of bobak was unsuccessful. According to VA. Matveyev (2006), in the 1990s the bobak spread widely in the district, but later the colonies and families began to disappear. Matveyev (2006) attributes their decline to strong anthropogenic pressure. Further introductions of bobak in this region of the Republic are considered by the specialists of the Fauna Protection Department of Udmurtia as unlikely to be successful.

A different picture was observed in Karakulinsky and Sarapulsky districts. Released bobak quickly settled and established colonies in the numerous gullies there. The animals settled in the original colony, and formed new colonies and or established in other areas as isolated families (separate spatial groups consisting of a single bobak family). The dynamics of the number of known colonies and isolated families in Udmurtia is shown in Fig. 1.

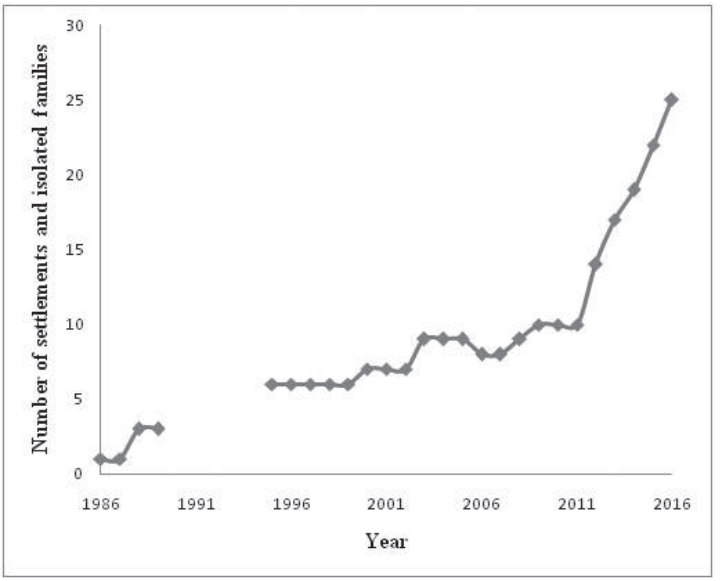

Fig.1. *The dynamics of the number of known colonies and isolated families in Udmurtia*

From the end of the translocation efforts in 1989 to 1997, the number of bobak spatial grouping in the Republic almost doubled. The exact number of colonies and the time of their formation between 1989 and 1997 is not known because of the absence of systematic observations during that time period. In the 1990s the colony in the Uvinsky region went extinct (Matveev, 2006). Not later than 1998, a new colony was formed in the Karakulinsky district near of village of Kulushevo (N56°01' E53°34') (Doskovskaya et al., 1999). Between 1999 and 2003, the number of colonies increased. It can be assumed that the bobak established themselves at optimal sites in the ravine systems, and as the colony grew, individuals actively dispersed to other locations. In the same time period, the Sokolovskoe colony in the Sarapulsky district was established. After 2003, the number of colonies stabilized at around eight to 10.

Some decline in the number of colonies between 2005 and 2007 can be attributed to changes in human economic activity. Livestock grazing was stopped around many colonies in the Karakulinsky district, which had negative consequences for bobak. The ravines began to overgrow with high grass. This negatively impacted bobak forage conditions and disrupted the visual and sound contact between individuals. The positive role of moderate grazing has been repeatedly discussed in the literature (Kolesnikov, 2006; Savchenko & Ronkin, 1999, Resolution..., 2010). At the Chegandinsky colony, where grazing was stopped in 2007, the number of bobak families had decreased by half by 2010 (Kapitonov, 2015). However, from 2011, there has been a steady increase in the population of the bobak in the Republic and an emergence of new spatial groups (small colonies and individual families) outside the original colonies. In the Karakulinsky and Sarapulsky districts, new colonies have established on the sites of previously known colonies. Isolated families and small colonies of two to three families have been annually observed. In 2015 and2016, 25 bobak spatial groupings were documented. The increase in the dispersal activity of the animals could be due to the reaching of capacity in the ravine systems or to a decrease in the habitat suitability of the ravines due to the cessation of livestock grazing activities.

The initial migration of bobaks and the formation of new colonies and isolated families was noted in the Karakulinsky district in 1995 nine years after bobaks were first introduced, while in the Sarapulsky district migration was first observed in 2009, eight years after the bobaks' initial release.. It thus appears that after eight or nine years bobaks were sufficiently adapted to conditions at the introduction sites to begin expanding and colonizing new areas.. According to the literature, , daughter colonies usually begin to form, on average, six to14 years after the initial release of individuals (Mashkin, 2000).

Modern distribution of bobak in Udmurtia

At the present time, we have information on 25 spatial groupings of bobak in the Udmurt Republic, including 15 colonies and 10 isolated families. The locations of known colonies and isolated families of bobak in Udmurtia are presented in Fig. 2. Bobak colonies are named for the nearest human village.

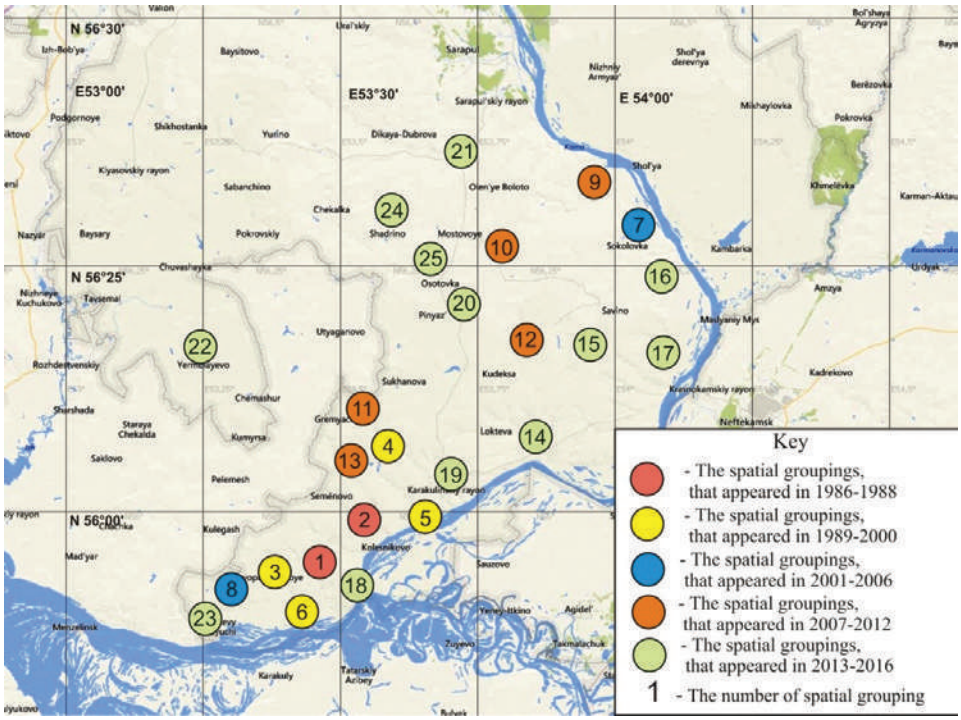

Fig.2. *The locations of colonies and isolated families of bobak in the Udmurt Republic. The numbers indicate colony names. 1 - Chegandinskoe colony, 2 - Kolesnikovskoe colony, 3 - Novopoleselenskoe colony, 4 - Kulyushevskoe colony, 5 - Yunginskoe colony, 6 - Shignandinskaya family, 7 - Sokolovskoe colony, 8 - Nyrgyndynskoe colony, 9 - Mazuninskoe colony, 10 - Bisarskaya family, 11 - Gremyachevskoye colony, 11 - 12 - Popovskaya family, 13 – Ust'-Saklynskoe colony, 14 - Vyatskinskoe colony, 15 - Kalmashinskaya family, 16 - Tarasovskoe colony, 17 - Galanovskoe colony, 18 - Chegandinskaya family, 19 - Karakulinskoe colony, 20 - Pinyazskaya family, 21 - Kostinskaya family 22 - Ermolaevskaya family 23 - Zuyevo-Klyuchinskoe colony 24 - Shadrinskaya family 25 - Zaborinskaya family. The map was taken from Bing Maps (www.bing.com/maps)*

We note that of all colonies only five (№№. 1,2,3,4,7 in Fig.1) had more than 10 families. Others had two to five families. The greatest number of spatial groupings were located in the Karakulinsky district (12 colonies and five isolated families). There were three colonies and four isolated families in the Sarapulsky district and one isolated family was in the Kiyasovsky region of the Republic.

Some features of colonies

Colonies and families usually ocurred in treeless ravine networks with small rivers and streams. Colonies №. 5, 19, 23 and family №. 18 were located on a terrace on the high bank of the Kama River. The families №№. 6, 17, 20, 25 occurred at the placer . Families №№. 20 and 25 were in the fields sown with forage grasses alfalfa and maize.

The Sarapulsky and Karakulinsky districts show the greatest economic development of the districts in the Republic (Rysin, 2009). As a consequence, all bobak colonies were subjected to significant anthropogenic influence. In addition to the obvious negative aspects (poaching, disturbance of animals), there were also some positive aspects of anthropogenic influence. Cattle grazing and raising of forage grasses both benefit bobak. Grazing occurred at the sites of 14 colonies and 11 colonies were adjacent to fields of forage grasses (in five of them cattle were not grazed).

Three types of colonies were distinguished from a study of the spatial distribution of marmot colonies: diffuse, ribbon, and mosaic (Bibikov, 1989). Most of theresearch dealing with the typology of marmot colonies in Udmurtia identified ribbon type colony structure (V. Kapitonov, K. Kapitonov, 2001, Kapitonov et al, 2002). The arrangement of bobak families along the slopes of ravines and significant plant associations are cited in the literature as signs of this type (Mashkin et al, 2010). Note that all large colonies (№№. 1,2,3,4), with the exception of №. 7, had remote subcolonies, located at a distance of more than 1 km from neighboring ones. This was primarily observed in colonies №№. 2 and 4. Small colonies (from 1 to 5 families) were found in different parts of the ravine network and were separated by areas unsuitable for marmots. These features resulted in bobak colonies of the mosaic type (Mashkin et al, 2010). Thus, only colony №. 7, was consistent with the description of a ribbon-type colony. The large colonies №№ 1 and 3 can be defined by the term ribbon-mosaic. A "mixed" classification was applied for some colonies of bobak in the mountains: D.I. Bibikov (1967) referred to them as ribbon-diffuse. Colonies №№. 2 and 4 were the closest to the mosaic type. The signs of focal colonies were cited for the Kolesnikovskoe colony earlier (Doskovskaya et al, 1999). The presence of mosaic colonies is expected for bobak at the northern limit of their range (Mashkin, 1997).

Number of families and individuals

During our research from 2011 to 2016, we annually marked the locations of new families of bobak. Since 2011, the number of bobak families has increased by 1.8 times: from 88 to 161 families (Fig. 3). Each year the number of family groups increased, by an average 14.6 families (from 6 to 29 new families in different years of research). The rate of increase was between 4% to 23%, with an average 13% annual increase.

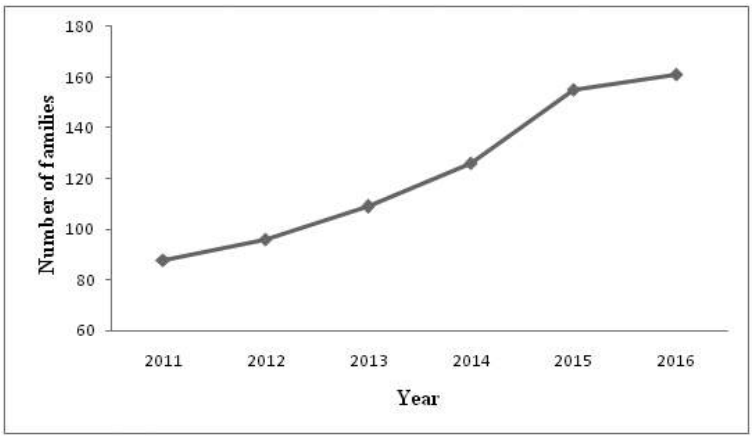

Fig.3. *The dynamics of the number of families of bobak in Udmurtia in 2011-2016.*

Between 2011 and 2016, the number of colonies and isolated families increased from nine to 25 (in 2.7 times). Annually the number of colonies increased by two to five colonies (an average of 3.2). Growth rates ranged from a 12% to 56% increase (23% on average). Thus, the number of bobak family groups in Udmurtia increased at a lower rate than the number of colonies. Consequently, the observed tendencies suggest an increase in the dispersal activity of the animals and their desire to occupy new territories. The number of ravines and gullies inhabited by bobaks and the number of colonies increased. Along with this, there was an increase in the overall number of individuals.

To estimate the total number of bobak living in Udmurtia at the present time, we extrapolated using the mean number of individuals in each family, obtained from the observation of large colonies. The average number of individuals per family in 2014 in colonies №№. 1 and 7, was 4.1 and 4.7. Based on this we estimated that the total number of bobaks in 2014 equaled 520-600 individuals. In 2015 and 2016 the average number of individuals in the family was not determined, but we assumed a further increase in bobak population size, based on the observation of new families, subcolonies, and colonies.

During our studies the average number of individuals in the family ranged from three up to seven7, with 4.3 ± 0.4 on average. The average size of bobak familiesin Udmurtia was within the limits of values obtained by researchers in other parts of the bobak's range (Tokarsky, 1997; Kolesnikov & Mashkin, 1999; Soroka, 2001). According to V.I. Mashkin (1997), an average family size of more than four individuals is favorable for the stable persistence and growth of a bobak population.

Conclusion

As a result of translocation work initiated in July 1986, the most northern, viable population of the bobak, outside of its natural range,was formed in the territory of the Udmurt Republic. Currently, 25 spatial groupings (colonies and isolated families) have been identified across three districts Karakulinsky, Sarapulsky and Kiyasovsky. The total number of bobak in the Republic is estimated at approximately 550-600 individuals.

Bobak in the forest zone inhabit the treeless ravine systems in the southeastern districts of the Republic. Most of the spatial groups of bobak are confined to places where livestock are grazed or forage grasses are planted.

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