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

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PROCEEDINGS of the 7th

International Conference on the Genus *Marmota*

Marmots of the Old and New World

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

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PREFACE

The first international conference of marmot scientists took place in Italy (Aosta, 1991), and the II conference was held in 1994 in France (Aussois). The III international conference took place in August, 1997 in Cheboksar (Russia), while the IV conference was held in Montreux, Switzerland in September, 2002. At the suggestion of the International Marmot Scientists' Bureau, the Vth international conference was held in Tashkent, Uzbekistan, and the VI conference was held in Italy again in 2008 in Cogne, Valle d'Aosta. The VII conference was planned to be held in Slovakia, however, due to circumstances, it was canceled.

Seventeen years after the first international conference in Aosta, Italy, in 1991, under the leadership of the Institute of General & Experimental Biology of the Mongolian Academy of Sciences and the Ministry of Nature, Environment, and Tourism of Mongolia, and in cooperation with scientists and researchers from Mongolia and other countries, we are organizing the VII international conference on marmot research in Ulaanbaatar, the capital city of Mongolia.

In the "Marmots of the Old and New World" conference, 121 scientists and researchers from 13 countries, Mongolia, the Russian Federation, Austria, England, the USA, Germany, Italy, Kazakhstan, Kyrgyzstan, Ukraine, France, China, and Japan, have already sent us the results of their studies, and 52 abstracts and 28 papers have been published in a conference proceedings. The conference proceedings have covered many interesting topics including the world distribution of marmot species, marmot population numbers, ecological and biological characteristics, historical reviews of regional data and research , studies of marmot taxonomy using modern molecular biology methods, determination of species genome sequences, studies of marmot skin gland structure using electronic microscopy and accompanying discussion of behavioral and scent identification and signal issues, marmot handling experiences, and auditory communication among different species of marmot.

As a part of our preparations for the VII conference of marmot scientists, we summarized and published the main results and abstracts of the previous six conferences, and we have organized a photo contest among amateur marmot lovers and researchers showing the different colors, body structure, and specific behavioral characteristics of all 15 of the world's marmot species. We have also produced a short educational and popular movie on marmot ecology, biology, sustainable use, and conservation activities.

All these activities and documents will be valuable resources for marmot lovers, scientists, researchers, rangers, and conservationists, university teachers and students, as well as policymakers and stakeholders.

Our deepest gratitude goes to sponsors and organizers of this important conference, including the Ministry of Nature, Environment, and Tourism of Mongolia, the Mongolian Academy of Sciences, and, of course, to those scientists and individuals who have worked so hard to make this conference successful.

DIRECTOR OF THE INSTITUTE OF GENERAL AND EXPERIMENTAL BIOLOGY,
MONGOLIAN ACADEMY OF SCIENCES

ADIYA YANSANJAV

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OPENING SPEECH BY THE VICE-MINISTER OF NATURE, ENVIRONMENT, AND TOURISM, MR. TS. BATBAYAR, FOR THE INTERNATIONAL CONFERENCE OF MARMOT SCIENTISTS ‘MARMOTS OF THE OLD AND NEW WORLD’

Good morning, distinguished scientists, delegates, and guests, ladies and gentlemen,

On behalf of the organizers of this international conference, the Ministry of Nature, Environment and Tourism of Mongolia, and the Institute of General & Experimental Biology of the Mongolian Academy of Sciences, I would like to congratulate all delegates and guests and wish you great success in your important scientific studies and endeavors.

Urbanization, mining, and infrastructure development, livestock population increase, and climate change over the last 20 years in Mongolia have negatively affected the biodiversity of the country. For the last 75 years, the average annual soil surface temperature has risen by 2.2^0C, while annual precipitation by volume has decreased by 7%, and 70% of pastureland has shown signs of desertification. In the face of these challenges, the conservation of Mongolian biodiversity will require close cooperation with international organizations, scientists, and researchers and policy decisions that are based on sound scientific data and conclusions.

In Mongolia more than 60 mammal species have been registered as having potential for sport and sustainable hunting. Twenty-four of these species, including Argali sheep, Siberian ibex, Mongolian and Altai marmots, Mongolian and goitered gazelles, red deer, roe deer, and wild boar have been considered the main hunting species. The hunting of marmots and Mongolian gazelles plays a significant role in the countries economy and the livelihoods of individuals.

Until the end of last century, Mongols hunted marmots for their meat, oil, and fur. However, the increase of marmot skin price on the international market from 1880 to 1990 led to the mass hunting of marmots up until the 1990s. Over 150 million marmot skins were sold on domestic and international markets. The transition to a market economy in the 1990s ed to collapse of the country’s hunting policies and systems, and the systems for the monitoring and control of weapons and bullet purchase were weakened. These factors, in combination with the market increase in the price of marmot skins and the resulting increase in illegal hunting led to destruction of marmot habitat and a decrease in marmot populations, including some local extinctions.

From ancient times Mongols have traditionally had a deep respect for wildlife and acommitment to conservation and the sustainable use of wildlife, especially marmots. The relationship between humans and marmots and other wildlife was regulated by wise principles and laws. These were written in famous historical documents such as Chingis Khaan’s Ikh Zasag, Khalkh Juram, the Rules of the Golden Khan, and in the present Constitution and other laws.

The Ministry of Nature, Environment and Tourism, as the central governmental organization for environmental issues of the country, is responsible for the sustainable development and enforcement of the government’s policies.

Mongolia is now a member of various environmental conventions for biodiversity conservation and actively participates in different conservation actions at both a regional and global levels. Mongolia joined the Convention on Biodiversity Conservation in 1993 and has a close and active relationship with the UNDP and other international organizations, coopertively implementing joint environmental and conservation projects. The current Mongolian government, which was established in 2016, has adopted and implemented new versions of the "Sustainable Development Policy of Mongolia-2030", the National Biodiversity Conservation Program, the National Program for the Conservation of Rare and Endangered Mammalian Species, and the Aichi 20 targets by 2020. The ban on the commercial and private hunting of marmots, first ordered by the Minister of Nature and the Environment in 2005, continues today. By financial assistance from the MNET and different national and international organizations, many marmot conservation activities, including the reintroduction of marmots to former ranges and other activities, have been organized. As a result, marmot numbers are increasing and their areas of distribution have begun to expand, especially in the mountain steppes and forest steppes of the country

For the conservation and recovery of the national treasure that is the Mongolian marmot, , for the education of national scientists and conservationists, for the establishment of innovative national strategies for the sustainable use of marmot products, for the realization of "User-Saver" principles and economic mechanisms, we need sound government policies, active participation from social organizations, and from all members of society.

I wish you all great success in the work of the VII International Conference "Marmots of the Old and New World" .

Thank you very much for your attention

VICE-MINISTER FOR NATURE, ENVIRONMENT AND TOURISM

TS. BATBAYAR

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OPENING SPEECH BY THE PRESIDENT OF MONGOLIAN ACADEMY OF SCIENCES, ACADEMICIAN D.REGDEL

Good morning, distinguished scientists, delegates, and guests, ladies and gentlemen

After 17 years from the 1st International conference in Aosta, Italy, in 1991, under leadership by the Institute of General & Experimental Biology of Mongolian Academy of Sciences, and the Ministry of Nature, Environment and Tourism of Mongolia in cooperation with scientists and researchers from Mongolia and other countries, we are organizing the VIIth International Conference on Marmot research in Ulaanbaatar, the capital city of Mongolia.

In this “Marmots of Old and New World” conference, 121 scientists and researchers from 13 countries such as Mongolia, Russian Federation, Austria, England, USA, Germany, Italy, Kazakhstan, Kirgizstan, Ukraine, France, China and Japan have already sent the results of their study, and 52 abstracts and 28 papers have being published in a conference proceedings. Within the preparation activities for the VIIth conference of marmot scientists, we have organized a photo contest showing the different colors, body structure, and specific behavioral characteristics of all 15 species of World’s marmots among amateur marmot lovers and researchers, as well as we have produced a short educational and popular movie on marmot ecology, biology, sustainable use and conservation activities.

This conference will give a perfect chance for young researchers and students to meet world renowned marmot scientists from technologically advanced countries, share ideas and on future cooperation identifying possible collaboration fields, and to learn modern research methodologies and technologies.

The conference proceedings have covered many interesting topics such as world’s marmot distribution, population numbers, ecological and biological characteristics, regional historical research data review, studies on taxonomy of marmot species using modern molecular biology methodologies, determination of species genome sequences, studies of marmot specific structures of skin glands using electronic microscopy and discussing behavioral and scent identification and signal issues, marmot handling experiences, and communication sound and noise studies among different species of marmots.

Mongolia is situated in eastern most area of marmots’ distribution in Eurasia and the Mongolian marmot is widely distributed in more than 500 thousand square km of country’s territory. On ecological level the marmot is prey species for many predators and one of the main carriers and reservoirs of plague viruses, as well as natural soil “engineer” and increasing the vegetation production and positively changing air moisture regime by digging holes and mixing inner and outer soils. The marmot skin is a valuable source in international trade fairs.

For many centuries Mongols have a rich tradition on sustainable and wise use of marmot products such as skin, meat, and oil by developing through the time classic national technologies adapted to people’s unique style of life and hunting techniques, marmot’s habitat and behavior.

From one adult individual during the hunting season, we can have 10-14 square decimeter skin, 2.3-3.5 kg of meat, rich with valuable amino acids and vitamins, 0.8-1.2 кg fat, and 250-300 g pure oil. Beside of that, 3.6-5.4 cм long canines can be used as souvenirs, and the contents of stomach and meat soup often used as additional food for livestock, while intestines like liver, gallbladder, heart and kidneys used in traditional medicine.

The marmot is a very valuable and suitable animal that can be used as a model species to study ecology and biology of other Mongolian wildlife in relatively pristine nature, as well as it can be used as example species for collection of raw data, comparative materials using modern and innovative technologies and methodologies. Also it can be used as a tool to understand historical experiences and methods in local traditional medicine of nomadic Mongols.

I believe that this conference will make sound and scientifically based recommendations on scientific studies of world's marmot species diversity, Mongolian marmot ecology and biology, as well as the ways on marmot conservation and sustainable use, on establishment of innovative and modern technologies for the production of raw materials' processing by combining the efforts of international scientists and implementing joint projects

I want to express my sincere gratitude to the organizers of VIIth international conference of marmot scientists and wish a success in conference activities.

I also wish a great success to all participants and welcome you to Mongolia.

PRESIDENT OF MONGOLIAN ACADEMY OF SCIENCES, ACADEMICIAN
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MONGOLIAN MARMOT SKIN GLAND MORPHOLOGY

Adiya Yansanjav

Institute of General & Experimental Biology Mongolian Academy of Sciences

Specific skin glands, as sources of chemosignals, have attracted the attention of scientists for many years. These glands are diverse in terms of location, quantity, size, and histological structure and in the chemical compositions produced by the glands. Until now, however, in many mammalian species skin gland structure has not been well studied, and in many species their topography has not even been described, desptiet the fact that in all species glands play an important biological role. This is particularly true for most rodent species, including marmots.

At present, the histostructure of anal, sole, cheek, Meibomia, and Garderova glands and mystacial glands have been discovered and described in detail in 11 out of the world's 14 marmot species. Besides a short description of anatomical structure and a possible role of anal glands in marking of territories (Tarasov, 1960, 1961), no more skin gland studies for the Mongolian marmot *(Marmota sibirica)* have been done until today (see Table 1).

Table. 1.

Marmot species	Specific skin glands					
	Anal glands	Cheek glands	Mystacial glands	Sole glands	Garderova glands	Supraorbital glands
M.sibirica	+* (1.2,30-34,35)	-	*o#(30-34,35)	*o# (30-34,35)	*o# (30,34,35,)	*o# (30,34,35)
M.baibacina	+* (1.3)	+ (4)	-	-	-	-
M.bobac	+*o (5.6)	+o (7)	*o (5.6)	*o(5.6)	-	-
M.camtchatica	*o (8)	-	*o (8)	*o (8)	*o (8)	*o (8)
M.cauduta	-	* (9)	-	*o (6)	-	-
M.menzbier	+* (9.10)	+* (9.10)	+ (9.10)	+ (9)	-	-
M.monax	+*# (11, 12,15)	+*o (13.15)	+*o (14.15. 29)	-	-	-
M.caligata	+*o (15)	+*o (15.16)	*o (15)	-	-	-
M.marmota	+*o 15,17, 18, 19)	+*o (15.20.21.22)	-	-	-	-
M.broweri	+*o (15)	+*o (15.23)	*o (15)	-	-	-
M.flaventris	-	+*o (15.24.25.26)	-	-	-	-
M.olimpus	+* (27)	+*o (15.27.28)	-	-	-	-

*Notes: + data on markings; * data on gland existence and short anatomical description; 0 – short description of histological structure; # ultrastructure description; - no data. Numbers in brackets are literature references.*

1. Tarasov, 1960; 2. Tarasov, 1961; Berendyaev, Kulkova, 1965; 4. Kapitonov, 1975; 5. Skurat, 1972; 6. Sokolov, 1973; 7. Spivakova, Kapitonov, 1982; 8. Skurat, Potapova, 1991; 9. Mashkin, Baturin, 1982; 10. Mashkin, 1983; 11. Hamilton, 1934; 12. Smidt, Hearn, 1979; 13. Hebert, Frescott, 1983; ; 14.Walro,et al 1983; 15.Rausch, Bridgens,1989; 16.Taulman, James, 1990; 17.Perrault, 1731; 18.Schaffer,1940; 19.Kratochvil, Hrabe,1967; 20.Psenner,1956; 21.Munsh,1958; 22.Koenig,1957; 23.Rausch, Rausch, 1971; 24.Armitage,1962; 25.Armitage,1974; 26.Armitage,1976; 27.Barach, 1973; 28.Thiessen, Rice, 1976; 29.Meier.,1991; 30. Adiya, 1993, 1993a; 31. 32. Sokolov, Adiya, Stepanova, 1992, 1993; 33. Sokolov, Stepanova, Adiya, 1993; 34. Adiya, 2002; 35. Adiya, 2007.

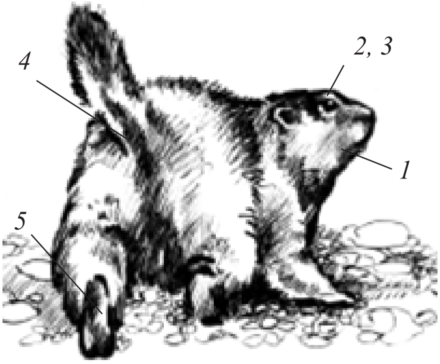


Figure 1. *Location of specific glands on the Mongolian marmot (Marmota sibirica).*

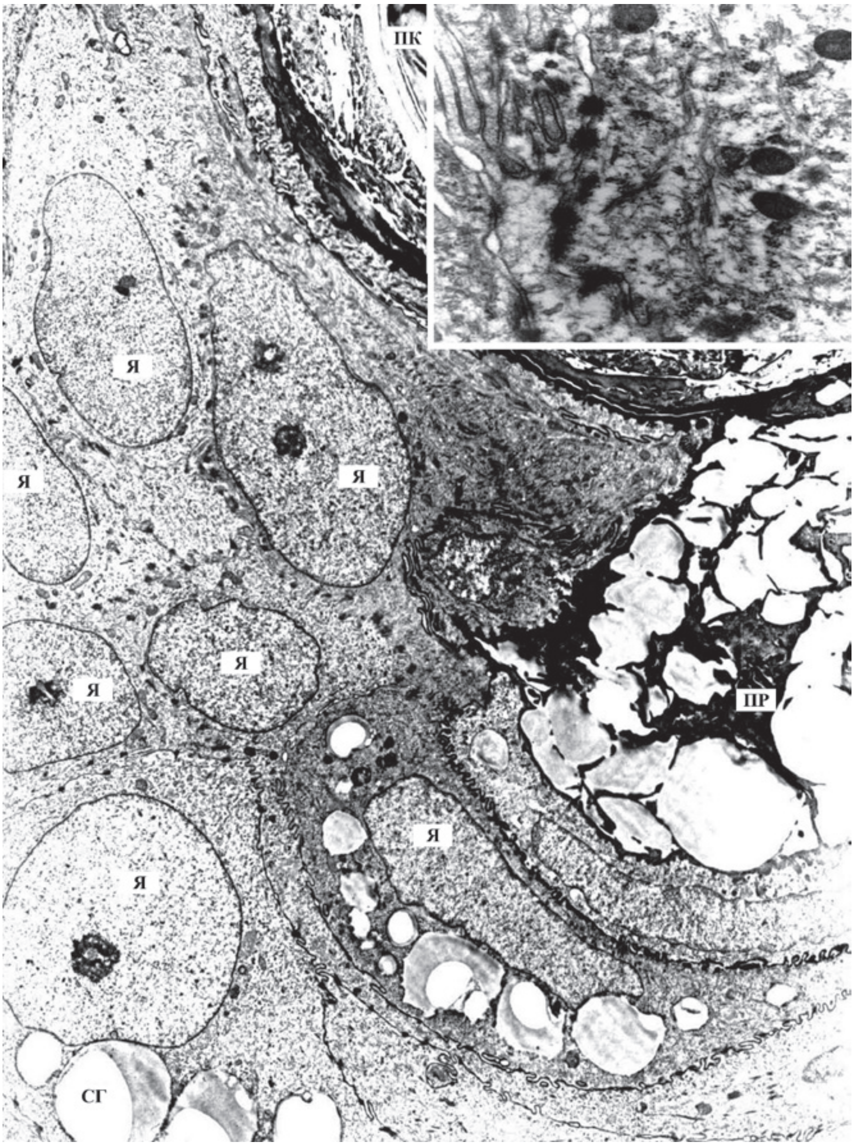
1 - Mystacial . 2, 3 - Supraorbital and Garder's glands. 4 - anal, and 5 - sole gland.

To study the skin gland structure of both subspecies of Mongolian marmot (38 individuals from the Arkhangai and Central provinces) samples were taken from different parts of marmot's body: spine, neck, belly, mouth, forehead, anus, upper and lower eyelids, the soles of fore and rear paws, and Garderov's glands. We used light and electronic microscopes to analyze collected samples (Sokolov et. Al., 1988; Humpry, Pitman, 1979).

Results

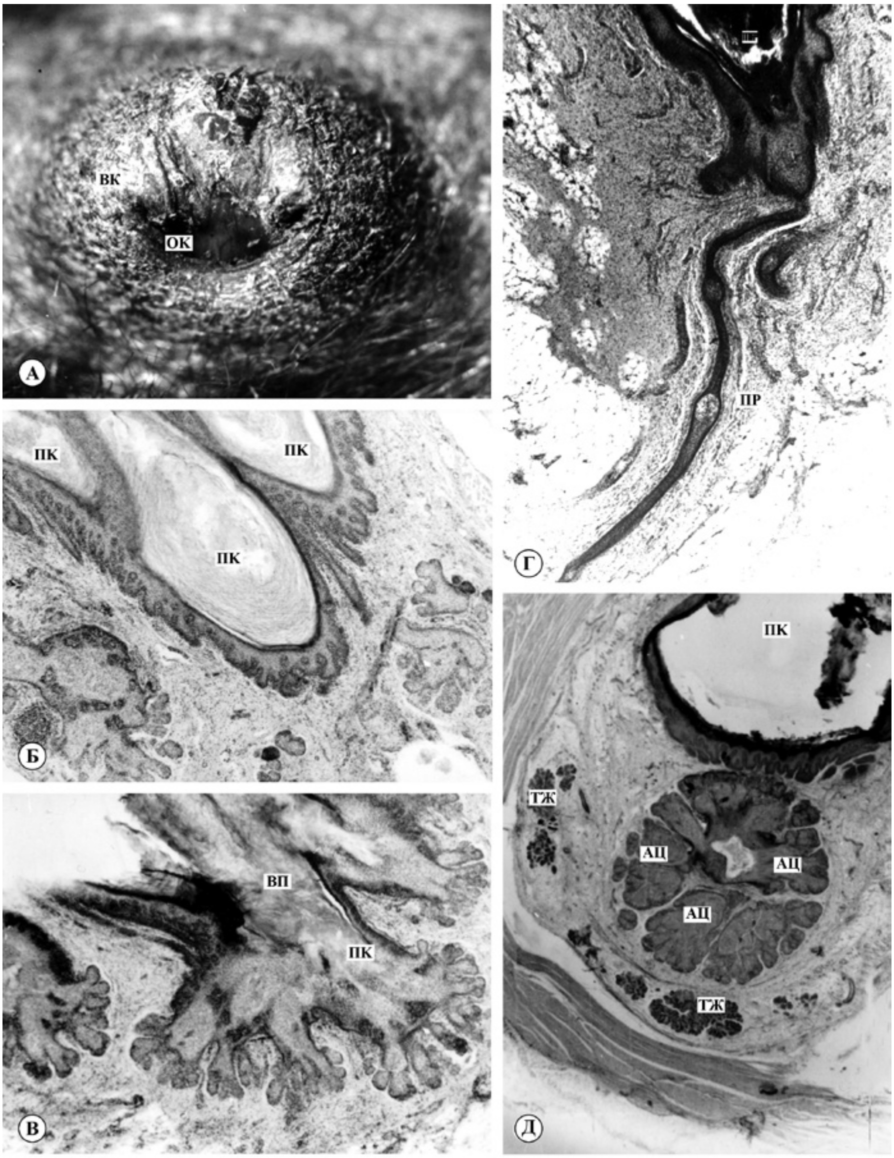
Acinar glands. Compared to many taxonomic groups of mammals, rodents do not have diffusely located skin tubular glands, but they do have acinar (lipid synthesizing) glands (Sokolov, 1973). In the skins of Mongolian marmots, acinar glands are placed in pairs nearby hairs, and the size of the gland in adult marmots does not exceed 112 x 62 µm.

There are some differences between male and female gland cells in their ultrastructural characteristics, which indicate specialization by sex, with different glands having the ability to synthesize substances of different chemical natures. In male cells the smooth reticulum is not distinguished and there are many free ribosomes. Granule secretions havemiddle electronic density with large, electronically transparent "vacuoles" of different sizes. Sometimes these "vacuoles" occupy almost all of the granule, so that appears transparent, with dark rings around the periphery (Figure 2). .



Pigure.2. *Acinar gland of male's nape. Translucent electronic microscope. Acinus fragment nearby channel that flows into pocket hollow full of gland. In cells surrounding channel, gland granules can be seen specific to male cells (X5000. On insertion, fragment of cytoplasm with GER cisterns (X 10 000)*

Anal glands. The anal glands of marmots occur in three skin pockets situated on the dorsal and lateral sides of anus. Only one individual (a juvenile) had pockets with three branches. Pocket exit tubes were situated in the wall of the anus. In adult individuals the exit tubes of the central pocket had diameters of 1.2-1.5 mm and lengths of 8-10 mm. Pocket sizes were almost the same with a 7-9 mm length and 3-5 mm width (Figure 3).

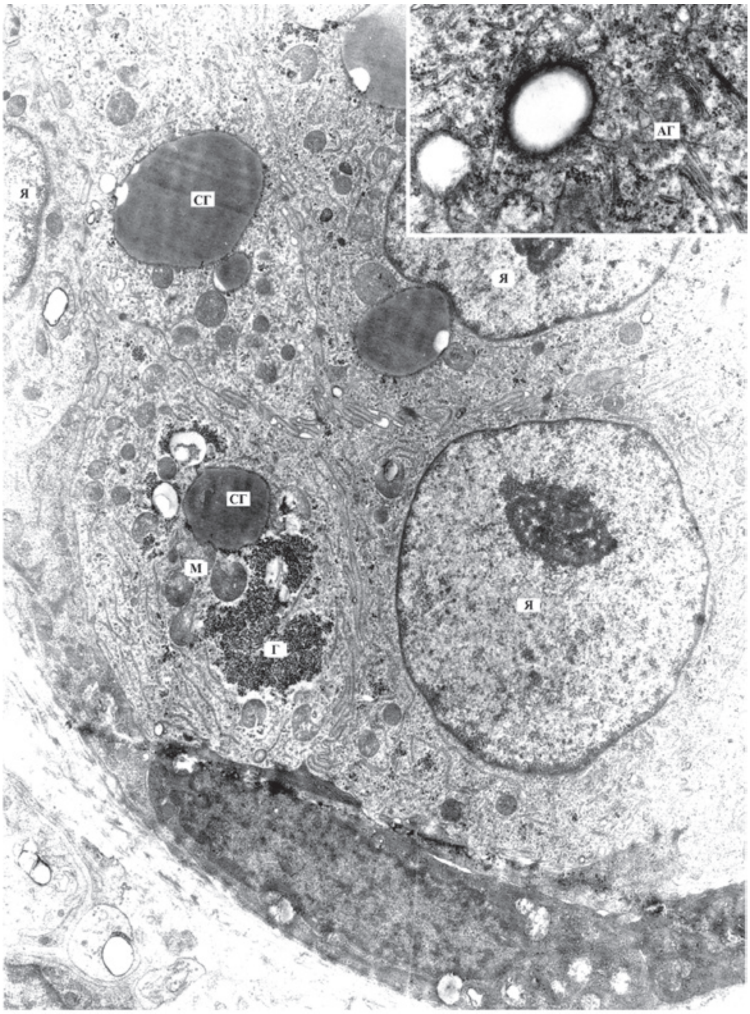


Pigure.3. *Acinar gland of anal pocket (coloured by hematoxylin-eosin). A-anal part (anus is artificially widened. Б-three-branched central pocket of anal gland from days old youngster (об x 5). В – side pocket of anal gland (об x 2,5). Г- Exporting channel of tubular gland enlarged 10x25, coloured by hematoxylin-eosin. ПР-exporting channel, Д-semi-thin cutting of acinar gland (об x 100).*

Pocket bottoms were formed by a strong dermal layer, where polilobical acinar glands were layered, while tubular glands are layered below. The total length of glands in adults was 3800 to 4380 mm, and the maximum thickness was 700 µm (Figure 3 б.в а).

Anal pocket glands. Every lobe of acinar glands consists of acini with their own excretory tube. The acinar glands of anal pockets are considered free and they are not associated with hair follicles. On a histological level, neither seasonal and nor sexual differences in the structure of acinar glands were detected (Figure 3).

Electronic microscope studies showed that male's acinal glands had the following characteristics: nuclei with small amounts of heterochromatin and a large active nucleolus, a synthetic apparatus with a substantial amount of long granular endoplasmic reticulum (GER), free ribosomes,and and roundish mitochondria. The distinguishing features of cells were big glicogene conglomerates concentrated around gland granules and their morphology. Granules were oval in shape with middle electronic density and were surrounded by dark circles (1-5 μm in diameter). (Figure 4).



Pigure.4. *Male acinar gland of anal pocket. Translucent electronic microscopy. Acinus periphery. On a basal membrane there can be seen undifferentiated compressed cell (X 8300). On insertion, fragment of near nucleus cytoplasm (X 10 000).*

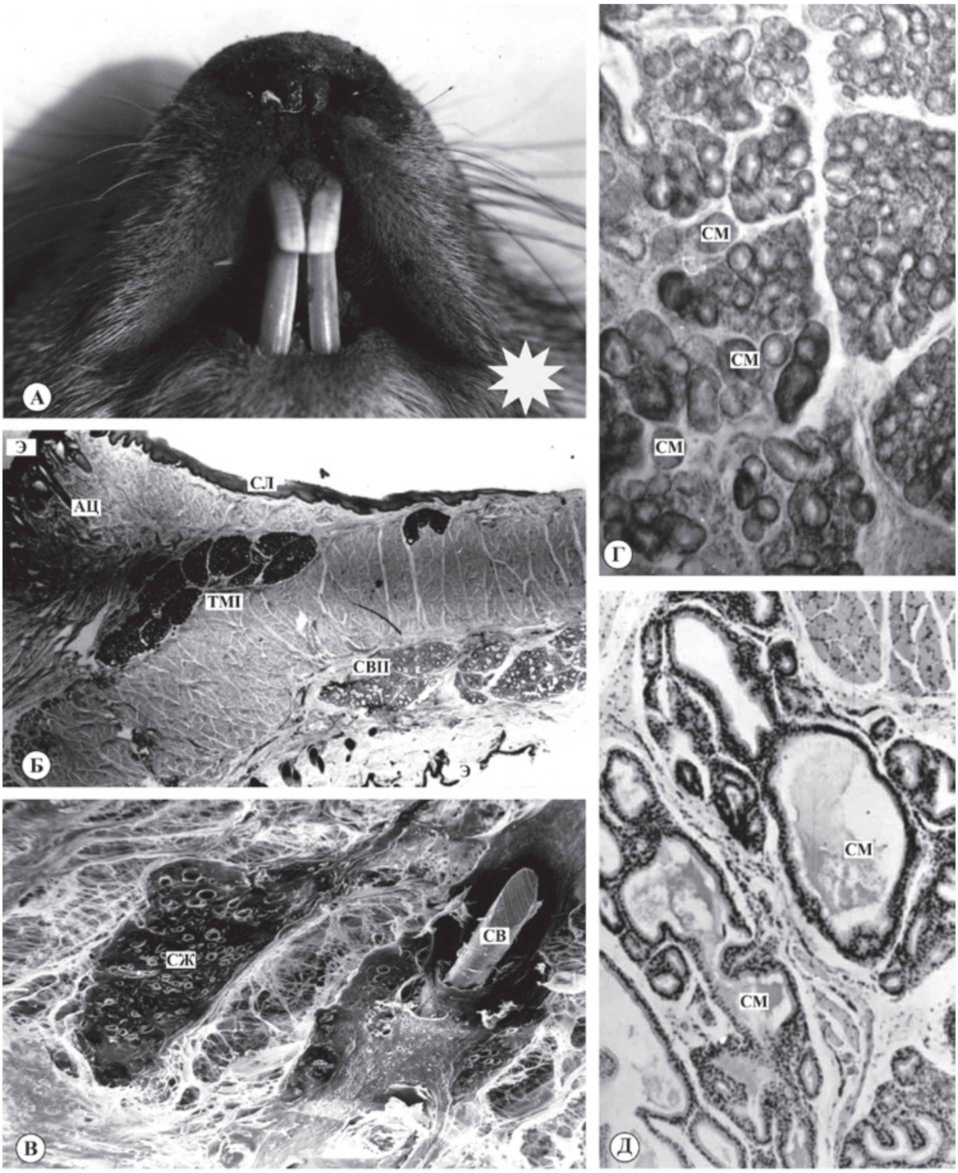
In deeper dermal layers, under acinar glands were the tubular glands of anal pockets. They wee represented by two complexes surrounding acinar glands in a C-shape form. From each complex there was one excretory duct leading into the pocket hollow, located near tubes of acinar glands. Glands appeared as dense rolled up tubes separated by connecting tissue. The cytoplasm was basophilic. On a histological level, seasonal, sexual, and/or age differences were not observed.

Electron microscope studies of anal pocket tubular glands showed clear sexual differences in the epithelia of the cells. In cells of both sexes there ere well developed protein synthesizing apparatus (with numerous ribosomes and separated short cisterns of GER) and a gel-synthesizing conveyer,the Golji apparatus. The Golji apparatus in males was a dominant organelle and occupied a substantial area of the cytoplasm. In females, the Golji apparatus was substantially smaller and there were fewer mitochondria. In addition to the usual-sized mitochondria, however, there ere also some gigantic mitochondria (up to 7µm , ten times larger than the standard size). Similar mitochondria (up to 3 µm in diameter) have been described only once in gland epithelia for human apocrine glands (Kurosimi et al., 1984). Gland granules in females cells were represented by following three types: 1) similar to those of male cells (not many), i.e. translucent and surrounded by membranes with soft nets; 2) small dark granules concentrated in the apical part of the cell; 3) electronically translucent granules with a definite membrane. Compared with Smith & Hearn, (1979), our data showed species differences in the ultra-structural characteristics of cells (in the structure of synthetic apparatus, the morphology of granules, and reserves and distribution of glycogens) in acinar glands in anal pockets of Mongolian and forest-steppe marmots *(M. kastschenkoi)*.

There were some species differences in the anal glands at at anatomical and histological level. Alpine marmot *(M. baibacina)* anal acinar glands are smaller than those of Mongolian marmots, but the complex of tubular glands are bigger (Kratochvil, Hrabe, 1967). In steppe *(M. bobak)* and black-capped marmots *(M. camtschatica)* the tubular glands are represented by one (not by two) complexes (Skurat, 1972; Skurat, Potapova, 1991).

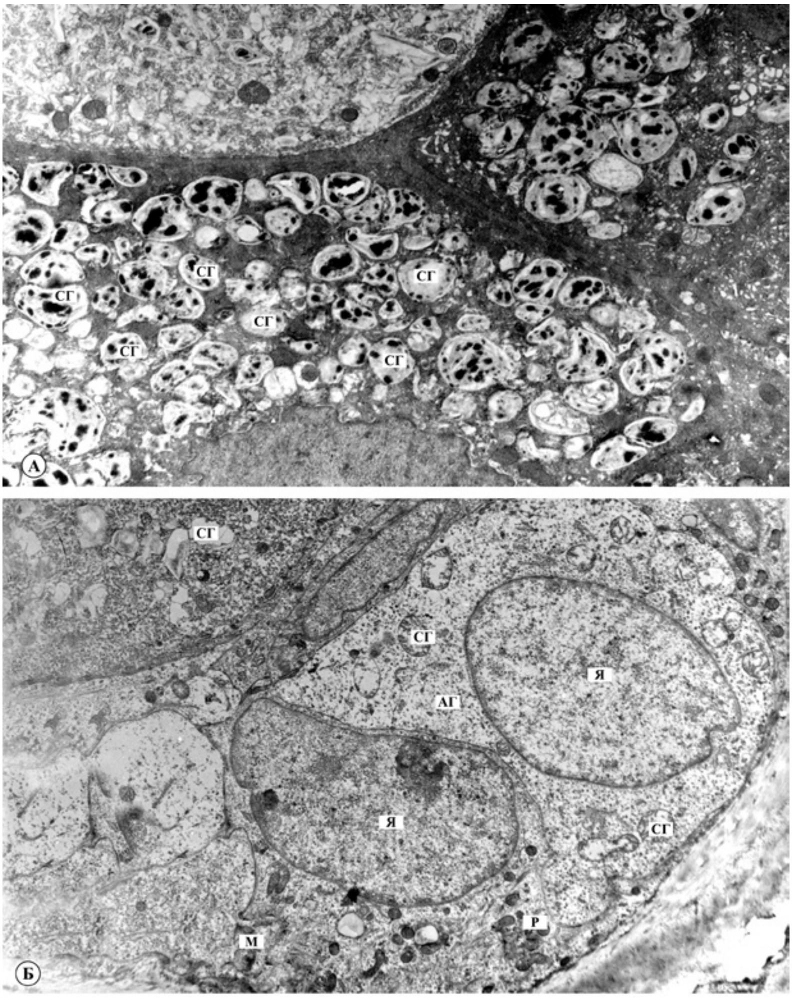
To conclude, the anal glands of Mongolian marmots have various of anatomical, histological and ultra-structural peculiarities, differentiating these glands either from glands on the body, or from similar glands of other species of the genus *Marmota* (Figure 3).

Mystacial glands. Mongolian marmot's mystacial glands are located in the skin near the lips. The skin (1.5 x 1.5 cm) which is located on the upper lip , is substantially (3-4 times) thicker than nearby cheek skins. Histological sectioning of the thickened skin showedthat there are multipartial acinar glands in both sides of hairs and below are two complexes of tubular glands (Figure 5 а.б.в).

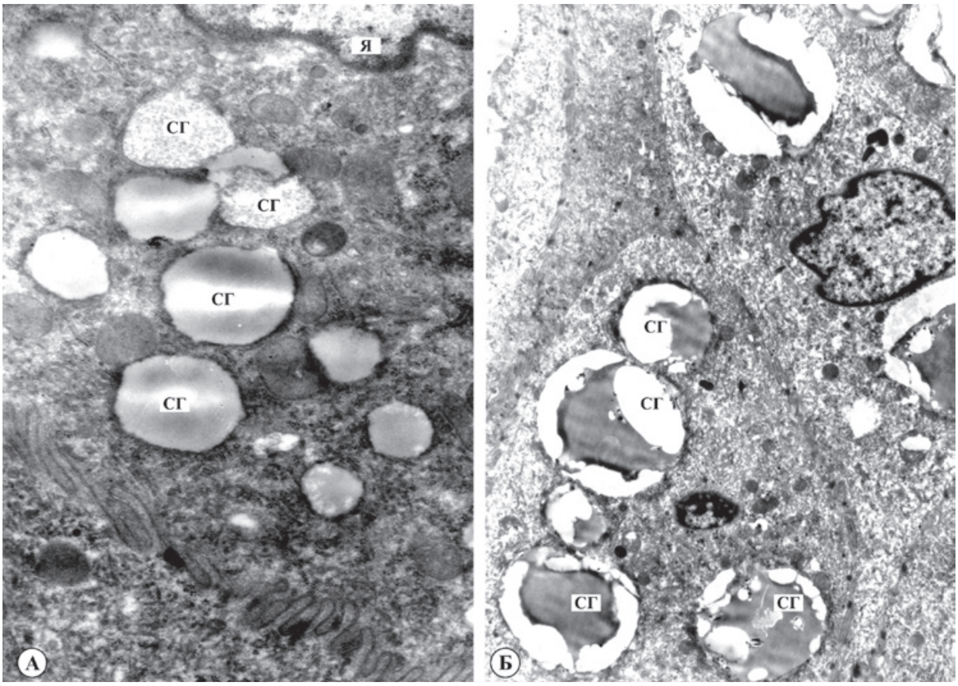


Pigure.5. *Acinar glands of mouth angle (coloured by hematoxylin-eosin). A-widened area of skin whre the glands are located, Б-three complex of glands: dark-coloured (тмI) and light-coloured (свII) tubular and acinar (об x 1,2). В – acinar glands scanning electronic microscope, X300). Tubular glands of mouth angle (coloured by hematoxylin-eosin). Г-dark-coloured (I complex), (обx10). Д – light-coloured (II complex, (об x 5 и 10).*

Males had bigger glands than females and there were some fluctuations in sizes of organelles. The biggest glands (923.2 x 275.7 μm) were observed in males during the mating season. Glands of both sexes were different by not only size, but also by cell epithelia. Although the cells of both sexes ynthesize the lipids, the GER does not . Females had fewer and shorter cisterns of granular reticulum, and males had fewer, longer reticulum grouped in five to six profiles. Female granules were surrounded by separate membranes. They had translucent contents with defined dark ingredients of different forms. Male cells hasfour types of granules: 1) tiny electronically-thick; 2) transparent with a dark and narrow border; 3) transparent with dark heart with a polygonal form; 4) translucent with sensitive retina (Figure 6.7).



Pigure.6. *Female's acinar glands of mouth angle. Translucent electronic microscope. А – fragments of three different cells filled with granules that gives cells "tiger-like" picture (X 5 000). Б - cytoplasm location nearby nucleus with very rare GER cisterns, ribosomes compacted in polysomes and Goldgi apparatus (X 10 000). On insertion, gland granules characteristic to female's glands surrounded with membranoid structures (X 10 000).*



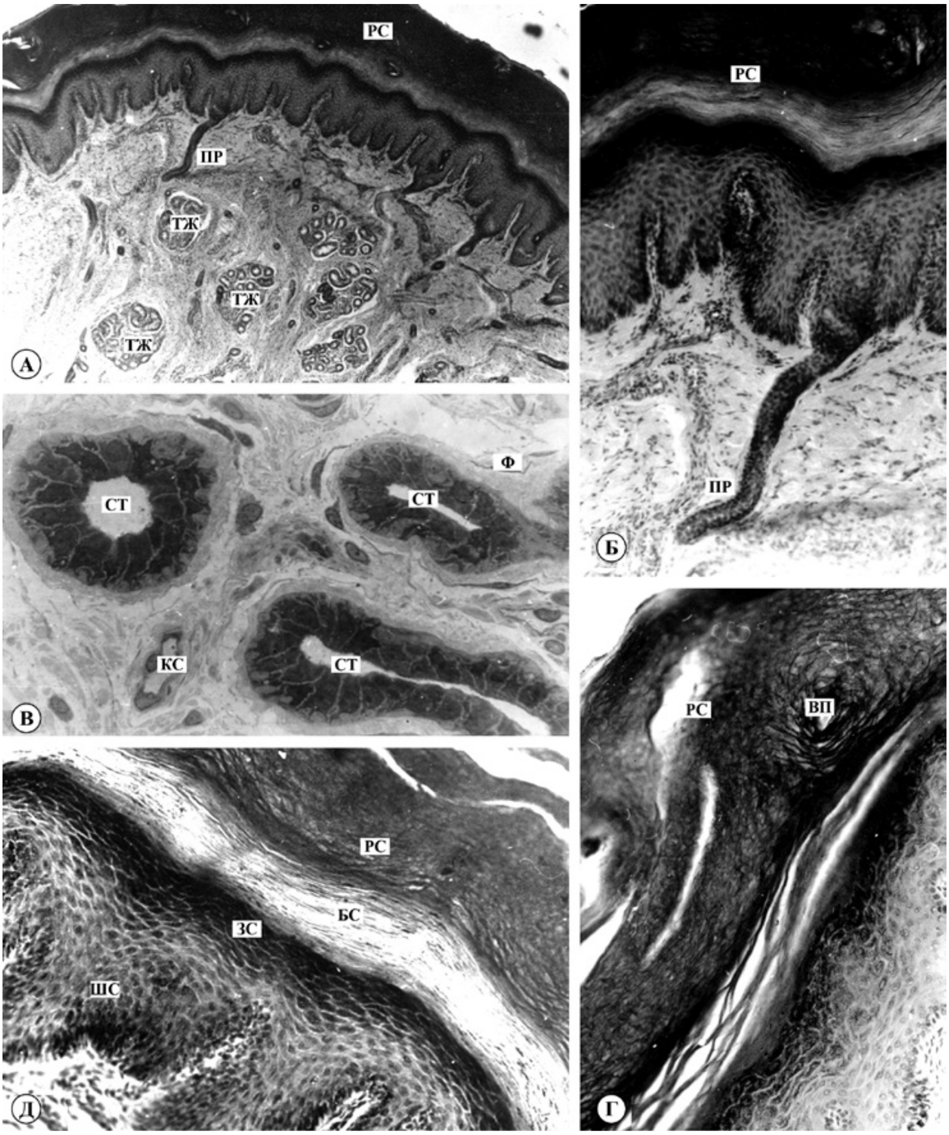
Pigure.7. *Acinar gland in male's mouth angle. Translucent electronic microscopy. А – cytoplasm nearby nucleus. Two types of granules: granules with smooth nets and granules with dark rounding (X10 000). Б - granules with dark hearth polygonal form (X 10 000).*

Below the lipid glands through the depth of the derma there were two complexes of tubular glands. The first complex was in the mouth cavity at the centre or slightly closer to the thickened part of the skin on the upper lip and 1 cm from the mystacial area, 0.8-1.2 mm from mouth cavity. There were usually seven to 12 s egments in the complex.

The second complex of tubular glands was located nearly in 2 cm from the mystacial area of the mouth. The depth from the skin surface was 1.8-2.8 mm. Similar to the first complex, it had a tubular structure and tubular sizes of 650 x 110 μm in width, while some even reached 850 x 250 μm.

As was mentioned before, the mystacial glands of Mongolian marmots have not been previously described. However, in steppe marmots (Skurat, 1972; Rausch, Bridgens, 1989), Alaskan *(M. broweri)* and gray marmots (Rausch, Bridgens, 1989) glands of similar location have been studied for histological analysis. None of the above authors mentioned the three complex glands in the marmot's mouth.

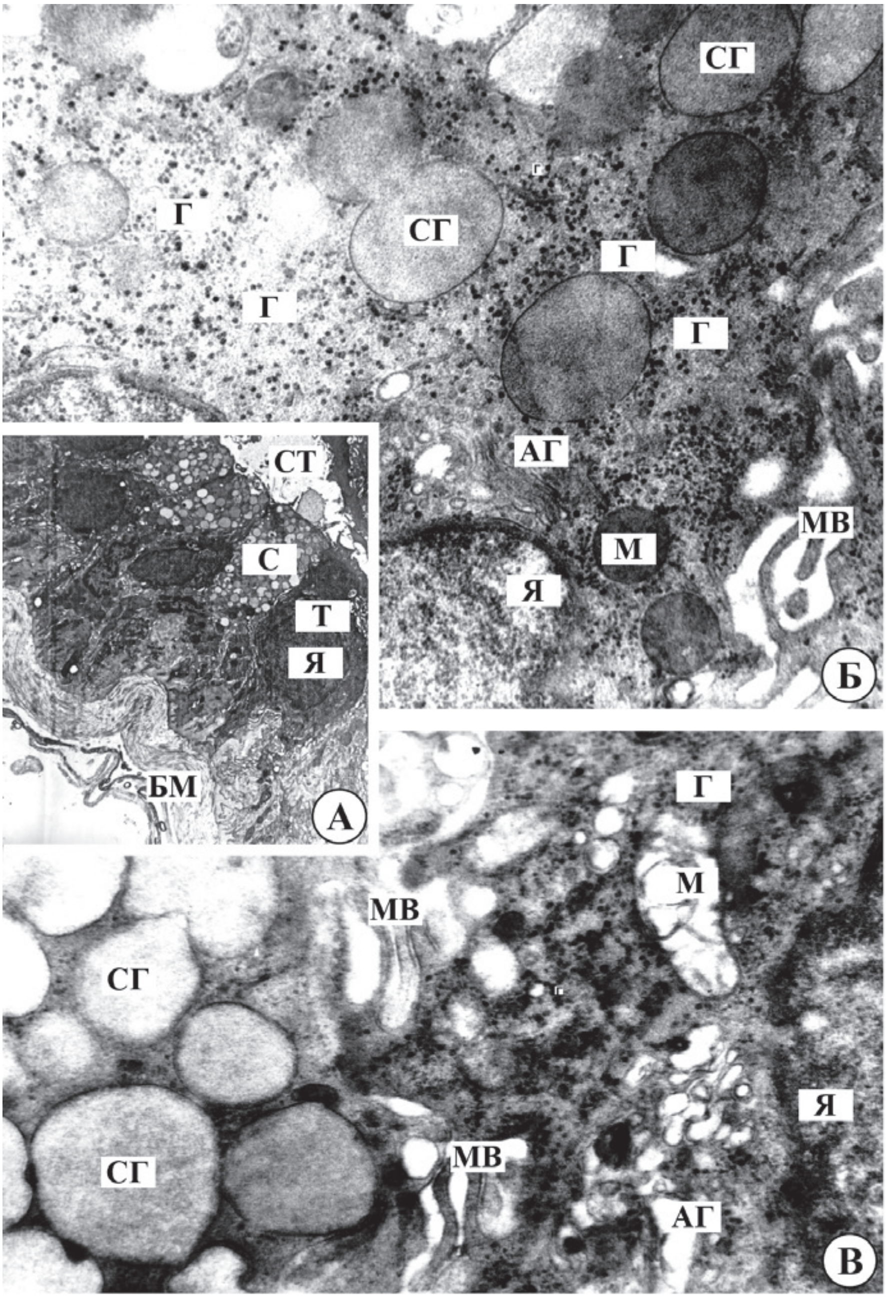
Sole glands. These tubular glands are located not only in the skin of the finger pads and paws, but also in the hairless skin of the paw. The greatest concentration of glomerulus is observed in the fingers pads. There was no difference in size among sexes and seasonal fluctuations were not observed. However, some observations suggested that in March and April some adults had enlarged glands, up to 880-270 μm (Figure 8).



Pigure.8. *Sole glans. (coloured by hematoxylin-eosin). A- Gland location in derma (об х 5). Б – Skin epidermis of sole (об х 20). В – half-tone cutting through gland’s tubes (об х 100). Г – epidermis ceratoid layer (об х 20). Д – Exit of excretory tube on epidermis surface (об.х 20).*

Short cisterns of granulated endoplasmatic reticulum in male epithelium was rare, and agranular reticulum was not observed. The Golgi apparatus was very distinct. It was very well developed, positioned near the nucleus, its cisterns were short and widened, its contents were translucent, and very few vesicles were present.

In female glands the sizes were narrow, but for males they ere wide. Females had more cells enriched with bright granules than did males (Figure 9).



Pigure.9. *Female's sole gland. Translucent electronic microscope. A – part of gland tube. Б, В - gland cells' fragments (X10 000).*

Meimodian glands of the eyelid. Meimodian glands are multi-segment acinar glands that are open to the surface of the eyelid skin. Histological structure is typical to acinar glands.

Eyelid glands are well developed and actively functioning throughout the lifetime of the animal. The biggest glands were observed in males during the mating season. In autumn they became smaller. Meimodian glands have not been studied in any other species of marmot, or even in other mammalian species.

Garder’s glands. Garder’s glands are located in the corners o f the eyelids and of the complex of orbital glands, are the largest ones. Garder’s glands in adult Mongolian marmots are 430 mg in weight. The glands have a tubular-alveolar structure. The main synthetic products in many mammalian species are lipids (Sakai, 1981). The main difference in the glands cells of Garder’ glands is that they do not have a unique system for lipid bio-synthesis in large quantity. The lipid are exported through exocytose, but not through the holocrynic type (Wooding, 1980).

The epithelial cells of marmot glands have different types of coloring. Some look brighter, while some are darker. Cells that are protein-lipid secreting have granules of two types. They have a well developed GER. Sexual dimorphism was not observed.

The comparison of ultra-structural characteristics of cells in sole glands, the tubular components of anal glands, and the glands of the mouth brings us to the conclusion that the specialization of cells and the characteristics of glands are different depending on their location in the body of marmots.

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СТРУКТУРНЫЕ ОСОБЕННОСТИ КОЖНЫХ ЖЕЛЕЗ МОНГОЛЬСКОГО СУРКА.

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Специфические кожные железы давно привлекали внимание ученых. По мере развития этологии млекопитающих значительно возрастает интерес к специфическим кожным железам-источникам хемосигналов.Эти железы необычайно разнообразны по расположению и количеству на теле, размерам, гистологическому строению и химическому составу выделяемого секрета. Однако до сих пор далеко не у всех видов млекопитающих не только не установлена структура, но даже не описана топография кожных желез, хотя эти органы играют столь важную роль в жизни млекопитающих. В полной мере это относится и к многочисленному отряду грызунов, в том числе роду сурков.

У 11 из 14 живущих в настоящее время на Земле видов сурков обнаружены и разной степени подробности описано гистоструктура анальных, подошвенных, щечных, Мейбомиевых, Гардеровых желез и желез углов рта. Кроме краткого упоминания об анатомическом строении и о возможном участии анальных желез в маркировке (Тарасов,1960,1961), другие кожные железы монгольского сурка до нас не исследовались (см. табл.1).

Таблица 1

Изученность специфических кожных желез разных видов сурков

Виды сурков	Кожные специфические железы					
	Анальные железы	Щечные железы	Железы в углах рта	Подошвенные железы	Гардеровые железы	Железы века
M.sibirica	+* (1.2,30-34,35)	-	*o#(30-34,35)	*o#(30-34,35)	*o# (30,34,35,)	*o# (30,34,35)
M.baibacina	+* (1.3)	+ (4)	-	-	-	-
M.bobac	+*o (5.6)	+o (7)	*o (5.6)	*o(5.6)	-	-
M.camtchatica	*o (8)	-	*o (8)	*o (8)	*o (8)	*o (8)
M.cauduta	-	* (9)	-	*o (6)	-	-
M.menzbier	+* (9.10)	+* (9.10)	+ (9.10)	+ (9)	-	-
M.monax	+*# (11, 12,15)	+*o (13.15)	+*o (14.15. 29)	-	-	-
M.caligata	+*o (15)	+*o (15.16)	*o (15)	-	-	-
M.marmota	+*o 15,17, 18, 19)	+*o (15.20.21.22)	-	-	-	-
M.broweri	+*o (15)	+*o (15.23)	*o (15)	-	-	-
M.flaventris	-	+*o (15.24.25.26)	-	-	-	-
M.olimpus	+* (27)	+*o (15.27.28)	-	-	-	-

Условные знаки: *+ сведения о маркировке * -упоминание о наличии желез и краткое анатомическое описание, о – краткое описание гистологической структуры, # описание ультраструктуры, - отсутствие данных. Цифры в скобках – литературные источники,*

1. Тарасов.1960; 2. Тарасов.1961; 3. Берендяев, Кулькова,1965; 4. Капито-нов,1975; 5. Скурат,1972; 6. Соколов,1973; 7. Спивакова, Капитонов,1982; 8. Скурат, Потапова,1991; 9. Машкин, Батурин,1982; 10. Машкин.1983; 11. Hamilton,1934; 12. Smidt,Hearn,1979; 13. Hebert, Frescott,1983; 14. Walro,et al 1983; 15. Rausch, Bridgens,1989; 16. Taulman, James, 1990; 17. Perrault, 1731; 18. Schaffer,1940; 19. Kratochvil, Hrabe,1967; 20. Psenner,1956; 21. Munsh,1958; 22. Koenig,1957; 23. Rausch, Rausch, 1971; 24. Armitage,1962; 25. Armitage,1974; 26. Armitage,1976; 27. Barach, 1973; 28. Thiessen, Rice, 1976; 29. Meier.,1991; 30. Адъяа,1993,1993а; 31. 32. Соколов, Адъяа, Степанова, 1992,1993); 33. Соколов, Степанова, Адъяа,1993; 34. Адъяа, 2002; 35. Адъяа,2007

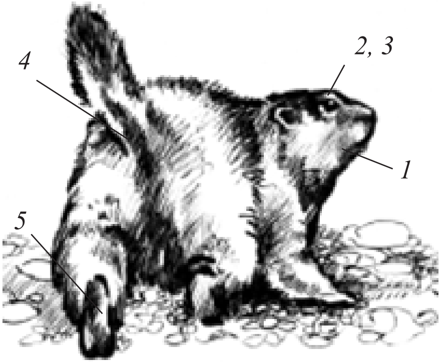

Рис1. *Расположение специфических желез тарбагана. 1- угла рта, 2,3-железы века и гардера, 4-анальный; 5-подошвенный*

Для изучения строения кожных желез у двух подвидов монгольского сурка (Архангайский и Центральный аймак, 38 особей) пробы брали из разных топографических участков тела: спины, загривка, брюха, угла рта, заглазничной и анальной области, верхнего и нижнего век, подошв передней и задней лап и Гардеровы железы. Собранные материалы изучали методами световой и электронной микроскопии (Соколов и др, 1988; Humpry, Pittman, 1979).

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ

Диффузно расположенные ацинарные железы. В отличие от многих таксономических групп млекопитающих, у грызунов в коже туловища от¬сутствуют диффузно расположенные кожные трубчатые железы, хотя широко представлены ацинарные (липидсинтезирующие) (Соколов,1973). В коже монгольского сурка ацинарные железы располагаются попарно возле волос, но их размеры у половозрелых особей не превышают 112 x 62 мкм (в области загривка).

Ультраструктурные характеристики железистых клеток у самок и самцов выявляют определенные различия, свидетельствующие о их разной специализации, т.е. способности синтезировать вещества разной химической природы. В клетках самцов гладкий ретикулум не выявляется, но короткие цистерны ГЭР распределены по всей цитоплазме; много свободных рибосом. Секреторные гранулы средней электронной плотности с крупными электроннопрозрачными "вакуолями" разных размеров. Иногда такая "вакуоль" занимает почти всю гранулу, так что она оказывается электронно-прозрачной с более темным кольцом по периферии (Рис.2).

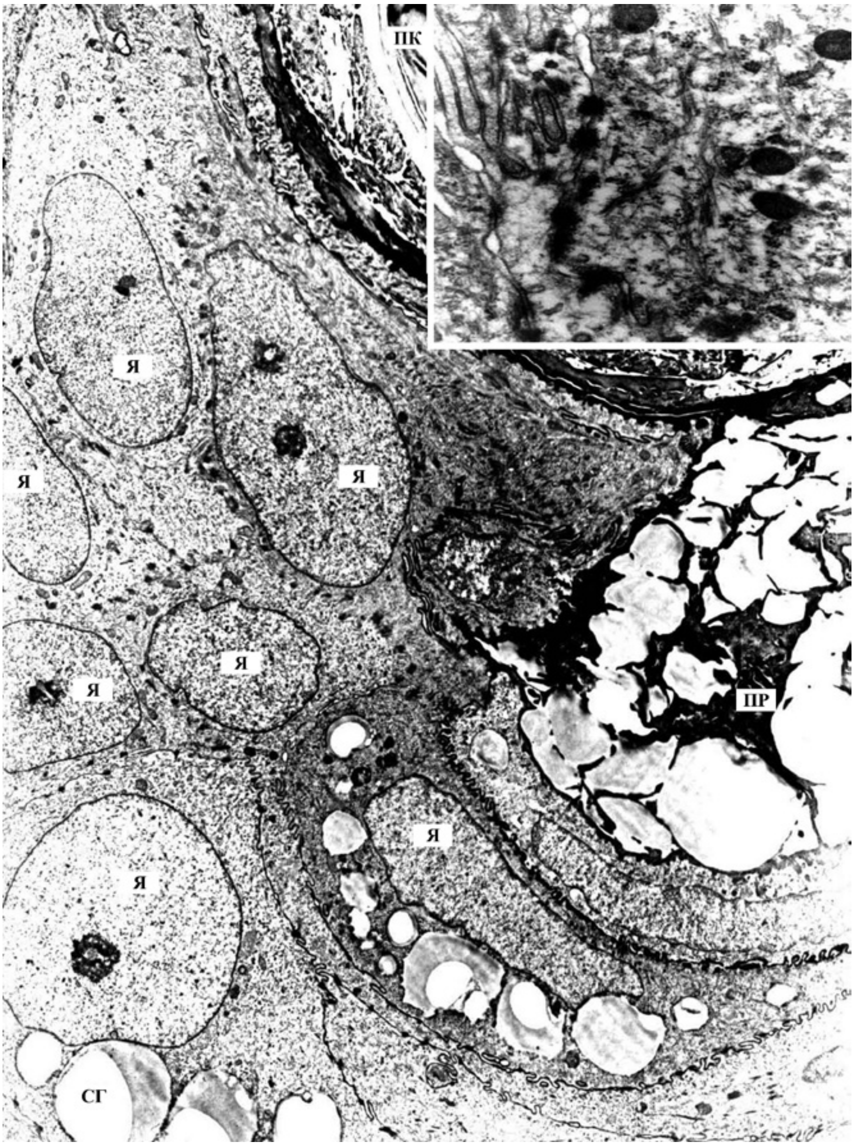

Рис.2. *Ацинарная железа загривка самца. Просвечивающий электронный микроскоп. Фрагмент ацинуса возле протока, впадающего в полость кармана, заполненного секретом. Секреторные гранулы видны и в протоке. В клетках, окружающих проток видны секреторные гранулы, характерные для клеток самца (X5000). На вставке фрагмент цитоплазмы с цистернами ГЭР (X 10 000).*

Анальные железы. Анальные железы тарбагана представлены тремя кожными карманами, расположенными на дорзальной и латеральных сторонах заднепроходного отверстия. Только у одной особи (сеголеток) карманы оказались трехкамерными. Выходы протоков карманов расположены в стенке анального отверстия. Диаметр выводного протока центрального кармана половозрелых особей 1,2-1,5 мм, а его длина равна 8-10 мм. Размеры карманов почти равны, 7-9 мм длиной, 3-5 мм шириной (Рис.3а).

Дно карманов образовано мощным дермальным слоем, где залегают многодольчатые ацинарные железы, а ниже - трубчатые. У особей с трехкамерными карманами ацинарные железы располагались возле каждой камеры. Общая протяженность железистого поля, состоящего из ацинарных желез у половозрелых особей, от 3800 до 4380 мкм, а наибольшая толщина 700 мкм (Рис.3б,в,д). Уже 20-дневные и двухмесячные особи имеют полностью сформированные и активно секретирующие ацинарные железы, а их размеры почти соответствуют таковым взрослых особей (3800 х 600 и 3900 х 650 мкм).

Железы анального кармана. Каждая долька ацинарных желез состоит из ацинусов с самостоятельным выводным протоком. Общий широкий выводной проток от всех долек открывается прямо в карман. Таким образом, ацинарные железы анального кармана относятся к свободным, т.е. они не связаны с волосяными фолликулами. Ни сезонных, ни половых отличий в строении ацинарных желез на гистологическом уровне не обнаружено (Рис.3).

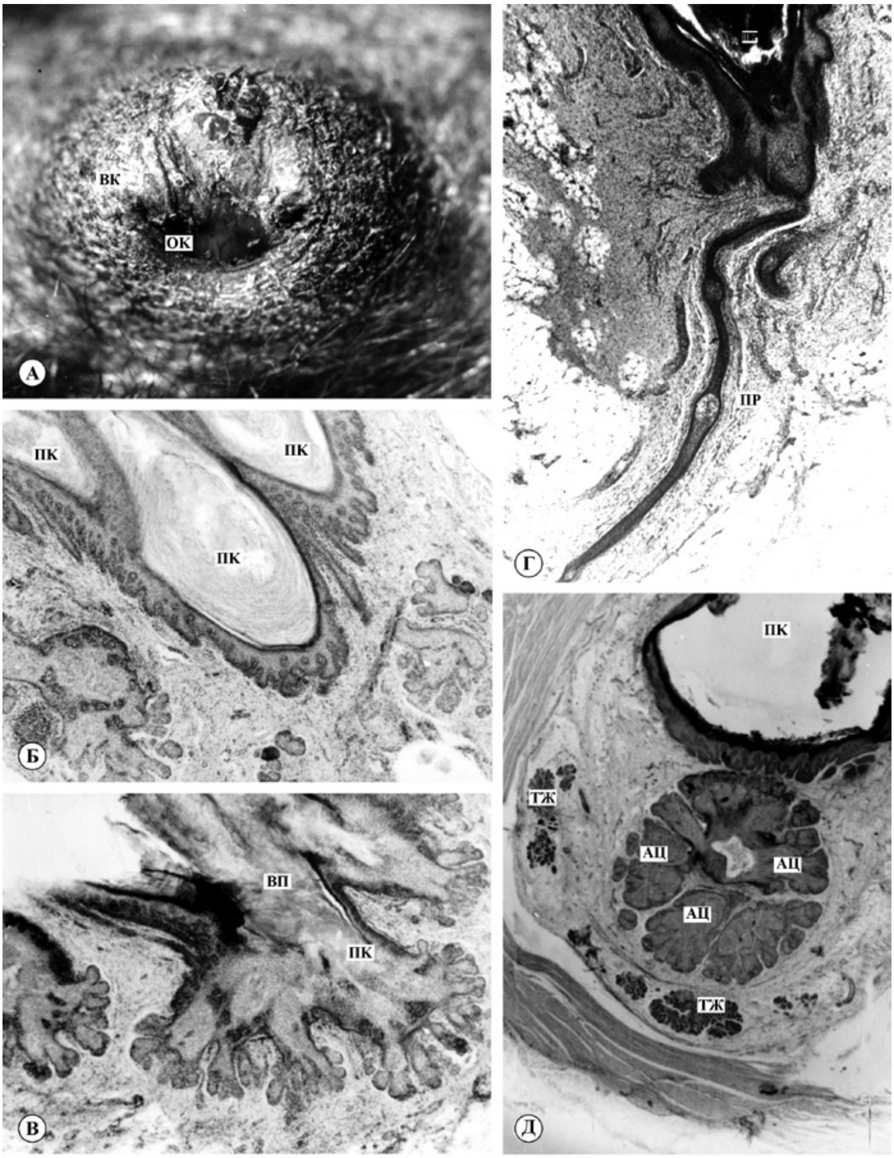

Рис.3. *Ацинарная железа анального кармана (окраска гематоксилин-эозин). А-анальная область (анальное отверстие искусственно расширено), Б-трехкамерный центральный карман анальной железы 20 дневнего сеголетка (об х 5). В - боковой карман анальной железы (об х 2,5). Г- Выводный проток трубчатых желез увел.10х25, окраска гематоксилин-эозином. ПР-выводный проток, Д-полутонкий срез ацинарной железы (об х 100).*

Электронномикроскопическое исследование показало, что клетки ацинарных желез самцов сурка имеют следующие ультраструктурные характеристики: ядра с малым количеством гетерохроматина и крупными активными ядрышками, синтетический аппарат представлен значительным количеством длинных цистерн гранулярного эндоплазматического ретикулума (ГЭР) и свободными рибосомами, митохондрии округлые, с темным матриксом и плохо выраженными кристами. Отличительной особенностью клеток являются большие конгломераты гликогена, концен-трирующееся вокруг секреторных гранул и морфология секреторных гранул. Последние округлы, средней электронной плотности с темным ободком по периферии (от 1 до 5 мкм в диаметре). Некоторые из гранул имеют более светлые зоны (Рис.4).

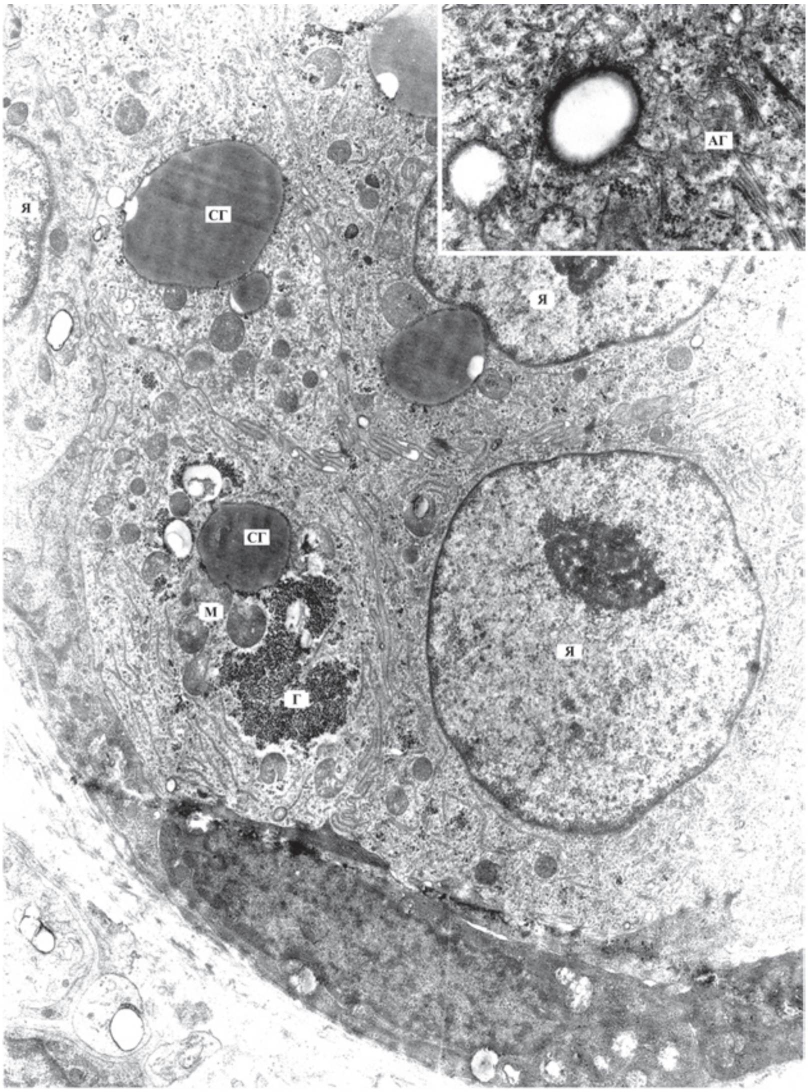

Рис.4. *Ацинарная железа анального кармана самца. Просвечивающая электронная микроскопия. Периферия ацинуса. На базальной мембране видна недиф-ференцированная уплощенная клетка (X 8300). На вставке фрагмент около-ядерной цитоплазмы (X 10 000).*

В более глубоких слоях дермы под ацинарными железами располагаются трубчатые железы анального кармана. Они представлены двумя комплексами, которые в виде полумесяцев окружают ацинарные. От каждого комплекса отходит по одному выводному протоку и впадает в полость кармана. Место их впадения рядом с протоком ацинарных желез. Железы представляют собой плотно свернутые в клубочки трубочки, разделенные соединительной тканью. Цитоплазма базофильна. На гистологическом уровне не отмечено сезонных, половых или возрастных различий.

Электронномикроскопические исследования трубчатых желез анального кармана выявили четкие половые отличия эпителиальных клеток. В клетках обоих полов развиты и белок-синтезирующий аппарат (многочисленные рибосомы и отдельные короткие цистерны ГЭР) и слизь- синтезирующий конвеер (аппарат Гольджи). Однако аппарат Гольджи в клетках самцов - доминирующая органелла; он занимает значительный объем цитоплазмы. Чрезвычайно многочисленны в клетках крупные митохондрии с четкими многочисленными кристами. Продукты синтеза собраны в гранулы трех типов. В клетках самок аппарат Гольджи значительно меньше, меньше в них и митохондрий. Однако в этих клетках наряду с обычными мелкими митохондриями есть гигантские (до 7 мкм), превышающие в десятки раз лежащие рядом. Подобные митохондрии (до 3 мкм в диаметре) описаны всего лишь один раз в железистом эпителии, а именно в апокриновой железе человека (Kurosumi et al.,1984). Секреторные гранулы в клетках самок, представлены 3 типами: 1) аналогичные тем, что имеются в клетках самцов (их немного), т.е. прозрачные, окруженные мембраной с нежной сеточкой; 2) мелкие темные гранулы (концентрируются в апикальной части клетки); 3) электронно прозрачные гранулы с четкой мембраной. Сравнительный анализ наших результатов с данными Smith & Hearn, (1979) выявил видовые различия в ультраструк-турных характеристиках эпителиальных клеток (в структуре синтетичес-кого аппарата, морфологии гранул, запасах и распределении гликогена), ацинарных желез анальных карманов у монгольского и лесного сурков.

Есть некоторые видовые отличия анальных желез и на анатомо-гистологическом уровне. В отличие от монгольского сурка, анальные ацинарные железы у альпийского сурка мелкие, а комплексы трубчатых, наоборот, крупные (Kratochvil, Hrabe, 1967), у байбака и черношапочного сурков трубчатые железы представлены одним (а не двумя) комплексом (Скурат, 1972; Скурат, Потапова, 1991). Такие различия в анатомическом строении анальных желез разных видов сурков, по-видимому, также являются видовыми особенностями.

В заключение следует сказать, что анальные железы монгольского сурка обладают рядом анатомических, гистологических и ультраструк-турных особенностей, отличающих эти железы как от диффузно расположенных на теле, так и аналогичных желез других видов рода Marmota (Рис.3).

Железы угла рта. Железы в углах рта монгольского сурка располо-жены в коже области смыкания губ. Участок кожи (1,5 х 1,5 см), располо-женный в углу рта, сильно (в 3-4 раза) утолщен по сравнению с густо оволосненной окружающей кожей щек. На гистологических срезах утолщенного участка кожи видно, что с обеих сторон волос располагаются многодольчатые ацинарные железы, а ниже

2 комплекса трубчатых. Ацинарные железы угла рта имеют сферическую или овоидную форму, а их секреторные части состоят из нескольких долек, окруженных соединительной тканью. Дольки каждой железы соединяются в общий выводной проток, образованный ороговевающим эпителием и впадающим в волосяной канал (Рис.5 а,б,в).

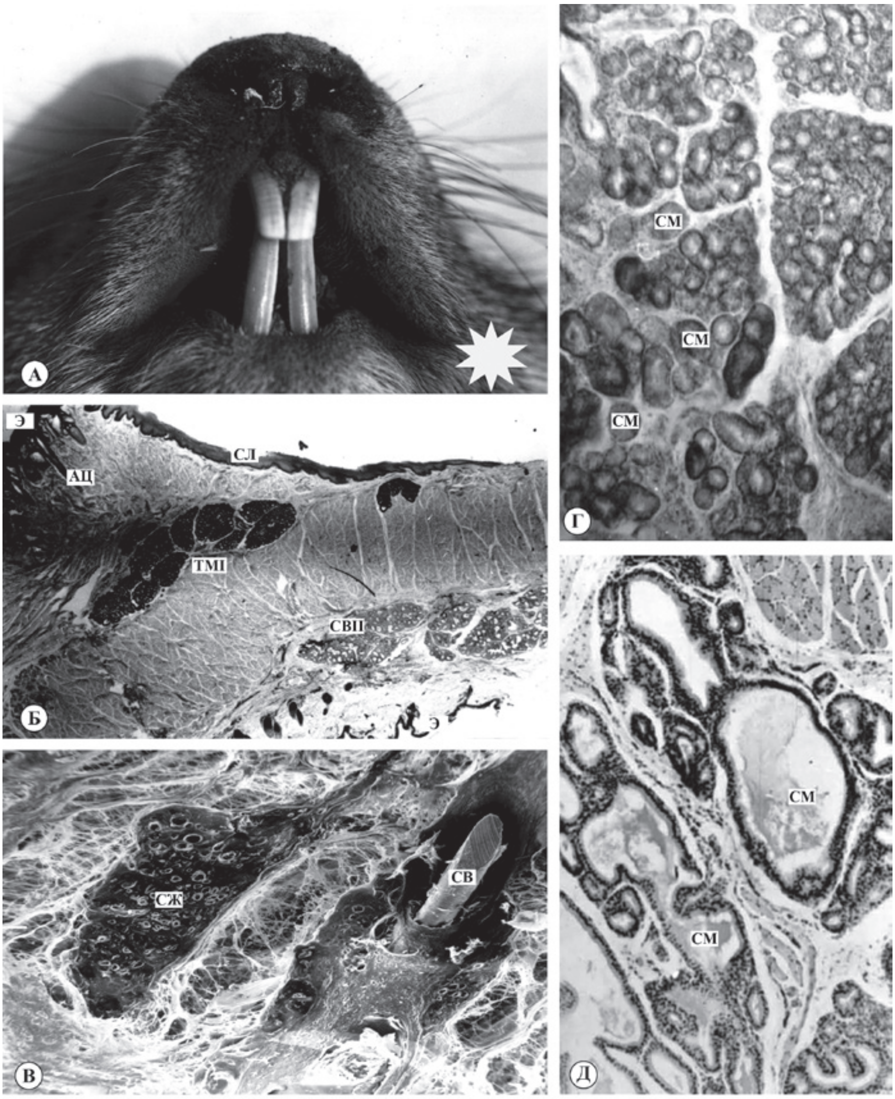

Рис.5. *Ацинарные железы угла рта (окраска гематоксилин-эозин). А-утолщенный участок кожи, где расположены железы, Б-три комплекса желез: темноокрашенные (тмI) и светлоокрашенне (свII) трубчатые и ацинарные (об х 1,2). В - ацинарные железы (сканирующий электронный микроскоп, Х300). Трубчатые железы угла рта (окраска гематоксилин-эозин). Г-темноокрашенный (I комплекс), (обх10). Д - светлоокрашенный (II комплекс), (об х 5 и 10).*

У самцов железы крупнее, чем у самок; отмечаются и сезонные флуктуации размеров органов. Наиболее крупные железы (923,2 х 275,7 мкм) наблюдаются у самцов в период гона. Железы самцов и самок отличны не только по размерам, но и по специализации клеточного эпителия. Несмотря на то, что клетки у обоих полов липидсинтезирующие, ГЭР в них не обнаружен. Белоксинтезирующий аппарат представлен полисомами и ГЭР. У самок цистерны гранулярного ретикулума редкие и короткие, у самцов, хотя и немногочисленные, но довольно длинные, собраны в группы по 5-6 профилей. Наиболее заметны различия клеток по составу гранул. В клетках самок синтезированные продукты упакованы в гранулы, размеры которых колеблются в довольно больших пределах, их форма чаще всего округлая или овальная, но нередко полигональная. Гранулы окружены мембраной, не сливаются. Их содержимое полупроз-рачно с очень характерными темными включениями самой причудливой формы. Дифференцированные клетки, переполненные такими гранулами приобретают "тигровый рисунок". Клетки самцов содержат гранулы 4-х типов: 1) мелкие электронноплотные; 2) прозрачные с темным узким ободком по периферии; 3) прозрачные с темной сердцевиной полигональной формы; 4) прозрачные с нежной сеточкой (Рис.6,7).

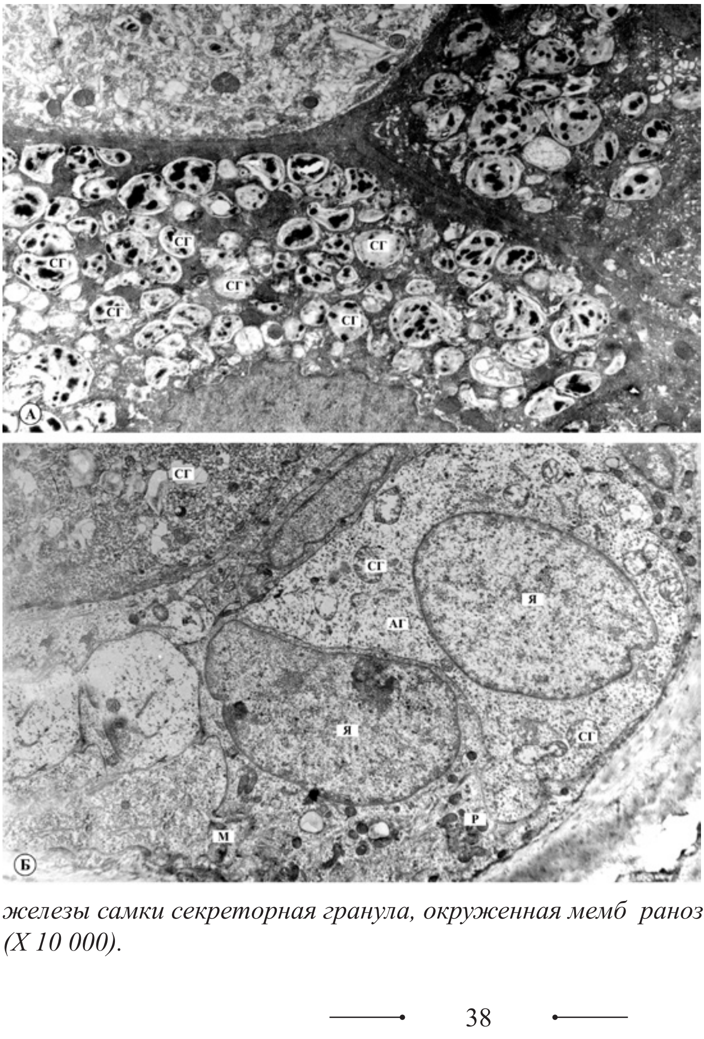

Рис.6. *Ацинарная железа в углу рта самки. Просвечивающая электронная микроскопия. А - фрагменты трех дифференцирующихся клеток, заполненных гранулами, придающих клеткам характерный “ тигровый “ рисунок. (X 5 000). Б - околоядерный участок цитоплазмы с очень редкими цистернами ГЭР, рибосомами собранными в полисомы и аппаратом Гольджи (X 10 000). На вставке характерная для железы самки секреторная гранула, окруженная мемб ранозными структурами (X 10 000).*

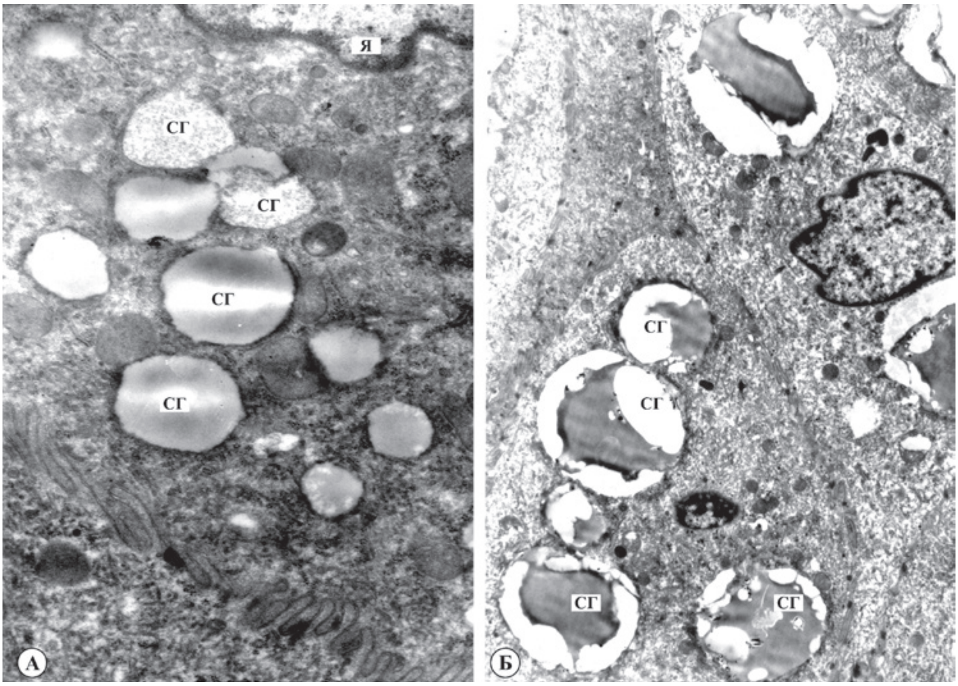

Рис.7. *Ацинарная железа в углу рта самца. Просвечивающая электронная микроскопия. А - околоядерная цитоплазма. Гранулы двух типов: гранулы с нежной сеточкой и гранулы с темным ободком (X10 000). Б - гранулы с темной сердцевиной полигональной формы (X 10 000).*

Ниже сальных желез по глубине дермы располагаются два комплекса трубчатых желез. Первый комплекс лежит в центре или несколько смещен к ротовой полости утолщенного участка кожи, на расстоянии примерно 1 см от угла рта, на глубине 0,8-1.2 мм от слизистой ротовой полости. Этот комплекс представляет собой плотно свернутые в клубочки трубочки, разделенные соединительной тканью. Обычно в комплексе насчитывается 7-12 долек. Отдельные трубочки имеют небольшие просветы от 50 до 130 мкм.

Второй комплекс трубчатых желез располагается почти в двух сантиметрах от края угла рта, уже за пределами утолщенного участка кожи, но ближе к поверхности эпидермиса, чем первый комплекс. Он залегает на глубине 1,8-2,8 мм от поверхности кожи. Так же, как и первый комплекс, имеет трубчато-дольчатое строение. Просветы его трубочек очень широкие: 650 x 110 мкм, а некоторые достигают 850 x 250 мкм.

Как выше было отмечено, железы в углах рта монгольского сурка прежде не были описаны, но у байбака (Скурат, 1972; Rausch, Bridgens, 1989), аляскинского и седого сурков (Rausch, Bridgens, 1989) проведены гистологические исследования желез данной локализации. Ни один из цитированных авторов не описывает трех комплексов желез в коже углов рта сурков.

Подошвенные железы. Это трубчатые органы, располагающиеся не только в коже подушечек пальцев и мозолей лап, но и во всей неволосен-ной коже подошвы.

При этом наибольшие скопления клубочков наблю-даются в подушечках пальцев. Разница в размерах клубочков между полами не обнаружена. Сезонные колебания четко не выражены. Однако отмечено, что весной (март, апрель) у половозрелых особей лишь отдельные клубочки увеличены до 880 х 270 мкм (Рис.8).

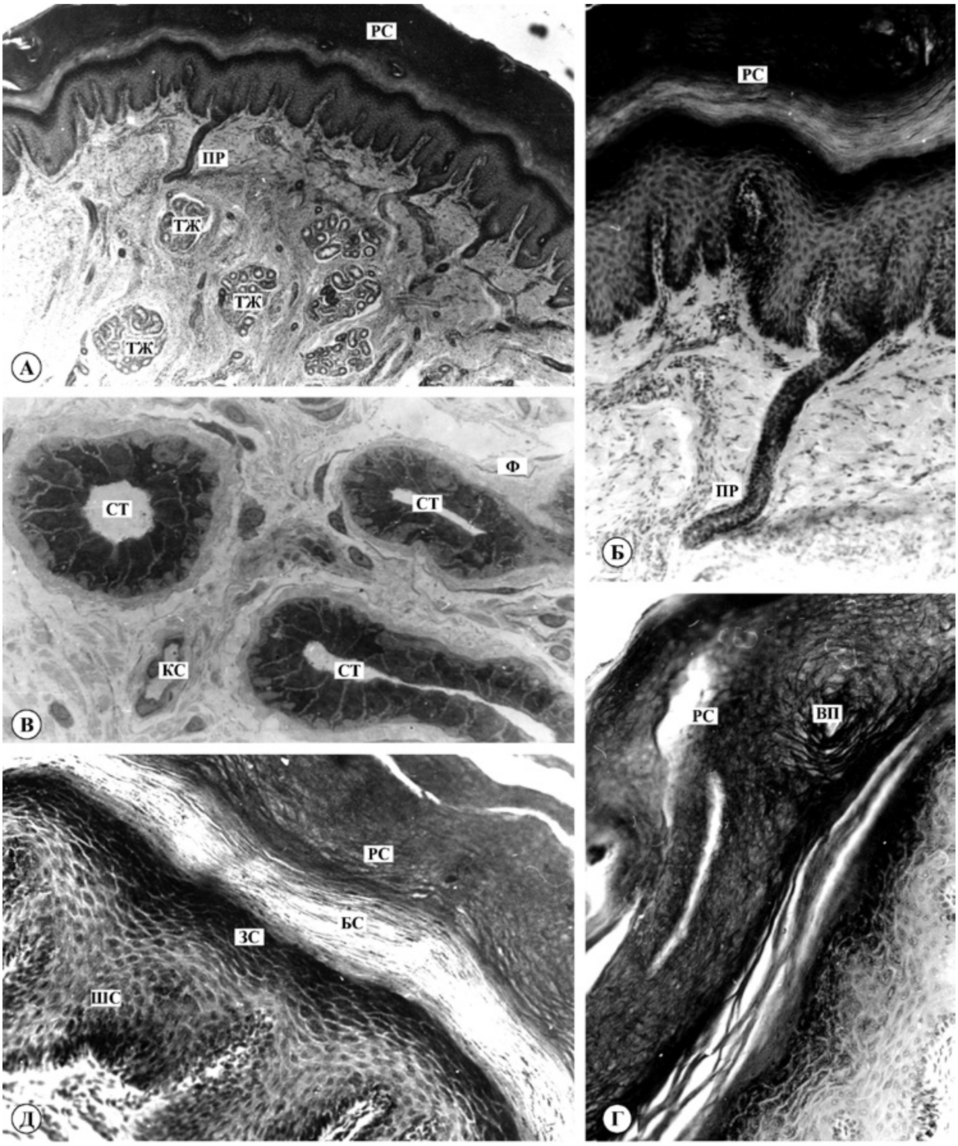

Рис.8. *Подошвенные железы. (окраска гематоксилин-эозин). А- Расположение желез в дерме (об х 5). Б - Эпидермис кожи подошвы лап (об х 20). В - полутонкий срез через секреторные трубочки (об х 100). Г - роговой слой эпидермиса (об х 20). Д -Выход выводного протока на поверхность эпидермиса (об.х 20).*

Железистые трубочки выстланы довольно высоким колончатым или кубоидальным эпителием, по-разному воспринимающим красители (есть так называемые темные и светлые клетки). Миоэпителиальные клетки почти сплошным кольцом окружают железистые (Рис.8,в).. Секреторные клетки располагаются в трубочке так, что между ними, а также между секретор-ными и миоэпителиальными имеются широкие щели, куда обращены многочисленные длинные, нередко ветвящиеся микроворсинки. Они на апикальной плазмолемме несколько короче, чем на базальной. Ядра клеток крупные, с очень небольшим количеством гетерохроматина, слегка сдвинуты к базальной части клеток. В цитоплазме много митохондрий среднего размера, овальных, с матриксом средней электронной плотности и плохо выраженными кристами.

В эпителии самцов короткие цистерны гранулярного эндоплазмати-ческого ретикулума очень редки, агранулярный ретикулум не выявлен. Аппарат Гольджи весьма примечателен: он хорошо развит, локализуется в непосредственной близости от ядра, его цистерны собраны в невысокие стопки, коротки, расширены, а содержимое их электронно-прозрачно; везикулы немногочисленны. Секреторные гранулы двух типов. Оба типа гранул выводятся из клетки путем экзоцитоза. Темные и светлые клетки имеют один и тот же набор органелл.

В железах самок секреторные трубочки имеют очень узкие просветы, в то время как у самцов они расширены. Количество клеток, заполненных светлыми гранулами, заметно больше у самок, чем у самцов. В секреторных клетках самок гранулярный эндоплазматический ретикулум более развит; аппарат Гольджи везикулярной формы: его цистерны коротки и расширены, и многочисленны везикулы. Кроме светлых секреторных гранул присутствуют темные (Рис.9).

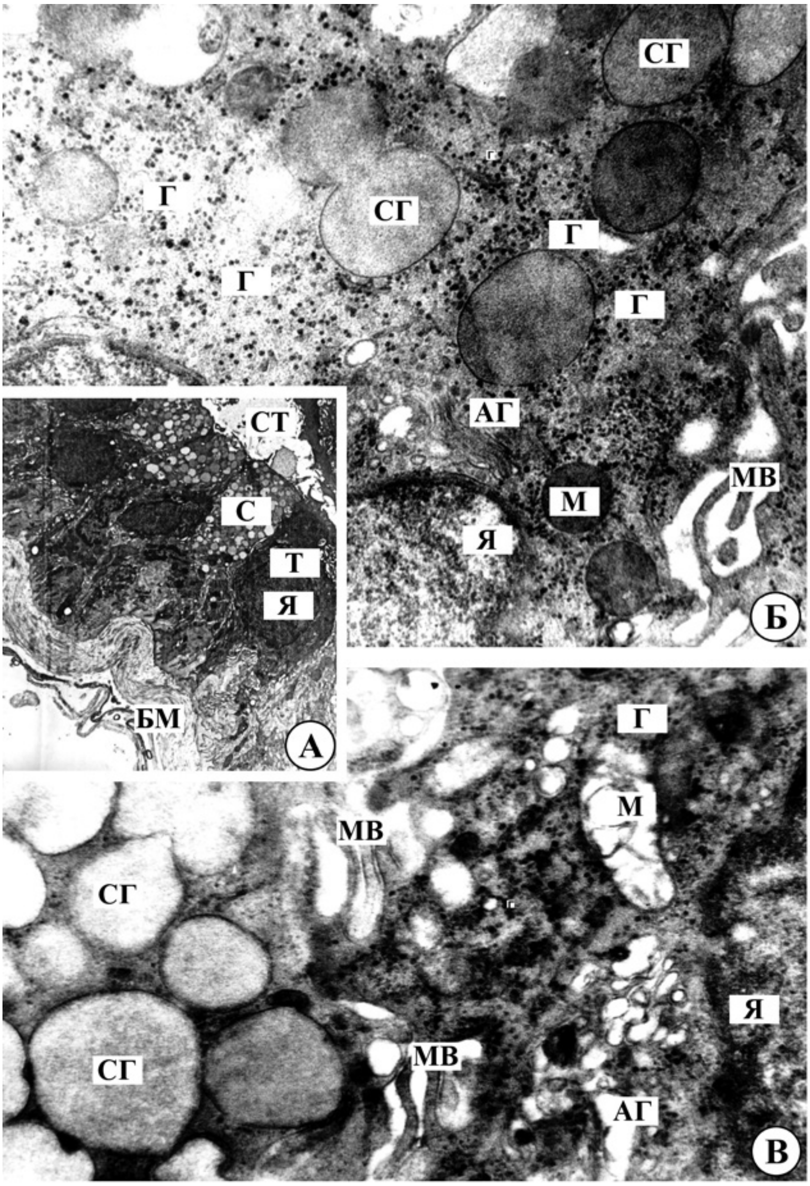

Рис.9. *Подошвенная железа самки. Просвечивающая электронная микрос копия. А - часть секреторной трубочки. Б, В - фрагменты секреторных клеток (Х10 000).*

Меймобиевы железы века. Железы века представляют собой многодольчатые ацинарные железки, проток которых свободно открывается на поверхности кожи века. Гистологическое строение типично для ацинарных желез.

Железы века хорошо развиты и активно функционируют на протяжении всей жизни индивидуума, самые крупные размеры желез отмечены нами у самцов в период гона, а в осенний период их размеры уменьшаются. Однако, в активный период жизни размеры железистого поля века у самцов были больше, чем у самок. Эти железы сколько-нибудь подробно не исследованы ни у одного вида не только сурков, но и других млекопитающих.

Железа Гардера. Она располагается в пределах орбиты глаза и входит в комплекс орбитальных желез, являясь самой крупной в этом комплексе. У половозрелых монгольских сурков она весит примерно 430 мг. Железа имеет трубчато-альвеолярную архитектуру. Основными продуктами синтеза у многих видов млекопитающих являются липиды (Sakai,1981). Особенность секреторных клеток Гардеровых желез заклю-чается в том, что, обладая уникальной системой биосинтеза липидов в больших количествах, они экспортируют их путем экзоцитоза, а не по голокриновому типу (Wooding,1980).

Эпителиальные клетки железы сурка по разному воспринимают краситель: одни из них выглядят светлыми, другие - темными. Клетки часто двуядерны, а их апикальные части покрыты многочисленными длинными и весьма регулярно расположенными микроворсинками. По специализации клетки являются белок-липидсекретирующими: в них одинаково хорошо развит гладкий и ГЭР. Продукты синтеза сконцентри-рованы в гранулах двух типов; белки в мелких электронноплотных, а липиды в крупных округлых с неровными контурами электронно-прозрачных гранулах, окруженных темным ободком. Полового диморфиз-ма мы не наблюдали.

Таким образом, по данным электронной микроскопии в железах загривка, в ацинарных компонентах анальных желез и желез угла рта эпителиальные клетки специализированы на выработку веществ липидной природы, т.к. каждая клетка снабжена соответствующим синтетическим аппаратом, однако, различие в упаковке этого аппарата, присутствие гранулярного ретикулума в клетках желез загривка и конгломератов гликогена в клетках анальных желез, а также присутствие совершенно различных по морфологии гранул делает клетки непохожими друг на друга и позволяет отнести их к разным морфотипам (Sokolov, Stepanova,1986), а это означает, что вещества синтезируемые этими клетками имеют разную химическую структуру.

Сравнение ультраструктурных характеристик клеток подошвенных желез, трубчатых компонентов анальных желез и желез угла рта приводит к заключению, что и в этом случае специализация клеток различна и характерна для железы данной локализации. Кроме того, мы выявили наличие полового диморфизма (различную специализацию клеток самок и самцов) в подошвенных железах и железах загривка. Итак, проведенные нами электронномикроскопические исследования показывают, что кожные железы монгольского сурка представляют собой гетерогенную группу органов. Эпителиальные клетки каждой железы специализированы на выделение вещества или набора веществ, характерных для данной железы.

Полученные результаты дают основание полагать, что железы разной локализации могут служить источниками химических сигналов, несущих разную информацию. Логично предположить также, что секреты желез, обладающих половым диморфизмом (диморфизм вклеточной специализации) могут нести и информацию о поле.

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THE STRUCTURE AND CONSTRUCTION OF MONGOLIAN MARMOT *(Marmota sibirica Radde.1862)* BURROWS

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A marmot runs to the nearest burrow to escape from the predators. In bad weather, marmots stay in their burrows. In burrows they mate, give birth, and raise their pups. Marmots hibernate for 180 days in Mongolia. Only a short portion of their time is spent outside of their burrows. During the six months that they are awake, (as they wake up in spring from their winter hibernation and are active until the fall), they spend only five to seven hours a day outside of their hole. Those five to seven hours are spent grazing, sun bathing, repairing their burrows, and marking their territory. The rest of their time (87.5%), is spent in their holes and burrows. This shows that how important burrows and holes are to marmots.

Summary of previous research. Several researchers have explored the structure and construction of marmot burrows, working with marmot species from the Euro-Asian steppe, the Altai, and Mongolia (Berendiev,1956, Bibikov,1967, Capitonov,1978, Lobanov,1983, Mashkin, Baturin,1993, Tokarskii, 2008, Tristan, Classovskii, 1956).

Since G.Radde dug up and documented marmot burrows near Baikal in 1862 and published his findings, several studies have been conducted exploring Mongolian marmot *(Marmota sibirica)* burrows in the Tuva, Buriat, and Chita regions and a series of articles have been published on marmot burrow structure and temperature characteristics (Pavlov, 1930, Ryabov, 1948, Nekipelov, 1950, Letov,1950, Nekipelov, Peshkov, 1958, Jovtii, 1962). However, there has been only limited research on the characteristics of marmot burrows in Mongolia. Studies have been conducted only in the Khangai (Suntsov, 1982, Romanovskii 1961, Adiya, 2000), and Khentii mountain ranges (Bavaasan, 1970).

In this article we summarize current knowledge of marmot burrow structure from the literature, from interviews with local hunters and citizens, and our own field work, with the aim of describing the structure of Mongolian marmot burrows and comparing with the burrow structures of other marmot species. Field research was conducted from 1988 to the present day, in the territories of the Arkhangai, Tov, and Zavkhan provinces of Mongolia. Nineteen temporary holes, three summer holes and 14 hibernation holes were assessed. During May through December, the structure of holes and burrows were sketched, and the length and depth of tunnels was measured. During hibernation the characteristics of hibernacula were explored and during the summer and fall, burrow tunnels, structure, and construction were investigated.

Hole and burrow sketching included documenting grasses dropped during transportation to the burrow chamber holding the winter food reserve, claw rake marks left by marmots, and hoarfrost on the stone. All these signs indicate the direction of the marmot's hibernaculum. When the plug at the opening of the hibernaculum was reached the soil and stone of the burrow floor was found to be weaker and the tunnel opening widened.

RESULTS OF THE STUDY

From ancient times, before humans possessed hunting tools, to the present day, Mongolians have hunted marmots during hibernation and even just in colder weather, by digging up their burrows.. Burrows were also dug up to reach marmots who were shot and then died underground. In the process of digging, hunters learned about basic burrow structure and how it is influence by soil, surface composition, and other factors. Hunters also developed and use terms for describing the conditions of the hole, including 'plug ', баасны өхтөө /scat pile/, нүхний хөл /end tunnel/, дэр сум /secondary tunnel/, and also terms related to the digging method, such as sitting, vertical, and horizontal.

Digging is mostly used to hunt marmots in the Khangai mountain range, at the sources of the of the Terkh, Khar us, and Shar us rivers. In those areas underground water is close to the surface and many marmots hibernate together in same burrow in dry river valleys. At those sites the soil is weaker and burrows are easier to dig up.. Hunters have developed terminology for describing burrows in these areas, including terms such as /barrel/, /two-chamber/, and /bull/, depending on the burrow's appearance, position, and general structure. Бүрхээр /barrel/ burrows have the nesting chambers located under the burrow opening top, / two-chamber / burrows have two nesting chambers, which are located parallel to each other. If one of burrow hole is filled out from the inside and the marmot comes out filles the second empty hole down from the outside, it is called a бух /bull/ burrow.

Depending on the structure and use, marmot holes are classified as hibernaculum / ичээ/, summer burrows /зусаал/, and temporary burrows /муу нүх/. Marmots may dig new burrows, but also renovate old temporary burrows or dig out old vole burrows, which have small openings and are underneath stones or large rocks.

Temporary burrow /Муу нүх/. Temporary burrows are used as short-term refuges to escape from predators. They are located on the preferii of the colony. They are usually ~1 m deep and have a simple structure with no nesting chamber. There is only one entrance and a short tunnel, , usually 1.5-7 m long. Temporary burrows are often built into the bottom of banks, or underneath stones or large boulders. These burrows are also used to escape insects.

Summer burrow /Зусаал нүх/. Summer burrows have a simpler structure than winter (hibernation) burrows. Temperatures in summer burrows can change rapidly, but they are useful as temporary refuges, protecting marmots from predators while they forage in areas away from their hibernation burrows. Summer burrows have no nesting chamber. Usually the burrow's main tunnel is no deeper than 1.7m, has ~10 entry points, although that number can range from four to 16. The multiple entrances are linked together by underground tunnels.

Hibernation burrow /Ичээ нүх/. This type of burrow can be used for years by many generations of marmots. Hibernation burrows are usually quite deep (1-3 m or more), have many tunnels leading in different directions, and have one or more nesting chambers (hibernacula). Hibernation burrows are also called whelping burrows, winter burrows, and summer burrows, when they are used as such.. Hibernation burrows can be used for centuries and the burrow openings may be thousands of years old (Zimina, Gerasimov,1971).

The many tunnels of the hibernation burrows also have different names, such as; burrow line "нүхний сум", end tunnel "хөл", secondary tunnel "дэр сум", and scat pile “баасны өхтөө”. The long and short tunnels go from the nesting chamber down, with no outlet. These tunnels are called burrow ends “хөл сум”. Secondary tunnels “дэр сум” go up for a short distance from the nesting chamber. The main tunnels of hibernation burrows that are located on the slopes of the mountain hills are usually short (5-12 m), but the main tunnels of a burrows located lower elevation river valleys with permafrost or where there is underground water near the surface, are long (up to 25 m). These tunnelshave many side forks, some of which have dead ends and some of which loop back to connect to the main tunnel.. Tunnels of all types have an average diameter of 30cm, but are wider at tunnel forks and intersections.

The structure and size of Mongolian marmot (Marmota sibirica) burrows

#	*Burrow location*	*Burrow length (m)*	*Tunnel length (m)*	*Burrow depth (cm)*	*Diameter of the tunnel (cm)*	*Hibernating burrows*				*Volume (m³)*	*Weight of burrow (kg)*
						** Number*	*Depth (cm) ***	*Width of nesting chamber (cm)****	*Burrow size (cm) (N*H*W)*		
1	Khangai sum of Arkhangai province. Southern Terkh, Untaa, Morongiin am (slopes of the mountain), (Aug-Nov)	15.6	5.9	270	25x30	1	310	250	120x80x60	0.58	4.1
2		11.9	4.7	230	24x29	1	260	200	90x80x60	0.43	3.8
3		13.6	5.2	230	25x30	2	280	220	130x75x60	0.59	4.7
4		18.4	5.3	240	25x30	1	260	210	110x80x40	0.35	3.7
5		9.5	4.2	280	27x32	1	330	270	135x86x60	0.75	5.2
6		9.8	6.5	80	28x32	2	108	45	84x65x55	0.30	2.3
7	Khangai sum of Arkhangai province. Untaa, Morongiin am , Jargalant, Khantragatiin am (river valley)	25.0	7.0	75	25x30	1	118	60	120x86x58	0.60	3.6
8		11.7	6.4	50	23-30	1	90	40	125x65x50	0.40	4.5
9		17.7	5.8	45	25-32	1	80	35	75x55x45	0.19	3.2
10		12.4	6.2	115	24-32	2	130	80	80x70x50	0.28	3.6
11		19.8	5.4	90	24-30	1	110	50	90x65x60	0.35	5.4
12		16.5	5.8	75	25-32	1	90	30	80x60x60	0.29	3.9
13		22.5	6.7	60	25-30	1	85	40	70x55x45	0.17	4.3
14		16.2	3.8	210	25-32	3	250	190	130x70x60 90x70x50 110x70x50	0.55 0.32 0.39	4.8 1.7 2.3
15	Bayan sum of Central province in 4 km to SE from 14th railroad junction	23.7	6,8	220	25-33	2	270	210	120x60x70 100x50x60	0,5 0,3	1,9 0,8

number, ** depth, * width*

General characterization of hillocks and burrows. When digging their burrow, marmots take the excavated dirt out of the hole. This pile of excavated dirt is called a hillock. Hunters can estimate the depth of the nesting chamber by the size of the hillock The burrow is repaired every year, and additional dirt is removed, so the hillock gets bigger and bigger year after year. The hillocks of the hibernation and summer burrows are usually not that big. Sometimes the hillocks of burrows with many entrances or several adjacent burrows will combine to create an extra-large hillock. We measured the size of a colony in the Tarvagatai mountain range. The average size of hillocks in this colony (n=34) was 19.4 m in length, 13.6 m in width, and 0.9 m in height. The hillocks of burrows located on the slopes of mountains were lower, and were shaped like an ellipse. The hillocks of burrows located on flat landscapes had a round shape, and the downhill side was the tallest, usually with a height of up to 1.3m.

Scat pile. Scat pile tunnels are usually located a distance of 0.5-2.1 m from the main tunnel, usually to the east or west. Scat pile tunnels are usually 0.6 to 2.3m long dead-end tunnels, with a diameter of 30cm. These tunnels are used for excretion from spring until fall, when marmots start hibernation. Each burrow has usually two, but sometimes three to five, scat piles.

Plug. Burrows have many entrances. During hibernation marmots close these entrances with stone and soil from outside, leaving only one entrance. This last entrance is closed from inside the burrow by mixing scat piles with soil and stone gravel of 8-12 cm diameter. This is feature is called a plug. The plug in the last entrance is usually 2.5-9.5 cm long, but can be as deep as 0.5 to 1.8 m.

The last entrances of hibernation burrows located on mountain slopes usually have shallower plugs, while burrows in flat landscapes have longer plugs, especially on the downhill side, where they can be up to 9.5m deep Burrow plugs were shallower in the early fall than in the late fall. After the burrow entrances are closed for the winter, marmots do not appear to truly hibernate initially. Rather, for awhile they continue to add to the depth of the plug.

The nesting chamber. *Nesting chambers are usually located at a distance* of 9.5-25 m from burrow entrance, at a depth of 0.8-3.1 m from surface. They are usually located at the fork of a dead end tunnel or secondary tunnel. The nesting chambere has a volume of less than 0.7 m^3. Chambers of old burrows, located on the slopes of mountains are usually bigger, but the chambers of burrows located in river valleys and on the lower slopes of mountains are smaller, with a volume of 0.2-0.4 m^3.

Nest. Depending on natural zones, the colony site, weather conditions of the year, and the age, sexand condition of the marmots, they usually start to gather food stores for winter by the end of August. They usually gather 2.3 to 5.2 kilograms of dried grass, mostly of *Stipa spps.* This process is called stocking. Every spring, grasses not used during the winter are taken out of the burrow. Other items besides grasses can be collected as part of a the winter store, and are used as insulation rather than food.. Store size and content varies for each nest. Stores are can serve as mats or as blankets. Marmots in burrows on mountain slopes with a nesting chamber with a depth of more than 2 m make a mat of gathered materials. If the nesting chamber is up to 0.33 m deep, marmots fill the nesting chamber with dry grasses and hibernate in the grass pile. Nests of this kind, if dug up in the late fall, can be covered in some frost and frozen ice.

The number, age, and sex of marmots who hibernate together in one burrow differs depending on number and density of the individuals in the population and social structure of the marmot colony.

We recorded 318 individual marmots in 63 burrows on the Tarvagatai mountain in the Khangai mountain range at two research sites covering a total of 700 ha. Burrows were excavated in the fall, just before the hibernation season. Each burrow had 2-17 individ-

uals hibernating together. We excavated two burrows and found one burrow containing five marmots (two adult females, two adult males and one three-year-old juvenile) while the second burrow contained 13 marmots (three two-year-old juveniles, six adult females, and four adult males). In Hantraganat am of southern Terkh river, one burrow in 1946 was found to contain 28 adult marmots (G.Oidov, personal communication).

Mongolian marmot' burrows located in mountain foothills, gravelly river valleys, areas with permafrost, and places were underground water is near the surface, usually have central tunnels that are up to 25m long. The main tunnel often curves, and there are many smaller tunnels branching off, usually beginning 50-90cm below ground. The tunnels are usually 0.8 to 150cm deep and the nesting chambers have a volume of 0.2-0.4 m^3. Hibernation burrow plugs are usually quite long. The plug usually extends from the entrance to the threshold of the nesting chamber. Some burrows have a thin, (15-20 cm) roofs. Those burrows usually also have long dead end tunnels and secondary tunnels, compared to other burrows with thicker roofs..

Burrows located on higher mountain slopes usually have a shorter main tunnel (up to 3.1m deep) and nesting chambers with a volume of 1.2 m3. The floor of the nesting chamber is usually lined with a mat of grasses. Mountain burrows usually have fewer tunnels and tunnel branches, and the dead end and secondary tunnels, and the burrow plug are usually shorter..

We compared the burrow parameters of the Mongolian marmots to those of other marmot species, including *M. menzbieri, M. caudata, M. baibacina,* and *M. bobak* but did not find any significant differences.

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МОНГОЛ ТАРВАГАНЫ *(Marmota sibirica Radde.1862)* НҮХНИЙ БҮТЭЦ

Я.АДЪЯА

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Тарвага нүхэнд орж дайсан амьтад, цаг агаарын тааламжгүй нөхцөлөөс биеэ хамгаална. Мөн нүхэнд эвцэлдэж, үр төлөө бойжуулна. Монгол орны нөхцөлд жилд дунджаар 180 гаруй хоног ичээлнэ. Өөрөөр хэлбэл, зөвхөн хавар ичээнээс гарснаас хойш намар ичих хүртэлх 6 сарын хугацаанд идэшлэх, нарлах, ичээ, зусаал нүхээ засах, эзэмшил нутгийн хилийг сэргээн тэмдэглэх үедээ хоногт 5-7 цаг нүхний гадна байж үлдсэн бүх хугацааг (амьдралынхаа 87.5%-ийг) нүхэнд орогнон өнгөрүүлдэг гэсэн тооцоог хийж болно. Дээр дурьдсан цөөн баримт тарваганы амьдралд нүх ямар чухал ач холбогдолтой болохыг гэрчилнэ.

Судлагдсан байдал. ЕвроАзид тархсан тарваганы зарим зүйлийн ичээ нүхний бүтцийг судалсан ажлууд бий. Тухайлбал, талын [Лобанов, 1983, Токарский,20], манхан [Капитонов, 1978], алтай [Тристан, Классовский.1956], хотилдой [Машкин, Батурин, 1993], тарваганы цөөн тооны нүх малтан, ичээ нүхний бүтцийн онцлогийг тодорхойлон бичжээ.

Г.Радде 1862 онд Байгалын чанад дахь монгол тарваганы ичээ нүхийг малтаж, анхны мэдээг хэвлүүлснээс хойш Тува, Буриад, Чит мужийн монгол тарваганы ичээ нүхний бүтэц, дулааны хэмийн өөрчлөлттэй холбоотой судалгааны олон мэдээ баримт хэвлэгдсэн. [Павлов.1930, Рябов, 1948, Некипелов, 1950, Летов,1950, Некипелов, Пешков, 1958, Жовтый, 1962].

Байгалын өмнөд нутгийн монгол тарваганы ичээ нүхний урт 5-18 м [Рябов, 1948], дунджаар 21.5 м, бүр 45 м хүрнэ. Ичээ нүх 1-2 ноохойн тогоотой байх бөгөөд нүхний дундаж гүн 1.9 м, 0.8-2.4 м урт ихэвчлэн хоёр баасны өхтөөтэй [Летов,1950]. Ичигний урт 1.85-3.40 м дунджаар 2.8 м байна гэсэн баримтуудыг дурьджээ. Харин Монгол орны тарваганы ичээ нүхний бүтцийг судалсан судалгааны материал ховор. Хангай [Сунцов, 1982, Романовский 1961, Адъяа,2000], Хэнтийн нурууны [Баваасан 1970] тарваганы ичээ нүхний бүтцийг тоймлон бичсэн.

Далайн түвшнээс дээш 2500-3000 м өргөгдсөн Хангайн нурууны тарваганы ичээ нүхний сум 4-17 м буюу дунджаар 8 м урт байна. Ноохойн тогоог 2-5 м хөрсний гүнд татаж, 4 м орчим урт ичиг түлхэнэ [Романовский 1961]. Төв аймгийн Мөнгөнморьт сумын нутагт хөрсний усны түвшин дээр, голын хөндийд байрлалтай, ичээ нүхний ноохойн тогоо 0.6-1.2 м хөрсний гүнд байрласан байхад, уулын ар, өвөр бэлийнх 2-3 м гүнд байрладаг онцлогтой [Баваасан 1970] болохыг тэмдэглэжээ.

Бид тарваганы нүхний бүтцийн онцлогийг судалсан хэвлэлийн мэдээ баримтыг нэгтгэн дүгнэх, анчид, нутгийн иргэдээс нүхний бүтцийн холбогдолтой аман мэдээ цуглуулах, монгол тарваганы ичээ нүхний бүтцийн онцлогийг өөрсдийн хийсэн судалгааны дүнд тулгуурлан тодорхойлон бичих, бусад зүйлийн тарваганы ичээ нүхийг судалсан дүнтэй харьцуулан зарчмын ялгаа, өвөрмөц онцлогийг илрүүлэн тогтоох зорилготой судалгааны ажлыг 1988 оноос эхлэн Архангай, Төв, Завхан аймгийн нутагт хийж, туршлагатай анчдаас тарваганы амьдрал, нүхний бүтцийн холбогдолтой аман мэдээ авч, 9 муу нүх, 3 зусаал, 14 ичээ нүхийг (V-XII сард) малтан, үндсэн хэмжилт, бүтцийн зураглалыг хийсэн. Өвлийн улиралд ичээг ухахдаа ичигийг, зун намарт нүхний сумыг хөөн ухаж бүтэц байгууламжийг зурагласан.

Ичээ нүхийг ичиг хөөж ухах явцад газрын хөрснөөс ялгахад бэрхтэй болж алдагдах нь элбэг тохиолддог. Ийм үед ичиг байх газрын шороо чулууг нарийвчлан үзэж ноохой зөөх үед хаягдаж гээгдсэн өвс буюу "алдаш", зарим томхон чулуун дээр тарваганы хумсаар зурагдсан мөр, ичигний чулуу цан цохисон зэрэг шинжээр ичигийг олж үргэлжлүүлэн ухна. Ноохойн тогоонд ойртох дутам ичигний чулуунд цохисон цан, ноохойн “алдаш” ихсэж, ичиг цоорох дөхөхөд бөглөөсний шороо чулуу суларч нүх өргөснө.

СУДАЛГААНЫ ДҮН

Монголчууд агнуурын багаж зэвсэг хөгжөөгүй байсан эрт үеэс өнөөг хүртэл намар орой тарвага ичихээр цуглах үед буюу ичсэний дараа газар хөлдөхөөс өмнө ичээ нүхийг ухаж тарвага агнах аргыг хэрэглэж байна. Бас амь алдаж буудсан тарвагыг ухаж авах нь цөөнгүй. Энэ явцдаа гадаргын тогтоц, хөрсний бүтэц зэрэг олон хүчин зүйлээс хамааран ичээ, зусаал, муу нүхний бүтэц зохион байгуулалт өөр өөр байх онцлогийг сайтар танин мэдсэн. Бас нүхний бүтцийн өвөрмөц онцлогт тохирсон "ичиг", “баасны өхтөө”, “нүхний хөл, дэр сум”, ухах аргатай холбоотой “суугаа, босоо, хэвтээ алам” зэрэг оновчтой, тогтсон нэр томьёог хэрэглэнэ

Хангайн нурууны Урд, Хойд Тэрхийн эх, Хар-Ус, Шар-Усны голын сав нутгийн анчид хөрсний ус ойр,мөнхийн цэвдэгтэй голын хөндийн сайр чулуу, нуранги хөрстэй газрын олон тарвага ичсэн ичээ нүхийг сонгон малтаж тарвага агнах нь цөөнгүй. Энэ нутгийн анчид ичээ нүхийг ноохойн тогооны байрлал, ерөнхий бүтэц зохион байгуулалтаас хамааруулан "бүрхээр", "дайлан","бух" хэмээн ялган нэрлэнэ. “Бүрхээр” ичээний ноохойн тогоо дошин дороо байрлалтай, “дайлан” ичээ зэргэлдээ байрлах хоёр ноохойн тогоотой. Нэг нүхээ дотроос нь түлхээд нөгөө дөр нүхээр гарч гаднаас нь дарсан хоосон ичээг “бух” ичээ гэнэ.

Тарваганы нүхийг бүтэц зохион байгуулалт, ашиглах хэлбэрээр нь ичээ, зусаал, муу нүх хэмээн ангилна . Тарвага хуучин муу нүх, ухмалыг сэргээж засах буюу хад, чулууны ёроол, үлийн цагаан оготны үлий ухаж шинээр нүх малтах нь ажиглагддаг.

Муу нүх нь гэнэтийн аюул тохиолдох мөчид түр хоргодох зориулалттай, бүл, колонийн эзэмшил нутгийн захаар байрлах, харьцангуй энгийн бүтэцтэй, ноохойн тогоогүй, ихэвчлэн нэг амтай, нүхний сум нь урт биш (ойролцоогоор 1.5-7м), дунджаар нэг метр орчим хөрсний гүнд байрлана. Зуны халуунд эрэгний мухар, хадны хөндийд ухсан богино, мухар нүхэнд түр орогноно. Ийм нүхийг "тийрэгний" хэмээн нэрлэх нь бий.

Зусаал нүх. Дулааны улиралд байршин амьдрах, бүтэц зохион байгуулалт нь ичээ нүхнээс энгийн, дулаан хадгалалт муутай, харин эзэмшил нутгаа бүрэн ашиглах, гарч идэшлэх, дайсан амьтдаас биеэ хамгаалах, түр орогноход илүү тохиромжтой, “жинхэнэ” ноохойн тогоогүй, голдуу 1.7 м –аас илүүгүй хөрсний гүнд хонгил нүхийг малтсан, хоорондоо дөр 4-16 ихэвчлэн 10 хүртэл амтай нүхийг "зусаал" нүх гэнэ.

Ичээ нүх. Урт удаан хугацаанд тогтмол ашигладаг, харьцангуй зузаан хөрсний гүнд (1-3 м гаруй) малтсан олон салаа хонгил (сум) нүхнээс бүтэх, нэг ба хэд хэдэн ноохойн тогоотой ичээлэн өвөлждөг нүхийг ‘ичээ нүх’“ буюу ‘ичээ” хэмээн нэрлэнэ. Ичээ нүхийг ашиглах хэлбэрээр нь төрөх, өвөлжих, зусах [Бибиков, 1967] хэмээн ангилах нь бий. Тарваганы ичээ нүх мянган жилийн настай [Зимина, Герасимов,1971] байх нь цөөнгүй.

Ичээ нүхний олон хонгилыг “нүхний сум, хөл, дэр сум”, “баасны өхтөө” хэмээн ялган нэрлэнэ. Ноохойн тогооноос доош чиглэсэн урт богино мухар нүхийг “хөл сум”, ноохойн тогооноос гарсан дээш чиглэлтэй мухар нүхийг “дэр сум” гэнэ. Уулын өвөр, энгэр, арын ичээ нүхний төв хонгил буюу сум богино (5-12 м), харин уулын бэл, голын хөндийн мөнхийн цэвдэг, хөрсний ус ойрхон газарт байрласан ичээ нүхний сум (25 м хүрэх) урт, олон салж, мухар нүхийг үүсгэх буюу эргэж төв хонгилдоо нийлсэн дөр байх нь нийтлэг ажиглагдана. Нүхний голч дунджаар 30 орчим см, салаалсан хэсэгтээ нилээд өргөснө.

Монгол тарваганы (M.sibirica) ичээ нүхний бүтцийн үндсэн хэмжээ

#	*Газрын нэр, ичээ ухсан хугацаа* *Name of the plase and time*	*Нүхний урт “м“ Burrow’s length*	*Нүхний ичигний урт “м“*	*Нүхний гүн “см” Burrow’s depth*	*Нүхний голч “см“ Burrow’s diametr*	*Ноохойн тогооны Wintering holes*				*Багтаамж “$м^3$“ Volume*	*Ноохойн жин “кг“ weigt*
						** Too*	*Гүн “см”***	*Өрхний зузаан “см“ ****	*Хэмжээ (N*H*L) cize*		
1	*Архангай, Хангай сум Урд Тэрх, Унтаа, Мөрөнгийн ам (уулын ар өвөр) (VIII-XI сар)*	15.6	5.9	270	25x30	1	310	250	120x80x60	0.58	4.1
2		11.9	4.7	230	24x29	1	260	200	90x80x60	0.43	3.8
3		13.6	5.2	230	25x30	2	280	220	130x75x60	0.59	4.7
4		18.4	5.3	240	25x30	1	260	210	110x80x40	0.35	3.7
5		9.5	4.2	280	27x32	1	330	270	135x86x60	0.75	5.2
6		9.8	6.5	80	28x32	2	108	45	84x65x55	0.30	2.3
7	*Хангай сум, Унтаа, Мөрөн, Жаргалант, Хантрагатын ам (голын хөндий)*	25.0	7.0	75	25x30	1	118	60	120x86x58	0.60	3.6
8		11.7	6.4	50	23-30	1	90	40	125x65x50	0.40	4.5
9		17.7	5.8	45	25-32	1	80	35	75x55x45	0.19	3.2
10		12.4	6.2	115	24-32	2	130	80	80x70x50	0.28	3.6
11		19.8	5.4	90	24-30	1	110	50	90x65x60	0.35	5.4
12		16.5	5.8	75	25-32	1	90	30	80x60x60	0.29	3.9
13		22.5	6.7	60	25-30	1	85	40	70x55x45	0.17	4.3
14		16.2	3.8	210	25-32	3	250	190	130x70x60 90x70x50 110x70x50	0.55 0.32 0.39	4.8 1.7 2.3
15	*Төв аймгийн Баян сум Төмөр замын 14-р зөрлөгөөс зүүн урагш 4 км т*	23.7	6,8	220	25-33	2	270	210	120x60x70 100x50x60	0,5 0,3	1,9 0,8

Дош, ичээ нүхний гаднах шинж. Нүхийг ухахад гарсан шороо “дош” үүсгэнэ. Анчид ичээ нүхний нимгэн, зузааныг гарсан шорооны байдлаар таамаглана. Нүхийг жил бүр засаж ухан уртасгах тул дош үүсэх, томрох явц он удаан жил үргэлжилнэ. Ичээ, зусаал нүхний дош том, муу нүхнийх бага байна. Олон амтай ичээ нүхнээс ухаж гаргасан шороо өөр хоорондоо нийлж, дош улам томорно. Тарвагантайн нурууны хуучин 34 ичээний дошны дундаж урт 19.4 м, өргөн 13.6 м, өндөр 0.9 м байв. Уулын ар, өвөр, налуу энгэрийн ичээ нүхний дош тал бэлийнхээс урт зуувандуу, намхавтар байна. Харин харьцангуй тэгш гадаргатай тал, хөндий уулын бэлийн ичээний дош дугуйвтар хэлбэртэй, өндөр нь 1.3 м хүрэх нь бий.

Баасны өхтөө. Ичээ нүхний амсраас 0.5-2.1 м хол зайд баруун зүүн тийш салсан 0.6-2.3 м урт, 30 см орчим голчтой мухар нүх бий. Хавар ичээнээс гарснаас хойш ичих хүртлээ ялгадсаа хураадаг ийм мухар нүхийг баасны өхтөө гэнэ. Ичээ нүх голдуу хоёр, хааяа 3-5 баасны өхтөөтэй байх нь тохиолдоно.

Ичиг. Олон амтай ичээ нүхэнд тарвага ичихдээ нэг амыг онгорхой үлдээж бусдыг гаднаас нь шороо чулуугаар дарна. Үлдсэн нэг амыг дотроос нь баасны өхтөөнд хуримтлуулсан өтгөн ялгадсаа шороо, 8-12 см хүртэл хэмжээтэй чулуутай хольж, ялгадас дуусcанаас хойш дан шороо чулуугаар нягтруулан шахаж бөглөнө. Үүнийг ихэнх нутагт ичээ түлхэх, ичээ нүхний бөглөөг "ичиг" гэнэ. Ичигний урт 2.5-9.5 см хүрэх нь бий. Ичигээ 0.5-1.8 м зайтай түлхсэн байх нь тохиолдоно.

Уулын налуу өвөр, энгэр, арын ичээ нүхний ичиг богино (6 м хүртэл), голын хөндийн харьцангуй нимгэн ичээ нүхнийх 9.5 м хүртэл урт, ноохойн тогооны босгоо хүртэл түлхсэн байдаг. Намар эрт ухсан ичээнийх богино, орой ухсан нүхнийх харьцангуй урт байгаа нь түлхсэнээсээ хойш тодорхой хугацаанд сэрүүн байж ичигээ үргэлжлүүлэн түлхдэг бололтой.

Ноохойн тогоо. Судалгааны дүнгээс үзэхэд, нүхний амсраас 9.5-25 м хол зайд, газрын гадаргаас 0.8-3.1 м хөрсний гүнд, хөл, дэр сум хоёрын уулзварт ноохойн тогоо байрлана. Ноохойн тогоо голдуу 0.7 куб.м-с илүүгүй батаамжтай. Уулын ар, өвөр, энгэрийн хуучин ичээний ноохойн тогоо харьцангуй том, харин голын хөндийн “нимгэн” ичээ нүхний ноохойн тогооны багтаамж бага, 0.2-0.4 куб.м байна.

Ноохой. Байгалийн бүс, бүслүүр, тухайн жилийн цаг агаар, нас, хүйс, тарга тэвээрэг авсан байдлаас хамааран VIII сарын сүүлээс эхлэн монгол тарвага ичээлэхэд бэлтгэн нүхэндээ 2.3-5.2 кг хуурай өвс (хялгана голдуу) зөөж хураана. Үүнийг "ноохой зуух" гэнэ. Хавар хуучин ноохойгоо зөөж гаргана. Айлын өвөлжөө, хаваржааны ойрхи ичээний тарвага ноохойдоо өвснөөс гадна хуучин даавуу, нэхий, ширний өөдөс, өвсний мяндсан боодол хүртэл зөөсөн байх нь бий. Ноохойн өвсийг идэш тэжээлд хэрэглэдэггүй харин дулаалга маягаар ашиглана. Ноохойн хэмжээ, зассан байдал янз бүр. Ноохойг "дэвсгэр", "хучлага" гэж ангилна. Уулын ар, өвөр, энгэрийн 2 м илүү хөрсний гүнд ноохойн тогоотой ичээ нүхний тарвага ноохойгоо дэвсгэр маягаар засна. Харин ноохойн тогоо нь 1.3 м хүртэл хөрсний гүнд байвал ноохойн тогоог дүүртэл өвс хурааж, дотор нь орж ичдэг. Намар орой ийм ичээг ухахад ноохойн тогоо битүү цан цохин бага зэрэг мөстсөн байдаг.

Тухайн популяцийн тоо толгой, нягтшил, бүлийн бүтцээс хамааран нэг ичээ нүхэнд ичих бодгалийн тоо, нас хүйсний бүтэц өөр өөр байна.

Тарвагантайн нурууны агнуурын үндсэн эдлэн газарт сонгосон 700 га талбай бүхий судалгааны хоёр цэгт намар тарвага ичихийн өмнө 63 ичээ, 318 бодгаль бүртгэгдсэн. Энд нэг ичээнд 2-17 толгой тарвага ичихээр цуглаж байв. Хоёр ичээг сонгон ухахад нэг ичээнд 5 (2 тарч, 2 бурхи, 1 шар хацар), нөгөөд 13 тарвага (3 хотил, 6 тарч, 4 бурхи) ичсэн байлаа. Урд Тэрхийн Хантрагатын эхэнд 1946 оны үед нэг ичээнээс 28 бие гүйцсэн бурхи голдуу тарвага агнажээ (Г.Ойдов аман мэдээ).

Судалгааны дүнгээс үзэхэд, уулын бэл, голын хөндийн сул хайргатай, мөнхийн цэвдэг, хөрсний ус ойрхон газарт байрласан ичээ нүх 25 м хүртэл урт, тахир, мужиг, салаа салбар олонтой, дунджаар 50-90 см зузаан хөрсний гүнд нүхийг ухаж, 0.8-150 см гүнд 0.2-0.4 м.куб багтаамжтай ноохойн тогоог татан ичдэг ажээ. Ичиг харьцангуй урт, ихэвчлэн ноохойн тогооны босго хүртэл түлхсэн, хучлага ноохойтой байдаг онцлогтой. Зарим ичээ нүхний ноохойн тогооны өрхний зузаан 15-20 см хүртэл нимгэн байх тохиолдол бий. Ийм ичээний хөл, дэр сум харьцангуй урт байна.

Уулын налуу ар, өврийн ичээ нүх богино, 3.1 м хүртэл хөрсний гүнд 1.2 м.куб хүртэл багтаамжтай ноохойн тогоог татан ичдэг, дэвсгэр ноохойтой, мөнхийн цэвдэг, хөрсний ус ойр газрынхаас нүхний тахир, мужиг, салаа, салбар бага, хөл, дэр сум, ичиг богино, дэвсгэр ноохойтой байдаг өвөрмөц онцлог ажиглагдлаа.

Хангайн нурууны тарваганы ичээ нүхний бүтэц байгууламжийн холбогдолтой дээрхи материалыг Төв Азийн өндөр уул, нуруud, уулын хээрт тархсан хотилдой (M.menzbieri), сүүлэрхэг (M.caudata), алтай (M.baibacina), тал хээрийн бүсийн монгол (M.sibirica) тарваганыхтай [Бибиков, 1967, Берендяев, 1956] харьцуулан үзэхэд ерөнхий бүтэц нь хоорондоо төстэй зарчмын ялгаагүй байв.

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THE DELIVERY OF MONGOLIAN MARMOTS TO THE UENO ZOOLOGICAL GARDENS OF TOKYO, JAPAN.

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His Excellency, Mr. N. Bagabandi, president of Mongolia, during his official visit to Japan presented Mongolian marmots *(Marmota bobac)* to the Japanese government and the Japanese people. By resolution of the president of the Mongolian Academy of Sciences, in 1998 a working group was established, to capture Mongolian marmots from the wild and prepare them, and accompanying documentation, for transport to Japan. The working group followed the suggestions from Japanese partners and international rules regarding the handling of wild animals. The working group included, Doctor Ya. Adiya, head of the working group and scientist from the Institute of Biology of the Mongolian Academy of Sciences (MAS) Doctor L. Amgalan, also a scientist at the Institute, and Dr. D. Suran, a lecturer at the National University of Mongolia.

The working group's activities were supported by scientists from organizations including the Institute of Biology and the Institute Geoecology of at MAS, the National Center for Zoonotic Diseases at the Ministry of Health, the State Central Veterinary Laboratory, and the Public Health Institute of the Mongolian National University of Medical Sciences.

During 86 days, July 14-October 07, 1998, the following activities were undertaken by the working group;

1. Capture of several marmot pups without stress or injuries
2. Research of the biology, ecology, and behavior of marmots in captivity, particularly with regard to their habituation to humans
3. Develop video records and photos of marmots to show their life in the wild for the purpose of public education, and to prepare space and cages for the captive marmots.
4. To screen captured marmots for infections diseases and treat them for all present ecto-and endoparasites
5. Prepare documentation on the capture and adaptation of marmots to captivity in Mongolia, and design and order cages for transportation to Japan.
6. Select five marmots from the captive population and transport and deliver them to Ueno Zoological Gardens, Japan, and discuss and agree to future cooperation with Ueno Zoological Gardens.

The site selected to capture marmots for Ueno Zoological Gardens was in southern Zaisan valley of the Bogd Mountain Strictly Protected area. Methodology for the safe capture of marmots was developed and tested at the site. Ultimately a net was used to capture 14 marmot pups during July 14-31, 1998. Following capture, the pups appeared to adapt to captivity, captive feeding, and human contact with limited stress. During the capture period, the natural diet, habitat type and climate were also recorded. During the marmot's adaptation to captivity care was taken to create suitable enclosures, establish a high quality and natural diet, and also introduce domestic vegetables to their diet..

As a result of research into suitable enclosures, diet in captivity, and behavior, cages of suitable sizeand shape were built, and we found that in addition to their natural diet, marmots would also eat domestic vegetables including cabbage, carrots, beets, potatos, green onions, peas, and spotted barley. By the end of the adaptation period marmots pups were adapted to human presence, and could sometimes be fed by hand.

Five individuals were selected based on their age, sex, behaviour, and physiological condition for transport to Japan. The selected individuals were tested for for endoparasites and bacteria by specialists from the State Central Veterinary Laboratory. Tests detected the eggs of cestodes and nematodes, and the bacteria, *Yersinia entercolitica*). All were treated using Ivomec injections and a 1% Bolfo powder solution.. Tests for *Yersinia pseudotuberculosis, Yersinia pestis,* and *Francisella tularensis* were run by researchers at the National Center for Zoonotic Diseases at the Ministry of Health. None of the marmots tested positive All marmot pups were tested for Hepadnavirus in the blood serum. Only individuals who tested negative for this virus were selected to send to Japan. After all these preparations, permission to transport five marmots from Mongolia was received from the Nature Conservation Department of the Ministry of Nature and the Environment of Mongolia.

Dr. Ya.Adiya and Dr. D.Suran were in the delegation who delivered the marmots to the one hundred year old Ueno Zoological Gardens, in Japan by a plane flying from Ulaanbaatar to Osaka to Tokyo on October 03, 1998. The Ueno Zoological Gardens received, along with the five marmots, documentation on them, an introduction to them, and a 24 minute video intended to explain the marmot's ecology and biology and raise awareness of the species

The opening ceremony for the Mongolian Marmot Hall in the Ueno Zoological Gardens was on October 21, 1998. The staff of the Mongolian Embassy in Japan participated in the event.

Main results of the activity

1. The gift from His Excellency, the President of Mongolian , to the people of Japan and the Japanese government of Mongolian marmots was delivered officially to Ueno Zoological Gardens, Japan on October 03, 1998. The marmots sent were captured in the Bogd Mountain Strictly Protected Area of Mongolia. All marmots and their documentation were prepared following national and international rules and guidelines.,. The event symbolizes the long history of cooperation between the countries of Mongolia and Japan, and the commitment to future cooperation, which will build awareness of wildlife and of Mongolia in Japan among Japanese citizens.
2. This represents the first study of Mongolian marmot adaptation, behavior and diet in captivity. The process of capturing and transporting marmots to Japan also garnered a significant amount of information on marmot biology, ecology, and behavior in the wild and in captivity, which can be applied to future research projects

The Mongolian marmots brought to the Ueno Zoological Gardens in Japan lived for 16 years.

ACKNOWLEDGEMENTS

We are very thankful to have been offered to the opportunity to serve in the working group for marmot capture, adaptation, preparation for shipment to Japan.

We are grateful Mr. S. Bayar, Director of the President’s Administration Office, and Vice Director D.Namsrai, the Ministry of Nature and Environment, the Administration of the Mongolian Academy of Sciences, the Institute of Bilogy and other organizations, researchers, and scientists for their great support during the three months of the project’s activities.

ЯПОН УЛСЫН ҮЭНО АМЬТНЫ ХҮРЭЭЛЭНД МОНГОЛ ТАРВАГА ХҮРГЭСЭН ТУХАЙ

Я.Адъяа[1], Д.Суран[2], Л.Амгалан[1]

[1] *Монголын ШУА-ийн Ерөнхий болон сорилын биологийн хүрээлэн*

[2] *МУИС-ийн Шинжлэх ухааны сургууль*

Монгол Улсын Ерөнхийлөгч Н.Багабанди одоогоос 20 жилийн өмнө Япон улсад албан ёсны айлчлал хийх үедээ Японы Засгийн газар, ард түмэнд монгол тарвагыг бэлэглэсэн юм. Японы талаас тавьсан санал болон олон улсын хэмжээнд зэрлэг амьтадтай харьцахад дагаж мөрддөг нийтлэг журам шаардлагын дагуу амьтныг байгалиас барих, дагалдах бичиг баримтыг бүрдүүлэн Япон улсын “ҮЭНО”-ийн амьтны хүрээлэнд хүргүүлэх бэлтгэл ажлыг хангах ажлын хэсгийг Монгол улсын ШУА-ийн Ерөнхийлөгчийн 1998 оны 07 сарын 7-ны өдрийн 119-р тушаалаар ШУА-ийн Биологийн хүрээлэнгийн эрдэм шинжилгээний ажилтан дэд доктор Я.Адьяа / ажлын хэсгийн ахлагч/, тус хүрээлэнгийн эрдэм шинжилгээний ажилтан Л.Амгалан, МУИС-ийн багш дэд доктор Д.Суран нарын бүрэлдэхүүнтэй байгуулан ажиллажээ.

ШУА-ийн Биологийн хүрээлэн, МУИС-ийн Биологийн факультет, Геоэкологийн хурээлэн, ЭМЯ-ны харьяа Байгалийн голомтот халдварт өвчнийг эсэргүүцэн судлах төв, Улсын мал эмнэлэг ариун цэврийн төв лаборатори, АУИС-ийн харьяа Нийгмийн эрүүл мэндийн хүрээлэн зэрэг мэргэжлийн байгууллага, эрдэмтэдтэй хамтран ажиллав.

Ажлын хэсэг 1998.07.14-10.07 хүртэлх 86 хоногийн хугацаанд дараах үе шаттайгаар даалгаварт ажлыг хийж гүйцэтгэлээ .

1. Монгол тарваганы энэ жилийн төл, тодорхой тооны “мөндөл”-ийг гэмтээж бэртээлгүй барих,
2. Барьсан амьтдыг хүний нөлөөтэй орчинд дасган тэжээж гаршуулах, биологи экологийн судалгаа хийх,
3. Сурталчилгаанд зориулан монгол тарваганы амьдралын онцлогийг харуулсан дүрс бичлэг хийх, фото зураг авах, тэжээн байрлуулах торон сав, түр байрыг бэлтгэх,
4. Халдварт өвчний шинжилгээг хийлгэх, гадаад дотоод шимэгчдийг устгах, ариутгал хийх,
5. Монгол улсын болон олон улсын хэмжээнд дагаж мөрддөг хууль тогтоомж, журам дүрмийн дагуу дагалдах бичиг баримтыг бүрдүүлэх, зөөж тээврлэх тусгай зориулалтын хайрцгийн зураг зохион, захиалан хийлгэх,
6. Япон улсын Токио хотын “ҮЕНО"-ийн амьтны хүрээлэнд сонгож авсан 5 толгой тарвагыг хүлээлгэн өгөх, цаашид хамтран ажиллах санал тавих зэрэг асуудлыг шийдвэрлэх шаардлагатай байв.

Тарвага барих газрыг Дархан цаазат Богдхан уулын Өвөр Зайсанд сонгон, амьтан гэмтээж бэртээлгүй барих аргуудыг турших хээрийн туршилт судалгааны ажлыг эхэлсэн. Тарвага барих аргуудыг туршин хэрэглэж, ихэвчлэн “тор тавих” аргаар 14 толгой тарвагыг 1998.07.31 хүртэлх хугацаанд барьсан. Энэ үеэс барьсан амьтдыг хүний нөлөөтэй орчинд дасгах, байгалийн нөхцөл дахь идэш тэжээлийн ургамлын зүйлийн бүрдлийг тогтоох, тухайн нутгийн ургамалжилт, хөрсний бүтцийн бичиглэл хийх, уур амьсгалын холбогдолтой мэдээ бүрдүүлэх, хүнсний ногоо, тэжээлийн ургамлаар тэжээж дасгах, идэш тэжээлийн хоногийн норм зохиох, байршуулан тэжээх тор савны тохиромжтой хэмжээг тогтооход түлхүү анхааран ажилласан.

Амьдрахад тохиромжтой торон сав бэлтгэн байршуулж, зан төрх, идэш тэжээлийн онцлогийг анхааран судалсны дүнд байгалийн зэрлэг ургамлаас гадна байцаа, лууван, манжин, төмс, ногоон сонгино, вандуй зэрэг хүнсний ногоо улаан буудай, халтар арвай зэрэг тэжээлийн ургамлыг хүнээс айж цочихоо больж, гараас идэш тэжээл иддэг болгон, дасган тэжээсэн.

Нас, хүйс, зан төрх, бие бүтцийн онцлогийг харгалзан сонгон тэжээсэн амьтдад Улсын мал эмнэлэг ариун цэврийн төв лабораторийн мэргэжилтнүүд дотоод шимэгч хорхойн болон нян судлалын шинжилгээ хийхэд цестод, нематодын өндөг, (Yersinia entercolitica) нян илэрсэн тул Япон улсаас ирүүлсэн IVOMEC Injection, BOLFO POWDER 1% ариутгалын бодисыг тарваганд зохих зааврын дагуу хэрэглэн гадаад дотоод шимэгчдийг бүрэн устгасан. Байгалийн голомтот халдварт өвчнийг эсэргүүцэн судлах төвийн мэргэжилтэн нар хуурмаг сүрьеэ ба (Yersinia pseudotuberculosis), тарваган тахлын нян (Yersinia pestis), хулгана тахал (Francisella tularensis)-ын эсрэг бие илрүүлэх шинжилгээг хийж эрүүл гэсэн дүгнэлтийг гаргасан. Нийгмийн эрүүл мэндийн хүрээлэнгийн мэргэжилтнүүд мөндлийн цусны ийлдсэнд гепадновирус илрүүлэх шинжилгээг хийж, дүн саналыг үндэслэн эерэг дүнтэй гарсан мөндлийг Япон улсад илгээгээгүй болно. Дээрх шинжилгээний дүнг үндэслэн БОЯ-ны Байгаль орчныг хамгаалах албанаас холбогдох баримт бичгийг бүрдүүлэн 5 толгой тарвагыг Япон улсад илгээх зөвшөөрөл авсан.

Япон улсын Токио хотод тарвагыг хүргэх, хүлээлгэн өгөх ажлыг Я.Адьяа, Д.Суран нар хариуцан гүйцэтгэв. Бэлэглэсэн 5 толгой тарвагыг 1998.10.03-нд “Улаанбаатар, Осака, Токио” маршрутаар нисэх онгоцоор хүргэж, Токио хотын захиргааны харьяа 100 гаруй жилийн уламжлалт түүхтэй “ҮЭНО”-ийн амьтны хүрээлэнд дагалдах бичиг баримт, Монгол орны тарваганы тухай товч танилцуулга, сурталчилгаанд ашиглах 24 минутын тарваганы амьдралыг харуулсан дүрс бичлэгийн хамт хүлээлгэн өгсөн.

Монгол тарвагыг нийтэд үзүүлэх албан ёсны нээлтийн ажиллагаа 1998.10.21-нд “ҮЭНО” амьтны хүрээлэнд болж, Монгол улсаас Япон улсад суугаа элчин сайдын яамны ажилтнууд уг нээлтийн ажиллагаанд оролцсон байна.

АЖЛЫН ГОЛ ҮР ДҮН

1. Монгол улсын Ерөнхийлөгчийн Японы Засгийн газар, ард түмэнд бэлэглэсэн монгол тарвагыг Монгол улсын болон олон улсын хэмжээнд дагаж мөрддөг хууль, тогтоомж, шаардлагад нийцүүлэн бэлтгэл ажлыг хангаж, Японы талд албан ёсоор хүлээлгэн өглөө. Уг амьтан хоёр орны найрамдал хамтын ажиллагааг улам гүнзгийрүүлэн хөгжүүлэхийн билэгдэл болохын зэрэгцээ Монгол улсыг сурталчлан таниулахад онцгой ач холбогдолтой байх болно.

2. Монгол тарвагыг барьж, тэжээж, гаршуулах болон тарваганы биологи экологийн холбогдолтой онолын болон танин мэдэхүйн ач холбогдолтой их хэмжээний үнэт баримт мэдээлэл хуримтлагдсан бөгөөд энэ талаар хийгдсэн анхны томоохон туршилт судалгааны ажил болсон юм.

Япон улсын ҮЭНО амьтны хүрээлэнд монгол тарвага 16 жил амьдарсан нь судлаачдын сонирхлыг татсан баримт юм.

ТАЛАРХАЛ

Монгол тарвагыг Япон улсад бэлэглэх бэлтгэлийг хангах үүргийг хүлээлгэж ажиллах нөхцөл боломжоор хангаж, тавьсан санал хүсэлтийг хүлээн авч цаг тухайд нь шийдвэрлэн зохион байгуулсан Монгол Улсын Ерөнхийлөгчийн тамгын газрын дарга С.Баяр, дэд дарга Д.Намсрай, БОЯ, ШУА-ийн Тэргүүлэгчдийн газар, ШУА-ийн Биологийн хүрээлэн болон хамтран ажилласан байгууллага, хамт олонд гүн талархал дэвшүүлье.

THE CURRENT STATUS OF TRANSLOCATED MARMOTS IN KHENTII AND DORNOD PROVINCES, MONGOLIA

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Abstract

Forty-five Mongolian marmots *(Marmota sibirica)* were translocated and released in Batnorov and Norovlin soums in Khentii province in 2015, resulting in a population density increase of 210% in the two years following population reinforcement.. One hundred and seventeen individuals were introduced in Bayan-Uul and Tsagaan-Ovoo soums in Dornod province in 2016, resulting in a 26% population density increase. The reproductive rate of the Dornod population has been high, with young marmots making up 23-28% of the population

Keywords: *Mongolian marmot, Marmota sibirica, population reinforcement, translocation, monitoring*

Introduction

Consecutive years of unsustainable hunting practices, unaccompanied byproper planning and research , and combined with unfavorable environmental conditions have had negative impacts on marmot reproduction and overall population structure in Mongolia, and have resulted in a a reduction in marmot distribution and population size, nationwide. The greatest declines have been seen in southern Mongolia. The area from Bogd Khan Mountain to the Sergelen and Bayan soums of Tuv province, which once had very large marmot populations, now no longer have any. As more and more areas of marmot habitat are developed, for commercial or domestic use and particularly around Ulaanbaatar, available habitat is shrinking and becoming increasingly fragmented. As a result, it is becoming impossible for marmots in growing populations to disperse and also increasing the risk of plague outbreaks.

In consideration of above circumstances, , the Mammal Ecology Laboratory of the Institute of General and Experimental Biology in the Mongolian Academy of Sciences conducted two Mongolian marmot conservation translocation projects, with financing from the Ministry of Environment and Tourism, the UN Development Program, and MON 12/301 and MON 13,303 projects. In 2015, 45 marmots were released in Batnorov and Norovlin soums in Khentii province. In 2016, 117 marmots were released in Bayan-Uul and Tsagaan-Ovoo soums in Dornod province. The goal of the translocations was to to decrease marmot density and the risk of a plague outbreak in high density marmot areas near Ulaanbaatar, including Shargamorit, Huurain am, and Gunt. Here we present the results of an assessment of the effectiveness of the translocation project in the year following the last transport of marmots.

Materials and methods

Data were collected for the evaluation of the effectiveness of Mongolian marmot population reinforcements using methods developed by Mashkin (1983, 1989) and Mashkin et al. (1991).

Results

First release site

Monitoring of marmots released in 2015 on the Mogoitiin Har Undur mountain of Norovlin soum, was conducted in May, when marmots first emerge from hibernation. Sixty-one families were recorded on the inner slope of Mogoitiin Har Undur mountain and 16 families were observed in the vicinity of Suj mountain (Table1). The location of colonies and burrows is shown in Figure 1. Marmots were in good condition and active throughout the day.

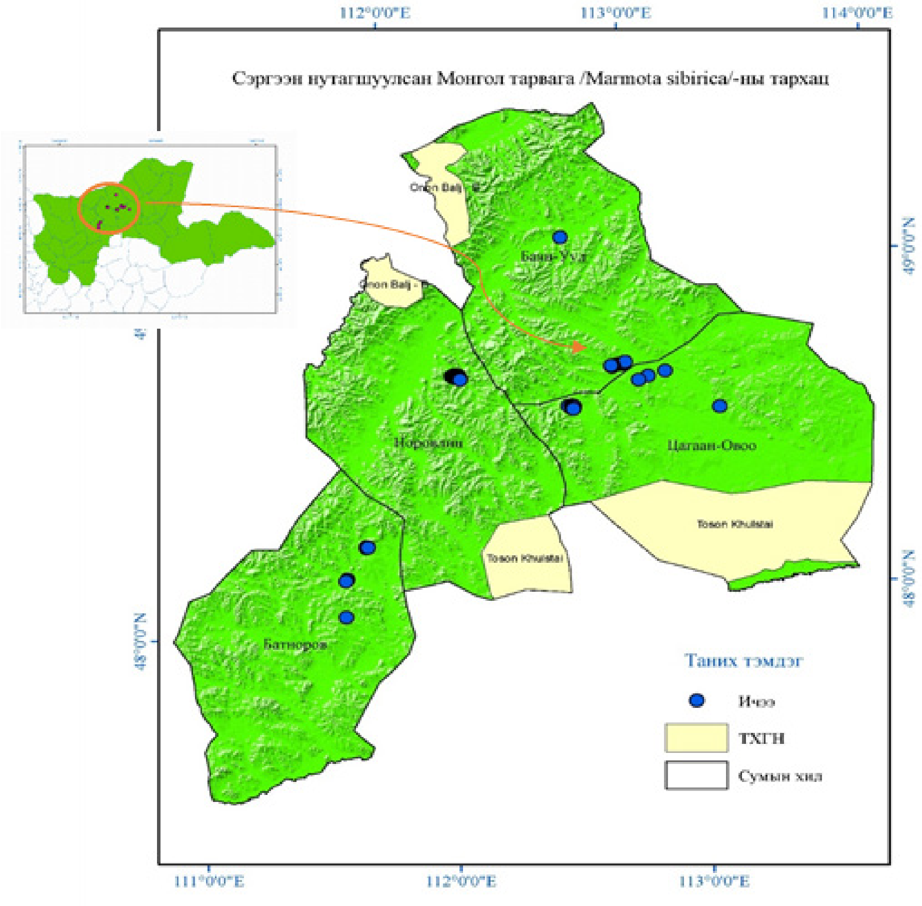

Figure 1. *Distribution of Mongolian marmots following population reinforcement in Khentii and Dornod provinces, Mongolia*

Out of 77 families and 287 individuals recorded in the release area, 88 (30.65%) were yearlings, 56 (19.6%) were two-year-olds, 69 (24.05%) were three-year-old, and 74 (25.79%) were adult marmots. The pre-reinforcement population in Batnorov and Norovlin soums in 2015 had a density of approximately 9.2 families per km2 . The 2017 survey showed an increase of 19.3 families per km2, a 210% population increase in two years. There was an average of 3.7 individuals per family.

Table 1. *Distribution and density of Mongolian marmots following population reinforcement in Norovlin and Batnorov soums in Khentii province, Mongolia*

№	*Location*	*Coordinate*		*Elevation*	*Burrow type*	*Number of families*	*Number of individuals*			
		Lat	*Long*				*1 year olds*	*2 year olds*	*3 year olds*	*Adults*
1	Mogoit mountain, Norovlin soum, Khentii province	48.72702	112.17976	1131	Chamber					2
2		48.72662	112.17921	1132	Den	1	4			1
3		48.72681	112.17834	1156	Chamber			2		2
4		48.72806	112.17938	1138	Den	1	1			
5		48.72805	112.18040	1121	Chamber					
6		48.7288	112.18242	1096	Den	1	1		1	3
7		48.72852	112.18318	1096	Den	1	2		2	2
8		48.72842	112.18363	1085	Den	1	3	2		1
9		48.72954	112.18315	1083	Den	1	1	1		2
10		48.72952	112.18300	1084	Den	1	3	1		2
11		48.7296	112.18259	1090	Den	1			1	3
12		48.73037	112.18204	1086	Den	1	1	2	4	
13		48.73137	112.18269	1071	Den	1	3	2		2
14		48.73093	112.18438	1068	Den	1	1	3		1
15		48.73172	112.18379	1065	Den	1	3	1		3
16		48.73145	112.18091	1072	Den	1	1		2	
17		48.73215	112.18243	1064	Chamber				1	
18		48.73303	112.18086	1076	Den	1		1		3
19		48.7338	112.17947	1061	Den	1			2	
20		48.73347	112.17677	1064	Den	1	4	1		2
21		48.73433	112.17762	1064	Den	1	1			3
22		48.73517	112.17513	1068	Den	1		2	2	
23		48.7345	112.17487	1067	Den	1	1		2	
24		48.73316	112.17348	1072	Den	1	3	1		2
25		48.73216	112.17012	1077	Den	1	1		1	1
26		48.73178	112.16383	1081	Den	1	2		1	1
27		48.73166	112.16278	1090	Den	1	3		1	3
28		48.73309	112.16765	1084	Den	1	1	1		2
29		48.73326	112.16929	1077	Den	1	3	1	2	
30		48.73428	112.16988	1081	Den	1	1	2		2
31		48.73415	112.17184	1072	Den	1	1	2		2
32		48.73587	112.17694	1065	Den	1			2	4
33		48.73393	112.18269	1056	Den	1	1		1	
34		48.73293	112.18500	1058	Den	1		2		
35		48.73011	112.18621	1063	Den	1			1	

36		48.73155	112.19071	1045	Den	1	1		4	
37		48.73296	112.19103	1043	Den	1	3	1		2
38		48.73063	112.19056	1047	Den	1	1		2	
39		48.72938	112.18987	1053	Den	1		4		
40		48.72937	112.18787	1062	Den	1			2	
41		48.72813	112.18825	1065	Den	1			1	
42		48.72895	112.19134	1045	Den	1	2			1
43		48.72853	112.19275	1044	Den	1	1			3
44		48.72823	112.19301	1043	Den	1	1		1	
45		48.72758	112.19418	1045	Den	1				2
46		48.72731	112.19355	1046	Den	1		2		
47		48.72692	112.19271	1048	Den	1			3	
48		48.72744	112.19181	1056	Den	1				
49		48.72675	112.19019	1057	Den	1	2		3	
50		48.72605	112.19218	1050	Den	1		2		2
51		48.72607	112.19267	1046	Den	1	4	1		2
52		48.7251	112.19119	1056	Den	1	1		1	
53		48.72411	112.19013	1059	Den	1				
54		48.72399	112.19080	1058	Den	1		1		
55		48.724	112.19312	1053	Den	1				2
56		48.72461	112.19689	1046	Den	1	2			
57		48.72433	112.19621	1046	Den	1			1	
58		48.72056	112.19781	1058	Den	1		1		
59		48.72581	112.18280	1104	Chamber					1
60		48.72505	112.18264	1103	Den	1		1		
61		48.72394	112.18245	1107	Den	1	2		1	
62		48.7235	112.17220	1133	Den	1		2		
63		48.72305	112.17969	1135	Den	1	1		6	
64		48.72172	112.18075	1133	Den	1		2		2
65		48.721	112.17932	1136	Den	1	1		2	
66		48.71935	112.18203	1112	Den	1	4		1	
67	Suj mountain, Batnorov soum, Khentii province	48.7191	112.18240	1105	Den	1	3			3
68		48.72235	112.18393	1095	Den	1		2	1	
69		48.72694	112.18303	1095	Chamber		1	2	1	
70		48.14334	111.65998	1085	Den	1	1	2		
71		48.14359	111.65829	1093	Den	1	2		3	
72		48.13935	111.65337	1123	Den	1	1		2	
73		48.13914	111.65218	1116	Den	1	3	2		1
74		48.23454	111.75016	1172	Den	1			4	
75		48.23516	111.74729	1179	Den	1		2		
76		48.23772	111.74639	1192	Den	1				1
77		48.23766	111.74763	1200	Den	1				
78		48.23675	111.75378	1176	Den	1			1	
79		48.23531	111.75397	1176	Den	1	4			
80		48.14287	111.66122	1381	Den	1			2	
81		48.14189	111.6396	1090	Chamber					

82		48.13872	111.65663	1108	Chamber			2		
83		48.23553	111.75244	1178	Den	1				
84		48.2375	111.75263	1191	Den	1	1			
85		48.23743	111.75267	1190	Chamber				1	
86		48.23697	111.75.409	1186	Chamber					
87		48.23553	111.75573	1135	Chamber					2
88		48.2356	111.75584	1179	Den	1				1
Total					287	77	88	56	69	74

At all sites, families had dug new holes, or fixed old holes for such purposes as protection from predators, reproduction, and hibernation. Families used areas with relatively abundant forage. During our observations the study site was windy and plant communities showed typical species composition and density. Families were relaxed in their grazing. They were active throughout the day and did not graze in the mornings or at night.

Second release site

Marmots were released at the second site in 2016, on the outer slope of Haraat mountain in Bayan-Uul soum and Uvur hooloi of Tsagaan-Ovoo soum. Follow-up surveys were conducted in May of 2017, at the same time as the first release site was surveyed. During surveys, weather was mildly favorable vegetation was abundant. Marmots were in good condition and reproductive rates were higher than at the first translocation site .

Surveys of the reinforced marmot populations in Bayan-Uul and Tsagaan-Ovoo soums of Dornod province recorded the distribution, location, and elevation of burrows and the number of individuals in each family, as well as their age and sex (Table 2). Out of 80 families and 348 individuals recorded at the release sites, 99 (28%) were yearlings, 79 (23%) were two-year-olds, 71 (21%) were three-year-olds, and 97 (28%) were adult marmots. The balance of the age distribution shows that adaptation to the release area and winter survival were normal and the breeding rate was high. The density of families in the Haraat mountain inner slope in 2016 was 13.8 families per km2. By 2017, the density had increased to 17.4 families per km2, a population increase of 26%.

Table 2. *Distribution and density of Mongolian marmots following population reinforcement in Bayan-Uul and Tsagaan-Ovoo soums, Dornod province, Mongolia.*

№	*Location*	*Coordinate*		*Elevation*	*Colony*	*Number of families*	*Number of individuals*			
		Lat	*Long*				*1 year olds*	*2 year olds*	*3 year olds*	*Adults*
1	Kharaat mountain, Bayan-Uul soum, Dornod province	48.69581	112.77112	1007	Den	1	4	1		2
2		48.69713	112.77187	1006	Den	1	2	1	1	2
3		48.70865	112.77538	995	Den	1	1			2
4		48.71883	112.80335	940	Den	1	3		2	
5		48.72696	112.81366	956	Den	1		4		
6		48.72272	112.82327	943	Den	1	1	3		2
7		48.72299	112.82718	944	Den	1	2		2	
8		48.72252	112.82805	943	Den	1	4			1
9		48.72281	112.82956	944	Den	1		3		2
10		48.72255	112.83113	943	Den	1	3	1		2

11		48.72315	112.83301	942	Den	1			1	3
12		48.72397	112.83321	942	Den	1	4		4	
13		48.72332	112.83618	941	Den	1	3	2		2
14		48.72396	112.83903	939	Den	1	1	3		1
15		48.724	112.84046	936	Den	1	3	1		3
16		48.72388	112.8411	935	Den	1	1	2	2	
17		48.72416	112.84222	937	Den	1			4	
18		48.72434	112.84381	935	Den	1		5		1
19		48.72429	112.84501	934	Den	1			3	
20		48.72433	112.84556	935	Den	1	4	1		2
21		48.72527	112.84833	935	Den	1	2	2		2
22		48.72491	112.85264	933	Den	1		1	3	
23		48.72421	112.85476	931	Den	1	5			1
24		48.72471	112.85692	930	Den	1	1	4		2
25		48.72504	112.85701	930	Den	1	3		2	
26		48.72523	112.8612	929	Den	1	5		1	1
27		48.72363	112.86165	930	Den	1	1		1	4
28		48.72633	112.86714	926	Den	1	1	1		2
29		48.72659	112.86938	925	Den	1			2	2
30		48.73045	112.87529	935	Den	1	1	2		2
31		48.72192	112.8255	940	Den	1	1	2		2
32		48.72133	112.82424	941	Den	1			2	4
33		48.72074	112.82166	940	Den	1	3		1	2
34		48.72064	112.82004	942	Den	1		2	1	
35		48.71901	112.8204	940	Den	1			3	1
36		48.72092	112.81616	942	Den	1	1		4	
37		48.72328	112.81697	944	Den	1				5
38		48.72327	112.81697	944	Den	1		4		
39		47.4843	110.93152	1003	Den	1			2	
40	Ovor khooloi, Tsagaa-Ovoo soum, Dornod province	48.60948	112.64336	1019	Den	1	2		2	4
41		48.6099	112.64344	1029	Den	1		2	2	
42		48.61015	112.64365	1031	Den	1	4			1
43		48.61202	112.64158	1035	Den	1	1			2
44		48.61273	112.64076	1037	Den	1	1	3		1
45		48.309	112.63733	1050	Den	1				2
46		48.61415	112.63851	1050	Den	1	2		5	
47		48.61296	112.64461	1039	Den	1		4		2
48		48.61022	112.64791	1035	Den	1	1		2	
49		48.60894	112.64940	1029	Den	1		3		1
50		48.6034	112.64539	1019	Den	1	4			1
51		48.6032	112.64342	1021	Den	1		2		2
52		48.60259	112.64329	1023	Chamber					
53		48.6018	112.64201	1021	Chamber					
54		48.60175	112.64435	1011	Chamber					
55		48.60667	112.64462	1022	Den	1	5			2
56		48.60663	112.64460	1018	Den	1			3	

57		48.66588	112.64636	1017	Den	1			3	
58		48.60549	112.64729	1007	Den	1		1		
59		48.6036	112.64705	1021	Den					1
60		48.60249	112.64707	1021	Den	1		1		
61		48.60231	112.64712	1020	Den	1	4		3	
62		48.6018	112.64675	1015	Den	1		2		
63		48.60108	112.64751	1017	Den	1	1		2	
64		48.6002	112.64705	1015	Den	1		1		4
65		48.6005	112.34793	1012	Den	1	1		2	2
66		48.60414	112.64735	1003	Chamber					
67		48.6127	112.62426	950	Chamber					
68		48.60833	112.64591	905	Den	1		3	1	
69		48.6127	112.64426	905	Den	1	1		1	
70		48.69269	113.03404	888	Den	1	3	2		
71		48.68228	112.96265	922	Chamber					
72		48.67213	112.92159	935	Chamber					
73		48.60948	112.64336	1019	Den	1	3	2		1
74		48.6099	112.64344	1029	Chamber					
75		48.61014	112.64365	1031	Den	4		1		4
76		48.61202	112.64158	1035	Den	3			3	3
77		48.61273	112.64077	1037	Den	4		1		1
78		48.61309	112.63733	1050	Den	1			3	
79		48.61415	112.63851	1050	Chamber					
80		48.61297	112.64461	1039	Chamber					
81		48.61022	112.64791	1035	Den	1		3		2
82		48.60894	112.6494	1029	Chamber					
83		48.60341	112.64539	1019	Chamber					
84		48.6032	112.64343	1021	Den	1	6			4
85		48.6025	112.64329	1023	Chamber					
86		48.6018	112.64201	1021	Chamber					
87		48.60175	112.64435	1011	Den	1		3		2
Total					348	80	99	79	73	97

As with the first translocation site, every family in the second area had dug new holes or fixed old holes for their use. Families occupied areas with abundant forage. During observations, weather at the study site was mildly windy and sunny, plant communities showed typical species composition and density, and the families were active grazing from morning until nightfall.

Conclusion

Our survey found that the number of families and the number of juvenile marmots (one to three years old) had increased following translocation and the proportion of juveniles in all populations was high (23-28% yearlings, 23-24.1% two-year olds) at all release sites . These results demonstrate low mortality and high reproduction rate at release sites and suggest that the translocation project was a success.

Sites of marmot population reinforcement were entrusted to local citizens and conservation cooperatives who will ensure that the marmot populations continue to thrive.

To ensure proper conservation and availability of marmots as a resource, it is critical that population structure and density, reproduction, and mortality are regularly monitored at all sites of interest. To further improve project outcomes, we recommend choosing release sites surrounded by larger areas of potentially suitable habit, so that as marmot populations grow, their range can be extended.

ХЭНТИЙ, ДОРНОД АЙМГИЙН НУТАГТ МОНГОЛ ТАРВАГА (*MARMOTA SIBIRICA* RADDE, 1862) СЭРГЭЭН НУТАГШУУЛСАН АЖЛЫН ДҮН, ӨНӨӨГИЙН БАЙДАЛ

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Товч агуулга.

2015 онд Хэнтий аймгийн Батноров, Норовлин сумын нутагт 45 бодгаль тарвагыг сэргээн нутагшуулж 2 жилийн хугацаанд бүлийн тоо 2,1 дахин өссөн, 2016 онд Дорнод аймгийн Баян-Уул, Цагаан-Овоо сумын нутагт нийт 117 толгой Монгол тарвага сэргээн нутагшуулж бүлийн тоо өмнөх жилийнхээс 26% -иар өссөн, тухайн популяцийн үржлийн эрчим өндөр, мөндөлийн эзлэх хувь 23-28 %-д хүрсэн байна.

Түлхүүр үг.

Монгол тарвага, сэргээн нутагшуулах, мониторинг судалгаа

Олон жил дараалан хайр гамгүй, тооцоо судалгаа муутай агнасан болон байгаль цаг уурын тааламжгүй хүчин зүйлээс шалтгаалан ихэнх нутагт тарваганы хэвийн үржил, нөхөн төлжилт, популяцийн зөв бүтэц алдагдаж, тархац нутаг тасархайтан хумигдаж, тоо толгой, нөөц эрс багасан зарим нутагт устаж үгүй болох явц ялангуяа тарваганы тархац нутгийн өмнөд зах хэсэгт илүү ихээр тэмдэглэгдэх болов. Тухайлбал, 1990-ээд он хүртэл элбэг тарвагатай байсан Төв аймгийн Богд хан уулаас урагш Сэргэлэн, Баян сумдын нутаг тарвагагүй боллоо. Харин айл өрх, аж ахуйн нэгж, албан байгууллага олноор суурьшин газар эзэмшиж байгаа зарим бүс, тухайлбал нийслэл Улаанбаатар хот орчмын зуслангийн газруудад дээрхийн эсрэг буюу Монгол тарваганы тархац нутаг хумигдаж, амьдрах орчин нь хязгаарлагдан нягтшил ихсэж, тархац нутгаа тэлэх боломжгүй болсны зэрэгцээ тахал өвчин тархаах эрсдэл дагуулж байна.

Дээрх нөхцөл байдлыг тооцон нийслэл хот орчмын тарваганы нягтшил өндөр, Шарга морьт, Хуурайн ам, Гүнт зэрэг хотын ногоон бүсийн тарваганы нягтшил, байгалийн голомтот өвчин тархах эрсдлийг бууруулах зорилгоор Байгаль орчин, аялал жуулчлалын яам, НҮБ-ын Хөгжлийн хөтөлбөр, МОН 12/301, МОН 13/303 төслөөс санхүүжүүлж Хөхтөн амьтны экологийн нийгэмлэг, ШУА-ийн Ерөнхий болон сорилын биологийн хүрээлэнгийн судлаачид хамтран 2015 онд Хэнтий аймгийн Батноров, Норовлин суманд 45 бодгаль, 2016 онд Дорнод аймгийн Баян-Уул, Цагаан-Овоо сумын нутагт нийт 117 толгой Монгол тарвага сэргээн нутагшуулах ажлыг тус тус хийж гүйцэтгэв. Энд бид дээрх тарвага сэргээн нутагшуулсан ажлын мониторинг судалгааны үр дүнг товчлов.

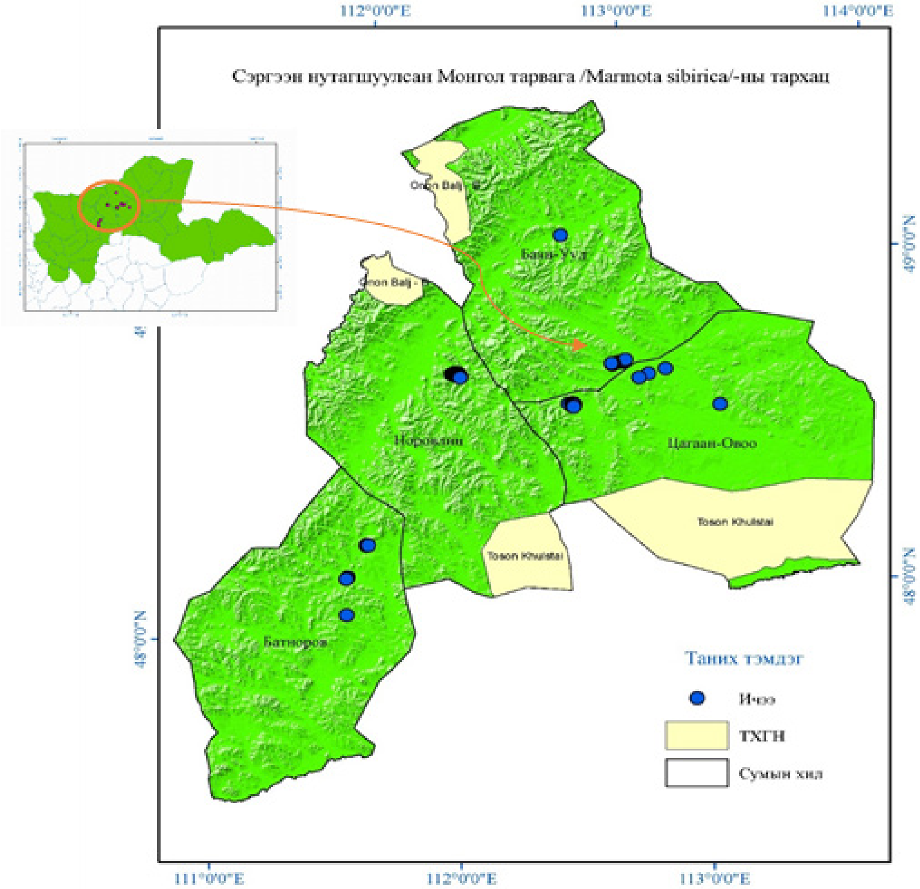
Судалгааны аргазүй, хэрэглэхүүн.

Дээрх сумдын нутагт сэргээн нутагшуулсан Монгол тарваганы нягтшил, нөөцийг үнэлэх мэдээ хэрэглэхүүнийг цуглуулах ажлыг Машкин, 1983, 1989; Машкин, Зарубин, Колесников, 1991 нарын боловсруулсан аргазүйн дагуу хийж гүйцэтгэв.

Судалгааны үр дүн

Сэргээн нутагшуулсан нэгдүгээр талбай. 2017 онд Норовлин сумын 3-р багийн Могойтын Хар өндөр уул болон Батноров сумын Сүүж хайрхны орчим сэргээн нутагшуулсан Монгол тарваганы мониторинг судалгааг зуны эхэн сард буюу мөндөл “гадаалсан” үеэр хийж гүйцэтгэв. Тус судалгаагаар Могойтын Хар өндөр уулын ар бэлд 61 бүл, Сүүж уулын орчим 16 бүл тарвага (хүснэгт 1) тус тус бүртгэн тэмдэглэв. Ичээ нүхний байршлыг Зураг 1-т үзүүлсэн. Бодгалиуд тарга хүч хэвийн, өдрийн турш идэвхи хөдөлгөөн сайтай байв.

Сэргээн нутагшуулалт хийсэн бүс нутагт нийт 77 бүл, 287 бодгаль тарвага тоологдсоноос 88 (30.65%) мөндөл, 56 (19.6%) хотил, 69 (24.05%) шар хацар, 74 (25.79%) бие гүйцсэн бодгаль тус тус бүртгэгдэв. 2015 онд тарвага сэргээн нутагшуулахын өмнөх тандан судалгаагаар Норовлин, Батноров суманд 100 га буюу 1 км/кв талбайд 9.2 орчим бүл ноогдож байсан бол 2017 оны мониторинг судалгаагаар 1 км/кв талбай дах бүлийн тоо нэмэгдэж 1 км/кв талбайд 19.3 бүл нягтшилтай дүн гарч, сэргээн нутагшуулалт хийхээс өмнөх үетэй буюу 2 жилийн хугацаанд даруй 2.1 дахин өссөн байна. Нэг бүлд ноогдох тарваганы тоо толгой дунджаар 3.7 байв.



Зураг 2. *Хэнтий, Дорнод аймагт сэргээн нутагшуулсан Монгол тарваганы ичээ нүхний байршил*

Бүл тус бүр дайсан амьтдаас биеэ хамгаалах, үржих, төрөх, ичээлэх зориулалт бүхий олон нүхийг шинээр ухсан, хуучин нүхийг зассан байсан ба бүлүүд идэш тэжээлийн ургамал харьцангуй арвин, байршил нутгийг эзэмшиж байв. Бидний ажиллах хугацаанд тухайн бүсэд салхитай, өвс ногооны гарц дундаж хэмжээнд байсан бөгөөд бодгалиуд өглөөнөөс орой болтол тайван идээшилж, өдрийн турш идэвхи сайтай, өглөө оройн гараагүй байв.

Хүснэгт 1. *Хэнтий аймгийн Батноров, Норовлин сумандсэргээн нутагшуулсан Монгол тарваганы тархац, байршил, бүлийн болон бодгалийн тоо*

№	*Газрын нэр*	*Координат*		*Өндөршил*	*Нүх*	*Бүлийн тоо*	*Бодгалийн тоо*			
		Lat	*Long*				*Мө*	*Хо*	*ШХ*	*БГ*
1	Хэнтий аймаг, Норовлин сум, Могойтын хар өндөр уул	48.72702	112.17976	1131	Зусаал					2
2		48.72662	112.17921	1132	Ичээ	1	4			1
3		48.72681	112.17834	1156	Зусаал			2		2
4		48.72806	112.17938	1138	Ичээ	1	1			
5		48.72805	112.18040	1121	Зусаал					
6		48.7288	112.18242	1096	Ичээ	1	1		1	3
7		48.72852	112.18318	1096	Ичээ	1	2		2	2
8		48.72842	112.18363	1085	Ичээ	1	3	2		1
9		48.72954	112.18315	1083	Ичээ	1	1	1		2
10		48.72952	112.18300	1084	Ичээ	1	3	1		2
11		48.7296	112.18259	1090	Ичээ	1			1	3
12		48.73037	112.18204	1086	Ичээ	1	1	2	4	
13		48.73137	112.18269	1071	Ичээ	1	3	2		2
14		48.73093	112.18438	1068	Ичээ	1	1	3		1
15		48.73172	112.18379	1065	Ичээ	1	3	1		3
16		48.73145	112.18091	1072	Ичээ	1	1		2	
17		48.73215	112.18243	1064	Зусаал				1	
18		48.73303	112.18086	1076	Ичээ	1		1		3
19		48.7338	112.17947	1061	Ичээ	1			2	
20		48.73347	112.17677	1064	Ичээ	1	4	1		2
21		48.73433	112.17762	1064	Ичээ	1	1			3
22		48.73517	112.17513	1068	Ичээ	1		2	2	
23		48.7345	112.17487	1067	Ичээ	1	1		2	
24		48.73316	112.17348	1072	Ичээ	1	3	1		2
25		48.73216	112.17012	1077	Ичээ	1	1		1	1
26		48.73178	112.16383	1081	Ичээ	1	2		1	1
27		48.73166	112.16278	1090	Ичээ	1	3		1	3
28		48.73309	112.16765	1084	Ичээ	1	1	1		2
29		48.73326	112.16929	1077	Ичээ	1	3	1	2	
30		48.73428	112.16988	1081	Ичээ	1	1	2		2
31		48.73415	112.17184	1072	Ичээ	1	1	2		2
32		48.73587	112.17694	1065	Ичээ	1			2	4
33		48.73393	112.18269	1056	Ичээ	1	1		1	
34		48.73293	112.18500	1058	Ичээ	1		2		
35		48.73011	112.18621	1063	Ичээ	1			1	
36		48.73155	112.19071	1045	Ичээ	1	1		4	
37		48.73296	112.19103	1043	Ичээ	1	3	1		2
38		48.73063	112.19056	1047	Ичээ	1	1		2	
39		48.72938	112.18987	1053	Ичээ	1		4		
40		48.72937	112.18787	1062	Ичээ	1			2	
41		48.72813	112.18825	1065	Ичээ	1			1	
42		48.72895	112.19134	1045	Ичээ	1	2			1

43		48.72853	112.19275	1044	Ичээ	1	1			3
44		48.72823	112.19301	1043	Ичээ	1	1		1	
45		48.72758	112.19418	1045	Ичээ	1				2
46		48.72731	112.19355	1046	Ичээ	1		2		
47		48.72692	112.19271	1048	Ичээ	1			3	
48		48.72744	112.19181	1056	Ичээ	1				
49		48.72675	112.19019	1057	Ичээ	1	2		3	
50		48.72605	112.19218	1050	Ичээ	1		2		2
51		48.72607	112.19267	1046	Ичээ	1	4	1		2
52		48.7251	112.19119	1056	Ичээ	1	1		1	
53		48.72411	112.19013	1059	Ичээ	1				
54		48.72399	112.19080	1058	Ичээ	1		1		
55		48.724	112.19312	1053	Ичээ	1				2
56		48.72461	112.19689	1046	Ичээ	1	2			
57		48.72433	112.19621	1046	Ичээ	1			1	
58		48.72056	112.19781	1058	Ичээ	1		1		
59		48.72581	112.18280	1104	Зусаал					1
60		48.72505	112.18264	1103	Ичээ	1		1		
61		48.72394	112.18245	1107	Ичээ	1	2		1	
62		48.7235	112.17220	1133	Ичээ	1		2		
63		48.72305	112.17969	1135	Ичээ	1	1		6	
64		48.72172	112.18075	1133	Ичээ	1		2		2
65		48.721	112.17932	1136	Ичээ	1	1		2	
66		48.71935	112.18203	1112	Ичээ	1	4		1	
67	Хэнтий аймаг, Батноров сум, Сүж уул	48.7191	112.18240	1105	Ичээ	1	3			3
68		48.72235	112.18393	1095	Ичээ	1		2	1	
69		48.72694	112.18303	1095	Зусаал		1	2	1	
70		48.14334	111.65998	1085	Ичээ	1	1	2		
71		48.14359	111.65829	1093	Ичээ	1	2		3	
72		48.13935	111.65337	1123	Ичээ	1	1		2	
73		48.13914	111.65218	1116	Ичээ	1	3	2		1
74		48.23454	111.75016	1172	Ичээ	1			4	
75		48.23516	111.74729	1179	Ичээ	1		2		
76		48.23772	111.74639	1192	Ичээ	1				1
77		48.23766	111.74763	1200	Ичээ	1				
78		48.23675	111.75378	1176	Ичээ	1			1	
79		48.23531	111.75397	1176	Ичээ	1	4			
80		48.14287	111.66122	1381	Ичээ	1			2	
81		48.14189	111.6396	1090	Зусаал					
82		48.13872	111.65663	1108	Зусаал			2		
83		48.23553	111.75244	1178	Ичээ	1				
84		48.2375	111.75263	1191	Ичээ	1	1			
85		48.23743	111.75267	1190	Зусаал				1	
86		48.23697	111.75.409	1186	Зусаал					
87		48.23553	111.75573	1135	Зусаал					2
88		48.2356	111.75584	1179	Ичээ	1				1
Нийт					287	77	88	56	69	74

Сэргээн нутагшуулсан хоёрдугаар талбай. 2016 онд сэргээн нутагшуулалт хийсэн уг популяцид өмнөх талбайтай нэгэн ижил буюу 2017 оны зуны эхэн сард Баян-Уул сумын Хараатын өвөр бэл болон Цагаан овоо сумын Өвөр хоолойд мониторинг судалгааг хийж гүйцэтгэв. Тухайн бүс нутагт цаг уурын таатай нөхцөлтэй, ургамал ногооны гарц сайн байв. Тус бүсэд тархан байршсан бодгалиуд тарга хүч хэвийн, үржлийн эрчим, төлөрхөг чанар (мөндөлийн тоо) давуу байгааг тогтоов.

Дорнод аймгийн Баян-Уул, Цагаан-Овоо суманд сэргэн нутагшиж буй Монгол тарваганы мониторинг судалгааны үр дүн тархац байршил, өндөршил, бодгалийн тоо, бүлийн нас хүйсний бүтцийг хүснэгт 2-д үзүүлэв.

Судалгааны явцад сэргээн нутагшуулалт хийсэн бүс нутагт нийт 80 бүл, 348 бодгаль тоологдсоноос 99 (28 %) мөндөл, 79 (23 %) хотил, 73 (21 %) шар хацар, 97 (28%) бие гүйцсэн бодгаль тус тус байна. Дээрх дүнгээс харахад насны бүтэц ойролцоо хувийг эзлэж байгаа нь сэргээн нутагшуулсан тухайн бүсэд тарвага дасан зохицож, өвөлжилтийг сайн давсан бөгөөд үржлийн эрчим өндөр байгааг харуулав.

2016 онд тарвага сэргээн нутагшуулахын өмнөх тандан судалгаагаар Хараатын өвөр бэлд 1 км/кв-д 13.8 бүл ноогдож байсан бол мониторинг судалгаагаар 1 км/кв талбайд 17.4 бүл тарвага ноогдож өмнөх жилийнхээс 1 км/кв талбайд 3.6 бүл тарвага буюу 26 %-иар өссөн байна.

Судалгааны нэгдүгээр талбайн нэгэн адилаар бүл тус бүр дайсан амьтдаас биеэ хамгаалах, үржих, төрөх, ичээлэх зориулалт бүхий олон нүхийг шинээр ухсан, хуучин нүхийг зассан, идэш тэжээлийн нөөц арвин байршил нутгийг эзэмшиж байв. Бидний ажиллах хугацаанд тухайн бүсэд тогтуун салхитай, хурц нартай, өвс ногооны гарц маш сайн бөгөөд бодгалиуд өглөөнөөс орой болтол идэвхитэй тайван идээшилж байв.

Хүснэгт 2. *Дорнод аймгийн Баян-Уул, Цагаан-Овоо суманд сэргээн нутагшуулсан Монгол тарваганы тархац, байршил, бүлийн тоо, бодгалийн тоо*

№	*Газрын нэр*	*Координат*		*Өндөршил*	*Нүх*	*Бүлийн тоо*	*Бодгалийн тоо*			
		Lat	*Long*				*Мө*	*Хо*	*ШХ*	*БГ*
1	Дорнод аймаг, Баян-Уул сум Хараатын өвөр	48.69581	112.77112	1007	Ичээ	1	4	1		2
2		48.69713	112.77187	1006	Ичээ	1	2	1	1	2
3		48.70865	112.77538	995	Ичээ	1	1			2
4		48.71883	112.80335	940	Ичээ	1	3		2	
5		48.72696	112.81366	956	Ичээ	1		4		
6		48.72272	112.82327	943	Ичээ	1	1	3		2
7		48.72299	112.82718	944	Ичээ	1	2		2	
8		48.72252	112.82805	943	Ичээ	1	4			1
9		48.72281	112.82956	944	Ичээ	1		3		2
10		48.72255	112.83113	943	Ичээ	1	3	1		2
11		48.72315	112.83301	942	Ичээ	1			1	3
12		48.72397	112.83321	942	Ичээ	1	4		4	
13		48.72332	112.83618	941	Ичээ	1	3	2		2
14		48.72396	112.83903	939	Ичээ	1	1	3		1
15		48.724	112.84046	936	Ичээ	1	3	1		3
16		48.72388	112.8411	935	Ичээ	1	1	2	2	

17		48.72416	112.84222	937	Ичээ	1			4	
18		48.72434	112.84381	935	Ичээ	1		5		1
19		48.72429	112.84501	934	Ичээ	1			3	
20		48.72433	112.84556	935	Ичээ	1	4	1		2
21		48.72527	112.84833	935	Ичээ	1	2	2		2
22		48.72491	112.85264	933	Ичээ	1		1	3	
23		48.72421	112.85476	931	Ичээ	1	5			1
24		48.72471	112.85692	930	Ичээ	1	1	4		2
25		48.72504	112.85701	930	Ичээ	1	3		2	
26		48.72523	112.8612	929	Ичээ	1	5		1	1
27		48.72363	112.86165	930	Ичээ	1	1		1	4
28		48.72633	112.86714	926	Ичээ	1	1	1		2
29		48.72659	112.86938	925	Ичээ	1			2	2
30		48.73045	112.87529	935	Ичээ	1	1	2		2
31		48.72192	112.8255	940	Ичээ	1	1	2		2
32		48.72133	112.82424	941	Ичээ	1			2	4
33		48.72074	112.82166	940	Ичээ	1	3		1	2
34		48.72064	112.82004	942	Ичээ	1		2	1	
35		48.71901	112.8204	940	Ичээ	1			3	1
36		48.72092	112.81616	942	Ичээ	1	1		4	
37		48.72328	112.81697	944	Ичээ	1				5
38		48.72327	112.81697	944	Ичээ	1		4		
39		47.4843	110.93152	1003	Ичээ	1			2	
40	Дорнод аймаг, Цагаан-Овоо сум Өвөр хоолой	48.60948	112.64336	1019	Ичээ	1	2		2	4
41		48.6099	112.64344	1029	Ичээ	1		2	2	
42		48.61015	112.64365	1031	Ичээ	1	4			1
43		48.61202	112.64158	1035	Ичээ	1	1			2
44		48.61273	112.64076	1037	Ичээ	1	1	3		1
45		48.309	112.63733	1050	Ичээ	1				2
46		48.61415	112.63851	1050	Ичээ	1	2		5	
47		48.61296	112.64461	1039	Ичээ	1		4		2
48		48.61022	112.64791	1035	Ичээ	1	1		2	
49		48.60894	112.64940	1029	Ичээ	1		3		1
50		48.6034	112.64539	1019	Ичээ	1	4			1
51		48.6032	112.64342	1021	Ичээ	1		2		2
52		48.60259	112.64329	1023	Зусаал					
53		48.6018	112.64201	1021	Зусаал					
54		48.60175	112.64435	1011	Зусаал					
55		48.60667	112.64462	1022	Ичээ	1	5			2
56		48.60663	112.64460	1018	Ичээ	1			3	
57		48.66588	112.64636	1017	Ичээ	1			3	
58		48.60549	112.64729	1007	Ичээ	1		1		
59		48.6036	112.64705	1021	Ичээ					1
60		48.60249	112.64707	1021	Ичээ	1		1		
61		48.60231	112.64712	1020	Ичээ	1	4		3	
62		48.6018	112.64675	1015	Ичээ	1		2		

63		48.60108	112.64751	1017	Ичээ	1	1		2	
64		48.6002	112.64705	1015	Ичээ	1		1		4
65		48.6005	112.34793	1012	Ичээ	1	1		2	2
66		48.60414	112.64735	1003	Зусаал					
67		48.6127	112.62426	950	Зусаал					
68		48.60833	112.64591	905	Ичээ	1		3	1	
69		48.6127	112.64426	905	Ичээ	1	1		1	
70		48.69269	113.03404	888	Ичээ	1	3	2		
71		48.68228	112.96265	922	Зусаал					
72		48.67213	112.92159	935	Зусаал					
73		48.60948	112.64336	1019	Ичээ	1	3	2		1
74		48.6099	112.64344	1029	Зусаал					
75		48.61014	112.64365	1031	Ичээ	4		1		4
76		48.61202	112.64158	1035	Ичээ	3			3	3
77		48.61273	112.64077	1037	Ичээ	4		1		1
78		48.61309	112.63733	1050	Ичээ	1			3	
79		48.61415	112.63851	1050	Зусаал					
80		48.61297	112.64461	1039	Зусаал					
81		48.61022	112.64791	1035	Ичээ	1		3		2
82		48.60894	112.6494	1029	Зусаал					
83		48.60341	112.64539	1019	Зусаал					
84		48.6032	112.64343	1021	Ичээ	1	6			4
85		48.6025	112.64329	1023	Зусаал					
86		48.6018	112.64201	1021	Зусаал					
87		48.60175	112.64435	1011	Ичээ	1		3		2
Нийт					348	80	99	79	73	97

Дүгнэлт, санал

Мониторинг судалгааны явцад бодгалиудын насны бүтцийг өмнөх жилүүдийнхтэй харьцуулж үзвэл, үржлийн хосын буюу бүлийн тоо, мөндөл, хотил зэрэг залуу бодгалийн тоо өссөн, тухайн популяцид эзлэх хувь өндөр (мөндөлийн эзлэх хувь 23-28%, хотилийнх 23-24.1%) байгаа нь биологийн үхэл хорогдол бага, үржлийн эрчим өндөр, сэргээн нутагшуулах ажил үр дүнтэй болсныг нотлон харуулж байна.

Тарвага сэргээн нутагшуулсан байршил нутгийг орон нутгийн ард иргэд, нөхөрлөлд хариуцуулан хамгаалуулж байгаа нь тоо толгой өсөх боломжийг бүрдүүлж байна.

Тарваганы баялагыг хамгаалах, зохистой ашиглах асуудлыг зөв шийдвэрлэхэд үржлийн онцлог, нөхөн төлжих чадавхи, үхэл хорогдлын шалтгааныг популяцийн нас, хүйсний бүтэц, тоо толгой, нягтшилтай нь холбон мониторинг судалгааг тогтмол хийж байх нь чухал болно. Дээрх тарвага сэргээн нутагшуулсан цэг нутагт зэргэлдээ орших тарвага байршин амьдрахад тохиромжтой орон газарт тархац нутгийг тэлэх зорилгоор дахин нэмж сэргээн нутагшуулах арга хэмжээг хэрэгжүүлэх нь энэ ажлын үр дүнг нэмэгдүүлэх ач холбогдолтой.

DISTRIBUTION OF MARMOTS AND THEIR EPIZOOTOLOGICAL VALUE IN AREAS OF NATURAL PLAGUE FOCI IN MONGOLIA

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The main host of plague in Mongolia is the marmot *(Marmota sibirica)*. Many areas in Mongolia with marmots, including reserves, are natural plague foci. There are a total 137 soums in 17 aimags in Mongolia with natural plague foci.

In Mongolia, human plague cases are frequently associated with marmot hunting. Since 2005, marmot hunting has been banned, but people still hunt marmots. They do so for societal reasons., Marmots are a high priced commodity and selling marmots can be an important source of income for some people. Of course, illegal and independent marmot hunting increases the risk of human plague cases and negatively affects the distribution of marmots.

Purpose: To define the distribution and epidemiological value of marmots in natural plague foci in Mongolia

Materials and Methods. We analysed monitoring data conducted in areas of natural plague foci in 127 soums and 13 aimags from 1998 through 2017. Geographical distribution analysis was performed using Arc View 3.2 software.

Results

From 1998 through 2017, monitoring was conducted in areas with natural plague foci in127 soums and 13 aimags. The study found that the average number of marmots per hectare was high in Bayan-Ulgii, Zavkhan, and Khovd aimags (2.0-3.0) and low in other aimags (0.5-1.8).

In the 1990s, marmots occurred in 229 soums and 16 aimags and there was an estimated 23 million marmots in the 252 000 km^2 area of these soums . The 1990s study served as a baseline for exploring changes in the distribution and status of marmots in Mongolia.

Since 2005, with the introduction of the marmot hunting ban, the average density of marmots per hectare has increased from where it was in 1998-2004, including in areas of natural plague foci.

During the study, 436 plague strains of *Y. pestis* were identified in 30 soums and 9 aimags. These soums were therefore considered to be natural plague foci. 76.1% of total plague strains were from marmot carcasses and 23.9% were from marmot fleas *(O . silantiew)*. The epizootological peak period in the natural plague foci occurred in August and September. In 1998-2017, the highest epizootic activity was in the natural plague foci in some soums in Bayan-Ulgii, Khovd, Khuvsgul, and Zavkhan aimags.

Fifty-eight cases of human plague in 30 soums and 9 aimags were recorded. Mortality rate was 36.2% (21). 68.7% of human plague patients were males and 31.3% were

females, with a sex ratio 2.2: 1. Patients were 4-61 years old, and their average age was 24. 47.5% of the patients suffered the septic form of plague, 33.3% the bubonic form, and 1.21% the pharyngeal form. 18% experienced primary pulmonary effects, and 70.4% experienced secondary-pulmonary complications. 67.4% of patients were infected by direct contact with marmots, including hunting and handling of marmots. 21.3% were bitten by marmot fleas, 8.8% were infected by airborne droplets, and 2.5% ate sraw marmot organs.

Conclusion

According to our study, the average density of marmots has increased in Bayan-Ulgii, Zavkhan, and Khovd aimags. Over the past 20 years, an average of 21 plague strains per soum have been found across 30 soums, indicating that natural plague foci in Mongolia are still active. Due to the high likelihood of being infected by marmots, it is important to improve the behavior and awareness of the people most likely to encounter them. Professional organizations, including scientists and health officials, should work to communicate the risks associated with illegal marmot hunting and the use of marmot organs as medicine, to reduce the chances of humans contracting plague from marmots..

Key words: marmot, density, plague, strain, natural foci, aimag, Mongolia,

МОНГОЛ ОРНЫ ТАРВАГАН ТАХЛЫН БАЙГАЛИЙН ГОЛОМТОТ НУТАГ ДАХЬ ТАРВАГАНЫ ТАРХАЛТ, ЭПИЗООТОЛОГИЙН ХОЛБОГДОЛ

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Зоонозын өвчин судлалын үндэсний төв

Монгол орны ойт хээр, уулын хээр, хээр, тал хээрийн экосистемийн түлхүүр зүйл нь Монгол тарвага *(Marmota sibirica)* юм. Манай орны 17 аймгийн 137 сум тарваган тахлын байгалийн голомттойгоос 51.7% нь тохиолдлын, 23.4% нь сул, 14.5% нь, дундаж, 9.5% нь өндөр, 0.7% нь онцгой идэвхжилийн бүс болохыг тогтоожээ (Батсайхан.В, 2001).

Улсын хэмжээнд тарваганы тархац, нөөц бүхий нутгийн ихэнх нь тарваган тахлын голомттой. Манай оронд тарваган тахлын хүний өвчлөл, тарвага агнуууртай холбогдон гардаг онцлогтой (Летов Г.С., 1953, Батсүх Д., Адъяасүрэн З., Төмөрбаатар Д., 1990, Долгор Т., Батсүх Д., 1988, Адъяасүрэн З., Ганбаатар С., 1988). Сүүлийн 20 гаруй жилийн хугацаанд тарваган тахлын голомтот нутгаас илрүүлсэн нийт өсгөврийн 75.5%-ийг тарвага, тарваганы зэм үхдэл болон түүний бүүрэгнээс, 9.4%-ийг үлийн цагаан оготоноос, 8.7%-ийг монгол огдойноос, 0.5%-ийг дагуурын огдойноос 5.5%-ийг зурамнаас, 0.4%-ийг шар чичүүлээс тус тус ялгасан байна.

Ж.Батболд нар, (2000) 1987-1989 онд Байгалийн голомтод халдварт өвчнийг эсэргүүцэн судлах системийн байгууллагуудын биологчдын судалгааны үр дүнгээр Монгол улсын хэмжээнд тарваганы тархацын зураглалыг 1:1500000 масштаб бүхий газын зураг дээр анх удаа буулгасан байна.

2005 оноос тарвага агнахыг хориглосон хэдий ч тарвага агнасаар байгаа нь тарваганы гаралтай түүхий эдийн үнэ ханш өндөр, ард иргэдийн амжиргааны түвшин доогуур байгаа зэрэг нийгмийн хүчин зүйлстэй салшгүй холбоотой юм. Энэ нь тарваган тахал өвчнөөр өвчлөх эрсдэл, нөхцөл шалтгааныг нэмэгдүүлэхийн зэрэгцээ тарваганы тархалтад сөргөөр нөлөөлж байна. Цаашид тарвага агналтыг хориглосноор тарваганы тархалт нэмэгдэж байгаа эсэхийг судлах шаардлагатай байна.

Монгол орны тарваган тахлын байгалийн голомтот нутгийн тарваганы тоо толгойн нягтшил, тархалт, эпизоотологийн холбогдлыг тогтоохыг зорилоо.

Судалгааны материал. Зоонозын өвчин судлах төв байгууллагуудаас1998-2017 онд 13 аймгийн 127 сумын нутагт хийгдсэн байгалийн голомтын тандалт судалгааны тоон мэдээлэлд бичиглэл судалгаа хийлээ. Тоон мэдээг ЗӨСҮТ-ийн архивт хадгалагдаж буй тайлангаас түүвэрлэв. Газар зүйн дүрслэлийг Arc Veiw 3.2 программыг ашиглан гүйцэтгэв.

СУДАЛГААНЫ ҮР ДҮН

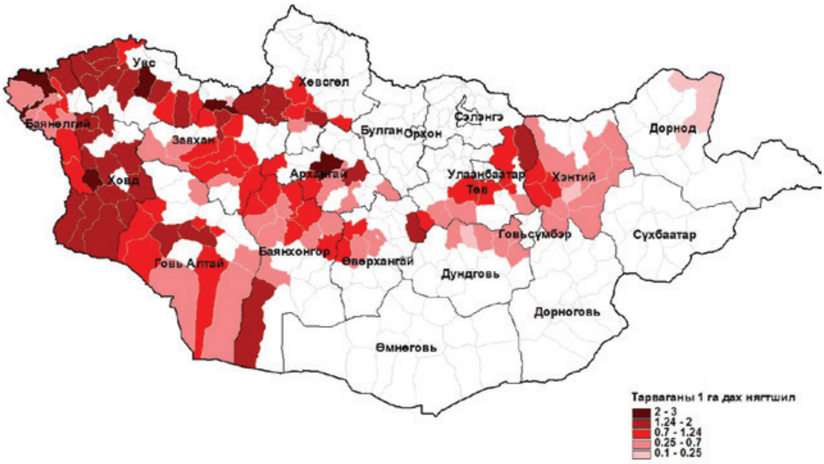
1998-2017 онд байгалийн голомтын тандалт судалгааг 13 аймгийн 127 сумаас Архангай аймгийн 7 сум, Баян-өлгий аймгийн 10 сум, Баянхонгор аймгийн 13 сум, Говь-Алтай аймгийн 11 сум, Дундговь аймгийн 7 сум, Завхан аймгийн 15 сум, Өвөрхангай аймгийн 5 сум, Төв аймгийн 9 сум, Увс аймгийн 13 сум, Ховд аймгийн 14 сум, Хөвсгөл аймгийн 7 сум, Хэнтий аймгийн 14 сум, Дорнод аймгийн 2 сумдын голомтот нутагт хийсэн байна (Хүснэгт 1).

Голомтын төлөв байдлаас хамааран Ховд, Завхан, Баян-Өлгий, Хэнтий, Говь-Алтай, Баянхонгор, Увс аймгуудаас 10-аас дээш сум тандалт судалгаанд хамрагдсан байна.

Хүснэгт 1. *1 га дахь тарваганы нягтшил*

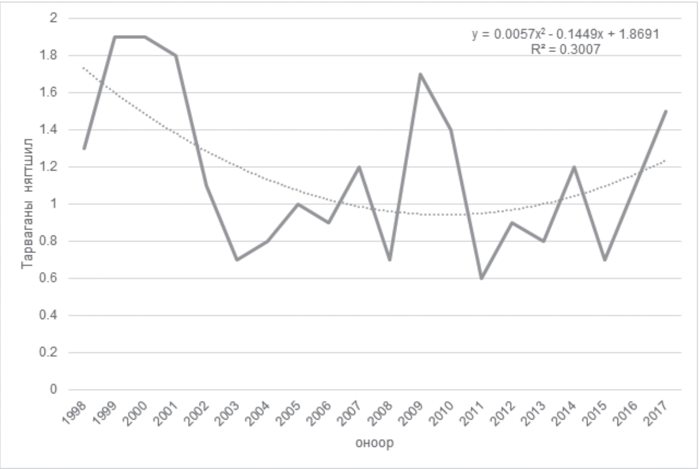
Аймаг	Сумын тоо	Тарваганы нягтшил (1 га талбайд дунджаар)
Архангай	7	0.21-1.1
Баян-Өлгий	10	1.5-2.3
Баянхонгор	13	0.38-1.02
Говь-Алтай	11	0.6-1.4
Дундговь	7	0.31-0.5
Завхан	15	0.2-3.0
Өвөрхангай	5	0.66-1.0
Төв	9	0.6-1.3
Увс	13	1.45-1.8
Ховд	14	1.3-2.0
Хөвсгөл	7	0.8-1.4
Хэнтий	14	0.3-1.0
Дорнод	2	0.1
Нийт	127	

Дээрх хүснэгтээс харахад тарваганы нягтшил 1 га талбайд дунджаар Баян-Өлгий, Завхан, Ховд, аймгуудын голомтот нутгуудад 2.0-3.0 буюу өндөр, харин бусад аймгийн голомтот нутагт 0.5-1.8 буюу бага нягтшилтай харагдаж байна.(Зураг 1). 1990 оны үед манай орны 16 аймгийн 229 сум тарвагатай, 73 сум тарвагагүй байсан. Тэдгээр 229 сумын 252 мянган км^2 талбайд 23 сая тарваганы нөөцтэй гэж тооцоолсон байдаг. Энэ судалгаа нь Монгол орны тарваганы тархац, нөөцийг тоймлон гаргаж чадсан суурь судалгаа болсон. Түүнээс хойш тархалт, нөөцийг үнэлэх ажил алга цоог хийгдэж байгаа боловч хамарсан газар нутаг хязгаарлагдмал, нэг ижил цаг хугацаанд, нэг арга зүйгээр хийгээгүйн улмаас тарваган тахлын голомтот нутагт хийгдсэн судалгааг 1990 оны суурь мэдээлэлтэй харьцуулах боломжгүй юм.



Зураг 1. *1 га дахь тарваганы тархалт нягтшилаар*

2005 оноос хойш тарвага агнахыг хориглосон хугацааг1998 онтой харьцуулахад тарваган тахлын голомтот нутгийн тарваганы нягтшил 1 га талбайд дунджаар өссөн үзүүлэлтэй байна (Зураг 1).

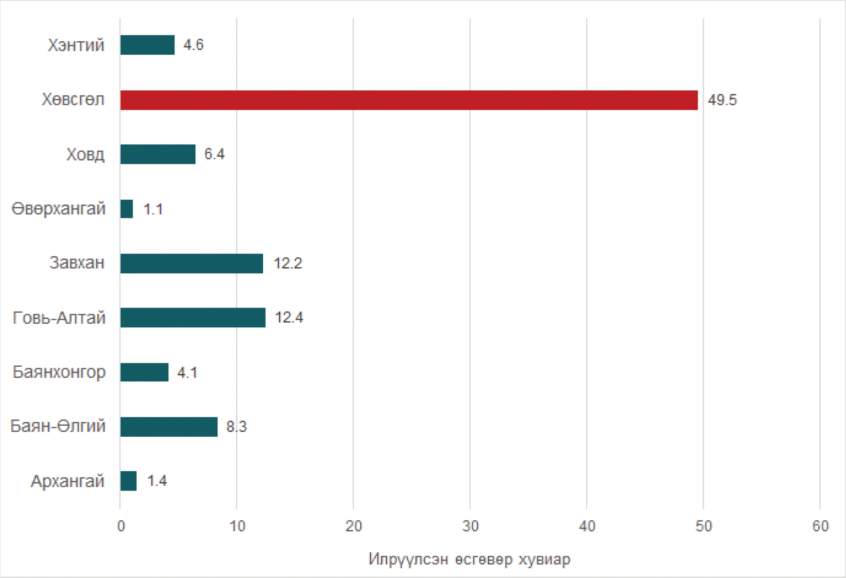


Зураг 2. *Тарваганы нягтшил (оноор)*

Судалгааны явцад нийт 6378 сорьц материал (тарвага, тарваганы зэм үхдэл) -ийг шинжлэхэд 9 аймгийн 30 сумдын тарваган тахлын байгалийн голомтот нутгаас 436 тарваган тахлын *Y.pestis* зүйлийн үүсгэгчийн өсгөврийг илрүүлж, тарваган тахал өвчний байгалийн голомт идэвхтэй байгааг тогтоосон (Хүснэгт 2, Зураг 2).

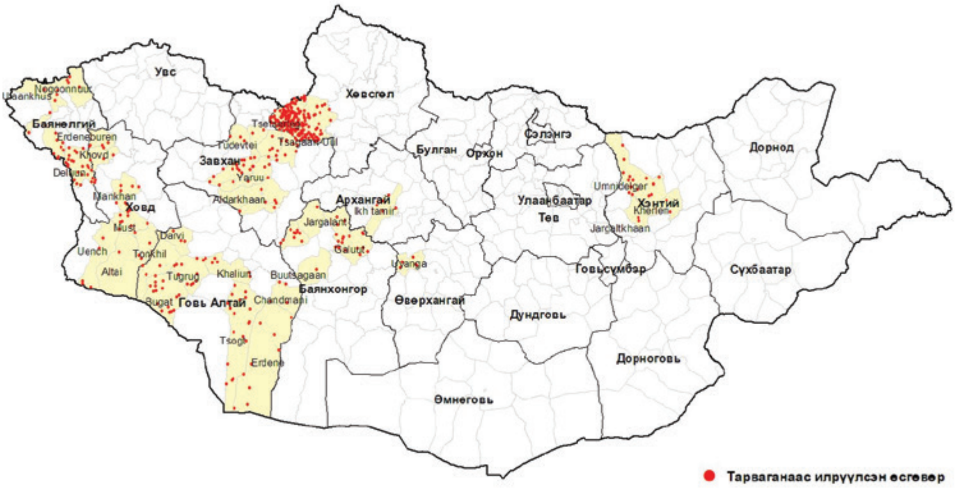
Хүснэгт 2. *Тарваган тахлын голомтот нутгаас илрүүлсэн өсгөврийн тоо*

Аймаг	сумын тоо	Илрүүлсэн өсгөврийн тоо/хувь
Архангай	1	6/1.4%
Баян-Өлгий	2	36/8.3%
Баянхонгор	5	18/4.1%
Говь-Алтай	6	54/12.4%
Завхан	5	53/12.2%
Өвөрхангай	2	5/1.1%
Ховд	6	28/6.4%
Хөвсгөл	2	21649.5
Хэнтий	1	20/4.6
Нийт	30	436



Зураг 3. *Тарваганаас илрүүлсэн өсгөврийн тоо*

Эдгээр илрүүлсэн өсгөврийн хамгийн их хувийг (49.5%) Хөвсгөл аймгийнЦэцэрлэг, Цагаан-Уул сумаас, хамгийн бага хувийг (1.1%) Өвөрхангай аймгийн Хайрхандулаан, Уянга сумаас илрүүлсэн өсгөвөр эзэлж байна. (Зураг 2). Тарваган тахлын байгалийн голомт нь газар зүйн тархалтаар ойт хээр, уулын хээр, хээр, тал хээрийн болон уулархаг нутгуудад тогтоогдож байгаа нь тарваган тахлын халдварын цар хүрээ өргөн болохыг харуулж байна.



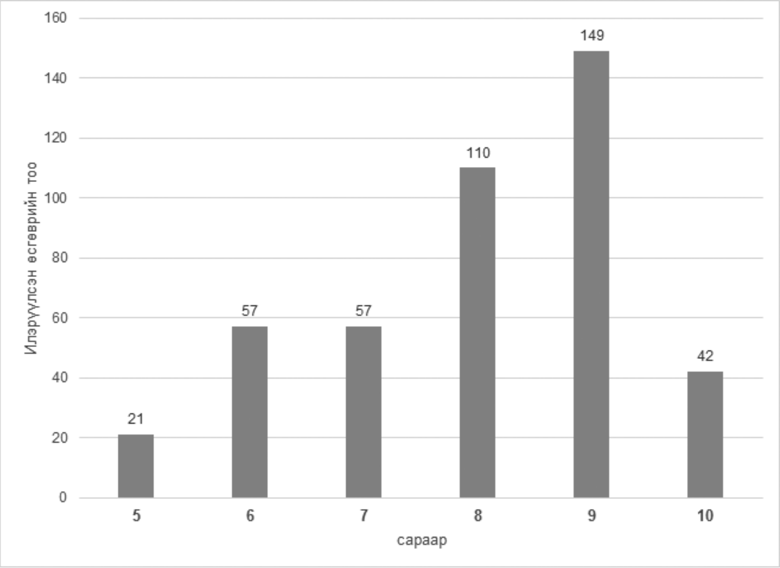
Зураг 4. *Тарваганаас илрүүлсэн өсгөврийн тархалт*

Тарваган тахлын байгалийн голомтоос илрүүлсэн өсгөврийн 76.1%-ийг тарвага,тарваганы зэм үхдэл, 23.9%-ийг тарваганы бүүрэг *(O.silantiew)* тус тус эзэлж байна (Хүснэгт 3).

Хүснэгт 3. *Тарвага түүний бүүрэгнээс ирүүлсэн өсгөвөр, бодит тоогоор*

Аймаг	Илрүүлсэн өсгөвөр /бодит тоогоор/			Нийт
	Тарвага	Тарваганы зэм үхдэл	Тарваганы бүүрэг	
Архангай	6	-	-	6
Баян-Өлгий	5	15	16	36
Баянхонгор	7	5	6	18
Говь-Алтай	5	31	18	54
Завхан	1	43	9	53
Өвөрхангай	2	3	-	5
Ховд	7	16	5	28
Хөвсгөл	11	132	73	216
Хэнтий	9	6	5	20
Нийт	56	281	99	436

Судалгааны дүнгээс үзэхэд тарваган тахлын нян нь цаг уурын өөрчлөлтөд тэсвэртэй учраас бараг жилийн турш байгальд орчих чадвартай, улиралчлалын хувьд эпизоотийн оргил хугацаа 8-9 дүгээр сард тохиолдож байна. Тарваган тахлын өсгөвөр илрэх хугацаа 5-р сараас эхэлж 10-р сар хүртэл үргэлжлэхдээ 9-р сар хүртэл тогтвортой өсч 8,9-р сард оргил үедээ хүрч, 10-р сард буурсан хандлага ажиглагдаж байна (Зураг 3).



Зураг 3. *Тарваганаас илрүүлсэн өсгөвөр, сараар*

1998-2017 онд Баян-Өлгийн аймгийн Ногооннуур, Улаанхус, Ховд аймгийн Мөст, Үенч, Булган, Хөвсгөл аймгийн Цэцэрлэг, Цагаан-Уул, Завхан аймгийн Эрдэнэхайрхан, Түдэвтэй сумдын тарваган тахлын байгалийн голомтод тарваган тахлын эпизооти өндөр идэвхитэй явагдаж байгааг тогтоогоод байна. Эпизоот тэмдэглэгдсэн дээрх 9 аймгийн 30 суманд тарваган тахлын хүний өвчлөлийн 58 тохиолдол бүртгэгдэж, нас баралт CFR 36.2 % (21) -тай байна. Эдгээр хүний өвчлөлийг аймаг, сумаар нь авч үзвэл Архангай аймгийн 2 сум (2), Хөвсгөл аймгийн 4 сум (7), Баянхонгор аймгийн 4 сум (9), Өвөрхангай аймгийн 3 сум (4), Завхан аймгийн 5 сум (9), Баян-Өлгий аймгийн 2 сум (2), Говь-Алтай аймгийн 5 сум (11), Ховд аймгийн 2 сум (7), Хэнтий аймгийн 3 (6) суманд тус тус хүн өвчилжээ. Эдгээр голомтот нутгаас Улаанбаатар хотод Өвөрхангай аймгийн Хайрхандулаан, Архангай аймгийн Ихтамир, Баянхонгор аймгийн Гурванбулаг сумдаас хүний өвчлөл зөөвөрлөгдсөн байна.

Нийт тохиолдлын 68.7% нь эрэгтэй, 31.3% нь эмэгтэйчүүд байсан ба хүйсийн харьцаа 2.2 :1, насны хувьд 4-61, эдгээрийн дундаж нас 24 байна. 44% нь 4-17 насны хүүхдүүд ба ихэнх хувийг эрэгтэй хүүхдүүд эзэлж байна Өвчлөгсдийн 47.5% нь үжил, 33.3% нь булчирхайн, 1.21% нь залгиур хоолойн, 18% нь анхдагч уушигны хэлбэрээр өвчилж, булчирхайн хэлбэрээр өвчлөгсдийн 70.4% хоёрдогч уушгины хэлбэрээр хүндэрсэн байна.

Нийт өвчлөгсдийн 67.4% нь тарвага агнаж, тарвага өвчих буюу мах эвдэх явцадаа гараа эсгэх, гарын хуучин шархаар дамжин халдвар авсанаас, 21.3%нь бүүргэнд хазуулсанаас, 8.8%нь агаар дуслын замаар, 2.5% нь өвчтэй тарваганы эд эрхтэнг түүхийгээр нь залгиж идсэнээс халдвар авсан байна. Энэхүү судалгааны дүнгээс харахад тарваган тахлын голомтот нутгийн тарваганы 1 га дахь нягтшил нь тарваганаас илрүүлсэн өсгөвөртэй 0.58 буюу дунд, хүний өвчлөлтэй 0.38 буюу сул хамааралтай байна.

ДҮГНЭЛТ

1. Судалгаагаар тарваганы нягтшил 1 га талбайд дунджаар Баян-Өлгий, Завхан, Ховд аймгуудад өндөр, харин бусад аймгийн голомтот нутагт бага тархацтай байна.
2. Сүүлийн 20 жилд 9 аймгийн 30 сумдын тахлын байгалийн голомтот нутгаас тарвага, түүний зэм үхдэлээс илэрсэн тарваган тахлын өсгөврийг авч үзвэл жилд дунджаар 30 суманд 21 өсгөвөр илэрч байгаа нь голомт идэвхтэй байгааг харуулж байна.
3. Тарваган тахал өвчнөөр өвчилсөн нийт тохиолдлын 67.4% нь тарвагатай хавьтал болсноос халдвар авч 8.8% нь өвчтэй хүнээс агаар дуслын замаар халдвар авсан нь тарваган тахал өвчний халдварын анхдагч эх уурхай тарвага болохыг харуулж байна. Өвчлөгсдийн 47.5%нь үжил, 33.3% нь булчирхайн, 1.21% нь залгиур хоолойн, 18% нь анхдагч уушигны хэлбэрээр өвчилж, булчирхайн хэлбэрээр өвчлөгсдийн 70.4% нь хоёрдогч уушгины хэлбэрээр хүндэрсэн байна.
4. Тарваган тахлын өвчлөл, нас баралтын ихэнх хувийг эрэгтэйчүүд эзэлж, халдварын эрсдэлд 4-17 насны эрэгтэй хүүхдүүд илүү өртөж байна.
5. Тарваганаас халдвар авч өвчний эрсдэлд өртөх магадлал өндөр байгаа тул хууль бус агналтыг хийхгүй байх, эрсдэл үүсгэх магадлалтай амьтны эд эрхтэнг түүхийгээр хэрэглэхгүй байх зэрэг ард иргэдийн зан үйл, мэдлэг хандлагыг сайжруулах ажлыг оновчтой зохион байгуулах шаардлагатай ба мэргэжлийн байгууллагууд хамтран ажиллах нь чухал байна.

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AMBIENT TEMPERATURE DURING HIBERNATION AS A FACTOR CONTRIBUTING TO THE DIVERSITY OF ECOLOGICAL NICHES IN MARMOT SPECIES.

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Marmots of different species are phenotypically varied but have very similar lifestyles. Even with a range covering a vast area and varied ecological conditions, species of *Marmota* maintain nearly identical ecological and behavioral characteristics. As a result, differentiation of ecological niches in this genus is not obvious. One of the most interesting and distinctive peculiarities of marmots is their winter hibernation. They spend three to nine months every year in their burrows with their body close to ambient temperature. Variation by species in the conditions and circumstances of hibernation can potentially be studied by direct measurements inside burrows or by mathematical modeling of potentially relevant parameters, such as temperature.

The easiest way to study hibernation is to investigate the duration of hibernation and the construction of burrows where hibernation takes place. Bibikov (1989) noted that variations in the duration of hibernation were more influenced by environmental conditions than by species. The hibernation period of steppe marmot *(M. bobak)*, for instance, ranges from six to eight months in different geographical populations. Many mountain-dwelling species have different periods of hibernation depending on the elevation and orientation of the slope on which they live. Only the most northern species, such as *M. camtschatica, M. caligata,* and *M. broweri* have specifically adapted their hibernation period for survival in harsh winter conditions (Bibikov 1989).

There is no evidence of variation in the depth of hibernacula or other burrow characteristics by species. The exception is the three northernmost species mentioned above, who live where permafrost prevents the construction of deep burrows.

Thus, there are two groups of species in genus *Marmota* with differing hibernation strategies: 'species of permafrost environment' with shallow burrows situated in the thin layer of soil over the permafrost and a long-period hibernation, and 'other species'. This study explores whether there is diversity or homogeneity of hibernation behaviour within the second group of *Marmota*.

M. bobak (steppe marmot) and *M. sibirica* (Mongolian marmot), together with *M. baibacina* (the grey marmot), are joined into the *'bobak'* group of species due to their similar ecology,, external appearance, and supposed relatively recent divergence as separate species. The shared range of these three species spreads for thousands of kilometers from Ukraine in the west to Mongolia and China in the east, making this suite of species good candidate for investigating possible differences in hibernation conditions by species. There has been no observed difference in the construction of the burrows between eastern and western populations (Ryabov, 1948; Shubin, 1991; Tokarskii, 1997). The beginning and end of hibernation occurs at the same time in Ukraine, at the western edge, and in Buryatia, at the eastern edge, of the species' range; extending from the middle/end of September to the beginning of April. Populations in Kazakhstan start hibernation earlier due to the scorching of grass in the end of summer and the resulting lack of a food supply for marmots in the early autumn.

The temperature inside the burrows of two marmot species of different geographical populations was mathematically modeled. The model was based on surface temperature data from reports published by weather stations (Spravochnik po klimatu…, 1965, 1966a, 1966b, 1967) and further estimation of temperature at burrow depth by solving a standard heat equation (ссылка). Method and results have been published previously (see Nikol'skii & Savchenko, 2005; Belovezhets, 2005; Belovezhets, 2006; Nikol'skii, 2009a; Nikol'skii, 2009b; Belovezhets & Nikol'skii, 2012).

Populations of *M. bobak* are found in eastern Ukraine, through the middle Volga and southern Ural region of Russia and into central Kazakhstan. A population of *M. sibirica* occurs in the Buryatia region of Russia..

Annual patterns of temperature variation were similar across all study populations, although absolute values decreased from west to east. The degree of annual temperature variation decreased and the maximum and minimum extremes are delayed at increasing depths below the surface. The delay in temperature fluctuations can be as long as 1.5 to 2 months at the depth of marmot hibernacula (Fig.1).

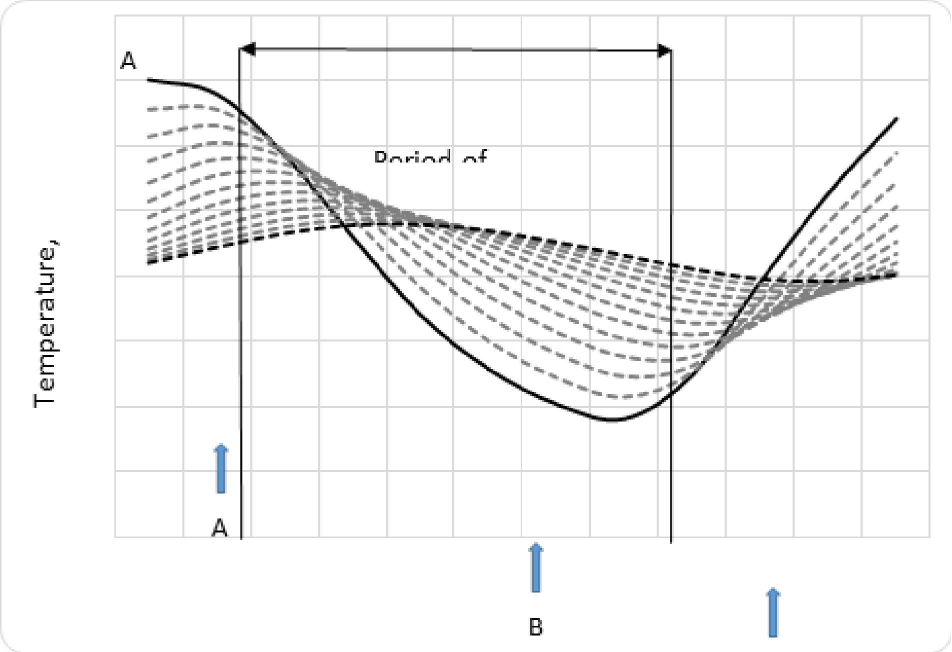

Fig. 1. *A typical pattern of temperature dynamics in the soil over marmots colonies over a year, shown is an example from Ukraine (Kharkov weather station, Spravochik… 1965). The solid line represents a depth of 2 m, the black dotted line represents a depth of 4 m, and grey dotted lines represent intermediate depths. A and B are year maxima and C and D are year minima at 2 and 4 m respectively.*

Investigations of animal physiology during hibernation show a complex and non-linear dependence of energy consumption on ambient temperature (Buck & Barnes, 1999; Armitage et al., 2003; Lee et al., 2009). There is an optimal range of temperature around 5-8°C, where energy consumption is minimized. This temperature range is typical for burrows during the hibernation of western populations of *M. bobak* from Ukraine and the Volga region. A further decrease in temperature forces marmots to spend additional energy to prevent their body temperature from dropping below freezing. Eastern populations of *M. bobak* from Southern Ural region and from Central Kazakhstan spend at least three out of seven to eight months of hibernation in conditions with temperatures lower than 5°C, and in some cases temperatures can fall below zero, especially in more shallow burrows (Fig 2).

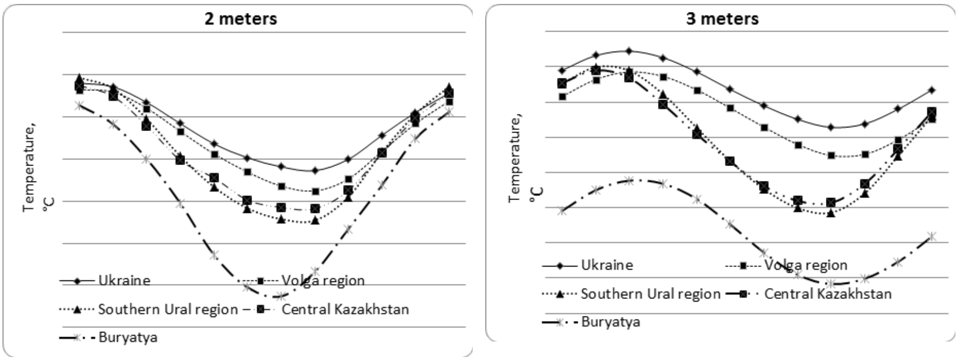

Fig.2. *Temperature in soil of marmot colonies at depths of 2 and 3 m in four populations of M. bobak (Ukraine, Volga region, Southern Ural region and Central Kazakhstan) and a population of M. sibirica from Buryatiya.*

Only the northern edge of *M. sibirica's* geographical range is within the territory of Russia. The temperature of the soil in areas with *M. sibirica* is lower than that within the range of *M. bobak*, and there can be local intrusions of permafrost. *M. sibirica* usually avoids settling in such hostile conditions, preferring more favorable and mosaic environments. Nevertheless, data from weather stations and further modeling show that soil at a depth of 3 m can be below freezing for as long as two to three months during the hibernation period. These results suggest that *M. sibirica* is capable of hibernating in burrows with negative temperatures. Moreover, unlike in populations of *M. bobak*, negative temperature in burrows of *M. sibirica* can be at any depth and animal cannot avoid them by constructing deeper burrows. We can suppose that at least northern populations of this *M. sibirica* regularly hibernate in temperature conditions below freezing.

In summary, we propose that the frequency of sub-freezing temperatures experienced by hibernating marmots potentially differentiates species and populations. . Observed populations can be divided in three groups, those whose burrow temperature:

- never falls below 0ºC (populations of *M. bobak* from Ukraine and Volga region of Russia);

- occasionally falls below 0ºC, depending on relief, burrow depth, and weather conditions (populations of *M. bobak* from Kazakhstan and Southern Ural region of Russia);
- falls below 0ºC regularly and predictably (*M. sibirica* in Buryatia).

These differences in ambient temperature conditions affect patterns of body mass loss during hibernation and fat accumulation activities prior to hibernation. The process of hibernation affects nearly every feature of marmots' lifestyle and our investigation of suggests that variation in the ambient temperature in burrows during hibernation may be one possible source of differentiation in the ecological niches of different marmot species.

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STEPPE MARMOTS IN NORTHWEST KAZAKHSTAN

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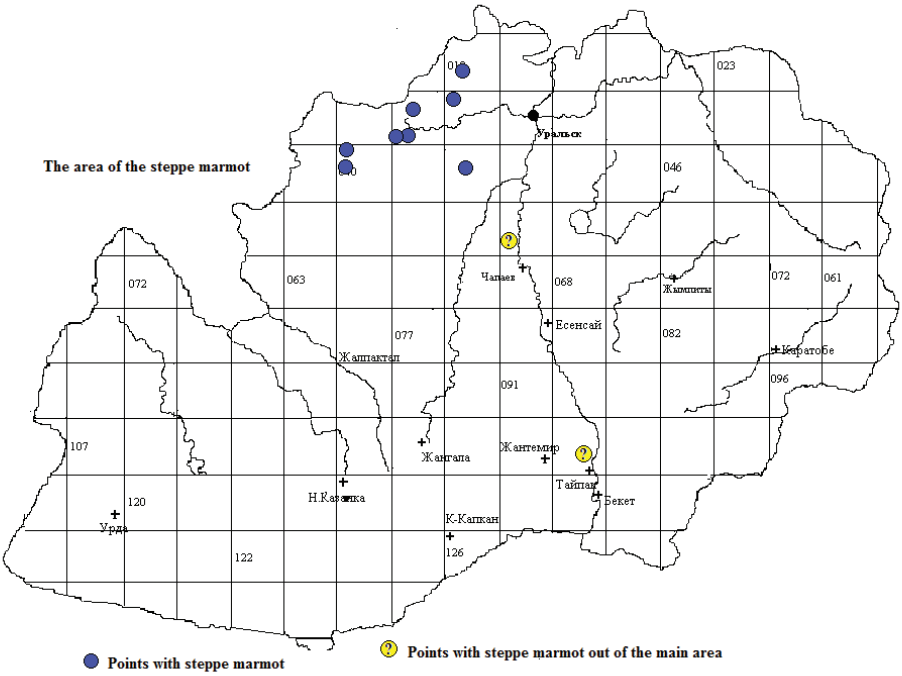
Assessments of the state of steppe marmot colonies state have been made throughout the 20th century. They have included the bobak colonies located in western Kazakhstan (Kuznetsov, 1928; Ognev, 1947; Kuznetsov, 1948; Demjashev, 1964; Shubin ,1969; Zimina &Polevaya ,1977; Okulova et al, 2016.). These data now have particular value, because previously assessed colonies have now disappeared due to the plowing of previously virgin soil, unlimited hunting of bobak, and poaching (Kuznetsov, 1928; Ognev, 1947; Kuznetsov, 1948; Demjashev, 1964)..

Analysis of the published data shows that in general the steppe marmots in western Kazakhstan are on the southern edge of their range, limited by dry steppe distribution and coinciding with the south border of the Obshchy Syrt Plateau. In areas near the Trans-Ural River, the bobak has spread throughout steppe habitat in the Poduralskoye Plateau in the Orenburg oblast' of Russia and in the Aktobe oblast' of Kazakhstan. West of the Ilek River no colonies were found. Reports of the species occurring in the Terectinskiy region of the west-Kazakhstan oblast' (WKO) in a Kuznecov' monograph (Kuznetsov, 1928) were not confirmed (Demjashev, 1964).

No sign of bobak colonies was found along the numerous roads used for great bustard *(Otis tarda)* assessments, which cover a significant part of the Poduralskoye Plateau located in the WKO. One exception was the observation of some structures which could be interpreted as old marmot burrows along a road near Kenashi village at the source of



the Olenty River. Mounds of earth with sizes (height and diameter) larger than would be expected for ground squirrels were discovered on the south slopes of the Poduralskoye Plateau. All were covered by indigenous vegetation (white wormwood, mainly) suggested the burrows had been unoccupied an extended period of time.

Some observations was made near Mount Bolshaya Ichka (51°12,200N; 50°15.300E) in the beginning of June (5.06.2007). Burrow complexes ("butan") were localized along the base of the mount and in adjacent ravines. The diameter of the occupied butans varied from 17 to 22 m with two to six holes connected by tracks. The surface of the butans were covered by weed vegetation, including austrian wormwood, peppergrass, mortuk, henbane, military grass, and agropyron with a low projecting cover. The distance between butans varied from 50 to 220 m. Nine butans were observed and seven adult marmots (usually one to three per butan) were counted.Observations were made in the middle of the day, which probably resulted in underestimation of the number of adult marmots present. Of nine butans, two were uninhabited and without any sign of marmots being present. In the evening, west of the Bolshaya Ichka mountain 13 marmots, including two young-of-year were observed within an area of about 25 ha. From these observations, we estimated the mean number of bobaks in the area to be 0.5 individuals per ha. It should be noted also that marmot burrows were also observed in ploughed areas.

On 7.06.2007 on an 8 km long road in Ichka-Taskala three butans with three adult bobaks were counted. On the same day, along the road from Taskala to Mereke (former Chizha2) marmots were discovered near Aktay village (51°01,143N;50°09.679E) and near Mereke. Near Aktay on a classic butan with the diameter 20 m, two adult marmots were observed and near Mereke (50°50,201N; 49°37.340E) on a small butan of 5x5 m one adult and two juveniles were observed. On 8.06.2018 near Ermolchevo village one adult plus one young marmot was observed at 50°56,540N; 49°06,609E.

In 2010, we conducted surveys to the east of those made in 2007. On 1.06.2010, near Pervosovetsk village three bobaks (one adult plus two juveniles) were observed in a butan. Next day two marmots were observed northeast of Cyganovo village at 51°18,298N;50°31.625E.

All observed butans are reflected on the map (Figure 1). Most bobak colonies located in northwestern Kazakhstan were situated in the dry steppe habitat of WKO in the south part of the Obshchy Syrt Plateau. They bordered with the bobak colonies in the Ozinskiy region of the Saratov oblast' of Russia. This colony represents about 80% of all bobaks dwelling in Trans-Volga Region of Saratov oblast'and numbers about 3000 individuals (Kondratenkov et al., 1999.). We did not have enough data to estimate the total population of bobaks in Kazakhstan, but we note that Russian and Kazakhstanian bobak colonies are linked and form an undivided transboundary population.

The data on unusual migration of the bobak published earlier stand independently (Bidashko et al.,2009; Demjashev ,1964). A dispersing female was found dead on the road from Uralsk to Atyrau more than 100 km from the main population. We were unable to find a marmot colony near the point where the dead female was found, so it remains unknown whether she was a disperser or member of an undocumented local colony. During the writing of this paper we have received information about a marmot colony located more to the south of the main population. This information was confirmed on 27.06.2018. The new colony was discovered not far from the Khankol location at 50°50.258N; 50°41.996E.

Seven bobaks including two juveniles were found. There were no clear butans, but burrows were observed. Local people said that the colony appeared three to four years ago. It is possible that the movement of bobak to the south is the result of successful reproduction, local population growth, and subsequent migration.

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MOLECULAR DIVERSITY AND TAXONOMY IN MARMOTS

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The use of molecular genetic methods for the assessment of biological diversity led to a revision of taxonomic systems based on morphological features. A widespread approach to assessing the reality of morphological subspecies using molecular genetics methods leads to a revision of intragenus and intraspecies systems in different groups of organisms. Cytogenetic and molecular genetic approach for the study of marmot variability lead to an increase in the number of species and changes in subgenus, superspecies and subspecies system of the genus *Marmota*.

The use of molecular genetic methods for the assessment of biological diversity led to a revision of taxonomic systems based on morphological features. Within the phylogenetic species conception, each phyletic lineage having an independent evolutionary history requires a taxonomic estimation. The crisis of the subspecies category is one consequence of this. A widespread approach to assessing the reality of morphological subspecies using molecular genetics methods leads to a revision of intragenus and intraspecies systems in different groups of organisms.

Marmots represent a clearly defined isolated group in the system of Sciuridae. This was reflected in the fact that, despite the different treatment of the family taxonomy, marmots were always distinguished as a separate genus and did not unite with other members of the family.

As for the species composition of the genus *Marmota*, only so few groups have expressed such contradictory opinions. The genus *Marmota* includes a number of forms that are not clearly diagnosed and differentiated at the morphological level. This is especially true for Palaearctic marmots including several wide spread species, whose independence and boundaries are being discussed. This found expression in the existence of many variety of species systems of Palearctic marmots with considerable unanimity in assessing the taxonomic composition of Nearctic marmots (Table 1).

Table 1. *Different variants of interpretation of the species composition of the genus Marmota.*

Source	Number of species and taxonomic interpretation of forms
Nearctic	
Nowak, 1991 Barash, 1989 Corbet, Hill, 1991 Wilson & Reeder, 2005 Steppan et al., 1999 Gromov et al., 1965 Bibikov, 1989	*1. M. broweri* *2. M. caligata* *3. M. flaviventris* *4. M. monax* *5. M. olympus* *6. M. vancouverensis*

Hall, 1981	*1. M. caligata caligata* *M. c. broweri* *2. M. flaviventris* *3. M. monax* *4. M. olympus* *5. M. vancouverensis*
Palearctic	
Brandler et al., 2010 Kryštufek & Vohralík, 2013	*1. M. marmota* *2. M. bobak* *3. M. baibacina* *4. M. sibirica* *5. M. menzbieri* *6. M. himalayana* *7. M. caudata* *8. M. camtschatica* *9. M. kastschenkoi*
Ognev, 1947 Gromov et al., 1965 Corbet & Hill, 1986 Pavlinov & Rossolimo, 1987 Gromov & Erbaeva, 1995 Rossolimo, 1995 Steppan et al., 1999 Wilson & Reeder, 2005	*1. M. marmota* *2. M. bobak* *3. M. baibacina* *M. b. kastschenkoi* *4. M. sibirica* *5. M. menzbieri* *6. M. himalayana* *7. M. caudata* *8. M. camtschatica*
Bibikov, 1967, 1989	*1. M. marmota* *2. M. camtschatica* *3. M. bobak bobak* *M. b. baibacina* *M. b. sibirica* *4. M. menzbieri* *5. M. caudata* *6. M. himalayana*
Bobrinskij et al., 1965	*1. M. marmota* *2. M. bobak bobak* *M. b. baibacina* *M. b. sibirica* *M. b. camtschatica* *3. M. menzbieri* *4. M. caudata* *5. M. himalayana*
Nowak, 1991 Corbet, 1978	*1. M. marmota* *2. M. camtschatica* *3. M. menzbieri* *4. M. bobak bobak* *M. b. baibacina* *M. b. himalayana* *M. b. sibirica* *5. M. caudata*

Ellerman & Morrison -Scott, 1951	*1. M. marmota marmota* *M. m. camtschatica* *M. m. baibacina* *M. m. menzbieri* *2. M. bobak bobak* *M. b. himalayana* *M. b. sibirica* *3. M. caudata*
Rausch, 1953	*1. M. marmota marmota* *M. m. camtschatica* *M. m. bobak* *M. m. himalayana* *M. m. sibirica* *M. m. menzbieri* *M. m. caudata* *M. m. himalayana*

Close species with fuzzy morphological diagnosis are usually combined into groups of species. The bobak group (Ognev, 1947) including *bobak, himalayana, baibacina* and *sibirica* is distinguished among the Palearctic species in the traditional systematics. Nearctic species were originally divided into caligata, flaviventris and monax groups (Howell, 1915). Palearctic *camtschatica* and *marmota* are often referred to one of the Nearctic groups, counting either the early *(marmota)* or the late *(camtschatica)* American migrants. The reality of species groups in marmots was recognized by most specialists, but the species composition of these groups (with the same names) differed among different authors.

Intraspecific taxonomy of marmots also reflects the weak differentiation of Old World marmots and more specific of New World ones. Widespread American species *caligata, flaviventris* and *monax* have 8, 11 and 9 subspecies respectively, and locally distributed *broweri, olympus* and *vancouverensis* do not form subspecies (Rausch, Rausch, 1965, Hall, 1981). At the same time, all Eurasian marmots have subspecies described but not more than four (Table 2), even for widespread species *baibacina* (4 subspecies), *bobak* (3), *camtschatica* (3) and *himalayana* (2) (Gromov et al., 1965; Gromov & Erbaeva, 1995).

Table 2. *System of the genus Marmota Blümenbach, 1779 based on classical approaches*

North American marmots (by Hall, 1981; Rausch & Rausch, 1965)	**Eurasian marmots** (by Gromov et al., 1965; Gromov & Erbaeva, 1995)
M. broweri Hall and Gilmore, 1934	*M. bobak* Müller, 1776
M. caligata Eschscholtz, 1829	*M. b. bobak* Müller, 1776
M. c. caligata Eschscholtz, 1829	*M. b. kozlovi* Fokanov, 1966
M. c. cascadensis Howell, 1914	*M. b. schaganensis* Bazhanov, 1930
M. c. nivaria Howell, 1914	*M. baibacina* Kastschenko, 1899
M. c. okanagana King, 1836	*M. b. baibacina* Kastschenko, 1899
M. c. oxytona Hollister, 1912	*M. b. kastschenkoi* Stroganov et Yudin, 1956
M. c. raceyi Anderson, 1932	*M. b. ognevi* Skalon, 1950
M. c. sheldoni Howell, 1914	*M. b. centralis* Thomas, 1909
M. c. vigilis Heller, 1909	*M. sibirica* Radde, 1862
M. flaviventris Audubon et Bachman, 1841	*M. s. sibirica* Radde, 1862
M. f. avara Bangs, 1899	*M. s. caliginosus* Bannikov et Skalon, 1949
M. f. dacota Merriam, 1889	*M. caudata* Geoffroy, 1842
M. f. engelhardti Allen, 1905	*M. c. caudata* Geoffroy, 1842
M. f. flaviventris Audubon et Bachman, 1841	*M. c. aurea* Blanford, 1875
M. f. fortirostris Grinnell, 1921	*M. menzbieri* Kaschkarov, 1925
M. f. luteola Howell, 1914	*M. m. menzbieri* Kaschkarov, 1925
M. f. nosophora Howell, 1914	*M. m. zachidovi* Petrov, 1963
M. f. notioros Warren, 1934	*M. camtschatica camtschatica* Pallas, 1811
M. f. obscura Howell, 1914	*M. c. camtschatica* Pallas, 1811
M. f. parvula Howell, 1915	*M. c. doppelmayri* Birula, 1922
M. f. sierrae Howell, 1915	*M. c. bungei* Kastschenko, 1901
M. monax Linnaeus, 1758	*M. himalayana,* Hodgson, 1841
M. m. bunkeri Black, 1935	*M. h. himalayana,* Hodgson, 1841
M. m. canadensis Erxleben, 1777	*M. h. robusta* Milne-Edwards, 1871
M. m. ignava Bangs, 1899	*M. marmota* L., 1758
M. m. johnsoni Anderson, 1943	*M. m. marmota* L., 1758
M. m. monax Linnaeus, 1758	*M. m. latirostris* Kratochvil, 1961
M. m. ochracea Swarth, 1911	
M. m. petrensis Howell, 1915	
M. m. preblorum Howell, 1914	
M. m. rufescens Howell, 1914	
M. olympus Merriam, 1898	
M. vancouverensis Swarth, 1911	

The use of genetic markers to assess the taxonomic composition and the level of taxa in marmots introduced changes in the Marmota system. The number of marmot species increased from 14 to 15 due to the acceptance of the species status of *M. kastschenkoi* on the basis of chromosome differences (Brandler, 2003; Pavlinov & Lissovsky, 2012; Kryštufek & Vohralík, 2013). Marmots became one of the first groups for the reconstruction of phylogenetic relations of which the sequencing of sufficiently long marker sequences of mtDNA cytochrome b was applied (Steppan et al., 1999). One of the results of this study was the division into two subgenus *Marmota* and *Petromarmota*, the composition of which was further refined (Brandler et al., 2010, Steppan et al., 2011). Earlier attempts dividing

Marmota into subgenus (Pocock, 1923) were not accepted by classical taxonomists (Gromov et al, 1965).

The study of intraspecific molecular-genetic variability of *Marmota* is in an active research stage. The set of used molecular markers has increased and includes both mitochondrial DNA sequences (cytochrome b, control region, etc.) and nuclear genome (microsatellites, introns of autosomal and sex-specific genes). At the same time the taxonomic significance of the obtained data for different species is different. Thus, for the Nearctic *M. caligata* it was shown that detected 2 mtDNA clades do not correspond to 9 morphological subspecies (Kerhoulas et al., 2015). Molecular variability of *M. broweri* does not form a spatial structure that could be interpreted as subspecific (Gunderson et al., 2012). On the contrary, for the Palearctic *M. himalayana*, two molecular phyletic lineages correspond to the described morphological subspecies (Yan et al., 2017).

Some of obtained by us data on the molecular genetic variability of Palearctic marmots correspond to the previously described subspecies structure in some species. Thus, the results of studying the variability of the nuclear genome according to inter-SINE-PCR support the separation of *M. camtschatica* into three subspecies and *M. sibirica* into two subspecies, but do not correspond to the described subspecies of *M. bobak* (Brandler et al., 2010). According to the sequencing of the complete control region of mtDNA in the tarbagan (Kapustina et al., 2015) the subspecies *M.s. caliginosus* is clustered into two groups, a subspecific divergence level of which may be discussed after collecting additional data. Intraspecific molecular-genetic differentiation of *M. baibacina* allows us to discuss a more complex subspecies structure than described by morphological features. The level of differentiation of the subspecies *M. b. centralis* within *M. baibacina* s. l. exceeds the differences between *baibacina* and *kastschenkoi* forms according to the variability of the nuclear genome (Brandler et al., 2010) and the sequencing of several molecular markers (our unpublished data). The latter indicate a noticeable differentiation of marmots from the southern Tien Shan in Xinjiang within the framework of gray marmots. Earlier, the superspecies *M. baibacina* was proposed in composition of *M. baibacina* s. str. and *M. kastschenkoi* basing on an analysis of the complex of features (Brandler et al., 2010). Our preliminary data on the molecular genetic variability of *M. bobak* (Brandler et al., 2011) do not correspond to subspecific division and possibly support the biogeographical concept of intra-species differentiation of steppe marmots (Rumyantsev, 1997).

We can propose for discussion a system of Palearctic marmots, including the separation of species groups, superspecies and infra-species forms (Table 3), which does not contradict the available data of molecular-genetic variability.

Table 3. *Proposed classification of Palearctic species of the genus Marmota.*

Species groups	Superspecies	Species	Subspecies
		M. caudata	*M. c. caudata* *M. c. aurea*
		M. menzbieri	*M. m. menzbieri* *M. m. zachidovi*
		M. marmota	*M. m. marmota* *M. m. latirostris*
bobak	*M. baibacina*	*M. baibacina*	*M. b. kastschenkoi* *M. b. centralis* *M. b. ssp. nov.*
		M. kastschenkoi	
		M. bobak	
camtschatica		*M. camtschatica*	*M. c. camtschatica* *M. c. doppelmayri* *M. c. bungei*
		M. himalayana	*M. h. himalayana* *M. h. robusta*
		M. sibirica	*M. s. sibirica* *M. s. caliginosus* *M. s. ssp. nov.*

We distinguish bobak and camtschatica groups but do not support the caudata group (Steppan et al., 1999) which was composed from *M. caudata* and *M. menzbieri* based on the similarity of mtDNA markers. According to the morphological data and the variability of nDNA markers these species are distant related (Brandler et al., 2010). The separation of the marmota group (Kryštufek & Vohralík, 2013) in the same species *M. marmota* composition seems to us unjustified.

The separation of *M. camtschatica* superspecies (Boeskorov et al., 1999) seems to us to be insufficiently justified. It is necessary to obtain additional data for acceptance of the species independents of *doppelmayri*. The mention of new subspecies in *M. baibacina* and *M. sibirica* (Table 3) is suggested by us as the discussed possibility of their reality.

It should be noted that the available data on intraspecific molecular-genetic variability of marmots are fragmentary and not obtained for all species. In this regard, further research in this area is relevant.

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SIBERIAN MARMOT *(MARMOTA SIBIRICA)* ECOSYSTEM ENGINEERING SUPPORTS DARKLING BEETLES *(BLAPS RUGOSA)* IN HUSTAI NATIONAL PARK, MONGOLIA

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Ecosystem engineering – the physical modification of habitat by a species - can create habitat patches that affect the distribution and abundance of other species relative to adjacent, unmodified habitats. The Siberian marmot *(Marmota sibirica)* is a large, endangered rodent that lives colonially and creates extensive burrow systems that change the soil nutrient profile and influence plant and animal community composition and productivity. The effect of marmot burrows on invertebrates remains largely unexplored, yet may have conservation implications for species that perform various ecosystem services. Here we surveyed the occupancy of darkling beetles *(Blaps rugosa)*, a common invertebrate in forest-steppe ecosystems, in relation to marmot burrow colonies and other landscape variables in Hustai National Park, Mongolia. We surveyed 130 sites, including 43 active burrow sites, 45 non-active burrow sites, and 42 control sites with no burrows in the summer of 2016 and used a model selection approach to develop an occupancy model for the species that accounted for imperfect detection. We recorded beetles at 30 active and 27 non-active sites during 43.8% of surveys. Our top-ranking model indicated that beetle occupancy probability was positively influenced by the presence of marmot burrows (both active and inactive) and that detection probability was a function of temperature and was highest at +26.5°C. Our model represents the first quantitative, empirically-based occupancy model of Blaps rugosa, and reveals the impact of marmot engineering on the distribution of beetles in a landscape. Our results also suggest that improving the conservation status of marmots will indirectly benefit beetles.

Key words: *Blaps rugosa*, ecosystem engineering, forest steppe, marmot burrow, *Marmota sibirica*, Mongolia

Running title: Buyandelger et al. Siberian marmot ecosystem engineering supports darkling beetles

Introduction

Siberian marmots (*Marmota sibirica* (Radde, 1862) are large (approximately 3.9-4.2 kg as adults) herbivorous rodents that burrow and live colonially. Marmots are highly endangered in Mongolia due to overharvesting for fur and meat (IUCN Red List 'EN'; criteria A2 ad) and have been experiencing significant population declines (62%-75%) across Mongolia (Kolesnikov et al., 2009; Buuveibaatar & Yoshihara, 2012).

Burrowing mammals are keystone ecosystem engineers in many communities because burrowing is an engineering activity that can directly and indirectly alter the availability of resources, has affects at multiple spatial and temporal scales, and has a significant role in community organization (Dickman, 1999; Reichman & Seabloom, 2002).

Siberian marmots are known as ecosystem engineers and their mound building transforms grassland landscapes, creating unique habitats for many other species (Van Staalduinen & Werger, 2007; Davidson et al., 2008; Townsend, 2009). Ecosystem engineers are organisms that control the availability of resources for other species by creating and modifying habitat (Jones et al., 1994). Ecosystem engineers alter habitat in such a way as to reduce physical and biological stresses for other organisms (Crain & Bertness, 2006). We expect that the Siberian marmot has an important role in their ecosystems within their range, and is likely a 'keystone species' (Mills et al., 1993; Adiya, 2000; Townsend & Zahler, 2006), however, little is known about some of its ecological role, and in particular if marmot colonies represent a biodiversity hotspot.

Ecosystem engineering is the physical modification of habitat by a species which creates patches with altered species richness relative to adjacent, unmodified habitats. One marmot family or colony usually has several burrows, including active burrows (summer and wintering burrows) and non-active burrows (Adiya, 2000). Non-active burrows are those which temporarily shelter marmots from carnivores, raptors, and bad weather conditions, when traveling looking for food far from their active burrows. In Eastern Mongolia, where the marmot density is high, one family could have an average of 2.9 (2.1–3.5) non-active burrows, whereas marmots in lower density areas have an average of 4.8 (3.7–5.7) non-active burrows (Kucheruk, 1983).

Marmot colonies also act as primary producers and providers of rich resources of organic materials as well as important shelter in the microenvironment (e.g. microclimate, soil nutrients and moisture) which they create. They are of vital importance for the distribution and structure of soil and ground-dwelling invertebrate communities (Deville, 1927; Zinchenko, 2006). Rodent burrows appear to exert disproportionately large effects on species of Coleoptera, especially Scarabaeidae (Moradi and Ziani 2009, 2010; Ziani and Moradi, 2011) and Leiodidae (Peck and Skelley 2001).

The diversity of Coleoptera found in marmot burrows has been studied by various authors. Zinchenko (1997) recorded 31 species of beetles belonging to three families including Histeridae, Scarabaeidae, and Eucinetidae from burrows of *M. bobak* in Orenburg Province, Russia. Zinchenko (1999, 2002) found 44 species of Scarabaeidae from the burrows of *M. baibacina* in the European part of Russia, and 25 species belonging to five families of beetles from the burrows of *M. bobak* in Kemerovo Province, Russia. In addition, several new species, such as *Atheta mariei, Aleochara marmotae* (Staphylinidae), *Catops joffrei* (Leiodidae), and *Cryptophagus arctomyos* (Cryptophagidae) were found in marmot burrows (Deville, 1927) and Grandinaphodius inferorum (Scarabaeidae) in small rodent burrows (Ziani, 2002). Beetles found in marmot burrows represented the families Scarabaeidae, Histeridae, Phalacridae, Staphylinidae, and Eucinatidae. There was no record of *Blaps rugosa* or other member of the family Tenebrionidae. However, the studies at the same sites did show that species richness and abundance of coprophilous beetles (Scarabaeidae) had negative correlations with domestic herbivore density (Bayartogtokh & Otgonjargal, 2009).

The omnivorous and saprophagous *Blaps rugosa* (Tenebrionidae) is a flightless darkling beetle which is well adapted to semi-arid and arid environments because of specific behavioral and morphological traits. Its body structure and habits allow it to live in the dry and hot habitats. Adults are not attracted to light, and their living activities have clear cycles. The beetles live mostly underground in the burrows of rodents and in natural holes. They also can be found under various objects, such as livestock and wild herbivore dung, logs, accumulated plant debris etc., which serve as shelter. The hatching larvae and beetles hibernate inside rodent burrows and appear above ground at the end of April, when the sun warms the upper soil layers (Sagdi, 1996). The species is known to make use of a defensive gland to protect itself, and it is possible that the gland secretion might be usuable as a crude medicine (Gunbilig & Boland, 2009).

One of the important ecosystem services performed by *B. rugosa* is that the faeces of the darkling beetles, despite their insignificant mass, have a great stimulating effect on cellulose-degrading microflora, which contributes to an increase in the rate of mineralization of plant litter in arid and semi-arid zones (Dorzhieva & Chimitova, 2008, Mordkovich, 2003). In addition, various *Blaps* species become food resources for other animals. For example, *B. femoralis* formed 89.5% of the content of Daurian hedgehog scats (N=38 scats) (Murdoch et al., 2006), and was present in 10.1-12.9% of corsac fox *(Vulpes corsac)* scats (N=996), 9.8-21.6% of red fox *(Vulpes vulpes)* scats (N=1142) (Buyandelger 2008) and ~40% (unpublished data table) of Eurasian badger *(Meles leucurus)* scats (N=116) (50% of Tenebrionidae (Murdoch and Buyandelger 2010). Many birds also feed on the Blaps beetles, including Mongolian Skylark *(Melanocorypha mongolica mongolica)* (Ling, 1992) and Lesser Kestrels *(Falco naumanni)* (Onolragchaa et al., 2017).

In this paper, we estimate *B. rugosa* occurrence in relation to the availability of marmot colonies. More specifically, we examined the influence of colonies on the probability of *B. rugosa* occurring within certain habitat on the landscape. Our general hypothesis was that marmot colonies have a positive influence on *B. rugosa* occupancy probability because burrows offer shelter from environmental conditions and refuges from predation, and also support a high diversity of insects and other prey items. We also examined an alternative hypothesis focused on investigating the influence of forest steppe habitats in Hustai National Park, including open plains, foothills and upper slopes, drainages, and near springs on *B. rugosa* occupancy. Our approach involved 1) developing a set of a priori candidate models that we believed potentially described *B. rugosa* occupancy in the landscape, 2) surveying *B. rugosa* at multiple sites to collect detection and non-detection data, and information on marmot and habitat features associated with each site, and 3) using model selection to rank models to evaluate which best represented the data.

Material and Methods

Study area

We conducted this study in the Hustai National Park, situated 100 km southwest of Ulaanbaatar, the capital city of Mongolia. Hustai National Parkcovers approximately 60,000 has at elevations ranging from 1100 to 1840 m above sea level. The National Park occurs at the southern edge of the forest-steppe zone and includes mountains, plains, dunes, and a river valley. Only 4%, or 2000 ha, of the park is covered by forest and 88% is grassland and shrub-land steppe (Buuveibaatar & Yoshihara 2012). Several dry steppe and mountain steppe vegetation types, which occur in the Mongol Dahuria and Middle Khalkha biogeographical regions, are represented in the park. The region is arid with ≤240 mm of annual precipitation, which falls mostly as rain (80%) between June and August, and air temperature ranges from -40 (average winter temperature -20°C) to +40 (average summer temperature +18°C). The landscape is dominated by mountains of granitic rocks with valleys creating varying habitat types. The vegetation is dominated by bunch grass, *Stipa krylovi*, with *Artemisia adamsii, Artemisia frigida, Agropyron cristatum* and *Cymbaria dahurica* as typical species (van Staalduinen, 2005). Marmot abundance is high there, with population density of 70.6 families/km^2 (Kolesnikov et al., 2009). Grey wolves *(Canis lupus)* and raptors, such as steppe eagle *(Aquila rapax)* and golden eagle *(Aquila chrysaetos)* prey on marmots.

Survey

We surveyed 130 sites (Figure 1), including 45 non-active, 43 active burrow sites and 42 control sites during the summer of 2016. The randomly surveyed sites were selected from an array of elevation outcroppings in variable areas, and from a digitized land cover layer using ArcGIS version 10.3 (ESRI, Redlands California, USA) in combination with information from the rangers of the National Park. We visited all the selected points and identified active and non-active colonies as we observed marmots or saw signs of recent marmot activity, including ≥3 open burrows with fresh scat and tracks at the beginning of the study. The recording of new sites was spaced >500 m apart to ensure independence, and this distance was based on another lizard survey (see Murdoch et al., 2013). We recorded *B. rugosa* occupancy with three repetitions in a plot, and conducted our first survey in June, the second in July, and the third in August.

Each survey site was a 25 m radius circular plot. We estimated air temperature and wind speed (at the plot center) using a handheld weather station (measured with a Kestrel 3000 Pocket Weather Meter) at the beginning of each survey, then an observer walked through the plot in a circlular pattern for 5 min, and recorded whether the beetles were present (1) or absent (0). We based the survey time on trials before the study began that indicated *B. rugosa* were usually quickly detected.

At each site, we quantified habitat on the basis of substrate. Habitats were classified by aspect/elevation 1) foothill, which included a low hill at the base of the mountain, 2) upper slope, which included the side of a hill or mountain, 3) open plain, which included gently rolling gravel plains of short grasses and forbs, or 4) drainage, which included natural removal of surface and sub-surface water from an area.

Survey modeling approach

Occupancy modeling is a statistical tool developed to estimate population parameters and investigate the influence of habitat variables on those parameters (Mackenzie et al., 2002). We used single-season occupancy models implemented in the program PRESENCE (v. 4.4, J. E. Hines, Patuxent Wildlife Research Center, Laurel, Maryland, USA) adjusted for detection probabilities. Models were ranked by their AIC (Akaike Information Criterion) scores corrected for small sample size (AIC_c) and weight (AIC weight) in program PRESENCE for model selection (Burnham & Anderson, 2002). We considered the model with the smallest AICc value to be the best model to fit the data and any model within 2 AICc values as a competing model (Burnham & Anderson 2002). We used Akaike weights to assess the strength of evidence for one model versus another model.

Results

We conducted 390 surveys and detected *B. rugosa* during 43.8% of them. We detected *B. rugosa* at 30 marmot active burrow sites and 27 non-active burrow sites, resulting in a naïve occupancy estimate (i.e., total number of sites where darkling beetles were detected/total number of sites surveyed) of 0.452 across all sites. Air temperature in the survey ranged from +17.4 to +38.0°C (mean ± SD = 24.23±0.26). The mean percent of habitat surrounding sites was: 28±0.2 for foothill, 33±0.1 for drainage, 25±0.2 for open plain and 14±0.1 for upper slope.

Bootstrap analysis indicated that our data fit the assumptions of single-season occupancy modelling (MacKenzie et al., 2002). The χ^2 of the observed data was 11.696 and probability of this value was 0.0594 (mean χ^2 of the bootstraps simulations =5.1267). Given little evidence of lack of fit, we continued with model selection procedures to estimate the weight of evidence of all models in the model set.

Model selection results indicated that *B. rugosa* occupancy is influenced by burrow presence: Marmot burrow ψ(Burrow), p(temp+temp^2) was the best approximating model (Table 1). This model accounted for 55.7% of the AICc weight among the competing models, with no competing model <1.70ΔAIC$_c$. The exclusion of habitat to the top model produced the 2nd ranked model (AICc weight = 23.8), and followed by exclusion detection probability from the top model (Table 1, AIC$_c$ weight = 14.5%). The model which included burrow as a variable was >70.24%, and habitat+burrow was <29.75%.

The remaining models were ≥19.2 ΔAICc from the best model. Beta (β) coefficients for both the active burrow sites and non-active burrow sites were positive, indicating that with a higher percent of these marmot colonies around a given site on the landscape, occupancy probability increased (Table 2). Confidence intervals (95%) around these betas also did not cross zero, suggesting that the effect of these parameters on occupancy was real (Table 2). Additionally, aspect/elevation had little influence on the *B. rugosa* occupancy.

Our top model estimated the effect of temperature on detection probability. Beta estimates from the model (Table 2) indicated that detection probability was >37% between +20.8°C and +27.1°C (Figure 2). B. rugosa detection probability was highest at approximately +26.5°C.

Discussion

This study is consistent with the hypothesis that Siberian marmot may be keystone species for certain species' occupancy due to their engineering activities (Murdoch et al., 2013). Our results show that ecosystem engineering by Siberian marmot had keystone-level effects on *B. rugosa* occupancy in all types of habitat in the study area. *B. rugosa* occupancy 55.7% in relation to marmot burrows ± detection probability.. Especially interesting was our finding that habitat diversity and elevation did not affect the beetles' occupancy. The occupancy of many other invertebrates is largely associated with rodent burrows. The reason may be the availability of habitat patches, through ecosystem engineering (Bangert & Slobodchikoff, 2006; Davidson & Lightfoot, 2007; Kenney et al., 2016), food resources (Zinchenko, 1997, 1999, 2002; Peck & Skelley, 2001; Moradi & Ziani, 2009, 2010; Ziani & Moradi, 2011), shelter (Adiya, 2000; Nikol'skii, 2003), and increased nitrogen level in soils for oviposition(Dempster, 1963).

Burrowing reduces soil bulk density, which in turn increases water infiltration into the soil, as well as the concentration of soil nutrients, such as carbon, nitrogen and phosphorus (Gabet et al., 2003; Eldridge et al., 2012). Burrowing activity by marmots indirectly creates favorable microhabitat for plant communities by a physical process that mixes and aerates soil layers (Townsend, 2006; Yoshihara et al., 2010b). By providing key habitat with high concentration of resources, rodent burrows enhance population, species richness, and occupancy for various taxonomic groups. The insect-pollinated plant productivity promoted by marmot ecosystem engineering supports pollinators (Yoshihara et al., 2010a). Furthermore, we very often observed the darkling beetles at the entrance of marmot burrows. Burrow entrances are usually surrounded by bare soil and short-turf vegetation. Cizek et al. (2012) showed that *B. lethifera* was associated with bare-ground patches, especially rodent burrows.

The strong association of omnivorous *B. rugosa* with marmot burrows appears to be in large part because burrows provided food sources. Other studies showed that keratinophilic fungi, especially *Microsporum gypseum* had greater occurrence in marmot burrow soil than in the surrounding area (Battelli, 1978). *B. rugosa* can use marmot faeces as their food resource, in the same manner as dung beetles. Also, *B. rugosa* probably feeds as a scavenger on decomposing nest matter or microorganisms growing on the marmot faeces in the burrow, same as carrion beetles (Peck & Skelley, 2001).

Darkling beetle occupancy is not only limited to the active burrow sites. They also occur in non-active marmot burrows (see Figure 3). The non-active burrow, which is usually farther away from the active burrow, is also used by species besides marmots (Kucheruk, 1983). *B. rugosa* may not use burrows only as a food source , but also for shelter from extreme environmental conditions. Microclimate in marmot burrows is relatively stable, not overheating even in hot weather, and remains above freezing even with significant decreases in air temperature on the soil surface (Adiya, 2000; Nikol'skii, 2003). The high moisture content is probably advantageous to many species, especially in arid environments where evaporative water loss may be significant above ground, although high relative humidity may restrict evaporative cooling in animals, which may be a problem for individuals with excessively high body temperatures (Reichman & Smith, 1990). Rodent burrows also support species richness as many beetles, including those from the families Leiodidae, Staphylinidae, Carabidae, Scarabaeidae etc. use marmot droppings as a food resource for themselves and their larvae.

Another alternative hypothesis for the co-occurrence of rodents and beetles is that beetles lay their eggs in rodent burrows. Species searching for a substrate upon which to oviposit must be guided in the darkness by an acute sense of smell (Pont & Ackland, 1995). Therefore, for the darkling beetle the oviposition process might include the need for conditions such as the presence of animal droppings, burrows, or caves etc. McIntyre (1999) showed that some darkling beetles use ant nest-sites for oviposition and thermoregulation in the grasslands of North America. However, at our research site, darkling beetle occupancy was significantly influenced by marmot burrow presence not only in the breeding season of the beetle but also during non-breeding periods.

The ecosystem engineering concept focuses on how organisms physically change their landscape and how these changes create feedback mechanisms that affect the biota of these sites (Jones et al., 1994). Our research results give insight into how marmots create important habitats for the darkling beetle and demonstrate that engineering species have an irreplaceable role in this ecosystem. Marmot burrows provide a network of basking sites for thermoregulation, foraging locations, and refuge for *B. rugosa* across the landscape, likely resulting in more favorable habitat and higher survivorship at the landscape-scale. Our occupancy analysis supports our hypothesis that marmot colonies have a positive influence on *B. rugosa* occupancy probability because burrows offer shelter from extreme environmental conditions, refuges from predation, and support a high diversity of insects and other prey items.

Our model is the first quantitative, empirically based occupancy model of *B. rugosa*, and may be adaptable for analysis of different ecosystems with marmots in Mongolia. Further studies should consider examining the *B. rugosa* diet, the relationship between marmot burrows and *B. rugosa* food preferences, the ontogenetic life history of this darkling beetle species, and importance burrows for the species' larval development. Other burrow digging rodents may influence darkling beetle occupancy in the steppe ecosystem. We focused on marmot colonies and habitat types at one spatial scale. It is possible that *B. rugosa* occupancy may also be influenced by other predators (e.g. hedgehog, badger and birds) and sympatric species (e.g., *B. reflexa and Carabus spp.*), and further studies should consider assessing patterns of co-occurrence with these species.

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Table 1. *Response variables used to examine Blaps rugosa occupancy probability (ψ) in Hustai National Park, from June to August 2016.*

Covariate name	Description	Measure	Predicted effect on ψ	Supporting Literature
Burrow	Occupancy probability influenced by active burrow site and in non-active burrow.	Active and non-active	Positive	Murdoch et al, 2009, 2013, 2016; Shipley and Reading 2006
Upper slope	Including the side of a hill or mountain	Proportion	Negative	Todgerel 1998, Yoshihara et al, 2010 b
Foothill	Including a low hill at the base of a mountain	Proportion	Positive	Todgerel 1998, Yoshihara et al, 2010b
Drainage	Including natural removal of surface and sub-surface water from an area	Proportion	Positive	Todgerel 1998, Yoshihara et al, 2010b
Open plain	Including gently rolling gravel plains of short grasses and forbs	Proportion	Positive	Murdoch et al, 2013, 2016, Yoshihara et al, 2010 b

Table 2. *Model selection results of Blaps rugosa probability of occupancy (ψ) indicating the fit of 8 models to the observed data collected in Hustai National Park, from June to August 2016. Occupancy covariates included: presence on marmot burrow site, and habitat including foothill, open plain, drainage and upper slope within 250 m of a site.*

Model	AIC	deltaAIC	AIC wgt	Model Likelihood	no.Par.
psi(Burrow),p(temp+temp^2)	371	0	0.5572	1	5
psi(Burrow+Habitat),p(temp+temp_sq)	373.65	1.70	0.2382	02328	6
psi(Burrow),p(.)	374.64	2.69	0.1452	0.1065	3
psi(Burrow+Habitat),p(.)	376.43	4.48	0.0593	0.1065	4
psi(.),p(temp+temp2)	391.21	19.26	0.0000	0.0001	4
psi(Habitat),p(temp+temp2)	392.76	20.81	0.0000	0.0000	5
psi(.),p(.)	394.16	22.21	0.0000	0.0000	2
psi(Habitat),p(.)	395.77	23.82	0.0000	0.0000	3

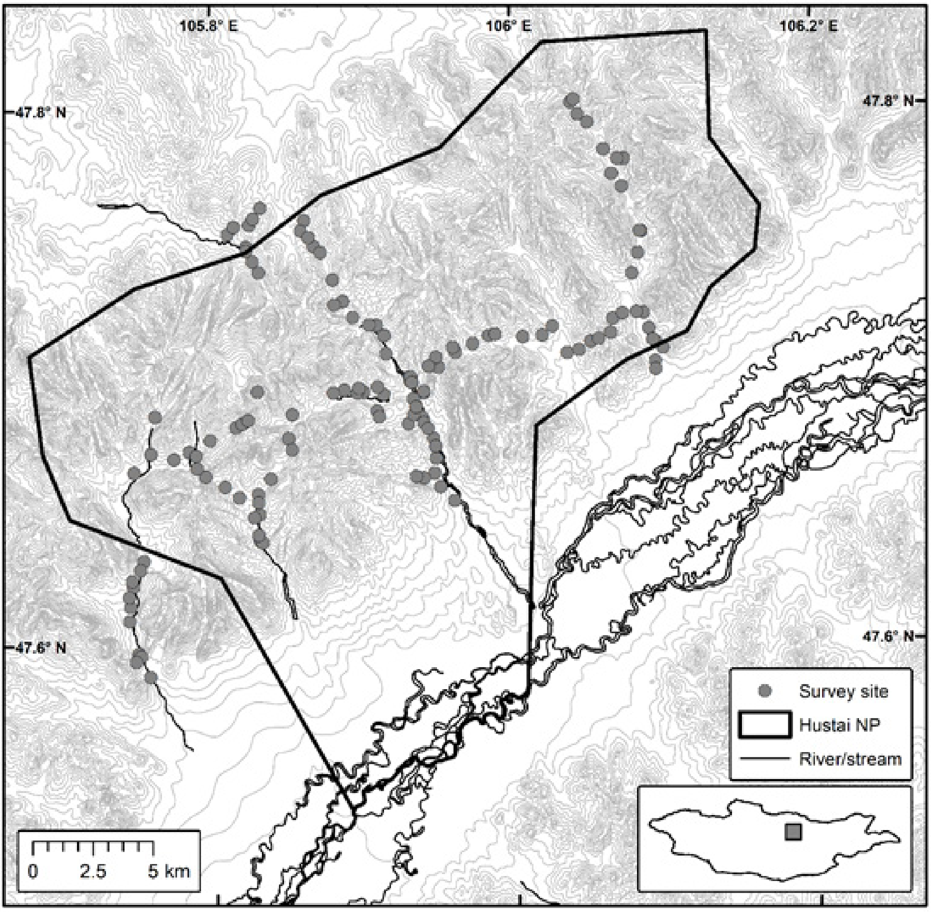

Figure 1. *Map of the study area in Hustai National Park, Mongolia, showing the survey spots in the main areas of marmot distribution.*

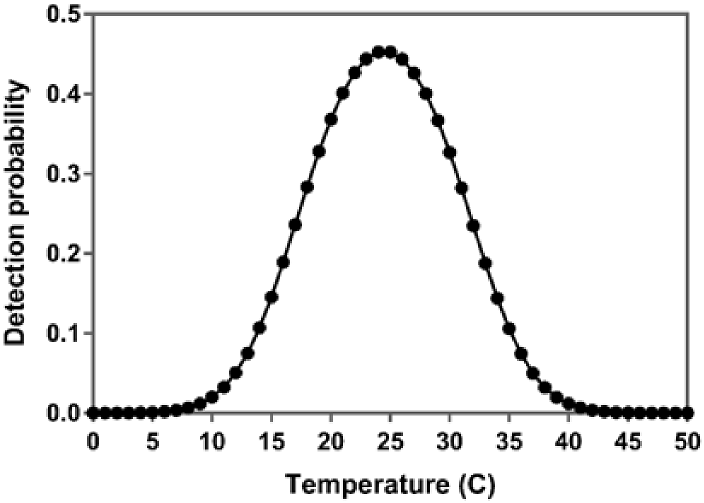

Figure 2. *Blaps rugosa probability of detection p(temp+temp2) as a function of temperature. Probability estimated from the top-ranking model of occupancy data collected in Hustai National Park, from June to August 2016.*

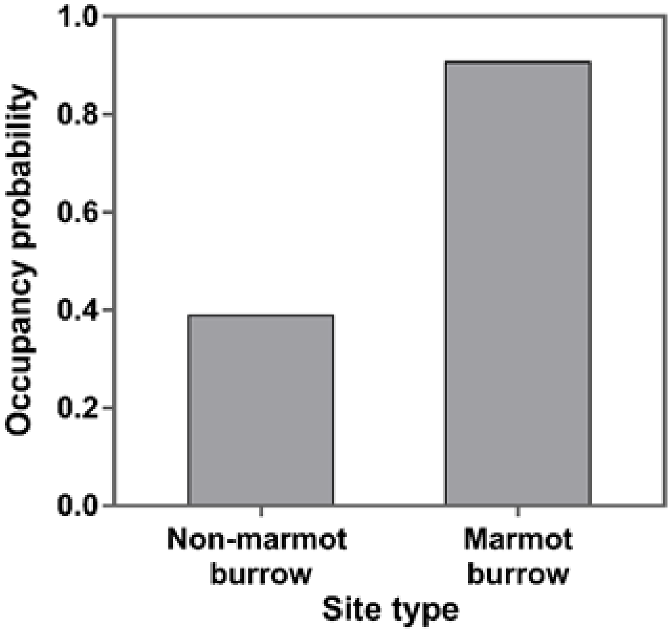

Figure 3. *Blaps rugosa occupancy probability ψ(Burrow) as a function of the proportion of marmot burrow site within 250 m of each location. Probability estimated from the top-ranking model of occupancy data collected in Hustai National Park, from June to August 2016.*

BIBLIOGRAPHY OF SCIENTIFIC WORKS DEVOTED TO THE STUDY OF STEPPE MARMOT IN THE SOUTH URAL REGION

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Steppe marmot (Marmota bobak Müller, 1776) is a typical inhabitant of the South Ural steppes. References to it go back centuries, to the legends and signs of the indigenous peoples of the South Ural region – Bashkirs. The first scientific mention of the steppe marmot appeared in the classical works of researchers of the Orenburg region relatively recently, in XVIII-XIX centuries. To the present time there is a significant amount of information about the steppe marmot. Various works on the biology and ecology of bobak have been carried out. Numerous articles, notes, monographs, abstracts of dissertations requiring a systematic approach to their analysis were published.

This paper presents bibliographic listing of scientific papers grouped according to the subject and the nature of their content.

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This paper presents a very incomplete list of publications the authors of which in different years covered the most important aspects of biology and ecology of steppe marmot in the South Ural Region. However, it is necessary to carry out additional studies concerning the ecology and modern distribution of the species in the area in order to preserve the bobak in the South Ural steppes .

БИБЛИОГРАФИЯ НАУЧНЫХ РАБОТ, ПОСВЯЩЕННЫХ ИЗУЧЕНИЮ СТЕПНОГО СУРКА НА ЮЖНОМ УРАЛЕ.

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Степной сурок (Marmota bobak Müller, 1776) - типичный обитатель южноуральских степей. Упоминания о нем уходят в глубь веков, к приданиям и приметам коренных народов Южного Урала - башкирам. Первые научные упоминания о степном сурке появились сравнительно недавно в классических трудах исследователей Оренбургского края в XVIII-XIX вв. К настоящему времени накопился значительный объём информации о степном сурке. Проведены разносторонние работы по изучению биологии и экологии байбака. Опубликованы многочисленные статьи, заметки, монографии, авторефераты диссертационных работ и т.п., требующие системного подхода в их анализе.

В данной работе представлены библиографические списки научных работ, сгруппированные в соответствии с тематикой и характером их содержания.

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В данной работе представлен далеко не полный перечень публикаций, авторы которых в разные годы освещали важнейшие аспекты биологии и экологии степного сурка в южноуральском регионе. Однако для сохранения байбака в южноуральских степях необходимы дополнительные исследования, касающиеся экологии и современного распространения вида на данной территории.

THE HISTORY OF THE STUDY OF STEPPE MARMOT IN THE SOUTH URAL REGION

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Steppe marmot, or bobac (Marmota bobak), lives in the South Ural steppes from ancient times attracting a person’s attention. So, in the Bashkir folk calendar the last snow blizzards were called "huur buran" ("huur" is «bobac» in Bashkir) since according to the folk sign - the first whistle of a bobac (Kirikov, 1980) precedes the approach of these burans. The first mention of the steppe marmot appeared in the classic works of researchers of the Orenburg region in the XVIII-XIX centuries. Thus, P. S. Pallas (1786) wrote about the" great multitude" of bobacs in the vicinity of the Tatishcheva fortress. He reported that near the village Novosergievka marmots and ground squirrels lived in all grave hills. In a note to the general land surveying of the Orenburg district the habitation of marmots was noted in the lands of the Verkhneye-Ozernaya, Nizhneye-Ozernaya and Elinskaya fortresses, settlement Kargala of Sakmarskii town. In the middle of the XIX century, according to E. A. Eversman’s reports (1850), there were many marmots in the steppes of Obshchiy Syrt, in the south-western and southern foothills of the Ural covered with "northern grass steppes". Noting the distribution features of the marmot in the forest-steppe Urals, the author wrote that the settlements of marmots had been found in the steppe with hilly and mountainous terrain. However, E. A. Eversman pointed out that these animals were mined only by the local population using their meat for food, and skins for the manufacture of caps and edges of caftans and fur coats. Every year up to one hundred thousand or more marmot skins were brought to the Orsk fortress for sale.

In the second half of the XIX century S. T. Aksakov had given some information about the way of life of marmots in the Buguruslan district in his "Notes of rifle hunter of Orenburg province" (Aksakov, 1852): "...I still remember that around the villages, where used will not look, everywhere on the hillocks, remaining after digging a hole, they were sitting on their hind legs like bear cubs, and noisy whistles echo each other".

Later, at the end of the XIX century, N.A. Zarudny had described the settlement of marmots in the Orenburg steppes in detail in the "Notes to the knowledge of the mammal fauna of the Orenburg territory" (Zarudny, 1897) noting them in the north of the middle course of the Ural river, in the feather-grass steppes between Kargala and the Yangiz, aroud the Salmysh, on the watershed between the bottom of the Sakmara river and the valley of the middle Ural river, in the steppes between the Sakmara and the Guberlinsky mountains. He had met numerous colonies in the Ural-Ilek interfluve of the rivers near the Donguz river, the Vetlyanka river, the Peschanka river, the Berdanka river, etc. Also, N. A. Zarudny had described an interesting migration of marmots. In 1890 on the Grebenskaya mountain where there was a colony of 30-35 marmots most of its inhabitants abandoned it for no apparent reason and established a new settlement 15 miles to the East. He had repeatedly observed the movement of marmots on several individuals in the morning, evening, and even at night when they sailed among the hollow water. In addition, he noted the time of hibernation and the revival of the Orenburg bobac.

More detailed studies relating to the distribution features of the steppe marmot were conducted at the beginning of the XX century. However, these activities were sporadic. So, in the South-Western part of the Orenburg region, on the left bank of the Chagan river, near the village Miroshkino, a subspecies of the steppe marmot *Marmota bobak skaganensis* (Bazhanov, 1930) was first described, now it is called *"kazakhstanskiy"* (Bazhanov, 1930). Small colonies of marmots were described near Buzuluk (Bazhanov, 1928), on the watershed of the Kamsak and the Kumak (Kuznetsov, 1928).

A. P. Raysky (1951) was observing the colony of marmots almost in the forest on the border of the Orenburg region with Bashkiria between the villages Otradny and Ermolaevka. The author described an unusual way of hunting animals: hunters hiding behind the trees guard the coming out of marmots from holes. In S.V. Kirikov's work (1952) it was mentioned that the colony including more than a hundred animals was located on 25 hectares on the left bank of the Curuil river, between the villages Curuil and Yanybaevo, and it was also described several colonies in the Ural left bank of the hills in surrounding villages Konoplyanka, Podgorny, Adaevo, Ilinskaya. Later, Yu. A. Dubrovsky (1962) mentioned small colonies of marmots located to the East of the upper reaches of the Kumak river to Zhety-Kol lake on the plain areas of turf-grass steppes. According to the author, the most extensive settlements were concentrated on the watershed of the Irgiz and Ushkaty rivers as well as the basin of Shalkar-Yega-Kara lake.

Thus, the main result of the work of the second half of the XVIII century-the first half of the XX century was the study of the geographical distribution of the species. No other purposeful researches had been carried out during that period in the South Ural steppes.

Scientific work on the study of the bobac population in the steppes of the South Ural region intensified only in the 70-80s of the XX century. It was during that period that there was an increase in general interest in the study of the steppe marmot in the region. Therefore, it is not accidental that the published works of that time covered a variety of aspects of biology and ecology of the species.

Thus, a number of works on bioacoustic analysis of the vocalization of marmots by A. A. Nikol'sky (1969, 1976, 1983, 1984, etc.) was published. A. A. Nikol'sky (1969) suggested the term "phonotype" to describe biologically similar signals of bobacs with their similar physical characteristics. Later, he showed the species specificity of the marmot scream and determined its reflective features which turned out to be spectral and amplitude-time characteristics (Nikolsky, 1976, 1984). A warning signal of the marmot with absolute specificity of species is a reliable diagnostic feature for taxonomic studies (Nikol'sky, 1976).

No less actuality in that period were the works devoted to the biology of reproduction of steppe marmot in the South Ural region (Rudi et al., 1993, 1994, 1996; Soustin et al., 1996; Shevlyuk, 1996b, 1997; Shevlyuk et al., 1997, 1999, 2000; Bragirova (Fedorenko), Shevlyuk, 2002). Thus, these studies revealed a clear age structure of populations which includes animals of three groups: 1. fingerlings - animals of the same age, don't participate in the reproduction; 2. yearlings-in reproduction, as a rule, not participating; 3. animals at the age of 2-3 years and elder-are the main producers. The seasonal dynamics of the marmot reproductive activity was determined, which has several significant features: the mating period is limited to very short time frames; males are characterized by extremely deep inhibition of the functions of the sex glands which occurs immediately after the mating; the presence of two peaks of the concentration of male sex hormones in the blood serum of these animals; the state of reproductive activity depends on calendar terms but not on weather conditions (Shevlyuk et al., 2000).

In addition, it was studied in detail such aspects of biology of reproduction of steppe marmot as the fecundity of the species, the sex ratio in the population as well as caring for offspring, which is realized by the resources of the family group in which marmot cubs were born (Shevlyuk et al., 2000).

With the advent of the Commission for the study of marmots at the Academy of Sciences of the USSR, organized by D. I. Bibikov, this research had accelerated not only in the South Ural region and in many regions of the country but also abroad. During the implementation of the joint Russian-French program "Ecological basis for management of marmots biodiversity in Eurasia" in the period from 1994 -1996 various works on the study of steppe marmot ecology were carried out. In particular, the comparative effect of anthropogenic and abiotic factors as well as their combined effect on marmot settlements (Le Berre et al., 1994) were investigated.

In the future, one of the important directions in the study of biology and ecology of steppe marmot was the fact that absolutely protected mode in the areas of the state nature reserve "Orenburgsky", organized in 1989, influences on the population of the bobac. In the works of G. M. Geide (1991) the distribution of marmot settlements was described in detail as well as the approximate number of species in the reserve. A little later, O. V. Soroka (2001) noted that the population of bobaks increased for a ten-year period of conducting absolutely-reserved mode in the territory of the state nature reserve "Orenburg". As a result of long-term observations in the protected area environmental factors affecting the dynamics of seasonal and daily activity of bobak as well as the duration of its hibernation (Soroka, 2000) were identified. It was established that hibernation of animals in our region lasts for about 8 months, and the period of active life makes only 4 months that coincides with phenological timing which are a characteristic feature of marmots living in the Central Kazakhstan (Shubin, 1963).

At the turn of the centuries, researches devoted to the influence of human economic activity on the steppe marmot population and its adaptation to man-made landscapes as well as the protection and rational use of marmots come to the fore (Bibikov, 1980; Bibikov, Rudi, 1987; Mashkin, 1991, 1997, 2000; Rudi, 1989, 1991, 1994, 1995, 1997; Rudi, Malyutina, 1991; Rudi, Smetanin, 1996, 1997, 1999; Rudi, Shevlyuk, 2000; Fedorenko et al., 2005; Fedorenko, 2006). As the authors note, with the advent of the settled population in the XVI-XVII centuries in the South Ural region, the human impact on the environment had increased. Steppes were getting to be ploughed. The development of virgin and fallow lands continued in the XX century. Thus, by the middle of the 1960s most of the South Ural steppes had turned into agricultural land. Therefore, not plowed lands, pastures and grazings, inconveniences and boundaries became the main biotopes of the steppe marmot. However, the marmot had adapted to living on plowed lands, crops of cereals, fields of perennial forage grasses, roads, on the territory of not promising villages, etc. (Rudi, Shevlyuk, 2000).

Just almost bicentennial history of the study of the marmot in the South Ural region more than 350 papers that outline the main aspects of the biology of the steppe marmot, the peculiarities of its distribution and spatial distribution had been published. However, it is necessary to carry out additional studies concerning the ecology and modern distribution of the species in the area in order to preserve the bobak in the South Ural steppes (Bezuglov, 2009).

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ИСТОРИЯ ИЗУЧЕНИЯ СТЕПНОГО СУРКА НА ЮЖНОМ УРАЛЕ

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Степной сурок, или байбак *(Marmota bobak)* издревле обитает в южноуральских степях, привлекая внимание человека. Так, в народном календаре башкир последние снежные метели получили название «хуур буран» («хуур» - по башкирски байбак), так как согласно народной примете - наступлению этих буранов предшествует первый свист байбака (Кириков, 1980).

Первые упоминания о степном сурке появились в классических трудах исследователей Оренбургского края в XVIII-XIX вв. Так, о «великом множестве» байбаков в окрестностях Татищевой крепости писал еще П.С. Паллас (1786). Он сообщал, что у села Новосергиевка сурки и суслики живут во всех могильных холмах. В примечании к генеральному межеванию Оренбургского уезда обитание сурков отмечено на землях Верхнее-Озерной, Нижнее-Озерной и Ильинской крепостей, слободы Каргала Сакмарского городка. В середине XIX в., по данным Э.А. Эверсмана (1850), сурков было много в степях по Общему Сырту, по юго-западным и южным предгорьям Урала, покрытым «северными травяными степями». Отмечая особенности распространения байбака в лесостепном Предуралье, автор писал, что поселения сурков встречались в степи с холмистым и горным рельефом. Вместе с тем, Э.А Эверсман указывал, что этих зверьков добывало лишь местное население, используя мясо в пищу, а шкурки для изготовления шапок и опушки кафтанов и шуб. Ежегодно в Орскую крепость привозили для продажи до ста тысяч и более шкурок сурка.

Во второй половине XIX в. некоторые сведения об образе жизни сурков в Бугурусланском уезде приводит С.Т. Аксаков в «Записках ружейного охотника Оренбургской губернии» (Аксаков, 1852): «…я еще помню, что около самих деревень, куда, бывало не взглянешь, везде по сурчинам сидят они на задних лапках, как медвежата, и шумным свистом перекликаются между собой».

Несколько позже, в конце XIX в., Н.А. Зарудный в работе «Заметки к познанию фауны млекопитающих Оренбургского края» (Зарудный, 1897) подробно описывает поселения сурков в Оренбургских степях, отмечая их на севере от среднего течения реки Урал, в ковыльной степи между Каргалой и Янгизом, по Салмышу, на водоразделе между нижней Сакмарой и долиной среднего Урала, в степи между Сакмарой и Губерлинскими горами. Многочисленные колонии были встречены им в Урало-Илекском междуречье вблизи рек Донгуз, Ветлянки, Песчанки, Бердянки и др. Также Н.А. Зарудным была описана интересная миграция сурков. В 1890 году на Гребенской горе, где существовала колония в 30-35 сурчин, большинство ее обитателей без всякой видимой причины бросили ее и обосновали новое поселение в 15 верстах к востоку. Он не раз наблюдал передвижение сурков по несколько особей в утренние, вечерние часы и даже ночью, когда они плыли среди полой воды. Кроме этого, им были отмечены сроки залегания и пробуждения оренбургских байбаков.

Более детальные исследования, касающиеся особенностей распространения степного сурка, проводились в начале XX в. Однако эти работы носили эпизодический характер. Так, в юго-западной части Оренбургской области на левобережье реки Чаган близ пос. Мирошкино был впервые описан подвид степного сурка Marmota bobak skaganensis Bazanov, 1930, ныне именуемый «казахстанским» (Бажанов, 1928). Небольшие колонии байбаков были описаны вблизи Бузулука (Бажанов, 1928), на водоразделе Камсака и Кумака (Кузнецов, 1928).

А.П. Райский (1951) наблюдал колонию сурков почти в лесу на границе Оренбургской области с Башкирией между селами Отрадным и Ермолаевкой. Автор описал необычный способ охоты на зверьков: охотники, прячась за деревьями, караулили выход сурков из нор. В работе С.В. Кирикова (1952) упоминается о колонии, включающей более сотни зверьков, располагавшейся на 25 га по левобережью реки Куруил, между селами Куруил и Яныбаево, а также описывается несколько колоний в Приуральском левобережном мелкосопочнике в окрестностях сел Коноплянки, Подгорного, Адаева, станицы Ильинской. Позже Ю.А. Дубровский (1962) упоминает о небольших колониях байбаков располагавшихся к востоку от верховьев реки Кумак до озера Жеты-Коль на равнинных участках дерновинно-злаковой степи. Наиболее обширные поселения, по сведениям автора, сосредоточены на водоразделе Иргиза и Ушкаты, а также бассейна озера Шалкар-Ега-Кара.

Таким образом, главным результатом работ второй половины XVIII века – первой половины XX века, стало изучение географического распространения вида. Других целенаправленных исследований в указанный период в южноуральских степях не проводились.

Научные работы по изучению популяции байбака в степях Южного Урала активизировались лишь в 70-80-е годы XX века. Именно в этот период наблюдалось повышение общего интереса к изучению степного сурка в регионе. Поэтому не случайно, что опубликованные работы этого времени охватывали самые разнообразные аспекты биологии и экологии вида.

Так, выходит ряд работ А.А. Никольского (1969, 1976, 1983, 1984 и др.) по биоакустическому анализу вокализации сурков. Для описания биологически сходных сигналов с близкими физическими характеристиками А.А. Никольский (1969) предложил термин «фонотип». Впоследствии он показал видоспецифичность крика сурков и определил отражающие ее признаки, которыми оказались спектральные и амплитудно-временные особенности (Никольский, 1976, 1984). Предупреждающий об опасности сигнал сурков, обладающий абсолютной видоспецифичностью, является надежным диагностическим признаком в таксономических исследованиях (Никольский, 1976).

Не меньшую актуальность в этот период имеют работы, посвященные вопросу биологии размножения степного сурка на Южном Урале (Руди, Соустин, Шевлюк, 1993, 1994, 1996; Соустин и др., 1996; Шевлюк, 1996а, 1996б, 1997; Шевлюк, Руди, Стадников, 1997, 1999, 2000; Брагирова (Федоренко), Шевлюк, 2002). Так, в ходе этих исследований выявлена четкая возрастная структура популяций, которая включает животных трех групп: 1. сеголетки - животные одного возраста, в размножении участия не принимают; 2. годовики - в репродукции, как правило, не участвующие; 3. животные в возрасте 2-3-х лет и старше - основные производители. Определена сезонная динамика репродуктивной активности сурка, имеющая несколько существенных особенностей: период спаривания ограничен очень короткими временными рамками; для самцов характерно чрезвычайно глубокое угнетение функций половых желез, наступающее сразу после завершения спаривания; наличие двух пиков концентрации мужских половых гормонов в сыворотке крови этих животных; состояние репродуктивной активности зависит от календарных сроков, а не от погодных условий (Шевлюк, Руди, Стадников, 2000).

Кроме того, подробно изучены такие аспекты биологии размножения сурка как, плодовитость вида, соотношение полов в популяции, а так же забота о потомстве, реализуемая за счет ресурсов той семейной группы, в которой родились сурчата (Шевлюк, Руди, Стадников, 2000).

С появлением Комиссии по изучению сурков при Академии наук СССР, организатором которой был Д.И. Бибиков, ускорились исследования не только на Южном Урале и во многих регионах страны, но и за рубежом. При выполнении совместной российско-французской программы «Экологический базис для управления биоразнообразием сурков в Евразии» в период с 1994-1996 гг. проведены разносторонние работы по изучению экологии степного сурка. В частности исследовано сравнительное действие антропогенных и абиотических факторов, а так же их совместное воздействие на поселения сурка (Ле-Бер и др., 1994).

В дальнейшем одним из важных направлений в исследовании биологии и экологии степного сурка стало изучение влияние на популяции байбака абсолютно заповедного режима на участках государственного природного заповедника «Оренбургский», организованного в 1989 году. В работах Г.М. Гейде (1991) подробно охарактеризовано распределение поселений сурка, а также указана примерная численность вида на территории заповедника. Несколько позже О.В. Сорока (2001) отмечает, что за десятилетний период ведения абсолютно-заповедного режима численность байбака на территории ГПЗ «Оренбургский» увеличилась. В результате многолетних наблюдений на заповедной территории были выявлены факторы окружающей среды, влияющие на динамику сезонной и суточной активности байбака, а также продолжительность его спячки (Сорока, 2000). Было установлено, что спячка зверьков в нашем регионе длится примерно 8 месяцев, а период активной жизни составляет всего 4 месяца, что совпадает с фенологическими сроками, характерными для сурков, обитающих в Центральном Казахстане (Шубин, 1963).

На рубеже веков на первый план выходят исследования, посвященные влиянию хозяйственной деятельности человека на популяцию степного сурка и его адаптации к антропогенным ландшафтам, а также охране и рациональному использованию сурков (Бибиков, 1980; Бибиков, Руди, 1987; Машкин, 1991, 1997, 2000; Руди, 1989, 1991, 1994, 1995, 1997; Руди, Малютина, 1991; Руди, Сметанин, 1996, 1997, 1999; Руди, Шевлюк, 2000; Федоренко, Чибилев, Левыкин, 2005; Федоренко, 2006). Как отмечают авторы, с появлением оседлого населения в XVI-XVII вв. на Южном Урале воздействие человека на окружающую природную среду усилилось. Степи начинают распахиваться. Освоение целинных и залежных земель продолжалось и в

XX столетии. Таким образом, к середине 60-х годов большая часть южноуральских степей превращена в сельскохозяйственные угодья. Поэтому нераспаханные земли, выгоны и пастбища, неудобья и межи стали основными биотопами степного сурка. Однако сурок адаптировался и к обитанию на распаханных землях, посевах злаковых культур, полях многолетних кормовых трав, дорогах, на территории не перспективных сел и т.д. (Руди, Шевлюк, 2000).

Всего за почти двухсотлетнюю историю изучению байбака на Южном Урале опубликовано более 350 работ, в которых освещены главнейшие аспекты биологии степного сурка, особенности его распространения и пространственного размещения. Однако для сохранения байбака в южноуральских степях необходимы дополнительные исследования, касающиеся экологии и современного распространения вида на данной территории (Безуглов, 2009).

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PAST DISTRIBUTION OF THE MARMOTS IN THE SOUTH-EAST OF WESTERN SIBERIA

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Three marmot species currently inhabit the south-east of Western Siberia: steppe marmot (*Marmota bobak* Müller 1776), gray marmot (M. baibacina Kastschenko 1899) and forest-steppe marmot (*M. kastschenkoi* Stroganov et Yudin, 1956). We reconstructed the past ranges of these three species using original and previously published data on marmot remains from 43 Holocene localities and records of marmot historical distribution. Species discrimination of marmot remains was conducted using discriminant analysis of skull morphometric characteristics. Results suggest that throughout the Holocene, the northern extent of marmot distribution reached the southern limit of the forest zone. In the Ob river valley, it stretched above the treeline and then crossed the Yenisei River at 56° N. At the end of the Late Holocene the northern limit of marmot distribution in the Yenisey valley shifted to the south-west. Discriminant analysis of remains from the Aidashinskaya cave of Lower Chulym (56°12' N; 90°18' E) suggests the presence of gray and forest-steppe marmots. Neither species now inhabits the area. One skull and mandible from the Aidashinskaya cave was attributed to gray marmot, and one skull and three mandibles were attributed to forest-steppe marmot. We can assume that in the Late Holocene the range of the gray marmot has retreated to the south-east and the range of the forest-steppe marmot has shifted to the west. The eastern boundary of the steppe marmot was most likely limited to the Irtysh river valley. Range fragmentation in all three species was caused by spread of farming in the last 100-150 years and extirpation of remaining populations of marmots.

The current distribution of the three marmot species, steppe marmot, gray marmot, and forest-steppe marmot, extend across or stop in the territory of the south-east of Western Siberia and adjacent regions of Altai and Kazakhstan. The eastern part of the steppe marmot range extends from the flat steppes of Central Kazakhstan to the left bank of Irtysh river, where it overlaps with the western part of the gray marmot range. The most northern colonies of gray marmot occur in the Northern Altai near the Cherga settlement (51°34' N). Further to the east the gray marmot's range extends to the Abakan riverhead and the south-east districts of the Tyva Republic (Bibikov&Berendyaev, 1978; Ognev, 1947). The forest-steppe marmot's range extends along the right bank of the Ob river beginning at the Tom river mouth (56°N) in the north and continuing to the south boundary of the forest-steppe zone, at the confluence of the Biya and Katun' rivers (52°N). At the present time, there is no overlap between its range and that of the gray marmot (Taranenko, 2011). The Mongolian marmot (*Marmota sibirica* Radde 1862) occupies an adjacent region of southern Tyva and the Mongolian Altai (Gromov&Erbaeva, 1995).

The problem of species identification arises during the investigation of subfossils of the *Marmota* genus obtained from the territory of south-east Western Siberia. The difficulty is due to the morphological similarity of steppe, gray, and forest-steppe marmots, who are phylogenetically close to each other. In the past, some authors regard this taxon as one species with two subspecies – steppe and gray marmots (Bibikov, 1986). Others referred to steppe and gray marmots as separate species but considerfed forest-steppe marmot a subspecies of gray marmot (Laptev&Yudin, 1952; Gromov&Erbaeva, 1995), or even as the same species (Ognev, 1947). Recent investigations have shown that genetically, steppe, gray, and forest-steppe marmots represent three closely related but still taxonomically separate 'bobak'-type species (Brandler et al., 2010).

Modern representatives of the Marmota genus morphologically differ by fur color and density, length of awn hairs, skull structure, and by the form of their tooth crowns (Gromov, 1965; Galkina et al. 1970; Galkina et al., 2005). Because this study worked with subfossil material not all of these characteristics could be used for species identification. Assessment of morphotypic and morphometric features of the cranium and mandible is the optimal diagnosis method for identifying steppe vs grey marmots (Gasilin&Kosintsev, 2011) . This method was also used to identify potential members of the third species – forest-steppe marmot - samples from which were also present in the ofsubfossil material from the study area. The range of the Mongolian marmot is further to the south-east (Fig.1) so it was not included in the analysis.

The aim of the study was to investigate the history of the range of the Marmota genus with a focus on three representative species, steppe marmot, gray marmot, and forest-steppe marmot, in the territory of the south-east of Western Siberia during the Holocene.

Materials and methods

The study area was in the subtaiga, forest-steppe, and steppe zones of the south-eastern part of the Western Siberian Plain, the Salair Ridge, the Kuznetsk Alatau, and the East Sayan Mountains also (Fig.1).

We investigated subfossil materials from zoogenic deposits and mixed complexes from deposits in karst cavities, and from archaeological sites.

Zoogenic material was dated using the base of deposit's stratigraphy data and by the accompanying fauna subfossils. Some of the material collected had a very wide date range – the whole Holocene (10300–300 years B.P.). Other samples were dated with the help of archaeological methods (Troitskaya&Novikov, 2004). Some sites possessed radiocarbon dates (Table 5). The dates of marmot samples were correlated with climate-stratigraphy subdivisions of the Holocene (Khotinsky et al., 1991) for analysis. The subfossil bones of marmots from a total of 45 sites were explored (Fig.1).

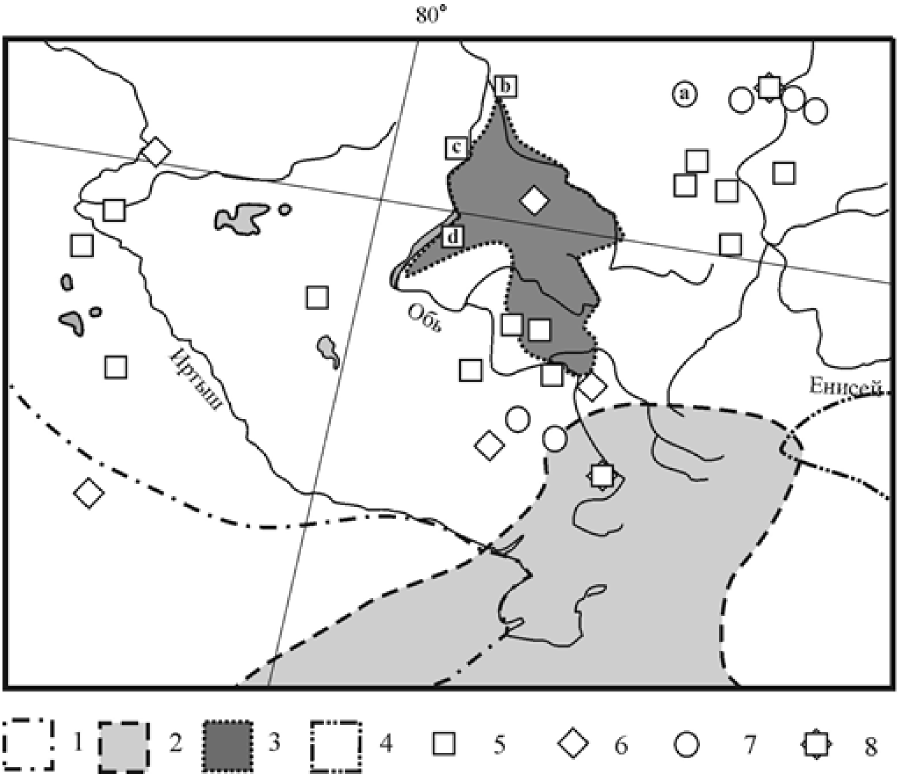

Figure. 1. *Modern boundaries of the ranges of representatives of the genus Marmota and the location of their remains in the southeast of Western Siberia. 1 - north-eastern border of the range of steppe marmot (Marmota bobak); 2 - northern border of the range of gray marmots (M. baibacina); 3 - the range of forest-steppe marmot (M. kastschenkoi); 4 - the western border of the range of Mongolian marmot (M. sibirica); 5 - samples of marmots dating from the late Holocene, Subboreal period; 6 - samples of marmots dating from the Subatlantic period of the Holocene; 7 - samples of marmots dating from the late Pleistocene-Holocene; 8 - samples of marmots dating from the Subboreal and Subatlantic periods of the Holocene; a - Aidashinskaya cave; b - Chekist settlement; c - Elovskoye settlement; d - Milovanovo 3 settlement.*

To develop a method for identifying recent species we used craniums with mandibles from 68 steppe marmot (from the collection of the Zoological Institute of the Russian Academy of Sciences [RAS]), 58 gray marmot(from the collection of the Museum of the Institute of Plant and Animal Ecology, Ural Branch of the RAS and the Museum of the Institute of Systematics and Ecology of Animals, Siberian Branch of the RAS [ISEA SB RAS]) and 51 forest-steppe marmot(from the collection of the Museum of ISEA SB RAS and Zoological Museum of Tomsk State University). We took 20 measurements (Fig. 2) from the skulls (Gasilin&Kosintsev, 2011). The set of cranial measurements (Gasilin&Kosintsev, 2011) was supplemented by measurements 26–29 (Fig. 3) whereas measurements 4–7 were not taken and were not analyzed because it is rare to find subfossil mandibles with teeth.

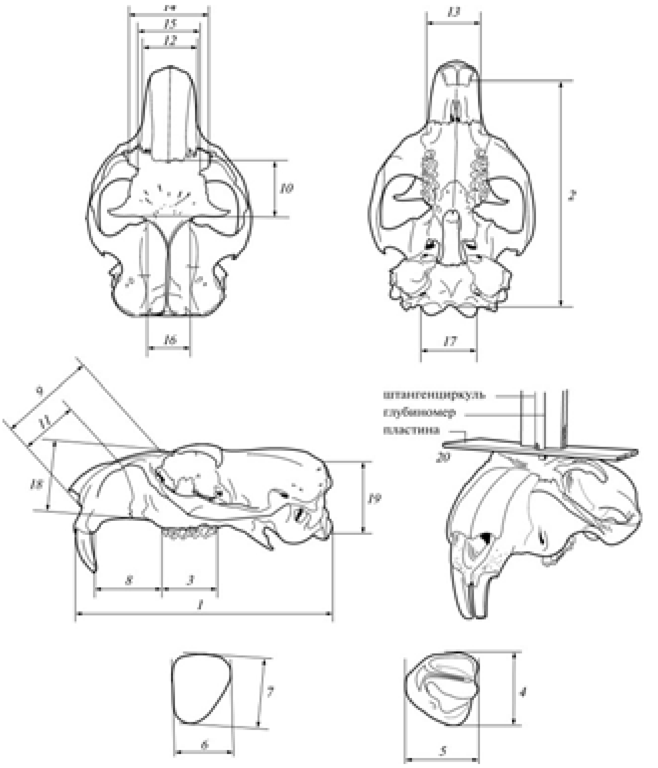

Fig. 2. *Skull measurements used for this study (Gasilin &Kosintsev, 2011).*

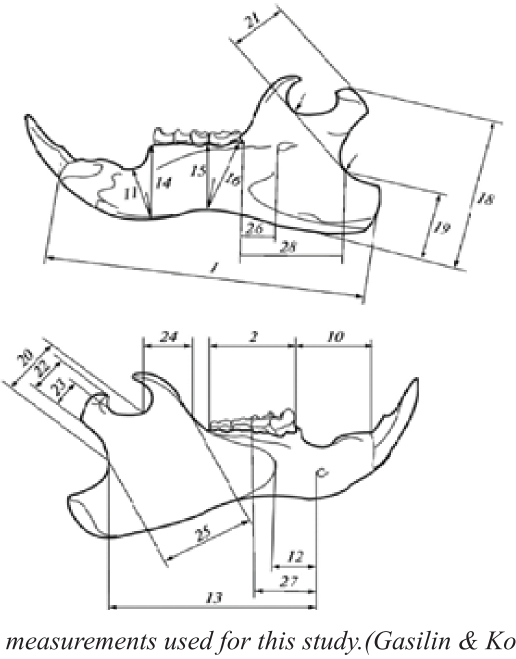

Fig. 3. *Mandible measurements used for this study.(Gasilin & Kosintsev, 2011)*

The samples used for species identification included the whole and fragmented skulls (n=4) and mandibles (n=18) from four sites located in the territory of the Russian Federation. All skulls and 14 mandibles were found in Aidashinskaya cave, located in Krasnoyarsk region ner Achinsk town (56°12'N; 90°18'E). Osteological material from this cave covered a wide date range - the whole Holocene (Ovodov, 1980). Four mandibles were found in archaeological sites from the Late Bronze Age - the end of Subboreal period (SB3, 3200-2600 years B.P.) - in the settlements Elovskoe (n=2), Chekist (n=1) and Milovanovo 3 (n=1). The settlement Elovskoe is located in Kozhevnikovsky district of the Tomsk region (55°34'N; 83°25'E); Chekist is located in the Tomsk district of Tomsk region (56°22'N; 84°29'E), and Milovanovo 3 in the Ordynsky district of the Novosibirsk region (54°5'N; 81°33'E).

Measurements were conducted with the help of electronic caliper accurate to 0.1 mm. The software package Statistica 6 was used for statistical calculations.

Discriminant analysis with standard and single-step inclusion of variants was used to determine the species of recent and subfossil samples. The sexual dimorphism of marmots by dimensional features was not greater than the interspecies differences (Cardini, 2004). Thus, sexual dimorphism did not interfere with the results of species identification, so sex identification was not included in analysis. Statistical models for species classification were specially built for almost every subfossil cranium or mandible because most samples were fragmented. Besides morphometric characteristics, lacrimal bone morphotype analysis of the subfossil cranium was also used for species identification(Fig. 4).

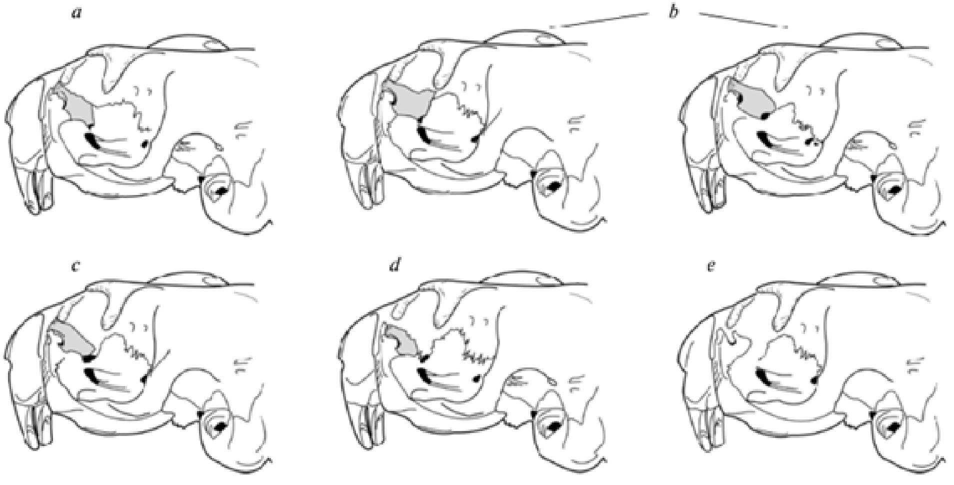

Fig. 4. *Morphotypes of the position of the lacrimal bone in representatives of the genus Marmota used in this study (Gasilin & Kosintsev, 2011)*

Results and discussion

The diagnostics of recent representatives of *Marmota*

Morphotypic characteristics. The results of the analysis showed that lacrimal bone morphotypes *a, b, c, d* and *e* occurred in steppe marmot samples, morphotype b in gray marmot samples (Gasilin&Kosintsev, 2011) and morphotypes *a, b* and *c* in forest-steppe marmots. The frequencies of these morphotypes in forest-steppe and steppe marmots was virtually equal while b was the most common morphotype among all three species (Table 1).

Table 1. *Percent of samples showing each morphotype of lacrimal bone position for each marmot species; steppe (Marmota bobak), gray (M. baibacina) and forest-steppe (M. kastschenkoi) .*

Species	% of samples showing each morphotype					# of samples
	a	b	c	d	e	
M. bobak	14±2,6	68	9±2,2	8±2,1	1±0,1	173
M. baibacina	0	100±0	0	0	0	218
M. kastschenkoi.	18±5,3	74±6,1	8±3,8	0	0	52

Morphotypes d and e appear to be diagnostic of steppe marmot. The absolute predominance (100%) of morphotype b in gray marmot suggests that the occurrence of this morphotype can be used to determine the presence of gray marmots. An occurrence of >75% of samples with the b morphotype (68% and 74% of steppe and forest-steppe marmots had morphotype b in the sample population) may indicate the presence of gray marmots.

Morphometric characteristics. Metric data from recent marmot samples constituted learning groups used in standard and single-step with inclusion discriminant analysis. Correct identification of sampling on the total assortment of characteristics both for cranium and mandible was 97–98%. The validity of the resulting statistical model was examined with the help of test groups that included three mandibles of known species. All test samples were identified correctly. Thus, the model appears to be effective in discriminating between the three species based on cranium and mandible measurements. The degree of differentiation of forest-steppe marmot from grey and steppe marmots based on cranium and mandible measurements was close to 100% (Fig. 5).

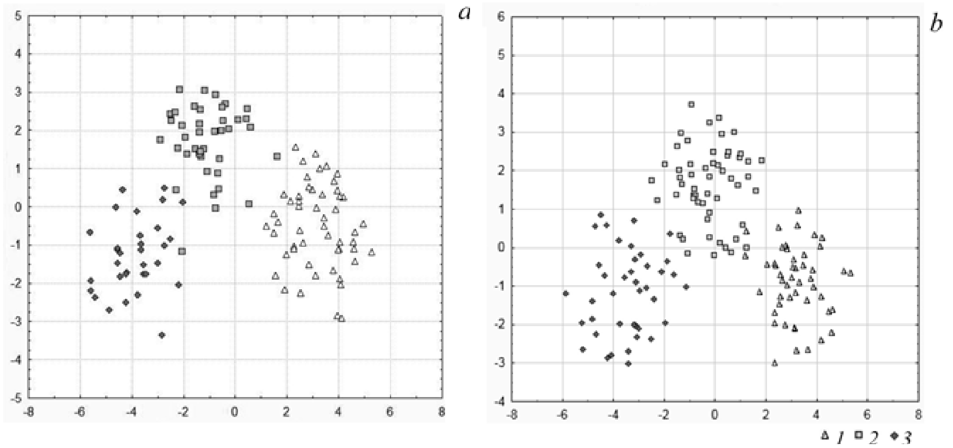

Fig. 5. *Distribution of recurrent cranium (a) and mandible (b) measurements in the space of discriminant axes: 1–steppe marmot (Marmota bobak); 2–gray marmot (M. baibacina); 3–forest-steppe marmot (M. kastschenkoi).*

Determining the species of subfossil cranium remains.

Lacrimal bones were not common in the sampled subfossil skulls and only displayed morphotype b. Thus, it was not possible to determine marmot species based on the lacrimal bone morphology of the sample population.

Using morphometric characteristics, two craniums and four mandibles from two sites were identified to species level. Samples from the Chekist and Milovanovo sites could not be identified to species level. The marmot mandibles from the Elovskoe settlement belonged to forest-steppe marmot. Of particular interest were the subfossil remains from Aidashinskaya cave. Two species were identified there, with one cranium and one mandible belong to gray marmots, and one cranium and three mandibles to forest-steppe marmots.

The area reconstruction of the *Marmota* genus.

Marmot remains were found at one Early Holocene site (9680–8860 years B.P.), 14 Middle Holocene sites (3800–2600 years B.P.), seven Late Holocene sites (2500–300 years B.P.), and 23 sites dated from sometime during the Holocene.

The most northern occurrence of *Marmota* from Priirtyshje was documented at the Isakovsky 1 burial ground (55°27'N), dated by archaeological and radiocarbon dating as from beginning of the Subatlantic period of the Late Holocene. The most northern occurrence of *Marmota* from Priobye was from the Chekist settlement (56°36'N), dated from the end of the Subboeral period (SB3, 3200–2600 years B.P.) of the Holocene. Sites of *Marmota* bones from the Yenisei river basin were found at about 56°20'N (the caves Eleneva and Karaul'naya 1), and dated as Early (PB–BO, 9600-8000 years B.P.) and Middle Holocene (AT, 8000–5000 years B.P.). The most northern occurrence of *Marmota* from the samples, dated as from sometime during the Holocene, were from theAudashinskaya cave (56°12'N) and from caves on the Yenisei river (Ledopadnaya, Kazyreevskie and others nearby at 56°N). There data show that the northern boundary of *Marmota* distribution in the Early and the Middle Holocene was between 56 and 57°N in the south-east of Western Siberia. At the beginning of the Late Holocene the range extended to 55°27'N in Priirtyshje. The northern extent of *Marmota*'s range in Priobye hasn't shifted latitude between modern days and the end of the Middle Holocene. The edge of *Marmota*'s range along the Yenisey river in the Late Holocene isn't precisely known. In the 18th and 19th centuries, the distribution of *Marmota* did not change in Priirtyshje, and signs of marmot habitation have been documented at 55°N (Ognev, 1947). Although the range of marmots was unchanged over time in Priobye, along the Yenisei river up to the beginning of the 17th century t there is no record of marmots occurring in the Krasnoyarsk outskirts or on the right bank of Yenisei river.

In the central and southern parts of the study area there were numerous Middle Holocene sites with marmot remains and a few Late Holocene sites (Fig. 1). Marmots occurred here in the 18th and 19th centuries as well. In the description of Kolyvanskie plants there is reference to the abundance of marmots in the Altai forest-steppe territory in 1730 . In the middle of 18th century, P.S. Pallas encountered a great number of marmots on the woodless slopes between the Aley and Talovka rivers (Kirikov, 1966). All these data seem to indicate that the southern boundary range of *Marmota* hasn't substantially changed over the last few thousand years.

The area reconstruction of separate species

According to findings at the Elovskoe settlement, the forest-steppe marmot has inhabited the region of Novosibirsk Priobye and partly Tomsk Priobye since the end of Subboreal period of the Holocene. However, the range of the forest-steppe marmot was considerably larger during the Subboreal period than it is today.. Its range extended to the east at least as far as upstream of the Chulym river, where the remains of forest-steppe marmot were found in the Aidashinskaya cave. The forest-steppe marmot was initially identified as a gray marmot by the first scientists to document it. Since then, it has also been identified as a subspecies of gray marmot (Ognev, 1947). As a result, it is challenging to differentiate the historical, and recent, southern boundary of the forest-steppe marmot's range from that of the northern edge of the gray marmot's historical range. The forest-steppe marmot appears to have had a limited range over the last few centuries. There was sharp decrease in its population size in the middle of the 20th century due to systematic hunting (Laptev, 1958). According to data from the Western Siberian Branch of "VNIIOZ" the forest-steppe marmot's population hasn't undergone considerable changes in recent years and has showed some signs of increase (The resolution…, 2014).

The first written record of the distribution of gray marmot in the Altai Mountains appeared at the beginning of the 20th century. According to the records of different authors (Ognev, 1947; Yudin et al., 1979), gray marmot inhabited a large part of the Altai Mountains during this time. It was absent only in taiga districts of the northern and partly the north-eastern parts of the Altai and also in the forest south-west of the Ust-Koksinskiy district of Altai Republic. The boundaries of the gray marmot's range experienced some fluctuations during this time. The main cause was usually direct extermination by man (Yudin et al., 1979). It is challenging to assess the range of the gray marmot over the 21st century due to lack of data.

ubfossil bones confirmed to be those steppe marmot were absent. Written records on its distribution from the south-east of West Siberia are from the 19th century. During that time the northern edge of its range came up to 55°N, on the Irtysh river. At the end of the 19th century steppe marmot was recorded in the Omsk town outskirts (Ognev, 1947). The decline of the steppe marmot population and the shift of its range began in 1865, when mass peasant migrations to the forest-steppe zone began (Kirikov, 1966). From that time the steppe marmot's range shifted to what it is today, retreating to the south and dividing into isolated pockets. According to data from the Western Siberian Branch of "VNIIOZ", in 2008, the population of steppe marmot showed increases and its range appeared less patchy (Mashkin, 2009).

Conclusion

The analysis of the results of subfossil cranium remains from Holocene sites, together with records from the 19th and 20th centuries made it possible to reconstruct shifts in the range of *Marmota* over time in the south-east of Western Siberia in the Holocene. We used discriminant analysis to identify the species of marmot cranium remains. This method allowed us to differentiate forest-steppe marmots from gray and steppe marmots with close to 100% confidence.

The distribution of marmot remains indicates that the northern boundary of *Marmota*'s range during the Holocene extended along the south boundary of the forest zone, to the basin of the Ob river, across the mountains of Southern Siberia, and over the Yenisei river at a latitude of about 56°N, extending to its east bank. Written records did not confirm the presence of marmots in basin of Chulym river or in the outskirts of Krasnoyarsk city. It may be the marmot's range retreated from the area before Russian colonization, i.e. more than 300 years B.P. By the time of Russian colonization, the range extended to the basin of the Yenisei river had been to the south and west to the Western Sayan Mountains, and marmots had disappeared from the east bank of the Yenisei river. In the first third of the 20th century the northern boundary extending to the basin of the Irtysh river was displaced to the south (Ognev, 1947).

Species identification of marmot cranium remains showed that the range of gray and forest-steppe marmots was larger in the past and included the upper stream of the Chulym river (56°12'N; 90°18'E). The current range of the gray marmot is now considerably further south (between 51° and 52°N). Forest-steppe marmots inhabit more western territories (between 85° and 86°E) in the indicated district (Fig.1). The edge of the steppe marmot's range in the Holocene is not well known. During the last 100 to 150 years the range of all three species contracted and fragmented due to the expansion of agriculture and active extirpation of marmots by humans.

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CONSECUTIVE EVENTS OF CLIMATE- AND NICHE ADAPTATION PROGRESSIVELY DEPRIVE GENETIC DIVERSITY FROM A LARGE POPULATION OF AN ICE-AGE ADAPTED RODENT

THE GENOME OF ALPINE MARMOT

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There are several cases in evolutionary history, in which species of large population size get suddenly extinct. While low genetic diversity is considered a general risk factor, the sudden disappearance of a species has often followed global changes in climate, such as the disappearance of the Pleistocene cold-steppe, commonly known as the great ice age. Upon assembling a reference genome and re-sequencing individuals from representative populations, we reconstructed the genetic past of the Alpine Marmot *(Marmota marmota)*, a rodent remnant of this glacial epoch that persists in large numbers in the high altitude Alpine meadow. Unexpectedly, despite a large consensus population size, we called the so far lowest level of intra-individual genetic diversity of any wild animal, and discover that the marmot is compromised in purifying selection of deleterious mutations. We can trace this situation to a life history that is characterized by consecutive events of climate and niche adaptation. By acting together, these events disentangle population size from genetic diversity. First, a successful metabolic adaptation to an ice-age climate altered Marmot's fatty acid metabolism, and consistent with a life history of an increase in body size, triggered a progressive, long-term decline from an effective population size of more than 200,000 to only tens of thousands. Upon disappearance of the cold steppe a colonisation of the high Altitude habitat, in which temperatures remained in their favourable range, created local bottlenecks. In the warmer Neocene, the new habitat eventually insularized the Marmot sub-populations, effectively preventing their genetic diversity to recover. The case of the Alpine marmot reveals that upon a global changes in climate, a large population size does not necessarily ensure purifying selection of deleterious variants, and predispose a species for the progressive loss of its genetic fitness.

INTRODUCTION

With the threat of global climate change, it is increasingly important to understand how populations respond to rapidly changing environments. Past events have shown that while some species respond successfully to major changes in climate (Kumar et al., 2015; Robson et al., 2015), others fail to adapt and get extinct (Nogues-Bravo et al., 2008). Mechanisms that define the successful re-adaptation are barely understood, and at present, it is hence difficult to predict the outcome for a given species in the context of contemporary or even future changes in climate.

A major change in the prehistoric climate was characterized by the disappearance of the cold steppe of the Pleistocene, an extensive biome during the Last Glacial Maximum, spanning Eurasia to North America, and from the Arctic islands southwards to China. This habitat was Abundant for approximately 100,000 years, but disappeared about 12,000 years ago. With the decline of the cold steppe, came a decline of its fauna, with several uniquely adapted species, like the woolly mammoth (Mammuthus primigenius), and woolly rhinoceros (Coelodonta antiquitatis), becoming extinct, while others, like the muskox (Ovibos moschatus) and Arctic fox (Dicrostonyx torquatus) persisted in the arctic, where temperatures remained in the favourable range (Alvarez-Lao and Garcia, 2011; Stewart et al., 2010).

A third group of ice-age adapted animals persisted in high-altitude mountain habitats. This group contains a ground-dwelling squirrel, known as the Alpine marmot (Marmota marmota), a close relative of the American groundhog. Widely distributed across the European Steppe during the cold period of the early Quaternary (Besson, 1971; Couturier, 1955), the Alpine marmot now inhabits the high altitude meadows of the Alps and Tatra

Mountains. Here it persists with a cold-adapted physiology and lifestyle, including large body size, an extensive period of winter hibernation, and a high degree of sociality, including a form of cooperative breeding, where adult subordinates warm juveniles during hibernation (Allaine and Theuriau, 2004; Arnold, 1988; Zimina and Gerasimov, 1973).

With tens of thousands of animals found in a wide range of populations across the Alps, according to the current IUCN classification, the conservation status of the Alpine marmot is considered of least concern. However, recent surveys revealed that Alpine marmots are affected by contemporary climate warming over the last 25 years. Body mass, litter size, and pup winter survival are all negatively impacted by increases in winter temperature (Canale et al., 2016; Rezouki et al., 2016; Tafani et al., 2013). Paradoxically, this is explained by a decrease in the temperature of their winter burrows, caused by thinning of the snow cover (Canale et al., 2016; Rezouki et al., 2016; Tafani et al., 2013). A direct sensitivity to the most recent changes in climate is specific to the *Alpine marmot*, and not observed in the 13 other species of marmots, and consistent with their tight niche adaptation. (Bichet et al., 2016; Tafani etal., 2013).

Here, we addressed the genetic basis of the Alpine marmot's physiology and adaptation, by sequencing, assembling and analysing its complete genome, extended by re-sequencing individuals from different populations, that enabled a combined demographic, phylogenetic and physiological analysis of this species in unprecedented detail. We find, to our surprise, that despite clear evidence for effective niche adaptation and large census population size, the Alpine marmot represents one of the most extreme cases of low genetic diversity among mammalia. For instance, we observe lower levels of heterozygosity than extremely isolated or endangered species such as the Iberian Lynx, and comparable levels to artificially inbred laboratory mice. As a consequence, - at present - purifying selection appears ineffective. We find an explanation to this situation in a very slow recovery from past losses in genetic diversity, including that caused by the range contraction at the end of the Pleistocene. We show further that this slow recovery is a consequence of the marmot's climate-adapted life history. The case of the Alpine marmot, revealing a species that does not recover its genetic diversity due to its climate-adapted life history, provides a plausible explanation why a large population size might not protect a species from ineffective natural selection, or even sudden extinction (Murray et al., 2017).

METHODS

Sample collection

Four animals (two males, two females) each were obtained from three wild Alpine marmot populations in the Central Alps near Mauls (I, at 2367 m.a.s.l. at Mt Senges 46°52'40.55"N 11°34'56.12"E (Suppl Figure 1), around St Martin, Gsies, (I) (at >2,000 m.a.s.l, 46°49'44.2"N 12°12'15.5"E), and in the nature reserve of La Grande Sassiere (at 2,340 m a.s.l., French Alps, 45°29'N, 65°90'E, animals 1426, 1442, 1467 and 1508). All animals were from different families. The animals' sex was confirmed by genome analysis (Supplementary Table 12).

DNA extraction, genomic sequencing and resequencing

Genomic DNA was extracted from spleen, liver, bone and hair tissues by the QIAamp DNA Mini-Kit (Qiagen) according to the manufacturer's instructions (including proteinase K digest to obtain high molecular weight DNA). To create the Alpine marmot reference genome, we sequenced an animal from the most centrally located population (Mauls I) using Illumina Hiseq 2500 short read and Roche / 454 long read sequencing technologies. We constructed paired end (500 bp and 800 bp gel selected fragment size, Truseq version2 kit), mate pair ("gelfree" library (MP3000) and 5kbp, lOkbp and 20kbp gel selected fragment size, Nextera Mate Pair Kit) and Roche/454 single read libraries. We produced a high sequencing coverage based on the paired end libraries and supplementary lower coverage using the mate pair libraries and the 454 technology. For genome re-sequencing of the other individuals we constructed paired end libraries with insert sizes of 300-500 bp using the Illumina Truseq version2 kit. Sequence data were generated by either Hiseq2500 (2 x 100 bp) or Nextseq500 sequencers (2 x 150 bp).

RESULTS

To sequence, assemble and annotate a reference genome for the Alpine marmot (Figure 1A) including both sex chromosomes, we selected a wild-living male, in a typical habitat: a high altitude valley of the Central Alps that is largely free of artificial barriers due to tourism or industrial agriculture (mount Senges, near 'Mauls' village, Bolzano province, Italy, 46°52'40.5"N 11°34'56.1"E, 2367 above sea level; In order to minimize potential technology biases in low-frequency variant calling (Raiser et al., 2012), genomic DNA was sequenced by two complementary sequencing technologies (Illumina, Roche/454) and different types of library protocols for illumina sequencing. Using a hybrid assembly approach to make the best use of short and long read data we assembled a genome consensus sequence of 2.51 Gbp, with a contigN_{50} size of ~44 Kbp, scaffold N_{50} size of 5.6 Mbp and superscaffold N50 size of 31.3 Mbp. The large superscaffold N_{50} size was achieved by collinearity analyses based on the genome of the thirteen-lined ground squirrel *(Ictidomys tridecemlineatus)*, the closest Alpine marmot relative for which a genome was available), and the house mouse (*Mus musculus*, Supplementary Table 2). The draft genome assemblies of thirteen-lined ground squirrel (scaff N_{50}=8.2 Mbp) and Alpine marmot (scaff N_{50}=5.6 Mbp) were highly complementary during the collinearity scaffolding process. Thus a future genome assembly version of the thirteen-lined ground squirrel could likewise take advantage from the *M marmota* genome assembly. The Alpine marmot genome was then annotated upon the inclusion of mRNA expression data, generated by mRNA sequencing from spleen and liver tissues, employing the MAKER pipeline (Cantarel et al., 2008), expanded by comparative approaches as well as manual curation. Eventually, we yielded a reference set of 22,349 protein coding genes. Of this gene set, -19,000 genes could be annotated with gene symbols and -14,700 associated to functional pathways.

Slow rates of evolution in the nuclear genome of the Alpine marmot.

A phylogenomic analysis of the Alpine marmot genome confirmed its relationships to other mammalian and rodent species (Blanga-Kanfi et al., 2009; Fabre et al., 2012) (Figure 1B-D). Consistent results were obtained from collinearity analyses of conserved regions (Figure 1B), and from phylogenetic inference, whether using large alignments of nuclear genome (Figure 1C), or whole mitochondrial genomes (Figure 1D), or the well-sampled Cytochrome B gene.

We also identified an integration of the mitochondrial genome into the nuclear genome (a nuclear mitochondrial DNA segment or NUMT (Hazkani-Covo et al., 2010). The marmot NUMT is unusually large (comprising 91% of the mitochondrial genome), and well conserved (with 84% similarity). This conservation is unlikely to be due to purifying selection, because the NUMT carries a high number of stop codons (due to differences between the nuclear and mitochondrial genetic codes), and had no detectable mRNA expression. Furthermore, the conservation cannot be attributed to a very recent date of insertion. The same NUMT is found in Ictidomys (NW_004936830.1), and phylogenetic analysis suggests that the insertion occurred before the common ancestor of Marmota, Ictidomys and Cynomys. Over the same evolutionary time period, substitutions occurred at most synonymous sites in their mitochondrial genomes (mitochondrial KS estimates: Ictidomys-Marmota 0.48; Tamias-Marmota 1.11). As such, the high conservation of the NUMT suggests a slow rate of evolution in the nuclear genome of the Alpine marmot, particularly when compared to rodent species such as the mouse and rat. This is also consistent with the high levels of conservation observed between the marmot and human genome assemblies (Figure 1B). and the short branch leading to the marmot in (Figure 1C). This slow rate is one way that the life history of the marmot can affect its genome evolution.

DISCUSSION

When environments change, some populations respond successfully, while others go extinct. The reasons for this variation remain unclear, and particular uncertainty surrounds the role - if any - of low genetic variation. This is especially true of notorious cases in which a very large population has suddenly become extinct. The passenger pigeon is one such case, and a recent genomic analysis has shown, intriguingly, that this species was characterized by low variation (Murray et al., 2017). But this cannot tell us whether the low variation contributed to the extinction. Indeed, some evidence against a causal role comes from the work of Romiguier et al. (Romiguier et al., 2014), who showed, across a wide range of animal species, that genome-wide variation was well predicted by their life history, and not at all by their conservation status (Romiguier et al., 2014).

Our analyses of the genomic history of the Alpine marmot has a special relevance to these debates. We have shown that the Alpine marmot is extremely well adapted to its current niche, with an adaptive life history that is matched by physiological changes in fatty acid biosynthesis and storage, and with parasite clearance, which occurs before hibernation. This high level of adaptive fit is reflected in the species' current abundance in its Alpine meadow habitat. However, we have also shown that natural selection against deleterious mutations is now largely ineffective in this species. This is because, despite its large population size, the Alpine marmot has very low levels of genetic variation. Indeed, the levels observed have previously been associated to species associated with serious conservation concerns, or extreme isolation, such as the the extremely isolated California island fox, Iberian lynx or Polar Bear, and are much lower as the values obtained for Mountain Gorilla or Naked Mole rat, for instance (Figure 3A).

We have shown that a reduction in genetic variation occurred during a past event of climate change: the retreat of the cold steppe at the end of the last glacial cycle. But despite this signature of contingent environmental change, we have also shown that the low diversity of the Alpine marmot was explained from its life history, both before and after the range contraction. We have argued that these two facts are intimately connected. The recovery of genetic variation, following the end-Pleistocene event, has been retarded by the marmot's adaptive life history. Put another way, the long-lasting effects of occasional environmental changes have led to the predictably low levels of genetic variation we observe today.

Our results have two, contrasting implications for our understanding of extinction risk. First, it is clear that low levels of genome-wide variation, on their own, need not imply an imminent threat of extinction. The Alpine marmot has persisted successfully, with low levels of genetic variation, for tens of thousands of years. Conversely, however, there is no cause for complacency. If adaptation to future environmental change does require abundant genomic variation, then populations may be unable to respond, even if they are characterized by high levels of microsatellite diversity and large population size. If low genetic variation is a contributory factor to extinction risk, then large populations might be at risk, as well as small ones.

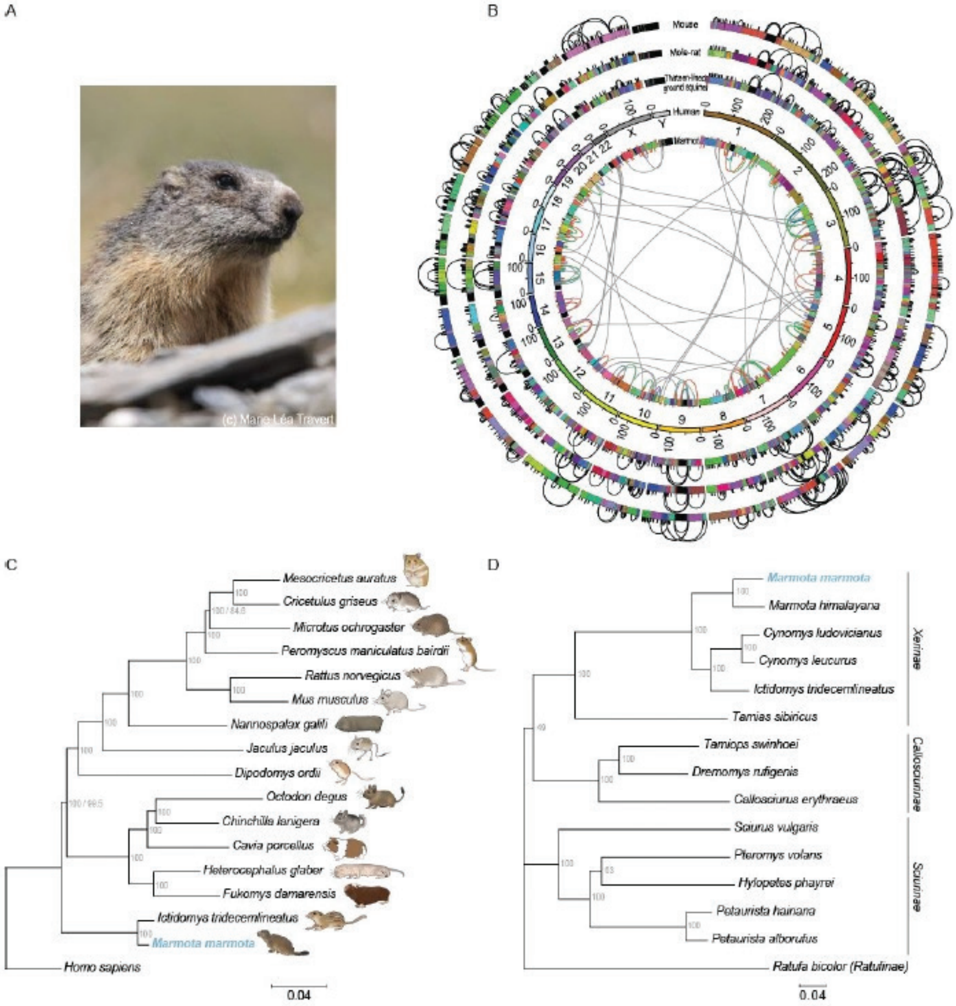


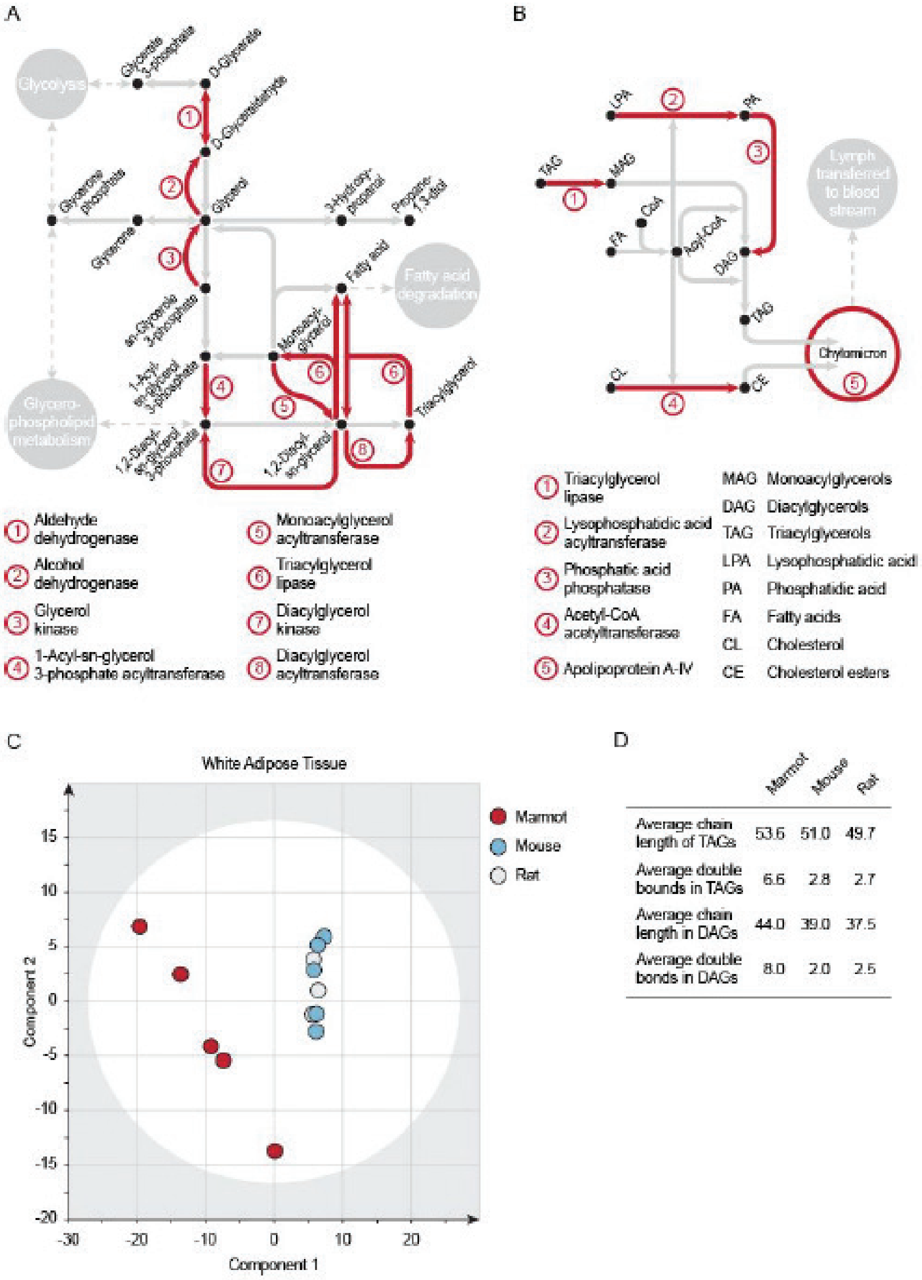
Figure 1. *A slow rate of genomic evolution and the phylogenetic relationship of the Alpine marmot as revealed by its nuclear and mitochondrial reference genome.*

A. *Marmota marmota* is a large, ground-dwelling, highly social rodent, which has colonized high-altitude meadows across the Alps since the end of the last glaciation in the Quaternary.

B. Collinearity of the *M. marmota marmota* genome with its close relatives, and that of other rodents. The *M marmota* genome aligns to a higher fraction of the human genome (outgroup) than to its fellow rodents (i.e. mouse and mole), one of several indicators of a slower rate of genomic evolution. Here collinear blocks in the human chromosomes are colored by assigning random colors for each scaffold/chromosome in the aligned species genome assemblies. Thus small blocks with many colors depict lower N_{50} scaffold length of genome assemblies. Connections indicate collinearity breaks / block rearrangements compared to thehuman genome (intra-chromosomal only for the plotted rodents, except for *M marmota* where interchromosomal rearrangements are plotted inside of the graph). Connections observed in *M. marmota* that are conserved across the rodents shown (green; //=72); in all except *M. musculus* (blue, n=13); conserved between I. tridecemlineatus and *M. marmota* (purple; //=57); or specific to *M marmota* (orange; n=148/

C. Reconstruction of the phylogenetic tree of Rodentia. The tree is derived from multiple whole-genome alignments of protein coding and non-coding sequences from avilable rodent genomes (about 94 Mbp alignment per species). Humans are included as an outgroup. The short branch length of the Alpine marmot since the split from the LCA of primates and rodents agrees with the higher fraction of alignable genomic sequence between the Alpine marmot and human compared to Alpine marmot and Mouse/Mole-rat (Supp. Table 6).

D. A phylogenetic tree for Sciuridae based on their mitochondrial genomes, of the subfamilies Xerinae (including Marmotini), Sciurinae (Squirrels), Callosciurinae, and Ratufmae.



	Marmot	Mouse	Rat
Average chain length of TAGs	53.6	51.0	49.7
Average double bounds in TAGs	6.6	2.8	2.7
Average chain length in DAGs	44.0	39.0	37.5
Average double bonds in DAGs	8.0	2.0	2.5

Figure 2. *Genomic signatures of cold-climate adaptation affect metabolism in the Alpine marmot*

A. Phylogenetic Analysis by Maximum Likelihood (PAML) followed by tests for functional enrichment identifies biological processes that underwent increased selection in Alpine marmot The hibernating rodents, marmot and thirteen-lined ground squirrel, show significant enrichment of adaptive substitutions in the metabolic pathways required for diacylglyceride (DAG) and triacylglyceride (TAG) biosynthesis. Enzymes encoded by genes under positive selection are highlighted in red.

B. Alpine marmot shows specific and significant enrichment of adaptive substitutions in genes required for fatty acid storage, when compared to the thirteen-lined ground squirrel. Enzyme encoding genes positively selected are highlighted in red.

C. Partial least squares-discriminatory analysis (PLS-DA), of the white adipose tissue (WAT) lipid composition, as determined by liquid chromatography - tandem mass spectrometry, comparing mouse, rat, and Alpine marmot WAT. The Alpine marmot WAT clearly distinguishes from that of rat and mouse.

D. Higher degree of unsaturation, and longer chain lengths, in Alpine marmot WAT DAGs and TAGs, as determined by liquid chromatography - tandem mass spectrometry.

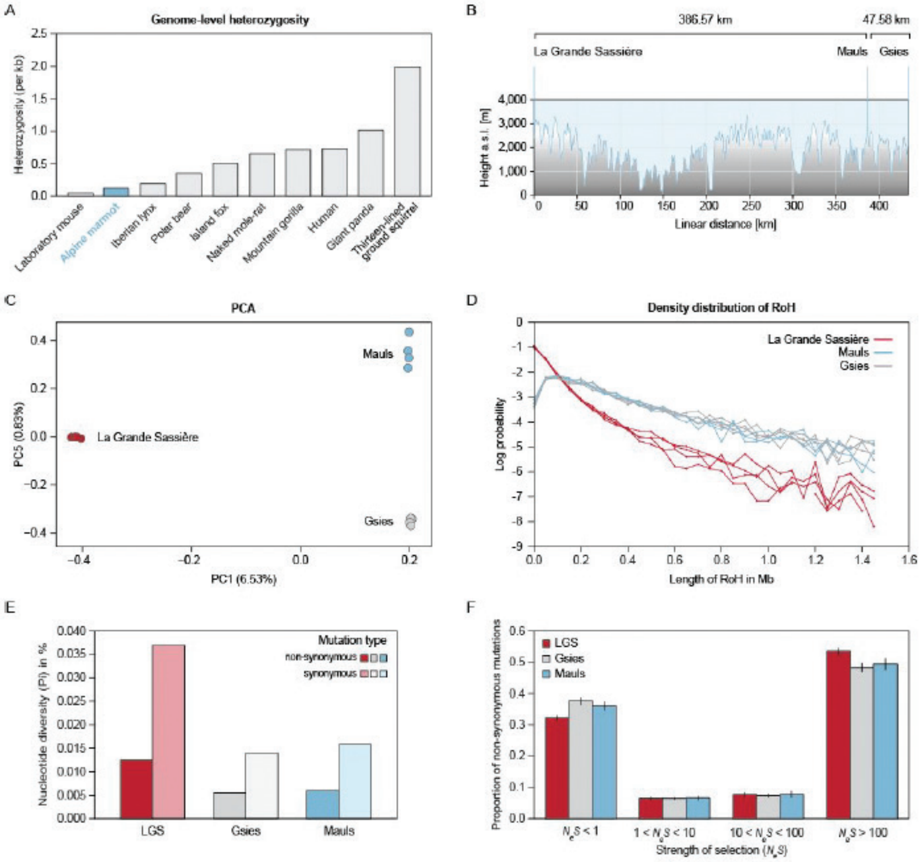


Figure 3. *Extremely low levels of genetic diversity and impaired purifying selection characterize different Alpine marmot populations*

A. The Alpine marmot genome is characterized by low heterozygosity at the genome level. The heterozygosity for the other mammalian genomes has been determined by re-mapping the original sequence reads used to assemble their reference genomes, using identical software parameters (Supplementary Table 11).

B. Alpine marmot populations located in Mauls (I, Supplementary Figure 1), Gsies (I) and La Grande Sassiere (LGS), shown as geographical distances as well as height profiles between these.

C. Principal component analysis (PCA) of whole genome genetic diversity (single nucleotide polymorphisms, including singletons) of animals from Mauls, Gsies, and La Grande Sassiere. PCI distinguishes the Mauls and Gsies from the La Grande Sassiere marmots, while PC5 separates all three populations. Axes 2 to 4 mainly describe genetic diversity within the "La Grande Sassiere" (LGS) population, which has comparable diversity to the combined sample.

D. Logarithmic density distributions of runs of homozygosity for individuals of the three populations. Distributions are very similar for the Mauls and Gsies populations but different for LGS, well explained by their differences in local breeding sizes. There is little evidence of consanguineous mating, nor of a recent bottleneck recovery.

E. Differences in the coding diversity (synonymous and nonsynonymous sites) among the three marmot populations. La Grande Sassiere (LGS) individuals are around three times more diverse that the inner Alpine populations. (Right panel)

F. Distribution of fitness effects of nonsynonymous mutations suggests that more than 30% of nonsynonymous mutations within the Alpine marmot populations are effectively neutral, with a further 5-10% in the nearly neutral range. There is little variation of fitness effects across populations.

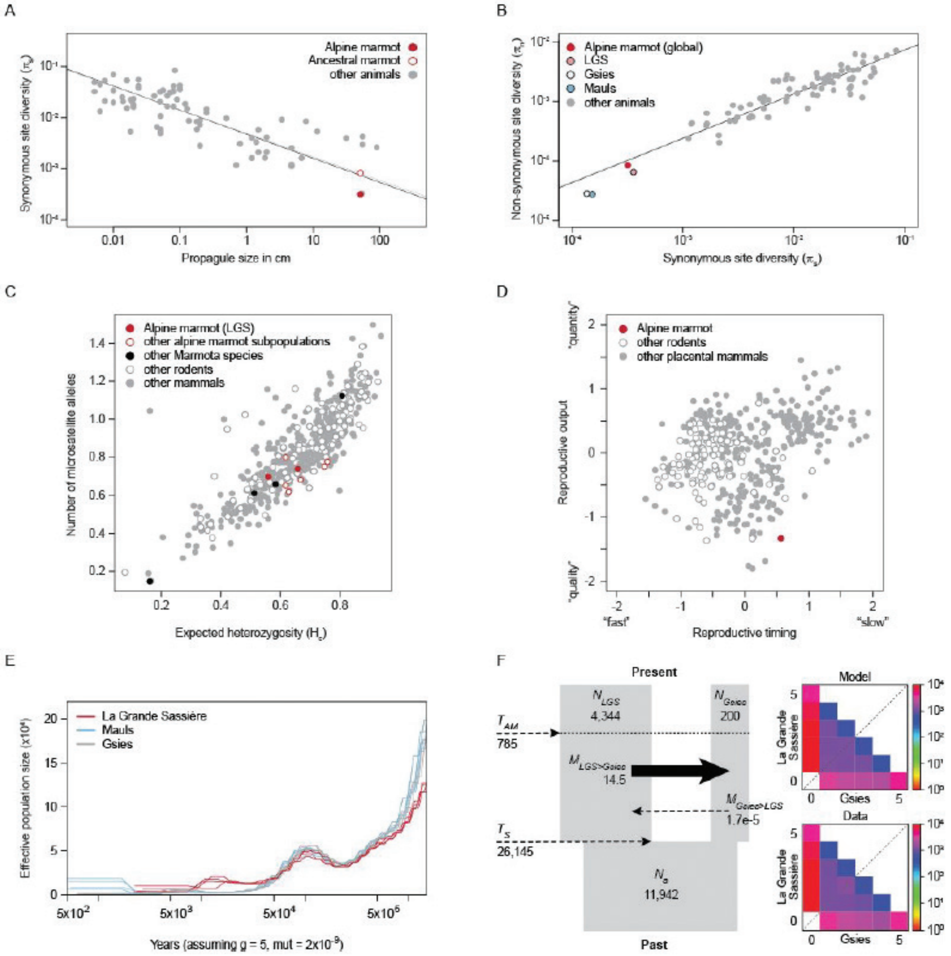


Figure 4. *The low genomic diversity in the Alpine marmot is explained by its life history and a lack of recovery from a past bottleneck*

A. The genetic diversity of the Alpine marmot is explained from its Life History. Species-wide synonymous site diversity from a wide range of animal species (Romiguier et al., 2014), plotted against their "propagule size" (i.e., the size in centimetres of the dispersing life stage). The delayed dispersal of the alpine marmot, and its large adult body size, yields a very large propagule size (Ge et al., 2013), consistent with the observed low diversity (filled red point). The fit is even closer when we consider the diversity we have inferred for the ancestral marmot population at the end of the Pleistocene (empty red point; Figure 4F). The correlations observed are very similar whether the marmot data are excluded (gray lines) or included (black lines).

B. The strength of purifying selection on amino acid variation in Alpine marmots is consistent with their effective population size, and the pattern observed across diverse animal species. Data from the Alpine marmot (colored points), have been added to the data of (Romiguier et al., 2014). The correlations are very similar whether the marmot data are excluded (gray lines) or included (black lines).

C. Microsatellite diversity in different Alpine marmot populations compared to many other species of mammals, including other marmot and rodent species. The number of microsatellite alleles (y-axis) is plotted against the expected heterozygosity (x-axis). Populations of the Alpine marmot from LGS are shown as red points, and estimates from other subpopulations of the same species, also from the French alps, are shown in as empty red bordered circles. Other species in the genus Marmota are shown as black filled circles, including the threatened M. Vancouver ensis, which appears at the bottom left of the graph.

D. Life history of the Alpine marmot (red point) in comparison to other Eutherian mammals (data from (Jones et al., 2009)). After correcting for body mass, much of the variance in mammalian life histories can be captured by two factors (Bielby et al., 2007): "reproductive output" (in which species vary according to their investment in offspring "quality" versus "quantity") and "reproductive timing" (in which species vary on a "fast-slow" continuum). The Alpine marmot appears as an extreme outlier.

E. Pairwise sequential Markovian coalescent (PSMC) analysis reveals details of the genetic past of the Alpine marmot. Evident is a decline in the LGS population after the last glacial maximum. Earlier events might suggest a longer-term decline, but might also indicate partial isolation between breeding populations.

F. The ancient migration {AM) is the most likely demographic scenario for the Gsies and La Grande Sassiere (LGS) populations inferred from the joint site frequency spectrum (SFS). This model predicts that a large ancestral population split up ~26,145ya into two smaller daughter populations. Gene flow between these two populations ceased ~785ya and was strongly asymmetrical with most migrants going from the large LGS population to the very small Gsies population (right upper panel). The joint SFS for the LGS and Gsies populations was obtained from 178,098 SNPs (right lower panel).

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NONSPECIFIC PREVENTION OF PLAGUE IN FOCAL MOUNTAINOUS AREAS

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Summary. It was found that nonspecific prophylaxis carried out by the method of pest control in marmot burrows in areas of high-mountain natural plague foci in the Kyrgyz Republic is an effective means of reducing their epizootic activity. The results of the survey carried out in recent decades confirm the possibility of an epizootic plague occurring independently in populations of mouse-like rodents and in populations of marmots. These facts give us reason to believe that the Tien-Shan natural plague focus is not strictly monohostal as it was considered to be for many years. It was also documented the return of plague enzootic to previously treated areas by introduction of the pathogen from the adjacent focal area, where preventive work was not carried out, although the return of infection took longer than previously expected.

Key words: nonspecific prophylaxis, pest control, highland plague foci, epizootic activity, plague microbe, marmots, fleas, mouse-like rodents.

The plague foci in the territory of Kyrgyzstan is confined mainly to the cold mountain zone of Tien Shan and Pamiro-Alai and are characterized as monohostal where the main carriers of infection are marmots because of their dominant position among other rodents, as the main carriers of fleas (O. Silantievi, R. li ventricosa and C. Lebedevi). This is facilitated by the continuous mosaic of colonies of marmots across relatively large areas, characterized by a significant diversity of environmental conditions. The lack of optimal habitats can promote high mobility of marmots, which results in close interpopulation contact, which provides the possibility of circulation of the plague microbe. The cold, severe climate of the high plateau negatively influences migration activity and delays marmot flea activity.The peculiar microclimate in the deep burrows - high humidity and low temperature without significant seasonal fluctuations - largely determines the life span of fleas and their preservation of the causative agent of plague in their bodies. In some years, the causative agent of the infection is isolated from other warm-blooded animals (narrow-skull and silver voles, gray hamsters, forest mice, steppe polecat, ermine, fox, hare, shrews) and from some representatives of arthropods (ticks; *Ixodes crenulatus*, lice; *Neohaematopinus palaearctus*) but such cases are rare (Bibikov et al., 1961; Tyulembaev et al.,1982).

A great variety of natural conditions in the mountains and obstacles for the dispersal of marmots made it possible isolate the Tien Shan plague focus from other foci in Aksai, Verkhnenaryn and Saryjaz. Using landscape-epizootological zoning, autonomous foci, and the Alai natural focus divided by the areas of foci - mezofoci, differing by the nature of the distribution of the number of main carriers and vectors of the pathogen, the degree of activity of epizootics can be determined (Bibikov et al., 1973; Usenbaev et al., 1985).

The annual registration of epizootics, from 1941 to 1983 and up until the end of non-specific prevention activities in 1989, demonstrated how persistent the presence of the causative agent in the foci was. At the same time, the degree of intensity of epizootics at the sites were different. Infected marmots averaged 0.5% of the population at each site, and in some years in some areas this figure reached 1% (Bibikov et al., 1973; Usenbaev et al., 1985).

The observed stable and intense epizooty of plague among marmots created the constant threat of human infection. In connection with the current epizootological situation, non-specific prevention has become an important part of a number of sanitary and preventive measures to influence the natural foci of the plague. Preventive measures were carried out by disrupting natural biocenoses focused on parts directly related to the circulation of the plague microbe. Anti-epizootic effect was achieved by reducing the number of main carriers, marmots, and vectors of the plague pathogen.

Non-specific prophylaxis by elimination of marmots was initiated in 1955. The effort focused on killing marmorts across large areas within the natural boundaries of their colonies. Conducted from 1955 to 1972 in the Aksai autonomous region, the focus of the extermination work was on an area of 700 thousand hectares. Two extermination events, in some areas more, did not provide long-term suppression of epizootic activity. Seven years after extermination efforts epizootic plague among marmots continued to occur. In the Saryjaz autonomous region focus on the cultural agent of plague was highlighted in –the three to four years following extermination efforts.

The low antiepizootic efficiency of marmot elimination lead specialists to shift focus to developing another method of preventing plague, aimed at control of the vectors, marmot fleas. During 1957-1970 various insecticides were used in a series of experiments conducted under the direction of S.V. Vishnyakov and V.K. Popov. Results of the experiments showed high Pulicidae mortality and anti-epizootic effectiveness of DDT dust in the field. During the study, the dosage of the drug was established, organizational forms, applied technology for burrow treatment, and production standards were developed. An important positive feature of this method was the ability to preserve marmots as valuable objects for fur trade. The insecticide was introduced into the burrows by shots from the AL-1 dinners, and settled in the courses of the upper tier of the burrow system.

Further transportation of the poison to the places with high concentrations of fleas (nesting chambers of burrows) was completed by animals, who transported dust that adhered to their fur at the opening of the burrow. Persistent targeted and antiepizootic effect was achieved by two consecutive applications of the treatment regularly repeated in the years following the initial treatment year. The highest effect of field disinfection was observed in high-altitude areas, where the number of fleas in marmot nests (in comparison with the pre-work period) decreased by more than 1000 times.

In the areas of the middle reaches on the Gulchinsky site of the Alai natural plague focus the number of fleas decreased by only 68 times.

Across large areas, the method of deep de-infestation of marmot burrows has been used since 1971. The area of the recovered territories using this method by 1989, was 1584,4 thousand has at the Tien Shan natural focus, and 216 thousand has at the Alay natural focus-.

Control over the treated territories was regularly carried out by anti-epidemic teams and zoological groups in each autonomous focus region of Tien Shan, as well as in the Alai natural foci. Long-term control stationary points were organized, taking into account the typical landscape and biocenotic features characteristic of the treated territories. Over 20 years, from 1974 to 2003, more than 39 800 marmots, 31 252 fleas, 25 814 other animals, 55 472 mites, and 16 393 lice from the healthy territories of the Tianshan natural focus of plague were tested.

Currently, we can say that the experience of the prevention method for thorough insect extermination in the burrows of marmots in the conditions of Tien Shan and Alai natural foci showed positive results .

In the territory of the Aksai autonomous region focal area from 1941 to 1975 before carrying out insect control actions 667 cultures of the causative agent of plague were detected.

After insect control activities, control surveys for the period from 1978 to 2016 detected only 5 cultures of the causative agent of plague (of which two cultures were from gray hamsters and three from their fleas, *A. primaries*). Among the marmots and their ectoparasites specific cultures of the plague pathogen were not detected.

In the Verkhnenarynsky autonomous focal area, before the field pest control programme was implemented, during a 30-year period, 838 crops were isolated. After a deep disinfestation of the burrows of marmots, in the following 11 years at the Bolgart focal site three plague cultures were identified (one from silver vole and two from grey hamsters).

In the 23rd year after working on the Ishtyk-Akshirak plague focal area, nine cultures of the plague pathogen were detected: six from marmots, two from narrow-skulled voles and one culture from a silver vole. At the time of culture collection, the number of fleas of the marmots was in this region at only 20-70% of the original population (Ibragimov & Gavrilova, 2001). An epizootological inspection at the same site in 2015 and 2016 detected two occurrences of the causative agent of plague (one from a marmot and one from a flea) .

In the Saryjaz autonomous focal site in the territory of Kyrgyzstan from 1944 to 1976, 462 cultures of the plague were detected. In 2012 (after 25 years spent using insect eradication in marmot burrows), one of the focal areas detected five occurrences of plague infection (four from marmots and one from grey hamster). In 2013, in the same focal area one case of human infection of with bubonic plague as a result of contact with a sick marmot was registered. In 2014 in the same areathree plague cultures (two from the corpses of marmots and one from a killed marmot with fleas). By this time, the number fleas on main host, marmots, was everywhere restored to the original level of population.

In the Alai focal areas, including the 1975 Gulczinski site, for the period from 1948 to 1981 (prior to the insect eradication programme intiation) 145 cultures of the plague microbe were detected. After initiation of the treatments here in 1982-1983, cultures of plague in these areas were not again identified, although the number of fleas of the marmots in the middle reaches of the Gulchinsky focal area have reached pre-treatment capacity.

Analysis of the results of long-term (over 40 years) epizootological survey of the territory, on which non-specific prophylaxis was carried out by the method of deep disinfestation of marmot burrows, showed that over this period there was no spread of plague from neighbouring areas where insect eradications were not carried out (Ibragimov, 2015).

After the recovery of the natural state of the focal areas were this method was applied, there was a noticeable increase in the frequency of cases of plague occurrence in mouse-like rodents and their ectoparasites without participation in the epizootic process by marmots and their specific ectoparasites. This fact indicates the possibility of occurrence of epizootics among species besides marmots, including species such as mouse-like rodents. Results also suggest that in the Tien-Shan focal area plague is not strictly monohostal, as it was considered to be for many decades (Pole et al., 1996; Pole, 1999; Ibragimov, 2017). Our main conclusion is that the use of non-specific prevention methods for deep disinsection of burrows of marmots in the Alpine conditions of focal areas of the Tian-Shan and Alai is an effective measure to reduce epizootic activity of these mountain foci of plague.

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BEST TIMES FOR QUANTITATIVE POPULATION ASSESSMENT OF NORTHERN POPULATIONS OF THE BOBAK (*MARMOTA BOBAK* MÜLL.)

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Abstract

From studying the terrestrial activity of bobak (*Marmota bobak*; also known as steppe marmot) from 2009 to 2010 in the Sokolovsky colony (Udmurt republic, Russia) we determined the optimal time for quantitative assessment at the northern edge of the species' distribution range. We recommend performing quantitative assessments of bobak populations during the second half of June in the morning and evening hours.

Estimation of population density is one of the most important tasks in marmot population studies and also has a great importance for managing marmot protection and rational use as a resource. The main methods for marmot quantitative assessment are based on the visual observation of animals during their periods terrestrial activity (Bibikov, 1989; Mashkin, 1997). To obtain more accurate data on population size, it is important to conduct surveys at times when the maximum number of animals are above ground.

To determine the best time for quantitative assessment of bobak at the northern limit of their distribution, we investigated trends in bobak terrestrial activity in the Sarapulsky district of Udmurtia, where bobak were introduced in 2001-2003. During the snowless period of 2009-2010, quantitative assessment of bobak in the Sokolovsky colony (56°16'53 "N, 54°03'10" E) were conducted. This colony is currently one of the northernmost outside the natural range of the species. Bobak were counted from the moment the first individual appeared on the surface in the morning ntil the last one entered its burrow in the evening. We used field binoculars for observations. Knowing the exact number of bobak in the observed families, we calculated the proportion of animals that were present on the surface together at any given time across the day. Observations took place every month for three to seven days

We found that the most active above ground period for post-hibernation bobak, before the young-of-year first appeared on the surface (which usually occurred by the end of May or beginning of June), was from 6 to 8 a.m. and 5 to 7 p.m. (Samara time, UTC+4). At the end of the first fortnight of Maya maximum of 56% of individuals were simultaneously on the surface, with bi-modal peaks of activity in morning and evening (Fig.1). Thus, in the spring a considerable underestimation of the total number of successfully overwintered individuals is possible.

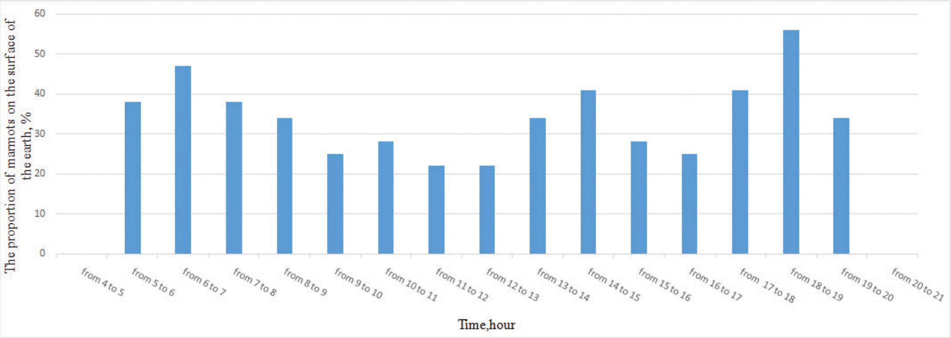

Fig. 1. *The dynamics of terrestrial activity of overwintered bobak in May (showing observations from 08.05.2010).*

In June, after young-of-year begin to appear above ground, the greatest proportion (75-80%) of bobak above ground at the same time occurred between 5 and 7 a.m. and between 7 and 9 p.m. At the end of the first fortnight ofJune, in the morning 100% of yearlings were observed above ground (Fig.2).

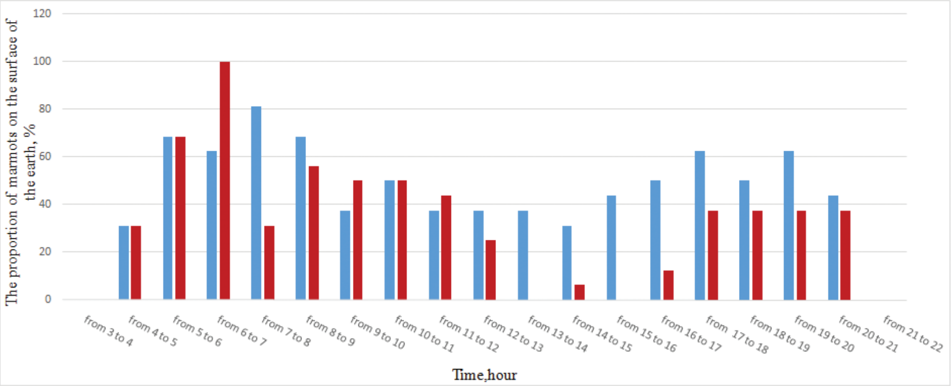

Fig. 2. *The dynamics of terrestrial activity of adult (blue) and young (red) bobak in June (showing observations from 08.06.2010).*

In July and August the maximum proportion of above ground bobak did not exceed 75%. In September, before hibernation, a single peak of above ground activity occurred in the afternoon, from 1 p.m. to 5 p.m. (Fig.3).

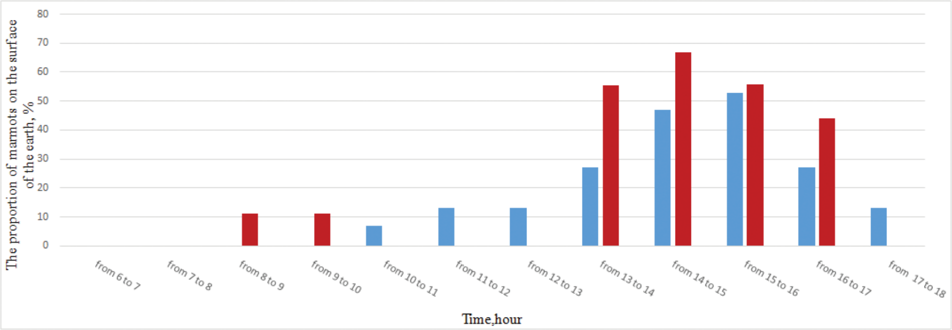

Fig. 3. *The dynamics of terrestrial activity of adult (blue) and young (red) bobak in September (according to observations at 10.09.2010).*

High air temperatures during the day and high levels of human activity near the bobak colony during strawberry gathering season both negatively affected the above ground activity of the bobak. During the strawberry gathering season, bobak peak activity shifted to a later time.

Thus, to maximize the accuracy of bobak population estimates in northern populations, we recommend conducting population counts in the second and third weeks of June, between 5 and 7 a.m. and between 7 and 9 p.m. Further, population counts are best performed on cool days with clear dry weather, as the most bobak tend to be above ground in those conditions.

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ECO-GENETICALLY FACTORS DETERMINING THE STRUCTURE AND FUNCTION OF THE SOUND SIGNAL OF EURASIAN MARMOTS

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Marmots are a life form (or ecotype), characterized by diurnal activity, high population density and dwelling in open landscapes. The key behavioral component of this life form is the timely warning of neighbors about the danger by means of a sound signal. Among ecological determined factors, I distinguish selection for the specialization of vocal activity of marmots, selection for optimization of the rhythmic structure of signal and selection for increasing the noise immunity of the transmitted message. Among the genetically determined factors, I distinguish the process of speciation, geographical variability, and gene drift in small isolated populations and variability in joint settlements of different species of marmots. The role of the landscape is so great that it even affects the rhythmical structure of the alarm call. The rhythmical structure of the signal is controlled by a vertical dismemberment of the relief of the terrain populated by marmots. The alarm call is designed not only for the animals outside of the burrow but also for those in the burrow. Similar to tubes, burrows have radial resonance. Judging from their diameter marmot burrows suppress the frequencies higher than 1 kHz but amplifies the lower frequencies. In order to increase noise immunity in the burrows the marmot alarm call has the low frequency component and an amplitude modulation. All the marmot species are characterized by species-specificity of structure of the alarm call. The genetically-determined species specificity of the signal structure encodes the population genotype. As a result; different species encode the same function using different symbols.

By this report, I sum up the long-term field studies of the vocal activity of Eurasian marmots, associated with an acoustic warning of danger.

All species of plants and animals are affected by two main factors – ecologically determined and genetically determined. Among ecological determined factors, determining the structure and function of the sound signal of Eurasian marmots, I distinguish selection for the specialization of vocal activity of marmots, selection for optimization of the rhythmic structure of signal and selection for increasing the noise immunity of the transmitted message. Among the genetically determined factors, I distinguish the process of speciation, geographical variability, and gene drift in small isolated populations and variability in joint settlements of different species of marmots. The above factors confirm that the alarm call performs two basic functions: facilitates the implementation of the ecological niche of species and the realization of the gene pool of populations (Nikol’skii, 2016).

Among the ecological factors responsible for the alarm call key factor is selection for specialization of vocal activity. Marmots are a life form (or ecotype), characterized by diurnal activity, high population density and dwelling in open landscapes. Open landscapes make it possible to see danger at a great distance and warn neighbors of it. The key behavioral component of this life form is the timely warning of neighbors about the danger by means of a sound signal.

The role of the landscape is so great that it even affects the structure of the signal. The rhythmical structure of the alarm call is controlled by a vertical dismemberment of the relief of the terrain populated by marmots. The greater the dismemberment of the relief the shorter the period of sound sequence producing the call. On the plain these are normally series of slow sound sequences. In the mountains these are series of rapid sequences.

Regressive analysis (Fig. 1) has supported a strong relationship between the relief of the terrain populated by marmots and the period of sound sequence.

$$t=(1.88731-0.00172041\mathrm{x}h)^2;\ R^2=89.8\%,\ p<0.001.$$

Where t is the period of sound sequence, h is the vertical dismemberment of the relief.

Assumed to be an independent variable is the vertical dismemberment of the relief - the distance from the nearest mountain top to the bottom of the valley. The relationship revealed is supported both on the intra- and inter-specific level (Никольский, 1984, Nikol'skii. 2002, Nikol'skii. 1994).

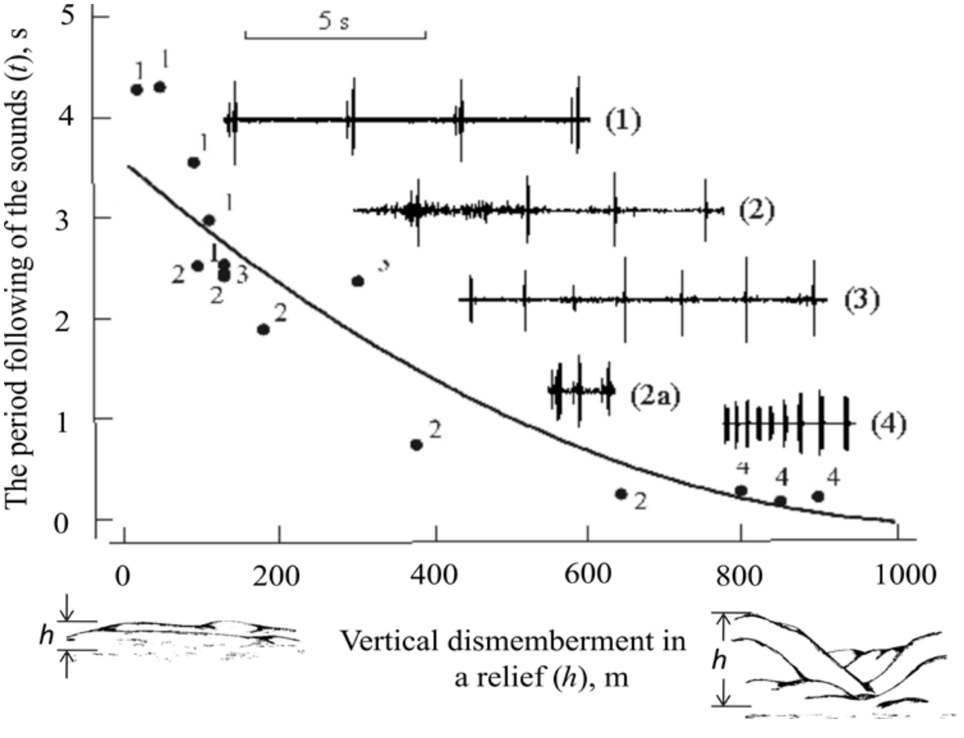


Fig. 1. *The relationship between extent of a vertical dismemberment (h) in a relief and the period following of the sounds (t). Species of marmot: 1 – M. bobak, 2 – M. baibacina, 3 – M. sibirica, 4 – M. caudata. Fragments of the signal of the listed species in one time scale – (1), (2, 2a), (3), (4).*

I believe that the selection mechanism is a high probability of marmots facing danger at an unexpectedly short distance. This is promoted by the down cuttings to the main slope, divided by ridges (Fig. 2).

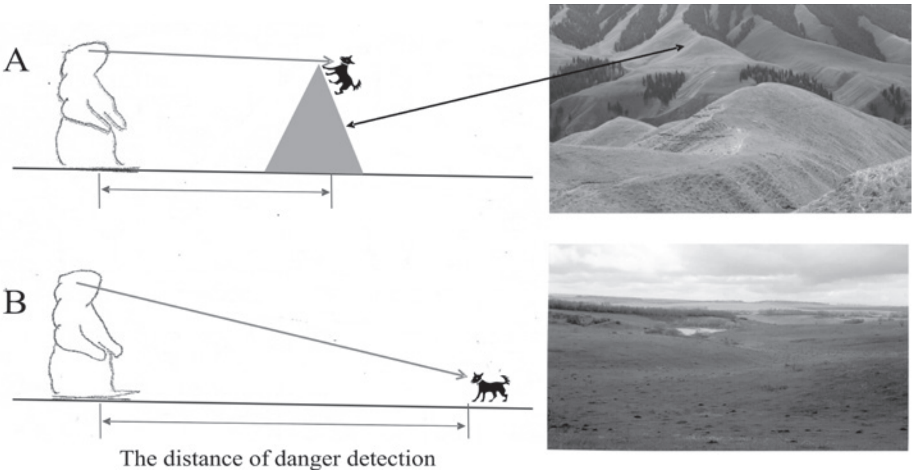


Fig. 2. *Influence of relief on the perception of danger by marmots. A – Mountainous relief. B – Flat relief.*

We do not know what factors are selected at the nervous system level.

There are grounds to believe that selection fixes different levels of reactivity in marmots. The levels of reactivity can be estimated by the gradients of situational changes in the rhythmical structure of the signal, as shown in Figure 3. The Situation “A” of moderate danger is associated with a low level of reactivity. The Situation “B” implies an increased danger level and is associated with a high level of reactivity. An increase in the level of reactivity is accompanied by a reduction in the periods of following the sounds in the signal. In extreme cases, the signal turns into a series of rapidly following sounds, which is typical for all species of marmots (Fig. 3). In the mountains the probability of increased danger (Situation “B”) is higher than in a plain area. As a result, selection extracts a high reactivity of the animals and respective rhythmic structure of the signal from the gradient of situational changes.

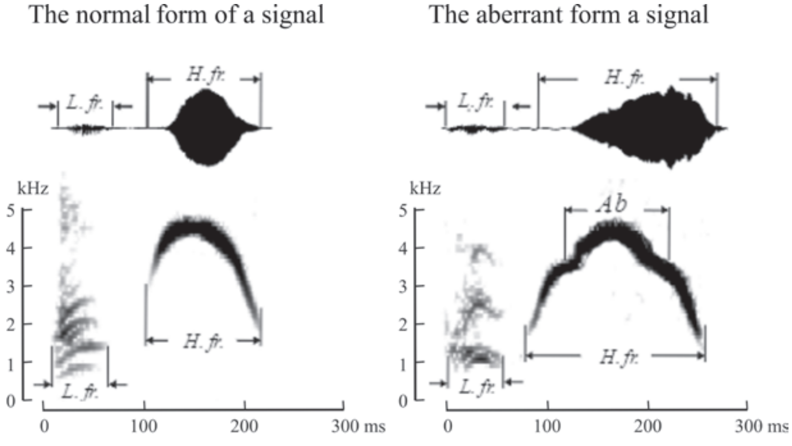


Fig. 3. *Situational changes in the signal. A - The rhythmic structure of the signal corresponding to situation "A". B - The same is situation “B”.*

A special case is the variability of the rhythmic structure of the signal of the Marmota sibirica. In the signal of one individual, there may be single sounds, doubles and a series of three sounds, as shown on the Figure 4. In my opinion, the signal of the Mongolian marmot is an intermediate (or transitional) form of the rhythmic structure of the alarm call. Further research may be useful for understanding the evolutionary mechanisms of signal structure formation.

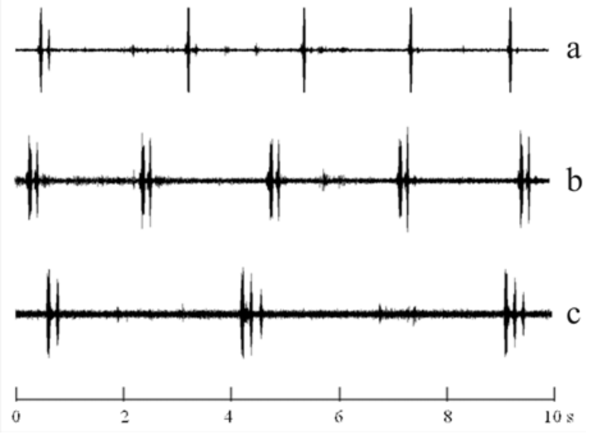


Fig. 4. *The diversity of the rhythmic structure of the signal of Marmota. sibirica. The signal forms: a – Single sounds predominate, there are double; b – Absolutely dominate the dual sounds; c – Doubled sounds predominate, there are a series of three sounds.*

The structure of any signal is to have some properties ensuring noise immunity of the messages transmitted .The alarm call is designed not only for the animals outside of the burrow but also for those in the burrow. Similar to tubes, burrows have radial resonance. Judging from their diameter marmot burrows suppress the frequencies higher than 1 kHz but amplifies the lower frequencies (Nikol'skii, Vinogradov, 2000).

In order to increase noise immunity in the burrows the marmot alarm call has two sources of lower frequency – the low frequency component and an amplitude modulation (Nikol'skii et al., 2015). The main energy of the low-frequency component is concentrated in the range lower than 500 Hz. The frequency of modulating oscillation ranges from several dozens to hundreds of Hz.

On an example of the Marmota bobak (Figure, 5). The Figure 5 demonstrates the function of the low-frequency component as a source of low frequency augmenting the noise immunity of the call in the burrows. We see that dominant on the surface is the high frequency component, whereas in the burrow, the low-frequency component predominates.

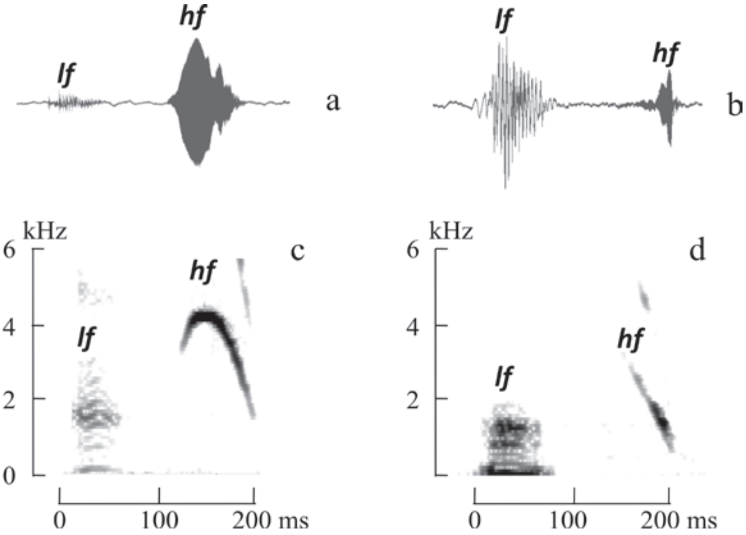


Fig. 5. *Low-frequency component as a source of low frequency. M. bobak. The signal on the surface of burrow: a – oscillation, c – sonogram. The signal into burrow: b – oscillation, d – sonogram. lf – low-frequency component; hf – high-frequency component.*

On an example of the call of the Marmota caudate the Figure 6 shows the functions of the amplitude modulations as a source of low frequency increasing the noise immunity of the call in case of its distribution in the burrows. The source of low frequency is a slow modulating oscillation. One can see that in the burrow the rapid carrier frequency is suppressed but the slow frequency of the amplitude modulation is dominant.

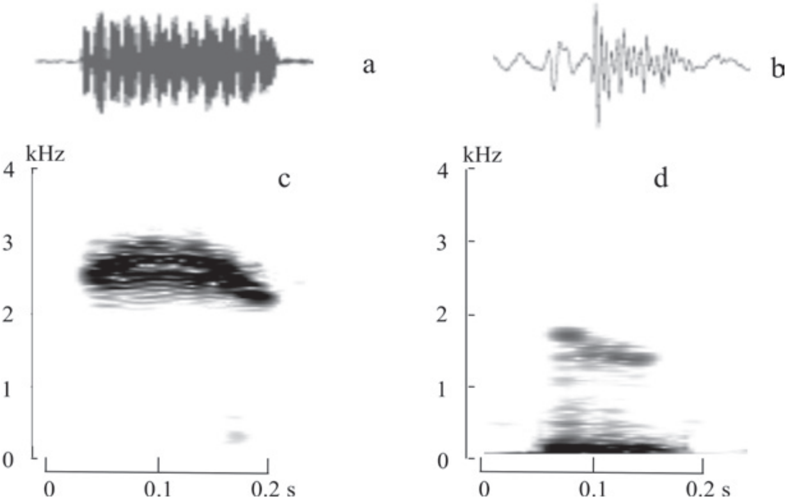


Fig. 6. *Amplitude modulation as a source of low frequency. M. caudate. The signal on the surface of burrow: a – oscillation, c – sonogram. The signal into burrow: b – oscillation, d – sonogram.*

In some species as, for instance, the Marmota baibacina and the Marmota sibirica the call may contain both sources of low frequency – the high frequency component and amplitude modulation (Nikol'skii, 2014).

The signal structure is highly-sensitive to genetically-determined variability. We have found 4 forms of genetically-determined structure variability of the signal, reflecting species-specificity, geographic variability and aberrations in small-number populations and also variability in joint inter-species settlements.

All the marmot species are characterized by species-specificity of the alarm call (Nikol'skii, 2014).

The genetically-determined species specificity of the signal structure encodes the population genotype and the ecologically-determined function (danger warning). As a result; different species encode the same function using different symbols (Figure 7).

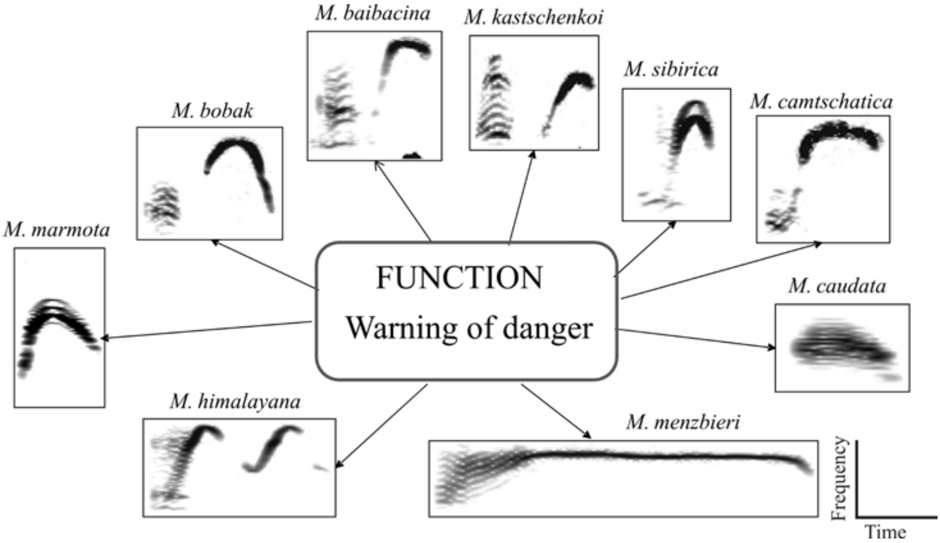


***Fig.** 7. The same ecologically determined function of the alarm call is encoded by different genetically determined symbols.*

This phenomenon of parallelism of function and divergence of the structure of sound signals is widespread in many groups of animals, but has not been practically studied. These indicate to two relatively independent directions of evolution: ecological expediency and genetic uniqueness.

Naturally, in the course of geographical (allopathic) species formation was preceded by geographic variability of the populations divided by eco-geographical barriers.

A characteristic example is the geographic variability of the signal of the Marmota caudata in the Central Pamir, where the southern and the northern population groups (Fig. 8), which are attributed the subspecies status were for a long time isolated by a thickness of the glacier (Nikol'skii et al., 1999). The boundary passes along the deep valleys of modern rivers Bartang, Murgab and Aksu (Fig. 9).

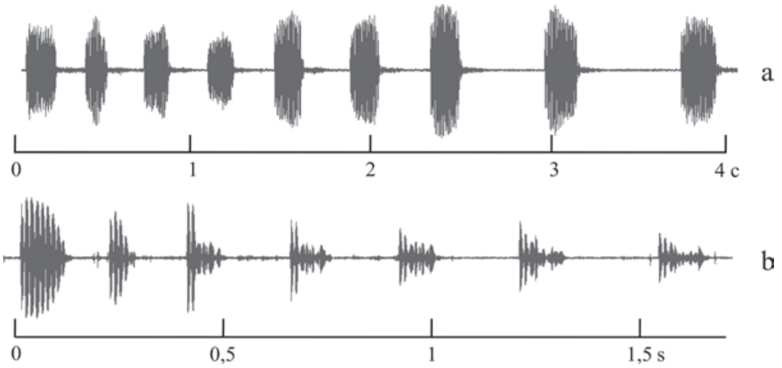


Fig. 8. *Geographic variability of the signal. M. caudate. a – the north form of signal; b – the southern form of signal .*

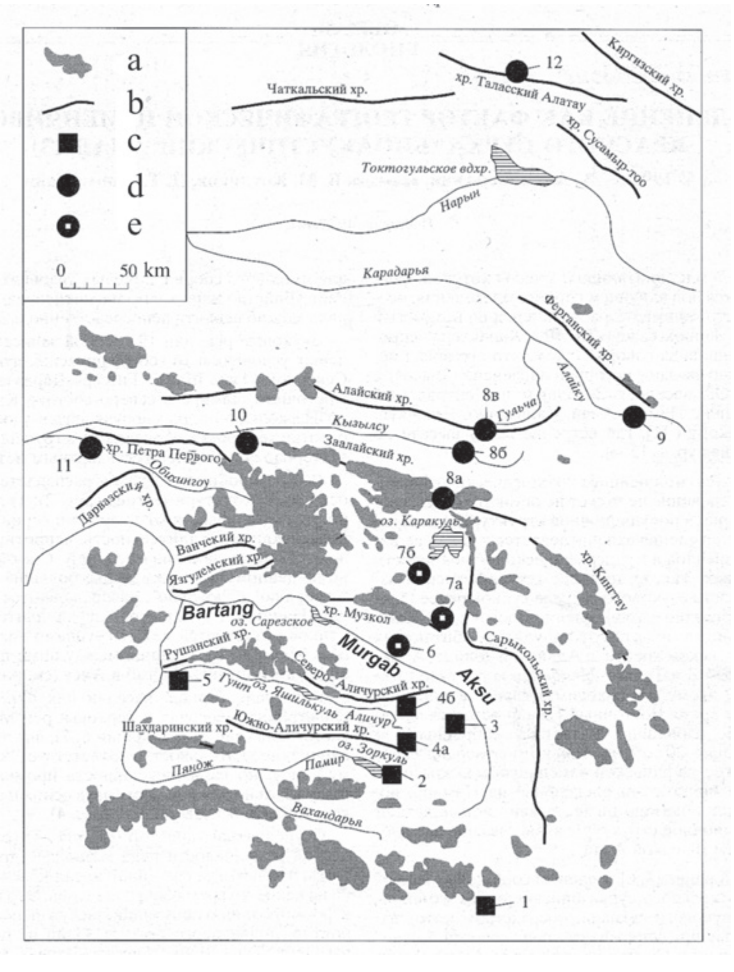


Fig. 9. *Local populations of M. caudate. 1 – 12 – local populations. a – glaciers; b – ridges; c – southern group of local populations; d – northern group of local populations; e – group of populations with intermediate signal signs.*

Another example of genetically-determined variability of the signal is the high probability of the aberrations that occur in small isolated populations, which is in keeping with the theory of gene drift.

A very high frequency of signal aberrations was revealed in the most distant population of the Marmota bobak in Ukraine (Nikol'skii, 2008a, b). This small population is isolated in main portion of the species distribution range along hundreds of miles (Fig. 10).

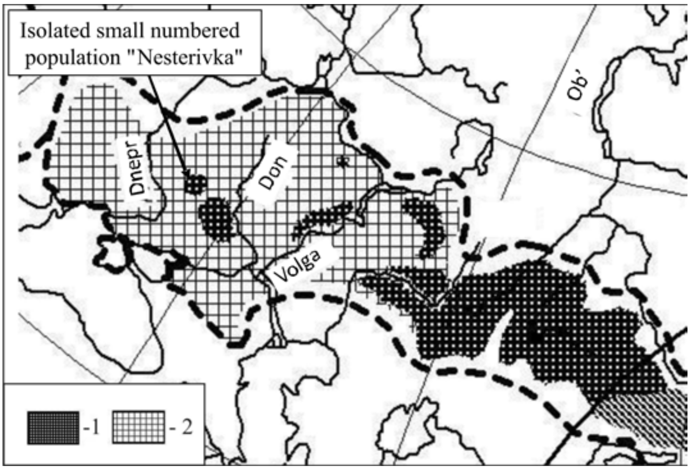


Fig. 10. *The modern (1) and restored (2) area of M. bobak.*

An aberration is a distorted characteristic of frequency modulation as shown in the Figure 10. This is the most common aberration that is found not only in the Steppe marmot but also in the Marmota baibacina and Marmota sibirica.

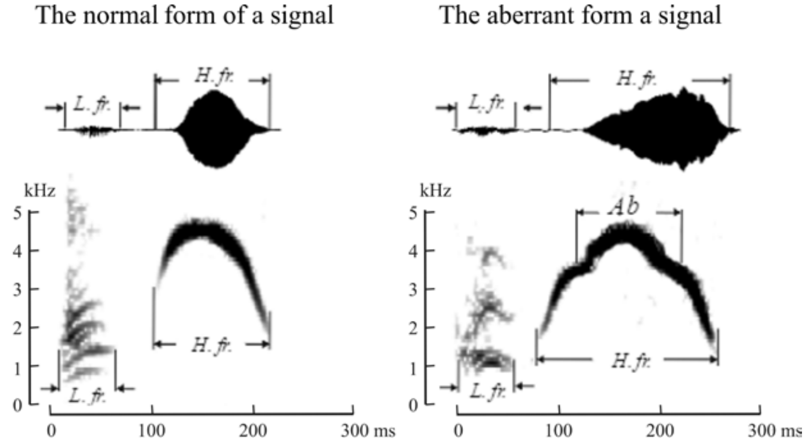


Fig. 11. *Aberration of a frequency modulation of the signal of M. bobak. L. fr. – Low-frequency component; H. Fr – High-frequency component; Ab – aberration.*

The Steppe marmot has a rare aberration of "amplitude modulation". There are only 3 instances per over 400 observations. The aberrant alarm call of the Steppe marmot is little different from the normal call of the Mongolian marmot. For it, the amplitude modulation is common. The distance between the species is several thousand kilometers.

The Fig. 12 shows that the probability of the signal aberration in the Steppe marmot increases from the center of the species range to its periphery, where fragmentation is particularly great.

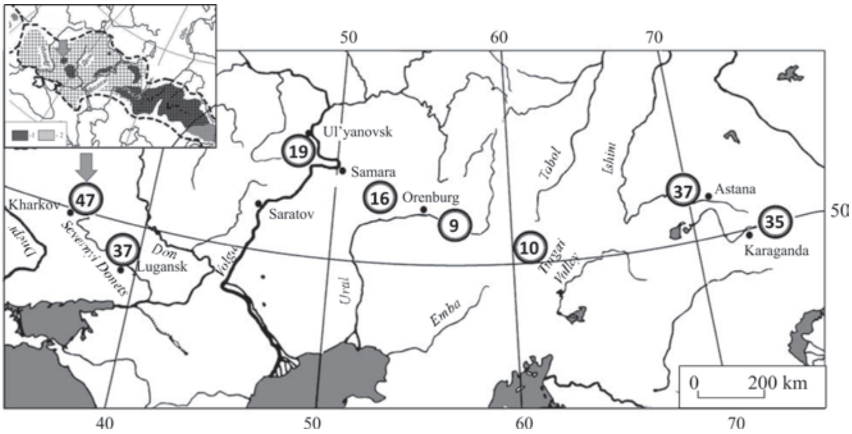


Fig. 12. *Probability (percents, in circles) of aberrations in populations of M. bobak.*

The fourth genetic factors are the variability of the signal in the zone of secondary contacts. In joint interspecies settlements variability is such that there are grounds to infer hybridization between the species.

In particular, in the joint settlements of Marmota baibacina and Marmota bobak in Central Kazakhstan we revealed a great diversity of signal forms – from species-specific to intermediate forms (Никольский и др., 1983). In intermediate forms the relationship between the ascending and descending branches of frequency modulation shows a great diversity. As demonstrated in the Figures 13, they are normally equal.

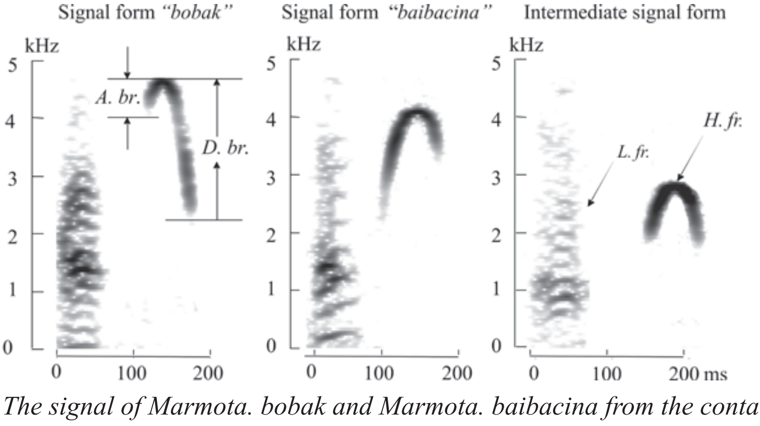


Fig. 13. *The signal of Marmota. bobak and Marmota. baibacina from the contact zone in the Central Kazakhstan. The ascending branch (A. br.) and descending branch (D. br.) of the frequency modulation characteristic. L. fr. – low-frequency component; H. fr – high-frequency component.*

With increasing distance from the boundary of the contact between the species the probability of species-specific forms of the signal increases (Fig. 14).

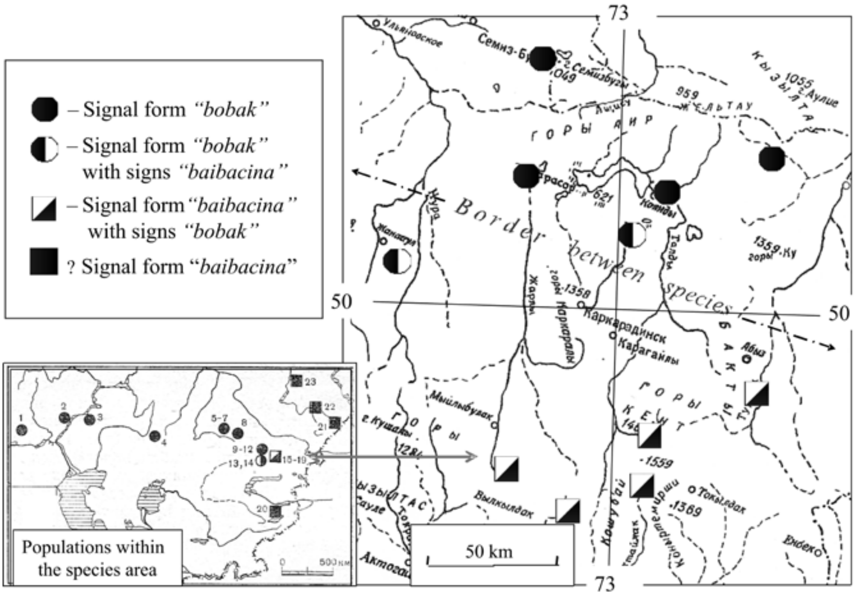
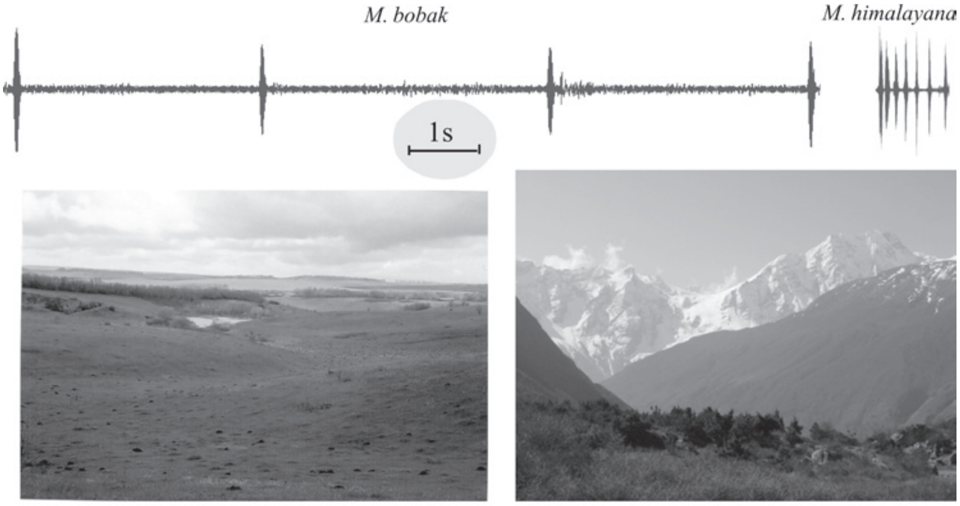


Fig. 14. *Populations in the contact zone of Marmota. bobak and Marmota. Baibacina.*

The results obtained confirm the existence of two relatively independent processes: 1) the influence of ecologically determined factors on the vocal activity of marmots and the structure of the sound signal associated with increasing the noise immunity of the transmitted message; 2) the influence of genetically determined factors on the structure of the signal. These two processes are relatively independent, and their most significant result is: 1) inter specific parallelisms of the signal function and 2) inter- and intr a specific divergence of the signal structure. The relative independence of the two directions of evolution confirms that the signal performs two basic functions – the realization of the species of ecological niches and the realization of the population's genotype.

The above suggests the most unexpected and intriguing conclusion is the effect of the relief of the terrain populated by marmots on the rhythmic organization of the signal. The greater the dismemberment of the relief, the shorter the periods of sound sequence. The extreme forms differ by an order of magnitude as demonstrated by the Figure 15. The main intrigue lies in the fact that so far we can only state a strong effect of selection on the signal structure. But we do not know that is the object of selection at the nervous system level. True enough, selection does not affect the signal directly but rather its source – the nervous system of marmots.



Plains of Ukraine. *M. bobak*

The highest mountains of Nepal. *M. hymalayana*

Fig. 15. *The extreme forms of the dismemberment of the relief and their respective the extreme forms of the rhythmic organization of the signal.*

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РАСПРОСТРАНЕНИЕ И ЭКОЛОГИЯ ГИМАЛАЙСКОГО СУРКА (RODENTIA, SCIURIDAE, MARMOTA HIMALAYANA HODGSON 1841) В КИТАЙСКОЙ НАРОДНОЙ РЕСПУБЛИКЕ

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В обзоре распространения и экологии гималайского сурка (Marmota himalayana Hodgson 1841) на территории Китайской Народной Республики использована литература на китайском языке. В Китае гималайский сурок населяет Цинхай-Тибетское нагорье от верхней границы леса и до снеговой линии в диапазоне высот от 1800 до 5670 м над ур. м. Благодаря высокому положению гор вид проникает далеко на юг, в Гималаи, почти до 27° с.ш. Продвижению гималайского сурка на север препятствуют пустыни Центральной Азии. Наибольшая плотность населения гималайского сурка характерна для нижней части склонов на подножной равнине. Питается гималайский сурок в основном вегетативными частями многих видов злаковых, осоковых, бобовых, гречишных и розоцветных. Тяготеет к поселениям человека, где выпасаемый скот способствует постоянному возобновлению верхушечных побегов растений, которыми питаются сурки. Наибольшая наземная активность наблюдается в июле - августе, наименьшая - в сентябре. Наибольшая суточная активность отмечена в течение 3 часов после восхода солнца и за 4 часа до захода. Семья состоит из взрослых самца и самки, сеголетков и двухлетних сурков. Норы гималайского сурка двух типов - постоянные и временные. Температура воздуха в норах колеблется от 1°C до 7°C, относительная влажность воздуха приближается к 100%. Сурки залегают в спячку в третьей декаде октября. Спячка длится 5-8 месяцев. После выхода из спячки сурки спариваются. Беременность самок длится 30-35 дней. В помете 4-6 детенышей. Гималайский сурок является одним из активных компонентов природного очага чумы, что особенно актуально для Китая в связи с эксплуатацией Цинхай-Тибетской железной дороги.

Ключевые слова: Гималайский сурок, Китайская Народная Республика, распространение, экология, Цинхай-Тибетское нагорье.

Учитывая незначительный объем публикаций на русском языке, посвященных гималайскому сурку, и традиционно высокий интерес к изучению сурков в России и в некоторых соседних странах, задача нашего сообщения состоит в том, чтобы, используя литературу на китайском языке, представить обзор, посвященный распространению и экологии гималайского сурка в Китае. Устойчивый интерес к экологии сурков объясняется их мощным влиянием на экосистемы, широким распространением и большим практическим значением, прежде всего, активным участием сурков в поддержании природного очага чумы в густонаселенных районах Центральной Азии.

Гималайский сурок является одним из наиболее значимых компонентов Центрально-Азиатского очага чумы. Его ареал совпадает с ареалом чумного микроба (Сунцов, Сунцова, 2006), культура которого впервые выделена в 1954 г. в провинции Цинхай (Дзи Шули, 1988; Ван Чжицзюнь, 1992). Дальнейшие исследования показали, что на гималайском сурке обычны носители возбудителя чумы. В основном это 3 вида блох: *Callopsylla dolabris, Oropsylla silantiewi, Rhadinopsylla ralipsyllali* (Ван Чжицзюнь, 1992).

В последние годы в Китае изучению экологии гималайского сурка придается особое значение в связи со строительством Цинхай-Тибетской железной дороги. Эксплуатация транстибетской магистрали во много раз повышает вероятность контактов человека с грызунами и их блохами (Цзян Чжиюн, Ли Цзинчжун, 2009). Начиная с 1990-х годов, в поселениях гималайского сурка регулярно регистрируют не только эпизоотии чумы, но и заражения чумой человека (Лю Сяочжи, Хай Жун, 2010).

Используя имеющиеся в китайской научной литературе сведения о гималайском сурке, мы смогли выделить в нашем обзоре такие разделы как: распространение гималайского сурка в Китае, его места обитания, устройство и использование нор, питание, размножение, сезонная и суточная активность, включая активность, связанную с зимней спячкой, линька. Полезным оказалось сравнение некоторых черт экологии гималайского сурка с экологическими особенностями других видов сурков Евразии.

Изображение гималайского сурка в его естественной среде обитания (в Непале) представлено на рис. 1.

Распространение. Описывая распространение гималайского сурка, мы, в том числе, ссылаемся на соответствующие провинции Китая. Но из-за ограниченного масштаба карты (рис. 2) мы не изобразили границы провинций. В качестве компромиссного варианта мы обозначили административные центры провинций и город Лицзян, окрестности которого являются южной границей ареала гималайского сурка в Китае. При первом упоминании провинций в скобках указаны их административные центры.

Хотя сурок и называется "гималайским", но по характеру распространения он, конечно, "тибетский" − основная часть его ареала находится в Тибете (в широком понимании этого топонима, Юсов, 1958), и лишь краевые популяции проникают в Гималаи (Никольский, Улак, 2005).

Вид включает два подвида: *M. himalayana himalayana* Hodgson 1841 и *M. h. robusta* Milne-Edwards 1871 (Громов и др., 1965). *M. h. himalayana* распространен в южной части Тибетского автономного района, Сицзан (Лхаса), а *M. h. robusta* – в провинции Цинхай (Синин), в Тибетском автономном районе, на западе провинции Сычуань (Чэнду), в провинциях Юньнань (Куньмин), Ганьсу (Ланьчжоу) и в Синьцзян-Уйгурском автономном районе (Урумчи) (Hoffmann et al., 2010).

В Китае гималайский сурок населяет Цинхай-Тибетское нагорье и прилегающие к нему районы (рис. 2) к востоку до юга провинции Ганьсу и до запада провинции Сычуань, к югу до Тибета и северо-западной части провинции Юньнань, и на север до северной части системных хребтов Циляньшань в провинции Ганьсу (Мэн Дежун, 1996). Цинхай-Тибетское нагорье является не только основной частью ареала гималайского сурка, но, как считает Чжао Чжунши (1982), центром происхождения вида.

Гималайский сурок населяет многие горные массивы Китая, такие как Куньлунь, Баян-Хара-Ула, Амне Мачин, Аркатаг, Алтынтаг, Каракорум в Тибетском автономном районе, Нань-Шань в провинции Ганьсу, Хэндуаньшань (Сино-Тибетские горы) на северо-западе провинции Сычуань и массивы Дечен, Шангри-Ла, Лицзян на северо-западе провинции Юньнань (Чжао Чжунши, 1982). Южные пределы области распространения гималайского сурка доходят до границы Тибета с Гималаями и южными склонами горной системы Каракорум в Кашмире (Ван Сыбо, Ян Ганюн, 1983).

Распространение горных видов сурков ограничивает соотношение географической широты гор и их высоты над уровнем моря. Высокое положение гор позволяет гималайскому сурку проникать далеко на юг (Никольский, Улак, 2005). В районе Хэндуаньшань, включая восточную часть Тибета, запад провинции Сычуань (Лисянь, Литанг) и запад провинции Юньнань (Шангри-Ла, Лицзян), ареал гималайского сурка доходит до 27º15´-29º20´ с.ш. и 98º25´-100º25´ в.д. Здесь он из Палеарктики проникает в Индо-Малайскую область (Чжао Чжунши, 1982). Это единственный случай проникновения сурков Евразии за пределы Палеарктики. Южной точкой нахождения гималайского сурка на территории Китая являются окрестности города Лицзян в провинции Юньнань (27º15´ с.ш.).

Продвижению вида на юг способствуют высокие Сино-Тибетские горы (Хэндуаньшань). В этом районе на широте 27º06´ с.ш. граница леса поднимается до 4200 м, выше которой расположены альпийские кустарники и луга, что позволяет суркам селиться от 4200 до 4800 м над ур. м. вплоть до ледника Юйлунсюэшань. Этот ледник, самый высокий из южных ледников Китая, достигает высоты 5596 м (Чжао Чжунши, 1982). Таким образом, южные пределы распространения гималайского сурка, как в Гималаях, так и в Сино-Тибетских горах доходят почти до 27º с.ш.

Северную границу ареала гималайского сурка образуют хребты Куньлунь, Алтынтаг, Циляньшань. Эти хребты являются экологическими коридорами между пустынями Такла-Макан, Гоби и Алашань на севере и пустынной высокогорной равниной Цайдам, лежащей на высоте 2000-3000 м над ур. м. между хребтами Алтынтаг, Нань-Шань и Куньлунь (рис. 2) (Никольский и др., 2014).

Преградами, лимитирующими расширение ареала гималайского сурка на север и северо-запад, являются равнинные пустыни Центральной Азии. Грандиозные размеры центрально-азиатских пустынь на территории Китая не преодолимы для сурков (Никольский и др., 2014). Они протянулись с запада на восток на многие тысячи километров: Таримская впадина, включая одну из величайших пустынь мира − пустыню Такла-Макан, пустыни Алашань, Гоби, Ордос, Лессовое плато.

Расширение ареала гималайского сурка на запад ограничивают горные вершины, покрытые ледниками, и реки. Его западной границей являются вершины Музтагата (7546 м) и Чогори (8611 м), которые находятся на восточном берегу верховья реки Яркенд. Обе вершины, а также река Яркенд, приток Тарима, представляют собой барьер, разделяющий ареалы гималайского и красного, или длиннохвостого *(M. caudata)* сурков.

Согласно личному сообщению Ляо Лифу, на юго-западе Таримской впадины в волости Тэдоне, уезда Ташкургана с географическими координатами 37º68´ с.ш., 76º21´ в.д. гималайский и красный сурки образуют небольшую зону перекрывания ареалов, но совместные поселения этих двух видов не известны.

В Синьцзян-Уйгурском автономном районе гималайский сурок встречается в горах Куньлунь от верховья реки Ядигар к востоку. Западнее, на северном склоне Куньлунь, сурков нет из-за преграды, образуемой рекой Ядигар. Горы, которые находятся на правом (восточном) берегу верховьев реки Ядигар, образуют западную границу ареала гималайского сурка (Ван Сыбо, Ян Ганюн, 1983).

Места обитания. В пределах ареала на территории Китая гималайский сурок обитает от верхней границы леса до снеговой линии от 1800 до 5670 м над ур. м. (Ван Чжицзюнь, 1992; Hoffmann et al., 2010). Ранее сообщалось (Никольский, Улак, 2005), что нижняя граница распространения гималайского сурка не опускается ниже 3000 м, что справедливо для Непала, но не соответствует особенностям его распространения в Китае.

В Тибетском автономном районе (Сицзан) и в провинции Цинхай сурки населяют альпийские и горностепные луга с кустарниками. В основном на высоте от 3750 до 5200 м, местами поднимаясь до 5670 м. Кроме северо-западных пустынь и некоторых лесных районов на юге, сурки распространены почти по всему региону. Здесь, в зависимости от местообитания, плотность населения сурков колеблется в широких пределах, от 8 до 114 особей на 1 км² (Цзе Ян, Смит, 2009; Hoffmann et al., 2010).

В горах Куньлунь сурки обычны от 3300 до 4300 м над ур. м. Но наиболее пригодные места обитания сосредоточены в узком степном поясе, от 3500 до 4100 м. Здесь, в поселениях ленточного типа, плотность популяции достигает 10+20 особей на 1 км². На высоте от 2500 до 2800 м над ур. м. сурки изредка встречаются в малочисленных, одиночно разбросанных поселениях (Чжао Чжунши, 1982).

В провинции Ганьсу, в восточной части системных хребтов Циляньшань (Нань-Шань), сурки предпочитают селиться на высотах от 3000 до 3500 м над ур. м. Ниже 3200 м и выше 3500 м число нор сокращается. На выбор местообитания влияет крутизна склона. Оптимальной является крутизна от 5° до 15°. По мере увеличения крутизны склонов число нор уменьшается (Дай Шимэй и др., 2008).

Гималайский сурок тяготеет к лугам с разреженным травостоем и кустарником. В растительном покрове большинства мест его обитания обычны осока, сныть, ковыль. Когда луговая степь переходит в сухие или опустыненные степи, плотность популяции сурков сокращается. Если же в таких засушливых местах обитания на северных склонах гор кустарников нет, но хорошо развиты клетра *(Clethra sp.)* и пятилистник кустарниковый *(Potentilla fruticosa)*, численность сурков вновь возрастает (Цзян Чжиюн, Ли Цзинчжун, 2009).

Другие авторы отмечают, что гималайский сурок тяготеет к относительно засушливым условиям обитания и открытому ландшафту (Ван Сыбо, Ян Ганюн, 1983; Хан Чунсюань, 2005; Hoffmann et al., 2010). В Цинхай-Тибетском нагорье он часто живет по высокогорным долинам, где предпочитает солнечные, хорошо прогреваемые склоны. Но наибольшая плотность популяции сурков характерна для подножной равнины, в нижней части прогреваемых склонов. На террасах и в долинах рек сурки встречаются реже (Ван Сыбо, Ян Ганюн, 1983).

В 60-х годах прошлого столетия площадь поселений гималайского сурка в Северо-Западном нагорье Китая была очень высокой, но к 90-м годам пригодные места обитания сильно сократились. Антропогенная трансформация ландшафта и активное преследование сурков охотниками вытеснили их из открытых местообитаний луговой степи на окраины лесостепных лугов и лугов с кустарниками (Ли Дошоу, 1995).

Дай Шимэй с соавторами (Дай Шимэй и др., 2008) разделяют географические и экологические факторы, влияющие на распространение сурков в провинции Ганьсю. Ведущими географическими факторами, согласно их наблюдениям, являются высота над уровнем моря, крутизна склонов и географическая долгота. Экологические факторы, такие как высота растительного покрова и надземная биомасса, оказывают совместное влияние с перечисленными выше географическими факторами. Наибольшая плотность нор на единицу площади отмечена в местах обитания, где высота травяного покрова составляет 10-15 см, а надземная биомасса превышает 150 г на м2. Высота травостоя более 15 см неблагоприятна для обнаружения сурками врагов, поэтому число нор на единицу площади в этом случае сокращается (Дай Шимэй и др., 2008).

Близость жилья, дорог, сельскохозяйственных угодий привлекают сурков (рис. 3). По мере удаления от человеческого жилья и увеличения расстояния от дорог норы сурков встречаются реже (Дай Шимэй и др., 2008).

В соседнем Непале (рис. 1), как и в Китае, сурки так же терпимо относятся к человеку (Никольский, Улак, 2006). Тяготение гималайских сурков к поселениям человека связано, вероятно, с выпасом скота. Выпас способствует постоянному возобновлению верхушечных побегов растений, которыми питаются сурки. Ранее мы предположили, что в прошлом гималайский сурок делил пастбища с яком *(Poëphagus mutus)*, который был не только обычен, но и многочислен в Тибете (Пржевальский, 1946), в основной части ареала гималайского сурка. В настоящее время место дикого яка занял домашний скот, включая и одомашненных яков, образ жизни которых мало отличается от образа жизни их диких предков (Никольский, Улак, 2006).

Привязанность сурков к антропогенному ландшафту повышает вероятность контактов человека с сурками и их блохами, повышая, соответственно, вероятность заболевания человека чумой, что является предметом сильного беспокойства медицинской службы Китая (Лю Сяочжи, Хай Жун, 2010)

Норы. Колония гималайского сурка объединяет нескольких семей. Семья состоит из взрослых самца и самки, сеголеток и двухлетних сурков. Каждая семья занимает свою, отдельную нору. Молодые звери расселяются после достижения ими половой зрелости (Цзян Чжиюн, Ли Цзинчжун, 2009).

Норы у гималайских сурков бывают постоянные и временные. Постоянные норы делятся на зимовочные норы и летние, выводковые, в которых самки выращивают потомство.

Глубина, устройство и сезонная динамика использования гималайскими сурками нор связаны, в том числе, с распространением вечной мерзлоты, погребенной в одном из почвенных горизонтов. В Цинхай-Тибетском нагорье, где норы сурков проникают в 4 почвенных горизонта, верхний слой представлен слабощелочной степной почвой, его подстилает желтозём, за ним следует третий слой, слой чистого песка, и, наконец, четвёртый слой, образованный смесью песка и глины. Вечная мерзлота сосредоточена в третьем слое на глубине около 2-2.5 м (табл. 1) (Ван Чжицзюнь,1992).

Сурки выкапывают норы выше, или ниже мерзлого грунта. Все гнездовые камеры, находящиеся над вечной мерзлотой, обычно достигают глубины 1.5-3.0, максимум - до 4.0 м. Гнездовые камеры ниже этого слоя расположены на глубине от 1.5 до 6-7 м, а зимовочная камера может находиться еще глубже (Ван Чжицзюнь 1992; Хан Чунсюань, 2005; Цзян Чжиюн, Ли Цзинчжун, 2009). Насколько "глубже" авторы не сообщают, но замечание Юсова (1958, с. 152), что гималайский сурок, которого он называет "тибетским", проводит зиму в норах "до 10 м и более", повторенное Банниковым (Банников и др., 1964), скорее всего, не соответствует действительности.

Согласно наблюдениям Ван Чжицзюнь (1992), характерные для Цинхай-Тибетского нагорья постоянные норы обычно имеют две гнездовые камеры, зимнюю и летнюю (рис. 4). Первый поворот от входа расположен на глубине 100 − 140 см. Объём гнездовых камер составляет примерно 0.23 м3.

По другим наблюдениям (Цзян Чжиюн, Ли Цзинчжун 2009), в одной зимовочной норе размещается до 5 гнездовых камер, объем каждой из них около 0.0875 $м^3$ (0.5х0.5х0.35 м). От входа вниз под углом 15-45° спускается полукруглый в поперечнике ход. Достигнув глубины 0.5 м, он постепенно выравнивается параллельно поверхности земли. Последнее замечание очень важно – уменьшение угла наклона ходов замедляет конвективный перенос тепла, делая температурный режим норы более ровным, менее зависимым от колебаний температуры в приземной атмосфере (Никольский, Хуторской, 2001).

В высокогорье, где обычно сезонное промерзание почвы, норы сурков располагаются ниже наибольшей глубины мерзлого грунта (Цзян Чжиюн, Ли Цзинчжун, 2009).

Диаметр входа в нору равен 18-20 см, диаметр туннеля – 20-23 см (Ван Чжицзюнь, 1992), но зимовочные, чаще посещаемые и дольше используемые норы, имеют существенно больший поперечник входного отверстия, в среднем равный 38.1 см (Цзян Чжиюн, Ли Цзинчжун, 2009).

Все ведущие наружу ходы на зиму закрываются земляными пробками. Выходя из норы после спячки, сурки используют новое отверстие. Длина забитых ходов составляет 1.5-2, реже -3 м. Число старых входов в нору колеблется от 7 до 15, входы соединены между собой тропинками. (Цзян Чжиюн, Ли Цзинчжун, 2009).

Старые норы, используемые многими поколениями сурков, образуют матрицу стабильных элементов (Наумов и др., 1981) биологического сигнального поля, где главными аттракторами (стабильными элементами поля) являются норовые отверстия, выбросы грунта и тропинки. Характерные для ландшафтов, населённых сурками (Ванисова, 2015), они, конечно, характерны и для поселений гималайского сурка (рис. 3а).

Длина отдельных ходов в норах гималайского сурка составляет 7-12 м, а их общая протяженность достигает 10-30 м. В норах нет специально устроенных уборных и кладовой. В качестве уборных сурки используют тупиковые ходы (Ван Чжицзюнь, 1992; Хан Чунсюань, 2005; Цзян Чжиюн, Ли Цзинчжун, 2009).

Глубина мелких летних нор не превышает 1-2 м (Хан Чунсюань, 2005; Цзян Чжиюн, Ли Цзинчжун, 2009). Хан Чунсюань (2005) называет их “временными норами”. Они располагаются под утоптанной площадкой около постоянных нор и открываются одним-двумя отверстиями. Как правило, летние норы имеют одну небольшую камеру, 1-2 входа и легко узнаются по небольшого размера сурчине. Подстилка в летних камерах состоит из свежих растений. Временные норы могут быть перестроены в летнюю выводковую нору. Осенью сурки оставляют ее, или превращают в зимовочную нору (Цзян Чжиюн, Ли Цзинчжун, 2009).

В 2014 г. на Северо-Западном плато в провинции Цинхай (Qinghai) нам удалось сделать фотографию обнажения норы, образованного обрушением склона (рис. 5). На фотографии видно, что нора старая, вырыта в мощной, не менее 4 м, толще мелкозема, ходы расположены на одном уровне, на глубине 1-2 м от поверхности. Судя по следам многочисленных пробок, ниже расположен еще один ярус ходов. На это же указывает и открытый обрушением ход, уходящий в глубину норы под большим углом. Судя по свежести следов, эта постоянная гнездовая нора до настоящего времени используется сурками как выводковая, или как зимовочная. Судя по фотографии (рис. 5), основную толщу обнажения образует лёсс. Лёсс обычен в районе наших наблюдений на западной периферии Ланьчжоуской (Lanzhou) впадины и далее на восток, где простирается Лёссовое плато (Павлинов, 1959, с. 56).

Одним из характерных свойств лёссовых грунтов является их склонность к *вертикальному* отслаиванию (Кригер, 1965, с. 95). Следы вертикального отслаивания хорошо видны на нашей фотографии – по всей поверхности обнажения, за исключением верхнего, гумусового горизонта, сглаженные поверхности грунта указывают на границу раздела вертикальных слоёв, по которым прошло обрушение склона. Именно вертикальное отслаивание придаёт характерный облик ландшафту в местах распространения лёссовых грунтов (Павлинов, 1959; Крюгер, 1965). Вертикальное отслаивание лёсса представляет собой постоянную угрозу разрушения нор сурков, ограничивая, тем самым, их распространение.

Ранее (Никольский и др., 2014) мы показали, что в Китае мощной, непреодолимой преградой, отделяющей ареалы красного *(M. caudata)*, серого *(M. baibacina)* и монгольского *(M. sibirica)* сурков от ареала гималайского сурка являются равнинные пустыни Центральной Азии. Обнаруженное нами обрушение норы гималайского сурка на северо-восточной окраине его ареала подсказывает, что его распространению на восток препятствуют свойства грунта: лёссовые грунты, обладающие склонностью к вертикальному отслаиванию, создают постоянную угрозу разрушению нор сурков.

Гималайские сурки, роя норы на склонах гор, в долинах и по берегам рек, избегают грунтовых вод (Цзян Чжиюн, Ли Цзинчжун, 2009). Как правило, норы располагаются на хорошо прогреваемых склонах, где после снегопада снег лежит недолго, а места обитания более сухие (Ван Чжицзюнь, 1992).

Зимнюю спячку сурки проводят в условиях относительно устойчивого микроклимата. Как считает Ван Чжицзюнь (1992), устойчивость микроклимата в норах сурков зависит от многих факторов, таких как диаметр и длина ходов, глубина залегания и свойства грунта.

Мы добавим от себя, что гнездовые камеры, особенно зимовочные, находятся на глубине термонейтрального слоя, в который не проникают, или почти не проникают колебания температуры приземной атмосферы (Никольский, Хуторской, 2001; Никольский и др., 2005). Большая глубина нор гималайского сурка вполне соответствует этому важнейшему условию температурного режима нор. Зимняя спячка черношапочного сурка *(M. camtschatica)* в Северном Верхоянье (Капитонов, 1978, см. ниже) - редкий пример уникальной специализации к обитанию за пределами термонейтрального слоя. В этом регионе термонейтральный слой находится в вечномерзлом грунте,

Устойчивый микроклимат нор гималайского сурка, характеризуется стабильно высокой относительной влажностью воздуха и относительно низкой, но стабильной температурой (Ван Чжицзюнь, 1992). Круглый год температура в норах выше 0°С, но редко превышает 10°С. Обычно температура колеблется в диапазоне от 1°С до 7°С, а влажность приближается к 100% (Цзян Чжиюн, Ли Цзинчжун, 2009).

По наблюдениям Ван Шучунь (1988), если в нежилой зимней гнездовой камере относительная влажность воздуха достигает 100%, то в жилой камере − влажность ниже, составляя 85%-90%. Амплитуда среднемесячной температуры в зимней гнездовой камере меньше 1°С. Летом средняя температура в более глубоких зимовочных норах составляет примерно 7°С, а в летних норах – 9.3°С. Увеличение числа сурков в жилых норах на одну особь повышает температуру воздуха в норе примерно на 1°С.

Подобно гималайскому сурку, у разных видов сурков существуют устойчивые адаптации к избеганию мерзлого грунта (Беловежец, 2015). Эти адаптации могут быть различны, в зависимости от генезиса, мощности и глубины залегания мерзлоты.

Так, у красного сурка зимние камеры находятся ниже максимальной глубины сезонного промерзания почвы. В алайской популяции почва промерзает до глубины 2.5 м, а зимние камеры располагаются на глубине до 3.6 м. Авторы (Кизилов, Берендяев, 1978) приводят аналогичные примеры и для других популяций красного сурка, где промерзание грунта на меньшую глубину сопровождается менее глубоким расположением зимовочных камер. В данном случае речь идёт о сезонном промерзании грунта.

Иную стратегию избегания мерзлоты применяют черношапочные сурки в Хараулахских горах (около 70° с.ш.) в устье реки Лены. Если гималайский и красный сурки роют глубокие норы ниже мерзлого грунта, то черношапочный сурок располагает мелкие зимовочные норы над вечной мерзлотой. В Северном Верхоянье, мощность слоя мелкозема над гнездовой камерой сурков составляет всего 0.25-0.61 м (в среднем 0.47 м), а температура грунта на этой глубине понижается до -14°С, -16°С и даже до -22 °С. В хребте Хараулах толща многолетнемерзлых пород достигает 450-600 м, а глубина сезонного протаивания, с конца мая – начала июня и до середины сентября, составляет всего лишь 0.3-1.4 м (Корейша, 1989).

Черношапочный сурок утепляет зимовочную камеру мощной гнездовой подстилкой, вес которой достигает 9-12 кг, присыпая нору с поверхности щебнем (Капитонов, 1978). Гималайский сурок, по наблюдениям Ван Чжицзюнь (1992), делает на зиму небольшие, около 6 кг, запасы “сена”, часть которого к весне превращается в труху, а часть съедается сурками.

Приведенные выше примеры позволяют выделить 3 различные стратегии избегания сурками мерзлого грунта. Гималайский сурок располагает зимовочные камеры под слоем сезонной или вечной мерзлоты. Красный сурок располагает зимовочные камеры под сезонной мерзлотой. Черношапочный сурок сооружает неглубокие зимние норы над многометровой толщей вечномерзлых пород, зимуя в сезонно мерзлом грунте в утепленной камере. Не исключено, что монгольский сурок, или тарбаган *(M. sibirica)*, так же проводит зимнюю спячку в мерзлом грунте (Сунцов, Сунцова, 2006). Устойчивые разнообразные адаптации сурков к избеганию мерзлоты косвенно указывают на давнюю связь предков современных сурков с ландшафтами, для которых был характерен мощный слой мелкозема, осложнённый вечной или сезонной мерзлотой.

Питание. Питается гималайский сурок в основном вегетативными частями травянистых растений, но также поедает корни и семена. В его рацион входят в основном злаки и осоковые, далее идут бобовые, гречишные и розоцветные (Hoffmann et al., 2010). Воду сурки не пьют, но в начале дня поедают траву с утренней росой (Хан Чунсюань, 2005). Как и другие виды сурков (Бибиков, 1967; Давыдов, 1974; Токарский, 1997; Ронкин, Савченко, 2000), гималайский сурок кормится на пастбищах, где выпасаемый скот поддерживает кормовые растения в состоянии вегетации. Вблизи человека сурки часто пасутся на посевах сельскохозяйственных культур (Ван Сыбо, Ян Ганюн, 1983).

Состав кормов у гималайского сурка зависит от сезонной и локальной доступности пищи. Ранней весной, во время выхода из спячки, сурки почти не едят, расходуя остатки накопленного с осени жира. В это время они питаются, главным образом, осокой и пушицей *(Eriophorum)*. В желудке сурков находили также ковыль пурпурный *(Stipa purpurea)*, пятилистник кустарниковый *(Potentilla fruticose)*, лапчатку китайскую *(Potentilla chinensis)*, горец головчатый *(Polygonum capitatum)* (Хан Чунсюань, 2005).

Летом сурки едят очень много. Вес их желудка после приема пищи достигает 500 г. А в условиях клеточного содержания расход свежей травы на одну голову доходил до 1500 г в сутки (Хан Чунсюань, 2005).

Кормятся сурки в пределах семейного участка, не уходя от норы далее чем на 350 м. Непрерывное питание на поверхности длится до 2 ч. Радиус наземной активности меняется по сезонам. Самый большой − в июле – августе, наименьший – в сентябре (Ван Сыбо, Ян Ганюн, 1983; Цзян Чжиюн, Ли Цзинчжун, 2009). Взрослые сурки удаляются от норы на большее расстояние, чем молодые, а самцы – на большее, чем самки (Цзян Чжиюн, Ли Цзинчжун, 2009).

Размножение. Половой зрелости сурки достигают на третье лето, в возрасте двух лет, но вступают в размножение только в трехлетнем возрасте (Хан Чунсюань, 2005).

В Цинхай-Тибетском нагорье сурки пробуждаются от зимней спячки в середине апреля и вскоре начинают спариваться (Ван Чжицзюнь, 1992). Беременности длится 30-35 дней. Роды проходят в середине мая. Кормление молоком матери продолжается около пяти недель. Число участвующих в размножении самок близко к 50% от их общей численности в популяции. Средняя величина выводка 4-6 детенышей на одну самку. Молодые появляются на поверхности норы спустя три недели после рождения, как правило, во второй декаде июня.

Ритмы активности. Зимняя спячка. Чтобы избежать повторов, мы сочли целесообразным объединить описание ритмов активности гималайских сурков с особенностями их зимней спячки (начало, окончание, продолжительность).

Наибольшая наземная активность гималайских сурков наблюдается в течение 3-х первых часов после восхода солнца и за 4 часа до захода. На активность сурков влияют погодные условия. Во время сильных дождей, в холодную и ветреную погоду, особенно со снегом, их активность сокращается, и они в течение всего дня могут не выходить на поверхность (Цзян Чжиюн, Ли Цзинчжун, 2009).

При подготовке к спячке, в первой − второй декаде сентября, у сурков возрастает частота пребывания на поверхности. Они выталкивают из нор старую подстилку и камни, приносят в нору траву, придерживая ее зубами, забивают входы, постепенно оставляя только один из них. Но уже с третьей декады сентября и до начала октября обитатели норы все реже появляются на поверхности. В это время они не кормятся и освобождают кишечник, выходя из нор в 11-15 ч, чтобы погреться на солнце. В третьей декаде октября сурки, выталкивая грунт изнутри норы, забивают пробкой последний вход. На время долгой зимней спячки семьи собираются в гнездовой камере зимовочных нор, где они делают небольшие запасы корма. Обычно в центре гнездовой камеры лежит копна, а рядом с ней крошеное сено, в котором сурки спят. В начале выхода из спячки сурки поедают оставшееся в гнездовой камере сено (Ван Чжицзюнь, 1992).

В норе обычно зимует одна семья. Но известны случаи, когда в одной норе зимовали несколько семей. Больные особи зимуют отдельно от остальных (Хан Чунсюань, 2005). Во время спячки взрослые животные лежат в гнездовой камере плашмя, а между ними укладываются сурчата. Если нет сурчат, взрослые лежат, плотно свернувшись, их морда обращена к хвосту (Хан Чунсюань, 2005). Поза, характерная вероятно, для всех видов сурков во время спячки (Бибиков, 1967).

Пробуждаются гималайские сурки, когда температура воздуха устанавливается выше 5°С. Выход на поверхность начинается за две недели до появления зелени (Чэнь Хунцзянь, 2005).

Сезонная активность в большой мере связана с различиями в сезонных ритмах в разных географических популяциях. Например, на северном склоне горного массива Куньлунь на зимних пастбищах выход из спячки начинается у сурков в конце марта, а на летних пастбищах − в конце апреля. Залегание в спячку на зимних пастбищах начинается в конце октября, а на летних пастбищах − в конце сентября (Ван Сыбо, Ян Ганюн, 1983).

В Цинхай-Тибетском нагорье в разных географических популяциях сроки пробуждения и залегания сурков в спячку различаются на 15 дней (Чэнь Хунцзянь, 2005).

По наблюдениям Хан Чунсюань (2005), залегать в спячку сурки начинают после появления первой желтизны на растениях. В это время температура воздуха приближается к 0°С. В сентябре они завершают накопление запасов жира, вес которого достигает 2.5 кг. Подготовка к спячке (ремонт убежищ, смена подстилки) начинается во второй декаде сентября, а залегание в спячку – в третьей декаде октября. Внутренние входные отверстия сурки забивают пробкой из земли и экскрементов. В конце мая ‒ в начале июня начинается расселение перезимовавших зверей (Табл. 2).

Ранее Сунцов и Сунцова (2006, с. 122) сообщали: “В отличие от *прочих* (курсив наш – *А.Н., В.Ч.*) видов, монгольский сурок устраивает зимовочные пробки из специально подготовленной смеси щебня и каловых масс, накапливаемых в отнорках-уборных”. Это ошибочный акцент. Не только тарбаган и его сосед по ареалу, гималайский сурок используют для приготовления пробки экскременты, но и другие (не все) виды сурков. Например, степной сурок *(M. bobak)* использует экскременты для приготовления пробки (Машкин, 1997), а серый *(M. baibacina)* (Бибиков, 1967) и красный (Кизилов, Семенова, 1967) сурки не используют. Авторы (Сунцов, Сунцова, 2006), опираясь, в том числе, на эту особенность биологии тарбагана отводят ему исключительную роль в происхождении природного очага чумы в Центральной Азии. Не исключено, что со временем место тарбагана в концепции происхождения чумы займет гималайский сурок.

Согласно наблюдениям Ван Чжицзюнь (1992), у взрослых сурков перед залеганием в спячку вес тела достигает 10 кг, а в конце спячки не превышает 3-4 кг. В период зимней спячки частота сердечных ритмов составляет 20 ударов, а частота дыхательных ритмов – l4 в минуту. Но через 20 минут после извлечения сурков из гнездовых нор частота сердечных ритмов повышается до 62 ударов, а дыхание 22-28 циклов в минуту. Если во время спячки достать сурков из зимовочных нор, то спустя 5 минут они начинают просыпаться, а через 25 минут пробуждаются полностью.

Линька. Линяют гималайские сурки один раз в году. Линька начинается в конце мая. После выхода из спячки кончики волос изнашиваются, старый волосяной покров тускнеет и приобретает сероватый оттенок. Отпадение волос начинается со спины и продвигается к бокам и огузку, последовательно охватывая голову, хвост и конечности. В начале линьки волосяной покров постепенно редеет, а в конце июня волосы в массе выпадают. Одновременно с выпадением старых волос отрастают новые. Заканчивается линька в первой декаде августа. Новый волосяной покров, приобретая свежий вид, становится гладким, В разные сезоны года мех гималайских сурков имеет разные оттенки. Весной мех светлее, с желтизной, а осенью темнеет, приобретая синеватый оттенок (Хан Чунсюань, 2005).

Заключение. Китай населяют 4 вида сурков. Кроме гималайского сурка, это красный сурок, серый и тарбаган. Все они, в отличие от гималайского сурка, представлены краевыми популяциями (Никольский и др., 2014).

Красный сурок населяет западные районы провинции Синьцзян в уездах Улугчат, Акт, Ташкурган. Здесь он обитает на южных отрогах Восточного Тянь-Шаня, на хребтах Каракорум, в северо-западном Куньлуне и в нагорьях Восточного Памира (Ван Сыбо, Ян Ганюн, 1983).

Серый сурок в пределах Китая проникает в северо-западную часть Синьцзян-Уйгурского автономного района. Его ареал состоит из трех не связанных между собой частей. Они располагаются в Восточном Тянь-Шане, Джунгарских горах (западные горы Джунгарской впадины) и в отрогах Монгольского Алтая (Ван Сыбо, Ян Ганюн, 1983; Ма Юн и др., 1987).

Тарбаган распространен в сухих степях северо-восточных и центральных частей Внутренней Монголии (Дэн Юнфэн, 1986).

Основными лимитирующими факторами распространения всех видов сурков является наличие мощного слоя мелкозема, необходимого для устройства глубоких нор (Коблов, 1941), и обширные открытые пространства, покрытые травянистой растительностью. Это могут быть луго-степи, степи, сухие степи и даже полупустыни, мозаика которых широко представлена в горных системах Китая (Юсов, 1958). Горы, с повсеместным развитием аккумулятивно-эрозионных форм рельефа, предоставляют суркам идеальные условия для устройства нор в широком диапазоне высот (Никольский, Улак, 2006).

Используя знания, накопленные в китайской литературе, мы предложили схему высотного распространения сурков на территории Китая (рис. 6) (Ван Чи, 2016).

Согласно наблюдениям специалистов (Чжао Чжунши, 1982; Ван Сыбо, Ян Ганюн, 1983; Дэн Юнфэн, 1986; Ма Юн и др., 1987; Ван Чжицзюнь, 1992; Дай Шимэй и др., 2008; Hoffmann et al., 2010), оптимумы обитания сурков, населяющих территорию Китая, расположены в разных высотных диапазонах: гималайский сурок − 3800-5200 м над ур. м.; красный сурок − 3500-4500 м над ур. м.; серый сурок в – 1500-3000 м над ур. м. и тарбаган − 800-1100 м над ур. м. Невозможно выделить общую для всех видов предпочитаемую высоту вертикального распространения, что связано как с историческими причинами формирования ареала каждого из четырех видов, так и со спецификой взаимодействия экологических факторов. Прежде всего, таких как, высота над уровнем моря и географическая широта, взаимодействие которых формирует высотную поясность, и экспозиция склонов, испытывающих влияние воздушного переноса тепла и влаги.

Гималайский сурок, населяя высочайшие горы планеты, смог проникнуть далеко на юг (почти до 27° с.ш.) благодаря высокому положению снеговой линии, а его обитание в Тибете стало возможным в значительной степени из-за того, что эта, высоко поднятая горная страна, находится в дождевой тени Гималаев. Гималаи, протянувшись более чем на 1000 км, защищают Тибет от мощного продолжительного муссона, приходящего летом с Индийского океана (Юсов, 1958).

Подводя общий итог, мы можем выделить следующие специфические для гималайского сурка особенности его экологии и образа жизни:

1. Южные пределы распространения гималайского сурка являются южной границей распространения рода *Marmota*. Достигая почти 27° с.ш., вид из Палеарктики проникает в Индо-Малайскую область.
2. Гималайский сурок является наиболее высокогорным видом среди сурков мировой фауны. Его поселения достигают снеговой линии выше 5500 м над ур. м.

3. Гималайский сурок занимает самый широкий диапазон высотного распространения среди сурков мировой фауны – от 1800 до 5670 м над ур. м.
4. Глубина, устройство и сезонная динамика использования нор гималайскими сурками связаны с распространением вечной и сезонной мерзлоты в пределах Цинхай-Тибетского нагорья.

Благодарности. Мы благодарим наших китайских коллег Су Цзяньпин и Чжан Тунцзо, сотрудников Института биологии Северо-западного плато Китайской Академии наук (г. Синин), за содействие в организации полевых наблюдений в Цинхай-Тибетском нагорье и за помощь в подборе литературы на китайском языке. Мы благодарим сотрудников Центра по профилактике и контролю заболеваний в Синьцзяне Ляо Лифу и Сюй Бин за личные сообщения о распространении и экологии сурков в Китае. Мы благодарим Т.Ю. Лисицыну и Е.А. Ванисову за помощь в работе над рукописью нашей статьи. Мы благодарим Ан.А. Никольского за фотографию гималайского сурка в его естественной среде обитания в Непале.

DISTRIBUTION AND ECOLOGY OF THE HIMALAYAN MARMOT (RODENTIA, SCIURIDAE, MARMOTA HIMALAYANA HODGSON 1841) IN THE PEOPLE'S REPUBLIC OF CHINA

A. A. Nikol'skii, Wang Chi

Review of the spread and ecology of the *Marmota himalayana* in the People's Republic of China. In China, the Himalayan marmot inhabits all of the Qinghai-Tibet Highlands. It penetrates to the south almost to 27 ° N. The Himalayan marmot is distributed from the upper boundary of the forest and up to the snow line. The altitude optimum ranges from 4800 to 5200 m above sea level. It feeds on vegetative parts of plants. It had the greatest ground activity in July - August, the lowest - in September. It had the greatest daily activity with sunrise for 3 hours and 4 hours before sunset. Hibernation begins in the third ten-day period of October. Pregnancy lasts 30-35 days. There are 4-6 cubs in the litter.

Keywords: *Marmota himalayana*, People's Republic of China, distribution, ecology, Qinghai-Tibet Highlands.

Таблица 1. *Структура почвы в одной из нор гималайского сурка (по Ван Чжицзюнь, 1992)*

<table>
<tr><td rowspan="2">Почва</td><td colspan="5">Порядковый номер слоя</td></tr>
<tr><td>1</td><td>2</td><td colspan="2">3</td><td>4</td></tr>
<tr><td>Состав</td><td>Чернозёмы</td><td>Желтозёмы</td><td colspan="2">Чистые пески</td><td>Смесь песка и глины</td></tr>
<tr><td rowspan="2">Мощность, см</td><td rowspan="2">60</td><td rowspan="2">80</td><td colspan="2">100</td><td rowspan="2">Больше 100</td></tr>
<tr><td>40</td><td>60</td></tr>
<tr><td>Характеристика</td><td colspan="3">Сложные ходы нор</td><td>Слой мерзлоты</td><td>Зимовочные камеры</td></tr>
</table>

Таблица 2. *Сезонная активность гималайского сурка (по Хан Чунсюань, 2005)*

Время года	Активность
Конец марта	Выход из спячки на зимних пастбищах
	Сурки не расселяются
Конец апреля	Выход из спячки на летних пастбищах
	Сурки не расселяются
Третья декада мая	Сурки расселяются
	Наземная активность возрастает
	Радиус наземной активности 200-300 м
	Низкая кормовая активность (раз в 5-10 мин)
	Размножение
После третьей декады июня	Рост кормовой активности
	Увеличение радиуса наземной активности

Июль-август	Накопление жира
	Наибольшая наземная активность
Вторая и третья декада сентября	Подготовка к спячке
Конец сентября	Залегание в спячку на летних пастбищах
Конец октября	Залегание в спячку на зимних пастбищах

Подписи к рисункам статьи А.А. Никольского, Ван Чи “Распространение и экология гималайского сурка (Rodentia, Sciuridae, *Marmota himalayana* Hodgson, 1841) в Китайской Народной Республике”

Рис. 1. Гималайский сурок около норы на выпасе домашнего скота. Центральный Непал, горный массив Манаслу, 3530 м над ур. м. (Фото Ан.А. Никольского, конец апреля 2004 г.).

Рис.2. Распространение гималайского сурка на территории Китайской Народной Республики (по Никольский, Румянцев, Ван Чи, 2014). Детали распространения гималайского сурка, на основании которых составлена карта, опубликованы в Hoffmann et al., 2010. 1 – горные системы; 2 – горные вершины; 3 – распространение гималайского сурка, 4 – административные центры провинций; 5 – город Лицзян. окрестности которого являются южной границей ареала гималайского сурка в Китае.

Рис. 3. Норы гималайского сурка на Северо-Западном плато в провинции Цинхай (КНР). Высота над уровнем моря 3100 м. а – норовые отверстия, выбросы грунта из норы, тропинки между входами в нору – основные стабильные элементы, главные аттракторы биологического сигнального поля в поселении сурков; б – на переднем плане вход в нору гималайского сурка, на заднем плане видна регулярно используемая людьми дорога и сельскохозяйственные угодья. На обоих снимках видны следы выпаса домашнего скота. (Фото А.А. Никольского, август, 2012 г.)

Рис. 4. Горизонтальная проекция гнездовой норы гималайского сурка (по Ван Чжицзюнь, 1992). Чтобы не отходить от оригинала, мы не стали выносить в легенду условные обозначения.

Рис. 5. Разрез норы гималайского сурка, образованный в результате обрушения склона. Северо-Западное плато в провинции Цинхай (КНР), высота над ур. м. 3100 м. 1 – бутаны, выбросы грунта над норой; 2 – входные отверстия в нору; 3 – открытые в результате обрушения ходы внутри норы; 4 – стрелками показаны границы земляных пробок внутри ходов; изогнутая двойная стрелка слева – траектория вдоль вскрытого обрушением хода норы. (Фото А.А. Никольского, август, 2012 г.).

Рис. 6. Схема высотного распространения сурков, населяющих территорию Китая. 1 – высотный диапазон распространения сурков; 2 – предпочитаемый сурками диапазон высот. При составлении схемы использованы публикации: Чжао Чжунши, 1982; Ван Сыбо, Ян Ганюн, 1983; Дэн Юнфэн, 1986; Ма Юн и др., 1987; Ван Чжицзюнь, 1992; Дай Шимэй и др., 2008; Hoffmann et al., 2010.

Рис. 1

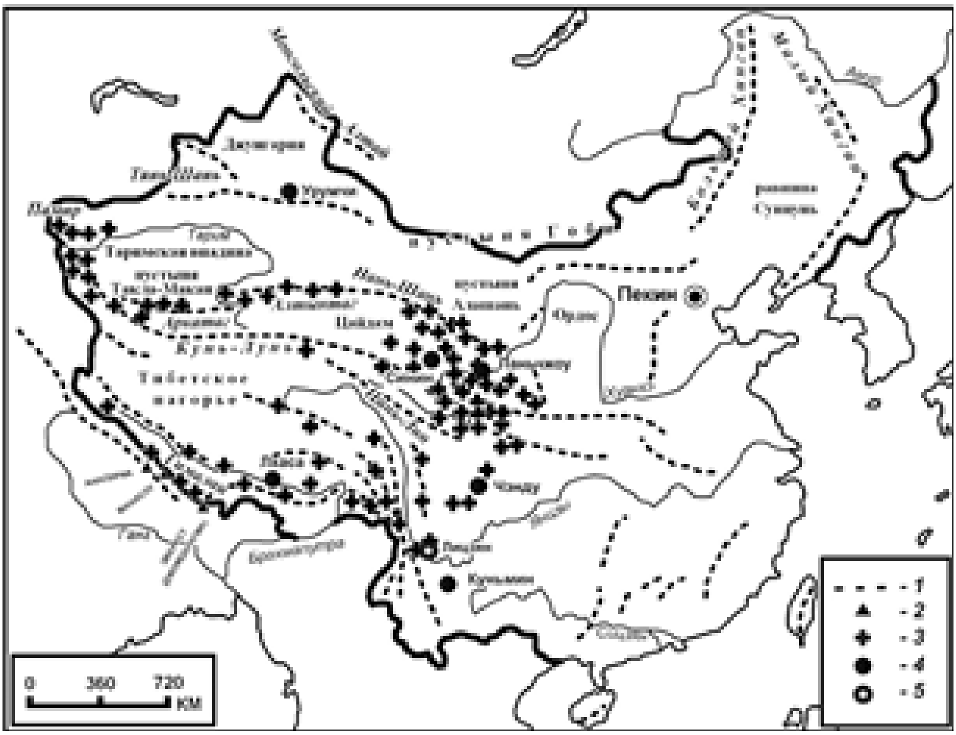
Джунгария
Урумчи
Тянь-Шань
Памир
Тарим
Таримская впадина
пустыня
Такла-Макан
Аркатаг
Кунь-Лунь
Тибетское
нагорье
Лхаса
Цайдам
пустыня
Алашань
Ордос
Пекин
Чэнду
Ганг
Брахмапутра
пустыня Гоби
равнина
Сунляо
Амур
0
360
720
КМ
- 1
- 2
- 3
- 4
- 5

Рис. 2

Рис. 3.

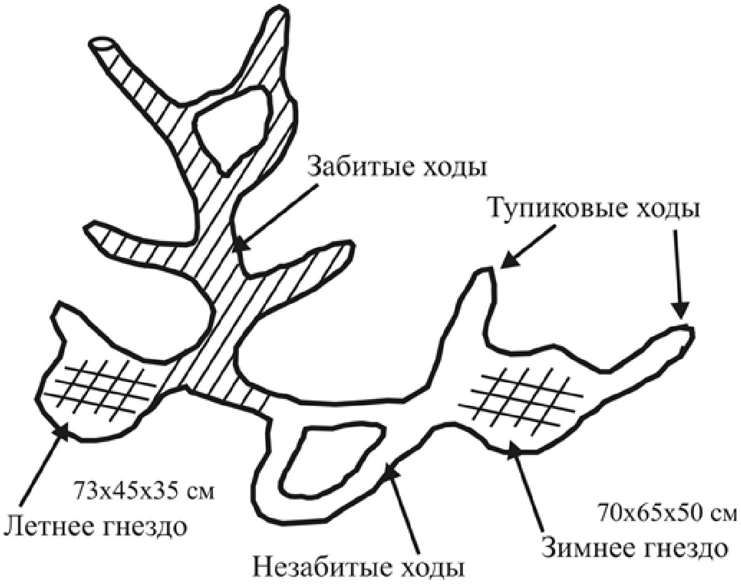

Рис. 4

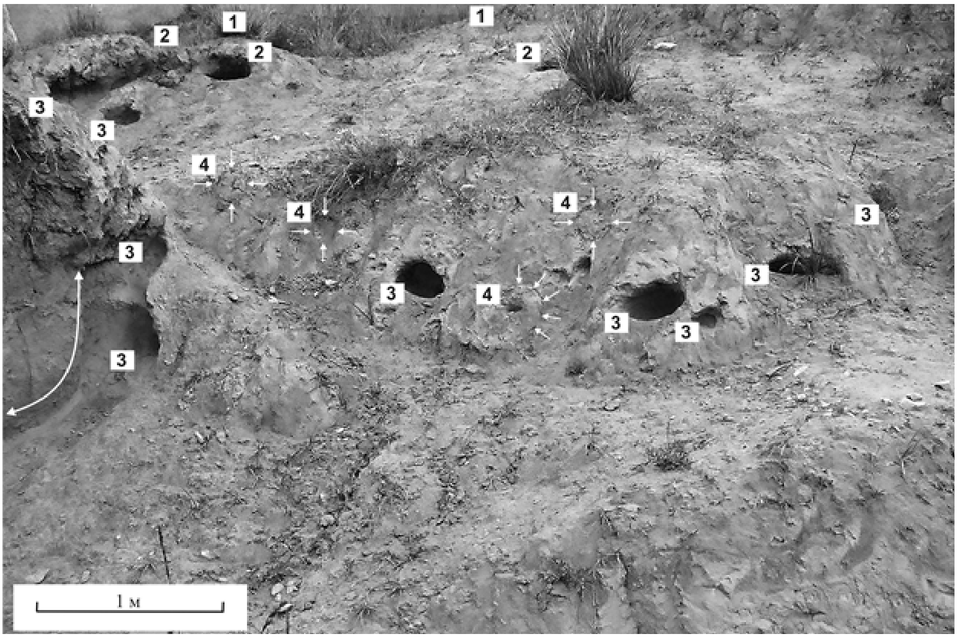

Рис. 5 (желательно разместить рисунок горизонтально, чтобы лучше были видны детали)

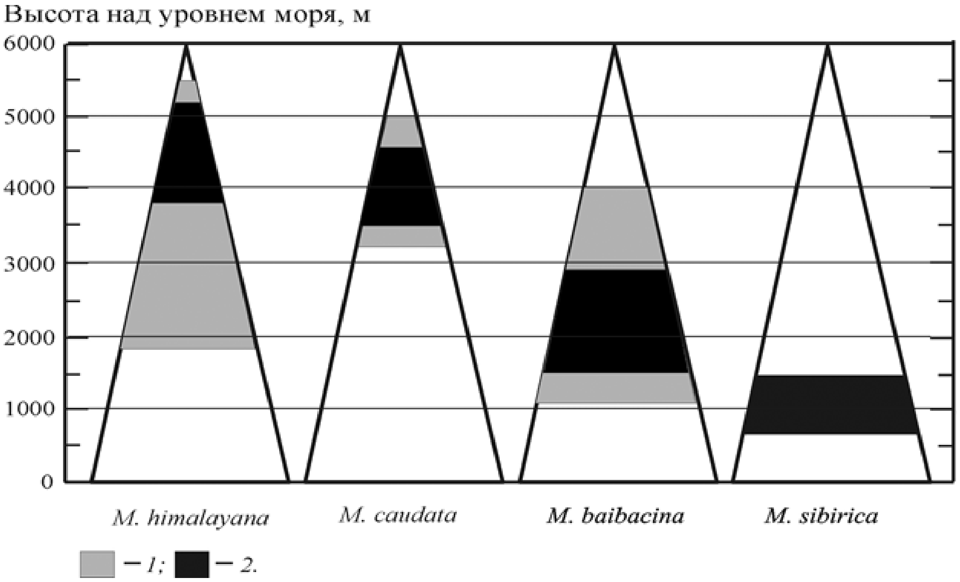
Высота над уровнем моря, м
6000
5000
4000
3000
2000
1000
0
M. himalayana
M. caudata
M. baibacina
M. sibirica
▒ – 1; ■ – 2.

Рис. 6

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MONITORING OF GRAY MARMOT *(MARMOTA BAIBACINA)* IN A ZONE OF ACTIVE TOURISM IN ZAILIYSKY ALATAU

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The paper analyzes the literature and own data (from may 2007 to September 2017) on the structure of the settlements of the gray marmot (Marmota baibacina Kastschenko, 1899) on a limited section of the Northern slope of the Zailiysky Alatau, located near the city of Almaty and often visited by tourists. Its territory is considered to be potentially focal for plague and was previously examined by specialists of the anti-plague service for the presence of the causative agent of plague with a negative result. However, the rare frequency of surveys and the small amount of field material studied are not sufficient to assess the epizootic situation. The main carrier of plague in adjacent mountain natural foci is a grey marmot, therefore, additional observations are required for the spatial distribution and the number of rodents of this species. The results of long-term monitoring of settlements on the site showed that the spatial distribution and fluctuations in the number of marmots depend on a complex of abiotic and biotic factors, with anthropogenic influence is not dominant. The absence of marmot in the low mountains and the decrease in its number in the subalpine zone of the surveyed area is mainly due to the cessation of grazing.

Key words: Zailiysky Alatau, settlement of gray marmot, spatial distribution, family burrows (bhutan), namber, human influence.

Introduction. The surveyed area is located on the Northern slope of the Zailiysky Alatau ridge (Fig. 1) within the boundaries of Kungei-Zailiysky geographical population of the Tianshan subspecies of the grey marmot - one of the most isolated and insufficiently studied species in the area (Bibikov, 1965; Bibikov, Berendyaev, 1978)

Judging by the literature data, the distribution of grey marmot on the territory of observations in the 30-60s of the last century was much wider. So, E.M. Vakulenko-Snegirevskaya (1940) noted that in the summer of 1933 "dwelling burrows of marmots met at 1 kilometer above the resort Medeo on the right bank of the river M. Almatinka, and the whole settlement of gray marmot was begun from the height of 1600-1700 m.". Ognev S.I. (1940) in 1937-1938 noted quite a large number of marmots in subalpine zone on passes Terisbutak and Talgar. According to Kapitonov V.I. (1969), the settlements of the gray marmot in Zailiysky Alatau in the 60s were located at altitudes from 1400 to 3500 m above sea level, although the density of their populations near the lower border of settlements was significantly reduced by human activities. In publications of recent years, it has been suggested that the reason for the reduction population of the grey marmot in the Northern slopes of the ridge of the Ile (Zailiysky) Alatau is the anthropogenic pressure, including tourism development (Tashibaev et al., 2012; Grachev et al., 2014).

The Northern slope of Zailiysky Alatau is considered to be potentially focal in plaque territory (Aubakirov et al., 1992). In 1993-1994 epizootological observation was carried out in the basins of the rivers Malaya and Bolshaya Almatinka at altitudes of 1075 to 2100 m a.s.l. as a result of examination of plague microbe was not found (Zveryfnsky et

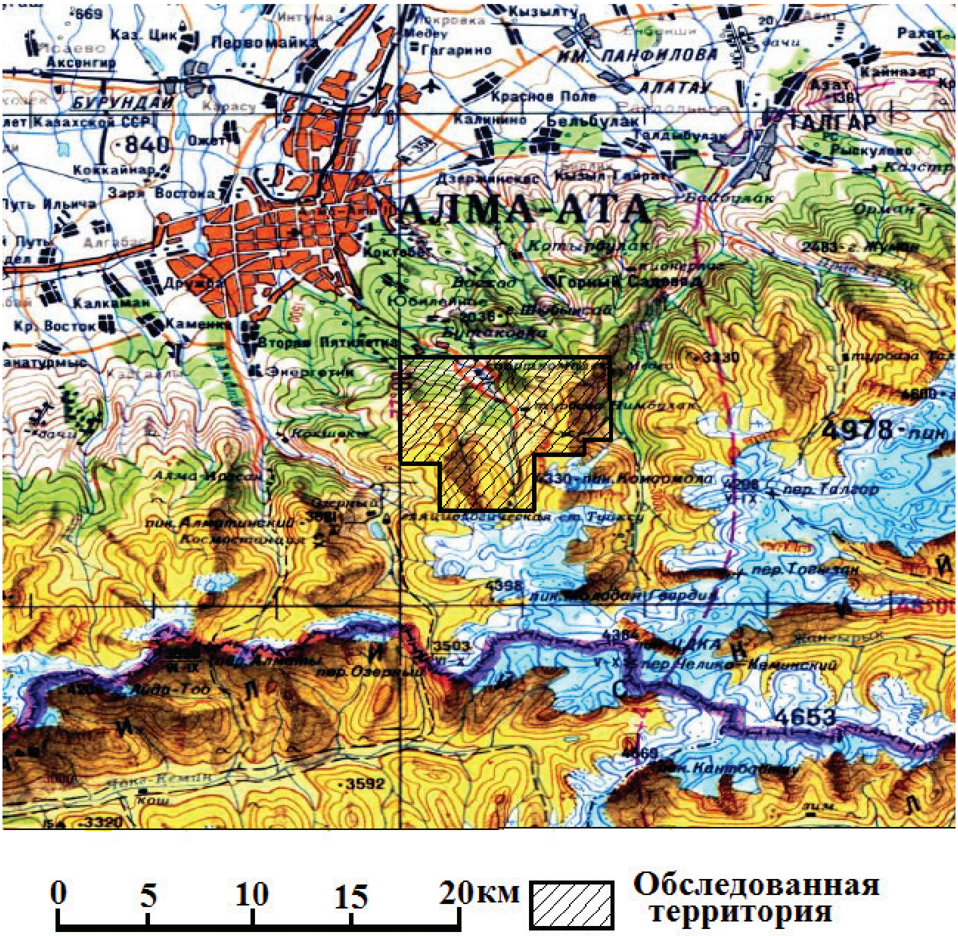

Fig. 1. The location of the surveyed area.

al., 1996). However, it should be taken into account that the investigated field samples consisted mainly of mouse-like rodents and their fleas, while the main carrier of plague in adjacent mountain natural foci of plague is a gray marmot (Pole et al., 1996; Atshabar et al., 2012). Therefore, a reliable assessment of the epizootic situation in this area requires further study, taking into account the spatial structure and a namber of marmot population.

Material and methods. Mapping of the settlements of the grey marmot (Marmota baibacina Kastschenko, 1899) was carried out between May 3, 2007 and September 23, 2017 within the boundaries of the Ile-Alatau state natural Park. Covered area of 100 square kilometers from the left Talgar river (in the East) to the watershed between the rivers Kazashka and Kumbel (in the West) and from Lake Maloe Almatinskoe (South) to the northern slope of Katyrbulak (North - 43,17° N. lat.). Surveyed the upper reaches of the rivers komisarivka and Gorelnik, Kazashka, Malaya Almatinka, the area adjacent to the passes Butakovsky, Talgar, Terisbutak and Sarasai, Katyrbulak and the slopes of the Kumbel ridge. During the observation period, we visited the family burrow (bhutan) grey marmot with a frequency of 1 to 4 times a year. The number of marmots was recorded on footpaths in the middle of the day and coincided with the reduced daily activity of adults and adult animals. For this reason, additional indirect signs of habitat of burrows (the presence of trails, litter, traces of clearing, etc.) were taken into account.

Research result. Kungei-zailiyskaya geographical population inhabits the periphery of the species area, so it, like many species populations, is characterized by a relatively high amplitude of fluctuations in the number of individuals and the instability of the spatial structure, compared with its central part (Bibikov, 1967; Odum, 1975). For Kungei-zailiyskaya grey marmot population, as for most Tien Shan subspecies populations, the daily activity of animals in the early spring and late summer has the form of a single-vertex curve, and in the middle of summer - a two-vertex (Bibikov, 1967; Kapitonov, 1969).

During the survey period, 159 bhutanes (family burrows) of the grey marmot were observed, with all occupied burrow within the range of 2,450 m to 3,550 m above sea level. This indicates that during the 40-year period the lower boundary of the marmot settlements moved up by more than 1000 m. Most of the observed family burrows referred us to the type of the permanent winter-summer, a few - for the summer, but only two for the winter. In a radius of 200 m around the occupied bhutans found 197 protective burows, more than 90% of which were old or very old. In the summer marmots often use stone scree (with a stones diameter of 0.3 to 4 m), located both in close proximity to the occupied burrow, and at a distance of 100-150 m from them. For this reason, in the period from mid-June to early August bhutans, located near the scree, less visited marmots and had a non-residential appearance (especially after the summer rains). Such burows are more difficult to differentiate between inhabited and visited, as well as difficult to determine the size of the family plot.

Marmots are most often settled in old moraine with low grasses and the slopes of the gully to the river. Settlements of predominantly island and belt types occupy about 10-25% of the territory, consist of isolated colonies (usually from 1 to 5 families), distributed unevenly across the territory (Pole et al., 1971).

During the period of observation of the 159 bhutane, mapped on the site, 136 differentiated as constant and periodically inhabited, 9-as uninhabited, 14-as long ago abandoned. Moreover, bhutans classified as the last category were equally located, both at the lower border of the settlements (at an altitude of 2230-2600 m) and in the upper part (at an altitude of 2800-3080 m). Over 90% of permanently inhabited burrows were in the Alpine meadows at altitudes of 2800-3450 m above sea level (optimum zone). In the subalpine zone inhabited settlement remained only in the upper reaches at altitudes from 2450 to 2600 m.

To determine the trends in the number of marmots in the survey territory, we have identified areas with different multiplicity of accounting (tables 1, 2).

Table 1. *The dynamics of the number of marmots (individuals by year) in areas with a maximum number of accounts.*

Years of observation	The upper reaches of r. Komisarovka and the surrounding area of Butakovskiy pass	The upper reaches of the river Gorelnik	Slopes of the Left Talgar river	The upper reaches of the river Malaya Almatinka	The upper reaches of the river Kazashka
2007	22-25	81-84	-	-	-
2008	21-24	80-83	20-23	-	-
2009	16-19	85-88	19-22	230-240	48-52
2010	17-20	86-89	18-20	225-235	53-58
2011	14-16	84-88	16-18	235-240	52-56
2012	12-15	85-89	17-20	245-250	50-54
2013	10-13	84-88	17-20	240-245	38-42
2014	9-12	87-90	18-21	235-240	42-45
2015	8-11	81-84	16-17	235-240	48-52
2016	5-6	86-89	8-10	245-250	46-50
2017	6-8	93-97	18-21	250-255	50-54
The trend in the number	Falling	Poor growth	Stable	Growth	Stable

Analysis of the data table. 1 shows that in intensively visited by tourists upper reaches of the basin of the Malaya Almatinka and Gorelnik, the number of marmots in the settlements has increased. One of the largest inhabited bhutan is located at a distance of about 150 m from the terminal station of the cable car. In the upper reaches of the river Gorelnik inhabited settlement gray marmot is located from a height of 3040 m to 3400 m. During the observations all bhutans within the settlement were occupied or visited, and, in 2009, 2010 and in 2016 in the colony appeared three new family burrow. The exception was one small bhutan, where in May 2010, found dead young marmot, after that the animals burrow left. Abandoned burrows observed here at 0.5-1.0 km lower slopes at an altitude of 2800-2900 m. Settlement of gray marmots in the upper river Malaya Almatinka and the river Gorelnik can be considered the same as rodents can theoretically contact in Mynzhilki space and, especially, in the region of "Tuyuksu Gate", where the distance between the inhabited burrows does not exceed 400-450 m. A high probability of contacts between marmots from these settlements is possible at the Talgar pass (at an altitude of 3475 m), where cleared protective burrows are found.

The decline in the number was observed only on one site of the five-in the upper Komissarovka river and near Butakovsky pass. In the upper river Komissarovka in the North-Western slope of a hill Furmanovka, in the period of our observation was inhabited by 2 families of marmots on the elevation 2625 m and 3060 m a.s.l. The upper bhutan was occupied all the years of observation. Lower bhutane marmots settled in 2007, 2008, 2010 and 2011. In 2009, marmots were not observed on it, but in the early summer of 2010, a adult male was observed there, and in the spring of 2011, young growth appeared. In subsequent years bhutan was not inhabited.

In the basin of the river Butakovka at altitudes 2230-2535 m was recorded, mainly, long ago abandoned by marmots burrows. In the South-Eastern slope of the Butakovka pass at the altitude of 2750-2900m at the beginning of the observations (2007) noted the inhabited colony, but gradually the number of marmots has declined and by August 2015, the inhabited burrows were not recorded (Fig. 2).

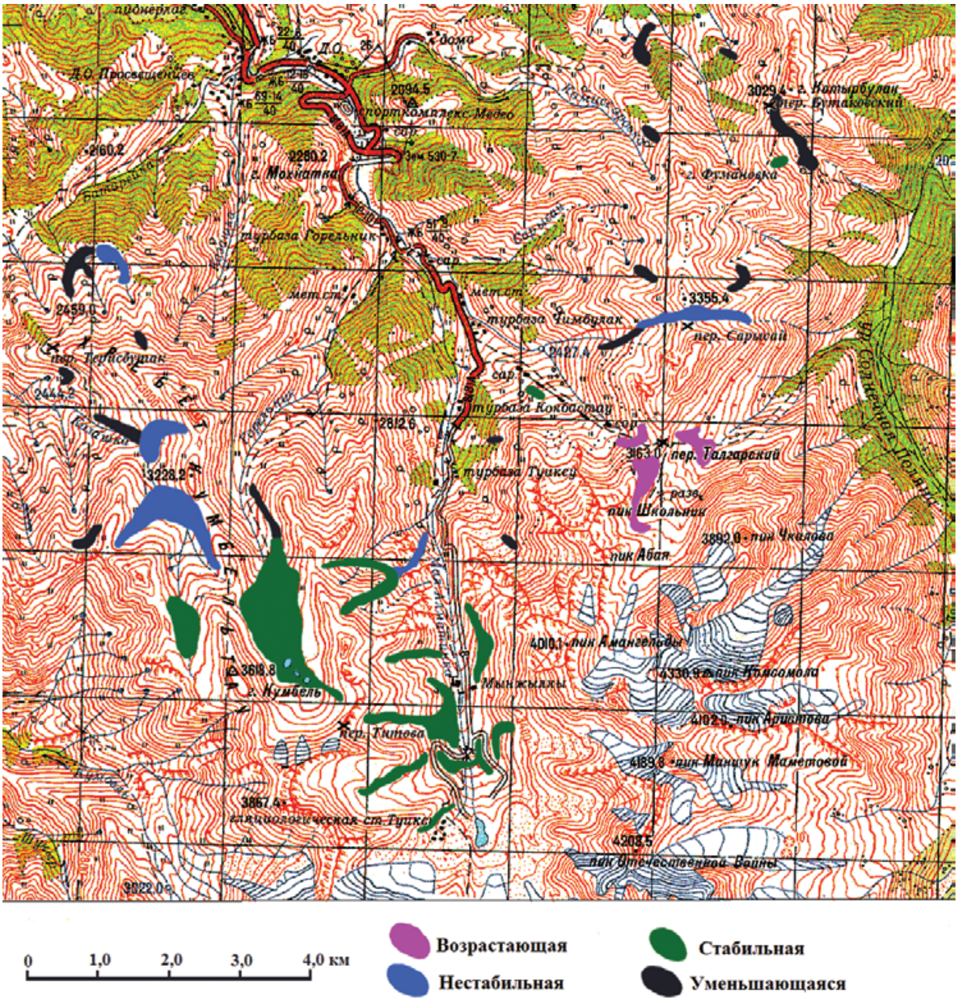

Fig. 2. The trend of changes in the number of marmot in the surveyed area in 2007-2017

Table 2. *Dynamics of the number of marmots (individuals by year) in areas with average and minimum number of accounts.*

Years of observation	The surroundings of pass Sarysai	The Northern slopes of the ridge Kumbel.	The neighborhood of pass Talgarsky
2011	35-40	-	-
2012	38-42	5-6	-
2013	36-39	6-7	-
2014	30-35	9-11	-
2015	15-18	11-14	75-80
2016	2-5	12-15	82-90
2017	9-12	10-11	84-95
The trend of changes in the number	Unstable	Growth	Growth

On the Northern slopes of the Kumbel ridge on the local site was inhabited by a colony of marmots (1-3 families), resettlement from this site to the previously inhabited territory did not occur – all bhutan were uninhabited or abandoned. In the vicinity of Talgar pass the number of animals increased and at the end of summer 2017 all Bhutan were inhabited (Table. 2, Fig. 2). In the vicinity of the pass Sarysai for the period of 2015-2016, the number of marmots has declined sharply, but in 2017, began its restoration (Table 2, Fig. 3-4).

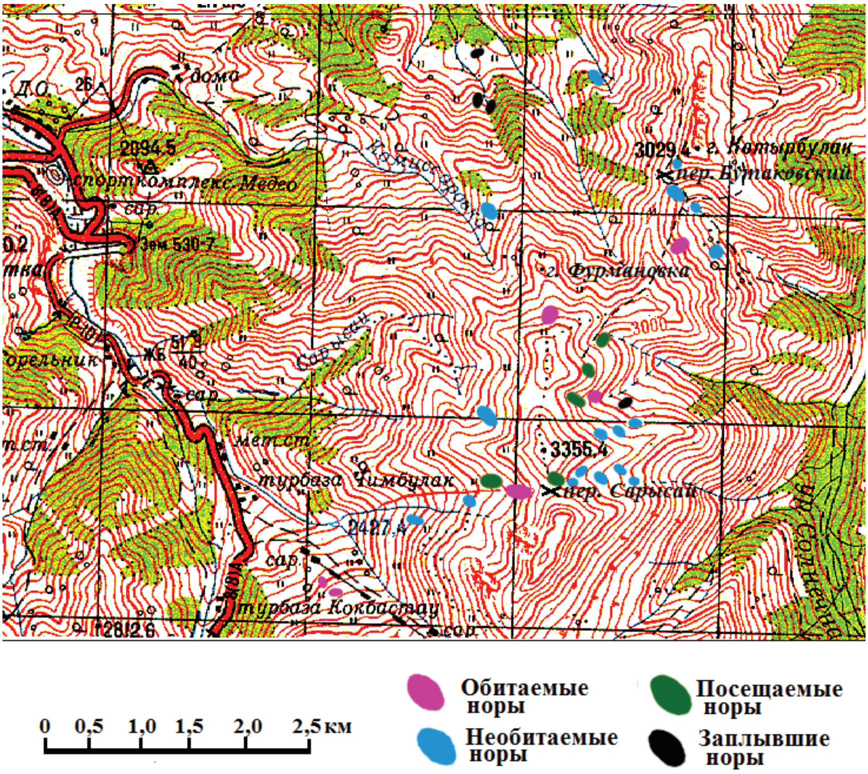

Fig. 3. *A fragment of the surveyed area in August 2016*

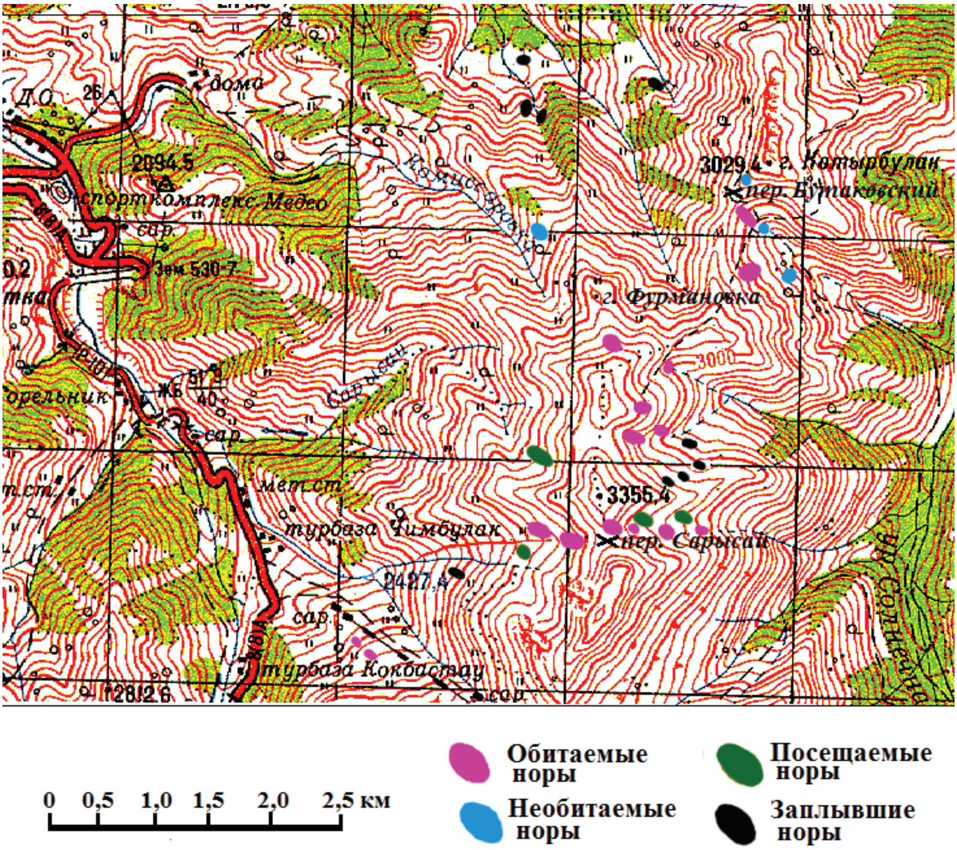

Fig. 4. *A fragment of the surveyed area in August 2017*

In upper reaches of Malaya Almatinka river (Mynzhilki region) despite the large number of tourists and the weather station located there, the number of marmots is relatively high with almost one hundred percent of the occupied burrows. On the left bank of river the habitat optimal for marmot and the number of animals is much higher than on the right bank.

The upper limit of settlement in Mynzhilki region is in the area of scientific glaciological station at the height of 3400-3525 m. The lower boundary of marmot's settlements are harder to catch because of the high grass.

Abandoned burrows on the left bank of the river Malaya Almatinka are marked at an altitude of 2600 m (at a distance of about 900 m from the nearest inhabited burrows). At the end of August 2016, these burrows were infested by 2 adults. On the right bank of the river. M. Almatinka settlement marmots begins at an altitude of 3000 m.

Cases of resettlement of marmots we have registered twice. In July 2010, in the upper reaches of the Kazashka river on 2 bhutans, the corpse of a young and fresh bone remains of an adult marmot were found, after which the animals ceased to visit these holes. In June 2011 near to a large family bhutan the cowherds ' camp appeared with a few shepherds herding dogs. The marmots who lived here left and the next 5 years (till 2016) only occasionally visited peripheral entrance openings of this bhutan.

In 2015, 500 m Southeast of the pass Terisbutak at the height of 2660 meters was discovered a small but frequently visited bhutan, at the distance of 1 km from the nearest settlement of marmots in the upper river Kazashka. Bhutan was inhabited until the summer of 2016, bhutan probably served as temporary shelters for the migrating individuals. In previous years, only 2 abandoned burrows were found in this area on the Northern slope of pass Kumbel at an altitude of 2460 and 2850 m.

During the monitoring period within the boundaries of the study area taken into account from 450 to 520 marmot (average site density was about 5 individuals per 1 sq km), with 65-70% of the individuals lived in the upper reaches of the river Malaya Almatinka and the river Gorelnik.

The output of gray marmots after hibernation to the surface at the altitude 2450-2550 m a.s.l. it was noted in the 3 decade of March – 1 decade of April, at the height of 2550-2650 m – in the 2nd-3rd decades of April, at the altitude of 2750-3250 m – 3 decade of April - 1 decade of May.

The most intensive resettlement took place from the second decade of June to the 2nd decade of July. Occurrence of animals in hibernation began at the lower border of settlements since the middle of August, the most mass it was noted in 3 decade of August-1 decade of September, and by the middle of September, as a rule, marmots lay everywhere.

Discussion.

The main factors destabilizing the spatial structure in the area of the Tian Shan subspecies of the gray marmot in the second half of the last century were: field deratization in order to suppress plague epizooty, hunting, poaching and economic use of the territory, including plowing of land, mowing, laying roads, grazing, etc.

The first of these destabilizing factors have dominated in the territory of natural foci of plague until 1972, when anti-plague service switched to method the flea of pest control. It is also important to note that in places of winter pastures the pressure of the person was shown much less, than in the territory of summer pastures where during all warm period marmots are caught by herding dogs and the affects the factor of disturbance (Pole, 1990). In contrast to the action of destabilizing factors, ecological adaptations of compensatory nature aimed at restoring the disturbed specific structure are manifested. In places with a low number of marmots, the spatial structure of their settlements is characterized by an island and belt type of colonies (from 5 to 30 families). Within the boundaries of such isolated clusters, the density is close to optimal and the species need of marmots in the family-colonial way of life is realized (Pole, 1974; 1980). However, in dismembered the settlements of marmots (as is the case in the surveyed area) the level of intra-population contacts dramatically reduced, at the expense of what was achieved and anti-epidemic effect.

Currently enzootic plague in the mountainous areas bordering on the East with the Kungey-zailiyskaya population, at altitudes of about 2000 m has preserved the traditional farming, and along rivers and streams through the 400-600 m are herders, with cattle and dogs. In such places of illegal extraction of marmot by shepherds is ongoing (mainly due to healing of fat and feed the dogs), and marmots are very shy there. But, at the same time, the number of marmots in this area is relatively stable and has remained at the level of 32 to 46 individuals per 1 square km in recent years (Nauryzbayev et al., 2014.

The attachment of marmots to pastures and their connection with ungulates have long been widely known to specialists (Bibikov, 1967; Kapitonov, 1969). One of the key factors of the ecological niche of marmots (Marmota) is their biotopic timed to the places of grazing ungulate mammals, wild or domestic. Ungulates, forming a coadaptive complex with marmots, represent selective force in relation to them, acting as a selection factor (Karpukhina et al, 2015). This problem is studied in detail on the example of a steppe marmot. Thus, according to V.V. Kolesnikov (2007), "the reduction in the number of colonies in bobak in the South of the Ulyanovsk region was due to a decline in the number of grazing cattle from 1990 to 2004 by 14 times". The most negative impact on the resources of marmots plowing, extermination and excessive extraction, and the most positive effect of intensive grazing (Kolesnikov, 2011). In the highlands, the impact of grazing on the number of gray marmots is estimated ambiguously. Thus, according to Van Chi (2016), "the anthropogenic impact on the distribution and density of marmot populations in China is not too great. If people are not actively pursuing marmot, they peacefully coexist with man".

Judging from the remaining traces, in the subalpine zone of the observed area, the intensity of grazing in the past was incomparably higher than in recent decades. This fact gives the basis to claim that in the subalpine zone this factor had a positive impact on the life of marmots. In the conditions of a sharp reduction in livestock and grazing area in the surveyed area in the summer, the height of the vegetation cover reaches 1-1.5 m, which is likely to have served as the main reason for the displacement of the lower boundary of the marmot settlements by more than 1000 m up the slopes. At the same time, in the Alpine zone of the study area during the observation period, was observed as a single uninhabited butane, and the group of nonoccupied and abandoned burrow suitable for marmots and have sites not visited by people (the river basin of Kazashka, North-Western and North-Eastern slopes of the pass Sarysai). Thus, in the vicinity of pass Sarysai in 2011-2013 there was a high number of gray marmot. During the period from 2014 to 2015, there was a sharp reduction in it and by the summer of 2016 there was one residential family burrow (table. 2). This fact allows to conclude that the number of marmots in the subalpine zone is under the influence of a complex of biotic and abiotic factors not related to grazing.

Summary.

1. The distribution of gray marmot in the surveyed area is currently uneven. Its settlements date back to the island and belt type, relatively isolated from each other and occupy less than 20% of habitable areas.
2. Over the past 60 years, the lower boundary of the settlements has moved up by more than 1000 m (from 1400 to 2450 m).
3. Low density of marmots, the isolation of their settlements and the low level of intra-population contacts in the study area define a slight chance of plague.
4. Man-made factor has a significant impact on the spatial distribution and number of marmots, and in the middle high-altitude zone is more important to limit grazing and, as a result, the increase in height and density of grass, and in the Alpine zone operates a complex of abiotic and biotic factors.

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МОНИТОРИНГ СЕРОГО СУРКА *(MARMOTA BAIBACINA)* В ЗОНЕ АКТИВНОГО ТУРИЗМА ЗАИЛИЙСКОГО АЛАТАУ

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Аннотация. Проанализированы литературные и собственные (за период с мая 2007 по сентябрь 2017 гг.) данные по структуре поселений серого сурка (*Marmota baibacina* Kastschenko, 1899) на ограниченном участке северного склона Заилийского Алатау, расположенного вблизи города Алматы и часто посещаемого туристами. Его территория считается потенциально очаговой по чуме и ранее была обследована специалистами противочумной службы на наличие возбудителя чумы с отрицательным результатом. Однако, редкая частота обследований и малый объем исследованного полевого материала не достаточны для оценки эпизоотической ситуации. Основным носителем чумы в сопредельных горных природных очагах является серый сурок, поэтому требуются дополнительные наблюдения за пространственным распределением и численностью грызунов этого вида. Результаты длительного мониторинга поселений на участке показали, что пространственное размещение и колебания численности сурков зависят от комплекса абиотических и биотических факторов, причем антропогенное влияние не является доминирующим. Отсутствие сурка в низкогорьях и снижение его численности в субальпийском поясе обследуемой территории связано, главным образом, с прекращением выпаса скота.

Ключевые слова: поселения серого сурка, пространственное распределение, семейная нора (бутан), численность, антропогенное влияние, Заилийский Алатау.

Введение. Обследованный участок расположен на северном склоне хребта Заилийский Алатау (Рис. 1) в границах кунгей-заилийской географической популяции тяньшаньского подвида серого сурка – одной из наиболее изолированных и недостаточно изученных в ареале вида (Бибиков, 1967; Бибиков & Берендяев, 1978).

Рис. 1. *Расположение обследованного участка.*

Судя по литературным данным, распространение сурка на территории наблюдений в 30-60-е годы прошлого столетия было значительно шире. Так, Е.М. Вакуленко-Снегиревская (1940) отмечала, что летом 1933 г. «жилые норы сурков встречались на 1 километр выше курорта Медео на правом берегу р. М. Алматинки, а в целом поселения серого сурка начинались с высоты 1600-1700 м». С.И. Огнев в 1937-1938 гг. отмечал довольно большое количество сурков в субальпийском поясе на перевалах Терисбутак и Талгар (Огнев, 1940). По данным В.И. Капитонова, поселения серого сурка в Заилийском Алатау в 60-е годы располагались на высотах от 1400 до 3500 м над уровнем моря, хотя плотность их населений у нижней границы поселений была значительно снижена деятельностью человека (Капитонов, 1969). В публикациях последних лет высказывается мнение, что причиной сокращения популяция серого сурка на северном макросклоне хребта Иле (Заилийского) Алатау является антропогенный прессинг, в том числе и развитие туризма (Ташибаев и др., 2012; Грачёв и др., 2014).

Северный склон Заилийского Алатау считается потенциально очаговой по чуме территорией (Аубакиров и др., 1992). В 1993-1994 гг. было проведено эпизоотологическое обследование в бассейнах рек Малой и Большой Алматинки на высотах 1075 до 2100 м н. у. м. В результате обследования чумной микроб не был найден (Зверянский и др., 1996). Однако, следует учитывать, что исследованные полевые пробы состояли преимущественно из мышевидных грызунов и их блох, тогда как основным носителем чумы в сопредельных горных природных очагах чумы является серый сурок (Pole et al., 1996; Атшабар и др., 2012). Поэтому достоверная оценка эпизоотической ситуации на этой территории требует дополнительного изучения с учетом пространственной структуры и численности популяции сурков.

Материал и методы. Картирование поселений серого сурка (Marmota baibacina Kastschenko, 1899) проведено в период с 3 мая 2007 по 23 сентября 2017 гг. в границах Иле-Алатауского государственного природного национального парка. Охвачена территория площадью 100 кв. км: от р. Левый Талгар (на востоке) до водораздела между рр. Казашка и Кумбель (на западе) и от оз. Малое Алматинское (на юге) до северного склона Котырбулак (на севере – 43,17° с. ш.). Обследованы верховья р.р. Комиссаровка, Горельник, Казашка, Малая Алматинка, территория, прилегающая к перевалам Бутаковский, Талгарский, Терисбутак и Сарысай, склоны Котырбулак и хребта Кумбель. В период наблюдений бутаны серого сурка посещались нами с частотой от 1 до 4 раз в год. Учёт численности сурков проводился на пеших маршрутах в середине дня и, по времени, совпадал со сниженной суточной активностью взрослых и полувзрослых зверьков. По этой причине дополнительно учитывались косвенные признаки обитаемости нор (наличие троп, помет, следы расчистки и др.).

Результаты исследований. Кунгей-заилийская географическая популяция заселяет периферию ареала вида, поэтому для нее, как и для многих видовых популяций, характерны относительно высокая амплитуда колебаний численности особей и нестабильность пространственной структуры, по сравнению с центральной его частью (Бибиков, 1967; Одум, 1975). Для кунгей-заилийской популяции серого сурка, как и для большинства популяций тяньшанского подвида, суточная активность зверьков в ранневесенний и позднелетний период имеет вид одновершинной кривой, а в середине лета – двухвершинной (Бибиков, 1967; Капитонов, 1969).

За период обследования под наблюдением находилось 159 бутанов (семейных нор) серого сурка, причем все обитаемые бутаны отмечены в пределах от 2450 м до 3550 м над уровнем моря. Это свидетельствует о том, что за 40-летний период нижняя граница поселений переместилась вверх более чем на 1000 м. Большинство из наблюдаемых семейных нор отнесены нами к типу постоянных (зимне-летних), несколько – к летним и только две – к зимним. В радиусе 200 м вокруг бутанов обнаружено 197 защитных нор, более 90% из которых были старыми или очень старыми. Летом сурки часто используют каменные осыпи (с диаметром камней 0,3 до 4 м), находящиеся как в непосредственной близости от бутанов, так и на расстоянии 100-150 м от них. По этой причине в период с середины июня до начала августа бутаны, находящиеся вблизи осыпей, реже посещались сурками и имели нежилой вид (особенно после летних дождей). Такие норы сложнее дифференцировать на обитаемые и посещаемые, а также затрудняют определение размеров семейного участка.

Сурки наиболее часто заселяли старые морены с невысоким разнотравьем и склоны распадков к руслам рек. Поселения преимущественно островного и ленточного типов занимают около 10-25% территории, состоят из изолированных колоний (обычно из 1-5 семей), распределенных по территории неравномерно (Поле и др., 1971).

За период наблюдения из 159 бутанов, закартированных на участке, 136 дифференцированы как постоянные и периодически обитаемые, 9 – как необитаемые и 14 – как давно брошенные. Причем бутаны, отнесенные к последней категории, располагались поровну, как у нижней границы поселений (на высоте 2230-2600 м), так и в верхней их части (на высоте 2800-3080 м). Свыше 90% постоянно обитаемых нор находилась в зоне альпийских лугов на высотах 2800-3450 м над уровнем моря (зона оптимума). В субальпийском поясе обитаемое поселение осталось только в верховьях на высотах от 2450 до 2600 м.

Для определения тенденций динамики численности сурков на территории обследования мы выделили участки с различной кратностью проведения учетов (таблицы 1, 2).

Таблица 1. *Динамика численности сурков (особей по годам) на участках с максимальным количеством учетов.*

Годы наблюдений	Верховья р. Комиссаровка и окр. пер. Бутаковский	Верховья р. Горельник	Склоны р. Лев. Талгар	Верховья р. Мал. Алматинка	Верховья р. Казашка
2007	22-25	81-84			
2008	21-24	80-83	20-23	-	-
2009	16-19	85-88	19-22	230-240	48-52
2010	17-20	86-89	18-20	225-235	53-58
2011	14-16	84-88	16-18	235-240	52-56
2012	12-15	85-89	17-20	245-250	50-54
2013	10-13	84-88	17-20	240-245	38-42
2014	9-12	87-90	18-21	235-240	42-45
2015	8-11	81-84	16-17	235-240	48-52
2016	5-6	86-89	8-10	245-250	46-50
2017	6-8	93-97	18-21	250-255	50-54
Тенденция изменения численности	Падение	Слабый рост	Стабильна	Рост	Стабильна

Анализ данных табл. 1 показывает, что в интенсивно посещаемых туристами верховьях бассейна р. Малая Алматинка и ур. Горельник численность сурков в поселениях возросла. Один из самых крупных обитаемых бутанов расположен на расстоянии около 150 м от конечной станции канатной дороги. В верховьях р. Горельник обитаемое поселение серого сурка располагается с высоты 3040 м и до 3400 м. За время наблюдений все бутаны в пределах поселения были обитаемыми или посещаемыми, причем, в 2009, 2010 гг. и в 2016 в колонии появились три новых семейных норы. Исключение составил один небольшой бутан, на котором в мае 2010 г. найден труп полувзрослого сурка, после чего зверьки нору покинули. Заплывшие (брошенные) норы отмечены здесь в 0,5-1,0 км ниже по склонам на высоте 2800-2900 м. Поселения серых сурков в верховьях р. Малая Алматинка и р. Горельник можно считать едиными, так как грызуны теоритически могут контактировать в ур. Мынжилки и, особенно, в окрестности «Ворот Туюксу», где расстояние между обитаемыми бутанами не превышает 400-450 м. Высокая вероятность контактов между сурками из этих поселений возможна на проходном Талгарском перевале (на высоте 3475 м.), где обнаружены расчищенные защитные норы.

Падение численности отмечено лишь на одном участке из пяти – в верховьях р. Комиссаровка и в районе Бутаковского перевала. В верховьях р. Комиссаровка на северо-западном склоне сопки Фурмановка, в период наших наблюдений, обитали 2 семьи сурков на высотах 2625 м и 3060 м н. у. м. Верхний бутан был обитаем все годы наблюдений. Нижний бутан сурки заселяли в 2007, 2008, 2010 и 2011 гг. В 2009 г. сурков на нём не наблюдалось, но начале лета 2010 г. там наблюдали полувзрослого самца, а весной 2011 г. появился молодняк. В последующие годы бутан был необитаем. В бассейне р. Бутаковка на высотах 2230-2535 м регистрировались, в основном, заплывшие (давно брошенные сурками) норы. На юго-восточном склоне Бутаковского перевала на высоте 2750-2900 м в начале наблюдений (2007 г.) отмечалась обитаемая колония, но постепенно численность сурков уменьшалась и к августу 2015 г. обитаемые норы там не фиксировались (рис. 2).

Рис. 2. *Тенденция изменений численности в поселениях сурка на обследованной территории в 2007-2017 гг:*

Таблица 2. *Динамика численности сурков (особей по годам) на участках со средним и минимальным количеством учетов.*

Годы наблюдений	Окрестности пер. Сарысай	Сев. склоны хр. Кумбель	Окрестности пер. Талгарский
2011	35-40	-	-
2012	38-42	5-6	-
2013	36-39	6-7	-
2014	30-35	9-11	-
2015	15-18	11-14	75-80
2016	2-5	12-15	82-90
2017	9-12	10-11	84-95
Тенденция изменений численности	Нестабильна	Рост	Рост

На северных склонах хребта Кумбель на локальном участке обитала колония сурков (1-3 семьи), расселение с этого участка на ранее обитаемую территорию не происходило – все бутаны были необитаемыми или заброшенными. В окрестностях Талгарского перевала численность зверьков увеличивалась и в конце лета 2017 г. все бутаны были обитаемыми (Табл. 2, Рис. 2). В окрестности перевала Сарысай за 2015-2016 гг. численность сурков резко снизилась, но в 2017 г. началось её восстановление (табл. 2, Рис. 3-4).

Рис. 3. *Фрагмент обследованной территории в августе 2016 г,*

Рис. 4. *Фрагмент обследованной территории в августе 2017 г*

В верховьях р. М. Алматинка (ур. Мынжилки) несмотря на большое количество туристов и расположенную там метеостанцию численность сурков относительно высокая при практически стопроцентной обитаемости нор. На левом берегу места обитания наиболее оптимальны для сурков и численность зверьков здесь заметно выше, чем на правобережье. Верхняя граница поселения в ур. Мынжилки находится в районе научной гляциологической станции на высоте 3400-3525 м. Нижние границы поселений обитания сурков обнаружить сложнее из-за высокого травостоя. Заплывшие норы на левобережье р. М. Алматинка отмечены на высоте 2600 м (на расстоянии около 900 м от ближайших обитаемых нор). В конце августа 2016 г. в эти норы вселились 2 взрослые особи. На правом берегу р. М. Алматинка поселение сурков начинается на высоте 3000 м.

Случаи переселения сурков нами зарегистрированы дважды. В июле 2010 г. в верховьях р. Казашка на 2 бутанах были обнаружены труп молодого и свежие костные останки взрослого сурка, после чего зверьки перестали посещать эти норы. В июне 2011 г. рядом с крупным семейным бутаном появилась стоянка чабанов с несколькими пастушьими собаками. Обитавшие здесь сурки ушли и последующие 5 лет (до 2016 г.) лишь эпизодически посещали периферические входные отверстия этого бутана.

В 2015 году в 500 м юго-восточнее перевала Терисбутак на высоте 2660 м был обнаружен небольшой, но часто посещаемый бутан, отстоящий на 1 км от ближайшего поселения сурков в верховьях р. Казашка. Бутан был обитаем до лета 2016 г. Вероятно бутан служил временным убежищем для мигрировавших особей. В предшествующие годы в этом районе нами были обнаружены лишь 2 заплывших бутана на северном склоне хр. Кумбель на высоте 2460 и 2850 м.

За период наблюдения в границах обследованной территории учтено от 450 до 520 сурков (в среднем по территории плотность составила около 5 особей на 1 кв. км), причем 65-70% особей обитали в верховьях р. Малая Алматинка и р. Горельник.

Выход серых сурков после спячки на поверхность на высоте 2450-2550 м н. у. м. отмечался в 3 декаде марта-1 декаде апреля, на высоте 2550-2650 м – во 2-3 декадах апреля, на высоте 2750-3250 м – 3 декаде апреля -1 декаде мая.

Наиболее интенсивное расселение проходило со второй декады июня по 2 декаду июля. Залегание зверьков в спячку начиналось у нижней границы поселений с середины августа, наиболее массовое отмечалось в 3 декаде августа-1 декаде сентября, а к середине сентября, как правило, сурки залегали повсеместно.

Обсуждение.

Основными факторами дестабилизации пространственной структуры в ареале тяньшанского подвида серого сурка во второй половине прошлого века являлись: полевая дератизация в целях подавления эпизоотий чумы, промысел, браконьерская охота и хозяйственное использование территории, включая распашку земель, сенокошение, прокладку дорог, выпас скота, и др. Первый из перечисленных дестабилизирующих факторов доминировал на территории природных очагов чумы до 1972 года, когда противочумная служба перешла на метод полевой дезинсекции. Важно также отметить, что в местах зимних выпасов давление человека проявлялось значительно меньше, чем на территории летних выпасов, где в течение всего тёплого периода сурков ловят чабанские собаки и сказывается фактор беспокойства (Поле, 1990). В противовес действию дестабилизирующих факторов проявляются экологические адаптации компенсаторного характера, направленные на восстановление нарушенной специфической структуры. В местах с низкой численностью сурков для пространственной структуры их поселений характерен островной и ленточный тип колоний (от 5 до 30 семей). В границах таких изолированных скоплений плотность близка к оптимальной и реализуется видовая потребность сурков в семейно-колониальном образе жизни (Поле, 1974; 1980). Однако в разорванных поселениях сурков (как это имеет место на обследованной нами территории) уровень внутрипопуляционных контактов резко снижен, за счет чего и достигался противоэпизоотический эффект.

В настоящее время в энзоотичных по чуме горных районах, граничащих на востоке с кунгей-заилийской популяцией, на высотах около 2000 м сохранилось традиционное животноводство, а вдоль рек и ручьев через 400-600 м располагаются чабанские стоянки со скотом и собаками. В таких местах браконьерская добыча сурков чабанами ведётся постоянно (в основном, из-за целебного жира и на прокорм собакам), а сурки там очень пугливы. Но, вместе с тем, численность сурков на этой территории относительно стабильна и держится в последние годы на уровне от 32 до 46 особей на 1 кв. км (Наурузбаев и др, 2014).

Привязанность сурков к пастбищам и их связь с копытными давно и широко известны специалистам (Бибиков, 1967; Капитонов, 1969). Одним из ключевых факторов экологической ниши сурков *(Marmota)* является их биотопическая приуроченность к местам выпаса копытных млекопитающих, диких или домашних. Копытные, образуя с сурками коадаптивный комплекс, представляют собой по отношению к ним селективную силу, действуя как фактор отбора (Карпухина и др., 2015). Наиболее детально эта проблема изучена на примере степного сурка. Так, по мнению В.В. Колесникова, «сокращение количества колоний байбака на юге Ульяновской области произошло вследствие сокращения количества выпасаемого скота с 1990 до 2004 гг. в 14 раз» (Колесников, 2007). Наиболее отрицательно на ресурсы сурков влияет распашка, истребление и неумеренная добыча, а наиболее положительно сказывается интенсивный выпас скота (Колесников, 2011).

В высокогорье влияние выпаса скота на численность серых сурков оценивается неоднозначно. Так, по мнению Ван Чи (2016), «антропогенное влияние на распространение и плотность популяции сурков в Китае не слишком велико. Если люди активно не преследует сурков, они вполне мирно уживаются с человеком».

Судя по сохранившимся следам, в субальпийской зоне наблюдаемого участка интенсивность выпаса в прошлом была несравненно выше, чем в последние десятилетия. Это обстоятельство дает основание утверждать, что в субальпийской зоне этот фактор оказал положительное влияние на жизнедеятельность сурков. В условиях резкого сокращения поголовья скота и площади выпасов на обследованной территории в летний период высота растительного покрова достигает 1-1,5 м, что, вероятно, и послужило основной причиной смещения нижней границы поселений сурков более чем на 1000 м вверх по склонам. В тоже время, в альпийском поясе обследуемой территории в течение всего периода наблюдения, отмечались как одиночные необитаемые бутаны, так и группы необитаемых и заплывших нор на подходящих для сурков и давно не посещаемых людьми участках (бассейн р. Казашка, северо-западные и северо-восточные склоны пер. Сарысай). Так, в окрестностях пер. Сарысай в 2011-2013 гг. отмечалась высокая численность серого сурка. За период с 2014 по 2015 гг. произошло резкое её сокращение и к лету 2016 г. осталась одна жилая семейная нора (табл. 2). Это обстоятельство позволяет заключить, что численность сурков в субальпийском поясе находится под влиянием комплекса биотических и абиотических факторов, не связанных с выпасом.

Выводы.

1. Распределение серого сурка на обследованной территории в настоящее время неравномерно. Его поселения относятся к ленточному и островному типу, относительно изолированы друг от друга и занимают менее 20% пригодной для обитания территории.
2. За последние 60 лет нижняя граница поселений переместилась вверх более чем на 1000 м (с 1400 до 2450 м н. у. м.).
3. Низкая плотность сурков, изолированность их поселений и низкий уровень внутрипопуляционных контактов на обследованной территории определяют слабую вероятность энзоотии чумы.
4. Антропогенный фактор оказывает заметное влияние на пространственное распределение и численность сурков, причем в среднем высотном поясе большее значение имеет ограничение выпаса скота и, как следствие, увеличение высоты и густоты травостоя, а в альпийской зоне действует комплекс абиотических и биотических факторов.

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COMPLETE GENOME SEQUENCING OF MONGOLIAN MARMOT HEPADNAVIRUS

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Background

Previously proposed the animal models for studies of immune-pathogenesis of hepadnavirus infection, particularly the mechanisms of hepatocellular carcinoma: North American Woodchuck (Summers, et al. 1978) Tree squirrels (Feitelson, M.A et al. 1980). Therefore, we thought that we can find similar virus in population of Mongolian marmots. On the other hand, sequencing of the latent virus in the organism allows to make conclusion on origin and evolutionary pathway of host organism.

Goal

To detect the hepadnavirus and to sequence complete genome, to propose new animal model for studies of immune-pathogenesis of hepadnavirus infection

Objectives

Detecting of hepadnavirus in the population of Mongolian marmots (Marmota sibirica, Radde, 1862)

Sequencing of complete genome of marmot hepadnavirus

To propose the new animal model of immune-pathogenesis studies of hepadnavirus infection

Materials and methods

In total, we collected 980 samples of blood serum and liver samples. We used ELISA kits for detection of HBV and WHV markers. We performed PCR using the conserved primers of hepadnavirus and complete genome was sequenced.

Results

We detected anti-WHc in 25.3%, anti-WHs in 8.9% of Mongolian marmot population. These markers were different in Khentii, East Gobi, and Gobi-Altay Regions. We sequenced complete genome of Mongolian marmot hepadnavirus by amplification of genome by PCR, then sequencing.

Comparison of nucleotide and amino acid sequences of MMHV and WHV

Gene regions	Number of nucleotide and amino acid		Differences in nucleotides		Differences in amino acids	
	Number	%	Number	%	Number	%
Gene "S" (Pre-sI+Pre-sII+s)	1296/432	1296/432	0	0	0	0
Gene "X"	426/142	402/134	5	1.24	4	2.98
Gene "C"	678/226	678/226	1	0.14	0	0
Gene "P"	2655/885	2655/885	11	0.41	7	0.79

Total length of MMHV was 3223 nucleotides. By comparing of MMHV genome regions to WHV was found that there were no nucleotide and amino acid differences in "S" region, there was 1.24% difference in nucleotide and 2.98% difference in amino acid sequences in "X" region, 0.14% difference in nucleotide, however no difference in amino acid sequence in "C" region, there was 0.41% in nucleotide, 0.79% difference in amino acid sequence in "P" region. "X" gene, which has a trans-activating role for the genome is shorter in 24 nucleotides, its product in 8 amino acids in the MMHV than the WHV, therefore virion numbers are very few 10^2 to 10^3. MMHV genome sequence was the most conserved comparing to five published sequences of Woodchuck hepatitis viruses. In the example of human hepatitis B virus was shown "X" gene is getting longer by evolution development. Above mentioned data show that Mongolian marmot might be an ancestor species among the marmot family. 2 marmots were taken to animal house and infected by MMHV, and observed PCR detection, however no infection.

Conclusion

Mongolian marmot and MMHV are the new model for studies of immune-pathogenesis of hepadnavirus infection.

MMHV genome has a most conserved sequence and "X" gene, which has a trans-activating role for the genome is shorter in 24 nucleotides, its product in 8 amino acids than the WHV, therefore its host the Mongolian marmot is the most ancestor of marmot family.

МОНГОЛ ТАРВАГАНЫ ХЕПАДНАВИРҮСИЙН ГЕНОМЫН БҮРЭН ДАРААЛАЛ

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[1] *Нийгмийн эрүүл мэндийн үндэсний төв*

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Хепаднавирүсийн халдварын эмгэг жам, нэн ялангуяа Элэгний анхдагч өмөн (ЭАӨ) үүсэх механизмыг судлах Хойд Америкийн ойн тарваганы вирүс (Summers, J et al. 1978), ойн хэрэмний вирүс (Feitelson, M.A et al. 1980) зэрэг сүүн тэжээлтний загварыг гарган авсан нь бидэнд монгол тарваганы популяцид хепаднавирүс илрүүлэх шинжилгээ хийх сэдлийг төрүүлсэн юм. Нөгөө талаас тухай биемахбодид бугшдаг вирүсийн генийн дарааллыг тогтоох нь эзэн биемахбодийн гарал үүсэл, эволюци хөгжлийн талаар дүгнэлт хийх бололцоо олгох юм.

Зорилго. Монгол тарваганы популяцид (*Marmota sibirica*, Radde, 1862) Хепаднавирүс илрүүлж, түүний геномын бүтэц, бүрэн дарааллыг тодорхойлж, уг вирүсийн халдварын эмгэг жамыг судлах амьтны загвар гарган авах

Зорилт. Монгол тарваганы популяцид хепаднавирүс илрүүлэх, Хепаднавирүсийн геномын бүрэн дарааллыг тодорхойлох, Хепаднавирүсийн халдварын эмгэг жамыг судлах вирүс-амьтны загвар гарган авах

Материал, аргазүй. Хэнтий, Говь-Алтай, Төв ба Дундговь аймгийн нутгаас нийт 980 тарваганы цусны ийлдэс, элэгний дээж цуглуулсан. Хепаднавирүс илрүүлэхийн тулд ХВВ-ийн ба Америкийн ойн тарваганы гадаргын эсрэгтөрөгч ба эсрэгбие илрүүлэх ФХУ-ын цомог, хепаднавирүсийн нийтлэг дараалалд үндэслэн праймер нийлэгжүүлж, ПГУ-аар геномын дарааллыг олшруулан бүтэн геномын секвенс хийв.

Үр дүн. Монгол тарваганы популяцид хепаднавирүсийн (МТХВ) цөмийн эсрэгтөрөгчийн эсрэгбие дунджаар 25.3%, гадаргын эсрэгтөрөгчийн эсрэгбие 8.9% байв. Эдгээр маркерууд Хэнтий, Дундговь, Говь-Алтайн тарваганы сүрэгт өөр, өөр байлаа. Хепаднавирүсийн нийтлэг праймер ашиглан ПГУ-аар геномын дарааллыг олшруулан секвенс хийхэд Монгол тарваганы хепаднавирүсийн геномын урт 3223 нуклеотид байв. 2 тарвагыг гаршуулж МТХВ-ээр халдаахад ПГУ-аар иэлрч байсан боловч, тарвага халдвар аваагүй.

МТХВ ба ОТХВ-ийн нуклеотидын ба аминхүчлийн ялгааг харьцуулсан дүн

Ген	Нуклеотид ба аминхүчлийн хэмжээ		Нуклеотидуудын ялгаа		Аминхүчлүүдийн ялгаа	
	ОТХВ	МТХВ	Тоо	Хувь	Тоо	Хувь
“S” ген	1296/432	1296/432	0	0	0	0
“X” ген	426/142	402/134	5	1.24	4	2.98
“C” ген	678/226	678/226	1	0.14	0	0
“P” ген	2655/885	2655/885	11	0.41	7	0.79

МТХВ-ийн геномын дарааллыг Хойд Америкийн ойн тарваганы (ОТХВ) геномтой харьцуулахад “S” генд нуклеотидын ба аминхүчлийн дарааллын ялгаа байхгүй, “X” генд нуклеотидын дараалалд 1.24%, аминхүчлийн дараалалд 2.98%-ийн, “C” генд нуклеотидын дараалалд 0.14%-ийн ялгаатай боловч аминхүчлийн дараалалд ялгаа байхгүй, “P” генд нуклеотидын түвшинд 0.41%, аминхүчлийн дараалалд 0.79%-ийн ялгаатай байв. Монгол тарваганы популяцид хепаднавирүсийн вирионы тоо маш цөөн буюу 10^2-10^3 байв.

ОТХВ-ийн геномын хэвлэгдсэн 5 дараалалтай харьцуулахад МТХВ хамгийн өвөг, уламжлагдсан дараалалтай байв. Мөн хүний ХВВ-ийн жишээн дээр “X” ген эволюци хөгжлийн явцад уртасч буйг баталсан бөгөөд энэ нь МТХВ-ийн геномд 24 нуклеотидээр, түүний бүтээгдэхүүн нь 8 аминхүчлээр богино байв. Эдгээр нь МТХВ-ийн эзэн биемахбодь болох Монгол тарвага нь бусад тарваганы өвөг болохыг үзүүлж байна.

Дүгнэлт

МТХВ нь хепаднавирүсийн халдварын эмгэгжамыг судлах шинэ загвар болж байна. МТХВ-ийн геном нь хамгийн уламжлагдсан дараалалтай байгаа ба идэвхжүүлэх үүрэг бүхий “X” ген нь 24 нуклеотид, бүтээгдэхүүн нь 8 аминхүчлээр богино байгаа тул Монгол тарвага нь өвөг шинжтэй гэсэн дүгнэлтийг хийх бололцоо олгож байна.

MARMOTS ADAPTATION IN CAGE CONDITIONS

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Introduction

We obtain from marmots their pelts, edible meat and healing medicinal fat. All those products are in high demand. For 5-8 months a year marmots are dormant, and need neither food provision for winter, nor care in that season. The base of their nutrition is vegetable foods. Marmots are large sized: the body length of adult animals is 40 to 70 cm, the weight, 3.5 - 10 kg. In nature marmots spend 9/10 of their life span in burrows. Estrus occurs in April-May, and pregnancy lasts 30-35 days. They whelp 4-6 kits on the average. Lactation lasts 35-50 days (Bibikov, 1989).

Material and methods

The subjects of the study were steppe marmots (n=280) of a European subspecies (*Marmota bobak bobak* Müller, 1776) (Figure 1) and black-capped marmots (n=26) of a Kamchatka subspecies (*Marmota camtschatica camtschatica* Pallas, 1811) (Figure 2).

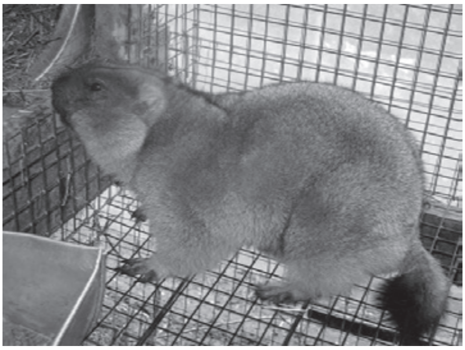

Figure 1. *The steppe marmot (photo M.V. Plugina).*

Figure 2. *The black-capped marmot.*

Several housing types for keeping marmots were tested: warm houses of squared beams and bricks; wooden 4-row barn-shed 7 x 68 meters (Figure 3); the common 2-row open shed (Figure 4); and an open 2-row shed with underground houses. The animals also were housed in cages under a lean-to and in corrals. For winter hibernation, separately placed cages in which houses were covered with snow for better warmth, were employed.

Figure 3. *Wooden 4-row barn-shed.*

Figure 4. *2-row open-shed.*

Figure 5. *Cages for marmots.*

The cages were those used for industrial breeding of red foxes and polar foxes, with open air, galvanized, welded wire-mesh and a wooden house. We lined the house with wire-mesh from inside. The distance between the wooden and wire-mesh bottoms in the house was increased up to 10 cm to make a thicker stratum of warming material for winter keeping of the marmots (Figure 5).

When keeping marmots in a shed with underground houses we installed, on both sides along the shed, concrete trays, which we dug into the earth 1.5 meters deep. We covered the shed with concrete and filled earth to the landscape level. Inside the trays we made brick partitions. We connected the underground houses with the open air sites with a tubular passage.

The temperature of the air in the cages recorded at M-16 thermograph. The body weight of animals was measured once a month on electronic scales. Statistical analysis was performed using Microsoft Excel 2010.

Results and discussion

There were considerable differences in temperature conditions for winter hibernation between shed and barn housing. Both steppe and black-capped marmots kept in cages can readily endure severe winters with temperatures as low as -30 to -35^{0}C (Plotnikov & Zabolotskikh, 2000). During winter hibernation, which lasts from October to the beginning of April in the temperature zone of Russia, marmots reduced body weight by 30-45%. Black-capped marmots had a 3-4% lower weight decrease than did the steppe variety. Grown individuals of both species lose 5-6% more weight than did the young. When kept in cages with insulated houses in a closed shed marmot body weight is reduced 30-33%, while the average for animals kept in a shed with open sides was 37%. The weight reduction percent in marmots wintering in cages under snow cover was greater. Keeping marmots in closed, non-heated premises, provides a better temperature regime than in an open shed. Degree of illumination of outside rows of cages on a sunny day is 80-850 lx. With 4-row sheds, reduced natural lighting to the inside rows of cages was noted (1-29 lx).

Open shed techniques have the advantage of lower building expenses but do not suit areas with severe winters. Making shed side walls of removable screens allows their use in various climatic zones. In southern regions where summer temperature is more than +35^{0}C, the simple shed version is also not recommendable. For that zone, sheds with underground houses suit marmots better. Keeping marmots in winter in premises with artificial heating did not give good results. Under such conditions hibernation was interrupted, and moult and growth cycles are disrupted.

The marmots' feeding period lasts approximately 6.5 months, from April to October. During this period, intensive growth of the young is observed and the restoration of body mass in adults. Fat accumulation, compressing energy resource storage for wintering and early spring is underway. Before entering hibernation, marmots must have body weight not less than the following indices: adult steppe marmots: 5.2-5.8 kg, yearlings: 2.7-3.2 kg; adult black-capped marmots: 4.4-5.0 kg, yearlings: 1.4-1.8 kg (Plotnikov, 2012).

In captivity, marmots eat a variety of foods. They may be fed with: mangel-wurzel, carrots and other roots; boiled potatoes, cabbages, pumpkins and other vegetables, alfalfa, clover, various grasses, soaked with water or vapour combined foods, roots and oil-cake, milk and whey, bread and meal scraps and waste. It is impossible to satisfy the nutrient requirements of marmots without concentrated foods. Cereals without preliminary cooking and dry, loose combined foods are highly suitable for marmots. We recommend that marmots be fed granulated combined foods with granules 4.8-10 mm made for rabbits, nutrias, laboratory animals, pond fish and swine (Figure 6).

Figure 6. *Granulated feed.*

Figure 7. *Bunker feeder KKB-1M.*

Steppe marmots eat 300 g of granulated food per day (Mukhamedyanov et al., 2009). Unlike steppe marmot the black-capped variety eats 42-52% less dry combined foods, but both species similarly consume root vegetables and other succulent foods. The requirement of steppe marmots in nutrients on 1 МДж exchange energy makes (g): solid - 82,5; protein - 15,2; fat - 1,9; cellulose - 2,8; an azotic extractives - 31,6. On 1 kg of weight of a body it is required to marmots (g): 9,1 protein; 1,1 fat; 1,7 cellulose; 18,9 an azotic extractives; 0,9 calcium and 0,5 phosphorus. The requirement for all nutrients increases by 1 kg of live weight in the spring, and decreases on 23-30 % in the autumn.

At the cellular contents it is possible to provide need of marmots for nutrients with feeding by the granulated compound feed according to the developed recipes. It is established that when using in feeding of marmots of the granulated compound feed KKB – 1M, feeding trough, applied to rabbits is most technological (Figure 7).

Marmots, eating the granulated compound feed, try to take it paws. The part of a forage inevitably falls under a cage. For decrease in losses of a forage on a bottom under a bunker feeding trough it is necessary to attach in addition a shelf from sheet iron. As a result of this device the dropped – out forage fails not at once under a cage and steals up marmots.

Conditions of the cellular contents and technology of feeding of marmots cause level of need of marmots in water. Especially big need for water when feeding by dry compound feeds and at high surrounding temperatures. The general consumption of water in hot days of summer reaches on a marmots farm 500 g on the head per day. Feed marmots 2 times a day – in the morning and in the evening.

Fat storage at high levels in marmots before entering hibernation is of the key importance to their successive reproduction. Young female animals and those in a poor nutritive state in spring have incomplete estrous cycles as the heat and ovulation are absent. In vaginal smears mainly basal, parabasal, intermediate and a few surface epithelial cells are present (Figure 8, 9). This is the evidence for insufficient estrogens in the bodies of such females, as indicated in other studies (Rymalov, 1996).

Figure 8. *Stage of proestrus 2.*

Figure 9. *Estrus stage.*

Marmots have a long reproductive period (7-10 years) and because they are a good model for a monitoring of different population parameters during long period of time. The first problem was providing of whelping. Even slight intervention in a liter life provoked a great female stress. Later, in domestication process, female had become calmer. Inspection at the day of whelping and moving whelps from one female to another were feasible.

Marmots are born without hair cover with smooth pink skin. Body mass of a newborn marmot is about 35 g, body length is about 10 cm. Eyes and ears are tightly closed; there are no teeth. The teeth emerge and the eyes open after 20 days of age. The weaning of the young is at the age of 45 days (Figure 10).

Figure 10. *Young marmots.*

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ESTIMATION OF BLACK-CAPPED MARMOT, MARMOTA CAMTSCHATICA, ABUNDANCE AND HABITATS QUALITY IN KAMCHATSKY KRAY

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The area of the black-capped marmot range is 840 thousands ha, a total species abundance comprises about 40 thousands individuals. Animals density within of high quality habitats is 60-80 individuals per 1 thousand ha, within habitats of lower than moderate quality – 30-60 individuals per 1 thousand ha and within habitats of poor quality – 0,1-5 individuals per 1 thousand ha. Population status in general is considered as safe.

The black-capped marmot in general and his Kamchatka subspecies in particular is the worst studied marmot species. For a long time, the black-capped marmot abundance within the whole range and was conditionally estimated in Kamchatka region (Bibikov & Zimina, 1983; Bibikov, 1989). The first estimation of this marmot species abundance on Kamchatka was based on the results of 1984 All-Union count of marmot abundance – 10 thousand individuals. It should be noted that this count was conducted in limited scales, in inappropriate seasons for Kamchatka (June-July) and by inexperienced counters and extrapolation as such was not performed (one of the authors participated in these works). As a result, the abundance was highly underestimated.

Latter D. I. Bibikov (1989) estimated species abundance on Kamchatka as 50 thousand individuals based on data of field surveys on black-capped marmot of V.A. Tokarskiy & A.S. Valentsev on Kamchatka in 1987.

Some authors attempted to estimate marmot abundance in several parts of the region. So V.I. Kapitonov (1978) based on data of A.A. Portenko et.al. (1963) determined marmot abundance in the southern half of Koryakskoe upland (the north of region) as 20 thousand animals by expert knowledge. In Elizovskiy district of Kamchatka (the southern part of region) marmot abundance was estimated as 32 thousand individuals (Tokarskiy & Valentsev, 1994; Tokarskiy, 1997). In total marmot abundance in the region was estimated as 200-226 thousand animals (Tokarskiy & Valentsev, 1991, 1994). It should be mentioned that at first for this estimation data on marmot density from the southern part of Sredyniy Range where it was among the highest in this portion of the range with much lower within the rest of the range have been considered. Secondly, all types of habitats (mountain tundra, slide-rocks, screes) were included in extrapolation. But as was found in the further field surveys not all these habitats were suitable for black-capped marmots and inhabited by them. As a result the abundance was highly overestimated and latter determined as not more than 100 thousands individuals (Valentsev et.al., 1996; Valentsev & Lebed'ko, 1999).

In preparation of this work authors used data on black-capped marmot density in the southern part of Sredyniy Range including the rivers Yurtynaya, Utudumyts, Kagnyssin (tributaries of Bystraya (Bol'shaya) River), Goreliy and Avachinskiy volcanoes, Tolmachevskiy Doll, a headstream of Pravaya Vorovskaya River (Tokarskiy & Valentsev, 1991, 1994, personal field surveys of 1995-2003). Data of V.A. Tokarskiy were used for the middle part of Sredyniy Range in a headstream of Bystraya (Khairyuzova) River, data of V.A. Tokarskiy & V.I. Mosolov (1993) were used for Kronotskiy Reserve. Questionnaire data, materials on game resources management of 1967-1977, literature data (Portenko et.al., 1963; Kapitonov, 1978) were used for the north of the peninsula.

The area of habitats (mountain tundra including alpine and subalpine meadows, mountains without plants – rocks and screes, rocky shores, ancient volcanic lava fields) was determined on the basis of the last game resources management (2014-2016). Explication of habitats was performed using current GIS-technologies and satellite images of the areal. Percentage of habitats inhabited by black-capped marmot was determined based on data of personal field surveys, literature data and questionnaire information. We consider this assessment of species abundance in the region as expert estimation because field surveys have not been conducted within the significant part of the range and data for this areal are calculated data.

A total area of appropriate habitats of black-capped marmot in Kamchatkiy kray is about 6,5 million ha. Marmots inhabit about 840 thousand ha of this area at one degree or another. The highest percentage of inhabited habitats located in the central and south-west parts of the peninsula – 20-25%, the lowest of 5-15% – the northern mainland areas. The highest population density is recorded within the peninsula – 75-80 ind/1000 ha, the lowest density of 5,1-50 ind/1000 ha – in the north of the region. Total black-capped marmot abundance is estimated as about 40 thousand individuals including about 34 thousands animals within the peninsula (Table 1).

Table 1. *Expert estimation of black-capped marmot abundance in Kamchatskiy kray*

Administrative districts	Total area of appropriate habitats, thous. ha	% habitats inhabited by marmot	Area of inhabited habitats, thous. ha	Average population density, ind/1000 ha	Number of individuals
Bystrinskiy	313,9	25,0	78,5	80	6280
Elizovskiy	312,1	15,0	46,8	75	3510
Myl'kovskiy	240,6	25,0	60,2	80	4816
Sobolevskiy	98,8	25,0	24,7	80	1976
Ust'-Bol'sheretskiy	63,2	25,0	15,8	75	1185
Ust'-Kamchatskiy	419,0	15,0	62,9	80	5032
Karaginskiy	414,5	20,0	82,9	80	6632
Tygil'skiy	258,3	20,0	51,7	80	4136
Olyutorskiy, including Koryakskoye upland, Olyutorskiy and Pylginskiy Ranges	2112,2	15,0	316,8 41,0	5,1 50,0	1615 2050
Penzhinskiy	2252,0	5,0	112,6	5,1	574
TOTAL	6484,6	5,0-25,0	839,9	62,7	37806

A common status of black-capped marmot population in the region is considered as safe. Risks for decrease of marmot population density and abundance exist only within localized areas of mining developments, fuel-energy complexes and recreational tourism (volcanoes Goreliy, Avachinskiy). Among abiotic factors marmots threaten with volcanic eruptions and associated aerial ash falls, lava flows and mudflows (vol. Kyzimen in 2010-2011, vol. Tolbachik in 2012-2013).

Species habitats in the region are localized within mountain, mountain-volcanic areas and rocky shore terraces. The black-capped marmot habitats include the following categories and classes: mountain tundra including subalpine and alpine meadows, mountain without vegetation (screes) and a coastal complex of adjacent water objects (seas and ocean). The first widely distributed on Kamchatka type of habitats – moraines – predominates in Koryakskoye upland (mainland part of the region). The second type of habitats – volcanic plateau (dolls) – occur only on Kamchatka peninsula where they are widely distributed southward and eastward to Kamchatka River valley as well as southward to Ganalskiy Range up to the south of the peninsula – Lopatka Cape. Marmots inhabit there only nicks (mountain circuses) located upper of forest and subalpine (pine and alder bushes) borders. Vegetation of these habitats is presented by alpine and subalpine plants within descent sites and mountain-tundra plants within windy upper sites. Rocky coastlines being the third habitat type are widely distributed along the east cost of Kamchatka and Koryakskoye upland (from Lopatka Cape on the south up to Anastasiya Bay on the north). There marmot live at a height of from 50-200 to 300-400 meters above sea level (Averin, 1948; Kapitonov, 1978).

Assessment of habitat quality (valuation) was conducted according to the method of D.N. Danilov et.al. (1966). A habitat of the highest quality for black capped marmot was evaluated as rank II (a habitat of rank I has not been distinguished). It is presented by the following classes: subalpine and alpine meadows and coastal complexes. A total area of the best habitats comprises 1, 97 million ha. They are localized only within Kamchatka peninsula. Living conditions for black-capped marmot in habitats of the highest quality are optimal. During a vegetation period they are characterized by abundant and diverse food resources, good conditions for arrangement of wintering holes and for reproduction. Screes and rocks along the meadows borders provide marmots with conditions to arrange summer temporal holes and shelters from predators and observation points.

Habitats of the middle quality – rank III – are presented by mountain tundra and coastal complexes. They are mainly located in the northern mainland areas. Climate here is characterized as extremely severe with long winter, cold and short summer, less annual precipitation, presence of the large sites of permafrost, low border of snow line and more scarce food base. A total area of middle quality habitat is 217, 7 thousand ha.

Habitats of lower than middle quality – rank IV – are presented by mountains without any vegetation (screes). The area of IV rank habitats as a total within the region comprises 1, 08 million ha. As mentioned above during summer these habitats neighboring with alpine meadows serve as shelters from predators and for arrangement of temporal holes.

Habitats of poor quality – rank V – are located on the north of the region in the mainland part of Penzhinskiy district and presented by screes at the area of about 30 thousand ha. They are characterized by the most severe climate and extreme living conditions for species (Table 2).

Table 2. *Evaluation of quality of black-capped marmot habitat in Kamchatskiy kray*

Predominant categories, classes and subclasses of habitats	The area of ranked habitats, thous. ha (average population density, individuals/thous. ha)			
	II	III	IV	V
Subalpine and alpine meadows	1969 (60-80)	-	-	-
Mountain tundra	-	133 (30-60)	-	-
Screes	-	-	1078 (5-30)	30 (0,1-5)
Coastal complex of adjacent water areas	2,1 (60-80)	84,7 (30-60)	-	-
Total	1971,1	217,7	1078	30

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ОЦЕНКА ЧИСЛЕННОСТИ И КАЧЕСТВА МЕСТООБИТАНИЙ ЧЕРНОШАПОЧНОГО СУРКА MARMOTA CAMTSCHATICA В КАМЧАТСКОМ КРАЕ

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Площадь заселённых сурками местообитаний составляет 840 тыс. га, общая численность вида около 40 тыс. особей. В местообитаниях хорошего качества плотность населения равна 60-80 особей на 1 тыс. га, среднего качества – 30-60 особей на 1 тыс. га, ниже среднего качества – 5-30 особей на 1 тыс. га и в местообитаниях плохого качества – 0,1-5 особей на 1 тыс. га. Состояние популяции в целом оценивается как благополучное.

Черношапочный сурок в целом и его камчатский подвид в частности относятся к наименее изученному виду сурков. Долгое время численность черношапочного сурка в целом по ареалу и в Камчатском регионе оценивалась лишь условно (Бибиков, Зимина, 1983; Бибиков, 1989). Первая оценка численности этого вида сурка на Камчатке была сделана после подведения итогов Всесоюзного учёта численности сурков в 1984 г. – 10 тыс. особей. Необходимо отметить, что учёт в то время проводился в крайне небольших объёмах, в неподходящие для Камчатки сроки (июнь-июль), неопытными учётчиками и экстраполяции как таковой не делалось (один из авторов участвовал в тех работах). В итоге численность была сильно занижена.

Позднее Д.И. Бибиков (1989) после полевых работ В.А. Токарского и А.С. Валенцева по черношапочному сурку на Камчатке в 1987 г. и по их данным оценил численность вида на Камчатке в 50 тыс. особей.

Некоторыми авторами делалась попытка оценить численность сурка в отдельных частях региона. Так, В.И. Капитонов (1978) по данным А.А. Портенко и др. (1963) экспертно определил численность сурка в южной половине Корякского нагорья (север региона) в 20 тыс. зверьков. В Елизовском районе Камчатки (южная часть региона) численность сурков оценивалась в 32 тыс. особей (Токарский, Валенцев, 1994; Токарский, 1997). В целом по региону численность определялась в 200-226 тыс. зверьков (Токарский, Валенцев, 1991, 1994). В этой связи необходимо отметить, что при расчёте этой численности, во-первых, брались плотности населения сурков, полученные в южной части Срединного хребта – одни из самых высоких в этой части ареала, на других участках они часто намного ниже. Во-вторых, в площадь экстраполяции включались все свойственные угодья (горные тундры, гольцы, каменные осыпи и т.п.). А как выяснилось после дальнейших полевых исследований, эти угодья далеко не все пригодны для обитания черношапочного сурка и не вся площадь пригодных угодий заселена им. В итоге численность оказалась сильно завышена, и позднее она оценивалась не более 100 тыс. особей (Valentsev and all, 1996; Валенцев, Лебедько, 1999).

При подготовке настоящей работы авторы использовали материалы по плотности населения черношапочного сурка в южной части Срединного хребта – рр. Юртиная, Утудумиц, Кагниссин (притоки р. Быстрой (Большой)), влк. Горелый, Авачинский, Толмачёвский Дол, истоки р. Правой Воровской (Токарский, Валенцев, 1991, 1994, собственные полевые исследования 1995-2003 гг.). В средней части Срединного хребта в верховьях р. Быстрой (Хайрюзовой) – данные В.А. Токарского (1991), по Кроноцкому заповеднику – материалы В.А. Токарского и В.И. Мосолова (1993). По северной части полуострова и материковым районам края использовались опросные сведения, материалы охотустройства 1967-1977 гг., литературные данные (Портенко и др., 1963; Капитонов, 1978).

Площадь свойственных местообитаний (горные тундры, включая альпийские и субальпийские луга, горы без растительности – гольцы и каменистые осыпи, береговые скалистые комплексы, старые вулканические лавовые поля) определялась по данным последнего охотустройства (2014-2016). Экспликация местообитаний при этом делалась с применением современных ГИС-технологий и использованием космоснимков местности. Процент заселённости местообитаний сурком определялся по материалам собственных полевых исследований, литературным данным и опросным сведениям. Данный расчёт численности вида в регионе мы склонны считать экспертной оценкой, поскольку на значительной части ареала полевые исследования не проводились и сведения по этим площадям сугубо расчётные.

Общая площадь свойственных местообитаний черношапочного сурка в крае составляет около 6,5 млн. га. Из них заселено зверьками в той или иной степени около 840 тыс. га. Наибольший процент заселённых угодий отмечается в центральных и юго-западных районах полуострова – 20-25 %, наименьший – в северных материковых районах – 5-15 %. Наибольшая плотность населения отмечена на полуострове – 75-80 особ./1000 га, наименьшая – на севере региона – 5,1-50 особ./1000 га. Общая численность черношапочного сурка в регионе оценивается около 40 тыс. особей, в том числе на полуострове – около 34 тыс. зверьков (табл. 1).

Таблица 1. *Экспертная оценка численности черношапочного сурка в Камчатском крае*

Административные районы	Общая площадь свойственных местообитаний, тыс. га	% заселённых сурком угодий	Площадь заселённых угодий, тыс. га	Средняя плотность населения, ос/1000 га	Численность, особей
Быстринский	313,9	25,0	78,5	80	6280
Елизовский	312,1	15,0	46,8	75	3510
Мильковский	240,6	25,0	60,2	80	4816
Соболевский	98,8	25,0	24,7	80	1976
Усть-Большерецкий	63,2	25,0	15,8	75	1185
Усть-Камчатский	419,0	15,0	62,9	80	5032
Карагинский	414,5	20,0	82,9	80	6632
Тигильский	258,3	20,0	51,7	80	4136

Олюторский, в т.ч. Корякское нагорье, Олюторский и Пылгинский хребты	2112,2	15,0	316,8 41,0	5,1 50,0	1615 2050
Пенжинский	2252,0	5,0	112,6	5,1	574
ИТОГО	6484,6	5,0-25,0	839,9	62,7	37806

Общее состояние популяции черношапочного сурка в регионе оценивается как благополучное. Лишь на отдельных локальных участках горнорудных разработок, топливно-энергетического комплекса и активного туризма существует угроза снижения плотности населения и численности сурка (влк. Горелый, Мутновский, Авачинский). Из абиотических факторов угрозу суркам представляют извержения вулканов и сопутствующие им аэральные пеплопады, лавовые и грязекаменные потоки (в 2010-2011 г. – влк. Кизимен, в 2012-2013 г. – влк. Толбачик).

Местообитания вида в регионе приурочены к горным, горно-вулканическим районам и приморским скальным террасам. Среда обитания черношапочного сурка представлена следующими категориями и классами: горные тундры с субальпийскими и альпийскими лугами, горы без растительности (каменные осыпи), береговой комплекс внешних водных объектов (морей и океана). Первый тип местообитаний – ледниковые морены, широко распространённые на Камчатке, преобладают в Корякском нагорье (материковая часть региона). Второй тип местообитаний – вулканические плато (долы) встречаются лишь на полуострове Камчатка, где они широко распространены к югу и востоку от долины р. Камчатка, а также восточнее хр. Ганальского вплоть до южной оконечности полуострова – мыса Лопатка. Зверьки населяют здесь лишь распадки (горные цирки), расположенные выше границы леса и субальпийского пояса (кедровых и ольховых стлаников). Растительность этих местообитаний альпийская и субальпийская в понижениях и горно-тундровая – на обдуваемых ветром повышенных участках. Третий тип местообитаний – скалистые морские побережья – широко распространён по восточному побережью Камчатки и Корякского нагорья (от мыса Лопатка на юге до бухты Анастасии на севере). Здесь сурки живут на высотах от 50-200 до 300-400 м над уровнем моря (Аверин, 1948; Капитонов, 1978).

Оценка качества местообитаний (бонитировка) проводилась нами по методике Д.Н. Данилова и др. (1966). Среда обитания для черношапочного сурка лучшего качества – угодья оценённые II бонитетом (угодья I бонитета не выделены). Представлены следующим классами: субальпийскими и альпийскими лугами, береговыми комплексами. Общая площадь лучших местообитаний составляет 1,97 млн. га. Они расположены только в пределах полуострова Камчатка. Условия существования для сурка в угодьях лучшего качества оптимальны. В период вегетации здесь отмечается обильная и разнообразная кормовая база, хорошие условия для устройства зимовальных нор и размножения. Наличие по границам лугов каменных осыпей и скал обеспечивают суркам условия для устройства летних временных нор и укрытий от хищников, наблюдательных пунктов.

Местообитания среднего качества – III бонитет – представлены классами горные тундры и береговые комплексы. Расположены они в основном в северных материковых районах. Климат здесь отличается большой суровостью – длинная зима, холодное и короткое лето, меньшее количество годовых осадков, наличие больших пятен вечной мерзлоты, низкое положение снеговой линии, более скудная кормовая база. Общая площадь угодий среднего качества 217,7 тыс. га.

Местообитания ниже среднего качества – IV бонитет – представлены горами без растительности (каменистыми осыпями). Площадь угодий IV бонитета в целом по региону составляет 1,08 млн. га. Граничащие с альпийскими лугами, эти угодья в летнее время, как говорилось выше, служат для устройства временных нор и укрытий от врагов.

Местообитания низкого качества – V бонитет – расположены на севере региона в материковом Пенжинском районе и представлены каменистыми осыпями площадью около 30 тыс. га. Характеризуются самым суровым климатом и экстремальными условиями существования для вида (табл. 2).

Таблица 2. *Оценка качества среды обитания черношапочного сурка в Камчатском крае*

Доминирующие категории, классы и подклассы местообитаний	Площадь бонитетов, тыс. га (средняя плотность населения, особей/тыс. га)			
	II	III	IV	V
Субальпийские и альпийские луга	1969 (60-80)	-	-	-
Горные тундры	-	133 (30-60)	-	-
Каменистые осыпи	-	-	1078 (5-30)	30 (0,1-5)
Береговой комплекс внешних водных объектов	2,1 (60-80)	84,7 (30-60)	-	-
Итого	1971,1	217,7	1078	30

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THE POPULATION SIZE AND DISTRIBUTION OF MARMOTS IN RUSSIA

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The population size and distribution of marmots in the territory of Russia in the last 20 years have not undergone major changes, but there is a weak tendency of decreasing marmot numbers. In the Central, Privolzhsky and Southern federal districts the number of bobaks *(Marmota bobak)* is relatively stable. Now there is a tendency for a shift in the location of marmot colonies across the territory, caused by a decrease in grazing and increased mowing in agrolandscapes. Forage conditions for marmots have begun to deteriorate due to a decrease in grazing and overgrowing of colonies with high grass. It is especially difficult for marmots to survive in the early spring period, as last year's weeds cause the late growth of fodder plants and reduces visibility, which is unfavorable for marmots. Individuals have begun to migrate to more elevated areas, with better visibility. Migration is accompanied by greater individual mortality. In general, over the last five to ten years, the number of bobak has decreased very slightly and now amounts to 337.7 thousand of the European subspecies *(M.b.bobak)* and 75.5 thousand of the Kazakhstan subspecies *(M.b. schaganensis)*. According to the estimates of specialists and hunting correspondents, the number of tarbagan (Siberian marmot; *M. sibirica*) and gray marmots *(M. baibacina)* also decreased very slightly and is estimated at 93 and 168.8 thousand individuals respectively. Forest steppe marmots *(M. kastschenkoi)* number about 14 thousand individuals and black-capped marmots *(Marmota camtschatica)* around 145.4 thousand. In total, the Russian marmot population is estimated at 834.9 thousand individuals, which is 6.6% of the total Eurasian marmot population.

Steppe species (tarbagan and bobak) can be considered evolutionarily most successful. At the beginning of the twentieth century, their total numbers exceeded 45 million and accounted for more than 90% of Eurasian marmots. The same species were less protected from humans and so experienced higher mortality than other marmot species. Today, the number of Eurasian marmots slightly exceeds 12.5 million, of which 81% are tarbagan or bobak.

Specialists of our institute have been monitoring the resources of game animals for more than 80 years - this is the so-called "Harvest Service". Marmots are among the species monitored. Information about marmot population size and distribution were gathered from special surveys, reports of our permanent and voluntary correspondents, andfrom literary and departmental sources.

The resources and distribution of marmots in the territory of Russia in the last 20 years has not undergone great changes, but there is a slight decrease in population size over time (Table 1, Figure 3), mainly related to the refinement of population estimation methods.

__Table 1.__ Number of marmots in the territory of the Russian Federation, thousand individuals

Федеральный округ	2018 г.	2009 г.	2010 г.	2011 г.	2012 г.	2013 г.	2014 г.	2015 г.	2016 г.	2017 г.
Центральный	82,3	83,4	83,4	84,7	84,9	88,1	103,6	86,5	86,5	88,1
Приволжский	139,5	139,3	139,2	138,2	139,1	140,1	136,9	144,3	135,3	133,9
Южный	80,5	83,2	83,2	85,7	86,2	86,9	138,0	165,0	158,4	154,2
Уральский	36,0	36,0	37,0	37,0	37,0	39,0	38,0	38,5	34,3	37,0
Сибирский	322,2	335,2	335,2	335,4	335,4	334,0	329,5	329,5	291,6	285,8
Дальневосточный	139,5	140,0	140,1	144,0	144,0	142,6	143,9	143,9	140,2	135,9
Россия	**800**	**817,1**	**818,1**	**825**	**826,6**	**830,7**	**889,9**	**907,7**	**846,3**	**834,9**

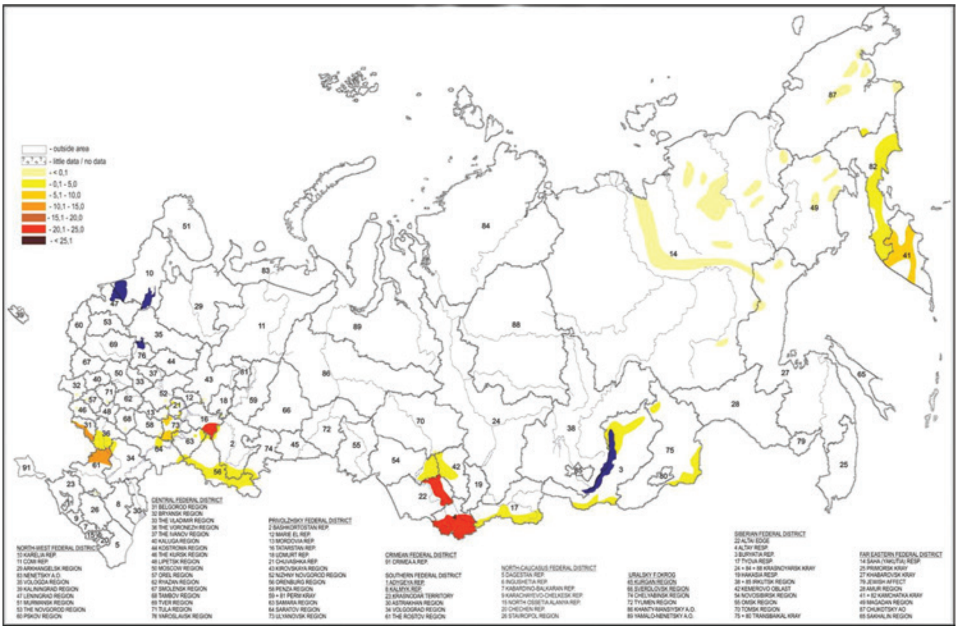

__Fig. 1.__ Distribution of marmots in the territory of the Russian Federation, individual/1000 hectares

In the Central, Privolzhsky and Southern federal districts the number of bobaks *(Marmota bobak)* is relatively stable. Now there is a tendency for a shift in the location of marmot colonies across the territory, caused by a decrease in grazing and increased mowing in agrolandscapes. Forage conditions for marmots have begun to deteriorate due to a decrease in grazing and overgrowing of colonies with high grass. It is especially difficult for marmots to survive during the early spring period, as last year's weeds cause later growth of forage plants and reduced the visibility, which is unfavorable for marmots. Individuals have begun to migrate to higher elevations with better visibility. Migration is accompanied by increased individual mortality. Marmots are more likely to occur in the Saratov, Samara, and Ulyanovsk regions and in Tatarstan. In most populations in European Russia in the Southern Urals, Kamchatka, and Altai, the population density of marmots has not changed.

Due to the natural migration patterns of marmots in the European part of Russia (Volgograd, Voronezh, and Belgorod regions), many isolated subpopulations have been joined in a larger population with a mosaic distribution across the territory. Observed habitat use and population trends have been confirmed in two regions of the European part of Russia - in the Kursk and Orel regions. In general, over the last five to ten years, the number of the bobak has decreased slightly and is now at 337.7 thousand individuals of the European subspecies *(M.b.bobak)* and 75.5 thousand of the Kazakhstan subspecies *(M.b. schaganensis)* (Table 2). According to the estimates of specialists and hunting correspondents, the numbers of tarbagan *(M. sibirica)* and gray marmot *(M. baibacina)* have also decreased very slightly and are estimated at 93 and 168,8 thousand individuals respectively. Forest steppe marmots *(M. kastschenkoi)* number about 14 thousand individuals and black-capped marmots *(Marmota camtschatica)* at 145.4 individuals.

In total, the Russian marmot population is estimated at 834.9 thousand individuals, which is 6.6% of the total Eurasian marmot population.

Table 2. *The number of different species of marmots in Russia, thousand individuals*

Species and subspecies of marmots		2013 г.	2014 г.	2015 г.	2016 г.	2017 г.
Marmota bobak	*M.b.bobak*	278,1	341	356,6	341,7	337,7
	M.b. schaganensis	76,0	75,5	77,7	72,8	75,5
Marmota kastschenkoi		12,8	15,0	15,0	14,5	14,5
Marmota baibacina		208,2	207,5	207,5	172,1	168,8
Marmota sibirica		101,9	95,9	95,9	94,7	93,0
Marmota camtschatica	*M. c. doppelmayri*	11,1	11,1	11,1	10,4	9,5
	M. c. bungei	32,6	32,9	32,9	33,1	33,4
	M. c. camtschatica	110,0	111,0	111,0	107,0	102,5
Total		**830,7**	**889,9**	**907,7**	**846,3**	**834,9**

The main drivers of change in Eurasian marmot population size are related to human activities (Abelentsev, 1971, 1975, Bibikov, Zimina, 1983, Mashkin et al. 2010). Among the most significant cause of marmot population decreases, three are worth noting (Fig. 2). Significant reduction in the number of tarbagan is associated with their extermination in the fight against plague in the early twentieth century. These losses are estimated at about 4 million individuals. From the plowing of habitat, the bobak suffered a greater population decrease than other species. It is very difficult to estimate the reduction of the European bobak population in central and eastern Europe prior to the twentieth century, but in Kazakhstan and Russia the plowing of virgin lands in 1953-1965 reduced the number of marmots by more than 15 million. Tarbagan populations decreased by 7.5 million from mortality from snaring in Mongolia in the first decade of this century (Kolesnikov et al. 2009). In other areas of Eurasia marmot populations have increased with the help of humans (Litvinenko, 1928; Migulin, 1928; Milkov, Dvurechensky, 1974; Abrakhina, 1983; Mashkin, 1989; Tokarskii et al., 1990, 1991). The alpine marmot *(Marmota marmota)* population has doubled (increasing by 60-70 thousand individuals) and the population growth of colonies of European bobak in Russia and Ukraine is estimated at about 350 thousand individuals (Fig. 3). Overall, however, population trends represent a net loss. The Eurasian marmot population decreased by 35 million individuals over the last century under the influence of anthropogenic factors. Steppe species (tarbagan and bobak) can be considered evolutionarily most successful. At the beginning of the twentieth century, their total numbers exceeded 45 million and accounted for 94% of Eurasian marmots. The same species was less protected from humans than other species and their populations suffered the greatest declines Today, the overall Eurasian marmots population slightly exceed 12.5 million, of which 81% are tarbagan and bobak (Fig. 4). Most Eurasian marmots live in Mongolia (Fig. 5). We need develop strategies for protecting marmots and their habitat to conserve this "TERRA MARMOTA" for our descendants.

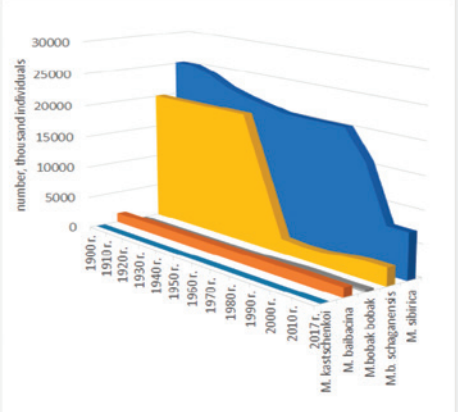

Fig. 2. Population trends for the "steppe" marmots of Eurasia

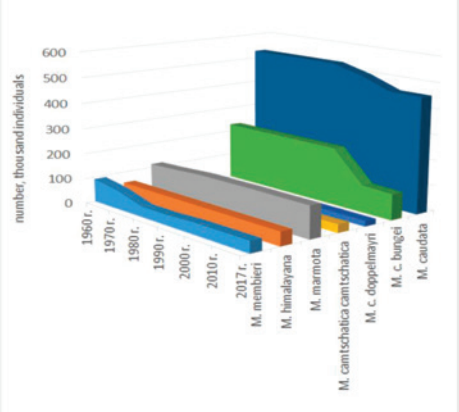

Fig. 3. Population trends for the "mountain" marmots of Eurasia.

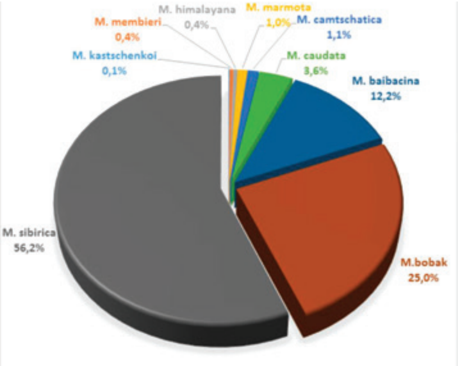

Fig. 4. The relative abundance of different species of Eurasian marmots.

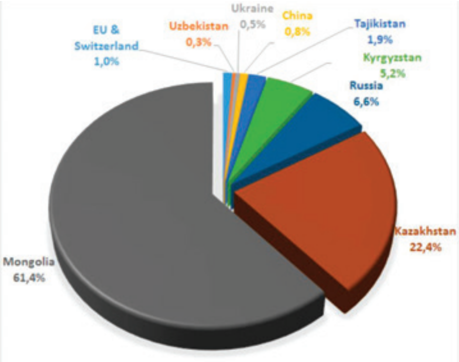

Fig. 5. The relative abudance of marmots in different countries of Eurasia.

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THE EFFICACY OF MARMOT BROWN FAT IN TREATMENT OF ACUTE PANCREATITIS

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Introduction

Acute pancreatitis (AP) is an acute inflammation of the pancreas characterized by swelling and at times even destruction of pancreatic tissue. The most common causes of AP are gallstones and excessive alcohol consumption. Other causes include medication, abdominal trauma, infections, and genetic abnormalities of the pancreas [1]. The retroperitoneal space location of the pancreas makes biopsy, detecting histopathological structure and dysfunction, and controlling action of medication difficult in the clinical practice. Therefore, animal-based experimental study is useful to medical science in this case.

Mongolian statistical data from 2005 to 2009 showed pancreatitis and other related diseases increased 1.7-fold during these 5 years. 41.4% of pancreatitis patients were treated in Ulaanbaatar city [2]. Normal treatment of AP uses scientific medications, which follow treatment guidelines [3]. However, for many years Mongolian people have been using marmot brown fat (MBF) for treatment of pancreatitis. The Mongolian people called it “human meat” because they abstain from eating it.

The marmot *(Marmota sibirica)* is a species of the rodent in the family Sciuridae. It is found in China (Inner Mongolia), northern and western Mongolia, and Russia. By our hypothesis the “human meat” of the marmot might have been first noted by a small religious sect of Tibetan medicine. A Russian study based on questionnaires and interviews showed that all organs of marmots are used for treatment of some disease [4]. No previous scientific results describing an association between MBF and pancreatitis were found in the literature. Therefore in this animal-based experimental study we aimed to the determine effect of MBF on caerulein-induced AP.

Materials and Methods

The experiment was conducted with 82 female Wistar rats weighing 250-280 g. They were maintained in a room at a controlled temperature of 22 ±2ºC with 12-hour light/dark cycles and fed an *ad libitum* diet. This study was conducted in accordance with the “Ethics of Biomedical Study Guidelines for Animal-Based Experiment” of the Mongolian Ministry of Health. The MBF was taken from the subclavian of the marmot for the purpose of treating AP of rats under a license of slaughter from the Mongolian Ministry of Nature, Environment, and Green Development.

1. Caerulein -induced AP

AP was induced by tail vein injection of caerulein (5 µg/kg, Sigma Aldrich, USA) four times at one-hour intervals [5]. Mild AP was confirmed 12 hours after the last dose of caerulein by the serum α-amylase level (SAAL) and a histological evaluation of the pancreas [6]. During the experiment, the rats were fed a liquid diet since standard food might have induced some signs of pancreatitis or influenced biochemical results.

2. Treatment of AP

A suspension of MBF was prepared so that rats could be fed by catheter, so as to avoid digestion in the mouth of the rats. To prepare the MBF suspension, first the extracted brown fat was transported at -20 ºC in a dedicated icebox. Next, connecting tissue and capsules were removed from the ground MBF preparation . Then, 20 mL distilled water were added to the remaining parts. This MBF solution was administered one time daily over three days. The daily dose was 2 mL per day.

For rats treated with a Sandostatin dose, 4 µg/kg of Sandostatin (0.05 mg/ml, Octreotide, Novartis Pharma, Switzerland) was administered through their tail vein. The tail vein injection method was in accordance with the "Institutional Animal Care and Use Committee, IACUC" protocol [7]. The Sandostatin was administered one time daily over three days as 0.3 mL of solution made from 0.1mL of Sandostatin and 10 mL of 0.9% saline.

3. Experimental protocols

The caerulein-induced AP model consisted of four groups in this study. Group 1 was 10 control rats. Group 2, 3, and 4 were caerulein-induced AP groups with 24 rats each. Group 3 was treated with the suspension of MBF by catheter and group 4 was treated with a Sandostatin injection through their tail vein 12 hours after the last dose of caerulein. Group 2 did not have any treatment. The experimental study was continued for 12 days.

4. Biochemical analysis

Cardiac puncture in accordance with "Guidelines for Collection of Blood Laboratory Animals" was used to collected blood from the rats [6]. Cardiac puncture is the prefered technique for terminal collection of large blood volumes. The SAALs were determined by the Fully Automatic Biochemical Analyzer (FA- 300, Clindiag Systems B.A.B.V, Belgium).

5. Histological examination

Preparation of histological slides consisted of fixing, processing, embedding, sectioning and staining. First, tissues were fixed and dehydrated with 10% formaldehyde for 48 hours. Second, the tissue was placed in warm paraffin wax which filled the spaces that had water in them. Tissue-Tek VIP 5 Jr. (Sakura LLC, Japan) was used to deyhrate the tissue. Third, the tissue was trimmed and mounted for cutting by a LEICA, DSC 2 microtome (Leica Biosystems, USA). Thin sections were cut for subsequent staining and mounting on microscope slides. Fourth, the tissue was stained by hematoxylin and eosin. Fifth, slides were viewed with a light microscope (Olympus, USA) and photos were captured by an MU 500 5.1MP camera (AmScope, USA).

6. Statistical analysis

Data are presented as the mean and standard deviation (SD). Comparative results between Group 1 with other groups were tested using a Student's t-test. The data analysis was performed using SPSS (version 18.0). A p-value of 0.05 was considered statistically significant.

Results

1. Serum α-amylase level with AP

The injection through the tail vain protocol of caerulein (0.4 mL/hour) for Groups 2, 3 and 4 was completed four times at one-hour intervals to induce AP in the rats. Mild AP was confirmed by SAAL results and pancreatic histology evaluation. SAAL was significantly ($p < 0.02$) increased in Group 2 rats compared to Group 1. SAAL was 1347.10 ±10.76 units (U)/L in Group 1 and 1804.50 ±134.32 U/L in Group 2 twelve hours after the last dose of caerulein. After AP was confirmed, the treatment was initiated.

SAAL was 2005.73 ±110.69 U/L in Group 2, 2352.45 ±15.36 U/L in Group 3, and 1953.77 ±96.04 U/L in Group 4 on the third day of experiment. The fifth day, the health condition of rats in Group 3 was poor as their movement was slower than other days. They had decreased appetite and some died because of breathing difficulties and heart dysfunction. During the cardiac puncture the blood viscosity of Group 3 was higher than normal and the blood color was like bistre. The macrostructure of the pancreas was indistinguishable from fatty tissue, and additionally hydrothorax, cardiac hypertrophy, and pneumonia were detected. The health condition of rats in Group 4 was mild, but from the fifth day, experimental treatments were stopped. For Group 2, on the fifth day of the experiment, SAAL was decreased (1787.17 ±74.25 U/L) when compared to the third day of the experiment (1804.50 ±134.32 U/L) ($p > 0.05$), but the change was not significant. In contrast, SAAL was statistically lower in Group 3 (591.15 ±88.61 U/L, $p < 0.001$) and Group 4 (983.40 ±27.16 U/L, $p < 0.001$) between the fifth and third day of experiment (Figure 1).

2. Histological Evaluation of Pancreatic Damage

The observed change in our study resembles a mild form of AP, characterized by acinar cell adhesion caused by apical pole enzyme secretion of acinar cells (Figure 2A). The ducts lumen was empty between acini (Figure 2B) and the veins were engorged (Figure 2C).

The histological evaluation of the pancreas was completed for three rats from each group (2, 3, and 4) on the third day of the experiment. Dilated acinar cells pressed on the peripheral vessels and intermediate tissue were filled with enzyme in Group 2 (Figure 3C). The acinar cells were filled with enzymes, and ducts of the pancreas were invisible since they were narrowed in Group 3 (Figure 3A). Additionally, intermediate fluid accumulation (edema) was observed with peripheral vascular stenosis (Figure 3A). In Group 4, the pancreatic exocrine cells were filled with enzymes, and intermediate tissue edema was lower compared with Group 3 (Figure 3B). The peripheral vascular circulation was normal (Figure 3B).

On the fifth day of the experiment, the health condition of rats in Group 3 was poor. Maladjustment and inactivity were observed and three rats died. Therefore, blood was collected and the pancreas was examined histologically. The histological examination of the pancreas in Group 3 rats showed that: (1) the acinar cell configuration was changed to be located near the vessels and the cell nucleus was pressed as a result of edema (Figure 4A), (2) the acinar cell configuration was changed and the intermediate fluid accumulation (edema) was increased (Figure 4B), (3) the histological change was similar with (1) and (2) and additionally microvascular strokes were observed (Figure 4C).

Due to the rats' health condition and the pancreas histological results, treatments were stopped after the fifth day of the experiment. Also, inflammation of the lungs, infiltration of the spleen and sticky pancreas tissue was observed. After stopping treatment six rats were selected from each group on the sixth day for histological examination. The acinar cell shape change was revived and vascular dilatation was observed in Group 3.

Discussion

Our study is the first study to use a MBF suspension in rats with AP. Although Mongolian people have been using MBF suspension for treatment of pancreatitis (acute or chronic pancreatitis is not clear) for many years, there have been no scientifically-based results confirming its efficacy. Therefore, the main purpose of our basic study was to determine the efficacy of MBF suspension on treating pancreatitis. These study results might be a source of a novel medication for pancreatitis in the future but not AP.

In this study, we confirmed AP using SAAL. Matull et al.[8] showed that amylase level is one of the biochemical markers of AP and is the most commonly used in the clinical practice to confirm AP. Caerulein was effective at inducing mild AP as confirmed by the SAAL in the rats. SAAL was not significantly different in Group 2 between the third (2005.73 ±110.69 U/L) and fifth (1787.17 ±74.25 U/L) days of the experiment. In both treatment groups, SAAL was significantly decreased on the fifth day of the experiment. In Group 4, acinar cell damage was relatively lower than Group 3. The lower damage of acinar cell might be related to the Sandostatin (octreotide) having beneficial effect in the treatment of severe AP [9]. Interestingly, the pancreatic cell advanced damage (microvascular strokes, intermediate fluid accumulation, acinar cell configuration and autolysis) was observed in Group 3. Additionally, the health condition of Group 3 rats was poor and spleen and lung tissue damage was detected by histological examination. Secretion of pro-inflammatory mediators such as interleukin 1 (IL), tumor necrosis factor-α, and IL-6 can lead to pancreatic cell necrosis and cell death [10-12].

Regarding results related to MBF, Purevdorj et al.[13] determined the chemical composition of MBF. The study results showed linoleic acid at 33.11% in MBF and are different from lamb and infants [13]. Furthermore Dugarsuren and Dagdanbazar [14] and Nyamdorj et al.[15] found lymphoid cells in MBF. The researchers suggested that MBF might have an immune activity function [14, 15].

Our study has important implications for the traditional use of MBF to treat pancreatitis in people and is the first to use a scientific approach to test the effect of a MBF suspension as a treatment for caerulein-induced AP in rats. There were limitations to our study. Our marmot sample size was related to the license of slaughter issued by the Ministery of Nature, Environment, and Green Development of Mongolia.

In conclusion, our study results suggest that the MBF suspension might stimulate pancreatic juice secretion. Therefore, the suspension is not beneficial in the treatment of AP. Future medical studies should clarify the correct MBF suspension dose and its effects on chronic pancreatitis.

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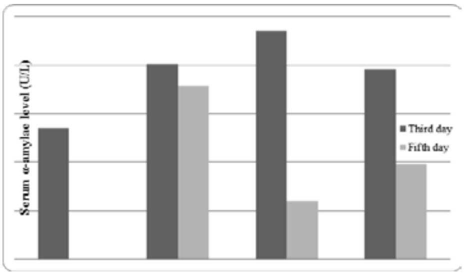

Figure 1. *The serum α-amylase levels on the third and fifth day of experiment.*

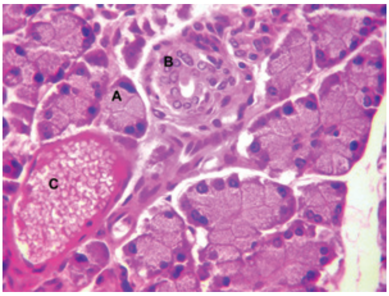

Figure 2. *Pancreatic microstructure of a section with AP stained by hematoxylin and eosin at 400x magnification. Observed is: (A) acinar cell adhesion by apical pole, (B) empty duct between acinus, and (C) engorged veins between acinus.*

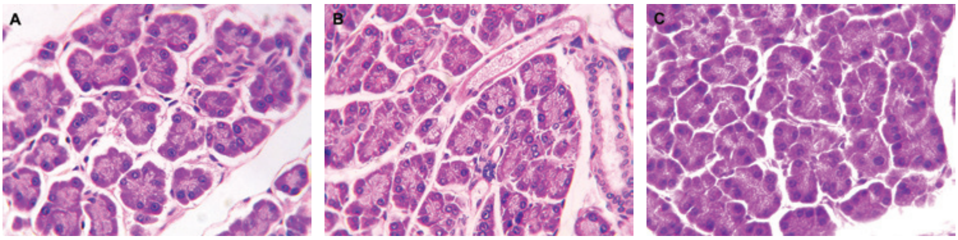

Figure 3. *Pancreatic microstructure on the third day of the experiment for a section stained by hematoxylin and eosin at 400x magnification. Observed is: (A) pressed nucleus and edema in group 3, (B) lower edema and normal microvascular structure in group 4, (C) acinar cells filled with enzymes leading to pressed vessels and intermediate tissue in group.*

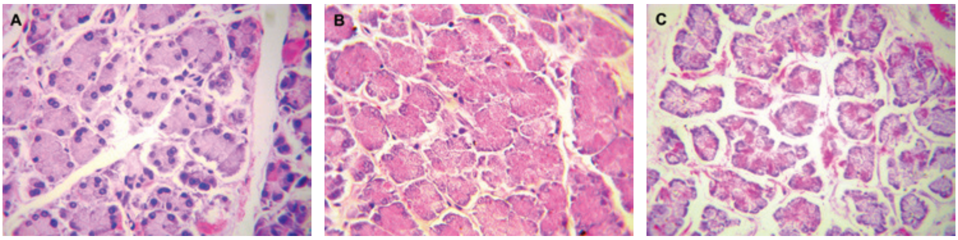

Figure 4. *Pancreatic microstructure on the fifth day of the experiment for group 3 for sections stained by hematoxylin and eosin at 400x magnification.*

VEGETATION ON MARMOT MOUNDS IN THE STEPPES OF CENTRAL MONGOLIA

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The authors aim to show the influence of Mongolian marmot (Marmota sibirica)'s activity on surrounding vegetation. Observed plant structure on marmot mounds and the process of succession is considered in this paper.

Key words: Mongolian marmot, mound, vegetation, succession.

Introduction

The impact of mammalian burrowing activity on the ecosystems of different landscapes has long attracted the attention of researchers. Rodents and hares have considerable impact on biogeocenosis in arid zones (Formozov, 1929; Bannikov, 1954; Kojemyakin, 1978; Sokolov,& Orlov, 1980; Allen, 1938, 1940; Stubbe,& Chotolchu, 1968; Dmitriev & Guricheva, 1978; Avirmed, 1989; Dmitriev, 1991). Among the rodents of steppe landscapes with a strong influence on biogeocenosis, marmots are especially prominent as generations of marmots will live for decades or even centuries in the same colony in the same place(Bibikov, 1967, 1989; Dinesman, 1968; Dmitriev, 2006). They actively participate in the formation of the microrelief, the soil-forming process, and they influence the growth and diversity of vegetation in the area around the colony (Krupennikov, Stepanitskay, 1943; Zubkova, 1967; Zimina, Zlotin, 1980; Dinesman, Kisileva, Knyazev, 1989; and others).

We characterized the vegetation on the burrow mounds of Mongolian marmots (*Marmota sibirica* Radde, 1862) in the *Stipa spp.* steppe of Central Mongolia. Prior to our research, the vegetation of the marmot burrows in Mongolia has only been studied in the East Khangai (Guricheva & Dmitriev, 1997).

Materials and methods

Study area. The study was conducted at Hustai National Park, located 100 km west of Ulaanbaatar, Mongolia (47˚50´N, 106˚00´E). Hustai National Park is situated in the forest steppe region of Mongolia and occupies 50600 ha at elevations ranging from 1190 to 1800 m above sea level. About 88% the area is covered by grassland and shrubland steppe and 5% is covered by birch dominated forest. In the park, there are 44 species of mammals (Todgerel, 2002) including Przewalski's horse *(Equus ferus przewalskii)*, red deer *(Cervus elaphus)*, roe deer *(Capreolus capreolus)*, wild boar *(Sus scrofa)*, argali sheep *(Ovis ammon)*, Mongolian gazelle *(Otocolobus manul)*, grey wolf *(Canis lupus)*, manul *(Otocolobus manul)*, Eurasian lynx *(Lynx lynx)*, and Mongolian marmot. The Mongolian marmot's range covers 12873 ha (25.7%) of the park (Todgerel, 1999).Marmot density in the park was 1.16 marmots per ha in areas were they occurred. In the central and best protected area of the park the density was higher, withwith 3.85 marmots per ha.

Material. In May, June, and July in 1999, 2000 and 2001, all present plant species and vegetation cover types were recorded for the mounds of 696 summer and shelter burrows and also 305 1m^2 plots located near the marmot mounds in the feather grass-pea shrub community *(Caragana microphylla + Caragana pygmaea + Stipa Krylovii + Koeleria macrantha + Agropyron cristatum + Cliestogenes squarrosa + Artemisia frigida)*. Geobotanical descriptions were developed following Shennikov (1964) and Martin and Coker (1992).

Statistical analyses. TWINSPAN ("Two Way INdicator SPecies ANalysis" /TWINSPAN/ [Jongman, Ter Braak, Van Tongeren, 1995]) was used to classify vegetation community types and stages of succession on the marmot mounds. For the classification of community types, the program constructed an ordered two-way table displaying site-by-species. Community classifications were defined by 4 indicator species, 3 division levels, and default cut levels of 0, 5, 10, 20, and 40. Each species cover percentage was replaced by a 1-5 score. 1=0-4%, 2=5-9%, 3=10-19%, 4=20-39%, and 5=40-49%. For the construction of species-by-sites tables, two additional features were necessary. First, the dichotomies were ordered, and second, the species were classified. The order of the site groups was determined by comparison of the two site groups formed at any level with site groups at two higher hierarchical levels.

Differences were considered significant at $p<0.05$ with the statistical package SPSS 11 for Windows.

Results

Species composition on the mounds. A total of 61 species from 46 genera in 24 families were documented on the marmot mounds. The most numerous families were *Poaceae* (8 species), *Asteraceae* (7), *Rosaceae* (7), *Fabaceae* (6), *Chenopodiaceae* (5), *Scrophulariaceae* (4), *Brassicaceae* (3), *Ranunculaceae* (2), *Liliaceae* (2), *Cyperaceae* (2), and *Apiaceae* (2). Families with one species represented were: *Caryophyllaceae, Crassulaceae, Lamaiaceae, Polygonaceae, Polemoniaceae, Convolvulaceae, Ephedraceae, Iridaceae, Plumbaginaceae, Rutaceae, Thymelaeaceae, Urticaceae.* Of the species observed, 42 were perennial grasses, 11 were annual grasses, 5 were semi shrubs, and 3 were shrubs. Vegetation on the mound included 15 caespitose species, 18 rhizomatous species and 33 stoloniferous species.

Vegetation community types on the mounds. Vegetation on the marmot mounds was divided into two main communities: *Stipa krylovii +Agropyron cristatum;* and *Artemisia adamsii+Leymus chinensis.* Each community was further divided into four sub-community types.

Community of *Artemisia adamsii +Leymus chinensis.* A total of 54 species were documented in this community, which occurred on 46% (n=319) of marmot mounds (Table 1). This community was dominated by the rhizomatous species *Artemisia adamsii, Leymus chinensis,* and *Carex duriuscula* and the salt annual *Salsola collina*. These species are present mostly in salt soil and degraded pasture. *Artemisia adamsii* and *Leymus chinensis* frequency was 35-40% more and cover was 27% more than the same species in the *Stipa krylovii+Agropyron cristatum* community. The caespitose species *Stipa krylovii* was present on all mounds, but its cover percentage was less in the *Artemisia adamsii+Leymus chinensis* community than in the *Stipa krylovii+Agropyron cristatum* community and

Stipa klemenzii was not present in the former. Other caespitose species such as *Koeleria macrantha, Cleistogenes squarrosa,* and *Poa attenuata* occurred but were not abundant.

Of the shrubs, *Caragana pygmaea* was documented in 13% and *C.microphylla* in 3% of this community.

Of the semishrubs, the frequency of *Artemisia frigida* was 50% lower in the *Artemisia adamsii+Leymus chinensis* community than in the *Stipa krylovii+Agropyron cristatum* community.

Some herbs such as *Potentilla bifurca, Heteropappus hispidus,* and *Potentilla acaulis* and some annuals such as *Cheneopodium album, Ch.aristatum, Ch.acuminatum* were abundant.

The classification identified four sub-community types.

Type 1. *Salsola collina+Artemisia Adamsii+Leymus chinensis* community type.

A total of 22 species were documented on ten mounds. One species had 100% frequency of occurrence, two species had 80% frequency of occurrence, one had 50% occurrence, four had 40% occurrence, two had 30%, two had 20%, and ten had 10% frequency of occurrence. This type dominated by *Salsola collina* with co-dominant *Artemisia adamsii, Carex duriuscula, Leymus chinensis* and *Ptilotrichum canescens. Potentilla acaulis, Chenopodium aristatum* and *Ptilotrichum canescens* were also abundant .

Type 2. *Artemisia adamsii + Leymus chinenisis +Salsola collina* community type.

A total of 52 species were documented on 203 mounds. 41 species had frequencies of 0-20% and 11 species had frequencies of 21-90%. This type dominated by the rhizomatous species *Artemisia adamsii,* which had a frequency of 90% and was dominant on 62% of all mounds with 10-60% cover. Co-dominant *Leymus chinensis* was dominant on 19% of all mounds with 10-35% cover. Some species, such as the caespitose species *Stipa krylovii, Cleistogenes squarrosa,* and *Agropyron cristatum,* the shrub *Potentilla bifurca* and the annual species *Chenopodium album* and *Salsola collina* were dominant on a few mounds.

Type 3. *Carex duriuscula + Leymus chinensis +Artemisia Adamsii* community type.

A total of 29 species were documented on 40 mounds. 25 species had frequencies of 0-20% and 4 species had frequencies of 71-100%. This type was dominated by *Carex duriuscula, Artemisia adamsii,* and *Leymus chinensis. Carex duriuscula* was present on all mounds (92.5%) and dominant on 67% of mounds of this type with 10-50% cover. *Artemisia adamsii* was dominant on 15% of this type with 10-20% cover. *Leymus chinensis* was dominant with 5-30% cover on 40% of all mounds in this type. Besides the dominant species mentioned above, *Potentilla bifurca, P.acaulis* and *Stipa krylovii* were also dominant on a few mounds.

Type 4. *Leymus chinensis+Artemisia Adamsii+Carex duriuscula + Cymbaria dahurica +Artemisia frigida* community type.

A total of 40 species were documented on 66 mounds. 31 species had frequencies of 0-20% and nine species had frequencies of 21-100%. This type was dominated by the rhizomatous grass *Leymus chinensis,* which was present on all mounds (100%) of this type and which dominated with 5-40% cover on 95% of all mounds. *Artemisia adamsii* (48%)

and *Carex duriuscula* (36%) were abundantly present but they were not recorded as dominant (Table 1). Some species such as *Ephedra sinica, Cymbaria dahurica,* and *Artemisia dracanculus* were dominant on one or two mounds. The frequency and cover of *Artemisia adamsii* was lower than in the other three community types.

Table 1. *Synoptic table of Artemisia adamsii+Leymus chinensis community classification*

Community types	1		2		3		4	
Number of mounds	10		203		40		66	
Percent of mounds	1,43%		29,17%		5,7%		9,48%	
Species number in one mound	7±3		7±3		5±2		6±2	
Cover (%)	39,44±8,31		32±14,18		36,31±15,54		29,54±14,35	
Species number in the type	22		52		29		40	
	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency
Grasses								
Koeleria macrantha			1,10	4,93	1,50	20,00	1,00	21,21
Poa attenuata			1,00		3,00	2,50	1,25	6,06
Stipa lrylovii	1,12	80,00	1,39	77,83	1,96	72,50	1,11	78,79
Agropyron cristatum	1,00	20,00	1,28	18,72	1,67	7,50	1,00	19,70
Stipa sibirica			1,00	0,49				
Cleistogenes squarrosa	1,00	30,00	1,18	26,60	1,00	5,00	1,00	7,58
Leymus chinensis	1,50	40,00	1,61	76,85	2,26	85,00	3,30	100,00
Herbs								
Allium bidentatum			1,00	5,91			1,00	1,52
Iris tigrida			1,00	0,99			1,00	1,52
Amblinotus rupestris			1,12	3,94	1,00	5,00		
Convolvulus ammani							1,00	1,52
Orostachys spinosa			1,00	0,99				
Astragalus brevifolius			1,00	1,00			1,00	6,06
Sibbaldianthe adpressa							1,00	3,03
Bupleurum scorzonerifolium			1,00	0,49				
Cymbaria dahurica			1,04	23,15	1,33	7,50	1,12	36,36
Pulsatilla bungeana			1,00	0,99			1,00	1,52
Veronica incana			1,00	1,48				
Potentilla acaulis	1,00	40,00	1,17	11,33	1,75	10,00	1,00	6,06
Stellera chamaejasme			1,50	2,96	1,00	5,00	1,00	1,52
Dontostemon integrifolius	1,00	10,00	1,00	13,30	1,00	2,50	1,08	18,18
Thalictrum foetidum			1,00	0,49				
Lepidium densiflorum	1,00	10,00	1,52	8,37			1,00	4,55
Allium odorum			1,00	0,99	1,00	5,00		
Hedysarum collinum			1,00	0,99				
Goniolimon speciosum			1,00	1,97	1,50	5,00	1,28	10,61
Potentilla tanansitifolia			1,00	10,84	1,00	7,50	1,00	15,15
Saussurea salicifolia	1,00	10,00	1,00	8,37	1,00	12,50	1,17	9,09
Taraxacum collinum	1,00	10,00	1,00	0,49	1,00	2,50		
Potentilla bifurca	1,00	20,00	1,36	32,51	1,40	25,00	1,14	33,33
Potentilla strigosa	1,00	10,00					1,00	1,52
Asteraecea sp			1,00	3,45	1,00	10,00	1,00	10,61

Artemisia drancanculus					1,00	2,50	1,67	4,55
Phlomis tuberose			1,50	0,99	1,00	2,50	1,50	3,03
Artemisia scoparia			1,00	1,48			1,00	1,52
Rheum undulatum			1,00	0,99			1,00	4,55
Chenopodium album	1,00	10,00	1,46	31,03	1,43	17,50	1,09	16,67
Chenopodiacea sp			1,00	1,48			1,00	1,52
Salsola collina	3,70	100,00	1,13	28,57	1,00	2,50	1,00	10,61
Kochia prostrate			1,00	5,42				
Heteropappus hispidus	1,00	10,00	1,13	22,66	1,50	5,00	1,00	6,06
Urtica cannabiana			1,00	0,54				
Chenopodium aristatum	1,00	10,00	1,10	4,93				
Alliacea sp			1,00	0,49				
Lappula myosotis			1,00	0,49				
Chenopodium acuminatum			1,86	7,39			1,00	3,03
Potentlla conferta			1,00	1,48				
Sedge								
Carex duriuscula	1,00	40,00	1,30	44,83	3,19	92,50	1,37	36,36
Shrubs								
Caragana microphylla			1,50	2,96	1,00	2,50	1,00	4,55
Caragana pygmaea			1,21	18,72	1,00	7,50	1,00	16,67
Semishrubs								
Haplophyllum dahuricum			1,00	1,00				
Artemisia frigida	1,00	40,00	1,13	25,62	1,33	7,50	1,09	46,97
Ptilotrichum canescens	1,40	50,00	1,24	18,72	1,00	5,00	1,00	4,55
Ephedra sinica			1,00	1,48			1,80	15,15
Artemisia Adamsii	1,75	80,00	3,25	90,64	1,80	75,00	1,28	48,48
Forbs								
Thermopsis dahurica	1,00	30,00	1,04	10,34	1,50	5,00	1,07	21,21

Community of *Stipa krylovii+Agropyron cristatum.* A total of 59 species were documented in this community, which occurred on 54% (n=377) of all marmot mounds (Table 2). This community was dominated by *Stipa krylovii. Agropyron cristatum, Koeleria macrantha, Poa attenuata* and *Cleistigenes squarrosa* also occurred in this community. *Leymus chinensis* had lower cover and frequency values in this community.

Of the shrubs, *Caragana pygmaea'*s frequency was 63% and *Caragana microphylla'*s frequency was 10%. Some semi-shrubs such as *Ptilotrichum canescens* and *Artemisia frigida* were abundant, while the occurrence of *Artemisia adamsii* was low.

Carex duriuscula's frequency of occurrence was similar to that observed in the degraded pasture community type *(Artemisia adamsii +Leymus chinensis)* but the percent coverage was lower.

Type 5. *Stipa krylovii + Leymus chinensis + Agropyron cristatum + Potentilla bifurca* community type.

A total of 50 species were documented on 112 mounds. 35 species had frequencies of 0-20% and 15 species had frequencies of 21-100%. The frequency of the dominant species, *Stipa krylovii* was 5-50% on half of all mounds. The rhizomatous grass *Leymus* *chinensis* was dominant with 10-30% cover on 24% of Type 5 mounds. Some species such as *Thermopsis dahurica, Poa attenuata, Agropyron cristatum, Potentilla acaulis, Carex duriuscula, Koeleria macrantha, Cymbaria dahurica, Cleistogenes squarrosa* and *Potentilla tanansitifolia* were dominant on a few mounds.

Type 6. *Stipa krylovii + Agropyron cristatum + Potentilla bifurca + Dontostemon integrifolius* community type.

A total of 46 species were documented on 128 mounds. 33 species had frequencies of 0-20% and 13 species had frequencies of 21-100%. This sub-community type was dominated by the caespitose grasses *Stipa krylovii* and *Agropyron cristatum. Cymbaria dahurica* (47%), *Dontostemon integrifolius* (56%) and *Carex duriuscula* (60%) were often abundant and were dominant on a few mounds. *Potentilla bifurca* (52%) was present on about half of all mounds and was dominant on 8% of all mounds with cover values of 5 to40%.

Type 7. *Caragana pygmaea<Stipa krylovii+Agropyron cristatum+Artemisia adamsii* community type.

A total of 41 species were documented on 57 mounds. 29 species had frequencies of 0-20% and 12 species had frequencies of 21-100%. This sub-community type was dominated by *Stipa krylovii*, which had 5 to50% cover on 12 to 40% of mounds, more than the other three community types. Species such as *Lepidium densiflorum, Agropyron cristatum* and *Potentilla tanansitifolia* were dominant on one or two mounds.

Type 8. *Caragana pygmaea<Stipa krylovii+Agropyron cristatum* community type.

A total of 44 species were documented on 80 mounds. 31 species had frequencies of 0-20% and 13 species had frequencies of 21-100%. The caespitose grass *Stipa krylovii* was present on all mounds in all four subcommunity types. The species' cover value was 10-40% and it was the most dominant species in this sub-community type Besides *Stipa krylovii, Poa attenuata, Ptilotrichum canescens, Cymbaria dahurica, Artemisia frigida,* and *Caragana microphylla* were all dominant on a few mounds. *Agropyron cristatum* and *Koeleria macrantha* occurred in 57.5-70% of all mounds of this type. *Poa attenuata* and *Cleistogenes squarrosa* occurred in 25-34% of all mounds. The frequency of the herb *Allium bidentatum* was higher than in the other three community types and the cover value (1.00) was similar to types 7 and 6. *Amblinotus rupestris, Cymbaria dahurica* and *Saussurea salicifolia* were all abundant. In contrast, *Potentilla acualis* (6.25%), *Artemisia drancanculus* (3.75%) and *Potentilla bifurca* (3.75%) were rare and their cover was 20-30% more than other herb species. Indicator species of pasture degradation such as *Carex duriuscula* (18.75%), *Artemisia adamsii* (7.5%), and *Leymus chinensis* (13.75%) occurred on a few mounds. The frequency of *Caragana pygmaea* (61%) was greater than that of *C.microphylla* in this sub-community.

Table 2. *Synoptic table of the Stipa krylovii+Agropyron cristatum community's classification*

Community types	5		6		7		8	
Number of mounds	112		128		57		80	
Percent of mounds	16,09%		18,39%		8,18%		11,49%	
Species number in one mound	9±3		8±3		8±3		9±3	
Cover (%)	37,7±13		25±15		42,5±16,8		33±14,3	
Species number in the type	50		46		41		44	
	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency
Grasses								
Koeleria macrantha	1,23	34,82	1,12	32,81	1,13	26,32	1,28	57,50
Poa attenuate	1,46	25,00	1,11	7,03	1,07	24,56	1,48	33,75
Stipa klimenzii	2,60	2,68	1,00	2,34	1,67	10,53	1,10	23,75
Stipa krylovii	2,60	94,64	2,10	92,97	3,50	98,25	3,19	97,50
Agropyron cristatum	1,26	60,71	1,17	53,91	1,19	63,16	1,23	70,00
Stipa sibirica			3,00	1,56			1,00	1,25
Cleistogenes squarrosa	1,14	37,50	1,00	21,88	1,22	15,79	1,10	25,00
Leymus chinensis	1,99	73,21	1,04	39,84	1,11	15,79	1,81	13,75
Herbs								
Allium bidentatum	1,22	8,04	1,00	5,47	1,00	12,28	1,00	46,25
Iris tigrida	1,00	2,68	1,00	3,13	1,00	8,77	1,00	18,75
Amblinotus rupestris	1,00	13,39	1,00	7,81	1,00	10,53	1,09	42,50
Convolvulus ammani	1,00	1,79	1,00	0,78	1,00	3,51	1,33	3,75
Orostachys spinosa	1,50	1,79	1,00	5,47	1,00	15,79	1,00	15,00
Linaria acutiloba					1,00	1,75		
Astragalus brevifolius	1,00	4,46	1,33	7,03	1,00	8,77	1,00	17,50
Sibbaldianthe adpressa	1,00	4,46	1,00	3,13	1,00	7,02	1,27	13,75
Bupleurum scorzonerifolium					1,00	3,51	1,00	3,75
Arenaria capillaries							1,00	3,75
Cymbaria dahurica	1,28	57,14	1,13	46,88	1,02	59,65	1,24	67,50
Chamaerhodos erecta	1,00	0,89						
Pulsatilla bungeana	1,07	12,50	1,00	3,13	1,00	5,26	1,00	3,75
Veronica incana	1,17	5,36						
Potentilla acaulis	1,30	41,07	1,23	17,19	1,00	5,26	1,80	6,25
Stellera chamaejasme	1,05	17,86	1,00	0,78	1,40	8,77	1,12	10,00
Pedicularis flava	1,00	0,89						
Dontostemon integrifolius	1,13	13,39	1,17	56,25	1,05	35,09	1,00	10,00
Thalictrum foetidum	1,50	5,36	1,00	1,56				
Bupleurum bicaule			1,00	0,78				
Lepidium densiflorum	1,00	4,46	1,25	3,13	1,65	29,82	1,17	15,00
Allium odorum					1,00	3,51	1,00	5,00
Hedysarum collinum	1,00	1,79					1,00	3,75
Goniolimon speciosum	1,12	14,29	1,00	1,56	1,00	1,75	1,00	1,25
Potentilla tanansitifolia	1,20	26,79	1,00	21,09	1,22	15,79	1,00	12,50
Saussurea salicifolia	1,06	28,57	1,00	7,03	1,00	19,30	1,00	28,75
Taraxacum collinum	1,00	3,57	1,00	1,56				

Potentilla bifurca	1,25	42,86	1,37	52,34	1,00	8,77	1,67	3,75
Potentilla strigosa			1,00	3,91				
Asteraecea spp	1,00	3,57	1,35	13,28	1,50	7,02		
Artemisia drancanculus	1,00	2,68	1,00	3,91	1,00	1,75	1,67	3,75
Artemisia scoparia	1,00	0,89						
Rheum undulatum	1,00	1,79						
Chenopodium album	1,08	11,61	1,11	20,31	1,00	8,77	1,00	3,75
Chenopodiacea sp	1,00	0,89						
Salsola collina	1,08	10,71	1,00	5,47	1,00	1,75	1,00	2,50
Kochia prostrata			1,00	1,56	1,00	7,02		
Heteropappus hispidus	1,09	9,82	1,00	1,56	1,00	3,51	1,00	5,00
Chenopodium aristatum	1,00	0,89					1,00	2,50
Lappula myosotis							1,00	1,25
Chenopodium acuminatum			1,00	0,78	1,00	5,26	1,12	10,00
Potentlla conferta			1,00	1,56				
Sedge								
Carex pediformis	1,00	1,79	1,00	0,78	1,00	1,75		
Carex duriuscula	1,83	43,75	1,62	60,16	1,00	42,11	1,00	18,75
Shrubs								
Caragana microphylla	1,00	3,57	1,10	7,81	1,55	15,79	1,36	13,75
Caragana pygmaea	1,00	9,82	1,02	35,94	1,02	66,67	1,04	61,25
Semishrubs								
Haplophyllum dahuricum	2,00	0,89	1,00	0,78			1,00	16,25
Artemisia frigida	1,37	71,43	1,08	50,78	1,17	40,35	1,41	78,75
Ptilotrichum canescens	1,06	28,57	1,25	9,38	1,05	33,33	1,59	40,00
Ephedra sinica	1,00	2,68						
Artemisia adamsii	1,35	17,86	1,44	70,31	2,14	100,00	1,50	7,50
Forbs								
Medicago falcata	1,00	2,68						
Thermopsis dahurica	1,56	22,32	1,00	2,34			1,00	1,25

Succession of vegetation on the mounds. Fig 1 shows the succession of vegetation on the marmot mounds, which is represented by eight stages. Each stage corresponds to a certain community type, which has its own characteristics (Tables 1,2). Of the eight stages of succession of vegetation on the mounds, the second stage was most often encountered. This suggests that the mounds often revert to the beginning stage of succession because the marmots do not allow vegetation to develop normally.

On summer burrows, where the mounds are larger in size, the vegetation develops more or less evenly. Nevertheless, depending on marmot's level of activityand their number, as well as the location of the burrows and the structure of the soil cover, etc. on different burrow mounds, succession proceeds differently.

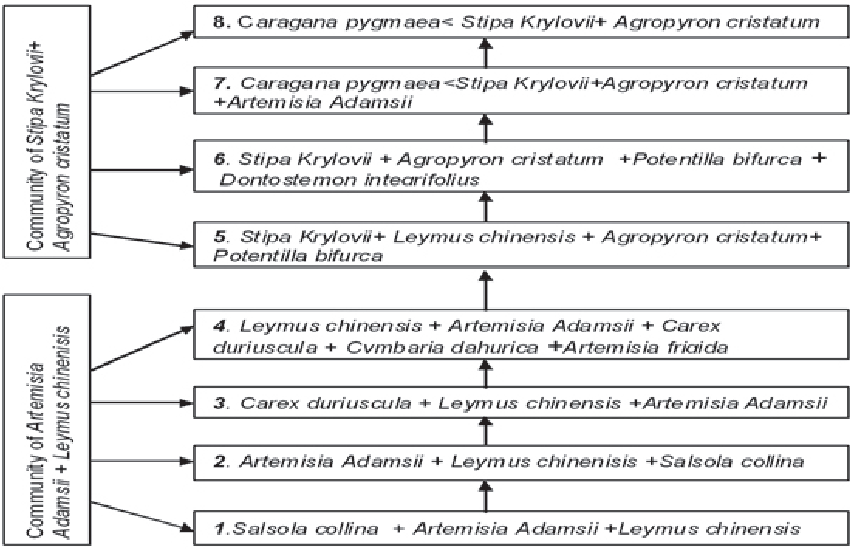

Fig 1. *Vegetation community types at different stages of succession on marmot mounds (Numbers 1-8 indicate the vegetation community types by stage of succession)*

28% of mounds had 1-5 plant species present, 58% had 6-10 species, 12% had 11-15 species, and 2% had 16-20 species present, including eight community types. Over progressive stages of succession, the average number of species gradually increased. At the final stages, where *S. krylovii* dominated, the number of species reached 16-20 (Table 3).

Table 3. *Classification of species number on the mounds of community types*

Community type	1*	2*	3*	4*	5*	6*	7*	8*
Number of mounds	n=10	n=203	n=40	n=66	n=112	n=128	n=57	n=80
Mounds with 1-5 species	n=3 30%	n= 80 39%	n=26 64%	n=23 35%	n=15 13%	n=17 13%	8/ 15%	9/ 11%
Mounds with 6-10 species	n=6 60%	n=105 52%	n=14 36%	n=41 62%	n=68 61%	n=91 71%	n=38 66%	n=43 54%
Mounds with 11-15 species	n=1 10%	n=16 8%	0	n=2 3%	n=27 24%	n=19 15%	n=8 15%	n=19 24%
Mounds with 16-20 species	0	n=2 1%	0	0	n=2 2%	n=1 1%	n=2 4%	n=9 11%

* – number of community type table 1, 2 and fig 1.

As succession at a mound progressed, changes in the structure of the vegetation occurred. At a certain stage of succession, the vegetation shifted from an *Artemisia adamsii+Leymus chinensis* community to a *Stipa krylovii+Agropyron cristatum* community.

Frequency and cover of the caespitose grasses and shrubs increased and frequencies and cover of rhizomatous species *(Artemisia Aaamsii, Leymus chinensis, Carex duriuscula)* decreased during the shift from a degraded pasture community *(Artemisia Adamsii+-Leymus chinensis)* to a steppe community *(Stipa Krylovii+Agropyron cristatum)* (Figs 2, 3).

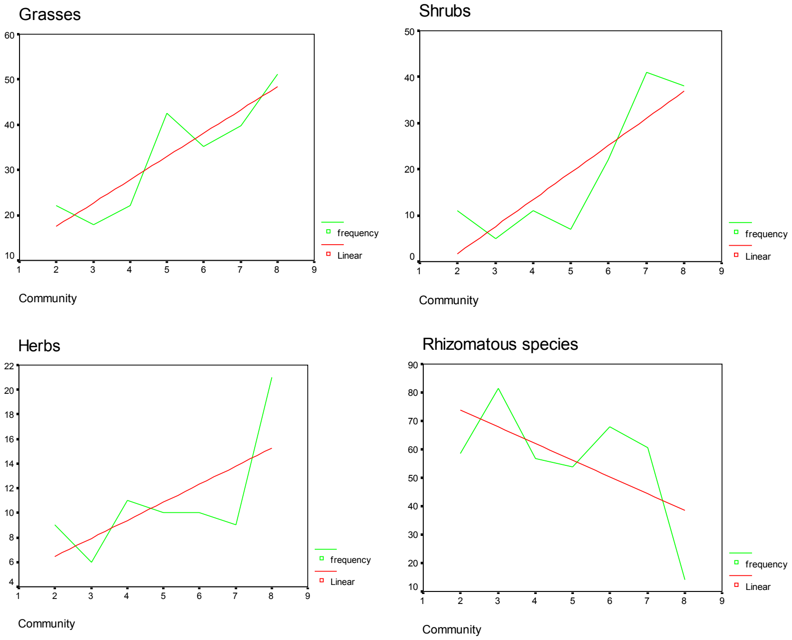

Fig 2. *Frequencies of grasses, shrubs, herbs and rhizomatous species of the community types on the mounds*

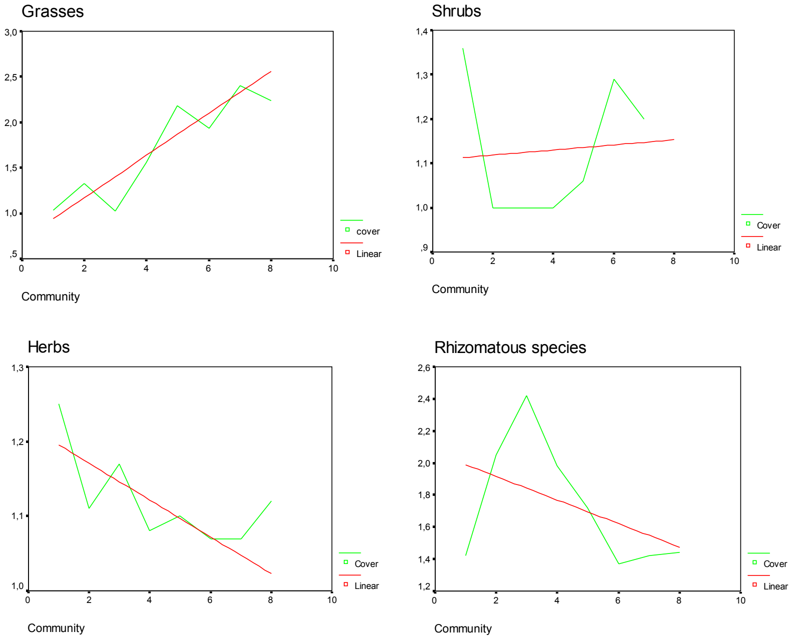

Fig 3. *Cover of grasses, shrubs, herbs, and rhizomatous species of the community types on the mounds*

Although the frequency and cover values for *Leymus chinensis* decreased as succession progressed, the species still had greater frequency and cover than other caespitose grasses This is may be because the mounds were still in use by marmots.

All grasses, herbs, and shrubs did not have significant differences in occurrence by subcommunity type. Only rhizomatous species had significant differences in frequency (p=0.04, p<0.05) and then only between community types 2 and 8.

The higher cover value of *Stipa krylovii* in all community types compared to other grasses, including *Agropyron cristatum, Cleistogenes squarrosa, Koeleria macrantha, Leymus chinensis,* and *Poa attenuata* was statistically significant.

The frequency of three species and the cover of 13 species were significantly different between the marmot mounds and the plots without mounds. The higher frequency and cover of the rhizomatous species *Artemisia adamsii* on marmot mounds compared to plots without marmot mounds was significant (p=0.013) (Table 4, 5).

Table 4. *Means of species frequency on mounds and plots without mounds*

Species name	Means		Statistical significance (P<0.05)
	Mounds	Plots without mounds	
Artemisia adamsii	59.7	30.78	0.013
Artemisia frigida	50.12	83.99	0.003
Allium bidentatum	11.32	54.54	0.024

Table 5. *Means of species cover on mounds and plots without mounds*

Species name	Means		Statistical significance (P<0.05)
	Mounds	Plots without mound	
Artemisia adamsii	6,09	1,71	0,000
Leymus chinensis	5,78	2,79	0,000
Agropyron cristatum	2,33	1,39	0,02
Potentilla bifurca	2,09	0,8	0,000
Chenopodium album	1,69	0,23	0,000
Potentilla acualis	1,42	0,61	0,003
Dontostemon integrifolius	1,27	0,66	0,000
Caragana pygmaea	0,85	0,29	0,000
Potentilla tanansitifolia	0,99	0,65	0,034
Stipa krylovii	9,51	14,03	0,000
Artemisia frigida	1,82	3,34	0,000
Cleistogenes squarrosa	0,84	1,26	0,036
Allium bidentatum	0,53	1,19	0,000

Discussion and conclusions

Avirmed (1989) studied the effects of Brandt's vole *(Lasiopodomus brandtii)* on changes in vegetation cover and defined succession by species composition, abundance, cover, and sequences of change in dominant species. Successive communities were: 1). *Artemisia frigid* + *Carex duriuscula,* 2). *Chenopodium album* + *Salsola collina,* 3). *Artemisia adamsii,* and 4). grasses and herbs present in recovering empty colonies.

Chognii (1971) studied the effects of Brandt's voles on communities of *Koeleria macrantha -Agropyron cristatum* and defined four community types: 1). *Leymus chinensis* + *Salsola collina,* 2). *Salsola collina,* 3). *Artemisia adamsii,* and 4). *Leymus chinensis*

The marmot mounds were dominated by the ceaspitose species *Stipa krylovii, Agropyron cristatum,* rhizomatous species such as *Leymus chinensis, Artemisia adamsii,* and *Carex duriuscula;* and annual species including *Dontostemon integrifolius* and *Salsola collina*. The rhizomatous species were not dominant in the steppe zone (Davaajamts, 1980). Under light or moderate grazing the caespitose species *Stipa krylovii* is the dominant grass species. When grazing pressure increases rhizomatous species become dominant (Bayasgalan, 2002; Chognii, 2002, Avirmed, 1989). In this way the four sub-community types of the *Artemisia adamsiii* + *Leymus chinensis* community identified by TWINSPAN analysis were similar to the vegetation in areas with a heavy Brandt's vole presence or areas overgrazed by livestock. The stage of vegetation succession on marmot mounds was different than the vegetative community of the surrounding area. When a mound is created by burrowing marmots, it is initially covered by bare soil. This can be easily colonized by *Artemisia adamsii*, a common perennial steppe forb. It produces many, easily dispersed seeds, that establish well on degraded vegetation, bare soil, and around burrows. *Leymus chinensis* shows a fast lateral spread by forming rhizomes. *Stipa spp.,* however, are caespitose grass species much slower lateral spread.

Mongolian marmots, living in the same places for many years, can have a significant impact on the structure of local vegetation. The vegetation of the mounds is unique and is determined by the peculiarity of the structure and use of burrows, as well as the burrowing activity of the marmots. The vegetation of the mounds differs from nearby communities in the ratio and composition of species present.

A comparative analysis of vegetation on mounds and surrounding areas has shown that relatively independent patterns of succession occur on burrows in association of the temporal dynamics of burrow usage.

At the end of succession, there is no similarity between mound vegetation and the surrounding biocenoses. Thus, the burrowing activity of the marmots causes significant and irreversible changes to the environmental conditions around the mounds. Marmots, together with other species of mammals, are clearly actively involved in the formation and development of vegetative communities in the arid territories of Mongolia.

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THE CHANGE OF COLONY DENSITY AND POPULATION SIZE OF STEPPE MARMOTS IN THE REGIONAL LANDSCAPE PARK"VELYKOBURLUTSKIY STEP" TERRITORY

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Substantial changes in land use, foremost the decrease in livestock grazing and the accompanying decrease in suitable marmot habitat has taken place across the range of European subspecies of steppe marmot . From 2005 to 2016, the number of cattle has decreased by a third and the number of steppe marmot by half. If the number of cattle and horses remain at their current population size, we predict a further sharp decline in marmot populations both in Russia and in Ukraine. An increase in agriculture, and particularly livestock, would result in the marmot population expanding its range to its former extent. Grazing large ungulates adjacent to gullies and ravines typical of those used by marmot colonies, create critical habitats for many species of herbivores of the steppe, including marmots.

Key words: steppe marmot, population, number, history, *abundance, state of populations*.

Introduction

The Regional landscape park "Velykoburlutskiy Step" was organized following the decision of Kharkiv regional council on June 27, 2000. The area of the park is 2042.6 hectares. The aim of the organization of the Regional landscape park "Velykoburlutskiy Step" is to preserve the steppe landscapes of Eastern Europe in their natural state, to provide multifaceted scientific research, to protect and rationally use natural resources, to ensure biological diversity rehabilitation, and to provide conditions for organized recovery(?) of edemic species populations. In 1929 this territory was planned to become a part of the Great Eastern Steppe Reserve (32,740 hectares), which was one of 12 sites involved in the first long-term plan of organization of new state reserves of Ukraine. The park is located in Velykoburlutskiy district, which is in the northeast of the Kharkiv region. Maximum elevations in the area reaches 230 - 239 m.

The predominant inclination of the surface is from north to south. The area is located on the southwestern slope of the Central Russian Upland. Geologically it is divided into two subareas, the Burluk plateau to the northwest and the Pryoskolske plateau to the southeast. They are broken up by river valleys, arroyos, and gullies. Among mineral resources there is raw material for building material production (chalk, loams, clay, sand). The main rivers of the district are Velykyi Burluk, Gnylytsia, and Plotva.

Agricultural land in the area covers 101.2 thousand hectares, of which 81.8 thousand hectares are cropland land and 18.8 thousand hectares are pastures and hayfields. There are 15 collective agricultural enterprises and four state farms (1995) in the area. The main specializations of agriculture in the area are grain cultivation, beetroot cultivation, and stock raising.

The river Velykyi Burluk is the confluent of the Siverskiy Donets River. It divides the Burluk Plateau in the north-east of Kharkiv Region. The width of the river valley varies from 0.5 to 3 km. The meadow terrace is well developed. The slopes are cut by gullies and arroyos. From the early 70's through the early 80's the river was reclaimed and turned into a canal.

Despite the fact that wide-open spaces prevail in the Velykoburlutskiy district, regional biotopes are quite diverse. In the low-lying steppe and meadow areas marshes and fens with overgrown shores occur frequently. Some of the gullies, where there is enough moisture, are covered with gully forests. Therefore, all biotopes characteristic of the forest-steppe of Ukraine can be found there. More open biotopes are the most common with motley grass – fescue – feather grass steppes (grasslands) and dry and floodplain meadows.

From a landscape perspective, the area of the park is a typical of the regions, with a system of arroyos that lead to an elevated plateau. The park is located in the steppe zone according to the geological and botanical zonation of Ukraine.

The modern conserved territory of the park consists of three parts: the gully forests near Nesterivka village, the steppe between Nesterivka and Zelenyi Gai villages, and the steppe near Rogozyanka village. In addition, the Regional Landscape Park "Velykoburlutskiy Step" included the reserves Ekaterynivskyi and Velykoburlutskiy, which are of national importance and were organized back in 1977 to protect colonies of steppe marmot.

The territory of the park is inhabited by many mammal species, including European polecat *(Mustela putorius)*, stoat *(Mustela erminea)*, least weasel *(Mustela nivalis)*, Eurasian otter *(Lutra lutra)*, European badger *(Meles meles)*, martens –beech marten *(Martes foina)* and European pine marten *(Martes martes)*,- gray wolf *(Canis lupus)*, red fox *(Vulpes vulpes)*, and European hare *(Lepus europaeus)*. In the recent past European mink *(Mustela lutreola)* were also found there. In the steppe areas of the gully-arroyos system there were numerous greater mole-rats *(Spalax microphthalmus)*, steppe marmots *(Marmota bobak)*, and steppe mice *(Mus spicilegus)*. Less common species include the speckled ground squirrel *(Spermophilus suslicus)*, the southern birch mouse *(Sicista subtilis)*, the great jerboa *(Allactaga major)*, the European hamster *(Cricetus cricetus)*, the grey dwarf hamster *(Cricetulus migratorius)*, and the northern mole vole *(Ellobius talpinus)*. Species of moderate number include the steppe lemming *(Lagurus lagurus)* and the sibling vole *(Microtus rossiaemeridionalis)*. The valleys of rivers Velykyi Burluk and Nyzhnya Dvorichna are inhabited by the Eurasian beaver *(Castor fiber)*, which became established there in the 1980s. Ungulates include the wild boar *(Sus scrofa)* and the European roe deer *(Capreolus capreolus)*, which are common in the territory. Elk (moose, *Alces alces*) migrations have also been noted.

Materials and methods

As mentioned above, the steppe marmot population in Velykoburlutsky district was studied for several years by a number of researchers. From their data it appears both the distribution and size of the steppe marmot population in the study area have changed over the years. To perform a detailed description of steppe marmot colony spatial structure, a plot with a typical steppe marmot colony was chosen in a broad gully-arroyos system station near Nesterivka village (that is about 90 km to the northeast of Kharkiv city). Investigations covered the gully-arroyos network from the "Babachi Yar" stow near Zelenyi Gai village up to the Seredniy Burluk village. The total area within which observations were made was about 800 hectares. All study sites were assigned to one of three types, depending on the intensity of agriculture in the area. The first type of plot was those not used for agricultural or other economic purposes, i.e., without grazing and annual mowing. The second type of plot was characterized as moderate, with grazing or annual mowing. Vegetation at these plots had signs of pasture digression of the vegetative cover at the second to fourth stage. The third type of plot had, until 2015, been subjected to constant (intensive) cattle grazing, and was characterized by signs of pasture digression at the fourth to fifth stages. Currently, grazing has been stopped at these plots.

The territory of the regional landscape park in Nesterivka village. In the center of the gully-arroyos system, one can notice light points which indicate steppe marmot burrows (Figure 1).

Fig. 1. *The territory of the regional landscape park in Nesterivka village. In the center of the gully-arroyos system, one can notice light points which indicate steppe marmot burrows*

The work was carried out in two stages:

1. Mapping of colonies using a GPS-navigator.

2. Counting the number of individuals in the family.

Observations were carried out with binoculars from the shelter immediately after the animals emerged above ground, usually from 7 a.m. to 10 a.m. in the morning and then in the evening from 5 p.m. to 8 p.m. In a number of cases, a visual count was performed along a survey route, where the observer walked past on foot and recorded the number of animals in each family. Counts were conducted across three days. The number of families (family plots), the total number of adults, and the total number of yearlings was counted. Average family size and average number of adults and yearlings per burrow was calculated by dividing the number of adults (or the number of yearlings) by the number of families.

To analyze the distribution of marmot settlements over the terrain an electronic image compiled from topographic maps (scale 1: 100,000) was used. From these data the boundaries of the local population were projected.

At the beginning of the 20th century, in the Velykyi Burluk District a small number of marmots lived in three areas: on the gully slopes of the Burlukriver valley, on the lands of the Shipovate horse farm,and near the farmsteads of Ploske and Tsytsorino. From 1966-1968, the marmots occurred in 16 collective and/or state farms (Krivitsky, Tokarsky, 1983). According to V.I. Abelentsev (1971), in 1967 the whole Velykyi Burluk marmot population totaled 1,710 animals. The majority were observed in the studied administrative district but several localities out of 28 listed by the author belonged to other neighbouring districts.

Due to organized protection, as well as the almost complete absence of natural predators and the marmot's high ecological plasticity, its population in this region continued to increase until 1980-1981. Marmots settled almost all areas used for grazing. Their number was the highest in the Kharkiv Region (28 000 individuals in 1987) due to the ideal habitat presented by a well-developed ravine and gully system, which occupies about 17-18 thousand hectares (14.2%) of the district's territory.

Our records indicate overall a large number of animals in the colonies and some peculiarities of their distribution in the VelykyiBurluk District. The marmot's population density largely depended on the age of the colonies; being larger in the plots where families had been living for many years (Tokarsky, 1997; Tokarsky et al., 2006).

A survey of the colonies conducted in June, 1977 showed that the number of residential burrows had significantly decreased in the areas bordering villages and frequented by people. A total of 50 families were mapped.

In the marmot colonies mores remote from the District center and the main roads (for instance, near the village of Andriivka), the total number of individuals was higher and the colony conditions were better. Interestingly, some families that were forced out by plowing from the gully bottom dug burrows on the sides of an asphalt road, which crossed the lower part of the gully. Here, on the road slopes, the animals fed freely near the asphalt, and would cross the road within a few meters of passing cars (Tokarskyet al., 2006).

Wild gregarious ungulates are an integral component of pasture ecosystems. Their vital activities form and maintain open and semi-open landscapes. However,they were the first to suffer significant losses because of human activities, and during the historical period gradually lost their positions as major players in the ecosystems'structural organization (Abaturov, 2006; Kolesnikov, 1997). Their loss resulted in a significant decrease in the biological and landscape diversity in the forest and steppe zones of Eastern Europe

(Smirnova et al, 2001a). Awareness of this fact has recently led to development of methods for ecosystem recovery and conservation through reintroduction of key species into their former ranges (Smirnova et al., 2001b; Akimov et al., 1999). Grazing of large ungulates is one of the key ecological factors that create habitat for many herbivorous steppe species such as marmots, and thus the presence or absence of ungulatest affects the number and density of their populations (Kolesnikov, 1997; Ronkin, Savchenko, 2000; Tokarsky et al., 2006). We attribute the decrease in the number of marmot family colonies, as well as their number per area unit, to the decrease in grazing pressure on the steppe marmot habitats.The area of the ravine and gully system occupied by the colonies in the study area has remained practically unchanged since the late 1980s,while the number of livestock (including cattle) has decreased dramatically (Table 1).

Table 1. *The number of steppe marmots in the area of. Nesterika (Tokarsky A., Savchenko, Ronkin, 2012, 2016- our results)*

Location of colonies	Area (ha)	Number of households		
		1992-1996	2005-2006	2016
Seredniy Burluk, a beam north of the village, beyond the pond	31	19	12	5
Seredniy Burluk, a beam north-west of the village, behind the pond	98	49	19	6
Green Guy, a beam Babachi yar	70	30	28	5
Nesterivka, a neighborhood of the village within the right bank of the river. V.Burluk: - Extensively grazed beams; - non-unstained beams	93 77	28 14	37 15	4 1

Table 2. *Steppe marmot habitat size, number of cattle, and number of steppe marmots in the Velikoburluksky district*

	1987	2005	2016
Total area, ha haymaking; pasture; yarov	17712 2429 14589 694	17412 3011 13774 627	17412 3011 13774 627
Number of cattle	52760	10237	3750
Pasture load, head / ha	3,6	0,7	0,27
Total	28100	10550	5000

During the last ten years livestock numbers decreased by a third and the marmot numbers by half. From the curve of the cattle dynamics in Velykei Burluk district, seen in Fig.2, livestock numbers reached their peak in the1980s and then began a rapid decline in the 1990s.

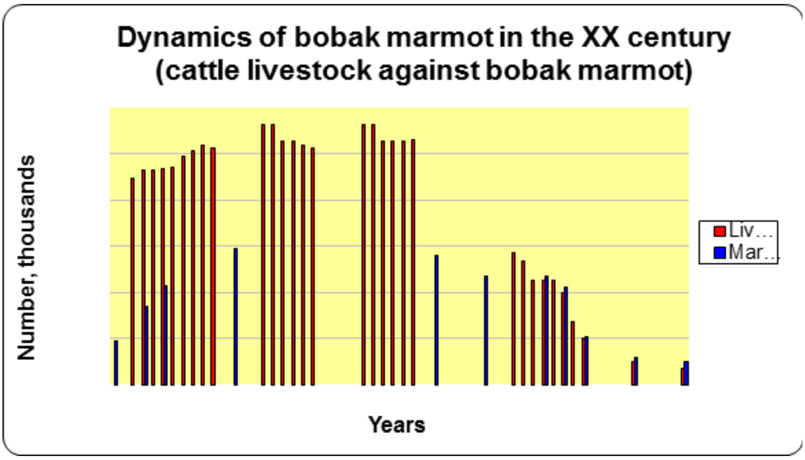

Fig. 2. *Dynamics of the number of marmots relative to livestock pasture load in the Velykoburluksky district in 1970-2005.*

A sharp decrease in grazing pressure caused qualitative changes in steppe marmot habitat that resultedin an unbroken "forest" (often at human growth height) of ruderal plants, with *Carduusacanthoides sp.* L. and *Onopordumacanthium sp.* L as the dominant species'. The growth of these plants significantly reduced the quality of forage at marmot family plots, as the ratio of forage to non-forage phytomass had changed radically (Ronkin, Savenko, 2000; Ronkin, 2003). Deterioration of forage quality led to a decrease in marmot numbers. Figure 2 depicts the dependence of marmot numbers on the level of grazing pressure in Velykyi Burluk district in 1970-2005. The number of steppe marmots dropped from 28 thousand individuals in the late 1980s to about 10.5 thousand (2110 families) in 2005 (Figure 2).

In the late 1990s, we found a steppe marmot settlement near the village of Nesterivka (Velykyi Burluk distr.) with 39 family plots (fig. 3). Of these, two were located at a distance from the main colony. Fourteen plots formed the center and four plots the periphery of the colony. The nearest (in both sides) colony centers were located at a distance of about 2 km along the gully system. Three family plots partly encompassed agricultural areas and eight plots bordered a country road. After the complete cessation of cattle grazing in 2015, marmots almost completely disappeared in this territory.

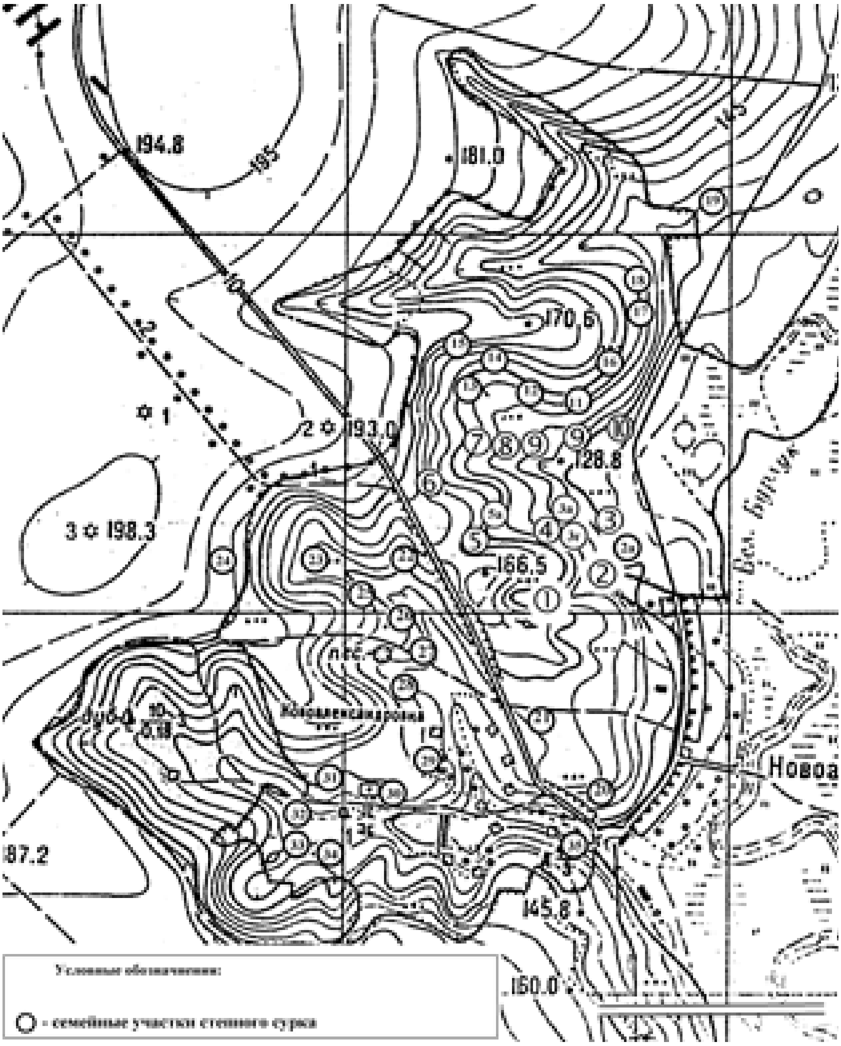

Fig. 3. *Placing of family sites of steppe marmots in the territory of the regional landscape park "Velikoburlukskaya Steppe" near the village of Nesterivka (2010). Scale 1:12500.*

We registered repeated cases of dispersal by young marmots, and sometimes the adults, to neighbouring and more distant family plots. The latter were out of the line of sight and up to 850 m away from the original burrow. Males were more active than females, and juveniles more active than adults. In the monitored colony, it was possible to distinguish relatively isolated stable families and the unstable ones, with a complete change of family members and continuous rotation between neighbouring groups (Savchenko, 2012). Two adult marmots placed into a man-made burrow at a distance of 1 km from their family plot, unerringly found their way home.

The average distance between the nearest winter burrows was 119 + 31 m (n = 45). In five cases out of 50, the distance did not exceed 25 m. Observing individually marked animals, we found that in three cases such closely spaced wintering burrows belonged to the same family, whose members year after year shared these burrows and the area around them. In two other cases, we observed either separate use of neighbouring winter burrows by two social groups, whose joint hibernation had not been fixed but still was possible, or marmots sharing territory and burrows but hibernating in two separate sealed burrows (Ronkin, Savchenko,2000; Savchenko, 2002).

The number of adult animals in each family varied from two to five. The density of the burrows in which hibernation was possible (i.e., recorded at least once for the entire observation period) was similar throughout the colony, 1.5-1.7 burrows / ha. The density of the animal population in different parts of the colony showed sharp contrast, from 1.2 families / ha at the center to 0.3 families / ha at the periphery.

Since a single family may have a varying number of wintering burrows (in our case, from one to three), the average distance between the burrows of neighboring families also varied considerably. The average distance between the wintering burrows of neighboring families in the center of the colony was 61±8 m (n = 10, $p < 0.01$). In the rest of the colony it was almost twice as high and equal to 115±26 (n = 46, $p = 0.5$) (Savchenko, 2000).

Disrupted topography created a variety of conditions important for steppe marmot activity. Each animal used multiple tree landscape elements: watershed, gully slope, and gully bottom. Wintering burrows were usually located on the slopes and in watersheds, while the meadows on lower slopes and gully bottoms were preferred for feeding.

As has been discussed throughout the article, certain historical periods are followed by a decrease in the number of domestic animals. The most noteworthy were the decreases in livestock numbers during the First World War, collectivization, and then from the 1980s to now. The latter is associated with the adaptation to modern market conditions. During these periods, we observed a sharp decline in the number of steppe marmots despite a total hunting ban (since 1929, the commercial hunting on this species has been banned).

The third period of decline is ongoing. Now we can foresee two possible futures. If the number of cattle and horses remains at the same level, we can confidently predict a further sharp decline in marmot population in both in Russia and Ukraine. If this happens, the marmot will disappear in thirty years. If agriculture, and primarily cattle breeding, activities increase the marmot population should be capable of restoring its geographic range to its former extent.

Grazing of large ungulates, in combination with terrain typified by ravines-and gullies, are key environmental factors that influence habitat suitability for many herbivorous steppe species, including marmots. Pasture steppe ecosystems are necessary conditions for biodiversity conservation.

Conclusions

A significant decrease in the steppe marmot numbers has occurred in Velykyi Burluk district. The population declined from 28 000 individuals in the late 1980s to 10 500 (2110 families) in 2005. After the complete cessation of cattle grazing in 2015, marmots almost completely disappeared from the area.

Livestock numbers decreased by one third while marmot numbers decreasedby half. At present, there is a catastrophic decline in the number of steppe marmots. We can envision two possible futures for the steppe marmot in Russia and Ukraine. If the number of cattle and horses remains at the same level, we can confidently predict an ongoing sharp decline in the marmot populations of both Russia and Ukraine. If agricultural activities, and primarily cattle breeding, increase, the marmot population should be capable of recovering and re-expanding to cover its former range.

Grazing of large ungulates, in combination with terrain typified by ravines-and gullies, are key environmental factors that influence the habitat suitability for many herbivorous steppe species, including marmots. Pasture steppe ecosystems are necessary conditions for biodiversity conservation.

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REVIEW ON SIBERIAN MARMOT RESEARCH OF HUSTAI NATIONAL PARK

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ABSTRACT

There are fourteen species of marmots recorded in the world, from those two species marmots widespread in the Mongolia which are Siberian marmot (*Marmota sibirica*, Radde 1862) and Altai marmot (*Marmota baibacina*, Kastschenko 1899). The Siberian marmot has been recorded in Hustai National Park (HNP), this species qualifies as endangered under criterion A2ad. In Mongolia, the total of population size of Siberian marmots has decreased sharply from 40 million to 10 million in the last 60 years, because of overhunting, bad weather condition and disease. Since the 1993 Siberian marmot study has been started in Hustai National Park and run on up to date. Siberian marmot`s potentially live area in Hustai National Park accorded 33707 ha from those they are live in 19464 ha area equal to 57.7 of total territory. In 2017, the overall marmot density in Hustai National Park was 4.2 individual per ha.

Key words. Siberian marmot, *Marmota sibirica*, Illegal hunting, Hustai National Park, Mongolia

Introduction. In the global conservation experience, recent approach of an effective way of conservation action is to conserve with the ecosystem level or specially protected area and many activities done related with this approach (Primack et al, 2003).

Pursuant to Mongolia has stated internationally to conserve up to 30 percent of its territory specifically in supporting its biodiversity conservation, today there are 102 special protected areas established 17.2% of total territory. One of them is Hustai National Park. Implementing the Przewalski's horse reintroduction program was the fundamental reason for establishing Hustai National Park. After the scientific programs being run out of the reserve since 1992 achieved measureable success and provided valuable conservation outputs Hustai was upgraded to a national park in 1998. Hustai National Park was legally protected such as hunting, logging, and grazing of livestock in the park were prohibited.

Since 1993, some long-term monitoring studies such as a wildlife, weather condition, vegetation and wild horses. One of them is Mongolian marmot study have been done every year. The park administration is supporting research activities for many years. Marmot population studies in Hustai were carried out by different researchers in different time. However, due to different methodologies, the population status and distribution area of the marmot are still questionable with no confirmed data.

In Mongolia Siberian marmots play an important role in nutrient recycling through burrowing, grazing, defecating and urinating, activities are now recognized as typical of ecosystem engineers (Van Staalduinen and Werger, 2007; Yoshihara et al, 2009).

In this review article is try to clarify result of long-term monitoring studies.

Materials. We were used and reviewed 1997-2017 long-term monitoring study materials in Hustai National Park.

Study area. Since the 1993 Siberian marmot study was conducted in Hustai National Park which is located 100 km southwest of Ulaanbaatar (47°50`N, 106°00`E, elevation 1100-1840 asl). Hustai National Park covered 50620 ha, of which the largest part was steppe and only 4% was forested. The forest contained 3 birch species *(Betula fruticosa, B.fusca, B.platyphylla)* and popular *(Populus pilosa)*. About 88% of the area is covered by grassland shrub steppes. Average annual precipitation was 270 mm and mean annual temperature was 0.2°C (Wallis de Vries et al. 1996).

Geomorphologically, Hustai National Park belongs to Tuul river basin, zone of Orkhon and Selenge rivers basin, Central Asia (Manibazar et al, 1999). In terms of plant-geography, it belongs to south forestry steppe zone, Mongolian Daurian mountains, however it is also included to Dundad khalkh steppe (Manibazar, 1996). Siberian marmot feed on 60-80 species of plants (Adiya, 2000).

RESULT

In Hustai National Park Siberian marmot study have been done 1993-1997 by Hans Hovens. Even though the marmot studies in the area, covered just a fields, including the changes in the number of marmots there. However, no research covering the whole area, was conducted yet. Therefore, a research work for the determination of the distribution, density and reserve of marmots within the reserve, is being carried out since 1997.

Henceforth 1998-2018 up to date Siberian marmot study conducted by methodology processed by T. Todgerel et al. Here in:

- T.Todgerel (Todgerel, 1998) was studied under the subjects which are Siberian marmot`s density, distribution, resource and management. The researcher has divided the total territory of the reserve, into 33 fields (the grid reports of the Hustain Nuruu map, dividing it into plots of 4 km square, was used) of 16 km square (1600 ha) and numbered these fields marking them in the map. The density if marmot families was determined by the method of the transect (V.V.Kuchiruk and G.A.Korenberg), according to which the researcher has counted emirate and inhabitant holes of marmot, passing through the 2 km long route with 30 m front (plot of 6 ha) and the number of holes in one ha, has been determined. The study result was shown as Siberian marmot density in HNP was 1.6 individual in per ha. The mother-Siberian marmot can gives birth to average 3.84 off-spring.

- In 1999 (Todgerel, 1999) Siberian marmot number has been recorded as 24248 numbers. The average number of marmots in one family, is 4.38+2.26 and the number of young marmots in one family, is 3.53. This result shown as Siberian marmot's reproductive success was high enough and should be done monitoring study on Siberian marmot.

- Siberian marmot`s population, number monitoring study conducting every year and methodology processed by Todgerel in 1998 (Todgerel, 1998), that study had been done by students which are Otgonbaatar, Davaadorj, Khurelshagai and Bilguun. However, the researchers (students) paid more attention to their numbers and reserves and in some cases mistakes were made on the process.

- In 2003, 2004 Otgonbaatar (Otgonbaatar, 2004) studied Siberian marmot. Total 126 families 247 marmot counted in chosen 8 plots. Density was 0.4 individual in per ha.

- In 2008 Davaadorj (Davaadorj, 2008) studied Siberian marmot. Total 104 families 321 marmot counted in chosen 8 plots. From those adults 135, yearlings 52, off-spring 52 were recorded. Density was 3.57 individual in per ha.

- In 2013 Khurelshagai (Khurelshagai, 2013) studied Siberian marmot. Total 90 families 220 marmot counted in chosen 8 plots. Hereof adults 100 or 45.5%, yearlings 47 or 21.3% and off-spring 73 or 33.1%.

- In 2016-2017 Bilguun (Bilguun, 2017) studied Siberian marmot. Total 80 families 224 marmot counted in chosen 8 plots. Hereof adults 93 or 41.5%, yearlings 63 or 28.3% and off-spring 68 or 30.3 %. Density was 4.2 individual in per ha.

- In 2008 Y.Yoshihara et al concluded that marmot disturbance affects the spatial hetero-geneity of vegetation at coarse spatial scale by maintaining the mosaic structure of graminoids and forbs or by modifying patch structure. The generality of scale dependency of spatial heterogeneity by grazing can be explained by relative relationships between disturbance size and measurement scale.

- In 2009 Y.Yoshihara et al, study results burrowing by semi-fossorial rodents modifies soil properties and plant communities. The effects of this burrowing on plants, however, are typically evaluated only by assessing changes in photosynthetic or production traits, not pollination traits. Therefore little is known about the indirect effects of burrowing on pollinators through its effects on the emergence of insect-pollinated plants. Study result recorded the relative elevation, grass cover and flower height of insect-pollinated plant species; the number of inflorescences and the number of pollinators in a marmot colony on the Mongolian steppe. They compared these parameters on and off marmot mounds and searched for factors that might explain variations in pollinator biodiversity at the plot and individual-plant levels. Flower numbers and flower visitation frequency per plot were significantly higher in the on-mound plots. The number of pollinators at the plot level was positively correlated with the relative elevation and number of flowers. Species richness of the pollinators was negatively correlated with grass cover. These results demonstrate that mounds created by marmots attracted pollinators by increasing flower numbers and by making flowers more conspicuous by raising them above the surrounding vegetation or removing that vegetation.

- In 2009, Lhagvasuren (Lhagvasuren, 2009) determined the current population status and distribution area of the marmot within the Park. This study was made according to an agreement between the Hustai National Park administration and the Institute of Biology, Mongolian Academy of Sciences. According his analyses potential marmot habitat in Hustai National Park is 337.07 square kilometer, and only 194.64 square kilometer area is inhabited by 9166±261 individuals with a density of 48.4 marmots per 100 ha. The survey were done using transect and plot survey methods by Mashkin to collect marmot density and number's data within the Hustai National Park. Study method were different from the another research of Siberian marmot in Hustai. The mean number of Siberian marmots' family was 16.2 per 1 square km and 3.2 individuals in one family. Therefore, marmot number declines due to natural conditions and direct and indirect human influences. Main factor decreasing the marmot population in the Hustai National Park was the number of the livestock which increases seasonally. Number of livestock in the Hustai National Park is gradually increasing from year to year. The high number of livestock which is exceeding the pasture's carrying capacity, is always leading to overgrazing and pasture degradation.

- Uuganbayar recorded the number of livestock in Hustai National Park its buffer zone (Uuganbayar, 2017) - There are 128 nomad camp included total 83141 livestock (Table-1).

Table-1. *Livestock number of Hustai National Park its buffer zone*

Year	Horse	Cattle	Sheep	Goat	Total
2013	4513	4056	38208	22073	68850
2014	4728	4290	40212	23136	72366
2015	4937	4821	43225	24148	77131
2016	5094	5347	45172	25914	81527
2017	3945	5521	46153	27522	83141

Illegal hunting of Siberian marmot. There are many summer camps of buffer zone 3 soums citizen`s located in the Hustai border area. It is also close to Ulaanbaatar and is near the highway to the city from the western part of the country, and poachers are often moved to the area. Case Siberian marmot illegal hunting occurs 40 times every year, to a certain extent affect the Siberian marmot population in a territory of Hustai (Table-2).

Table-2. *Poached marmots by individuals (2001-2017).*

Year	Adult male	Adult female	Young	Juvenile	Total
2001	-	-	-	-	94
2002					82
2003					161
2004					124
2005					98
2006					76
2007					79
2008					61
2009					57
2010					65
2011					88
2012					79
2013					75
2014					82
2015					73
2016	11	19	27	14	71
2017	10	15	19	12	56

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CONCLUSION

There are many studies in Hustai were carried out by different researchers in different time. However, due to different methodologies, the population status and distribution area of the marmot are still questionable with no confirmed data. Thus it should be studied new methodology approved by scientific council meeting.

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CHEMICAL BASIS OF STABLE ELEMENTS FOR THE BIOLOGICAL SIGNAL FIELD OF MARMOTS

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Abstract. Chemical substances of the skin glands secretion products, of excrements and their decomposition products create the chemical basis of stable elements for the biological signal field of marmots. The chemical composition of the volatile substances that could be stable elements and form olfactory image of the territory inhabited by marmots is discussed. Uneven accumulation of these substances in the soil cover (related to the probability of leaving a scent trail by rodents) creates gradients of the biological signal field facilitating the orientation in the space for marmots.

The biological signal field (Naumov, 1971; Vanisova & Nikol'skii, 2013) is one of the main sources of information about the territory with resources on it. The traces of animal vital activity (burrows, paths, feces accumulations etc.) create an odor-visual image of the space and, left by many generations of Mammals, preserve and transmit information about the territory that organizes the use of space by each generation of animals.

The study conducted on the example of a steppe marmot colony *(Marmota bobak)* (Vanisova et al., 2016) was the first attempt to describe the chemical structure of the biological signal field of Mammals. Chemical analysis (by gas chromatography / mass spectrometry) of the topsoil samples (collected directly on the entrance to the central burrows, on the paths at 5 meters from them and at 30 meters from the central burrow holes away from the paths and butanes, where there are no visible traces of marmots' vital activity) showed the unevenness of the olfactory image of the marmots' family sectors. It is related to the probability of leaving a scent trail by marmots.

The quantitative content of volatile compounds in samples of the upper soil layer, taken from sites of the territory regularly visited by marmots (from the entrance to the burrow and from the paths; Me = 248,35 mkg/g, n = 19) statistically significantly (by the Mann-Whitney test, p = 0,046) exceeds their content in the background (Me = 143,56 mkg/g, n = 10), that marmots do not attend or attend episodically. Uneven accumulation of substances in the soil in the process of marmots' vital activity creates gradients of the olfactory biological signal field, facilitating the orientation of rodents in the territory of colony.

As part of the volatile fraction of the topsoil samples from family sectors cover of steppe marmot were found from 50 to 110 components per sample - chemical compounds, presumably carrying information in the context of the biological signal field formed by many generations of rodents. The chemical composition of samples is heterogeneous and characterized by the predominance of various classes of organic substances, that is probably connected with the presence of free fatty acids and their derivatives, as well as with the processes of their oxidation (Chloe & Min, 2006). The main classes of volatile components selected from the soil samples in the steppe marmot colony coincide with the main classes of volatile components of the mammalian skin glands secretion (Sokolov &

Stepanova, 1986): fatty acids, amines, hydrocarbons, ketones, alcohols, aldehydes, organosulfur compounds. Hydrocarbons, including normal alkanes, unsaturated hydrocarbons, branched hydrocarbons and aldehydes are the most common compounds found in all soil samples from the steppe marmot colony. Organosulfur compounds, amines and ketones are rare and their relative content in the samples is low.

The main source of chemical information left by marmots on the ground surface is probably the plantar gland, known in many species of Mammals (Sokolov, 1977; Ad'yaa, 1993; Mashkin & Baturin, 1993; Shubin & Spivakova, 1993). Other sources of chemical substances is secretion products of the jugal glands, left by marmots when marking the territory. Chemical analysis of samples of jugal glands secretion products of alpine marmot *(Marmota marmota)* (Bel, 1998) revealed mainly fatty acids and esters in various concentrations, alcohols and hydrocarbons, organosulfur compounds, ketones. Notably, the compounds characteristic for the secretion of the jugal glands of alpine marmot, and the compounds found in the soil cover of steppe marmot colony, belong to the general classes of substances.

An important constant source of the olfactory image in the marmot colony is latrines, located in depressions on the surface of butanes. The source of volatile substances here can be excrements and the products of their decomposition. 16 compounds were identified in the volatile fraction from a sample of fresh excrement of steppe marmot (Vanisova et al., 2016). Some components of the excrement were found in all soil samples, and their content in the samples from the entrance to the burrows and from the paths is slightly higher than content of these volatile substances in the samples from background. Probably there is a relatively stable group of substances in the accumulated over a long time the mass of excrements, that creates an odor image of the place of constant accumulation of excrements, performing the function of a stable element of the biological signal field.

Presumably, the substances (the skin glands secretion products, the excrements and products of their decomposition) interact with the soil cover, retaining, accumulate in it, creating a stable scent image of space. Because the volatile components left by Mammals on the substrate belong mainly to the same classes of substances, then we can assume that different parts of the territory smell the same, but with different intensity, forming gradients of the biological signal field. Herewith, there may be differences in the structure of the odor spectrum of volatile substances from different individuals, as shown on alpine marmot (Bel, 1998). The species differences probably also concern the structure of the olfactory spectrum – the ratio of the number of some chemical components and the loss / presence of one or other of them. Moreover, the chemical image of a Mammal's territory can be mediated by a species-specific microflora (Ushakova & Andreev, 1985; Sokolov & Ushakova, 1986).

Volatile substances, chemical traces of marmots, superimposed on the system of visible (optical) elements of the biological signal field, take part in creating a matrix of stable elements, supplementing and enhancing the visual image of the territory inhabited by marmots, form the odor-visual image of space. The creation and regular renewal of stable and less stable elements in the biological signaling field of marmots contributes to the accumulation and transfer of information about the territories with the resources located on it, necessary for each generation of these hibernating burrowing rodents.

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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.

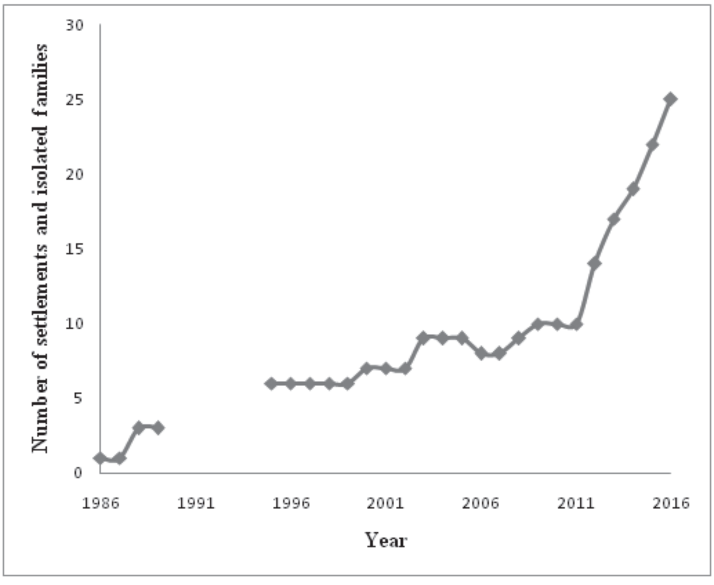

Fig.1. *The dynamics of the number of known colonies and isolated families in Udmurtia*

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.

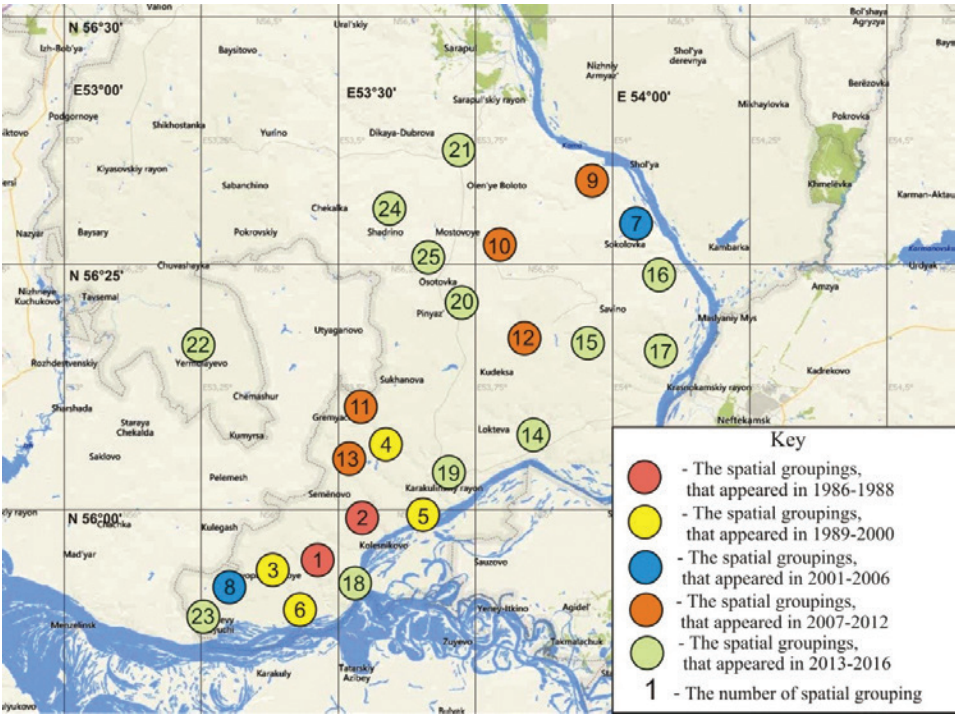

Fig.2. *The locations of colonies and isolated families of bobak in the Udmurt Republic. The numbers indicate colony names. 1 - Chegandinskoe colony, 2 - Kolesnikovskoe colony, 3 - Novopoleselenskoe colony, 4 - Kulyushevskoe colony, 5 - Yunginskoe colony, 6 - Shignandinskaya family, 7 - Sokolovskoe colony, 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.

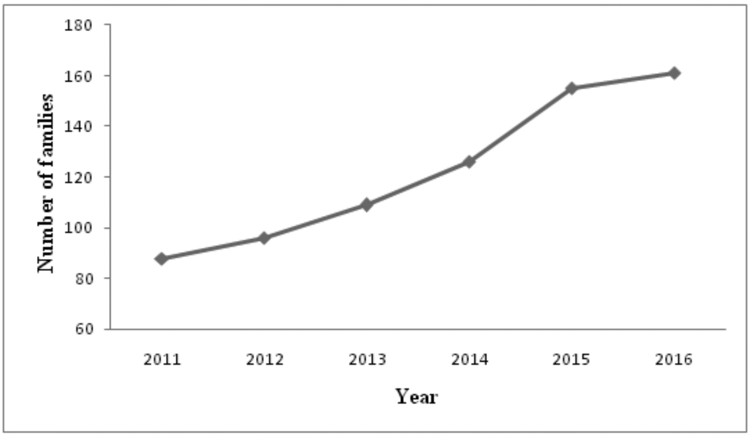

Fig.3. *The dynamics of the number of families of bobak in Udmurtia in 2011-2016.*

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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