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# ON THE STRUCTURE OF POPULATIONS AND REPRODUCTION OF THE GREAT GERBIL (*RHOMBOMYS OPIMUS LICHTENSTEIN*, 1823) WITH DIFFERENT NUMBERS OF INDIVIDUALS

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**ABSTRACT**

*Observations were carried out during the spring-summer season 2021-2023. in the northern and southern parts of the Beltau LEA, where the population of the great gerbil reaches high densities and the number of these rodents varies widely. The survey was carried out in some areas of the Asian desert plague focus, in the Karakalpak Kyzylkum desert in 2021-2023. in the enzootic territories of Beltau, adjacent closer to the Takhta-Kupyr oasis. It is known that during declines in the population of the great gerbil, inhabited colonies often remain in groups with different numbers of colonies. Thus, the circulation of the plague microbe can occur even during periods of deep declines in the gerbil population.*

**KEYWORDS:** *Embryo, pregnant, giving birth, population, zooid, epizootic, enzootic, infection carrier, vector, microbe, colony, dominant, depression, peak, young, fatness, reproduction.*

## INTRODUCTION

In the Republic of Karakalpakstan and other regions, in each landscape-ecological epizootological site there is little unambiguous information about long-term indicators of rodent population dynamics, and its epizootological and epidemiological values are practically absent.

Outbreaks of rodent epizootics during a period of economic instability and insufficient financing of anti-epidemic measures, a decrease in the level of the immune layer among the population, as well as transparency of the boundaries of the focal area can cause major epidemic complications not only in the territory of Beltau LER, but also throughout Northwestern Kyzylkum. The situation is further complicated by the fact that many regions of the republic remain inaccessible, and therefore poorly studied in this aspect. The enzooticity of the plague and the isolation of the plague microbe from the large the range of carriers and vectors makes it necessary to generalize the data of long-term flea collections from various rodent species, as well as to study the biology and ecology of these ectoparasites in an enzootic territory. Moreover, over the past period, a significant amount of new data has accumulated on the epizootology of natural focal infections, on the number and location of their carriers and vectors in the conditions of the outbreak.

The purpose of the study is to clarify the natural pest-hole of the plague of Karakalpakstan on the territory of Beltau, a peculiar braking effect aimed at preventing undesirable changes in the number of the great gerbil (*Rhombomys opimus* Licht.(1823)) in order to improve epizootological monitoring and increase the effectiveness of preventive (antiepidemic measures) measures.

## MATERIAL AND METHODS

For the analysis, data from epizootological monitoring of populations of gerbils of the Central Asian desert natural plague outbreak in the Republic of Karakalpakstan for 2021-2023 were used [Hamidi K., Mohammadi S., Ghassemi-Khademi T.(2021)]. According to the passport, the epizootic index of the Beltau landscape-ecological area is 0.25 [Sludsky A.A., Boiko A.V., Lyapin M.N., Tarasov M.A.

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(2020)]. An epizootological survey of an area of 20,000 km2 was carried out. Epidemiological, epizootological, and statistical research methods were used in data processing.

The observations were carried out during the spring-summer and autumn surveys in 2021-2023 in the North-western Kyzylkum (Karakalpakstan) part of the Beltau LER at two experimental sites, the first of them Eshki olgen (northern subzone), and the second Zhetinur (southern subzone). The observations were carried out in the main landscape zones of the desert. Laboratory work and autopsy of animals were carried out according to the method of K.E. Koptyaeva (2018) [Koptyaeva K., Muzhikyan A., Guschin Ya., Belyaeva E., Makarova M., Makarov V, (2018)]., specific territories were determined by the location of field hospitals and scientific bases of the Karakalpak Anti-Plague Center of the Takhtakupir department.

Based on the analysis of literary information and personal observations, we present a working hypothesis that in different habitat conditions of populations of the great gerbil, different mechanisms of movement of the number of individuals operate and plague epizootics occur among these rodents in a peculiar way.

## RESEARCH RESULTS

The weather conditions in autumn 2022 were favorable for rodents in the Kyzylkum landscape epidemiological region of Beltau. The temperature regime was close to the long-term norm. The amount of precipitation in October-November was twice the average annual norm (24.5 mm versus 12 mm). The winter was cold and the average monthly temperatures in January and February were 2-3 times lower than norm ($-14.2^0$ – 8.8 and -5.3). Precipitation in winter fell below the norm of 24.9 mm versus 29 mm (XII-II). Unlike the warm early spring of 2022, the spring of 2023 was prolonged and precipitation fell by 13 mm less (25.3 mm versus 38 mm). From October 2022 to May 2023, 74.7 mm of precipitation fell, which is close to the long-term norm. The summer months of 2023 (V-VII) were dry. The autumn months were characterized by dry and warm weather up to and including December.

The feeding behavior of rodents is spatially active. The feed is unevenly distributed. The materials of our observations show that the animal feeds where it is safe for it. Since movements through the territory are determined primarily by the relative location of burrows, the location of the feeding areas selected by the animal is a secondary structural element. The quality of the feed determines the hierarchical preference for the order of visits to a particular area.

The growing season of desert vegetation in 2023 was delayed by one decade. The vegetation in spring was not abundant compared to the years of increased moisture. The green cover of herbaceous plants in the Northern part of Beltau was formed in mid-April, reaching its greatest development in early May *Carex* L.(1753)., *Eremopyrum orientale* (L.) Jaub. & Spach.(1851), *Bromus tectorum* L. (1753) etc. *Ferula assa-foetida* (1712). vegetated in relatively small quantities throughout the territory and dried up by mid-May. By the end of May, other plants of the herbaceous cover had dried up. In June, only *Corispérmum* B.Juss.ex L.(1753). *and Halimocnemis* C.A.MeY.(1829). were vegetated from herbaceous plants. Vegetation of trees and shrubs occurred in 2023 with the usual intensity as in 2022.

Various species of *Salsola* L.(1753), usually abundant in autumn, were absent throughout the Beltau territory. Therefore, the basis of the diet of *Rhombomys opimus* Licht.(1823) in autumn were branches of shrubs *Haloxylon persicum* Bunge ex Boiss. & Buhse (1860), *Ammodendron* Fisch. ex DC.,(1825), *Ephedra* L.**(**1753), *Salsola arbuscula* Pall (1771). Active food storage of rodents was observed in October. Judging by the data from the excavations of the colonies, the amount of stored feed is quite enough for overwintering of *Rhombomys opimus* Licht. (1823). In burrows and adjacent intermediate areas disturbed by large gerbils, shrubs were oppressed with a decrease in vegetation cover and aboveground biomass.

As a result, “niche gaps” formed in the disturbed territories, which served as a refuge for herbaceous annual and perennial plants. Thus, the existence of large gerbils has increased the overall species richness of the desert. In addition, herbaceous annual and perennial plants are the main food source for gerbils in spring, which indicates a mutually beneficial relationship between gerbils and herbaceous plants. The actual material on the eating of plant species by the great gerbil is given in Table 1 [Xu W., Liu W., Yang W., Wang M., Xu F., Blank D. (2015)].

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**Table 1.**
**Plants eaten by a large gerbil on the territory of Beltau (April-May 2023).**

| Types of plants | Life form | Beltau LER |
|---|---|---|
| *Haloxylon persicum* Bunge ex Boiss. & Buhse (1860) | Bush | +++ |
| *Artemisia diffusa* N. Krasch | Subshrub | +++ |
| *Acanthophyllum borsczowii* Litv. | Subshrub | +++ |
| *Carex physodes* M.Bieb | Ephemeroid | ++++ |
| *Ferula assa-foetida* (1712) | Ephemeroid | +++ |
| *Chenopodium acuminatum* Willd. (1799) | Ephemera | +++ |
| *Chorispora sibirica* (L) DC | Ephemera | ++ |
| *Bromus tectorum* L. (1753) | Ephemera | ++++ |
| *Eremopyrum orientale* (L) Jaub.&.SPACH(1851) | Ephemera | ++++ |
| *Salsola dendroides* Pall, (1803) | Bush | ++ |
| *Astragalus ammodendron* Bunge | Bush | ++ |

We took: for the dominant plants in the rodent diet, damage to which was noted in more than half of the examined colonies (++++); those that are important in nutrition found in eating 1/5-1/2 of all colonies (+++); secondary food registered for no more than 1/5 of the colonies (++). We did not note the storage of large gerbils for food and the eating of underground parts of plants. The rodent disposed of fresh growing leaves, stems, branches.

Condition and number of rodents: In the territory of Beltau, the mortality rate of *Rhombomys opimus* Licht. (1823) during the cold period of 2022-2023 amounted to 21-60% of the initial population in autumn 2022, which is less than the value of natural waste for the same period of 2021-2022 (table 2). The highest mortality rate of about 50-60% was observed in the territory of Beltau, where during the depression period of 2019-2020 areas of increased abundance were preserved.

**Table 2.**
**Comparative data on natural waste in the population of *Rhombomys opimus* Licht.(1823) for the cold period of the year.**

| Region | Landscape-epidemiological area | The amount of waste % | | | | |
|---|---|---|---|---|---|---|
| | | 2019-2020 | 2020-2021 | 2021-2022 | 2021-2022 | 2022-2023 |
| Western Kyzylkum | Beltau | 60 | 80 | 31 | 25 | 50 |

This paper presents the results of studying the rodent fauna in the spring-summer and autumn seasons of 2021-2023 in Beltau LER on ridge-cellular sands, where the settlements of the great gerbil reach a high density (up to 4-6 colonies per hectare), and the number of these rodents varies widely. Two populations of *Rhombomys opimus* Licht. (1823), which were in different phases of population dynamics, were compared in terms of family size, reproduction intensity, age and sex structure. The observation sites are located 40 km from each other, the weather and feeding conditions were the same. Both rodent populations did not experience significant human exposure [Zhang C., Long L., Fasi W., Feiqing Z., Wanfu W., Xuefen Z., Yongqiang Y. (2023); Shabbir M., Aleem M., Javed S., Wagner D.M., Keim P.S., Eqani S.A., Bokhari H. (2016)].

In the first of them (1 site of Eshki olgen) in 2021, an increase in the density of individuals close to the peak was observed (11-16 animals per 1 ha with a colony habitability of 100%); in the second (2 site of Zhetinur), a predepressive state of abundance (3-5 animals per 1 ha with a habitability of 40%). The sites covered an area of 6-7 $km^2$, where observations were carried out every year in a new undisturbed part of the settlements [Ma T., Zheng J., Wen A., Chen M., Mu C. (2018); Wilschut L.I., Heesterbeek J.A.P., Begon M., de Jong S.M., Ageyev V., Laudisoit A., Addink E.A. (2018); Heier L., Viljugrein H., Storvik G.O. (2015)].

In general, 38 small animals were caught in the first site by fully catching 5 families, and 14 adult females were additionally caught to determine their generative state. In the second section, 2 families were totally captured (12 animals were captured) and an additional 5 adult females [Wen X., Zhao G., Cheng X., Chang G., Dong X., Lin X. (2022)].

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By the spring of 2023, the number of great gerbils in significant parts of the territories of Kyzylkum and Beltau decreased by 2-3 times compared to the number in the autumn of 2022. (table 2.) and in March-April ranged from 1 to 6 animals per 1 ha with 28-37% of colony habitability (against 0.6 animals, 6-29% of colony habitability in 2022).

In the territories of Beltau (Eshki olgen, Zhetinur) where the number of large gerbils ranged from 2 to 4.8 animals per 1 ha at 40-91% of the habitable colonies. In October 2023, the population of the great gerbil was distributed as follows (table 3).

On the territory of Beltau, there are 3-6 animals per 1 ha with 61-86% of the inhabitability of colonies against 1-4 animals, 25-75% of the inhabitability of colonies in 2022.

**Table 3.**
**The number of great gerbils by season and year Beltau LER.**

| LEA | an object | 2022 | 2023 | | |
|---|---|---|---|---|---|
| | | X | III-IV | VI | X |
| Beltau | Eshki Olgen | 5.3/74 | 2.4/77 | 6.7/61 | 5/85 |
| | Zhetinur | 4.8/75 | 2.7/70 | 5.7/67 | 5.6/77 |

*Note: the numerator contains the number of animals per 1 ha*
*the denominator is the % habitability of colonies.*

Compared with the autumn of 2022, in most of the territory of the sites (Eshki Olgen, Zhetinur), there was a further increase in the number of large gerbils, the level of which exceeded the average in the sites, the number in the territory increased slightly (by 1/3).

In the autumn of 2023, the number of colonies with 6-10 animals was 45-60-82%, and from 11-15 specimens ranged from 5 to 10-24%. The number of colonies with 16 or more animals is 4-10% of all captured or visually counted colonies. All this indicates the complete release of large gerbils from the depressive state of abundance in the Beltau sites.

Unfavorable weather conditions (prolonged spring) and food storage conditions, that is, the short duration of vegetation of succulent herbaceous forage plants, led to less intensive reproduction of large gerbils in 2023. The breeding intensity was average, in some places below average.

Offspring in populations of large gerbils in 2023, in the area (Eshki olgen) it was 1.3 embryos lower for 1 female, in the second site (Zhetinur) it was 1.2 embryos lower for 1 female compared to 2022 in both sites.

Due to the prolonged spring, breeding began later than in 2022. The first peak of pregnant females was recorded in the I-half of April, the second peak in the I-decade of May in the territory of Beltau (the site of Eshki Olgen, Zhetinur) – 56-72,6 and 60-64% of pregnant females. Starting from the second half of May, the number of pregnant females decreased sharply and did not exceed 16-25%. The average number of embryos in 2021 was lower everywhere than in 2022 (table 4).

**Table 4.**
**Calculation of the number of broods and offspring in large gerbils in Kyzylkum landscape epidemiological region of Beltau in 2023.**

| An object | Year | Month | Autopsy of adult females | | | Embryos counted | | Intensive reproduction (embryo number for 1 female) | One female per year | | Offspring of the population per year in % | % of females among sexually mature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Pregnant | | Total | Average in one pregnant female | | Pregnancy | Embryos | | |
| | | | | Absolute number | in % | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1-object Eshki Olgen | 2021 | IV | 22 | 19 | 86.4 | 111 | 5.8 | 7.824 | 1.1 | 5.2 | 280.8 | 51.4 |
| | | VIII | 3 | 1 | 33.3 | 4 | 4.0 | | | | | |
| | | X | 30 | 1 | 3.3 | 5 | 5.0 | | | | | |
| | 2022 | IV | 24 | 13 | 54.2 | 46 | 3.5 | 2.622 | 0.5 | 1.7 | 95.4 | 56.1 |

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| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | X | 28 | 4 | 14.3 | 17 | 4.2 | | | | | |
| | 2023 | IV | 12 | 5 | 41.7 | 23 | 4.6 | 1.918 | 0.3 | 1.3 | 41.7 | 54.8 |
| | | VII | 14 | - | - | - | - | | | | | |
| | | IX | 8 | - | - | - | - | | | | | |
| 2-object Zhetinur | 2021 | V | 16 | 10 | 62.5 | 82 | 8.2 | 5.125 | 0.3 | 3.4 | 198.6 | 58.4 |
| | | X | 15 | - | - | - | - | | | | | |
| | 2022 | V | 26 | 3 | 11.5 | 13 | 4.3 | 0.494 | 0.1 | 0.3 | 17.9 | 59.7 |
| | | X | 9 | - | - | - | - | | | | | |
| | 2023 | IV | 29 | 11 | 37.9 | 53 | 4.8 | 1.819 | 0.2 | 1.2 | 84.2 | 70.2 |
| | | X | 11 | - | - | - | - | | | | | |

Distinctive features of reproduction in large gerbils in 2023 are the absence of embryo resorption in pregnant females, fertility and short duration. (4 months versus 8 in 2023).

Young gerbils of the first brood began to surface from the end of April, in early May they accounted for 40-50%, and by the end of May and early June 60-70% of the entire *Rhombomys opimus* Licht.(1823) population. The mass settlement of the young of the first brood began at the end of May. The ratios of sex groups in the population of large gerbils (mature) in the sites are shown in table 5.

**Table 5**
**The ratio of sex and age groups in the population of large gerbils in the Beltau area in 2021-2023.**

| Year | 1-object Eshki Olgen | | 2-object Zhetinur | |
|---|---|---|---|---|
| **2021** | 0.9 | 51.4 | 0.9 | 58.4 |
| **2022** | 0.6 | 56.1 | 0.4 | 59.7 |
| **2023** | 0.8 | 54.8 | 0.4 | 70.2 |

***Note:*** **1. The number of males per 1 female among the sexually mature.**
**2. % of the sexually mature in the population.**

In April, among the overwintered large gerbils in the first site, males predominated in number - 0.8, the ratio of sexually mature ones was 54.8%, in the second site males were 0.4, the ratio was 70.2%. During the breeding season, the mortality rate of males was higher than that of females. In May-June, females predominated among the animals and there were 0.5-0.6 males per female. By autumn, the sex ratio had changed (1.18-1, 2-1,4 and 1.15 males per female). Among young immature individuals, the sex ratio in May-June was almost the same (approximately 0.96-0.92). In the population of large gerbils in spring (III-IV), sexually mature individuals predominate (100-97%), in May-June their number decreased to 41-23% and in autumn with the young reaching puberty, they amounted to 93-100% of the total population.

In these populations, all overwintered females participated in reproduction. By June, each of them had given a second brood, that is, there was no difference in this regard. However, there are differences in the number of embryos. The females from the first site had an average of 1.3 (with fluctuations from 5 to 8), from the second site - 1.2 embryos (with fluctuations from 3 to 7).

A more significant difference in the compared populations was revealed in their structure. Thus, in the first site, in 23% of residential burrow colonies, 3-4 mature individuals lived simultaneously (one male with two, sometimes three females), forming a single family group. Part of the burrow colonies were inhabited by two family groups (6% of the total number of burrows).

Solitary animals accounted for 10% of the reproductive part of the population. The sex ratio among overwintered individuals was close to 1:1, but males significantly prevailed among the young of the first generation (63%). The young accounted for 59% of the total population.

In the second site, solitary individuals accounted for 30% of the mature population and occupied 50% of the total number of inhabited burrows. These animals were mostly pregnant or lactating females. More than two adult gerbils (male and female) were not found in the same family group. Females significantly prevailed among sexually mature rodents (62%), however, the sex ratio of young animals turned out to be 1:1. The young in the population accounted for 41%.

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Due to the good long-term vegetation of succulent forage plants in the Beltau site, the physiological state of large gerbils during the breeding period (III-VI) was characterized by high fatness in all landscape-ecological areas (table. 6) where the first fatness score prevailed.

The second and third fatness scores (medium and fat) in March and April were noted in large gerbils in the Beltau sites, and in May and June, the fatness of the animals was the same everywhere. The second (average) fatness score (74-100%) was noted among gerbils in autumn (IX-X), and the third fatness score was 20-25%.

In October, during the period of intensive forage harvesting for the winter, the number of medium-fat gerbils prevailed (91%), and the group with 2-3 fatness points amounted to 60-70%. Gerbils with 3 fatness points were noted only in isolated cases (3-8%) in October on the territory of Beltau.

**Table 6.**
**Fatness of a large gerbil in the Beltau area in 2021-2023**

| Site | Year | Sexually mature | | | | | | | | Immature | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Males | | | | Females | | | | Males | | | | Females | | | |
| | | Number of examined specimens | Fatness points (in %) | | | Number of examined specimens | Fatness points (in %) | | | Number of examined specimens | Fatness points (in %) | | | Number of examined | Fatness points (in %) | | |
| | | | 1 | 2 | 3 | | 1 | 2 | 3 | | 1 | 2 | 3 | | 1 | 2 | 3 |
| Eshki Olgen | 2021 | 52 | 100 | - | - | 55 | 100 | - | - | 9 | 100 | - | - | 3 | 100 | - | - |
| | 2022 | 23 | 65.2 | 13,1 | 21.7 | 41 | 74.7 | 17.4 | 7.9 | 2 | 100 | - | - | 25 | 100 | - | - |
| | 2023 | 28 | 39.2 | 42,8 | 17.8 | 34 | 11.8 | 52.9 | 35.3 | - | - | - | - | - | - | - | - |
| Zhetinur | 2021 | 27 | 100 | - | - | 31 | 100 | - | - | - | - | - | - | 2 | 100 | - | - |
| | 2022 | 16 | 100 | - | - | 35 | 100 | - | - | 2 | 100 | - | - | - | - | - | - |
| | 2023 | 17 | 100 | - | - | 40 | 100 | - | - | - | - | - | - | - | - | - | - |

Analyzing the information obtained, it can be assumed that overdensification has already begun in the first of the considered populations. This was evidenced by the 100% population of burrow colonies and the habitation of solitary animals in settlements or in temporary shelters. At the same time, reproduction was still quite intense.

However, the subsequent settlement of young animals seemed limited in this case due to the lack of free burrows. Not only the overdensification of individuals in colonies, but also the significant predominance of males among the young can be considered as one of the constraining factors for further population growth.

In the second population, despite the continued decline in numbers, mechanisms of rodent resistance to the onset of depression have emerged. This appeared, in particular, in the increasing proportion of females and the equalization of the sex ratio among the young. Obviously, the predominance of females during depression contributes to the preservation of the necessary reproductive potential, which should be one of the most important conditions for a new increase in numbers.

Thus, in both populations, the formation of a specific mechanism (a kind of inhibition effect) aimed at preventing undesirable changes in numbers was observed. This was most clearly manifested in 2021; in 2022-2023, the density of the considered populations of *Rhombomys opimus* Licht.(1823) practically stabilized, remaining mainly at the level reached by that time.

Consequently, a significant predominance of males (in particular among young ones) can be considered as one of the factors reducing further population growth, and an increase in the proportion of females in the population as a sign of more reliable conservation and subsequent realization of the potential reproduction of the species.

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## CONCLUSION

The number of *Rhombomys opimus* Licht.(1823)decreased by 21-60% in the territories of Beltau during the cold period of 2022-2023. The highest mortality rate (50-60%) was observed in the territory of an increased number of rodents during the depression period of 2019-2020.

The lack of precipitation in the winter of 2022-2023 and the prolonged spring caused a delayed, weak vegetation and the development of succulent forage ephemeroid and herbaceous plants. As a result, the reproduction of *Rhombomys opimus* Licht.(1823) occurred less intensively and in a short time. The number of offspring was half less than in 2022 and 2021 (41.7 versus 280.8% in 2021, 95.4% in 2022).

By the autumn of 2023, in most of the territory of Beltau, in the northern part of the 1st site of Eshki Olgen, a high number of *Rhombomys opimus* Licht.(1823) (6-10 and 11-15 or more rodents per 1 hectare) was noted. The number of *Rhombomys opimus* Licht.(1823) remains at the lower average level in the Southern part of the sands of the 2nd site of rinur (1-5 rodents per 1 hectare).

The basis of the spatial structure of terrestrial rodents is the habitat area. A rodent habitat is a space whose resources are systematically and naturally used over a biologically significant period of time.

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