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Specifics of distribution and ecology of the flat-headed vole (*Alticola strelzowi* (Kastschenko, 1899)) in the conditions of northeastern Kazakhstan and Altai territory

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Abstract

Flat-headed vole (*Alticola strelzowi* (Kastschenko, 1899)) is a stenobiont species, which can be potentially used as a bioindicator of climatic changes and anthropogenic impact in the territories of northeastern Kazakhstan. Furthermore, these rodents can carry plague pathogens. In both cases, it is important to understand the distribution areas and lifestyle of these voles in order to effectively record and regulate their numbers. Therefore, the aim of this study was to systematise the available data on the ecology and distribution of *Alticola strelzowi* from the archives of the Siberian Zoological Museum of the Institute of Animal Systematics and Ecology of the Siberian Branch of the Russian Academy of Sciences (Novosibirsk) and the Zoomuseum of Moscow State University, St. Petersburg, and to test the possibility of breeding these voles under vivarium conditions. For this purpose, data of archives in the territory of distribution and time of vole findings were studied and grouped, and average values of several morphometric parameters for voles of East Kazakhstan and Pavlodar regions and separate populations from the Altai territory were calculated. Using the Google Earth resource, an approximate map of the regions where the described specimens of flat-headed voles were captured was formed. For the experiment in natural conditions using automatic traps, voles were captured in the territory of the southeastern Altai, on the Sailugem Ridge. As a result of the work, significant differences between voles of *Alticola strelzowi* species of different populations were revealed, especially between the individuals living on different sides of the South Altai Ridge. On average, voles

found in Kazakhstan had 15% longer body length and almost twice the body weight. Voles reared under vivarium conditions generally lived less long than in the field, but were reproductively active. In general, this study laid the foundation for systematic further observations and the tracking of population dynamics of flat-headed voles, and also outlined the prospect of using these data for monitoring ecological and climatic changes.

Keywords
Small mammals; rodent range; rodent morphometric indices; vivarium conditions; population

Introduction

Stenobiont species of animals and plants can live only in a narrow range of conditions and occupy specific habitats. They practically do not develop new habitats. Lack of lability in adaptation to changes in environmental factors leads to the fact that stenobiont species are often the first victims of climate change or anthropogenic interference (Bezsonov & Andreev, 2016; Skliar et al., 2024).

For example, due to global warming over the last 54 years, according to the International Union for Conservation of Nature more than 571 vertebrate species have become extinct (International Union for Conservation of Nature, 2024). Over the last 10 years, such stenobiont species as the beckoning crayfish (*Cambarus callainus*) (Román-Palacios & Wiens, 2020), the Sumatran orangutan (*Pongo abelii*) and so on have ceased to exist worldwide (World Wildlife Fund, 2024). The extinction of all these animals has been a consequence of human economic activities. Many animals are now at risk (Kirimbayeva et al., 2023; Abutalip et al., 2024a). Kazakhstan has also lost many animal species during this time. These include the Turanian tiger (*Panthera tigris tigris*), which inhabited the southern and eastern regions (World Conservation Monitoring Centre, 2001), the Aral sturgeon (*Acipenser nudiventris*) from the Aral Sea, the saiga (*Saiga tatarica*) and gazelle (*Gazella subgutturosa*), which were once widespread throughout the country, and the great bustard (*Otis tarda*), which lived in the steppes. These animals have disappeared due to habitat loss, hunting and poaching (Bragina et al., 2017; Nurgaliyeva et al., 2024).

At the same time, the study of stenobiont and endemic species, in particular the monitoring of their population dynamics, can be of diagnostic value for detecting the first signs of ecological changes. Timely realisation of the presence, nature, and cause of these changes may give time to stop the effect of unfavourable factors or to change strategies and plans of economic activities in the respective territories.

Thus, the Ukrainian Soviet soil scientist Dokuchaev (1883) published works on the use of stenobiont plants to determine soil characteristics as early as 1833, Napierała et al. (2015) monitor ecological changes in Central European forests by studying uropod mites (*Mesostigmata uropodina*), and in Kazakhstan, Mordkovich et al. (2020) conduct long-term observations of climate change in the Central Kazakh steppe, observing population dynamics of beetles of the genera Carabidae and Tenebrionidae. Mordkovich et al. conduct long-term monitoring of climate

change in the Central Kazakh steppe, observing the population dynamics of beetles of the families Carabidae and Tenebrionidae (Napierała et al., 2015; Oralova et al., 2015).

Also, for Kazakhstan, such an important diagnostic stenobiont may be the flat-headed vole *Alticola strelzowi*. This is a species of vole, first described by Nikolai Kastschenko in 1899 (Pozdnyakov, 2022). According to (Kastschenko, 1899), it was divided into three subspecies: *A. s. strelzowi* (fur coloration is relatively dark, grey, with a brownish tinge), *A. s. desertorum* (close to the previous one, coloration is somewhat paler) and *A. s. depressus* (zygomatic arches less widely spaced than in the previous forms, interorbital space of the skull with a noticeable narrowing of its posterior part), occupying limited areas in the territories of the Kazakh Uplands, Altai, northwestern China, and southwestern Tuva. The main factor that determines the range and density of their settlement is the presence of rocky shelters. Voles live in them in families/colonies, stocking dry plants for wintering, the diversity of which, in certain parts of the range of animals, can reach 68 species (Panteleeva et al., 2020).

Numbers of voles are actually quite unstable, often changing and fluctuating (Tapbergenov et al., 2013; Sakkaraeva & Abdurashitov, 2024). The most favourable for the increase in numbers are territories in which a significant part of the area is occupied by rocky groupings, which are not very far from each other (Yespembetov et al., 2019; Chulenbayeva et al., 2022). It is in such places that their numbers can reach 30-40% of hits per 100 trap sessions (Global Core Biodata Resource, 2024).

The rocky terrain is inaccessible and therefore makes it difficult to study the intraspecific taxonomy of voles and the variability of their dispersal (Abutalip et al., 2024b). In addition, the animals are poorly studied due to their limited distribution range. Usually, studies of morphological features of voles are aimed at clearly defining their taxonomy (Bolshakov et al., 2012).

The aim of this study is to bring together all the information available concerning existing finds and specimens now in museum collections, and to describe our own research concerning the possibility of keeping *Alticola strelzowi* under vivarium conditions.

Materials and methods

To begin the work, it was necessary to identify areas for comparison to fulfil the needs of the study. The research design was organised into three semantic blocks, which took place in three stages. At the first stage, a thorough systematisation of data obtained by other scientists was carried out. The study of materials from the archives of the Siberian Zoological Museum of the Institute of Animal Systematics and Ecology of the Siberian Branch of the Russian Academy of Sciences (SB RAS), Novosibirsk, and the Zoomuseum of the Moscow State University (MSU), St. Petersburg, was taken as a basis (Novikov et al., 2023; Kassenbayev et al., 2024).

When working with the archives, we recorded the places of finds of *Alticola strelzowi*, by which we determined the approximate area of its distribution. Since the geodata of most specimens of the museum are missing, the approximate locality for each specimen was determined using the Google Earth service (Zakanova et al., 2023). The approximate location of colonies was marked with geolocation symbols – different colours for different countries. For further analysis, we selected specimens found oin the territory of Northeast Kazakhstan, i.e., East Kazakhstan and Pavlodar regions, as well as in the Kazakhstan and Russian territories of Altai.

After obtaining a map with approximate settlement points and taking them into account, the second stage involved systematising the data on the main morphometric parameters, if it was possible to obtain them from the materials of the museums involved. Four main criteria were taken into account: body length from the anus to the end of the nose, tail length from the base to the tip, hind foot from the heel bone to the end of the phalanx of the middle toe, and ear length from the base of the ear cartilage to the most protruding point of the apex of the ear itself.

The data were grouped by distribution area and period of the expedition that found the described voles, and the main trends and differences between different populations of voles of northeastern Kazakhstan and Altai Territory were determined. Also, where possible, the dynamics of morphometric parameters within the population with time was assessed. Limitations regarding the northeastern territories of Kazakhstan are due to the fact that they directly border Altai, so populations of voles there are formed in similar conditions and probably have the possibility of gene exchange.

The third, experimental, stage consisted in the study of voles in vivarium conditions in order to expand the existing ideas about the peculiarities of their development. Capture was carried out in the southeastern Altai, on the Sailugem Ridge, in June-August 2016. Excrement, grass reserves and characteristic bones were used as landmarks to identify traces of life activity. Remnants, rocky places, especially those arranged in groups, and rocky outcrops were examined. Trap trenches and crush lines were placed at trace locations in numbers appropriate to the terrain. Trap localisation was recorded using photography and Garmin GPS.

The rodents were identified on the basis of the mentioned morphometric parameters, taking into account the coloration of skin and tail and the pattern of the chewing surface of teeth. The animals were quarantined for 14 days in a separate room in the vivarium. The lighting regime was 14 hours of light and 10 hours of darkness. Life span, breeding dates, annual cycle, morphometric indices and development of the resulting offspring were recorded.

Results

According to the materials of the Siberian Zoological Museum of the Institute of Animal Systematics and Ecology of the Siberian Branch of the Russian Academy

Figure 1. Administrative and territorial units where *Alticola strelzowi* were found. Source: compiled by the authors based on Global Core Biodata Resource (2024).

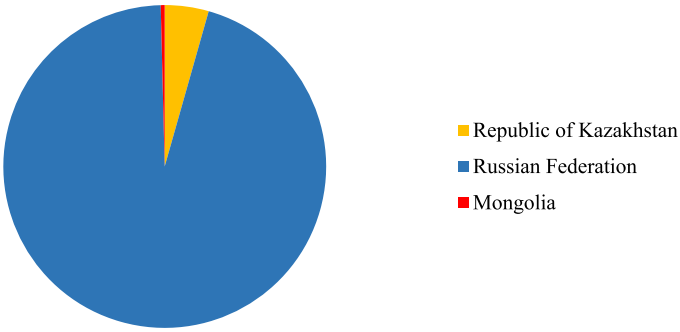

Figure 2. Percentage distribution of finds in the territories of different countries. Source: compiled by the authors.

of Sciences (Novosibirsk) and the Zoomuseum of the MSU, St. Petersburg, the distribution areas of the flat-headed vole are located in three countries: the Republic of Kazakhstan, the Russian Federation, and Mongolia (Novikov et al., 2023; Kassenbayev et al., 2024). One such region can be identified in Mongolia, 18 in Russia, and 6 in Kazakhstan. Predominantly, the habitats of *Alticola strelzowi* are associated with the Altai Mountains, in particular the Russian-controlled Altai territory, and Southern Altai, which is actually a mountain range belonging to Kazakhstan, as well as with the Sailugem Range, which is located on the border of the three countries, but predominantly repeats the border of Russia and Mongolia (fig. 1).

A total of 501 specimens were captured, distributed among the territories of the countries as follows: 22 were collected in the territory of Kazakhstan, and 478 in the territories of Russia and border Mongolia. Of these, 419 were collected in the Altai territories (fig. 2).

Table 1.
Finds made in the territory of the Republic of Kazakhstan.

Date	Number of finds	Location
1 June 1948	1	Ukirek village
1 June 1948	1	Zhanaarkinsky district, Zhezkazgan region
1981-1982	1	East Kazakhstan Region (EKR)
1981-1982	1	Southern Altai
1981-1982	1	Azu-Tau Ridge
1981-1982	1	Lake Markakol
6 June 1971	2	East Kazakhstan region, Ulan district, vicinity of Tainti village
15 June 1971	1	East Kazakhstan region, Ulan district, vicinity of Tainti village
7 June 1971	1	East Kazakhstan region, Ulan district, vicinity of Tainti village
18 June 1971	1	East Kazakhstan region, Ulan district, vicinity of Tainti village
28 May 2008-30 June 2008	11	Pavlodar region, Bayanaul district, neighbourhood of Bayanaul village, the Kazakh Uplands

Source: compiled by the authors.

The oldest specimen is dated 15 June 1946, found in the vicinity of Teeli village, Bai-Taiga district, Republic of Tuva, Russian Federation. The first specimens in the territory of Kazakhstan were caught two years later: 01 June 1948 in the central parts of the country: on the outskirts of Unrek village and in Zhanaarka district, Zhezkazgan region. The oldest specimens from the Altai territory were collected on 10 1November959, on the bank of the Akkol River, Kosh-Agach district. The latest finds that were entered in the registers were found in the period from 9 to 19 September 2016, 7 km from the southwestern part of Chagan-Uzun village, Kosh-Agach district, Russian part of Altai. The newest finds in the territory of Kazakhstan were obtained as a result of the expedition from 28 May to 30 June 2008, on the outskirts of Bayanaul village, Bayanaul district, Pavlodar region (table 1).

Morphological characteristics could not be described for all finds. Of all 22 specimens of flat-headed voles of northeastern Kazakhstan, only five, found in 1971 in the East Kazakhstan region, Ulan district, were characterised in this way (table 1). Two voles were male and three were female, respectively.

The body length of voles from the tip of the nose to the anal opening averaged 122 mm, where the maximum was 128 mm and the minimum 119 mm. A clearly expressed sexual dimorphism was recorded: the length of males exceeded the length of females by 4-9 mm.

The tail length from the base to the tip averaged 43.4 mm. The difference of this indicator for males and females had no traceable tendencies. The maximum value was 49 mm and the minimum was 39 mm. It is noteworthy that longer tails were inherent to individuals with short bodies and vice versa: the shortest tail was in the

Table 2.
Morphological parameters of *Alticola strelzowi* found in the territory of East Kazakhstan region.

Date	Sex	*L* (mm)	*C* (mm)	Pl (mm)	Au (mm)	Weight (g)
006 June 1971	Male	123	43	21	19	48
06 June 1971	Male	128	39	–	14	51.2
15 June 1971	Female	120	42	21	15	57
07 June 1971	Female	120	44	22	17	58.2
18 June 1971	Female	119	49	22	18	63.2

L, body length from nose to anal opening; *C*, tail length from the base to the tip; Pl, hind foot length from heel bone to end of phalanx of the middle toe; Au, ear length. Source: compiled by the authors.

male with the highest value of body length. Next, the length of the hind foot from the beginning of the middle toe phalanx to the end of the heel bone was recorded. It was rather homogeneous: from 21 to 22 mm. The average length of the ear was 16.6 mm. The range was 14 to 19 mm, with no obvious correlation with sex. The last parameter was mass. Here again there was a difference between individuals of different sexes. The mass of females, despite their smaller size, was almost 20% greater than that of males. The mean mass of females was 59.5 g, while for males this number was 49.6 g. The total mean mass was 55.5 g, with a maximum value of 63.2 g and a minimum of 48 g (table 2).

Among 419 specimens captured in the Altai area, morphological parameters could be obtained for 268. The characteristics of three female specimens, collected in 1959 on the Ukok plateau, were as follows: body length from 97 to 108 mm, with an average value of 103 mm, tail length averaged 38.6 mm, where the highest and lowest values of 43.2 and 33.5 mm, respectively, correlated with body length values similar to those of specimens from East Kazakhstan. The length of the hind foot was within 20 mm without significant variation, ear length showed variability from 13 to 15.6 mm, and the average mass was 27.7 g. In comparison with indicators of individuals found in the territory of Kazakhstan, all indicators are smaller: body length differs on the average by 19 mm, or by 17, if to compare sexes, mass at the same time appeared twice less.

The following 62 specimens were collected during July and August 1962 in the vicinity and at the headwaters of the Yustid River. Of these, 23 were females and 37 males. The mean body length was 104.2 mm. The minimum value was 87 mm and the maximum 168 mm. Sexual dimorphism was poorly expressed. Tail length averaged 38.7 mm. For these specimens, for the first time, the correlation between body and tail length predominantly meant that individuals with longer bodies had proportionally longer tails. Hind foot length was stable, averaging 19.4 mm. The average ear length was 17.2 mm, which was longer than in the previous two cases. Similar to voles in eastern Kazakhstan, females weighed more than males of comparable size, but when comparing direct measures, voles found at Yustid River averaged 24 mm smaller and weighed almost half as much. In July of the same year, another

16 specimens were found in the vicinity of Kindyktykul Lake, also in the Northeast Altai. Gender distribution of specimens: five females and nine males. The figures are comparable to those for voles from the vicinity of Yustid River, but slightly smaller overall. Mean length is 103.5 mm, with no obvious correlation with sex, tail length is 35.6 mm, hind foot is 19.2 mm, and ear length is 16.1 mm. The mass of females is higher than that of males of corresponding sizes, averaging 26.9 g.

At the same time, 62 more specimens were collected at Lake Dzhulukul in the same part of the Altai (26 females, 36 males). Body length ranged from 86 to 125 mm, averaging 105.5 mm. The average tail length is 37.9 mm, and the correlation is the same as in the examined voles of the southeastern Altai. The size of the hind foot averages 19.4 mm, and the length of the ear averages 17.2 mm. The average mass value is 30.1 g, females are heavier than males. In general, all parameters are not significantly different from those of previous specimens from this area.

The next section is 1964. In July and August of this year, specimens were collected in the territory of the western Spurs of the Chikhachev Range, at the source of the Tekelu River. Forty-six specimens were found, including 17 females and 29 males. There was no correlation with sex for body length, and its mean value was 103.2 mm, with a distribution from 81 to 125 mm. The average tail length is slightly higher than the value for voles collected in 1962 in other territories of the southeastern Altai, and is 41 mm. The value for foot length is typical for all voles: 20 mm. The average length of the ear is 16 mm. The mass of females is considerably higher than that of males, although insignificantly lower than that of voles of the corresponding zones: 29.4 g.

In the same year, another 10 specimens, of which six were males and four females, were found on the eastern spurs of the South Chui Squirrel in Altai. The body length of females is more uniform: from 92 to 96 mm, while the corresponding parameters of males range from 79.3 to 108 mm. The average value was 95.5 mm, which is less than that of all the groups of specimens considered. The mean tail length was 34.7 mm; no obvious correlation with sex or body length was observed. The value of foot length was 20 mm and ear length was 16.5 mm. The ears of these voles, proportionally, like the body length, are on average smaller than in the previous specimens. The same applies to the mass, the average value of which is 24.7 g. At the same time, the mass indices are rather correlated with body size than with sex, as in the cases above.

A similar situation with body length was observed in voles collected in the same year in Ongudai district on the southern slopes of the Semensky Ridge. The average value of this indicator among eight voles was 98.3 mm. At the same time, all other average parameters, except for the lengths of the foot and ear, are noticeably higher than for the previous specimens from the Altai territory: tail length 44.8 mm, and mass 35.5 g. At the same time, these indices have no traceable correlation with sex or size. During the same time period, 11 specimens were collected on the Terektin Ridge near the Black Sugash River. Their values are comparable to those in

the western Spurs of the Chihachev Ridge. No mass values are available for these samples.

In 1973, a search was conducted in the Altai territory: three specimens were found in the area of Kempi Gorge, four at the Chike-Taman Pass and 13 at Lake Manzherok. The average length for voles from all three locations was in the region of 104 mm, and the average tail length for the former and latter was 40.3 and 40.6 mm, respectively. There was an inverse relationship between body and tail length, similar to that seen in voles from eastern Kazakhstan. In voles of Lake Manzherok, this dependence is opposite, and the tails themselves are rather long: 45.5 mm. Mass values for these specimens are also not available. In 1974, voles of the Central Altai were studied in the territory of Ongudai settlement and on the right bank of the Chemal River. The mean body lengths of these voles were comparable: 102 and 101.5 mm. The correlation between tail and body length was not expressed. Weight values are average for Altai, 31 g and 35.5 g, and correlate more with body size than with sex (table 3).

In spite of the fact that data on voles found in Ulansky district were captured in small numbers, it is still clearly seen that the size and especially the mass of individuals exceeds those for any population in the Altai territory, irrespective of the comparability of time periods of expeditions. Also, clear correlations between body length and tail length, parameters and sex, etc. were characteristic of the voles from the East Kazakhstan Region.

Voles for the vivarium were captured in the Sailugem Range, southeastern Altai. Their morphological features corresponded to those averaged for Altai: body length 106 mm, tail length 37.5 mm and mass 35.5 g. Of the 34 individuals, 15 were male and 19 were female. Their average lifespan was approximately nine months, the shortest lifespan was one month and the longest was three years and four months. Four voles were of nonreproductive age at the time of capture. A group of 15 voles, of which 12 females, three of them of nonreproductive age, had two broods of 7-8 cubs in each reproductively mature female. A group of 10 individuals, of which four were reproductively mature females, did not have a second brood. The remaining voles were not reproductively active.

Discussion

Northeastern Kazakhstan and Altai are geographically separated by both the South Altai Range proper and the Irtysh and Ob rivers. From the data on the place where voles are described, it can also be noted that they often disperse along the perimeter of fresh water bodies: rivers, lakes, etc. Accordingly, free exchange of genes between different populations of voles is somewhat difficult. This is probably the reason for a rather statistically significant difference between all the morphometric indices studied.

Also, when analysing the geographical features of relief and climate of the territories of vole settlement, it can be noted that voles found in the territory of East

Table 3.
Specimens obtained on the Altai territory.

Location	Date	Specimens	*L* (av.)	*C* (av.)	Pl (av.)	Au (av.)	Weight (av.)
East Kazakhstan region, Ulan district, vicinity of Tainti village	15 June 1971	5	122	43.4	21.5	16.6	55.5
Altai, Kosh-Agach district, Ukok plateau	10 November 1959	3	103	38.6	20	14.2	27.7
Southeastern Altai, upper Yustid River	23 July-30 August 1962	62	104.2	38.7	19.4	17.2	33
Southeastern Altai, Kosh-Agachsky district, Kyndyktykul lake area	27 July-30 July 1962	16	103.5	35.6	19.2	16.1	26.9
Southeastern Altai, vicinity of Dzhulu-Kul Lake	12 July-2 August 1962	62	105.5	37.9	19.4	17.2	30.1
Southeastern Altai, western spurs of the Chikhachev Ridge, Sailugem, upper Tekelyu river	30 July-3 August 1964	46	103.2	41.0	20.0	16.0	29.4
Altai, eastern spurs of the South Chuysky Squirrel	22 July-27 July 1964	10	95.5	34.7	20.0	16.5	24.7
Altai, Ongudaysky district, southern slopes of Semenskiy ridge	22 July-10 August 1964	8	98.3	44.8	20.5	17.8	35.5
Altai, Usit-Koksinskiy district, Terektinskiy ridge, middle reaches of Black Sugash River	12 July-15 July 1964	11	105.8	39.6	20.0	17.9	–
Altai territory, Kosh-Agach, Kempi Gorge	6 August 1973	3	112.0	40.7	21.2	20.3	–
Altai territory, Chike-Taman pass, rock outcrops, Khabarovka village vicinity	10 August 1973	4	104.4	40.3	20.8	17.0	–
Altai territory, Mailinsky district, Manzherok Lake	1 June-30 August 1973	5	104.8	45.5	20.6	18.2	–
Central Altai, Ongudai district, Ongudai village	27 July-13 August 1974	9	101.5	39.9	20.4	17.3	31.8
Central Altai, right bank of Chemal River	24 August-25 August 1974	4	103.0	33.8	21.4	14.3	35.5

Source: compiled by the authors.

Kazakhstan and Pavlodar oblasts lived mainly in steppe conditions, and in the specific relief formation of the Kazakh Uplands and climate zone, which is also closer to steppe conditions than to mountainous conditions of the Altai Mountains. Probably, the large size of voles found in the territories of Kazakhstan is due to the fact

that it is easier for them to form caches and burrows in the rock. Although it is worth noting the low statistical diversity of these voles due to the small number of expeditions in the territories of Kazakhstan.

The ratio of finds in the territories of the Republic of Kazakhstan, the Russian Federation and Mongolia is also due to the number and frequency of expeditions rather than the ratio of vole distribution. The Global Core Biodata Resource (2024) website, which is an international network for the collection and availability of diversity data, presents 298 results for the query *Alticola strelzowi*. Of these, 225 are in Mongolia, 58 in Russia and eight in Kazakhstan. Finds made in Kazakhstan are dated 2016 and were made in Aktogai district of Pavlodar region, northern Kazakhstan. The predominance of finds from Mongolia is, accordingly, due to the fact that data from collections of Mongolian nature research institutes were entered into the site, but the data from this resource expand our understanding of the distribution of voles. Also, if we believe the distribution map of flat-headed voles provided by the resource, it also shows that *Alticola strelzowi* tends to settle near large freshwater bodies.

The conclusions about the significant difference in morphometric indices of flat-headed voles of northern Kazakhstan and southeastern Altai were made in the work of Oralova et al. (2015). For the study, voles were captured in the Pavlodar region and on the Sailugem Range, and museum materials for the respective regions were used. Although the authors focused on studies of other parameters, such as various skull parameters (basal and anterior length, tooth row parameters, diastema length, auditory ossicles, etc.), they similarly concluded that taxonomically significant parameters differ between these populations. The authors also generally agree with the assumption that these differences are caused by milder and warmer climatic conditions of the steppe in the territory of Kazakhstan, and note the different timing of breeding in the populations, which may additionally affect the comparison of these parameters of voles collected in different areas at the same time (Kassenbayev et al., 2024).

Bolshakov et al. (2012) compared voles of the genus *Alticola* in Russia, Kazakhstan, and Moldova. The authors determined that voles of the same species have different morphometric indices in different territories. They also emphasise climatic conditions and terrain features as one of the main factors of species diversification of voles of this genus. The shape of the crown of the third molar was fixed as the main morphometric index in the work. The work of Novikov et al. (2022) is devoted to the study of regularities between longevity and morphometric indices. Thus, the authors suggest that there is a direct correlation between the size and mass of small rodents, in particular flat-headed voles, and their life span. Taking into account these results, it can be suggested that voles from Pavlodar region and East Kazakhstan may have a longer life span than their species from the Altai territories.

Recently, studies related to the study of anthropogenic impact on the fauna of small mammals, in particular voles, have begun. Such a study was carried out by Zakanova et al. (2023). In their work, they studied how the number and species

composition of microvoles changes depending on the remoteness of the territory of their settlement from industrial zones and factories. It was determined that with the expansion of industrial zones, the fauna of small mammals in the vicinity decreases. Similar conclusions are reached by Dupal et al. (2017) in a similar study of industrial zones of the Pavlodar region. The authors note a decrease in the number and diversity of small mammals near zones of significant anthropogenic pollution, and the formation of an impoverished single-dominant fauna in such zones. With the reduction of anthropogenic impact, the percentage of biodiversity increases, but some species disappear or significantly reduce their number due to the dissection and destruction of biotopes (Shukurlu, 2020; Suchshikh et al., 2023).

The fragmentation of vole ranges is mentioned in the work of Abramov et al. (2019). This study was devoted to the review of ecological conditions with subsequent modelling of *Alticola tuvinicus* distribution ranges. In the course of this work, a number of factors affecting the decline in the numbers of these rodents were highlighted, among them anthropogenic impact, and expansion of industrial and technogenic zones, which deepen the separation caused by geographical and climatic factors.

Kotti & Zhilzova (2020) and Dahmana et al. (2020) studied the distribution of voles and small mammals in general and concluded that many of them are vectors of plague pathogens. The study of Matrosov et al. (2021) was devoted to the effectiveness of emergency disinsection and deratisation carried out as part of the nonspecific prevention of plague in the territory of the Sailugem Ridge in 2016-2021. According to Gravinatti et al. (2020), during these years, the efficiency of deratisation in the territories of populated areas was 88%. This aspect obviously complicates the prospects of bioindication using voles. Also, Fay et al. (2020) give an example of using other rodents to track the habitat of voles. It may also be possible to monitor the abundance of other species using voles.

The results of rearing *Alticola strelzowi* in vivarium conditions in this study gave mixed results and rather significant variation in the age and reproductive potential of voles. At the same time, it is worth saying with certainty that voles of this species are able to live and reproduce in captivity. Novikov et al. (2022) conducted studies to compare the survival rate of two voles of the genus *Alticola* in laboratory conditions and to determine their life span. It was noted that the maximum age reached by the flat-headed vole was six years and three months, which is almost twice as long as the values obtained in this study. However, on average, lowland voles *A. tuvinicus* lived longer in the vivarium. The authors justify this by the unsuitability of vivarium conditions for high-mountain voles and suggest that in nature, flat-headed voles live longer than representatives of other species, although in general the two vole species studied here had a significantly higher life expectancy in captivity than others (Zakanova et al., 2023).

In general, the differences in morphometric indices between *Alticola strelzowi* of Kazakhstan and Altai are confirmed both by this study and the data obtained by other scientists. This is rather due to the geographical separation and climatic

features of the regions, together with the peculiarities of their relief. The systematisation of the available preserved data on voles of these regions opens up the possibility of using this information both for bioindication of anthropogenic impact on the region and, if necessary, for understanding the territories of distribution of these rodents for preventive measures related to the possibility of their transmission of infections dangerous for the population.

Conclusions

Stenobiont species of small mammals have prospects to be used in bioindication of climate change and negative anthropological impact. For Kazakhstan, such a species could be the flat-headed vole, *Alticola strelzowi*. There is little information on this species of vole, and what is available is rather unsystematised. The data obtained during the study of the archives of the Siberian Zoological Museum of the Institute of Animal Systematics and Ecology of the Siberian Branch of the Russian Academy of Sciences (Novosibirsk) and the Zoomuseum of the MSU, St. Petersburg allowed us to outline a scheme of dispersal of these voles and compare morphometric indices of their different populations found in the territory of northeastern Kazakhstan and Altai.

It was determined that flat-headed voles found in East Kazakhstan and Pavlodar regions exceeded the size of voles settled in Altai. Thus, body and tail lengths differed by 15% on average, with the average for Kazakhstan being 122 mm and for Altai 104 ($\pm$4) mm. The average mass differed by a factor of almost two: 55.5 g vs. 35.5 g. Also, morphometric indices of Kazakhstan voles had more correlations with sex. Thus, the mass of females significantly exceeded that of males, while the body length of females was shorter. Tail length was predominantly inversely proportional to body length, i.e., voles with short bodies had long tails and vice versa. Such correlations were less frequent for voles found in Altai. Most often, although not in all populations, the tendency to predominance of the weight of females over this indicator in males was preserved. In rare populations, a correlation between tail length and body length was observed, but there was a direct relationship between these values.

No traceable trends in morphometric parameters were observed over time. The differences between populations are most likely due to geographical separation and different climatic conditions. However, data on the prevalence and condition of *Alticola strelzowi* populations need to be expanded and updated. Under vivarium conditions, the longevity of voles was significantly reduced compared to free-living individuals, but they were reproductively active. Most females produced at least one brood during the summer. Therefore, further studies in this direction are promising, to study details of vole behaviour and activity.

Author contributions

A.Z.: software, visualisation, writing (original draft); Z.S.: data curation, formal analysis, project administration; M.K.: investigation, formal analysis; N.E.: resources; R.U.: conceptualisation, methodology, supervision, writing (review and editing). All authors have read and agree to the published version of the manuscript.

References

Abramov, S.A., Lopatina, N.V., Moroldoev, I.V. & Litvinov, Y.N. (2019) Present range of Tuva mountain vole *Alticola tuvinicus* Ognev, 1950 (Review of Environmental Conditions and Modeling). *Contemp. Probl. Ecol.*, 12, 453-463. DOI:10.1134/s1995425519050020.

Abutalip, A., Bizhanov, A., Matikhan, N., Karabassova, A. & Orynbayeva, B. (2024a) Regional epidemiology of brucellosis infection in modern conditions of animal husbandry technology in Kazakhstan (by the degree of spread and incidence). *Sci. Horiz.*, 27, 20-31. DOI:10.48077/scihor5.2024.20.

Abutalip, A., Suchshikh, V., Aitzhanov, B., Ospanov, Y. & Kanatov, B. (2024b) Current state of animal anthrax problems in the Republic of Kazakhstan and ways to solve it. *Int. J. Vet. Sci.*, 13, 922-930. DOI:10.47278/journal.ijvs/2024.198.

Bezsonov, Y. & Andreev, V. (2016) Justification and formalization of approach to regional environmental safety evaluation. *East.-Eur. J. Enterp. Technol.*, 2, 9-18. DOI:10.15587/1729-4061.2016.64843.

Bolshakov, V.N., Vasilyeva, I.A. & Vasilyev, A.G. (2012) Morphological disparity among rock voles of the genus *Alticola* from Mongolia, Kazakhstan and Russia (Rodentia, Cricetidae). *Erforsch. Biol. Res. Mongol.*, 12, 105-115. https://digitalcommons.unl.edu/biolmongol/13/.

Bragina, T.M., Nowak, A., Vanselow, K.A. & Wagner, V. (2017) Grasslands of Kazakhstan and Middle Asia: the ecology, conservation and use of a vast and globally important area. In: V.R. Squires, J. Dengler, L. Hua & H. Feng (Eds) *Grasslands of the World: Diversity, Management and Conservation*, pp. 139-167. CRC Press. Boca Raton, FL, USA.

Chulenbayeva, L., Ilderbayev, O., Suleymeneva, D., Kaliyeva, A., Kabdykanov, S., Nurgaziyev, M., Nurgozhina, A., Sergazy, S., Kozhakhmetov, S. & Kushugulova, A. (2022) Prolonged inhalation exposure to coal dust on irradiated rats and consequences. *Sci. World J.*, 2022, 8824275. DOI:10.1155/2022/8824275.

Dahmana, H., Granjon, L., Diagne, C., Davoust, B., Fenollar, F. & Mediannikov, O. (2020) Rodents as hosts of pathogens and related zoonotic disease risk. *Pathogens*, 9, 202. DOI:10.3390/pathogens9030202.

Dokuchaev, V. (1883) *Russian Chernozem*. A.S. Suvorin Typography, St. Petersburg, Russia. Available at: https://irbis-nbuv.gov.ua/ulib/item/ukr0000013126.

Dupal, T.A., Sergazinova, Z.M., Erzhanov, N.T. & Litvinov, Y.N. (2017) Preliminary assessment of changes in the structure of small mammal communities caused by industrial pollution in the North Kazakhstan Region. *Contemp. Probl. Ecol.*, 10, 700-706. DOI:10.1134/s199542551706004x.

Fay, R., Michler, S., Laesser, J., Jeanmonod, J. & Schaub, M. (2020) Large-scale vole population synchrony in Central Europe revealed by kestrel breeding performance. *Front. Ecol. Evol.*, 7, 512. DOI:10.3389/fevo.2019.00512.

Global Core Biodata Resource (2024) Alticola strelzowi *(Kastschenko, 1899)*. Available at: https://www.gbif.org/ru/occurrence/map?taxon_key=2438719.

Gravinatti, M.L., Barbosa, C.M., Soares, R.M. & Gregori, F. (2020) Synanthropic rodents as virus reservoirs and transmitters. *Rev. Soc. Bras. Med. Trop.*, 53, e20190486. DOI:10.1590/0037-8682-0486-2019.

International Union for Conservation of Nature (2024) *Red List of Threatened Species: Flat-headed Vole:* Alticola strelzowi. Available at: https://www.iucnredlist.org/species/958/115055112.

Kassenbayev, G., Kerimova, U., Rakhimzhanova, G. & Shalgimbayeva, K. (2024) Animal husbandry market in Kazakhstan: dynamics and prognosis. *Sci. Hor.*, 27, 176-188. DOI:10.48077/scihor4.2024.176.

Kirimbayeva, Z., Abutalip, A., Mussayeva, A., Kuzembekova, G. & Yegorova, N. (2023) Epizootological monitoring of some bacterial infectious diseases of animals on the territory of the Republic of Kazakhstan. *Comp. Immunol. Microbiol. Infect. Dis.*, 102, 102061. DOI:10.1016/j.cimid.2023.102061.

Kotti, B.K. & Zhilzova, M.V. (2020) The significance of fleas (Siphonaptera) in the natural plague foci. *Entomol. Rev.*, 100, 191-199. DOI:10.1134/s0013873820020074.

Matrosov, A.N., Chipanin, E.V., Nikitin, A.Y., Denisov, A.V., Mishchenko, A.I., Rozhdestvensky, E.N., Kuznetsov, A.A. & Popov, N.V. (2021) Efficiency of disinsection and deratization aimed at reducing epidemiologic risks in Gorno-Altaiskiy high-mountain natural plague focus. *Health Risk Anal.*, 4, 136-145. DOI:10.21668/health.risk/2021.4.15.eng.

Mordkovich, V.G., Khudyaev, S.A., Dudko, R.Y. & Lyubechanskii, I.I. (2020) Zoological indication of climate change in the Central Kazakh steppe compared to the middle of the 20th century using the example of carabid and tenebrionid beetles. *Contemp. Probl. Ecol.*, 13, 443-468. DOI:10.1134/s1995425520050078.

Napierała, A., Labijak, B., Skwierczyński, F., Konwerski, S. & Błoszyk, J. (2015) Influence of habitat type and natural disturbances on uropodine mite communities (Acari: Mesostigmata: Uropodina) in oak-hornbeam forests in Central Europe. *Int. J Acarol.*, 41, 41-52. DOI:10.1080/01647954.2014.985713.

Novikov, E.A., Lopatina, N.V., Titova, T.V., Zadubrovskiy, P.A. & Litvinov, Y.N. (2022) Physical condition, activity, and longevity of two rock vole species: *Alticola tuvinicus* and *A. strelzowi*. *Proc. Zool. Soc.*, 75, 103-110. DOI:10.1007/s12595-021-00428-9.

Novikov, E.A., Demchenko, E.E., Zadubrovskaya, I.V., Zadubrovskiy, P.A., Matskalo, L.L., Nazarova, G.G., Novikova, E.V., Potapov, M.A., Potapova, O.F. & Proskurnyak, L.P. (2023) What determines the life span of a species? *Biol. Bull. Rev.*, 13, 383-396. DOI:10.1134/s2079086423050043.

Nurgaliyeva, A., Zhumagalieva, B., Asrepov, G., Bekniyazova, D. & Kussainov, K. (2024) Development of innovative processes in the field of agriculture of the Republic of Kazakhstan. *Sci. Horiz.*, 25, 141-151. DOI:10.48077/scihor6.2024.141.

Oralova, A.B., Erzhanov, N.T., Abramov, S.A., Lopatina, N.V. & Litvinov, Y.N. (2015) Craniometrical differentiation of population of the flat-headed vole in North Kazakhstan and South-East Altai. *Biosci. Biotechnol. Res. Asia*, 12, 783-790. DOI:10.13005/bbra/2260.

Panteleeva, S.N., Levenets, J.V., Novikovskaya, A.A., Reznikova, Z.I., Lopatina, N.V. & Litvinov, Y.N. (2020) Experimental investigations of hunting behavior in the mountain voles *Alticola strelzowi* and *Alticola Tuvinicus* (Rodentia, Cricetidae). *Biol. Bull.*, 47, 1059-1065. DOI:10.1134/s1062359020080099.

Pozdnyakov, A.A. (2022) Application of the epigenetic landscape model to the study of the structure of morphotypic variability in the third upper molar (M3) of rock voles (*Alticola*, Rodentia: Arvicolinae). *Biol. Bull.*, 49, 1433-1442. DOI:10.1134/s106235902209028x.

Román-Palacios, C. & Wiens, J.J. (2020) Recent responses to climate change reveal the drivers of species extinction and survival. *Proc. Natl Acad. Sci. U.S.A.*, 117, 4211-4217. DOI:10.1073/pnas.1913007117.

Sakkaraeva, D. & Abdurashitov, A. (2024) Application of environmental, social and governance practices in agriculture. *Sci. Hor.*, 27, 116-127. DOI:10.48077/scihor12.2024.116.

Shukurlu, Y.H. (2020) The effect of selenium on the supramolecular structure and thermal characteristics of fibroin bombyx mori l. *Period. Tche Quim.*, 17, 591-598. http://www.deboni.he.com.br/Periodico34.pdf.

Skliar, V., Skliar, Y., Sherstiuk, M., Smoliar, N. & Kanivets, O. (2024) Use of environmental indicators to assess the state of forest ecosystems. *Ukr. J. For. Wood Sci.*, 15, 25-42. DOI:10.31548/forest/3.2024.25.

Suchshikh, V., Karimov, A., Yussupov, M., Aitzhanov, B., Abutalip, A., Mussayeva, A., Yegorova, N., Mamanova, S. & Kanatov, B. (2023) Effectiveness of different means of disinfection against soil foci of anthrax (Bacillus anthracis) burials at a depth of up to 3.5 m: an experimental study. *Casp. J. Environ. Sci.*, 21, 893-902. DOI:10.22124/cjes.2023.7147.

Tapbergenov, S.O., Zhetpisbaev, B.A., Ilderbayev, O.Z., Zhetpisbaeva, H.S., Olzhayeva, R.R., Prozor, I.I., Usenova, O.A. & Ilderbayeva, G.O. (2013) Free radical oxidation in rats in the delayed period after combined exposure to dust and radiation. *Bull. Exp. Biol. Med.*, 154, 747-749. DOI:10.1007/s10517-013-2046-z.

World Conservation Monitoring Centre (2001) *Tiger*. Available at: https://wwfeu.awsassets.panda.org/downloads/Tigeraccounto1.doc.

World Wildlife Fund (2024) *Sumatran Orangutan*. Available at: https://www.worldwildlife.org/species/sumatran-orangutan.

Yespembetov, B.A., Syrym, N.S., Syzdykov, M.S., Kuznetsov, A.N., Koshemetov, Z.K., Mussayeva, A.K., Basybekov, S.Z., Kanatbayev, S.G., Mankibaev, A.T. & Romashev, C.M. (2019) Impact of geographical factors on the spread of animal brucellosis in the Republic of Kazakhstan. *Comp. Immunol. Microbiol. Infect. Dis.*, 67, 101349. DOI:10.1016/j.cimid.2019.101349.

Zakanova, A.N., Erzhanov, N.T. & Litvinov, Y.N. (2023) Diversity and characteristics of small mammals in the north-east Kazakhstan with various anthropogenic pollution. *Exp. Biol.*, 97, 117-131. DOI:10.26577/eb.2023.v97.i4.011.