

Conference Paper

Current State of Pasture Vegetation of the Arid Zone (On the Example of Key Rural Municipalities of the Republic of Kalmykia)

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Abstract

The article presents the results of field observations over 2012--2018 carried out by the Department of Environmental Research of the Institute for Complex Studies of Arid Territories. The work includes materials on the climatic review and the original results of geobotanical investigation of 5 farms in rural municipalities of the Republic of Kalmykia (RK) over the period of the study. We used materials of a large geobotanical survey of YUZHNIIGIPROZEM Company (1991--1995) and materials of earth remote sensing (by Landsat satellite). According to the studies, the period from 2012 to 2018 demonstrates a general trend of climate warming throughout the territory of Kalmykia accompanied by a decrease in precipitation and an increase in extreme droughts in the summer. Geocological monitoring of pastures at five key sites of the RK revealed that in the dry steppe zone (Manych municipality) and in the semi-desert zone (Khanatinsky municipality), deterioration of pastures is observed; in the desert zone (Adykovskoye municipality), significant degradation processes were identified associated with strong anthropogenic impact and fires, manifested in the loss of valuable food crops (wormwood) and increased influence of cereal crops. Floristic and phytocenotic analyzes revealed an increase in the number of plant species in the weed and ruderal groups.

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1. Introduction

The main branch of the agro-industrial complex (AIC) of the Republic of Kalmykia is animal husbandry, due to the presence of pasture land occupying more than 80% of its territory. Since the beginning of the 1960s, Kalmyk Caspian pastures began to be used year-round. The number of grazed livestock until 1985 was increasing annually. Overloading of pastures in this period varied from 320 to 550 %, and the average yield as a result of strong overgrazing decreased to 0.8--1.4 centners per hectare forming a strong and very strong stages of pasture digression [1]. The influence of several

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factors during this period of time, such as periodic droughts, abnormal load on pastures, plowing of not arable land, etc., led to the formation of the first anthropogenic desert in the south-east of the republic. In the early 1990s, there was a sharp decline in livestock due to the difficult socio-economic situation in Russia, which affected all branches of the agro-industrial complex. A sharp decline in livestock has served to some restoration of pasture vegetation, but as a result, non-compliance with pasture rotation, excessive overgrazing and lack of measures to care for grass stand led to a deterioration of pasture vegetation, an increase in the extent of their shedding and the growth of harmful plants.

The study of the current state of vegetation and soil cover, most sensitive to the increasing anthropogenic impact, is the main task for the development of adaptive agriculture in arid regions of the Republic of Kalmykia. The dry periods, characteristic of the republic, provide for the peculiarity of using natural pastures. Currently, there is a progressive climate warming trend [2], accompanied by a decrease in precipitation and an increase in strong droughts in the summer period. All this is reflected in pasture yields, its decline, and as a result, leads to a reduction in feed capacity of pastures.

To determine the current state of pastures of the studied objects in the period from 2012 to 2018, studies were conducted in three natural-agricultural zones (dry steppe, semi-desert, desert), while in terms of geobotanical zoning (steppe and desert), in vegetation zones within the republic.

2. Materials and Methods

The materials of the study were own field data collected during geobotanical monitoring during the growing seasons of 2012-2018. Key pasture ranges were selected based on the analysis of geobotanical survey materials of the Kalmyk branch of YUZHNI-IGIPROZEM (1980, 1989, 1991, 1994–1995) and the analysis of materials from different-time satellite imagery from the Landsat satellite (2012–2013).

The objects of research are located in different natural-agricultural zones [3]: in the dry-steppe zone, the Manych municipality of the Iki-Burul'sky district; in the semi-desert, Yergeninsky municipality of the Ketchenerov'sky district; Khanatinskoe municipality of the Maloderbetov'sky District; in the desert zone, Privolnoye municipality of the Yashkul district and Adykov municipality of the Chernozemelsky district.

The authors conducted a set of studies, including: a standard geobotanical description of the sites, sampling of plant samples to determine the yield of the vegetative mass, description of soil cuts and soil sampling for laboratory studies [4, 5]. When

assessing the phytocenotic composition of plant communities, the principle of phytocenosis isolation was used based on the biotope generality, species composition and species dominance.

Accounting sites for determining the yield with the dimensions of 1x2.5 m were laid with 4-fold repetition. Yield determination was carried out by cutting plants at a height of 2–3 cm from the soil surface. Latin names of plants are given using a report of S.K. Cherepanov [6]. The abundance of plants was assessed according to the Drude scale. The laboratory stage included the creation of a database of field research results in MS Excel, which included geodata on soil typology, vegetation, species composition of plants, GPS receiver data for stationary and reconnaissance observations.

3. Discussion

3.1. Analysis of the climatic conditions of the Republic of Kalmykia over 2012--2018

The Republic of Kalmykia is mainly under the influence of the Asian anticyclone. With insufficient atmospheric moistening, the territory of Kalmykia is sufficiently supplied with heat, as evidenced by the sum of temperatures during the period of active vegetation of plants. The annual variation of monthly average air temperatures is a sinusoidal curve: from February to July an increase in temperature is observed, and its further fall until January. The average annual rainfall is small. In different parts of Kalmykia, it amounts from 150 to 350 mm of precipitation. Among the adverse weather phenomena that impede the normal growth and development of pasture vegetation are late spring and early autumn frosts, dry winds, strong winds and dust storms [7].

Over 2012--2018, there is a general trend of climate warming throughout the territory of Kalmykia. In the desert and semi-desert zones, there were long periods of drought (May-August) and an uneven distribution of precipitation throughout the year. In the dry steppe zone in summer the amount of precipitation was higher than in other zones.

Warm winters should be attributed to the peculiarities of climatic changes on the territory of Kalmykia. Over this period, extremely low temperatures were not observed; the cold period was characterized by frequent thaws. The amount of precipitation during the cold period at the indicated lands changed as follows: a small amount of precipitation was noted in 2015--2017 (from 143.2 to 205.1 mm), average values were noted in 2013, 2018 (from 188 to 379 mm), and the largest amount of precipitation, during the study period, was recorded in 2014 and ranged from 256 to 515 mm [8--11].

The last three years of observations (2016--2018) were characterized by an increase in the winter frost-free period with no low winter temperatures; in early spring, with increasing temperatures from the first decade of April; a long dry summer and a long period of high temperatures with a period (July temperatures rose to +40...+43 °C), dry winds and occasional thunderstorms. The autumn-winter period was marked by warm positive temperatures and a large amount of precipitation at the end of autumn. The negative impact of the prevailing weather conditions was also aggravated by soil drought, which begins as early as the end of April.

3.2. Yergeninsky municipality of the Ketchenerovsky district of Kalmykia

The territory of the pasture testing lands of the Yergeninsky municipality of the Ketchenerovsky district is located within two geomorphological areas--the Yergeninsky Upland and the Pre-Caspian lowland. The land tenure of the farm is located in a semi-desert zone; according to geobotanical zoning, the territory of the farm belongs to the steppe zone. The zonal soils of the Yergeninsky SMO are light and medium-solonetzic light chestnut soils in combination with medium and small solonetz.

Total for the period of 2012-2018, 116 geobotanic descriptions of plant communities for the spring and autumn vegetation periods were performed at 10 key sites. As a result of the analysis of the species composition of the flora of 10 key areas in the phytocenoses, 124 species of plants belonging to 29 families and 86 genera were recorded. The most numerous of them are species species of the family *Poaceae* (22), *Asteraceae* (20), *Chenopodiaceae* (13), *Brassicaceae* (9) and *Fabaceae* (9). The remaining families are represented by 1 to 7 species, of which 12 families are single-species. Most of the plants surveyed key areas are perennial herbaceous plants (51.6 %), as well as annual and biennial species (35.5 %), which is characteristic of the floras of arid territories. Dwarf shrubs account for 9.7 % of the total number of marked plants (*Artemisia lerchiana*, *A. pauciflora*, *A. santonica*, *A. taurica*, *Anabasis aphylla*, *Kochia prostrata*, *Tanacetum achilleifolium*). Semishrubs take up 2.4 % (*Anabasis aphylla*, *Halocnemum strobilaceum*, *Teucrium polium*). Shrubs are represented by one species (0.8 %) -- *Ephedra distachia*.

At the key plots under study, valuable (well eaten by animals) in fodder plant species occupy 14 %, poorly eaten take up 23 %, weed and poisonous species amount to 30 %, non-eaten make up 33 % of the total number of species.

The comparative analysis of the geobotanical data of vegetation cover of this key object over 1989 [12] and 2012-2018 showed some changes in the composition and

structure of plant communities. At 4 key sites, there was a slight improvement in the state of pasture phytocenoses: annuals dropped out of the names of plant communities, their abundance did not exceed 5--7 %, while valuable fodder plants such as fescue (*Festuca valesiaca*), coves (*Stipa lessingiana*, *S. sareptana*, *S. capillata*) and Lerch wormwood (*Artemisia lerchiana*) have increased their abundance and act as dominants and subdominants of the phytocenoses. At the remaining 6 key grazing grounds (60 %), no significant changes occurred; the digression stage remained unchanged.

3.3. Khanatinsky municipality of the Maloderbetovsky district of Kalmykia

The territory of the Khanatinsky municipality is located in the northern part of the Caspian lowland -- Sarpinsky lowland, which is a plain with a slope to the south-east in the semi-desert zone. The land tenure of the farm is located in a semi-desert zone; according to geobotanical zoning, the territory of the farm belongs to the steppe zone. The prevailing soils on the territory of the Khanatinsky municipality of the Maloderbetovsky district of the Republic of Kalmykia are brown semi-desert soils in combination with medium and small solonetz.

During the study period, 123 geobotanical descriptions were performed. The total species richness in the flora of 10 key areas in the study area amounted to 147 species of higher flowering and 1 species of higher spore plants (*Equisetum arvense* L.), belonging to 99 genera and 24 families. The most numerous families are *Asteraceae* (29 species), *Chenopodiaceae* (27 species), *Poaceae* (22 species) and *Brassicaceae* (9 species). Polycarpic and monocarpic herbs occupy the dominant role in the flora of the key sites studied, 47.3 % and 42.5 %, respectively. The main form of polycarpic herbs is represented by firm-bunch and taproot perennials. The dwarf shrubs, comprising 12 species (5 species of the genus *Artemisia*, 2 species of the genus *Camphorosma*, *Kochia prostrata*, *Tanacetum achilleifolium*, *Limonium suffruticosum*, *Potentilla bifurca*, *Salsola dendroides*), accounted for 8.1 %. Of the semi-shrubs involved in plant communities of key plots, 2 species (1.4 %) were noted -- *Alhagi pseudalhagi* and *Anabasis aphylla*. Shrubs are represented by 1 species (0.7 %) -- *Salsola arbuscula*.

A comparative analysis of the consumption of plant species revealed that valuable, well eaten by various animal species, feed species occupy 11 %, poorly eaten take up 19 %, weed and poisonous species take up 36 %, non-hungry make up 34 % of the total number of species.

Comparative analysis of current data with geobotanical description of 1980 [13] showed changes in the state of pastures. At 6 key sites out of 10 (60 % of the total) degradation processes occur with an increase in the pasture digression stage by one or two steps. There was a change of dominant species in the studied phytocenoses: feather grass (*Stipa capillata*), prairie June grass (*Koeleria cristata*), Volga fescue (*Festuca valesiaca*) were replaced by bulbous bluegrass (*Poa bulbosa*), which began to play the role of a subdominant in 6 key areas. At 4 key areas (40 %), there was no improvement in pasture status compared to the 1980-data, the stage of pasture digression remained unchanged.

3.4. Adykovskoye municipality of the Chernozemelskiy district of Kalmykia

The territory of the key areas of the object of study is located within the Caspian lowland of the desert zone. The predominant soils are zonal brown sabulous and sandy occurring in combination with solonetz.

During the period 2012--2018, we carried out 110 geobotanical descriptions. The total species diversity of the test lands at 9 key sites comprised 96 species of flowering plants belonging to 21 families. The most numerous families are *Poaceae* (24 species), *Asteraceae* (19 species) and *Brassicaceae* (9 species). Monocarpic grasses constituting 50.0 % are mainly represented by weed and ruderal species such as *Lappula squarrosa*, *Anisantha tectorum*, *Ceratocarpus arenarius*, and others. Polycarpic herbs make up 37.5 % (*Poa bulbosa*, *Stipa lessingiana*, *S. sareptana*, *S. capillata*, and others). The dwarf shrubs account for 9.4 % (*Artemisia taurica*, *Kochia prostrata*, *Camphorosma monspeliaca*, *Tanacetum achilleifolium*, *Frankenia hirsuta*). Among dwarf shrubs, we noted *Alhagi pseudalhagi* and *Anabasis aphylla*, which amount to 2.1 %, as well as shrub (1.0 %) *Tamarix ramosissima*.

A comparative analysis of the consumption of plant species revealed that valuable, well eaten by various animal species, feed species occupy 16 %, poorly eaten take up 29 %, weed and poisonous species take up 30 %, non-hungry make up 25 % of the total number of species.

Comparison of field data with 1995 data [14] showed deterioration of vegetation on pastures. Only at one key area (9th), there was an improvement and a decline in the stage of pasture digression as a result of a change in the dominant ephemeroïd of the bulbous bluegrass (*Poa bulbosa*) to Lerch wormwood (*Artemisia lerchiana*). The remaining 8 key sites showed a deterioration in the state of vegetation cover and

an increase in the stages of pasture digression. The spread of Crimean wormwood (*Artemisia taurica*), feather grass (*Stipa capillata*), where swarf shrub desert-steppe species (Lerch wormwood) have been replaced by turf-grass steppe species has been identified. The wide spread of explerents of low love grass (*Eragrostis minor*) and green amaranth (*Amaranthus retroflexus*) was noted. On the medium solonetztes, wormwood dominated; however, overgrazing led to the formation of monodominant bulbous-bluegrass communities with a general projective cover of the community (5--15 %), poor floristic composition (6--11 species) and consisting of ruderal-ephemeral plant species.

3.5. Privolnoye municipality of the Yashkulskiy district of Kalmykia

Pasture areas of the research object are located in the desert zone (grazing grounds of the Privolnensky municipality of the Yashkul district). The last geobotanical descriptions of this territory were made in 1994. Zonal brown soils are widespread throughout the key site and occupy even areas of relief.

During the studies of 2012--2018, we carried out 151 geobotanical descriptions. The total species diversity of the test lands at 9 key sites comprised 112 species of flowering plants belonging to 23 families. In the 2018 growing season, we noted 57 species of flowering plants. Numerous families are *Chenopodiaceae* (20 species), *Asteraceae* (19 species) and *Poaceae* (19 species). The dominant life forms are polycarpic (42.0 %) and monocarpic (42.8 %) herbs. Most monocarpic grasses are represented by ruderal, harmful and poisonous species: *Lappula patula*, *Anisantha tectorum*, *Ceratocarpus arenarius*, etc. Of the total number of plant species in key areas involved in the addition of vegetation, the share of dwarf shrubs accounts for 12.5 %, subshrub (*Alhagi pseudalhagi*, *Anabasis aphylla*) take up 1.8 %, shrubs (*Ephedra distachya*) make up 0.9 %.

At the key plots under study, valuable (well eaten) in fodder plant species occupy 13 %, poorly eaten take up 20 %, weed and poisonous species amount to 36 %, non-eaten make up 31 % of the total number of species.

A comparison of the field data for the period 2012--2018 with the data of geobotanical survey in 1994 [15] revealed the followin: in four of the nine pasture range studied, there was a slight improvement in vegetation. At the remaining five plots, the stage of pasture digression remained consistently high. Just as in the Adykovsky municipality, explerants -- low love grass (*Eragrostis minor*) and green amaranth (*Amaranthus retroflexus*) -- are widespread throughout the entire household.

3.6. Manych municipality of the Iki-Burulsky district of Kalmykia

The territory of the pasture lands of the Manychsky municipality is located in the southern marginal part of the Ergeninsky Upland, within the limits of the dry steppe agricultural zone and the steppe geobotanical zone. The soil cover is characterized by heterogeneity, a wide distribution of light chestnut soils in combination with solonchaks.

During the work in 2012--2018, 107 geobotanical descriptions of communities were made in the study area. The total species diversity of phytocenoses of pastures on the 8 studied sites was 177 plants belonging to 32 families; 1 species belonged to the lichen Parmeliaceae. The most numerous were the families *Asteraceae* (28 species), *Poaceae* (26 species), *Chenopodiaceae* (20 species). Representatives of the *Poaceae* family and *Asteraceae* were edificators, dominants and co-dominants of the studied communities: *Stipa lessingiana*, *Stipa capillata*, *Stipa sareptana*, *Poa bulbosa*, *Festuca valesiaca*, *Artemisia taurica*, *A.austriaca*. The analysis of life forms showed that polycarpic herbs dominate in the flora of the object under study (50.2 %), of which taproot perennials are numerous, and rhizomatous and caespitose forms take a smaller share. Monocarpic grasses (41.8 %) also have a large group in the composition of the grass stand, most of which fall on long-growing annuals, which indicates an increase in disturbance of the studied communities. A variety of dwarf shrubs is sufficient (6.5 %), most of them are community co-dominants, and they dominate on saline soils.

At the key plots under study, valuable (well eaten) in fodder plant species occupy 10 %, poorly eaten take up 18 %, weed and poisonous species amount to 37 %, non-eaten make up 35 % of the total number of species.

Analysis of geobotanical data (1991) [16] and data from field studies 2012--2018 showed a change of communities, where at 6 key areas of eight marked there was deterioration of vegetation and an increase in pasture digression. At 2 key sites, the state of phytocenoses and the stage of pasture digression did not change. The transformation took place in the change of the dominant species: the caespitose cereals (*Stipa lessingiana*, *S.sareptana*) became community co-dominants, the Lerch wormwood (*A.lerchiana*) was replaced by *Arthmisia taurica* and Austrian wormwood (*A. austriaca*). There was a decrease in the abundance and projective cover of the caespitose cereals (*Festuca valesiaca*, *Stipa lessingiana*), an increase in the bulbous bluegrass ephemeroïd (*Poa bulbosa*), which indicates a degradation of the vegetation of pasture lands.

4. Conclusions

Long-term studies of five key objects allowed determining the current state of pasture vegetation: on pasture lands of the *Manychsky municipality of the Ika-Burulsky district*, located in the dry-steppe natural-agricultural zone, there was a deterioration of pasture status at 6 key areas of 8. There were changes in the shift of dominant species, where forage species decreased their abundance, while the species less eaten (weed) began to dominate and form communities. A similar situation is observed in the pastures of the *Khanatinsky municipality of the Maloderbetovsky district* (semi-desert agricultural zone), where instead of the caespitose cereals (feather grass, prairie June grass, Volga fescue), the bulbous bluegrass ephemeroïd began to play the leading role in the composition of the phytocenoses. In the *Yergeninsky municipality of the Ketchenerovsky District* (semi-desert agricultural zone) and in the *Privolnensky municipality of the Yashkul district* (desert agricultural zone), there were no significant changes in the composition and structure of plant communities; the stages of pasture digression did not change. On the territory of the *Adykovo municipality Chernozemelsky District* (desert agricultural zone), significant degradation processes were identified associated with a strong anthropogenic pressure and fires, manifested in the loss of valuable fodder plant species (wormwood) from the herbage and increased influence of the cereal species.

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