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Studying the Impact of Grazing on The Current State of Grassland in The Semi-desert Zone

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Agrarians of the Republic of Kazakhstan face the task of exporting 60 tons of meat by 2016. While 20 years ago Kazakhstan exported over 180 thousand tons of meat, in 2009 it exported only 300 tons. This shows great unfulfilled potential of livestock breeding. Since 2015, thanks to the Eurasian Union, barriers have been eliminated between many countries, licensing procedures were simplified, and veterinary norms were unified, thus creating all conditions for increasing export. Availability of natural forage lands, low-cost pasture technology of beef cattle breeding creates the potential for establishing Kazakhstan as a significant and a competitive player in the global market. In this regard, increasing productivity of natural pastures is a priority task. The purpose of the research is to develop adaptive technologies for rational use of natural grassland ecosystems, ensuring their faster recovery and increasing their productivity, and improving the parameters of the environment in the semi-desert zone of Kazakhstan. The modern state of the semi-desert grassland areas has been determined in the study. The results of the research have established feasibility of moderate (65-75% grazing) pasture use. With intensive use of pastures, a change in floristic composition and productivity has been detected, as well as deterioration of agrochemical and agrophysical parameters of pasture soils. The research performed on a variety of environmental and anthropogenic levels in terms of light-chestnut soils of the semi-desert zone revealed 5 degrees of pasture degradation.

Keywords: Pastures, Monitoring, Pasturing, Floristic composition, Soil cover, Productivity, Pastoral degradation.

Research background

The Republic of Kazakhstan has all necessary conditions for developing beef cattle breeding. These are availability of natural forage lands and unused arable land, low-cost pasture technology of beef cattle breeding. In addition, livestock breeding is traditional craft of the indigenous population. All this creates the potential for establishing Kazakhstan as a significant and a competitive player in the global market. In this regard, increasing productivity of natural pastures is a priority task.

In the XX century, arid ecosystems of Eurasia experienced a heavy anthropogenic impact. Therefore, their efficiency decreased, valuable forage species disappeared from the herbage, and sensitive ecosystems are being degraded. Moving sands cover pastures, which intensifies the

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desertification process. Today, the republic has 187 million hectares of pastures, out of which about 81 million hectares are used, with that, out of the used pastures, 26 million hectares are degraded - these are mainly the grasslands located close to settlements. In brown and sandy soils, where festuca-stipa, festuca-stipa-absinthia, stipa-festuca, festuca-absinthia and stipa-absinthia communities are widespread, pasture productivity ranges between 1.5 and 7 kg/ha, but more often - between 2 and 5 kg/ha. In alkali soils dominated by absinthial and salt grass communities, annual growth of Lerch absinthe ranges from 2 to 5 kg/ha, and the share of black absinthe does not exceed 1 to 3 kg/ha. Located on almost 20 million hectares, anabasis-salsa communities in favorable by moisturization years provide 1.5 to 3 kg/ha of pasture mass, and in arid years - not more than 0.5 to 1.0 kg/ha; their productivity continues to decrease (Asanov, 1992; Baitkanov, 2007; Shamsutdinov, 2012; Gayevskaya, 2006; Gayevskaya and Krasnopolin, 2006).

This dictates the need for consistent ecologization of use and improvement of pastures and development of models for forecasting and planning harvest, which is rather actively done by grassland farmers in the EEC countries, in France and in the USA.

In arid regions of Russia, Kazakhstan and Central Asia, similar works are almost not performed. The reputable professor L. E. Rodin from the Botanical Institute n.a. Komarov of the Russian Academy of Sciences believes that modern arid ecosystems are, without exception, secondary anthropogenic formations. Under the influence of overgrazing, burning out and plowing their productivity is greatly reduced; the species and cenotic deficiency is expressed in relatively simplified structural organization, impoverished botanic composition of the herbage, and low occupancy of biohorizons of arid communities by plant organs, therefore resulting in the fact that there remains unused potential for production of organic matter (Rodin, 1975).

Transformation of the vegetable cover as a result of human activities is characteristic for many regions and countries, but scientists started studying this problem seriously after the 80-ies of the last century (Smith, 1958; Rachkovskaya, 1960).

The first experience in special studies of transformation of vegetation and ecosystems as a result of various factors was obtained in the work of the Soviet-Mongolian complex biological expedition (1985-1990), where Kazakhstan geobotanists participated - E. I. Rachkovskaya and N. P. Ogar. The issues of pasture degradation in forage lands have been well studied in the research performed by Russian scientists (Smelov, 1966; Larin, 1969).

Similar studies were performed in foreign countries, as well. In Mongolia climatic data for the period between 2000 and 2007 have been collected for 14 stations located in the Selenge, Darkhan, Central, Gov-Sumber and East Gobi aimaks. The research made it possible to more reasonably approach assessing the state of pastures, their anthropogenic displacement, and in the end - the nature of transformation of steppe ecosystems used for pastures (Miklyaeva and Fakhire, 2004; Zhang and Zhao, 2011; Chogniy, 2008).

In the late 80's - early 90-ies, works on transformation of grassland vegetation were performed in Kazakhstan as well (Bizhanov and Kurochkin, 1989; Bizhanov, 1998).

In 1995-1998, under the direction of N. P. Ogar, the topic of fundamental research "Transformation of vegetation of Kazakhstan in the conditions of modern nature management" was developed as well (Ogar, 1999).

In the steppes of Kostanay region, transformation of vegetation was studied in detail by O. V. Marynich (Marynich, 1999).

The issues of pasture degradation were reflected inresearches of other scientists of Kazakhstan, too, which showed reduction in productivity of degraded communities under the influence of intensive grazing. It is shown that in course of pasture degradation, changes occur in the floristic composition and the ratio of ecological groups and life forms; projective cover, height of vegetation, recovering ability, longevity of plants, and yield reduce. Changes in vegetation cover after grazing occur gradually. There are certain stages of deterioration of the initial state of herbage, called «stages of pasture degradation» (Bedareva, 2006; Ramensky et al., 1956; Bykov, 1975; Rachkovskaya, 1999; Mirzadinov, 2007; Kirienko, 1980).

Justification of the choice of the line of

research

The territory of semi-desert zones of Kazakhstan is represented by a combination of broken and fixed sands, inter-hill and inter-ridge lowlands occupied by takyrs, saline marches or mixed herb grassland associations. Anthropogenic activities in this territory caused major changes in the dynamics of the vegetation cover, its species composition and productivity. In particular, the area of eroded and degraded pastures dramatically increased, grazing load increased, while forage consumption and quality of forage decreased. Here pastures occupy about 80% of the area of the zone. They are the starting point and the material basis for sheep breeding, which is the mainstream in agricultural activities. However, the grazing load that increased over recent years has changed the natural balance and contributed to their degradation and desertification due to increased vulnerability of semi-arid and arid ecosystems. All this could not fail to affect the condition of semi-arid grasslands. These processes cause a threat to well-being of livestock breeding and destabilize the habitat of the population, and the alarming trends require deep analysis of the state of arid pastures, identification of the reasons for their degradation and development of effective measures for efficient use, considering features of the main types of grassland ecosystems.

The research is aimed at solving important problems of geo-ecology and rational environmental management, associated with comprehensive biogeocenotic and agro-ecological researches that identify the degree of degradation of agricultural landscapes, which are an important component of sustainable functioning of the biosphere.

The task of analyzing degradation of pasture ecosystems in semi-arid areas, detecting main regularities of semi-arid ecosystems transformation resulting from unsustainable grazing, establishing the nature of changes in plant communities with degradation processes, the impact of deletion of above-ground mass of dominant species of pasture plants in the process of grazing animals on their feed efficiency, and determining the optimum functioning conditions of semi-arid ecosystems with regard to their economic and environmental value is an important area of research that is of paramount scientific and technological importance for sustainable development of viable agriculture in the Republic.

Numerous scientific research and developments of scientific institutions of agricultural and biological profile show that in order to support pastures' capacity for permanent seed and vegetative regeneration and reproduction of the necessary level of feed resources, must be operated within the environmental imperative. The first environmental commandment of pastures management is the principle of their natural capacity conformity to the number of their pastured animals. Many years of scientific studies performed in the second half of the 20th century by scientists from different countries show that 25 to 75% of aboveground plant mass can be removed in different natural zones without negative impact on subsequent productivity of pastures. In arid conditions of Russia and Central Asia, 60-75% of the annual growth of plants can be removed (Asanov, 1992; Baitkanov, 2007; Shamsutdinov, 2012; Gaevskaya, 2006; Smelov, 1966; Larin, 1969; Zhambakin, 1995).

Thus, the main issues of ecologically sustainable pasture management are the size of the removed land and the frequency of pasturing. 65-75% of the annual plants growth can be removed without negative impact on renewal processes. Removing this amount of aboveground forage mass is the level that is balanced with intensity of eating fodder plants by animals. Removal of annual growth at this level forms natural favorable conditions for vegetative and seed renewal of plants, creates preconditions for the annual reproduction of plant mass and eliminates the possibility of interference with the ecological relations in the vegetation community, and thus ensures stability of the entire pasture ecosystems.

However, such research in the semi-desert zone of Kazakhstan has not been performed. In this regard, the research was focused on studying the effect of removing annual growth of above-ground parts of dominant species of pasture plants at different times and with different intensities on their forage production, phytocenotic structure, and population composition.

Pastures in the areas of research cover

over 80% of economic use land, and are the main sources of forage. Considering importance of the problems of livestock development in light of new challenges for increasing export potential of the country, the survey data are highly relevant.

METHODS

The research was performed in the West Kazakhstan Agrarian Technical University n.a. Zhangir Khan in 2012-2014 (Republic of Kazakhstan,Uralsk).

To solve the set tasks on the grasslands of the semi-arid zone of Western-Kazakhstan area (Zhangala region) on the monitoring grid on the gradient of environmental series, accounting for the yield and regime monitoring of changes in species composition, monitoring cenopopulation patterns of pastures ecosystems throughout the seasons - spring, summer and autumn were performed, forage capacity was defined, natural and anthropogenic transformation of pastures was described.

In order to obtain objective conclusions about the spatial and temporal dynamics of vegetation, environmental series are defined on the basis of the most typical territory for this landscape, which allows performing analysis of changes in all of its adjacent elements, including the degree of economic use (decreasing factor - grazing). The rows have been selected in the pastures with various degrees of anthropogenic impact (from the most downed territories, e.g., wells, sheepfold sheds, wintering grounds, to less altered areas, up to protected areas).

Considerable attention was paid to studying the effect of alienation of the annual growth of above-ground mass in the process of grazing on zonal typical pastures. For this purpose, 100x50 m transects were laid. Grazing was performed in the early spring, in the mid spring, in the late spring, in the summer and in the autumn.

Grazing of herbages was performed according to the scheme:

1. Complete 100% grazing of annual growth of pasture plants;
2. Moderate grazing of annual growth of pasture plants - 65 to 75%;

Complete (100% of annual growth) and moderate (65-75% of annual growth) grazing was performed during all periods of grazing: in the early spring, in the mid spring, in the late spring, in the summer and in the autumn.

In the experiments aimed at studying the effect of grazing on pasture ecosystems, the following surveys and observations have been performed:

1) phenological observations;
2) changes in the species composition of herbage in pastures;
3) the age structure of cenopopulation;
4) changes in the yield of forage mass over years and seasons;
5) changes in the agrophysical and agrochemical properties of soil under the influence of grazing animals.

Soil samples weretakenfrom horizons A1 and B1.

The following indicators have been defined the samples:

a) humus (by Tyurin in the CINAS modification (GOST 26213-91);
b) agile compositions of P_2O_5 (acc. to I. Machigin in CINAS modification (GOST 26205-91);
c) absorbed bases - acc. to B. Pfeffer;
d) particle size distribution (using the pyrophosphate method).

RESULTS AND DISCUSSION

Influence of grazing on vegetation of the pastures

Grazing affects the composition of herbage directly or through soil, especially intensive and unregulated grazing. Its direct effect is that it suppresses some types of herbs and promotes growth of others. Grazing significantly affects the composition of herbage: it reduces abundance of some tall species and contributes to increasing the number of herbs. Overgrazing leads to thinning of herbage and to dominance of inedible and surface-foliaceous herbs [9, 10].

Deserted grasslands of the semi-desert zone are characterized by a two-member, three-member and four-member communities, called spotted or “mottled” steppes. Dominating components of these lands are grasses (Stipa capillata, S. sareptana, Festuca valesiaca) è dwarf subshrubs (Artemisia lerchiana, A. pauciflora,

Camphorosma monspeliaca, Atriplex cana).

In the territory of the Zhangal area, stipa-and- festuca vegetation is dominating. Forage lands are presented by communities dominated by Stipa lessingiana, S. capillata, S. pennata, Festuca valesiaca, Artemisia austriaca. Xerophytes are observed among herbs: Astra galus testiculatus, Crinitaria tatarica, Ñ. villosa, Falcaria vulgaris, Phlomis pungens.

Pastures of the semi-desert area are characterized by formations of Stipa sareptana, Festuca valesiaca, Artemisia Ierchiana. In the Stipa sareptana formation the following associations are identified: Stipa sareptana & Artemisia lerchiana, and Stipa sareptana & Agropyron desertorum.

In pastures with moderate grazing (65 to 75% of annual growth of pasture plants) typical steppe crops are detected (Stipa capillata, S. sareptana, Festuca valesiaca et al), only several plans of Agropyron desertorum have been found. Floristic diversity here is represented by 30 species, among which there are many representatives of the steppe grasses: Phlomis tuberosa, Astragalus longipetalus, Glycyrrhiza glabra, Tragopogon sp and perennial grasses — Stipa capillata, Agropyron desertorum, Puccinellia gigantea.

In pastures with intensive grazing (100% grazing of the annual growth of pasture plants) the species diversity is the lowest - 17 species which are represented mainly by poorly grazing species and weeds (Artemisia taurica, Alhagi pseudoalhagi, Petrosimonia oppositifolia, Tribulus terrestris, Polygonum aviculare, Cynodon dactylon, Chenopodium album, Ceratocarpus arenarius and others).

In all pastures, ephemera are developed in the spring. There is a variety of ephemeroids (Poa bulbosa, Tulipa biebersteiniana, T. gesneriana, Ornithogalum fischerianum, Gagea bulbifera, Iris pumila). The herbage is dominated by xerophytic dwarf semishrubs: Artemisia austriaca, A. lerchiana, A. pauciflora, Kochia prostrata, Thymus marschallianus, Tanacetum achilleifolium.

In the spring, along with ephemera, two sites are dominated by Artemisia lerchiana, which increases its share in the herbage, as the pasture load increases. So, with 100% occurrence in all pastures, the number of shrubs of Artemisia lerchiana in the pasture with intensive grazing is almost twice higher than in the pastures with moderate grazing

The manner of use also effects abundance of the ephemera. From the ephemera that increase their share with an increasing load, one note Veronica praecox and Alyssum turkestanicum, occurrence of which in a pastures with intensive grazing is 2 - 3 times higher than in pastures with moderate grazing.

Annual ephemera such as Poa bulbosa and Tulipa biebersteiniana, same as wormwood reduce their participation in the composition of herbage communities with increasing load.

In mid-June, in the pastures with moderate grazing, two tiers are allocated: the higher - up to 60 cm represented by dominating Stipa capillata and less frequently by Agropyron desertorum; and the lower - up to 10-12 cm, formed by Artemisia lerchiana, with projected cover of 35%.

In the pasture with moderate grazing, Artemisia lerchiana together with Kochia prostrata form a one-tier community up to 30 cm high, and their total projective cover increases here up to 40%.

In the pasture with intensive grazing, tiering is not expressed either; the projective cover of Artemisia lerchiana increases up to 50% with the average height of herbs of 17-20 cm.

In the autumn, in the pasture with moderate grazing, the total projective cover decreased down to 55% due to wormwood losing some leaves. In the pasture with 100-percent grazing, it was 45% and the share of Artemisia lerchiana was 42%. By the end of vegetation period, the number of vegetative plants of Artemisia lerchiana in both pastures decreased almost twice.

Compared to Artemisia lerchiana, Kochia prostrata was represented by single plants in the pasture with 100% grazing.

Influence of the manner of use on productivity of pastures

The maximum phytomass production on a pasture with intensive grazing was noted in the period of mass development of the ephemera, and reached 2.34 hw/ha. The main components of the product were Bromus mollis, Poa bulbosa, and

Anisantha tectorum. Further, reduction was observed here down to 1.2 hw/ha till the end of the vegetation period.

In pastures with moderate grazing where the ephemera do not play a significant role, the maximum of the product was observed in the beginning of June, correspondingly 4.05 hw/ha. By the end of the summer, in the pasture with moderate grazing, a reduction in productivity occurs down to the minimum values, due to disappearance of herbs from the composition of the herbage, and to crops drying - 2.38 hw/ha.

In the pastures with 100% grazing, the projective cover of the native vegetation was between 6.14% and 6.82% Proliferation of ruderal vegetation was observed at the level of 3%. Pastures have more cattle trails, which fact indicates greater load and high degree of trampling pastures with agricultural animals. Today's productivity is lower than the potential (33.06-39.85%) reserve of forage decreased down to 13.00-14.61%. The ecosystem of these pastures is presented by short time derived communities. Herbage height is at the level of 15.22-17.86 cm.

In the pastures with 65-75%, or moderate grazing, the projective cover of the native vegetation was between 28.76 and 32.08% Forage lands have the level of decreasing forage reserves from 1.95 to 2.13 %, and today's productivity of pastures is 87.82-92.20% from the potential. Long term derived communities are widespread, and cattle trails are not observed in the pastures.Herbage height is at the level of 25.22-32.86 cm.

Grazing and the state of soil cover of the pastures

Moving along the pasture and eating herbs, animals influence the soil, compact it with hooves, which in turn leads to drying soil and accelerates turf development. According to the data of agro-chemical monitoring, the indicators of soil cover in the pastures of the Zhangala region with moderate 65 - 75% grazing have been changed to a lesser extent. Decrease in humus reserves in the profile A+B1 in indicated sections compared to virgin soil was within 5.04-9.68%

Decrease in the content of agile phosphorus compared to the moderate level of reserves in sections specified for pastures with moderate grazing at the level of 8.67 to 9.67 %, with decreasing content of physical clay from 4.60 to 4.93 %.

Increased content of exchange sodium was observed in these sections from the capacity of cation exchange by 3.25-4.82%.

The greatest changes in soil indicators have been detected in the pastures with intensive 100% grazing.

In the soil cover of these pastures, with thickness of horizon A+B1 of 33.70 to 34.00 cm, the decrease of humus reserves in profile A+B1, compared to virgin soil, was 41.77 to 44.68%.

Decreased content of agile phosphorus, compared to the average reserves, is at the level of 43.33 - 44.00%.

Increased content of exchange sodium in soil cover from the capacity of cation exchange amounts to 17.11-17.28% with increased content of physical play, compared to the reference (virgin soil) from 28.26 to 24.73 %

Stages of pasture degradation

In our opinion, the number of stages of pasture degradation increases with appearance of various life forms of plants, diversity of species inside individual life forms in the native phytocenoses. The number of stages of pasture degradation may be decreased in multi-specie communities, if the dominating species of the initial stages of degradation are hardly eaten by animals.

Peculiarities of pasture degradation in light-chestnut mid-loamy soils are caused by the differences in specie composition of the initial plant communities that had been formed in the conditions of various grazing loads. The greatest number of the stages of pasture degradation (five) is detected in the communities in zonal light chestnut loamy soils, which fact is caused by availability of perennial grasses: Festuca valesiaca, Stipa lessingiana, Stipa capillata in native plant communities.

Agro-ecological monitoring identified the following stages of pasture degradation of plant communities on light chestnut loamy soils:

1st stage of pasture degradation. In the vegetation cover on zonal loamy soils with moderate grazing, native plant communities are preserved with dominating perennial crops: Festuca valesiaca, Stipa lessingiana, Stipa

capillata, Agropyron desertorum, Koeleria cristata. Subdominants are subshrubs Artemisia lerchiana and Tanacetum achilleifolium.--

2d stage of pasture degradation. Increasing sheep grazing leads to decreasing abundance of Festuca valesiaca: it becomes sub-dominant; in case where in the native community Festuca valesiaca was present as a sub-dominant, its abundance reduces to the level where it is not included into the name of the community. Fescue communities are replaced by Stipa capillata, and camomile communities. In case of increased grazing of cattle, Stipa capillata at this stage of degradation is replaced by Festuca valesiaca.

3d stage of pasture degradation. It is characterized by increased abundance of Stipa capillata, ephemeroid Ðîà bulbosa, Tanacetum achilleifolium and Artemisia lerchiana. In case of sheep grazing, plant communities dominated by Stipa capillata are preserved at this stage.

4th stage of pasture degradation. It is characterized by decreased abundance of Artemisia lerchiana, which becomes sub-dominant instead of dominant. Abundance of Tanacetum achilleifolium, Ðîà bulbosa and Ceratocarpus arenarius increases.

5th stage of pasture degradation. Plant communities are dominated by Ðîà bulbosa, Ceratocarpus arenarius, Tanacetum achilleifolium.-

CONCLUSION

Thus, in the conditions of semi-desert zone of the Western Kazakhstan region, plant and soil cover of pastures changes depending on grazing load.

100%, or complete grazing, as compared to 65-75%, or moderate grazing, leads to changing floristic composition, productivity of plant cover, and degradation of soil cover in the pastures of the semi-desert zone. In this case, degradation of native plant communities in the pastures reaches 5th stage.

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