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Indicators of Pasture Digression in Steppe Ecosystems of Mongolia

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Indicators of pasture digression in steppe ecosystems of Mongolia

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Abstract

The research shows that widely used key measures of vegetation structure (species diversity, projected cover and above-ground phytomass) are not always suitable as indicators of pasture degradation. Based on an analysis above-ground phytomass composition, new quantitative indices are offered that give a more realistic picture of rangeland condition in Mongolia.

Key words: pasture degradation, vegetation structure, Mongolia

Introduction

Steppe ecosystems of Mongolia are traditionally used as rangelands, and according to a number of authors remain in a largely natural state if pasture loads are optimal (GORSHKOVA & LOBANOVA 1972, ABATUROV 2001). Therefore steppe ecosystems have preserved their ecological potential until today, and especially the territory of the Mongolian steppe province was only slightly transformed (VORONOV & KUCHERUK 1977). Pasture loads have, however, increased dramatically in the last decade due to the so-called “livestock boom”, changing the ecological balance, promoting intensification of pasture digression related to the high vulnerability of semi-arid and arid ecosystems, and leading to anthropogenic disturbance and transformation. Many aspects of phytocoenoses’ structure change under lasting and intensive grazing on steppe communities. Researchers used different indicators for assessment of pasture condition. YUNATOV (1950), MIROSHNICHENKO (1967), MIKLYAEVA & FAKHIRE (2004) relied basically on species composition in their assessments of pasture condition. GORSHKOVA & LOBANOVA (1972) used measures of dominant species’ vitality and the composition of ecological plant groups in steppe communities for the identification of digression stages. During the study on grazing effects in forest-steppe and steppe zones of Mongolia, CHOGNYI (1988) distinguished several stages of pasture digression, based on the analysis of several indicators such as species composition, projective cover and above-ground phytomass. These studies demonstrate the wide range of indicators used in assessments of pasture digression. The number of degradation stages distinguished varies from 3-4 to 9-10 depending on different approaches.

The impacts of livestock on rangelands are diverse and depend on many factors differing between types of rangelands (RAMENSKY et al. 1956, TSATSENKIN & KASACH 1960). It is thus necessary to follow a comparative approach using the natural ecological state and structure of the phytocoenosis in protected conditions as a reference, allowing identifying a set of suitable degradation indicators and quantitative thresholds. This allows on the one hand identifying differences between degradation stages and undisturbed steppes, and on the other hand classifying stages of anthropogenic disturbance and related communities’ transformation. Here, we identify indicators of pasture digression, characterize different degrees of anthropogenic disturbance for the main steppe associations, and reveal quantitative thresholds, that indicate conversion of steppe rangelands to transformed communities.

From a practical point of view, quantitative indicators of pasture digression are urgently needed, which determine the necessity to rotate herds to other pastures at an appropriate time. We have addressed this problem in an earlier publication (BAZHA et al. 2012); now we will discuss more precisely what the reason to introduce these indicators is.

Materials and methods

Synchronism and parallelism of works were the two major principles in the organization of field surveys, allowing for a direct comparison of the results. Between 2000 and 2007 (table 1), studies on steppe ecosystems have been carried out on 10 key plots situated along the sub-meridian transect Sukhbaatar – Ulaanbaatar – Dzamyn-Ud that crosses Mongolia from NNW to SSE. Observations coincided with the period of maximal vegetation development (from the second half of July until the end of August). Reference sites with undisturbed or weakly modified soil-plant cover were chosen at every key plot. These sites are extensive areas protected from grazing by a fence along the Trans-Mongolian railway. Sites have been reserved over 30–50 years. Grazed sites have been studied close to the fenced sites in the same landscape and under the same ecological conditions. Complex studies on plant communities were carried out on every pair of sites (reserved area and pasture): geobotanical descriptions on 100 m^2 quadrates, evaluation of above-ground phytomass by cutting biomass on 1 m^2 in three replications, examination of habitus of the main dominants. Soil conditions: descriptions of soil profile sampling for assessments of soil moisture, granulometric texture and chemical composition.

Results and discussion

According to the ecological-floristic classification (YUNATOV 1950, LAVRENKO et al. 1991), there are 6 types of steppe ecosystems: mountain-meadow steppe, meadow steppe, true steppe, dry steppe, desertified steppe and desert steppe. Under reserved conditions *Stipa krylovii, S. sibirica* and *Festuca sibirica* are dominant species in the studied mountain-meadow steppe communities; *Stipa baicalensis* and *Allium senescens* dominate in meadow steppe; *Stipa baicalensis* and *S. krylovii* are edificators in true steppe; *Stipa krylovii* is common in dry steppe; *Allium bidentatum* and *Stipa gobica* are typical in desertified steppe; and *Stipa gobica* dominates in desert steppe (BAZHA et al. 2012).

As it has been mentioned above, there is no universally accepted approach to the assessment of rangeland condition, and the range of indicators used to determine stages of pasture digression differs widely. We performed a quantitative analysis of key measures of vegetation structure in order to reveal indicators that can be applicable for all communities studied in Central Mongolia. These included morphometrical characteristics of dominant species, their reproductive ability, species diversity, total projective cover, and above-ground phytomass of plant communities.

Morphometrical characteristics of dominant species

Slowed and often fully interrupted shoot growth may be a consequence of long browsing and grazing (SMELOV 1966). Our comparison between grazed and long-term protected stands of dominant species in zonal communities along the large-scale transect revealed diminishing plants' height and diameter (bunch) in practically all cases (fig. 1). Height of shoots and diameter of bunches of *Festuca sibirica* – dominant in mountain-meadow steppe, decreased by > 75 % under intense grazing. Height of shoots of *Stipa krylovii* as a sub-dominant of the same community has decreased by 1.5 times while bunch diameter decreased by 2 times. In true steppe, a similar difference was detected between height of shoots of the dominant *Stipa baicalensis* in fenced communities and pastures. Height of shoots of the dominant species in dry-steppe, *Stipa krylovii*, decreased by more than 2 times and its bunch diameter by 1.5 times. Differences in height of shoots of desert-steppe dominants (*Allium mongolicum, Stipa gobica*) are not as pronounced as in other communities under reservation and pasture. Height was only 1.3–1.4 times lower under grazing; while *Stipa gobica*'s bunch size has decreased by almost 2 times.

Thus, in spite of the fact that quantitative indicators showed no entirely identical patterns with respect to reduction of height and bunch diameter, it is possible to conclude that there were reasonably well-defined changes of pasqual digression at practically all key plots.

Table 1: Position and characteristic of key plots along a sub-meridian transect Sukhbaatar – Ulaanbaatar – Dzamyn-Ud

type of steppe	index of key plots	association	position	altitude, m	mode of management
mountain-meadow	XXXIII	*[Caragana pygmaea]-Stipa sibirica, S. baicalensis + Galium verum*	N 49° 23' 46.0" E 106° 15' 10.9"	885	reserved area
		[Caragana pygmaea]-Artemisia frigida+Stipa baicalensis, S. sibirica + Carex korshinskyi	N 49° 23' 57.9" E 106° 15' 16.4"	882	pasture
	XXXII	*[Caragana pygmaea]-Stipa grandis + Artemisia scoparia+Galium verum*	N 49° 23' 24.1" E 106° 14' 13.7"	873	reserved area
		[Caragana pygmaea]-Stipa grandis + Artemisia scoparia+Kochia prostrata + Carex korshinskyi	N 49° 23' 17.5" E 106° 14' 05.7"	875	pasture
	II	*Festuca sibirica+Stipa krylovii + Carex pediformis*	N 47° 37' 22.3" E 107° 11' 10.5"	1654	reserved area
		Agropyron cristatum+Stipa krylovii + Carex pediformis + Koeleria cristata	N 47° 37' 22.6" E 107° 11' 11.0"	1655	pasture
meadow	XXXVIII	*Stipa baicalensis + Allium ramosum*	N 49° 23' 35.1" E 105° 55' 23.3"	699	reserved area
		Stipa baicalensis + Cleistogenes squarrosa + Carex duriuscula	N 49° 23' 35.2" E 105° 55' 22.3"	699	pasture
	XXXVII	*Allium senescens + Cleistogenes squarrosa*	N 49° 23' 29.0" E 105° 55' 20.7"	703	reserved area
		Artemisia frigida + A. scoparia + Cleistogenes squarrosa + Carex duriuscula	N 49° 23' 22.2" E 105° 55' 18.3"	702	pasture
true	XXXV	*[Caragana microphylla]-Stipa baicalensis*	N 49° 11' 58.3" E 105° 47' 14.8"	789	reserved area
		[Caragana microphylla]-Carex duriuscula + Leymus chinensis + Stipa baicalensis + Allium ramosum	N 49° 11' 57.5" E 105° 47' 14.7"	789	pasture
	XXVI	*Stipa baicalensis + Allium anisopodium + Bupleurum scorzonerifolium*	N 48° 04' 54.7" E 106° 35' 23.8"	1278	reserved area
		Agropyron cristatum + Stipa krylovii, S. baicalensis +Leymus chinensis + Artemisia adamsii + Potentilla acaulis	N 48° 05' 07.7" E 106° 35' 13.8"	1280	pasture
dry	XV	*[Caragana microphylla]-Stipa krylovii*	N 46° 56' 41.7" E 107° 43' 39.9"	1330	reserved area
		[Caragana microphylla]-Artemisia frigida + Salsola pestifera	N 46° 56' 41.5" E 107° 43' 37.4"	1334	pasture
desertified	XIV	*[Caragana stenophylla]-Allium ramosum, A. Bidentatum + Cleistogenes squarrosa + Stipa gobica + S. krylovii-Kochia prostrata*	N 46° 09' 19.6" E 108° 37' 14.9"	1221	reserved area
		[Caragana stenophylla]-Stipa krylovii + Cleistogenes squarrosa + S. Gobica + Allium bidentatum + Sibbaldianthe adpressa	N 46° 09' 17.7" E 108° 37' 13.9"	1219	pasture
desert	XXX	*[Caragana korshinskii, C. pygmaea]-Stipa gobica + Asparagus gobicus + Allium mongolicum*	N 43° 55' 02.0" E 111° 37'23.2"	989	reserved area

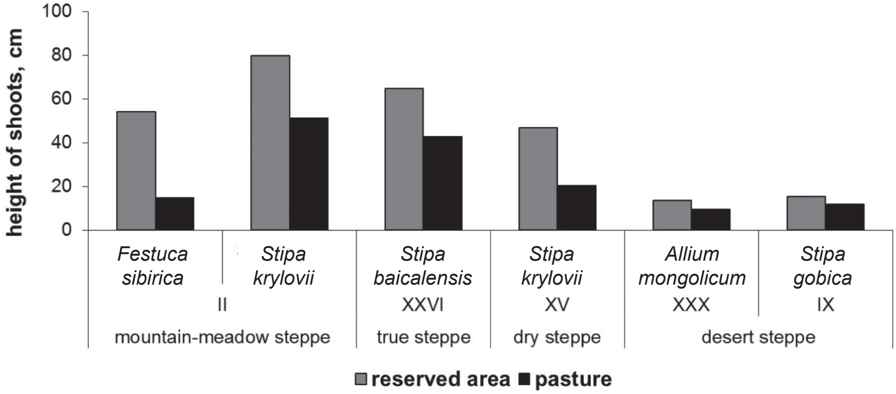

Fig. 1: Change of shoot height of dominant species in main types of steppe ecosystems under grazing impact (interpretation of Latin numbers is presented in table 1).

Reproduction potential of dominant species

In this context the reduction of reproductive potential of dominant species can be seen as one of the most important indicators of pasture digression. Reproductive potential has been studied for *Festuca sibirica* and *Stipa krylovii* in mountain-meadow steppe; *Stipa baicalensis* in true steppe; *Stipa krylovii* in dry steppe, and *Stipa gobica* in desert steppe. In reserved areas, 80 – 100 % of all individuals of a given species were flowering irrespective of steppe type. Average number of reproductive shoots per individual of *Festuca sibirica* equaled 12, *Stipa krylovii* – 27, *S. baicalensis* – 4, *S. krylovii* – 10, *S. gobica* – 4 (fig. 2).

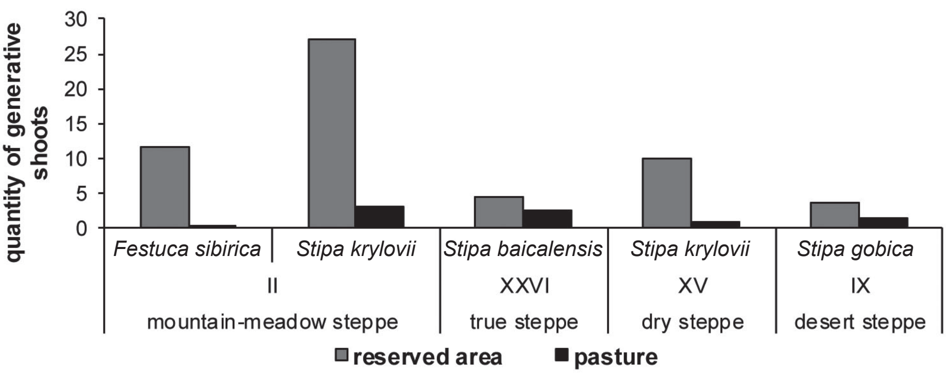

Fig. 2: Changes in number of generative shoots per individual of the given dominant species in main types of steppe ecosystems under grazing impact.

The share of generative individuals was not more than 70 % in communities under grazing, and the number of generative shoots decreased sharply. Average numbers of generative shoots per individual had decreased by 39 times for *Festuca sibirica*, numbers for *Stipa krylovii* were – 9, *S. baicalensis* – 2, *S. krylovii* – 10, *S. gobica* – 3 times lower in comparison to the reserved communities (fig. 2).

The data show that the reproductive potential of dominant species, i.e. the share of individuals with generative shoots and the absolute quantity of generative shoots per individual, varied considerably among individuals of a given species and between individuals of different species dominating in other communities. The data indicate that these indicators should only be used at early stages of pasture digression when plant communities have not yet changed radically.

Species composition

Figure 3 shows that species diversity ranged between 48 species on 100 m² in mountain-meadow steppe and 12 species in desert steppe, i.e. species richness decreased by 4 times from the North to the South. In turn, indices of species similarity of reserved communities and pastures are maximum (70 %) in desert steppe and minimum (43 %) in mountain-meadow steppe. The lowest similarity is thus noted in communities with the highest diversity, and the highest similarity in the most species-poor communities. In some cases, however, species richness at grazed sites equaled values in fenced communities or even exceeded them; examples include true, desertified, and desert steppes (fig. 3).

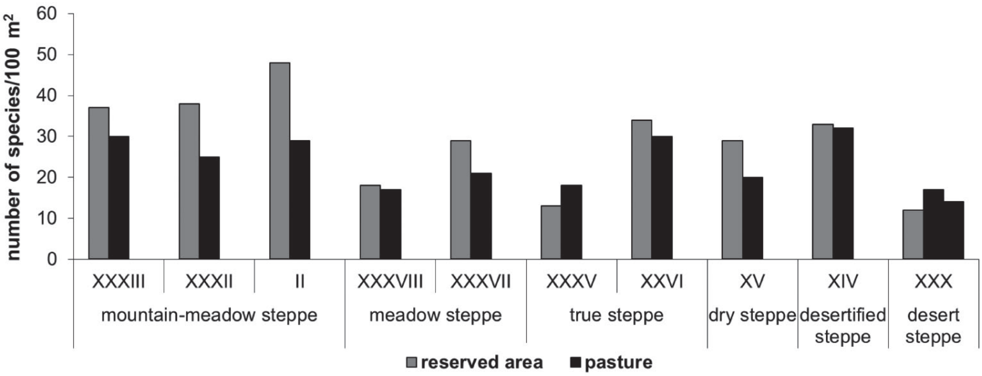

Fig. 3: Change of species diversity of steppe communities under influence of grazing.

Total projected cover

The values of total projected cover varied within even greater limits than species diversity and ranged between 12 % in desert steppe and 80 % in dry steppe along the transect. A decrease of total cover under grazing was most apparent in the dry steppe, where cover was halved. There was no unequivocal trend in communities of other types of steppes on pastoral lands. Values of projective cover for reserved communities exceeded those of pastures by 1.2 – 1.5 in mountain-meadow, meadow, and true steppes (fig. 4), but for some other sites cover was even higher under grazing. The results show that projective cover did not always respond to anthropogenic disturbance and doesn't always correspond to actual state of plant communities.

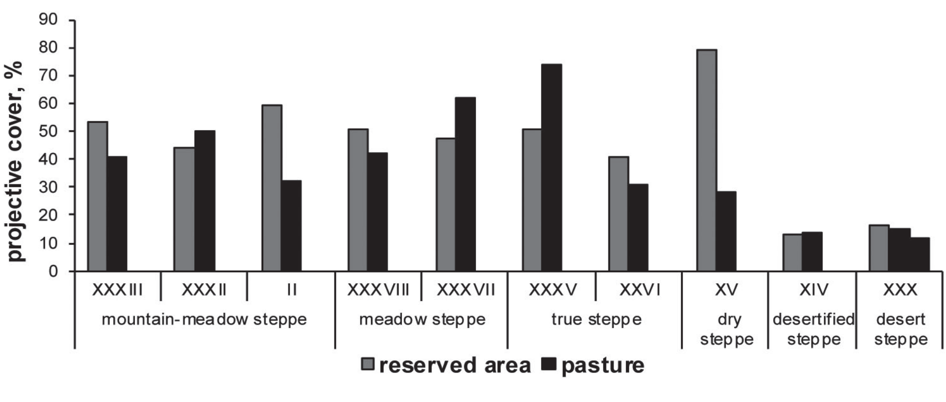

Fig. 4: Change of total projective cover of communities in main types of steppe ecosystems under influence of grazing.

Above-ground phytomass

Our comparisons revealed a decrease of total phytomass as a result of overgrazing in basically in all investigated steppes regions. The above-ground phytomass amounted to up to 271.1 g/m^2 (mountain-meadow steppe), 188.2 (meadow steppe), 261.4 (true steppe), 164.2 (dry steppe), 15.5 (desertified steppe), and 34.1 g/m^2 (desert steppe) inside the fenced plots. Phytomass of pasture communities was reduced by 1.2-1.6 times depending on steppe types under moderate and strong disturbance; in desert steppe; however, phytomass of degraded communities remained unchanged or even increased by 1.3 times (fig. 5).

Above-ground phytomass partly worked as an indicator for very strong disturbance, which resulted in a sharp reduction (more than by 2 times) as demonstrated by the three examples from meadows and true steppes. Values of phytomass showed limited responses in other investigated steppe communities (mountain-meadow, dry and desertified steppes), or even exceeded values in reserved communities as it was observed in desert steppe with *Caragana korshinskii* and *C. stenophylla*.

Using the mentioned indicators under field conditions has clearly demonstrated their limitations, especially when applied over a wide range of ecological conditions. Morphometrical characteristics and reproductive ability of dominant species have some potential for use in early stages of pasture digression. Species diversity, projective cover and above-ground phytomass differed in response to grazing along our large-scale transect, rendering a widespread application questionable.

We think that it is thus impossible to infer conditions of plant communities (and even less so for degrees of anthropogenic disturbance) using only these indicators. Additional criteria must be searched for, which allow better assessments of extreme effects of pasture digression. Our results imply that ratios may have a promising potential; such as the ratio of above-ground phytomass of bushy vs. grass species, invasive vs. indigenous species, and palatable vs. impalatable species. These can be represented as coefficients for shrub-encroachment, invasiveness and palatability.

Replacement of grass species by bush species

Shrub encroachment is a prominent feature of the Dahurian-Mongolian Subregion of the Eurasian steppes. Dominants include different species of shrubs, sub-shrubs and dwarf semi-shrubs of the genera *Caragana, Artemisia, Spiraea, Armeniaca, Amygdalus, Dasiphora,* and others (YUNATOV 1950, KARAMYSHEVA & KHRAMTSOV 1995). Earlier studies did not consider bushy steppes as a result of pasture digression under influence of wild animals and domestic cattle.

The dwarf semi-shrub *Artemisia frigida* was listed as the only woody species which grows intensively under pastoral loads and forms secondary communities (MIROSHNICHENKO 1965, CHOGNYI 1988). In order to assess the role of shrubs in the process of digression we propose to use a coefficient of shrub-encroachment based on the ratio of phytomass of woody species (shrubs, sub-shrubs and dwarf semi-shrubs) vs. phytomass of grass species, calculated per unit of area (m^2 or ha).

Values of the coefficient of shrub encroachment were below 1.0 in communities under fenced conditions and changed from 0.01 in meadow steppe to 0.9 in desert steppe. Values of were always higher under pastoral use than in reserved communities, and varied between 0.3 – 9.6 (table 2). The highest values were registered in degraded communities of mountain-meadow steppe (2.0), meadow steppe (3.9), dry steppe (6.5), and desert steppe (3.8 – 9.6).

We rated communities with a coefficient of shrub encroachment of 2.0 or higher as having a very strong degree of anthropogenic disturbance, effectively representing transformed communities. These are *[Caragana pygmaea]-Artemisia frigida + Stipa baicalensis, S. sibirica + Carex korshinskyi* (XXXIII) in mountain-meadow steppe, *Artemisia frigida, A. scoparia + Cleistogenes squarrosa + Carex duriuscula* (XXXVII) in meadow steppe, *[Caragana microphylla]-Artemisia frigida* +

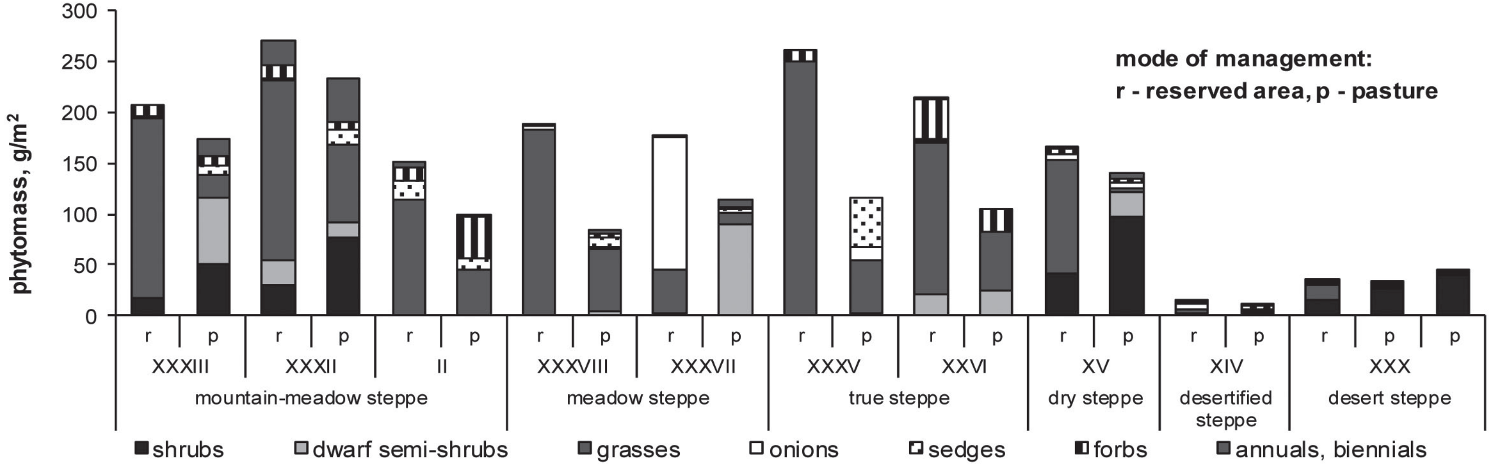

Fig. 5: Change of above-ground phytomass and structure of communities in main types of steppe communities under influence of grazing.

Table 2: Values of coefficients of shrub-encroachment, invasiveness and palatability in the main types of steppe communities in Central Mongolia

Type of steppe	Key plot No.	Coefficient of shrub-encroachment		Coefficient of invasiveness		Coefficient of palatability	
		reserved area	pasture	reserved area	pasture	reserved area	Pasture
mountain-meadow	XXXIII	0.1	2.0	0.2	6.7	33.0	6.2
	XXXII	0.2	0.6	0.5	2.1	8.2	3.6
	II	-	-	0.2	1.3	15.0	3.9
meadow	XXXVIII	-	-	0.01	1.3	234.2	8.4
	XXXVII	0.01	3.9	0.4	74.9	292.6	11.7
typical	XXXV	-	-	0.07	3.4	-	-
	XXVI	0.1	0.3	0.4	2.7	3.8	1.2
dry	XV	0.3	6.5	0.5	17.9	25.5	14.9
desertified	XIV	0.2	0.3	1.1	1.6	2.5	2.2
desert	XXX	0.9	3.8-9.6	1.0	5.9-19.8	11.1	7.2-19.8

Salsola pestifera (XV) in dry steppe, *[Caragana korshinskii, C. pygmaea]-Asparagus gobicus + Allium mongolicum + Stipa gobica,* and *[Caragana korshinskii, C. pygmaea]-Asparagus gobicus + Allium mongolicum + Cleistogenes songorica + Stipa gobica* (XXX) in desert steppe.

Many shrubs are more xerophytic than indigenous steppe grass plants (cereals, sedges, forbs) and have widely extended their areas from original petrophytic and psamophytic sites. They invaded typical zonal steppe communities following grazing that lasted for more than a millennium of pastoral land use.

Invasion of alien species into steppe communities

The relative share of typical steppe dominants and invasive species changes in steppe communities during pasture digression (MIKLJAEVA & FAKHIRE 2004). Invasive species are able to occupy empty ecological niches due to their ecological-phytocoenotical strategies, and some have strong advantage under grazing (DIMEEVA 2004). Over the last decades, they have increasingly been considered as threats, because invasions of adventive species are one of the key factors of ecosystems transformation (Biological invasions … 2004). Thus, a reliable indicator of transformation can be obtained by using the coefficient of invasiveness calculated as the ratio of phytomass of invasive species to phytomass of indigenous dominants. According to T.A. Rabotnov's definition, invasive species are nonindigenous species extrinsic to the community (RABOTNOV 1978). In the present context, almost all species are indigenous and thus the question is only about ***intra-coenotic*** invasions. According to their live strategy, Rabotnov has classified invasive species as violent (= competitors in Grime's scheme; *Artemisia frigida, A. laciniata, Caragana microphylla, C. korshinskii, C. pygmaea* et al.), patient (= Grime's stress-tolerant; *Artemisia commutata, Leymus chinensis* et al.) and explorent (= Grime's ruderal; *Artemisia palustris, A. pectinata, A. scoparia, Bassia dasyphylla, Chenopodium album, Salsola collina, S. pestifera* et al.). A classification according to life-form is shrubs, sub-shrubs and dwarf semi-shrubs, polycarpic and monocarpic grasses.

In parallel to the coefficient of shrub-encroachment, we can state that almost all communities (except desertified steppe) have a coefficient of invasiveness lower than 1.0, ranging from 0.01 in meadow steppe to 1.0 – 1.1 in desertified and desert steppes under reserved conditions. Values of this coefficient were always higher on disturbed sites, and varied across rather wide limits at 1.6 – 19.8 (table 2).

We rated communities with a coefficient of invasiveness of 5.0 and higher as those with very strong disturbance being already transformed by overgrazing. These include *[Caragana pygmaea]-Artemisia frigida + Stipa baicalensis, S. sibirica + Carex korshinskyi* (XXXIII) in mountain-meadow steppe; *Artemisia frigida, A. scoparia + Cleistogenes squarrosa + Carex duriuscula* (XXXVII) in meadow steppe; *[Caragana microphylla]-Artemisia frigida + Salsola pestifera* (XV) in dry steppe; *[Caragana korshinskii, C. pygmaea]-Asparagus gobicus + Allium mongolicum + Stipa gobica* and *[Caragana korshinskii, C. pygmaea]-Asparagus gobicus + Allium mongolicum + Cleistogenes songorica + Stipa gobica* (XXX) in desert steppe.

Decline of palatable species

The determination of the economic value of steppe ecosystems depends on the palatability of plants. The coefficient of palatability has been introduced to compare the share of palatable and non-palatable species in the total phytomass. This index is defined as the ratio of phytomass of good and satisfactory palatable species to phytomass of poorly palatable and non-palatable ones. Estimates of steppe species' palatability follow recommendations and data published by Russian specialists (TSATSENKIN & YUNATOV 1951, YUNATOV 1950; Methodical guidelines…1989, KURKIN 2005).

Values of the coefficient of phytomass palatability varied strongly (between 1.2 and 292.0) depending on types and use of steppe communities studied (pasture, reserving; table 2). Although values were mostly lower under grazing (except for desert steppe), using them for assessments of pasture change and strong disturbance or transformation nonetheless seems impracticable. Additional information would be required on the nutritious value of forage plants, including first of all the content of digestible protein (ERMAKOVA & MIKHEEV 1963, NECHAEVA 1970, MIRKIN et al. 1988). Moreover, plants' palatability is an ambiguous category that depends on many factors: kind and number of livestock; season; meteorological conditions; geographical regions (ABATUROV 2001, NECHAEVA 1987, KURKIN 2005). According to experts in the livestock sector of Mongolian economy, these data are still lacking (SHAGDARSUREN 2011).

Conclusion

Our study of the main phytocoenotic characteristics of the main plant communities found along a transect crossing Central Mongolia from NNW to SSE, conducted in comparison with their analogues developed under grazing protection, allowed us to conclude that widely used indicators such as species diversity, projective cover and total above-ground phytomass are suitable for general assessments of overgrazing. The coefficients of shrub-encroachment and invasiveness defined based on the ratio of quantitative values of above-ground phytomass are more suitable. These allow us, on the one hand, to define features of pasture digression of plant communities in all main types of steppes, and to reveal aspects of transformation of steppe communities on the other hand. Analyses of these coefficients have demonstrated that areas with strongly and very strongly disturbed plant communities prevail among plant communities in the present period of high animal loads in pastures. Thus, processes of pasture digression and even complete transformation of entire phytocoenoses are characteristic for the steppes of Central Mongolia.

References

ABATUROV, B.D. (2001): Ecological implications of hoofed mammals' pasture for ecosystems of semi-desert. Ecological Processes in Arid Biogeocenosis. – Moscow, p. 57–83 (Russ.).

BAZHA, S.N.; GUNIN, P.D.; DANZHALOVA, E.V.; DROBYSHEV, Yu.I.; PRISHCEPA, A.V. (2012): Pastoral degradation of steppe ecosystems in Central Mongolia. – In: WERGER, M.J.A.; van STAALDUINEN, M.A. (eds.): Eurasian steppes. – Ecological Problems and Livelihoods in a Changing World, Ser. Plant and Vegetation **6**. – Springer Science+Business Media B. V., p. 289–320.

CHOGNYI, O. (1988): Principles of pascual digression and postpascual demutation of pasturelands. – Phytocoenotic Bases of Improving of Natural Fodder Lands in Mongolian People's Republic. – Moscow, Nauka, p. 45–87 (Russ.).

DIMEEVA, L.A. (2004): About additional criteria of assessment of state and restoration of anthropogenic ecosystems. – Arid Ecosystems (Moscow), Vol. **10** N 22–23: 112–120 (Russ.).

ERMAKOVA, I.A.; MIKHEEV, G.D. (1963): About nutritiousness of main pasture fodders in Turcmenian SSR. – Izv. AN TSSR. Biol. Series N **6**: 119–128 (Russ.).

GORSHKOVA, A.A.; LOBANOVA, I.N. (1972): Change of ecology and structure of steppe communities in Transbaikalia under influence of pastoral mode. – Tr. Instituta geographii Sibiri i Dal'nego Vostoka. Irkutsk **34:** 38–43 (Russ.).

KARAMYSHEVA Z.V.; KHRAMTSOV V.N. (1995): Steppes of Mongolia. – Braun-Blanquetia. Camerino **17**, 79 p. (Eng.).

KURKIN, K.A. (2005): Methods of assessment of productivity of pastures on floodplain of Oka river on the bases of ecological-genetics classification. – Bot. Zhurn. **90** N 5: 768–778 (russ.).

LAVRENKO, E.M.; KARAMYSHEVA, Z.V.; NIKULINA, R.I. (1991): Steppe of Eurasia. – Leningrad: Nauka, 44 p. (Russ.).

GUNIN, P.D.; VOSTOKOVA, E.A. (eds.) (1989): Methodical guidelines of assessment and mapping of modern state of ecosystems. – Ulaanbataar, GUGK MIR, 108 p. (Russ.).

MIKLYAEVA, I.M.; FAKHIRE, A. (2004): Pasture digression of dry steppe in Central Mongolia. – Vestn. Mosc. Universiteta, Ser. 5. Geography N 6: 38–43 (Russ.).

MIRKIN, B.M.; KASHAPOV, R.Sh.; ALIMBEKOVA, L.M. (1988): Geobotanical and economical characteristics of hayfield and pasturelands of state farm “Tevshruleh”. – Phytocoenotic Bases of Improving of Natural Fodder Lands in Mongolian People’s Republic. – Moscow, Nauka, p. 7–44.

MIROSHNICHENKO, Yu.M. (1967): Dynamics of steppe and desert vegetation in central part of Mongolian People’s Republic. – Avtoref. diss. kand. biol. Nauk, Leningrad, 20 p.

RAMENSKYI, L.G.; TSATSENKIN, I.A.; CHIZHIKOV, O.N.; ANTIPIN, N.A. (1956): Ecological assessment of fodder lands on plant-cover. – Izd-vo s/h lit-ry, Moscow, 471 p.

SHAGDARSUREN, O. (2011): Biology of pasture kinds of livestock and features of nomad cattle-breeding of Mongolia. – Moscow, 264 p. (Russ).

SMELOV, S.P. (1966): Theoretical bases of meadow cultivation. – Moscow, Kolos, 366 p.

TSATSENKIN, I.A.; KASACH, I.A. (1970): Ecological Assessment of Pasturelands and Hayfields. – Dushanbe, Donysh, 94 p. (Russ.).

TSATSENKIN, I.A.; YUNATOV, A.A. (1951): Natural fodder resources of Mongolian People’s Republic. – Izd-vo AN SSSR, 350 p., Moscow (Russ.).

NECHAEVA N.T. (ed.) (1970): Vegetation of the Central Karakum and their productivity. – Ashhabad, “Ylym”, 171 p. (Russ.).

VORONOV, A.G.; KUCHERUK, V.V. (1977): Biotical variety of Palaearctic: questions of study and conservation. – Biosphere reservation. – Tr. I Sovetsko-Amerikanskogo symposiuma. Leningrad: Gidrometeoizdat: 7–20. (Russ.).

YUNATOV, A.A. (1950): The main features of the vegetation cover of the Mongolian People’s Republic. – Moscow-Leningrad, Izd-vo RAN SSSR, 224 p. (Russ.).

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