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Vegetation structure studies on steppe and semidesert plant communities of Outer Mongolia 1. Textural relations

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Abstract: Eight linear samplings of 510-1070 microquadrats (0.01 - 0.25 m^2) were undertaken in different lowland and high-mountain semidesert and steppe plant communities of Outer Mongolia for a complex textural and structural analysis. In this paper species- and family-level richness, floral composition, life-form spectra are analyzed.

INTRODUCTION

In order to decipher the basic rules of spatial organization of plant communities, one has to find "clear", undisturbed objects in sufficient extension and quantity for comparative analysis. It is almost impossible to find such localities in Europe, at least in the case of the steppic and semidesert communities which possess the advantage of the relative simplicity too, but Mongolia has proven to be an optimal site. As much as 78% of the country is extensively used pasture and the ratio of the arable land amounts only about 1.0% (National Economy of the MPR - Statistical collection, 1981). The vegetation history of the last glacial and interglacial periods has been relatively uneventful without drastic changes such as e.g. in Europe (SHILOVA 1973).

The various types of that semideserts - one feels as if one walks on top of centuries-old, buried but living forests - suggest that the plant species can replace each other in a community based on their ecological role, and the differences between their floral composition are mainly "historical", due to past events, representing some kind of "frozen chance". The physiognomy and patchiness of a *Brachanthemum gobicum*-semidesert seems very similar to a *Reaumuria soongorica*- or a *Potaninia mongolica*- or an *Eurotia ceratoides*- or a *Convolvulus fruticosus*-type, and also very similar is the climate and the soil of these habitats (taxonomy and biogeographical subdivision after GRUBOV 1982). This phenomenon is contrastive in these poor communities, where the patchiness-creating unit is a population of a species, just like as in the richest ones, in the tropical rain forests, where the compartments of the life forms play the same role (PÓCS 1976). Probably it is valid also for the medium rich communities, but it is more difficult to determine their relevant units, the coalitions.

In Mongolia the whole range of the two-dimensional plant communities of the temperate zone can be found from the deserts to the tall-grass steppes, from the salt marshes to the mountain tundra. I sampled zonal and subalpine chamaephyton-grass semideserts and mid-grass, forb-rich steppes (ELLENBERG and MUELLER-DOMBOIS 1967a).

Special perspectives and difficulties

With help of the family of information statistics models (JUHÁSZ-NAGY 1972, 1973, 1976, 1980, 1984) botanists have at their disposal a very many-sided and efficient tool to describe any aspect of the synphenetical characteristics of a plant community.

However because of the universality of these models the researcher faces hard tasks to formulate the problem precisely; to select adequate methods and sampling parameters; and to explain results. I tried to compare different geographical variants of cold-continental semidesert and steppe formations supposed being in climax stage, and to exploit the ability of the information statistic models to manage the joint spatial behaviour of any species combination, hoping to find the functional units of the formation, the coalitions.

In this first publication I describe the sampling sites and sampling parameters and characterize the textural relations (the frequency distributions) of the samples from some traditional viewpoints: species richness, family distribution and life form spectra (ELLENBERG and MUELLER-DOMBOIS 1967b). In contrast to the elegantly established theory the practical difficulties are more prosaic. First of all, sampling requires much manpower: a minimal programme, a linear sampling of 500-1000 adjacent microquadrates demands 1-2 days of two experienced botanists, and this often proves to be insufficient because of the unexpected, larger scale patchiness of the communities. These larger scale patches (10-100 m in diameter, mostly irregular, convex ones), especially in the steppe communities are to be expected from the small scale vegetation maps (LAVRENKO and SOKOLOV 1984, BANNIKOVA *et al.* 1986), but they cannot be detected simply, at a glance. It would be interesting to take lines of 10,000-100,000 units, with the help of remote sensing on growing scale to establish the scale hierarchy in the patchiness of the vegetation, and Mongolia is an optimal field for such researches with its extensive, homogeneous, plain semidesert and steppe communities.

Another important problem is the scale dependence of the sampling. In general, the size of the sampling unit is adjusted to the scale of the average plant size. The main problems with it are as follows:

- Even the dominant species of a community can belong to different size scales (e.g. *Caragana* and *Stipa* or *Allium*). The communities of this type were excluded from the research except one sample (Myangat), where I applied different sample sizes to the shrubs and to all species (not included in this paper), but it has been shown that this community differs both from the clear grass-herb and the bush formations structure, and one cannot consider it simply as their combination.

- The underground part of a plant can be considerably more extensive than its overground organs, as a rule among semidesert shrubs and chamaephyta (MIROSNICHENKO 1975).
- The size of the projection of a plant's overground part considerably depends on its construction, that is, on growth form.
- The "individual" is often undetectable in the vegetative colonies which are very common both in the semidesert and steppic communities.
- The three latter viewpoints and some practical considerations - so as not to obtain too many empty sampling units - made it necessary to apply a quasi-linear sampling instead of the strictly linear, one dimensional method. The width of the "line" equals to the length of the sampling unit (10-50 cm), that is composed by in one dimension adjacent microquadrats. Therefore the presence of a species in the sample represents something between its abundance and the frequency of its individuals, not very much distorting either of them. In the microquadrats only the presence or absence of a species was registered without quantitative estimation.

An easier problem is the identification of the unfertile plants. Many of them were grazed down, several others flourish rarely at those extreme climatic conditions, but all of them can be identified at family level, and most of them at the generic level.

Their life form, growth and reproductive strategies can be determined without a more precise taxonomic identification. The unclear, polytypic taxa (*Agropyron cristatum, Potentilla bifurca, Artemisia frigida*, etc.) have been managed in a similar way, however in some cases the life form and growth form differences between the races remained problematic.

The role of age structure and the different phenological stages seems to be important, especially in the more complex steppic formations. Such data have been collected, but are not elaborated here.

The sampling areas and parameters

Therefore I tried to choose sampling areas as similar as possible in their physiognomy, and environmental conditions and as different as possible in their floral composition. For the first requirement I had to work in the same vegetation zones, and for the latter one in places as far from each other as possible. The expected vegetation types were determined from the vegetation map of Mongolia (LAVRENKO 1979), but its scale often is too large (1:1,000,000) for an exact identification.

1. Bayan Tsagan

Plain semidesert in a high basin of the Gobi Altai mountains, 15 km south of Bayan Tsagan village (Bayan Khongor district), at cca. 1700 m a. s. l., debris ground with some sand fraction without developed soil, 6-10% vegetation cover, *Stipa glareosa - Ajania achilleoides* dominance (according to the vegetation map: brown sandy soil, *Stipa glareosa -Anabasis brevifolia - Allium polyrrhizum* dominance).

Sampling parameters: 1024 sampling units along a straight line, unit size 0.5 × 0.5 m, on 2nd August, 1988.

2. Bayan Dalay

Plain semidesert at the foot of the Gobi Altai mountains, 12 km east-southeast of Bayan Dalay village (South Gobi district), cca. at 1200 m a. s. l., inclination of northern slope less than 5 degrees, sandy ground with some debris fraction without developed soil, 10-15% vegetation cover, *Stipa glareosa - Artemisia frigida - Cleistogenes songorica* dominance (according to the vegetation map: brown sandy soil, *Stipa gobica - Cleistogenes songorica* dominance).

Sampling parameters: 1024 sampling units along a straight line, unit size 0.5 × 0.5 m, taken on 29th and 30th July, 1988.

3. Khovd

Plain semidesert in the Great Lakes' Basin, in the northern foot of the Mongol Altai mountains, 30 km southeast of the county center Khovd (Khovd district), cca. at 1200 m a. s. l., inclination of southern slope less than 5 degrees, sandy debris ground without developed soil, 20-25% vegetation cover, *Stipa glareosa - Artemisia altaica* dominance (according to the vegetation map: brown sandy soil, *Stipa glareosa - Allium polyrrhizum - Anabasis brevifolia* dominance).

Sampling parameters: 840 sampling units along a slightly (150 degrees at its mid) broken line, sampling unit size 0.1 × 0.1 m, taken on 22th August, 1989.

4. Myangat

Plain semidesert in the Great Lakes' Basin, on the northwestern shore of the Khara Ovs Nor (Blackwater Lake), 5 km north of Myangat village (Khovd district), cca. at 1200 m a. s. l., sandy debris ground without developed soil, 10-15% vegetation cover, *Caragana leucophloea - Stipa glareosa* dominance (but the most frequent is *Convolvulus ammannii!*). The vegetation map indicates *Caragana - Stipa* dominance and brown sand soil.

Sampling parameters: 808 sampling units along a straight line, sampling unit size 0.1 × 0.1 m, taken on 24th August, 1989.

5. Munkh Khairhan

Subalpine semidesert in a high mountain basin of the central ridge of the Mongol Altai mountains, 40 km southwest of Munkh Khairkhan village (Khovd district), cca. at 3200 m a. s. l., debris ground without developed soil, inclination of eastern slope about 20 degrees, 10-15% vegetation cover, *Astragalus - Artemisia* - Gramineae dominance (on the map: mountain tundra with *Kobresia* and rock vegetation with *Dryas, Waldheimia* and *Saxifraga* dominance).

Sampling parameters: 518 sampling units along a straight line, rectangular to the slope direction, sampling unit size 0.1 × 0.1 m, taken on 20th August, 1989.

6. Arvaykher

Mountain semidesert steppe in a mountain basin of the Eastern Khangai mountains, 40 km northeast of county center Arvaykher (Övörkhangai county) cca. at 1800 m a. s. l., inclination of southeastern slope less than 5 degrees, debris

ground without developed soil, vegetation cover 25-30%, *Agropyron - Allium - Artemisia* dominance (on the vegetation map: forb-rich *Stipa* semidesert steppe).

Sampling parameters: 1024 sampling units along a slightly (with cca. 150 grades at its mid) broken line, sampling unit size 0.1 × 0.1 m, taken on 13th August, 1989.

7. Ulaanbaatar

Mountain steppe on the northern slope of the Bogdo Ula mountains, 6 km east of the airport Ulaanbaatar (Töv district), cca. at 1400 m a. s. l., inclination of northwestern slope about 20 degrees, chestnut-brown soil, forb-rich mid-grass steppe (meadow steppe), same assignment according to the vegetation map.

Sampling parameters: 1070 sampling units along a convex polygon closing into itself, sampling unit size 0.1 × 0.1 m, taken on 17-18th July, 1988.

8. Erdenet

Mountain steppe in the mountains Buren Nur, 2 km east of Erdenet city (Bulgan district), cca. at 1300 m a. s. l., inclination of southwestern slope about 10 degrees, dark chestnut-brown soil, forb-rich meadow steppe, same assignment according to the vegetation map.

Sampling parameters: 555 sampling units of 0.1 × 0.1 m size along a slightly (with 150 degrees at its mid) broken line, rectangularly to the direction of the slope, taken on 9 and 10th August, 1989.

Floral composition of the samples

The samples can be ordered into a series on the basis of their species richness; the treatment follows this sequence. Most of the differences can probably be explained by climatic effects, however the available data are to be accepted with some reservations. Usually the meteorological stations lie far from the sampling sites and under different mesoclimatic circumstances (altitude, exposition, rain-shadow, etc.).

I tried to minimize the effect of variation in soil by choosing places of similar character: debris or settled sand with predominance of debris in the case of semi-deserts, average size of rubble considerably smaller than that of the plants, no extremely acidic or basic stones, mostly the "reliable", neutral or slightly acidic granite; and chestnut brown soil of finer texture in the case of the steppes.

The life form terms in this first approach are as follows: grass type (gra) of the Gramineae and Cyperaceae without respect to their cespitosus or repens growth form; dwarf shrubs and herbs with woody basis, that is chamaephyta (cha); perennial herbs in Raunkiaer's sense, i. e. hemicryptophyta (hem); geophyta (geo) in Raunkiaer's sense again, mostly bulbous-tuberous perennials; low shrubs, nanophanerophyta (nan) up to 2 m height, the sampled species mostly under 1 and even 0.5 m; annual herbs and grasses, therophyta (the); and foliose lichens, i.e. thallo-hemicryptophyta (tha).

During the analysis I had expected to determine three types of samples by their

physiognomy: the plain semidesert of the lower basins (up to 1200-1300 m); the high mountain semidesert above 1700 m; and the steppes of the more humid and temperate zones.

Their floral compositions do not confirm it: the high mountain semideserts of distant areas are considerably more similar to their neighbouring lowland variants than to each other. Why do they appear to be richer than they are? First of all, probably because of their more even species-, family- and life form- distribution at the scale of the sampling, then probably because of their more contrasting patchiness at larger scale which could not be detected by this study. Nevertheless, for didactical reasons I follow this division and present all three groups: the two "successful" ones and the one that failed.

The locality of the two poorest samples (Bayan Tsagan, 9 species, Bayan Dalay, 14 species) belong to the floral district Gobi Altai: the first one in its northwestern part, in a smaller isolated higher elevation basin, the second one at the southeastern foot of the mountains, in an extensive lowland (which is only relatively low, being at an 1200 m average altitude a. s. l.). Despite of differences and the 400 km distance between them, their floral distribution is very similar (Bayan Tsagan: Table 1, Figs 1a-c, Bayan Dalay: Table 2, Figs 2a-c, Plate 1).

The frequency data are influenced by size of the sampling unit and the logarithmic data by number of the sampling unit, respectively, but in these two cases these parameters are the same, so a comparison is possible. The species poorness and prevailing dominance of the most common species, the cespitous grasses and artemisioid (wormwood- relative) dwarf shrubs (*Stipa glareosa* and *Ajania achilleoides* at Bayan Tsagan and *Stipa glareosa* - *Cleistogenes songorica* with *Artemisia frigida* at Bayan Dalay) is remarkable. It determines the life form spectra and family distribution as well. Without further investigation the background of the lack of moderately rare species in the Bayan Tsagan sample, the break in the frequency distributions is not clear. Such distributions are characteristic of extreme desert conditions or/and to the overuse or underuse of pastures (HARPER 1977).

A special multifold problem is in all desert and semidesert communities is the occupation of space by slowly decomposable dead plants and plant colonies. They can make the environment more coarse-grained (MacARTHUR and LEVINS 1967); it is hard to estimate their underground extension; and sometimes it is hard to establish whether they are entirely and definitely dead. One may not exclude their possible allelopathic effect either. This phenomenon was extremely striking in the Bayan Dalay sample where the dead tussocks of *Stipa, Cleistogenes, Iris* and *Allium* amounted to about 10-20% of the living fraction. We registered them, but excluded from this analysis.

The two other lowland semidesert samples (Khovd: Table 3, Figs 3a-c, Plate 2; Myangat: Table 4, Figs 4a-c) are situated in another floral district (Great Lakes' Basin), cca. 750 km northeast of Bayan Tsagan and 1200 km of Bayan Dalay; and 100 km from each other. There is no considerable difference in the amount and distribution of the precipitation (120-150 mm/year, maximum in June-August, according to the National Economy of the MPR - Statistical yearbook), but probably is there such a difference in the mean annual temperature and that of January, even with the reservations mentioned above. The data of Khovd

city (119 mm rainfall, 0.3 °C mean annual temperature and -25.4 °C January mean temperature) are more or less applicable to the Khovd and Myangat samples.

The climate of the Bayan Dalay sampling site probably resembles that of the Dalandsadgad (132 mm precipitation, 3.9 °C mean annual temperature and -15.4 °C January mean temperature), at most a little drier and warmer, but one cannot say anything about Bayan Tsagan.

It is hard to decide whether the climatic difference (the less evapotranspirational loss because of the same rainfall and lower temperature) or the floristically richer surrounding (Mongol Altai, Khangai and Kharkhira mountains) causes the higher species, family and life-orm richness and diversity; or by chance the nearer groundwater level because of the proximity (less than 20 km) of the Khara Ovs Nor (Blackwater Lake).

The effect of the milder environmental conditions is shown both in the higher vegetation cover values and in the higher number of species (18-18). The number of families is similar in the "northern" and "southern" semidesert samples, i. e. the species/family rates are higher. Much more difference exists between the life form spectra: the predominance of the grasses and dwarf shrubs is broken, although their proportion still remains considerable and in the Myangat sample the chamaephyta are replaced by a similar life form, the nanophanerophyta. The dominant grass *Stipa glareosa* is the same, if ever a species occurring in such a wide range can be genetically the same in such different communities. The apparent hemicryptophyton dominance in the Myangat sample is mostly due to one small-size, degradation tolerant species, *Convolvulus ammannii* and to the sampling size problem mentioned above; this species plays much less importance in the community by its abundance and biomass. The degradation (overgrazing) of the Myangat site is indicated by the appearance of some annual weeds as well (*Corispermum mongolicum, Salsola pestifera*, and *Setaria viridis*).

The Munkh Khairkhan sample shows similar distribution of species and life-forms, but the floral composition is particular, due to the high mountain character of the site. Even without an arealgeographical analysis one can notice the appearance of some Eurosibirian elements (Rosaceae, *Pulsatilla, Poa, Festuca*) and the absence of some Central Asian ones (e.g. Chenopodiaceae). This phenomenon is more explicit in the neighbouring subnival tundra and rock vegetation. The extremities of the climate are expressed in the life form composition (chamaephyton-grass dominance again), as well as its relatively more temperate and humid character (9 species of hemicryptophyta).

While the Munkh Khairkhan sample can be regarded as an enriched variant of the surrounding lowland semidesert by the infiltration of high mountain glacial relicts, the physiognomically similar Arvaykher sample is undoubtedly an impoverished mountain steppe. The 38 registered species represent a flora almost twice as rich. The first 8-10 dominants and subdominanta are characteristic both of the steppes and the semideserts, and mainly to their transitional zones. This transitional character is shown in the life from spectrum too; the mass of the chamaephyta is still considerable, but most species belong to the hemicryptophyta.

The real mid-grass steppes with over 50% vegetation cover and 50-70 species

are situated in the more humid climatic zone (with about 250 mm or more mean annual precipitation and often with annual mean temperature below zero).

The Ulaanbaatar sample represents a site at the periphery of this range, lying near the southern border of the forest steppe zone. It contains many short-grass steppe and semidesert steppe elements. The 53 species belong to 19 families, though some of them can reach such high relative abundance surely by tolerance of overgrazing (e.g. the low, dense cushions forming *Eritrichum pauciflorum* and *Androsace villosa*, the poisonous *Stellera chamaejasme* or the foliose lichens). This sample is the richest in life-forms, and contains a considerable amount of chamaephyta in addition to the dominant grasses (by frequency) and hemicryptophyta (by species number).

The Erdenet sample with its 80% vegetation cover, hemicryptophyton-grass overdominance, 60 species and 20 families is a representative of the true forb-rich mid-grass steppes in the midst of the cold-continental forest steppe zone. Grazing is also more moderate than is at Ulaanbaatar. The breakdown in the frequency distribution curve after the six most frequent species may be caused by the insufficient sampling unit number and/or by entering into and unforeseeable "patch" mentioned among the "special perspectives and difficulties".

CONCLUSIONS

With the classic methods of floral analysis we obtained classic results: the semideserts are poorer in species, overground vegetation cover and moderately rare species (the logarithmic distribution is steeper) than the steppes; the high-mountain variants are influenced mostly by their floral surrounding; the grasses play an important, often determining role in the communities everywhere; the codominants are chamaephyta in the semideserts and hemicryptophyta in the steppes; in the wide transitional climatic range the life-form distribution varies and in general it is more even.

Further information can be obtained by approaches from two directions:

- distribution analysis from the viewpoints of growth-form, reproductive and dispersal strategies, grazing preferences and (known or supposed) allelopathic effects;
- testing the characteristic areas of the species and species combinations by information statistics functions.

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Table 1. The Bayan Tsagan sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Stipa cf. glareosa P. Smirn.	Poac.	gra	996	.973	3.00
Ajania achilleoides (Turcz.) Poljak.	Aste.	cha	794	.775	2.90
Anabasis brevifolia C.A.Mey.	Chen.	cha	103	.101	2.01
Eurotia ceratoides (L.) C.A.Mey.	Chen.	cha	45	.044	1.65
Iris Bungei Maxim.	Irid.	geo	37	.036	1.57
Oxytropis aciphylla Ldb.	Faba.	cha	15	.015	1.18
Ptilotrichum canescens C.A.Mey.	Bras.	cha	12	.012	1.08
Dontostemon senilis Maxim.	Bras.	hem	3	.003	0.48
Astragalus Junatovii Sancz.	Faba.	cha	1	.001	0

Table 2. The Bayan Dalay sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Stipa glareosa P.Smirn.	Poac.	gra	937	.915	2.97
Artemisia frigida Willd.	Aste.	cha	783	.765	2.89
Cleistogenes songorica (Roshev.) Ohwi	Poac.	gra	442	.432	2.65
Oxytropis aciphylla Ldb.	Faba.	cha	231	.226	2.36
Allium polyrrhizum Turcz. ex Rgl.	Lili.	geo	178	.174	2.25
Astragalus Junatovii Sancz.	Faba.	cha	69	.067	1.84
Bassia hyssopifolia (Pall.) Ktze.	Chen.	the	52	.051	1.72
Ptilotrichum canescens C.A.Mey.	Bras.	cha	41	.040	1.61
Salsola pestifera Nels.	Chen.	the	37	.036	1.57
Iris Bungei Maxim.	Irid.	geo	30	.029	1.48
Asparagus gobicus Ivanova ex Grub.	Lili.	hem	20	.020	1.30
Ferula Bungeana Kitag.	Apia.	hem	9	.009	0.95
Convolvulus ammannii Desr.	Conv.	hem	4	.004	0.60
Haplophyllum dahuricum (L.) G. Don	Ruta.	cha	2	.002	0.30

Table 3. The Kvod sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Artemisia cf. altaiensis Krasch.	Aste.	cha	457	.544	2.66
Stipa glareosa P.Smirn.	Poac.	gra	445	.530	2.65
Asterothamnus hetero-pappoides Novopokr.	Aste.	cha	177	.211	2.25
Convolvulus Ammannii Desr.	Conv.	hem	146	.175	2.16
Gypsophila desertorum (Bge.) Fenzl	Cary.	hem	126	.150	2.10
Kochia prostrata (L.) Schrad.	Chen.	cha	114	.136	2.06
Allium cf. polyrrhizum Turcz. ex Rgl.	Lili.	geo	110	.131	2.04
Allium mongolicum Rgl.	Lili.	geo	71	.085	1.85
Astragalus cf. dilutus Bge.	Faba.	hem	36	.043	1.56
Graminea sp.1.	Poac.	gra	26	.031	1.41
Astragalus vallestris R. Kam.	Faba.	hem	26	.031	1.41
Dontostemon senilis Maxim.	Bras.	hem	12	.014	1.08
Lagochilus ilicifolius Bge.	Lami.	hem	11	.013	1.04
Eurotia ceratoides (L.) C.A.Mey.	Chen.	cha	10	.012	1
Graminea sp.2.	Poac.	gra	2	.002	0.30
Astragalus cf. grubovii Sancz.	Faba.	hem	2	.002	0.30
Limonium Semenovii (Herd.) Ktze.	Plum.	hem	2	.002	0.30
Potentilla astragalifolia Bge.	Rosa.	hem	1	.001	0

Table 4. The Myangat sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Convolvulus ammannii Desr.	Conv.	hem	179	.222	2.25
Stipa glareosa P.Smirn.	Poac.	gra	141	.175	2.15
Caragana leucophloea Pojark.	Faba.	nan	94	.116	1.97
Allium mongolicum Rgl.	Lili.	geo	53	.066	1.72
Atraphaxis bracteata Losinsk.	Poly.	nan	37	.046	1.57
Artemisia sp.1.	Aste.	cha	25	.031	1.40
Corispermum cf. mongolicum Iljin	Chen.	the	10	.011	1
Eurotia ceratoides (L.) C.A.Mey.	Chen.	cha	6	.007	0.78
Salsola cf. pestifera Nels.	Chen.	the	4	.005	0.60
Atraphaxis pungens (M.B.) Jaub. et Spach	Poly.	nan	3	.004	0.48
Convolvulus fruticosus Pall.	Conv.	nan	3	.004	0.48
Artemisia sp.2.	Aste.	hem	2	.002	0.30
Artemisia sp.3.	Aste.	hem	2	.002	0.30
Chenopodium frutescens C.A.Mey.	Chen.	cha	2	.002	0.30
Gypsophila desertorum (Bge.) Fenzl.	Cary.	hem	2	.002	0.30
Setaria viridis (L.) P.B.	Poac.	the	2	.002	0.30
Anabasis brevifolia C.A.Mey.	Chen.	cha	1	.001	0
Scorzonera pseudodivaricata Lipsch.	Aste.	hem	1	.001	0

Table 5. The Munkh Khairkhan sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Astragalus cf. brevifolius Ldb.	Faba.	cha	275	.531	2.44
Artemisia sp.1.	Aste.	cha	214	.413	2.33
Agropyron cf. aegilopoides Drob.	Poac.	gra	121	.234	2.08
Poa attenuata Trin.	Poac.	gra	98	.189	1.99
Agropyron cristatum (L.) P.B.	Poac.	gra	62	.120	1.79
Oxytropis trichophysa Bge.	Faba.	hem	45	.087	1.65
Potentilla cf. bifurca L.	Rosa.	hem	32	.062	1.51
Artemisia sp.2.	Aste.	hem	11	.021	1.04
Carex sp.1.	Cype.	gra	11	.021	1.04
Festuca brachyphylla Schult. et Schult.f.	Poac.	gra	10	.019	1
Smelovskia calycina (Steph.) C.A.Mey.	Bras.	hem	9	.017	0.95
Sibbaldianthe adpressa (Bge.) Juz.	Rosa.	cha	6	.012	0.78
Pulsatilla Bungeana C.A.Mey.	Ranu.	hem	4	.008	0.60
Astragalus cf. argutensis Bge.	Faba.	hem	4	.008	0.60
Boraginacea sp.	Bora.	hem	3	.006	0.48
Iris Potaninii Maxim.	Irid.	geo	2	.004	0.30

Species	Family	Life-form	Number (n)	Frequency	log(n)
Chamaerhodos cf. altaica (Laxm.) Bge.	Rosa.	cha	2	.004	0.30
Artemisia cf. intricata Franch.	Aste.	hem	1	.002	0
Peucedanum hystrix Bge.	Apia.	hem	1	.002	0

Table 6. The Arvaykher sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Agropyron cristatum (L.) P.B.	Poac.	gra	449	.438	2.65
Allium cf. prostratum Trev.	Lili.	geo	446	.436	2.65
Ptilotrichum canescens C.A.Mey.	Bras.	cha	362	.354	2.56
Artemisia changaica Krasch.	Aste.	hem	339	.331	2.53
Koeleria cf. macrantha (Ldb.)Schult.	Poac.	gra	287	.280	2.46
Stipa cf. Krylovii Roshev.	Poac.	gra	195	.190	2.29
Gentiana decumbens L.f.	Gent.	hem	192	.188	2.28
Astragalus cf. brevifolius Ldb.	Faba.	cha	144	.141	2.16
Artemisia Adamsii Bess.	Aste.	cha	112	.109	2.05
Carex sp.	Cype.	gra	103	.101	2.01
Potentilla verticillaris Steph. ex Willd.	Rosa.	hem	97	.095	1.99
Saussurea sp. (sect. Saussurea)	Aste.	hem	90	.088	1.95
Cymbaria dahurica L.	Scro.	hem	54	.053	1.73
Taraxacum sp.	Aste.	hem	33	.032	1.52
Poa attenuata Trin.	Poac.	gra	24	.023	1.38
Heteropappus altaicus (Willd.)Novopokr.	Aste.	hem	22	.021	1.34
Amblynotus rupestris (Pall.) M.Pop.	Bora.	hem	18	.018	1.26
Hedysarum cf. pumilum (Ldb.) B. Fedtsch.	Faba.	hem	16	.016	1.20
Astragalus miniatus Bge.	Faba.	hem	12	.012	1.08
Potentilla astragalifolia Bge.	Rosa.	hem	11	.011	1.04
Eritrichum pauciflorum (Ldb.) DC.	Bora.	hem	11	.011	1.04
Draba sp.	Bras.	hem	10	.010	1
Pulsatilla cf. Bungeana C.A.Mey.	Ranu.	hem	9	.009	0.95
Thermopsis cf. dahurica Czefr.	Faba.	hem	7	.007	0.85
Arenaria cf. capillaris Poir.	Cary.	hem	7	.007	0.85
Pedicularis flava Pall.	Scro.	hem	7	.007	0.85
Oxytropis viridiflava Kom.	Faba.	hem	7	.007	0.85
Bupleurum bicaule Helm.	Apia.	hem	5	.005	0.70
Polygonum angustifolium Pall.	Poly.	hem	4	.004	0.60
Thymus cf. gobicus Tschern.	Lami.	cha	3	.003	0.48
Potentilla cf. conferta Bge.	Rosa.	hem	2	.002	0.30
Rheum undulatum L.	Poly.	hem	2	.002	0.30

Species	Family	Life-form	Number (n)	Frequency	log(n)
Sibbaldianthe adpressa (Bge.) Juz.	Rosa.	cha	1	.001	0
Astragalus Junatovii Sancz.	Faba.	cha	1	.001	0
Iris cf. Potaninii Maxim.	Irid.	geo	1	.001	0
Delphinium grandiflorum L.	Ranu.	hem	1	.001	0

Table 7. The Ulaanbaatar sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Eritrichum pauciflorum (Ldb.) DC.	Bora.	hem	688	.644	2.84
Carex duriuscula C.A.Mey.	Cype.	gra	685	.641	2.84
Cladonia sp.	Cryp.	tha	624	.584	2.80
Artemisia frigida Willd.	Aste.	cha	530	.496	2.72
Agropyron sp.	Poac.	gra	417	.390	2.62
Heteropappus altaicus (Willd.) Novopokr.	Aste.	hem	374	.350	2.57
Stellera chamaejasme L.	Thym.	hem	361	.338	2.56
Poa sp.	Poac.	gra	295	.276	2.47
Ptilotrichum tenuifolium (Steph.) C.A.Mey.	Bras.	cha	245	.229	2.39
Androsace incana Lam.	Prim.	cha	240	.225	2.38
Koeleria sp.	Poac.	gra	167	.156	2.22
Graminea sp.1.	Poac.	gra	160	.150	2.20
Graminea sp.2.	Poac.	gra	154	.144	2.19
Bupleurum bicaule Helm.	Apia.	hem	109	.102	2.04
Carex Korshinskyi Kom.	Cype.	gra	87	.081	1.94
Allium cf. bidentatum Fisch. ex Prokh.	Lili.	geo	68	.064	1.83
Iris cf. tigridia Bge.	Irid.	geo	62	.058	1.79
Potentilla acaulis L.	Rosa.	hem	55	.051	1.74
Oxytropis viridiflava Kom.	Faba.	hem	46	.043	1.66
Alyssum obovatum (C.A.Mey.) Turcz.	Bras.	cha	45	.042	1.65
Graminea sp.3.	Poac.	gra	45	.042	1.65
Taraxacum sp.	Aste.	hem	44	.041	1.64
Sibbaldianthe adpressa (Bge.) Juz.	Rosa.	cha	38	.036	1.58
Graminea sp.4.	Poac.	gra	38	.036	1.58
Pulsatilla Turczaninovii Kryl. et Serg.	Ranu.	hem	33	.031	1.52
Astragalus scaberrimus Bge.	Faba.	cha	30	.028	1.48
Caragana pygmaea (L.) DC.	Faba.	nan	25	.023	1.40
Cymbaria dahurica L.	Scro.	hem	23	.022	1.36
Crepis crocea (Lam.)Babc.	Aste	hem	20	.019	1,30
Stipa Krylovii Roshev.	Poac.	gra	17	.016	1.23
Graminea sp.5.	Poac.	gra	15	.014	1.18
Graminea sp.6.	Poac.	gra	14	.013	1.15
Potentilla bifurca L.	Rosa	hem	12	.011	1.08

Species	Family	Life-form	Number (n)	Frequency	log(n)
Schizonepeta multifida (L.) Briqu.	Lami.	hem	12	.011	1.08
Peucedanum vaginatum Ldb.	Apia.	hem	11	.010	1.04
Stipa sp.	Poac.	gra	8	.007	0.90
Artemisia dracunculus L.	Aste.	hem	8	.007	0.90
Saussurea salicifolia (L.) DC.	Aste.	hem	6	.006	0.78
Carum carvi L.	Apia.	the	5	.005	0.70
Potentilla cf. multifida L.	Rosa.	hem	4	.004	0.60
Gentiana decumbens L.f.	Gent.	hem	4	.004	0.60
Dontostemon integrifolius (L.) C.A.Mey.	Bras.	the	4	.004	0.60
Veronica incana L.	Scro.	hem	3	.003	0.48
Xanthoparmelia sp.	Cryp.	tha	3	.003	0.48
Chamaerhodos erecta (L.)Bge.	Rosa.	the	3	.003	0.48
Linaria acutiloba Fisch. ex Rchb.	Scro.	hem	2	.002	0.30
Dianthus versicolor Fisch.	Cary.	hem	2	.002	0.30
Melandrium apricum (Turcz.)Rohrb.	Cary.	the	2	.002	0.30
Pedicularis flava Pall.	Scro.	hem	1	.001	0
Polygala tenuifolia Willd.	Polg.	hem	1	.001	0
Scorzonera cf. austriaca Willd.	Aste.	hem	1	.001	0
Leontopodium leontopodioides (Willd.)Beauvd.	Aste.	hem	1	.001	0
Ixeridium gramineum (A.Gray)Tzvel.	Aste.	the	1	.001	0

Table 8. The Erdenet sample

Species	Family	Life-form	Number (n)	Frequency	log(n)
Poa attenuata Trin.	Poac.	gra	492	.883	2.69
Agropyron repens (L.).P.B.	Poac.	gra	397	.713	2.60
Cleistogenes squarrosa (Trin.) Keng	Poac.	gra	313	.562	2.50
Heteropappus altaicus (Willd.) Novopokr.	Aste.	hem	284	.510	2.45
Carex sp.	Cype.	gra	278	.499	2.44
Thermopsis cf. dahurica Czefr.	Faba.	hem	270	.485	2.43
Plantago depressa Willd.	Plan.	hem	142	.255	2.15
Artemisia dracunculus L.	Aste.	hem	139	.252	2.14
Artemisia cf. Sieversiana Willd.	Aste.	hem	136	.244	2.09
Koeleria macrantha (Ldb.) Schult.	Poac.	gra	123	.221	2.04
Galium verum L.	Rubi.	hem	110	.197	1.94
Bupleurum bicaule Helm.	Apia.	hem	88	.158	1.86
Peucedanum vaginatum Ldb.	Apia.	hem	73	.131	1.84
Medicago ruthenica (L.) Ldb.	Faba.	hem	69	.124	1.84
Ixeridium gramineum (Fisch.) Tzvel.	Aste.	the	60	.108	1.78

Species	Family	Life-form	Number (n)	Frequency	log(n)
Astragalus scaberrimus Bge.	Faba.	hem	57	.102	1.76
Scutellaria scordiifolia Fisch. ex Schrank	Lami.	hem	55	.099	1.74
Veronica incana L.	Scop.	hem	53	.095	1.72
Potentilla tanacetifolia Willd. ex Schlecht.	Rosa.	hem	49	.088	1.69
Taraxacum sp.	Aste.	hem	48	.086	1.68
Potentilla acaulis L.	Rosa.	hem	46	.083	1.66
Stellera chamaejasme L.	Thym.	hem	41	.074	1.61
Potentilla bifurca L.	Rosa.	hem	39	.070	1.59
Allium. cf. prostratum Trev.	Lili.	geo	38	.068	1.58
Artemisia cf. scoparia Waldst. et Kit.	Aste.	hem	37	.066	1.57
Stipa baicalensis Roshev.	Poac.	gra	36	.065	1.56
Astragalus adsurgens Pall.	Faba.	hem	32	.057	1.51
Iris cf. tigridia Bge.	Irid.	geo	32	.057	1.51
Oxytropis viridiflava Kom.	Faba.	hem	32	.057	1.51
Artemisia cf. xanthochroa Krasch.	Aste.	cha	26	.047	1.41
Dianthus versicolor Fisch.	Cary.	hem	24	.043	1.38
Gentiana squarrosa Ldb.	Gent.	the	20	.036	1.30
Leontopodium leonto-podioides (Willd.) Beauvd.	Aste.	hem	16	.029	1.20
Artemisia phaeolepis Krasch.	Aste.	hem	16	.029	1.20
Hierochloe odorata (L.)P.B.	Poac.	gra	14	.025	1.15
Graminea sp.1.	Poac.	gra	13	.023	1.11
Potentilla cf. multifida L.	Rosa.	hem	12	.022	1.08
Graminea sp.2.	Poac.	gra	10	.018	1
Melandrium apricum (Turcz.) Rohrb.	Cary.	the	9	.016	0.95
Sibbaldianthe adpressa (Bge.) Juz.	Rosa.	cha	6	.011	0.78
Scabiosa comosa Fisch.	Dips.	hem	6	.011	0.78
Arenaria capillaris Poir.	Cary.	hem	6	.011	0.78
Graminea sp.3.	Poac.	gra	6	.011	0.78
Pulsatilla Turczaninovii Kryl. et Serg.	Ranu.	hem	5	.009	0.70
Delphinium grandiflorum L.	Ranu.	hem	5	.009	0.70
Schizonepeta multifida (L.) Briqu.	Lami.	hem	5	.009	0.70
Thesium cf. saxatile Turcz. ex DC.	Sant.	hem	5	.009	0.70
Cymbaria dahurica L.	Scro.	hem	4	.007	0.60
Erigeron cf. acer L.	Aste.	the	3	.005	0.48
Agropyron cristatum (L.)P.B.	Poac.	gra	3	.005	0.48
Goniolimon speciosum (L.) Boiss.	Plum.	hem	2	.004	0.30
Pulsatilla Bungeana C.A.Mey.	Ranu.	hem	2	.004	0.30
Festuca sp.	Poac.	gra	2	.004	0.30
Boraginacea sp.	Bora.	the	1	.002	0

Species	Family	Life-form	Number (n)	Frequency	log(n)
Serratula centauroides L.	Aste.	hem	1	.002	0
Leibnitzia anandria (L.) Turcz.	Aste.	hem	1	.002	0
Carum carvi L.	Apia.	the	1	.002	0
Gentiana decumbens L.f.	Gent.	hem	1	.002	0
Stellaria gypsophiloides Fenzl	Cary.	hem	1	.002	0
Limonium flexuosum (L.) Kize.	Plum.	hem	1	.002	0

Plate I



1. The Bayan Dalay sampling area



2. The Khovd sampling area

Plate II



1 The Munkh Khairhan sampling area



2 The Ulaanbaatar sampling area

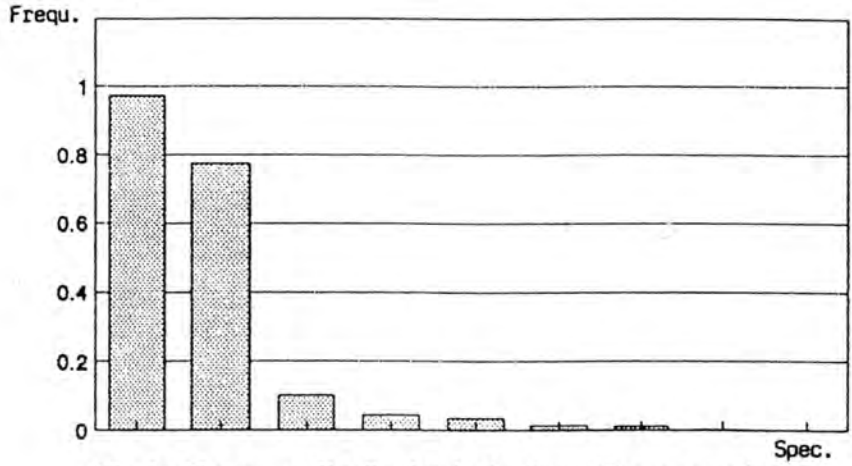


Fig. 1a. Frequency distribution in the Bayan Tsagan sample

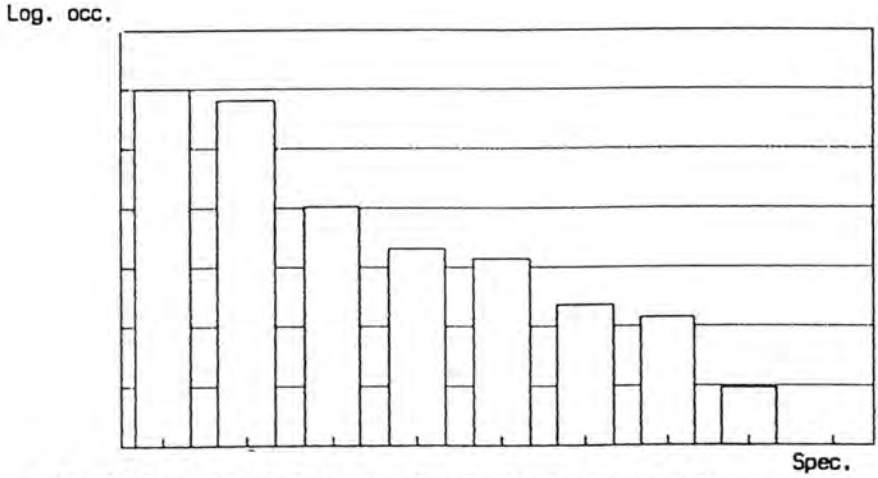


Fig. 1b. Logarithmic frequency distribution in the Bayan Tsagan sample

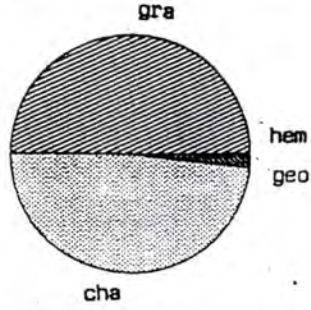


Fig. 1c. Life form spectrum of the Bayan Tsagan sample

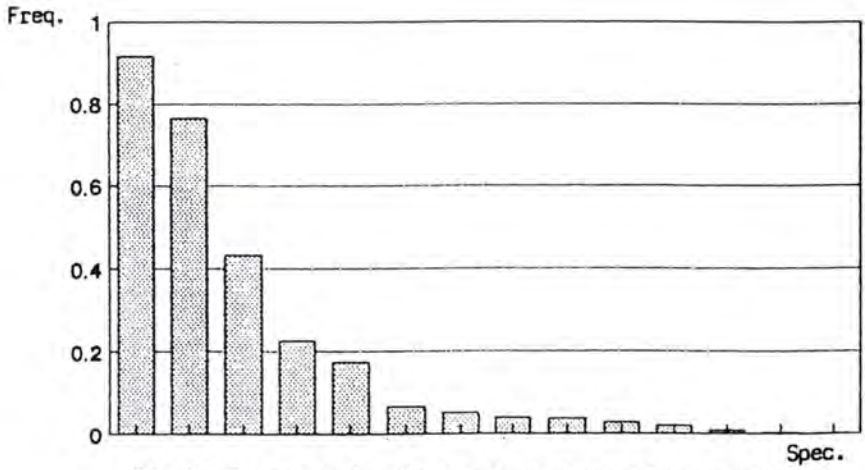


Fig. 2a. Frequency distribution in the Bayan Dalay sample

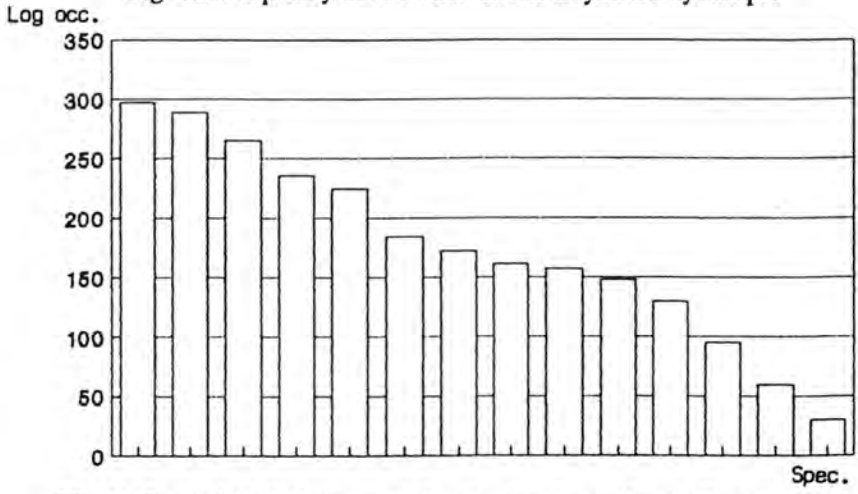


Fig. 2b. Logarithmic frequency distribution in the Bayan Dalay sample

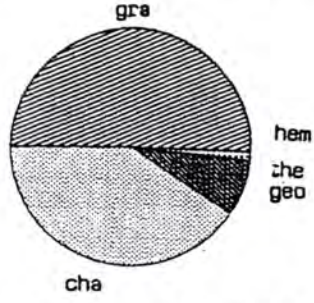


Fig. 2c. Life form spectrum of the Bayan Dalay sample

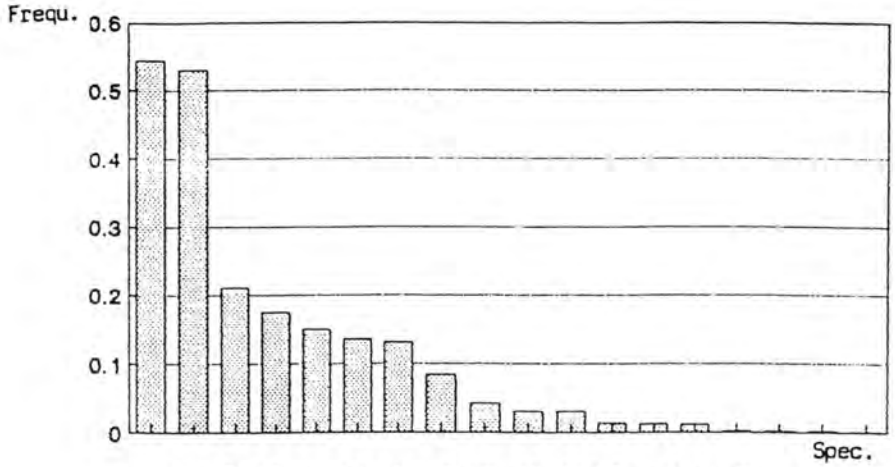


Fig. 3a. Frequency distribution in the Khovd sample

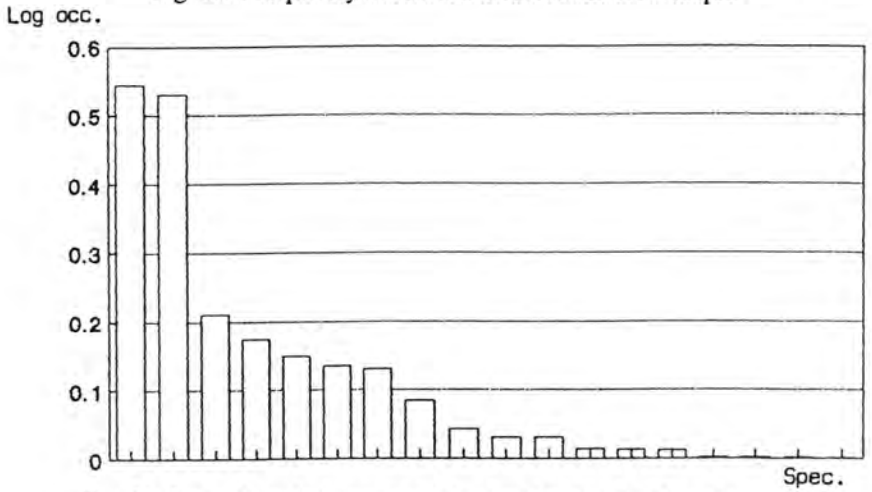


Fig. 3b. Logarithmic frequency distribution in the Khovd sample

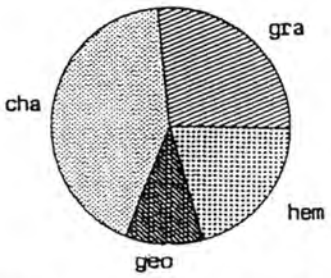


Fig. 3c. Life form spectrum of the Khovd sample

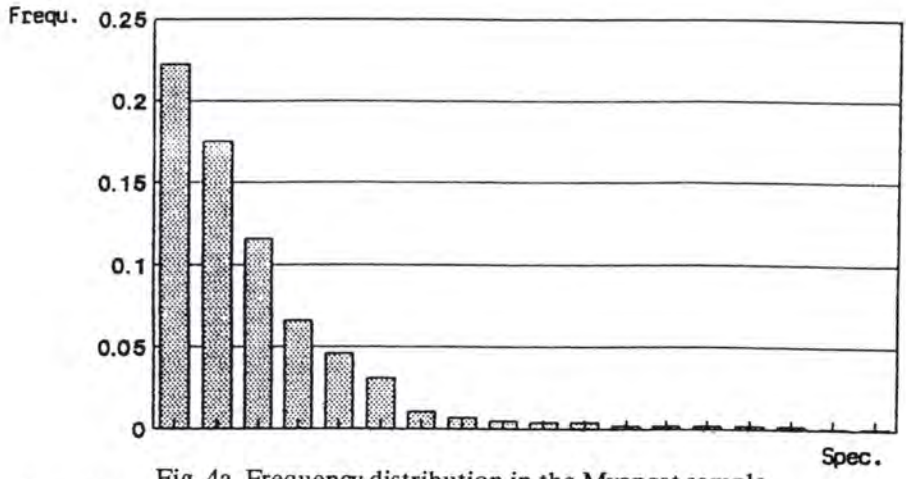


Fig. 4a. Frequency distribution in the Myangat sample

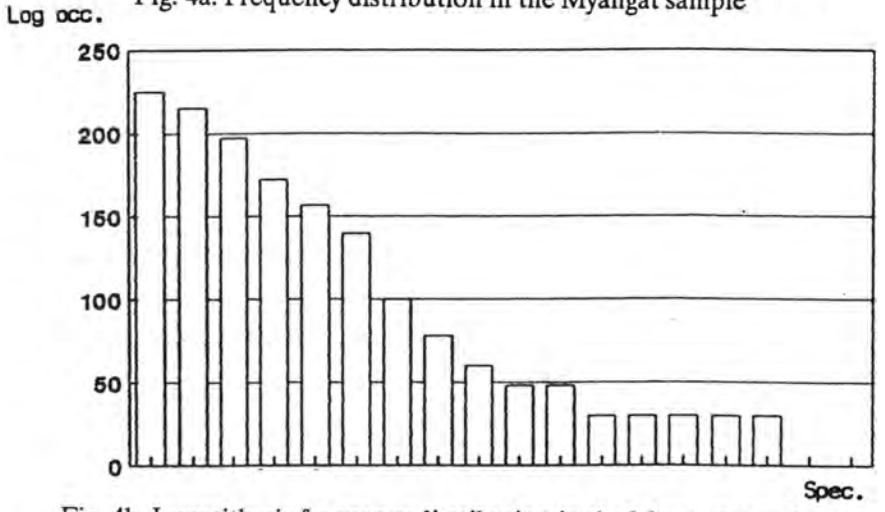


Fig. 4b. Logarithmic frequency distribution in the Myangat sample



Fig. 4c. Life form spectrum of the Myangat sample

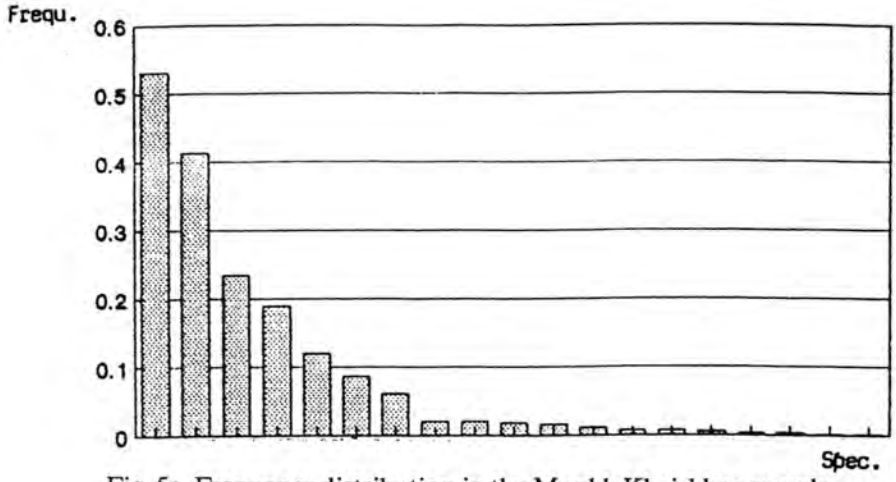


Fig. 5a. Frequency distribution in the Munkh Khairkhan sample

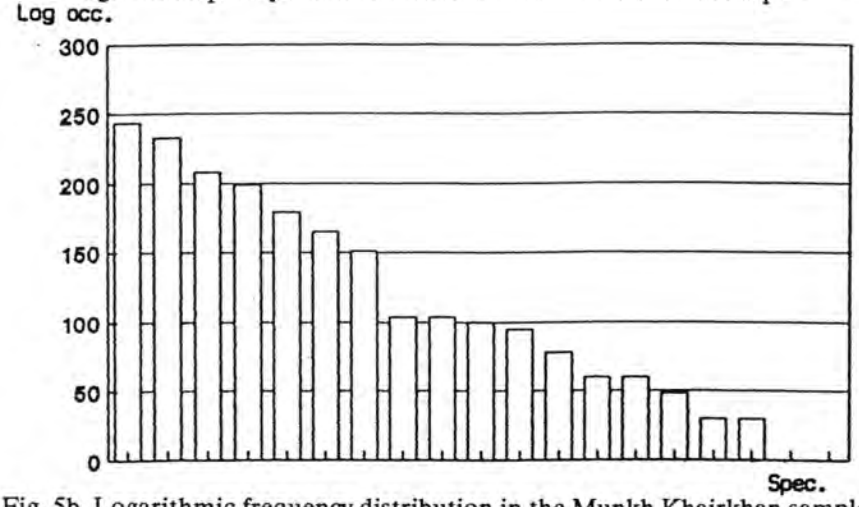


Fig. 5b. Logarithmic frequency distribution in the Munkh Khairkhan sample

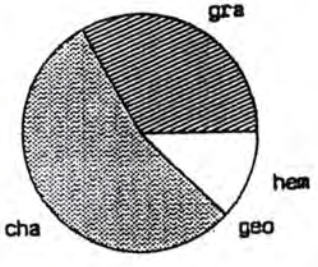


Fig. 5c. Life form spectrum of the Munkh Khairkhan sample

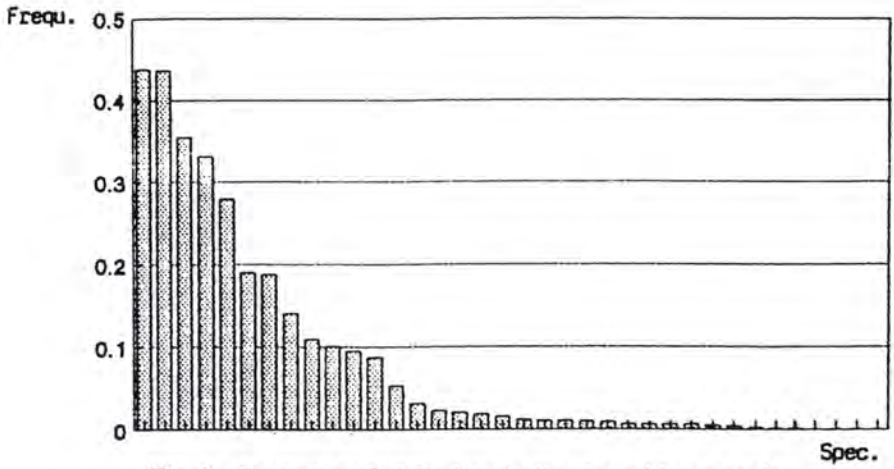


Fig. 6a. Frequency distribution in the Arvaykher sample

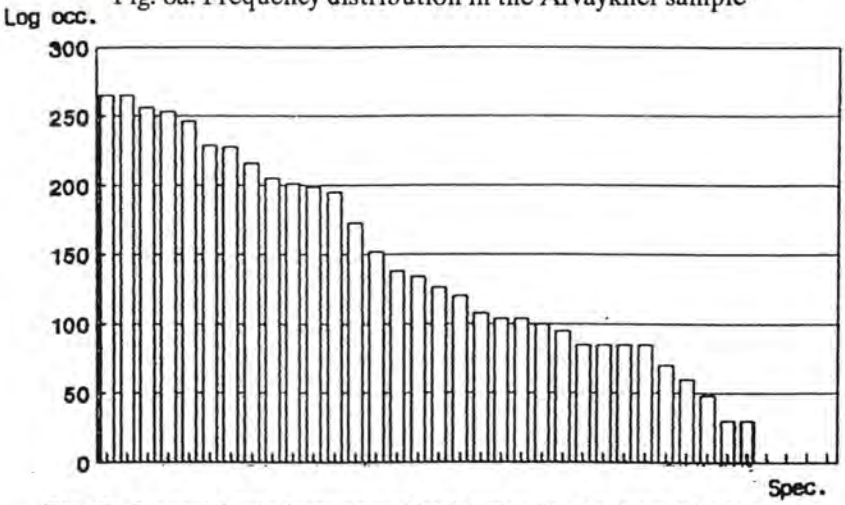


Fig. 6b. Logarithmic frequency distribution in the Arvaykher sample

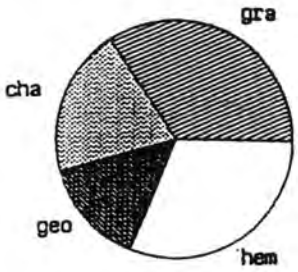


Fig. 6c. Life form spectrum of the Arvaykher sample

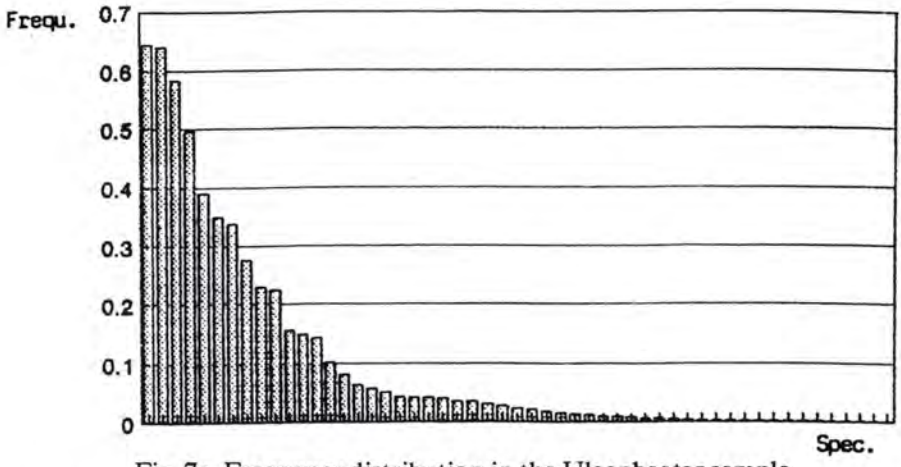


Fig. 7a. Frequency distribution in the Ulaanbaatar sample

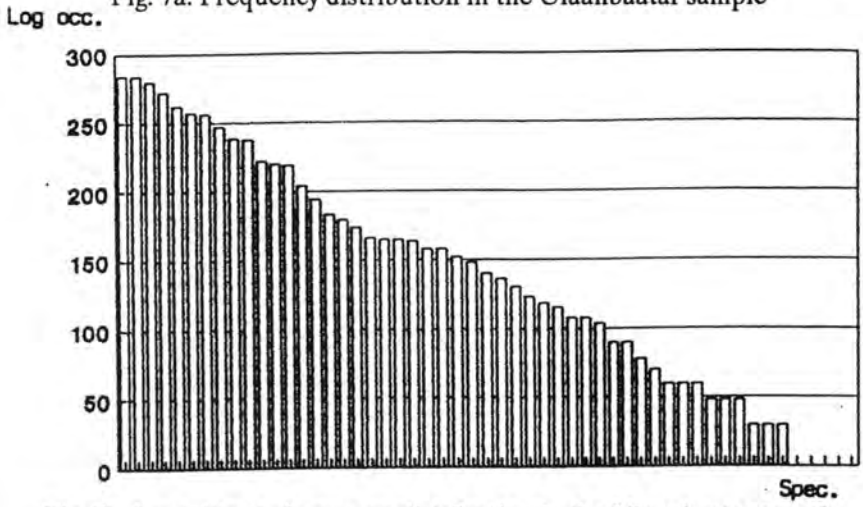


Fig. 7b. Logarithmic frequency distribution in the Ulaanbaatar sample

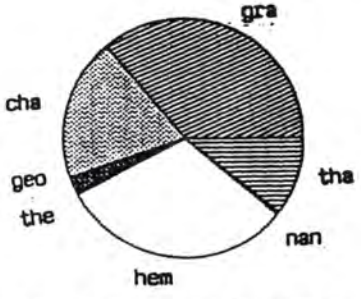


Fig. 7c. Life form spectrum of the Ulaanbaatar sample

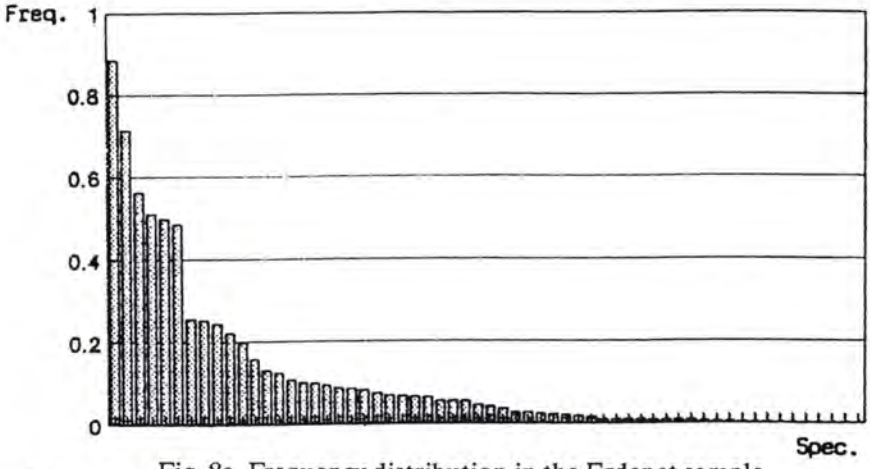


Fig. 8a. Frequency distribution in the Erdenet sample

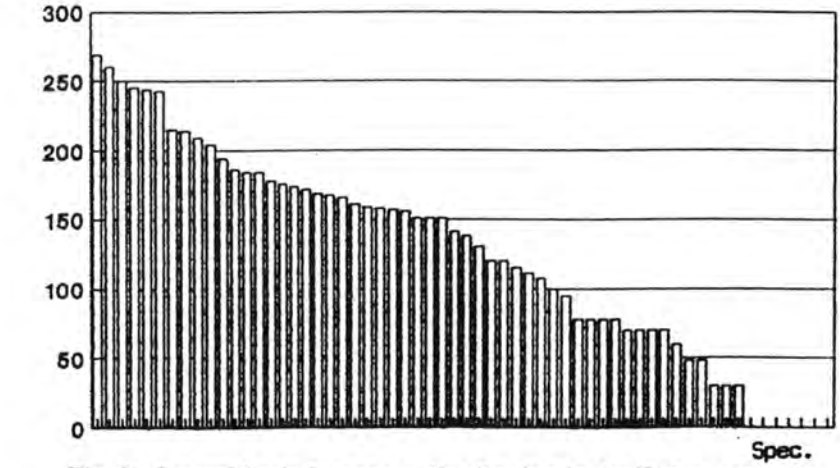


Fig. 8b. Logarithmic frequency distribution in the Erdenet sample



Fig. 8c. Life form spectrum of the Erdenet sample