Structure of the phytomass of Azerbaijan's steppe vegetation

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Abstract. In the period 1990–1998 the seasonal and annual dynamics of the phytomass and its agrobotanical properties were studied in the associations *Festucetum, Stipetum* and *Botriochloetum* in Azerbaijan. In favourable years, the average phytomass could reach 130 gr/cm^2. The total underground and aboveground phytomass of the steppe vegetation averaged for eight years amounted to 932.6 gr/cm^2. It was found that the phytomass varied between 41–497 gr/m^2, with aboveground phytomass registering 5–29 gr/m^2 and underground phytomass recording 35–473 gr/m^2 for the three associations. The ratio of aboveground/underground phytomass has changed from 1:0.3 to 1:0.7. About 30–50 % of the total phytomass was provided by *Poaceae (Festuca valesiaca, Stipa lessingiana* and *Botriochloa ischaemum*). Aboveground phytomass amounted to 0–30 cm (90 %) and underground phytomass to 0–20 cm (80 %).

Key words: Azerbaijan, dynamics, phytomass, steppe, structure, vegetation

Introduction

Vegetation of forest, desert, semidesert, pasture, phrygana, and steppe type is widespread in Azerbaijan's plant cover (Grossheym 1948; Prilipko 1970; Haciyev 1970, 1992; Haciyev & al. 1979, 1990; Atamov 1993, 1996, 2000). Steppes claim 15.5 % of Azerbaijan's area, which amounts 86.600 km^2, at altitudes from 300–1500 m to 2200–2600 m. The steppes in the south and southeast of the country are dominated mostly by the xerophytic species of *Festuca, Stipa, Botriochloa, Koeleria*, *Thymus, Astragalus,* and *Ziziphora*. The soils there are rich in $CaCO_3$ (Atamov 1996). Yearly rainfalls amount to 280–550 mm (Shihlinskyi 1968).

There are 463 flowering plant species (173 monocotes), which account for 98.2 % of the steppe flora. According to the results from our study, 648 (14.4 %) species of Azerbaijan's flora, which is represented by 4500 species in general, form the floristic composition of steppe vegetation (Atamov 1996, 1998). *Poaceae, Asteraceae, Lamiaceae, Fabaceae,* and *Liliaceae* can be listed as the major vegetation families.

Since steppe vegetation occurs on different altitudes, its ecological environment varies, thus entailing differences in the floristic composition and phytocoenological structure. Along these lines, Azerbaijan's steppe vegetation is divided into four phytocoenotypes: desert steppes, main steppes, xerophyte shrub mid-mountain steppes, and cryophyte high-mountain steppes.

The floristic and phytocoenological properties of each phytocoenotype are quite different (Semenova-Tyan-Shanskaya 1966; Haciyev & al.1979, 1990; Atamov 1993, 1998, 2000).

Azerbaijan's steppe vegetation has been also investigated regionally and divided into six steppe provinces (Gobustan, Bozdag, Nahcivan, Talysh, Major Caucasus and Minor Caucasus) and 12 sub-provinces (Atamov 1998).

The investigation of phytomass in phytocoenoses, its vertical distribution and properties of some phytocoenoses have made is possible to determine the importance of phytomass in the vertical structure of vegetation. Sukachev (1972) investigated in detail the layering of forest phytocoenoses. The distribution of aboveground and underground phytomass of phytocoenoses is a seasonally important element. Contrary to forests, in grasslands, and especially in the steppe phytocoenoses, it is difficult to distinguish the layers. For example, biomorphs in the composition of steppe phytocoenoses do not show any marked differences in their morphological characteristics as they do in forests. Vertical structure and phytomass of the steppe phytocoenoses was investigated and well understood by such researchers as Dohman (1960), Shalit (1960), Makarova & Fartushina (1972), Korneeva (1974), Miroshnicenko (1975), Semenova-Tyan-Shanskaya (1977), Sims & Singh (1978), Danilov (1983), Rabotnov (1983), Lebedeva (1984), Titlyanova (1977), Ilin (1988), and Atamov (2000, 2001), who in their works suggested further investigation of steppe layering and vegetation, so as to determine the distribution of phytomass in the layers.

It is quite difficult to place every plant which belongs to steppe phytocoenoses into a specified layer by merely measuring its optimum length. The structure of some rare species in the phytocoenoses and the phytocoenologic role are mostly ignored. For example, in the steppe vegetation of Azerbaijan *Tulipa biebersteiniana*, *T. eichleri*, *Vicia cordata*, *V. hybrida,* etc. play an important role in the phytocoenose structure in autumn.

Therefore, within the time span of the commonly observable vegetation cover both of phytocoenoses and species, measuring needs to be carried out repeatedly, so as to shed the necessary light. Vertical structure of vegetative organs differs in the species and in the phytomass dynamics throughout different seasons. Furthermore, to investigate the analytic relationship of phytomass to vertical structure in the steppe phytocoenoses, one certainly needs to investigate separately the productivity of dominant species and agrobotanic fractions, such as cereals, legumes plants and some grasses, in the layers. Such investigations will explicitly clarify the role of the various dominant species and agrobotanical fractions in the association of vertical structure of steppe phytocoenoses.

Similarly, it would take analytical studies to investigate the vertical structure of underground steppe vegetation (Shalit 1960; Makarova & Fartushina 1972; Sims & Singh 1978; Danilov 1983; Lapinskine 1986; Atamov 2001).

Material and methods

Vertical distribution and structure of steppe pytocenoses in Azerbaijan were studied in the dominant associations of *Festucetum, Botriochloetum* and *Stipetum* in the steppes of Gobustan, Bozdagh, Pirgulu, and similar destinations, in the period 1990–1998. Monthly study trips were organized to the important geobotanical regions of Gobustan (Şamahı-Altagac), Bozdag (Türyançay), Talysh (the mountainous part of Yardımlı and Lerik), and Major Caucasus (Pirkulu) in Azerbaijan. Study materials included *Festucetum (Festuca valesiaca), Stipetum (Stipa lessingiana*) and *Botriochloetum (Botriochloa ischaemum*), widespread in the steppe associations in these regions. The studied species were very common in the research destinations at altitudes of 400–1500 (2000) m. The coldest month of the years was January, when the average monthly temperature ranged from 1.0 °C to 1.5 °C, while the hottest month of the years was July, when monthly temperature ranged from 7.1 °C to 12.5 °C. As annual rainfalls in Gobustan are below 15 % , summers are always dry. Rainfalls are very common in autumn and winter. Yearly precipitation varied between 323–557 mm in the region. The climate was drier and hotter in Bozdagh and Gobustan.

The structure of phytomass fractions was studied as annual green pytomass (G), aboveground dry phytomass (D), dry litter phytomass (L), underground alive phytomass (R), total dead underground phytomass ($D+L+V$), dead underground phytomass (V), total phytomass ($G+R+D+L+V$). These parameters, as products of the herbaceous ecosystems, were studied according to the methods of Korchagin (1976), Vagina & Satochina (1976) and Ilin (1988), while underground phytomass was studied according to the method of Shalit (1958, 1960) and Lapinskine (1986)

Three associations of *Festucetum, Botriochloetum* and *Stipetum* were investigated and measured in plots of 100 m^2 each. Three measurements per month for each phenophase of each species in the phytocoenoses were carried out in the course of eight years. Similarly was determined the aboveground and underground phytomass in a soil layer of 10 cm. The measurements were performed in five replications on 1 m^2 plots for the aboveground phytomass, and on 50 cm^2 plots for underground phytomass. Aboveground phytomass was collected at 10–30 cm and 30–60 cm, while underground pytomass was taken at 0–40 cm.

In order to determine the amount of hygroscopic water (in phytomass studies), the fresh and dry weight were measured and the differences between them were defined as hygroscopic moisture. The sampled green mass above ground was divided into cereals, legumes and other grasses. The average multiple-year results are given in Tables 1-5 and Figs 1-10**.** The results were evaluated statistically (Lakin 1973).

Results and discussion

Underground and aboveground phytomass changes with the steppe phytocoenotypes and the regions of distribution. Its variation is particularly obvious with the annual change of meteorological conditions, especially when it rains. It depends on the steppe phytocoenotypes and definitely on seasonal climatic changes. Consequently, the plants are exposed to open moisture depression. This depression is high, especially in desert steppes, but gradually decreases in the gramineous main steppes and xerophytic bush mid-mountain steppes, and even more so in the high-mountain cryophyte pasture steppes. The variation can be traced out in phytocoenologic properties, as well as in the underground and aboveground phytomass of the vegetation (Table 1).

Table 1. Amounts of total phytomass, aboveground and underground phytomass in Azerbaijan steppes.

Steppe types	Phytomass (sent/ha)		
	Aboveground	Underground	Total
Desert steppe (*Artemisio fragransi-Botriochloetum ischaemumae*)	5.0–11.2	40.0–147.3	45.0–158.5
Main steppe (*Stipetum lessingianae*)	12.6–24.0	219.7–473.0	242.3–497.0
Xerophytic shrub steppe (*Festucetum valesiacae*)	13.5–28.7	225.0–450.0	238.5–478.7
High-mountain cryophyte pasture steppe (*Alchemillo sericeae-Festucetum variae*)	6.1–9.9	34.8–128.5	40.9–137.0

*** sent=100kg; ha=hectare**

As it could be seen in Table 1, the ratio of the aboveground phytomass is different in various steppe phytocoenotypes, but it is closer for shrub mountain steppes (13.5–28.7 sent/ha) and main steppes (12.6–24 sent/ha). Analogous similarity can be found for the underground phytomass (225.0–450.0 sent/ha and 219.7–473.0 sent/ha), too. However, the similarity between desert steppes and cryophyte shrub steppes is only quantitative. The content of phytomass components certainly differs. Total change of the phytomass in Azerbaijan's steppe vegetation is limited to 40.9–497.0 sent/ha.

Table 2. Seasonal dynamics of the fractions: green (*G*), dry (*D*) and dry litter (*L*) aboveground phytomass (gr/m2) in *Festucetum* (I), *Botriochloetum* (II) and *Stipetum* (III) associations.

Aboveground phytomass fractions	Associations	Investigation period (months)								
		III	IVa	IVb	V	VI	VII	VIII	IX	X
Green mass (*G*)	I	1.5	2.7	8.3	13.6	13.8	12.9	11.5	9.4	3.7
	II	1.2	2.9	7.5	14.4	14.9	14.2	12.1	10.2	5.3
	III	2.8	4.1	12.3	18.9	17.5	17.3	15.4	14.1	6.7
Dry mass (*D*)	I	2.1	1.5	1.1	0.8	0.5	1.5	3.2	4.8	4.5
	II	3.4	2.2	1.5	0.9	0.3	2.1	4.1	5.2	6.3
	III	2.3	1.7	1.2	0.7	0.6	3.5	5.7	8.1	9.1
Dry litter mass (*L*)	I	3.6	2.1	1.9	2.2	1.8	1.4	2.7	3.4	5.8
	II	2.7	1.8	1.7	1.9	1.5	1.7	5.1	5.3	4.7
	III	3.2	3.1	2.8	3.4	2.3	5.2	6.2	8.7	8.2
Dead mass (*D+L*)	I	5.7	3.6	3.0	3.0	2.3	2.9	5.9	8.2	10.3
	II	6.1	4.0	3.2	2.8	1.8	3.8	9.2	10.5	11.0
	III	5.5	4.8	4.0	4.1	2.9	8.7	11.9	16.8	17.3
Aboveground mass (*G+D+L*)	I	7.2	6.3	11.3	16.6	16.1	15.8	17.4	17.6	14.0
	II	7.3	6.9	10.7	17.2	16.7	17.9	21.3	20.7	16.3
	III	8.3	8.9	16.3	23.0	20.4	26.0	27.3	30.9	24.0

Table 2 presents the seasonal dynamics of the green mass, dry aboveground phytomass, dry litter aboveground phytomass, dead phytomass, and general aboveground phytomass in *Festucetum*, *Stipetum* and *Botriochloetum* associations for the period 1993–1995, between March and October. The parameters show changes according to seasons and associations. In the *Stipetum* association, the phytomass of different fractions exceeds that in the other two associations *(Festucetum, Botriochloetum*). Thus, the aboveground green mass (*G*) in *Stipetum* was 2.8–18.9 sent/ha, in *Botriochloetum* 1.2–14.9 sent/ha and in *Festucetum* 1.5–13.8 sent/ha (Fig. 1). In each of the three associations, the green phytomass (which forms in March) clearly increases, reaching its maximum at the end of May and the middle of June. Then in the following months it decreases, reaching its minimum in November. The reasons for this increase are high temperature and humidity of the soil. These factors provide a suitable environment for plants in efflorescence. The amount of green phytomass and dynamic properties of *Botriochloetum* and *Festcetum* were close to each other but differed from *Stipetum.* As it could be seen in Table 2, in *Stipetum* the amount of dry but not separated from the plant phytomass (*D*) was higher and ranged between 0.6–9.1 sent/ha, but it changed within the range of 0.3–6.3 sent/ha in *Festucetum*. Each of the three associations from the beginning of March to the middle of June marked a gradual increase, which after midsummer climbed up to reach its maximum in the early fall (Fig. 2). In the investigated steppe associations, the amount of phytomass fraction (*C*) of dry litter in *Stipetum* varied between 2.3–8.7 sent/ha, in *Festucetum* between 1.4–5.8 sent/ha and in *Botriochloetum* between 1.5–5.3 sent/ha (Table 2).

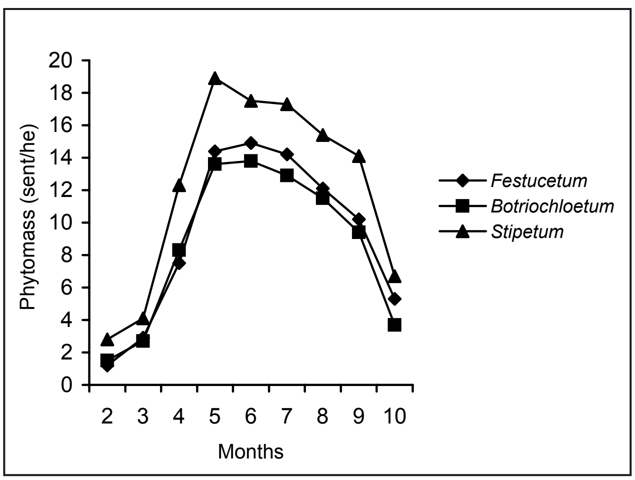

Fig. 1. Seasonal dynamics of the green phytomass (*G*) in steppe vegetation.

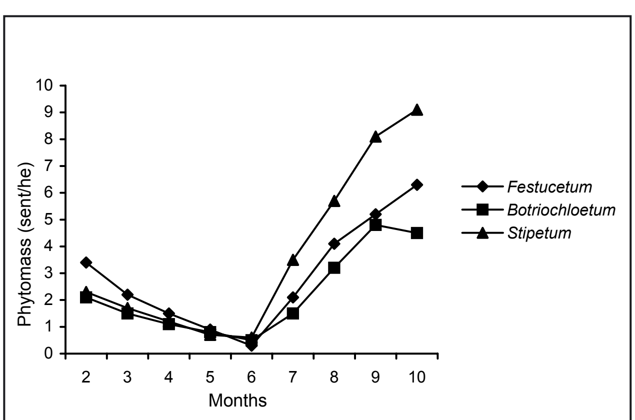

Fig. 2. Seasonal dynamics of dry phytomass (*D*) in steppe vegetation.

In each of the three associations, the seasonal dynamic changes of *L* gradually decreased from the beginning of March to midsummer, with a subsequent increase until mid-autumn (Fig. 3). This increase was generally related to the increase of green phytomass in that period and of dry aboveground parts of the ephemerous and ephemeroid species, which completed their short life period, i.e. the amount of green phytomass and the amount of dry litter phytomass scored high ratios (Figs 1, 2, 3) with the change of seasonal dynamics. In May the alive phytomass (*G*) reaches the maximum values, at autumn these values reaches minimum. Conversely, the dry phytomass (*D*, *L*, *D*+*L*) values are maximum in autumn and minimum in May (Figs 1, 2, 3).

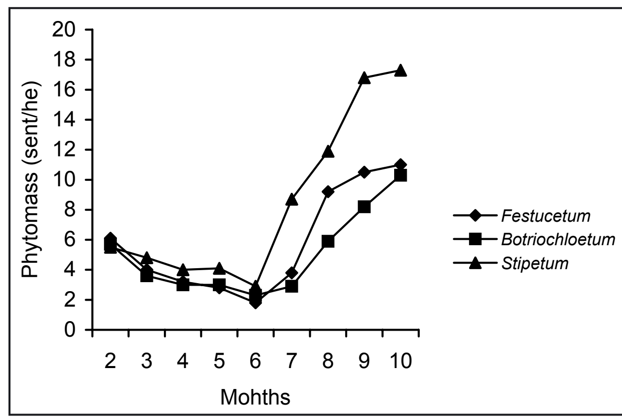

Fig. 3. Seasonal dynamics of dry litter phytomass (*L*) in steppe vegetation.

D and *L* featured parts of dead aboveground phytomass and their total seasonal change ranged between 2.9–17.3 sent/ha in *Stipetum*, 2.3–10.3 sent/ha in *Festucetum*, and 1.8–11.0 sent/ha in *Botriochloetum* (Table 2). Seasonally, *D*+*L* have decreased since the beginning of March until midsummer, but subsequently reached a maximum at the beginning of October (Fig. 4).

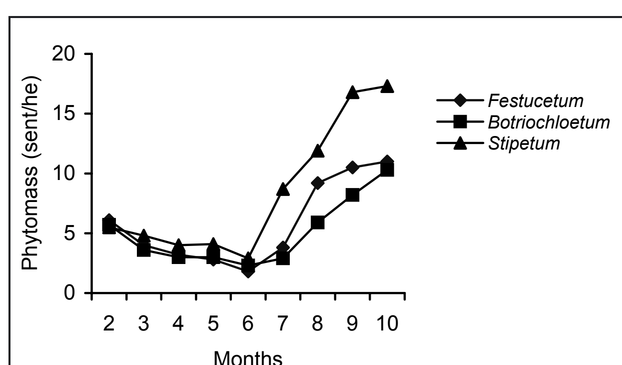

Fig. 4. Seasonal dynamics of dead phytomass (*D*+*L*) in steppe vegetation.

The total green mass (*G*) and the dry mass (*D+L*) form the general aboveground phytomass (*G+D+L*). In each investigated association, the seasonal change of *G+D+L* was at its minimum at the beginning of spring and reached its maximum at the end of summer and the beginning of autumn. *G+D+L* varied within the range of 8.3–30.9 sent/ha in *Stipetum*, 6.3–17.6 sent/ha in *Festucetum*, and 6.9–21.3 sent/ha in *Botriochloetum*. The seasonal dynamics of that change is given in Fig. 5. In each of the three associations *G+D+L* increased from the beginning of spring until June. Stagnation was observed in July. A decrease started since October. In terms of phytomass, *Stipetum* surpassed the other two associations.

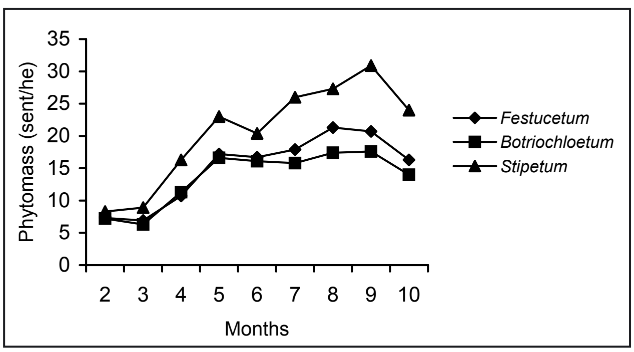

Fig. 5. Seasonal dynamics of aboveground phytomass(*G+D+L*) in steppe vegetation.

Furthermore, after 1991 the parameters (*G*, *D*, *L*) were investigated for the underground phytomass, annual root system, and living (*R*) and dead (*V*) mass of the roots. In the period 1991–1998, the dynamic changes were analyzed in the associations and the average values are given in Table 3.

These parameters have shown variability during some of the years (Table 3). An important factor for that variability was that the period 1993–1994 was rainy. Therefore, phytomass in the steppe vegetation was at its minimum, but abundant rainfalls in 1991, 1992 and 1995 had brought about an increase in the phytomass. The results from an eight-year period of investigations were used to determine the structure properties of the phytomass fractions of Azerbaijan's steppe vegetation (Table 4; Fig. 6).

Seasonal growth and characteristic species of the *Stipetum* association are shown in Fig. 6. Some species like *Tulipa biebersteiniana* L. and *Zerna rubens* L. have a short vegetation period, others a long one, while the height of some plants do not exceed 10 cm during vegetation (*Alyssum calucium*, *Phlomis pungens*). Some plants (*Carduus arabicus*, *Centaurea squarrosa*) are over 60–70 cm tall. This is important for abundance, horizontal distribution of phytomass and hygroscopic moisture.

Table 4. **Annual (1993–1995) quantitative (g/m^2) changes of phytomass in steppe vegetation.**

Associations / Phytomass fractions	*Artemisio fragransi-Botriochloetum ischaemumae*			*Stipetum lessingianae*			*Festucetum valesiacae*			*Alchemillo sericeae-Festucetum variae*		
	1993	1994	1995	1993	1994	1995	1993	1994	1995	1993	1994	1995
Green mass	6.5+0.6	8.6+1.6	12.5+0.2	9.3+1.8	14.7+1.7	18.3+0.3	8.2+1.6	10.5+2	16.3+1.3	4.2+0.8	6.7+1.5	9.8+1.8
Dead green mass	16.4+1.7	17.4+0.8	15.9+1.7	17.8+0.7	19.5+0.8	22.6+0.5	14.2+1.7	12.8+1.5	15.9+1.4	10.3+1.5	12.4+1.1	10.3+1.7
Total aboveground mass	22.9	26	28.4	27.1	35.2	40.9	22.4	23.3	32.2	14.5	19.1	20,1
Live underground mass	458+51	526+22	734+35	679+38	836+41	1126+56	1183+57	1150+62	1475+67	627+15	834+14	762+16
Dead underground mass	362+21	475+41	698+39	563+51	792+36	965+41	878+17	1056+69	1127+61	542+17	658+14	627+13
Total underground mass	820	1001	1432	1242	1628	2091	2161	2206	2602	1169	1492	1389
Total phytomass	842.9	1027	1460.4	1269	1663.2	2131.9	2163.4	2289.3	2534.2	1183.5	1911.1	1409

Table 3. **Annual dynamics of plant pytomass (gr/m^2) in gramineous main steppes (*Graminetum*).**

Years	Green mass (*G*)	Dry mass (*D*)	Dry litter mass (*L*)	Live underground mass (*R*)	Dead underground mass (*V*)	Underground mass (*R+V*)	Dead mass (*D+L+V*)	Total phytomass (*G+D+L+R+V*)
1991	164.3	140	120	415	312	727	572	1151.3
1992	135.4	83	79	310	286	596	448	893.4
1993	92.1	97	68	298	185	483	350	740.1
1994	110.2	68	53	327	336	663	457	894.2
1995	126.5	56	58	394	350	744	464	984.0
Average	**126.7**	**88.8**	**75.6**	**348.8**	**293.8**	**642.6**	**458.2**	**932.6**

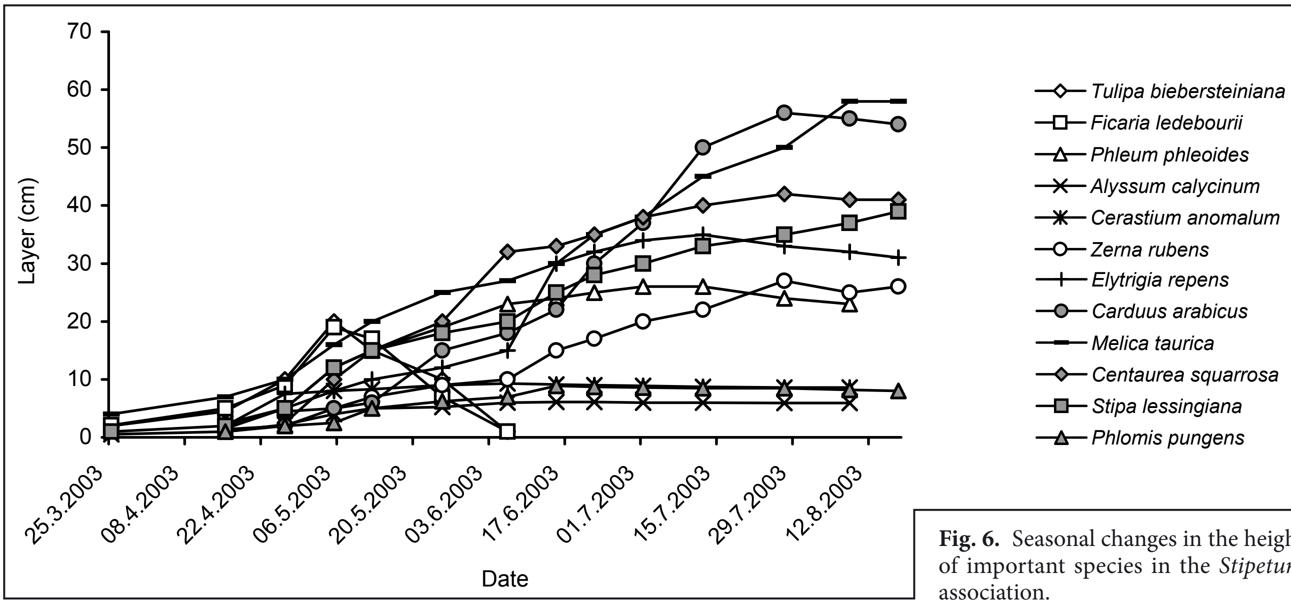

Fig. 6. Seasonal changes in the height of important species in the *Stipetum* association.

During the period 1993–1997, the parameters $G+D+L+R+V$ were studied separately in the steppe phytocoenotypes of desert steppes *(Artemiso-Botriochloetum* associations), gramineous main steppes *(Stipetum lessinginae*), mid-mountain xerophytic shrub steppes (*Thymo-Festucetum*), and high-mountain cryophyte pasture steppes *(Festucetum*) (Table 4). These parameters change according to the phytocoenotypes of the steppes. The highest amount of phytomass of these phytocoenotypes gradually decreased in mid-mountain shrub xerophytic steppes (*Thymeto-Festucetum*), followed by the high-mountain cryophyte pasture steppes (*Stipetum*), and finally by the desert steppes (*Artemis-Botriochloetum*) (Table 4).

Annual dynamic changes of these parameters (G, $D+L$, R, V) and of each parameter separately have shown similarity in the years (Figs 7, 8). They have increased as follows: *Artemisio-Botriochloetum* < *Festucetum* < *Stipetum* < *Alchemillo-Festucetum*. In the period 1993–1998, these parameters in association values ranged as follows: G=4.2–18.3 g/m^2; $D+L$=10.3–22.6 g/m^2; R=458–1477 g7m^2; and V=362–1156 g/m^2 (Table 4; Figs 7, 8).

Thus, aboveground and underground phytomass of the steppe vegetation change according to the meteorological conditions of the year. Aboveground phytomass has varied between 5.0–28.7 sent/ha, and underground phytomass varied between 40.9–497.0 sent/ha. Green phytomass (G) from March onwards has increased steadily until the end of May and has reached its maximum levels. Subsequently, it gradually decreased until the end of September. Dry phytomass (D) was reduced in amount from March until the end of June, but subsequently has gradually begun to increase and reached its maximum level at the beginning of November. Dry litter phytomass (L) went gradually down from March to June but then started to increase until November. $D+L$ repre-

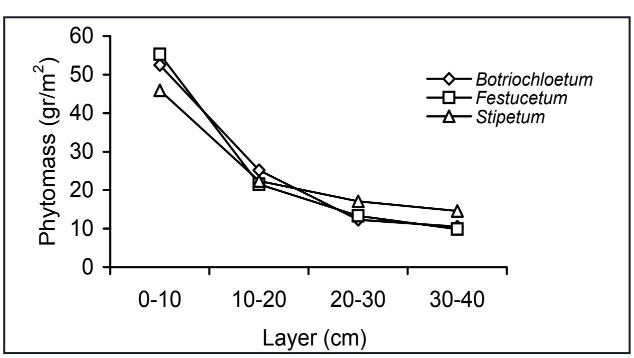

Fig. 7. Vertical distribution of the aboveground general phytomass in steppe associations (Fractions: various grasses).

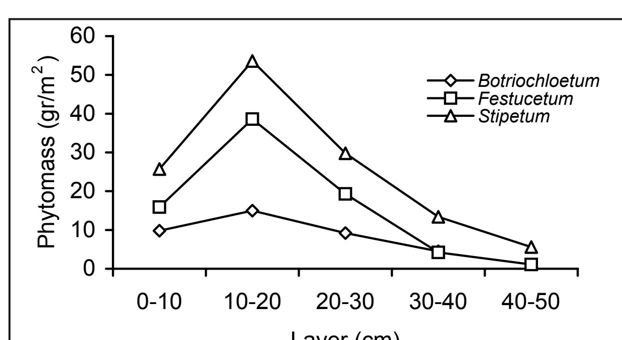

Fig. 8. Vertical distribution of the aboveground general phytomass in steppe associations (Fractions: gramineous).

sent the dead phytomass contribution to the association. Seasonally, *D+L* decreased from March until June, but subsequently reached their maximum level. Underground phytomass and its ratio have changed from 1:11 to 1:37. The ratio of underground and aboveground phytomass was low (1:4 to 1:8) in the humid years (1990, 1991, 1992, 1995) and high in the dry years (1993, 1994). Due to grazing and cutting the ratio has decreased both in dry and humid years (Atamov 1986).

Vertical distribution of the aboveground and underground phytomass and distribution of hygroscopic moisture in the aboveground phytomass are shown in Figs 6-11. They illustrate the role of different agrobotanical fractions in the productivity of steppe phytocoenoses.

The leaves on the stems of most steppe vegetation species are set 10–30 cm above the ground. The generative organs are set higher than 10–30 cm on the stem. In our research, we rated the plant species in categories by height. Dominant plant groups were determined by the number of individuals with similar height.

The height of most plants in the steppe phytocoenoses of Azerbaijan is restricted, owing to moisture content and altitude (Figs 6-11). Therefore, the major physiological body of the plant is rather positioned underground than aboveground. However, vertical structure and distribution of the phytomass in steppe phytocoenoses is simpler. Temperature, moisture and other ecological factors have increased acording to the height of plants in layering.

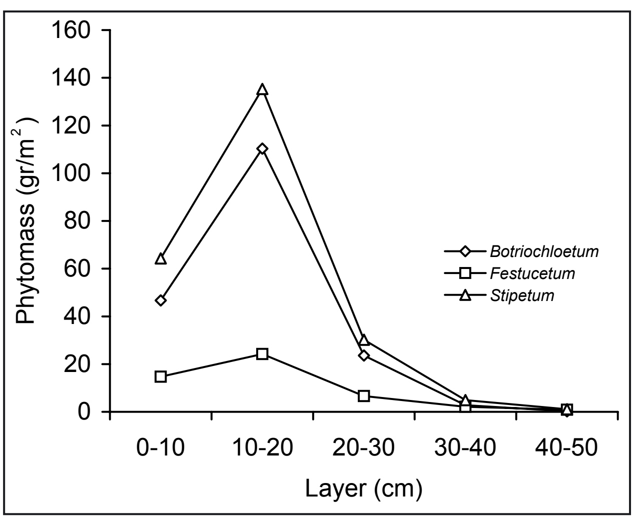

Fig. 9. Vertical distribution of the underground phytomass in steppe associations.

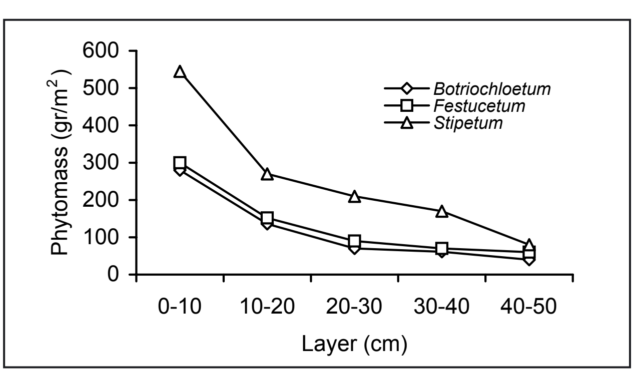

Fig. 10. Vertical fractional distribution of the underground general phytomass in steppe associations.

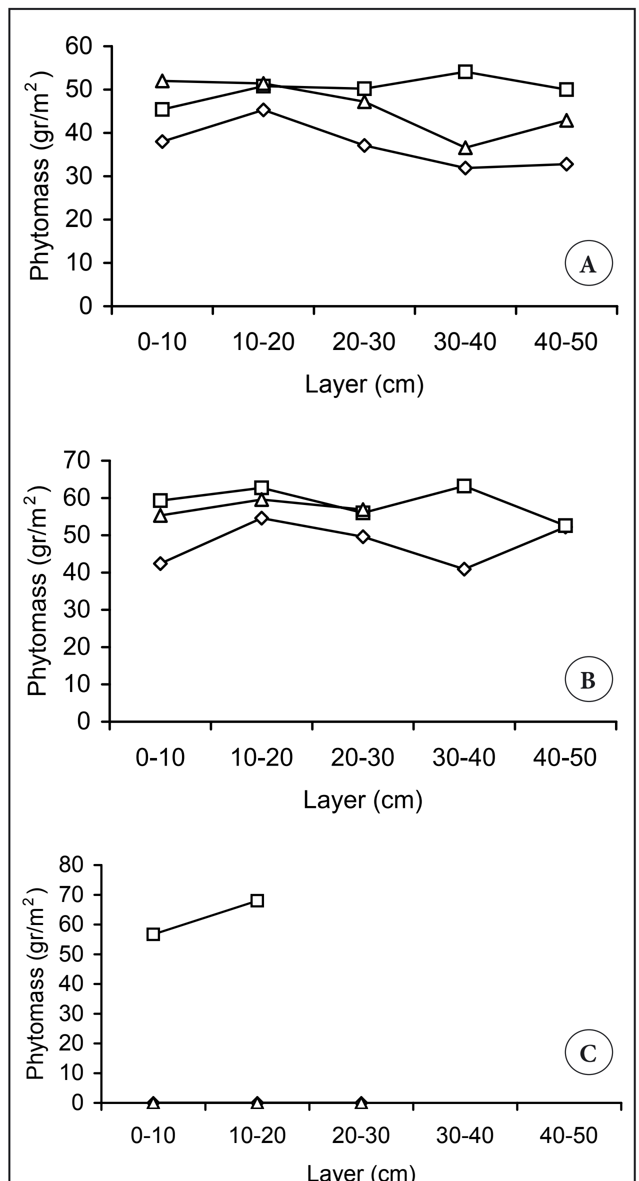

Fig. 11. Vertical fractional distribution of hygroscopic water in the aboveground phytomass of steppe vegetation.

Botriochloetum **A** – in the gramineous fraction.
Festucetum **B** – in the various herbs fraction.
Stipetum **C** – in the fabaceous fraction.

During the vegetation period, vertical and horizontal distribution of phytomass varies in the physiologically active organs of a general plant group, as well as within the various species, owing to the botanical composition of the plants. Vertical structure of the grass cover in Azerbaijan and, hence, the phytomass of steppe vegetation vary strongly throughout the year.

Vertical structure of the phytomass in steppe vegetation is determined by the morphological and biological characteristics of the dominant species and the composition of phytocoenoses. These characteristics are strongly related to climatic and soil conditions within the seasons of the year (Table 5).

Table 5. Vertical distribution of hygroscopic water (gr/m2) in the aboveground phytomass of Azerbaijan's steppe vegetation.

Agrobotanical groups	Layer (cm)	Associations		
		Botriochloetum	*Stipetum*	*Festucetum*
Gramineous	0–10	38.0	45.4	52.0
	10–20	45.3	50.8	51.4
	20–30	37.1	50.2	47.2
	30–40	31.9	54.1	36.6
	40–50	32.8	50.0	42.9
	50–60	–	–	40.0
	Average	**39**	**49.4**	**50.3**
Fabaceous	0–10	–	56.7	–
	10–20	–	68.0	–
	20–30	–	–	–
	30–40	–	–	–
	Average	–	**59.8**	–
Various herbs	0–10	42.4	59.3	55.3
	10–20	54.6	62.7	59.6
	20–30	49.6	56.0	56.9
	30–40	40.9	63.2	–
	40–50	52.2	52.6	–
	50–60	–	–	–
	Average	**50.7**	**60.7**	**57.0**
Average for the associations		**44.9**	**56.6**	**53.7**

In all three associations, the amount of underground (547.5–1182.5 gr/m^2) and aboveground (126.6–235.8 gr/m^2) phytomass has respectively changed depending on the soil type and its moisture characteristics.

Within the associations, vertical distribution of the hygroscopic water content in the phytomass was investigated. In all three associations, the hygroscopic water content was 31.9–54.1 % in the leaves of the cereals and 40.9–63.2 % in the various grasses. In the cereals, the maximum hygroscopic water content in all three associations ranged between 52.0 % and 51.4 %. This amount of water was contained in the second layer (10–20cm) of the phytocoenoses. In the various grasses of *Festucetum, Botriochloetum*, and *Stipetum* the water content was 54.6 %, 59.6 % and 62.7 %, respectively. In the *Stipetum* association the maximum moisture content was in the second layer (30–40 cm) (Fig. 11). Underground, moisture content was increasing in-depth from 10 cm to 40 cm . This increase was in direct proportion to the vegetative and generative organs in the aboveground phytomass and the vertical distribution of leaves.

Moisture content in the grass cover, especially vertical distribution of moisture content in the steppe vegetation, is strongly related to phytomass distribution, owing to its role in the structure of agrobotanical fractions and vertical phytocoenological structure of the coenosis.

Investigation of the vertical structure of steppe phytomass and vertical distribution of fractions is very important for more productive land use and for evaluation in land use planning. For example, the large amount of phytomass of *Festucetum* is in the lowest layer. These areas are good for grazing, while *Botriochloetum* and *Stipetum* vertically have pytomass in the highest layer. The maximum amount of the aboveground phytomass is in the 10–30 cm layer, while the minimum is in the 40–50 cm layer above ground. The amount of underground phytomass decreases depth-wise. Hygroscopic water content of the aboveground phytomass varies in relation to the vertical distribution of phytomass fractions.

This variability, especially in various grasses, depends on the phytomass ratio between the agrobotanical groups, the amount of vegetative and generative fractions and their location in the layers.

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