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Assessment of cenopopulations of some economically important species of the *Astragalus* L. (Fabales Fabaceae) genus distributed in Azerbaijan

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ABSTRACT The age structure of the ontogenesis of cenopopulations of the valuable fodder plants - *Astragalus glycyphyllys* L., *A. falcatus* Lam., *A. kubensis* Grossh. and *A. aduncus* Willd. - was determined with assessment and the dynamics of development and viability were revealed. A large number of generative individuals were observed during the study of age spectra. The species studied during this period were eagerly eaten by cattle. Scientific and practical importance in terms of analyzing the species composition of phytocenoses, increasing the fodder base in Azerbaijan, improving summer and winter pastures, nitrogen enrichment of arable lands, livestock development in agriculture, as well as their use in various industries of studied species have been determined at the level of cenopopulation.

KEY WORDS *Astragalus*; dynamics; ontogenesis; phytocenosis; population

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INTRODUCTION

Legumes - the world's second-largest economy after cereals - always played an important role in animal feed rations. Intensive grazing, anthropogenic influence and ecological imbalances are the main factors of degradation of meadows and pastures to varying areas, and as result have led areals of legume species (Etzold et al., 2015; Ibadullayeva, 2011; Mammadova, 2016). The economic importance of the *Astragalus glycyphyllys* L., *A.falcatus* Lam., *A.kubensis* Grossh. and *A.aduncus* Willd. species on cenopopulations (CP) level has been identified.

More than 140 of the 2,000 known species of the *Astragalus* L. genus (Fabales Fabaceae) grows in the arid climate of the Earth are widespread in Azerbaijan. The representatives of the *Astragalus* genus distributed in Azerbaijan are annual, perennial, semi-shrub, bush and shrub-like individuals according to their life forms, and perennial grasses are predominat among them (Asgarov, 2016; Ganbarov, 2016; Hajiyev et al., 1996). These legumes have great scientific and practical importance, especially in the development of livestock in agriculture, the creation of an abundant fodder base, the improvement of summer and winter pastures, the enrichment of arable lands with nitrogen. The *Astragalus* genus, which ranks first in terms of the number of legumes species in Azerbaijan also includes a lot of endemisms (Asgarov, 2016; Mammadova, 2011; Red Book of Azerbaijan Republic, 2013).

The main goal of research to conduct phytocenological studies in the populations of some members of the forage crops genus distinguished by economically important representatives.

MATERIAL AND METHODS

Astragalus glycyphyllys, *A.falcatus*, *A.kubensis* and *A.aduncus* species of *Astragalus* genus distributed in the flora of Azerbaijan are objects of research. The research was conducted in 2017–2020 in various botanical and geographical regions of Azerbaijan.

Methods developed by T.A.Rabotnov, A.A.Uranov, and their schools were used in the assessment of species cenopopulations (Ilina, 2017; Rabotnov, 1969; Semenova et al., 2016; Uranov, 1975). The most commonly accepted geobotanical methods (Field geobotany, 1959–1976; Plant senopopulations, 1977; Semenova et al., 2016; Uzun et al., 2019), methods of life forms determination (Asgarov, 2016; Cherepanov, 1995; Flora of Azerbaijan, 1950–1961; Ganbarov, 2016; Gasimzade, 2015), as well as many methods for systematic taxonomy of rare and endangered species (Asgarov, 2016; Ganbarov, 2016; Hajiyev, 1996; Red Book of Azerbaijan Republic, 2013) have been used in geobotanical and floristics research.

RESULTS AND DISCUSSIONS

Sprout, juvenile, immature, young generative, middle-aged generative, elderly generative, senile and subsenil age conditions were identified as economically important representatives of the legume genus - *Astragalus falcatus*, *A. glycyphyllus*, *A. kubensis* and *A. aduncus* species. Detailed data on the research on the structure and development dynamics of the ontogenesis of cenopopulations of *A. falcatus* and *A. glycyphyllus* species (within the Azerbaijan Republic) have been shown in the paper.

Astragalus falcatus is a perennial herbaceous plant with a strong straight stem, 40–90 cm tall. The upper part of the trunk is slightly furrowed, covered with dense hairs and weakly branched. The leaves are 9–18 pairs, 6–15 cm long, covered by sparse hairs from below. The inflorescence is longer than the leaves and covered by particularly dense hairs after flowering. The elongated brush is 8–12 cm long, very flowery. The fruits are curved, linear-oblong, 14–25 mm long, sickle-shaped. It flowers in May–June and bears fruit in August (Asgarov, 2016; Flora of Azerbaijan, 1950–1961).

Astragalus falcatus species is a main structural element of the studied groups, and plays an important role in the formation of meadow, mountain xerophytes and steppe vegetation types as have been shown studies of cenopopulations of the genus. So, the age and vital features of *A. falcatus* species under analyzing of species composition of phytocenoses have major importance.

Analyzing the species composition of phytocenoses have been shown each species consists of many individuals that differ in age and vital characteristics in the cenosis. The ecological optimum of a species depends on the availability of favorable conditions for its height and development as known. The direct influence of environmental factors on plant ecosystems has also been known to depend on age conditions.

The spring and autumn seedlings of *A. falcatus* species studied under natural conditions differed from each other. Thus, autumn seedlings grow very slowly. It depends also on the climatic conditions of the observed regions. Spring seedlings are preferred during the development period, as these seedlings are an indicator of the viability of the species and of great importance for cenopopulation as the variability of cenopopulation depends on their number (Mammadova, 2016; 2017).

The length of the juvenile age is also related to the environmental conditions in which the species grows as shown in studies. The presence of juvenile individuals in the cenopopulation indicates the survival rate of young plants in the cenosis. The structure of the ontogenesis of the cenopopulation of *A. falcatus* has been shown in Table 1.

The development of juvenile individuals of the *A. falcatus* species is normal as can be seen from Table 1. Juvenile individuals of the *A. falcatus* species are well developed, consisting of 1–2 leaves. No juvenile individuals were found in the sample sites in Gakh (I CP) and Dashkasan (III CP) districts in 2019, and in Sharur (II CP) districts of Azerbaijan in 2017 during the study years.

Individuals in immature age were characterized by short leaves and the formation of new vegetative shoots during the study. The formation of caudex was characteristic of immature individuals, with a shaft root system that did not develop additional roots. An immature individual consisting of 4–5 leaves by 3–4 cm has developed above the soil surface reaching 0.6–0.7 cm.

Vegetative shoots began to develop at the virginal age, the size of the shoots reached 5 cm, and the number of leaves reached 7–9 cm. The diameter of the caudex was about 0.2 cm. The maximum development of vegetative shoots was observed in the state of virginal age I CP in 2018.

Generative browse and buds developed at a young generative age, the length of generative browse varied from 10 to 18 cm, and the length of leaves from 0.6 to 1.3 cm. In some cases, flowering is observed even at this age. The process of fertilization and reproduction occurs in middle-aged and elderly generative age conditions. The development of generative individuals was lower than in I and II CP in the *Alchemileta-Amorietum-Anthyllisosum* formation group (III CP). Thus, the maximum number of generative (g_1+g_2+g_3) individuals in I CP was equal to 38 in 2018, 28 in II CP in 2019, and 25 in III CP in 2019 and 2020. This is the main sign of a gradual decline in the rate of cenosis. The reason was unsystematic grazing in the area.

Physiological processes are already weakened in the conditions of subsenil and senile age. It should be noted sub-senile and senile wet conditions, the surface of plant organs shrinks as shown by result of the analysis of biometric signs during the study. Most mature individuals were found in the I CP in 2019 (ss + s = 9) during a drought.

Transient and mature cenopopulations types were observed during the assessment of cenopopulations of *Astragalus falcatus* (Table 2).

The mature type in CP II in 2018 (Δ-ω= 0.47–0.71) and in CP III in 2020 (Δ-ω=0.46–0.73) in others were transitional on the basis of age and efficiency as can be seen from Table 2.

Astragalus glycyphyllus is a perennial herbaceous plant up to 1 m tall. The trunks are erect or elongated, the surface is furrowed and covered with scattered hairs. The leaves are 5–20 cm long, consisting of 5–6 (4–8) pairs of leaves, the upper part is bare, and the lower parts, especially the outer parts of the veins are hairy. The foliage is free. Clusters of many flowers are elongated elliptical, about 3–10 cm long. The inflorescences are bizarre, the edges are ciliated. The cup is densely white-haired or glabrous, the edges are serrated. The pulses are 3–4 cm long, linear or sickle-shaped. It flowers and bears fruit mainly in May–June (Asgarov, 2016; Flora of Azerbaijan, 1950–1961).

Cenopopulation studies of *Astragalus glycyphyllus* were conducted within 3 formation groups. Ontogez age conditions were monitored in 2017–2019 (Table 3). At first, the bioecological features of the species and its field of use were studied. Abundance in phytocenoses was estimated at 1–2 points.

Cenopopulations developed normally in the II CP and III CP formation groups as can be seen from Table 3. Virginal individuals have been routinely monitored within populations, indicating that the species is also vegetatively regenerating. As a result, the low incidence (2–5) of senile individuals in the studied populations reflects the development of the *Astragalus glycyphyllus* species. However, no juvenile individuals were found in the I CP formation group in 2018, and the number of generative individuals was also low (g_1+g_2+g_3=14). This means that the area of *A. glycyphyllus* distribution will be reduced in the future.

The high development of individuals of *A. glycyphyllus* species was in the *Thymetum-Astragalosum* formation group (II CP). The number of individuals of ontogeny in this formation group was 169 during three years (2017–2018). This is due to the favorable climatic conditions in the area where the species is widespread.

Age and efficiency indices were calculated based on the results of the research (Table 4). The cenopopulation type was the mature type (Δ-ω= 0.33–0.64) only in the *Caraganetum* formation group (I CP) in the Goygol districts of Azerbaijan. This is due to the same amount of immature and virginal individuals (17.3%) and in other populations it was transitional.

*Astragalus glycy*phyllus species fits in the threat category of the sensitive species (VU) based on direct observations (A_a), calculation of the abundance index according to the observations (A_b), reduction of the encounter distance in the distribution area (A_c), reduction of the distribution area according to the geographical range (B_2). Therefore, constant control over the species in the area is advisable.

The dynamics of development of cenopopulations of *Astragalus glycyphyllys*, *A. falcatus*, *A. kubensis* and *A. aduncus* of *Astragalus* genus species has also been studied. *Astragalus falcatus* in the study areas was a full member of legumes and cereals populations. Therefore, population recovery was at the expense of individuals. The max-

CP	Years	Ontogenetic age conditions								Σ
		j	Im	v	g_1	g_2	g_3	Ss	s	
I CP	2017	2	3	5	9	11	11	2	2	45
	2018	4	4	7	12	13	13	4	4	61
	2019	-	2	4	10	10	9	5	4	44
II CP	2017	-	3	5	7	10	9	4	3	41
	2018	1	2	4	8	9	8	3	-	35
	2019	2	3	5	9	11	8	-	4	42
III CP	2017	-	3	5	9	8	8	4	3	40
	2018	2	2	4	7	7	6	2	1	31
	2019	2	-	4	7	9	9	1	1	33
	Σ	13	22	43	78	88	81	25	22	372
	%	3.5	5.9	11.5	21	23.6	21.8	6.7	5.9	99.9

Table 1. Structure of the ontogenesis of the cenopopulation of *Astragalus falcatus* Lam. species.

CP	Years / Ont. periods	I CP			II CP			III CP		
		2017	2018	2019	2017	2018	2019	2018	2019	2020
Growth phases of ontogeny in %	j	4.4	6.5	-	-	2.8	4.8	-	6.4	6.1
	im	6.7	6.5	4.5	7.3	5.7	7.1	7.5	6.4	-
	v	11.1	11.5	9.1	12.1	11.4	11.9	12.5	12.9	12.1
	g_1	20	19.7	22.7	17	22.8	21.4	22.5	22.6	21.2
	g_2	24.4	21.3	22.7	24.4	25.7	26.2	20	22.6	27.2
	g_3	24.4	21.3	20.4	21.9	22.8	19	20	19.3	27.2
	ss	4.4	6.5	11.4	9.7	8.6	-	10	6.4	3
	s	4.4	6.5	9.1	7.3	-	9.5	7.5	3.2	3
Indexes	$\dot{I}_r$	0.32	0.39	0.21	0.31	0.28	0.36	0.32	0.40	0.24
	$\dot{I}_{rp}$	0.29	0.32	0.16	0.24	0.25	0.31	0.25	0.35	0.22
	Δ	0.48	0.48	0.52	0.50	0.47	0.47	0.51	0.45	0.46
	ω	0.68	0.64	0.67	0.67	0.71	0.66	0.65	0.65	0.73
CP type	Transition	+	+	+	+		+	+	+	
	Mature					+				+

Table 2. Assessment of cenopopulations of *Astragalus falcatus* species; j: juvenil; im: immature; v: verginile; g: generative; ss: subsenil; s: senil; Ir: restiration index; Irp: replaceability index; Δ: age index; ω: efficiency index.

CP	Years	Ontogenetic age conditions j	im	v	g_1	g_2	g_3	Ss	s	Σ
I CP	2017	2	3	3	7	7	6	2	-	30
	2018	-	4	4	5	4	5	1	-	23
	2019	1	3	5	7	7	8	2	2	35
II CP	2017	3	5	5	10	11	11	4	4	53
	2018	4	4	6	9	12	9	4	-	48
	2019	5	5	7	12	15	16	8	-	68
III CP	2017	-	4	7	8	9	9	6	5	48
	2018	-	5	8	10	9	10	4	2	48
	2019	5	7	10	11	11	10	4	2	60
	Σ	20	40	55	79	85	84	35	15	413
	%	4.8	9.7	13.3	19.1	20.6	20.3	8.5	3.6	99.9

Table 3. The structure of the ontogenesis of the cenopopulation in which the *Astragalus glycyphyllus* species is widespread.

CP	Ontog periods	I CP 2017	I CP 2018	I CP 2019	II CP 2017	II CP 2018	II CP 2019	III CP 2017	III CP 2018	III CP 2019
Growth phases of ontogeny in %	j	6.6	-	2.8	5.6	8.3	7.3	-	-	8.3
	im	10	17.3	8.6	9.4	8.3	7.3	8.3	10.4	11.7
	v	10	17.3	14.3	9.4	12.5	10.3	14.6	16.6	16.7
	g_1	23.3	21.7	20	18.8	18.7	17.6	16.6	20.8	18.3
	g_2	23.3	17.3	20	20.7	25	22	18.7	18.7	18.3
	g_3	20	21.7	22.8	20.7	18.7	23.5	18.7	20.8	16.7
	ss	6.6	4.3	5.7	7.5	8.3	11.8	12.5	8.3	6.6
	s	-	-	5.7	7.5	-	-	10.4	4.1	3.3
Indexes	$\dot{I}_r$	0.40	0.57	0.41	0.40	0.46	0.39	0.42	0.44	0.69
	$\dot{I}_{rp}$	0.36	0.53	0.35	0.32	0.41	0.33	0.29	0.37	0.58
	Δ	0.40	0.33	0.44	0.46	0.41	0.45	0.51	0.44	0.38
	ω	0.67	0.64	0.65	0.62	0.65	0.65	0.61	0.64	0.58
CP type	Transition	+		+	+	+	+	+	+	+
	Mature		+							

Table 4. Assessment of cenopopulations of *Astragalus glycyphyllus* species; j: juvenil; im: immature; v: verginile; g: generative; ss: subsenil; s: senil; Ir: restiration index; Irp: replaceability index; Δ: age index; ω: efficiency index.

imum recovery index (I_r=0.40) followed in the *Alchemileta-Amorietum-Anthyllisosum* formation group (III CP) in 2019, and the minimum recovery index (I_r=0.21) in the *Trifolietum-Nardosum* formation group (I CP) in 2018. Monitoring of the minimum recovery intensity is associated with low development of vegetative individuals (im + v = 13.6%). This, of course, leads to low species development in the future in the cenosis. Therefore, the organization of systematic grazing in the area is recommended.

Change in the population wave was observed, which was due to the fragmentation of the age spectrum during the study. The generative period is longer because the pre-generative and post-generative periods are dynamic according to the rate of development of cenopopulation (Fig. 1).

The size of the organs decreases as a result of the arid climate as we move from North to South. The highest density of *A. falcatus* species in the studied populations was in the *Trifolietum-Nardosum* D = 1.22 formation group (I CP) in 2018 (50 m^2 of sample area). The recovery index was I_r = 0.39 despite the high density. This is due to the weakening of development as a result of increasing density.

The dynamics of cenopopulations of the *A. glycyphyllus* L. was observed in 3 different plant types. The population wave changed more in subsequent years as a result of an increase in subsenil individuals in 2019 (11.8%) in the *Thymetum kotschyanus-Astragalosum falcatus* formation group (CP II) (Fig. 2). Although the lack of favorable plant conditions has led to a further decline in the number of generative individuals, other populations have been normal.

The maximum recovery index (I_r=0.69) was observed in 2019 in the *Caraganeta-Pistacetum-Juniperusosum* formation group (CP III). Reversible changes were observed in this cenopopulation. The succession of individuals during development is cyclical. The highest density was D = 1.36 in 2019 in the *Thymetum kotschyanus-Astragalosum falcatus* association (II CP). This is due to the fact that the climatic conditions are optimal for plant growth.

Assessment and development dynamics of cenopopulations of the *Astragalus cubensis* species - a rare and endangered genus of beans - was included in the Red Book of the Azerbaijan Republic and as well as the valuable fodder plant *Astragalus aduncus* species were also studied during the research. The development of many vegetative and generative shoots in the studied species increases the growth rate of the species population in the pasture, in general, was found. Therefore, grazing does not adversely affect the condition of the cenopopulation. But as a result of intensive grazing, generative shoots are destroyed. The number of seeds is sharply reduced and the seedlings are trampled.

As a result, it has a negative impact on the development of cenopopulation. Weather conditions are also an environmental factor with a greater impact on the number of seedlings. Seedlings are a relatively variable part of the cenopopulation, the composition and structure of the future cenosis depend on them. The durability of seedlings varies depending on the type of cenosis and the structure of the relief.

Each of these legumes can be used as a fodder plant after seeding to preserve its reserves. Prevention of their extinction and destruction by collecting seeds and increasing the number of farms is also possible. *Astragalus aduncus* is eagerly eaten both in wet and in dry grass forms. The introduction of this species in the lowlands of Azerbaijan and its use in livestock is promising. This species is a valuable fodder plant and can be obtained with high grass yields if grown in winter pastures. Therefore, grazing is recommended in the post-generative age. It should be noted that high grass yield can be obtained if the plant grows in winter pastures. Collecting the seeds of the plant from arid regions and sowing them in semi-desert winter pastures in Autumn is recommended for this purpose.

As a recommendation to the farm, it can be noted that large-scale cultivation of studied at the cenopulation levels protected, rare and endangered legume-plants (*Astragalus glycyphyllys*, *A. falcatus*, *A. kubensis*, *A. aduncus*), which are included in the "Red Book" of Azerbaijan will significantly improve the fodder base of the country. At the same time, as honey-producing plants they can be used in the development of beekeeping, as they are drought-resistant plants, and also can be widely used in the restoration of fodder reserves in desert areas, nitrogen enrichment of the soil, and against erosion.

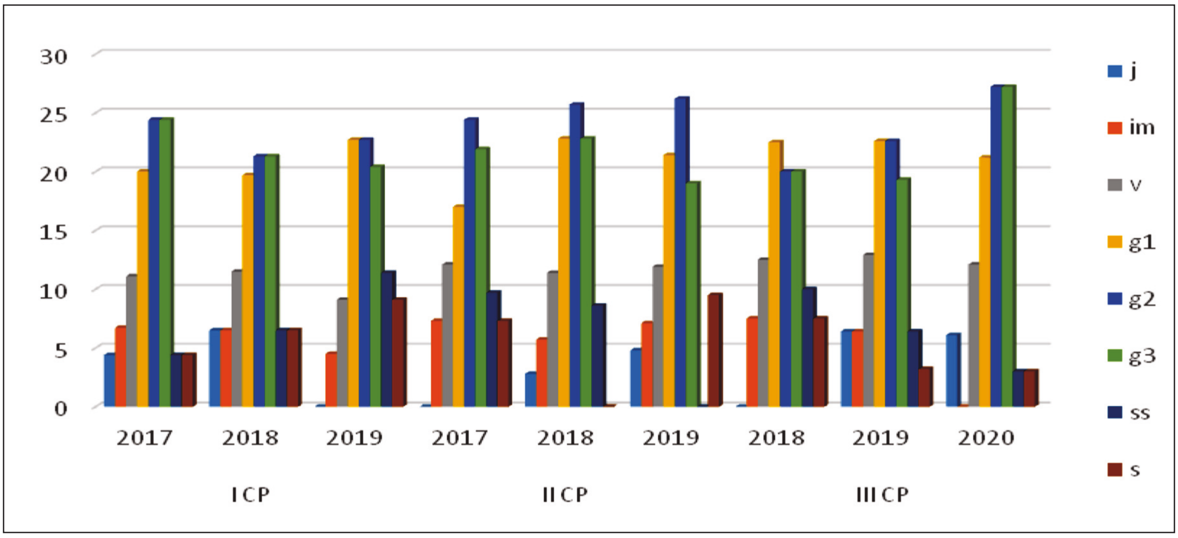

Figure 1. Development dynamics of the *Astragalus falcatus* Lam. species in different plant groups in the years 2017–2020.

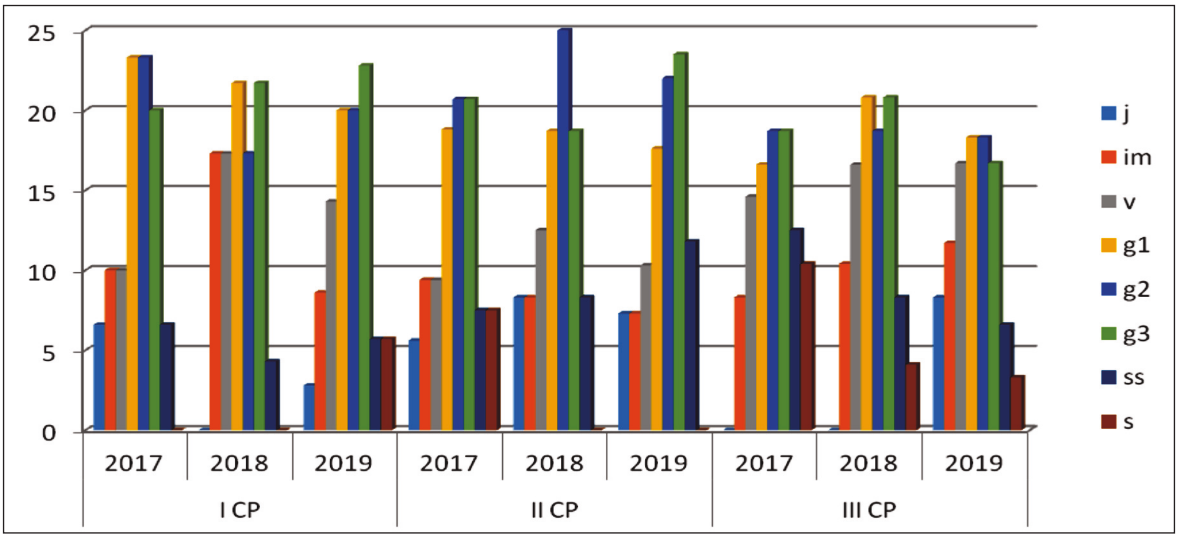

Figure 2. Development dynamics of *Astragalus glycyphyllus* L. species in different plant groups for 2017–2020.

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