NATURE & SCIENCE
October 2026, Volume 8, Issue 5, pp. 97–103
DOI: https://doi.org/10.36719/2707-1146/68/97-103

Ontogenetic Structure of a Cenopopulation of *Astragalus Cicer* L. in the Northeastern Lesser Caucasus

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Abstract. *The ontogenetic structure of Astragalus cicer* L. *(Fabaceae* Lindl.*) was studied in one natural cenopopulation in the northeastern Lesser Caucasus, near Asrik Jirdakhan village in the Tovuz district of Azerbaijan. Field observations were carried out in 2025 on a stony-gravelly slope at approximately 750–850 m above sea level. Thirty individuals were classified into six ontogenetic states on the basis of morphological characteristics and the development of vegetative and generative organs. The recorded numbers were juvenile, three (10.00%); immature, five (16.67%); virginal, six (20.00%); generative, twelve (40.00%); subsenile, three (10.00%); and senile, one (3.33%). The generative stage formed the maximum of the individual-stage ontogenetic spectrum. When grouped into broader developmental periods, pregenerative individuals accounted for 46.67%, generative individuals for 40.00%, and postgenerative individuals for 13.33%. The numerical ratio of pregenerative to generative individuals was 1.17. These findings provide a preliminary quantitative characterization of the studied cenopopulation. Because the observations concern a single site and survey year, repeated field studies are needed to assess population renewal and longer-term changes in ontogenetic composition.*

Keywords: *Astragalus cicer, cenopopulation, ontogenetic spectrum, Fabaceae, Lesser Caucasus*

Introduction

Studying the natural populations of plant species is of great importance for determining their distribution characteristics, developmental stages and current condition. One of the main characteristics of populations is their ontogenetic structure (Gatsuk et al., 1980; Barton et al., 2024). Ontogenetic structure reflects the proportions of individuals at different developmental stages within a population and helps assess the species' potential for renewal under natural conditions (Alahuhta et al., 2021; Gascoigne et al., 2023).

The genus *Astragalus* L., belonging to the family *Fabaceae*, is distinguished by its numerous species and adaptation to diverse ecological conditions. Representatives of this genus occur in various botanical-geographical regions of Azerbaijan and contribute to the formation of natural vegetation. Investigating the morphological, ecological and phytocoenological characteristics of Astragalus species is important for studying the condition of their natural populations (Asgarov, 2016; Gurbanov, 2024; Nasibova, 2025; Govaerts et al., 2021).

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Received: 8 April 2026; Accepted: 3 September 2026; Published online: 25 October 2026
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Astragalus cicer L. is a perennial herbaceous plant and a representative of the genus Astragalus. Identifying individuals belonging to different ontogenetic stages in the species' cenopopulations makes it possible to investigate its developmental characteristics and the distribution of individuals within the population. In particular, examining the ratio of young to generative individuals plays an important role in assessing the renewal characteristics of cenopopulations (Royal Botanic Gardens, Kew, 2026; World Flora Online, 2026).

Studies have been conducted in Azerbaijan on the bioecological and phytocoenological characteristics of species belonging to the genus *Astragalus*. In his research, D. Sh. Ganbarov (2016) examined the ecological and biological characteristics of *Astragalus* species occurring in the Nakhchivan Autonomous Republic and their participation in plant communities. At the same time, investigating the cenopopulation structure of individual species in different geographical areas remains important (Ganbarov, 2016).

The Tovuz district, located in the northeastern Lesser Caucasus, has diverse natural and ecological conditions. Studying the ontogenetic structure of cenopopulations of *Astragalus cicer* in this area is of interest for identifying the developmental characteristics of the species under local conditions and assessing its natural renewal status.

The aim of the study was to investigate the ontogenetic structure of cenopopulations of *Astragalus cicer* L. occurring in the Tovuz district of the northeastern Lesser Caucasus, determine the proportions of individuals at different developmental stages and assess their renewal characteristics.

Materials and Methods

The study object was *Astragalus cicer* L., belonging to the family *Fabaceae*. The research was conducted in 2025 near Asrik Jirdakhan village, Tovuz district, in the northeastern Lesser Caucasus. The reported coordinates of the study site are 40°51′19″ N and 45°37′24″ E. The site is situated at approximately 750–850 m above sea level in a stony-gravelly slope phytocoenosis along a river basin.

To investigate the ontogenetic structure of the species, one natural cenopopulation was selected, and the ontogenetic states of 30 individuals were assessed. Ontogenetic states were identified from morphological characteristics, the development of vegetative and generative organs, and signs of senescence, following the descriptive stage-based framework used in plant ontogenetic studies (Gatsuk et al., 1980). Contemporary research also emphasizes the value of stage-based observations for plant population assessment (DePrenger-Levin et al., 2025; Gatsuk et al., 1980; Uranov, 1975).

The studied individuals were divided into six groups according to ontogenetic state: juvenile (j), immature (im), virginal (v), generative (g), subsenile (ss) and senile (s). The juvenile stage included young individuals whose vegetative organs were not yet fully formed; the immature stage included individuals continuing vegetative development but not yet possessing all morphological characteristics typical of mature plants. The virginal stage included vegetatively developed individuals in which generative organs had not formed. Plants that had reached flowering or fruiting were classified as generative individuals. Individuals characterized by weakening vegetative and generative activity were assigned to the subsenile stage, while individuals showing clear signs of ageing were assigned to the senile stage.

During the analysis of ontogenetic structure, the number of individuals at each developmental stage was determined, and their percentage of the total sample was calculated. Percentage values were calculated using the following formula:

$$P = (n / N) \times 100$$

Here, P is the percentage of individuals at a given ontogenetic stage, n is the number of individuals recorded at that stage, and N is the total number of individuals studied (N = 30).

To summarize the ontogenetic structure of the cenopopulation, individuals were grouped into three main developmental periods: pregenerative (j + im + v), generative (g) and postgenerative (ss + s). The number and percentage of individuals belonging to each developmental period were calculated separately. The following formula was used to assess the numerical ratio of pregenerative to generative individuals:

$$K = (j + im + v) / g$$

Here, K is the numerical ratio of pregenerative to generative individuals; j, im, v and g are the numbers of juvenile, immature, virginal and generative individuals, respectively.

The data obtained were summarized in tables, and the ontogenetic spectrum of the cenopopulation was constructed from the percentages of ontogenetic stages. In analysing the results, the proportions of individual ontogenetic stages and the main developmental periods in the total sample were compared (Martorell et al., 2022; Gascoigne et al., 2023).

Results and Discussion

The ontogenetic structure of one cenopopulation of *Astragalus cicer* L. in the Tovuz district of the northeastern Lesser Caucasus was analysed. During the study, the ontogenetic states of 30 individuals were assessed, and their distribution across different developmental stages was determined. According to their ontogenetic states, individuals were assigned to juvenile (j), immature (im), virginal (v), generative (g), subsenile (ss) and senile (s) groups.

To assess ontogenetic structure, the number of individuals at each developmental stage and their percentage of the total sample were considered. The results are presented in Table 1.

Table 1
Ontogenetic structure of the A. cicer cenopopulation

Ontogenetic stage	Number of individuals	Share (%)
Juvenile (j)	3	10.00
Immature (im)	5	16.67
Virginal (v)	6	20.00
Generative (g)	12	40.00
Subsenile (ss)	3	10.00
Senile (s)	1	3.33
Total	30	100.00

As shown in the table, individuals at the generative stage predominated in the studied cenopopulation. The 12 individuals in this group accounted for 40.00% of the total sample. The higher proportion of generative individuals compared with other ontogenetic groups indicates that the maximum of the ontogenetic spectrum corresponds to the generative stage.

Among individuals in the pregenerative developmental period, plants at the virginal stage were recorded most frequently. There were six virginal individuals, accounting for 20.00% of the total sample; five immature individuals, accounting for 16.67%; and three juvenile individuals, accounting for 10.00%. Thus, all the indicated stages of the pregenerative period were represented in the studied cenopopulation.

The presence of juvenile and immature individuals indicates that early ontogenetic developmental stages are represented in the cenopopulation. The higher proportion of virginal individuals among the pregenerative groups indicates that this developmental stage is relatively well represented in the ontogenetic spectrum. Nevertheless, a single observation does not allow definitive conclusions about the rate at which young individuals pass into subsequent developmental stages or about the long-term renewal dynamics of the cenopopulation. This cautious interpretation is consistent with the need to distinguish observed stage composition from longitudinal demographic rates (Alahuhta et al., 2021; McDonald et al., 2016).

The number of individuals in the postgenerative period of ontogeny was relatively low. Three individuals (10.00%) were recorded at the subsenile stage and one (3.33%) at the senile stage. These results indicate that individuals at ageing stages were less represented in the sample than pregenerative and generative individuals. The lowest proportion of senile individuals reflects a decline in individual numbers at the final stage of the ontogenetic spectrum.

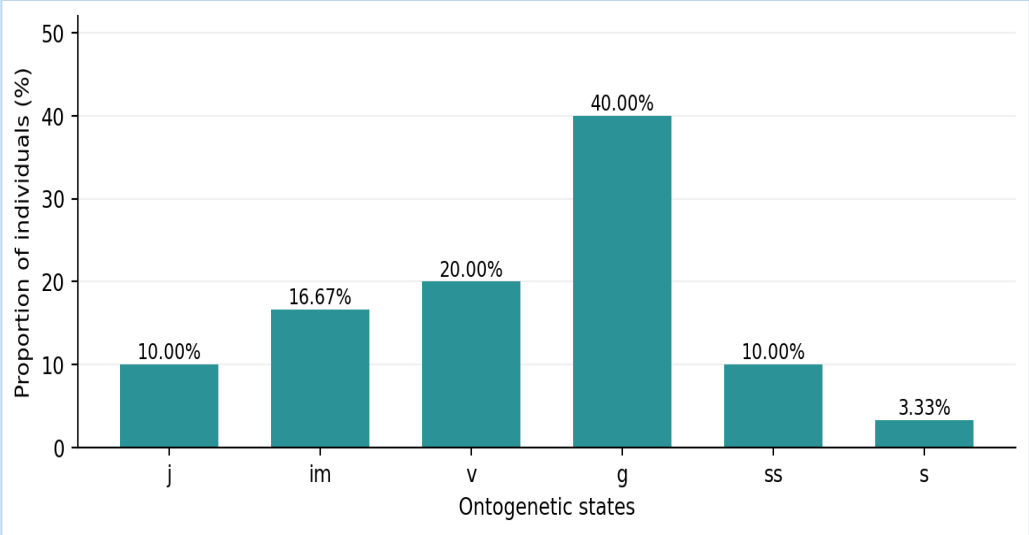


Figure 1
Ontogenetic spectrum of A. cicer (N = 30)

To assess the ontogenetic structure of the cenopopulation more generally, individuals were combined into three main developmental periods: pregenerative, generative and postgenerative.

Table 2
Distribution of A. cicer individuals by ontogenetic developmental period

Developmental period	Number of individuals	Share (%)
Pregenerative (j + im + v)	14	46.67
Generative (g)	12	40.00
Postgenerative (ss + s)	4	13.33
Total	30	100.00

Analysis by developmental period showed that pregenerative individuals had the largest overall share, accounting for 46.67% of the total sample. Generative individuals accounted for 40.00%, while postgenerative individuals accounted for 13.33%. Thus, individuals in the pregenerative and generative periods together constituted 86.67% of the cenopopulation.

Although generative individuals predominated when individual ontogenetic stages were compared, the total number of pregenerative individuals was higher when the data were grouped by developmental period. This difference is explained by the inclusion of three ontogenetic stages—juvenile, immature and virginal—in the pregenerative period.

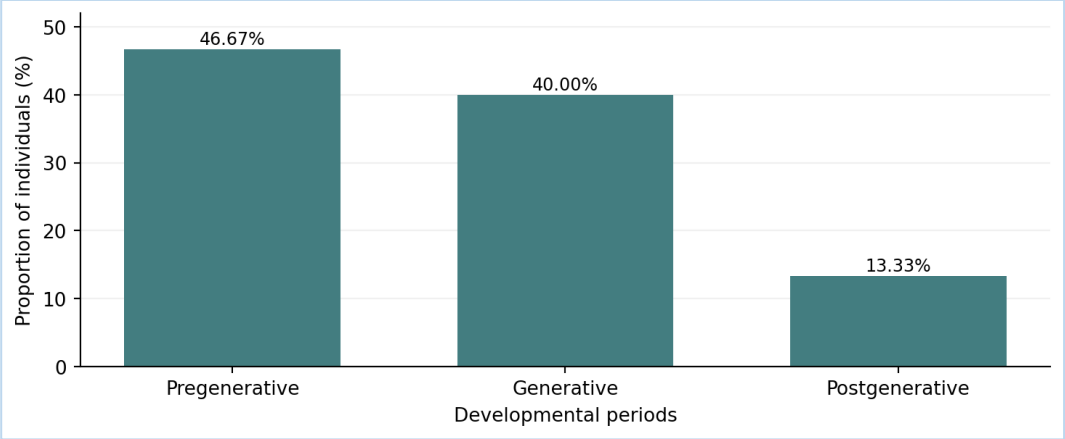


Figure 2
Distribution of individuals by developmental period (N = 30)

The numerical ratio of pregenerative to generative individuals was calculated as follows:

$$K = (j + im + v) / g = (3 + 5 + 6) / 12 = 1.17$$

The calculated ratio shows that the number of pregenerative individuals was approximately 1.17 times that of generative individuals. This indicator reflects the substantial representation of young developmental periods in the studied sample. However, this ratio does not fully characterize the self-renewal capacity of the cenopopulation. Additional information on seedling emergence, survival of young individuals, seed reproduction and changes in ontogenetic structure across different years is needed for this purpose. Detection-related uncertainty in demographic assessments of another Astragalus species further illustrates the need for repeated observations. Stage-based population assessments may also be affected by imperfect detection (DePrenger-Levin et al., 2025).

The overall analysis of the ontogenetic spectrum showed that the relative proportion of individuals increased from the juvenile to the generative stage and then decreased after the generative stage. The highest value was recorded at the generative stage (40.00%) and the lowest at the senile stage (3.33%). This feature indicates the formation of a generative maximum in the ontogenetic spectrum of the studied cenopopulation.

Considering the perennial life form of *Astragalus cicer* L., the simultaneous occurrence of individuals in different ontogenetic states within the cenopopulation can be regarded as an important characteristic of natural development. At the same time, the numerical proportions of ontogenetic groups may be influenced by habitat characteristics, plant growing conditions and the survival of individuals at different stages. Additional ecological observations are required to determine the role of these factors in the particular cenopopulation. More generally, demographic stages and seasonal variation can influence ecological interpretations (Zurell et al., 2024).

Ganbarov's (2016) study of the ecological, biological and phytocoenological characteristics of Astragalus species occurring in the Nakhchivan Autonomous Republic is important for the investigation of this genus in Azerbaijan. The present study complements this line of research by

providing data on the ontogenetic composition of one cenopopulation of *A. cicer* in the Tovuz district (Ganbarov, 2016).

Thus, the analysis established that individuals belonging to the pregenerative, generative and postgenerative developmental periods were represented in the studied cenopopulation of *Astragalus cicer* L. The ontogenetic spectrum had its maximum at the generative stage, whereas pregenerative individuals predominated when the data were summarized by developmental period. The findings are significant as an initial characterization of the species' ontogenetic structure in the northeastern Lesser Caucasus. Repeated investigations in different growing seasons are advisable to determine the long-term developmental trajectory and renewal dynamics of the cenopopulation.

Conclusion

In 2025, the ontogenetic structure of 30 individuals belonging to one cenopopulation of *Astragalus cicer* L. in the Tovuz district of the northeastern Lesser Caucasus was analysed. The study found that individuals were distributed among juvenile (j), immature (im), virginal (v), generative (g), subsenile (ss) and senile (s) stages.

Generative individuals predominated in the ontogenetic spectrum, accounting for 40.00% of the total sample. Virginal individuals accounted for 20.00%, immature individuals for 16.67%, juvenile and subsenile individuals for 10.00% each, and senile individuals for 3.33%. Thus, the maximum of the ontogenetic spectrum corresponded to the generative stage.

Analysis by ontogenetic developmental period showed that pregenerative individuals accounted for 46.67% of the total sample, generative individuals for 40.00%, and postgenerative individuals for 13.33%. The numerical ratio of pregenerative to generative individuals was 1.17. The relatively high proportion of pregenerative individuals and the representation of different ontogenetic stages reflect structural characteristics of the studied cenopopulation.

The results provide preliminary data for characterizing the ontogenetic structure of *Astragalus cicer* L. in the Tovuz district. Repeated observations in different growing seasons are necessary for a more accurate assessment of the renewal dynamics and long-term developmental trajectory of the cenopopulation.

Declarations of Competing Interests

The authors declare no competing interests.

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