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ASSESSMENT OF COENOPOPULATIONS STATUS OF *TANACETUM COCCINEUM* AND *ASTRANTIA MAXIMA* RARE PLANT SPECIES OF AZERBAIJAN

Academician of ANAS V.M.Ali-zade, N.P.Mehdiyeva, R.T.Abdiyeva, A.G.Ibrahimova

Phytocenotic confinedness, structure and state of natural coenopopulations of Tanacetum coccineum and Astrantia maxima rare plant species of Azerbaijan are studied. As a basic demographic parameters of the CP were used the ontogenetic spectrum, vitality and self-restoration method. Differences in development of population dynamics are discussed taking into account the rate of reproduction and the threat factors. The nature of the population state curves over time indicates a greater viability of T. coccineum in contrast to A. maxima, what allows to make adjustments to the assessment of their conservation status in future.

Keywords: coenopopulations, rare species, status assessment, predictive modeling

Introduction

The accruing process of decline in a global biodiversity and the rise in the number of rare plant species under the threat of extinction, led to the need of depth studying of mechanisms of sustainability of their populations, and to develop methods for prediction of the risks of extinction [1, 2]. Populations of these species are often under double stress conditions-unfavorable habitat conditions and strong anthropogenic impact [3]. Application of approaches of population ecology and plant demography to study the behavior of their populations allows us to predict their further development, to propose measures for the preservation and restoration of the diversity [4]. Differences in the initial state of populations against the background of stochastic risks of the different nature make assessments of sustainability and predictions of the dynamics of rare plant species populations quite difficult, but very important task. Present study is aimed at identifying the phytocenotic confinedness, structure and state of natural coenopopulations *Tanacetum coccineum* (Willd.) Grierson and *Astrantia maxima* Pall. – medicinal, essential-oil and ornamental plant species of Azerbaijan and applying possible modeling to the prediction of the dynamics of their populations development.

Objects and methods

The objects of the study are coenopopulations (CP) of rare species of *Tanacetum coccineum* and *Astrantia maxima* growing in meadow, forest, shrubby and etc. communities of the Greater (GC) and the Lesser Caucasus (LC) within Azerbaijan.

T. coccineum (Asteraceae Bercht. et J. Presl) – is rare species, national assessment of conservation status VU A2c + 3c. Perennial bare or absently pubescent short root plant, 25-80 (100) cm tall. *A. maxima* (Apiaceae Lindl.) – is rare species, national assessment of conservation status NT. Perennial short rhizomatous plant, 50-70 cm tall. The national assessment of above mentioned species are given in accordance with second edition of Red Book of Azerbaijan [5].

Studies were conducted in April-July 2015-2019 in the highlands of the GC and LC and covered protected areas (Shahdag National Park, Goygol National Park) and unprotected territories.

As a basic demographic parameters of the CP were studied the followings: ontogenetic (age) spectrum, vitality and self-restoration method. The demographic structure was defined as the ratio of different age groups. Ontogenetic spectra are presented in the form of diagrams, which reflect the relative participation of separate age groups (as a percentage of the total number of individuals). On selected plots (100 to 1000 m²) areas with 0.5–1 m² were laid, where the total number of individuals and the num-

ber of individuals of different age groups were calculated to compile ontogenetic spectra.

During carried out monitoring of rare plant species the ontogenetic (age) spectrum was studied as the main demographic parameters of CP [6]. To study the abundance and ontogenetic structure of the CP of the studied species, 25-30 small transects (1m^2) were laid on the general model areas (100m^2). To determine the ontogenetic spectrum at these sites, the total number of individuals and the number of individuals of different age groups were calculated. Ontogenetic spectrum is presented in the form of diagrams, which reflect the relative participation of separate age groups (as a percentage of the total number of individuals). The type of CP was determined by the delta-omega (Δ - ω) classification of normal population [7].

In the present study for the first time we apply a specific modeling program in R version 3.6.2 [8] to predict population status of studied plant species over a period of 10 years. The model created based on the following data of population: the number of individuals, vitality, reproduction rate and factors affecting the range of the species. We used an average number of the total number of individuals, such as pre-generatives, generatives and postgeneratives for studied period. The data obtained as a result of three repeated studies for each cenopopulation.

Results and discussion

In the present study investigated nine CP of *T. coccineum*, of which three in GC (Guba district - CP1-3), six - in LC (Dashkasan - CP4-5, Goygol - CP 6-7, Gadabay CP8- 9) and 12 CP of *A. maxima*, of which one - in GC (Guba - CP1), the remaining 10 CP - in LC (Dashkasan - CP2-6, Gadabay - CP7-9, Goygol - CP 10-12).

The habitats of *T. coccineum* differ in the degree of anthropogenic disturbance: 7 studied CP are located on pastures and hayfields, the remaining grow on the glade of the forest and in meadow coenosis in protected habitats. In most CP the species density reaches 1-3 individuals per 1m^2 . It has been established that all CP are normal, however, due to the absence of seedlings (p), they are incomplete. No senile (s) indi-

viduals were found in CP 2. An analysis of the ratio of individuals of different ontogenetic states showed that individuals of the generative period predominate in all CP - 48.9-75.1%. CP2 is characterized by the largest number of pregenerative individuals - 44.2%, and CP4 - by the postgenerative - 39% of the period (Fig. 1A).

This shows that the self-restoration processes of CP of *T. coccineum* passes relatively satisfactory. Among the nine studied CP only CP1 was young, CP4 - is rated as old, CP7 - ripening. The remaining 7 CP were characterized as transitional ($\Delta = 0.32 - 0.58$, $\omega = 0.48 - 0.71$).

A. maxima (CP 1-9) grows in the same habitats as *T. coccineum*. The density of the CP of *A. maxima* was slightly higher than *T. coccineum* and ranged from 2 to 5 individuals per 1m^2 . The maximum density was found in the CP in Goygol National Park - up to 12-18 individual/ m^2 . Studies of the ontogenetic structure of *A. maxima* showed that all CP of this species are normal, but due to the lack of seedlings (p), they are incomplete. The lowest indices of the pregenerative period individuals are noted in CP 2, 4, and 6 (23.8-28.1%), the generative period - in CP3, 8 and 11 (28.7-34.0%), the post-generative period - in CP 1, 3, 5, 7-12 (3.4 - 7.9%). Where as in CP2, 4 and 6, these values are 2-3 times higher (Fig. 1B). According to the classification " $\Delta - \omega$ ", out of 12 studied CP - 6 are young (CP 1, 3, 7-8, 10-11), 4 - transitional (CP 2, 4, 6, 12), 1 - old (CP 9). Thus, the predominance of the young and transitional fractions in *A. maxima* indicates the positive nature of running demographic processes.

Studies carried out over 5 years have shown that the coenopopulations of both studied species in unprotected areas are exposed to the negative impact of anthropogenic factors, such as haphazard haymaking, intensive grazing, expansion of infrastructure, collection of aboveground parts of plants for medicinal and decorative purposes, leading to a significant reduction in their number. In protected areas, the studied species are endured to high interspecific and intraspecific competition in cenoses, which affects their vitality and rate of renewal.

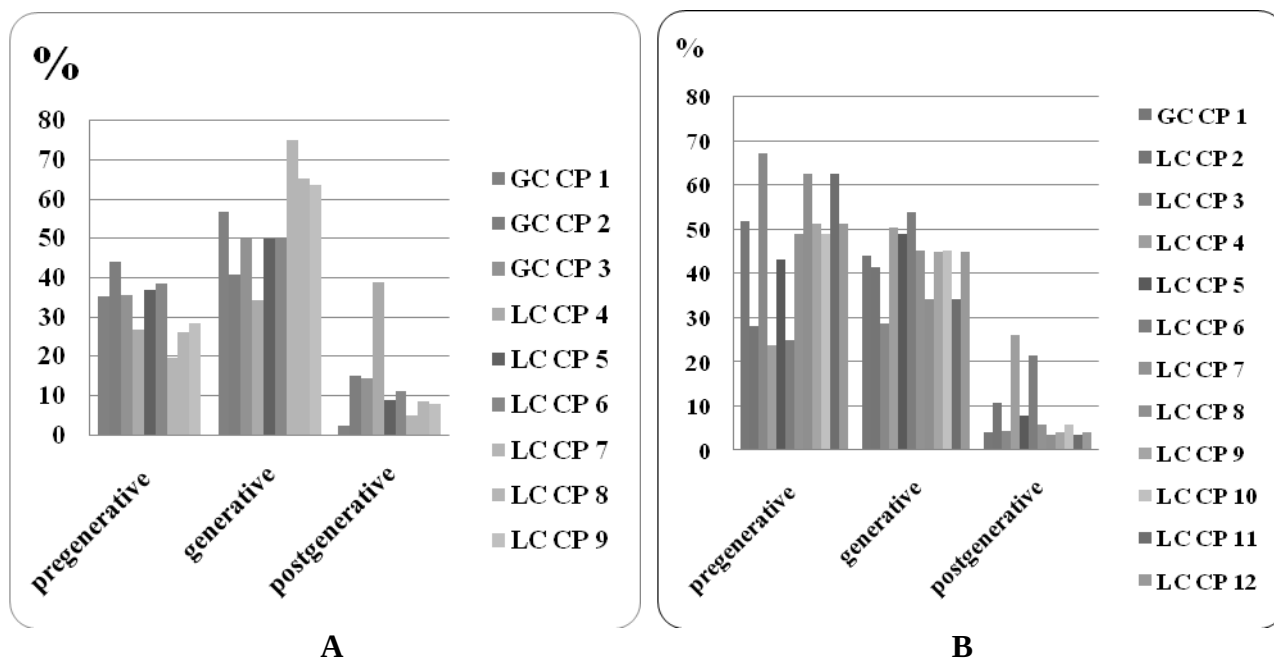


Fig.1. Ratio of individuals of different ontogenetic periods in coenopopulations of *Tanacetum coccineum* (A) and *Astrantia maxima* (B) (Greater Caucasus (GC) and Lesser Caucasus (LC))

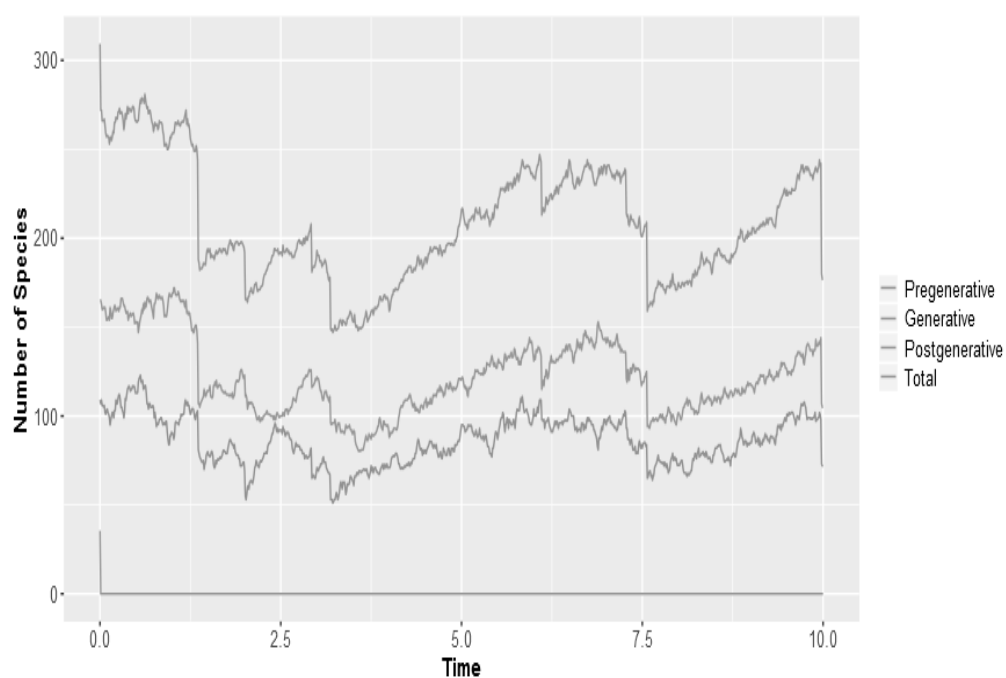


Fig. 2. Prediction of density of *Tanacetum coccineum* plant species over a period of 10 years

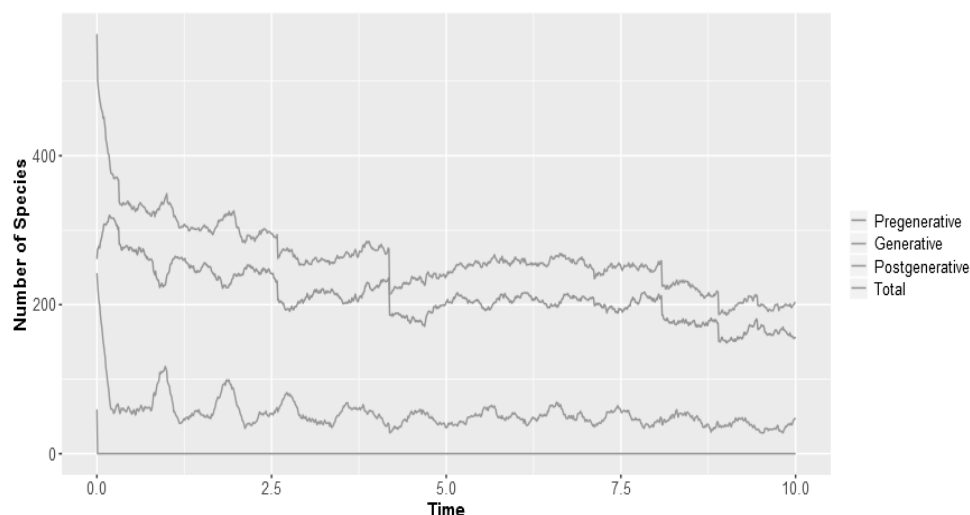


Fig. 3. Prediction of density of *Astrantia maxima* plant species over a period of 10 years

The applied computer model can serve for an effective and objective assessment and prediction of the development of populations of rare species over time. The model predicted a remarkable fluctuations for over 10 years for *T. coccineum* threatened plant species (Fig. 2).

During first one year, there will be no significant change in the number of individuals in the population structure. However, the number of individuals decreased sharply, and the number of species has dropped from 300 to about 145 in next 2-4 years. The decline of the number also will be observed in 7,5 years, about 155 individuals.

The above pot curves of *T. coccineum* shows that its populations, despite some periodic positive dynamics, show a ten-year period tendency to decline, the cause of which, apparently, can be the above-stated factors. A surge in the renewal process in the population may be associated with periodic activity of vegetative reproduction.

Based model results the number of individuals of *A. maxima* threatened plant species will decrease sharply from 500 to about 320 over the next year (Fig. 3).

However, there will be no significant change over the next decade. The number of species will decrease slowly from about 320 to 200 over a given period. This is due to the fact that the population of the species is mainly con-

centrated in areas of strong anthropogenic impact. Weak processes of vegetative renewal, and, consequently, weak vitality, mass uncontrolled collection of the generative part of *A. maxima* are negatively affected by the passage of a full life cycle and the achievement of the phase of semination, which is confirmed by the extremely low presence of postgenerative individuals. Consequently, the negative dynamics of this process will continue in the future. Taking into account the rate of reproduction and the threat factors, it is established that in the next 10 years, the population of *A. maxima* will decrease with a higher rate and key changes will occur in five years. In *T. coccineum*, in contrast to the first type, periods of negative dynamics will be replaced by positive ones with an interval of 2.5-3 years. In the meantime, as a result, there will also be a decrease. The nature of the population state curves over time indicates a greater viability of *T. coccineum* in contrast to *A. maxima*, what allows in future to make adjustments to the assessment of their conservation status.

Conclusion

As follows from above-mentioned results, the age-related range of the studied CP depends on the habitat conditions, the density of the grass stand, the degree of anthropogenic impacts and variations in weather conditions that

affect the characteristics of seed germination and the rate of development of individuals in a particular ontogenetic state.

Based on the data obtained, in order to preserve the natural habitats of the CP of such plant species, it is necessary to regulate human economic activities and reduce the recreational load. It is obvious that consequences of the revealed changes of the environment will be also reflected in the changes of population parameters and structure of the communities and their dynamics.

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Institute of Botany of ANAS

vm_alizade@yahoo.com

AZƏRBAYCANIN NADIR BİTKİ NÖVLƏRİ *TANACETUM COCCINEUM* VƏ *ASTRANTIA MAXIMA* SENOPOPULYASIYALARININ VƏZİYYƏTİNİN QIYMƏTLƏNDİRİLMƏSİ

V.M.Əlizadə, N.P.Mehdiyeva, R.T.Abdıyeva, A.Q.İbrahimova

Azərbaycanın yüksək dağlıq bitkiliyinin *Tanacetum coccineum* və *Astrantia maxima*. nadir bitki növlərinin təbii senopopulyasiyalarının fitosenotik xüsusiyyətləri, quruluşu və vəziyyəti tədqiq edilmişdir. SP-nin əsas demoqrafik göstəriciləri onun ontogenetik spektri, həyat qabiliyyəti və bərpaolunma prosesləri olmuşdur. Burada populyasiya dinamikasının inkişafındakı fərqlər, çoxalma dərəcələri və təhlükə amilləri nəzərə alınmaqla müzakirə olunmuşdur. Zamana görə populyasiya vəziyyətinin əyrilərinə əsasən, *A. maxima* növündən fərqli olaraq *T. coccineum* növü daha çox həyat qabiliyyətinə malikdir, bu da gələcəkdə onların qorunma vəziyyətinin qiymətləndirilməsini korrektə etməyə imkan verir.

Açar sözlər: senopopulyasiyalar, nadir növlər, statusun qiymətləndirilməsi, proqnozlu modelləşdirmə

ОЦЕНКА СОСТОЯНИЯ ЦЕНОПОПУЛЯЦИЙ РЕДКИХ ВИДОВ РАСТЕНИЙ АЗЕРБАЙДЖАНА *TANACETUM COCCINEUM* И *ASTRANTIA MAXIMA*

В.М.Али-заде, Н.П.Мехтиева, Р.Т.Абдиева, А.Г.Ибрагимова

Исследованы фитоценотические особенности, структура и состояние редких природных ценопопуляций (ЦП) *Tanacetum coccineum* и *Astrantia maxima* высокогорий Азербайджана. Основными демографическими параметрами ЦП были онтогенетический спектр, жизнеспособность и процессы самовосстановления. Обсуждаются различия в развитии динамики численности популяций с учетом темпов воспроизводства и факторов угрозы. Характер кривых популяционного статуса во времени свидетельствует о большей жизнеспособности *T. coccineum* в отличие от *A. maxima*, что позволяет в будущем корректировать оценку их природоохранного статуса.

Ключевые слова: ценопопуляции, редкие виды, оценка статуса, прогнозное моделирование