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Ekológia (Bratislava) - Journal of the Institute of Landscape Ecology, Slovak Academy of Sciences Vol. 42, No. 4, p. 349–353, 2023

DOI:10.2478/eko-2023-0039

ONTOGENETIC STRUCTURE OF POPULATIONS OF *Phlomis nubilans* (LAMIACEAE) IN UZBEKISTAN UNDER DROUGHT CLIMATE

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Received: 20 August 2023 / **Accepted:** 13 November 2023

Abstract

Akhmedov A., Beshko N., Keldiyorov X., Umurzakova Z., Hasanov M., Atayeva S., Rasulova Z., Shokhzod N., Maruf S., Jumayev N.: Ontogenetic structure of populations of *Phlomis nubilans* (Lamiaceae) in Uzbekistan under drought climate. Ekológia (Bratislava), Vol. 42, No. 4, p. 349–353, 2023.

The current study presents data on the structure of populations of an endemic species *Phlomis nubilans* Zakirov under a drought climate. The rare species *P. nubilans* belongs to the respective endemic genus of Uzbekistan. We studied the ontogenetic structure of populations, and the current state of *P. nubilans* populations was estimated based on a set of climate factors.
The study focused on the ontogenetic structure of two populations of *P. nubilans*, revealing that the examined populations grew under drought conditions. The ontogenetic structure was incomplete, that is, it did not include all age groups. Their ontogenetic spectrum was centered and coincided with the characteristic spectrum. The research determined that the ontogenetic type was mature. The studied populations do have not any young plants (juvenile, immature, virginal) due to extreme drought conditions and various factors of elimination, including irregular seed propagation.

Key words: climate change, anthropogenic factors, endemic, population structure, *Phlomis*.

Introduction

Under a drought climate change scenario, with a temperature increase up to 3.5 °C, this semi-arid region could become arid, resulting in desertification (Marengo et al., 2009).

The climate forecast for Uzbekistan includes a 5%–10% decrease in mean annual precipitation and a 3.5 °C increase in mean temperature by the end of this century (Mitchell et al., 2017).

Climate change will dramatically change global precipitation patterns (IPCC, 2001), making it increasingly significant that we understand how ecosystems will be impacted by more frequent and severe droughts (Kayler et al., 2015). Drying climate is a major stress in many grassland ecosystems (Knapp et al., 2017; Rakhimova et al., 2023). Long drought periods and a hotter climate in Uzbekistan in the coming decades should become a priority for the conservation of rare and endangered species (Akhmedov et al., 2021). Global warming and increased anthropogenic pressure on natural ecosystems adversely affect the state of populations of endemic and rare components of biodiversity. To date, the protection of natural populations of rare and endangered species is one of the priority directions of biodiversity conservation. In this context, the evaluation status of populations of rare and endangered species and the development of measures and prevention of factors threatening them are of great scientific and practical importance (Rakhimova et al., 2021; Akhmedov et al., 2022).

Flora of Uzbekistan have a large number of endemic (378) and globally important endangered species (10% of the global species) (Sennikov et al., 2016). The latest edition of the National Red Book of the Republic of Uzbekistan (2019) includes 314 species of vascular plants. Lamiaceae is a family with a cosmopolitan distribution and has 236 genera with 6900–7200 species (Harley et al., 2004). Members of Lamiaceae contain alcohols, lagochilin (0.6–2%), essential oils (0.03%), and vitamin K, and most of the genus members contain narcotic, hemostatic, and other substances (Malikova, Rakhimov, 1997; Akramov et al., 2021). The genus *Phlomis* L. encompasses 93 species native to Asia, Europe, and North Africa (www.plantsoftheworldonline.org) (Fig. 1). The genus *Phlomis* L. consists of 20 species in the flora of Uzbekistan. *Phlomis nubilans* is a rare endemic species of the Nuratau range and is included in the Red Book of the Republic of Uzbekistan (2019). *Phlomis is* a popular herbal tea enjoyed for its taste and aroma. *Phlomis* species has essential oils that are used in medical, pharmaceutical, and cosmetic industries (Amor et al., 2009). *P. nubilans* grows in Nuratau mountain only. Population studies are significant in assessing and conserving rare species (Saribaeva et al., 2022).

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In this regard, the purpose of this study is to assess the current condition of populations of this focal species under a drought climate.

Material and methods

Botanical description

The study focuses on *P. nubilans*. The genus *Phlomis* is distributed widely, and *P. nubilans* grows in the Nuratau mountain only (Fig. 1). This is an endemic polycarpic species of Nuratau mountain ridge (Fig. 1). It is a perennial plant with a height of about 30–40 cm. The species has perennial axes form a short multiaxial caudex and several stems. The leaves are ovate, entire, or indistinctly serrated, and have dissected stellate or simple hairs above and prominent veins and are star-like felted below. The flowers are sessile and in non-flowered (2–6) whorls placed in the axils of the upper leaves. Bracts are dilated, 1.5 times longer than calyx tubes. Calyx is about 10–13 mm in length, densely stellate, and pubescent. Corolla is pink in color, with a length of 23–27 mm. It blossoms in July, fruits in August, and reproduction is mainly by seeds (Vvedensky, 1961).

Study area and climate

The study was conducted in Zargarsay and Tikchasay of the Nuratau mountain ridge. Nuratau mountain is considered the northwestern continuation of the Pamir-Alay mountain system (Fig. 2). The climate of this site is Mediterranean, the mean annual temperature is 13.3 °C, and the mean annual rainfall exceeds 206 mm (Fig. 3). Soil is grey-brown, sandy, and brown (Zakirov, 1971).

Long-term meteorological data are unavailable in Uzbekistan. Therefore, the mean monthly precipitation and temperature data were obtained from the Climatic Research Unit (CRU) TS3.10 datasets (Harris et al., 2020) for each site.

Ontogenetic structure measurements

When describing population structure, we used the methods of Rabotnov (1950) and Uranov (1975) and the study Local Plant Populations (1976). The local population structure was studied with a generally accepted method (Uranov, 1975; Local Plant Populations, 1976). Transects of length 10 m were laid and divided into areas of 1 m^2 each. Each local population contained 10–30 such sites. The ontogenetic structure of local populations was calculated as the ratio of individuals with different ontogenetic states. An individual was taken as a counting unit. When characterizing the population structure, we relied on the idea of a characteristic ontogenetic spectrum (Zaugolnova, 1994).

Based on the nature of the distribution of ontogenetic groups, four types of spectra are distinguished: left-sided, centered, right-sided, and bimodal. The characteristic spectrum depends on the biological characteristics of the species. Local populations were characterized according to the ontogenetic structure classification of Uranov and Smirnova (1969). Population types were classified with the "delta–omega" (Δ–ω) method (Zhivotovsky 2001): delta (Δ) – an index of population age, which assesses the age level of populations at any moment (equation x), and omega (ω) – the effectiveness of the plant ontogenetic stages. According to the delta–omega classification, the population can be classified as young, maturing, transition, senescent, and old.

Results and discussion

Description of the vascular plant communities with Phlomis nubilans

The studies were carried out in Nuratau mountain. We studied two populations (pop) of *P. nubilans*. The first population was found in Zargarsay of Nuratau at an altitude of 1979 m a.s.l. Plant taxonomy of vascular plants was listed according to the Plants

Kingdom	**Plantae**
Phytum	**Tracheophyta**
Class	**Magnoliopsida**
Order	**Lamiales**
Family	**Lamiaceae**
Genus	**Phlomis L.**
Species	**Phlomis nubilans Zakirov**

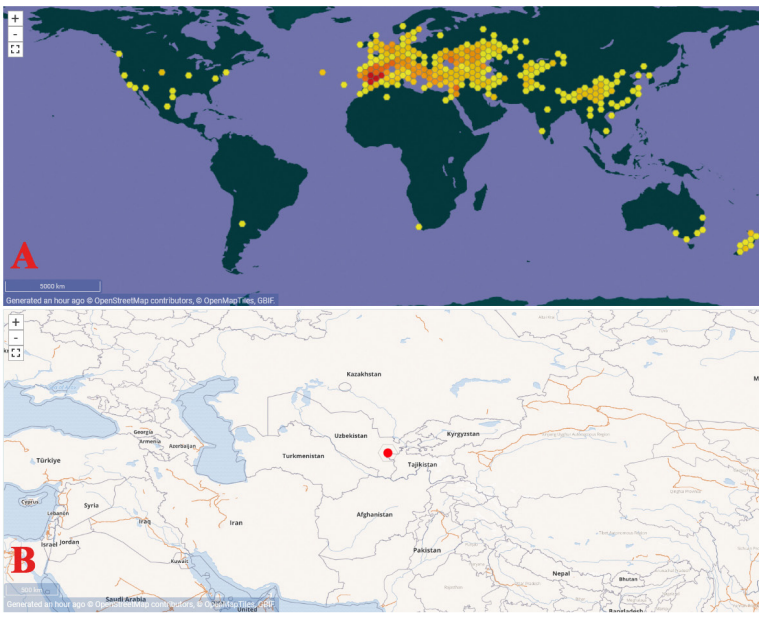


Fig. 1. Distribution map of the genus *Phlomis* L. (A) and *Phlomis nubilans* (B) by Gbif.org.

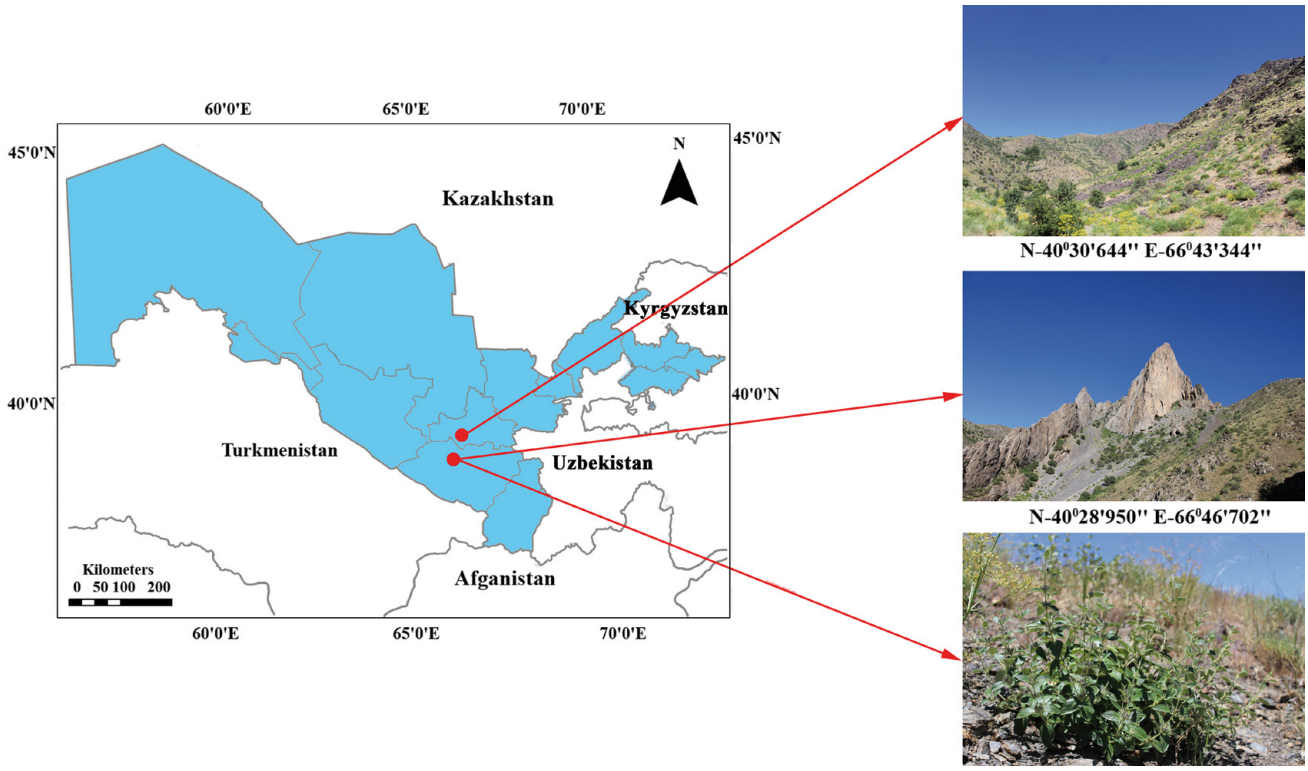


Fig. 2. Distribution map of *Phlomis nubilans* with sites.

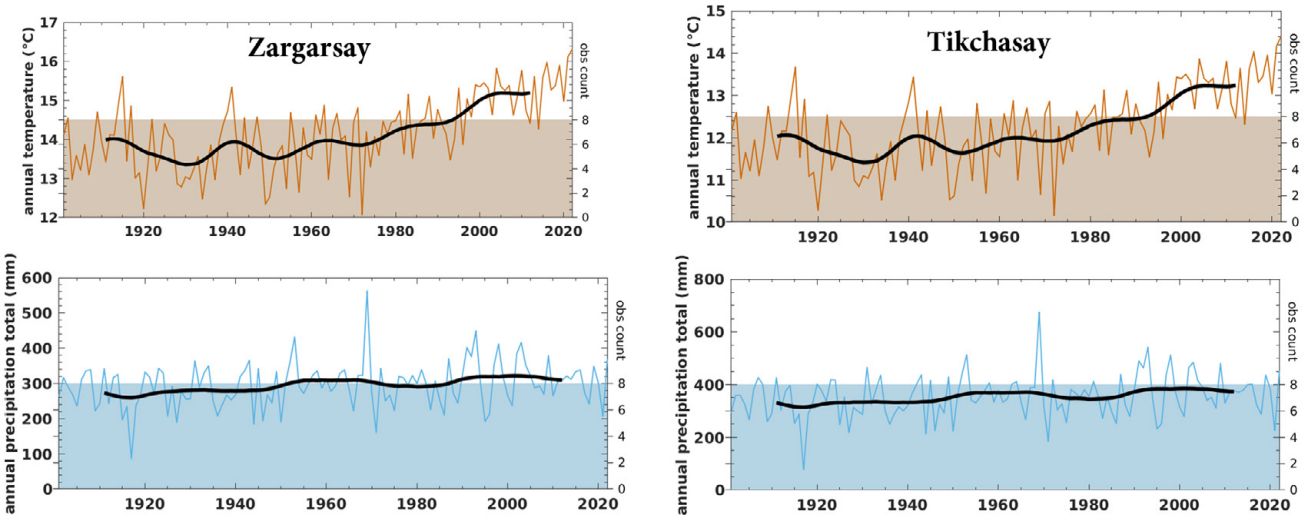


Fig. 3. Annual temperature (°C) with annual precipitation (mm) of the site.

of the World Online (POWO) datasets (www.plantsoftheworldonline.org). The vegetation cover was 35%. The total cover of *P. nubilans* was 1% (Table 1). We listed 27 species of vascular plants in the community.

The second population was recorded near Tikchasay at an altitude of 1672 m a.s.l. Herbaceous cover comprised forb–tree communities. The projective cover was around 45%, and the share of the studied species in it was 2%. The botanical composition of the community was 31 species of flowering plants (Table 1).

Ontogenetic structure of Phlomis nubilans

In the studied populations, according to Uranov and Smirnova (1969), *P. nubilans* was normal but incomplete. In all populations

Table 1. Characteristics of plant communities with *Phlomis nubilans*.

№. Pop	Geographic locations/Pop	Geographic coordinates Elevation (m)	Community/dominant species	Number of species in the community	Total projective cover (%)	The projective cover of P. nubilans
1	Zargarsay, Nuratau	N 40° 30′ 644″ E 66° 43‘ 344″ h = 1979	*Artemisia juncea, Oxytropis tachtensis, Poa relaxa, Ferula ovina, Bromus scoparius*	27	35	1
2	Tikchasay, Nuratau	N 40° 28′ 950″ E 66° 46‘ 702″ h = 1672	*Prunus bucharica, Artemisia tenuisecta, Galium pamiroalaicum, Poa bulbosa*	31	45	2

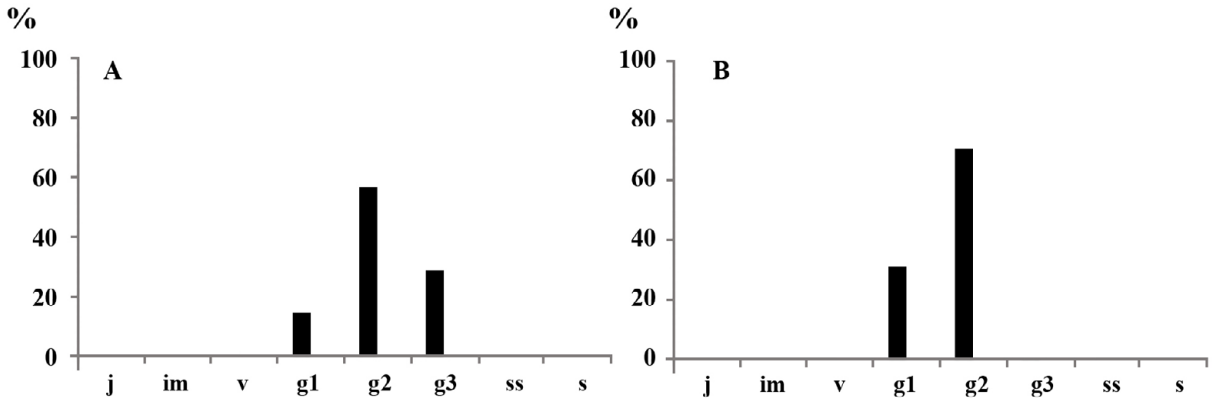


Fig. 4. Ontogenetic structure of *Phlomis nubilans*. Y-axis – age stages, %; X-axis – age stages.
Notes: j – juvenile; im – immature; v – virginal; g1 – young generative; g2 – middle-aged generative; g3 – aging generative; ss - subsenile, s – senile, %.

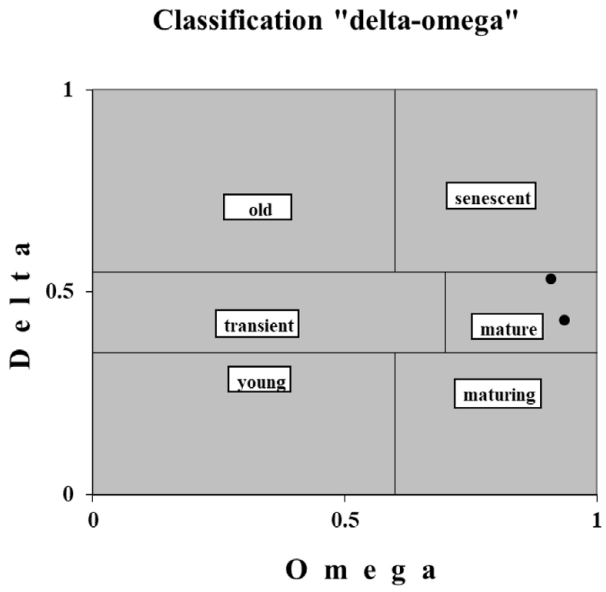


Fig. 5. Population types of *Phlomis nubilans*.
Notes: delta (Δ) – an index of population age, omega (ω) – the effectiveness of the plant ontogenetic stages.

(A, B), we did not find young individuals. There were centered types of ontogenetic spectra only.

Based on the biological characteristics of the species, low seed germination, rapid transition to flowering, and slow rates of development of individuals in a mature generative state, the characteristic spectrum of populations of this species was centered type with a peak in middle-aged generative individuals.

The peak found in the spectra of the studied populations belonged to a group of mature generative plants. In pop1 (A), the percentage ratio of these age groups was: young generative (g1) 14.2%, middle age (g2) 57.1%, and old generative (g3) plants 28.5%. In pop2 (B) was g1 30% and g2 70% (Fig. 4). The peak in the mature generative plant range was probably connected with the biology of the species, as it has low seed germination, rapid transition to flowering, and slow development of individuals in the mature generative state.

In turn, some are caused, on the one hand, by drought climate and higher temperature, and on the other, by grazing.

The recovery delta index of the first population was 0.53% and the next one was 0.43%, and the omega index was 0.90% for pop1 and 0.93% for pop2. According to the classification of Zhivotovsky (2001), all the examined populations were mature (Fig. 5). Our result showed that the first population was moved to a senescent position due to drought climate and grazing pressure.

In this regard, generative individuals accumulate in populations. The seedlings that have appeared do not have time to go into a young state and die. The habitats are subject to intensive grazing and long drought periods, which contributes to an increase in the number of mature individuals. In our case, the mature stages of *P. nubilans* are relatively tolerant to drought and have a long life cycle.

Conclusion

The study conducted of the two populations of the rare and endemic species *P. nubilans* revealed that the status of the populations is unsatisfactory.

The current study showed the climate is highly sensitive to change for the current population status of *P. nubilans* in Uzbekistan. Results presented here confirm the hypothesis that the populations of *P. nubilans* are at increasing risk due to lower precipitation, resulting in the absence of young generations.

The investigation indicated that the populations were all in generative states.

The spectra of all populations (with a centered spectrum) coincide with the characteristic one. The first population was mature but it was moving to the senescent.

The studied populations of *P. nubilans* were incomplete due to drought and anthropogenic factors causing negative effects on the population's structure; therefore, none young generations of *P. nubilans*. The loss of young fractions in this population was due to the irregularity of seed renewal.

Acknowledgements

This work was carried out as a part of the scholarship of the Agency of Innovative Development, Uzbekistan. No. 109.

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