

Variability of morphological features of *Dracocephalum multicaule* (Lamiaceae) in natural populations of Dagestan

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Abstract. The structure of intra- and inter-population variability of *Dracocephalum multicaule* Montbr. et Auch. ex Benth. along the altitude gradient was studied on the basis of a complex of morphological features of plants. Two populations of *D. multicaule* were collected from different altitude levels (800 and 1130 m above sea level). Differences between populations by place of growth (microclimatic conditions), communities in which the species grows, age composition, as well as morphological features were revealed. A decrease in the average values of quantitative and dimensional traits with the increase in altitude has been recorded, with the exception of two (the length of the inflorescence and the number of verticils). Intra- and inter-population variability of traits are at medium and high levels. Variability of the number of flowers in the inflorescence (43.5–51.5) and weight characteristics (36.1–50.0) are high. The interpopulation variability of species traits is the result of the influence of a complex of factors of the altitude gradient and the population age. The areas differ in ecological habitat conditions and the degree of anthropogenic load. The increasing anthropogenic impact in the places where the species grows disrupts the stability of natural populations and affects plant reproduction. In order to preserve the species of *D. multicaule* in natural habitats, it is necessary to reduce anthropogenic pressure, as well as to introduce the species into culture.

1 Introduction

Population studies under changing climatic and ecological conditions are one of the main directions of studying intraspecific diversity. Assessment of the variability and plasticity of morphological features in natural plant populations will allow determining biologically and ecologically informative indicators involved in the adaptation and sustainability of species. The obtained data are used to solve theoretical issues in the field of taxonomy and microevolution, practical problems of introduction and selection of species [1-7].

Of great interest is the study of the types of medicinal and essential oil plants used in folk medicine and serving as the basis for drugs. Valuable essential oil species also include

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representatives of the genus *Dracocephalum* from the *Lamiaceae* family with a rich component composition [8-10].

The genus *Dracocephalum* L. counts 74 species according to the website The Plant List [2013], distributed in temperate regions of Eurasia, as well as in Iran, China and Central Asia [10]. For the Caucasus, there are 7 species of *Dracocephalum*, in Dagestan there are 4 species – *D. austriacum* L., *D. botryoides* Stev., *D. ruyschiana* L. и *D. multicaule* [12, 13].

The study aims to examine the structure of intra- and inter-population variability of *D. multicaule* based on a complex of morphological features of plants along a high-altitude gradient.

2 Material and methods

D. multicaule (multi-stemmed dragonhead) is a perennial herbaceous plant with a height of 15-30 cm. The stems are multiple, erect, branched. The leaves are entire, smooth-edged; oblong- or linear-lanceolate. Inflorescence is capitate, loose; verticils are two-flowered. Corolla is pale yellow, pubescent on the outside, 25-30 mm long. Blooms in May-July. Can be found on rocky slopes, in the middle mountain belt [12, 14]. The plant commonly grows in the Eastern Caucasus, Eastern, Southern and Southwestern Transcaucasia, Turkey, Iran. In Dagestan, it is found in the Foothill and Akhtyn-Kurinsky floristic areas, in the mid-mountain belt.

D. multicaule contains terpenoids, steroids, flavonoids, alkaloids, lignans, phenols, coumarins and cyanogenic glucosides [15-24] and is widely used in folk medicine of different countries as a sedative, antibacterial, anti-inflammatory and antitumor agent, used in the treatment of colds and gastrointestinal disorders [25-28].

Two populations of *D. multicaule* from different altitude levels were examined: Karabudakhkentky district, in the vicinity of Gubden pass (800 m above sea level), and Akhtyn district, along the highway to the village of Djaba (1130 m).

At the sites where the studies were carried out, the species composition and a geobotanical description was determined according to classical methods [29-32]. For each population, 5 sites with a size of 1m² were assigned.

To study the morphological features of *D. multicaule*, a generative shoot (an elementary structural unit of a specimen) was used as a “module”, which goes through a full cycle of development from initiation in buds to a generative state [33, 34].

In each population, one generative shoot of this species was selected from 30 specimens. After taking into account the dimensional and quantitative characteristics, the shoot was fractionated into structural parts: stem, leaves, inflorescences, which were then dried in the shade to an air-dry mass. The plant mass was determined by fractions.

Statistical processing of the obtained biometric indicators was carried out using the Statistica 5.5 software. The levels of variation are according to Zaitsev [1991]: CV<10% – low, CV= 11-20% – medium, CV > 20% – high.

3 Results and discussion

D. multicaule has a fairly narrow range in the foothills of Dagestan. The studied populations are geographically isolated from each other and are located at the extreme points of the range.

The population of *D. multicaule* on the Gubden Pass is located on the dry rocky-clay slope of the southern exposure, along the highway. The slope steepness is about 30-45°, the total projective coverage of the sites is 70-90%. One to three specimens of the species, which make up 20-60% of the projective coverage, were recorded on the sites. *D. multicaule* plants were in the flowering stage. The average number of generative shoots per shrub – 18,

vegetative shoots – 10. The population as a whole consists of adult generative specimens (g_2). On the slope, areas of shale outcrop were observed in places, where 9 young generative specimens (g_1) were recorded on one site (1 m²). On this site, the average number of shoots per shrub was 40 generative and 21 vegetative, which is significantly higher than on sites with a stony-clay substrate. The highway at the pass is quite busy, which depressingly affects the state of the *D. multicaule* population.

Related species *Salvia canescens* C.A. Mey., *Teucrium chamaedrys* L., *T. polium* L., *Thymus dimorphus* Klokov et Des.-Shost., *Th. daghestanicus* Klok. et Shost., *Stachys balansae* Boiss. et Kotschy, *Onobrychis majorovii* Grossh., *Linum auctriacum* L., *L. tenuifolium* L., *Artemisia austriaca* Jacq., *Psephellus daghestanicus* Sosn., *Galium brachyphyllum* Rem. et Shult., *Euphorbia glareosa* Pall. ex M. Bieb., *Elytrigia gracillima* (Nevski) Nevski, *Stipa capillata* L., *Achnatherum caragana* (Trin.) Nevski, *Briza media* L. and others.

The population of *D. multicaule* in the vicinity of the village of Djaba is located along the highway on the talus shale slope of the southeastern exposure. The steepness of the slope is around 45-50°. Two to four specimens of the species were observed on the sites. Plants of *D. multicaule* were at the flowering-fruiting stage. The average number of shoots per shrub is 46 generative and 4 vegetative ones. This population consists mainly of young generative specimens (g_1). The total projective coverage of the sites is 50-90%, of which 40-80% falls on *D. multicaule*, the rest on related species. They are few: *Alcea rugosa* Alef., *Astragalus cornuta* Pall., *Artemisia taurica* Willd., *Satureja subdentata* Boiss., *Chenopodium foliosum* Aschers., *Stipa capillata* L., *Festuca pratensis* Huds. и *Bothriochloa ischaemum* (L.) Keng.

The slope is characterized by sparse locally grouped vegetation, which may be due to moisture availability.

Shrubs grow in the lower part of the slope: *Berberis vulgaris* L., *Spiraea hypericifolia* L., *Cotoneaster melanocarpus* Fisch. ex Blytt, *Colutea orientalis* Mill., *Rosa* sp.; of herbaceous plants: *Melilotus officinalis* L., *Onobrychis majorovii* Grossh., *Teucrium polium* L., *Convolvulus arvensis* L., *Cichorium intybus* L., *Stachys balansae* Boiss. et Kotschy, *Onopordum acanthum* L., *Astragalus calycinus* M. Bieb. (*Astragalus onobrychioides* M. Bieb.), *Reseda lutea* L., *Medicago caerulea* Less. ex Ledeb., *Medicago minima* (L.) Bartalini, *Astragalus captiosus* Boriss., *Galium verum* L., *Cirsium sinuatum* (Trautv.) Boiss., *Taraxacum officinale* Wigg., *Plantago media* L., *Lactuca serriola* L., *Anthemis fruticulosa* M. Bieb., *Psephellus hymenolepis* (Trautv.) Boiss., *Tragopogon graminifolius* DC., *Trisetum rigidum* (M. Bieb.) Roem. et Schult. and others.

The highway here leads to one locality and is not used as intensively as on the section of the Gubden Pass, the effect on the state of the *D. multicaule* population is insignificant.

As can be seen from the description, both populations are represented mainly by generative specimens of different ages, almost no seedlings and vegetative specimens were observed. According to the age spectrum, the population at 1130 m is younger than the population at 800 m above sea level.

The study of morphological features of *D. multicaule* revealed minor differences between populations (Table 1). With the increase in altitude, the average values of quantitative and dimensional traits decrease, with the exception of two, the indicators of which increase slightly (inflorescence length – 10.4 ± 0.56 – 11.0 ± 0.46 and the number of verticils – 4.6 ± 0.29 – 8.1 ± 0.44).

Table 1. Average data on morphological traits of *D. multicaule*.

№	Traits / Populations	Gubden, 830 m		Djaba, 1130 m		Combined sample	
		$\bar{x} \pm s_{\bar{x}}$	CV, %	$\bar{x} \pm s_{\bar{x}}$	CV, %	$\bar{x} \pm s_{\bar{x}}$	CV, %
1	Shoot length, cm	29.7±1.29	23.8	24.3±0.58	13.1	27.0±0.78	22.5
2	Stem part length, cm	19.3±0.88	24.9	13.3±0.47	19.4	16.3±0.63	30.0
3	Stem thickness, mm	1.9±0.06	19.9	1.7±0.06	20.6	1.8±0.05	19.6
4	Number of internodes, pcs	10.2±0.24	12.9	9.2±0.35	20.8	9.7±0.22	17.5
5	Inflorescence length, cm	10.4±0.56	29.5	11.0±0.46	22.9	10.7±0.36	26.2
6	Number of verticils in the inflorescence, pcs	4.6±0.29	21.0	8.1±0.44	29.5	7.9±0.26	26.0
7	Number of flowers in the inflorescence, pcs	24.4±1.94	43.5	23.3±2.20	51.5	23.9±1.45	47.2
8	Stem mass, g	0.37±0.030	44.1	0.22±0.016	39.5	0.30±0.019	50.0
9	Leaves mass, g	0.21±0.015	39.3	0.12±0.009	40.1	0.17±0.011	48.5
10	Inflorescences mass, g	0.61±0.043	39.0	0.58±0.053	49.7	0.59±0.034	44.1
11	Shoot mass, g	1.19±0.078	36.1	0.93±0.068	40.0	1.06±0.054	39.5

The analysis of the average values and coefficients of variation of the structural parts of the generative shoot of *D. multicaule* shows that the amplitude of variability of morphological traits in populations of the species is low (Table 1). Variability of both intra- and inter-population traits is at medium and high levels. Variability of the number of flowers in the inflorescence (43.5–51.5%) and mass characteristics (36.1–50.0%) are high.

The results of the one-way analysis of variance showed significant differences between populations in terms of size, quantitative and weight characteristics. According to the generative characteristics, the differences are unreliable (Fig. 1).

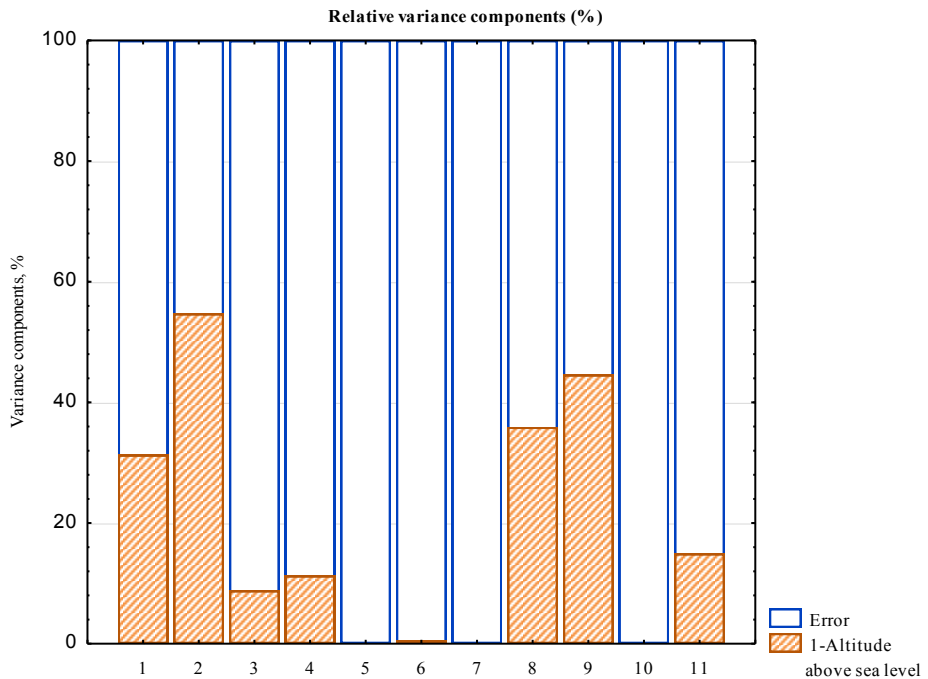


Fig. 1. Dispersion components of natural populations of *D. multicaule*.

According to the results of the correlation analysis, the majority of *D. multicaule* traits are in a positive correlation, significant at the level of $p < 0.05$, both in populations and in the combined sample (Table 2).

Table 2. Correlation coefficients of generative shoot traits of *D. multicaule* (combined sample).

Traits	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(2)	0,89*										
(3)	0,49*	0,30*									
(4)	0,19	0,44*	0,10								
(5)	0,61*	0,18	0,53*	-0,35*							
(6)	0,31*	-0,06	0,59*	-0,32*	0,78*						
(7)	0,48*	0,13	0,71*	-0,30*	0,81*	0,79*					
(8)	0,80*	0,75*	0,72*	0,28*	0,43*	0,34*	0,50*				
(9)	0,45*	0,51*	0,54*	0,41*	0,09	0,09	0,23	0,74*			
(10)	0,52*	0,17	0,76*	-0,28*	0,82*	0,84*	0,95*	0,60*	0,31*		
(11)	0,70*	0,47*	0,83*	0,00	0,68*	0,66*	0,82*	0,87*	0,65*	0,90*	
(12)	-0,45*	-0,63*	-0,25	-0,28*	0,12	0,14	-0,05	-0,48*	-0,55*	-0,05	-0,31*

Note: traits are indicated here as in Table 1; (12) – altitude above sea level; Significance is given by the correlation matrix at the level of $p < 0.05$.

All traits are in a significant positive correlation with the weight characteristics of a particular fraction and shoot as a whole. In a significant negative relationship, most of the traits are associated with altitude above sea level.

The recorded inter-population variability of the species traits is not only the result of the influence of a complex of factors of the altitude gradient, but also the age condition of populations.

4 Conclusion

Studies of *D. multicaule* populations have revealed differences between populations by place of growth (microclimatic conditions), communities in which the species grows, age composition, as well as morphological features. Both sites differ not only in ecological habitat conditions (the nature and humidity of the substrate, the steepness of the slope), but

also in the degree of anthropogenic load affecting the characteristics of plant reproduction (seed germination, specimens' development rate).

The increasing anthropogenic impact in the places where the species grows violates the stability of natural populations. In order to preserve the species of *D. multicaule* in natural habitats, it is necessary to reduce anthropogenic pressure, as well as to introduce the species into culture.

Thus, the state of *D. multicaule* populations is determined by the biology of the species, ecological and cenotic habitat conditions and anthropogenic load.

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