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Coenopopulation and Microelement Composition of the Plant Orchis Purpurea, Common in Different Ecological Conditions of Azerbaijan

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Abstract

The areas of distribution of purple orchid growing in the Gusar and Khizi regions, and the state of the plant in these regions were determined. Studies show that the 6 coenopopulations studied in both districts are incomplete coenopopulations. Some physical and chemical properties (pH, EC and heavy metal content) were studied by taking soil samples from the rhizosphere of the plant. Soil pH indicators were determined in the range of 5.3-7.3, EC 143.8-718 µS cm-1 in Khizi and Gusar districts, respectively. After studying the amount of heavy metals (Cu, Co, Cd, Zn, Pb, Br) both in plant and soil samples, it was found that their amounts are relatively high in the soils of the Gusar region and, regardless of the distribution area, Cu is located in the aboveground organs of the plant, and Zn, Pb, Cd is more collected in tubers.

Keywords: *Orchis purpurea*, coenopopulation (*cp*), rhizosphere, pH, EC, heavy metals

Introductıon

The negative impact of various natural and anthropogenic factors in the recent period caused quite serious damage to the vegetation of our planet and created a danger for useful and even medicinally important wild plants. Thus, the use of Orchis tubers as medicinal plants for centuries affects the decrease in its

number [J.A. Brinkmann,2019]. The recent decline of some representatives of the family Orchidacea in nature makes them rare plants. The family Orchidaceae Juss. is one of the most species-rich families among angiosperms and has about 28,000 species [M.J. Christenhusz, J.W. Byung, 2016]. Most representatives of the Orchidaceae family are found in foggy, moist mountain forests. While most of the representatives of the family are not found above 2000m above sea level, some can be found even at 5000m. There are 21 genera and up to 70 species of this family in the Caucasus, and 48 species of 19 genera are distributed in Azerbaijan. [Flora of Azerb, 1952]. According to R.T. Heydarov and co-authors, Orchids are represented by 21 genera and 54 species in the flora of Azerbaijan. Among them there are decorative and medicinal species [R.T. Haydarova, 2016].

Understanding how environmental contaminants affect plant emergence, growth, and development is key to effective management plans and potential biological remediation. Rare plants such as orchids have developed in modified habitats and soils with high concentrations of metals and metalloids and have been found to be able to accumulate these metals in their organs. However, their ecological and physiological responses to heavy metals remain unexplored [Antonio De Agostini et al., 2019]. Studies show that significantly higher concentrations of heavy metals in soils can act as ecological filters for some plant species [M. Laghlimi et al., 2015]. Since representatives of the Orchidaceae family are the most sensitive elements of the natural ecosystem, it is considered important to study the reasons for their decline in nature. Thus, the recent decrease in the number of this species of plant makes it necessary to study the ecological condition of the areas where they spread, including the morphogenetic characteristics of the soil, climate and other characteristics. So, in our research work, first of all, the assessment of the state of the coenopopulation (cp) of the Orchis purpurea plant and its biological characteristics, the ecological and phytocenotic characteristics of its distribution, the age structure and viability of the cp were studied. Also, the pH, electrical conductivity, and amount of microelements of soil samples taken from the rhizosphere of *Orchis purpurea* growing in the territories of Gusar and Khizi regions were studied.

Material and methods

As we mentioned, the plant *Orchis purpurea* Huds, which is spread in the territory of Khizi and Gusar regions located in the northeastern part of the Greater Caucasus, was taken as research material. (figure 1.). According to geobotanical zoning, Khizi and Gusar districts belong to the botanical-geographical region of the Guba mountain massif of the Greater Caucasus. Information about the terrain, climate, soil types of the studied regions was studied [Babayev M.,et.al., 2011]. A mild-hot climate with almost evenly distributed rainfall is suitable for Gusar district, and a mild-hot climate with dry summers for Khizi district.

The plant Orchis ourpurea is distributed in Atlantic and Central Europe, the eastern Mediterranean, the Balkans and the Asia Minor Peninsula. In Azerbaijan, the territory of this species is the Guba mountain massif of the GC -

Samur-Devachi lowland, Gobustan, the eastern part of the GC - the Kura-Araz lowland, the north and center of the LC. The plant grows mainly in forests, forest edges, meadows and thickets up to the middle montane zone [Flofa of Azerb., s.250].

Orchis purpurea Huds. is a perennial plant with a height of 30-80 cm. The tuber is oblong or oblong-ovate. The leaves are broad-oval or lanceolate, elliptic. The inflorescenceis ovoid-oblong, dense, multi-flowered. The flowers are relatively large and have a vanilla smell. The bractsof the flower is transparent, egg-shaped. The outer leaves of the perianths are elliptic-ovate, sharp, 3-veined. It is pointed, mottled and purplish in color. The inner leaves of the perianths are linear, and the lip is spotted in the form of a white or light pink, dark frilly point. Its length is up to 9 mm.

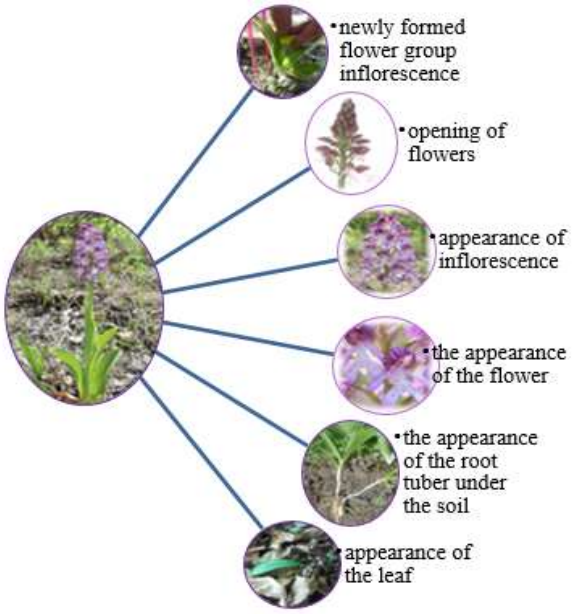

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Figure 1. As a result of observations in April-May, view of different phases of plant development of Orchis purpurea Huds.

The flowering period of the plant occurs in April-June.

Our research was carried out in forest massifs using generally accepted population-ontogenetic methods in April-June [Y.A. Zlobin, 2013]. As part of field studies, GPS coordinates of the areas of occurence of the studied plant were determined, phenological observations were made, photographs were taken, and soil samples were taken from the rhizosphere of the plant. (Map 1, figure 1.).

Map 1. Map-scheme of the studied districts

In order to preserve and protect the rare and endangered species that need to be protected, their condition in nature was first studied. The ontogenetic status and demographic structure of CP of Orchis purpure plant were studied according to the methods of Robotnov and Uranov [T.A. Rabotnov 1992, A.A. Uranov 1975]. The CP type was studied based on Zhivotovsky's Δ-ω ("delta-omega") criterion [L.A. Zhivotovsky, 2001].

The obtained results were processed in the Microsoft Excel program. For the integral characterization of the ontogenetic structure of the coenopopulation, the quantitative indices Ie, Ig, Ib developed by L.A. Zhukovo (1987) and N.V. Glotovo were used, and the demographic indicators ω-efficiency coefficient and Δ-age coefficient were calculated according to A.A. Uranov, L.A. Zhivotovsky .

Physical and chemical analysis

Soil sampling was carried out in accordance with the standards of "Collection and preparation of soil samples for analysis" (GOST 17.4.3.01-83 GOST 17.4.4.02-84).

The electrical conductivity (EC) of the soil was determined in the collected soil samples. EC was determined on a Cond 3110 (Xylem Analytics Germany GmbH D-82362 Weilheim) apparatus, and concentrations of heavy metals (Cu, Zn, Cd, Pb, Co and Br) were determined using polarized energy dispersive XRF.

During the research, a Spectro XLAB 2000 PEDXRF spectrometer equipped with an X-ray tube with a Rh anode and a 0.5 mm Be side window was used in the ICP and Microanalysis laboratory of the Geological Engineering Department of Ankara University.

Determination of soil pH in the studied soil samples was studied by the Sinao method.

Results and their discussion

In total, 6 CPs of Orchis purpurea were studied and their status was determined. Researches were carried out in the forest massifs (Quercus iberica and Paliurus spina-christi, Corylus colurna and Fagus orientalis) at altitudes of 515-591 m above sea level in Altiaghaj settlement of Khizi district, and at altitudes of 442-462 m in Gusar district. The investigated Khizi forests are bright, the soil is mountain forest-brown, dry, relatively clayey. The slope of the area is 20-25%. Gusar forests are relatively dark, the soil is dark brown, with low humidity. The slope of the area is 35%.

The distribution of the plant in the CP studied in both districts was in the form of a diffuse group.

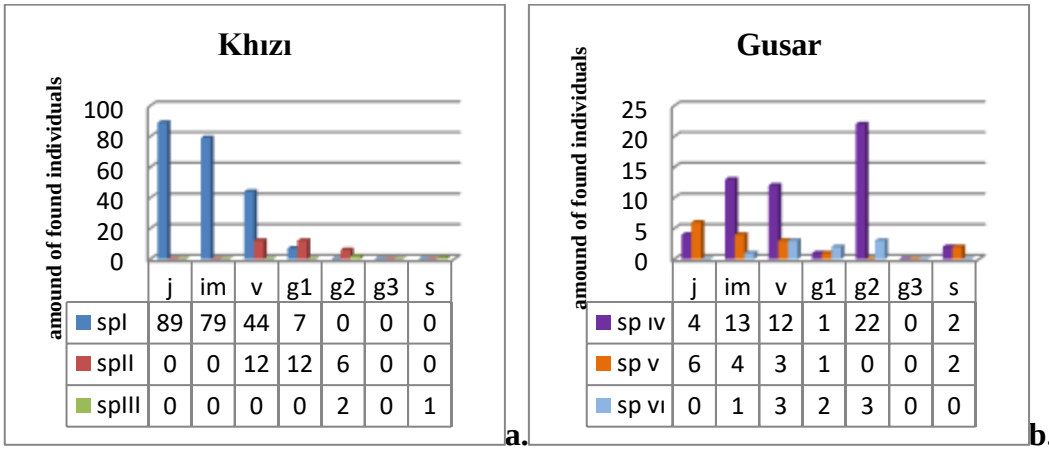


Figure 1. *Ontogenetic spectrum of coenopopulations of the plant Orchis purpurea Huds. in Khizi (a) and Gusar (b) districts*

It is also clear from the graphs that some individuals in the studied senopopulations have sp I- g2, g3, s; spII – j, im, g3, s; spIII- j, im, v, g1, g3; spIV- g3; spV- g2, g3; Cenopopulations are considered incomplete due to the absence of sp VI- j, g3, s (Fig.1).

Based on the number of individuals in the age group, the percentage indicators of vegetative and generative individuals of the coenopopulation and some demographic indicators are shown in the table below (table 1).

The number of pregenerative individuals was observed the most in CP I (Khizi district) and CP V (Gusar district). This is an indicator that those coenopopulations are of young type. While the recovery index and replacement index showed the highest value in CP I and CP V, the lowest value was observed in CP III. According to Δ and ω indices, other coenopopulations are in maturing (IM).

Indicators / No. of CP	% of Vegetative and Generative individuals		$İ_{r.}$	$İ_{rep.}$	$İ_a$	Δ	ω	Type of CP as per Δ-ω g
	V%	G%						
I (Khizi)	96.8	3.2	15.142	15.142	0	0.063	0.472	**Y**
II (Khizi)	40	60	0.667	0.667	0	0.255	0.682	**M**
III (Khizi)	0	100	0	0	0.33	0.651	0.729	**A**
IV (Gusar)	65.9	34.1	1.26	1.16	0.045	0.347	0.700	**M**
V (Gusar)	81.25	18.75	13	4.33	0.125	0.222	0.176	**Y**
VI (Gusar)	44.4	55.6	0.8	0.8	0	0.271	0.706	**M**

Table 1. Some demographic characteristics of the studied coenopopulation $I_{r.}$- recovery index, $I_{rep.}$ - replacement index, $I_{a.}$ – aging index, **Δ**- age index, **ω**- effeciency index.**Y**-young**, M-** in maturing**, A**–aging.

Some environmental indicators - air temperature, humidity and carbon dioxide (CO2) content - were measured in the distribution areas of the Orchis purpurea plant in Khizi and Gusar, where we conducted the research (fig.2.)

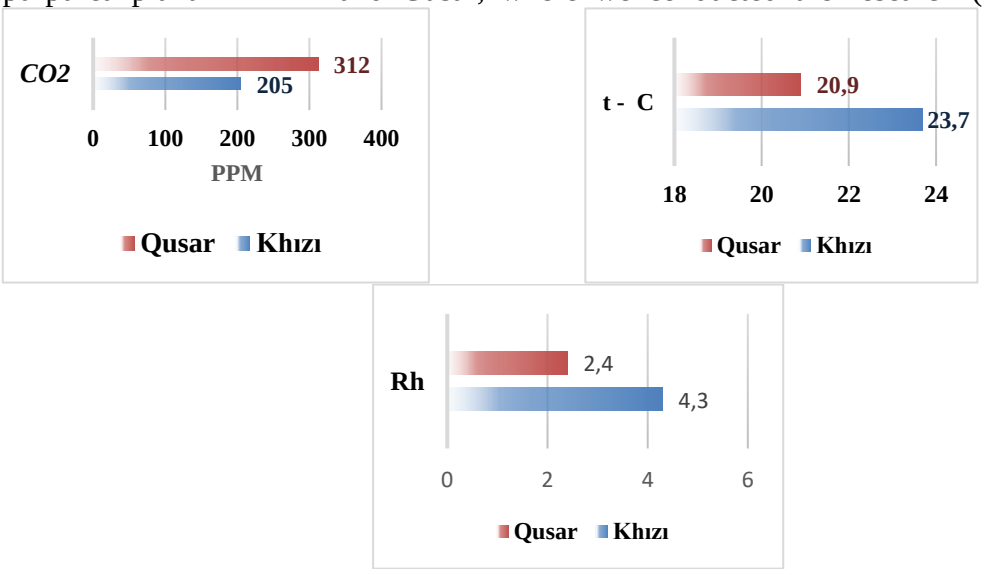


Figure 2. Air temperature, humidity, amount of carbon dioxide in the studied areas

Also, some physical and chemical properties of the soil collected from the rhizosphere of the plant were studied and the results are reflected in table 2 (below).

№	Territory	Gps	Altitude (m)	EC µS sm^{-1}	pH	Heavy metals amount (ppm)								
						Co	Zn	Cd	Pb	Cu	Br	Mo	Se	Hg
1	Khizi	40°50′08.1″ 049°01′45.0″	515	209	7.1	39.6	86	1	18.9	32.2	3.7	2.6	0.3	0.8
2		40°55′03.5″ 049°00′49.8″	591	143.8	7.2	11.5	64.8	1	14.7	28.9	3.5	3.1	0.2	0.6
3		40°55′05.1″ 048°00′20.8″	595	240	5.3	29.3	71.4	1.1	15.2	27.8	4.2	2.9	0.3	0.7
4	Gusar	41°29′54.8″ 048°29′22.8″	442	476	7.3	35.6	73.9	1	15.9	32.6	3.7	2.9	0.3	0.7
5		41°29′55.1″ 048°29′20.8″	462	482	7.3	27.7	59.7	1	17.9	30.3	3.4	3.2	0.2	0.6
6		41°28′44.2″ 048°29′18.7″	421	718	6.9	39.7	97.4	1	24.5	34.1	6.8	3.1	0.3	0.7

Table 2. Physico-chemical parameters of soils taken from the rhizosphere of Orchis purpurea plant: height (m), pH, trace element content (ppm), EC (µS cm-1)

As can be seen from the table, the amount of heavy metals in the studied soils exceeds the maximum permissible solidity limit.

In the studies conducted by Ors et al. (2011) in Bayburt, Bingöl and Erzurum areas of Turkey, the pH value of soils taken from the rhizosphere of Orchis plant was 6.57-7.81.Ortaş (2011) studied some physico-chemical properties of orchids, especially soils taken from the rhizosphere of orchids (different areas of Eastern Turkey) and concluded that regardless of the species of plant, the soils do not differ in their physical and chemical parameters and they are found in both weakly acidic and alkaline environments. We see that our results are identical to the results of the researchers mentioned above. Thus, the pH value of the soil samples taken from the rhizosphere of the plant from the territory of Gusar district is 6.9-7.3, and the pH value of the soil samples taken from the Khizi territory corresponds to the values of 5.3-7.2.

The electrical conductivity (EC) values of the soil samples were also studied during the research. Thus, it is noticeable that EC varies between 476-718 ms/cm in soils collected from Khizi territory, and 143.8-240 ms/cm in soil samples collected from Gusar territory (Table 2). The soil of both areas is evaluated as low salinity by us. It is mentioned in the literatures that there is no problem of salinity in the soils where orchids are grown [Soil Survey Staff, 1993].

When we compare the amount of micro-elements separately, we see that the average value (∑) of the identified elements (Co, Zn, Pb, Cu, Br) in Khizi soils is less than that of Gusar soils. The amount of Cd was the same in both regions. Correspondingly, Co 26.8ppm and 34.3ppm; Zn 74.1ppm and 77ppm; Pb 16.3ppm and 19.4ppm; Cu 29.6ppm and 32.3ppm; Br 3.8ppm and 4.6ppm.

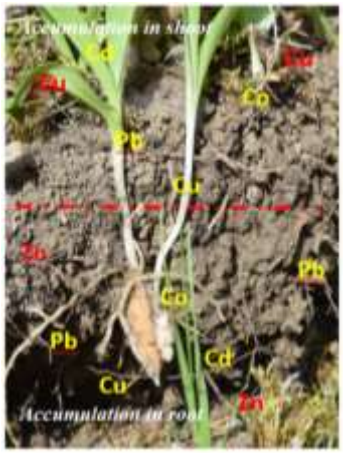
Comparing the obtained results with the results of other researchers, it was observed that the amount of heavy metals is higher in the soils studied by us. [S. Ors et. al.,2011]. The analysis of soils collected from the rhizosphere of Orchis purpurea growing in Gusar and Khizi regions shows that their pH, electrical conductivity and microelement content are different. This can also show itself in the morphological dimensions of the plant.In the course of the research, it was found that the root system of the plant performs the main barrier function on the way of the entry of heavy metals into most plants. Elements transferred from the root system are then collected in the stem and leaves, and finally in the reproductive organs of the plant (often seeds and fruits, as well as roots and tubers) [I.Y. Usmanov, et. Al. 2001; I.V. Seregin, et. Al. 2011].

As a result of the research, in addition to the soil, the amount of heavy metals was measured in the collected and dried plant samples. It helps to determine the sensitivity of the plant to heavy metals in the soil. Thus, the average value of plants obtained during the analysis and the average value of land by district are listed in Table 3.

№	Plant	Collected area		Heavy metals amount (ppm)			
				Zn	Cd	Pb	Cu
1	Orchis purpurea	Khizi	Soil	74.1	1	16.3	29.6
			Aboveground part of plant (S+L)	17.2	0.7	1.1	10.9
			Tuber	46.78	0.9	11.4	2.52
2		Gusar	Soil	77	1	19.4	32.3
			Aboveground part of plant (S+L)	17.4	1.3	1.6	10.9
			Tuber	44.72	1.9	17.7	2.83

Table 3. Heavy metal content of dried aerial parts of Orchis purpurea plant (ppm) S+L= stem+leaves

The results of the analysis show that a certain amount of heavy metals in the soil accumulate in plants. If we look at the regularity of the sequence of accumulation of 2heavy metals (Cu and Zn) in the above-ground and underground parts, it can be seen that the amount of Zn is accumulated in the root tuber, which is an underground organ, and the accumulation of Cu occurs in the leaf. This pattern coincides with the results obtained by other researchers in the study of other representatives of orchids. [Esra Bulunuz Palaz et. Al.,2018, Antonio De Agostini et. Al. , 2020]



Thus;

1. The determination of heavy metals in soil samples taken from the rhizosphere of the plant showed that their amount is relatively high in the soils of the Gusar district.

2. Regardless of the distribution area, Cu accumulates more in the above-ground organs of the plant, while Zn, Pb and Cd accumulate more in the roots.

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