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RESEARCH ARTICLE

Ecological and morphological features of *Rhodiola rosea* L. in natural populations in the Altai Mountains

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Abstract

The paper presents the results of the comprehensive study of *Rhodiola rosea* L. in natural populations in the Altai Mountains. The phytocoenotic confinement, demographic structure, and morphological characters of 9 coenopopulations of *Rh. rosea* were studied in different ecological and coenotic conditions in the Chemal and Kosh-Agach regions of the Republic of Altai. Correlation between the morphometric parameters and their calculated values for the shoot and sex of the studied individuals, as well as environmental factors, was revealed. *Rhodiola rosea* L. is a valuable medicinal plant used for functional diseases of the central nervous system. At present, the natural reserves and areas of natural growth of the golden root have decreased significantly. The species is included in the Red Data Book of the Russian Federation (2008) and many regional Red Data Books of Siberia. In the Altai Mountains, *Rh. rosea* is widespread throughout the highlands, where it has occupied a wide range of habitats. The study showed that the highest values of ecological and effective density are characteristic of coenopopulations which are part of various hygrophytic variants of alpine and subalpine miscellaneous herbs with a high total projective cover of the herbaceous layer (CP 1, 2, 3, 4). The lowest values were found for coenopopulations growing in communities with a scarce herbaceous layer or dense shrub layer, and on steep gravelly slopes with crumbling soil and nonuniform moisture distribution (CP 5, 6, 8, 9). The studied coenopopulations are normal, full-membered, or incomplete-membered (some of them lack postgenerative individuals). In terms of the ontogenetic spectra, they are mainly left-sided, with a predominance of young generative individuals (CP 4, 5, 7) or bimodal, with an additional peak for old generative individuals (CP 2, 3, 6, 8). Male and female individuals *Rh. rosea* differ in many morphometric characters of the generative shoots. In some coenopopulations (CP 2, 3, 6, 9), male and female individuals show multidirectional deviation of characters compared to the totality, which indicates that in different environmental conditions these characters are not only genetically determined but can also be related to the sex of individuals.

Keywords
Rhodiola rosea, rare medicinal plant, the Altai Mountains, phytocoenotic confinement, coenopopulation structure, morphological features

Introduction

Rhodiola rosea L. (golden root) is a herbaceous short-rhizome monopodially growing polycarpic with succulent leaves and an elongated erect shoot, hemicryptophyte (Bezdelev and Bezdeleva 2006; Goncharova 2006). This arctic-alpine species with a disjunctive Eurasian range grows in the mountains of Western Europe, the Balkan Peninsula, Asia Minor, Mongolia, China, East Turkestan, and the Scandinavian countries (Kim 1999). A significant part of the range covers the mountains of Southern Siberia: Altai, Western and Eastern Sayan, and the mountains of Tuva and Transbaikal (Polozhiy et al. 1985).

The species is widespread in the subalpine and alpine mountain belts; along river banks, it descends into the forest belt. In the forest belt, it grows on avalanche cones and in sparse forests along the banks of streams and rivers. It is most abundant in the subalpine belt on the upper slopes of the valleys. It is encountered in places with prolonged snow cover, along temporary streams, river banks, on stony placers, and rocky outcrops. In the alpine belt, it occurs on moraines, on the slopes of kars and cirques. The species is common but less abundant in alpine meadows (Surov 1973; Polozhiy et al. 1985; Kim 1999). The main part of the natural resources of *Rh. rosea* is located in Altai (Nekratova and Nekratov 2005), where its thickets occur mainly at 1700–2200 m a.s.l. (Nukhimovsky 1997).

The species is included in the Red Data Book of the Russian Federation (2008); Red Data Books of Siberia: Republic of Altai (2017), Republic of Buryatia (2013), Trans-Baikal Territory (2017), Irkutsk Region (2020), Kemerovo Region (2012), Republic of Sakha (Yakutia) (2017), Tyumen Region (2004), Republic of Khakassia (2012), Khanty-Mansi Autonomous Area-Yugra (2013), Yamal-Nenets Autonomous Area (2010).

Material and methods

Natural coenopopulations of *Rh. rosea* were studied in 2019–2021 in Southern Siberia within the Altai Mountains (Chemalsky and Kosh-Agachsky regions in the Republic of Altai). Most of the studies were conducted at the Aktru Research Station, Mega Installation, located in the highlands (2150 m) of the southeastern part of the Republic of Altai, in close proximity to the borders of Mongolia and China in the center of the Eurasian continent.

The species composition and structure of plant communities that include *Rh. rosea* were established based on geobotanical descriptions and specified by subsequent processing of the herbarium material. The phytocoenotic confinement of *Rh. rosea* coenopopulations was determined using conventional geobotanical approaches (Lavrenko and Korchagina 1964). Population studies were performed using the approaches employed in modern plant population biology (Rabotnov 1950; Uranov 1975; Zaugolnova et al. 1988; Zhivotovsky 2001). The ontogenetic state of an individual was determined based on a complex of qualitative morphological and biological characters (Rabotnov 1950; Uranov 1975; Zaugolnova et al. 1988).

The main qualitative criteria for ontogenesis periods are a feeding pattern (seed), the presence of embryonic, juvenile, immature, or adult structures and the capacity for seed and vegetative reproduction, the ratio of new growth and death, the level of the main biomorph character development in an individual.

The characters that determine the main ontogenetic stages include the presence of cotyledon leaves; the degree of development of aerial shoots; the number, morphology, and size of leaves; morphology, the degree of development, and size of the root system and generative shoots. The coenopopulation demographic structure was determined as the ratio of the ontogenetic groups (ontogenetic stage spectrum of the coenopopulation).

To study the density and demographic structure of coenopopulations in communities transects divided into areas of 1 m^2 were regularly laid. The total number of individuals per unit area was calculated to determine the coenopopulation ecological density, and the number of individuals of different ontogenetic stage was found to obtain ontogenetic spectra (proportion of ontogenetic groups of the total number of individuals). A morphologically isolated individual was used as a counting unit.

The coenopopulation type was determined based on the absolute maximum criterion (Uranov and Smirnova 1969) and according to the classification "delta-omega" (Δ-ω) by L.A. Zhivotovsky (2001). The fullness (incompleteness) of the coenopopulation is determined by the degree of representation of age groups in the spectrum. The coenopopulation self-maintenance was determined by the ability of the species to form viable progeny (seed or vegetative) in specific habitat conditions.

Works by I.G. Serebryakov (1962, 1964) and A.B. Bezdelev (Bezdelev and Bezdeleva 2006) were used as a methodological basis to study plant reproduction modes and plant life forms.

Due to the fact that this species is dioecious, data on the morphology of the generative male and female shoots were calculated for each individual coenopopulation, and then the data were combined to calculate the values of the totality. The data on individual populations were compared with the totality in the form of a deviation – by what percentage the mean values of the character are higher or lower compared to the totality.

Living plants and partially herbarium material were used to study morphological characters. In each coenopopulation, one generative shoot was taken from 30 generative male and 30 generative female individuals to measure shoot length, number of leaves, the diameter of inflorescence, and number of flowers. From each generative shoot, 1 leaf was collected; then leaves were plainly dried, weighed to determine the leaf dry weight, and photographed, and the length, width, and area of the leaf were measured with a calibration ruler and using the AxioVision software (Carl Zeiss, Germany). The data obtained were used to additionally calculate: the ratio of leaf number to shoot length as an indicator of the shoot foliage; leaf density as an indicator of the accumulated dry matter per unit of leaf area. The following parameters were calculated: mean value, standard deviation, coefficient of variation, Spearman's correlation coefficient.

Results and discussion

In the study, nine coenopopulations (CP) of *Rh. rosea* from different ecological and coenotic conditions have been investigated (Table 1).

CP 1: subalpine meadow at the edge of a cedar forest, 1840 m a.s.l., valley of Karakol lakes, Iolgo ridge.

The middle part of the forested slope (15–20 deg. inclination), western exposure. Outcrops of bedrock rocks occur. The total projective cover of the herbaceous layer is up to 85%. Tall herbaceous plants prevail. The maximum height of plants is 1.2 cm; the average height is 30 cm. The moss cover is poorly developed. The forest border is covered by thickets of *Salix glauca* L. and *Betula rotundifolia* Spach. Sporadic individuals of *Cotoneaster uniflorus* Bunge are recorded. The herbaceous cover is dominated by *Rh. rosea*, *Carex aterrima* Hoppe, *Bistorta officinalis* Delarbre, *Stellaria bungeana* Fenzl, *Saussurea latifolia* Ledeb., and *Alchemilla vulgaris* L.

The ecological density is 3.76 ind/m^2; the effective density is 2.67 ind/m^2. The ontogenetic spectrum is centered, with a predominance of mature generative individuals and a large proportion of young generative individuals. CP 1 is mature, normal, and full-membered.

CP 2: bushy alpine meadow in the southern part of the trough valley of the Karakol lakes, 1920 m a.s.l., Iolgo ridge.

The coenopopulation is located in the southern part of the Karakol lakes trough. The height of shrubs is similar to that of herbaceous plants. Shrubs include *Betula rotundifolia*, *Salix glauca* L., and, less often, *Salix caesia* Vill. The total projective cover of the herbaceous layer is up to 95–100%. The average height of plants is 25 cm. The herbaceous cover is dominated by *Rhodiola rosea*, *Carex sempervirens* Vill., *Bistorta officinalis*, *Allium schoenoprasum* L., and *Gentiana algida* Pall.

The ecological density is 5.72 ind/m^2; the effective density is 3.49 ind/m^2. The ontogenetic spectrum is bimodal, with a predominance of young and old generative individuals and a large proportion of juvenile and virginal individuals. CP 2 is transient, normal, and full-membered.

CP 3: alpine meadow in the mountain stream valley, 2715 m a.s.l., Kuraisky ridge.

The slope is south-eastern exposure (25–30 deg. inclination). Placers of large stones and well-developed moss cover on moist soils occur. Shrub plants are not identified on the studied sites. The total projective cover of the herbaceous layer is up to 80% and attains 30% in some areas. The maximum height of plants is 30 cm, the average height is 20 cm. *Anthoxanthum alpinum* Á. Löve & D. Löve, *Trisetum mongolicum* (Hultén) Peschkova, *Festuca kryloviana* Reverd., *Poa altaica* Trin., *Carex aterrima*, *Aconitum altaicum* Steinb., *Dracocephalum peregrinum* L., *Bistorta officinalis*, *Oxyria digyna*, *Allium schoenoprasum* and *Rhodiola coccinea* prevail in the herbaceous layer.

The ecological density is 3.80 ind/m^2; the effective density is 2.47 ind/m^2. The ontogenetic spectrum is bimodal, with a predominance of young and old generative individuals and a large proportion of virginal individuals. CP 3 is transient, normal, and full-membered.

CP 4: bushy polydominant subalpine meadow in the stream shallows, 2385 m a.s.l., Aktru mountain-glacial basin, North Chuisky Ridge.

The population is located along the bottom and sides of the stream shallows on unfixed loose soils, between stones and thickets of bushes. Plants of *Rh. rosea* are not found in soddy areas with developed vegetation outside the stream. The 3 m wide shallows stretch for 300 m from the middle part of the slope to its base. Large and medium stones make up about 10% of the area, the projective cover is 70%. The maximum height of shrubs and herbaceous plants is 60 cm; the average height of plants is 30 cm. The population contains glaucous and green individuals of *Rh. rosea*. The shrub layer contains *Salix cinerea* L., *Juniperus sibirica* Burgsd., and *J. sabina* L., *Cotoneaster uniflorus*, *Spiraea media* Schmidt, and *Atragene sibirica* L. Herbaceous plants are dominated by *Geranium albiflorum* Ledeb., *Rhodiola rosea*, *Saussurea frolowii* Ledeb., and *Aegopodium alpestre* Ledeb.

The ecological density is 3.63 ind/m^2; the effective density is 2.10 ind/m^2. The ontogenetic spectrum is left-sided, with a pedominance of young generative individuals and a large proportion of pregenerative individuals. CP 4 is young, normal, full-membered.

CP 5: community with sparse miscellaneous herbs on a steep slope, in the stream shallows with unfixed rubble sides, 2380 m a.s.l., Aktru mountain-glacial basin, North Chuya ridge.

The soil is loose, placers of stones of different sizes; no bushes. The projective cover of the herbaceous layer is 25%. The population of *Rh. rosea* is located in the central part of the shallows, within a 3 m wide line. All individuals are glaucous. Herbaceous plants are dominated by *Heracleum dissectum* Ledeb. and *Chamaenerion latifolium* (L.) Sweet.

The ecological density is 1.56 ind./m^2; the effective density is 0.83 ind./m^2. The ontogenetic spectrum is left-sided, with a predominance of young generative individuals and a large proportion of immature and virginal individuals. CP 5 is young, normal, and incomplete-membered (without senile individuals).

CP 6: stony-gravelly tundra along the stream, steep rocky slope, 2828 m a.s.l., Mount Sukor.

The north-eastern exposure slope (40–45 deg. inclination). Stony-gravelly tundra. *Rh. rosea* is found only along the stream, on gravelly areas with 7–35 cm stones. The population is severely disturbed due to cattle grazing and medicinal plant harvesting. Shrubs are not found, the herbaceous cover is heavily thin. The projective cover of the sites attains 15%. *Lagotis integrifolia* (Willd.) Schischk., *Minuartia verna* (L.) Hiern, *Dracocephalum nutans* L., *Cerastium lithospermifolium* Fisch., and *Rhodiola rosea* prevail in the herbaceous cover.

The ecological density is 1.38 ind./m^2; the effective density is 0.83 ind./m^2. The ontogenetic spectrum is bimodal, with a predominance of young generative, old generative, and subsenile individuals. CP 6 is transitional, normal, full-membered.

CP 7: bushy alpine meadow along the stream shallows, 2728 m a.s.l, Mount Sukor.

The population is confined to the lower part of the stream shallows, below the entrance to the abandoned mine. The projective cover varies from 40 to 60%. Shrubs are represented by *Salix berberifolia* Pall., *Salix glauca*, *Betula rotundifolia*, and *Juniperus sabina* L. Herbaceous plants are mainly represented by *Chamaenerion latifolium*, *Oxyria digyna*, *Lagotis integrifolia* (Willd.) Schischk., *Trifolium eximium*, and *Carex melanantha*.

The ecological density is 3.00 ind./m^2; the effective density is 1.89 ind./m^2. The ontogenetic spectrum is left-sided, with a predominance of young generative individuals and a large proportion of virginal and old generative individuals. CP 7 is mature, normal, full-membered.

CP 8: subalpine miscellaneous herbs among bushes along the bank of the Akkol River, 2453 m a.s.l., mountain-glacial Akkol basin (Sophia glacier), South Chuya ridge.

The population is confined to a leveled alluvial area stretching to the northwest with a slight 5 deg. inclination, pebbles along the left bank of the Akkol River. Stones up to 60 cm, rounded. The species diversity is scarce, but in some places, the projective cover attains 90%. Shrubs are represented by *Salix sajanensis* Nasarow, *Salix caesia* Vill. Cereals prevail in the herbaceous cover (up to 70%): *Trisetum mongolicum* (Hultén) Peschkova, *Deschampsia altaica* (Schischk.) O.D. Nikif., *Festuca altaica* Trin., *Festuca brachyphylla* and *Arctopoa tibetica* (Munro ex Stapf) Prob., as well as *Archangelica decurrens* Ledeb. and *Rhodiola rosea*.

The ecological density 3.13 ind./m^2; the effective density is 1.75 ind./m^2. The ontogenetic spectrum is bimodal, with a predominance of virginal, young generative, and old generative individuals. CP 9 is transitional, normal, full-membered.

CP 9: willow forest with subalpine miscellaneous herbs along the banks of the Tura-Oyuk stream, 2324 m a.s.l., the Akkol mountain-glacial basin (Sophia glacier), the South Chuya ridge.

In this population, *Rh. rosea* grows under the canopy of tall shrubs and between stones along the stream banks. The maximum height of shrubs is about 4 m. The shrub layer exhibits a number of species such as *Salix* (*Salix pentandra* L., *Salix sajanensis*, *Salix glauca* L.), *Lonicera altaica* Pall., *Spiraea alpina* Pall., *Betula rotundifolia* Spach., and *Rosa spinosissima* L. The projective cover of the herbaceous layer attains 90%. The maximum height of herbaceous plants is 1 m, the average is 40 cm. *Arctopoa tibetica*, *Rheum compactum* L., *Archangelica decurrens*, and *Primula nivalis* Pall prevail in the herbaceous layer.

Table 1. Demographic structure of *Rh. rosea* coenopopulations in the Republic of Altai

CP	Ontogenetic stage, %								Demographic rate				
	j	im	v	g_1	g_2	g_3	ss	s	M, ind./m^2	Me, ind./m^2	Δ	ω	CP type
1	1.1	5.3	9.6	27.7	28.7	13.8	10.6	3.2	3.76	2.67	0.46	0.71	Mature
2	14.0	6.3	13.3	21.0	14.6	25.2	4.2	1.4	5.72	3.49	0.41	0.61	Transitional
3	9.5	1.1	16.8	31.6	12.6	22.1	4.2	2.1	3.80	2.47	0.39	0.65	Transitional
4	10.3	10.3	15.5	32.8	6.9	19.1	3.4	1.7	3.63	2.10	0.33	0.58	Young
5	5.1	20.5	25.6	30.8	7.7	5.2	5.1	0	1.56	0.83	0.25	0.53	Young
6	2.5	10.0	5.0	20.0	12.5	22.5	22.5	5.0	1.38	0.83	0.54	0.60	Transitional
7	6.6	8.0	18.7	34.7	10.7	17.3	2.7	1.3	3.00	1.89	0.34	0.63	Maturing
8	10.5	8.5	17.0	21.3	10.6	17.0	12.8	2.1	3.13	1.75	0.39	0.56	Transitional
9	8.8	14.7	26.5	20.6	20.6	8.8	0	0	2.00	1.16	0.26	0.58	Young

Notes: CP – coenopopulation. Ontogenetic stage: j – juvenile, im – immature, v – virginile, g_1 – young generative, g_2 – mature generative, g_3 – old generative, ss – subsenile, s – senile. Demographic rate: M – ecological density, Me – effective density, Δ – age index, **ω** – efficiency index; ind./m^2 – number of individuals per 1 m^2.

The ecological density is 2.00 ind./m^2; the effective density is 1.16 ind./m^2. The ontogenetic spectrum is left-sided, with a predominance of virginal individuals and a large proportion of young generative and old generative individuals. CP 9 is young, normal, incomplete-membered (subsenile and senile individuals are absent).

The study revealed the highest values of the ecological (5.72) and effective (3.49) density for CP 2 growing in the coenosis with a high total projective cover of the herbaceous layer and favorable environmental conditions (fixed soil, sufficient moisture, good illumination). The lowest values of the ecological and effective density were recorded for coenopopulations growing on slopes with the crumbling substrate (CP 5), in shrub thickets (CP 9), or those subject to constant adverse anthropogenic effects (CP 6).

The studied *Rh. rosea* coenopopulations are full-membered or incomplete-membered (postgenerative individuals are absent in some coenopopulations). In terms of the ontogenetic spectra, they are mainly left-sided with a predominance of young generative individuals (CP 4, 5, 7), or bimodal with an additional peak for old generative individuals (CP 2, 3, 6, 8). In all the studied coenopopulations, generative individuals (g_1–g_3) make up more than half (50% and more) of their ontogenetic composition. As previously noted by other researchers, a large proportion of generative individuals is associated with the duration of *Rh. rosea* ontogenesis and a relatively long age of the indicated individuals (Nekratova and Nekratov 2005). Virginal (CP 5, 9) and senile (CP 6) individuals make up a large proportion of the ontogenetic composition of some coenopopulations.

In almost all coenopopulations, seedlings were noted in the study year (except for CP 6) (Table 1). In general, 6 out of 9 coenopopulations (CP 3, 4, 5, 7, 8, 9) exhibited the predominance of young individuals (j–g_1). A sufficient number of pregenerative individuals indicates regular reproduction by seeds.

The morphological characters of *Rh. rosea* were analyzed separately for male and female individuals. Measurements of a large number of morphological parameters enabled the development of data array and calculation of the statistical characteristics for all female and male individuals (totality) and revealed the differences between 9 individual coenopopulations and the totality.

Table 2 presents the morphometric parameters and their calculated values for male and female shoots for the totality and individual coenopopulations. A comparative analysis of the totality of females and males revealed significant differences in the morphometric parameters and their calculated values for generative shoots. Female shoots are 39% longer and have 16% more leaves, but the ratio of leaf number to shoot length (an integral characteristic of shoot foliage) is 18% less, which indicates that the internodes are longer. The length, width, and dry weight of leaves in female shoots are less than those in male ones, but the differences are not statistically significant. However, a slight decrease in the length and width reduces the leaf area by 10%, while the leaf density (an integral characteristic of the total accumulation of dry matter per unit leaf area) is higher by 9%, which indicates a more efficient production process in the aerial organs of female plants (likely to the detriment of the underground biomass accumulation). The diameter of the female inflorescences is 1.5 fold greater than that of the male ones, and the number of flowers is less by 12%.

The number of leaves per shoot, the ratio of leaf number to shoot length, and the ratio of leaf length to leaf width in both male and female individuals exhibit an average level of variability (V=18–24%), all other parameters are characterized by a high level of variability (V=25–48%), the most variable of which are the leaf dry weight and the number of flowers per inflorescence. The length, width, and dry weight of leaves in female and male shoots show a high positive correlation with leaf area, but in male shoots the correlation is stronger (r_s=0.80–0.83) than in female ones (r_s=0.73–0.75). Leaf density, an integral characteristic associated with area and weight, shows an average level of positive correlation with leaf dry weight (r_s=0.57 for male and r_s=0.58 for female shoots) and does not show a significant correlation with leaf area (in both female and male shoots).

The deviation of the parameters of shoot length and number of leaves in female plants in individual populations compared to the totality is unidirectional in all the cases (Fig. 1). Increased parameters are observed for CP 1, CP 2, CP 4, CP 5, and CP 9. Decreased parameters are found for CP 3, CP 6, and CP 8. In most cases, the shoot length deviates more strongly than the number of leaves – maximum positive deviation in CP 1 and maximum negative one in CP 6.

The deviation of the parameters of shoot length and number of leaves in male shoots of CP 3 and CP 8 is multidirectional (Fig. 2), in all other coenopopulations it is unidirectional. Similar to female shoots, the maximum increase in parameters is observed for CP 1, and the maximum decrease is found for CP 6.

The deviation of morphometric parameters and their calculated values for leaves in female shoots of most coenopopulations is unidirectional (Fig. 3). The most significant deviation is observed for leaf dry weight and leaf density, and a less significant deviation is found for leaf area. The deviation of morphometric parameters and their calculated values for leaves in male shoots of most coenopopulations is also unidirectional (Fig. 4). However, the direction of deviations in CP 3 and CP 7 is different for male and female shoots. This indicates that within the same CP, leaf growth and development (and, accordingly, production efficiency) can change in different directions in male and female plants under the impact of similar environmental factors. Thus, the implementation of these parameters in different environmental conditions is not only genetically determined but can also be related to the sex of individuals.

The deviation of the parameter of inflorescence diameter in individual coenopopulations compared to the totality is significantly less than the number of flowers per inflorescence in both female (Fig. 5) and male (Fig. 6) shoots.

The deviation of both parameters is mainly unidirectional. The deviation pattern differs in male and female shoots of CP 2, CP 3, CP 6, and CP 9, which indicates that in terms of these parameters, male and female plants of the same coenopopulation respond differently to similar environmental factors (specific for a given coenopopulation).

A different pattern of the deviations of morphometric parameters in individual coenopopulations compared to the totality characterizes populations as reference (with a large proportion of parameters with positive deviations in values) or depressed (with a large proportion of parameters with negative deviations in values).

Male and female plants of *Rh. rosea* differ in many morphometric parameters of generative shoots. In some coenopopulations, male and female individuals have a multidirectional deviation of parameters compared to the totality, which indicates that the implementation of these parameters in different environmental conditions is not only genetically determined but can also be related to the sex of individuals.

Table 2. Morphometric parameters and their calculated values of female and male shoots for the totality and individual coenopopulations of *Rh. rosea*

CP	Sex	Shoot length, cm	Number of leaves, pcs	Leaf number to shoot length ratio	Leaf dry weight, mg	Leaf length, mm	Leaf width, mm	Leaf area, mm²	Leaf density, mg/cm²	Inflorescence diameter, cm	Number of flowers, pcs
Totality	♀	31.4±0.6	55.2±0.8	1.8±0.03	9.6±0.7	26.3±0.9	9.7±0.3	201.1±11.6	4.8±0.2	3.4±0.05	56.3±1.4
	♂	22.5±0.4	47.7±0.6	2.2±0.03	9.8±0.8	27.6±0.9	10.1±0.4	223.5±13.5	4.4±0.2	2.2±0.04	63.8±1.9
CP 1	♀	42.4±0.8	74.4±1.2	1.8±0.1	8.8±0.5	31.7±0.6	9.8±0.2	235.3±8.0	3.8±0.2	3.2±0.1	54.0±3.8
	♂	29.9±1.0	65.0±1.4	2.2±0.1	8.3±0.6	28.0±0.9	8.4±0.2	202.5±12.6	4.1±0.1	1.9±0.1	46.4±4.0
CP 2	♀	31.9±0.6	68.6±1.4	2.2±0.1	8.6±0.3	27.3±0.4	8.5±0.2	178.0±5.0	4.9±0.1	3.8±0.1	66.5±2.4
	♂	26.8±0.6	60.7±1.1	2.3±0.1	9.0±0.8	28.8±1.3	9.9±0.3	228.9±18.7	4.0±0.2	1.8±0.1	63.3±3.7
CP 3	♀	28.0±0.8	47.5±1.5	1.7±0.1	12.7±0.7	27.2±1.0	11.6±0.3	234.8±13.8	5.4±0.1	4.0±0.1	74.2±4.7
	♂	24.9±0.2	41.6±0.7	1.7±0.03	8.3±0.6	26.1±0.5	10.2±0.3	189.2±8.8	4.3±0.2	2.0±0.1	21.7±6.9
CP 4	♀	39.2±1.1	59.3±1.4	1.5±0.03	11.7±0.4	26.4±0.3	9.1±0.3	194.7±6.8	6.1±0.1	3.3±0.1	40.2±3.5
	♂	26.7±0.8	50.2±1.2	1.9±0.1	11.2±0.7	27.0±0.8	9.9±0.3	223.9±10.6	5.0±0.2	2.0±0.1	75.6±6.1
CP 5	♀	36.5±0.9	55.9±1.3	1.6±0.04	14.1±0.7	31.4±0.6	10.5±0.2	266.3±10.7	5.3±0.2	3.4±0.2	67.1±5.4
	♂	25.0±0.7	52.9±0.9	2.2±0.1	14.8±0.7	34.4±1.0	11.6±0.3	305.9±11.5	4.8±0.1	2.2±0.1	75.6±6.1
CP 6	♀	17.0±0.7	40.2±1.1	2.4±0.1	7.8±0.5	20.3±0.5	9.1±0.3	149.1±8.0	5.2±0.1	3.0±0.1	41.2±2.5
	♂	12.3±0.4	36.4±1.3	3.0±0.1	7.8±0.4	23.4±0.6	8.9±0.4	167.2±9.3	4.8±0.2	2.7±0.1	70.0±5.9
CP 7	♀	23.3±0.6	41.8±1.4	1.8±0.1	9.4±0.6	22.2±0.6	8.5±0.3	154.6±8.8	6.1±0.2	3.4±0.1	51.4±3.7
	♂	18.3±0.6	39.3±1.2	2.2±0.03	13.8±0.7	28.4±0.6	11.7±0.5	258.6±12.8	5.4±0.1	2.5±0.1	58.9±5.6
CP 8	♀	29.7±0.9	50.0±1.4	1.7±0.1	8.1±0.6	26.0±0.8	10.2±0.3	213.0±12.9	3.7±0.1	3.0±0.1	48.2±4.0
	♂	21.5±0.8	49.4±1.1	2.3±0.04	8.0±0.5	26.6±0.8	9.7±0.2	208.5±10.1	3.8±0.1	2.2±0.1	58.9±5.6
CP 9	♀	35.8±1.3	59.2±1.6	1.7±0.1	5.4±0.4	24.7±0.7	10.1±0.2	187.6±9.2	2.9±0.2	2.9±0.1	63.5±4.6
	♂	26.9±0.4	51.3±0.8	1.9±0.03	7.0±0.4	26.5±0.5	11.0±0.3	230.5±9.8	3.0±0.1	3.1±0.2	114.6±5.3

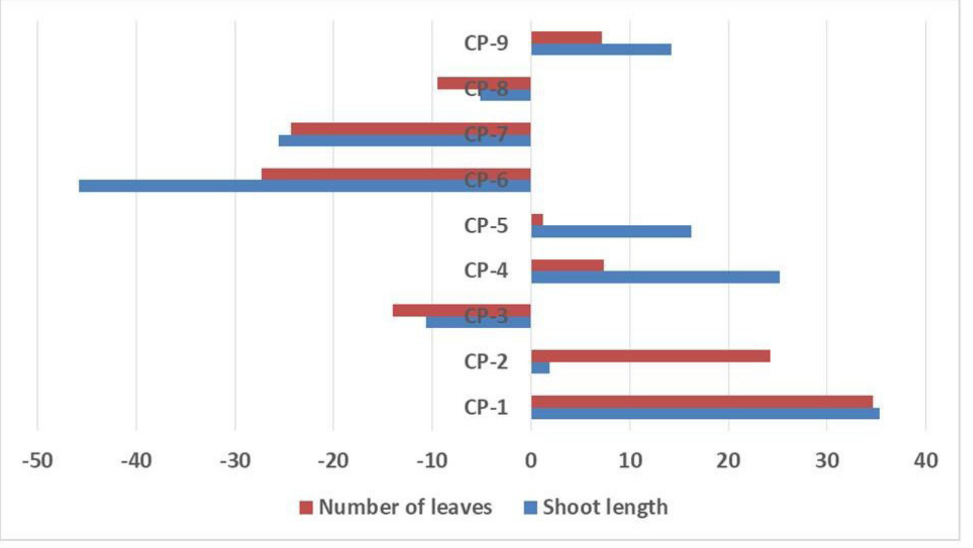

Figure 1. Deviation of the parameters of shoot length and number of leaves in female shoots of individual populations compared to the totality, %.

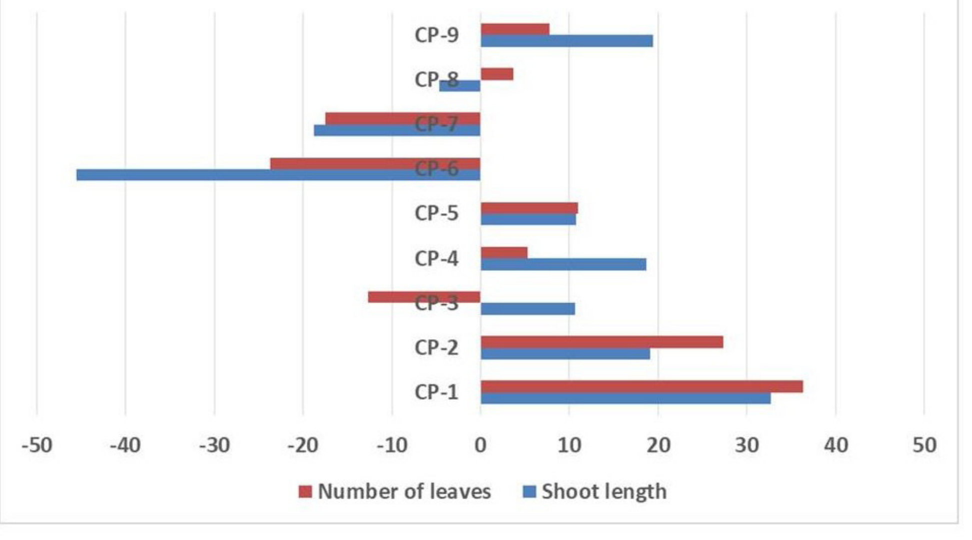

Figure 2. Deviation of the parameters of shoot length and number of leaves in male shoots of individual populations compared to the totality, %.

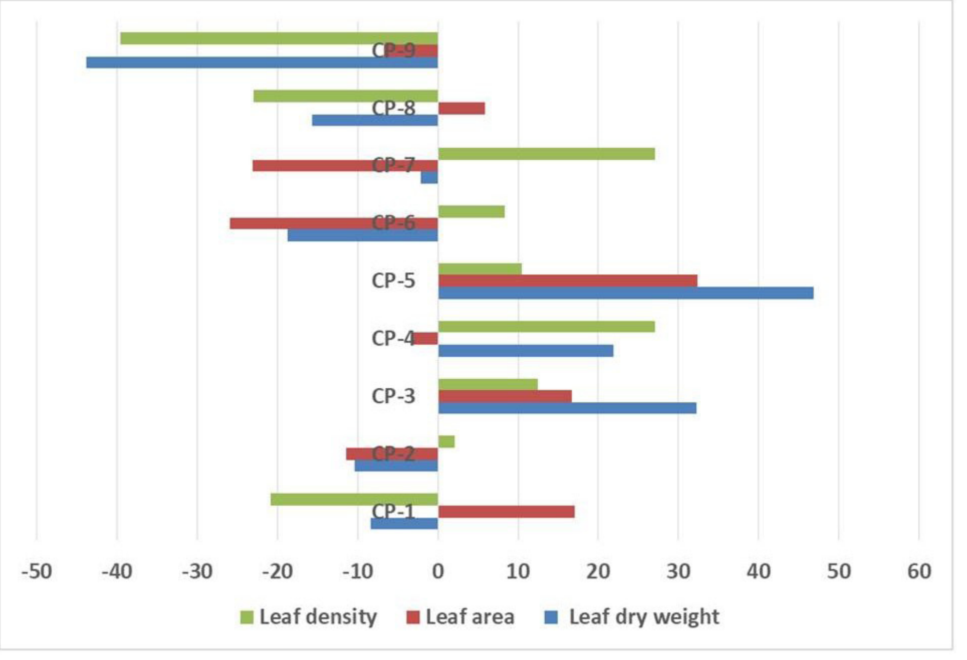

Figure 3. Deviation of the parameters of density, area and dry weight of leaves in female shoots of individual populations compared to the totality, %.

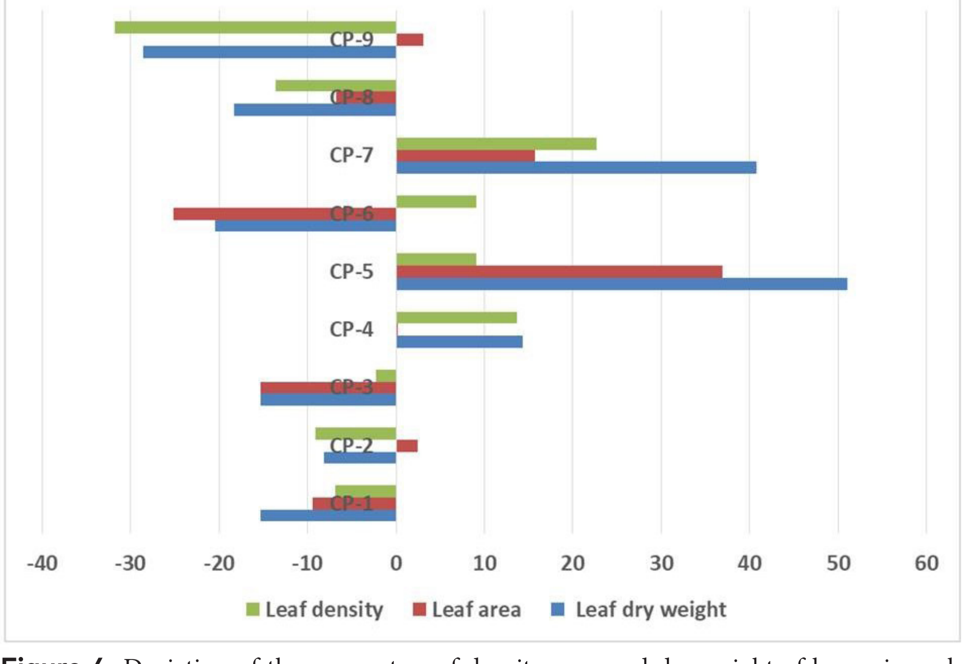

Figure 4. Deviation of the parameters of density, area and dry weight of leaves in male shoots of individual populations compared to the totallity, %.

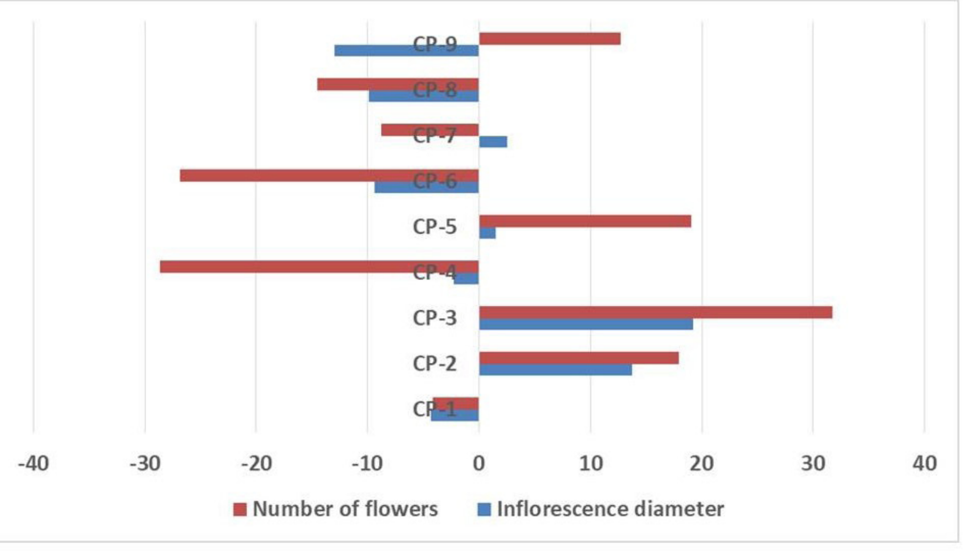

Figure 5. Deviation of the parameters of inflorescence diameter and the number of flowers in female shoots of individual populations compared to the totality, %.

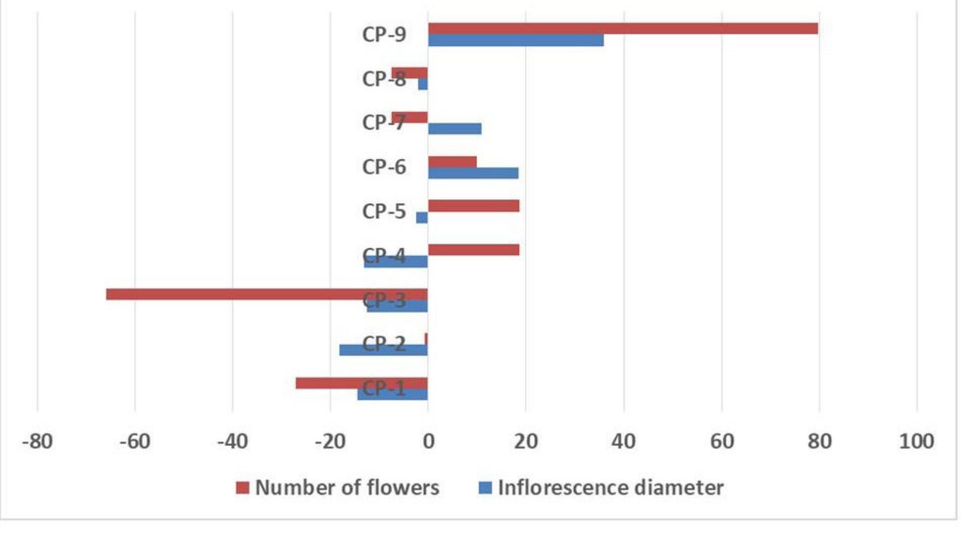

Figure 6. Deviation of the parameters of inflorescence diameter and the number of flowers in male shoots of individual populations compared to the totality, %.

Conclusion

The study of the ontogenetic composition showed that the investigated coenopopulations of *Rh. rosea* are normal, full-membered, or incomplete-membered. In terms of the ontogenetic spectra, they are mainly left-sided with a predominance of young generative individuals, or bimodal with an additional peak for old generative individuals. In all the studied coenopopulations, generative individuals make up more than half (50% and more) of the ontogenetic composition.

Male and female plants of *Rh. rosea* differ in a number of morphometric parameters of generative shoots. In some coenopopulations, male and female individuals exhibit a multidirectional deviation of parameters compared to the totality, which indicates that the implementation of these parameters in different environmental conditions is not only genetically determined but can also be related to the sex of individuals.

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