Coenopopulation Structures of Various Plant Species in Yakutia

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Abstract. This research work details analysis of the coenopopulation structure of 13 plants of various species in Yakutia and compares them with the characteristic spectra types of their species. The structure of plant coenopopulations was investigated from 2003 to 2019 in Central Yakutia. The left-sided and centered ontogenetic spectra are found in perennial plants with simple ontogenesis and shallow rejuvenation which were studied. The left-sided spectrum is the basic structure of these coenopopulations. The centered ontogenetic spectrum is largely found in unfavorable growing conditions under the impact of grazing and trampling by cattle and horses. This rule applies to the CP structure of *Veronica incana* which is an evergreen chamaephyte and for which the seasonal anthropogenic load contributes to the mechanical vegetative reproduction of its species, resulting in stable left-sided CP spectra. The ontogenetic spectra of the studied plants coincide with the characteristic spectra of the species and are considered stable.

The ontogenetic spectra of plants are applicable to all related life-forms. The value of this demographic indicator for population monitoring is specified by the fact that it may be used to assess the current state of coenopopulations (CP) and forecast their further development. The basic features of ontogenetic spectra (i.e. position and ratio of ups and downs) are directly related to the biological properties of the various species. L. B. Zaugolnova [1] called these population characteristics the characteristic of the ontogenetic spectrum. An actual ontogenetic spectrum corresponding to the characteristic ontogenetic spectrum may serve as an indicator of stable CP state.

For the first time we determined the CP ontogenetic spectra of plants of various life-forms on the territory of Yakutia as compared with the types of characteristic ontogenetic spectra of said plants.

The purpose of this research work is the study of the coenopopulation structures of plants of various life-forms in Yakutia.

Our research was carried out from 2003 to 2019 in Central Yakutia. The subject of the study were the coenopopulations of 13 plants of various life-forms: *Alyssum lenense* Adams., *Astragalus lenensis* Shemetova Schaulo et Lomon., *Clausia aprica* (Steph.) Korn.-Tr., *Gagea pauciflora* Turcz. ex Ledeb., *Linum komarovii* Juz., *Oxytropis candicans* (Pall.) DC., *Papaver jacuticum* Peshkova, *Patrinia sibirica* (L.) Juss., *Phlojodicarpus sibiricus*

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were (Fisch. Ex Spreng.) K.-Pol., *Plantago canescens* Adams., *Polygonum aviculare* L., *Valeriana alternifolia* Ledeb. and *Veronica incana* L. In total the CP structure of about 80 plants was studied [2-14].

The vast territory of Yakutia is covered with permafrost the thickness of which reaches 250 to 300 m in Central Yakutia. The climate of Central Yakutia is characterized by its extremely sharp continentality. The absolute minimum and maximum temperatures covered a range of 102 ^{o}C, from -64 ^{o}C in January up to +38 ^{o}C in July. With regard to the amount of precipitation, 140 to 180 mm, were registered with the regional level being close to that of the steppes and semi-desert regions of Central Asia [15]. Generally accepted population classification and research techniques were applied in our research work [16, 17]. L. B. Zaugolnova [1] compared the CP structure of the plants with the types of characteristic spectra of said plants.

The ontogenetic structure of the studied coenopopulations of species depends on the biological properties of plants and the dynamic CP states. The biological characteristics of the studied plants and their CP structure are presented in Table 1 and Table 2. According to L.B. Zaugolnova's [1] classification of plant life-forms making up a significant portion of the population features of the characteristic ontogenetic spectrum, the studied plants belong to taproot possessing plants reproducing by seed with no vegetative reproduction and having a simple type of ontogenesis. The rest of the studied species have a complex type of ontogenesis and vegetative reproduction with shallow and deep rejuvenation. The biomorph type of the studied plants is monocentric, except *for Clausia aprica* and *Veronica incana* which possess a long-rooted life-form, in which implicit polycentric biomorphs were observed and documented.

The demographic structure of CP in the studied plants is dependent on both the characteristics of plant biology and on various growing conditions. Left-sided and centered ontogenetic spectra were found during research. Moreover left-sided ontogenetic spectra were noted in all of the CP species under study. Centered CP were found in plants with a tap root system, except for one-year-old *Polygonum aviculare* as well as *Papaver jacuticum, Patrinia sibirica* and *Phlojodicarpus sibiricus.* However the CP of perennial plants was found within plants existing in relatively favorable growing conditions. A centered structure was also found in one CP of *Valeriana alternifolia* with a short-rootstock and brush-like life-form. The study covered 7 CPs over a 3 year period and centered CP was recorded only once. For the CP of plants under study, the increase in the proportion of middle-aged species occurred mainly against the back drop of unfavorable growing conditions caused by anthropogenic impact (the trampling and grazing of cattle and horses), when the percentage of advanced growth decreases with relation to the shared general spectrum.

Table 1. The biological characteristics of the studied plants and the ontogenetic structure of their related CP

No.	Species	Life-form	Lifetime, years/ontogenesis	Ontogenetic spectrum of CP	Characteristic ontogenetic spectrum of the species CP
1	*Alyssum lenense*	Taproot half-shrub	7-11 / Simple	Left-sided, centered	Left-sided, centered
2	*Astragalus lenensis*	Taproot chamephyte	10-24 / Simple	Left-sided, centered	Left-sided, centered
3	*Clausia aprica*	Long-rootstock taproot herbaceous perennial plant	1-4 / Complex with deep rejuvenation	Left-sided	Left-sided
4	*Gagea*	Bulbous herbaceous	6-7 /	Left-sided	Left-sided

	pauciflora	perennial plant	Complex with deep rejuvenation		
5	*Linum komarovii*	Taproot chamephyte	5-7 / Simple	Left-sided, centered	Left-sided, centered
6	*Oxytropis candicans*	Taproot herbaceous perennial plant	7-16 / Simple	Left-sided, centered	Left-sided, centered
7	*Papaver jacuticum*	Taproot herbaceous perennial plant	4–12 / Simple	Left-sided	Left-sided, centered
8	*Patrinia sibirica*	Taproot herbaceous perennial plant	10-12 / Simple	Left-sided	Left-sided, centered
9	*Phlojodicarpus sibiricus*	Taproot herbaceous perennial plant	/ Simple	Left-sided	Left-sided, centered
10	*Plantago canescens*	Short-rootstock taproot herbaceous perennial plant	4-11 / Complex with shallow rejuvenation	Left-sided, centered	Left-sided, centered
11	*Polygonum aviculare*	Taproot one-year-old plant	one-year-old / Simple	Left-sided	Left-sided
12	*Valeriana alternifolia*	Short-rootstock brush-like plant	10-20 / Complex with shallow rejuvenation	Left-sided, centered	Left-sided, centered
13	*Veronica incana*	Loosely-bunched chamephyte, forms a short-rootstock (nature), long-rootstock (nature), taproot (culture) biomorph	13-15 / Complex with shallow rejuvenation	Left-sided	Left-sided, centered

L.B. Zaugolnova's [1] characteristic ontogenetic spectrum for various life-forms basically matches our research. Our research may thus confirm and supplement the occurrence of characteristic plant spectra. The left-sided CP spectrum was found within favorable growing conditions of typical taproot possessing plants with simple ontogenesis provided for no vegetative reproduction. The centered ontogenetic spectra of these plants were found within unfavorable growing conditions under the impact of intensive trampling and grazing by cattle and horses.

The CP structures of plants (*Plantago canescens*, *Valeriana alternifolia*, *Veronica incana*) possessing a complex ontogenesis and shallow system rejuvenation with various life-forms complement the characteristic optional variants encountered in species spectra. The left-sided spectra were found in three studied plants. The centered spectra were reported in CP of *Plantago canescens* with short-rootstock taproot possessing life-forms and the CP *of Valeriana alternifolia* with a short-rootstock brush-like life-form when trampled by humans and grazed of cattle. L.B. Zaugolnova [1] noted that species with a complex ontogenesis and shallow rejuvenation developing according to a monocentric typing, were found only among forest grasses. It should be noted that in addition, there is an exception to the rule stating that the centered CPs are formed under unfavorable conditions for plant growth. Thus, the CP structure *of Veronica incana* with short-rootstock and long-rootstock life-forms possessing shallow rejuvenation within unfavorable growing conditions against the back drop of intensive trampling by people and transport loads, retains the left-sided spectrum. *Veronica incana* is an evergreen chamaephyte for which seasonal anthropogenic loads contribute to mechanical vegetative reproduction, leading to an increase in the proportion of immature and virginal groups of species within the CP structure.

The *Clausia aprica* and *Gagea pauciflora species* which possess complex ontogenesis and deep rejuvenation were described within conditions lacking anthropogenic impact. The left-sided spectra were found within these CPs while matching the characteristic spectra of the species.

Table 2. The ontogenetic spectra options for the CP of the studied species

No.	Species	Ontogenetic spectrum	j	im	v	g1	g2	g3	ss	s
1	*Alyssum lenense*	Left-sided	20,3	-	30,4	23,2	26,1	-	-	-
		Centered	32,7	-	15,5	9,4	41,6	0,8	-	-
2	*Astragalus lenensis*	Left-sided	3,1	18,8	25,0	18,8	18,8	6,2	3,1	6,2
		Centered	2,5	8,8	18,7	21,2	26,9	16,9	5,0	-
3	*Clausia aprica*	Left-sided	1,1	11,9	42,0	17,0	14,5	6,1	7,4	-
4	*Gagea pauciflora*	Left-sided	8,4	24,3	26,9	22,5	17,9	-	-	-
5	*Linum komarovii*	Left-sided	10,4	11,7	35,0	23,4	16,9	2,6	-	-
		Centered	1,8	10,0	20,0	19,4	24,7	15,3	8,8	-
6	*Oxytropis candicans*	Left-sided	3,3	5,6	62,2	6,7	15,6	2,2	3,3	1,1
		Centered	-	3,3	14,5	33,3	38,9	6,7	2,2	1,1
7	*Papaver jacuticum*	Left-sided	3,6	41,1	10,7	19,6	19,6	5,4	-	-
8	*Patrinia sibirica*	Left-sided	8,1	11,0	25,1	10,5	8,8	13,6	13,4	9,5
9	*Phlojodicarpus sibiricus*	Left-sided	42,1	7,9	35,0	3,6	5,7	1,4	4,3	-
10	*Plantago canescens*	Left-sided	7,55	14,84	34,85	12,24	26,23	3,19	1,1	-
11	*Polygonum aviculare*	Left-sided	-	-	47,6	52,4	-	-	-	-
12	*Valeriana alternifolia*	Centered	18,5	8,5	20,1	13,8	28,0	5,3	5,8	-
		Left-sided	69,4	19,2	4,3	4,6	2,2	0,3	-	-
13	*Veronica incana*	Left-sided	1,4	5,4	43,1	14,4	12,4	8,0	11,6	3,7

Thus, the left-sided and centered ontogenetic spectra are found in the studied perennial plants with simple ontogenesis and shallow rejuvenation. The left-sided spectrum is the basic structure of these coenopopulations. The centered ontogenetic spectrum is found in unfavorable growing conditions under the impact of grazing and trampling by cattle and horses. Within this rule the *Veronica incana* CP structure has developed, as it is an evergreen chamaephyte seasonal anthropogenic load contributes to the mechanical vegetative reproduction of its species, resulting in stable left-sided CP spectra.

The ontogenetic spectra of the studied plants matches the characteristic spectra of the associated species and are considered stable. The CP structure depends mainly on the biological properties of plants, the ontogenesis type and the vegetative reproduction nature, as well as on the related morphological structures and responses to anthropogenic factors.

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