Morphological variability of *Vaccinium uliginosum* L. in coenopopulations in Asian Russia

Tatyana Korobkova[1], *Vladimir* Sorokopudov[2,*], *Olga* Sorokopudova[2], and *Dmitriy* Lebedev[3]

[1]Yakut Botanical Garden, Siberian Branch of the Russian Academy of Sciences, Yakutsk, Russia
[2]All-Russian Scientific Research Institute of Medicinal and Aromatic Plants, Moscow, Russia
[3]Sakhalin Branch of the Botanical Garden Institute of the Far Eastern Branch of the Russian Academy of Sciences, Yuzhno-Sakhalinsk, Russia

Abstract. A paper contains materials on the study of bog bilberry in the conditions of Central Yakutia, which are presented in the paper. In the species, there is a variability in the morphological, endogenous, individual, geographical and ecological variability of generative and vegetative organs, as well as phenological development. Among the following traits, there was greatest variability: number of berries per bush (30.1%), and size of the branch (leaf blade length and thickness) 30.9% and 29.3%, respectively. Less variables were berry weight (15%) and height of fruit-bearing bushes (14.9%), but they were not much different from other variable traits. Among the traits that have been studied, the taiga zone of South Yakutia can be considered an ecological optimum for V.uliginosum due to the manifestation in most of the studied traits. Bog bilberry in the conditions of Central Yakutia requires more thorough study and brand-new agrotechnical cultivation methods due to the slow entry of plants into the generative stage of development. The introduction is required for an improved approach to plant production, as well as new agrotechnical techniques that are adapted to support the slow entry of plants into the generative stage of development.

1 Introduction

The research was and is carried out using biobjects of the unique scientific installation “Biocollections” of the VILAR (All-Russian Scientific Research Institute of Medicinal and Aromatic Plants). In Yakutia, picking up wild berries begins at the end of the first decade of July with strawberries and on the 20th of July with bilberries, the favorite berry of Yakut people. Bilberries can be found in various places in all regions of Yakutia; the estimated stock of bilberries in the middle taiga and north taiga subzones of the republic is 2.5 q/ha. At the same time, the area of forests with industrial reserves is 4.6 ml. ha. In terms of its reserves, bilberry is second only to lingonberry.

Bog bilberry (*V. uliginosum* L.) belongs to the genus *Vaccinium* L., family Ericaceae

*Corresponding author: sorokopud2301@mail.ru

Juss. In Yakutia, the genus is represented by only 4 species ubiquitous throughout the territory. In addition to *V. uliginosum*, there are *V. ssp. microphyllum* Lange (polar bilberry), *V. myrtillus* L. (European blueberry), *V. vitis-idaea* L. (cowberry) and *V. ssp. minus* (Lodd.) Halt. (lingonberry) [1].

A plant with a great presence in different regions of Russia, Bog bilberry is found to thrive in many habitats: mountain and lowland tundras, swampy coniferous forests, green mossy lightforests. Yerniks are the most popular place for this kind of vegetation. On poor acidic soils under subalpine trees, it grows on poor, acidic soils. Moreover, a wide range of natural environments contributes to the plant's adaptability. The large number of natural environments helped in creating an adaptable plant with different species distributed throughout Russia and Europe as well as Arctic regions: the Caucasus region is included in the list of European parts of Russia for its distribution on all continents, from Ukraine to the Far East. The various climatic conditions lead to variations in phenological rhythms, biological productivity and biochemical properties of the organism throughout its growth. This differing climatic and geographical conditions are due to these differences in climatic and geographical conditions that lead to different phenology periods for biological productivity, biochemical properties; phenological periods, morphological characteristics, and biochemical parameters all over its growth.

Vitamins B1, B2, and PP (up to 20 mg/100 g), vitamin C (up to 20% 100 g) are notable in the nutritional value of bog bilberries. The nutritional value of bog bilberries is notable, as they contain vitamins B1,B2, and PP (up to 20 mg/100 g), vitamin K1 (up to 20 mg/100 g). Along with this, their composition includes a wide range of macronutrients like iron, carbonic and carbonic compounds. In addition, they contain trace elements, analogue elements, and micronutrients. In addition, they contain anthocyanins and polyphenolic compounds that are endowing them with preventive and anti-therapeutic properties against many health problems. Their composition is rich in anthocyanins and phenolic compounds, which provide them with preventive and therapeutic properties against numerous diseases, including cardiovascular issues, oncological diseases, colds, and Alzheimer's disease. Scientists have found that Bilberries are capable of preventing brain aging, slowing cognitive decline, and providing protection from the harmful effects of radiation exposure.

Despite its significance, research on bilberries in Yakutia has been limited, primarily focusing on its biological characteristics and productivity. In the context of Yakutia, the current study is particularly interested in examining the variability of bilberry's morphological features and their connection to economically valuable traits.

2 Materials and Methods

The object of research, *V. uliginosum*, is a sympodially branching high shrub or a shrub formed by a small number of summer green shoots. Its leaves are alternate, from small elongated obovate to almost rounded, light green above, glaucous below and with noticeable veins. Formation shoots develop from axillary buds at the bottom of last year's shoots. In the leaf axils of the upper part of shoots, buds are formed with generative shoots that do not form leaves. Its flowers are small, spherical bell-shaped, white or pink and drooping. The calyx is fused with the ovary. The fruit is round or pear-shaped, juicy and bluish-black, with a glaucous wax coating. Under natural conditions, bilberries are more often renewed vegetatively [10].

The study of bilberry in natural habitats was carried out during expedition trips to the central and southern regions of Yakutia in 2004-2019. Plants from 16 cenopopulations (CP) were studied. The data on the bilberries distribution in hard-to-reach places in the Olekminsky district were collected by Kuzmina V.G. (2004-2005).

In natural habitats 3-5 plots (2x2m) were laid, the number of bilberry bushes and the

phenological phase of development were determined. The fruiting degree was noted according to the five-point Formozov scale. The authors of the present research analyzed the endogenous variability of the following traits: number of berries, weight and size per berry, leaf blade length and width, and bushes height and age. A correlation analysis was carried out between the morphological traits and yield characteristics in test plots; height, age, maximum and minimum crown diameters, fruiting degree and berries number were analyzed.

The following are typical communities in which *V. uliginosum* was most commonly encountered.

CP 1. The lingonberry larch forest, right bank of the Olekma River, 500 m south of the Bederdeeh cordon; *Pinus sylvestris* and *Sorbus sibirica* occur singly. The total shrub layer coverage is 20% and the herbaceous-shrub layer is 50%. The stand is secondary, after the fire. The moss-lichen layer is absent.

CP 2. The forb-lingonberry larch forest, lower slope of Mount Iyeken (valley of the Amga River, 450 km upstream from the village of Upper Amga). The herbaceous-shrub layer is dominated by *V. vitis-ideae, V. uliginosum, Duschekia fruticosa* and *Betula fruticosa*. The projective coverage is 59%.

CP 3. A mixed forest at the foot of the mountain itself at the altitude of 280-350 m above sea level. The forest is dominated by dark coniferous species – *P. sibirica, Abies sibirica, Picea obovata, Larix gmelinii*; *Rhododendron aureum* in the herbaceous-shrub layer, *V. uliginosum*, *Rheum compactum* and *Cypripedium calceolus* – under the forest canopy. The projective coverage is 70% and the occlusion is 0.6.

CP 4. The lingonberry-bilberry-lichen larch forest with an admixture of pine trees (Aldan, 18 km north of the Khanierdakh River). *L. gmelinii* and *P. sibirica* predominate. *Juniperus sibiricus, D. fruticosa, B. fruticosa* and *Salix hastate* were noted in the undergrowth. The projective shrub layer coverage is 60%.

CP 5. Lingonberry larch trees with the admixture of *P. sylvestris* (Ulakhan-Munku village, the Bolshaya Cherepakha River). The undergrowth is composed of *B. fruticosa*, *D. fruticosa*, *V. uliginosum* and *S. bebbiana*.

CP 6. The bilberry-lingonberry larch forest surrounding the mountains of Yakutsk, northern slope of the Chochur-Muran Mountain, 136 m above sea level. The stand is a significant admixture of *P. obovata*; the undergrowth is sparse, consisting of individual bushes – *Lonicera altaica*, *D. fruticosa*, *Ledum palustre* and *Rosa acicularis*. The herbaceous-shrub layer consists of *V. uliginosum*, the dominant *V. vitis-idaea*, and *Equisetum scirpoides*. The moss cover is continuous and green mosses predominate. The projective coverage is 40% and the occlusion is 0.4.

CP 7. An alder-lingonberry pine forest (outskirts of Yakutsk, foot of the Chochur-Muran Mountain) composed of *Alnus hirsute*, *Salix pyrolifolia*, *Betula*, *V. uliginosum*, and *L. palustre*. The projective coverage is 50% and the occlusion is 0.2.

CP 8. A bilberry moss larch forest 5 km north of settlement Biryuk, the Biryuk River. *A. hirsute*, *B. fruticosa*, *D. fruticosa* and *V. uliginosum* form the undergrowth. The moss cover is represented by *Pleurozium schreberi* and *Ptilidium ciliare*. The projective coverage is 60%.

CP 9. A lingonberry-green moss spruce forest, right bank of the Buotama River, 134 km away from Yakutsk. The shrub layer is well-expressed and consists of *S. sibirica*, *A. hirsute*, *Rosa acicularis*, *Spiraea media, B. fruticosa and S. alba.* The projective coverage is 65% and the occlusion is 0.6. The herbaceous-shrub layer is represented by *V. vitis-idaea*, *V. uliginosum, L. palustre, A. uva-ursi* and *Pyrola rotundifolia.*

3 Results and Discussion

The uliginosum begins its vegetation about one week after the snow melts, corresponding to five days of May in Central Yakutia and ten days of May in the southern regions. The V. Uliginosum begins its vegetation about an hour after it melts, corresponding to five days of May in Central Yakutia or ten days of May in the southern regions and the first five days of May in the southern regions and the first ten days of May in Central Yakutia [14]. Vegetative buds bloom, but they are bearing plant shoots. Vegetative buds first bloom, but they are bearing plant shoots. After 5 days, seeds with generative shoots are blooming after 5-7 days. After 5 days, seeds with generative shoots bloom after 5 days. Vegetative buds bloom before and in order to. Vegetative Buds begin to bloom before and in order to.

The timing of flowering differs from year to season, and is influenced by the type of forest and density. It is important to note that it varies from year to year in terms of the type of forest and the density of the vegetation. In pine forests, V. uliginosum develops more rapidly compared to larch forests. In Central Yakutia, flowering was observed on June 15 in 2014, while in the larch forest (CP 6), it occurred on June 19 in 2014. The Larch Forest (CP 6), that is, its flowering period. However, in the pine forest (CP 7, it was noted on June 15. In contrast, in the pine forest (CP 7), it was noted on June 15. In 2015, flowering was observed on June 18 and 23, respectively, in 2015. The following year, in 2015, flowering was observed on June 18 and 23. It is known that the process of fruit ripening typically spans 30 to 45 days. First berries emerge at the end of two to fourth or three-fourth days in August in central regions, and after that begins on the first week of September. Fruit-bearing bushes are in natural populations, fruit-bearing bushes have an average lifespan of around seven years. The fruiting of larch bushes aged 3 to 4 years has been observed in forests along the Olekma and Biryuk rivers, as well as in larch forests along the Olekma and Biryuk rivers.

V. uliginosum is in the stage of development, but some have exceeded six years old. In the conditions that are set, V. uliginosum is in the juvenile stage of development, although some samples have reached six years of age. When vegetative growth in controlled conditions begins in the first half of May, it is subject to weather condition. Examples of 2014, the growing season began on May 6, and leaves appeared on May 13, and they fully unfolded on May 20. In 2019, the dates of 2019 were shifted due to a late spring, with growth beginning on May 17, and then leaves appearing on May 22, full development occurring on May 30. The date for 2019. was increased due to a late spring. With growth beginning on May 17, leaf formation begins on May 22, leaves appearing on May 22. And full.

Throughout the studied area, it is possible to traced the endogenous, individual, ecological and geographical variability of generative and vegetative organs of V. uliginosum throughout the study area.

At the moment, in Table 1, it is notable that this trait – number of berries per plant – had the highest degree of variability (increased and medium) with the most degree of variability (increased and medium).

Table 1. Berries variability of *V. uliginosum*

Cenopopulation	Berries per bush*	V,%	Berries size, mm		V,%	Berries weight, g	V,%	Fruiting degree
			diameter	length				
CP 1	2-19 9.2±0.03	27.4	3-12 6.1±0.14	5-16 9.6±0.09	18.5	0.28±0.02	15.6	0-5 3.75
CP 2	1-11 5.3±0.03	30.1	2-5 4.0±0.05	4-12 7.8±0.02	12.5	0.32±0.04	15.0	0-5 3.98
CP 3	1-10 3.7±0.04	25.5	2-6 3.7±0.03	4-14 8.4±0.06	19.0	0.25±0.03	11.6	1-5 2.24
CP 4	1-15 5.2±0.04	27.3	2-9 4.4±0.11	5-16 9.9±0.06	27.5	0.54±0.02	14.9	0-5 3.4
CP 5	2-15 6.3±0.04	26.8	2-10 4.1±0.22	6-15 10.0±0.05	21.6	0.64±0.06	14.2	0-5 3.86
CP 6	2-15 6.0±0.05	26.0	2-8 4.6±0.04	5-16 9.9±0.06	22.8	0.52±0.03	14.5	0-5 3.36
CP 7.	1-10 5.1±0.02	16.5	2-6 3.9±0.01	5-15 9.5±0.05	29.3	0.34±0.03	16.6	2-5 3.7
CP 8	1-9 4.9±0.02	27.6	2-6 4.0±0.01	5-14 9.4±0.09	26.4	0.33±0.02	18.3	0-5 3.73
CP 9	1-9 3.3±0.06	20.0	2-8 4.5±0.05	5-13 8.1±0.09	22.7	0.27±0.05	8.3	0-5 2.67

Note: * – limits in the numerator, mean value and error in the denominator.

The largest number of berries on one bush, 9.2±0.03, was noted in the lingonberry larch forest (CP 1), the smallest one, 3.3±0.06 – in the spruce forest (CP 9), and 3.7±0.04 – in the forest mixed with dark coniferous breeds (CP 3).

Berry sizes were characterized by an average and high degree of variability. The largest berries were noted in larch forests; the increase in size occurred in the northeast to the southwest direction.

The berries weight had a low (8.3-15.6%) and average degree of variability (16.6-18.3). The maximum weight (0.64±0.06) was noted in CP 5, lingonberry larch forest (Olekminsky district); the minimum (0.27±0.05) weight was noted in CP 9, lingonberry-green-moss spruce forest (Central Yakutia). The fruiting was uneven throughout the population. In places, a significant number of fruit-bearing bushes with a large number of berries were alongside with clumps of bushes without berries. In general, the fruiting degree in populations is assessed as medium and good (3-4). A weak and medium fruiting degree (2-3) was noted in dark coniferous forests (CP 3 and CP 9). Pine forests had 1.5 times more fruit-bearing bushes than larch forests.

The berries shape varied, oval being most common, the length exceeding the diameter 1.5-2 times; bushes with round and pear-shaped berries were also noted, and also some of those growing along the Amga River bore spherical berries. The taste was sweet, and the color was blue with a glaucous plaque, blue-black or dark-purple.

Throughout the studied area, the vegetative traits variability was traced. The leaves shape and size varied from very narrow and small, elongated obovate, to quite large round ones. The most common leaves were obovate, their length exceeding their width 1.7 times. Within the population, the leaf blade size was characterized by an average and increased degree of variability (Table 2).

Table 2. Vegetative traits variability of *V. uliginosum*

Cenopopulation	Leaf length, mm*	V,%	Leaf width, mm	V,%	Bush height, m	V,%
CP 1	0.69-1.5 0.85±0.07	25.4	0.39-0.6 0.49±0.02	24.5	0.3-0.69 0.45	11.6
CP 2	0.68-1.6 0.97±0.04	30.0	0.4-0.72 0.56±0.08	22.4	0.23-0.7 0.42	15.3
CP 3	0.69-1.6 0.87±0.05	27.5	0.39-0.71 0.51±0.15	19.8	0.3-0.57 0.44	17.4
CP 4	0.69-1.6 0.89±0.02	25.6	0.38-0.70 0.52±0.04	27.5	0.3-0.66 0.43	10.1
CP 5	0.7-1.5 0.92±0.14	26.0	0.38-0.73 0.54±0.06	21.6	0.3-0.66 0.47	15.2
CP 6	0.68-1.2 0.85±0.15	29.3	0.38-0.73 0.50±0.12	22.8	0.3-0.57 0.41	15.5
CP 7.	0.68-1.4 0.92±0.09	29.4	0.38-0.73 0.51±0.20	29.3	0.24-0.69 0.47	17.9
CP 8	0.68-1.5 0.85±0.10	27.2	0.38-0.72 0.48±0.07	26.4	0.3-0.57 0.45	18.0
CP 9	0.68-1.6 0.86±0.14	30.9	0.38-0.73 0.50±0.03	22.7	0.16-0.66 0.40	12.7

Note: * – limits in the numerator, mean value and error in the denominator.

The leaf length and width limits were 0.68-1.6 cm and 0.38-0.73 cm, respectively. The maximum length was noted in CP 2 (0.97±0.04 cm), CP 5 and CP 7 (0.92±0.14, 0.92±0.09 cm). The maximum leaf blade width (0.56±0.08 cm) was noted in the forb-lingonberry larch forest (CP 2). The levels of leaf traits variability did not show differences depending on the phytocenotic environment.

The least variable trait (low or, rarely, medium degree of variability, 11.6-18.0%) was the height of bushes, averaging at about half a meter for populations (Table 2). The maximum height was 0.7 m and the minimum height – 0.16 m. Of all the studied bushes, 41.1% were 50 cm, 27% were 40 cm, 20% were 60 cm, 6% were 70 cm, 5.2% were 30 cm and 0.4% barely reached the height of 20 cm. The bushes height had a direct correlation with age; the age of bushes of fruit-bearing thickets varied from 3 to 20 years, with the height of 0.15 m to 0.7 m. The correlation coefficient in populations ranged from 0.2 to 0.61 with an experimental accuracy (P) of 1.6-4.4 %.

The dependence in CP 1 shows that the closest relation r=0.71 and r=0.66 is between the leaf blade length and width, and age. Notably, there is a significant relation r=0.65 between the fruiting degree and berries number, between the maximum and minimum diameter of berries, and between the fruiting degree and the maximum diameter of berries.

The data of the CP2 correlation matrices showed a stable relation between the leaf blade width and age (r=0.71) and between the fruiting degree and berries number (r=0.72). However, the age-height relation (r=0.2) is not significant.

The maximum berry diameter in CP 3 positively correlates with the minimum berry diameter, berries number and the fruiting degree. The correlation coefficients are 0.64, 0.34 and 0.41, respectively.

Significant correlations were also found in CP 4, 5 and 6 between the height and age (r=0.41-0.61). A moderate relation was established between the age and fruiting degree, leaf blade length and width (r=0.36-0.69). The berries number on CP 1, 2, 3, 6, 8 and 9 correlates with the fruiting degree; the correlation coefficients are 0.65, 0.72, 0.36, 0.36, 0.37 and 0.42, respectively.

4 Conclusion

The bilberry shows its morphological, endogenous, individual, ecological and geographical variability of generative and vegetative organs, as well as the phenological development of phenological organisms. It is also possible to observe its rhythms of phenological development throughout the studied area. Among the following traits, there was greatest variability: number of berries per bush (30.1%), and size of the branch (leaf blade length and thickness) 30.9% and 29.3%, respectively. During the study, it was found that the following features showed the smallest variability: berries weight (15%) and fruit-bearing bushes' size (14.9%). All traits had differences in the average value, depending on V. uliginosum's phytocenotic confinement and the average values of all traits were different due to the Phytocenotic confinement of V. uliginosum. In the forb-lingonberry larch forest, leaf traits were noted with the highest values. Statistics of productivity indicators (berries number and size) in the lingonberry larch forest have exceeded its minimum. From the central regions to the south, the gradient of increasing productivity indicators is directed from the central regions to the south. Among the maximum manifestation of most studied traits in South Yakutia, the southern taiga is considered an optimal habitat for V. uliginosum. The conclusion was also confirmed by T.I's contributions to the conclusion. Snakina [4], Snakina [3].

The introduction of Bog Bilberry into the culture in Central Yakutia, as well as the cultivation of agrotechnical methods that are new and more thoroughly studied for the development of plants is required to be carried out with an intensive study and brand-new agrotechnical cultivation methods. Plants show a slow entry into evolutionary stage after entering the generative stage of development.

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