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VACCINIUM VITIS-IDAEA IN ESTONIA

1. DISTRIBUTION AND GROWTH

The cowberry (*Vaccinium vitis-idaea* L.) is a species with a circumboreal distribution in the Northern Hemisphere; it is valued both as a berry plant and as a medicinal plant. The aim of the present work was to study several aspects of the cowberry biology and to specify the methods of studying its resources. In Part 2 an attempt is made to estimate the resources of the cowberry as a medicinal plant and examine the possibilities of its rational exploitation which would guarantee restoration. The number of research areas (the so-called "key sample areas") was six; they were located in nine forest districts of seven forest enterprises. The total number of analyses was 311.

Methods

Each analysis was based on a cowberry coenopopulation whose area was taken equal to a forest allotment (from 0.1 to 5.0 (10—15) ha). In order to determine the mean cover of the cowberry ($\bar{x}$, %), each analysis determined its cover on 100 systematically located 1 m^2 sample squares. A special frame applied as an aid for arranging the sample squares and for estimating the cover is described in an analogical study on the bearberry (Pihlik, 1988). The character of the cowberry cover was estimated visually and the type of distribution was determined within the allotment.

Field work was carried out either in spring before the beginning of the vegetation period, or at the end of summer. To obtain objective data on the length and biomass of cowberry ramets these parameters were determined 10 times in each analysis, always on the 5th, 15th, etc. sample square (in the absence of the cowberry, on the closest sample square). To estimate the biomass all cowberry ramets were cut from a 1 dm^2 area at a height of the moss or lichen layer, and the fresh weight (y, g, with a 0.1 g accuracy), air-dry weight (g) and the ratio of leaves and stems in the air-dry weight (p, %) were determined. The absolute dry weight was not considered, the cowberry being a medicinal plant.

The biomass of cowberry ramets (B, kg/ha) and its resources (W, kg per forest allotment) were determined as the air-dry weight in each analysis using the following formula

$$B=\bar{x}\cdot\bar{y}\cdot p,$$
$$W=B\cdot s,$$

where $\bar{x}$ is the mean cover of the cowberry, $\bar{y}$ — the fresh weight of cowberry ramets on 10 dm^2, p — the area of the allotment. The experiment design used for determining the restoration rate of biomass and the relevant explanation are presented, for the sake of clarity, in the second part of this paper.

In most analyses ($n=266$) the mean height of ramets was determined in two different ways (see for greater detail the corresponding section) and the significance of the difference between these mean values ($\bar{x}_{10}$ and $\bar{x}_{100}$) was estimated statistically, on the basis of criterion t. The fresh weight of 100 ramets (g) as well as the mean fresh and air-dry weight of one ramet were determined. In each coenopopulation (forest allotment) also a geobotanical analysis was carried out making use of the following estimation data on forest districts characterizing the tree stand: forest site type, the formula, age, height, fullness, and quality class of the tree stand. The ordination scale indices of soil moisture and soil fertility after Lõhmus (1984) were used for the qualitative characterization of the site type.

Since the correlation analysis revealed statistically significant correlations with soil moisture and soil fertility, a new correlation analysis was made by forest site types. The number of analyses and the critical correlation coefficients (level of significance 0.05) in basic forest site types were the following: in the *Cladonia* site type — $n=58$, $r_{0.05}\geqslant0.25$; in the *Calluna* site type — $n=39$, $r_{0.05}\geqslant0.30$; in the *Vaccinium* site type — $n=152$, $r_{0.05}\geqslant0.16$; and in the *Myrtillus* site type — $n=17$, $r_{0.05}\geqslant0.45$. Correlations between 30 parameters were examined which characterize the cowberry growth (mean cover, variance of cover in one analysis, distribution type, minimum number of sample squares for the determination of the mean cowberry cover with a required accuracy, fructification, mean length of ramets, mean fresh weight of one ramet, fresh weight of ramets on 10 dm^2, air-dry weight of leaves on 10 dm^2, air-dry biomass of ramets (kg/ha), air-dry biomass of leaves (kg/ha)), the effect of both time and the so-called "key area" (the month and year of carrying out the analysis, the sum of effective temperatures and precipitation in a given region during the vegetation period), and habitat conditions; the latter, in their turn, are divided into conditions characterizing the tree stand (height, quality class, fullness, age, proportion of the pine in the tree stand, density of the understorey on a three-stage scale) and those characterizing the lower layers (the number of species and the total cover of the dwarf-shrub, herb, moss and lichen layers).

The distribution and cover of the cowberry

Since the distribution of the cowberry in Estonia is relatively even, it was studied more thoroughly on six bigger study areas, the so-called "key sample areas" (Fig. 1), and the results obtained were extended to the other habitats. In the selection of key sample areas account was taken of geobotanical regions (Lippmaa, 1935), the present distribution of forests (pine forests) (Eesti metsad, 1974), and their earlier history (Laasimer, 1958); key sample areas were distributed as evenly as possible.

The cowberry is a species with a broad ecological amplitude which grows both in dry alvar forests and raised bogs. According to literature the coeno-area (Куваев, 1965) of the cowberry in Estonia (i. e. the territory where the coenotic importance of the cowberry in the phytocoenosis is considerably greater than within the total area) is related to pine forests. According to Lõhmus (1979, 1984) the cowberry is dominating in the *Cladonia* (further *Clad.*), *Calluna* (*Call.*), *Rhodococcum* = *Vaccinium* (*Vacc.*) and *Myrtillus* (*Myrt.*) site types, and among paludifying site types in the *Vaccinium uliginosum* (*Ulig.*) site type.

The total area of the forest allotments with 311 cowberry coenopopulations studied was 800 ha and their distribution according to the forest type, age, fullness, quality class and area is characterized in Table 1.

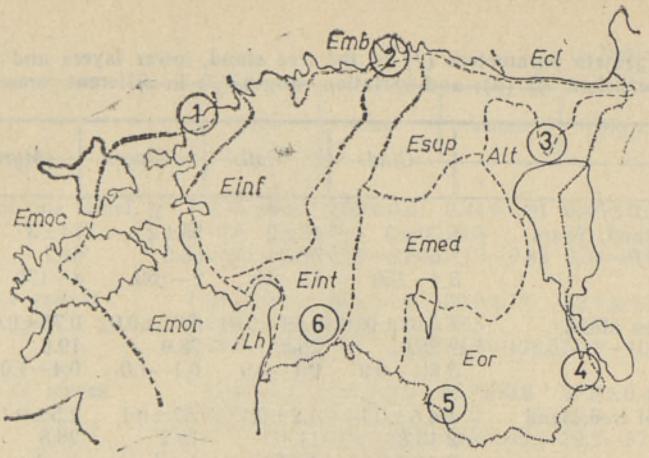


Fig. 1. Location of sample areas: *1* — Nõva, Riguldi and Vihterpalu forest districts, *2* — Valgejõe forest district, *3* — Alajõe forest district, *4* — Värska forest district, *5* — Taheva and Hargla forest districts, *6* — Lodja forest district. (*Emoc*, *Emor*, *Einf*, *Eint*, *Emb*, *Esup*, *Emed*, *Ecl*, *Aalt*, *Eor* — geobotanical regions.)

Table 1

Distribution of tree stands analysed
(311 analyses altogether)

Forest site type	%	Tree stand							
		Age, years	%	Fullness	%	Quality class	%	Area, ha	%
Cladonia	21.1	0—20	16.7	0.3	5.6	I	1.0	0.1—0.4	9.4
Calluna	12.9	21—40	20.6	0.4	4.4	II	18.6	0.5—1.0	28.3
Vaccinium	58.0	41—60	23.5	0.5	8.5	III	40.5	1.1—2.0	21.1
Myrtillus+Oxalis	6.7	61—80	17.4	0.6	16.9	IV	24.4	2.1—3.0	15.6
		81—100	7.4	0.7	25.1	V	12.9	3.1—5.0	13.6
Uliginosum+Carex	2.6	101—120	4.2	0.8	23.2	V^a	2.6	5.1—10.0	8.1
		121—140	2.9	0.9	12.9			10.1—15.0	3.9
		141—160	6.7	1.0	3.4				
Others	0.7	>160	0.6						

One can see that the share of tree stands of the *Vacc.* site type is the biggest (over 50%), while tree stands of *Clad.* and *Call.* site types are less represented. Some analyses are related to the site types similar to those of *Myrt.* and *Ulig.* A few nontypical site types are united under "Others". All age classes are represented although the share of younger tree stands of age classes I—IV (under 80 years) was somewhat larger. Tree stands with the fullness 0.7—0.8 make up nearly half of the forest sites studied and those with the fullness 0.5, only 1/5. The least represented are both extremes of soil fertility, i. e. quality classes I and V^a. Most of the tree stands are pure pine forests. The proportion of the pine in a tree stand is the greatest in the *Clad.* site type (9.89), though it is relatively great also in other site types (Table 2). The mean height of

Table 2

The mean growth parameters (*1*) of the tree stand, lower layers and cowberry; variation coefficient, % (*2*); and variation ranges (*3*) in different forest site types

		Clad.	*Call.*	*Vacc.*	*Myrt.*	*Ulig.*
Age of tree stand, years	*1*	70±3	45±2	55±2	74±3	45±2
	2	67.1	71.7	60.5	61.7	84.4
	3	4–160	1–141	2–150	8–170	4–101
Fullness of tree stand	*1*	0.62±0.01	0.69±0.01	0.71±0.02	0.75±0.01	0.52±0.02
	2	25.0	26.2	28.0	19.6	47.7
	3	0.1–0.9	0.1–0.9	0.1–1.0	0.4–1.0	0.1–0.7
Quality class of tree stand	*1*	4.6±0.1	4.2±0.1	2.7±0.1	2.5±0.1	4.3±0.1
	2	13.8	11.1	18.2	26.8	11.5
	3	4–5[a]	4–5[a]	1–3	1–4	4–5
Proportion of pine in tree stand	*1*	9.89±0.03	9.38±0.08	9.21±0.09	7.13±0.15	7.78±0.16
	2	4.6	13.7	17.3	36.4	37.9
	3	7–10	4–10	1–10	1–10	2–10
Height of tree stand, m	*1*	9.4±0.3	8.0±0.3	13.2±0.4	17.3±0.5	7.7±0.3
	2	57.9	58.4	50.8	45.8	74.1
	3	1–20	1–17	1–26	1–28	1–14
Cover of dwarf-shrub layer, %	*1*	32.5±1.2	29.4±1.1	16.9±0.8	9.6±0.6	28.0±1.0
	2	60.8	65.2	83.4	100.7	64.1
	3	0–92	8–91	0–85	0–48	9–66
Number of species in dwarf-shrub layer	*1*	4.02±0.1	4.0±0.1	3.8±0.1	2.9±0.1	5.1±0.1
	2	30.9	26.5	29.8	34.2	34.5
	3	0–7	2–7	2–7	2–5	2–7
Cover of herb layer, %	*1*	3.8±0.4	6.4±0.4	8.8±0.7	20.6±1.1	14.0±0.1
	2	160.9	114.3	133.0	91.4	97.3
	3	0–32	0–27	0–52	0–84	0–39
Number of species in herb layer	*1*	2.2±0.2	2.4±0.2	5.2±0.3	8.2±0.3	5.7±0.3
	2	124.5	79.8	85.1	46.3	85.1
	3	0–15	0–11	0–23	2–17	1–16
Cover of moss layer, %	*1*	50.3±1.6	64.1±1.8	74.5±1.7	59.1±2.2	53.5±2.0
	2	55.1	48.6	39.1	64.6	68.9
	3	0–95	5–98	0–100	2–98	0–98
Number of species in moss layer	*1*	2.6±0.1	3.0±0.1	3.2±0.1	3.7±0.1	3.9±0.1
	2	33.1	39.0	30.5	42.1	27.1
	3	0–5	1–7	0–6	1–7	3–6
Cover of lichen layer, %	*1*	24.2±0.9	9.6±0.6	3.4±0.4	0.5±0.2	2.2±0.2
	2	64.5	105.9	202.6	404.0	155.5
	3	0–70	0–40	0–40	0–10	0–11
Number of species in lichen layer	*1*	3.5±0.1	2.7±0.1	1.9±0.1	0.4±0.1	2.4±0.1
	2	32.9	47.7	80.3	240.5	79.5
	3	0–6	0–5	0–6	0–3	0–5
Mean cover of cowberry, %	*1*	5.9±0.2	8.1±0.3	5.7±0.3	3.0±0.2	5.6±0.2
	2	50.9	48.1	75.3	85.1	41.0
	3	0.1–13.6	0.4–19.5	0.1–21.4	0.3–7.3	2.4–10.2
Variation of mean cover of cowberry	*1*	100±4	95±3	117±4	138±3	123±2
	2	58.7	38.4	45.8	34.7	268.4
	3	52–337	44–251	53–335	68–263	80–175
Mean ramet length, cm	*1*	5.7±0.1	6.6±0.1	6.7±0.1	7.8±0.2	6.0±0.1
	2	21.2	18.0	23.4	26.8	33.4
	3	3.1–8.2	4.1–9.4	3.1–11.8	3.9–10.7	3.9–9.8

Table 2 (continued)

		Clad.	*Call.*	*Vacc.*	*Myrt.*	*Ulig.*
Fresh weight of one ramet, g	*1*	0.44±0.01	0.50±0.01	0.44±0.01	0.46±0.01	0.45±0.01
	2	19.8	21.8	20.5	17.1	23.4
	3	0.25–0.66	0.28–0.80	0.18–0.82	0.34–0.63	0.31–0.67
Fresh weight of ramets on 10 dm^2, g	*1*	85.7±1.3	98.5±1.2	90.0±1.6	82.1±1.0	89.2±1.2
	2	24.6	19.3	28.3	20.0	23.8
	3	48.9–138.8	63.1–138.9	34.9–198.5	50.9–106.9	62.2–119.2
Air-dry weight of leaves on 10 dm^2, g	*1*	32.4±0.5	36.4±0.5	32.7±0.6	27.9±0.4	31.3±0.4
	2	25.7	21.0	27.3	20.9	23.8
	3	17.9–53.3	21.3–53.6	13.5–66.8	19.2–37.4	21.4–41.4
Air-dry weight of stems on 10 dm^2, g	*1*	8.4±0.2	10.6±0.2	9.9±0.2	9.9±0.2	9.0±0.3
	2	34.9	23.3	39.1	30.2	47.1
	3	3.8–16.2	6.1–15.0	2.3–27.4	5.3–15.5	4.7–16.8
Air-dry weight of ramets, kg/ha	*1*	254.9±10.4	378.8±13.0	271.4±16.2	139.2±6.7	234.4±7.7
	2	66.8	56.5	97.3	81.4	60.8
	3	4.1–833.2	8.0–1009.0	1.9–2019.2	15.9–328.7	77.9–578.3
Air-dry weight of leaves, kg/ha	*1*	201±8.1	293.3±10.1	206.3±12.0	104.0±5.1	181.7±5.6
	2	65.6	56.4	94.3	81.7	57.1
	3	3.4–669.3	6.3–763.5	1.5–1430.6	10.0–247.7	60.4–422.0

tree stands is the greatest in the *Myrt.* site type (17.3 m) and the smallest in the *Ulig.* site type, which is in a good accordance with the soil fertility of the forest site types under study. The mean age of the tree stands was somewhat greater in the *Myrt.* and *Clad.* site types (over 70 years), in the other site types 15—20 years smaller.

The species with the greatest distribution frequency in the analyses (over 10%) are presented in Fig. 2 by layers. In the shrub layer the total number of species was 19, in one analysis mostly 3—4 species. In different forest site types the mean cover of the dwarf-shrub layer was from 10% to 30—40% (Table 2). The cover of the dwarf-shrub layer varied less in the *Clad.*, *Call.* and *Ulig.* site types. In the herb layer about 100 species were registered. Thus, phytocoenoses with the cowberry are considerably poorer in species here than phytocoenoses with the bearberry in which about 170 species were registered (Pihlik, 1988). More frequent species were: *Melampyrum pratense* (75.9%), *Lerchenfeldia flexuosa* (48.9%), and *Luzula pilosa* (43.6%); relatively frequent were *Trientalis europae* (24.7%), *Maianthemum bifolium* (23.4%), *Calamagrostis arundinaceae* (21.8%), and *Pteridium aquilinum* (21.2%). The number of the herb layer species in one analysis ranged from 0 to 23. An especially poor-in-species herb layer occurred in the *Clad.* and *Call.* site types where the number of species was usually only 2—3. The number of species varied most in the *Clad.* site type since within the limits of this site type environmental conditions are the most variegated and extreme. The mean cover of the herb layer was the greatest and varied the least in *Myrt.* and *Ulig.* site types. In the lower layers the number of species in one analysis was relatively small: in the moss layer on the average 2—4 species, and in the lichen layer 2—3 species. The cause of the minimum number of species of the lichen layer in the *Myrt.* site type is competition by the rich-in-species herb layer. The mean cover of the moss layer in forest site types

(50—70%) is substantially greater than the mean cover of the lichen layer which decreases from 24% in the *Clad.* site type to 0.5% in the *Myrt.* site type. The cover of the moss layer varied considerably less than that of the lichen layer.

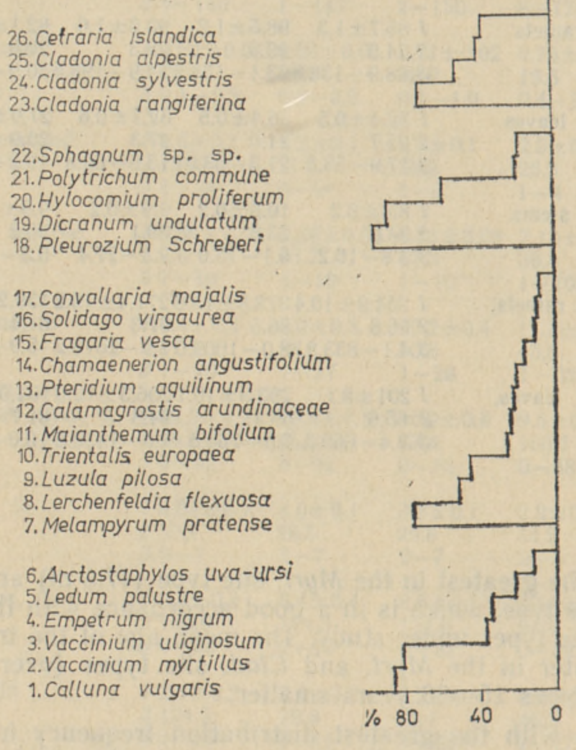


Fig. 2. The distribution frequency (%) of more widespread species analysed in dwarf-shrub (*1—6*), herb (*7—17*), moss (*18—22*), and lichen layers (*23—26*).

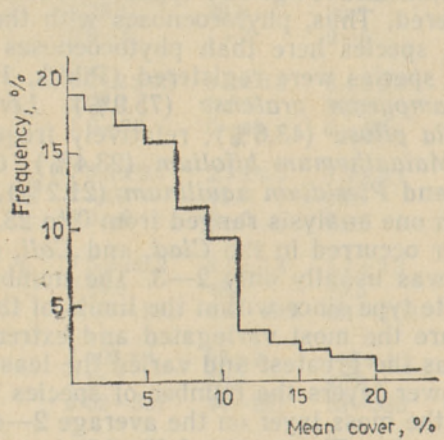


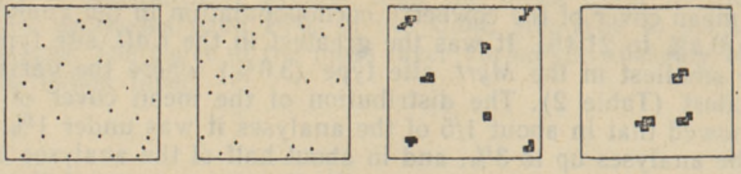
Fig. 3. Distribution of the mean cowberry cover, %.

The mean cover of the cowberry coenopopulation in the analyses ranged from 0.1% to 21.4%. It was the greatest in the *Call.* site type (8.1%) and the smallest in the *Myrt.* site type (3.0%) where the variation was the greatest (Table 2). The distribution of the mean cover of the cowberry showed that in about 1/5 of the analyses it was under 1%, in about 2/5 of the analyses up to 3%, and in about half of the analyses up to 5%. The share of the coenopopulations with the mean cover of the cowberry over 10% made up only 1/10 of all the analyses (Fig. 3). Thus, the scale used for estimating the cover in forest management in which the maximum cover exceeds 70% does not correspond to the real situation. According to our data the following scale should be used for an objective estimation: 0—5%, 6—15%, and over 15%.

The number of sample squares necessary for determining the mean cover

The accuracy of the determination of the biomass depends largely on the accuracy of the determination of the mean cover, i. e. on its arithmethical mean error. We were interested in the minimum number of sample squares, necessary for the determination of the mean cover with a given accuracy (in our case 15%), and its dependence on the character of the cowberry distribution within a coenopopulation. A relatively large number of papers deal with the dependence of the number of sample squares necessary for the determination of the mean cover or biomass on the form, size and number of sample areas, and on their location within a coenopopulation (Тюлин, 1972; Крылова, 1973; Борисова, 1974; Пааль, Пааль, 1980, 1982; Василевич, 1974). However, in most of them no attention is paid to the distribution character of the species under study.

V. I. Vasilevich (Василевич, 1969) distinguishes between three distribution types of species: regular, random and aggregated. Problems connected with the species distribution have been studied also by T. Frey (1967). The distribution of the cowberry within one coenopopulation is established by the interaction of two different factors and, depending on the intensity of vegetative reproduction, it can be either regular or random, and at the same time, depending on the number of branching points on the rhizome and on the thickness and branching of partial bushes, either aggregated or nonaggregated. Considering the growth and distribution of the cowberry, the following distribution types, suggested by N. A. Borisova (Борисова, 1974), seem to be most appropriate: random(-nonaggregated), regular(-nonaggregated), random-aggregated, and regular-aggregated. The distribution type of the cowberry within a coenopopulation was determined visually. The simplified schemes of the distribution types used (total cover is the same in all cases) are shown in Fig. 4. The share of the regular distribution type made up 16.2% of the 266 coenopopulations studied by us, regular-aggregated 32.3%, random 21.1% and random-aggregated 30.4%. Thus, aggregated distribution types (62.7%) prevailed; this is caused, first of all, by the vegetative reproduction of the cowberry. The occurrence frequency of distribution types and the determination accuracy of the mean cover of the cowberry are presented in Table 3 by forest districts. One can see that the occurrence of the random distribution type is lower in forest districts with a lower cover (Värska, Taheva, Hargla), and the determination accuracy is also lower there. The higher cover occurs more often together with regular and aggregated distribution types.



Regular (— nonaggregated) | Random (— nonaggregated) | Regular — aggregated | Random — aggregated

Fig. 4. Distribution types of the cowberry cover (cover is the same in all types).

Table 3

Distribution types and determination accuracy of the mean cowberry cover

Forest district	Distribution types (number of allotments)				Cover of cowberry, %			Distribution of determination accuracy of mean cowberry cover, %			
	Re	*Ra*	*Re-A*	*Ra-A*	min.	mean	max.	10%	10—15%	15—25%	>25%
Lodja	4	9	25	17	0.3	7.9±0.7	21.4	49	36	13	2
Värska	2	17	2	11	0.1	2.7±0.7	14.3	12	37	36	15
Taheva and Hargla	6	9	3	8	0.1	2.0±0.1	4.6	31	38	23	8
Nõva	30	18	41	34	0.4	6.5±0.3	14.0	65	26	4	5
Riguldi and Vihterpalu	1	3	9	8	1.1	7.7±0.3	18.3	67	28	0	5
Alajõe	0	0	6	3	2.7	3.9±0.1	6.2	89	11	0	0

Note: *Re* — regular, *Ra* — random, *Re-A* — regular-aggregated, *Ra-A* — random-aggregated.

The necessary number of sample squares (N) in Table 4 was found by means of the formula $N=\frac{V^2}{K^2}$ (Василевич, 1969), where V is the variation coefficient of the mean cowberry cover and K is the desired determination accuracy (15% in our case). It can be seen that the necessary number of sample squares for a regular distribution type is smaller than for a random distribution type which occurs namely in the conditions of the low cover (below 5% and 5—10%). A tendency for the decrease of the number of the necessary sample squares in the case of higher cover values is also evident since the distribution is then mostly regular. Thus, considering the distribution type of the cover, the number of sample squares for the determination of the mean cover can be taken 25 in the case of the regular distribution type, 30 in the case of the regular-aggregated distribution type and 60 in the case of the random-aggregated distribution type. Since, however, coenopopulations with a low cover have no practical importance with respect to resources, a large number of sample squares in the case of the random distribution type is not essential either.

Table 4

Number of sample squares (1 m^2) required for the determination of the mean cowberry cover (accuracy 15%)

Mean cover, %	Distribution types							
	Regular		Random		Regular-aggregated		Random-aggregated	
	n	*N*	*n*	*N*	*n*	*N*	*n*	*N*
under 5	13	32.5±3.1	65	179±15	9	38.9±4.7	45	63.8±3.3
5—10	24	20.5±1.5	1	114	42	30.4±1.7	33	48.8±2.8
10—15	5	18.6±1.9	0	—	30	25.6±1.2	3	52.0±7.4
over 15	1	19	0	—	5	20.2±4.8	0	—
Number of sample squares required		25		180		30		60

Note: *n* — number of forest allotments, *N* — number of sample squares, — data are lacking.

The length of cowberry ramets and its dependence on light conditions

The mean length of ramets in coenopopulations (the mean of 100 ramets) varied only from 3.1 to 11.8 cm (Tabel 2), although the maximum value reached up to 30 cm. The mean value among forest site types was the greatest in the *Myrt.* site type (7.8 cm) while it decreased down to 5.7 cm in the *Clad.* site type. The distribution curves of the ramet length (Fig. 5) show that the narrowest distribution interval is characteristic of *Clad.* and *Ulig.* site types (Table 5) where the mean length attains 19.5 cm. In the *Call.* site type the interval of the distribution curve is similar to the above-mentioned ones with the exclusion of one case with 26.5 cm. The intervals of the distribution curve in *Oxalis* (further *Ox.*) and *Myrt.* site types are 1.5—21.5 and 0.5—22.5 cm, respectively; in the *Vacc.* site type the maximum values attain 29.5 cm. The most even distribution of the ramet length is found in the *Myrt.* site type while the least even distribution occurs in the *Ulig.* site type. The difference in the length of the extreme types is consequently up to 10 cm. The distribution of the ramet length was examined also on the basis of the so-called 95%-interval, i. e. the interval containing 95% of the ramets and excluding the effect of single long ramets. According to this examination the narrowest interval is again characteristic of the *Clad.* site type (10.5 cm), followed by *Call.*, *Ulig.* (11.5 cm), *Vacc.* (12.5 cm), and *Ox.* (13.5 cm) site types. The maximum value in the 95%-interval occurred, however, in the *Myrt.* site type (15.5 cm). Thus, the difference in the mean length intervals of the extreme forest site types is only 5 cm. The results obtained from this analysis correspond well to the increase of soil moisture in the mentioned forest site types. The only exception is the *Ulig.* site type in which excessive moisture turns out to be a growth-limiting factor. We were also interested in the comparison of mean ramet lengths on the basis of the maximum frequency of length classes of the distribution curve (the so-called modality class). The advantage of this comparative method lies in the fact that the results do not depend on the values of either

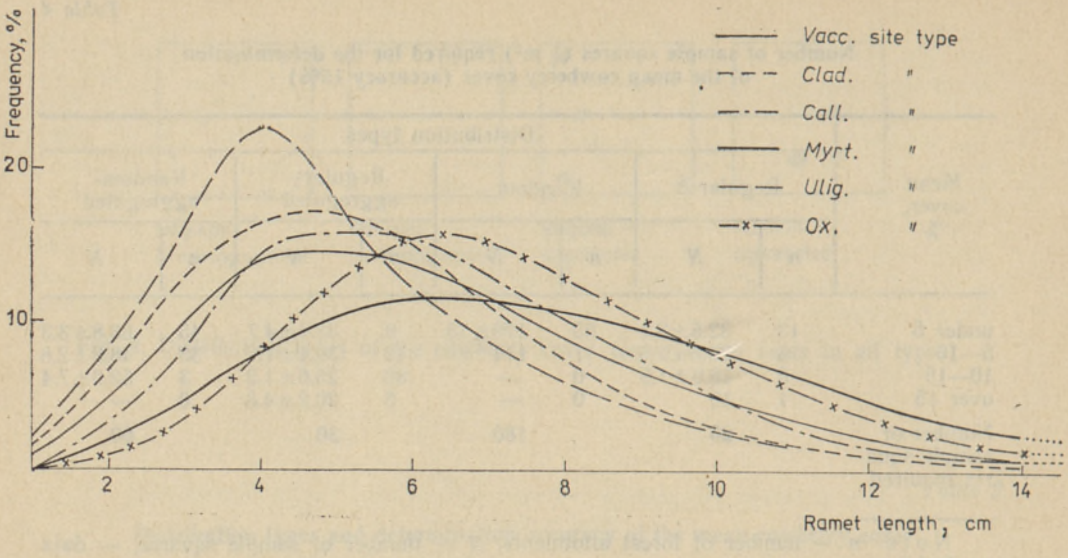


Fig. 5. Distribution of the cowberry ramet length (%) in different forest site types.

extremes (Василевич, 1969; Tiit et al., 1977). Forest site types were compared on the basis of the mean value of length classes of maximum frequency. Hence, the mode was minimum in the *Ulig.* site type in which the modal class with the mean value 4.0 cm had the occurrence frequency 22%, which shows that about 1/4 of the ramets had a length of 3.5—4.5 cm. In *Clad.* and *Vacc.* site types the mode was 5.0 cm, although in the *Clad.* site type the frequency of the modal class was somewhat higher — 17% with 14% in *Vacc.* In *Call.*, *Ox.* and *Myrt.* site types the mode was 6.0 cm while in the first two the frequency of the modal class was the same (15%), and in the *Myrt.* site type the minimum value (12%) refers to the most even distribution of the ramet length in the forest site types studied.

Table 5

Mean ramet length of the cowberry and the length distribution in different forest site types

Forest site type	Mean soil moisture of site type (according to Lõhmus, 1984)	Number of ramets	Mean ramet length, cm	Interval of ramet length		Modal class, cm	Frequency of modal class, %
				Total, cm	95%, cm		
Clad.	0.7	5700	5.59	19.5	10.5	4.5—5.5	17.1
Call.	2.6	3700	6.38	19.5	11.5	5.5—6.5	15.6
Vacc.	2.8	14900	6.43	29.5	12.5	4.5—5.5	14.6
Ox.	4.1	400	7.61	21.5	13.5	5.5—6.5	15.5
Myrt.	5.5	1500	8.14	22.5	15.5	5.5—6.5	11.9
Ulig.	6.2	600	5.37	19.5	11.5	3.5—4.5	22.5

The relation between the mean length of cowberry ramets and the age of the tree stand in three main forest site types is presented in Fig. 6. It can be seen that cowberry ramets are of the minimum length in young stands. The mean length of ramets increases earlier in the *Vacc.* site type, at the age of about 10 years, and somewhat later in *Call.* and *Clad.* site types, after about 15 years. The process of joining tree crowns and the resulting deterioration of light conditions and the increase of soil moisture which causes the lengthening of ramets, starts earlier in the *Vacc.* site type with its higher soil fertility than in other forest site types. The time of reaching the maximum ramet length is also different: in the *Vacc.* site type 20—30 years, in the *Call.* site type 30—45 years and in the *Clad.* site type 45—65 years. Thus, in high soil fertility site types the maximum ramet length arrives earlier and lasts for a shorter time than in low soil fertility site types.

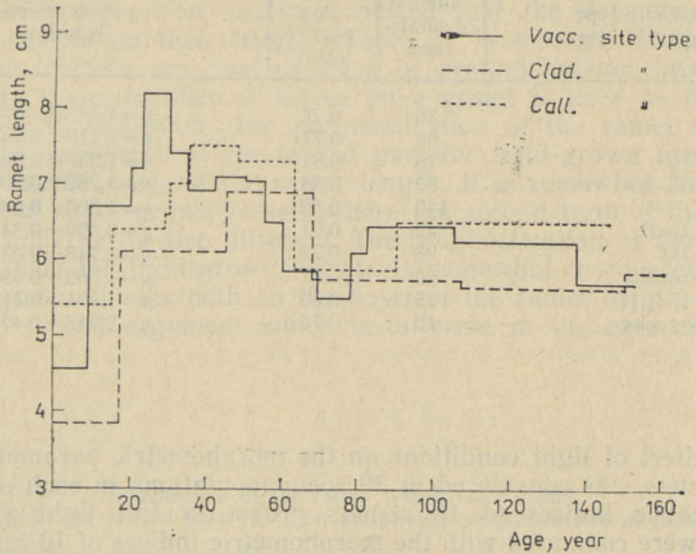


Fig. 6. Relation between the mean length of cowberry ramets and the age of the tree stand in different forest site types.

Reliable determination of the mean ramet length is, due to great variation, quite time- and labour-consuming. Therefore we were interested in obtaining reliable results on the basis of as few observations as possible. For this purpose the ramet length was determined in 262 coenopopulations in two different ways and the significance of the obtained difference of means was compared statistically. So, the average ramet length was visually estimated on ten 1 dm^2 squares, and its height from the moss or lichen layer was measured. The exact length of 100 random ramets out of all the ramets cut from these squares was measured. It became evident that the mean value of visual estimation (further $\bar{x}_{10}$) was in most cases slightly greater than the mean value obtained from measurements (further $\bar{x}_{100}$). The significance of the difference in the remaining 36 cases was checked with a modified t-test (Tiit et al., 1977). It appeared that only in 4 cases, i. e. 1.5% of the coenopopulations, the mean ramet length $\bar{x}_{100}$ was significantly greater ($P=0.05$) than the ramet length $\bar{x}_{10}$. Consequently, the visual estimation of the average ramet length does not take much time under field work conditions and enables to obtain satisfactorily exact data on the ramet length. Correction of somewhat greater results is possible by means of regression equations presented in Table 6. The correlation between the means obtained in two different ways is sufficiently strong both on the basis of summary data ($r=0.82$) and in all the groups classified on the basis of the forest type and quality class of the tree stand.

Table 6

Dependence of the mean ramet length on the way of measurement

Forest site type and quality class	Number of analyses	Correlation coefficient	Regression equation
Calluna	36	0.78	$y=2.84+0.49\bar{x}_{10}$
Cladonia	56	0.74	$y=2.113+0.55\bar{x}_{10}$
IV	26	0.81	$\mathrm{y}=1.237+0.668\bar{x}_{10}$
V—V^{a}	30	0.64	$y=3.262+0.387\bar{x}_{10}$
Vaccinium	140	0.82	$y=1.306+0.688\bar{x}_{10}$
I—II	42	0.91	$y=0.099+0.845\bar{x}_{10}$
III	98	0.78	$y=0.748+0.63\bar{x}_{10}$
Myrtillus+*Oxalis*	20	0.87	$y=1.569+0.695\bar{x}_{10}$
Myrtillus II—III	15	0.89	$y=1.004+0.741\bar{x}_{10}$
Paludifying types	10	0.74	$y=2.317+0.472\bar{x}_{10}$

The effect of light conditions on the morphometric parameters of cowberry ramets was considered in 30 coenopopulations in each of which the morphometric indices of 10 ramets grown in full light (light-grown ramets) were compared with the morphometric indices of 10 ramets grown in shade (shade-grown ramets). The following characteristics were determined for all ramets: length, length of the leaved part, increment of the current year, length and width of the leaf (always the fifth leaf of the year), the number of leaves on a ramet, air-dry weight of ramets, and the share of leaves in it. All the morphometric characteristics related to length were greater in shade-grown ramets than in light-grown ramets. The mean lengths of ramets were 9.79±0.57 and 6.65±0.32 cm, the mean lengths of the leaved part 6.59±0.44 cm and 4.82±0.25 cm, the mean annual increments 4.34±0.19 cm and 3.51±0.17 cm, respectively. Light conditions influence also the size of leaves: the mean lengths of the leaves were 1.87±0.07 cm and 1.53±0.05 cm, and the mean widths of the leaves 0.87±0.02 and 0.78±0.02 cm, respectively. A similar effect can be observed also in the number of leaves on a ramet: 19.4±1.2 and 18.5±1.0 leaves on a ramet, and in the weights of leaves on one ramet, 2.07±0.12 g and 1.71±0.13 g. Only the share of leaves in the total weight is somewhat greater in light-grown ramets (74.6%) than in shade-grown ramets (73.7%).

The correlation analysis shows that among the mean morphometric characteristics ($n=30$, $r_{0.01}=0.45$) the length of light-grown ramets has a strong correlation with the length of the leaved part ($r=0.92$), a weaker correlation with the ramet weight ($r=0.76$), and a weak correlation with the annual increment ($r=0.55$). The length of shade-grown ramets, however, is in a strong correlation both with the length of the leaved part ($r=0.87$) and the weight of ramets ($r=0.83$), and, similarly, in a weak correlation with the annual increment ($r=0.56$). Thus, light conditions affect more the length of the leaved part and the weight of ramets and less the annual increment which depends evidently more significantly on moisture. The length of the leaved part has quite a strong correlation with the ramet weight ($r=0.78$ in light-grown ramets and $r=0.73$ in shade-grown ramets). The annual increment is correlated with the mean length of the leaf only in the case of light-grown ramets ($r=0.71$); the latter showed also a strong correlation between the length and width of the leaf ($r=0.81$), which in the case of shade-grown ramets was considerably weaker ($r=0.49$).

The correlation between the number of leaves and their weight was relatively weak in both ramet types ($r=0.53$ in light-grown ramets and $r=0.60$ in shade-grown ones).

A stepwise regression analysis showed that the dependence of the weight of ramets on their length (Table 7) is stronger in the case of shade-grown ramets and the accuracy of prognostication increases for both ramets if the number of leaves on a ramet is used as the second argument in the equation. The prognostication of the ramet weight on the basis of the length of the leaved part for light-grown ramets is as reliable as on the basis of the ramet length. It is somewhat less reliable in the case of shade-grown ramets where the second term of the multiple regression equation is also different. The prognostication of the length of the leaved part for light-grown ramets is somewhat more accurate than for shade-grown ramets both on the basis of the ramet length and when adding the second argument which is different in the case of different ramet types.

Table 7

Dependence of the ramet weight (RW) and length of the leaved part (LP) on morphological parameters of ramets

Light-grown ramets	r	Shade-grown ramets	r
$RW=-0.289+0.300LR$	0.756	$RW=0.380+0.173LR$	0.826
$RW=-0.609+0.257LR+0.33NL$	0.786	$RW=-0.685+0.147LR+0.037NL$	0.892
$RW=-0.170+0.390LP$	0.776	$RW=0.765+0.199LP$	0.729
$RW=-0.857+0.358LP+0.548LL$	0.792	$RW=0.379+0.014LP+0.164LR$	0.819
$LP=0.003+0.724LR$	0.917	$LP=0.07+0.666LR$	0.867
$LP=-0.483+0.658LR+0.050NL$	0.933	$LP=-0.82+0.604LR+0.345AI$	0.871

Note: RW — air-dry weight of ramet, LP — length of leaved part, LR — length of ramet, NL — number of leaves on ramet, LL — length of leaf, AI — annual increment.

Thus, we can see that light conditions have a strong influence on several morphometric characteristics of the cowberry, the influence is usually greater on shade-grown plants. In the conditions of intensive light cowberry ramets are short, strongly branching and have small densely lying leaves. Shade-grown ramets are characterized by greater length, and by larger and more sparsely lying leaves.

Conclusion

In conclusion it can be said that although the cowberry is a widespread species in Estonia its mean cover in our pine forests is still relatively low; coenopopulations (= forest allotments) with the mean cowberry cover over 5% can be considered as economically promising. According to our data it is recommended in determining the mean cover to take into consideration also the distribution type of the cowberry within a coenopopulation (random, random-aggregated, regular, regular-aggregated) and, consequently, to apply the corresponding minimum number of sample squares necessary for the required determination accuracy (in our case 15%).

One of the parameters characterizing both the coenopopulation and the effect of site type conditions is the length of cowberry ramets. It became evident that coenopopulations growing in different forest site types are better characterized by the 95%-interval of the ramet length distribution and by the length class of highest frequency (the so-called mode) of the length distribution curve than by the total interval of the ramet length distribution. As a result of these two analyses forest site types were arranged by the ramet length according to their soil moisture (excl. the *Ulig.* site type where excessive moisture turns out to be a growth-inhibiting factor). Thus, the ramet length depends on soil moisture which is, to some extent, also related to the age and fullness of the tree stand. Our data show that ramets have the minimum length namely in young stands and reach the maximum length and retain it in different site types in tree stands of different ages.

According to our data a reliable determination of the mean ramet length under field conditions can be performed by relatively few measurements. The visually determined mean ramet length appeared in a statistical analysis to be slightly higher than the real one, but it was statistically significant ($P=0.05$) and the error could be corrected with respective regression equations. The growth and length of cowberry ramets are influenced by light conditions as well. All the morphological parameters pertaining to the cowberry length and also the leaf size and weight are greater in shade-grown ramets than in light-grown ramets of the same population. Mutual correlations between morphological parameters are also somewhat different in light-grown and shade-grown ramets.

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POHL EESTIS

1. Levik ja kasv

Pohl on hinnatud nii marja- kui ka ravimtaimena. Käesoleva töö eesmärk on uurida pohla bioloogia mõningaid aspekte ja täpsustada varude uurimise metoodikat. Uurimispiirkondi oli 6, need asusid 7 metsamajandi 9 metskonnas, kus tehti kokku 311 analüüsi.

Pohl on laia ökoloogilise amplituudiga liik, kuid tema tsönoareaal on seotud männikutega, kus ta domineerib sambliku, kanarbiku, pohla, mustika ning sinika kasvukohatüübis. Floristiliselt on pohla kasvukohad liigivaesed, kuid rinnete üldkatvus varieerub: puhmarindes esineb enamasti 3—4 liiki üldkatvusega kuni 90%, rohurindes 3—8 liiki keskmise katvusega 4—20%, sambla- ja samblikurindes esineb enamasti 2—4 liiki, mille üldkatvus on esimesel puhul 50—70% ning teisel 0,5—25%.

Pohla enda keskmine katvus tsönopopulatsioonis ulatus 0,1—21,4%-ni. Keskmine katvus oli suurim kanarbiku kasvukohatüübis (8,1%) ning madalaim mustika kasvukohatüübis (3,0%). Pohla katvuse analüüsi alusel tuleb Eestis produktiivseks pidada puistueraldusi keskmise katvusega üle 5% ning pohla varude takseerimisel sobib kasutuseks skaala: 0—5, 6—15 ja üle 15%.

Pohla jaotumuse uurimine tsönopopulatsioonides ($n=266$) näitas, et jaotumustüüpide sagedus oli: korrapärane-laiguline — 32,2%, juhuslik-laiguline — 30,4%, juhuslik — 21,1% ning korrapärane — 16,2%. Seega on valdav laiguline jaotumustüüp. Pohla keskmise katvuse määramiseks etteantud täpsusega (meil 15%) on vajalik minimaalne üheruutmeetriste prooviruutude arv korrapärase jaotumustüübi puhul 25, korrapärase-laigulise puhul 30 ja juhusliku-laigulise puhul 60.

Pohla võrsete keskmine pikkus tsönopopulatsioonides oli suurim mustika kasvukohatüübis (7,8 cm) ning minimaalne sambliku kasvukohatüübis (5,7 cm). Võrsete pikkuse jaotumist analüüsiti nii üldise intervalli, nn. 95-protsendise intervalli ja maksimaalse sagedusega pikkusklasside keskmise väärtuse (nn. moodi) alusel. Erinevus pikkuse jaotumise intervallis vaadeldud metsakasvukohatüüpide vahel oli esimesel juhul 10 cm, teisel ainult 5 cm ning metsakasvukohatüübid järjestusid siin vastavalt mullaniiskusele (v. a. sinika kasvukohatüüp). Kõige ebaühtlasem oli võrsete pikkuse jaotumine sinika kasvukohatüübis, kus modaalklassi (3,5—4,5 cm) sagedus oli 22%, ning kõige ühtlasem mustika kasvukohatüübis, kus modaalklassi (5,5—6,5 cm) sagedus oli ainult 12%. Pohla võrsete pikkus on seotud ka puistu vanusega ning tema muutumine sõltub metsakasvukohatüübist. Võrsete pikkus on minimaalne noorendikes. Võrsete keskmise pikkuse ($\bar{x}_{100}$) täpne määramine on üsna töömahukas. Meie andmetel võib statistiliselt usaldatava tulemuse saada ka kümne mõõtmisega ($\bar{x}_{10}$), hinnates võrsete keskmise pikkuse nivood. Mõnevõrra suuremate $\bar{x}_{10}$ tulemuste korrigeerimiseks on antud regressioonivõrrandid.

Valgustingimuste mõju pohla võrsetele näitas sama populatsiooni ($n=30$) valgus- ja varjuvõrsete võrdlemine. Olulisemad morfomeetrilised näitajad olid suuremad varjus kasvavatel taimedel. Ainult lehtede osa üldmassis oli suurem valgusvõrsetel. Morfoloogiliste näitajate vahelised korrelatiivsed seosed esinevad mõlemal võrsetüübil, kuigi on erinevusi nende seoste tugevuses. Sammsammuline regressioonanalüüs näitas võrsete massi ja lehistunud osa pikkuse prognoosimise võimalikkust mitme morfomeetrilise näitaja alusel.

Ульве ПИХЛИК

БРУСНИКА В ЭСТОНИИ

1. Распространение и рост

В настоящей работе поставлена цель изучить некоторые аспекты биологии брусники, уточнить методику изучения ресурсов.

Брусника — ценное ягодное и лекарственное растение с широкой экологической амплитудой. Ее ценоареал связан с сосняками, а именно, с лишайниковым, вересковым, брусничным, черничным и голубичным типами леса. Флористический состав местопроизрастаний брусники беден в отношении видов: в кустарничковом ярусе обычно 3—4 вида с общим проективным покрытием до 90%, в травянистом ярусе 3—8 видов со средним проективным покрытием 4—20%, в моховом и лишайниковом ярусах обычно 2—4 вида, покрытие которых в первом 50—70%, в другом изменяется от 0,5 до 25%.

Проективное покрытие брусники в ценопопуляциях достигает 0,1—21,4%. Оно больше в вересковом (8,1%) и меньше в черничном (3,0%) типе леса. Продуктивными в наших сосняках можно считать выделы леса со средним проективным покрытием брусники более 5%, и при таксации ее ресурсов целесообразно использовать следующую шкалу: 0—5%, 6—15% и более 15%.

Изучение размещения брусники в ценопопуляциях ($n=266$) показало, что чаще встречаются пятнистые типы размещения (равномерно-пятнистый 32,2%, случайно-пятнистый 30,4%) и меньше — непятнистые (случайный 21,1% и равномерный 16,2%). Минимальное число учетных площадок для установления среднего проективного покрытия с заданной точностью (15%) при равномерном типе 25, при равномерно-пятнистом 30 и случайно-пятнистом 60 площадок величиной 1 м^2.

Средняя высота побегов брусники в ценопопуляциях больше в черничном типе (7,8 см) и меньше в лишайниковом типе (5,7 см) леса. Распределение высоты побегов изучали на основе общего интервала, 95%-ного интервала и моды (т. е. среднее значение максимально встречающегося класса высоты). Различие в интервале высоты побегов между крайними типами леса в первом случае 10 см, во втором только 5, и расположение типов леса отвечает увеличению влажности почвы (кроме голубичного типа). Самым неравномерным распределение высоты побегов было в голубичном типе леса, где частота модального класса (3,5—4,5 см) 22%, а самое равномерное в черничном типе, где частота модального класса (5,5—6,5 см) только 12%. Высота побегов брусники связана с возрастом древостоя и зависит также от типа леса. Она минимальна в молодняках. Точное определение высоты побегов ($\bar{x}_{100}$) трудоемкое. По нашим данным, статистически достоверный результат можно получить также на основе измерения среднего визуально определенного уровня высоты побегов на 10 площадках ($\bar{x}_{10}$). Несколько повышенные результаты $\bar{x}_{10}$ можно откорректировать с помощью регрессионных уравнений.

Влияние световых условий на побеги было доказано при сравнении световых и теневых побегов одной и той же ценопопуляции ($n=30$). В основном изученные морфометрические показатели были больше у теневых побегов. Только доля листьев в общей массе была выше у световых побегов. Корреляционные связи между морфологическими показателями отмечены у обоих типов побегов, но теснота связей различна. С помощью пошагового регрессионного анализа можно прогнозировать массу побегов и длину облиственной части на основе некоторых морфометрических показателей.