DOI: 10.24427/978-83-67185-47-9_7

Rozdział 7
The estimation of morphostructure variability of *Rubus arcticus* L. in the Vyatka-Kama interfluve

Yulia Gudovskikha, Ekaterina Luginina***

**(gudovskih.yulia@mail.ru)*
***(etl@inbox.ru)*

Abstract. Variability characteristics of the Arctic bramble *Rubus arcticus* L. morphological structure were studied in different habitats within the Vyatka-Kama (Kirov region, Russia) interfluve area. As a result, a high level of variability of the studied parameters was defined. Furthermore, reliable differences and correlations between morphological parameters of the species were marked in plant communities of the investigated area.

Key words: Arctic bramble, Kirov region, morphostructure variability, non-wood forest resources

1. Introduction

It is common knowledge that any plant is a multifeatured biological system, and variability and contingency of its morphometric parameters demonstrate the potential abilities of the species and its reaction norms toward phytocoenotic surroundings, which allows one to define the species' vital conditions. The variability of linear parameters, along with the variability of productivity and polyvariety of vital states, is a result of the relations between the organism and the environment [1, 2]. Thus, the studies of the variability of structural parameters of rare plant species or those living in limitative environmental conditions become essential, as these plants are the most sensitive to their surroundings. Complex analyses and studies of the mechanisms of species' resistance in natural biotopes help one develop valid methods of rational use, conservation, and sustenance of populations. One of these species is the Arctic bramble *Rubus arcticus* L. spread in Northern and Eastern Europe, North-Eastern and Eastern Asia, and Northern America [3, 4]. *R. arcticus* is included in the lists of rare and threatened species of certain regions, namely the IUCN Red List of Threatened Species [5] and the Nature Serve Explorer database.

In the Kirov region, *R. arcticus* inhabits the southern border of its range [6] and is rarely found, mostly in small-leaved and coniferous marshy forests, mixed forests, afforested wood edges, and wet openings [7, 8, 9], edges of mesotrophic and upland bogs, on wet meadows overgrowing with a brush.

The study aimed to estimate the level of variability of morphometric parameters of the Arctic bramble in different conditions of the habitats.

2. Materials and methods

The study area is located in the subzone of the Kirov region's medium and southern taiga forests, included in the Vyatka-Kama interfluve. To estimate the essential and relatively stable characteristics of plant communities (moisture level, soil richness, disturbance limitations), we used the methods suggested by the researchers [10–13]. Community disturbance limitation is an important factor that affects the character of phytocoenoses and is widely used by researchers in ecological dynamic approaches to the classification of plant communities [10, 12]. The studied communities were grouped according to the restoration stages after disturbance. The communities with disturbance limitation of less than ten years on initiate stages of succession (meadows and openings), where the Arctic bramble was registered, were usually characterized by poor drainage, a relatively high moisture level (the communities were wet) as well as high (mixed-herbs-*Comarum* meadow, *Deschampsia*-mixed-herbs-sphagnum opening, *Deschampsia*-mixed-herbs meadow) and medium (*Deschampsia*-mixed-herbs opening, *Deschampsia-Comarum* meadow, *Deschampsia*-mixed-herbs meadow) level of soil richness.

The communities with intermediate stages of succession (10–60 years) were presented by *Deschampsia*-mixed-herbs aspen forests on the wet, poorly drained areas with relatively rich soils.

The majority of studied communities in the region are characterized by more belated stages of secondary succession (disturbance limitation of more than sixty years). These habitats are presented by wet and poorly drained medium rich (bilberry-moss birch forest) and rich communities (*Deschampsia*-mixed-herb sphagnum birch forest, *Filipendula*-mixed-herb birch forest); medium rich normally drained (mixed herb--green moss birch forest, bilberry-green moss pine forest) and medium rich marshy (marshy-herb birch forest, marshy-herb pine forest) habitats. The tree stand of the communities with disturbance limitation of more than sixty years is composed of *Betula pubescens* Ehrh., *Picea abies* (L.) H. Karst, *Picea ×fennica* (Regel) Kom. and *Pinus sylvestris* L., with *P. abies* and *P. ×fennica* dominating in the understory.

During the flowering stage in the plant communities, the following morphological parameters of generative above-ground partial sprouts (generative APS) of *R. arcticus* were measured (Fig. 1): height of the generative APS (H) (cm), number of internodes (I_{LP}) (pcs), length (L_{pet}) and width (Wh_{pet}) of the central lobe of the leaf

of the 3rd internode from the base of the sprout (cm), length of leaf's petiole ($N_{fol.pet}$) of the 3rd internode from the base (cm), length of the pedicle (N_L) (cm), number of flowers (NI) (pcs).

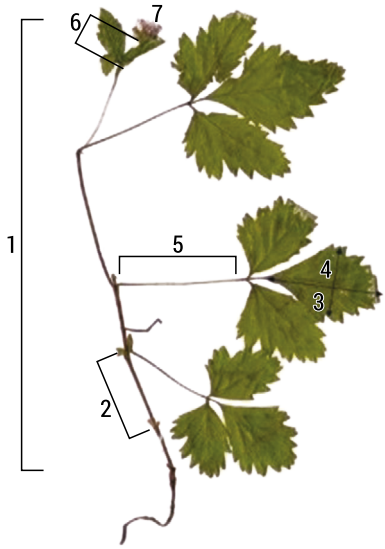

FIGURE 1. Morphological parameters of generative APS of *R. arcticus*. Legend: 1 – length of generative APS (cm); 2 – number of internodes (pcs); 3, 4, 5 – length and width of the central lobe, length of the leaf's petiole of the 3rd internode from the base (cm); 6 – length of the pedicle (cm); 7 – number of flowers (pcs)

The significance of differences in mean values (M±m) of the studied parameters of *R. arcticus* generative APS was tested with single-factor analyses of variance. For paired comparisons of group mean values in the samples, the HPC05 and Tukey's HSD tests were used. In addition, correlation analyses were used to estimate the connection between the morphometric parameters of generative APS. Correlation coefficients (r-Pearson) were considered reliable at $P \leq 0.05$.

The studied parameters were estimated with the coefficient of variability (CV) according to the scale of variability for dwarf subshrubs life forms: CV < 7% – very low, CV = 7–15% – low, CV = 16–25% – medium, CV = 26–35% – elevated, CV = 36–50% – high, CV > 50% – very high level [13].

3. Results

In the plant communities with initial stages of succession (disturbance limitation up to ten years), the generative APS were reliably higher in wet habitats with medium-rich soils (average 13.42±0.29 cm) than in the eutrophic ones (the APS height reaches 12.38±0.27 cm) (table 1). Furthermore, variability of the parameter is higher on rich

and medium-rich soils – 34% and 26%, correspondingly. Usually, two to eight internodes (Fig. 2B) were formed on the generative APS, average – 5; variability of the parameter in the studied communities was medium (22–25%).

Parameters of the central lobe of the leaf of the 3rd internode from the base of the sprout are characterized by very high and high levels of variability (CV = 37–63%), except for the width of the central lobe of the leaf of the 3rd internode from the base of the sprout in medium-rich wet habitats, which variability is medium and reaches 25%.

The height of the central lobe of the leaf of the 3rd internode from the base of the sprout in medium-rich communities (2.86±0.11 cm) is slightly lower than the one in the eutrophic habitats (2.90±0.07 cm). The width of the central lobe of the leaf of the 3rd internode from the base of the sprout is insignificantly higher in the medium-rich communities (3.07±0.07 cm) compared to the eutrophic ones (2.44±0.06 cm) (Fig. 2A). The length of the petiole of the central lobe of the leaf of the 3rd internode from the base of the sprout is reliably higher (2.54±0.08 cm) in rich habitats compared to the medium-rich ones (2.08±0.11 cm).

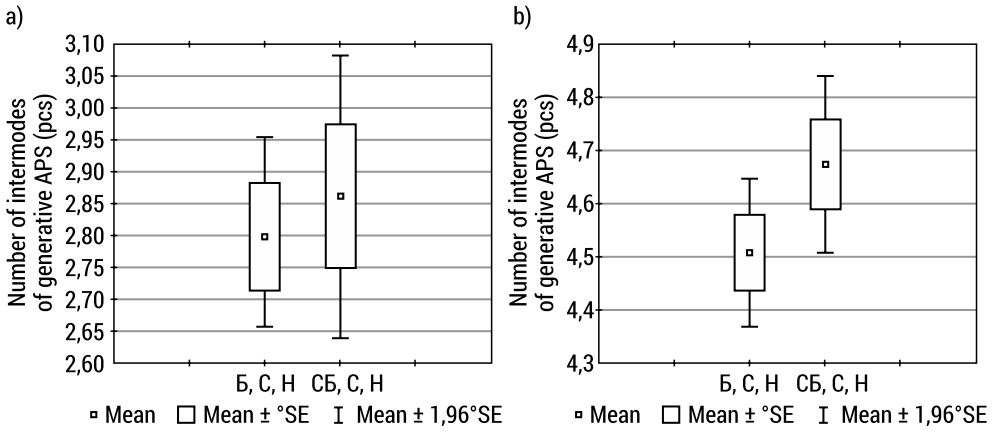

FIGURE 2. The width of the central lobe (A) of the leaf of the 3rd internode from the base of the sprout and a number of internodes (B) of the generative APS *R. arcticus* in communities with different levels of soil richness and moisture in initial stages of secondary succession (H). Legend: B, C – rich, wet; CB, C – medium-rich, wet

In the studied communities of initial stages of succession, up to four flowers were formed on the generative APS (average – 1); the parameter is highly variable (CV = 43–48%). The length of the pedicle in the eutrophic habitats is reliably higher (2.39±0.07 cm) than in the medium-rich ones (2.09±0.08 cm, CV = 22–25%).

Morphometric parameters of plants inhabiting areas with initial stages of secondary succession are characterized by a low number of correlations compared with other studied communities. In wet and eutrophic habitats, the height of the generative APS shows different levels of correlation with the other studied parameters ($r = 0.18–0.52$; $P < 0.05$), except for the petiole length of the leaf of the 3rd internode from the base

of the sprout (Fig. 2). A medium correlation (r = 0.23–0.39; P < 0.05) is marked between the length and width of the central lobe of the leaf of the 3rd internode from the base of the sprout, a number of internodes, between the length of the central lobe of the leaf of the 3rd internode from the base of the APS and a number of flowers on the APS, number of internodes. A weak correlation (r = 0.17–0.18; P < 0.05) is marked between the length of the central lobe of the leaf of the 3rd internode from the base of the APS and a number of flowers between a number of internodes and the length of the pedicle.

In wet and medium-rich communities, the parameters show different levels of correlation (r = 0.18–0.47; P < 0.05). Almost all studied parameters correlate with the height of the generative APS, except for the length of the central lobe of the leaf of the 3rd internode from the base of the APS and a number of flowers. A negative correlation was marked between the length and the width of the leaf of the 3rd internode from the base of the sprout (r = –0.17; P < 0.05). On the other hand, the length of the central lobe of the leaf of the 3rd internode from the base of the sprout shows a positive correlation with the length of the pedicle, a number of flowers, and internodes; a number of internodes correlate with the length of the pedicle and a number of flowers.

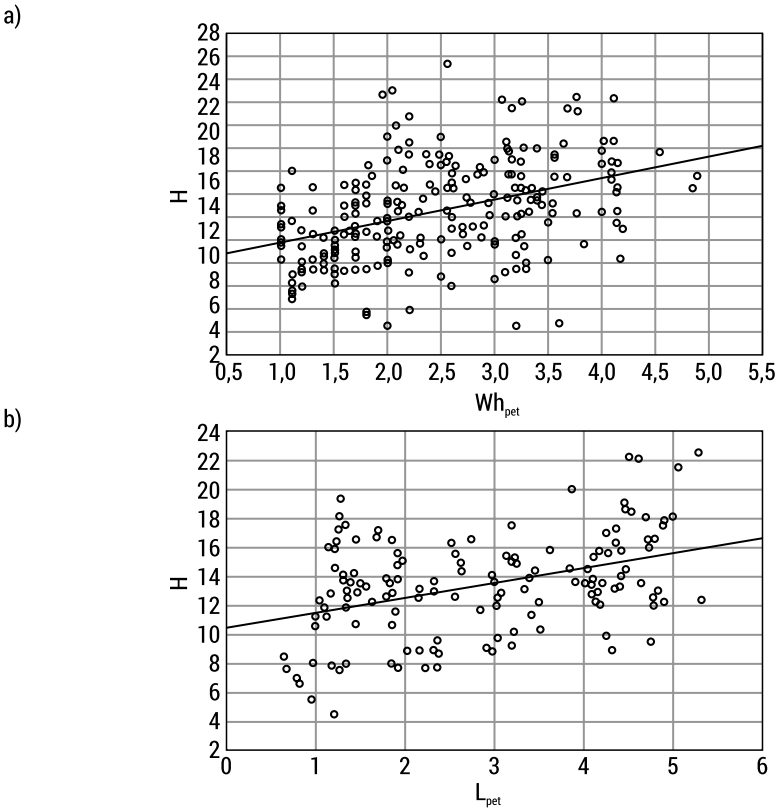

FIGURE 3. Correlation between the height of the generative APS (H), the width (A), and the length (B) of the central lobe of the leaf of the 3rd internode from the base of the sprout in wet and eutrophic habitats with initial stages of secondary succession.

TABLE 1. Morphometric parameters of the generative APS of *Rubus arcticus* in different types of habitats in the Kirov region

Parameter, unit	Eutrophic (rich) and wet	Medium-rich and wet	Eutrophic (rich) and wet	Eutrophic (rich) and wet	Medium-rich and wet	Medium-rich and normally drained	Medium-rich marshy	F-test ($F_{эмп}$)	Level of significance (p)	Criterion of the least significant difference, HPC_{05} (cm)
	initial stages of secondary succession		intermediate stages of secondary succession	belated stages of secondary succession						
H, cm	12.38±0.27 34	13.42±0.29 26	16.90±0.78 27	12.91±0.24 30	19.46±0.69 19	10.81±0.32 34	13.50±0.52 30	27.14	0.00	2.10
L_{pet}, cm	2.90±0.07 37	2.86±0.11 47	2.65±0.11 24	3.33±0.06 24	2.54±0.13 27	3.97±0.09 25	3.57±0.11 23	27.55	0.00	0.52
Wh_{pet}, cm	2.44±0.06 38	3.07±0.07 25	4.04±0.15 22	2.54±0.04 24	4.18±0.17 22	3.22±0.08 29	3.10±0.17 43	44.59	0.00	0.46
$N_{fol.pet}$, cm	2.54±0.08 52	2.08±0.11 63	2.19±0.08 21	3.04±0.07 36	1.94±0.06 17	3.31±0.12 40	2.76±0.07 18	22.99	0.00	0.60
N_L, cm	2.39±0.07 43	2.09±0.08 48	1.71±0.18 62	1.72±0.08 53	2.05±0.26 60	1.25±0.10 59	1.18±0.13 66	17.07	0.00	0.51
N_l, pcs	1.42±0.06 52	1.26±0.05 48	1.06±0.04 23	1.15±0.04 36	1.09±0.06 27	1.24±0.07 49	1.14±0.06 31	4.31	0.00	0.32
$I_{LP,}$ pcs	4.51±0.07 25	4.67±0.08 22	4.86±0.17 21	4.85±0.09 31	4.47±0.17 21	4.51±0.08 20	4.85±0.17 27	2.12	0.05	0.64

*Note: the nominator shows average values and standard errors (M±m); denominator – Cv (coefficient of variation, %)

Plant communities with the Arctic bramble with intermediate stages of succession (10–60 years) are presented by *Deschampsia*-mixed-herb aspen forests with relatively rich soils and poor drainage. The height of the generative APS in this type of community is characterized by an elevated level of variability (CV = 27%), and varies from 6.9 to 24.20 cm, with an average of 16.90±0.4 cm. The generative APS forms 5±0.17 internodes on average, varying from 3 to 7 (CV = 21%).

Parameters of the leaf of the 3rd internode from the base of APS and generative features of the plant in the communities show a medium variability level (CV = 21–24%), except for the length of the pedicle, which varies significantly from 0.23 to 3.96 cm (CV = 62%). The length of the central lobe of the leaf of the 3rd internode from the base of APS reaches 2.65±0.4 cm on average, and varies from 1.36 to 4.10 cm, the width – an average of 4.04±0.4 cm, varies from 2.13 to 5.60 cm, the petiole length – an average of 2.19±0.4 cm, varies from 1.39 to 3.69 cm. One flower is usually formed on the sprout.

A medium positive correlation is marked between the length of the petiole and the length of the central lobe of the leaf of the 3rd internode from the base of the sprout ($r = 0.41$; $P < 0.05$), and between a number of flowers and the pedicle length ($r = 0.41$; $P < 0.05$).

On belated stages of secondary succession (disturbance limitation of more than sixty years), the average height of the generative APS is significantly higher in wet habitats of medium richness, compared to medium-rich wet and normally drained, and reaches 19.46±0.4 cm. The variation coefficient of the APS height varies from 19% to 34%, the leaf width – varies from 22% to 43%. No reliable difference between the values of the width of the leaf of the 3rd internode from the base of APS was marked in the conditions of medium-rich normally drained and medium-rich marshy habitats (Fig. 4A). It was defined that an average number of internodes in medium--rich habitats on normally drained and wet soils was equal (Fig. 4B).

In the studied plant communities, the generative APS form 2 to 10 internodes, and the variability is medium to elevated (CV = 20–31%).

Parameters of the leaf of the 3rd internode from the base of the APS show medium to high variability levels (CV = 17–43%). The length of the central lobe of the leaf of the 3rd internode from the base of APS in medium-rich and wet habitats varied from 0.98 to 2.50 cm and is relatively stable (CV = 17%). The maximum variability levels (CV = 43%) were marked for the width of the central lobe of the leaf of the 3rd internode from the base of APS in marshy and rich habitats – 0.51 to 5.77 cm.

The maximum average length of the central lobe of the leaf of the 3rd internode from the base of APS was marked for plants from medium-rich and normally drained areas (3.97±0.06 cm), the minimum – for medium-rich and wet (2.54±0.13 cm). The minimum mean values were defined for the width of the central lobe of the leaf of the 3rd internode from the base of APS in rich and wet habitats (2.54±0.04 cm), the maximum – for plants in medium-rich normally drained areas (3.31±0.2 cm).

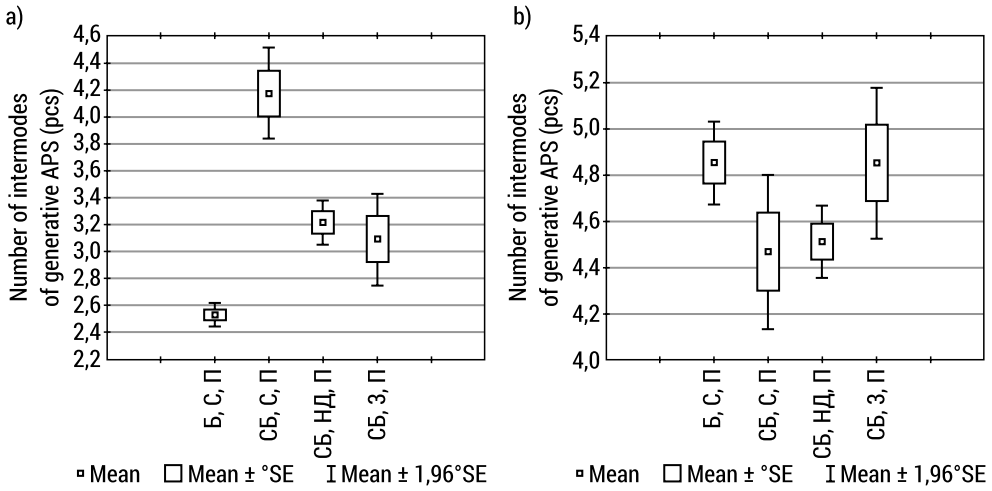

FIGURE 4. The width of the leaf of the 3rd internode from the base of APS (A) and a number of internodes (B) in different conditions of moisture and soil richness on belated stages of secondary succession (П)

The variation of the generative parameters is medium to high (CV = 27–66%). 1 to 4 flowers are formed on generative APS; variability level elevated to high (CV = 27 – 49%). The pedicle length varies from 0.1 to 4.30 cm, with the variation level being very high (CV = 53–66%).

The correlation analyses showed that in eutrophic and wet habitats, morphological parameters of the plants demonstrate a low integration degree ($r = 0.20–0.29$; $P < 0.05$): the length of the central lobe of the leaf of the 3rd internode from the base of APS shows correlation with its width; the width of the central lobe of the leaf of the 3rd internode from the base of APS – with length of the petiole of the leaf of the 3rd internode from the APS base. Furthermore, a number of internodes are positively connected with the length of the petiole of the leaf of the 3rd internode from the APS base and a number of flowers; negatively – with the pedicle length ($r = –0.25$; $P < 0.05$).

Among the parameters of plants inhabiting medium-rich and normally drained areas, a negative correlation between the height of the generative APS and the length of the petiole of the leaf of the 3rd internode from the APS base was marked ($r = –0.40$, $P < 0.05$), between the width of the central lobe of the leaf of the 3rd internode from the base of APS and the pedicle length ($r = –0.50$, $P < 0.05$); a positive correlation – between the length and the width of the central lobe of the leaf of the 3rd internode from the base of APS ($r = 0.36$, $P < 0.05$).

Analyses of the morphometric parameters of the species in marshy habitats of medium richness showed that the length of the central lobe of the leaf of the 3rd internode from the base of APS demonstrates a strong negative correlation with the pedicle length ($r = –0.71$, $P < 0.05$) and positive – with the width of the central lobe of the leaf of the 3rd internode from the base of APS ($r = 0.57$, $P < 0.05$). The height of the generative APS correlates with the width of the central lobe of the leaf of the 3rd internode

from the base of APS and a number of internodes ($r = 0.39–0.42$, $P < 0.05$). A negative correlation was marked between the width of the central lobe of the leaf of the 3rd internode from the base of APS and the pedicle length ($r = –0.44$, $P < 0.05$).

A medium positive correlation was marked between a number of internodes and the length of the leaf of the 3rd internode from the base of APS ($r = 0.47$; $P < 0.05$).

4. Conclusions

The studied morphometric parameters of *R. arcticus* are characterized by a wide total variation – from medium to very high (CV 17 to 63%). No parameters showed a low level of variation. TUsing Fischer's ratio test, the single-factor analyses of variance showed significant differences between the studied parameters in various habitat types in the Kirov region. The variation estimation in paired comparison of mean values between the morphological parameters using HPC05 and Tukey's HSD test demonstrated a statistically reliable influence of the habitats' conditions on the species' morphostructure, except for a number of internodes (the parameter showed no reliable differences within the studied coeno range).

Acknowledgements. The Authors are grateful to their colleagues from the Department of Plant Ecology and Resources of the Russian Research Institute of Game Management and Fur Farming (Kirov, Russia) for the support during the collection of field data; to scientific advisors from the Laboratories of Ecology of Plant Communities and Geobotany of V. L. Komarov Botanical Institute of the Russian Academy of Science (Saint Petersburg, Russia), and Head of the Department of Biogeography and Nature Conservation of the Saint Petersburg State University – A.A. Egorov – for methodical support during data processing and interpreting.

References

1. Zlobin Yu.A., *Principles and methods of investigation of coenotic populations of plants*, Kazan 1989.
2. Zlobin Yu.A., *Population ecology of plants: current state, growing points*, Sumy 2009.
3. Kurtto A., Weber H.E., Lampinen R., Sennikov A.N., *Atlas Florae Europaeae. Distribution of Vascular Plants in Europe. 15. Rosaceae (Rubus)*, Helsinki 2010.
4. Hulten E., Fries M., *Atlas of north European vascular plants north of the tropic of Cancer*, v.2, Königstein 1986.
5. *The IUCN Red list of threatened species*, web pages, www.theiucnredlist.org [access: 29.03.2021].
6. Schmidt V.M., *Ranges of medicinal and related plant of USSR: atlas*, Leningrad 1990.
7. Tarasova E.M., *Flora of Vyatsky Krai. P. 1. Vascular plants*, Kirov 2007.
8. Gudovskikh Yu.V., Egorova N.Yu., Egoshina T.L. *State of Rubus arcticus (Rosaceae) coenopopulations in Kirov region*, Botanicheskii Zhurnal, 2020, V. 105, 8.

9. Gudovskikh Yu.V., Luginina E.A., Egoshina T.L., *Ecological and biotopic parameters and resilience of arctic bramble (Rubus arcticus L.) in Kirov region*, IOP Conference Series: Earth and Environmental Science 2021, 42–59.
10. Fedorchuk N.V., Dyrenkov S.A., Melnitskaya G.B., Egorov A.A., Chernov I.M., Zotikova R.G., Федорчук В.Н., Дыренков С.А., Мельницкая Г.Б., Егоров А.А., Чернов И.М., Зотикова Р.Г., *Identification guide to the forest types of Leningrad region*, Leningrad 1978.
11. Fedorchuk N.V., Egorov A.A., Gauberville K., Chernov I.M., *Brief guide to forest types of Leningrad region*, Saint-Petersburg 2002.
12. Andreeva E.N., Bakkal I.Yu., Gorshkov V.V., Lyanguzova I.V., Maznaya E.A., Neshataev V.Yu., Neshataeva V.Yu., Stavrova N.I., Yarmishko V.T., Yarmishko M.A., *Methods of studies of forest communities*, Saint-Petersburg 2002.
13. Fedorchuk V.N., Neshataev V.Yu., Kuznetsova M.L. *Forest ecosystems of north-western regions of Russia: typology, dynamics, economical peculiarities*, Saint-Petersburg 2005.
14. Mamaev S.A., Chuyko N.M., *Individual variability of parameters of leaves of wild-growing stone-bramble species*, Trudy Instituta Ekologii Rastenii i Zhivotnykh, Individual and ecological-geographic variability of plants, Sverdlovsk 1975.