BIOLOGICA NYSSANA
2 (1) • September 2011: 7-18

Original Article

The nature of the variability of the morphological characteristics of the taxon *Jovibarba heuffelii* (Schott) A. Löve & D. Löve (Crassulaceae) in Serbia

Danijela Dimitrijević*[1], Jasmina Šinžar-Sekulić[2], Vladimir Ranđelović[1], Dmitar Lakušić[2]

[1]*Department of Biology and Ecology, Faculty of Sciences and Mathematics, University of Niš*
[2]*Faculty of Biology, Institute of Botany and Botanical Garden „Jevremovac", University of Belgrade*

** E-mail: danid@pmf.ni.ac.rs*

***Abstract*:**
Dimitrijević, D., Šinžar-Sekulić, J., Ranđelović, V., Lakušić, D.: ***The nature of the variability of the morphological characteristics of the taxon Jovibarba heuffelii (Schott) A. Löve & D. Löve (Crassulaceae) in Serbia, Biologica Nyssana, 2 (1), September 2011: 7-18.***

The aim of this paper was to investigate the nature of the variability of the morphological characters of the species *Jovibarba heuffelii* (Schott) A. Löve & D. Löve in Serbia. Morphometric analyses were performed on 219 individuals from 10 populations. Total of 38 morphometric characters were analyzed (25 metric and 13 ordinal). Statistical data analyses were done for 25 quantitative morphometric characters. Descriptive statistics (mean, standard deviation, minimum, maximum and standard error, coefficient of variation) were calculated for each character, together with correlative variability and variation between each character. Analysis of variance (ANOVA) was performed to identify significant variation between each character. The results of the analysis showed significant statistical variability of all investigated characters. Variability of the vegetative characters was higher when compared with reproductive characters. Also, the obtained results pointed to the altitude and geological substratum as the most important factors for morphological differentiation of analyzed populations.

Key words: *Jovibarba heuffelii,* morphological characteristics, analysis

Introduction

The genus *Jovibarba* Opiz. (Crassulaceae) is endemic to Europe (Jalas, 1999) and includes two species *J. globifera* (L.) J. Parnell and *J. heuffelii* (Schott) A. & D. Löve (Tutin, 1993).

Species *Jovibarba heuffelii* (Schott) A. Löve & D. Löve is a relatively common plant with a distribution in the middle part of the Balkan peninsula and the Central and Southern parts of Karpats. In Balkan, it can be found in eastern and southeastern Dinarids, in central and northern parts of Skardo-pind mountain system and in the western parts of Rodopian and Balkan mountain systems.

J. heuffelii is perennial blooming monocarpic plant with vegetative reproduction by spliting rosettes in two parts. In ecological sense, it is hardy xerophyte with high tolerance to temperature, humidity and insolation variability. This plant is located on rocky and karst places. It has wide ecological valency for geological substratum and spreads on silicates, carbonates and serpentinits.

Morphological characters of *J. heuffelii* are very important for taxonomy on intraspecific level.

Description of *J. heuffelii* is similar in literature (Praeger, 1985, Gajić, 1972, Micevski, 1998, Йорданов, 1970) with more or less details.

This investigation covers northern and central part of the species distribution area on Balkan peninsula. Localities were chosen by geological substrate and altitude - the goal was to include vide spectrum of different substratums and different altitudes, in order to investigate the morphological variability in more detail. Also, this approach was chosen in order to compare the populations from different geological localities.

The aim of this study was to describe the nature of *J. heuffelii* morphometric character's variability in Serbia.

Materials and methods

Study area and plant sampling. Ten populations of *J. heuffelii* (219 individuals) were sampled for morphometric analysis. The samples were taken from ten localities in Serbia: Mt. Kopaonik (Nebeske Stolice and Treska), Mt. Besna Kobila, Mt. Stara planina, Mt. Vidlič (Basarski Kamik), Mt. Radan, Mt. Pljačkovica, Studenica, Suvaja and Gradac gorges (**Fig. 1, Tab. 1**). Plant material was sampled during 2009-2010. Populations in flowering stage were collected at July and August. Fruits were collected at September and October.

The collected plant material was either dried out or fixed in 50% ethyl–alcohol and glycerol solution and deposited in the Herbarium of the Institute of Botany and Botanical Garden "Jevremovac", Faculty of Biology, University of Belgrade (BEOU - H o l m g r e n et al. 1990).

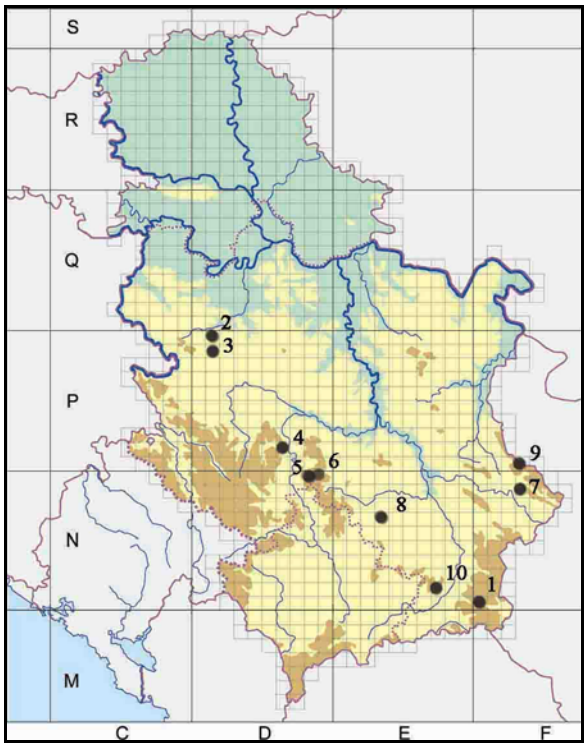

Figure 1. Distribution of populations of *J. heuffelii* in Serbia (for details see Table 1)

Table 1. Data on the plant collection localities **and voucher's number**

Population	Locality	N_lat E_long	Substratum	Altitude	Voucher
1	Pljačkovica	42 34 492 21 53 758	silicate	674	Dimitrijević, D. Dimitrijević, S. 16465
2	Gradac gorge	44 13 251 19 51 937	limestone	490	Dimitrijević, D., Nikolić, M. 16458
3	Suvaja gorge	44 09 726 19 53 196	limestone	417	Dimitrijević, D., Nikolić, M. 16457
4	Studenica gorge	43 29 220 20 32 390	serpentinite	486	Dimitrijević, D., Nikolić, M. 16461
5	Nebeske Stolice	43 15 645 21 50 031	serpentinite	1907	Dimitrijević, D., Nikolić, M. 16468
6	Treska	43 15 615 20 47 395	serpentinite	1628	Dimitrijević, D., Nikolić, M. 16462
7	Basarski Kamik	43 09 337 22 42 398	limestone	1350	Dimitrijević, D., Marković, M, 16460
8	Radan	42 55 039 21 33 450	andezite	802	Dimitrijević D., Ranđelović, V. 16456
9	Besna Kobila	42 31 437 22 14 105	silicate	1900	Dimitrijević, D., Nikolić, I. 16463
10	Stara planina	43 23 234 22 38 196	red sandstone	1840	Ranđelović, V., Savić, A. 16459

The studied region belongs to hilly-mountain part of Serbia (the area southern from Sava and Danube rivers).

Investigation covers Rhodope mountains, Besna Kobila, Radan and Pljačkovica, Kopaonik (which belongs to Dinaric mountain system (Vasović, 1988)) and Balkan system – Stara planina and Vidlič.

The species *J. heuffelii* is found in the wide range of altitudes, from 400 to 1900 m. In lower altitudes it is found mostly in the gorges and canyons, while mountain peaks are habitats on higher altitudes where the *J. heuffelii* can be found .

Depending on the geographical position, the studied populations grow in very different climatic conditions (Walter & Leith, 1964).

Populations inhabiting lower altitudes in central and eastern parts of Serbia are influenced by the continental climate from the east and Aegian variety of the Mediterranean climate from the south. This region is dominated by the sub-type of the semi-arid moderately-continental climate, also known as a sub-continental climate (type 2.2 sensu Stevanović & Stevanović, 1995; VI 3 sensu Walter & Leith, 1964). The characteristics of this sub-type of climate are relatively cold and moderately humid winters, while the summers are warm and dry (semi-dry). Total annual precipitation is between 620 and 760 mm, with its optimum in May and June. The dry period is absent, while the semi-dry one lasts two to three months.

Populations on high mountain peaks are influenced by continental mountain climate (type 4.2 sensu Stevanović & Stevanović, 1995; X 1 sensu Walter & Leith, 1964) with the annual precipitation between 850 and 1400 mm of water deposits.

Different populations inhabit the spaces of different biogeographical units. Studied region belongs to Balkans subregion of Middle-European biogeographical region and to Middle-South-European mountain biogeographical region (Stevanović, 1995).

Localities in gorges and at lower altitudes (Gradac, Suvaja, Studenica i Pljačkovica) belong to Western-Moesian province of Balkan biogeographical subregion. Those at higher altitudes (Mt. Kopaonik, Mt. Stara planina, Mt. Besna Kobila i Mt. Radan) are located on the teritory of the Balkan province of the Middle-European mountain biogeographical subregion, while Basarski Kamik belongs to the Moesian province of the Middle-South-European mountain biogeographical subregion (Stevanović, 1995).

Morphometric analysis. The measurements were performed on fresh material and hand made microscope slides on 219 plant individuals. All plant parts (leaves, rosettes, stem, flower, fruit) were measured and analyzed.

Characters were grouped in two categories: metric and ordinal characters.

To avoid elongation of stem and deformation of rosettes, these parts of the plant were measured on the field, immediately after collecting samples.

For measuring of the flowers, the native slides were used, where all flower parts were separated and individually placed on the microscopic glass.

Microscope slides were scaned first (ScanExpress A3 USB, Mustek) and than measured using image analyzing program DIGIMIZER version 3.7.0.0.

For purposes of measuring the smallest details on flowers (cusps at the petal's apex), these parts were photographed on microscope LEICA DM 1000.

I Metric characters: 1. Diameter of rosette **(Ros_D),** 2. Number of leaves in rosette **(LeRos_N)**, 3. Length of the biggest leaf **(LeRos_L max**), 4. Width of the biggest leaf **(LeRos_W max)**, 5. Distance of the widest part of leaf from the top of the leaf **(Apex_D1*),** 6. Height of the stem to the lowest flower branch **(Ste_H)**, 7. Number of the leaves at stem **(LeSte_N)**, 8. Length of the middle leaf on the stem (**MidLeSte_L)**, 9. Width of the middle leaf on the stem **(MidLeSte_W),** 10. Distance of the widest part of leaf from the top of the leaf **(Apex_D2**), 11. Number of floral branches **(FloBra_N)**, 12. Number of flowers at the stage of ripening fruit **(Flo_N),** 13. The length of the longest branch in floral fruit maturation stage **(FloBra_L max)**, 14. Length of sepal **(Sep_L),** 15. Width of sepal **(Sep_W)**, 16. Length of petal **(Pet_L),** 17. Width of petal **(Pet_W)**, 18. Number of teeth on the top of the corolla **(CoToo_N)**, 18. Length of the longest filamentum **(Fil_L max)**, 19. Height of ovary **(Ova_H)**, 20. Height of stylus **(Sty_H)**, 21. Height of fruit **(Fru_H),** 22. Width of fruit **(Fru_W)**, 23. Length of rostrum **(Rost_L),** 24. Height of central tooth **(CenToo_H),** 25. Height of lateral tooth **(LatToo_H),**

II Ordinal characters: 27. Length of the ciliate edge from the top (**CilEdg_L1***) (0- the edge is glabrous without cilia, 1- the whole leaf edge is under cilia , 2- ¾ of the leaf edge is under cilia, 3- ½ of the leaf edge is under cilia , 4- ¼ of the leaf edge is under cilia), 28. Glandular hair on the edge present (**GlaEdg_P1**) (present- 1; absent- 0), 29. Glandular hair on adaxial side of leaf- present (**GlaAdax_P1**), 30. Length of the ciliate edge of the leaf from the top (**CilEdg_L2**), 31. Glandular hair

on the edge of leaf present (**GlaEdg_P2**), 32. Glandular hair on adaxial side of leaf present (**GlaAdax_P2**), 33. Length of the ciliate edge of sepale from the top (**CilEdg_L3**), 34. Glandular hair on the edge of sepale present (**GlaEdg_P3**), 35. Glandular hair on abaxial side of sepale (**GlaAbax_P3**), 36. Length of the ciliate edge of petale from the top (**CilEdg_L4**), 37. Glandular hair on the edge of petale present (**GlaEdg_P4**), 38. Glandular hair on abaxial side of petale- present (**GlaAbax_P4**),

∗(**1**- leaves of rosette, **2** -leaves of stem, **3**- sepale, **4**- petale).

Descriptive statistics (mean, standard deviation, minimum, maximum and standard error, coefficient of variation) were calculated for 25 characters and correlative variability.

Analysis of variance (**ANOVA**) was performed to identify significant variation between each character. Statistical analyses were performed using the package Statistica 8.0 (Statsoft 2007).

Results and discussion

General characteristics of the morphometric characters. Descriptive statistics showed the significant variability of almost all morphological characters.

Rosette characteristics. The variability of rosette's diameter is very high and was in the range from 2.8 to 14.7 cm.

The highest variability in diameter of rosette was registered in populations collected from gorges of Gradac and Suvaja rivers and in population from Mt. Kopaonik. The smallest variability was noted in population from Mt. Besna Kobila.

The diameter of rosette is highly correlated with length of the biggest leaf (0.68) (**Tab. 3**).

The number of leaves in rosette varies from 16 to 62.

The lenght of the biggest leaf varies from 15.90 to 82.90 mm.

Table 2. Basic statistic parameters of the analyzed morphometric characters: Mean- Mean value, Min- Minimum value, Max- Maximum value, Std. Dev.- Standard Deviation, CV%- coefficient of variation

Variable	valid N	Mean	Min	Max	Std. dev	CV%
Ros_D	219	63.05	28.20	147.00	21.85	34.66
LeRos_N	219	36.37	16.00	62.00	9.26	25.46
LeRos_L max	219	36.20	15.90	82.90	11.19	30.90
LeRos_W max	219	12.70	6.30	26.90	3.35	26.37
Apex_D1	219	11.02	5.80	46.40	3.95	35.80
Ste_H	219	192.33	70.00	370.00	54.76	28.47
LeSte_N	219	25.29	14.00	37.00	4.45	17.60
MidLeSte_L	219	27.14	13.20	51.20	6.19	22.79
MidLeSte_W	219	9.25	4.20	16.10	2.15	23.26
Apex_D2	219	20.16	9.50	36.80	5.41	26.85
FloBra_N	219	5.29	3.00	10.00	0.90	17.04
Flo_N	219	37.63	14.00	83.00	14.28	37.94
FloBra_L max	219	21.76	5.00	70.00	11.24	51.66
Sep_L	219	6.28	4.17	9.06	0.95	15.20
Sep_W	219	2.31	1.63	3.33	0.31	13.22
Pet_L	229	9.32	6.66	11.36	0.85	9.12
Pet_W	219	3.31	2.46	4.46	0.39	11.84
Fil_L max	219	5.86	4.09	7.87	0.57	9.71
Ova_H	219	4.29	3.12	6.92	0.52	12.02
Sty_H	219	1.65	1.05	2.46	0.26	15.46
Fru_H	219	5.85	3.17	7.82	1.00	17.13
Fru_W	219	1.49	0.74	2.29	0.28	18.91
Rost_L	219	1.31	0.63	2.38	0.30	22.80
CenToo_H	219	0.67	0.21	1.15	0.16	23.38
LatToo_H	219	0.34	0.16	0.62	0.07	21.33

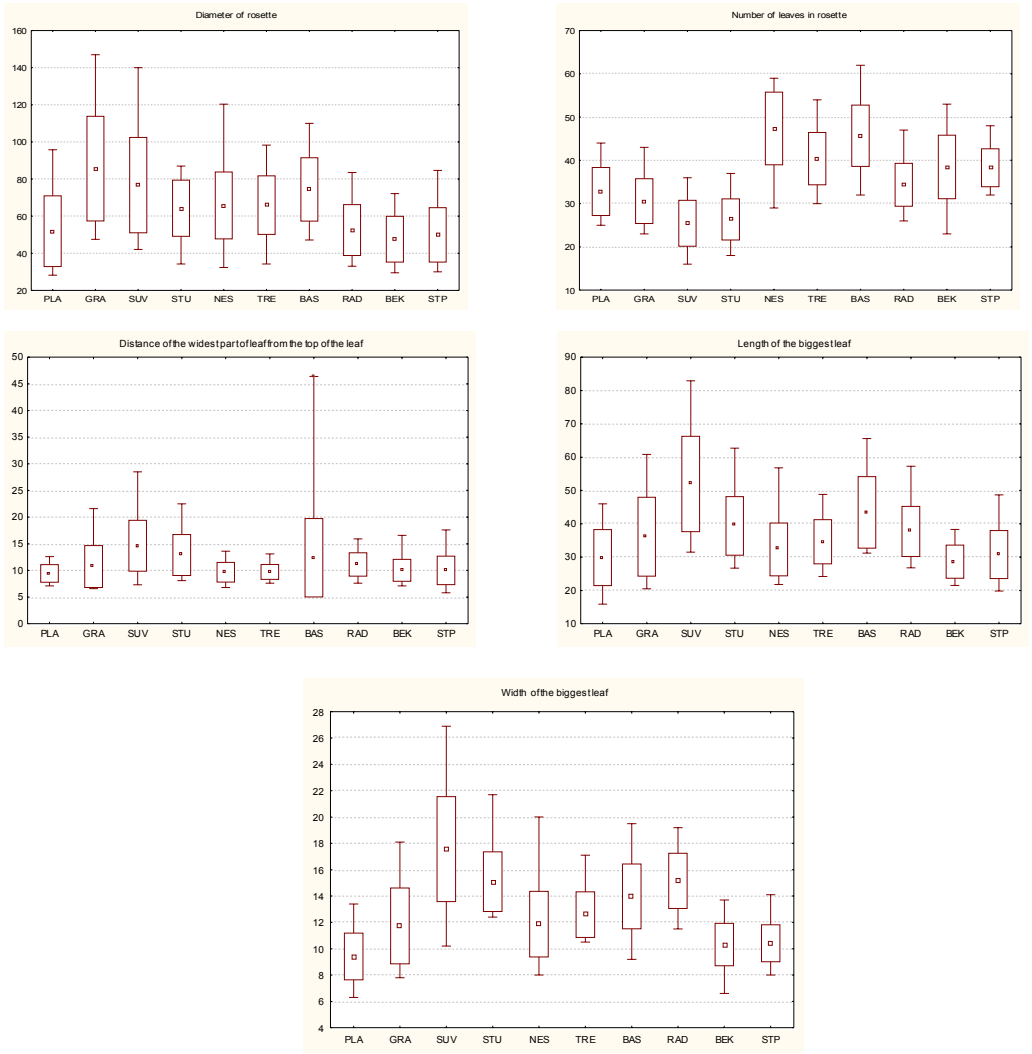

Figure 2. Box and whisker plots of basic statistic parameters of rosettes
Legend: Middle point = Mean; Box = Mean±SD; Whisker = Min-Max; O = Outliers,
PLA-Pljačkovica, GRA- Gradac, SUV- Suvaja, STU-Studenica, NES- Nebeske Stolice, TRE- Treska, BAS- Basarski Kamik, RAD- Radan, BEK- Besna Kobila, STP- Stara planina)

The maximum lenght of leaves was registered in population from Suvaja and in this population was the highest variation of lenght of leaves, while the population from Mt. Besna Kobila showed the lowest variation of this character. The minimum lenght of the bigest leaf in rosette was registered in population from Mt. Pljačkovica 15.90 mm.

The width of the biggest leaf varies in a same way as length of the biggest leaf **(Fig. 2).** The highest variation of this character was noticed in population from Suvaja gorge, less variation was in populations from Gradac and Studenica gorges and from Nebeske Stolice, while the lowest variation was in populations from Besna Kobila, Stara planina and Pljačkovica mountains.

In general, larger dimensions of leaves are noted on limestone localities at lower altitudes, while smaller leaves are registered in populations from silicate and serpentinits localities at higher altitudes.

The shape of leaves varies too, especially width of leaves.

In general, measured characteristics of rosettes show a high level of morphological variability, what is expected, beacuse vegetative organs are influenced by ecological factors. This is also pointed out by high degree of variation coefficient (CV= 25 -35%, **Tab. 2**). It was observed that the population from Mt. Besna Kobila was the most stable in the sense of morphological variability, while the population from Suvaja gorge was the most varied.

Stem characteristics. The height of the stem to the lowest flower branch (**Ste_H)** shows the fact that morphological characteristics of species *J. heuffelii* are very varied. **Ste-H** varies from 7 to 37 cm **(Fig. 3)**.

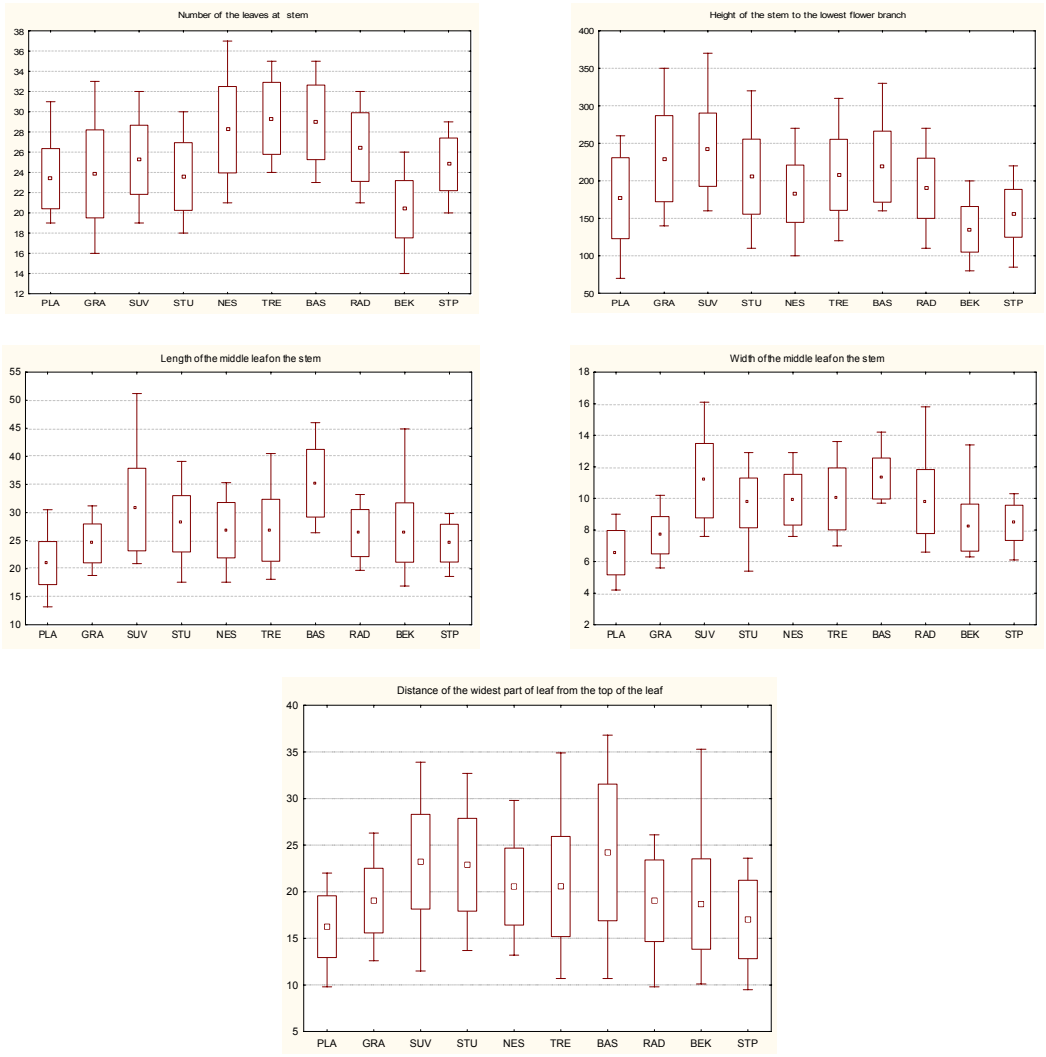

Figure 3. Box and whisker plots of basic statistic parameters of stem

This characteristic varies significantly in almost all of the populations. The moderate degree of variability was noted in populations from Mt. Besna Kobila and Mt. Stara planina, and in these populations stems of flowers, were noted to be shorter than in others. Other characters of the stem such as number of leaves at the stem, length and width of middle leaf on the stem, distance of the widest part of leaf from the top of the leaf have shown moderate degree of variability with coefficient of variations from 17.60 to 26.85.

Inflorescens characteristics. The number of floral branches varies from 3 to 10 per individua. The population from Nebeske Stolice is noticeable for variation of this character, while other populations have smaller variations in number of floral branches. The most common number of floral branches is 5 and 6 which is registered in most individual plants.

The variability of the character length of the longest branch in floral fruit maturation stage separates populations in two groups. First group is made up of populations from Suvaja, Gradac and Studenica gorges, with higher variability of this character and with an average value of 3 cm and above. This group has larger dimensions of inflorescens in comparison with the second group, made up of populations from Pljačkovica, Besna Kobila, Kopaonik and Stara planina mountains. The average value of this character in those populations is below or near 2 cm **(Fig. 4).** This indicates a clear differentiation between populations from gorges and mountains.

The number of flowers varies and is in range from 14 to 83 per individua.

Flowers characteristics. The flowers of *J. heuffelii* are hexameric in shape, and rarely of heptameric or pentameric shapes.

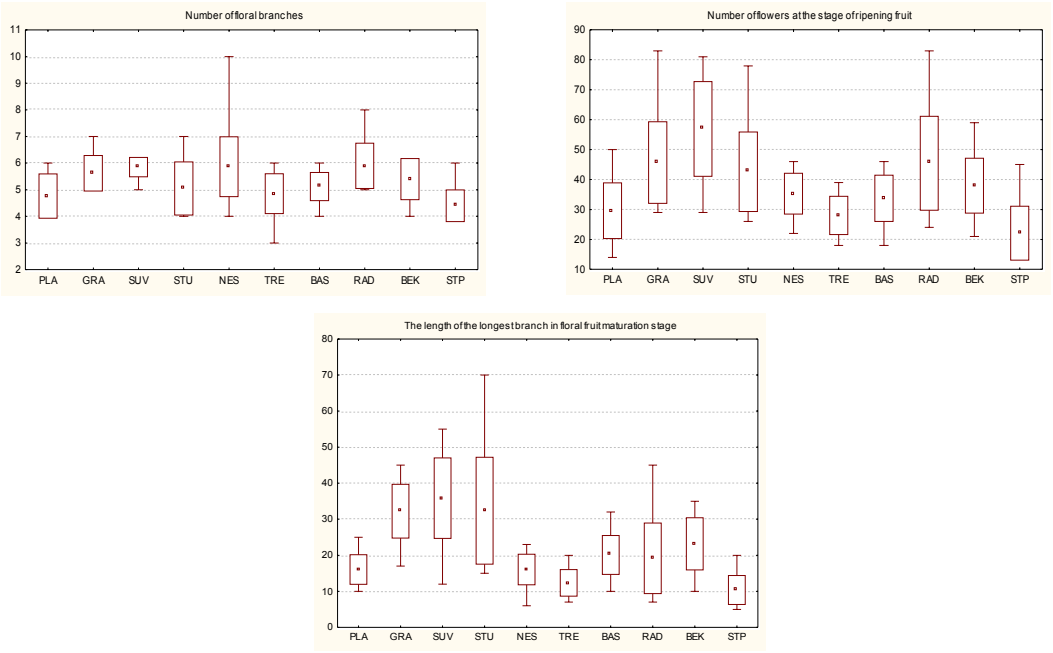

Figure 4. Box and whisker plots of basic statistic parameters of inflorescence

The length of sepal ranges from 4.17 to 9.06 mm. The maximum length of sepal was registered in population from Basarski Kamik (Mt. Vidlič), while the minimum length of sepal was registered in population from Besna Kobila mountain. The population from Basarski Kamik is distinguished by the size of the flowers with sepals longer than half of the corolla. The next character by which the populations were divided in two groups is the height of stylus. The populations from the gorges have a higher average value of this character than populations from the mountain regions. The height of ovary varies in small range comparing to other vegetative characteristics. Other reproductive characteristics vary in smaller range in regard to vegetative characteristics (**Fig. 5).**

Fruits characteristcs. The smallest variation of morphometric charactistics that is present in fruits suggests the possibility of their use in taxonomy. Measured characters were: height of fruit, width of fruit and the length of rostrum. Height of fruit and length of rostrum are the character which make the biggest difference between populations **(Fig. 6).**

Ordinal leaves charactistics are important for taxonomy. These charactistics were used for determination of varieties of *J. heuffelii* **(Gajić, 1972).**

The length of ciliate edge is character with smallest variability, because all the leaves of rosette and stem have ciliae along the edge. Ciliae are most noticeable in the upper part of leaf. In the middle and base part of leaf's edge ciliae are rarely distributed, their dimensions are smaller and they are alternating with glandular hairs whose density is biggest at the base of leaf. At the base of leaf the ciliae are absent. Glandular hairs have capitum and those that are located in the middle of leaf's edge are longest and biggest, while their dimensions are smaller around the base of leaf so they look like little capiti on short sticks.

The presence of glandular hairs on adaxial and abaxial side of leaves is distinguishing charactistic for species *J. heuffelii.*

J. heuffelii var. heuffelii has glandular hairs on adaxial and abaxial side of leaves of rosettes, while *var. glabrum* does not have glandular hairs on leaves of rosettes (Gajić, 1978).

The glandular hairs were not registered on adaxial and abaxial side of leaves of rosettes in analyzed populations. Only the population from Besna Kobila has the glandular hairs both on adaxial and abaxial side of leaves of stem and they are very noticeable both on the stem and inflorescences.

Analysis of variance **(ANOVA).** Analysis of variance showed that all of the morphometric characters significantly contribute to differentiation of analyzed populations.

Coefficient of Variation. Analysis of variation of morphometric characters was performed to determine that the highest number of characters show a moderate degree of variability (CV = 10-30% **Tab. 2.**)

The lowest coefficients of variation (CV< 10%) are shown by following characters: length of petal (9.11%) and length of the longest filamentum (9,71%). Some higher coefficient of variation,

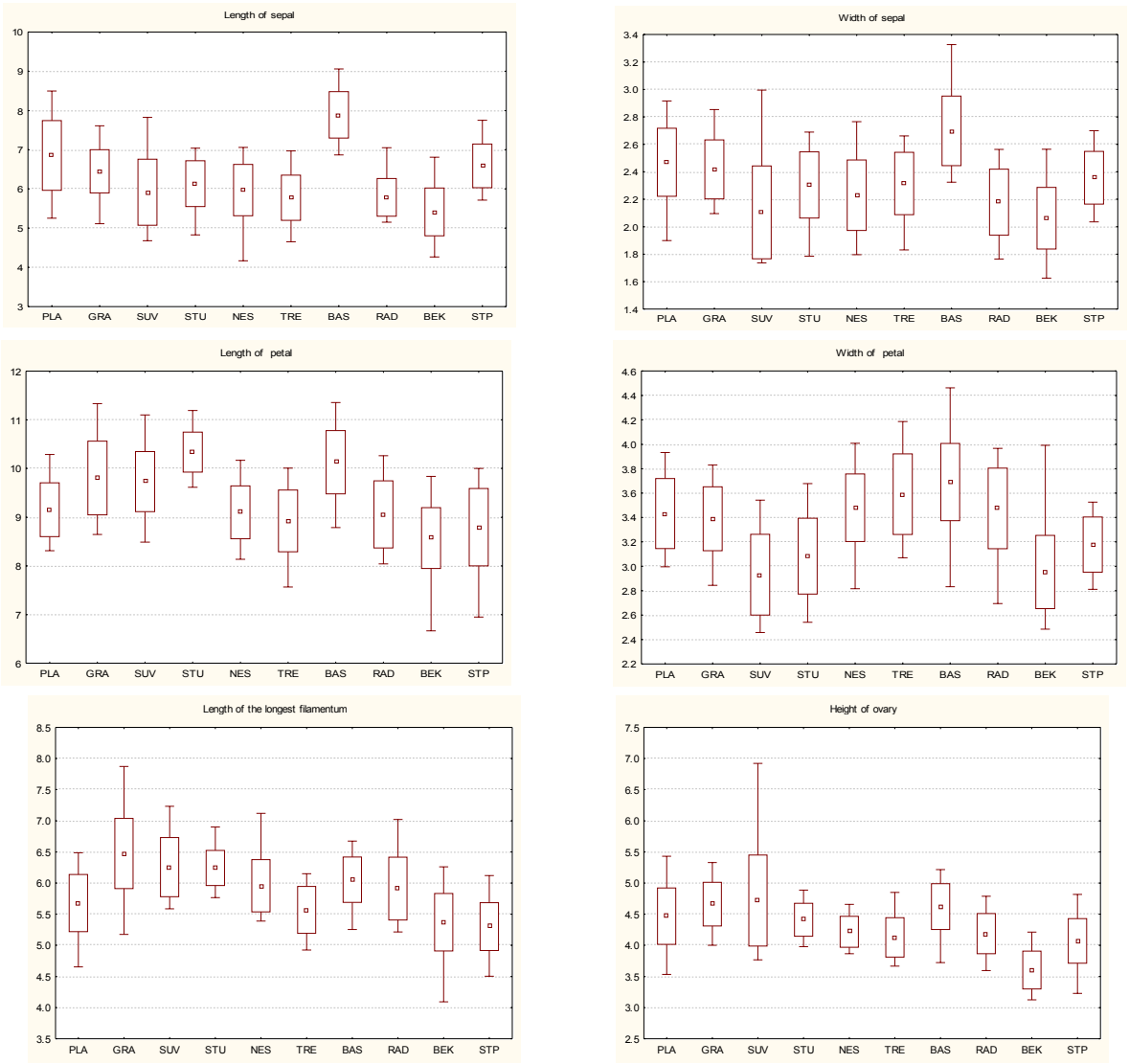

Figure 5. Box and whisker plots of basic statistic parameters of flowers

CV<20% have characters: width of petal (11.84%), height of ovary (12.02 %), width of sepal (13.22%), length of sepal (15.20%), height of stylus (15.46%), number of floral branches (17.04%), height of fruit (17.13%), number of the leaves at stem (17.60%) and width of fruit (18.91%).

It is obvious that all characters belong to reproductive organs of plant.

Within the group of highly variable characters, whose coefficient of variation is higher than 20% are the following: height of lateral tooth (21.33), length of the middle leaf on the stem (22.79), lenght of rostrum (22.80).

High variations (CV > 30%) are present within the characters: length of the biggest leaf of rosette (30, 90), diameter of rosette (34.66). The highest variation with CV > 40% is observed for one character-the length of the longest floral branch in fruit maturation stage (51.66).

The characters of vegetative organs showed the highest variation.

Correlative variability. The analysis of correlation of morphometric characteristics has shown that the highest number of characteristics is statistically significantly correlated **(Tab. 3)**. For analysis of correlative dependance of characteristics we took that the values of correlative coefficients 0.0-0.3 show low correlation of characteristics, values 0.3-0.7 moderate correlation and higher than 0.7 show high mutual characteristic dependance. Proportionally expressed, the biggest percentage (51%) of characteristics shows low correlation, 45% moderate correlation and only 4% high correlation of morphometric characteristics. 10% shows negative mutual correlation and 10% of

Table 3. Correlations of analyzed morphometric characters of ***Jovibarba heuffelii*** in Serbia (marked correlations are significant at p<0.05)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Ros_D	1.00	0.03	**0.68**	**0.53**	**0.39**	**0.56**	**0.34**	**0.35**	**0.34**	**0.33**	0.04	0.13	**0.19**	**0.23**	**0.31**	**0.38**	**0.18**	**0.40**	**0.47**	**0.29**	**0.37**	**0.31**	**0.21**	**0.14**	-0.03
LeRos_N	0.03	1.00	**-0.16**	**-0.15**	**-0.17**	**-0.14**	**0.32**	0.13	0.12	0.00	-0.05	**-0.31**	**-0.38**	**0.18**	**0.18**	**-0.21**	**0.29**	**-0.24**	**-0.14**	**-0.40**	**-0.22**	-0.07	**-0.35**	-0.07	0.05
LeRos_L max	**0.68**	**-0.16**	1.00	**0.81**	**0.64**	**0.61**	**0.35**	**0.54**	**0.55**	**0.47**	0.09	**0.24**	**0.26**	**0.20**	**0.15**	**0.40**	0.06	**0.33**	**0.42**	**0.31**	**0.30**	**0.21**	**0.16**	0.08	-0.05
LeRos_W max	**0.53**	**-0.15**	**0.81**	1.00	**0.56**	**0.52**	**0.29**	**0.48**	**0.60**	**0.45**	0.13	**0.32**	**0.29**	0.08	0.06	**0.40**	0.07	**0.39**	**0.37**	**0.34**	**0.30**	**0.18**	**0.18**	-0.04	**-0.15**
Apex_D1	**0.39**	**-0.17**	**0.64**	**0.56**	1.00	**0.38**	**0.14**	**0.33**	**0.32**	**0.30**	0.04	**0.19**	**0.23**	0.07	0.06	**0.24**	-0.04	**0.18**	**0.20**	**0.19**	**0.16**	0.12	**0.13**	0.05	-0.04
Ste_H	**0.56**	**-0.14**	**0.61**	**0.52**	**0.38**	1.00	**0.58**	**0.54**	**0.52**	**0.49**	0.10	**0.23**	**0.24**	**0.28**	**0.24**	**0.41**	**0.21**	**0.39**	**0.41**	**0.35**	**0.40**	**0.36**	**0.22**	**0.20**	0.02
LeSte_N	**0.34**	**0.32**	**0.35**	**0.29**	**0.14**	**0.58**	1.00	**0.39**	**0.52**	**0.33**	0.05	-0.08	**-0.19**	**0.29**	**0.26**	**0.16**	**0.37**	**0.15**	**0.25**	0.00	**0.18**	**0.23**	-0.05	0.12	0.07
MidLeSte_L	**0.35**	0.13	**0.54**	**0.48**	**0.33**	**0.54**	**0.39**	1.00	**0.78**	**0.76**	0.05	0.07	0.06	**0.36**	**0.23**	**0.34**	**0.19**	**0.16**	**0.20**	0.07	0.10	0.10	-0.02	**0.14**	0.05
MidLeSte_W	**0.34**	0.12	**0.55**	**0.60**	**0.32**	**0.52**	**0.52**	**0.78**	1.00	**0.65**	0.13	**0.13**	0.05	**0.23**	**0.21**	**0.34**	**0.23**	**0.22**	**0.26**	**0.11**	**0.17**	**0.15**	0.00	0.01	-0.03
Apex_D2	**0.33**	0.00	**0.47**	**0.45**	**0.30**	**0.49**	**0.33**	**0.76**	**0.65**	1.00	0.05	0.07	0.09	**0.27**	**0.20**	**0.34**	0.09	**0.20**	**0.25**	**0.21**	**0.18**	**0.15**	0.09	0.08	-0.02
FloBra_N	0.04	-0.05	0.09	**0.13**	0.04	0.10	0.05	0.05	0.13	0.05	1.00	**0.57**	**0.30**	-0.13	-0.10	0.05	0.05	**0.22**	0.05	**0.14**	0.06	0.06	0.04	**-0.18**	-0.13
Flo_N	0.13	**-0.31**	**0.24**	**0.32**	**0.19**	**0.23**	-0.08	0.07	0.13	0.07	**0.57**	1.00	**0.82**	**-0.17**	**-0.15**	**0.21**	-0.12	**0.32**	**0.17**	**0.32**	**0.22**	**0.19**	**0.21**	**-0.14**	**-0.17**
FloBra_L max	**0.19**	**-0.38**	**0.26**	**0.29**	**0.23**	**0.24**	**-0.19**	0.06	0.05	0.09	**0.30**	**0.82**	1.00	-0.12	-0.11	**0.32**	**-0.26**	**0.36**	**0.19**	**0.40**	**0.33**	**0.25**	**0.37**	-0.07	**-0.15**
Sep_L	**0.23**	**0.18**	**0.20**	0.08	0.07	**0.28**	**0.29**	**0.36**	**0.23**	**0.27**	**-0.13**	**-0.17**	-0.12	1.00	**0.67**	**0.49**	**0.44**	**0.30**	**0.51**	0.07	**0.39**	**0.39**	**0.29**	**0.44**	**0.21**
Sep_W	**0.31**	**0.18**	**0.15**	0.06	0.06	**0.24**	**0.26**	**0.23**	**0.21**	**0.20**	-0.10	**-0.15**	-0.11	**0.67**	1.00	**0.40**	**0.61**	**0.28**	**0.52**	0.08	**0.27**	**0.30**	**0.21**	**0.26**	**0.14**
Pet_L	**0.38**	**-0.21**	**0.40**	**0.40**	**0.24**	**0.41**	**0.16**	**0.34**	**0.34**	**0.34**	0.05	**0.21**	**0.32**	**0.49**	**0.40**	1.00	**0.23**	**0.64**	**0.55**	**0.47**	**0.52**	**0.41**	**0.50**	**0.19**	0.06
Pet_W	**0.18**	**0.29**	0.06	0.07	-0.04	**0.21**	**0.37**	**0.19**	**0.23**	0.09	0.05	-0.12	**-0.26**	**0.44**	**0.61**	**0.23**	1.00	**0.22**	**0.36**	-0.02	**0.17**	**0.29**	0.01	**0.16**	0.12
Fil_L max	**0.40**	**-0.24**	**0.33**	**0.39**	**0.18**	**0.39**	**0.15**	**0.16**	**0.22**	**0.20**	**0.22**	**0.32**	**0.36**	**0.30**	**0.28**	**0.64**	**0.22**	1.00	**0.65**	**0.57**	**0.53**	**0.40**	**0.47**	**0.15**	-0.10
Ova_H)	**0.47**	**-0.14**	**0.42**	**0.37**	**0.20**	**0.41**	**0.25**	**0.20**	**0.26**	**0.25**	0.05	**0.17**	**0.19**	**0.51**	**0.52**	**0.55**	**0.36**	**0.65**	1.00	**0.47**	**0.59**	**0.51**	**0.49**	**0.24**	-0.03
Sty_H	**0.29**	**-0.40**	**0.31**	**0.34**	**0.19**	**0.35**	0.00	0.07	0.11	**0.21**	0.14	**0.32**	**0.40**	0.07	0.08	**0.47**	-0.02	**0.57**	**0.47**	1.00	**0.50**	**0.32**	**0.55**	**0.17**	-0.04
Fru_H	**0.37**	**-0.22**	**0.30**	**0.30**	**0.16**	**0.40**	**0.18**	0.10	**0.17**	**0.18**	0.06	**0.22**	**0.33**	**0.39**	**0.27**	**0.52**	**0.17**	**0.53**	**0.59**	**0.50**	1.00	**0.84**	**0.78**	**0.40**	0.00
Fru_W	**0.31**	-0.07	**0.21**	**0.18**	**0.12**	**0.36**	**0.23**	0.10	**0.15**	**0.15**	0.06	**0.19**	**0.25**	**0.39**	**0.30**	**0.41**	**0.29**	**0.40**	**0.51**	**0.32**	**0.84**	1.00	**0.57**	**0.38**	-0.02
Rost_L	**0.21**	**-0.35**	**0.16**	**0.18**	**0.13**	**0.22**	-0.05	-0.02	0.00	0.09	0.04	**0.21**	**0.37**	**0.29**	**0.21**	**0.50**	0.01	**0.47**	**0.49**	**0.55**	**0.78**	**0.57**	1.00	**0.28**	0.01
CenToo_H	**0.14**	-0.07	0.08	-0.04	0.05	**0.20**	0.12	**0.14**	0.01	0.08	**-0.18**	**-0.14**	-0.07	**0.44**	**0.26**	**0.19**	**0.16**	**0.15**	**0.24**	**0.17**	**0.40**	**0.38**	**0.28**	1.00	**0.54**
LatToo_H	-0.03	0.05	-0.05	**-0.15**	-0.04	0.02	0.07	0.05	-0.03	-0.02	-0.13	**-0.17**	**-0.15**	**0.21**	**0.14**	0.06	0.12	-0.10	-0.03	-0.04	0.00	-0.02	0.01	**0.54**	1.00

characteristics doesn't have statistically significant correlation.

The highest degree of correlation was shown by the characters hight of fruit and width of fruit (0.84). The basic group of highly correlated characters (coefficient of correlation > 0.8) is made of: number of flowers at the stage of ripening fruit- the length of the longest branch in floral fruit maturation stage- length of the biggest leaf- width of the biggest leaf.

Within the group with a moderate level of correlation, the highest coefficient of correlation was shown by the following characters: diameter of rosette - length of the biggest leaf -distance of the widest part of leaf from the top of the leaf- length of sepal-width of sepal.

Variations in relation to environmental factors. Detailed analysis of morphological characters showed that there is a clear differentiation of populations and different trends in the variation of morphological characteristics depending on the geographical location, geological substrate and altitude.

Significant differentiation of population has occurred in relation to the geomorphological characteristics of the relief - populations from the canyons and river gorges have separated from one another's, by some characters. Regarding altitude, two groups of populations are separated: first belongs to altitude up to 1000 m asl (above sea level), and second above 1000m asl. The trend was noticed that character dimensions of vegetative organs such as rosette, leaves and stem, are higher on lower altitudes. With increasing altitude, dimensions of characteristics are decreased, while the number of leaves in rosette is vice versa. Regarding geological substrate we have distinguished populations on limestone, serpentinite, silicate and red sandstone.

Analysis of variability of morphological characters of populations of the species *J. heuffelii* regarding the ground on which they grow, has shown that the most common relation of characteristics' variability is the following: limestone> serpentinite> red sandstone> silicate.

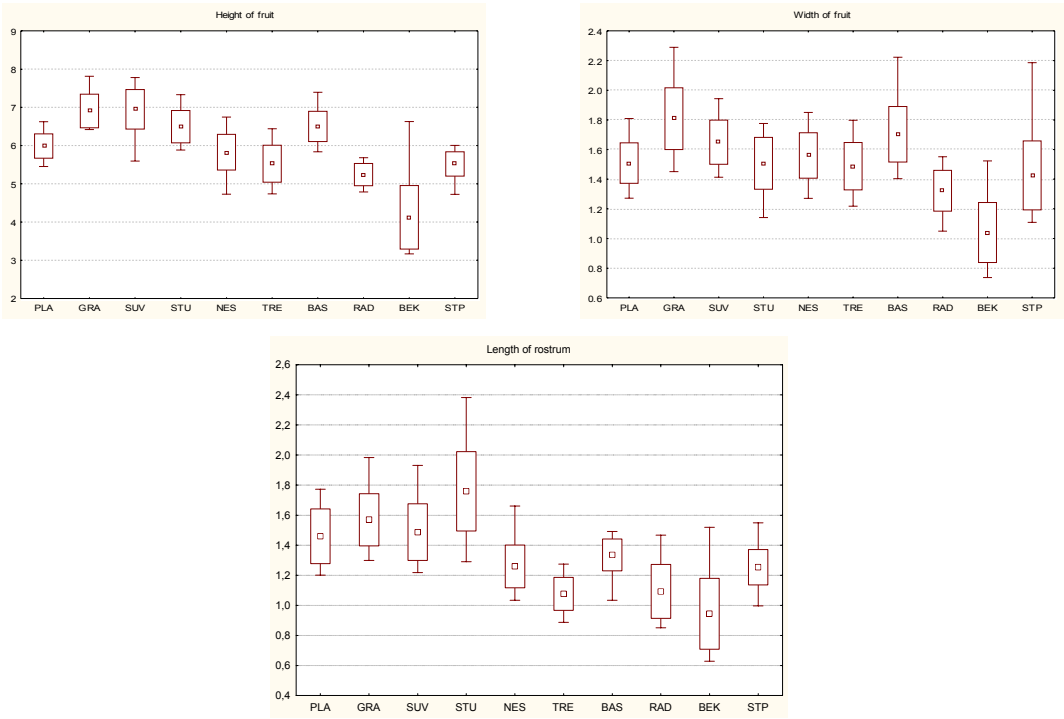

Figure 6. Box and whisker plots of basic statistic parameters of fruit

Conclusion

Analysis of variance demonstrated that all morphometric characters significantly contribute to the differentiation of the analyzed populations.

The coefficient of variation has shown that the reproductive characteristic have the higher morphological stability than vegetative characters.

The analysis of correlation of morphometric characters has shown that the highest number of characters are statistically significantly correlated.

The most notable fact is that the morphological characters of the vegetative organs (rosette, stem and leaf) are less correlated than reproductive organs (inflorescence, flower and fruit). That indicate that variability of morphological characteristics of vegetative organs is influenced by ecological factors.

Morphometric analysis of characters of species *J. heuffelii* in Serbia has shown that pedological substrate and altitude have a strong influence on variation of morphometric characters. The analysis of characters shows that variations of vegetative characters are higher then reproductive characters. Vegetative characteristics vary both in the interpopulation and intrapopulation level. Still, we can see a consistent difference in size between rosettes and leaves from higher altitude populations and those at lower altitudes and in gorges. Individuals at lower altitudes are larger, while at higher altitudes they are smaller. Amount of substrate on which they grow also determines their size. Populations that grow on rocks are smaller than those that grow in places with more soil. Geological background proved to be one of the most important factor that causes the interpopulation differentiation. The most variable characters are in populations which grow on limestone and those places record maximum values for many of the characters. Populations which grow on silicate have the smallest variations of morphology. When analyzing environmental factors, we cannot ignore the other factors such as light, temperature, precipitation, the field exposure that also affect the variability of characteristics more or less.

Acknowledgements. This work was supported by Ministry of Education and Science, Serbia, grant No.173030.

References

Gajić, M. 1972. Rod Sempervivum L., In: Josifović M. (ed.), Flora SR Srbije 4: 213-221, Srpska Akademija Nauka i Umetnosti, Beograd. (in serbian)

Holmgren, P.K., Holmgren, N.H., Barnett, L.C., 1990: Index Herbariorum. Part 1. The herbaria of the World.

Jalas J., Suominen J., Lampinen R., Kurtto A. 1999: Atlas Florae Europeae, distribution of vascular plant. 12 Resedaceae to Platanaceae, 65.

Jordanov, D. 1970. Nežit- Jovibarba Opiz. In: Flora na NR Bulgaria 4, 643-644, Sofija. (in bulgarian)

Micevski, K. 1998. Jovibarba Opiz. In: Flora na Republika Makedonija 1: 4, 1049-1050.(in macedonian)

Praeger, L.R. 1932: An Account of the Sempervivum group. The Royal Horticultural Society, London , 265 p.

Parnell, J., Favarger, C. 1993. Jovibarba Opiz. In: Tutin G.T., Burges A. N., Chater O.A., Edmondson R.J., Heywood H.V., Moore M. D., Valentine, S.M. Walters & D.A. Webb, (eds.), Flora Europaea 1: 428, Second edition, Cambridge University Press, Cambridge.

StatSoft, Inc. 2007. STATISTICA (data analysis software system), version 8.0.

Stevanović, V. & Stevanović B., 1995. Osnovni klimatski, geološki i pedološki činioci biodiverziteta kopnenih ekosistema Jugoslavije. In: Stevanović, V. & Vasić, V. (eds.), Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja, 75-95, Ecolibri, Beograd, Biološki fakultet, Beograd.

Stevanović, V. 1995. Biogeografska podela teritorije Jugoslavije. In: Stevanović, V. & Vasić, V. (eds.), Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja, 117-127, Ecolibri, Beograd, Biološki fakultet, Beograd.

Vasović, M., 1988: Geografska monografija- Stručna knjiga, Beograd.

Walter, H. & Leith, H., 1964. Klimadiagramm-Weltatlas. 2. Liefernug, Jena.