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## Morphometric characteristics of *Galium odoratum* L. (Scop). from Bulgaria

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### Abstract

The aim of the study is to analyze the morphometric parameters of 10 populations of *Galium odoratum* from Mala Planina and Ponor Mountains (Bulgaria), in accordance with the specific conditions of their habitat, and to define the similarity between their morphological characteristics by cluster analysis.

The majority of the studied morphometric parameters show a medium degree of variation between populations. Cluster analysis showed differences between the individual populations between 0 and 38%. The highest similarity was detected between the populations from habitat M-II-1 CD-2,3. With the soil humidity being the main difference between the habitat types, the analysis shows its strong role in the formation of biomass in *Galium odoratum*.

**Keywords:** *Galium odoratum*, morphometric characteristics, variation, similarity

### Introduction

*Galium odoratum* is a medicinal plant with proven pharmacological properties. In Bulgaria, the species grows in shady, predominantly beech and hornbeam forests, from 0 to 1700 m altitude (Bondev, 1995) [1].

*Galium odoratum* is subject to a special regime of conservation and use because of the risk of resource depletion. According to the provisions of the Medicinal Plants Act (2000), the special regime is determined annually until February 10<sup>th</sup> by an order of the Minister of Environment and Water. Since 2011 in the region, subject of the study, the collection of *Galium odoratum* for commercial purposes is prohibited. Cultivation of the species will provide the necessary raw material while reducing the negative impact on the natural populations of the species. In order to be effective, cultivation has to be based on a knowledge of the biology and ecology of the species. In Bulgaria, such studies for *Galium odoratum* are insufficient.

Investigation on the morphological variability of *Galium odoratum* in Southern Belgium (Martin & Bodson, 2010) [4] concluded that most of the morphological parameters (shoot growth, number of leaves in a node, leaf area, etc.) vary significantly in different locations. The morphological characteristics of the species in Bulgaria and their dependence on the environmental conditions are insufficiently studied. The aim of this article is to study the morphometric parameters of *Galium odoratum* from Mala Planina and Ponor Mountains, in accordance with the specific environmental conditions, and to define the similarity between populations from different localities by cluster analysis.

### Materials and Methods

Subject of the study are 10 populations of *Galium odoratum* from Mala Planina and Ponor Mountains. Measurement of the studied morphological characteristics was carried out on fresh plants harvested at the end of flowering - beginning of fructification.

The following parameters are analyzed: 1) leaf width; 2) leaf length; 3) leaf length/width ratio; 4) number of leaves per node; 5) number of leaves per stem; 6) stem diameter; 7) stem height; 8) inflorescence height; 9) number of flowers per stem. The leaf dimensions were analyzed separately per each node. The accuracy of measurement is 0.1 mm. For the statistical analysis only the dimensions of the first 4 nodes are used, as only part of the stems have more (5-8) nodes. The statistical analyses are performed using Microsoft Excel 2019 and NCSS 2019 software. The degree of variability of the measured characteristics is evaluated by the coefficient of variation (CV%), based on the scale of Mamaev (1968). Cluster analysis is made using the group average (unweighted pair-group) method, based on the Euclidean distances between the samples.

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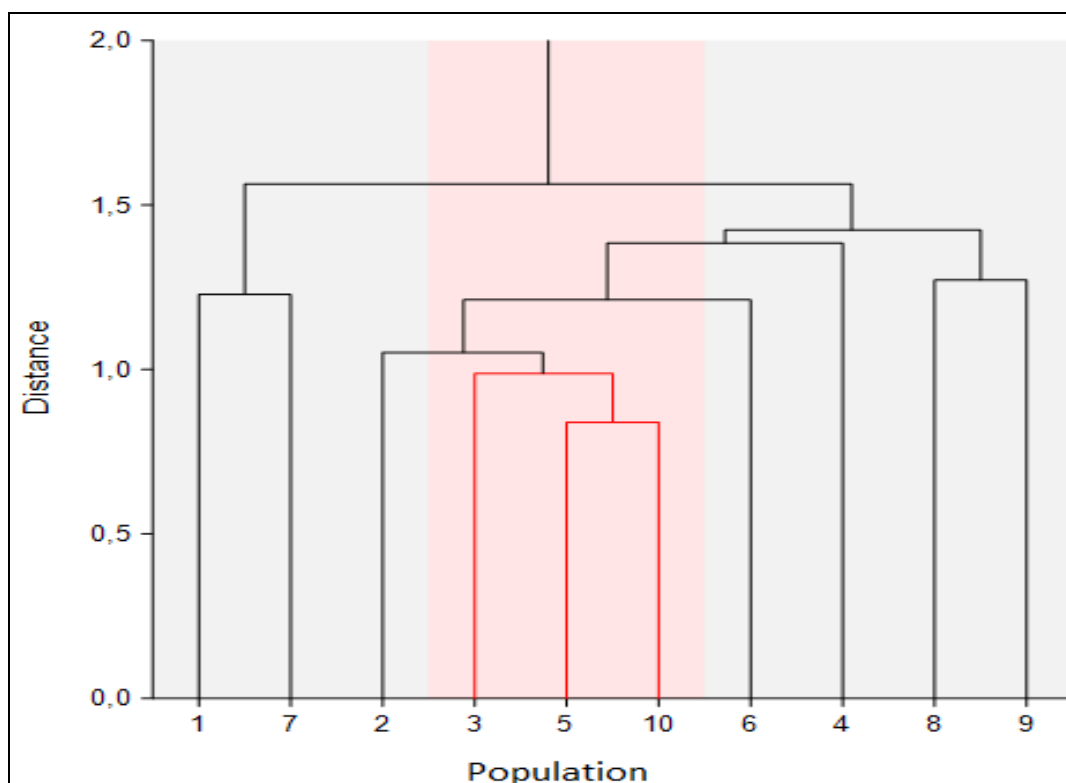
## Results and Discussion

The studied populations are located between 915 and 1070 m above sea level. The forest canopy is from 0 to 100%, mostly above 90%. The projective coverage of *Galium odoratum* is between 10 and 100%. The inclination and exposition of the slopes vary, with most of the populations growing on slopes with a north component. Eight of the ten populations grow in deciduous forests. The soils are brown transitional, clayey-sandy, slightly to medium stony, loose, medium deep to deep, fresh to moist, medium rich to rich, on quartzite or clayey shale. More information about the habitats is given in Table 1. According to the classification scheme of the types of forest habitats in Bulgaria (Executive Forest Agency, 2011) [2], the studied populations are from habitat types M-II-1 C-2 and M-II-1 CD-2,3. Both habitat types belong to the Moesian Forest Area, low mountain sub-belt of the middle mountain belt of beech and coniferous forests. Habitat M-II-1 C-2 is characterized by medium rich, fresh, medium deep and

medium stony soil, while habitat M-II-1 CD-2,3 is characterized by medium rich to rich, fresh to moist, medium deep to very deep, and slightly to medium stony soil.

The measurement of the studied morphometric parameters is done separately for the generative and vegetative stems. Since according to the conducted t-tests there are no statistically significant differences between the two fractions, the parameters are considered in general. The measured parameters and their variation between populations are given in Table 2.

The majority of the studied parameters (55%) show a medium degree of variation between populations. The lowest variation was detected in the number of leaves per node and per stem, the highest - in the leaves' length. There are no parameters with a very high degree of variation. A dendrogram showing the similarity of the studied populations with respect to the analyzed morphometric characteristics is presented in Figure 1.



**Fig 1:** Group similarity of the studied populations of *Galium odoratum*

In terms of the measured characteristics, cluster analysis showed differences between the individual populations from 0 to 38%. Populations are grouped into two main groups (Figure 1). In the first group fall populations 1 and 7. These are the populations with the lowest values of the measured parameters. All other 8 populations form the second group. In it, three of the populations are with the highest similarity – populations 3, 5, and 10, connected at less than 1 along the similarity line. These three populations are the ones from habitat M-II-1 CD-2,3.

The main difference between habitat M-II-1 C-2 and habitat M-II-1 CD-2,3 in the studied localities is the soil humidity.

While the soils in habitat M-II-1 C-2 are classified as “fresh”, the soils in habitat M-II-1 CD-2,3 are classified as “moisture” (Table 1). The results of the cluster analysis indicate that the habitat type, and hence the soil humidity is the most important factor, influencing the habitus of the plants. With the soil humidity being the main difference between the two habitat types, the analysis shows its strong role in the formation of biomass in *Galium odoratum*. The studied populations develop in localities from different forest types, slopes with different inclination and exposition, diverse shading conditions, etc. In these diverse conditions, the development of the biomass shows.

**Table 1:** Surveyed localities of *Galium odoratum*

No	Projective coverage (%)	Altitude (m)	Tree canopy	Inclination (°)	Slope	Part of the slope	Age of the trees	Height of the trees	Dominant tree sp.	Habitat type
1	20	970	100	45	N	top	60	16	Beech	M-II-1 C-2
2	30	980	100	15	N	top	60	16	Beech	M-II-1 C-2
3	10	960	100	0	N	low	60	15	Beech, hornbeam	M-II-1 CD-2,3
4	100	915	60	30	N	top	50	25	Douglas fir, Scots pine	M-II-1 C-2
5	80	928	95	40	N	top	70	18	Beech	M-II-1 CD-2,3
6	30	946	90	45	NE	top	50	15	Beech	M-II-1 C-2
7	30	1055	95	0	E	top	20	7	Beech, hornbeam	M-II-1 C-2
8	10	1064	0	0	E	top	65	16	Beech, hornbeam	M-II-1 C-2
9	15	1070	60	0	SE	top	65	16	Beech, hornbeam	M-II-1 C-2
10	75	975	100	0	NE	top	50	17	Scotch pine, beech, hornbeam	M-II-1 CD-2,3

**Table 2:** Morphometric characteristics of *Galium odoratum*

No	Width	Length	L/W	Number of leaves	Width	Length	L/W	Number of leaves	Width	Length	L/W	Number of leaves	Width	Length	L/W	Number of leaves	Number of nodes	Number of leaves	Height	Inflorescence height
1	3.0	8.3	3.0	5.0	4.5	14.3	3.2	5.8	7.4	23.6	3.7	6.6	6.8	22.8	3.4	7.2	3.8	21.9	140.0	30.1
2	3.9	12.0	3.4	5.6	6.3	18.4	3.1	6.1	8.6	30.1	3.6	7.6	8.1	31.0	3.8	7.1	4.4	27.4	222.0	40.4
3	4.4	12.7	3.2	5.9	6.6	20.1	2.9	6.4	9.9	27.3	2.8	7.0	10.0	27.0	2.4	6.6	3.9	27.2	200.0	41.0
4	4.7	16.2	3.4	5.8	8.8	32.4	3.8	6.9	10.2	38.7	3.9	7.3	10.5	31.7	3.3	7.3	4.4	30.8	249.3	34.3
5	4.8	12.1	2.4	5.9	6.5	19.9	3.1	6.2	8.4	27.9	3.4	7.5	9.9	27.8	3.7	7.2	4.3	28.9	200.5	42.1
6	4.1	11.9	2.9	6.2	7.1	24.4	3.4	7.2	7.5	29.1	3.9	7.7	7.2	27.0	3.7	7.6	3.8	26.7	224.3	41.3
7	3.7	8.5	2.4	6.0	5.6	15.4	2.8	6.4	6.5	19.0	3.0	7.3	6.1	20.3	3.4	7.9	4.3	30.0	212.0	41.9
8	3.9	13.5	3.5	6.1	4.9	17.6	3.7	6.7	5.2	20.4	3.9	7.4	5.8	24.7	4.3	6.9	4.6	31.7	241.1	45.5
9	4.9	13.9	2.8	6.4	7.0	22.2	3.1	6.9	7.8	25.5	3.2	7.1	7.6	28.0	3.7	7.3	5.1	34.5	246.8	47.9
10	4.5	12.9	3.1	5.9	7.6	22.2	3.0	7.1	9.1	27.7	3.0	7.6	6.9	26.2	3.5	7.2	4.0	27.8	213.4	42.8
Min	3.0	8.3	2.4	5.0	4.5	14.3	2.8	5.8	5.2	19.0	2.8	6.6	5.8	20.3	2.4	6.6	3.8	21.9	140.0	30.1
Max	4.9	16.2	3.5	6.4	8.8	32.4	3.8	7.2	10.2	38.7	3.9	7.7	10.5	31.7	4.3	7.9	5.1	34.5	249.3	47.9
Average	4.2	12.2	3.0	5.9	6.5	20.7	3.2	6.6	8.1	26.9	3.4	7.3	7.9	26.7	3.5	7.2	4.3	28.7	214.9	40.7
CV	14.1	19.4	12.8	6.6	19.6	25.0	10.6	7.2	18.7	20.4	12.3	4.7	21.4	12.9	13.5	4.9	9.8	11.8	14.8	12.6

### Conclusions

According to the classification scheme of the Executive Forest Agency (2011) [2], the studied populations are from habitat types M-II-1 C-2 and M-II-1 CD-2,3. The main difference between the two habitats in the studied areas is the soil humidity, with the soils in habitat M-II-1 C-2 being “fresh”, and the soils in habitat M-II-1 CD-2,3 classified as “moisture”. Within those habitat types, *Galium odoratum* inhabits localities with different shading conditions, inclination and exposition of the slopes, forest types, and moisture.

The populations from habitat M-II-1 CD-2,3 are connected at less than 1 along the similarity line. This indicates that the habitat type, and hence the soil humidity, is the most important factor, influencing the morphometric characteristics of the plants. Detailed studies are necessary to determine the optimal soil moisture conditions for the cultivation of *Galium odoratum*, which will assure the highest raw material yieldsignificant dependence on the moisture. Detailed studies are necessary to determine the optimal soil moisture conditions for the cultivation of *Galium odoratum*, which will assure the highest raw material yield

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