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Variability of *Pinus uliginosa* cones from the peat-bog in Węgliniec

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Abstract: Cones of *Pinus uliginosa* from the "Torfowisko pod Węglińcem" reserve were tested biometrically, on the basis of 16 characters. The obtained data were statistically analysed. The cone scale width, the ratio of cone length/width and the maximal diameter of cone were the most stable, while the cone scale thickness and the ratio of cone scale length/thickness were the most variable of the cone characters. The intrapopulational differentiation was not big. The examined pine species has cones with characters which are intermediate between *Pinus sylvestris*, *P. mugo* and *P. uncinata*.

Additional key words: pine, Poland, morphology, statistical analysis

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Introduction

The examined stand of *Pinus uliginosa* lies furtherest to the north limit of the species range (Jalas and Suominen 1973; Boratyński 1994). This is why it has caused much interest for years. In 1959 a natural reserve was established to protect of this peat-bog pine population. In spite of preservation, the population shows signs of aging and number of trees is decreasing, because of the lack of renewal. For the last 45 years, the number of trees has decreased by a half (compare data by Piotrowska 1958 and Danielewicz and Zieliński 2000). About 100 trees of average high of 10 m and trunk diameter of 20–30 cm grow in the reserve at the present time. The age of the oldest specimen (the dead and felled one) was calculated for more than 160 years (Danielewicz and Zieliński 2000). There are no young generations of the pine, beside of occasional seedlings. About 10 years ago, 50 young trees were planted in the east part of the reserve. The seeds for growing them had been obtained from a broken tree.

The *Pinus uliginosa* population in Węgliniec was the object of several studies. Staszkiewicz and Tyszkiewicz (1972) analysed the population differentiation on needle and cone characters. They proved that most of examined specimens from Węgliniec had cones of the *uncinata* type (within them mainly of the subtype *rostrata*), but at the same time these specimens showed typical features of *Pinus sylvestris*. According to Szweykowski and Bobowicz's (1977) investigation, based on analysis of 60 cones (from 10 trees) and 91 needles, the examined population has intermediate character between *P. sylvestris* and *P. mugo*, close to the pines from Zieleniec. Biometric studies of needles of Węgliniec pine conducted lately suggest that the pine shows features intermediate between *P. sylvestris* and *P. mugo*, but is much closer to the latter (Boratyńska et al. 2003).

The aim of the present work is to describe the morphological differentiation of *Pinus uliginosa* population in Węgliniec on the basis of cone characters, which are considered to be important from the taxonomic point of view. To determine whether the substantial decrease of the number of trees influenced the type of cones in the population, is an additional purpose (the comparison to the results of Staszkiewicz and Tyszkiewicz 1972).

Material and methods

The cones were collected from 42 individuals. Each specimen was represented by 5 cones (because of poor cones production). 16 cone characters were examined: 11 measured and 5 received as ratios (Table 1). Cones were prepared for measurement to get them closed. Measurement of the cone length, width, two diameters and the circumference of the cone (characters: 1, 2, 8, 9, 10, 11) were conducted in such a state. The scale characters were measured on the scales taken off from the convex side and maximal diameter of the cone. Cone scales were counted on the opened cone.

The data obtained were analysed statistically, with the Statistica for Windows, 1–5. Analyses were based on the measurement results, as well as on the averages of characters calculated for each individual. The arithmetical means, standard deviations and variation coefficient were calculated for each individual and for the whole sample, and the minimal and maximal values of characters were found. Connections between characters were tested with the Pearson's correlation coefficient (Zar 1999; Łomnicki 2000).

To determine characters differentiating specimens in the highest degree, and to show the intrapopulational variability the discriminate analysis was used (Krzyśko 1990; Morrison 1990). The differentiation of individuals in the population was also examined by means of cluster analysis using the shortest Euclidean distances (Marek 1989). The analyses were based on measured characters only.

Table 1. Cone characters analyzed

No	Characters	Precision
1	Length of cone	1 mm
2	Maximal diameter of cone	1 mm
3	Cone scale number	
4	Cone scale length	0.1 mm
5	Cone scale width	0.1 mm
6	Cone scale thickness	0.1 mm
7	Distance between umbo and scale tops	0.1 mm
8	Diameter of cone top	1 mm
9	Diameter of cone in meddle distance between top and maximal diameter	1 mm
10	Measurement of convex cone side from stalk to top	1 mm
11	Measurement of concave cone side from stalk to top	1 mm
12	Ratio of cone length/wide (1/2)	
13	Ratio of cone length/number of scales (1/3)	
14	Ratio of scale length/width (4/5)	
15	Ratio of scale length/thickness (4/6)	
16	Cone asymmetry (ratio of convex/concave cone measurements, 10/11)	

Results

Cones of the examined sample are rather small, with average length 33 mm (Table 2) and elongated, with length almost twice bigger then width (character 12). The big difference between diameters on the cone top (character 8) and in the middle distance between top and maximal diameter (character 9) informs on a conical shape of examined cones. The width of apophyses (character 5) is slightly bigger then their length (character 4), while the length of apophyses is usually twice bigger then their thickness (character 6). The asymmetry of cones is evident (character 16), cones of several specimens have the measurement of their convex side (character 10) twice longer then the measurement of their concave side (character 11) (Table 2).

The variability coefficient of particular characters ranged from 10 % to 32% (Fig. 1). The ratio of length to width of a cone scale (character 15) was the most variable character, strongly influenced by also very variable cone scale thickness (character 6). The ratio of cone length to cone width (i.e. the shape of the

Table 2. The characteristics of cones characters of *Pinus uliginosa* (number 1–16 as in Table 1)

Characters	Arithmetic mean	Minimum	Maximum	Standard deviation
1	33.24	25.20	44.00	4.6605
2	16.78	13.20	20.80	1.8597
3	76.20	62.60	94.80	8.4666
4	6.73	4.84	8.86	0.8646
5	6.93	5.94	8.38	0.6400
6	3.75	2.22	5.54	0.8428
7	4.37	2.48	6.12	0.8585
8	3.38	2.60	4.40	0.3946
9	12.23	9.20	14.80	1.4893
10	48.16	37.00	61.80	6.0183
11	34.60	25.00	43.20	4.7122
12	1.98	1.67	2.49	0.1707
13	0.44	0.33	0.58	0.0612
14	0.97	0.80	1.17	0.0922
15	1.92	1.03	3.56	0.5010
16	1.41	1.17	2.01	0.1680

Table 3. Correlation coefficients among 11 measured cone characters (value significant at level of: * p = 0.05, ** p = 0.01)

2	0.80**									
3	0.45**	0.55**								
4	0.48**	0.31*	-0.07							
5	0.47**	0.52**	-0.07	0.69**						
6	0.07	0.18	0.10	0.07	0.23					
7	0.27	0.21	0.08	0.57**	0.48**	0.66**				
8	0.14	0.26	-0.02	0.17	0.21	0.10	-0.16			
9	0.59**	0.85**	0.42**	0.25	0.48**	0.36*	0.22	0.43**		
10	0.88**	0.78**	0.42**	0.51**	0.52**	0.28	0.40*	0.27	0.75**	
11	0.88**	0.79**	0.45**	0.27	0.32*	0.02	0.00	0.17	0.58**	0.68**
Characters	1	2	3	4	5	6	7	8	9	10

cone, character 12) and the cone scale width (character 5) were the most stable characters (Fig. 1).

A number of significant correlations between measured cone characters were observed (Table 3). The strongest are the correlations between the cone length and measurements of convex and concave side of the cone (character 1 and characters 10, 11), and also between the length and the width of the cone (characters 1 and 2, respectively). The maximal cone

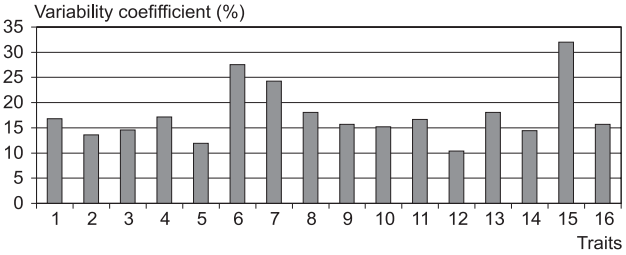

Fig. 1. Variability coefficients of particular traits of cone for 42 individuals of *P. uliginosa* (character numbers 1–16 as in Table 1)

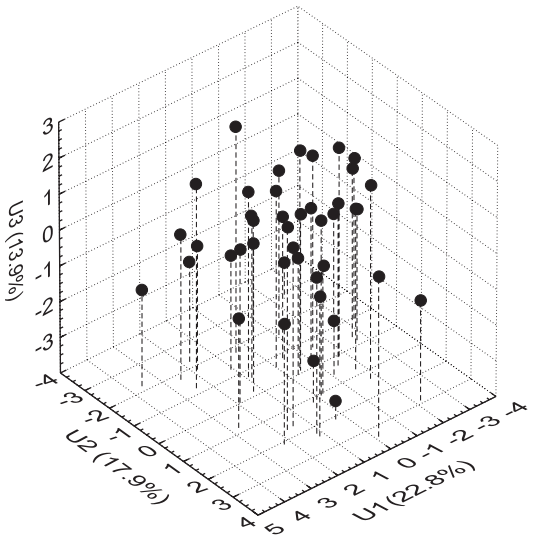

Fig. 2. Result of discriminant analysis based on 1–11 cones characters for *P. uliginosa* in the space of the first three discriminant variables U_1, U_2 and U_3

diameter (character 2) is strongly significantly correlated with the diameter measured in middle distance between top and maximal diameter (character 9), as well as with measurements of convex and concave sides of the cone (characters 10 and 11, respectively) (Table 3).

The analysis of discriminant function indicates that all characters, although in a small degree, had an influence on differentiation of individuals. The Wilk's lambda components of particular characters did not differ much and ranged from 0.421811 to 0.701991. The characters: the cone scale thickness (6) and width (5), the cone width (character 2), the number of scales (character 3) and the distance between umbo and scale top (character 7), were more important for the discrimination between individuals. The two diameters (character 8 and 9) were of the least importance for this discrimination.

The intrapopulational variation is presented on the diagram (Fig. 2) in the space of the first three variables U_1, U_2, U_3, which explained 54.56% of the whole variation of the sample. The first discriminant function U_1 is influenced by the distance between umbo and scale top (character 7), the measurement of the concave side of a cone (character 11), the cone

Table 4. Determination coefficients between discriminate variables U_1, U_2, U_3 and analysed cone characters (1–11 as in Table 1)

Characters	U_1 (22.8%)	U_2 (17.9%)	U_3 (13.9%)
1	2.1959	4.4682	2.4878
2	1.9181	0.4937	0.0466
3	0.6079	0.1841	0.1077
4	0.3740	3.1619	0.0858
5	0.6803	0.8701	0.0118
6	1.9017	2.6216	4.5729
7	5.2947	0.6520	2.2572
8	0.4759	0.2156	0.0001
9	0.9438	0.0472	0.2176
10	0.8966	1.9232	2.6856
11	4.6897	1.2211	1.2631

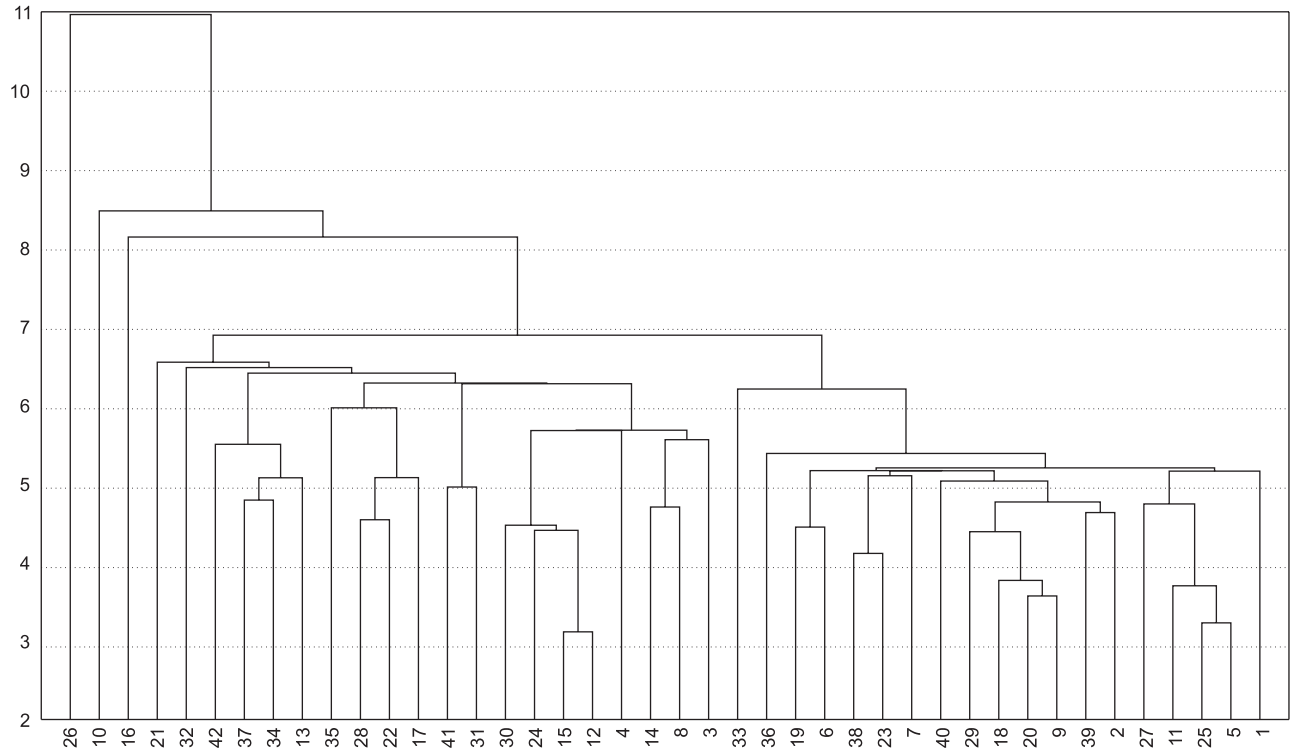

Fig. 3. Dendrograms based on 1–11 cones characters of *P. uliginosa* constructed on the basis of the shortest Euclidean distances

length and width (characters 1, 2) and cone scale thickness (character 6). The second discriminant function U_2 correlates strongest with the cone length (character 1), the cone scale length and thickness (characters 4, 6) and the cone circumference (characters 10 and 11), while the third function (U_3) with the cone scale thickness (character 6), the cone length (character 1), the distance between umbo and scale top (character 7) and the cone circumference (characters 10 and 11) (Table 4).

The differentiation of individuals within the population is not big (Fig. 2), which is also confirmed by the cluster analysis (Fig. 3). The specimen 26, having greater cones (characters 1 and 2), more numerous scales (character 3) of a slimmer shape (character 14), differs a little.

Discussion

Pinus uliginosa in Węgliniec has cones with characters which are intermediate between *Pinus sylvestris*, *P. mugo* and *P. uncinata* (Staszkiewicz and Tyszkiewicz 1972; Marcysiak 2003). Rather short cones with short and not very numerous scales resemble *Pinus mugo*, while the elongated, conical shape *Pinus sylvestris*. Cone scales of pine in Węgliniec are significantly thicker than these of a typical *P. mugo*, but not as thick as cone scales of *P. uncinata*. Cones of *P. uliginosa* are much smaller when compared with *P. uncinata*, but several calculated characters have values resembling those of the last species. The ratio of cone length/number of scales (character 13), ratio of cone length/width (character 14), ratio of cone scale length/thickness (character 15) and the cone asymmetry (character 16) of *P. uliginosa* from Węgliniec are very similar with these characters of *P. uncinata* cones. It can be concluded, that cones of *P. uliginosa* in Węgliniec resemble cones of *P. uncinata*, but they are smaller, have less numerous scales and their distance between umbo and the scale top is shorter (character 7) (data from K. Marcysiak 2003).

Staszkiewicz (1972) reached similar conclusion, including 70% of cones of researched Węgliniec specimens to *uncinata* type.

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