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Variability of *Picea abies* (L.) Karst. cones in Poland

INTRODUCTION

The variability of Norway spruce *Picea abies* (L). Karst. is manifest in the systematic differentiation of this species into a large number of varieties, cultivated forms and morphological types. A study of this variability is of considerable importance from the scientific as well as the economic point of view. For this reason there exists an urgent need for a closer characterization of the diagnostic characters for each population or race of spruce. This is likely to be possible since the species has undergone considerable differentiation while spreading over the wide reaches of Eurasia.

In Poland within the contemporary range of *P. abies* there are three regions of the species occurrance. They have formed as a result of migration from the refugia in the Slovak Carpathians, in the Eastern Carpathians and in Russia. In the late glacial and holocene history of this species one is likely to find the causes of the large scale of variability in the shoot morphology, in the needles and in the cones as well as in the physiological adaptability of the different populations. In central Europe, particularily in Poland, where several times the migration of spruce permitted crossings between different races, and the variability of the climate has induced intensive selection of new forms, the populations that have developed are characterized by great adaptability and therefore are of value well beyond their natural sites of occurrance.

For this reasons it is necessary to stress the value of the systematic studies on spruce, which in the years 1937 and 1938 Korzeniowski (1955) has conducted in the Eastern Carpathians (on Czarnohora) and in the Białowieża Forest. Korzeniowski assumes that cones as the generative organs of plants are least affected by the external conditions and have characters which will permit the recognition of lower taxonomic units within the species. In the Eastern Carpathians he has recognized individual spruce types on the basis of the cone scale tip, the arrangement of the scales on the cones, the cone shape and its dimentions. His "key" to spruce forms in the Czarnohora covers 14 types differing primarily in the shape of the cone scale.

In the Białowieża region Korzeniowski has found a much greater variability (19 morphological types) than in the isolated montane region. The author has compiled a morphological spectrum of cone scale shapes in the Białowieża Forest presenting simultaneously the percentage occurrence of the various types in the population. In spite of the reservations that one has to make concerning the subjective approach to the problem by Korzeniowski one has to admit that the study contains a very rich observation material which could be of use in the further studies on the variability of spruce.

The taxonomic studies of Lindquist (1948) on the main varieties of spruce in Europe constitute a review of the geographic varieties of the species described so far in the literature.

Within the range of *P. abies* the author recognizes three basic varieties, Siberian — var. *obovata* (Ledeb.) Fellm., the central-European var. *germanica* Lindq. and the north-European var. *arctica* Lindq. Lindquist believes that *Picea obovata* Ledeb. is an extremal variety of the polymorphic species *P. abies*. The existance of a wide transitory zone in the USSR in the regions where these two species meet and the absence of stability in the characters differentiating these two species in the western part of the distribution of the Siberian spruce are arguments in favour of the author's conclusions. Lindquist claims that this variety is very uneven in the shape of cone scales, which is supported by the fact that European forms of spruce can be found East of the Urals and in its vicinity. In Western Europe *P. abies* var. *obovata* grows usually in populations where the dominant cone scale types are var. *fennica* Reg. and var. *europaea* Tepl. The var. *obovata* spruce can be found according to Lindquist in northern Scandinavia, in Finland, in Czechoslovakia (High Tatras) in the lowland parts of the Carpathians and in the mountainous regions of Germany.

Picea abies var. *germanica* Lindq. has cones with scales similar in shape to both var. *europaea* Tepl. and var. *acuminata* Beck.

Mezera (1939) when writing about the natural distribution of spruce forms in the forest communities of Czechoslovakia recognizes the following varieties and forms: 1° var. *obovata* Ledeb. f. *transversa*, f. *typica*, f. *fennica*, 2° var. *europaea* Tepl. f. *cuneata*, f. *biloba*, f. *triloba*, 3° var. *acuminata* Beck, f. *apiculata*, f. *ligulata*, f. *typica*, and f. *squarrosa*. This division of *P. abies* into lower systematic units has been made on the basis of a visual analysis of 19 provenances collected in various parts of Czechoslovakia. The differentiating characters concern primarily the cone shape and the shape of cone scales. In conclusion based on the map of geographic distribution of the different forms, Mezera claims that var. *europaea* is very common in Czechoslovakia in the region from the Black Forest up to the east-Slovak and Carpathian range of beech (In the Sudetan Mts. this variety comprises 75 - 90% of the species). In the region east of the Slovak beech forests the var. *europaea* is replaced by var. *acuminata* (35 - 90% of occurance).

The author claims that the size of cones diminishes with an increase in elevation. He also points out the great variability of spruce cones within populations of the same geographic region.

The classification of spruce forms proposed by Priehäusser (1958) is less clear. Considering the shape of cone scales and two quantitative characters (ratio of the greatest width to length of scale and the distance of the widest part of the scale from its tip) he has recognized 6 basic varieties of spruce and a large number of intermediate forms. Studying a distribution of these forms in the mountains in the indiginous stands of the Bavarian Forest he came to the conclusion that at 1150 - 1455 m elevation there occurs primarily var. *obovata* Ledeb. and var. *fennica* Reg. and in the region between 700 and 1150 m var. *europaea* Tepl. dominates. In the mountains at an elevation of 600 to 700 m the most commonly found variety is *acuminata* Beck. Priehäusser believes that the distribution shows a certain analogy with the scatter of spruce varieties in the lowlands, where according to Heikinheimo above a latitude of 63°N varieties *obovata* and *fennica* occur and south of this region there is var. *europaea* and finally var. *acuminata*. He expresses the opinion that these last two varieties are the oldest which is shown by their ecology and cone scale shape.

The recently published data of Staszkiewicz (1966) on the variability of spruce cone scales demonstrate the results of a study conducted on cones collected from 48 stands of the species in Poland. A biometrical analysis of the material was based on the measurement of 5 cone characters (length and width of the cone and of the cone scale as well as the length of the cone scale tip) and on 4 ratios of these characters. A comparison of random samples has been made with the help of the graphical method of Jentys-Szaferowa. As a unit for comparison a cone sample was taken at random from 25 spruce populations. The results of the study have permitted the author to recognize the following groups of samples: montane, lowland north-eastern and highland from the eastern Carpathians. The author believes that the east Carpathian group represents a different morphological type of cones associated with the spruce refugium in that part of the Carpathians. Staszkiewicz presents the hypothesis that in the early holocene the east Carpathian range of spruce has been in contact with the southwestern range. Furthermore he comes to the conclusion that the spruceless zone which runs between the lowland and the upland ranges of *P. abies* does not form a definite boundry between two types of populations.

The biometric study of Ketner (1966) on the variability of present day and subfossil spruce cones in southern Poland indicates a great similarity of local samples of the cones from live and paleobotanical material, a small percentage of extremal types and the indiginuity of the described cone types.

The studies reported below on the variability of spruce cones in Poland aimed at describing the morphological differences between populations of spruce from 25 stands in various geographic regions of the species distribution in Poland. It is at the same time an attempt at characterizing the spruce populations with the help of classical methods (H. Ch.*) depending on a

* H. Ch. — Henryk Chylarecki, M. G. — Maciej Giertych.

visual estimate of the characters differentiating populations for comparison with the results obtained independently by a biometrical method (M.G.*). The classical evaluation of the populations concerned a separation of groups of populations akin in cone morphology and the selection of characters which would differentiate the populations best (as well as the determination of the best methods for the measurement of these characters and the establishment of scales for the nonmeasurable characters).

In the biometric part of the study 17 characters were measured, estimated or calculated for the cones and cone scales of the 25 spruce populations. On the basis of the results obtained discriminative value of the different characters and the variation of the populations with respect to each of the character were calculated. Furtheremore the degree of similarity between the different populations was calculated with the help of the dendritic method applied to weighed sums of differences arranged in the form of a Czekanowski table. In the discussion the separated groups of populations and their geographic distributions are discussed.

MATERIALS AND METHODS

For the study cones of 25 spruce populations were used. These were collected proportionately from 10 randomly selected trees from each stand. The geographic coordinates of the provenance of the cones are presented in table 1 (see

Table 1

List of spruce populations used in the study
Wykaz populacji świerkowych uwzględnionych w pracy

Population No. Nr popul.	Forest District Nadleśnictwo	Lat. Szerokość geogr.	Long. Długość geogr.	Alt. Wysokość n. p. m.
S-16-96	Brody Oddz. 105 k	51°42′	14°53′	80
S-16-97	Brody Oddz. 122 a	51°43′	14°48′	80
S-15-98	Kowary	50°48′	15°52′	625
S-03-99	Istebna	49°33′	18°52′	630
S-03-100	Wisła	49°37′	18°56′	650
S-04-101	Rycerka	49°32′	19°00′	530
S-04-103	Gorce	49°31′	20°07′	1000
S-09-104	Wetlina	49°08′	22°30′	700
S-10-106	Garbatka	51°31′	21°36′	130
S-10-107	Bliżyn	51°05′	20°42′	320
S-07-110	Iława	53°39′	19°34′	116
S-14-109	Konstancjewo	53°11′	19°08′	90
S-07-111	Nowe Ramuki	53°39′	20°34′	126 - 180
S-07-112	Sadłowo	53°55′	21°06′	125 - 160
S-11-113	Myszyniec	53°22′	21°09′	120
S-11-114	Sławki	53°03′	21°07′	120 - 140
S-07-115	Borki	54°06′	22°05′	155

S-07-116	Przerwanki	54°08′	22°04′	150
S-01-117	Gołdap	54°20′	22°24′	150
S-01-118	Suwałki	53°59′	23°07′	170
S-01-119	Augustów	53°54′	23°11′	130
S-01-120	Białowieża	52°40′	23°47′	160
S-01-121	Zwierzyniec	52°43′	23°47′	160
S-05-122	Międzyrzecz	52°03′	22°57′	154
S-15-125	Stronie Śląskie	50°18′	16°55′	840 - 900
S-04-133	Dolina Chochołowska	49°13′	19°48′	1400

also fig. 6). The cones were collected from felled trees taking from each tree a fixed volume of cones and mixing the cones together. After extraction of the seeds necessary for provenance experiments it was considered purposeful to subject the cones to a morphological study in order to utilize fully the available material. These results it will be possible in the future to compare with cone

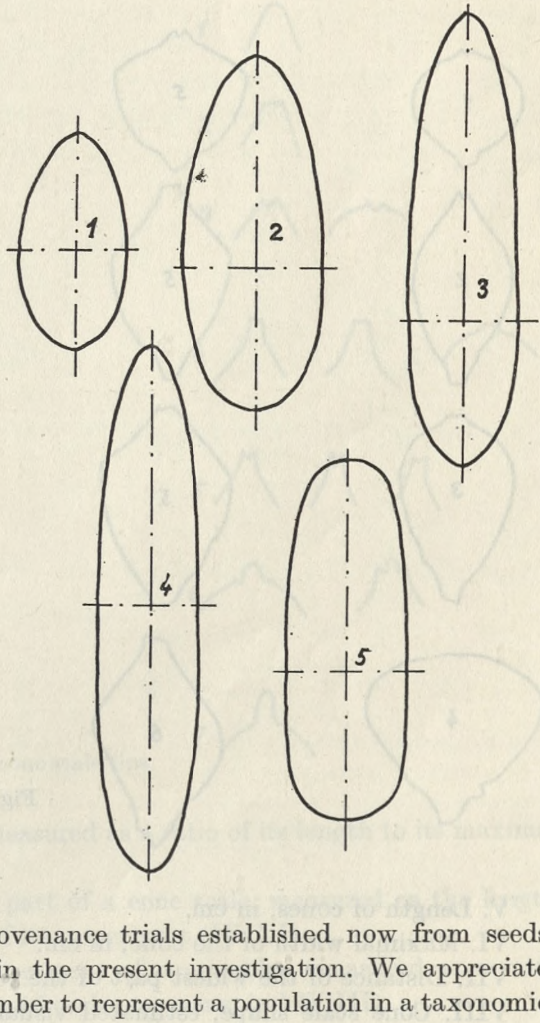

Fig. 1. Recognized types of cone shapes

characters from trees in field provenance trials established now from seeds extracted from the cones used in the present investigation. We appreciate that 10 trees is not a sufficient number to represent a population in a taxonomic sence, however we believe that this number at least in the general outline will characterize the morphological differentiation of spruce in Poland.

After an introductory observation of the cones one of us (H. Ch.) has selected 17 characters which are most likely to differentiate the populations. These are:

I. Cone shape — estimated visually on a 5 point scale: 1) ovate, 2) typical or elongate — ovate, 3) ovate — lanceolate, 4) narrowly elipsoidal, and 5) columnar (fig. 1).

II. Arrangement of scales — estimated visually on a 3 point scale: 1) appressed, 2) undulate, 3) lossely projecting.

III. Number of cone scales on one spiral — in absolute values.

IV. Angle of the spiral to the cone axis measured in the central part of the cone, in degrees.

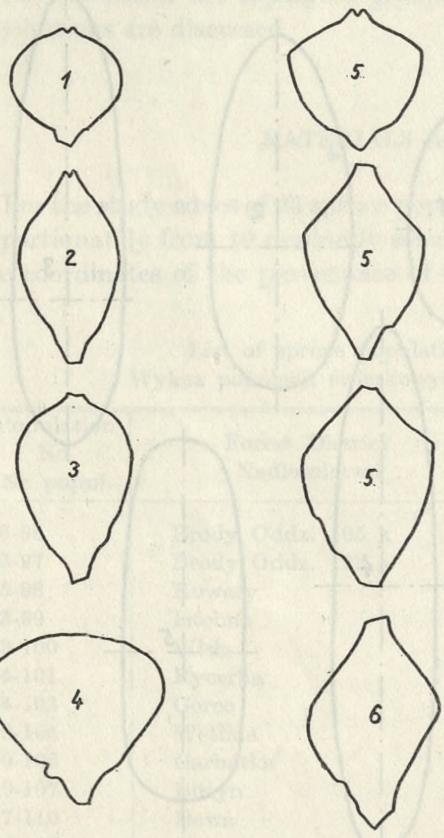

Fig. 2. Recognized types of cone scale shapes

V. Length of cones, in cm.

VI. Maximal width of the cone, in cm.

VII. Distance of the widest part of the cone from the base, in cm.

VIII. Cone scale shape, estimated visually on a 6 point scale: 1) round,

2) eliptical, 3) obovate, 4) fan-shaped, 5) crest-shaped, 6) rhomboidal (fig. 2).

IX. Length of cone scale (in the central part of the cone) in cm.

X. Maximal cone scale width, in cm.

XI. Length of the upper part of the cone scale, from the cone scale tip to its widest part, in cm.

XII. Shape of the cone scale tip, estimated visually on a 7 point scale: 1) rounded, 2) cut, 3) incized or bifid, 4) tongued, cut, 5) tongued incized or bifid, 6) tongued trifid, 7) projecting (fig. 3).

XIII. Cone slenderness measured as a ratio of its length to its maximal width (V/VI).

XIV. Position of the widest part of the cone, measured as a ratio of the distance from the base to the widest part to the length of the cone (VII/V).

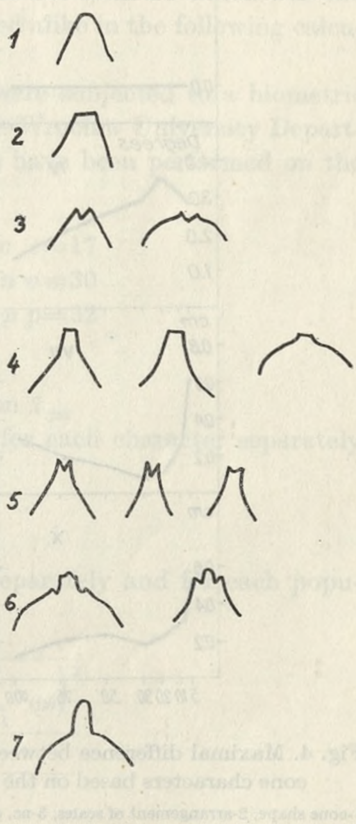

Fig. 3. Recognized types of cone scale tips

XV. Cone scale slenderness measured as a ratio of its length to its maximal width (IX/X).

XVI. Position of the widest part of a cone scale, measured as the length of the cone scale to the length of its upper part (IX/XI).

XVII. Looseness of the arrangement of cone scales, measured as a ratio of the cone length to the number of scales on one spiral (V/III).

In order to check the number of cones which have to be measured to describe each population fully a small auxillary experiment was performed. In the Gołdap forest district into 3 sacks 100 cones were collected from 100 felled trees, with only one cone per tree in each sack. The cones were extracted and measurements have been performed.

Comparing these three lots of cones on the basis of averages for each character obtained after measurement of 5, 10, 20, 30, 50, 75 and 100 cones it was established that the maximal difference between the three replicates ceases to be of any practical importance when 30 cones have been measured. For each of the first 12 characters a small graph was drawn of the maximal differ-

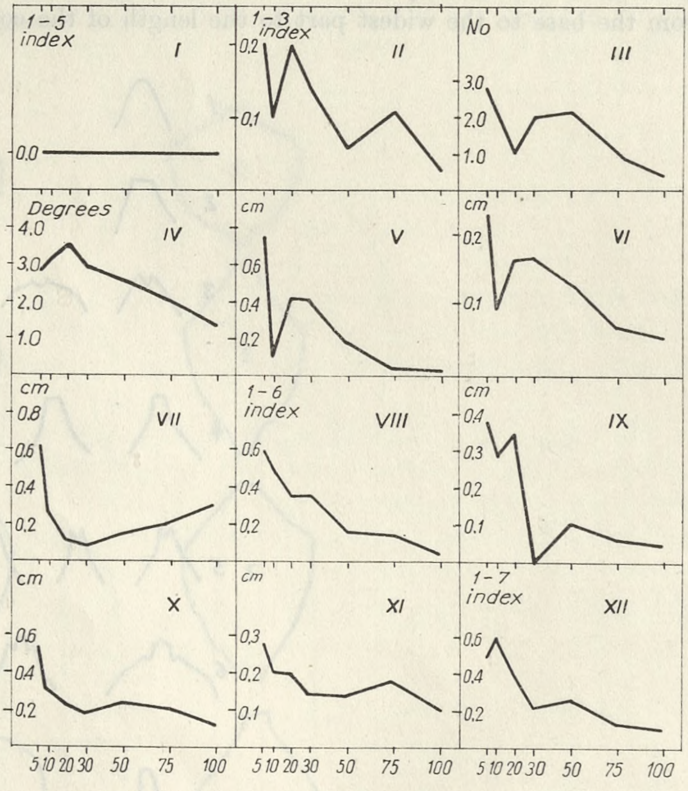

Fig. 4. Maximal difference between three independent measurements of mean values for cone characters based on the measurement of 5, 10, 20, 30, 50, 75 and 100 cones

1-cone shape, 2-arrangement of scales, 3-no. of scales on one spiral, 4-angle between spiral and axis, 5-cone length, 6-maximal cone diameter, 7-position of maximal diameter on axis, 8-shape of cone scales, 9-length of scale, 10-maximal scale width, 11-length of scale apex, 12-shape of scale apex

ence between replicates depending on the number of cones from which the averages were calculated. All the graphs were more or less hyperbolic. A further drop of the difference between replicates was for all the characters insignificant when the averages were based on a larger number of cones than 30 (fig. 4). It has been established therefore that in order to compare populations collection of one cone from 30 trees should be sufficient. In our case, where we had at our disposal mixed cones from 10 trees, for the characterization of the available population of cones measurement of a larger number of cones than 30 would be all the more useless. For this reason the measurements were done on 30 cones.

Before measurements the cones were soaked in water for 24 hours in order to obtain a closure of the cone scales. From each cone one scale was measured obtained from the middle part of the cone by breaking the cone in half.

In order to convince ourselves about the value of the conducted measurements for some of the populations they have been replicated, about which the man performing the measurements was not informed. Thus in all we have obtained measurements from 32 lots of cones and not from 26 which was the number of populations studied. All 32 were treated alike in the following calculations.

The measurements and estimates obtained were subjected to a biometric analysis with the help of an Elliot computer of the Wrocław University Department of Numerical Methods. The measurements have been performed on the following material:

17 characters 1 ... m ... c $c=17$
on 30 cones 1 ... i ... n $n=30$
separately for 32 populations 1 ... j ... p $p=32$

The following calculations were made:

1. Means for each character in each population $\bar{x}_{.jm}$
2. Sum of squares for each population and for each character separately

$$\sum_{i=1}^{n} x^2_{ijm}$$

3. Standard deviation s for each character separately and for each population

$$s = \sqrt{\frac{\sum_{i=1}^{n} x^2_{ijm} - \frac{\left(\sum_{i=1}^{n} x_{ijm}\right)^2}{n}}{n-1}}$$

4. Mean square for the population separately for each character

$$V_p = \frac{\frac{\sum_{j=1}^{p}\left(\sum_{i=1}^{n} x_{ijm}\right)^2}{n} - \frac{\left(\sum_{ij=1}^{np} x_{ijm}\right)^2}{np}}{p-1}$$

5. Mean square for the error term (within population) separately for each character.

$$V_e = \frac{\sum_{ji=1}^{np} x^2_{ijm} - \frac{\sum_{j=1}^{p}\left(\sum_{i=1}^{n} x_{ijm}\right)^2}{n}}{p(n-1)}$$

6. Least significant difference for each character.

$$D_m = Q\sqrt{\frac{V_e}{n}}$$

	Wetlina	Dol. Chochołowska	Dol. Chochołowska	Nowe Ramuki	Brody — 105	Konstancjewo	Międzyrzec	Iława	Iława	Brody — 122	Kowary	Brody — 122	Stronie Śląskie	Istebna	Przerwanki	Rycerka	Wisła	Borki	Borki	Gorce	Borki	Sadłowo	Gołdap	Augustów	Sławki	Suwałki	Bliżyn	Białowieża	Wisła	Zwierzyniec	Garbatka	Myszyniec	
	1						2														3						4						
Wetlina		3	4	6	10	20	19	20	18	22	14	16	12	12	11	12	14	8	6	4	6	6	12	12	8	12	19	21	17	22	23	23	
Dol. Chochołowska	3		0	3	6	14	16	19	15	17	14	13	12	10	12	11	12	8	9	5	6	8	12	13	9	12	18	20	17	23	26	26	
Dol. Chochołowska	4	0		1	3	10	12	16	11	13	10	10	10	7	9	7	8	7	6	5	3	6	8	10	7	9	15	17	14	21	23	22	
Nowe Ramuki	6	3	1		0	8	7	10	6	8	6	5	6	3	7	6	4	5	4	4	2	5	4	7	4	6	12	14	10	19	20	19	1
Brody — 105	10	6	3	0		4	6	8	4	6	3	4	3	4	5	7	3	6	4	6	8	8	6	9	10	12	17	18	12	22	26	24	
Konstancjewo	20	14	10	8	4		6	13	6	6	9	14	10	10	13	14	11	15	14	17	18	19	14	21	20	20	23	26	21	32	33	33	
Międzyrzec	19	16	12	7	6	6		2	0	2	7	5	7	3	6	8	4	8	9	14	12	10	5	12	13	10	10	12	9	20	20	21	
Iława	20	19	16	10	8	13	2		1	2	5	3	9	4	6	8	3	10	9	15	12	11	7	11	14	12	11	11	5	16	17	17	
Iława	18	15	11	6	4	6	0	1		1	4	1	4	1	4	6	2	6	7	12	11	10	5	11	13	11	13	12	7	17	20	21	
Brody — 122	22	17	13	8	6	6	2	2	1		3	4	8	5	8	9	7	12	11	16	14	14	9	14	16	14	13	15	16	21	22	23	
Kowary	14	14	10	6	3	9	7	5	4	3		1	3	1	2	4	4	6	4	6	8	10	7	9	14	13	15	16	8	17	22	22	
Brody — 122	16	13	10	5	4	14	5	3	1	4	1		3	2	3	5	2	5	3	9	6	6	5	6	9	8	10	8	3	11	17	15	
Stronie Śląskie	12	12	10	6	3	10	7	9	4	8	3	3		3	2	7	5	4	3	6	9	10	6	10	15	15	17	17	11	18	23	24	
Istebna	12	10	7	3	4	10	3	4	1	5	1	2	3		0	0	3	1	1	6	5	6	1	6	9	6	9	10	4	11	16	16	2
Przerwanki	11	12	9	7	5	13	6	6	4	8	2	3	2	0		0	3	1	1	4	5	6	5	6	11	8	12	11	5	11	17	17	
Rycerka	12	11	7	6	7	14	8	8	6	9	4	5	7	0	0		4	0	2	4	4	7	2	4	10	5	9	9	4	9	15	15	
Wisła	14	12	8	4	3	11	4	3	2	7	4	2	5	3	3	4		4	3	7	4	5	3	6	8	6	9	9	3	12	16	14	
Borki	8	8	7	5	6	15	8	10	6	12	6	5	4	1	1	0	4		1	3	3	2	2	4	9	6	11	11	6	10	15	16	
Borki	6	9	6	4	4	14	9	9	7	11	4	3	3	1	1	2	3	1		1	2	3	2	3	8	7	11	11	7	11	18	15	
Gorce	4	5	5	4	6	17	14	15	12	16	6	9	6	6	4	4	7	3	1		4	6	6	7	7	9	15	16	12	15	21	19	
Borki	6	6	3	2	8	18	12	12	11	14	8	6	9	5	5	4	4	3	2	4		1	2	1	3	2	7	8	5	10	12	11	
Sadłowo	6	8	6	5	8	19	10	11	10	14	10	6	10	6	6	7	5	2	3	6	1		2	2	2	2	5	6	5	9	9	10	
Gołdap	12	12	8	4	6	14	5	7	5	9	7	3	6	1	3	2	3	2	2	6	2	2		1	4	3	4	4	2	7	10	10	
Augustów	12	13	10	7	9	21	12	11	11	14	9	6	10	6	6	4	6	4	3	7	1	2	1		3	1	3	3	2	5	5	7	3
Sławki	8	9	7	4	10	20	13	14	13	16	14	9	15	9	11	10	8	9	8	7	3	2	4	3		2	4	7	7	12	10	9	
Suwałki	12	12	9	6	12	20	10	12	11	14	13	8	15	6	8	5	6	6	7	9	2	2	3	1	2		1	2	2	7	6	7	
Bliżyn	19	18	15	12	17	23	10	11	13	13	15	10	17	9	12	9	9	11	11	15	7	5	4	3	4	1		0	2	8	3	5	
Białowieża	21	20	17	14	18	26	12	11	12	15	16	8	17	10	11	9	9	11	11	16	8	6	4	3	7	2	0		1	3	2	4	
Wisła	17	17	14	10	12	21	9	5	7	16	8	3	11	4	5	4	2	6	7	12	5	5	2	2	7	2	2	1		4	6	5	
Zwierzyniec	22	23	21	19	22	32	20	16	17	21	17	11	18	11	11	9	12	10	11	15	10	9	7	5	12	7	8	3	4		4	4	4
Garbatka	23	26	23	20	26	33	20	17	20	22	22	17	23	16	17	15	16	15	18	21	12	9	10	5	10	6	3	2	6	4		2	
Myszyniec	23	26	22	19	24	33	21	17	21	23	22	15	24	16	17	15	14	16	15	19	11	10	10	7	9	7	5	4	5	4	2		

Fig. 5. Table of the sum of weighted means giving a comparison of each population with each. The shaded values (below 4) indicate populations between which no statistical differences have been demonstrated. In the table, 4 groups of populations are recognized with considerable similarities within the groups

$Q=2.77$ for $p(n-1)=928$ degrees of freedom and 0.05 confidence limits.

7. Summation of differences for each pair of populations that is for $\frac{p^2-p}{2}=$ $=496$ pairs.

$$\text{Summation of difference for one pair, eg. } P_1P_2 = \sum_{m=1}^{c} \frac{\sqrt{(\bar{x}_{.1m}-\bar{x}_{.2m})^2}-D_m}{D_m}$$

in this sum each component of the sum having a negative value has been considered as equal to zero (Wright and Bull 1963)

8. Theoretical distance between populations and groups of populations in a dendritic arrangement treating the table of the summation of differences as a Czekanowski type of table (Kowal and Kuźniewski 1958).

Comparing the mean square for a population with the mean square for the error term for each character a value of F was obtained, which is a measure of the discriminant value of the individual characters.

The values of the summation of differences have been arranged in the form a Czekanowski table. The sequence of populations in the table has been rearranged several times until such an arrangement was obtained in which as far as possible large values were positioned in the corners of the table and small values along the diagonal (fig. 5). In the table on fig. 5 the values of summation of difference from 0 to 4 have been shaded in order to accentuate the agglomeration of populations. A summation of difference equal to 4 is the largest that was found between any two replicates, thus values of 4 and below cannot be considered as demonstrating a difference between populations.

RESULTS

THE CLASSICAL EVALUATION

To start with the material was described in the classical sence that is exclusively on the basis of observations and descriptions of the cones. On the basis of this study one of us (H. Ch.) has recognized 6 groups of populations of spruce differing in the shape of cone scales.

1. The first and largest group, comprises 12 populations from the Mazurskie Lakes and the northern part of the Region of Great Valleys. It includes spruce populations from the forest districts Borki, Nowe Ramuki, Sadłowo, Przerwanki, Augustów, Suwałki, Gołdap, Zwierzyniec, Sławki and Myszyniec. The most important distinguishing features of this group are and elongate rhomboidal cone scale shape (fig. 2 nr 6) and the broadly cut acute angled or tongued tip (fig. 3 no 2 and 4), (morphological type akin to var. *acuminata* Beck and var. *europaea* Tepl.).

2. The second group consists of 8 spruce populations which have been found as outliers on the spruceless region (forest districts Iława, Konstancjewo,

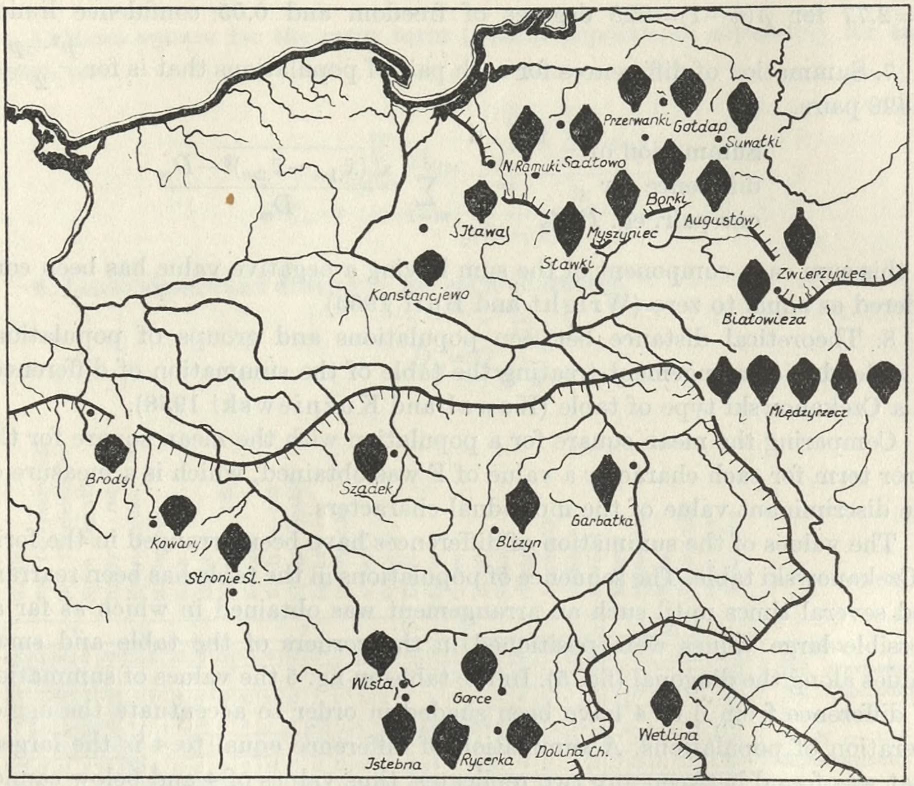

Fig. 6. Distribution of the morphological types of cone scales of spruce in Poland on the basis of a visual evaluation

Brody), and from the mountains in the Sudeto-carpathian region (forest districts Kowary, Stronie Śląskie, Wisła, Gorce and Dolina Chochołowska). These populations are characterized primarily by round or obovate cone scales of medium size (fig. 2 no 1 and 3) which have a rounded (fig. 3 no 1) or incized (fig. 3 no 3) tip or with a slight tongue (fig. 3 no 4). The greatest width of the cone scale has been noted in the middle of its length (morphological type akin to var. *obovata* f. *fennica*).

3. The third group comprises 2 spruce populations from the Silesian Beskids (forest districts Rycerka and Istebna). Cone scales of these populations are characterized by a marked assymetry, with one half of the cone scale having a distinctly rhomboidal shape (var. *europaea*) while the other has a round or obovate shape (f. *fennica*). The short tip is incized.

4. In the fourth group spruce populations from the Małopolska Upland (forest districts Garbatka, and Bliżyn) have been included, since their cone scales have a narrowly and widely rhomboidal shape (fig. 2 nr 6).

5. and 6. Furthermore two other populations deserved to be treated individually as separate groups since their cone scales are very special. The population from Międzyrzec Podlaski is characterized by an unusual variabi-

lity of the cone scales and the population from Wetlina in the Bieszczady, differed in having a very regular rhomboid shape of cone scales.

Shape characteristics of the cone scales were considered as most diagnostic. For each population a typical cone scale shape was drawn on the basis of a visual impression attempting to make the drawing as representative of the population as possible. These cone scale shapes have been drawn in onto a map of spruce distribution in Poland (fig. 6).

THE DISCRIMINATIVE VALUE OF CHARACTERS

From a comparison of the F values calculated for the populations from the analysis of variance of each character it was possible to establish to what extent the various characters are useful in differentiating the populations. All the values of F proved significant at the 0.01 level of significance, thus all the characters to some extent differentiate the populations. The order of characters from the most strongly to the most weakly discriminating between the populations is as follows: IX, XVII, XI, V, XIII, III, VII, XIV, I, II, XV, VI, XVI, VIII, X, IV and XII.

As can be seen from the above listing the characters that were estimated, I, II, VII and XII, belong to the less useful in differentiating populations. These characters play the greatest role in the visual evaluation of the variability since it is shape rather than size that one first notices. In the biometric study the role of shape characteristics declined primarily because these are characters that are difficult to present numerically. The characters of cone and cone scale length and the distance to their widest parts (V, IX, VII and XI) belong to the best characters while the width of cones (VI) and cone scales (X) are less useful. Unexpectedly the looseness of cone scale arrangement (XVII) proved to be one of the characters most useful in differentiating populations, while in the visual estimate it almost did not bear any weight at all. Also the number of cone scales in a spiral (III) belongs to the more useful characters. On the other hand the angle of the spiral (IV) which was very difficult to measure accurately did not differentiate the populations much. Cone slenderness (XIII) is somewhat more important than cone scale slenderness (XV). The character used as a basis for the distinction between var. *europaea* and var. *acuminata*, namely the ratio of the cone scale length to the length of its upper part (XVI), proved to belong to the less useful characters in differentiating populations.

THE DIFFERENTIATION OF POPULATIONS WITH RESPECT TO EACH CHARACTER

With the help of a computer mean values were obtained for each population with respect to each character. In figs. 7 - 23 the mean values are presented separately for each character. The sequence of the figures runs from the characters differentiating the populations most to those differentiating them least. In each drawing the populations are arranged from the lowest values to the highest for the character concerned. Together with the means also the range of the values for the particular character in each populations is shown as a horizontal line, the length of which was calculated as 1.96×the standard deviation. In this way 95% of individuals within each population are included in the limits demarcated by the horizontal line. Also on each graph the least significant difference D as calculated from the Duncan (1955) test has been drawn in in order to show the minimal difference between means of adjacent populations that can be considered as significantly distinguishing the populations, in the character concerned.

From these figures it was noticed that the large variability observed in the visual evaluation of the population from Międzyrzec Podlaski was only partially substanciated. It is large with respect to characters XI (length of the upper part of the cone scale fig. 9), XIII (cone scale slenderness fig. 11), III (number

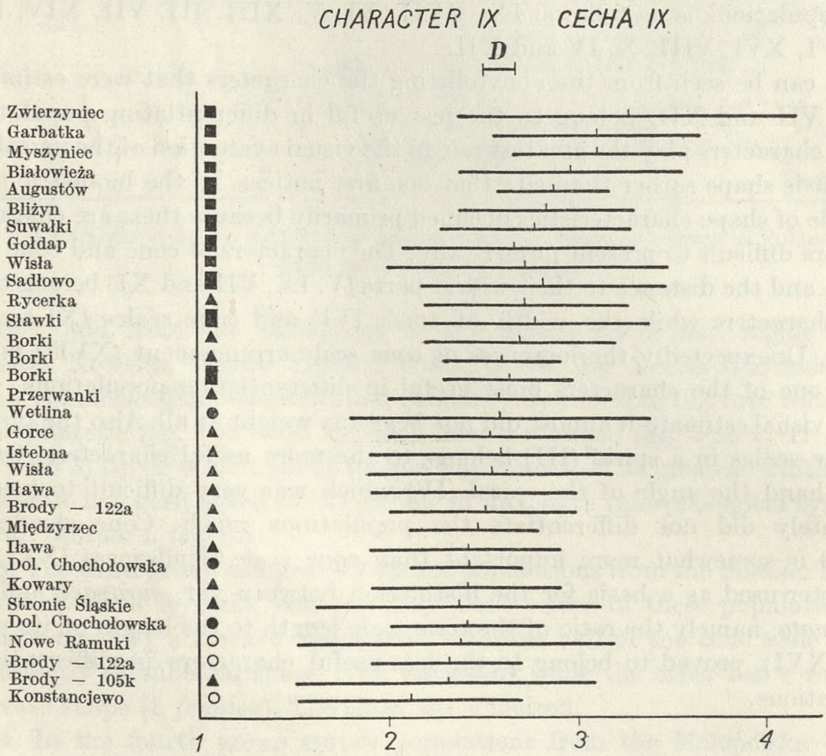

Fig. 7. Mean cone scale lengths and the dispersions within each population for this character (IX)

In figures 7 to 23 the symbols besides each population correspond to the groupings obtained from the biometric study Groups 1a, 1b, 2, 3 and 4 are marked by black circles, white circles, triangles, rectangles and squares respectively D – is the least significant difference.

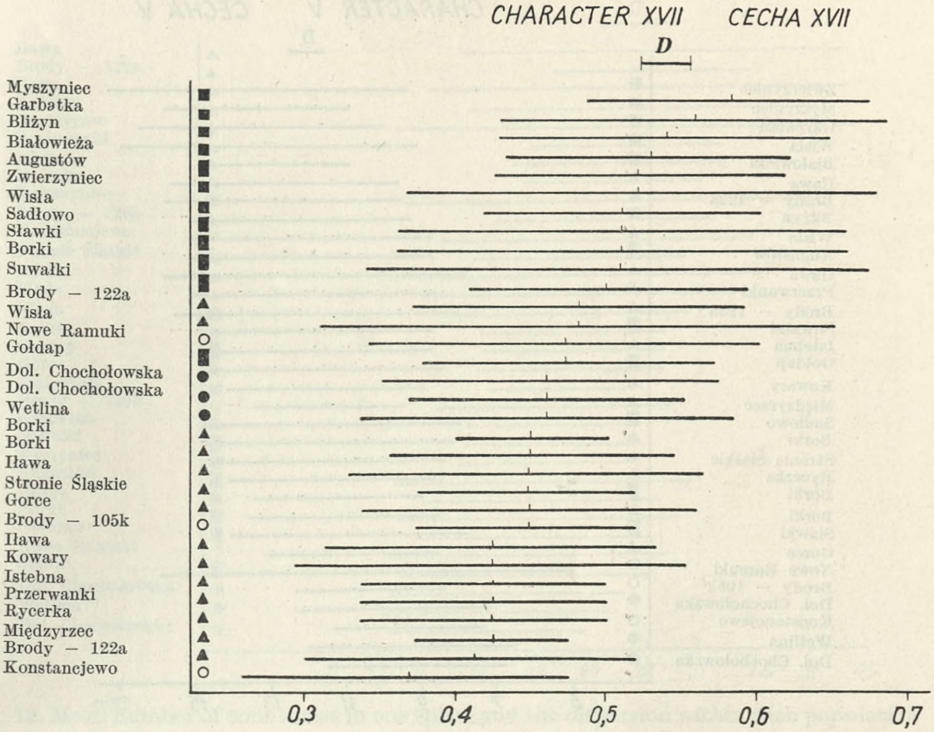

Fig. 8. Mean values of the looseness of cone scale arrangement and the dispersions within each population for this character (XVII)

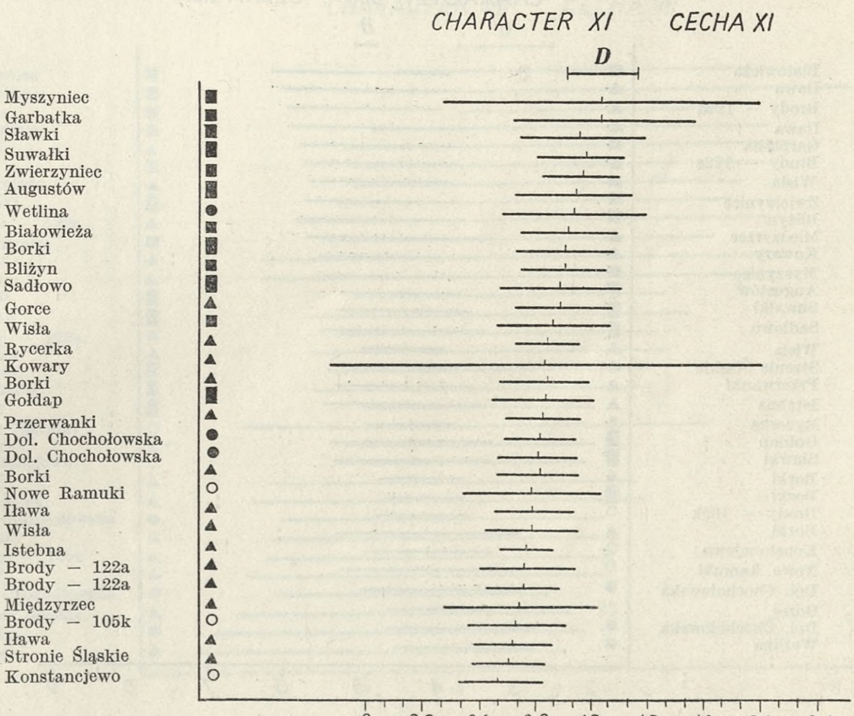

Fig. 9. Mean height of the cone scale tip and the dispersion within each population for this character (XI)

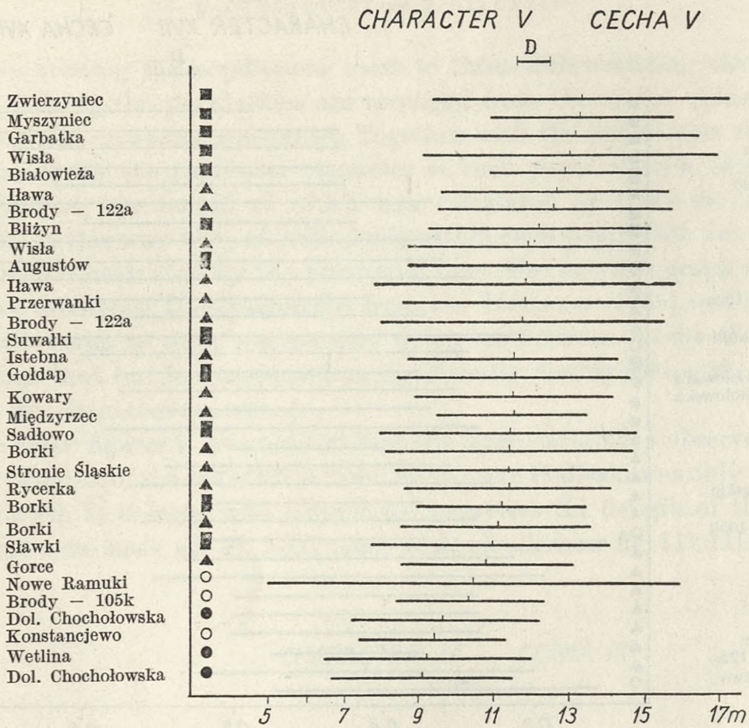

Fig. 10. Mean cone length and the dispersion within each population for this character (V)

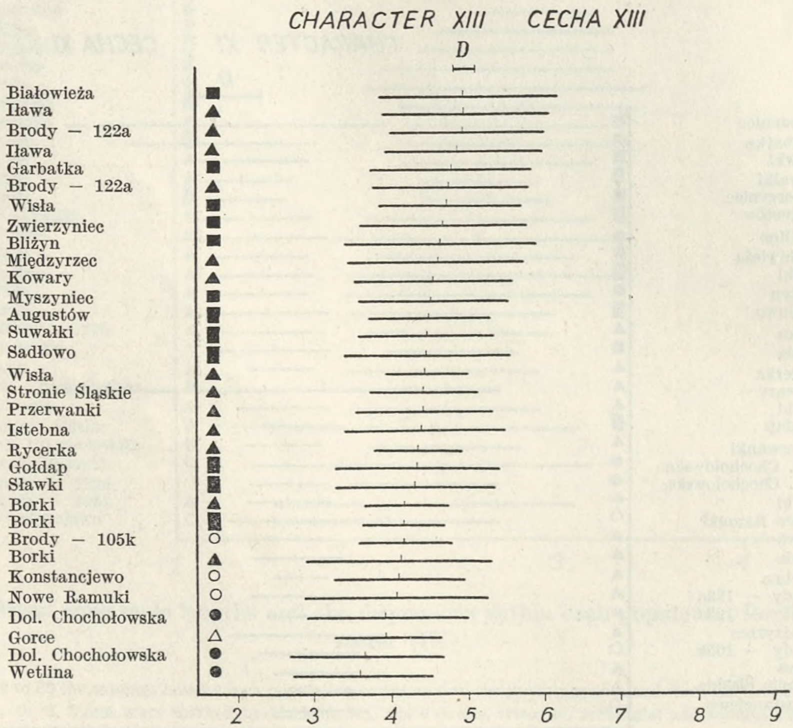

Fig. 11. Mean slenderness of cones and the dispersion within each population for this character (XIII)

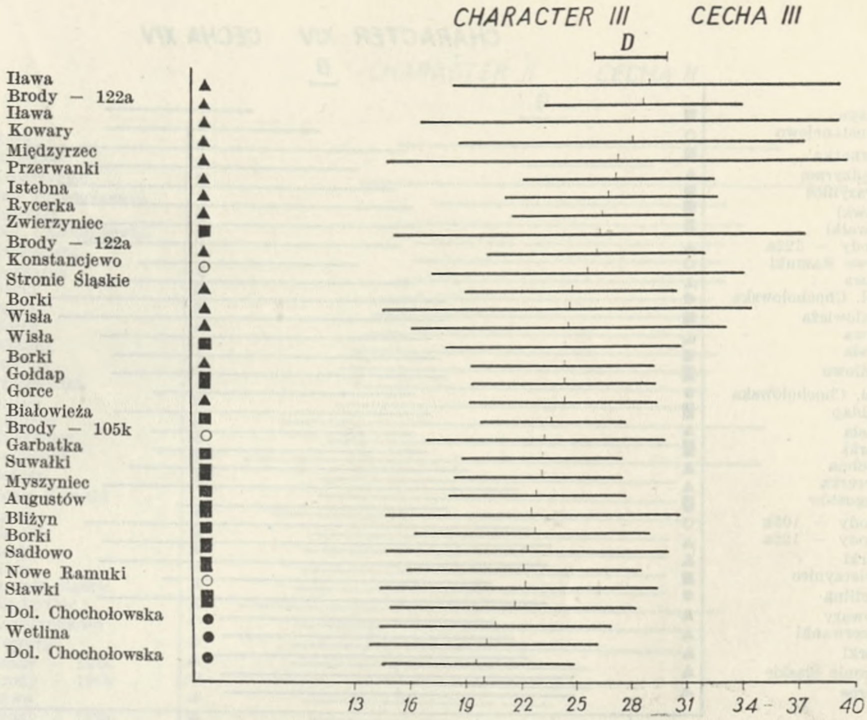

Fig. 12. Mean number of cone scales in one spiral and the dispersion within each population for this character (III)

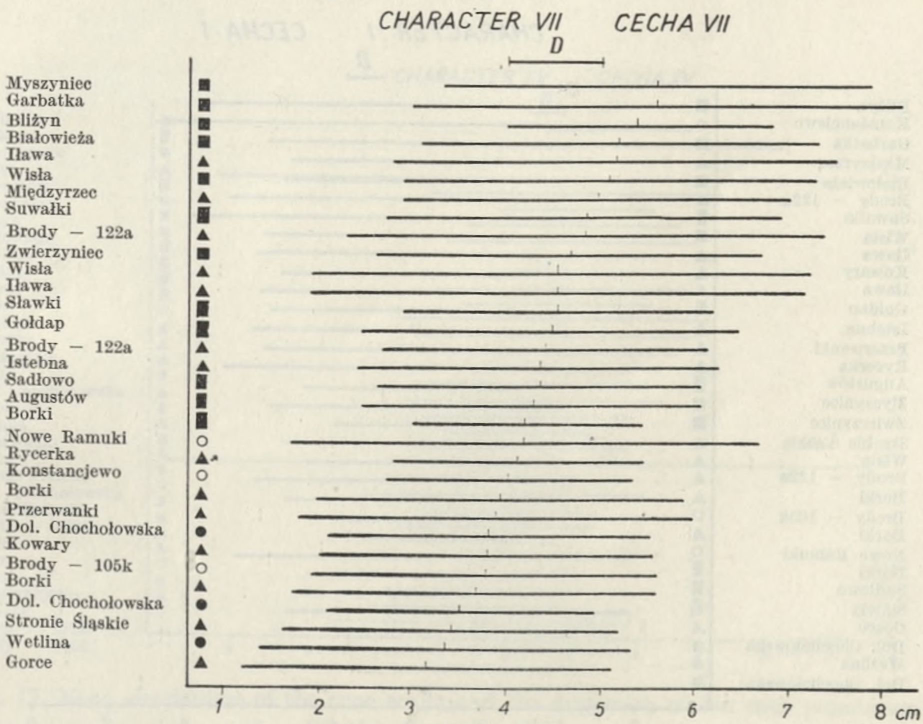

Fig. 13. Mean distance of the widest part of cone from cone base and the dispersion within each population for this character (VII)

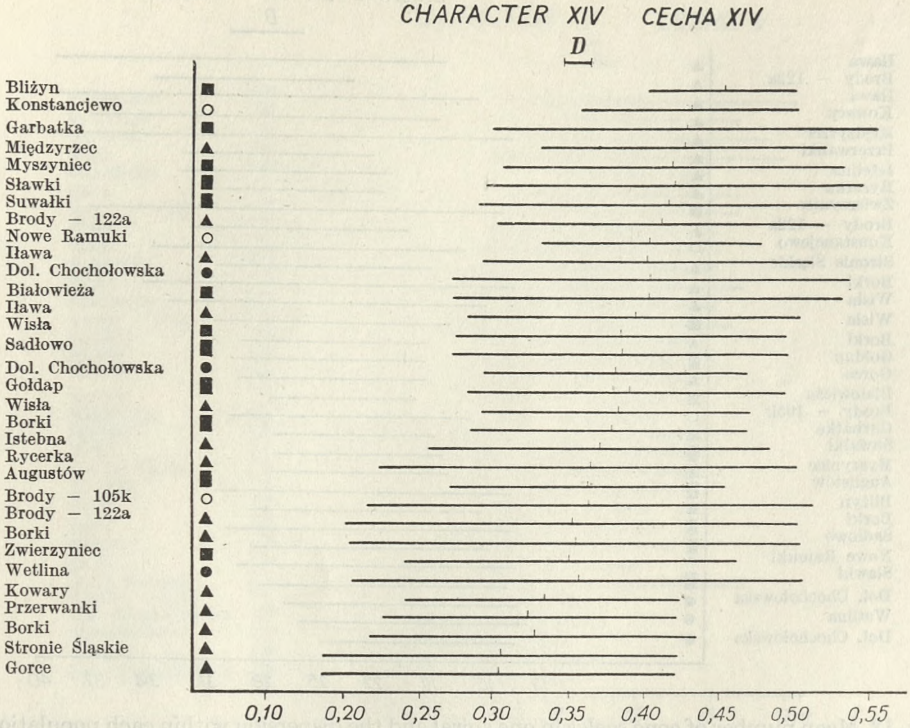

Fig. 14. Mean position of the cones widest part and the dispersion within each population for this character (XIV)

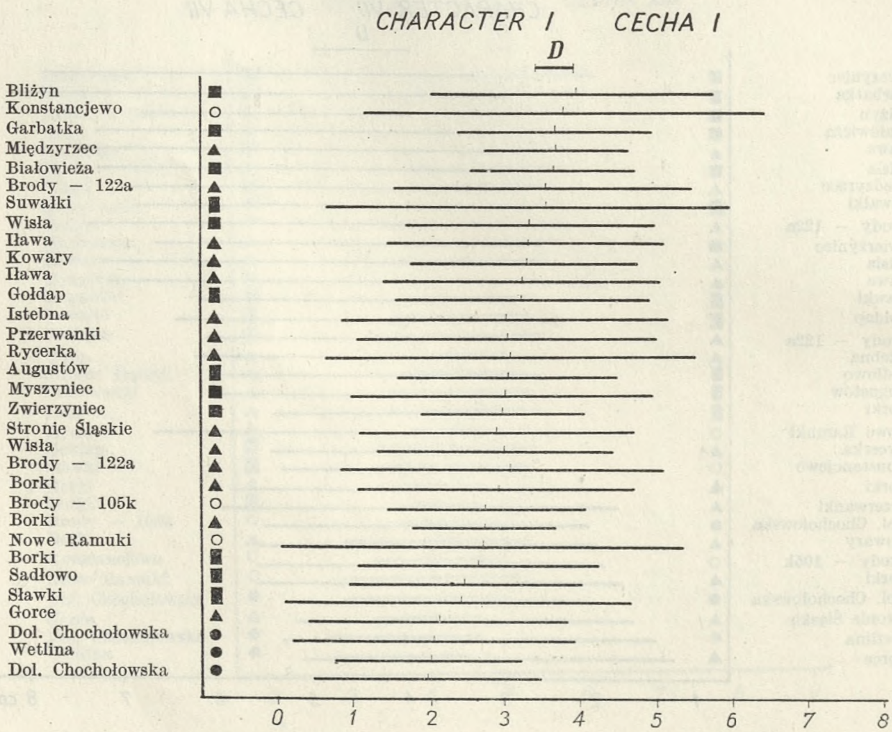

Fig. 15. Mean shape of cone and the dispersion within each population for this character (I)

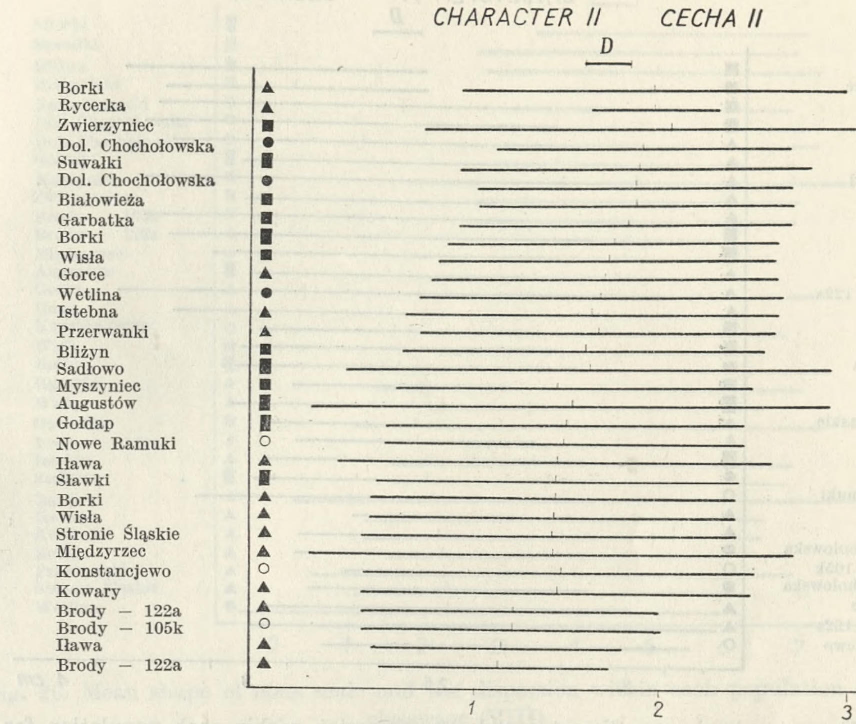

Fig. 16. Mean type of cone scale arrangement and the dispersion within each population for this character (II)

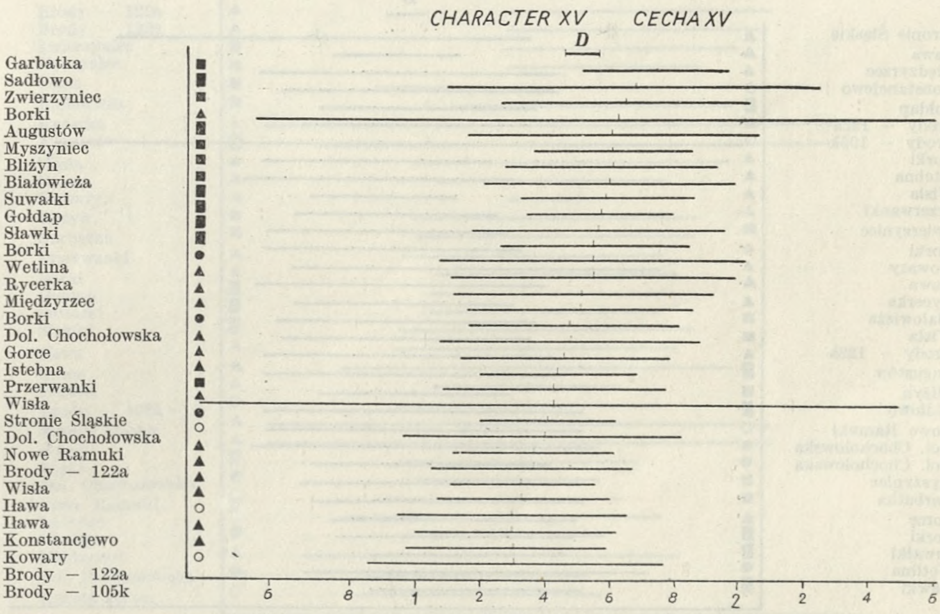

Fig. 17. Mean slenderness of the cone scales and the dispersion within each population for this character (XV)

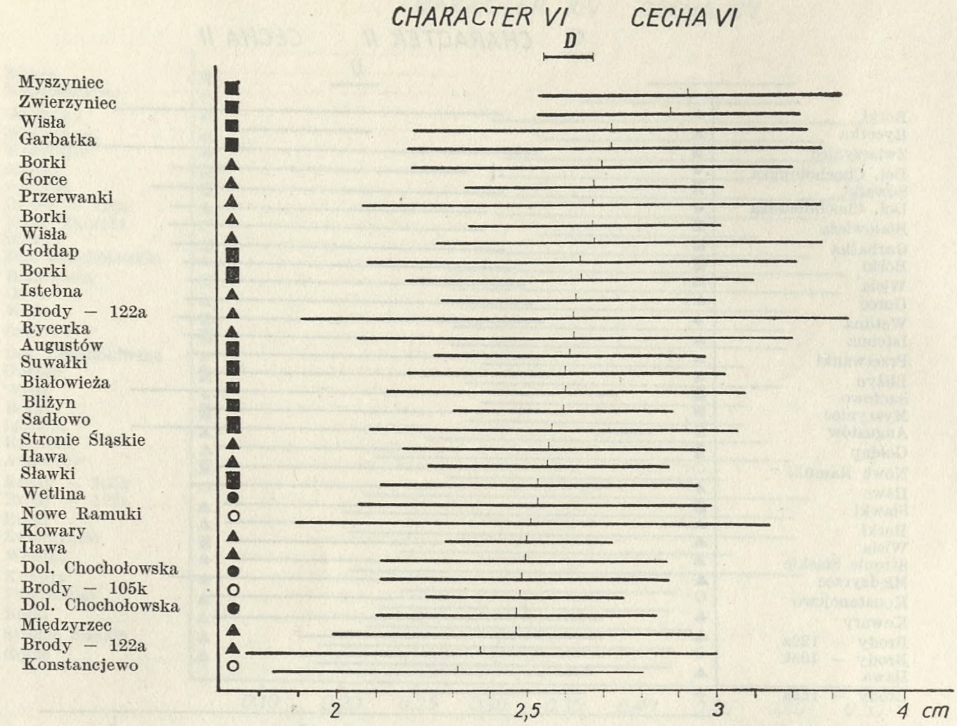

Fig. 18. Mean maximal cone diameter and the dispersion within each population for this character (VI)

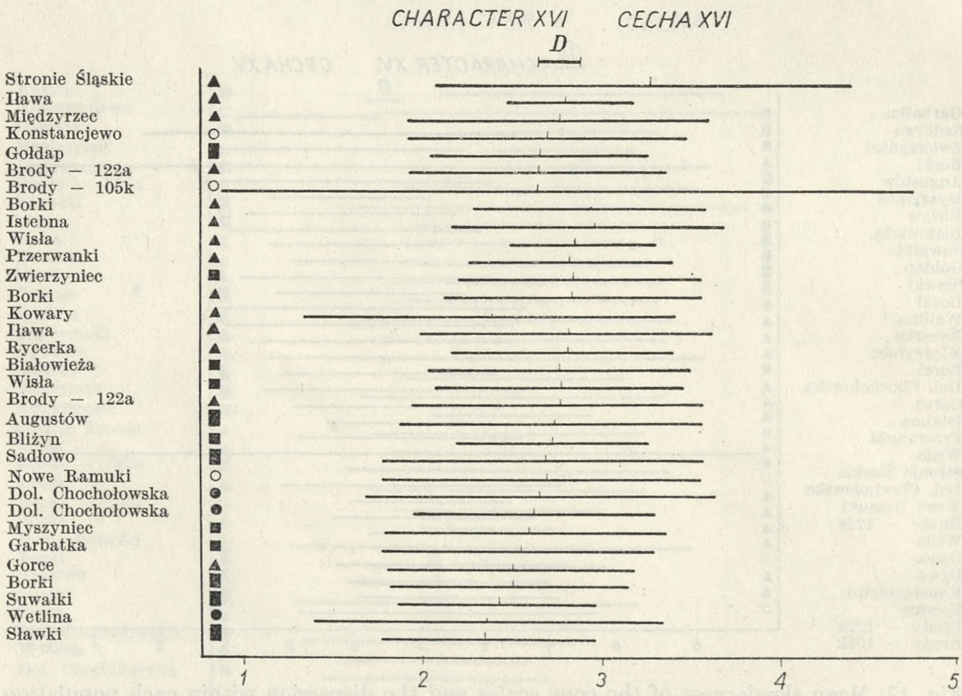

Fig. 19. Mean position of the cone scales widest part and the dispersion within each population for this character (XVI)

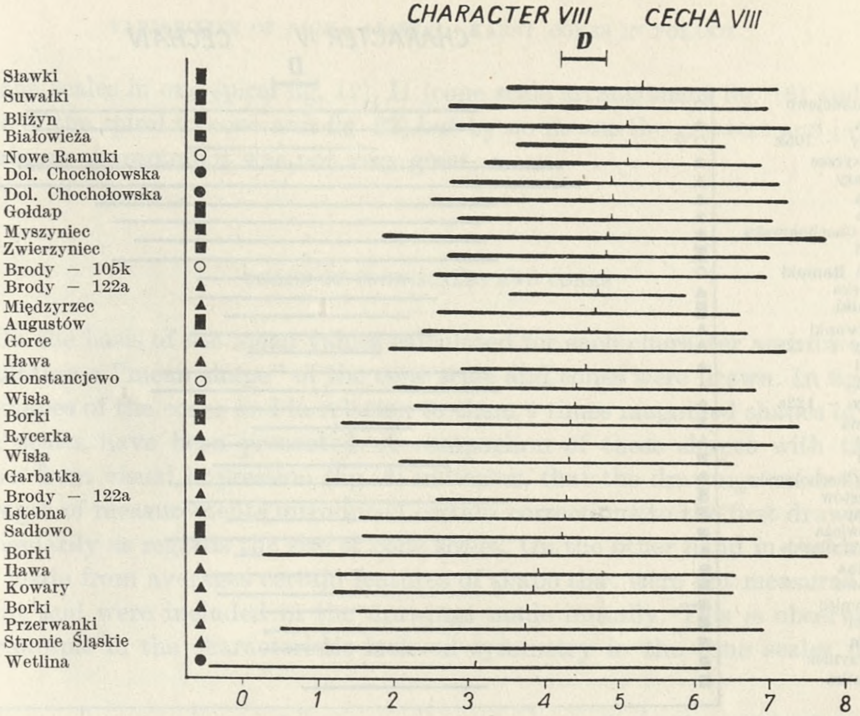

Fig. 20. Mean shape of cone scale and the dispersion within each population for this character (VIII)

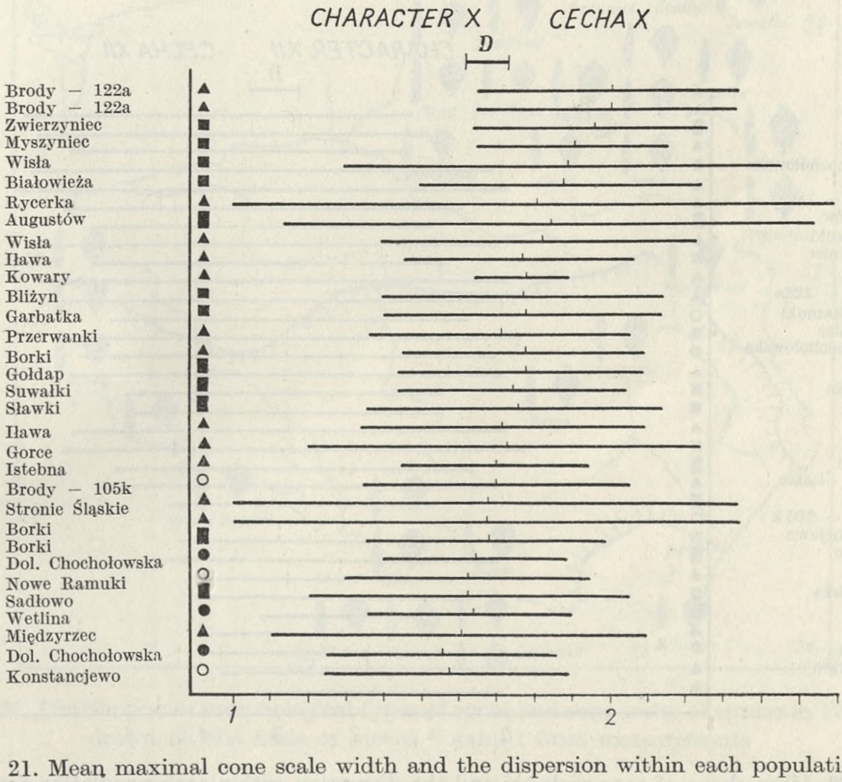

Fig. 21. Mean maximal cone scale width and the dispersion within each population for this character (X)

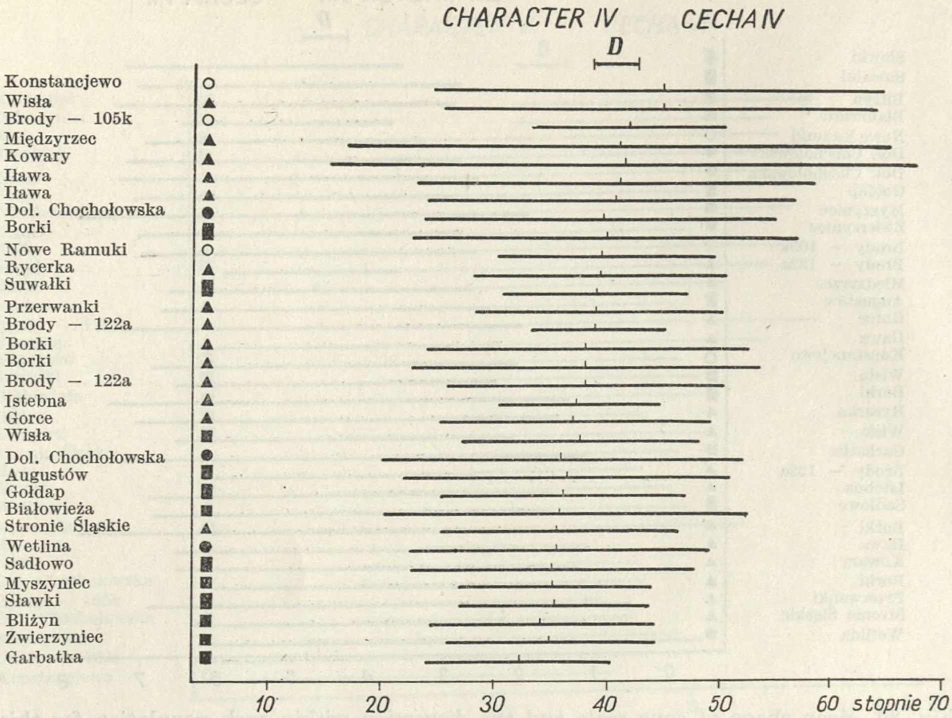

Fig. 22. Mean angle of the spiral to the cone axis and the dispersion within each population for this character (IV)

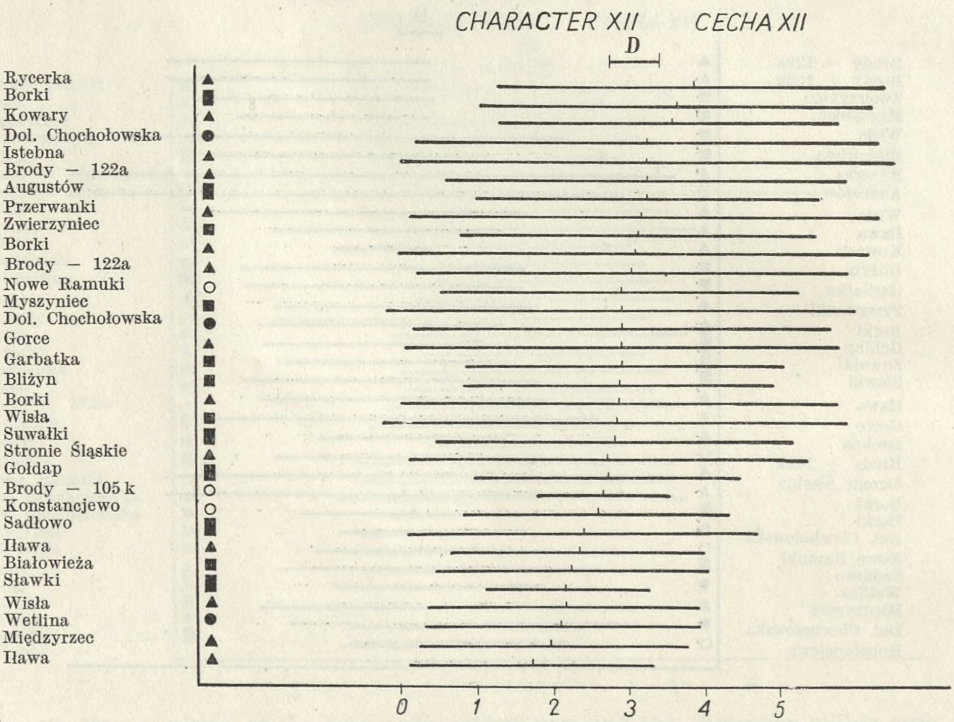

Fig. 23. Mean shape of cone scale tip and the dispersion within each population for this character (XII)

of cone scales in one spiral fig. 12), II (cone scale arrangement fig. 16) and IV angle of the spiral to cone axis fig. 22) but by no means the greatest and in the remaining characters it was not very great.

SHAPE OF CONE SCALES AND CONES

On the basis of the mean values calculated for each character and for each population a "mean shape" of the cone scale and cones were drawn. In fig. 24 the shapes of the cones and in relation to them 4 times magnified shapes of the cone scales have been presented. A comparison of these shapes with those drawn from visual impression (fig. 6) indicates, that the drawings made from averages of measurements introduced certain corrections to the first drawings, particularily as regards the size of cone scales. On the other hand in the drawings made from averages certain features of shape that were not measured are absent and were included in the drawings made initially. This is observable for example in the characteristic lack od symmetry in the cone scales from

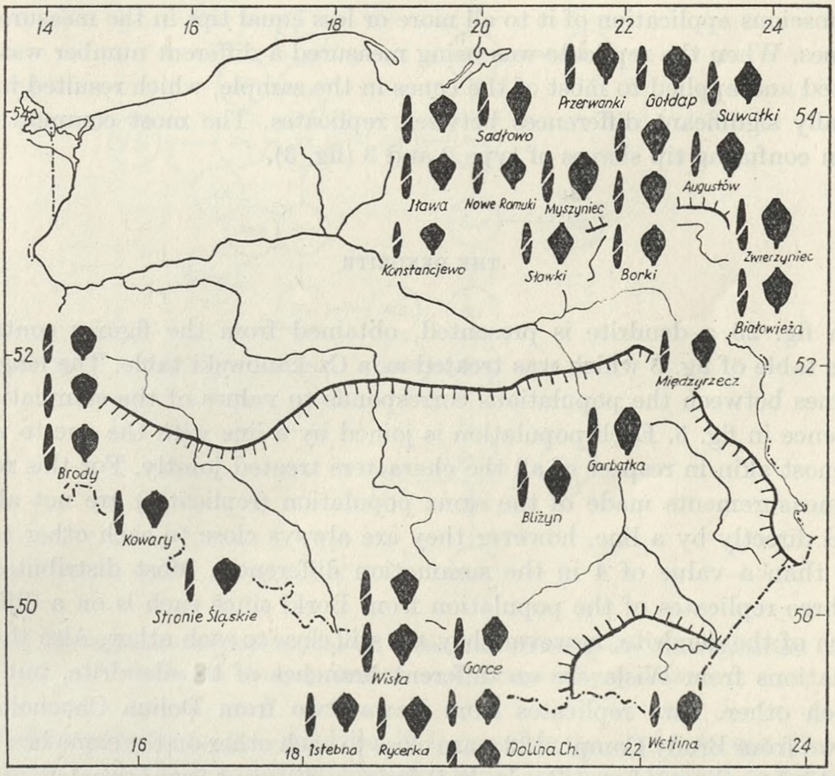

Fig. 24. Distribution of morphological types of cones and cone scales of spruce in Poland, drawn on the basis of means obtained from measurements

Istebna and Rycerka, which was not measurable. This character is common for these two populations and discriminates them from all others, however it was not noticed in the biometric studies. Also it was not possible to see on the averages the large variability of cone scale types that appeared to characterize the population from Międzyrzec.

Some cone scale shapes are completely different in the two drawings, for example for the populations from Wetlina, Zwierzyniec Białowieski, Wisła, Borki, and Nowe Ramuki. The differences originated presumably from an excessive impression made on the viewer by some cone scale shapes that are not necessarily typical for the population. Furthermore cone scale shape of type 4 (fig. 2) often occured in the averages but seldom in the material. This is the result of the shapes of type 3 and 5 often occuring in equal numbers. Thus it was sometimes difficult to draw a mean shape of type 4 together with the mean dimentions of the cone scales and the mean shapes of their tip.

Comparing the drawings made on the basis of measurements performed twice or trice for the same population, it was possible to establish that the greatest differences were to be found in the shape of the cone scale tip, which implies that in the estimation of character XII the largest number of errors was made. This was a result of selection of a cone scale tip number (fig. 3) and the subconscious application of it to all more or less equal tips in the measured lot of cones. When the replicate was being measured a different number was first selected and applied to most of the cones in the sample, which resulted in statistically significant differences between replicates. The most common error was in confusing tip shapes of type 2 and 3 (fig. 3).

THE DENDRITE

In fig. 25 a dendrite is presented, obtained from the figures contained in the table of fig. 5 which was treated as a Czekanowski table. The length of the lines between the populations corresponds to values of the summation of difference in fig. 5. Each population is joined by a line with the one to which it is most akin in respect of all the characters treated jointly. For this reason two measurements made of the same population (replicates) are not always joined directly by a line, however they are always close to each other (never more than a value of 4 in the summation difference). Most distributed are the three replicates of the population from Borki since each is on a different branch of the dendrite, however they are still close to each other. Also the two populations from Wisła are on different branches of the dendrite, but close to each other. Two replicates from Iława, two from Dolina Chochołowska and two from Brody Compt. 122 a are close to each other on the same branches. The third replicate from Brody but from a different compartment, 105 h, is on a different branch and it is difficult to draw it in proximity of the other Brody populations but in differs from them only by a value of 4.

Generally speaking the dendrite can be divided into 4 groups:

1) The population most distinct from the remainder comes from the outlier population in Konstancjewo. It is most related with Brody compt. 105h and with Nowe Ramuki. The other very isolated population is the one from Wetlina. It is most related to the spruce from Dolina Chochołowska. Both these groups are related with each other. In fig. 26 they are marked as circles, Wetlina and both replicates of Dolina Chochołowska in black and Konstancjewo, Nowe Ramuki and Brody 105h in black with white centres.

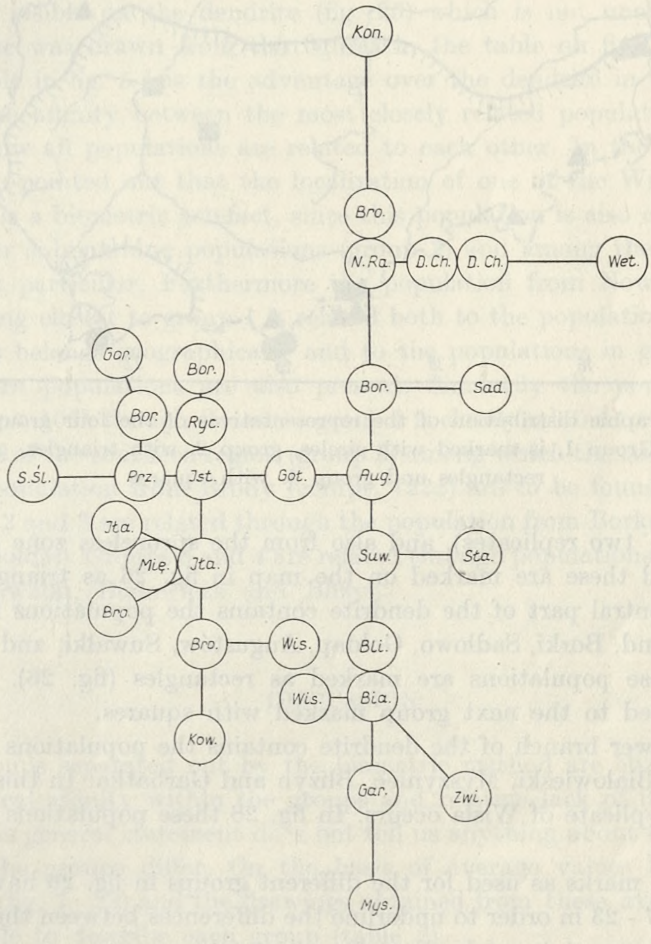

Fig. 25. Arrangement of populations on a dendrite showing the differentiation distances between the populations and groups of populations

2) Secondly from the dendrite it is possible to separate out the whole left branch containing the populations from southern Poland (submontane) Gorce, Rycerka, Istebna, Wisła, Stronie Śląskie, Kowary, Brody 122a (two replicates), from north eastern Poland (Borki — two replicates, Przerwanki

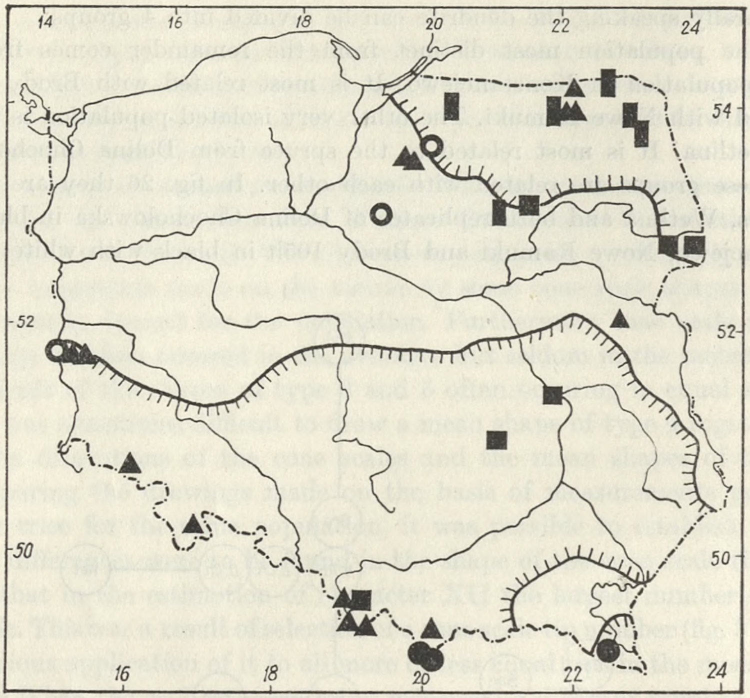

Fig. 26. Geographic distribution of the representatives of the four groups recognized by biometry. Group 1. is marked with circles, group 2. with triangles, group 3. with rectangles and group 4. with squares

and Iława — two replicates), and also from the spruceless zone (Międzyrzec Podlaski). All these are marked on the map in fig. 26 as triangles.

3) The central part of the dendrite contains the populations from north--eastern Poland, Borki, Sadłowo, Gołdap, Augustów, Suwałki, and Sławki. On the map these populations are marked as rectangles (fig. 26). This group is most related to the next group marked with squares.

4) The lower branch of the dendrite contains the populations Białowieża, Zwierzyniec Białowieski, Myszyniec, Bliżyn and Garbatka. In this group also the second replicate of Wisła occurs. In fig. 26 these populations are marked with squares.

The same marks as used for the different groups in fig. 26 have been also used in figs. 7 - 23 in order to underline the differences between the recognized groups with respect to each character separately.

SUMMATION OF WEIGHTED DIFFERENCES

In fig. 5 the table of the summation of weighted differences is presented for all population combinations. While arranging the sequence of populations in the table the information about their origin has not been made use of, thus the sequence as presented is entirely the result of the visual evaluation of the best sequence that would give most of the large values in the corners and the small values on the principal diagonal. In order to reach the present state of the table it was necessary to draw up 22 such tables at each change altering the arrangement of several populations. There is no way of checking whether the present arrangement is optimal, but judging the table visually it is difficult to see which change could bring a greater number of low values to the diagonal. The sequence obtained permits the separation of certain groups which in fig. 5 are delimited out by thick lines. These groups coincide with those visible on the dendrite (fig. 25) which is not unexpected since the dendrite was drawn from the figures in the table on fig. 5.

The table in fig. 5 has the advantage over the dendrite in that it shows not only the affinity between the most closely related populations but also indicates how all populations are related to each other. In the first place it needs to be pointed out that the localization of one of the Wisła replicates in group 4 is a biometric artefact, since this population is also closely related to the other submontane populations (group 2) and among these to its own replicate in particular. Furthermore the population from Nowe Ramuki in spite of being closest to group 1 is related both to the populations in group 3 to which is belongs geographically and to the populations in group 2 where north-eastern populations are also present. Similarily the population from Brody compt. 105h though closest to group 1 is closely related to the remaining populations of the southern region (group 2) among which the two replicates of the other population from Brody (compt. 122a) are to be found.

Groups 2 and 3 are related through the population from Borki (3 replicates) and from Gołdap. Groups 3 and 4 are related through populations in Augustów, Gołdap, Suwałki, Białowieża and Bliżyn.

DISCUSSION

The groups separated out by the biometric method are characterized by morphological affinity within the groups and relative lack of it between the groups. This general statement does not tell us anything about the characters in which the groups differ. On the basis of average values for individual characters (fig. 7 - 23) and the drawings obtained from these averges (fig. 24) it is possible to describe each group (table 2).

1. The first group contains two sub-groups, namely populations: a) Dolina Chochołowska and Wetlina and b) Konstancjewo, Nowe Ramuki and Brody, 105h. It is characterized by short (9 - 10.5 cm), thin (2.3 - 2.5 cm) but not slender cones with a small (3.2 - 4.3 cm) distance of the widest part from the base representing however a relatively large (35 - 43%) proportion of the cone length. The cone scales are short (2.1 - 2.6 cm) tightly arranged on the cone. Sub-group a) differs from sub-group b) in having more slender and

Table 2

Variability of the means for individual characters within each of the groups recognized by the biometrical analysis

Zmienność średnich wartości cech poszczególnych grup populacji wydzielonych drogą analizy biometrycznej

Characters Cechy	Groups — Grupy				
	1		2	3	4
	a	b			
IX	2.4 - 2.6	2.1 - 2.4	2.3 - 2.7	2.6 - 2.9	2.8 - 3.3
XVII	c. 0.46	.37 - .47	.41 - .48	.47 - .52	.51 - .58
XI	0.9 - 1.1	0.7 - 0.9	0.7 - 1.0	0.9 - 1.2	1.0 - 1.3
V	9.0 - 9.5	9.4 - 10.4	10.5 - 12.6	10.9 - 11.8	12.1 - 13.4
XIII	3.6 - 3.9	4.1 - 4.2	3.9 - 5.0	4.2 - 4.5	4.5 - 5.0
III	c. 20	22 - 26	24 - 29	22 - 24	22 - 26
VII	3.3 - 3.8	3.8 - 4.2	3.1 - 5.2	4.2 - 4.9	4.7 - 5.7
XIV	.35 - .40	.36 - .43	.29 - .43	.36 - .41	.35 - .45
I	1.9 - 2.2	2.6 - 3.8	2.3 - 3.6	2.4 - 3.3	2.9 - 3.9
II	1.7 - 1.9	1.2 - 1.5	1.1 - 2.0	1.4 - 1.9	1.5 - 2.0
XV	1.46 - 1.58	1.34 - 1.45	1.34 - 1.66	1.58 - 1.71	1.45 - 1.79
VI	2.43 - 2.53	2.31 - 2.51	2.37 - 2.70	2.53 - 2.64	2.59 - 2.93
XVI	2.41 - 2.68	2.71 - 3.03	2.54 - 3.22	2.36 - 3.03	2.58 - 2.90
VIII	3.1 - 5.0	4.5 - 5.1	3.7 - 4.7	4.2 - 5.4	4.3 - 5.2
X	1.57 - 1.64	1.56 - 1.71	1.60 - 1.96	1.62 - 1.82	1.77 - 1.95
IV	35 - 40	40 - 45	36 - 45	35 - 40	32 - 37
XII	2.05 - 3.35	2.55 - 2.85	1.70 - 3.80	2.35 - 3.60	2.25 - 3.05

longer cone scales (2.3 - 2.6 cm vs. 2.1 - 2.4 cm) with a slightly longer tip (0.9 - 1.1 cm vs. 0.7 - 0.9 cm) and a very small (about 20) number of scales on one spiral while in sub-group b) this value is greater and varies from 22 to 26. Angle of this spiral to the cone axis is 36° - 40° in sub-group a) and 40° - 45° in sub-group b).

In sub-group a) the population from Wetlina is distinguished by a somewhat longer cone scale (2.6 cm) and in sub-group b) the population from Konstancjewo stands out by having a very tight arrangement of cone scales (character XVII). In figs. 7 - 23 and 26 subgroup a) is marked with black circles and sub-group b) with white circles. Group 1 is the most heterogenous.

2. The second group includes the submontane populations: Gorce, Rycerka, Istebna, Wisła, Stronie Śląskie, Kowary, Brody compt. 122a (2 replicates), the northern populations: Borki (2 replicates), Przerwanki and Iława (2 replicates) and from the spruceless zone the oulier population Międzyrzec Podlaski. The group is characterized by cones of medium slenderness and length (10.5 - 12.5 cm) with the widest part positioned rather low (29 - 43% of the length), with a variable cone width (2.4 - 2.7 cm) and with a large number (24 - 29) of tightly arranged cone scales in a spiral, running at a large angle to the cone axis (36° - 45°). The cone scales are of medium length (2.3 - 2.7 cm) with a short (0.7 - 1.0 cm) tip. In figs. 7 - 23 and 26 populations belonging to this group are marked with triangles.

3. The third group includes the north-eastern populations Borki, Sadłowo, Gołdap, Augustów, Suwałki and Sławki. It is characterized by cones of medium slenderness, length (11 - 12 cm) and width (2.5 - 2.6 cm), a medium distance of the widest part from the cone base (4.2 - 4.8) also with respect to the cone length representing a medium proportion (36 - 41%), a small number (22 - 24) of loosely arranged cone scales on one spiral running at a medium angle with respect to the cone axis (35° - 40°), long (2.6 - 2.9 cm) slender cone scales with a long tip (0.9 - 1.2 cm). In figs. 7 - 23 and 26 the populations belonging to this group are marked by rectangles. The large number of characters under which this group is characterized by medium values to some extent is explicable by its central position on the dendrite (fig. 25).

4. The fourth group comprises the populations from Białowieża, Zwierzyniec Białowieski, Myszyniec, Bliżyn, Garbatka and the second replicate from Wisła. The group is characterized by very slender, long (12.0 - 13.5 cm), wide (2.6 - 2.9 cm) cones with a large distance of the widest part from the cone base (4.5 - 6.0 cm) representing also a large proportion (35% - 45%) of the cone length, a medium number (22 - 26) of loosely arranged cone scales in one spiral, running at an acute angle to the cone axis (32° - 36°) and very long (2.8 - 3.3 cm) slender cone scales with long (1.0 - 1.3 cm) tips. In figs. 7 - 23 and 26 the populations of this group are marked as squares.

A comparision of the groups of populations separated out by the two methods, the classical one and the biometrical one, shows distinct differences. It appears that in the classical method the separation of groups 3 - 6 resulted from the excessive consideration of the geographic distribution and of some particular characters. The most interesting result of the studies conducted is the demonstration with the use of both the methods that there is an affinity between the populations from Dolina Chochołowska, Konstancjewo and Brody.

The results obtained justify the suggestion that the first group recognized biometrically represents relicts of the oldest migration of spruce into Poland (morphologically close to var. *obovata*), while the second group and the third +fourth group represented two separate migrations, the former coming for the south west and latter from the north east. In our part of the world the spruce populations coming from these two directions have approached each other and got mixed possibly not without the helping hand of man.

It is perhaps legitimate to make a comment about the discussion as to whether there is a disjunction in the range of spruce in Poland. There is a very great likelihood that the spruce stands from which the seeds for provenance experiments and cones for the biometric analysis were collected are indiginous. If that is so the mixture of morphological types of spruce as found in the north eastern part of the range with those typical for the submontane populations and conversely in the submontane region with types typical for the lowland spruce would suggest that there is a lack of a distinct boundry separating the two regions. In the light of this we should feel inclined to agree with the opinion of those earlier investigators who claim that the disjunction was formed as a result of inappropriate land management which has had a negative effect on the water balance resulting in a decline of spruce occurrance in this geographic region. However the possibility cannot be excluded that some populations of spruce investigated in the present study are not indiginous but have developed from seed obtained from cone extraction plants in Austria or in southern Germany.

Our studies were aimed at establishing the morphological differences between spruce populations and not the description of lower taxonomic units within the species *P. abies*. However a detailed analysis of shape of the large number of cones and cone scales coming from different localities permits a few comments on the systematic rank of the best known spruce varieties.

In particular var. *obovata* Fellm., var. *europaea* Tepl. and var. *acuminata* Beck. can be commented upon. It appears that *P. abies* var. *obovata* as a result of its most characteristic cone scale shapes (short with a semicircular and flattened apical part and with a short distance of the tip from the widest part) and the tightness of cone scale arrangement in a spiral distinctly differ from the other varieties. Thus the systematic position of this variety does not present any doubts. On the other hand the other two varieties, var. *europaea* and var. *acuminata* appear to have a too high a taxonomic rank. We should be inclined to believe that we are dealing here with morphological types or forms of spruce, whose diagnostic characters are of little use in differentiating populations. It is very often possible to find both varieties in the same stand in immediate proximity and in approximately equal numbers. Our views here support the conclusions of Lindquist (1948) who in central Europe instead of the two varieties, *europaea* and *acuminata* proposed one var. *germanica* Lindq. with a cone scale shape characteristic for both the earlier varieties.

These conclusions have to be considered as introductory since the character of morphological variation of the studied spruces is unknown, as it is much affected by the environmental conditions in which the cones developed. Differences in cone morphology will have a use for taxonomic purposes only when we shall be able to establish that these differences are conditioned by genetic factors and not by the ecology of the site in which they grow. Information about this will only be available when field provenance experiments established from the seeds extracted from these cones will reach the age of reproduction.

The present study has demonstrated the usefulness of a simultaneous two directional approach to the study of population variability, through classical taxonomic methods and through biometry, since both these approaches are far from perfect. The classical method is subjective, and the biometric method is too artificial, since it is impossible to capture the richness of natural variability in figures. Only after a comparison of the results obtained by these two independent methods is it possible to draw credible conclusions.

Considering the method of biometric study it needs to be stressed that it proved very valuable to repeat the measurement of some of the populations without informing the man performing the measurements about it. This has permitted the rejection of differences between populations, which though statistically significant were artefacts due to the inadequacy of our measuring procedures, particularily concerning the characters that were visually estimated. It seems reasonable to suppose that a similar error affects the results of all other studies of this type which do not include such replications. The method of making certain measurements over several weeks undergoes subconsciously a certain gradual evolution, which even the best worker is unable to resist, and therefore replicates are essential in order to eliminate errors arrising from this source. Besides such replicates provide information about which characters it is possible to measure or estimate veritably and which are treachorous in this respect.

The values of the F function of Fisher used for the estimation of discriminative values of different characters (arrangement as in table 2) gives the information about which characters are most reliable when defining taxonomic units or describing populations*.

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HENRYK CHYLARECKI I MACIEJ GIERTYCH

Zmienność szyszek Picea abies (L.) Karst. w Polsce

Streszczenie

Praca niniejsza jest próbą oceny zmienności szyszek świerka w Polsce w wyniku analizy dostępnego materiału metodą systematyki klasycznej (H. Ch.) oraz przy pomocy analizy biometrycznej (M. G.).

Przedmiotem badań były szyszki 25 proweniencji świerka zebrane proporcjonalnie z 10 losowo wybranych drzew z każdego stanowiska.

Metodą taksonomii klasycznej wyodrębniono 6 grup proweniencji:

1. Populacje z Pojezierza Mazurskiego oraz z północnej części Krainy Wielkich Dolin (Borki, Nowe Ramuki, Sadłowo, Przerwanki, Augustów, Suwałki, Gołdap, Białowieża, Zwierzyniec Białowieski, Sławki i Myszyniec) charakteryzują się wydłużonym rombowym kształtem i szeroko ściętym ostrokątnym lub języczkowatym wierzchołkiem łusek nasiennych (zbliżone do var. *acuminata* Beck i var. *europaea* Tepl.).

2. Populacje ze stanowisk wyspowych (Iława, Konstancjewo, Brody) oraz w górach na obszarze sudecko-karpackim (Kowary, Stronie Śląskie, Wisła, Gorce, Dolina Chochołowska) charakteryzują się głównie kulistym lub odwrotnie jajowatym kształtem łusek nasiennych średniej wielkości z zaokrąglonym i wciętym wierzchołkiem lub nieznacznym języczkiem (zbliżone do var. *obovata* f. *fennica*).

3. Populacje Beskidu Śląskiego (Rycerka, Istebna) odznaczają się asymetrią łusek nasiennych. Połowa łuski ma kształt rombowy (var. *europaea*), a druga, kolisty lub odwrotnie jajowaty (f. *fennica*).

4. Świerki z Wyżyny Małopolskiej (Garbatka, Bliżyn) mają łuski nasienne o kształcie wąsko — i szerokorombowym.

5 i 6. Populacje z nadleśnictw Międzyrzecz Podlaski i Wetlina stanowią odrębne dwie grupy, pierwsza ze względu na bardzo szeroką skalę zmienności, a druga z uwagi na prawie idealnie romboidalny kształt łuski nasiennej.

Analiza biometryczna 17 cech szyszek i łusek nasiennych przeprowadzona metodą sumy różnic ważonych połączoną z dendrytem wykazała zgrupowanie populacji w 4 zasadnicze bloki. Pierwszy obejmuje dwie podgrupy, a) populacje wysokogórskie z Tatr i Bieszczad (Dolina Chochołowska i Wetlina) oraz b) 2 populacje ze stanowisk wyspowych (Brody Żarskie oddz. 105 i Konstancjewo) i jedną z Warmii (Nowe Ramuki). Drugi blok obejmuje populacje górskie i podgórskie oraz kilka stanowisk z północno-wschodniej Polski (Gorce, Rycerka, Istebna, Stronie Śląskie, Kowary, Wisła oraz Brody oddz. 122, Międzyrzecz, Iława, Przerwanki i Borki. Bloki trzeci i czwarty z północno-wschodniej i centralnej Polski są ze sobą spokrewnione (3. Sadłowo, Gołdap, Augustów, Suwałki i Sławki, 4. Myszyniec, Białowieża, Zwierzyniec, Garbatka i Bliżyn).

Jak widać z porównania metoda biometryczna wprowadziła pewne korektury do oceny klasycznej. Przede wszystkim nie zostało potwierdzone wydzielenie grup 3 - 6, co przypuszczalnie jest wynikiem zasugerowania się rozmieszczeniem geograficznym i pojedynczymi cechami. Poza tym grupa 2 odpowiada dwom wydzieleniom biometrycznym, 1 i 2. Obie metody wykazały pokrewieństwo świerka z Doliny Chochołowskiej ze świerkiem w Konstancjewie i w Brodach co uznać należy za najciekawszy rezultat przeprowadzonych badań.

Na podstawie otrzymanych wyników można by przypuszczać, że blok pierwszy obejmuje relikty z najstarszej inwazji świerka (pokrewne var. *obovata*), podczas gdy bloki 2 i 3+4 stanowią dwie odrębne inwazje świerka, jedna z południowego — zachodu a druga z północnego-wschodu, które zbliżyły się w naszym kraju i uległy pewnemu zmieszaniu, przypuszczalnie również i nie bez udziału człowieka.

ГЕНРИХ ХЫЛЯРЕЦКИИ И МАТЕИ ГЕРТЫХ

Изменчивость шишек Picea abies (L.) Karst. в Польше

Резюме

Настоящая работа является попыткой сравнительной оценки изменчивости шишек ели в Польше, основанной на анализе доступного материала как методами классической систематики (Г.Х.), так и при помощи биометрического метода (М.Г.)..

Объектом исследования были шишки 25 популаций ели; в каждом случае шишки собирались в равном количестве с 10 случайно выбранных деревьев данного местообитания.

Методом классической таксономии выделено 6 групп:

1. Популяции из Мазурского Приозерья и из северной части Пояса Больших Долин (Борки, Новые, Рамуки, Садлово, Пжерванки, Аугустув, Сувалки, Голдап, Бяловежа, Звежынец Бяловежский, Славки и Мышынец) характеризуются удлиненной ромбовидной формой и широко срезанной остроугольной или языковидной верхушкой семенных чешуй (близки к *var. acuminata* Beck и *var. europaea* Tepl.).

2. Популяции из „островных" местонахождений (Илава, Констанцево, Броды), и с гор Судетско-Карпатского района (Ковары, Строне Шленске, Висла, Горце, Долина Хохоловская) характеризуются преимущественно округлой или обратно яйцевидной формой семенных чешуй средней величины с округленной и врезанным или небольшим язычком (близки к *var. obovata f. fennica*).

3. Популяции Силезских Бескид (Рыцерка, Истебна) отличаются асиметрией семенных чешуй. Половина чешуй имеет ромбовидную форму (*var. europaea*), а другая — округлую или обратно яйцевидную (*f. fennica*).

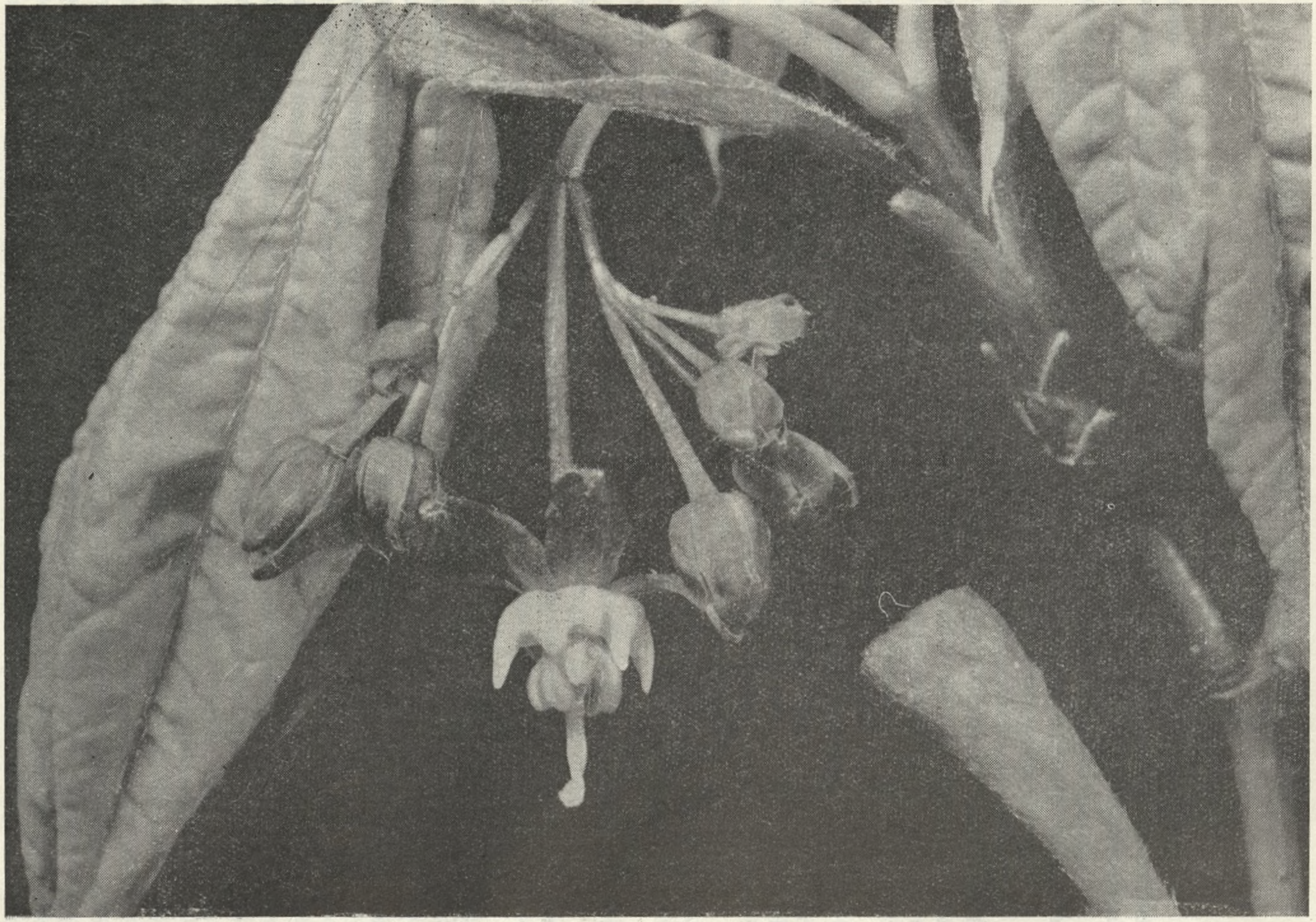
4. Ели из Малопольской возвышенности (Гарбатка, Ближын) имеют семенные чешую в форме узлов или широкого ромба.

5 и 6. Популяции из надлесничеств Мендзыжеч Подляский и Ветлина образуют две отдельные группы. Первая из-за очень широкой шкалы изменчивости, вторая — поскольку у нее почти идеальная ромбовидная форма семенной чешуи.

Биометрический анализ 17 признаков шишек и семенных чешуй, проведенный методом сумм взвешенных разностей в сочетании с методом дендритов, показал, что все изученные популяции группируются в четыре основных блока. Первый блок включает две подгруппы: а) высокогорные популяции из Татр и Бещад (Долина Хохоловская и Ветлина) и б) две популяции из островных местонахождений (Броды Жарске — отдел 105 и Констанцево) и одну из Вармии (Новые Рамуки). Другой блок охватывает горные и подгорные популяции, а также несколько местонахождений из северо-восточной Польши (Горце, Рыцерка, Истебна, Строне Шленске, Ковары, Висла, Броды — отдел 122, Мендзыжеч, Илава, Пжерванки и Борки). Третий и четвертый блоки из северо-восточной и Центральной Польши родственны между собой (3 блок: Садлово, Голдап, Аугустув, Сувалки, Славки; 4 блок: Мышынец, Бяловежа, Звежынец, Гарбатка и Ближын).

Как видно из сравнения, биометрический метод внес некоторые коррективы в оценку, основанную на классическом методе. Прежде всего, не было подтверждено выделение групп 3, 4, 5 и 6, явившееся, по-видимому, результатом преувеличенного значения, приданного географическому распространению и отдельным (изолированным) признакам. Кроме того, группе 2 соответствуют два блока, установленных биометрически — 1 и 2. Оба метода согласно показали родство ели из Констанцева и Брод, что следует признать наиболее интересным выводом проведенных исследований.

На основе полученных результатов можно предположить, что первый блок составляют реликты самой древней инвазии ели (родственные *var. obovata*) в то время как блок 2, с одной стороны, и блоки 2 и 3+4, с другой, представляют две самостоятельные инвазии (одна с югозапада, другая же с северо - востока), которые сощлись в нашей стране и подверглись здесь некоторому смешению, вероятно не без участия человека.



Acer circinatum Pursh. — fragment gałązki z kwiatostanem

Fot. K. Jakusz