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MORPHOMETRY OF THE LEAVES OF *CHAMAEDAPHNE CALYCULATA* (L.) MOENCH

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ABSTRACT. The paper reports results of a study on the variability of six morphological features of leaves of *Chamaedaphne calyculata* (L.) Moench, collected at nine sites in Poland and two abroad. The size of the leaves was found to be strongly dependent on the habitat conditions and was the parameter determining the division into ecophenotypic groups. A linear relation was observed between the length and the width of the leaves.

Key words: *Chamaedaphne*, variability, leaves, Poland

Introduction

Chamaedaphne calyculata (L.) Moench [= *Andromeda calyculata* (L.) = *Lyonia calyculata* (L.) Rchb.] belongs to the subfamily *Arbutoideae* of the family *Ericaceae*. It is a circumboreal species and its range covers North America, Asia and the part of Europe belonging to the subarctic and boreal zones (**Meusel** et **al.** 1978) so Finland, Lithuania, Latvia, Estonia, northern-central Belarus and Russia (**Polakowski** 1957 after **Kulczyński** 1922). The south-western border of its range crosses Poland where it is known from only nine isolated sites **(Kruszelnicki** 1993, **Szkudlarz** 1995).

The aim of the study reported was to describe the condition of *Chamaedaphne calyculata* at all sites in Poland on the basis of biometric analysis of assimilating leaves, general morphological appearance and habitat conditions. Moreover, a comparison of the size and shape of leaves was made at the three sites described by **Polakowski** (1957) to establish the possible changes in these parameters over the years 1955-1995. The studies were partly financed from the Committee for the Scientific Research grant No 6 PO4C 001 15.

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Material and methods

The biometric study of morphological features of assimilating leaves was performed on the population material in the years 1995 and 1999. Six features of the leaves were taken into account: 1 – length of the leaf blade, 2 – width of the leaf blade, 3 – length of the petiole, 4 – the ratio of the length to the width of the leaf blade, 5 – half of the angle at the base of the leaf blade, 6 – half of the angle at the apex of the leaf blade (Fig. 1).

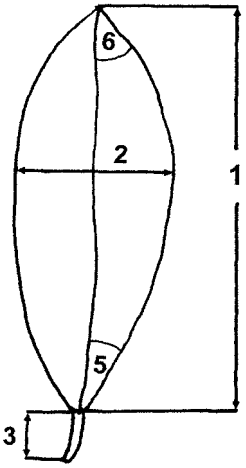

Fig. 1. The technique of measurement of the selected parameters of *Chamaedaphne calyculata* (L.) Moench
Ryc. 1. Sposób mierzenia cech *Chamaedaphne calyculata* (L.) Moench

The samples were compared by the graphic method of **Jentys-Szaferowa** (1959) and by object grouping by the method of closest neighbourhood (single bonds on the basis of Euclidean distances). Statistical analysis was performed using the program Statistica StatSoft, Inc. (1997).

Characterisation of the sites (Fig. 2)

1. Marshy coniferous forest near Krasnopol – the site noted by **Czerwiński** in 1967, confirmed and described by **Szkudlarz** (1995). *Ch. calyculata* occurs in an area of 2000 m^2. Dwarf-shrubs of this species form a few large clumps (up to 5 meters in diameter) and among them there are individual shoots. This population of *Ch. calyculata* is characterised by weak flowering and poor fruit production, probably because of considerable shading. It reproduces in the vegetative manner and numerous young shoots testify to good viability of the population (Figs 3, 5).

2. The reserve Jesionowe Góry (Ash-tree Mountains) in the Knyszyn Forest – the site observed for the first time in 1973 in the forest range Czarna Białostocka (**Sokołowski** 1976). The population of *Ch. calyculata* grows in a slight depression occupied by marshy coniferous forest and is made of not numerous individuals dispersed over a small area (Figs 3, 5).

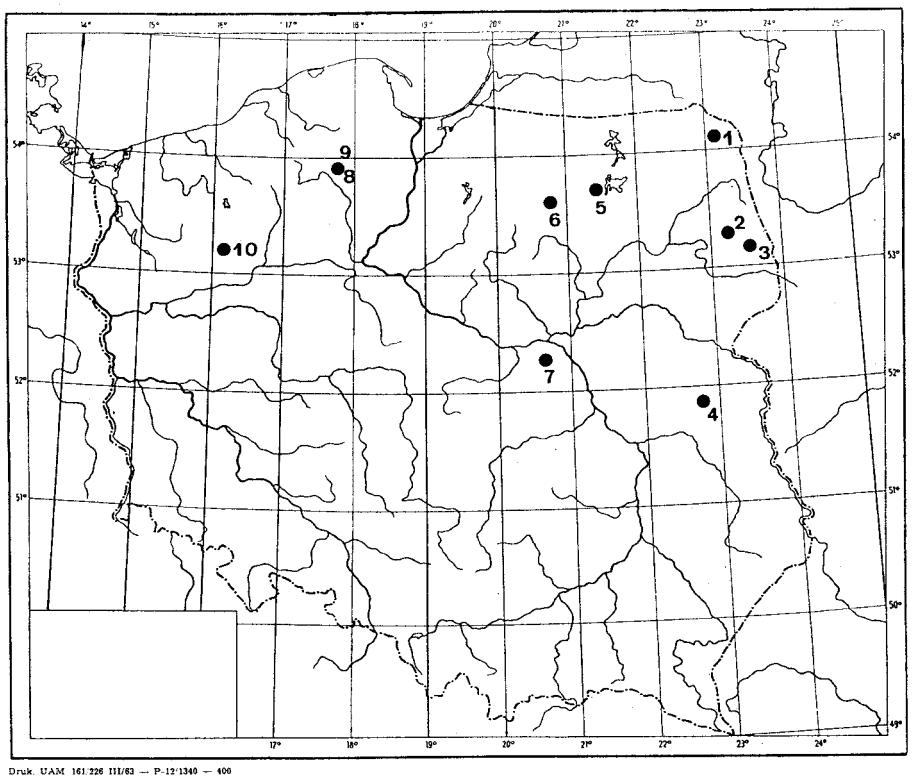

Fig. 2. Distribution of the sites of *Chamaedaphne calyculata* (L.) Moench studied
Ryc. 2. Rozmieszczenie badanych stanowisk *Chamaedaphne calyculata* (L.) Moench

3. The reserve Gorbacz, near Michałowo village, east of Bialystok. The population of *Ch. calyculata* grows on the western side of a lake, at a border between high peatbog and marshy coniferous forest. In 1994 the western and southern parts of the reserve were destroyed by fire, which also swallowed the population of *Ch. calyculata*. Fortunately, it recovered from the underground parts. At a distance of about 1.5 km SW from this population another one was found in pine forest shrubs. The other population is scarce and devoid of young shoots. It grows on much dried soil in direct neighbourhood to a peat-pit (Figs 3, 5).

4. A disappearing peatbog Lisie Jamy near Siemień, grown with pine (*Pinus sylvestris* L.) trees with an admixture of downy birch trees. Individual plants of *Ch. calyculata* grow on the edge of an old peat-pit and groups of this species occupy the bottom of the pit, an area of about 15 m^2. The shoots reach 30 cm in height and sporadically produce flowers. Because of unstable habitat conditions this population is much threatened (Figs 3, 5).

5. Krutyń a small peatbog surrounded by mezotrophic marsh with *Calla palustris* L. and sometimes also *Hottonia palustris* L. The population of *Ch. calyculata* occupies an area of 1.2 ha and is in good condition. The highest shoots reach 80 cm. The population expands towards the south into habitats of mezotrophic character (Figs 3, 5).

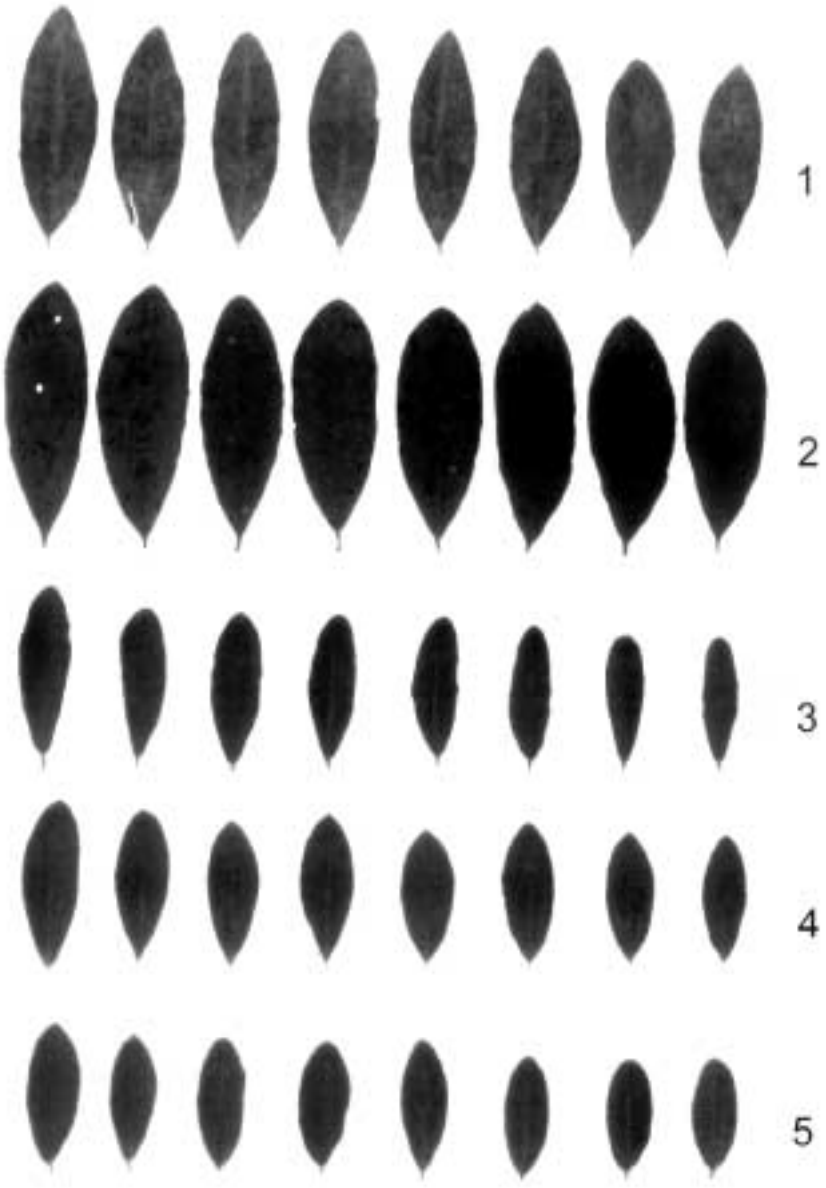

Fig. 3. Morphological types of *Chamaedaphne calyculata* (L.) Moench leaves (number of samples as in Fig. 2)
Ryc. 3. Typy morfologiczne liści *Chamaedaphne calyculata* (L.) Moench (numeracja prób jak na ryc. 2)

6. The reserve Sołtysek near Grom, a high peatbog. The population of *Ch. calyculata* abundant but dispersed over an area of about 2000 m^2. Individual plants are strongly branched and relatively high (Figs 4, 5).

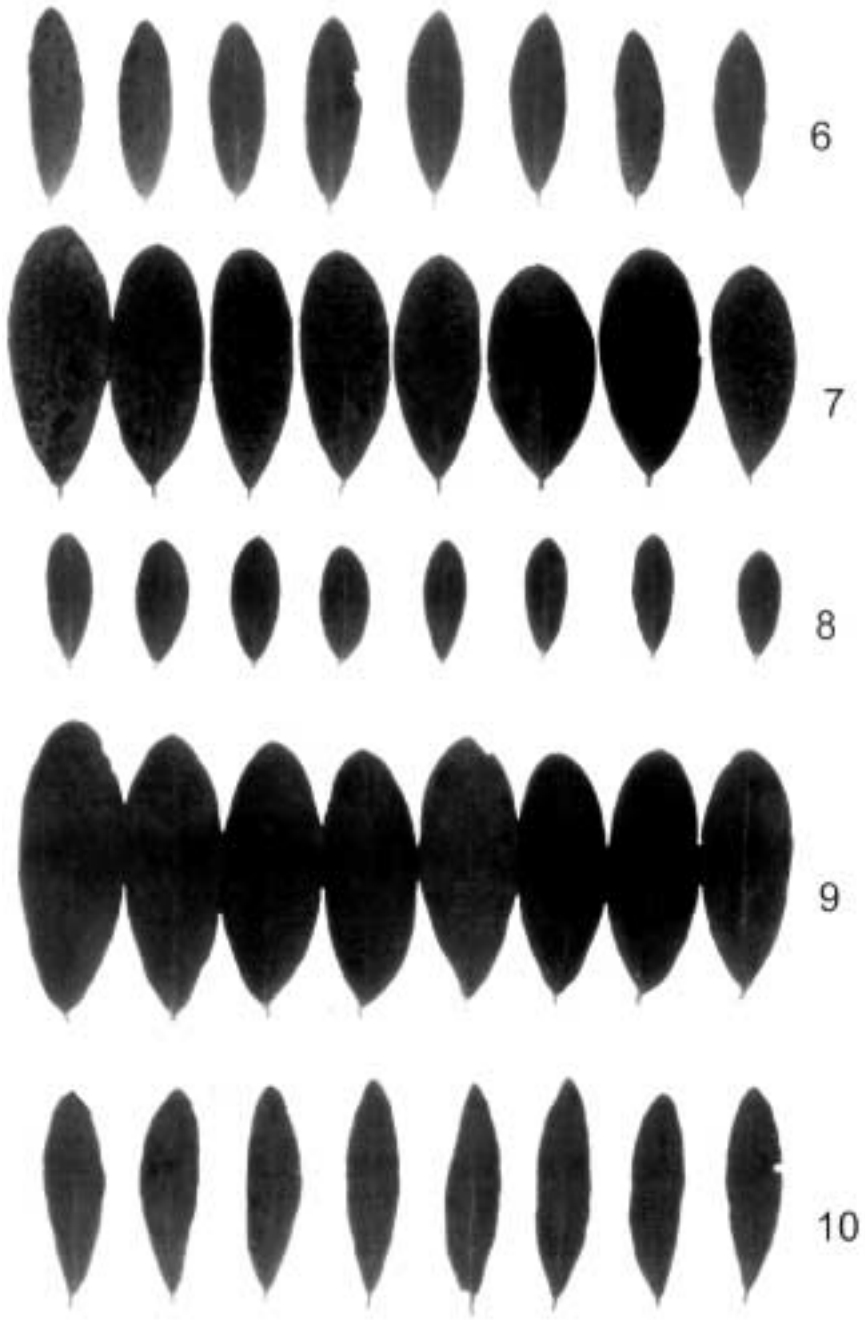

Fig. 4. Morphological types of *Chamaedaphne calyculata* (L.) Moench leaves (number of samples as in Fig. 2)
Ryc. 4. Typy morfologiczne liści *Chamaedaphne calyculata* (L.) Moench (numeracja prób jak na ryc. 2)

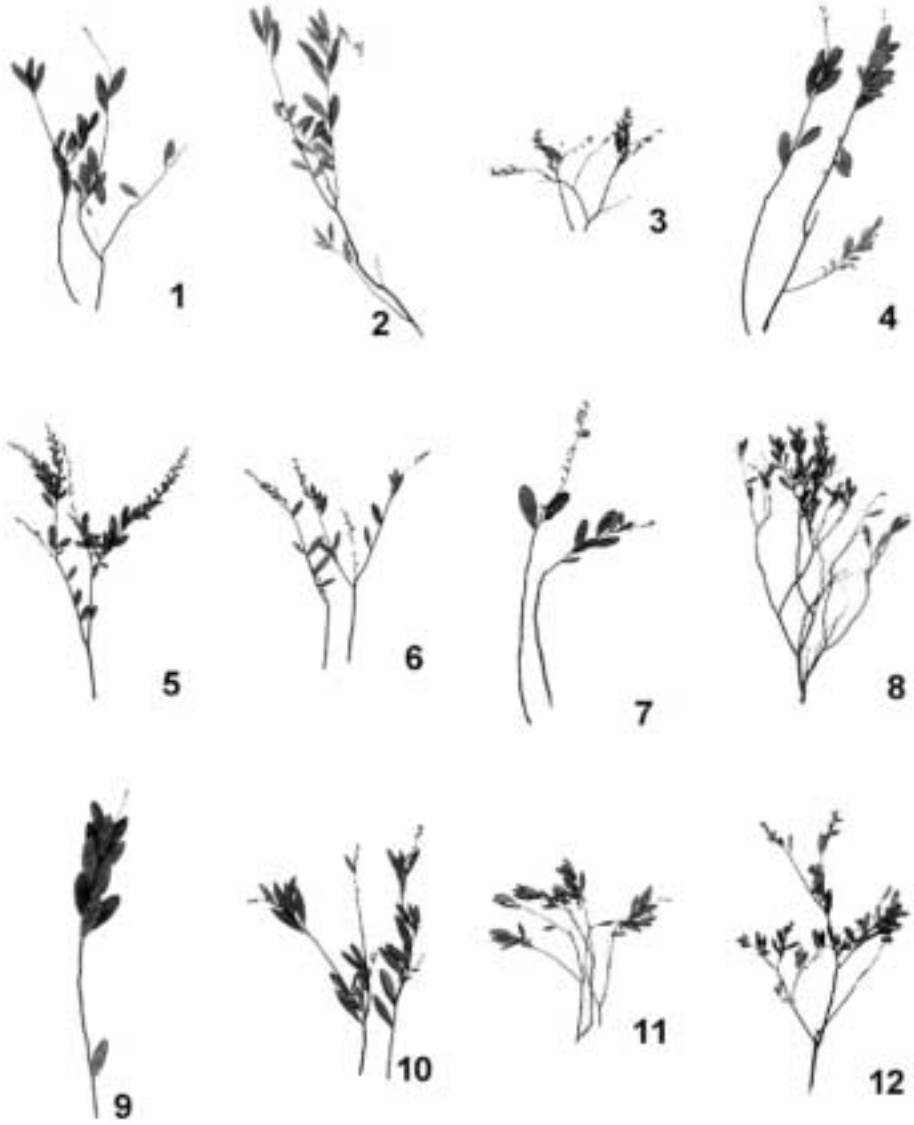

Fig. 5. *Chamaedaphne calyculata* (L.) Moench
Ryc. 5. *Chamaedaphne calyculata* (L.) Moench

7. The reserve Sieraków in the Kampinos National Park, marsh coniferous forest of relatively high tree stand (22 m) mainly with *Pinus sylvestris* L. and *Betula pubescens* Ehrh. The population of *Ch. calyculata* abundant and growing over more than 1000 m^2 (Figs 4, 5).

8 and 9. Sowiniec in the Bory Tucholskie a site with a population of *Ch. calyculata* is localised in section 168. A clump of *Ch. calyculata* is composed of about 60 individuals

growing in an area of 500 m^2. The size of the individual plants varies – the above ground shoots reach up to 80 cm. Two samples of eight (small leaf blades) and nine (large leaf blades) were collected (Figs 4, 5).

10. Sitno – a peatbog in the middle of the forest, taking an area of 2.11 ha, in section 322b of the forest range Martew, in a narrow depression at the southern end of Sitno lake. The population of *Ch. calyculata* in a very good condition. The rhizomes are longer than 1 m, above ground shoots are from 60 to 80 cm high and with abundant foliage (Figs 4, 5). Two samples from outside Poland were also analysed for the sake of comparison.

11. Babagniewa – east of Archangielsk, marshy coniferous forest. *Ch. calyculata* grows in a shadowy habitat in rather small clumps, has much branched ramets of up to 60 cm in height (Fig. 5).

12. Archangielsk – high peat bog at the outskirts of the city. *Ch. calyculata* grows in small loose aggregations, has rather low shoots with poorly developed branches (Fig. 5).

Results

The interpopulation variation of *Ch. calyculata* was assessed by comparing the arithmetic means of particular features analysed for each sample with the corresponding means of a theoretical sample known also as a general sample. On the basis of analysis of the samples from the first nine sites three groups of populations were distinguished.

The first includes samples 8, 12, 5, 11 and 4 characterised by smaller leaf blades than those from the reference sample, in particular smaller feature 3 – samples 8 and 5, smaller feature 4 – sample 4 and smaller features 5 and 6 – sample 3 (Fig. 6). The second group comprises samples 1, 2, 7 and 9, showing much greater leaves, longer petioles and diverse angles. The angles of the leaves from samples 1 and 2 are much smaller than those obtained for the reference sample, while those of sample 9 leaves are much greater (Fig. 6). The third group is composed of the samples 3, 6 and 10 with slightly longer leaves but narrower than in the comparative unit, also with longer petioles and smaller angles both of the base and at the top (Fig. 7).

The morphological structure of the leaves from the populations studied, i.e. the shape and size of the features analysed, depends on the habitat conditions. All the analysed features of all samples reveal great variability and the coefficient of variation for the majority of them is higher than 10%. The highest coefficient of variability was determined for the length of petiole 15.78 to 30.00%, whereas the most stable feature was the ratio of the length to the width of the leaf blade – 8.39 to 16.05% (Tab. 1).

The feature whose values were characterised by the greatest scatter was the angle at the leaf base (1/2) characterised by dispersion of 16°-81°, the angle at the leaf apex (1/2) – dispersion 23°-82° and the length of petiole – 0.03-0.36 mm. The results obtained for the samples from Russia were compared to those for the general sample from Poland. The variability of leaf features in these two samples was similar as that for the samples from Poland (Fig. 6). In particular a resemblance was found between sample 11 (Babagniewa) and sample 5 (Krutyń), and sample 12 (Archangielsk) and sample 8 (Bory Tucholskie) the one characterised by fine leaves, greater angles at the base and at the apex of leaves.

Table 1

Arithmetic means (X), standard deviation (SD) and variability coefficient (V) local samples and general sample of *Chamaedaphne calyculata* (L.) Moench
Średnie arytmetyczne (X), odchylenie standardowe (SD) i współczynnik zmienności (V) populacji lokalnych i próby ogólnej *Chamaedaphne calyculata* (L.) Moench

No samples Nr prób	Characteristics Charakterystyki	Feature – Cecha					
		1	2	3	4	5	6
1	x±SD V%	3,38±0,51 15,08	1,09±0,15 13,76	0,19±0,03 15,78	3,08±0,31 10,06	31,71±6,2 19,80	52,24±8,1 15,63
2	x±SD V%	3,69±0,40 10,84	1,29±0,14 10,85	0,23±0,05 21,74	2,86±0,29 10,14	30,21±5,4 18,07	51,49±6,3 12,31
3	x±SD V%	2,34±0,39 16,66	0,72±0,13 18,05	0,17±0,04 23,53	3,26±0,34 10,43	27,51±6,0 21,84	48,41±6,5 13,42
4	x±SD V%	2,32±0,30 12,93	0,91±0,14 15,38	0,18±0,04 22,22	2,55±0,40 15,68	39,78±7,1 17,92	48,36±8,41 7,47
5	x±SD V%	2,23±0,30 13,45	0,85±0,11 12,94	0,12±0,03 25,00	2,66±0,36 13,53	47,58±8,4 17,84	53,03±9,1 17,27
6	x±SD V%	3,08±0,45 14,61	0,89±0,13 14,61	0,20±0,06 30,00	3,48±0,42 12,07	30,14±6,4 21,23	46,48±8,9 19,23
7	x±SD V%	3,54±0,36 10,17	1,35±0,18 13,33	0,19±0,04 21,05	2,62±0,22 8,39	34,29±4,7 13,76	65,31±6,7 10,33
8	x±SD V%	1,95±0,27 13,85	0,71±0,10 14,08	0,12±0,03 25,00	2,74±0,44 16,06	40,61±6,4 15,91	52,20±9,8 18,91
9	x±SD V%	3,53±0,87 24,64	1,26±0,28 22,22	0,14±0,04 28,57	2,80±0,33 11,78	41,25±6,5 15,95	54,22±7,8 14,40
10	x±SD V%	3,17±0,25 7,88	0,98±0,11 11,22	0,18±0,04 22,22	3,21±0,29 9,03	25,32±4,9 19,47	45,87±6,7 14,80
11	x±SD V%	2,77±0,38 13,72	0,84±0,13 15,47	0,14±0,04 28,57	3,40±0,40 12,35	37,14±5,3 14,40	55,56±7,0 12,71
12	x±SD V%	1,89±0,26 13,76	0,64±0,10 15,62	0,13±0,03 23,07	2,78±0,42 15,11	37,43±5,5 14,75	55,19±9,2 16,79
General sample Próba ogólna	x±SD V%	2,92±0,41 14,04	1,00±0,13 13,00	0,17±0,04 23,53	2,92±0,34 11,64	34,84±4,5 13,14	51,80±6,2 12,00

The dendrograms (Figs 8, 9) were obtained by the grouping of multidimentional objects by the method of the closest neighbourhood, on the basis of Euclidean distances, in three variants for 6, 4 and 2 features. In the case of 6 and 2 features with the latter being he angles of the leaf base and leaf apex, the same result was obtained, which means that the grouping was determined by these angles.

On the basis of dendrograms, two groups of populations can be distinguished: one including samples 1, 2, 6, 10 and the other with samples 4, 5 and 8 (Fig. 8). In the dendrogram for six features (Fig. 9) and four features (1-4) the samples 7 and 3, respectively, are isolated. The results obtained from dendrograms are consistent with those following from the graphic method of plant shape comparison.

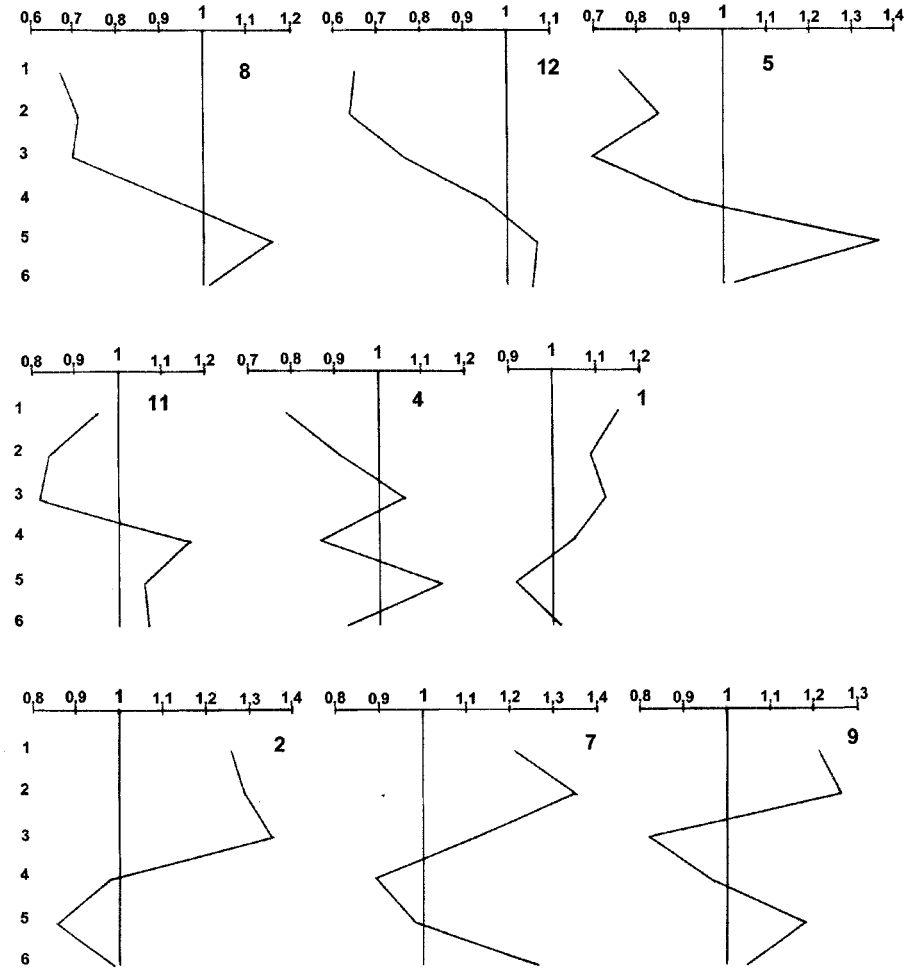

Fig. 6. A comparison of the size and shape of *Chamaedaphne calyculata* (L.) Moench leaves obtained for local samples (broken lines) with the corresponding parameters for the general sample (vertical line)
Ryc. 6. Porównanie linii wielkości i kształtu liści *Chamaedaphne calyculata* (L.) Moench populacji lokalnych (linie łamane) z próbą ogólną (linia prosta)

Having the opportunity of using the results of **Polakowski** (1957), a comparison was made of the size and shape of assimilating leaves from the three sites he analysed after 40 years. The numbers characterising the features studied are given in Table 2.

The results of the comparison show the development of the populations compared. The leaf blades have increased their length and width, so their shape has become more elliptical. The mean length of the petiole has also slightly increased. The greatest differences have been noted in the angles at the base and at the apex of the leaves (1/2), however they might be partly due to the differences in the accuracy of measurements.

Table 2

A comparision of the features of the leaves of *Chamaedaphne calyculata* (L.) Moench
Porównanie cech liści *Chamaedaphne calyculata* (L.) Moench

Feature Cecha	Locality – Stanowisko					
	Sieraków		Sołtysek		Lisie Jamy	
	1955 year	1995 year	1955 year	1995 year	1955 year	1995 year
1	3,11	3,54	2,94	3,08	1,91	2,32
2	1,25	1,35	0,78	0,89	0,72	0,91
3	0,17	0,19	0,20	0,21	0,12	0,18
4	2,48	2,62	3,78	3,46	2,66	2,55
5	42,85	34,29	31,36	30,14	32,26	39,78
6	61,31	65,31	35,82	46,48	42,11	48,36

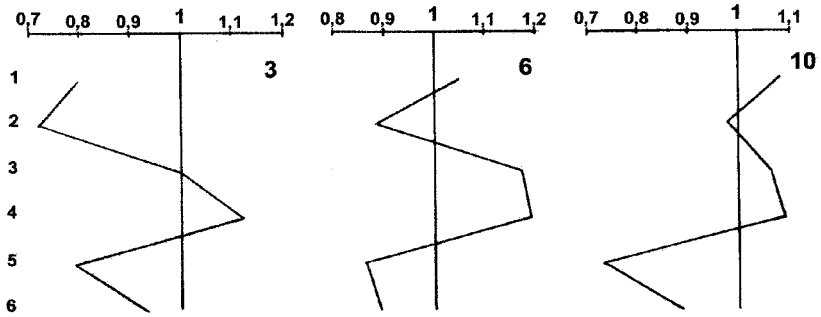

Fig. 7. A comparision of the size and shape of *Chamaedaphne calyculata* (L.) Moench leaves obtained for local samples (broken lines) with the corresponding parameters for the general sample (vertical line)
Ryc. 7. Porównanie linii wielkości i kształtu liści *Chamaedaphne calyculata* (L.) Moench populacji lokalnych (linie łamane) z próbą ogólną (linia prosta)

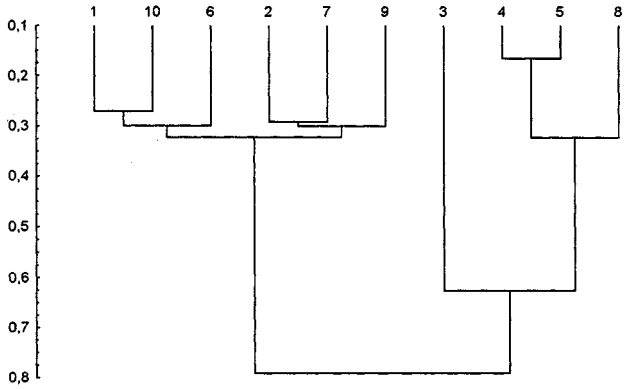

Fig. 8. Dendrogram of Euclidean distances for four features (1-4) of *Chamaedaphne calyculata* (L.) Moench leaves
Ryc. 8. Dendrogram odległości Euklidesa czterech cech (1-4) liści *Chamaedaphne calyculata* (L.) Moench

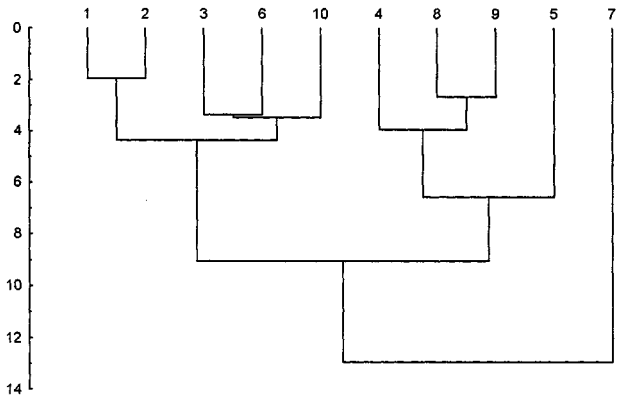

Fig. 9. Dendrogram of Euclidean distances for six features (1-6) of *Chamaedaphne calyculata* (L.) Moench leaves
Ryc. 9. Dendrogram odległości Euklidesa sześciu cech (1-6) liści *Chamaedaphne calyculata* (L.) Moench

In general the results suggest that in the time from 1955 to 1995 the habitat conditions in the sites compared have improved. In particular this concerns humidity conditions, whose improvement has been reflected in the vegetative development of *Ch. calyculata* in the peatbog in Sieraków and Sołtysek. In 1995 the shoots were much branched and relatively high – up to 50 cm, while the rhizomes reached over 1 m in length.

Conclusions

A comparison of the coefficients of variability has shown that the most variable feature is the length of petiole, while the other features are moderately variable. A linear relation was noted between the length and the width of the leaf blade. The ratio of the length to the width of the leaves determines the shape of the leaves, which can be more elongated or more elliptical. The size of the leaves is closely related to the habitat conditions and on the basis of this feature ecophenotypic groups can be distinguished samples (8, 9). No significant differences have been found between the features of the samples collected in the country and at the two far off sites.

At the nine Polish sites of occurrence of *Chamaedaphne calyculata*, isolated from its main range, this species should be considered as a relic of the last glaciation. It is a very interesting species and its present occurrence may testify migration of the plants characteristic of northern areas in the epoch of diluvial shifts of glaciers. The species should be under close protection. In Poland it shows significant local variability and occurs in specific habitat conditions accompanied by *Ledum palustre* L., *Andromeda polifolia* L., *Vaccinium uliginosum* L., *Pinus sylvestris* L. and some species from the genus *Sphagnum*. Preservation of the peatbogs at which it occurs by including them into reserves should be a measure significantly increasing chances of its survival.

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MORFOMETRIA LIŚCI *CHAMAEDAPHNE CALYCULATA* (L.) MOENCH

S t r e s z c z e n i e

Na obszarze Polski przebiega południowo-zachodnia granica zasięgu chamedafne północnej. Odosobnione, izolowane dziewięć stanowisk leży daleko od współczesnego centrum rozmieszczenia na północy, dlatego można je traktować jako stanowiska reliktowe.

Chamaedaphne calyculata (L.) Moench ma wyraźnie zaznaczoną amplitudę ekologiczną. Na obszarze Polski i w Rosji występuje w określonych warunkach na torfowiskach wysokich. Chamedafne północna charakteryzuje się zmiennością lokalną. Zmienność ta, zaznaczająca się zmianą wielkości i kształtu liści, jest uwarunkowana przede wszystkim różnymi warunkami siedliskowymi na poszczególnych stanowiskach.