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Variation patterns within the *Carex flava* agg. in Bulgaria and Czechoslovakia

Variabilita populací druhů komplexu *Carex flava* agg. v Bulharsku a Československu

Milka P. Stoeva and Jitka Štěpánková

STOEVA M. P.[1]) et ŠTĚPÁNKOVÁ J.[2]) (1990): Variation patterns within the *Carex flava* agg. in Bulgaria and Czechoslovakia. — Preslia, Praha, 62 : 1–24.

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Correlations between morphological variability, chromosome numbers and habitat conditions were studied in 31 populations of the *Carex flava* agg. in Bulgaria and Czechoslovakia. The following taxa were included: *C. flava* L. var. *flava*, *C. flava* var. *alpina* KNEUCKER, *C. lepidocarpa* TAUSCH, *C. tumidicarpa* ANDERSS. and *C. serotina* MÉRAT. Within and between population variability were compared in each taxon. The main source of the variability of individual taxa is the intrapopulational variation of large populations of the species that are not fully genetically isolated from each other in the regions studied.

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INTRODUCTION

The *Carex flava* agg. has always presented taxonomic difficulties. Overlapping ranges of morphological variation of the members of this group result in the fact that they are hard to differentiate.

Despite a wide attention focused on this group by many northern and western European botanists (WIINSTEDT 1936, 1945, 1947, SENAY 1950–51, DAVIES 1953, 1955a,b, 1956, PALMGREN 1959, CRETIN et BIDAULT 1974, NK 1979) details of the population variability within this group were only udied in a rather limited territory of Switzerland, and published by SCHMID (1980, 1982, 1983, 1984a, 1984b, 1986a, 1986b) in a comprehensive biosystematical work.

The present study is concerned with the population variability of *Carex flava* L. var. *flava*, *C. flava* var. *alpina* KNEUCKER (sensu SCHMID 1983), *C. lepidocarpa* TAUSCH, *C. tumidicarpa* ANDERSS. and *C. serotina* MÉRAT in two comparatively remote regions, Bulgaria and Czechoslovakia. Up to now in the Balkan Peninsula, this group has not been examined in detail, and in Czechoslovakia morphological variation and distribution patterns of the members of this group were investigated by one of the authors of this paper (HAVLÍČKOVÁ 1982, 1983).

In studying the patterns of morphological variation, chromosome numbers and ecology of the above taxa, the following problems were considered:

Tab. 1. — List of the studied populations of the *Carex flava* agg.

No.	Sites	2n
Carex lepidocarpa		
1 (686)	Bohemia, pag. Lysá n. Labem: in prato uliginoso in reservatione ,,Hrabanovská černava" dicta.	68
2 (1113)	Bohemia, opp. Mělník, vic. Mělnická Vrutice: in prato uliginoso in reservatione ,,Polabská černava" dicta.	68
3 (1114)	Bohemia, opp. Řevničov, vic. Třtice: in prato uliginoso in reservatione ,,V bahnách" dicta.	68
4 (10)	Slovacia, montes Veľká Fatra: in loco scaturiginoso in reservatione ,,Rojkov", ca 2 km situ or. a pag. Kraľovany.	69 (68)
5 (1264)	Bulgaria: in pratis humidis inter vicos Aleksandrovo, Manolovo et Tarnichene.	68
Carex flava var. *alpina*		
6 (1033)	Bulgaria, montes Vitoša: in pratis h midis secundum viam turisticam inter montem Ušite et casam alpinam Aleko.	60
7 (71)	Slovacia, montes Chočské vrchy: in loco scaturiginoso ad clivum montis Predný Choč.	60
Carex flava × *C. serotina*		
8 (1070)	Bulgaria, montes Rila: in loco scaturiginoso, ca 300 m situ mer.-occ. a pago Govedarci.	66
9 (1031)	Bulgaria, montes Vitoša: in prato humido haud procul a statione viae ferratae pensilis ,,Baj Krastju" super vico Dragalevci.	64 (66)
Carex flava × ?		
10 (1051)	Bulgaria, montes Rodopi occ.: in pratis humidis in loco ,,Rakovo dere" dictis, secundum viam publicam Dospat-Batak, ca 8 km situ mer. ab opp. Batak.	53
Carex flava var. *flava*		
11 (1115)	Bohemia, opp. Řevničov, vic. Třtice: in prato uliginoso in reservatione "V bahnách" dicta.	60
12 (48)	Bohemia, opp. Mělník, vic. Mělnická Vrutice: in prato uliginoso in reservatione ,,Polabská černava" dicta.	58
13 (711)	Bohemia, opp. Pardubice, vic. Horní Ředice: in prato humido ad ripam piscinae Mordýř.	60
14 (893)	Bohemia, opp. Rakovník: in prato humido ca 3 km situ mer. a vico Račice.	60

15 (1032)	Bulgaria, montes Vitoša: in prato humido haud procul a statione viae ferratae pensilis „Baj Krastju“ super vico Dragalevci.	60
16 (704)	Bulgaria, montes Rodopi occ., opp. Batak: ad ripam rivi ca 1,2 km situ occ. a casa alpina Beglika, haud procul a reservatione „Vasil Kolarov“.	60
17 (989)	Bulgaria, montes Rila: in prato turfoso prope viam publicam inter pagum Goverdarci et deversorium Maljovica, ca 2,5 km situ occ. -mer.-occ. a pago Govedarci.	58
18 (700)	Bulgaria, montes Rodopi occ.: in pratis humidis „Roženski livadi“ dictis secundum viam publicam inter pagum Progled et vicum Sokolovci.	60
Carex serotina		
19 (1110)	Slovacia, opp. Kraľovany: in loco scaturiginoso ad peripheriam occ. pagi Rojkov.	?
20 (817)	Slovacia, opp. Komárno: in loco humido apud viam ferream prope pagum Chotín.	70
21 (1112)	Bohemia, opp. Mělník, vic. Mělnická Vrutice: in prato uliginoso in reservatione „Polabská černava“ dicta.	68
22 (720)	Bohemia: in loco humido ad peripheriam bor.-occ. pagi Řeporyje.	68
23 (988)	Bulgaria, montes Rila: in prato turfoso prope viam publicam inter pagum Goverdarci et deversorium Maljovica, ca 2,5 km situ occ.-mer.-occ. a pago Govedarci.	?
24 (1041)	Bulgaria, montes Sredna Gora: in pratis turfosis haud procul a pag. Klissura.	70
25 (1030)	Bulgaria, Sofia: in prato uliginoso prope vicum Kazičene.	70
26 (1008)	Bulgaria, montes Rodopi occ.: ad ripam lacus loco „Smoljanski ezera“, ca 6 km situ bor. ab opp. Smoljan.	(70) 68
Carex tumidicarpa		
27 (9)	Slovacia, montes Nízké Tatry: in loco humido in valle Ráztocká dolina, ca 300 m bor. a vico Liptovská Lužná.	70
28 (972)	Bohemia, pag. Hostomice: in loco humido apud casam venatoriam Zátor dictam.	70
29 (722)	Bohemia, montes Šumava: in loco humido, ca 400 m situ or. a statione ferroviae Kubova Huť.	70
Carex flava × (C. flava × C. lepidocarpa)?		
30 (1094)	Bulgaria, montes Rila, pag. Borovec: in pratis humidis secundum viam publicam Belmeken — Borovec.	62
Carex flava × C. serotina		
31 (984)	Bulgaria, montes Rila: in prato turfoso prope viam publicam inter pagum Govedarci et deversorium Maljovica, ca 2,5 km situ occ.-mer.-occ. a pago Govedarci.	66 (68)

1. how a within-population variability and between-population variation contribute to the overall variability of individual taxa,
2. possible differences in morphological variation between the populations occurring in two climatically different regions,
3. a correlation of morphological variation with habitat factors,
4. a correlation between chromosome numbers and morphology,
5. is there any apparent relationship between the extent of threat (of some members of this group) and variation ranges of their characters?

MATERIAL

Morphological and karyological analyses were carried out on 31 populations. All the data were taken from the plants growing under natural conditions. Localities and notes on habitat are included in Tables 1 and 5. Phytosociological relevés were recorded at each locality using the common Braun-Blanquet scale (Tabs. 6—9).

KARYOLOGY

Methods

Chromosome counts were based on root tip mitoses of plants cultivated in the greenhouse of the Botanical Institute, Sofia. The tips were fixed in Clarkés fixative (three parts of 96 % ethanol and one part of acetic acid) for 30 minutes, hydrolysed in 1N HCl at 60°C for 40 minutes, transferred into a mixture of ether and 1N HCl (equal proportions) for 10 minutes and stained with hematoxylin at 60°C for 30 minutes. Root tips were squashed in 45 % acetic acid, and the squashes were made permanent by the quickfreeze method with CO_2.

The numbers of vouchers deposited in the private herbarium of Stoeva, Sofia, are given in the Tab. 1 (in the brackets).

Results

In the material of the *Carex flava* group from Bulgaria and Czechoslovakia, nine chromosome numbers were ascertained, forming an aneuploid series containing the following somatic numbers: 2n = 53, 58, 60, 62, 64, 66, 68, 69, 70. All but one (2n = 69) have been found in the material from Bulgaria, whereas 2n = 58, 60, 68, 69, 70 occurred in the Czechoslovak material.

All the chromosomes are holocentric and very small. The longest of them are 2—3 times longer than the shortest ones. Bulgarian populations from the Rila Mts. (No. 30, No. 31) are exceptional in this respect: the plants posses two very small chromosomes, much shorter than the longest ones within the chromosome set (Fig. 1).

Carex flava L.

In this species (incl. two varieties — var. *flava*, var. *alpina*) the chromosome number 2n = 60 is predominating, having been found in four Bulgarian and four Czechoslovak populations. The same chromosome number was ascertained in the material from C. Slovakia (Liptovská Lužná, cf. Stoeva et Štěpánková 1988). This number is in agreement with most of the data given in the literature under the name *C. flava* (cf. Davies 1955b, 1956, Schmid 1982).

The number 2n = 58 was also established in the material from both regions. It is in accordance with the results of SCHMID (1982).

Furthermore, *C. flava* var. *alpina* is reported to have 2n = 60 in Bavaria, Italy and Yugoslavia (SCHMID 1982).

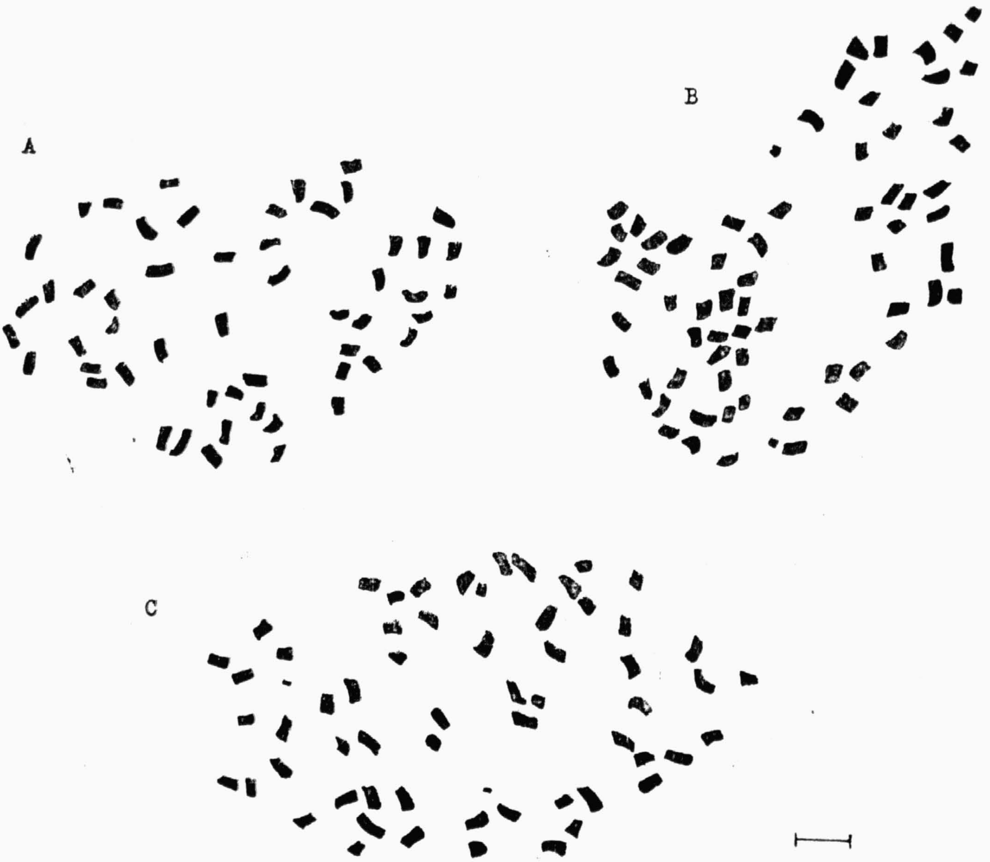


Fig. 1. — Metaphase in root-tip meristem, — A: *Carex flava* × ?, 2n = 53. — B: *C. flava* × *C. serotina*, 2n = 66 + 2. — C: *C. flava* × (*C. flava* × *C. lepidocarpa*), 2n = 60 + 2. Scale = 2 μm.

Carex lepidocarpa TAUSCH

The number 2n = 68 has been ascertained in all the populations examined, four from Czechoslovakia and one from Bulgaria.

However, in the population No. 4, 2n = 69 was found to be more frequent than 2n = 68; this latter number was also revealed in the material from Liptovská Lužná (STOEVA et ŠTĚPÁNKOVÁ 1988).

The former chromosome number seems to predominate in Great Britain, Sweden and Switzerland (cf. SCHMID 1982).

Carex tumidicarpa ANDERSS.

The plants from Czechoslovakia proved to have 2n = 70, which is in a good agreement with the data given in the literature (cf. SCHMID 1982).

Carex serotina MÉRAT

Six populations, three Bulgarian and three Czechoslovak, were studied karyologically. All the Bulgarian populations proved to have 2n=70, in one of them (No. 26) 2n=68 was also found. Similar pattern is involved in the Czechoslovak populations, two populations having 2n=60, and one possesing 2n=70. The latter chromosome number is in good agreement with the literature data (for review see SCHMID 1982). According to SCHMID 2n=70 predominates in Sweden, Great Britain, Iceland, Switzerland and France. The lower number, 2n=68 was reported by SCHMID (1982) from Austria and Switzerland.

Hybrid populations

Five additional chromosome numbers were found to occur in the Bulgarian hybrid populations of the *C. flava* parentage, viz. 2n=53, 62, 64, 66 and 68. 2n=53 represents an exceptional number only found in sterile plants at Rakovo dere, the W. Rhodopi Mts. (No. 10). The karyotype of the 2n=62 plants is characterized by a pair of dwarf chromosomes. (We suppose that plants of this populations (No. 30) represent backcrosses *C. flava* × (*C. flava* × *C. lepidocarpa*). In the population 9 (*C. flava* × *C. serotina*) 2n=64 was predominating, whereas 2n=66 occurred relatively rarely, both cytotypes growing in the vicinity of a 2n=60 population (No. 15). In two Bulgarian populations (Nos. 31, 8) we established 2n=66. Some roots of the first population had 2n=68, but two of the chromosomes were very small (see Fig. 1).

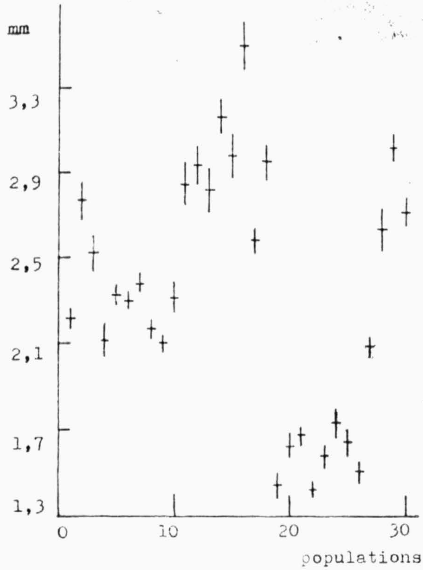
In Czechoslovakia, hybrid populations were examined at a selected locality in the Nízké Tatry Mts., C. Slovakia (STOEVA et ŠTĚPÁNKOVÁ 1988). A series of hybrid plants intermediate between the parent species, *C. flava*, *C. lepidocarpa* and *C. tumidicarpa*, was ascertained. A similar series of chromosome numbers 2n=63, 68 and 69 was found, too.

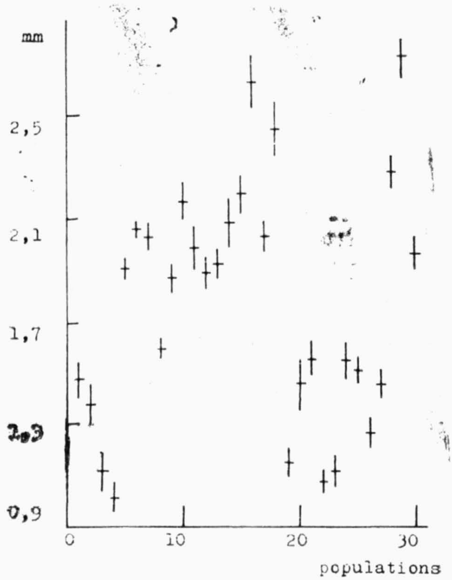
RESULTS OF MORPHOLOGICAL ANALYSIS

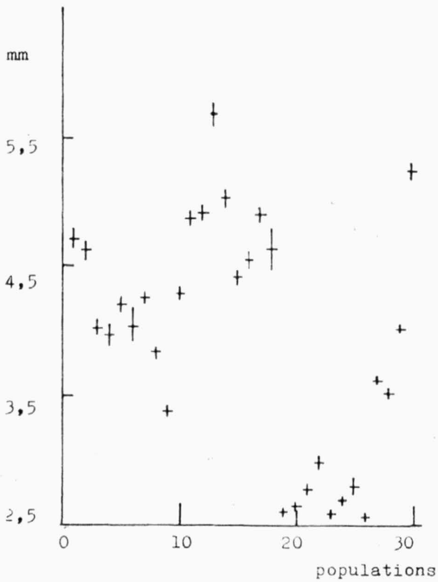
Methods

Numerical analyses are based on 30 populations (900 plants). On the basis of the statistical analyses of 37 characters (HAVLÍČKOVÁ 1982), nine quantitative characters were selected (Tab. 2). Between and within population variation was computed using univariate statistical analysis in order to asses a contribution of each character to the distinctiveness of each population.

The overall variation pattern was obtained by cluster analysis using PC — Ord programme (MCCUNE 1987).







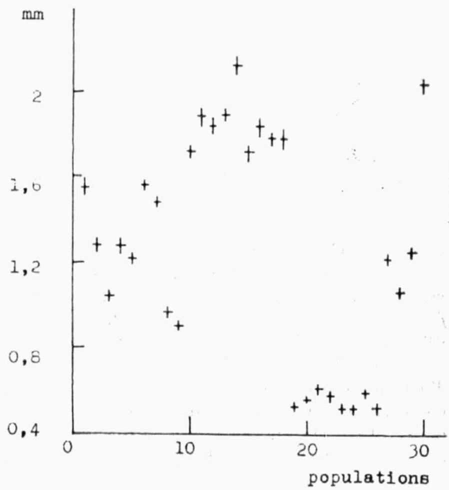


Fig. 2. — Breadth of leaves, arithmetical means (horizontal lines) and ± standard deviations (vertical lines) for each population (left up).

Fig. 3. — Breadth of bracts leaf-like, arithmetical means and ± standard deviations for each population (right up).

Fig. 4. — Length of perigynium, arithmetical means and ± standard deviations for each population (left below).

Fig. 5. — Length of perigynium beak, arithmetical means and ± standard deviations for each population (right below).

Tab. 2. — Characters used in the analyses (mm)

1	Breadth of leaf	6	Length of male spikes
2	Breadth of bract	7	Length of perigynium
3	Length of sheath of bract	8	Breadth of perigynium
4	Number of female spikes	9	Length of perigynium beak
5	Length of female spikes		

Morphological variation of characters

A survey of results of statistical analysis of populational variability in each character is given in Tab. 3. Four most important and most frequently employed traits are documented by graphs (Figs. 2—5).

Position of taxonomically obscure or hybrid populations (versus the "pure" parental ones) may be analysed on the graph — Fig. 6.

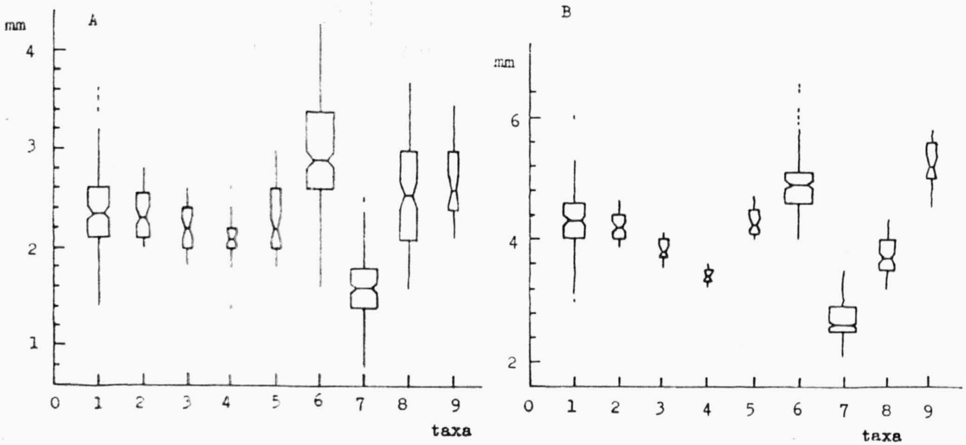


Fig. 6. — Comparison of the nine taxa of *Carex flava* — group, based on — A: breadth of leaves — B: length of perigynium. 1 — *C. lepidocarpa*, 2 — *C. flava* var. *alpina*, 3, 4 — *C. flava* × *C serotina*, 5 — *C. flava* × ?, 6 — *C. flava* var. *flava*, 7 — *C. serotina*, 8 — *C. tumidicarpa*, 9 — *C. flava* × *C. flava* × *C. lepidocarpa*.
(The box together with the vertical line cover the middle 75 % of the data values, the box contains the central 50 % of the values. The individual points represent the remaining extreme values. The width of the box corresponds to the square root of the number of observation in the data set, the central line is at the median. The notch of the box is proportional to width of the confidence interval for the median. The confidence level on the notches is set to allow pairwise comparisons to be performed at the 95 % level by examining whether two notches overlap).

Tab. 3. — Statistical characteristics for each measured character. (The first line — mean, the second line — variance)

Pop.	Characters								
No.	1	2	3	4	5	6	7	8	9
1	2,2 0,75	1,4 0,15	2,8 3,14	2,2 0,16	10,7 1,80	15,9 9,20	4,1 0,16	1,6 0,01	1,5 0,05

Tab. 3. — (continued)

2	2,8	1,4	2,8	2,6	13,0	17,0	4,6	1,7	1,3
	0,22	0,21	2,43	0,45	2,03	8,17	0,13	0,05	0,03
3	2,5	1,1	3,0	2,1	11,4	17,2	4,0	1,6	1,0
	0,18	0,19	2,16	0,23	1,49	10,14	0,08	0,03	0,01
4	2,1	1,0	2,2	2,0	10,8	15,6	4,0	1,6	1,3
	0,18	0,13	2,09	0,24	1,36	6,73	0,22	0,04	0,04
5	2,3	1,9	3,0	2,0	10,4	10,2	4,2	1,5	1,2
	0,07	0,06	1,35	0,20	0,52	1,33	0,08	0,01	0,01
6	2,3	2,0	2,0	2,2	8,3	8,3	4,04	1,5	1,5
	0,05	0,03	0,12	0,16	1,16	3,73	0,51	0,01	0,01
7	2,4	2,0	1,9	2,2	9,13	9,0	4,25	1,5	1,5
	0,06	0,08	0,12	0,14	1,22	2,10	0,03	0,01	0,01
8	2,2	1,6	2,2	3,3	9,8	13,9	3,8	1,4	0,9
	0,06	0,05	1,03	0,42	2,87	9,09	0,03	0,01	0,01
9	2,1	1,9	2,0	2,8	8,5	11,9	3,4	1,4	0,9
	0,05	0,08	0,32	0,28	0,80	4,18	0,01	0,01	0,01
10	2,3	2,1	2,8	2,5	9,7	11,2	4,3	1,5	1,7
	0,13	0,16	1,14	0,26	0,56	2,99	0,04	0,01	0,02
11	2,8	2,0	2,0	3,0	11,1	12,4	4,9	1,5	1,8
	0,32	0,21	0,78	0,34	1,43	2,46	0,07	0,03	0,0
12	2,9	1,9	2,2	2,6	10,7	11,4	4,9	1,7	1,84
	0,25	0,12	1,28	0,37	1,51	9,36	0,08	0,04	0,05
13	2,8	1,9	2,0	2,4	12,2	14,4	5,7	1,9	1,9
	0,31	0,10	1,03	0,25	5,08	5,08	0,18	0,02	0,04
14	3,2	2,1	2,0	2,9	12,3	12,9	5,0	1,8	2,1
	0,19	0,26	1,45	0,45	1,44	4,27	0,08	0,01	0,02
15	3,0	2,2	1,4	3,0	10,2	11,3	4,4	1,6	1,7
	0,35	0,16	0,40	0,21	1,77	5,54	0,07	0,01	0,04
16	3,5	2,6	2,1	3,2	11,3	12,3	4,5	1,5	1,8
	0,44	0,31	1,77	0,30	1,40	4,41	0,11	0,01	0,04
17	2,6	2,0	2,1	2,8	10,1	11,1	4,9	1,4	1,8
	0,09	0,11	2,14	0,35	1,35	3,86	0,06	0,02	0,03
18	3,0	2,4	3,1	2,8	11,1	12,1	4,6	1,9	1,8
	0,19	0,31	4,33	0,35	1,67	6,57	0,71	0,30	0,07
19	1,4	1,1	2,3	2,7	6,7	9,1	2,6	1,2	0,06
	0,10	0,09	2,73	0,25	0,76	2,02	0,02	0,34	0,01
20	1,6	1,4	3.1	3,4	7,2	7,9	2,6	0,9	0,5
	0,10	0,38	1.73	0,59	0,76	1,58	0,03	0,01	0,01
21	1,6	1,5	3,3	2,8	7,5	10,0	2,7	1,2	0,6
	0,06	0,13	2,77	0,35	1,29	5,93	0,04	0,01	0,01
22	1,4	1,1	2,7	3,6	7,1	7,0	3,0	1,2	0,6
	0,04	0,06	2,50	0,58	0,47	1,17	0,04	0,01	0,01
23	1,6	1,1	3,0	3,2	6,8	9,1	2,6	1,1	0,5
	0,09	0,11	4,86	0,35	0,39	5,88	0,03	0,01	0,01
24	1,7	1,5	3,2	3,6	8,2	8,8	2,6	1,3	0,5
	0,14	0,15	4,98	0,37	1,70	4,02	0,03	0,02	0,01
25	1,6	1,5	3,0	3,4	7,8	12,0	2,8	1,2	0,6
	0,18	0,09	4,96	0,46	1,10	8,06	0,09	0,01	0,01
26	1,5	1,3	3,3	2,8	7,5	11,2	2,5	1,2	0,5
	0,07	0,12	4,05	0,44	1,70	7,35	0,02	0,01	0,01
27	2,1	1,4	2,6	2,6	10,1	15,2	3,6	1,4	1,2
	0,06	0,10	0,75	0,22	1,05	3,90	0,01	0,01	0,01
28	2,6	2,3	3,2	3,5	10,3	13,1	3,5	1,4	1,1
	0,29	0,12	1,37	0,39	1,33	10,62	0,03	0,01	0,1
29	3,0	2,7	2,4	3,3	10,6	13,8	4,0	1,5	1,2
	0,13	0,23	0,72	0,24	0,92	6,41	0,01	0,01	0,01
30	2,7	1,9	2,3	2,2	11,5	16,6	5,2	1,5	2,0
	0,14	0,10	0,63	0,18	1,22	3,06	0,12	0,02	0,04

As a criterion of plasticity of a character within a population, variance values were taken. In all the populations examined, the length of basal bract sheath and length of male spikes were found to be the most variable characters (cf. Tab. 3). On the other hand, lowest variance values were

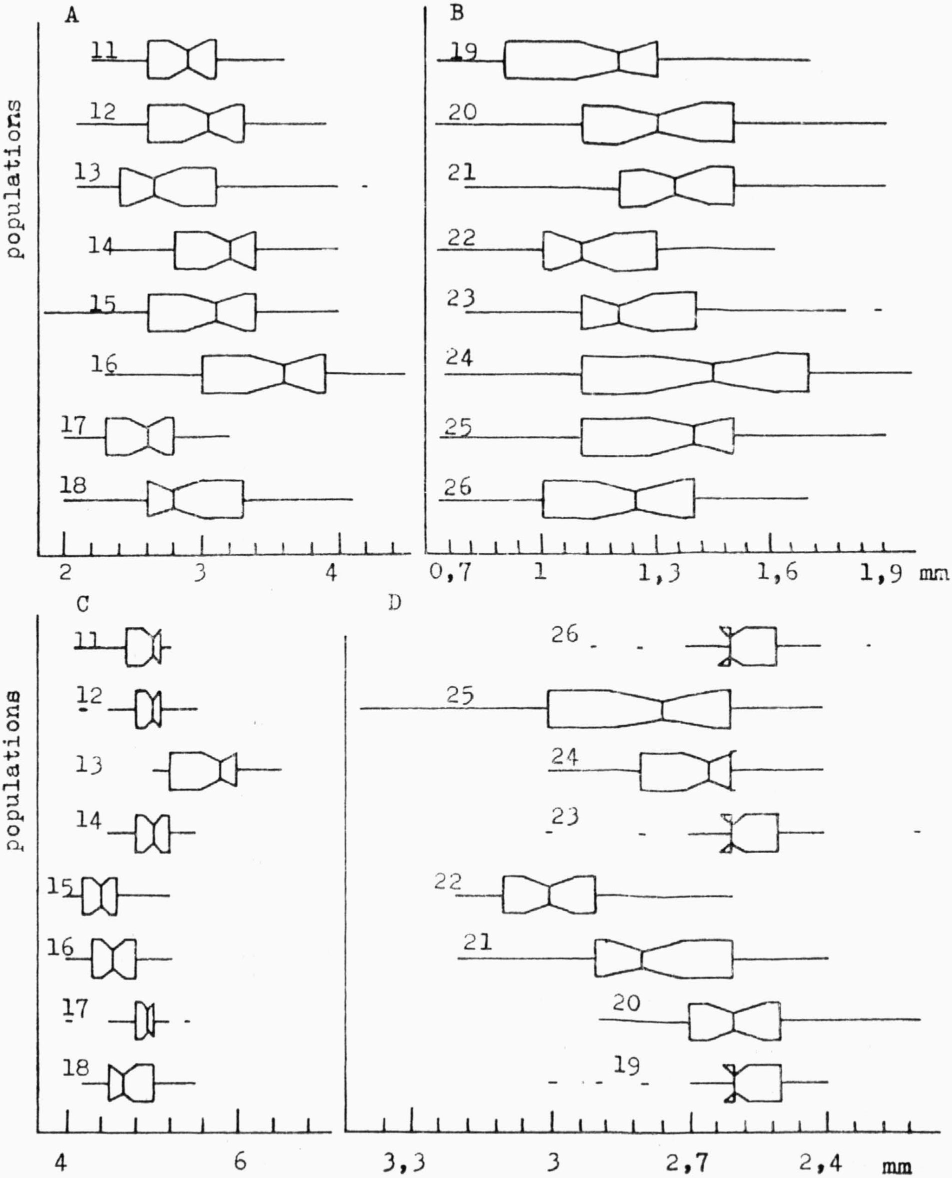


Fig. 7. — Plots obtained from results of ANOVA.
A — breadth of leaves of populations of *C. flava* var. *flava*, B — breadth of leaves of populations of *C. serotina*, C — length of perigynium of populations of *C. flava* var. *flava*, D — length of perigynium of populations of *C. serotina*.

ascertained in the perigynium features. At the same time, the greatest taxonomic value is accorded to these latter characters. This high importance was also confirmed by means of multivariate analyses of the whole character set (see Havlíčková 1982).

One-way analysis of variance was employed (using F-values) to find how populations within a given taxon differ in morphological variability. F-values and significance levels of the differences in individual characters are summarized in Tab. 4. The populations were significantly different in nearly all the variables tested. On the basis of ANOVA, the graphic plots clearly showed the fact that, within a given species, no character allowed to find two morphologically distinct groups for Bulgarian and Czechoslovak material, respectively (see Fig. 7).

By means of one way ANOVA, we have studied how a within-population variability and between-population variation contribute to the overall variability of individual taxa. It can be shown that the proportion of variation within populations is higher than that among a set of populations. Tab. 4 shows a percentage of within-population variation in the overall variability of the given taxon. It is obvious from this Table that there are certain differences between the values of vegetative characters and the generative ones.

Tab. 4. — Results of analysis of variance. First number in column — F value, $^{+}P < 0{,}05$, $^{++}P < 0{,}01$, ns = not significant at $P = 0{,}05$; second number — variance within populations (% in overall variance of each taxon)

Species Character	*flava* var. *flava* d. f. 7,232	*lepidocarpa* d. f. 4,145	*tumidicarpa* d. f. 2,87	*serotina* d. f. 7,232
1	$8{,}1^{++}$ 85	$13{,}3^{++}$ 80	$38{,}6^{++}$ 90	$3{,}9^{++}$ 65
2	$10{,}4^{++}$ 80	$24{,}9^{++}$ 79	$81{,}2^{++}$ 80	$8{,}7^{++}$ 60
3	$3{,}9^{++}$ 90	$1{,}6^{ns}$ 85	$5{,}4^{+}$ 88	$0{,}9^{ns}$ 77
4	$5{,}7^{++}$ 85	$6{,}2^{++}$ 85	$20{,}8^{++}$ 67	$9{,}7^{++}$ 77
5	$10{,}1^{++}$ 73	$22{,}5^{++}$ 62	$1{,}9^{ns}$ 95	$7{,}6^{++}$ 81
6	$6{,}8^{++}$ 82	$34{,}6^{++}$ 58	$4{,}7^{+}$ 90	$18{,}3^{++}$ 64
7	$25{,}9^{++}$ 56	$25{,}9^{++}$ 58	$40{,}1^{++}$ 52	$14{,}7^{++}$ 74
8	$40{,}3^{++}$ 51	$6{,}6^{++}$ 69	$6{,}2^{++}$ 64	$19{,}6^{++}$ 72
9	$10{,}3^{++}$ 65	$30{,}2^{++}$ 56	$22{,}8^{++}$ 64	$3{,}8^{++}$ 92

When percentage of the within-population variation is compared between two groups of characters that are only weakly correlated to each other, the following conclusions are reached (width of leaves [1] and bract width [2] were selected as representatives of strongly ecologically influenced vegetative features, and perigynium length and beak length [7, 9] as strongly genetically fixed generative features, much more independent of environment).

Whereas in *C. flava*, C. *lepidocarpa* and *C. tumidicarpa* the proportion of intrapopulational variability is higher for the vegetative features (on the other hand, the ratio between inter- and intrapopulational variation for the perigynium features approaches unity), a contrary situation was found in *C. serotina*. More significant inter-population differences were found in vegetative features for this latter species (very likely due to higher habitat differences between the studied localities of the populations of it), while in the perigynium features, intrapopulational variability clearly predominates.

However, SCHMID (1984b, 1986a) arrived at divergent conclusions: "The most r-selected taxon of the group, *C. viridula* ssp. *viridula* (= *C. serotina*) has indeed the lowest genetic variability within population but, in ecologically important characters, expresses the highest plasticity" (SCHMID, 1984b : 1).

Results of cluster analysis

Cluster analysis was performed using Ward's method as the criterion for the fusion of cluster. Ward's method attemps to find a set of clusters with the minimum total within cluster variance.

As is evident from Fig. 8, the most striking feature of the overall pattern is the exclusive isolation of the set of populations of *C. serotina*. The populations of the *C. flava* var. *flava* also cluster well in a very wide cluster A (see Fig. 8) together with two populations of *C. tumidicarpa*. A set of po-

Tab. 5. — Habitat characteristics of sites of studied populations.

Locality Relevé	Altitude m s.m.	Slope aspect	pH (H_2O)	Ca^{2+} (%)	Plot area (m^2)	Cover (%)	Taxa
1	180	O	7,1	4,2	14	90	*C. lepido-*
2	180	O	8,2	3,6	14	90	*carpa*
3	430	N	6,4	5,6	10	85	
4	450	N	8,3	13,2	13	90	
5	420	O	6,5	2,6	14	70	
6	1850	0	5,2	0,3	5	90	*C. flava*
7	950	E	7,8	9,3	9	80	var. *alpina*
8	1200	NNW	5,4	0,0	12	70	*C. flava* × *C.*
9	1350	N	5,5	0,1	10	75	*serotina*
10	1600	O	5,1	0,0	12	75	*C. flava* × ?
11	430	N	6,4	0,5	12	90	*C. flava*
12	180	0	8,3	3,6	12	85	var. *flava*
13	240	O	6,5	0,7	10	85	
14	420	N	7,7	0,8	10	95	
15	1350	N	5,3	0,3	10	85	
16	1600	SE	5,9	0,7	9	80	
17	1300	NNW	5,8	0,1	10	80	
18	1600	NNW	5,6	0,3	9	90	
19	450	0	8,3	13,2	13	60	*C. serotina*
20	120	0	8,3	4,1	14	60	
21	180	0	8,1	2,5	10	65	
22	320	0	8,0	4,1	14	55	
23	1250	NNW	5,5	0,1	12	65	
24	950	NW	6,2	0,1	6	75	
25	550	O	6,9	2,1	8	70	
26	1520	NNE	4,7	0,0	12	55	
27	850	S	6,3	0,1	12	85	*C. tumidicarpa*
28	580	NW	5,9	0,0	12	80	
29	950	SW	5,4	0,0	10	85	
30	1350	NE	6,2	1,0	12	90	*C. flava* × (*C. flava* × *C. lepidocarpa*)
31	1250	NNW	5,5	0,1	12	65	*C. flava* × (*C. serotina*)

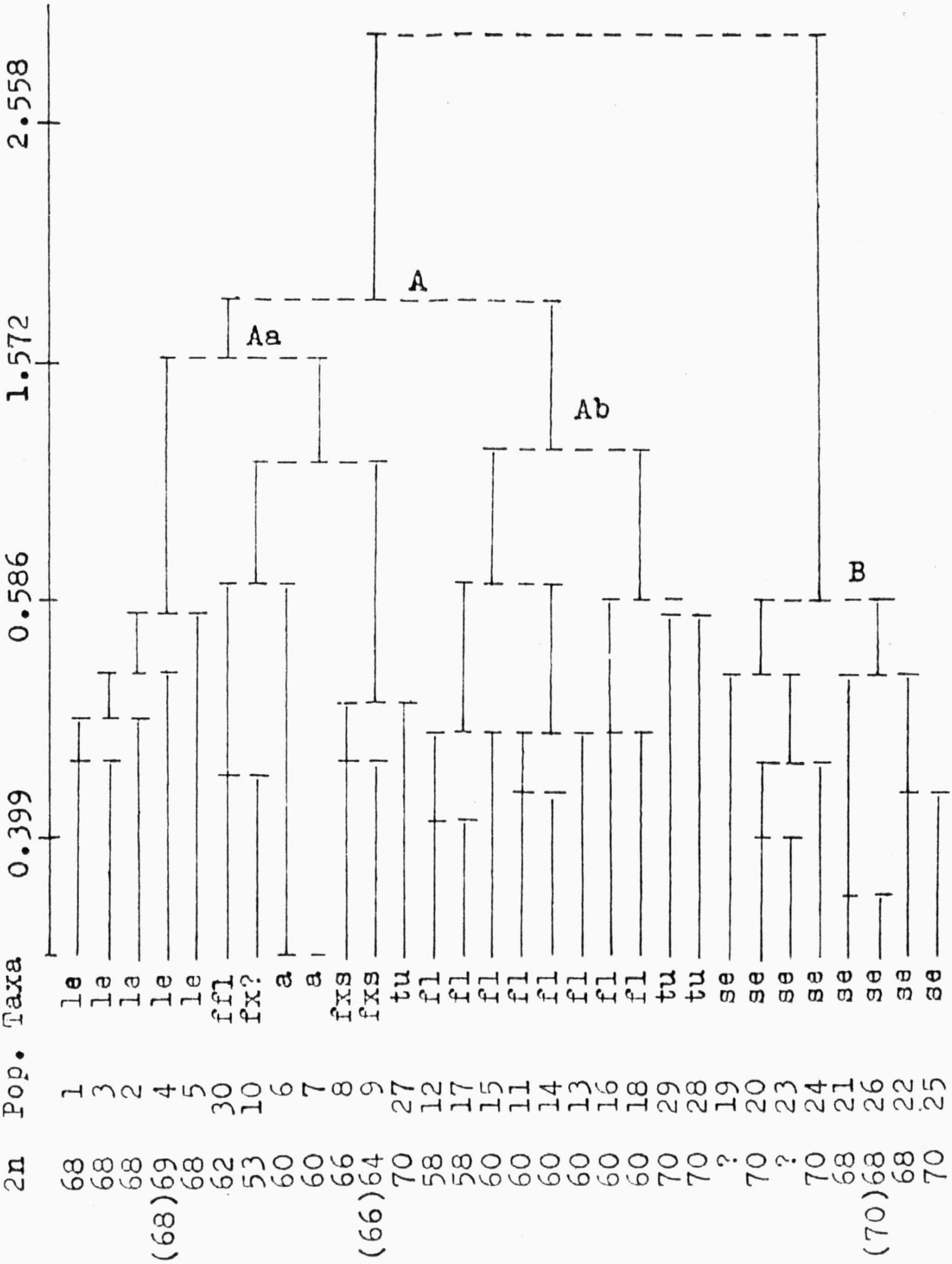


Fig. 8. — Cluster analysis, Ward's method. (fl = *Carex flava* var. *flava*, a = *C. flava* var. *alpina*, le = *C. lepidocarpa*, se = *C. serotina*, tu = *C. tumidicarpa*, ffl = *C. flava* × (*C. flava* × *C. lepidocarpa*), fxs = *C. flava* × *C. serotina*, fx? = *C. flava* × ?).

Tab. 6. — Phytosociological relevés with the *Carex flava* L. var. *flava*, *C. flava* var. *alpina* KNEUCKER and hybrids *C. flava* L. var. *flava* × *C. serotina* MÉRAT and *C. flava* L. var. *flava* × (*C. flava* L. var. *flava* × *C. lepidocarpa* TAUSCH).

Relevé	11	12	13	14	7	6	15	16	17	18	10	30
E_1												
Carex flava L. var. *flava*	1	2	1	1	.	.	1	1	2–3	2	1	.
Potentilla erecta (L.) RÄUSCHEL	+	1	+	.	+	+	+	+	1	+	+	.
Carex echinata MURRAY	.	.	.	+	1	+	1	.	1	1	.	.
Carex nigra (L.) REICHARD	.	.	1	2	2	2	2	.	.	+	1	1
Carex panicea L.	.	1	+	+	.	.	.	1–2	1	.	+	+
Galium uliginosum L.	+	r	.	+	+	.	.	+	+	.	.	.
Juncus effusus L.	+	.	.	1	2	.	.	1	.	1	.	.
Parnassia palustris L.	.	.	.	+	.	.	.	+	+	+–1	+	.
Prunella vulgaris L.	+	.	.	1	1	.	.	+	.	r	.	.
Carex canescens L.	.	.	+	.	.	1	.	1	.	.	1–2	.
Deschampsia cespitosa (L.) BEAUV.	.	.	1	.	.	.	1	1	.	.	2	.
Juncus articulatus L.	.	.	.	+	.	.	1	.	1	+	.	.
Mentha arvensis L.	1	+	.	+	.	.	.	.	.	.	.	+
Molinia caerulea (L.) MOENCH	1–2	1	1–2	.	.	.	.	.	.	1	.	.
Ranunculus acris L.	.	.	1	.	.	.	+	1	.	.	1	.
Agrostis stolonifera L.	.	.	.	.	+	.	.	1	1	.	.	.
Cynosurus cristatus L.	.	.	.	.	.	.	.	1	.	+	.	+
Equisetum palustre L.	1	.	.	1	.	.	.	.	.	.	.	+
Eriophorum angustifolium HONCKENY	.	.	.	.	.	.	2	.	2	2	.	.
Eriophorum latifolium HOPPE	.	+	1	.	.	1	.	.	.	.	.	.
Geum rivale L.	.	.	.	.	.	.	.	1	.	+	2	.
Lathyrus pratensis L.	.	.	.	+	.	1	.	.	.	+	.	.
Myosotis nemorosa BESSER	.	.	.	.	1	.	1	.	.	+	.	.
Scirpus sylvaticus L.	.	.	.	1–2	.	.	.	..	.	1	.	1
Succisa pratensis MOENCH	.	1	+	.	+	.	.	.	.	.	.	.
Trifolium pratense L.	.	.	.	.	.	.	.	1	.	.	1	1
Alchemilla crinita BUSEP	.	.	.	.	.	.	.	.	.	+	.	1
Alchemilla monticola OPIZ	.	.	.	.	.	.	+	.	.	+	.	.
Leontodon hispidus L.	.	.	.	.	.	.	.	+–1	.	.	.	+
Lychnis flos-cuculi L.	+	.	.	.	.	.	.	.	.	.	.	+
Mentha longifolia (L.) HUDSON	.	1	.	.	.	.	.	.	.	.	.	1
Myosotis orbelica VELEN.	.	.	.	.	.	.	.	.	1	.	+	.
Nardus stricta L.	.	.	.	.	.	.	.	.	.	+	1	.
Orchis morio L.	.	.	.	.	.	.	.	+	.	1	.	.

Phragmites australis (Cav.) Trin. ex Steudel	[illegible]	[illegible]	.	.	.	.	.	.	.	.	.	.
Pinguicula vulgaris L.	.	.	.	.	.	+	.	.	.	+	.	.
Plantago lanceolata L.	.	.	.	+	.	.	.	.	.	+	.	.
Polygonum bistorta L.	.	.	.	+	.	.	.	.	.	+	.	.
Sanguisorba officinalis L.	.	.	.	1	.	.	.	.	.	.	.	1
Soldanella sp.	.	.	.	.	.	.	1	.	.	1	.	.
Trifolium repens L.	.	.	.	+	.	.	.	.	.	+	.	.
Tussilago farfara L.	1	.	.	.	.	.	.	.	.	.	.	1
Vicia cracca L.	.	.	.	1	.	.	.	.	1	.	.	.
Anthoxanthum odoratum L.	.	.	.	.	.	.	.	.	.	+	1	.
Caltha palustris L.	.	.	.	.	1	.	.	.	.	+	.	.
Cardamine opizii J. Presl et C. Presl	.	.	.	.	1	.	.	1	.	.	.	.
Carex davalliana Sm.	.	1	1	.	.	.	.	.	.	.	.	.
Carex flava var. *alpina* Kneucker	.	.	.	.	1	2	.	.	.	.	.	.
Cirsium palustre (L.) Scop.	.	.	.	1	.	.	1	.	.	.	.	.
Crepis paludosa (L.) Moench	.	.	.	.	1	.	.	.	.	1	.	.
Cruciata laevipes Opiz	.	.	.	.	.	.	.	+	.	r	.	.
Epipactis palustris (L.) Crantz	.	.	1	.	.	.	1	.	.	.	.	.
Equisetum fluviatile L.	.	.	.	.	.	+	.	.	.	r	.	.
Festuca rubra L. s.l.	.	.	.	.	.	.	.	1	.	+	.	.
Galium palustre L.	+	.	+	.	.	.	.	.	.	.	.	.
Gentiana pneumonanthe L.	+	.	+	.	.	.	.	.	.	.	.	.
Gymnadenia conopsea (L.) R. Br.	.	.	.	.	.	.	.	.	.	1	.	+
Holcus lanatus L.	.	.	.	.	.	.	.	.	.	+	1	.
Hypericum perforatum L.	.	.	.	.	.	.	.	+–1	.	.	.	+

Species occurring in one relevé only: 11: *Carex paniculata* L. 2; *Carex rostrata* Stokes 1; *Leucanthemum vulgare* Lam. 1; *Luzula multiflora* (Ehrh.) Lej. +; *Lythrum salicaria* L. 1; *Viola palustris* L. +; 12: *Carex hosteana* DC. 1–2; *Carex serotina* Mérat 1; *Triglochin palustre* L. +; 13: *Carex hartmanii* Cajander 1; *Scutellaria galericulata* L. +–1; 14: *Hypericum maculatum* Crantz 1; *Valeriana dioica* L. +; 7: *Eleocharis quinqueflora* (F. K. Hartmann) O. Schwarz 1; *Listera ovata* (L.) R. Bp. +; 6: *Leucorchis albida* (L.) E. Meyer +–1; 15: *Carex flava* L. var. *flava* × *C. serotina* Mérat 1; *Luzula* sp. (sect. *Alpinae* Chrtek et Křísa) +; 16: *Ajuga genevensis* L. +; *Briza media* L. +; *Calamagrostis epigejos* (L.) Roth 1; *Carex hirta* L. 1; *Euphorbia amygdaloides* L. 1; *Fragaria vesca* L. +; *Luzula luzuloides* (Lam.) Dandy et Wilmott 1; 17: *Bruckenthalia spiculifolia* (Salisb.) Reichenb. +; *Drosera rotundifolia* L. +–1; *Ranunculus flammula* L. 1; 18: *Carex leporina* L. +–1; *Carex pallescens* L. 1; *Primula elatior* (L.) Hill +; *Trifolium spadiceum* L. 1; 10: *Carex flava* L. var. *flava* × ? 1; *Lycopus europaeus* L. 1; 30: *Dactylorhiza maculata* (L.) Soó 1; *Juncus inflexus* L. 1; *Veronica beccabunga* L. 1.

pulations of *C. lepidocarpa* is amalgamated together with the remaining populations in the taxonomically heterogeneous subcluster Aa.

Now a few aberrant populations should be mentioned: The population 30

Tab. 7. — Phytosociological relevés with *Carex serotina* MÉRAT and the hybrid *C. flava* L. var. *flava* × *C. serotina* MÉRAT.

Relevé	19	20	21	22	23	24	25	26	8
Carex serotina MÉRAT	1	2	1–2	2	2–3	1	2	2–3	1
Carex echinata MU RAY	.	1	.	.	1	2	.	1	1
Prunella vulgaris L.	.	1	.	.	1	1	1	.	1
Lotus corniculatus L.	1	.	.	1	.	1	1	.	.
Carex panicea L.	.	.	1	.	.	.	1	.	1
Juncus articulatus L.	.	.	.	1	.	1	1	.	.
Molinia caerulea (L.) MOENCH	1–2	.	1	.	.	.	.	1	.
Myosotis orbelica VELEN.	.	.	.	.	1	.	.	r	1
Trifolium pratense L.	.	.	.	.	.	1	1	+	.
Agrostis stolonifera L.	.	.	.	.	.	.	2	2	.
Blysmus compressus (L.) PANZER ex LINK	.	.	.	.	.	1–2	2–3	.	.
Carex distans L.	.	2	.	.	.	.	1	.	.
Carex leporina L.	.	+	.	.	.	+	.	.	.
Carex pallescens L.	.	.	.	.	.	1	.	1	.
Centaurium uliginosum (WALDST. et KIT.) BECK ex RONNIGER	+	+	.	.	.	.	.	.	.
Daucus carota L.	+	+	.	.	.	.	.	.	.
Festuca rubra L. s. l.	.	.	.	.	.	1	1	.	.
Holcus lanatus L.	.	.	.	.	.	1	1	.	.
Juncus effusus L.	.	.	.	.	1–2	.	.	.	1
Leontodon autumnalis L.	.	+	.	+	.	.	.	.	.
Lycopus europaeus L.	.	.	.	1	.	.	.	.	1
Mentha arvensis L.	.	.	+	+	.	.	.	.	.
Phragmites australis (CAV.) TRIN. ex STEUDEL	.	1–2	1	.	.	.	.	.	.
Potentilla erecta (L.) RÄUSCHEL	.	.	.	.	1	.	.	.	+
Rhinanthus minor L.	.	.	.	.	.	+	.	r	.
Trifolium repens L.	.	.	.	.	.	1	1	.	.

Species occurring in one relevé only: 19: *Epipactis palustris* (L.) CRANTZ 1; *Euphrasia rostkoviana* HAYNE +; *Plantago major* L. +–1; *Poa compressa* L.+; *Primula farinosa* L. +–1; *Tofieldia calyculata* (L.) WAHLENB. +–1; *Trifolium montanum* L. +; 20: *Achillea millefolium* L. +; *Centaurea jacea* L. 1–2; *Eriophorum latifolium* HOPPE +; *Linum catharticum* L. +; *Pastinaca sativa* L. 1; *Potentilla anserina* L. +; *Tetragonolobus maritimus* (L.) ROTH 1; *Colobium taraxacoides* (VILL.) HOLUB 1; 21: *Calamagrostis arundinacea* (L.) ROTH 1; *Carex flacca* SCHREBER 1; *Carex flava* L. 1; *Carex hirta* L. +; *Carex hosteana* DC. 1–2; *Carex lepidocarpa* TAUSCH 1; *Cirsium oleraceum* (L.) SCOP. 1–2; 22: *Equisetum arvense*. L. 1; *Odontites verna* (BELLARDI) DUMORT. 1; *Ranunculus acris* L. +: *Trifolium fragiferum* L. 1: *Tussilago farfara* L. 1; 23: *Drosera rotundifolia* L. +; *Juncus conglomeratus* L. 1; *Pinguicula vulgaris* L. 1; *Succisa pratensis* MOENCH 1; 24: *Anthoxanthum odoratum* L. +; *Cynosurus cristatus* L. 1; *Deschampsia cespitosa* (L.) BEAUV. 1; *Euphrasia illyrica* WETTST. +; *Myosotis caespitosa* C. F. SCHULTZ +–1; *Rumex acetosa* L. 1; *Silene ciliata* POURR. +–1; *Trifolium badium* SCHREBER +–1; 25: *Caltha minor* MILL. 1; *Eleocharis quinqueflora* (F. K. HARTMANN) O. SCHWARZ 2; *Eleocharis palustris* (L.) ROEMER et SCHULTES 2; *Mentha pulegium* L. +; *Menyanthes trifoliata* L. 1; *Ranunculus repens* L. 1; 26: *Cirsium waldsteinii* ROUY 1; 8: *Carex flava* L. var. *flava* × *C. serotina* MÉRAT 2; *Epilobium parviflorum* SCHREBER 1; *Galium uliginosum* L. +; *Holcus mollis* L. 1; *Mentha longifolia* (L.) HUDSON 1; *Scirpus sylvaticus* L. 1;

contains fertile plants with 2n = 62, morphologically intermediate between *C. flava* and *C. lepidocarpa*. We suppose that the population 30 might represent a case of so called "cryptic backcross" *C. flava* × (*C. flava* × *C. lepidocarpa*) (sensu SCHMID 1982). This population is associated with the population 10, which is rather unclear taxonomically. It has proved to have 2n = 53, the plants being sterile (to a relatively high extent), and in general appearance, approaching hybrids involving *C. flava* in their parentage. This pair of populations is connected with its nearest neighbours (populations of the *C. flava* var. *alpina*) in the dendrogram at low similarity level. This amalgamation of two taxonomically different samples in this cluster analysis can be accounted for by the fact that neither qualitative characters nor biological features (e. g. sterility) were included in the data.

This is very likely the reason why populations 8 and 9 (hybrids between *C. flava* and *C. serotina*) are found in one subcluster with population 27 (*C. tumidicarpa*).

DISCUSSION

Results of statistical and multivariate analyses showed that no significant morphological difference can be found between the Bulgarian and Czechoslovak populations within the individual species of the *Carex flava* agg. However, differences have been ascertained concerning the habitat characteristics.

The localities of *Carex flava* (including var. *alpina*) fall the height span of 180 to 1800 m a. s. l., all the Bulgarian sites being above 1300 m (Tab. 5). Results of the soil samples analyses (Tab. 5) have also shown differences in pH values and the Ca^{2+} contents. The Czechoslovak samples exhibit higher values of both characteristics. SCHMID (1984a), in a thorough study of the *C. flava* group in Switzerland, found the pH range almost identical to that ascertained by us (our results: pH 5,2—8,3 versus 5,15—8,1 in the Schmid's work).

In order to illustrate the vegetation with *Carex flava*, phytosociological relevés were recorded at each locality (Tab. 6). In accordance with higher pH and Ca^{2+} values, the relevés from Czechoslovakia include a higher number of species typical for calcareous grasslands (e. g., *C. lepidocarpa*, *C. hosteana*, *Epipactis palustris*, *Eriophorum latifolium*, *Tofieldia calyculata*).

Similar differences in the environmental factors were found in the case of *C. serotina*. While in Czechoslovakia this species is distributed mainly from lowlands to the submontane belt, in Bulgaria it is most frequently met with in the mountains (for instance, it has been collected in the Vitoša Mts., at the altitude 2200 m). *Carex serotina* is characterized by a wide ecological amplitude, which answers to wide pH and Ca^{2+} ranges documented in Tab. 5. Again, the higher values occurred in the samples from Czechoslovakia. SCHMID (op. c.) gives the pH range of 6,30—8,18 for *C. serotina* from altitudes between 285 and 1030 m, while our measurements formed a wider amplitude (4,7—8,3). Floristic composition of the vegetation with *C. serotina* is recorded in Tab. 7. Lower cover values (see Tab. 5) can be considered as a typical feature of these communities. SCHMID (1984a : 113) suggested this fact to be in agreement with the life history of *C. serotina*; he arrived at the conclusion that the life cycles of the members of the *Carex flava* group "can be placed along the r-K continuum in the order *viridula*, *brachyrrhyncha*, *alpina* and *flava*. Along this continuum the habitat requirements change from open to moderately close".[1])

Only one population of *C. lepidocarpa* was available from Bulgaria. The pH and Ca^{2+} values found at this locality fall within the range ascertained in Czechoslovakia. SCHMID (op. c.) published identical pH amplitude for this taxon. Phytosociologically, the vegetation with *Carex lepidocarpa* belongs to the alliance *Caricion davallianae* in Czechoslovakia. A detailed analysis of the ecological condition at the Bulgarian locality is given in a paper by JORDANOV et al. (1975). In addition to *C. lepidocarpa* the following species were recorded there: *Cladium mariscus*, *Carex acutiformis*, *C. echinata*, *C. nigra*, *C. panicea*, *C. paniculata*, *C. serotina*, *Eleocharis palustris*, *Eleocharis pauciflora*, *Eriophorum latifolium*, *Schoenus nigricans* var. *intermedius*, *Triglochin palustre*.[2])

Carex lepidocarpa represents a strongly endangered species in Bulgaria and Czechoslovakia. It is due to its almost exclusive occurrence in calcareous grasslands (often in lower altitudes). This type of habitat disappears very fast, which is a result of changing methods and intensification of farming.

Carex tumidicarpa follows *C. flava* in the distribution frequency in Czechoslovakia. It has not been recorded in Bulgaria. For the sake of completeness, three populations were analysed from Czechoslovakia. *C. tumidicarpa* occurs from the hill belt to the submontane belt, its common habitats being peaty meadows on silicate substrates, in the montane belt, it is also met with in peat-bogs (HAVLÍČKOVÁ 1983).

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[1]) SCHMID (1983) published a taxonomic and nomenclatural revision of the *C. flava* group in Europe, presenting an original biological species concept for the group. This new conception is mainly based on karyology and hybridization of Swiss representatives of this group. The species rank is retained for *C. flava* and *C. viridula* (= *C. serotina*), whereas the other taxa are accorded lower status.

In the course of our studies in Bulgaria and Czechoslovakia we have arrived at rather different results, suggesting that the rank of species answers better to the relationships within the group. In Bulgaria and Czechoslovakia, the following species are recognized, *C. flava* var. *flava*, *C. flava* var. *alpina*, *C. lepidocarpa*, *C. tumidicarpa* (only in Czechoslovakia) and *C. serotina*, which, respectively corresponds to *C. flava* var. *flava*, *C. flava* var. *alpina*, *C. viridula* subsp. *brachyrrhyncha*, *C. viridula* subsp. *oedocarpa*, and *C. viridula* subsp. *viridula* in the Schmid conception.

[2]) During revision of the distribution of *C. lepidocarpa* in Bulgaria, it became clear that there is a discrepancy between the data from literature and the herbarium material. The distribution of *C. lepidocarpa* (as *C. flava* ssp. *lepidocarpa*) is characterized as "widespread" in the Flora of Bulgaria (JORDANOV 1964), while *C. flava* is reported to be confined to two regions. This is predominantly based on the work of ACHTAROV (1957). The main herbarium collections consulted by Achtarov were those of SO, SOA, SOM. After revising these herbarium collections, we have reached a contrary conclusion. *C. flava* is a common species in Bulgaria, particularly in the mountains, whereas *C. lepidocarpa* is found much less frequently. Many of the Achtarov localities of *C. lepidocarpa* refer in fact to *C. flava*. In the herbarium material the following localities of *C. lepidocarpa* were only ascertained: Sofijsko, Vasilovci (ca 400 m a.s.l.); Šipčenska planina, Usaña; Samokov: Prodanovci and Chrelovo (ca 1000 m); Pirin, meadows below Razlog (ca 1100 m). VELENOVSKÝ (1881) gives *C. lepidocarpa* also from the calcareous grasslands along the Marica river at Sadovo. We have visited the Vasilovci and the Sadovo localities but we failed to find suitable habitats for this species in both strongly agriculturally changed regions. At Usana and Razlog we found only *C. flava* var. *flava*.

Tab. 8. — Phytosociological relevés with *Carex lepidocarpa* Tausch

Relevé	1	2	3	4
E_2				
Salix rosmarinifolia L.	1	.	.	.
E_1				
Carex lepidocarpa Tausch	2	1	2	1
Carex hosteana DC.	1	1—2	1	1—2
Carex panicea L.	1	1	1	+
Molinia caerulea (L.) Moench	2	1	1	.
Potentilla erecta (L.) Räuschel	1	1	.	+
Agrostis stolonifera L.	+	.	+	.
Briza media L.	+	.	.	+
Carex davalliana Sm.	.	1	.	2
Carex rostrata Stokes	.	.	2	1
Cirsium palustre (L.) Scop.	+	.	+	.
Epipactis palustris (L.) Crantz	.	+	.	2
Equisetum palustre L.	.	.	1	1
Eriophorum latifolium Hoppe	.	+	.	1
Galium uliginosum L.	r	r	.	.
Juncus conglomeratus L.	.	1	+	.
Lythrum salicaria L.	1	.	1	.
Mentha arvensis L.	+	+	.	.
Phragmites australis (Cav.) Trin. ex Steudel	.	2	1	.
Prunella vulgaris L.	.	.	+	1
Succisa pratensis Moench	+—1	1	.	.
Valeriana dioica L.	+	.	.	1

Species occurring in one relevé only: 1: *Centaurea jacea* L. 1; *Galium verum* L. 1; *Juncus subnodulosus* Schrank 1; *Linum catharticum* L. +; *Parnassia palustris* L. +; *Schoenus ferrugineus* L. 2; 2: *Carex flava* L. 1; *Carex serotina* Mérat 1; *Triglochin palustris* L. 1; 3: *Carex echinata* Murray +; *Cirsium oleraceum* (L.) Scop. 1; *Juncus articulatus* L. +; *Lychnis flos-cuculi* L. 1—2; *Tussilago farfara* L. 1; 3: *Agrostis capillaris* L. +; *Crepis paludosa* (L.) Moench +; *Pinguicula vulgaris* L. +; *Primula farinosa* L. 1; *Tofieldia calyculata* (L.) Wahlenb.

This is in accordance with low pH values and particularly, a negligible calcium contents in the soil samples from the localities of *C. tumidicarpa*. Almost identical pH range was found in Swiss localities of this species.

It follows from the comparison of the habitat factors variation that diversity of environmental factors between sites of the populations studied gradually decreases in this order: *C. serotina*, *C. flava*, *C. tumidicarpa* and *C. lepidocarpa*. At the same time, *C. lepidocarpa* and *C. tumidicarpa* are ecologically most distinct from each other within the *C. flava* complex.

The results of CA and ANOVA have shown, that variability of macroenvironmental factors (such as altitude, pH and Ca^{2+} values, macroclimatic differences) are only weakly correlated with the morphological variability of the populations. For instance, populations 26 and 21 are the closest neighbours within the *C. serotina* cluster, but they come from highly different habitats, similar situation is found in the case of Nos. 20 and 23. Likewise populations Nos. 12 and 17 sampled at the localities differing considerably in the altitude and soil calcium contents were very close morphologically within *C. flava* var. *flava*.

Tab. 9. — Phytosociological relevés with *Carex tumidicarpa* ANDERSS.

Relevé	27	28	29
E_1			
Carex tumidicarpa ANDERSS.	2	3	1
Carex panicea L.	+	+	1
Prunella vulgaris L.	+	1	+
Agrostis stolonifera L.	1	2	.
Anthoxanthum odoratum L.	1	.	r
Carex leporina L.	1	+	.
Carex nigra (L.) REICHARD	+	1	.
Carex pallescens L.	1	.	1—2
Juncus articulatus L.	2	+	.
Lotus corniculatus L.	.	+	+
Myosotis nemorosa BESSER	1	1	.
Plantago major L.	+	1	.
Poa pratensis L.	1	.	r
Potentilla erecta (L.) RÄUSCHEL	.	1	+
Ranunculus repens L.	.	+	1
Trifolium repens L.	1	.	+

Species occurring in one relevé only: 27: *Carex hirta* L. 1; *Deschampsia flexuosa* (L.) TRIN. 2; *Equisetum palustre* L. 1; *Linum catharticum* L. r; *Lychnis flos-cuculi* L. 2; *Mentha longifolia* (L.) HUDSON +; *Potentilla anserina* L. +; *Trifolium pratense* L. 2; 28: *Cirsium palustre* (L.) SCOP. +; *Deschampsia cespitosa* (L.) BEAUV. +; *Isolepis setacea* (L.) R. BR. 1;; *Juncus bulbosus* L. 1; *Juncus effusus* L. 1; *Leontodon autumnalis* L. +; *Ranunculus flammula* L. 2; *Veronica serpyllifolia* L. 2; 29: *Agrostis capillaris* L. 2; *Briza media* L. +; *Carex pilulifera* L. r; *Calycocorsus stipitatus* (JACQ.) RAUSCHERT r — +; *Cirsium canum* L. 2; *Cynosurus cristatus* L. +; *Homogyne alpina* (L.) CASS. + — 1; *Tussilago farfara* L. 2.

In comparing the results of morphological and karyological analyses (see Fig. 8), we have arrived at conclusion that there is a correlation between the chromosome number and phenetic variation within a given taxon.

The above results suggest that the interpopulational variability was under influence of the genotype variation to an extent greater than that of the variability of the macrohabitat factors.

Analysis of variance showed that the main source of the overall variability within a species was the intrapopulational variation, which applies to all the species concerned. Particularly, it is apparent in the case of vegetative features of *C. flava*, *C. lepidocarpa* and *C. tumidicarpa*, while *C. serotina* was characterized by a higher proportion of the within population variability of the perigynium traits.

Let us compare the above results with those published by SCHMID (op. varia) on the basis of the Swiss material. We can quote the relevant paragraph: "In an evolutionary context the most important result reported here is that, with the exception of *flava-alpina*, patterns of both phenotypic and genetic variation of the *C. flava* group are characterized by large between- and small within-population differences. ... The sedges of the *C. flava* group as a whole are comparatively rare plants, and within the group effective population sizes decrease from *flava* to *viridula* while at the same time between-population variation increases and within-population variation decreases." (SCHMID 1986a : 125). Further conclusions are given on page 124: "Effective population sizes, gene flow between populations, and introgression from other taxa all decrease in the series *flava, alpina, brachyrrhyncha, oedocarpa, viridula*."

We failed to confirm such a sequence in our material. This difference is chiefly due to a different population structure of *C. serotina* in Switzerland upon comparison with the situation in Bulgaria and Czechoslovakia. SCHMID (1986a) characterizes Swiss populations of *C. serotina* as being "smaller and genetically more isolated." However, particularly at the Bulgarian localities, *C. serotina* formed large populations, often with more than 100 individuals.

At the localities with a common occurrence of *C. serotina* and another representative of the *C. flava* group, hybridization often took place giving rise to incompletely sterile F_1 plants. In this respect, all the members of the *C. flava* agg. behave in a very similar way. Therefore, no particular isolation barrier has been ascertained between *C. serotina* and the other species at the localities studied.

Furthermore, the differences in the results of (above all) the analyses of intrapopulational variability can very likely be accounted for by considerably different sizes of the population samples studied (cf. DOOLITTLE 1987). Schmid analysed approximately five to six individuals from each population, whereas we have examined samples amounting to 30 plants.

Analysis of variance also provided results useful in examination of the *C. lepidocarpa* variation range. A rapid decline of its localities can be observed nowadays, and influence on the variation pattern might be expected. We have found, however, that the variance values were comparable with those computed in the less endangered *C. flava* (this latter taxon represents morphologically and biologically the closest member of *C. lepidocarpa* within the group). Taking a fact into consideration that the main source of the overall variability in *C. lepidocarpa* is found within populations, we can conclude that preservation of the population size at the remaining localities may be sufficient to retain the variation range of this species in spite of the widespread habitat destruction by human activity.

CONCLUSIONS

The following conclusions are made basing on the analyses of karyological, morphological and ecological variability of 31 populations of the *Carex flava* complex in Bulgaria and Czechoslovakia:

1. The intrapopulational variation represents the main source of the overall variability, while proportions of the interpopulational variation were equally low in the species concerned. This situation is closely connected with the population structure. The taxa studied were formed by large populations without strong isolation barriers between the species.
2. The populations (within species) did not split up into two morphologically distinct groups in relation to their geographical origin.
3. The influence of the differences in macrohabitat factors was not ascertained in the variation patterns of the populations studied.
4. A correlation has been found between the chromosome number and morphological variation of the populations.

5. In spite of the decline of the biotops suitable for *C. lepidocarpa*, the variation range of the populations of this species need not be narrowed provided that sufficiently large populations will be preserved at the remaining localities.

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SOUHRN

V příspěvku je podán rozbor vzájemných vztahů mezi morfologickou variabilitou, počtem chromosomů a ekologickými faktory stanovišť u vybraných populací komplexu *Carex flava* agg. na území Bulharska a Československa. (Jedná se o taxony *C. flava* L. var. *flava*, *C. flava* var. *alpina* KNEUCKER, *C. lepidocarpa* TAUSCH, *C. tumidicarpa* ANDERSS. a *C. serotina* MÉRAT). Výsledky, kterých bylo dosaženo, lze shrnout do následujících bodů:

1. Za pomoci analýzy variance bylo zjištěno, že shodně u všech studovaných druhů komplexu se na jejich celkové variabilitě podílí ve větší míře proměnlivost zjištěná uvnitř populací než proměnlivost mezi populacemi.
2. Bulharské a československé populace v rámci jednotlivých taxonů nevytvářely ani v jednom ze sledovaných morfologických znaků výrazněji separované skupiny.
3. Nebyla zjištěna závislost variability morfologických znaků na sledovaných vnějších faktorech stanovišť (nadmořská výška, pH, obsah Ca^{2+} iontů v půdních vzorcích, makroklimatické rozdíly).
4. U sledovaných populací (v rámci jednotlivých druhů) byla zjištěna korelace mezi variabilitou morfologických znaků a chromosomových počtů.
5. Z hlediska ochrany genofondu nejvíce ohroženého druhu této skupiny — *C. lepidocarpa*, bylo důležitým výsledkem této studie rovněž zjištění, že hodnoty variance pro jednotlivé znaky u tohoto taxonu byly srovnatelné s hodnotami zjištěnými u ostatních, méně ohrožených druhů skupiny (např. u druhu *C. flava*, který jak morfologickými, tak biologickými vlastnostmi stojí nejblíže druhu *C. lepidocarpa*). Jestliže vezmeme v úvahu i fakt, že zdrojem celkové variability tohoto druhu je především vnitropopulační proměnlivost, pak lze předpokládat, že při zachování dostatečně širokých populací na současných lokalitách se úbytek vhodných biotopů pro tento druh nemusí negativně projevit na zachování šíře jeho celkové variability.

REFERENCES

ACHTAROV V. (1957): Rodat Carex na Balgarii. — Sofia.

CRETIN C. et BIDAULT M. (1974): Cytologie et biosystematique de Carex groupe flava L. s.l., — Compt. Rend. Soc. Biol., Paris, 168 : 466—470.

DAVIES E. W. (1953): Notes on Carex flava and its allies. — Watsonia, London, 3 : 66—69, 70—73, 74—79, 80—84.

— (1955a): The ecology and distribution of Carex flava and its allies in the British Isles. — Bot. Not., Lund, 109 : 50—74.

— (1955b): The cytogenetics of Carex flava and its allies. — Watsonia, London; 3 : 129—137.

— (1956): Cytology, evolution and origin of the aneuploid series in the genus Carex. — Hereditas, Lund, 42 : 349—365.

DOOLITLLE D. P. (1987): Population genetics. Basic principles. — Berlin.

HAVLÍČKOVÁ J. (1982): Carex flava-complex in the Czech lands I. Analysis of the variability of morphological characters. — Preslia, Praha, 54 : 201—222.

— (1983): Carex flava-complex in the Czech lands II. Notes on the geographical distribution. — Ibid., 55 : 245—263.

JORDANOV D. [red.] (1964): Flora na narodna republika Balgarija. Vol. 2. — Sofia.

JORDANOV D., GANČEV S., DANČEV T., MEŠINĚV T. et NIKOLOV N. (1975): Novi danni za razprostranenieto i ekologeografskite osobenosti na njakolko vida rastenija ot zapadnata čast na Kazanlškata kotlovina. — Izv. Bot. Inst., Sofia, 23 : 135—142.

McCune B. (1987): Multivariate analysis on the PC-Ord System. — HRI Report, Indianopolis, 75.
Palmgren A. (1959): Carex — Gruppen Fulvellae Fr. i Fennoskandien. — Soc. Fauna Fl. Fenn., Helsinki, 2 : 1—165.
Schmid B. (1980): Carex flava L. s.l. im Lichte der r-Selektion. — Ms. [Ph. D. thesis, University of Zürich].
— (1982): Karyology and hybridization in the Carex flava complex in Switzerland. — Feddes Repert., Berlin, 93 : 23—59.
— (1983): Notes on the nomenclature and taxonomy of the Carex flava group in Europe. — Watsonia, London, 14 : 309—319.
— (1984a): Life histories in clonal plants of the Carex flava group. — J. Ecol., Oxford, 72 : 93—114.
— (1984b): Niche width and variation within and between populations in colonizing species (Carex flava group). — Oecologia, Berlin, 63 : 1—5.
— (1986a): Patterns of variation and population structure in the Carex flava group. — Symb. Bot. Upsal., Uppsala, 27 : 113—126.
— (1986b): Colonizing plants with persistent seeds and persistent seedlings (Carex flava group). — Bot. Helv., Basel, 96 : 19—26.
Senay P. (1950—51): Le groupe Carex flava et Carex oederi. — Bull. Mus. Nat. Hist. Natur., Paris, 22 : 618—624, 790—796, 23 : 146—152.
Stoeva M. P. et Štěpánková J. (1988): Investigation of sympatric species of the Carex flava group and their hybrids in the Low Tatra Mountains in Slovakia. — In: Marhold K. [red.], Proc. Intern. Workshop of COMECON Countries "Carpathian Flora", p. 118—120, Bratislava.
Velenovský J. (1881): Flora Bulgarica. — Prag.
Vonk D. H. (1979): Biosystematic studies of the Carex flava complex I. Flowering. — Acta Bot. Neerl., Amsterdam, 28 : 1—20.
Wiinstedt K. (1936): Carex oederi coll. — Bot. Tidsskr., Kobenhavn, 43 : 504—506.
— (1945): Cyperaceae udbredelse i Danmark II. Caricoideae. — Ibid., 47 : 146—244.
— (1947): Bildrag til polymorfien hos den tidligere som Carex oederi Retz., Kendte Art. — Ibid., 48 : 192—206.

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Polhill Diana:

Flora of Tropical East Africa

Index of collecting localities

Royal Botanic Gardens, Kew 1988, 398 str., 1 mapa. (Kniha je v knihovně ČSBS.)

Vědecký výzkum tropické africké květeny začal před dvěma sty lety. Jeho pionýry byli dánští lékaři P. E. Isert a P. Thonning, kteří na území dnešní Ghany sebrali 2000 herbářových položek, z nichž je 474 typových položek pro nově popsané druhy. Hutchinsonova Flora Západní Afriky měla proto jistý předstih; její druhé vydání bylo dokončené již v r. 1972. Úspěchem byla také květena někdejšího belgického Konga. Zvláštní místo v botanice tropické Afriky zaujímá mnohosvazková Flóra tropické východní Afriky, která pokrývá území dnešní Tanzanie, Keni a Ugandy.

Jako důležitý doplněk k této květeně vychází nyní index lokalit, z nichž byly sebrány herbářové položky anebo jež jsou jmenovány v itinerářích východoafrických floristů. Recenzovaná kniha je vlastně již druhým vydáním staršího seznamu z r. 1970 a vychází z kartotéky založené J. B. Gilletem na začátku celého projektu květeny.

Evropští botanikové znají potíže, které vyvolává čtení herbářových sched a identifikace nalezišť starších botaniků. To se jeví zvlášť výrazně při floristickém mapování v územích, která byla osídlena několika národnostmi anebo prodělala změny v osídlení. V Africe jsou tyto potíže mnohem větší. Na území dnešních států žijí zpravidla desítky etnik, jež mají svůj jazyk a pochopitelně i svá topografická jména; potíž se stupňuje při přepisu těchto lokálních jmen do některé ‚lingua franca', jakou je ve vých. Africe v současné době angličtina. Toponyma vznikají u všech národů podobným způsobem — jako ustálení obecných jmen — a proto při velkém počtu kmenových jazyků vznikla ve vých. Africe početná synonyma a homonyma. Staré mapové náčrty a plány jsou rozptýlené v muzeích a podrobné mapy jsou v této oblasti k dispozici teprve od druhé poloviny našeho století; také toto zpoždění dělá africkým fytogeografům potíže.

Můžeme tedy gratulovat africkým botanikům k publikaci, která značně usnadní identifikaci starých údajů a vypomůže při správné lokalizaci údajů nových. Součástí knihy je skládací mapa, na níž je východní Afrika rozdělena — s ohledem na suverénní státy — na provincie (kraje) a distrikty (okresy); i při jejím malém měřítku je to nesmírná pomůcka pro toho, kdo se ocitne v tomto území na krátké expedici. Vlastní text pak tvoří abecední seznam toponym s uvedením provincie, distriktu, zeměpisných souřadnic a jména sběratele, který lokalitu uvádí na schedě nebo ve svém itineráři. Pořadatelka tohoto indexu udělala mnoho práce při celkovém zmnožení a doplnění tohoto seznamu a hlavně při ujednocení přepisu toponym i zpřesnění jejich lokalizace. Při tom využila četné staré mapy a písemné materiály, které jí poskytla muzea i soukromníci.

Tímto počinem se dostává do rukou stále se zmnožujících přírodovědců důležitý zdroj, který zabrání mnoha omylům, vyplývajícím zejména z množství synonym a homonym, která jsou častá v hraničních územích jednotlivých národů a pohraničí dnešních států. Index bude jistě cenným zdrojem pro studie zeměpisců a jazykovědců, protože ukazuje frekvenci a distribuci některých hlásek v afrických jazycích. Evropský botanik se jistě také poučí, i když bude od realizace podobného jednotného díla — např. pro státy střední Evropy — jistě hodně daleko. Fytogeografové a geobotanikové si zároveň uvědomí, jakou zátěží pro moderní vědu může být obrovská literatura a herbáře čítající položky v miliónech.

J. Jeník