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Morphological variability of the *Carex oederi* s. l. inflorescence

Helena Więcław

Department of Plant Taxonomy and Phytogeography, University of Szczecin, Wąska 13, 71-415 Szczecin, Poland, e-mail: wieclawh@univ.szczecin.pl

Abstract: The most variable features describing *Carex oederi* s. l. include: (*i*) the distance between two lower female spikes, (*ii*) the length of the peduncle of a lower female spike, (*iii*) the distance between two upper female spikes, (*iv*) the length of inflorescence and peduncle of a male spike. Most of observed stems had (3)4-5 female spikes, which were crowded around a sessile and short male spike. Specimens with fewer female spikes (2-3) were characterized generally by their loose positioning on a stem (occasionally a lower female spike was distant and had a peduncle) and the presence of usually longer male spikes on a peduncle. In conclusion, *C. oederi* s. l. is highly variable morphologically. In the investigated materials, there are no apparent discontinuities. Further (planned) biometric research will be extended to the characteristics of the perygynium and vegetative features.

Key words: *Carex oederi* s. l., Cyperaceae, inflorescence, spikes, variation

1. Introduction

Carex oederi s. 1. is a taxon spread on the circumboreal region (Hulten & Fries 1986). Predominantly, it grows along banks of lakes, seas and wet meadows, on marshes and mires. In Poland, it is a species characteristic for the *Cyperetum flaveascentis* community from *Isoëto-Nanojuncetea* class (Matuszkiewicz 2005). In Europe, it occurs in three varieties: *C. oederi* var. *oederi* (the most common), *C. oederi* var. *pulchella* (spread from the British Isles, Finland, Norway, Sweden, Russia, Scotland, the Netherlands, Poland and western Germany) and *C. oederi* var. *bergrothii* (endemic in northern Europe – recorded in Finland, Sweden, Norway, Estonia and Russia) (Davies 1953; Zając 1968; Pykälä & Toivonen 1994; Hedrén 2004). *C. oederi* s. l. is characterized by high variability of morphological features. The combination of random genetic drift and local selection in small, spatially and temporally isolated populations of *C. oederi* s. 1., explains the evolution of many of its morphotypes (Schmid 1986; Hedrén 2003). The generative features were the most significant taxonomically in distinguishing the different varieties (Davies 1953; Zając 1968; Schmid 1986; Pykälä & Toivonen 1994; Hedrén 2003). Therefore, the purpose of this study was to analyze the range of morphological variability of the inflorescence characteristics of *C. oederi* s. l. in Poland.

2. Material and methods

The study was performed on 320 specimens (living or herbarium). Live specimens were collected during the field work conducted in Western Pomerania. Herbarium materials came from 16 Polish herbaria (BNPH, BYDG, DRAPN, KRFB, KTC, KTU, LBLM, OLTC, OPOL, PBMA, POZ, SPNH, UGDA, WA, WSRP, ZAMU). 12 features were estimated in relation to the volume of inflorescence (1 – inflorescence length, 2 – male spike length, 3 – male spike width, 4 – male spike peduncle length, 5 – number of female spikes, 6 – distance between the upper female spikes, 7 – distance between the lower female spikes, 8 – lower female spike length, 9 – lower female spike width, 10 – lower female spike peduncle length, 11 – upper female spike length, 12 – upper female spike width). The measurements were performed with the usage of a caliper with accuracy of 0.02 mm. The results of the measurements were subjected to basic statistical analysis using Statistica 8. The significance of differences between the

empirical and theoretical distribution of the normal distribution was examined using the Shapiro-Wilk test (Łomnicki 2003; Stanisz 2006). Compatibility of two empirical distributions was examined using the U Mann-Withney test. Spearson's correlation coefficients were calculated in order to examine the relationship between the characteristics of inflorescence.

3. Results

3.1. The range of characteristics variation

The most variable characteristics describing *Carex oederi* s. l. include: the distance between two lower female spikes, the length of the peduncle of the lower female spike, the distance between the two upper female spikes, the length of inflorescence and peduncle length of the male spike. Classic coefficient of variation (Vs) calculated for the characteristics number 6, 7 and 10 is very high and reaches respectively 90%, 139% and 125% (Table 1).

Table 1. Major important statistical characteristics of *Carex oederi* s. l. individuals

Variable	x	Min	Max	s	Me	Q	V_s	V_Q
1	3.37	0.70	17.40	2.4305	2.60	0.8250	72.0	31.7
2	0.98	0.14	2.13	0.3813	0.90	0.2825	39.0	31.4
3	0.16	0.07	0.26	0.0334	0.16	0.0250	20.3	15.6
4	0.35	0.08	1.02	0.2019	0.32	0.1225	57.6	38.3
5	3.43	2.00	6.00	0.9610	3.00	0.5000	28.0	16.7
6	0.35	0.00	3.02	0.3126	0.31	0.1400	90.2	45.9
7	1.54	0.17	14.80	2.1418	0.75	0.4175	139.2	56.0
8	0.86	0.43	1.42	0.1691	0.84	0.1200	19.7	14.3
9	0.56	0.30	0.89	0.0755	0.55	0.0450	13.6	8.2
10	0.35	0.02	4.89	0.4358	0.25	0.1175	124.6	47.0
11	0.65	0.21	1.14	0.1324	0.64	0.0875	20.4	13.7
12	0.53	0.37	0.88	0.0728	0.53	0.0400	13.6	7.5

Explanations: x – arithmetic mean, Min – minimum value, Max – maximum value, s – standard deviation, Me – median, Q – quartile deviation, V_s – classic coefficient of variation, V_Q – positional coefficient of variation

The higher the coefficient of variation the sample is less homogeneous, in terms of test features, set of observation units. In such cases (and if the test is a series of extreme values significantly different from the average, as variables 1, 6, 7, 10) it is preferable to calculate the positional coefficient of variation (V_Q). The value of positional coefficient of variation also clearly indicates the high variability of above mentioned characteristics (Table 1).

3.2. Character of correlation

Inflorescence length is significantly positively correlated with the distance between the lower female spikes (Table 2). The high correlation coefficient defines also a significant correlation between the number of female spikes and the distance between the upper female spikes (r_S = -0.606269), length and width of the upper female spike (r_S = 0.586652), length and width of the lower female spike (r_S = 0.557760), width of the upper female spike and width of the lower female spike (r_S = 0.553406), the distance between the lower female spikes and the length of peduncle of the lower female spike (r_S = 0.547648) as well as among the length of male spike and the length of inflorescence (r_S = 0.522310). Other correlation coefficients showing the average and the lower level are shown in Table 2.

The studied variables were grouped by the presence or absence of the male peduncle spike and peduncles of the lower female spike and by the number of female spikes (Figs. 1-3). There were statistically significant differences in inflorescence length and the distance between the lower female spikes linked to the presence or absence of female peduncle spike (respectively Z = 4.2065, p = 0.000026 and Z = 5.56680, p = 0.000000). Statistically significant differences were also recorded when the characteristics were grouped by the presence of the male peduncle spike. There was a significant difference in inflorescence length (Z = -4.47635, p = 0.000008), male spike length (Z = -9.80024, p = 0.000000), the number of female spikes (Z = 8.32382, p = 0.000000), the distance between the upper female spikes (Z = -9.33454, p = 0.000000) and the length (Z = -6.68550, p = 0.000000) and width (Z = -3.15860, p = 0.001585) of the upper female spike.

Table 2. Matrix of significant correlation coefficients for inflorescence characters in *Carex oederi* s. l. (significance level $\alpha = 0.05$)

Character number	1	2	3	4	5	6	7	8	9	10	11
12	0.245161	0.281182	0.095347	0.017355	-0.160054	0.275420	0.162378	0.326744	0.553406	0.165932	0.586652
11	0.346174	0.504181	0.149983	0.360708	-0.343074	0.418005	0.217532	0.442855	0.402481	0.150934	
10	0.494274	0.087662	0.190633	0.222509	0.310684	0.130774	0.547648	0.292560	0.157086		
9	0.231869	0.268351	0.144317	-0.053938	0.069983	0.057018	0.153999	0.557760			
8	0.349894	0.316984	0.313539	0.027116	0.262697	0.040430	0.278602				
7	0.879893	0.276909	0.178378	0.240558	0.298735	0.291046					
6	0.301839	0.428894	0.009912	0.472503	-0.606269						
5	0.255023	-0.319677	0.216845	-0.348857							
4	0.303718	0.349153	0.109037								
3	0.186944	0.129519									
2	0.522310										

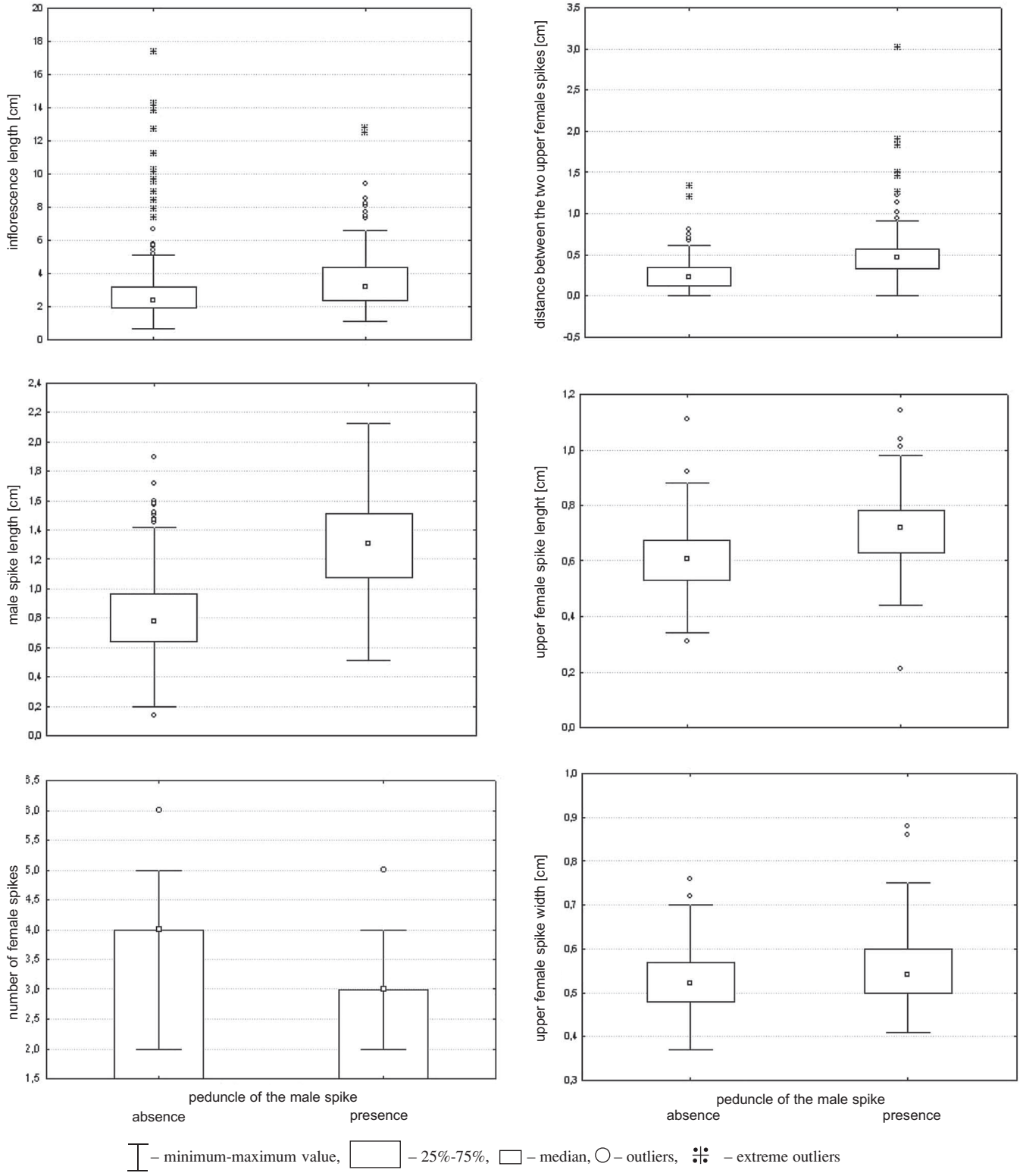

Fig. 1. Inflorescence length, male spike length, number of female spikes, the distance between the upper female spikes, upper female spike length and width grouped by the presence or absence of the male peduncle spike

When grouping variables by the number of female spikes, the study found statistically significant differences in the length of the male spike ($Z = 4.35831$, $p = 0.000013$), the length of its peduncle ($Z = 2.60609$, $p = 0.009159$) and the distance between the upper female spikes ($Z = 6.48947$, $p = 0.000000$). Based on the collected data the following relationships can be concluded: (*i*) specimens with peduncled male spike (as compared to those that have no peduncle) have longer inflorescences, longer male spike, larger dimensions of the upper female spike, fewer female spikes and upper female spikes are spaced more apart (Fig. 1) (*ii*) specimens with peduncled lower female spike have a longer inflorescence, and distanced the lowest female spike

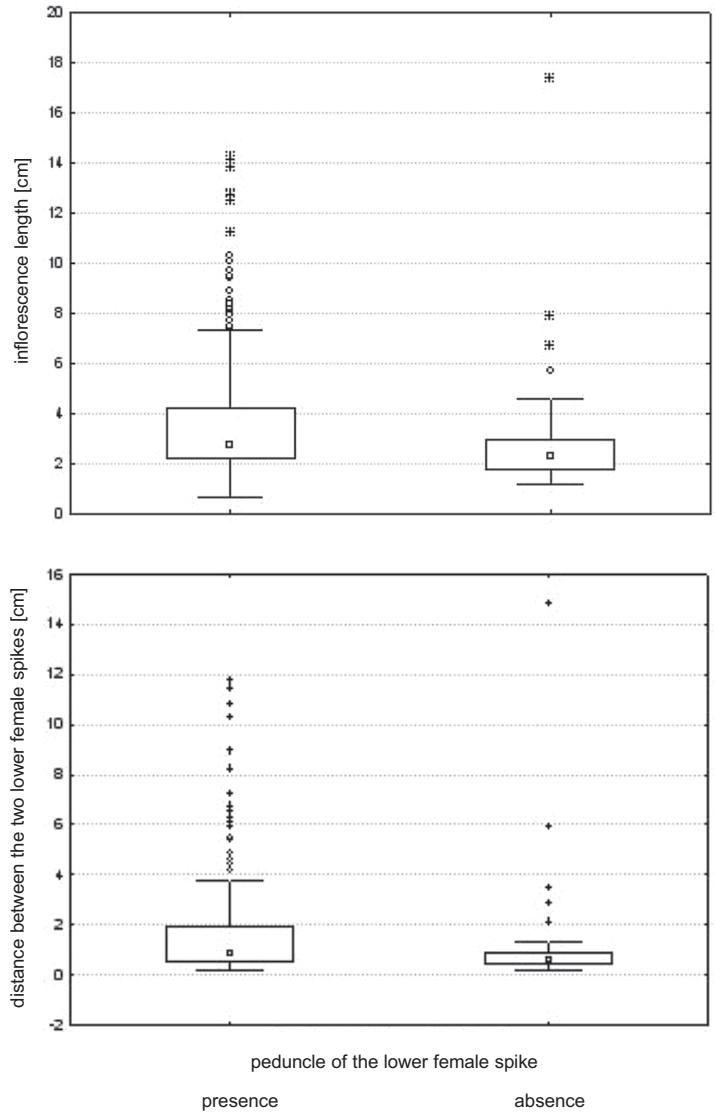

Fig. 2. Inflorescence length and the distance between the lower female spikes grouped by the presence or absence of the female peduncle spike

(Fig. 2), (*iii*) a larger number of female spikes occur in specimens with shorter male spikes and shorter male spike peduncles (if peduncles are present at all), and crowded female spikes (Fig. 3).

4. Discussion

Morphological variation of *C. oederi* s. 1. inflorescence in Poland appears to be similar to the variation found in other regions of Europe (Davies 1953; Schmid 1986; Pykälä & Toivonen 1994; Hedrén 2003), although in this study, a narrow taxonomic treatment, consistent with the results of the Scandinavian population (Hedrén 2003, 2004) was adopted. When a broader taxonomic appraoch is adopted, the investigated sedges are associated with *C. demissa* and *C. lepidocarpa* into one collective group under the name of *Carex viridula* s. l. (Schmid 1983, 1986). However, studies in Scandinavia (Pykälä & Toivonen 1994; Hedrén 2003, 2004) and the research conducted in Poland (Więcław, unpubl. data) confirm the validity of distinguishing *C. demissa* and *C. lepidocarpa* at the species level. Despite the usage of the narrow taxonomic recognition, the tested specimens are characterized by high variability of inflorescence characteristics. The study recorded stems with sessile male spikes as well as spikes on peduncle of different length and various numbers of female spikes. Individual specimens differed significantly also in the way of location of female spikes and the presence of the peduncle of the lower female spike. Most of the observed stems had (3)4-5 female spikes, which were crowded around the sessile and a short male spike. These features are frequent in the most common variety *C. oederi* var. *oederi* (Davies 1953; Schmid 1986; Pykälä & Toivonen 1994; Hedrén 2003). Specimens with fewer female spikes (2-3) were characterized generally by their

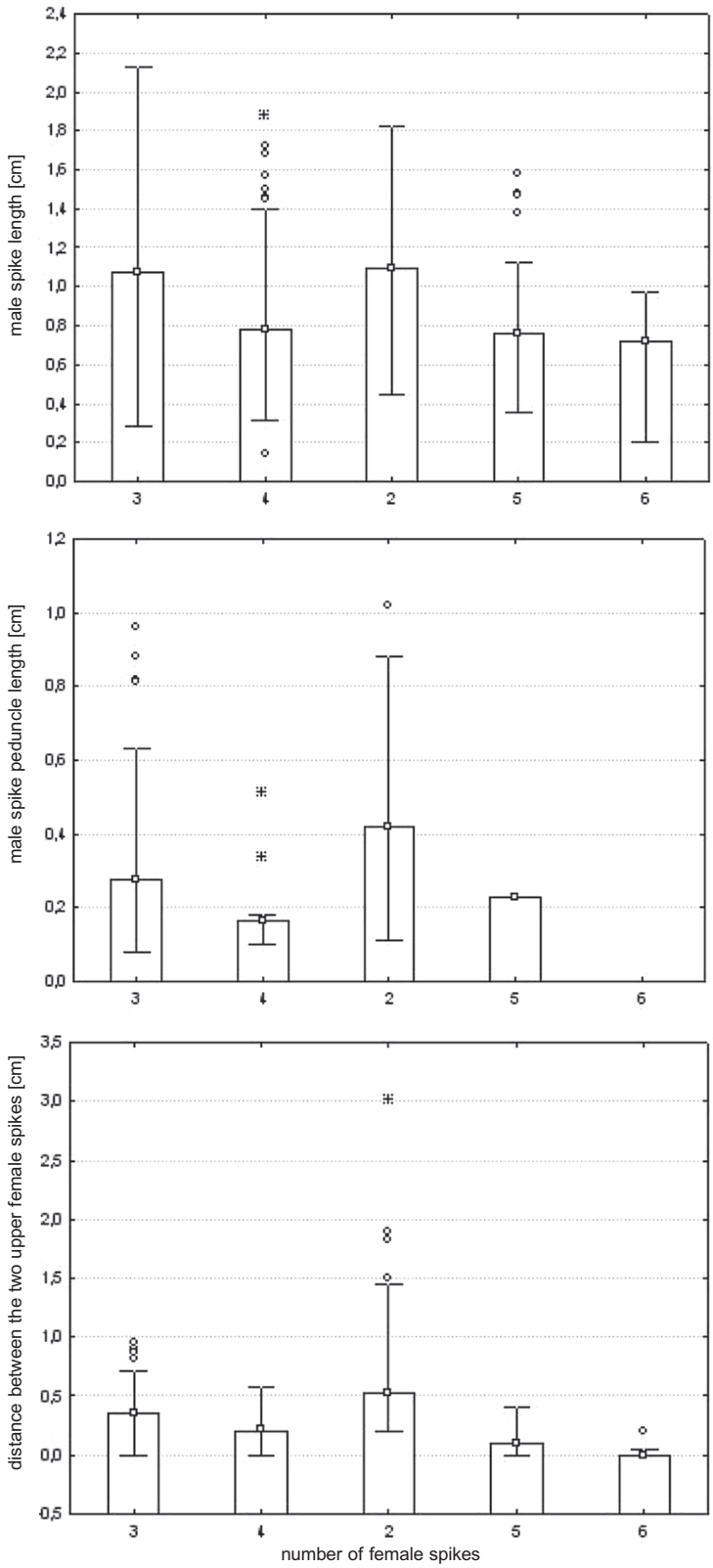

Fig. 3. Male spike length, male spike peduncle length and distance between the upper female spikes grouped by the number of female spikes

loose positioning on the stem (occasionally the lower female spike was distant and had a peduncle) and the presence of usually longer male spike on the peduncle. The spikes are located similarly in the smallest variety *C. oederi* var. *pulchella* (Davies 1953; Zając 1968; Pykälä & Toivonen 1994). However, it should be noted that *C. oederi* s. l. is highly variable morphologically and when distinguishing its varieties it is necessary to expand the research on biometric characteristics of the perygynium and vegetative features. In addition, there are still extreme disparities among scientists in terms of taxonomic treatment of these sedges (Schmid 1983,

1986; Hedrén 2003, 2004). Between different varieties, there are no apparent discontinuities. In the wide variation range of *C. oederi* s. 1., marginal specimens relate to the different varieties. As emphasized by Hedrén (2004), *C. oederi* s. l. varieties may have taxonomic value, if we apply the concept of ecological species (Van Valen 1976). Probably the extreme morphotypes of *C. oederi* s. l. developed locally from the typical form as a response to the different selection pressures.

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