

Morphological variability of *Carex spicata* Huds. utricles among plant communities

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Abstract

Differentiation in the size and number of seeds among populations or particular individuals of a given species may depend on genetic features and environmental conditions. The objective of our study was to answer two questions: whether any differences exist in the size and shape of utricles among *Carex spicata* populations growing in several plant communities and whether the hypothesized differences remain constant in ‘common garden’ conditions (i.e. if the sedges grown in different plant communities are evolving distinctly separate ecotypes). We studied utricle morphological traits (projected area, width, length, W/L ratio and projected perimeter) and number of utricles per spike collected from plants grown in five different plant communities (natural sites) and from plants transferred to common garden conditions. *C. spicata* utricles showed significant variability of morphological traits that depended on the plant community of origin. Among five plant communities, the largest utricles were found in *Agropyron repens*–*Urtica dioica* and *Convolvulo arvensis*–*Agropyretum repentis* communities, while the smallest ones were in plants from the *Lolio-Plantaginietum* community. The similarity of the analyzed populations regarding sedge utricle traits corresponded to the similarity of plant communities where the populations had grown. Moreover, the differences in utricle traits collected from natural conditions remained stable in common garden conditions. This indicated that differences in traits among utricles had a physiological dependence on different biotope conditions or different interspecific interactions prevailing in the particular plant communities. The relationship between the similarities in the diaspores of the populations studied and the similarities in the ecological conditions of the communities may also indicate that the variability of utricles is important for evolution and adaptation.

The results support the hypothesis that *C. spicata* populations in different communities are producing separate ecotypes, i.e. specific species forms with genetically fixed traits adapted to narrowly determined habitat conditions.

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Introduction

Investigation of adaptation mechanisms in sedge (*Carex* L., Cyperaceae) diaspores to differentiated

habitats is particularly interesting because of specific and complicated fruit structures that are regarded by some researchers as factors that enabled the members of this genus to undergo species radiation and colonization of differentiated habitats (Egorova, 1999).

Carex spicata Huds. (= *C. contigua* Hoppe), a common taxon in Europe with wide ecological amplitude and found in many plant communities, is characterized by a distinct morphological variability of vegetative organs dependent on habitat conditions and on the type of plant community in which it occurs (Janyszek, 2004; Szczepanik-Janyszek, 2001). Although the genus *Carex* is a frequent component of plant communities, very little is known regarding the differentiation of sedge diaspores to different habitat conditions (ecophysiological traits: Busch, 2001). The majority of existing studies have focused primarily on the mass of diaspores in connection with their spread or germination (e.g. Baskin et al., 1993; Leck and Schütz, 2005) and on the importance of seed size as an adaptation that affects survival of seedlings during germination (Bakker et al., 1996; Thompson, 1984). It is known that habitat features, including moisture, have a significant effect on the size and number of propagules (Kelly and Sork, 2002; Weiner, 1988). For example, many hygrophilous representatives of *Carex* produce smaller fruits when grown in dry localities than populations of the same species occurring in wet habitat (Leck and Schütz, 2005).

One of the methods to identify the habitat conditions of a specific population is the subordination of the local phytocenoses, in which the given plant had grown, to the phytosociological association. Plant associations (communities) distinguished on the basis of the presence of a suite of characteristic species in their composition are comparatively closely associated with soil and moisture conditions. Patches of plant associations are also characterized by relatively stable conditions, e.g. spatial structure, interspecific competition for soil resources, water and light, as well as the influence of herbivores. At the same time, similarities and differences among plant communities may be estimated by comparison of common and differential plant species for particular communities (Braun-Blanquet, 1964; Dierschke, 1994; Tüxen, 1972).

The objective of our study was to investigate: (1) whether any differences exist in the size and shape of utricles between *Carex spicata* populations growing in various plant communities and (2) whether the hypothesized differences remain constant in 'common garden' conditions (i.e. if the sedges grown in different plant communities have distinctly separate ecotypes). We also looked for correlations between utricule traits of the *Carex* populations analyzed and spatial structures and the habitat conditions of plant communities they inhabit.

Methods

In *Carex*, the element which is directly sown is not the seed or fruit, as in the majority of plant species, but rather an utricle that is characterized as a unit of the nutlet proper together with its enveloping bract. Such a diaspore unit is typical for the entire genus *Carex*. Therefore, for biometrical measurements, entire utricles (i.e. diaspores) were sampled. For the species studied, this is justified because the utricle and fruit size are closely correlated (Szczepanik-Janyszek, 2001).

We conducted two studies. In September 2002, we collected ca. 30,800 utricles of *C. spicata* from specimens growing in 71 natural localities in Poland (Fig. 1). Utricles were collected in five different plant communities singled out on the basis of Matuszkiewicz (2001). The size of utricle samples depended on the occurrence frequency of *C. spicata* in the given community and on the occurrence frequency of the given community in Poland. Mature utricles were taken from at least 30 spikes from each population. The total number of utricles from the particular communities ranged from 3000 to 10,400 utricles (Table 1).

During September 2002, we also established a common garden experiment. From each of the plant communities studied, we transferred 15 tufts of *C. spicata* (75 in total) and cultivated them in homogeneous soil, light and humidity conditions, without any competition from other plant species (Janyszek et al., 2007). In September 2004, about 4700 utricles were collected for morphological measurements, including at least 30 spikes from *C. spicata* that originated in each community (Table 1).

Plant communities in which we collected sedge utricles were markedly diversified regarding their structure and site conditions they occupied (Braun-Blanquet, 1964; Matuszkiewicz, 2001). However, there are no quantitative comparisons of the plant communities available, so we described spatial structures and site conditions typical for each plant community (Table 2).

Morphological traits of fully developed utricles were determined using an image analysis system and the WinSEEDLE™ 2003a Software (Regent Instruments Inc., Quebec, Canada; <http://www.regentinstruments.com/>). For each diaspore, the length (mm), width (mm), *W/L* ratio, projected area (mm²) and projected perimeter (mm) were measured. In spite of the fact that many descriptions (e.g. Baskin et al., 1993; Leck and Schütz, 2005) are based on measurements of utricle mass, this trait was not investigated in this study because it does not represent any significant value due to the variability in size and mass of the utricle cork callosity. In addition, we counted the number of utricles per spike (for at least 30 spikes per population) at each of the natural sites and in common garden experiment.

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