Fundam. Appl. Limnol., Arch. Hydrobiol. Vol. 177/3, 197–208 **Article**
Stuttgart, July 2010

Vegetative and reproductive traits of *Sagittaria trifolia* (Alismataceae) in response to sediment heterogeneity and plant density

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With 8 figures and 4 tables

Abstract: Changes in vegetative and reproductive traits of the emergent aquatic plant *Sagittaria trifolia* (Alismataceae) in response to sediment heterogeneity and plant density were investigated under two sediment treatments (homogeneous and heterogeneous) and three density treatments (10, 30, and 100 plants m^{-2}). For the heterogeneous sediment treatment (He), an experimental bin was constructed with clay on the top layer and sandy loam on the bottom layer. For the homogeneous treatment (Ho), an equal mixture of clay and sandy loams was placed in both layers. The biomass accumulation per bin was not affected by plant density or sediment type; however, individual biomass was affected by both factors. The root-to-leaf ratio was only affected by density, whereas root distribution was only affected by sediment type. In the He treatment group, 54–56 % of the roots were located in the top layer. In contrast, the Ho treatment group had 52–53 % of the roots located in the bottom layer. Plants of *S. trifolia* produced male-biased floral sex ratios with flower numbers that increased in the later inflorescences. Moreover, the ratio of female to male flower production (F/M) increased significantly with the inflorescence number. The relative allocation to sexual and asexual reproduction was 7 % and 60 % higher in the He treatment than in the Ho treatment, respectively. When plant density increased from 10 to 100 plants m^{-2}, the relative allocation to asexual reproduction increased from 0.03 to 0.12, but the relative allocation to sexual reproduction decreased from 0.41 to 0.19, respectively. These data indicate that reproduction is shifted towards an asexual mode at higher plant densities. Our results suggest that *S. trifolia* can adjust its vegetative traits and reproductive strategy in response to plant density and sediment type. This hypothesis is consistent with the view that monoecy is a flexible sexual strategy for adjusting male and female allocation in various environments.

Key words: aquatic plant, reproductive allocation, root distribution, sediment heterogeneity, plant density.

Introduction

Morphological plasticity is the ability of an individual organism to alter its morphology in response to variation in environmental conditions. Acquisition of nutrients in plants requires plasticity in terms of biomass allocation and pattern of root distribution (Hutchings & de Kroon 1994, Xie & Yu 2003). For example, longer specific root lengths and larger root-to-shoot ratios are characteristic of plants grown under relatively infertile conditions. Nutrient availability in a natural habitat is heterogeneous even on a small scale (Jackson & Caldwell 1993, Ikegami et al. 2008). In terrestrial systems, nutrient patches are often created from organic inputs and their subsequent decomposition. Plants respond to this nutrient heterogeneity by modifying root morphology, root distribution, and root-to-shoot ratios (Hutchings & de Kroon 1994, Einsmann et al. 1999,

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DOI: 10.1127/1863-9135/2010/0177-0197
1863-9135/10/0177-0197 $ 3.00