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Seed production of *Menyanthes trifoliata* inside and outside a *Phragmites australis* canopy

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Abstract

Reproduction of *Menyanthes trifoliata* L. was compared inside and outside a *Phragmites australis* (Cav.) Trin. ex. Steud. canopy in a floating peat mat in Mizorogaike Pond, Central Japan. Different factors influenced the reproductive organs of *M. trifoliata* during the seed production process inside and outside the *P. australis* canopy. *M. trifoliata* inside the canopy produced a low number of flower buds, but the inflorescences showed a higher survival rate than at the open site, hence inflorescence density per unit area did not differ significantly. However, both the seed setting ratio and the total number of seeds produced were much lower within the *Phragmites* site.
Key words : floating peat, *Menyanthes trifoliata*, Mizorogaike Pond, *Phragmites australis*, reproduction

Introduction

It is reported that *Menyanthes trifoliata* L. changed its phenotypic and phenological properties inside a *Phragmites australis* (Cav.) Trin. ex. Steud. canopy[1]. Shading usually affects phenotypic and phenological properties of plants[2)-3)] and this is shown by *M. trifoliata* in its higher specific leaf area, longer petioles and earlier leaf extension under the *P. australis* canopy.

The aim of the present study was to investigate the reproduction of *M. trifoliata* growing inside and outside the *P. australis* canopy in the floating mat in Mizorogaike Pond. Environmental conditions (*e.g.* light conditions over the canopy, water table depth, temperature, redox potential (Eh) of surface peat) of the pure *M. trifoliata* site and the mixed *M. trifoliata* and *P. australis* site were quite similar among the whole of the floating mat[1], so the interspecific relationships between these species could be analyzed independently of these environmental conditions.

Materials and methods

The study area was at Mizorogaike Pond (*c.* 400 m×200 m, maximum depth *c.* 2 m), situated north of Kyoto City, Japan (35°04′N, 135°45′E, 75 m a.s.l.). An extensive floating mat of peat (*c.* 240 m × 140 m) covers the pond. The rhizomes of *M. trifoliata* cover almost all the mat except for the center of the hummocks. *P. australis* is the most abundant species creating a mixed site with *M. trifoliata*[4]. A pure *M. trifoliata* site and a mixed site of *M. trifoliata* and *P. australis* are located next to each other. Flower buds of *M. trifoliata* form in September and remain dormant over winter. They begin to grow in early March and flowering begins in early April. Seeds are produced in late April or May.

Three and eleven quadrats (1×1 m^2) were located in the mixed *M. trifoliata* and *P. australis* site (*Phragmites* site) and in the pure *M. trifoliata* site (open site), respectively. The numbers of quadrats were roughly proportional to the areas of each site. All the quadrats were in the open site, and light conditions over the canopy were homogeneous.

The vegetative shoot density of *P. australis* was 60.7/m^2 in the *Phragmites* site (SE=20.2, n=3, determined 24 July 1986). In each quadrat, the shoot density of *M. trifoliata* was determined on 24 April 1986 and the density of inflorescences and infructescences was determined on 30 April and 15 May 1986, respectively. The number of flowers and fruits per inflorescence was determined in the field on 15 May 1986. Senescent infructescences which had no fruits were excluded. Two inflorescences were randomly collected in each quadrat to determine the number of seeds per fruit. The density of shoots having flower bud in autumn was estimated from the ratio of the number of sampled shoots with inflorescences (or scars) per total vegetative shoots multiplied by vegetative shoot density, because some of the flower buds decayed before flowering. The ratio of flower bud formation was obtained by sampling shoots from October 1986 to September 1987 in the open site (n=90) and the *Phragmites* site (n=91).

Results

Although shoot density of *M. trifoliata* showed little difference between the *Phragmites* site and open site, the estimated density of flower buds produced in September was much lower in the *Phragmites* site (Fig. 1a). Despite the difference in flower bud density produced in September, the density of the inflorescences with flowers determined in April showed no significant difference between the sites. Infructescences, however, did show a significant difference, and the infructescences of *M. trifoliata* in the *Phragmites* site almost disappeared before maturation of the fruits.

Despite the similarity in the number of flowers per inflorescence between the *Phragmites* site and open site, the number of fruits per infructescence in the *Phragmites* site was significantly lower than that in the open site (Fig. 1b). The number of seeds per fruit in the *Phragmites* site (2.6 ; SE=0.17 n=18) was also significantly lower than that in the open site (10.6 ; SE=0.03 n=215) by t-test at $p<0.01$. Estimation of the number of seeds produced per shoot was made using

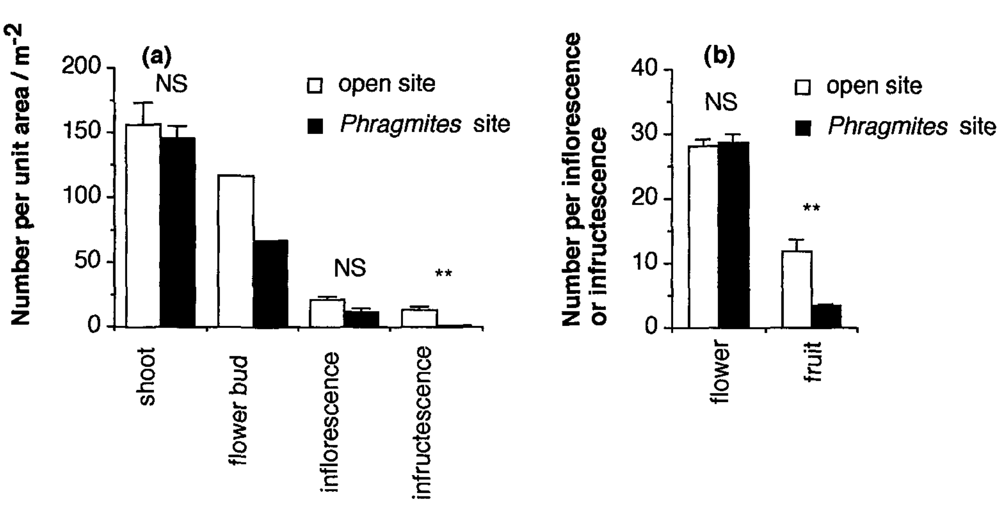

Fig. 1. Means + SE of (a) number of vegetative shoots, prepared flowering shoots (estimated values of inflorescences produced in September 1986 ; not presented SE), inflorescences (determined inflorescences with flower in April 1987) and infructescences of *Menyanthes trifoliata* in $1m^2$ in open site (open bar ; n=11) and in *Phragmites* site (closed bar ; n=3) and (b) number of flowers and fruits per inflorescence of *M. trifoliata* in open site (open bar ; n=54) and in *Phragmites* site (closed bar ; n=32) in the floating mat in Mizorogaike Pond. Significance level of t-test : $^{**}p<0.01$; NS, not significant $p>0.05$

data for infructescence density, number of fruits per inflorescence and seed number per fruit. The number of seeds produced in the *Phragmites* site was 0.1/shoot, much less than in the open site (13.5/shoot). The mean weight of an individual seed produced in the *Phragmites* site and the open site was 2.53 mg and 2.36 mg, respectively.

Discussion

The study on seed production showed that different kinds of factors influenced the inflorescences of *M. trifoliata* inside and outside the *Phragmites* canopy. Although the shoot density showed little difference between the sites, the number of flower buds produced in September in the *Phragmites* site was much lower than in the open site. This is presumably due to the lower annual dry matter production in the *Phragmites* site because of shading by *P. australis*. In the process of development of flower buds to inflorescences (March-April), mortality of inflorescences in the *Phragmites* site was less than in the open site. During the stage when inflorescences developed to infructescences, the mortality of inflorescences due to failure of fruit set was higher in the *Phragmites* site. Further, the number of fruits per inflorescence of *M. trifoliata* in the *Phragmites* site was lower than that in the open site, although the number of flowers per inflorescence showed no significant difference (Fig. 1b). *M. trifoliata* is pollinated by insects[5)-6)] and a bagging experiment showed that this species is completely self-incompatible[7)]. Since the time of flowering of *M. trifoliata* in the *Phragmites* site was *c.* 1 week earlier than that in the open site, the mean temperature of the flowering period in the *Phragmites* site is lower than that in open site. The activity of pollinators would be low at low temperatures, and hence the probability of pollination in the *Phragmites* site would be lower than that in the open site. Besides, crowded dead culms of *P. australis* may create steric hindrance for pollination.

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