Watsonia, **20**, 33–39 (1994)

Aspects of the ecology and conservation of *Damasonium alisma* Miller in Western Europe

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ABSTRACT

Damasonium alisma Miller (Alismataceae) is rare and declining over at least the western part of its range. An account is given of some aspects of its ecology and life cycle. This information is used to discuss the reasons for its decline and to provide recommendations for its conservation.

KEYWORDS: Britain, France, life cycle, habitat restoration, Alismataceae.

INTRODUCTION

Damasonium alisma Miller (Alismataceae), Starfruit, is a semi-aquatic herb (Fig. 1), found in England, France, Italy, Spain and possibly south-western Asia where there is confusion between it and *D. bourgaei* Cosson.

Its populations have declined in recent decades and this species is now "very rare" in France (Aymonin 1974), "possibly nationally rare" in Spain (Smith 1988), and "endangered" in England (Perring & Farrell 1983) where it is protected under the Wildlife and Countryside Act (1981).

This paper examines aspects of the ecology and life cycle of *D. alisma* and considers how best this species may be conserved.

ECOLOGY AND LIFE CYCLE

METHODS

Between 1987 and 1990, information was collected from five habitats of *D. alisma* including data on the general nature of each habitat, vegetation structure and percentage of bare ground in 1 m^2 quadrats placed over *D. alisma* plants, associated species of vascular plants (within two metres of each *D. alisma* plant), and the physical composition and pH of the substrate (top 6 cm). Three sites were in England (one in Surrey, two in Buckinghamshire – referred to as Bucks. Sites A and B) and two in France (in the Loire valley close to Angers and in the Sologne region close to Marcilly-en-Gault).

Observations on its life cycle were made in the wild and in cultivation – a population was grown outside in a large tank for three years.

Information on germination was obtained from cultivation experiments; fresh seeds collected from cultivated plants were sown into pots of sterile loam.

HABITAT

The three English populations grow in shallow ponds, formerly used for watering livestock, on commons on acid soil. The Sologne population grows in a shallow pond originally dug for fish husbandry, and that at Angers grows in a periodically flooded sand pit, beside the River Loire. At each site water levels fluctuated seasonally – they were flooded in winter, but were dry, at least in part, during summer.

All the sites had disturbed soil, at least in the vicinity of the *D. alisma* plants; the causes of the disturbance varied from site to site and included recent pond restoration work (Surrey, Bucks. Site A), the occasional beaching of a small boat (Sologne), trampling by dogs and people (Bucks. Site B), and sand extraction (Angers). Many of the English populations of *D. alisma* recorded in the past were on grazed commons, where livestock drinking at the ponds would have caused soil disturbance.

At the sites examined, the vegetation was patchy with large areas of bare substrate where the *D. alisma* plants were growing. At the Surrey and Sologne sites *D. alisma* grew among sparse, stunted emergents (*Sparganium erectum* (Surrey) and *Typha latifolia* (Sologne)). Other small herbs were present but were infrequent. Bare substrate comprised 75–90% of each 1 m^2 quadrat. At Bucks. Site A, *D. alisma* grew among a sparse carpet of *Glyceria fluitans* and other small herbs, and bare substrate comprised 60–90% of the quadrat area. At Bucks. Site B only one plant of *D. alisma* was seen in an otherwise bare area. In the Angers sand pit, in the driest, sunniest part of the pit, *D. alisma* occurred as tiny terrestrial plants, in small depressions, with the minute, annual *Lythrum borysthenicum* and little else; bare ground amounted to 90–98% of the quadrat area. In slightly less extreme conditions, Starfruit grew scattered amongst a sparse, patchy carpet of small, mainly annual, herbs. In damp, shaded areas this association was enriched with perennial, creeping grasses; bare substrate comprised 35–75% of the quadrat area. At Angers a few feeble *D. alisma* plants were found in flower growing as true aquatics in shallow pools containing a dense stand of *Chara vulgaris*, filamentous algae, perennial grasses and other emergents. Species associated with *D. alisma* are listed in Table 1.

Pond vegetation is notoriously difficult to classify. Often it is narrowly zoned and contains several partly developed communities in close proximity. From year to year the prominence of each community may vary according to the water level and pond management. Moreover, as ponds are often artificial their flora is partly the product of chance colonisation. It has not been possible to classify satisfactorily the vegetation at the five sites as one distinct community, but elements from several different communities, as defined by Ellenberg (1988), may be recognised.

a. *Littorelletea*, comprising plants which grow in shallow water at the edge of nutrient-deficient pools of low pH on sand or gravel (indicator species for this community are marked 'L' on Table 1).

b. *Isoeto-Nanojuncetea*, comprising dwarf plants which grow on land that is inundated only in the winter (marked 'I').

c. *Plantaginetea*, a pioneer community of pathways and flooded or damp places (marked 'Pl').

d. *Phragmitetea*, a swamp community of tall reeds and sedges (marked 'Ph').

e. *Potamogetonetea*, a community of rooted aquatic plants (marked 'Po').

The environment preferred by Starfruit frequently resulted in the stunting of species characteristic of the *Phragmitetea* and *Potamogetonetea* communities.

Species not marked as indicators are either aliens (e.g. *Paspalum distichum*), or plants which occur in a wide range of damp or aquatic habitats (e.g. *Juncus articulatus*, *Solanum dulcamara*), or arable weeds (e.g. *Persicaria maculosa*).

The composition of the top 6 cm of soil at four of the study sites (data are not available for Bucks. Site B), and the pH range and parent material of all sites are shown in Table 2. These data support observations by Salisbury (1970), Hess *et al.* (1976), Lousley (1976), Rose (1981) and Meikle (1985) (see also Sowerby 1883).

LIFE CYCLE

D. alisma seeds germinate only below water. Two lots of 120 seeds were sown; eight germinated below water, while none germinated when sown in merely damp conditions. Most germination occurred within three months of sowing. Dormant, submerged seeds can be stimulated to germinate by allowing the seeds to dry and then resubmerging them. 200 seed were sown below water; 14 germinated within three months. The dormant seeds were divided into two lots, half being kept below water, and the other half was dried and resubmerged. None of the continuously submerged seeds germinated whereas 22% (20 out of 93) of the dried and resubmerged seeds germinated after seven months.

Although seed sown in damp conditions but not below water will not germinate, it remains viable for at least a year and a high proportion (93% of 150 seeds) germinate when submerged.

These observations suggest that dormant seeds remain dormant as long as they are either constantly damp or constantly submerged.

D. alisma seeds may remain dormant for a long time. In 1989, *D. alisma* re-appeared at Bucks. Site B after an apparent absence of 87 years (the last report was 1902). Although it is possible that *D. alisma* set seeds in intervening years, but was not seen by botanists, the pond was unsuitable for Starfruit, because of a dense stand of emergents, for at least a decade prior to its restoration. In

TABLE 1. SPECIES ASSOCIATED WITH *D. ALISMA* AT THE FIVE STUDY SITES (NOMENCLATURE FOLLOWS STACE (1991) AND *FLORA EUROPAEA*)

Species	Community code*	Study Sites: Surrey	Bucks. A	Bucks. B	Angers	Sologne
Agrostis stolonifera	Pl	X				X
Alisma lanceolatum						X
A. plantago-aquatica	Ph				X	
Alopecurus geniculatus	Pl			X	X	
Apium inundatum	L	X	X			X
Baldellia ranunculoides	L					X
Bidens tripartita		X		X	X	X
Callitriche spp.	Po	X	X			
Chara vulgaris					X	
Corrigiola litoralis					X	
Cynodon dactylon	I				X	
Elatine alsinastrum	I					X
E. hexandra	L					X
Eleocharis acicularis	L				X	X
E. palustris	Ph	X			X	
Epilobium montanum × ciliatum			X			
E. obscurum		X				
Eragrostis pectinacea					X	
Glyceria declinata				X		
G. fluitans	Ph		X			
Gnaphalium uliginosum	I					X
Hypericum humifusum	I	X				
Iris pseudacorus	Ph		X	X		
Juncus articulatus		X	X			
J. bulbosus	L	X				
J. effusus		X	X			
J. cf. *tenageia*	I					X
Lemna minor			X			
Limosella aquatica	I				X	
Lindernia dubia	I				X	
Lycopus europaeus				X		
Lythrum borysthenicum	I				X	
L. hyssopifolia	I				X	X
L. portula	I	X		X		
Mentha pulegium	I				X	
Myriophyllum alterniflorum	L		X			
Oenanthe aquatica	Ph					X
Paspalum distichum					X	
Plantago major	Pl			X		
Persicaria hydropiper						X
P. maculosa			X		X	X
Potamogeton crispus	Po					X
P. natans	Po	X	X			
Pulicaria vulgaris					X	X
Ranunculus flammula		X				
R. peltatus	Po	X	X	X		
R. repens		X	X			
Rorippa islandica				X		X
R. pyrenaica					X	
Solanum dulcamara		X	X			X
Sparganium erectum	Ph	X				
Stellaria uliginosa			X			
Typha latifolia	Ph					X
Veronica scutellata	L	X				

* community code – see text.

TABLE 2. PHYSICAL COMPOSITION, pH AND PARENT MATERIAL OF THE SUBSTRATE AT THE *D. ALISMA* SITES

	Site				
	Sologne	Angers	Surrey	Bucks. A	Bucks. B
Parent material	Sand/clay drift	Alluvial sand	Plateau drift/ mesozoic & tertiary sands	Plateau drift/clay with flints	Gault-lined pond on plateau drift
Composition (% dry wt)					
Stones (>1 cm diam.)	0·0	0·0	4·8	0·0	Clay with flint gravel
$CaCO_3$ (>1 cm)	0·0	0·0	0·0	0·0	
Stones (0·2–1 cm)	2·6	8·1	10·7	0·0	
$CaCO_3$ (0·2–1 cm)	0·0	0·0	0·0	0·0	
Coarse sand	72·4	72·7	21·2	6·0	
Fine sand	12·7	10·6	31·9	43·2	
Silt	8·8	2·8	7·7	21·8	
Clay	2·7	4·9	21·0	27·4	
$CaCO_3$ (<2 cm)*	0·0	0·4	0·9	0·0	
Organic matter**	0·8	0·5	1·7	1·5	
pH*** (range for five samples)	4·5–5·6	4·9–6·3	4·0–5·2	4·3–5·6	4·5–5·6

* using a Rothamsted Calcimeter
** by combustion at 350 °C
*** in slurry with water using Gallenkamp pH meter

FIGURE 1. *Damasonium alisma* growing at the edge of a fish pond, Sologne, France (June 1989).

Surrey, *D. alisma* reappeared in 1973 (following disturbance of the pond) after an apparent absence of eight years (H. W. Mackworth-Praed, pers. comm. 1987).

In cultivation, germination is most prolific in early winter (November–January). The winter, submerged state of Starfruit has short, linear leaves and forms a small 'grassy' tuft. The tufts can be smothered by large pieces of sunken organic matter such as leaves; this vulnerability may explain the disappearance of Starfruit from ponds now surrounded by woodland. In the spring, long-petioled, floating leaves are produced. Water levels generally fall in early summer, and the young leaves of *D. alisma* plants are exposed. The floating leaves die and are replaced by short-petioled leaves as plants assume terrestrial growth form. Sometimes, during a wet summer when water levels remain high, plants retain floating leaves and produce flowers held above water on long peduncles. Flowers submerged by a rise in water level do not set seed. In cultivation, *D. alisma* grows well as a true aquatic plant, but in the wild it is often smothered by vigorous growth of other water plants.

In England anthesis occurs between June and August. Cultivated plants were visited by small flies (Agromyzidae), beetles (Nitidulidae) and hoverflies (Syriphidae) which feed on pollen or nectar. These insects often had *D. alisma* pollen on their bodies and are probably legitimate pollinators for this species. Starfruit is facultatively autogamous; self-pollination occurs but is infrequent (Vuille 1987).

Terrestrial plants vary in size and can bear from one to about 150 flowers or fruits. The size and fecundity of an exposed plant is limited by the length of time its substrate remains moist; the quicker it dries, the smaller the plant will be, and the fewer flowers it will bear. The larger, more floriferous plants are usually found in shaded habitats or in depressions which retain rain water whereas the smaller plants occur in exposed, sunny positions.

The fruit of *D. alisma* usually consists of six follicles arranged like the rays of a star, each containing one or two seeds. The follicles remain firmly attached to the plant until the fruit is submerged, after which they dissociate. The proximal seed in each follicle is then released but the other seed (if present) remains trapped in the follicle – despite being trapped, this seed can germinate and grow into a young plant.

In cultivation, individual plants, grown as aquatics in a competition-free environment, have survived for three years, although they become progressively weaker each year. Terrestrial plants always behave as annuals. No mature plants were seen on autumn visits to English habitats suggesting that Starfruit behaves as an annual.

CONCLUSION

D. alisma grows in fluctuating ponds with disturbed margins on soil of low pH. These conditions are not necessary for successful growth and regeneration but tend to reduce competition from more vigorous species.

Any pond with fluctuating water levels is a harsh, unreliable habitat. Several adaptations assist *D. alisma* to exploit this habitat; an annual life cycle, plasticity and two different life forms, and a germination strategy that prevents total commitment to a single, possibly unfavourable year.

CONSERVATION

THE DECLINE IN ENGLAND

D. alisma has been recorded from more than one hundred localities, in 50 10-km squares, mainly in the south-east of England. However, at any one time living plants were reported only from a fraction of these. Starfruit has been considered rare for at least a century (e.g. Sowerby 1883; Perring & Farrell 1983). During the present century it has become scarcer and by 1990 only three small populations were reliably reported. This apparent decline may be illustrated using the summary of records for this species compiled by the Biological Records Centre, Monks Wood:

Period	No. of populations verified
1830–1870	21
1870–1910	25
1910–1950	14
1950–1990	7

To identify possible reasons for the decline of *D. alisma* in England, the present conditions at a number of former sites for this species were surveyed. All these sites are now unsuitable habitats for the following reasons: ponds had been filled (e.g. Claygate (Surrey), Oxshott (Surrey), West Molesey (Surrey)); ponds had been abandoned and now contain dense stands of emergents and are surrounded by woodland (e.g. Whitmoor Common (Surrey), Withybed Corner Pond, Walton-on-the-Hill (Surrey), Naphill Common (Bucks.), Littleworth Common (Bucks.)); water levels are artificially regulated for fishing, etc. (e.g. Holmwood Common (Surrey), Wandsworth Common (Surrey), Earlswood Common (Surrey), Brittens Pond near Guildford (Surrey), Tylers Green (Bucks.), Coleshill (Bucks.)); ponds are habitats for large flocks of waterfowl (e.g. at Mitcham Common (Surrey) and the Mere Pond, Walton-on-the-Hill, (Surrey)), which by their trampling, feeding and defecation cause all but the most resilient aquatic plants to disappear.

MANAGING EXISTING POPULATIONS

The habitat of extant populations of Starfruit should be managed so that water-levels fluctuate seasonally, open vegetation with areas of bare soil is maintained by removing invasive plants if necessary, large quantities of smothering organic matter do not accumulate in ponds, and large flocks of waterfowl are discouraged.

RESTORING POPULATIONS AT FORMER SITES

It is possible that viable, dormant seeds of *D. alisma* survive at some of its former habitats. Appropriate restoration may allow populations to become established again through germination of the dormant seed. Restoration may require the dredging of accumulated organic matter (being careful not to deepen the pond or to remove the mineral mud which may contain dormant seed), removal of dense stands of emergents, felling trees, and promoting the seasonal fluctuation of water levels. The re-appearance of *D. alisma* following the restoration of a Buckinghamshire pond provides good grounds for hope that such restoration will be successful elsewhere.

If *D. alisma* does not re-appear of its own accord after the restoration, a population could be re-established by transferring seeds from elsewhere. However, this should only be done following the approval of the national conservation authority and must be fully documented.

CONCLUSIONS

D. alisma has specific habitat requirements and is vulnerable to changes in those habitats. However, an appreciation of its ecology suggests that extant populations can be managed and the apparent ability of viable seed to survive, probably for several decades, in the soil suggests that former populations may be resurrected by the restoration of former habitats.

ACKNOWLEDGMENTS

I am grateful to Dr C. D. Pigott, Ms L. Farrell and Ms J. R. Andrews for their comments on an earlier draft of this paper and Dr A. Jarman for determining the insects visiting *D. alisma* flowers. I would also like to thank the staff of Cambridge Botanic Garden, in particular Mrs J. Free, Mr P. Freeman and Mrs B. Stace, for their support during the course of my work there. The fieldwork in the U.K. was funded by the Nature Conservancy Council and the fieldwork in France by a British Ecological Society's Small Ecological Project Grant (No. 723).

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(*Accepted May 1993*)