Comparing hand pollination success with natural pollination of wild asparagus *Asparagus prostratus*, at colonies on The Gower, Pembrokeshire, west Wales, and in Cornwall, south-west England

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SUMMARY

In order to establish if wild asparagus *Asparagus prostratus* fruit-set is limited by pollination, experiments were undertaken to compare natural insect pollination with hand pollination at four colonies (one in west Wales and three in Cornwall, south-west England). Hand pollination was successful in increasing fruit-set relative to natural pollination in three of the four populations. Overall, hand pollination resulted in a 4.5-fold higher fruit-set (54 fruits) compared to fruit-set of naturally pollinated plants (12 fruits).

BACKGROUND

Morpholgical and genetic evidence has shown that wild asparagus, *Asparagus prostratus*, can be treated as a separate species to garden asparagus, *Asparagus officinalis*, of which until recently it was considered a subspecies. This adds weight to the argument that wild asparagus, a UK SAP (Species Action Plan) and Red Data Book species generally protected under the Wildlife and Countryside Act 1981, should be specifically protected; wild asparagus is classed as 'endangered' in the UK (Cheffings & Farrell 2005). The National Trust is the lead partner for the SAP as most wild asparagus plants in the UK can be found on Trust-owned land. As a result, the Trust and other key partners must endeavour to ensure the maintenance of the geographic range in Britain and Ireland, and also the restoration of small populations of less than 10 plants.

Endemic to Western Europe, wild asparagus (a prostrate, dioecious perennial) is found on coastal dunes and cliff tops in open grassy vegetation. On mainland Britain, it is found at 28 sites, of which several are small populations including five in Cornwall, one in Dorset, three in Glamorgan and one in Pembrokeshire (Rich *et al*. 2002). The larger colonies have quite healthy populations, though the critically small ones are in decline (anon 2007). Wild asparagus also occurs in the Channel Isles, on the northern Spanish and western French coasts, in Belgium, Holland, Ireland, and previously in Germany (anon 1998).

Factors which may account for the decline include lack of management e.g. under-grazing which allows too dense a grass sward to dominate; over-grazing; visitor trampling eroding cliff-top habitats; invasion by Hottentot fig *Carpobrotus edulis*; a low rate of vegetative spread; and the perpetuating problem of loss of genetic variation (anon 1998). Although there is no direct evidence, field observations strongly suggest that natural pollination of the plants by insects tends to be very low. This is due to several factors including few pollinators; low flower production; unfavourable (low) temperatures with damp and windy weather during the flowering season, and the fact that plants of different sexes can be spatially isolated. This means that sexual reproduction is limited, although wild asparagus also slowly spreads

through vegetative reproduction from the rhizomes.

This study compared natural (insect) pollination in wild asparagus plants with hand pollination at sites in west Wales and southwest England to see if fruit production was limited by pollination, thereby indicating if conservation could be enhanced by manual pollination in the future.

ACTION

Wild asparagus workshops: Due to the potential problem of low pollination levels, and thus low seed production in wild asparagus, two 'pollinator workshops' were held in May 2005 at four sites: The Gower (Pobbles), in Pembrokeshire southwest Wales; and three localities in Cornwall (southwest England): Tubby's Head (St. Agnes); the Lizard Lighthouse; and Pen Olver. The workshops aimed to identify whether asparagus fruit-set could be enhanced by hand pollinating plants as opposed to natural pollination by insects. This is part of a wider investigation into the reproductive biology of wild asparagus, and also hoped to demonstrate good techniques for hand-pollination. There were attendees from the UK statutory agencies and the voluntary sector. The weather was very fine (warm and dry) for both workshops.

Wild Asparagus Pollination Project: These pollinator workshops led on to the Wild Asparagus Pollination Project, which aims to enhance fruit-set and seed production, with the long term aim of bolstering population sizes of the UK colonies.

Hand pollination: Hand pollination of a total of 60 plants was carried out at the four colonies. This was undertaken by gently rubbing pollen from the male anthers onto the female stigmas. A diagram of a male and a female flower is shown in Figure 1. Anthers from young freshly-opened male flowers were picked to pollinate the female plants, and specifically anthers that were at dehiscence i.e. when the anther has opened up at maturity, identified by a lot of visible shiny, sticky yellow pollen (Fig. 2 shows a demonstration of the hand pollination technique). A hand-lens was used to check pollen was evident on the stigma. Little pollen is actually needed for a successful pollination which subsequently leads to development of a fruiting body which may contain up to six seeds. This was done on several different flowering branches of the plant, if they were present. The female flowers that were hand pollinated were marked using a loop of red cotton thread, and the comparison sample left to be naturally pollinated was marked with blue cotton.

At Pobbles hand pollination had also been undertaken in May of 2004.

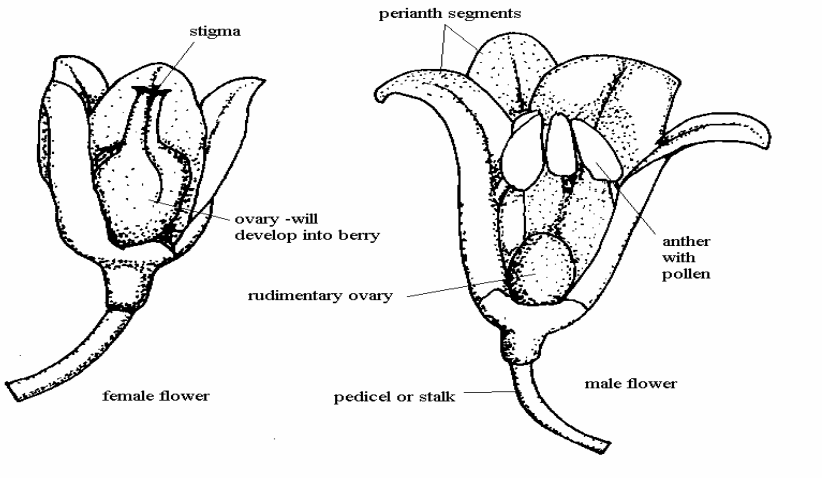

Figure1. Anatomy of wild asparagus female (left) and male flowers (source: Rich *et al*. 2002).

Figure 2. Tim Rich demonstrating hand pollination technique on The Gower, May 2005. (Photo: Lucy Cordrey/NT)

Berry production: In late August 2005, the marked female plants were relocated and the number of ripe (bright red) berries recorded (Fig. 3). It was important to carefully search under and around shrivelled plants that had died back to check for fallen cotton thread, indicating that berries had not formed. The percentage fruit set was calculated for all of the plants (those hand pollinated and those of the naturally pollinated 'controls') in the experiment.

Figure 3. Two ripe wild asparagus berries, one marked with a piece of red cotton thread to indicate that the flower had been hand pollinated, Tubby's Head, August 2005. (Photo: Tim Rich/NMW)

CONSEQUENCES

Fruit-set: The success of hand pollination compared with natural pollination of wild asparagus plants at the Cornish colonies and on The Gower are summarised in Table 1. Overall analysis reveals that hand-pollination resulted in a 4.5-fold higher set of fruit (54 fruits) compared to fruit-set of naturally pollinated plants (12 fruits).

At the one site hand pollinated in 2004 (Pobbles, west side), hand-pollination was significantly more successful when compared with a sample of flowers subject to natural pollination; of 30 flowers hand-pollinated 27 fruit were produced, compared to only one fruit resulting from natural pollination.

In 2005, hand pollination significantly increased the fruit-set of wild asparagus relative to natural pollination in two (Lizard Lghthouse and Pobbles, east side) of the six colonies. At Pobbles, the results between years were very different. Compared to 2004, the 2005 fruit-set was very low, which also emphasises that pollination between years can be very variable, the reasons for this are unknown. It may have been beneficial to have counted the berries a little earlier in 2005, particularly at Tubby's Head and Pobbles, where some berries had already been dispersed by the time of the visit in late August, though luckily the results could still be assessed as the cotton thread markers were still visible attached to the pedicel (flower/fruit stalk).

Seed production: At Pobbles an analysis of the seeds produced per berry was made in 2004 and 2005. There was an average of 2.5 seeds per berry for naturally pollinated flowers, and 3.0 seeds per berry for hand pollinated flowers. Although not statistically significant, it may indicate that hand pollination leads to higher rates of fertilisation than pollination by insects due to more pollen being deposited.

Seed dispersal: The bright red ripe berries of wild asparagus are usually eaten by birds and seed dispersed via their droppings. A small store of berries and seeds was found at Tubby's Head half hidden under a rock, presumably cached by a small mammal, possibly a bank vole *Clethrionomys glareolus*. This suggests that perhaps some small mammals may help with wild asparagus seed dispersal within sites, alongside birds which are known to be seed dispersers over greater distances. However, unlike birds which tend to swallow the berries whole with seeds passing through their digestive tract unharmed, small mammals may eat the seeds as well as feeding on the fleshy fruit/pericarp; it is thought that the effect of small mammals may vary according to species, e.g. bank voles eat the fruit and leave the seeds, whilst wood mice *Apodemus sylvaticus* eat the seeds and leave the fruit.

Table 1. Comparison of the success of hand pollination and control (natural) pollination of wild asparagus *Asparagus prostratus* plants in Cornwall and on The Gower, 2004-2005.

Colony and pollination year	No. of flowers in each treatment	% fruiting success of hand-pollinated flowers (fruit produced)	% fruiting success of control flowers (fruit produced)	Probability using chi-squared	Significance
Cornwall					
Lizard Lighthouse steps, 2005	15	33 (5)	0	0.014	p <0.05
Pen Olver	30	7 (2)	23 (7)	0.071	not significant
Tubby's Head (lower plant in grass), 2005	17	12 (2)	0	0.145	not significant
Tubby's Head (upper plant in rock), 2005	30	23 (7)	7 (2)	0.071	not significant
The Gower					
Pobbles (west side), 2004	30	90 (27)	3 (1)	<0.001	p <0.001
Pobbles (west side), 2005	30	3 (1)	0	0.313	not significant
Pobbles (east side), 2005	30	33 (10)	6 (2)	0.01	p <0.01

Conclusions: Hand pollination was successful in increasing the fruit-set of wild asparagus relative to natural pollination in three of the four populations (six colonies) where it was undertaken. The reasons for lower fruiting success of hand-pollinated flowers at Pen Olver (the one site where natural pollination was more successful than hand pollination) are not known. At the one site where hand-pollination was undertaken over two consecutive years (Pobbles west side, on The Gower in 2004-2005) fruit-set varied over the two years. The reasons for this are also unknown. It should be borne in mind when drawing conclusions from this hand pollination experiment that results are based on a low sample size. However, an overall analysis reveals that hand pollination resulted in a 4.5-fold higher fruit-set (54 fruits) compared to that of naturally pollinated plants (12 fruits) over the two years; seeds per berry were also higher on average (3.0) for hand pollinated flowers, than naturally pollinated ones (2.5 seeds).

REFERENCES

Anon (1998) Tranche 2 Action Plans – Vol. 1: Vertebrates and vascular plants (pp.129). UK Biodiversity Group. http://www.ukbap.org.uk/UKPlans.aspx?ID=118

Anon (2007) National Action Plan - *Asparagus officinalis* ssp. *prostratus* (Wild Asparagus). http://www.ukbap-reporting.org.uk/plans/national.asp

Cheffings C. & Farrell L. (Eds) (2005) *The Vascular Plant Red Data List for Great Britain.* JNCC, UK. http://www.jncc.gov.uk/pdf/pub05_speciesstatusvpredlist3_web.pdf

Rich T.C.G., Bennallick I.J., Cordrey L., Kay Q.O.N., Lockton A. & Rich L. K. (2002) Distribution and population sizes of *Asparagus prostratus* Dumort. Wild asparagus in Britain. *Watsonia*, **24**, 183-192.