

Introducing yellow rattle (*Rhinanthus minor* L.) to enhance biodiversity in an ungrazed flood meadow

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Introduction

The Hurst Water Meadow Trust manages a small flood meadow alongside the River Thame, just a mile upstream from its confluence with the River Thames. One of the Trust's aims is to restore the meadow to the floriferous state believed to have existed in medieval times. The intention was to use grazing cattle to reduce the vigour of the grasses but, as result of the impact of the Foot and Mouth outbreak in 2001, it became very difficult to find graziers. Even when we did find one, he expected to be paid, rather than his paying the Trust for the grazing. Consequently, in 2004 we looked for an alternative way of reducing the vigour of the grass and thought it would be worth working with yellow rattle.

Yellow rattle (*Rhinanthus minor* L. (Scrophulariaceae)) (Fig. 1) has been in England since glacial times and it survives best on tracts of old grassland (Rackham 1986). According to Killick et al (1998), yellow rattle, first recorded in 1699, is a hemi-parasitic plant commonly found in dry pastures and heaths where it feeds on the roots of grasses and clovers. It used to be abundant and widely distributed around Oxford, but has declined in recent years. However, it can cause much harm to grassland, particularly in dry seasons. It reaches peak flowering in May/June (Keble Martin 1986) and sheds its seed before the middle of July. The seed germinates in March, but not unless it has been exposed to freezing weather.

Pywell et al (2004) quantified the effect of yellow rattle on productive grassland, particularly interesting work, on a pasture (Church Meadow) owned by the Northmoor Trust at Little Wittenham, Abingdon, Oxon, literally within sight of the Hurst Water Meadow. The authors confirmed that yellow rattle reduces sward height and increases the persistence of introduced forbs (wild herbaceous plants excluding grasses, rushes and sedges). They concluded that yellow rattle 'has a potentially central role in determining the structure and dynamics of grassland communities'. (Yellow rattle had been introduced into Church Meadow and was abundant some years before work began on the Hurst; we knew of its success but unfortunately were not made aware of the scientific work that underpinned it.)

Coming soon after, Westbury et al (2006), working at sites in Somerset and West Yorkshire, found that sowing yellow rattle seed in 30-cm slots of bare ground formed by the weedicide glyphosphate gave improved establishment and performance, as did scarification of the sward. However, the results were inconsistent due most probably to variations in vegetation density.

In the past yellow rattle would not always have found favour with farmers because of its deleterious effect on grass yields and the knock-on effect on livestock yields. But this same characteristic is now welcomed by environmentalists, especially those aiming to restore the wild flower meadows of earlier times, as the reduced grass crop allows forbs to compete more effectively. This, the Hurst Trustees set out to imitate in pioneering style, but now, in 2011, a Google search reveals many suppliers of yellow rattle seed and advice on getting it established.

The experiments on the Hurst

Location

The Hurst is a 7 ha flood meadow located between the River Thame and the Overy mill stream; a hay cut is taken as soon after 16th July as the weather and the availability of a contractor allow and is followed by aftermath grazing by ponies. The experimental area was at the west end (SU582942) and was left ungrazed. The soil is a silty clay loam (pH 6.6; total N 0.78%; P 14mg/l; K 90mg/l; Mg 98mg/l). The vegetation (Killick, *pers. comm.*, 15.06.2006) is dominated by seven species of vigorous grasses: meadow foxtail (*Alopecurus pratensis*), false oat-grass (*Arrhenatherum elatius*), cock's foot (*Dactylis glomerata*), common couch (*Elytrigia repens*), red fescue (*Festuca rubra agg*), Yorkshire fog (*Holcus lanatus*), meadow barley (*Hordeum secalinum*), and rough meadow-grass (*Poa trivialis*). Buttercups (*Ranunculus* spp.) and cut-leaf geranium (*Geranium dissectum*) were classified as frequent, while the 15 other species of forbs were occasional or rare.

Ground treatments

- Five parallel strips, 80x4 m, with a 2 m buffer between each, were marked out east- west across the field.
- Various treatments were applied to the strips from the autumn of 2004 to 2009.
- In September each year four strips were close-mown (to 3-4 cm) and cuttings removed; if the following winter was mild, there would be a second mowing before the emergence of yellow rattle (March) or high enough to clear the young seedlings. One strip was left unmown.
- The four mown strips were each given a different ground treatment (Fig 2-4): (1) medium rotavation (Fig.2) (to ca 25-50mm) with a hand-held tiller (Honda F6500); (2) light rotavation (Fig.4), as 1 but more spaced out; (3) scarified (Fig.3) with a Turf Doctor to a depth of 10mm; (4) no treatment (Fig.4).
- The strips were rolled with a Countax roller after the seeds were scattered; this treatment was discontinued after two years as it may have pressed the seed into contact with the soil on the control and scarified strips, but was less effective on the rotavated strips.
- The hay cut was taken as soon as possible after 16th July but was sometimes delayed for a month by weather and/or the lack of a contractor.

Seeds and pot plants

- In years 1-3, in September, yellow rattle seed for each strip was weighed out at the equivalent of 0.4g/m², bulked up with sawdust and spread evenly by hand.
- In year 2, in September, mixed forb seed was weighed out and broadcast by hand at the equivalent of 0.5g/m² on the easternmost one-third of each strip. The species sown were a damp meadow mix including: great burnet (*Sanguisorba officinalis*), pepper saxifrage (*Silvaum silaus*), tufted vetch (*Vicia cracca*), cowslip (*Primula veris*), yarrow (*Achillea millefolium*), lady's bedstraw (*Galium verum*), meadowsweet (*Filipendula ulmaria*), lesser knapweed (*Centaurea nemoralis*), ox-eye daisy (*Leucanthemum vulgare*), self-heal (*Prunella vulgaris*), saw-wort (*Serratula tinctoria*), meadow vetchling

(*Lathyrus pratensis*), birdsfoot trefoil (*Lotus corniculatus*), devilsbit scabious (*Succisa pratensis*), rough hawkbit (*Leontodon hispidus*) and betony (*Stachys officinalis*).

- In year 3, the forb seeds were the 'Headland mix'. This included some of the above, plus wild carrot (*Daucus carota*), field scabious (*Knautia arvensis*), musk mallow (*Malva moschata*), common vetch (*Vicia sativa*) and white campion (*Silene pratense*).
- In year 4, the seeds were a special selection of the species occurring on the nearby Iron Age Dyke Hills, the best stretch of natural grassland for miles around. These were cowslip, bird's foot trefoil, ox-eye daisy, meadow vetchling, field scabious, meadow crane's bill (*Geranium pratense*), salad burnet (*Sanguisorba minor*), perforated St John's wort (*Hypericum perforatum*), dropwort (*Filipendula vulgaris*), meadow saxifrage (*Saxifraga granulata*) and common rockrose (*Helianthemum nummularium*).
- In year 4, in February, 120 pot-reared forbs were planted on the westernmost one-third of each strip, leaving one-third without plants or seed. The following species were planted: birdsfoot trefoil, salad burnet, field scabious, meadow crane's bill, lesser knapweed, meadow vetchling, perforated St John's wort, oxeye daisy, lady's bedstraw.
- In year 5, September, the untreated strip was close-mown and planted with 600 pot-reared forbs (same species as in year 4). Also, yellow rattle was sown in one-third of this strip at one of three rates (1g/m², 2g/m² and 4g/m²). Surplus yellow rattle seed was broadcast over the west end not occupied by the strips.

Measurements and observations

- In June/July each year all yellow rattle plants (large and small) in one-metre squares were counted (ten squares per strip). The squares were well distributed along each strip, but not strictly random. Numbers are given as no./m², together with the range. There was no analysis of variance.
- The presence of forbs was noted, but they were not counted.
- The vigour of the grasses was noted.

Results and discussion

Yellow rattle

The results from sowing yellow rattle in the strips were generally clear:

- The feature common to every treatment in every year (Table I) was the very wide range in yellow rattle numbers between sample squares; this made it difficult to draw conclusions. Despite this limitation we took the total number for each square, and used the means for the ten squares in each strip as the measure of yellow rattle success.
- Small numbers of yellow rattle plants germinated and reached maturity in the first year (sown 2004, flowered 2005), but by years 4-5 the numbers were very large, becoming the dominant plant in some patches.
- The first question to arise in year 1 was whether the short sward had allowed yellow rattle to succeed.
- Accordingly, in years 2-4 an unmown strip was added to the experiment and then seeded. No plants established in years 2-3, and only 1 plant in year 4. Clearly, the vigorous, thick grasses prevented establishment. Interestingly we saw the same effect in the buffer strips, and in Church Meadow some years after the end of Pywell's (2004) experiments.

Table 1. Yellow rattle counts (mean per m² and maximum and minimum per m²) according to treatment

	Mown, and cuttings removed				Control
	Medium rotavation	Light rotavation	Scarified	Mown only	un-mown
Year 1 2005	5.6 (0-18)	3.2 (1-8)	4.6 (0-15)	3.5 (0-16)	N/A
Year 2 2006	42.8 (2-105)	21.9 (1-29)	57.6 (4-105)	36.7 (6-82)	0
Year 3 2007	15.2 (1-58)	26.4 (4-95)	44.3 (6-138)	25.7 (1-104)	0
Year 4 2008	66.5 (13-137)	78.1 (1-285)	110.6 (2-335)	48.4 (0-210)	1
Year 5 2009	68.2 (6-174)	64.0 (0-121)	53.3 (15-165)	41.2 (2-84)	55.6 (9-102)

- There were marked differences in yellow rattle numbers each year but the nearly ten-fold increase in year 2 stands out irrespective of ground treatment. The most likely explanation of this is the large amount of seed, the combined effect of seed shed from the previous year's plants and that sown by hand.
- Conversely, in year 3 yellow rattle numbers fell back slightly, possibly because a proportion of the self-sown seed was lifted with the grass cuttings at the time of the September cut; the very distinctive seeds were clearly seen amongst the cuttings in the bin.
- In years 4-5 yellow rattle numbers appeared to have reached a peak at 50 – 70 plants/m²; at this density the growth of the grasses was clearly reduced.
- It was characteristic of all strips that the growth of the grasses, yellow rattle and forbs was very patchy.
- Also in year 5, whether seed was sown at 1, 2 or 4g/m² in the control strip mown for the first time made no difference to the rate of establishment; yellow rattle plants reached high levels in the first year.
- Over the five years the strip mown but receiving no ground treatment had generally fewer established yellow rattle plants, but there was no analysis of variance to back this up.
- An adjoining whole-field trial, run by Peter Pritchard and Charles Flower, well rotavated before sowing, provided useful complementary information:
- In the first year the germination of yellow rattle virtually failed, but in the second year was hugely successful. Intermittent problems with the seed drill resulted in localised very heavy applications of seed, but this clearly indicated that there was a limit to the amount of grass that could coexist with the yellow rattle. Here, yellow rattle parasitized the grasses so severely that there was virtually no pasture left.
- The pasture took more than 2 years to recover.

Introduced forbs (wild flowers)

- Close mowing had a marked effect on some forbs present on the strips, particularly bulbous buttercup (*Ranunculus bulbosus*) which grew so densely that the strips were clearly marked by the colour of the flowers.
- Over the five years small numbers of introduced forbs did germinate and reach maturity, but never enough to make counts meaningful. Those seen following broadcast seeding were: ox-eye daisy, birdsfoot trefoil, knapweed, selfheal, wild carrot, lady's bedstraw.
- Pot-grown plants were used extensively, particularly in year 5, but the results were barely better than with seed, the following being seen: birdsfoot trefoil, salad burnet, field scabious, meadow crane's bill, lesser knapweed, meadow vetchling, perforated St John's wort, oxeye daisy, lady's bedstraw.
- The main problem was that the ground was compacted, and the roots from the pot plants did not readily penetrate beyond the compost they arrived in.
- Forb seed sown in the rotavated field trial ground germinated than in that in the experimental strips.

Conclusions

These experiments have confirmed and added to knowledge on the use of yellow rattle as a means of increasing biodiversity in an ungrazed flood meadow.

- Yellow rattle seed scattered on vigorous unmown pasture does not become established: it is unable to germinate or is swamped by rank grasses if it does germinate.
- Yellow rattle established easily on our particular field when the sward was cut short in September, even when applied at low rates (0.4g/m²).
- Care must be taken not to apply an excessive amount of rattle seed.
- The short sward allowed a few introduced forbs to germinate and grow to maturity, notably selfheal, ox-eye daisy, wild carrot, and birdsfoot trefoil.
- It is possible that forb numbers did not increase because most of them failed to form hard seed before the hay was cut.
- Some of the forbs introduced as pot plants did settle in, but at £1.70 per plant would not be cost-effective on a large scale.

The strips will continue to be observed informally over the coming years. Will the yellow rattle hold its place in the strips in the absence of the September mowing? Will the introduced forbs survive, in particular, our specially nurtured clump of snake's head fritillary brought in nearly ten years ago? It will be interesting to see.

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Fig.1. Yellow rattle in flower



Fig.2. Rotavated with hand-held tiller (Honda 6500)



Fig.3 Scarified with Turf Doctor



Fig.4. The four treatments from foreground to rear: lightly rotavated, uncultivated, scarified and rotated



Fig.5. Sowing seed by hand



Fig.6. Planting potted forbs



Fig.7. Dense stand of yellow rattle (not dense enough to hinder growth of grass)



Fig.8. Grass in the buffer strip (no yellow rattle becomes established)