

CENTRE FOR EVIDENCE-BASED CONSERVATION

Review No. 5

Working Title: Control of ragwort species

Review Protocol

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1. Background

Common ragwort (*Senecio jacobaea*), Marsh ragwort (*S. aquaticus*), Oxford ragwort (*S. squalidus*) and Hoary ragwort (*S. erucifolius*) are all members of the *Asteraceae* family. They are mostly native species that can be found growing as a component of many stands of natural and semi-natural habitats, throughout Europe and North America, Australia and New Zealand (Simpson 1993; EN 2003).

Common ragwort (*S. jacobaea*) is the most widespread of the *Senecio* species, normally biennial, however, can become perennial causing regeneration of new rosettes under conditions which prevent flowering or the plants crown to become damaged. It is associated with free-draining calcareous soils, dunes and drought prone sites where pasture has been poorly maintained opening gaps in the vegetation sward to allow easy establishment of seedlings. Marsh ragwort (*S. aquaticus*) is more strictly a biennial species, having more elliptical or oval shaped leaves than *S. jacobaea*. It occurs in wet meadows, ditches, mud and marshes with prevalence to sites with high rainfall or upland areas, particularly in the north and west of Britain. Both species seedlings germinate during year one, over wintering as rosettes, flowering between, late June to October (August for *S. aquaticus*) the following year. Oxford ragwort (*S. squalidus*) originates from Sicily, introduced in the early 1700s to the Oxford Botanic Garden (hence its name). It has since spread its distribution to local patches throughout the Midlands, S. England and Wales. These three ragwort species (*S. jacobaea*, *S. aquaticus* and *S. squalidus*) are non-stoloniferous, meaning that they do not have a ground-lying or trailing stem that produces roots allowing the establishment of new individuals (Grimes, Hodgson et al. 1988).

Hoary ragwort (*S. erucifolius*) is a native species, much narrower, less bushy and more erect than *S. jacobaea*. Flowering later than the other ragwort species (July- late October) it provides a late nectar source to many insects. This species is stoloniferous, producing runners which can produce new

individuals when rooting occurs at the node, therefore allowing greater spread of the species if the whole plant is not controlled properly.

All species are usually self-pollinated, rarely insect pollinated even though they support a large variety of species. Many of the rosettes die without flowering and show large annual fluctuations in population density each year (Goodman and Gillham 1954; Simpson 1993; Prakash, Pereira et al. 1999; Bacon 2004; Oates 2004)

Ragwort species are known to be toxic to grazing animals (Defra 2003), whether freshly grazed by the animal or consumed within feed (dried grass) or foliage (silage, hay or haylage). Therefore, are included within the designation of the Weeds Act 1959 and the upcoming Ragwort Control Bill which is currently passing through Parliament.

The seed bank of *Senecio* species is large, but short-lived with a germination rate known to be as high as 90% in the right conditions, especially on freshly disturbed sites for the first year, reducing to 1% after four to five years. Therefore the potential spread of the species under the right conditions is rapid and can cause a dramatic change upon the appearance of the landscape as well as establish upon areas likely to be grazed or used regularly by animals, causing morbidity and mortality to livestock and equestrian species (EN 2003).

All parts of the plants are known to be toxic, with the flowers containing the highest concentrations of pyrrolizidine alkaloids (PAs). These are rapidly absorbed from the gastro-intestinal tract to accumulate within the liver of the consumer where they are broken down to produce a highly toxic compound called pyrroles. Pyrroles cause liver damage by acting on the DNA of hepatocytes, preventing cell division and therefore becoming large cells called megalocytes. When these megalocytes die they release the toxins to become available for uptake by neighbouring cells. These dead cells are then replaced by fibrosis, which may cause further damage. The liver of the infected animal is able to maintain normal function until approximately half to two-thirds of the tissue is destroyed. By the time the symptoms are displayed the damage to the liver is generally too extensive for treatment, if treatment is successful the damage to the liver is permanent. PAs have also been identified to accumulate within the human diet (Prakash, Pereira et al. 1999; Knottenbelt 2001).

Ragwort species occur upon numerous sites designated for nature conservation such as National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs) and Local Authority Parks. On the majority of these sites wildlife/biodiversity is the most important management practice. However, where there are other management priorities control of may be necessary (EN 2003):

- As part of a 'good neighbour policy'
- To comply with the guidelines of the Weed Act 1959 - *S. jacobaea* only
- As part of a corrective action programme to clear areas of infestations that occurred under previous management regimes
- To remove the poisoning risk on grassland sites managed by grazing.

S. jacobaea is the food plant for approximately 77 species of insect herbivores, including 27 species of moth, 22 species of thrip, 13 species of bug, nine species of flies and six species of beetle. It is also a nectar source for approximately 177 species of insects all of which consist as a component of a food chain for numerous predators and parasites. Some species even benefit from the plants poisons, reducing their own attractiveness to predation (Harper and Wood 1957; EN 2003). Therefore reduction management might be preferable to total eradication from a site. However, it is foreseen that in areas grazed, removal from the grazed area and margins might be more applicable, with other areas of the site being managed to hold the population at a stable level.

There have been no previous systematic reviews on the control of ragwort species, however there are available a number of reviews on the plants biology and ecology (Harper and Wood 1957). A systematic review on the control of ragwort species would allow practitioners to base their management decisions on the best available scientific evidence whilst identifying any possible gaps in knowledge for the scientific community.

Several practices have been proposed and recommended by various nature conservation agencies for the control/reduction of the extent of both species. For the purposes of this systematic review they are grouped as follows:

1. Hand-pulling
2. Chemical Application (herbicide)
3. Mechanical Control
4. Biological Control
5. Combination Techniques

The above reviews will compare each of the intervention (control) methods to no intervention to investigate the effectiveness of each method.

2. Specific Objectives

- To investigate the effectiveness of the various control methods for controlling the spread of ragwort species:
 - i. Non-stoloniferous ragwort species (*S jacobaea*, *S. aquaticus* and *S. squalidus*)
 - ii. Stoloniferous ragwort species (*S. erucifolius*)
- To provide an effective synthesis of the relevant studies including meta-analysis if appropriate data exists.
- To perform, when appropriate subgroup analysis on the data sets, for example:
 - i. For the non-stoloniferous ragwort species, the different species.
 - ii. For hand-pulling, performed with or without a tool.
 - iii. For chemical control, spraying versus weed wiping.
 - iv. For biological control, cinnabar moth (*Tyria jacobaeae*) or the ragwort flea beetle (*Longitarsus jacobaeae*).

3. Methods

3.1. Search Strategy

The following web-based databases will be searched to identify relevant studies:

1. **ISI Web of Knowledge (WoK)** using CrossSearch Form involving the searching of the following products:
ISI Web of Science (1981 to present).
ISI Proceedings (1990 to present).
2. **Science Direct** – Agricultural and Biological Sciences (1823 to present).
3. **JSTOR** (dependant on the journal).
4. **Index to Theses** (1970 to 2003).
5. **UMI ProQuest Digital Dissertations** (1950s to 2003).
6. **COPAC** – database of the 24 main British and Irish university libraries and the British Library and National Library of Scotland.
7. **Natural History Museum Library** (1980 to present + 80% prior).
8. **AGRICOLA** – two databases for the National Agricultural Library:
Online Public Access Catalogue (books).
Journal Article Citation Index (journals).
9. **SCIRUS** – Scientific Search Engine.

A search strategy will be constructed using the following search terms:

1. Ragwort AND Control
2. *Senecio* AND Control
3. Pulling AND (Ragwort OR *Senecio*)
4. Herbicide AND (Ragwort OR *Senecio*)
5. Spraying AND (Ragwort OR *Senecio*)
6. Wiping AND (Ragwort OR *Senecio*)
7. “Spot Treatment” AND (Ragwort OR *Senecio*)
8. Cutting AND (Ragwort OR *Senecio*)
9. Mechanical AND (Ragwort OR *Senecio*)
10. Biological AND Control AND (Ragwort OR *Senecio*)
11. Cinnabar AND Moth
12. *Tyria* AND *jacobaeae*
13. Ragwort AND “flea beetle”
14. *Longitarsus* AND *jacobaeae*

Reviewers will also contact relevant organisations (e.g. English Nature, National Trust) and search relevant organisations publication databases in an attempt to establish if they hold any grey literature or unpublished material.

All first or correspondence listed authors will be contacted in an attempt to establish if they hold any unpublished data and to clarify information about publications (including missing data if applicable).

An internet search will be conducted using “Alltheweb.com”

The reference lists of all primary studies and reviews will be scanned to capture any further studies missed in the database search.

Conference proceedings will be captured by searching the ISI Proceedings (1990 to present) component of the web-based Web of Knowledge along with British Library and SCIRUS searches.

Book chapters on the intervention methods are to be included within this review. Personal communications will be undertaken to establish the experts within the area and to identify additional sources that maybe of interest.

A single reviewer (PDR) will perform the searches of the web-based databases recording the number of citations returned for each search. To avoid duplication in the final review, all retrieved citations will be imported into ENDNOTE, a reference managing programme. However the number of duplications from the searches will be recorded and presented within the final review.

The selection of studies for the final review will be performed at title/abstract and full text stages to the inclusion/exclusion criteria presented previously on pages 2 and 3. Initially the criteria will be applied liberally to the retrieved citations at title/abstract level. Unless a citation can be excluded without doubts with the title/abstract being identified as potentially relevant to the final review then it should be provisionally included for consideration at full text level. Up until full text level the inclusion/exclusion screening against the selection criteria will be performed by one reviewer (PDR). Full text of all potentially relevant citations will be retrieved and screening against the inclusion/exclusion criteria will be performed independently by two reviews (PDR and AP). Any disagreement in inclusion/exclusion of studies will be resolved by discussion and if necessary consultation with a third reviewer. At all stages the reasons for citations being excluded will be recorded and presented in the final review as a table, along with a flow diagram of the current number of studies remaining at each level of inclusion/exclusion.

3.2 Study Inclusion Criteria

- **Relevant Subjects.** All studies that consider:
 - i. Common ragwort (*S. jacobaea*)
 - ii. Marsh ragwort (*S. aquaticus*)
 - iii. Oxford ragwort (*S. squalidus*)
 - iv. Hoary ragwort (*S. erucifolius*)
- **Types of Intervention.** Studies that include the following interventions will be included in the review:
 - i. Hand-pulling.
 - ii. Chemical Application (e.g. spraying, spot-treatment and weed wiping).
 - iii. Mechanical.
 - iv. Biological Control (*Tyria jacobaeae* and *Longitarsus jacobaeae*).
 - v. Combination of above control methods.

- **Types of Comparator.** Studies that have intervention versus control (no intervention) would be most desired along with studies that consider time series. Studies with combinations of intervention procedures will be included and summary tables.
- **Types of Outcome Measures.** The outcomes of interest for this review are
 - Primarily:**
 - i. Measures of the change in the abundance of ragwort. (e.g. Biomass, number, density, cover, frequency)
 - ii. Measures in the diversity of the sward or sward composition. (e.g. Number of species, change in sward classification)
 - iii. Any side effects for using the various interventions (For chemical intervention affect on other species and soil)
 - iv. Measurement of sward density
 - v. Re-occurrence rate measure
 - Secondary:**
 - vi. Potential Conflicts between biodiversity objectives and site users

Due to the biennial nature of ragwort, the outcome measures should cover two seasons after the intervention was undertaken.

- **Types of Studies.** There will be no restriction on the types of study eligible for inclusion in this review. The search process will not be limited to location of the sites, language or publication status.

3.3 Study Quality Assessment

The methodological quality of all the eligible studies identified will be assessed against a checklist of criteria. As no studies are being excluded from the review at the inclusion/exclusion stage due to the study quality a variety in the methodological quality of studies is anticipated. All studies will be assessed against (Pullin and Knight 2003) for their methodological rigour. This will be presented in tabular form within the review.

3.4 Data Extraction

Data extraction will be carried out independently, in duplicate by two reviewers (PDR and AP) using a data extraction form, as before with any differences being discussed before consulting a third reviewer. The following data will be entered on the customised data collection form, tailored specifically to each of the questions, however comprising of the following general areas (see overleaf):

- Year of publication, publication type and source of identification
- Baseline characteristics of the site and study (incl. study year)
- Intervention Type
- Sample sizes
- Outcomes measured, details and time between intervention and outcome measurement
- Side-effects

Pilots of all the forms (inclusion/exclusion, data extraction and study quality) will be performed on a sample number of studies to ensure the correct data is included with the review.

3.4 Data Synthesis

Assessment of the appropriateness for statistical analysis and data synthesis will be undertaken on all the finally accepted studies within the review. If statistical analysis is deemed inappropriate summary tables of the components of each study will be presented within the review report.

4. Potential Conflict of Interests and Sources of Support

Part of a Natural Environment Research Council (NERC) PhD Studentship

5. References

Bacon, J. (2004). Personal communication.

Defra (2003). Draft Code of Practice to Prevent and Control the Spread of Ragwort, Department for Environment, Food and Rural Affairs.

EN (2003). Information note - Common ragwort, *Senecio jacobaea*. T. W. Team.

Goodman, G. T. and M. E. Gillham (1954). "Ecology of the Pembrookeshire islands II. Stockholm environment and vegetation." Journal of Ecology **42**: pp 296-327.

Grimes, J. P., J. G. Hodgson, et al. (1988). Comparative Plant Ecology: a functional approach to common British species. London, U.K., Unwin Hyman.

Harper, J. L. and W. A. Wood (1957). "Biological Flora of the British Isles: - *Senecio jacobaea* L." Journal of Ecology **45**(2): 617-637.

Knottenbelt (2001). Early test for ragwort poisoning. University of Liverpool.

Oates, M. (2004). Personal communication.

Prakash, A. S., T. N. Pereira, et al. (1999). "Pyrrolizidine alkaloids in human diet." Mutation Research **443**: 53-67.

Pullin, A. S. and T. M. Knight (2003). "Support for decision making in conservation practice: an evidence-based approach." Journal of Nature Conservation **11**: 83-90.

Simpson, N. (1993). A summary review of information on the autecology and control of six grassland weed species. English Nature Research Reports 44. Peterborough.