

The management of semi-natural
lowland grassland for selected rare
and scarce vascular plants

A review

No. 216 - English Nature Research Reports



English Nature Research Reports

Number 216

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vascular plants: a review**

English Nature Contract no. Low/5.1(G)

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1. Introduction

Lowland semi-natural grassland provides a habitat for a number of nationally rare and scarce vascular plants. The first edition of the *Lowland grassland management handbook* (Crofts & Jefferson 1994) provided guidance on many aspects of grassland management but gave little specific advice on individual plant species. The aim of this report is to draw together ecological and management information on fourteen rare or scarce vascular plant species for the second edition.

The species selected partly reflect those for which advice on management is most often requested (eg orchids) or where requirements may differ from the 'normal' habitat management regimes. The species are *Aceras anthropophorum* (Man orchid), *Epipactis atrorubens* (Dark-red helleborine), *Gentianella anglica* (Early gentian), *Herminium monorchis* (Musk orchid), *Himantoglossum hircinum* (Lizard orchid), *Iberis amara* (Candytuft), *Linum perenne* subsp. *anglicum* (Perennial flax), *Ophrys fuciflora* (Late spider-orchid), *Ophrys sphegodes* (Early spider-orchid), *Orchis ustulata* (Burnt orchid), *Polemonium caeruleum* (Jacob's ladder), *Pulsatilla vulgaris* (Pasque flower), *Teucrium botrys* (Cut-leaved germander), and the two subspecies of *Veronica spicata* (Spiked speedwell), subsp. *spicata* and subsp. *hybrida*.

The objectives of this report were to:

- carry out a literature search for information relating to the autecology and habitat management requirements of the species.
- collate relevant information from nature reserve managers and research workers.
- draw up habitat management prescriptions for each species.

2. Methods and information sources

2.1 Methods

The accounts have been drawn up in a standard format for each species reviewing the status, life cycle, distribution, ecology and practical management details. There is a variable amount of information available about each species and some are much better known (e.g. *Pulsatilla*) than others (eg *Herminium*). A diagrammatic summary of the life cycles of individual species is given in Figure 1 (Section 3.16); the precise times of leaf, flower and fruit production will vary between sites and seasons.

When drawing up management plans information should be collated both from a literature search and from contacts with relevant experts and land managers to review all the available information before making any decisions (a plant in the land is worth two in the book).

Primary sources of information and direct experience are always preferred to second-hand knowledge. Many land managers have practical experience of whether individual species increase or decrease under particular regimes, and it is essential to draw on their knowledge. Sharing information and experience can have benefits for all.

Understanding the life cycle is critical. Plants may be annuals, biennials or short- or long-lived perennials, and may flower once only (monocarpic) or many times (polycarpic). Some short-lived plants may also be a little plastic in these respects, and may behave differently in cultivation to the wild (eg *Teucrium botrys*). The times at which each species produces leaves,

flowers and fruits should be taken into account when deciding the timing of management work or grazing.

Some species reproduce by seed alone, some by both seed and vegetative growth, and a few can spread vegetatively without producing seed. In the former two cases, allowing the populations to produce both flowers and ripe seed is clearly essential. The presence of a seed bank is especially important for restoration management. For many species research and careful observation is required to determine which stages in the life cycle are the critical factors which actually limit reproduction; it is notable that many rare orchids produce very few ripe seed pods due to limited pollination. An understanding of natural population cycles, which may vary according to the life cycle and climate in addition to management, is also valuable and may require observation over a period of five years or more.

Ideally the management should aim to maximise reproductive output and the amount of suitable habitat. The vegetation structure and composition, especially the height and amount of bare ground, are often critical for grassland species and can be obtained from known healthy populations. A range of environmental factors can affect plants from drought to soil types and herbivory, and knowledge of these can help explain unexpected changes in populations, such as the effects of drought on population cycles in *Gentianella* and *Herminium*. It may however only be possible to control some factors such as stock grazing regimes; if sites are to be grazed, then knowledge of the palatability of the plants to different types of stock is critical.

There is no substitute for practical experience of management, especially when this is coupled with detailed population studies. Although there is often much published about the ecology and life cycles of individual species, suitable management regimes are rarely documented in the literature. Management is also often a compromise between different requirements of the different plants, animals or habitats on the sites and it is important to be clear which are the priorities.

Management regimes are often unique to each reserve due to the sheer practicalities of management, especially where land or stock are not owned, but the general principles can often be applied elsewhere. As many species can survive in a range of regimes, even if sub-optimal, details of a range of management regimes can enable compromises to be reached if needed. Optimum as opposed to adequate management on particular sites is often an iterative process which can only be carried out by trial and error.

The main forms of management are grazing, mowing, controlled burning, disturbance and non-intervention (for full details see Crofts & Jefferson 1994). For grazing regimes both the stocking (stock type, numbers of animals per hectare, timing) and swards heights/condition are useful to allow suitable habitat conditions to be obtained from either the stock or the grassland. For mowing, the timing and height of cutting and whether cuttings should be removed should be considered. For controlled burning the time of year and frequency are important as these affect the temperature of the fire which may affect the plants. Disturbance in the form of ploughing, rotovation, chain harrowing, clearing saws, hand digging, etc. needs also to be carried out at specific times of year prior to germination. A few sites such as sea cliff top grasslands require no intervention.

The recommendations for management regimes are based on current best advice, and may need to be revised in light of further information which would be welcomed.

2.2 Information sources

The literature search for relevant information was carried out by a computer search on BIDS, a search through local and national floras, BSBI Abstracts, the bibliographical index of the British flora (Simpson 1960), biological floras in the *Journal of Ecology*, English Nature's library catalogue, etc. References traced are listed in the bibliography (Section 5); a small number mainly relating to European work which not been seen are listed separately at the end of the bibliography.

Contacts were made with nature reserve managers and research workers (see Section 5. Acknowledgements), and details of management practices which either work or are known not to work were collated, concentrating on types of animals, stocking levels, timing of grazing and sward types. Additional unpublished reports were also requested.

A glossary of some of the more technical terms is given in Section 4.

3. Species accounts

3.1 *Aceras anthroporum* - Man orchid

Nationally Scarce species recorded in 50/109 10-km squares in Britain since 1970 (Stewart, Pearman & Preston 1994).

Life cycle

A moderately short-lived, polycarpic, strongly mycorrhizal herb which reproduces by seed. The first green leaf is produced about five years after germination. Plants may live to over fourteen years and flower for up to five years in succession. The half-life ranges from 4-8 years, the linear survivorship curve suggesting that the risk of death is fairly constant through the life of the population (Wells 1981).

Leaves appear above ground in October/November and are winter-green, dying down to the tuber in May/June when the flowers appear. It flowers in May and June (rarely into early July), and seed is dispersed by the wind by late June/early July (Wells 1981, 1994). There are few observations on cross- or self-pollination (Hall & Pearsall 1933; Summerhayes 1968), and hand pollination has been carried out at some sites with few plants (eg Warren Bank; G. Bellamy, pers. comm. 1996). There is little information on development of seedlings in the wild (Grubb 1990).

Populations at different sites vary from a few plants to several thousand. The numbers fluctuate a little from year to year within each site, and the proportion flowering may be quite small (eg 41% on average over 14 years; Wells 1981). Recruitment occurs at irregular intervals, and populations are often uneven-aged (Wells 1981, 1994).

Distribution and ecology

Recorded widely in lowland England (recent map in Wells 1994), and most abundant in the south-east (Lousley 1950).

It occurs in lightly-grazed and rank calcareous grasslands and pastures, scrub edges, woods (Lousley 1950), old chalk and limestone quarries, roadsides, coastal shingle (D. C. Lang, pers.

comm. 1996) and even in old sewage sludge beds (J. S. Redgrove, pers. comm. 1988). It occurs in a range of NVC types including CG2, CG3, CG4, CG5, W8 and W21 (Rodwell 1992; T. Rich pers. obs.). The soils are usually calcareous in Britain (not necessarily so elsewhere), and it often occurs on the deeper, damper soils at the base of slopes. It can withstand considerable shade and often grows best at the edge of scrub in rank grassland (Wells 1994). In Holland it is a pioneer colonist of open calcareous scree (M. Finnemore, pers. comm. 1996).

Rabbits are also noted to selectively eat this species (D. C. Lang, pers. comm. 1996). Being winter-green it may also be trampled or selectively eaten by winter stock.

Management

Very little is known about appropriate management, and more research including long term experiments is needed. Due to the period it spends underground as seedlings it may take five or more years to see the results of any management. The moderate life span indicates that variations in management are unlikely to threaten populations in the short-term.

It is a species most typical of rank grassland and open scrub, which will develop into closed scrub and woodland communities without management. These sites may only require scrub clearance to keep them open, a practice which is thought to have resulted in at least temporary increases in populations at Totternhoe Knolls NR (Wells 1981). However, clearance of scrub on a road verge in Hampshire by the Hampshire flora group has failed to halt the decline, though more time may be needed to see the results (M. Finnemore, pers. comm. 1996).

It does not grow well in heavily-grazed pastures and is often eliminated by heavy grazing (Wells 1994). In recent years it has declined markedly at Totternhoe Knolls due to excessive rabbit grazing (sward 1-2 cm tall with little bare ground); the site has now been rabbit-fenced and the rabbits controlled and it is hoped to introduce sheep grazing soon (A. Fleckney, pers. comm. 1996).

The small but stable population at Queendown Warren SSSI was grazed for many years between September and December/January with 1-2 cows/ha with plants growing in a sward of height of about 10-20 cm, with a few plants in short turf 2-3 cm tall (D. Hutton, pers. comm. 1996).

At Old Winchester Hill NNR and Beacon Hill NNR the management is not satisfactory and the populations are dwindling. One small population at Old Winchester Hill occurs in grass 20-30 cm tall in an area with various stages of succession from short *Festuca* turf (CG2) through to juniper scrub; it is grazed by sheep (less than 1 ewe/ha) between October and March. A second site with a few plants at the bottom of the rampart slopes has coarse grass and is also winter-grazed by sheep (less than 1 ewe/ha) with a sward to 3-4 cm tall. At Beacon Hill it occurs in CG3 turf at the top of the slope and scattered into scrub, and is grazed hard by cattle between October and April at stocking rates of up to 2.5 cows/ha (usually a lot less). Consideration is being given to creating some bare open ground for it to colonise (M. Finnemore, pers. comm. 1996).

At Barnack Hills and Holes NNR it occurs in the ranker parts of the site and is quite tolerant of the grazing regimes which is primarily for the benefit of *Pulsatilla vulgaris*. The site is grazed by sheep from September to December until the sward is short enough for the *Pulsatilla*, but the sheep do not tend to graze the ranker *Brachypodium pinnatum* grasslands in which *Aceras* occurs (C. Gardiner, pers. comm. 1996).

It survived close mowing on a private verge for many years at two sites in Suffolk and flowered when the mowing was stopped in May (Sanford 1991); there are now about 60 spikes at one verge (pers. comm. 1996).

There is no information on responses to burning, but it is likely to tolerate fires during the late summer when it is underground.

Sanford (1991) noted that plants were transplanted from a development site to a quarry in Suffolk, but they do not appear to have survived (M. Sanford, pers. comm. 1996).

Recommendations

A polycarpic, moderately short-lived perennial herb which reproduces by seed. It occurs in lightly-grazed and rank grassland and scrub, and possibly also as a pioneer of open calcareous ground. Surprisingly little is known about what management favours it; scrub clearance and light late summer-winter grazing by cattle or sheep (less than 2/ha) are currently thought to maintain populations, whilst heavy grazing or dense scrub and woodland development are probably undesirable. It may tolerate mowing.

3.2 *Epipactis atrorubens* - Dark-red helleborine

Nationally Scarce species recorded in 38/50 10-km squares in Britain since 1970 (Stewart, Pearman & Preston 1994).

Life cycle

A polycarpic perennial herb, reproducing by seed and spreading by rhizomes to form small groups. Summerhayes (1968) records that buds on the roots of this species are comparatively rare, but that they may give rise to new plants 30 cm or more away from the parent.

Leaves appear in spring from April onwards and flowering occurs in late June, July and August. Siriwardene (1995) recorded plants weekly at Thrislington NNR from mid May to July 1994. She found the inflorescence developed in late June, and plants flowered from early July continuing into August; no ripe seed had been set at the end of July when observations ceased. It may not flower regularly (eg Lousley 1950). Each spike may have 6-18 flowers. It is dependent on cross-pollination by bees and wasps to set seed (Summerhayes 1968), though which species have not been researched in Britain (Mueller 1988 lists pollinators observed in Germany). The stems die down again in October/November, possibly depending on timing of frosts.

Many populations consist of only a few plants, of which most may be sterile shoots and perhaps up to 50% flower. Population sizes are not thought to vary much from vary to year.

Some hybrids with *E. helleborine* have been reported (Stace 1991).

Distribution and ecology

It occurs scattered in the limestone areas of northern England, north Wales and Scotland, and has been recorded in 72 tetrads in 38/50 10-km squares since 1970 (for recent map see Wilson 1994).

It occurs on scree slopes, limestone grassland, limestone pavements, old quarries and on cliff ledges. It is a calcicole and is always associated with limestone soils or rocks, most of which

are shallow stony limestone rankers or protorendzinas. At Gaitbarrows NNR it is characteristic of the *Sesleria* grasslands which have developed on damaged pavements over the last 20 years, and it has benefited from the disturbance; it grows in grasslands with *Sesleria* tussocks to c.20 cm and 10-20% bare ground (R. Petley-Jones, pers. comm. 1996). Summerhayes (1968) suggests that it is not very dependent on its mycorrhiza. Most habitats are open or semi-shaded, and it does not tolerate deep shade.

Typical associated species include *Sesleria albicans*, *Carex flacca*, *Corylus avellana*, *Fraxinus excelsior* and *Teucrium scorodonia*. The NVC types in which it has been observed are CG1, CG2, CG3, CG6, CG8, CG9 and W21 (Graham 1988; D. Guest, pers. comm. 1996; T. Rich pers. obs.).

Deer, sheep and rabbits may graze inflorescences, and often only spikes growing in inaccessible places set fruit (Allan & Woods 1993). At Gaitbarrows deer often browse off the spikes before they flower (R. Petley-Jones, pers. comm. 1996). Slug damage has also been observed.

Management

The sites are usually unmanaged or lightly-grazed. Limestone pavements, cliffs and some screes may require no management at all (eg pavement areas at Gaitbarrows NNR). Scrub clearance (preferably with treatment of cut stumps) may be appropriate management for sites prone to invasion by woody species. At Gaitbarrows NNR scrub clearance has resulted in development of the *Sesleria* grasslands which *E. atrorubens* favours. There are no details of response to burning.

It does not survive heavy grazing or browsing. Plants at Gaitbarrows NNR flowered much better than normal in 1996 after a marked drop in deer numbers following culling. Rabbit control may also be required in some sites.

At Thrislington NNR a population of about 100 spikes occurs on a CG8 bank with grassland c. 10-15 cm tall and less than 5% bare ground. The current management is to graze with Beulah sheep between August and April (c. 5-6 sheep/ha) but not the summer, resulting in a summer sward height of about 10-15 cm. This management has been insufficient to stop the spread of *Bromopsis erecta* which requires control with more grazing in late winter and spring (M. Leakey, pers. comm. 1996).

Introduction of spring sheep grazing on a CG9 scree slope at Warton Crag, Lancashire in 1990 resulted in a small increase in a small *E. atrorubens* population in the following year, probably due to reduction in the cover of *Sesleria* (Rich, Rodwell & Malloch 1992); longer term responses are unknown.

At Arnside Knot NT it occurs on ungrazed open screes which are kept open by scrub cutting, and in pasture which is lightly-grazed by a tenant farmer by sheep (2/ha), sometimes supplemented with cattle (0.5/ha) between mid May and end of July; many of the plants get eaten (probably also by rabbits) and it is hoped to reduce the summer grazing pressure in the future. Management is primarily to maintain the CG9 *Sesleria* grassland which is important for the Scotch argus butterfly, but the *Epipactis* survives (A. Ferguson, pers. comm. 1996).

In Wales it is almost entirely restricted to cliff ledges and open vegetation on naturally bare or eroding substrates subject to little or no grazing pressure. Scrub encroachment may be a threat to some colonies, for example on the Great Orme where some colonies are being overwhelmed by woody species (notably alien *Cotoneaster* species) (D. Evans, D. Guest, A. Jones, D. Steven, pers. comm. 1996).

Thrislington NNR has occasionally, as a last resort when winter grazing has proved impractical, been mown to about 10 cm tall with a mini-forage harvester in late summer to reduce the sward height. This results in a less open sward without the variation created by grazing, but does not seem to have harmed the *Epipactis* populations (M. Leakey, pers. comm. 1996).

Recommendations

A perennial herb, reproducing by seed and forming small spreading clumps by rhizomes. It is susceptible to summer grazing (especially the inflorescences) and prefers ungrazed or lightly-grazed sites. Some ungrazed sites may require scrub clearance or no management at all. Some sites with populations in inaccessible place such as on ledges or limestone pavements can be grazed by stock at any density or timing. Other sites may be grazed by sheep at up to 5-6 animals/ha between September and April, preferably leaving a sward of about 10 cm tall and up to 10% bare ground.

3.3 *Gentianella anglica* - Early gentian

English and Welsh endemic (Rich 1997). Nationally Scarce species recorded in 62/102 10-km squares in Britain since 1970 (Stewart, Pearman & Preston 1994). Listed on Schedule 8, Wildlife and Countryside Act, the Species Directive of Bern Convention, and Annex I of EC Species and Habitats Directive.

Life cycle

Pritchard (1959) described it as a monocarpic biennial, with seeds germinating in spring and early summer, growing as rosettes through the summer, dying away to a small underground bud during the winter and resuming growth in the spring (second year rosettes were seen in February in Surrey) to flower in early summer. Plants grown in pots germinated in spring or early summer, but plants germinating in autumn died during the winter. In contrast Bennett (1892) reported observing germination near Croydon in the autumn, and watched the plants through the winter up to the flowering stage in May and June, and Telfer (1994) felt the plants were over-wintering annuals. Further investigation is being carried out but the biennial theory is favoured at the moment.

Peak flowering occurs from April to June, with records extending from March to July depending on weather. It is probably self-compatible but this has not been confirmed experimentally, and the extent of out-crossing is not known. It is pollinated by bumblebees (Telfer 1994).

Grubb (1976) reported a mean of 295 ± 38 s.e. seeds per plant (approximately one third of the seed output of *G. amarella*) and noted that germination was delayed over several years. He also suggested that there was evidence that the seeds did not persist in the seedbank, but this is contradicted by the recently-observed huge changes in populations from year to year, suggesting that there is a good seed bank (the closely related *G. amarella* is known to form a persistent seed bank; R. Jefferson, pers. comm. 1996). Further observations on the seed banks are needed, but gentians are known to be difficult to germinate (eg Pritchard 1959), possibly due to the presence of a well-marked endotrophic mycorrhiza (Grubb 1976). There are no specialised dispersal mechanisms and plants often recur in the same patches, not spreading to apparently suitable places a few metres away.

Populations vary enormously (up to 1000-fold) from year to year, related to the biennial habit and weather conditions (Rich *et al* 1996b), and many populations consist of fewer than 20

plants which appear sporadically. Only the sites with large populations may have flowering plants in poor years (Rich *et al* 1996a). It is likely that germination also depends on the weather conditions, with virtually no plants present after drought years but appearing two years later (to confirm in 1997!). Annual monitoring is required.

Plants differ in morphology between sites, but most plants are consistent within a site. Hybridisation with *G. amarella* occurs across southern England and may be a threat to some populations, and there may be some difficulty in distinguishing plants from *G. amarella* with which it often grows. *G. anglica* subsp. *cornubiensis* is no longer accepted as a distinct taxon and is regarded as the hybrid (Rich, Holyoak, Margetts & Murphy 1997).

Distribution and ecology

It occurs in chalk and limestone grassland and sand dunes scattered across southern England and South Wales (a slightly out-of-date map is given in Stewart, Pearman & Preston 1994). As with many annual/biennial chalk grassland plants, it has probably generally declined due to improvement of pastures, changes to rank grassland and scrub encroachment.

Typical habitats are chalk downs, cliffs, quarries, spoil heaps, dunes (rare on pure sand), ancient earthworks, trackways and path edges. It frequently occurs in open, exposed sites, where the soil depth is only 2-5 cm, often with considerable exposure of bare chalk. It is present in small gaps in the turf (Grubb 1976), but sometimes can grow in longer vegetation. It often occurs on steeply sloping ground rather than on the level. Among the commonly associated plants are *Asperula cynanchica*, *Briza media*, *Bromopsis erecta*, *Festuca ovina*, *F. rubra*, *Gentianella amarella*, *Hieracium pilosella*, *Linum catharticum*, *Lotus corniculatus*, *Sanguisorba minor* and *Thymus praecox*. It has been observed in most of the lowland NVC calcicolous grassland types (CG1-CG7) but mostly occurs in CG1, CG2 and CG3 where turf heights are typically between 1-10 (-20) cm tall. It occasionally persists in open parts of scrub (W21d).

Some plants may be eaten and grazed by stock and rabbit, often resulting in "coppicing" with production of basal shoots which flower, but in general the plants survive grazing well (Telfer 1994). Little is known about the effects of invertebrates, but Telfer (1994) reported mealy bugs, plume moths and other damage in the Isle of Wight. Some plants have been observed infected with a rust fungus.

Management

Before any changes in management are carried out, an understanding of the natural population cycles is needed as low population numbers may simply be part of a longer term cycle and not a cause for concern. It may be possible to control the spread of hybrids in populations by grazing heavily in their flowering period from late June onwards over a period of years.

The main management tools are disturbance and/or grazing to create and maintain open, bare ground for germination (c. 5% bare ground/m² is probably adequate) and short turf ideally 1-5 cm tall. Some exposed cliff-edge sites may not need any management. Whilst investigations are still under way, new plants have been observed 12-18 months after soil disturbance, so some patience is needed before the results of management are assessed.

Clearance of scrub and disturbance of soil resulted in re-appearance of a few plants at Banstead Downs in a situation where it had probably been dormant in the seed bank for at least 10 years, though due to the subsequent re-growth of scrub further management is required to maintain the populations in the longer term (Rich *et al.* 1996b). Plants also

appeared on ground disturbed to make a barrier at a car park at Martin Down about 2 years after the work was carried out (A. Knott, pers. comm. 1996). Soil disturbance should be carried out between November and March after peak years only to minimise potential damage to the next year's plants. Plants were formerly more frequent at Banstead Downs when chalk spoil heaps were maintained in a disturbed open state by low intensity, intermittent, motorbike scrambling. Harrowing and rotovation are also being proposed as possible techniques for soil disturbance to resurrect possible seed banks where this does not compromise other conservation interests as there is likely to be a low success rate (Rich *et al.* 1996b).

Grazing by rabbits, cattle, sheep or combinations are probably the best long-term grazing options. Cattle grazing works well on many reserves and tends to result in more poaching and open ground, which may favour the populations. Very heavy poaching may be detrimental (Telfer 1994).

At Castle Hill NNR plants occur in 2-5 cm tall, open CG2 grassland between clumps of longer CG5 grassland (the longer grass is important for invertebrates). It has a history of extensive cattle grazing (c. 0.5-1/ha, September-January) with some sheep (rabbits are also present). Between 1991 and 1996 the sheep component has been increased to light grazing all year round (c. 2 animals/ha), with increases to 4-6 animals/ha during the winter, and occasionally during flushes of grass growth. Cattle (0.5/ha) now graze between September and December. The grazing is adapted to the amount of grass present, and for example in the very dry summer of 1995 so little grass occurred that no cattle were put on in the autumn (M. Emery, pers. comm. 1996).

Wiltshire has a series of sites in grazed downland. At Parsonage Down NNR the site is grazed all year by cattle (1+calves/ha) and sheep (2.2+single lambs/ha) from April to February. The gentians occur in short turf c. 0.5-4 cm tall with bare ground recorded as 'occasional' or 'rare' in small quadrats, especially occurs in places slightly trampled by cattle.

Pewsey Downs NNR has a large population (often c. 2000 plants) scattered mainly along sunken ways, tracks and chalk pits and the grazing regime varies between compartments (A. Knott, pers. comm. 1996). The main NNR part has cattle (c. 1/ha) and sheep (0.7/ha + their lambs) all year to maintain the CG2 sward. A subsidiary NNR area has summer cattle grazing (0.8/ha) with higher stocking levels (1.2/ha) and sheep (0.5/ha) in the winter. A Nature Reserve Agreement compartment is grazed by cattle (0.8-1.6/ha) all year except for April (to allow a *Bromopsis erecta* growth flush), with a winter clean-up graze by sheep to maintain the CG2/CG3 sward structure. At Martin Down NNR there is a tiny population in short, mainly rabbit-grazed grassland which may be winter-grazed by sheep (A. Knott, pers. comm. 1996).

At Prescombe Down NNR various grazing regimes determined by local farming practices resulting in a quite open sward c. 1 cm tall have suited the gentian. It used to be grazed alternately in summer one year by sheep and the following year by cattle. It is now summer-grazed on a three year cycle; sheep (14 ewes+lambs/ha) from late April to October/November, followed the next year by sheep (2.2/ha) and cattle (2.5 sucklers + calves/ha) from April/May to October, followed finally by 3.2 young cattle from April/May to July (D. Burton, pers. comm. 1996).

Hambledon Hill NNR supports thousands of plants in a good year. The sward is low fertility CG2 grassland usually about 2-5(-8) cm tall with up to 5(-10)% bare ground where the gentians occur. The site is grazed by beef cattle (c. 0.6 animal/ha) from late April/early May to July-September depending on the amount of grass, and then sheep-grazed (4-5/ha) for 6-8

weeks from early October and then for another 3-4 weeks in late January (this is due to practicality of grazing management rather than deliberate policy - the exact timing of the winter grazing is not thought to be critical). There are also significant rabbit populations in some areas (I. Nicholl, pers. comm. 1996).

It appears to have been eliminated by frequent summer mowing on some sites (Banstead golf club fairways and roughs), but trials are under way with one-off winter cutting at Bostal Pit to see if sites can be restored and maintained in this way (Rich *et al* 1996b). It is abundant at Beachy Head in a meadow which is mown and then grazed (details unavailable). Mowing alone is unlikely to provide the open ground necessary for germination, and cuttings must be removed.

There is no information on response to burning.

Recommendations

A monocarpic, biennial herb of open chalk turf which reproduces solely by seed and varies markedly in abundance from year to year. Management is flexible but should aim to keep the turf less than 5 cm tall and with 2-10% bare ground, preferably by natural rabbit grazing or autumn-winter sheep or cattle (0.5-2 animals/ha) grazing from August to March.

3.4 *Herminium monorchis* - Musk orchid

Nationally Scarce species recorded in 46/100 10-km squares in Britain since 1970 (Stewart, Pearman & Preston 1994).

Life cycle

This is a polycarpic, probably short-lived, mycorrhizal perennial, which reproduces both by seed and from buds on the rhizomes. It produces two or more tubers each year which are borne at the ends of 'stolons' 10-20 cm away from the parent, and one of these (exceptionally two) usually flowers the following year (Summerhayes 1968). These ramets become disconnected and form daughter clones. Large colonies can be formed this way in a short period in favourable conditions, though equally with a half-life of 2-3 years for each ramet during a period of decline they can also disappear quickly (Wells 1981, 1994).

Leaves are present from late May to September but are easily overlooked. They die down for the winter and the plant persists as tubers underground. It has a long flowering season in June and July which can vary by three weeks from year to year (Lousley 1950), and sometimes flowers can be found in August in north-facing sites. As many as 73 flowers have been seen on a single spike, but the number is normally much smaller. Flowers are visited by many small flying and crawling insects attracted by the scent (especially Diptera and Hymenoptera; Nilsson 1979), but also self-fertilise. Seed is dispersed by the wind in August and September. Seedlings have rarely been observed (Summerhayes 1968).

Sometimes *Herminium* can be so abundant as to make the hillsides smell of honey, but often populations are small with fewer than 30 plants. Populations can fluctuate markedly within a few years related to the life cycle and recruitment. Only a small percentage of the plants present may flower each year (17% flower on average, and in drought years this may be less than 1% with carry-over effects into the next year). Stress conditions during the period of active growth in summer adversely affect flowering performance; the number of plants flowering correlates negatively with summer rainfall in the current year and positively with late summer rainfall from the previous year (Wells 1981). At Malling Down NR the drought

of 1976 caused a population crash from tens of thousands of plants to a handful and it has not recovered although all other factors appear suitable (D. C. Lang, pers. comm. 1996).

Distribution and ecology

It occurs scattered in lowland southern England on calcareous soils (recent map in Wells 1994).

It occurs on short calcareous grassland less than 10 cm tall, especially on the narrow terracettes formed by soil creep down steep slopes, on quarry floors, spoil heaps and rarely in open scrub. It does not tolerate shade or tall grass. The soils are usually calcareous and may be quite damp. It occurs mostly in NVC types CG2 and CG3 (Rodwell 1992; T. Rich pers. obs.). Some moisture is clearly important in its life cycle and in Europe it often grows in damp places such as fens (there is also one possible British record from Redgrave Fen, Suffolk; Sanford 1991).

The rosettes are unlikely to be eaten by stock due to their small size, but inflorescences may be.

Management

Some sites are unmanaged and will presumably go to rank grass and scrub in due course ultimately resulting in loss of populations. Short, tightly grazed turf is essential (D. C. Lang, pers. comm. 1996).

At Totternhoe Knolls NR intensive rabbit grazing has produced a sward 1-2 cm tall with little bare ground; rabbits have grazed off all the flowering plants since 1993. The site has now been rabbit-fenced and the rabbits controlled and it is hoped to introduce sheep grazing soon (A. Fleckney, pers. comm. 1996).

In the Cotswolds it typically occurs in very short CG2 turf in quarries and on spoil heaps. There are no exact grazing details but provided the turf is short and open c. 1 cm tall and with up to 30% bare ground then the habitat is probably suitable (M. Wilkinson, pers. comm. 1996).

At the Rifle Range, Grangelands and Pulpit Hill SSSI there is a small population in CG3 grassland which was being encroached by scrub after 40 years with no grazing. The site is now grazed by steers and ewes between September and November aiming to achieve a short turf (5-7 cm) with occasional tussocky patches for invertebrates, and when this is achieved the stock are removed (this is regarded as a fairly 'safe' approach for restoration of grassland when the requirements of varied target organisms are not known exactly). *Herminium* increased in numbers until it was hit by the 1995 drought (C. Damant, pers. comm. 1996).

At Park Gate Down NR it has declined over the last 20 years from hundreds to tens of plants probably as a consequence of under-grazing by cattle resulting in build up of rank grass and leaf litter. The site is now managed for a number of plants and invertebrates with yearly rotational grazing of compartments with cattle (0.4 store animals/ha) or sheep (0.5-1 animal/ha) through no grazing, spring grazing, summer grazing then all year grazing, though results need to be assessed in the longer term (J. McAllister, pers. comm. 1996).

The rank CG4 grassland at Park Gate Down NR was given a controlled burn in February 1985 and followed up with ruthless summer grazing resulting in a sward 2-3 cm tall and with c. 1% bare ground, and then grazing was removed in 1986. *Herminium* reappeared in hundreds in

the following years, but declined again when the grazing was not maintained due to practicalities (J. McAllister, pers. comm. 1996).

Recommendations

A perennial herb which reproduces both from seed and vegetatively. Populations vary in size depending on management and climate. The grazing regimes can be quite variable but if reproduction from seed is required it should not be grazed from June to September. It should be aimed to get a short open sward up to 5 cm tall and 30% bare ground, probably with intensive sheep grazing.

3.5 *Himantoglossum hircinum* - Lizard orchid

Red Data Book species (Farrell, in prep.). Listed on Schedule 8 of the Wildlife and Countryside Act 1981.

Life cycle

A biological flora is in preparation by P. Carey and L. Farrell, who have provided much of the information below.

A polycarpic, mycorrhizal, long-lived perennial, which reproduces by seed. Studies on populations on a site in Cambridgeshire gave a half-life of the order of 15 years. Some individuals can live to at least 20 years. In cultivation, plants often dwindle and die after a few years, they are often monocarpic, and seed germination is rarely successful (Good 1936).

Leaves are winter-green and are present from late August-October (depending on rainfall) to June, withering before or immediately after flowering. Non-flowering plants die back earlier in May. Flowering occurs from late May to early July. Except for fruiting spikes the plants persist for the summer as underground tubers.

Individual plants may flower irregularly, and the whole colony at Lakenheath did not flower for ten years (Rutterford 1985). Inflorescences may have over 150 flowers. Cross-pollination is carried out by honeybees in France (Hall & Pearsall 1933) and by the solitary bee *Andrena carbonaria* in Germany; the flowers appear to have little or no other attraction for other insects (Proctor & Yeo 1973). More recent studies at Sandwich have found cross-pollination by the bee *Megachile maritima*, hoverflies and moths (L. Farrell, P. Carey, pers. comms. 1996).

Ripe fruit and seed is produced about six weeks after flowering. Fruits are produced in variable quantity from site to site and year to year sometimes in only very small amounts; only 20 capsules were produced in the whole Cambridgeshire population in 1978 - the rest were either picked or not cross-pollinated (Donald 1978). Sanford (1991) noted that about one third of the flowers produced capsules. 1994 was a good year for seed production, though little was produced in 1995 and 1996 (P. Carey, pers. comm. 1996). Seeds are wind dispersed; it has been suggested that these are released when dry air blows from the north-east rather than humid air from the south-west, as new plants consistently appeared upwind of the prevailing south-westerly wind direction at Rye (M. Briggs, pers. comm. 1991). Other studies at the Kent site show random dispersal and establishment of seeds (P. Carey 1995 Orchid conference). Some seeds remain in the capsules which may explain clustering of seedlings near parents.

There is little information on the development of seedlings in the wild (Grubb 1990). Good (1936) reported seedlings were present three years after a plant flowered and died but some

seedlings may produce leaves more rapidly, perhaps even with a few months (experiments are under way; P. Carey, pers. comm. 1996). Small, single-leaved plants have been recorded at the Cambridgeshire site near mature plants; these appear to be seedlings and have subsequently developed into mature plants (L. Farrell, pers. obs. over 15 years).

It is a species whose populations are usually very small and which are sporadic with great discontinuity in space and time (Good 1936). Often there may only be single plants present and rarely are there more than 10-12 plants, but the Kent population has had up to 50,000 plants (P. Carey, pers. comm. 1996). Good (1936) found that many colonies persisted for less than three years, with only a few persisting more than ten. Lousley (1950) reported one east Kent locality that had persisted for at least 26 years. Populations, especially those over 10 plants, have been persisting for longer recently (six for over 50 years) primarily due to protection of the sites and plants (P. Carey, pers. comm. 1996). Established populations also fluctuate in size from year to year (Crompton in Grubb 1990).

The increase between the 1900s and 1930s was attributed by Good (1936) to be related to climate warming, but is now thought to be more likely to be due to the increase in the amount of unmanaged grassland (J. S. Rodwell, J. Sheail, P. Carey, pers. comms. 1990, 1996). From the Great Depression of the 1880s onwards until probably at least the Second World War much of the downs was converted from arable to pasture with much abandoned to rabbits (Smith 1980), and the Victorian road and rail network also resulted in the creation of much of its neglected edge habitat. Although the climate has continued to ameliorate the plant declined again after the war.

Distribution and ecology

Typical habitats are grassland, ancient earthworks, scrub, open woodland, road, track and path sides, quarries, railway banks and calcareous sands; six of the current populations in these habitats are on golf courses. It has also occurred rarely under a hedge in a garden in Sussex, on a grass mound in a Mortello tower, on a retaining wall of a river and in a wood. Many of the sites are small, undisturbed patches rather than large open grasslands.

It is a calcicole occurring predominantly on chalk, with other records from limestone and sand dunes, and a few from recent or glacial deposits (Good 1936). Most soils are low in phosphate and nitrogen, and low in productivity. The ideal habitat is tall, open, calcareous grassland with a sward height of 5-30 cm and up to 50% bare soil. Seedlings appear to be poor competitors; they cannot tolerate a build up of leaf litter and may even be out-competed by moss (P. Carey, L. Farrell, pers. comms. 1996). It occurs in NVC types CG3, CG4, CG5, edges of W21 and in SD8a on sand dune communities.

Plants grow best in years with warm wet winters and late summer (August) droughts. Early summer droughts have a bad effect on the concurrent flowering performance, but do not affect established plants significantly in the longer term (Rutterford 1975, 1985; P. Carey, L. Farrell, pers. comms. 1996). Frost may also damage leaves but have no effect in the long term (Rutterford 1985).

It does not appear to tolerate grazing and one population of 60 plants at Lakenheath was eliminated over a period of about ten years by grazing by travellers' ponies. Fortunately most sites have few or no rabbits, which are likely to graze off young plants before they are even recognised. Muntjac deer or hares have also grazed some plants (Rutterford 1975; L. Farrell, G. Crompton & A. Cooke, pers. obs.). Slugs and snails also damage plants (Rutterford 1975; Sanford 1991).

Management

Management by mowing, burning, scrub clearance and/or raking of leaf litter should aim to create tall open grassland as above if possible. Management work has been carried out successfully in August when the plants are underground (P. Carey, pers. comm. 1996). Some sites on dunes as at the Kent site require no management. Protection from people may be a significant consideration, and heavy trampling may damage seedlings.

Mowing is likely to be detrimental unless carried out at the right time of year (August) and to an appropriate height (c. 10 cm is recommended). Plants survive at the Kent site on the edges of the fairways where they are mown twice a year. If sites are mown, cuttings should be removed to keep the soil open and prevent nutrient build-up, and hand raking may be needed to reduce leaf litter and moss at the bottom of the grassland (experiments are currently under way; P. Carey, pers. comm. 1996). The road verge sites are not mown except for sight lines.

Winter burning was carried out in the past in Kent and every five years in Cambridgeshire but is no longer used (D. Radley, B. Banks, pers. comms. 1996). The necessary open ground was maintained by a rapid surface burn in February or March which removed the litter. A fire on the Cambridgeshire site in April 1978 resulted in a few plants being burnt but they flowered as normal in July with no long-term damage (Donald 1979). Another fire in the winter of 1992/1993 resulted in a severe burn from which the plants also recovered.

Grazing is not recommended and none of the current sites are grazed. If rabbit grazing problems develop plants may need to be protected by rabbit-fencing. Rutterford (1975) controlled snail damage at Lakenheath by placing stones near the plants to be used as anvils by thrushes.

Scrub or bramble control (preferably with treatment of cut stumps) may be needed in some sites to keep them open. This should be carried out in August.

Several plants are reported to have survived being transplanted into cultivation (Sanford 1991) but the species is now statutorily protected and should not be removed from the wild.

Recommendations

A polycarpic, winter-green, long-lived perennial plant which reproduces by seed and is often sporadic in appearance and in small quantities. The ideal habitat is tall, open, calcareous grassland with a sward height of 5-30 cm and up to 50% bare soil, which should be maintained by management in August by mowing with raking of leaf litter and moss, burning or scrub clearance. Grazing is not recommended.

3.6 *Iberis amara* - Candytuft

Nationally Scarce species accepted as native in 22/46 10-km squares in Britain since 1970 (Stewart, Pearman & Preston 1994), and more widely recorded as a casual or garden escape.

Life cycle

Usually a monocarpic, winter annual or summer annual in the wild (exceptionally a polycarpic, short-lived perennial in cultivation). Populations vary in size, flower colour, leaf shape and fruit size and shape between populations (Rich 1991).

Seedlings germinate throughout the autumn, winter and spring depending on the weather. The rosettes are winter-green, and stems begin elongating from late spring. It flowers from May to November depending on time of germination (spring germinating plants flowering later). The outer flowers open first and are often sterile, serving to attract insects (Proctor & Yeo 1973). It is largely self-incompatible and requires cross-pollination (Bateman 1954), but it usually sets fruit freely. Fruits ripen about 6 weeks after pollination. It dies after flowering.

It has a good seed bank and can reappear repeatedly in arable fields and after clearance of scrub. Population sizes vary from year to year and depend on the amount of suitable open habitat.

Distribution and ecology

It is mainly confined to the chalk in southern England, and has been recorded in 52 tetrads centred on the Chilterns (for recent map see Showler 1994), but has also been widely recorded as an introduction elsewhere. Smith (1986) regarded the arable weed populations as static and not declining.

Its natural habitats are open patches and screes on hill slopes, clearings in woodland and scrub. It also occurs in the edges of cultivated fields, old quarries, tracks and recently-ploughed grassland. It tends to occur on south and south-west facing slopes (Showler 1994). It is very characteristic of shallow, calcareous soils (often one of the few plants to grow well on pure bare chalk) and only persists for long periods of time on chalk.

It requires open conditions to grow and is not found in closed vegetation. It has few typical associates, just random other calcicoles which can grow in similar places (Showler 1994). It has been recorded in NVC types CG2, CG3 and W21 (Rodwell 1992; T. Rich pers. obs.), and also occurs in arable weed headlands.

It is fairly tolerant of grazing and survives intensive rabbit-grazing much better than most plants. It is often characteristic of rabbit scrapings and latrines where there may be some nutrient enhancement. It is reputedly not eaten by stock, but does seem rare in pastures intensively grazed by stock alone, possibly as there is little bare ground.

It is eaten by white butterflies (*Pieris rapae*, *P. napi*) but has chemical deterrents (Huang, Renwick & Sachdevgupta 1993; Sachdevgupta, Radke & Renwick 1993).

Management

The primary requirement for the *Iberis* is for open chalky ground, and there is great flexibility in how this is achieved. Sites may be unmanaged, rabbit-grazed, or grazed by stock. Some chalk quarry sites may have bare, open chalk scree requiring no management - these are typically steep, dry, crumbly and south-facing (A. Showler, pers. comm. 1996). Other chalk screes may be prone to scrub invasion and need to be kept open manually.

Scrubby sites are typically unmanaged, but with time they close over and the plant disappears though seeds survive in the seed bank. Clearance of the scrub and woodland usually results in a rapid emergence from the seed bank (eg Juniperhill, Surrey). Many scrub and woodland sites were formerly open grassland.

Where it occurs as an arable weed, annual ploughing in the late autumn or spring is recommended. Duffey *et al* (1974) suggest that rotovation annually or every two-three years enables *Iberis* and other species of ruderal or disturbed habitats to be maintained.

It will survive and persist in sites very heavily-grazed by rabbits, though the plants may get nibbled and not appear at their best. As the rabbit populations change through natural cycles the *Iberis* may also fluctuate in numbers. In general, its rabbit-grazed sites require no additional intervention.

At Aston Rowant NNR it is most characteristic of the extensively grazed areas which have less than c. 0.4 sheep/ha during the summer in addition to the rabbit grazing. It does not occur in the intensively managed areas where there is a thick, even sward (G. Steven, pers. comm. 1996). At Pegsdon SSSI it occurs in rabbit-grazed swards without any additional stock grazing. It can stand quite long grass provided that there are bare open patches (G. Bellamy, pers. comm. 1996).

Recommendations

An annual with a long-persistent seed bank. It requires open, chalky ground which can be created manually in spring or autumn, or naturally by rabbits or light stock grazing. It is tolerant of a range of grazing practices provided open ground is available, though it does not appear to tolerate intensive stock grazing.

3.7 *Linum perenne* subsp. *anglicum* - Perennial flax

Subspecies *anglicum* is endemic to Britain. Nationally Scarce species recorded in 24/52 10-km squares in Britain since 1970 (Stewart, Pearman & Preston 1994).

Life cycle

Linum perenne varies morphologically within and between sites, and is part of a larger taxonomic complex across the northern hemisphere; our plants are afforded subspecific rank and are endemic.

A non-clonal, polycarpic, perennial herb which reproduces solely by seed. Plants may flower from their third or fourth year in the wild, and are long-lived perhaps for 10-20 years, so it can persist even when seedling recruitment is temporarily absent (Ockendon 1968).

It is heterostylous and most populations have approximately equal proportions of the two flower types (Ockendon 1968). The flowers require cross-pollination, and it sets little or no seed with self-pollination or pollinations from the same flower type (Proctor & Yeo 1973; Ockendon 1968; Nicholls 1986). Small populations may produce little or no seed if there is insufficient cross-pollination, but where cross-pollination does occur abundant seed is set each year.

Shoot elongation usually begins in late March and it flowers from the end of May through to August. Individual flowers only last one day and are usually pollinated by bumblebees, honeybees and hoverflies. Siriwardene (1995) recorded plants weekly at Thrislington NNR from mid May to July 1994, and found the inflorescences developed in late May and flower buds in early June. The main flowering period was from mid June to mid July. Ripe seed was present from late July onwards with capsules beginning to dehisce when observations ceased. Fruits take 5-7 weeks to ripen. Seed is shed immediately on ripening but there are no specialised dispersal mechanisms. Some seed can germinate immediately but most germination occurs in spring (Ockendon 1968). The plants die down for the winter.

Seeds have a variable dormancy period and germination is often sporadic, and the seed bank is probably important for maintaining the species (Ockendon 1968). Seedling germination in

North America has been found to be strongly related to habitat with a strong genetic basis, and it has a persistent seedbank (Meyer & Kitchen 1994); this may also apply in Britain.

Biotechnological approaches can be used to grow plants (eg Ling & Binding 1992) if there is a need to bulk-up small populations.

Distribution and ecology

Scattered mainly in the eastern half of Britain, with one locality in Scotland (for recent map see Foley 1994). The populations are often very small, and the only large ones occur at the Gog Magog Hills SSSI, Cambridgeshire and Thrislington NNR, Durham.

It occurs in chalk grassland, limestone grassland or on calcareous sands in Britain, but elsewhere it has a much wider ecological amplitude (Meyer & Kitchen 1994). It grows in open, exposed, well-drained sunny places on pastures, dry banks, disused railway embankments and roadsides, often on south- or west-facing slopes. It has been recorded in the NVC types CG2, CG3, CG4, CG6 and CG8 (Graham 1988; Rodwell 1992).

It is a slow-growing, poor competitor and is readily shaded out by tall herbs and scrub; plants in even partial shade may not flower. Its grassland habitats are described as moderately stable but occasionally disturbed, and seedling establishment is better in open rather than closed vegetation (Ockendon 1968).

It is highly palatable to rabbits and cattle, and it can be eliminated by intensive grazing (Ockendon 1968), though he also reports that mature plants are seldom damaged by animals. Large numbers of seeds are eaten by birds, and it may be dispersed by them (Ockendon 1968). Seedlings are very susceptible to grazing by slugs.

Management

At Thrislington NNR, a large population occurs in CG8 grassland c. 15-25 cm tall and with less than 1% bare ground. The current management is grazing with Beulah sheep between August and April (c. 5-6 sheep/ha) but not the summer, resulting in a summer sward height of about 10-15 cm. This management whilst suiting the rare plants has been insufficient to stop the spread of *Bromopsis erecta*, which may need more grazing in the winter and spring (M. Leakey, pers comm. 1996).

Thrislington NNR has also been mown on occasions when winter grazing has proved impractical to about 10 cm tall with a mini forage harvester in late summer to clear tall *Bromopsis* grassland; this results in a more closed sward without the variation created by grazing, but does not seem to have harmed the *Linum* populations (M. Leakey, pers comm. 1996).

Two sites in Yorkshire Wolds are managed by low-intensity grazing (D. Leach, pers. comm. 1996). Millington Wood and Pastures SSSI has a good population in a fairly open CG4 grassland c. 20-30 cm tall. It has been lightly cattle-grazed between May and October at a low intensity (rates not specified) for many years. Nine Spring Dale SSSI is a small but herb-rich site. Fewer than ten *Linum* plants occur in a CG2 sward less than 5 cm tall in an area mainly grazed by rabbits. The site has also been grazed on an *ad hoc* basis by sheep between August and October (sometimes into the winter) at a low intensity (rates not specified) and there is some scrub invasion.

The Gog Magog populations are subject to several frequencies and intensities of mowing. It is absent from the heavily mown fairways, but flourishes in the roughs which are mown to 10-15 cm height late in the year after seed has been set. If the mowing is carried out on a dry day many of the cuttings blow away and the others shrivel quickly so that the plants are not smothered (L. Upham, pers. comm. 1996). Mowing favours the decumbent growth form, and mown plants regenerate shoots freely from their base. In unmown areas it persists until it is shaded out by hawthorn scrub (Ockendon 1968).

It has been eliminated by ploughing but is able to reappear from the seed bank if the site is subsequently left undisturbed (Ockendon 1968).

Recommendations

A polycarpic perennial which reproduces by seed. It can be managed by mowing late in the year to 10-15 cm height, or by light cattle or sheep all year or preferably during the winter only leaving a reasonably long sward. It can persist for a number of years without management, or for short periods of moderate grazing all year.

3.8 *Ophrys fuciflora* - Late spider-orchid

Red Data Book species (Stone, in prep.). Listed on Schedule 8 of the Wildlife and Countryside Act 1981.

Life cycle

A polycarpic, probably moderately long-lived, mycorrhizal perennial. Duffield (1979) reported that 44% of the plants live for 1-3 years, 33% for 4-6 years, 18% for 7-9 years and 5% for 10 or more years (plants may possibly live at least thirty years; Stone, in prep.). Plants may be dormant for up to four to seven years (R.V. Russell, pers. comm. 1996). Recruitment is sporadic and colonies are maintained by vegetative spread from tubers as well as by sexual means. It can be quite variable in labellum markings within sites, and some populations appear to be different from others.

Leaves are produced in the autumn in September/October and are winter-green, persisting until about the end of flowering in July. Leaves of vegetative plants wither significantly earlier than flowering plants and may die back in June (Duffield 1979; P. Green, pers. comm. 1996). It survives high summer as underground tubers.

The proportion of plants flowering at a Kent site (site A) varies from year to year, and plants may flower for up to five years in succession (Duffield 1979; R.V. Russell, pers. comm. 1996). It has been recorded flowering from late May to late July but peak flowering is mid June to early July (dates of flowering vary between sites). Each spike produces from (2-)3 - 5(-9) flowers with a mean of 4.1 which are reputed to be pollinated by bees (*Eucera tuberculata* noted on the continent) but no pollinators were observed at Site A. Individuals studied at site A also rarely set seed and R.V. Russell obtained a long term average of 0.11% fruit set per flower. Duffield (1979) found that plants did not self-pollinate, though Summerhayes (1968) reported that self-pollination may occur. Fruit set is also very low (0-2%) in other Kent plants (P. Green, pers. comm. 1996). Hand-pollination is successful and usually carried out on a small proportion of plants each year, and pollination in one year does not affect flowering the following year (P. Green, pers. comm. 1996). Some inflorescences fail for no apparent reason (Duffield 1979). Seed is dispersed late July - early August (P. Green, pers. comm. 1996).