

British Native Orchids

An Introduction to their Biology and Ecology

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Introduction

The unique morphology, complex life-histories and rarity of orchids (Orchidaceae) have made them, along with butterflies, one of the most intensively studied groups of British organisms. Traditionally, the study of orchids has focused on population censusing, the measurement of morphological diversity, life history elucidation and the determination of pollination mechanisms (Godfrey, 1993; Wells, 1967). As a result of this work there are a vast number of texts which refer to these aspects of orchid biology, but which are phrased primarily in qualitative and anecdotal terms and so are of use primarily to orchid enthusiasts and amateur naturalists (for example Summerhayes, 1951; Lang, 1980; Lang, 2002).



In contrast to the historical literature, and when the iconic status of the Orchidaceae family is considered, the number of empirical studies reported in the modern scientific literature pertaining to orchids is actually quite limited. This observation reflects the general lack of research in plant ecology prior to the emergence of the conservation movement that was highlighted in 1983 by Perring and Farrell who reported that, of the then 317 rare and endangered plants in the British Red Data Book, only 6% had been the subject of detailed autecological study (Perring and Farrell, 1983). It was only in the 1960s-80s that the increasing pressure to conserve rare species and the emergence of the conservation biology field, led to a gradual change in orchid research to a more rigorous and applicable scientific approach.

Orchid Flower Morphology, Taxonomy and Genetics

It is estimated that, of the approximately 250 orchid species that occur in Europe, there are currently 52 that occur naturally in the UK (Bateman, 2004). The *Orchidaceae* family of flowering plants belong to the class of plants termed monocotyledons and those found in Britain are all terrestrial herbaceous perennials with fleshy tuberous root stock (Lang, 1980). In addition, they are all dependent on mycorrhizal fungus at some stage in their life-cycle. Members of the Orchidaceae family all have broadly the same overall floristic structure (as shown in Figure 1.1), but there is huge diversity in the colour and morphology of the flowers borne by different species.

This diversity results from their highly specific adaptations to their insect pollinators and makes them one of the most advanced families of flowering plants (Proctor *et al.*, 1996).

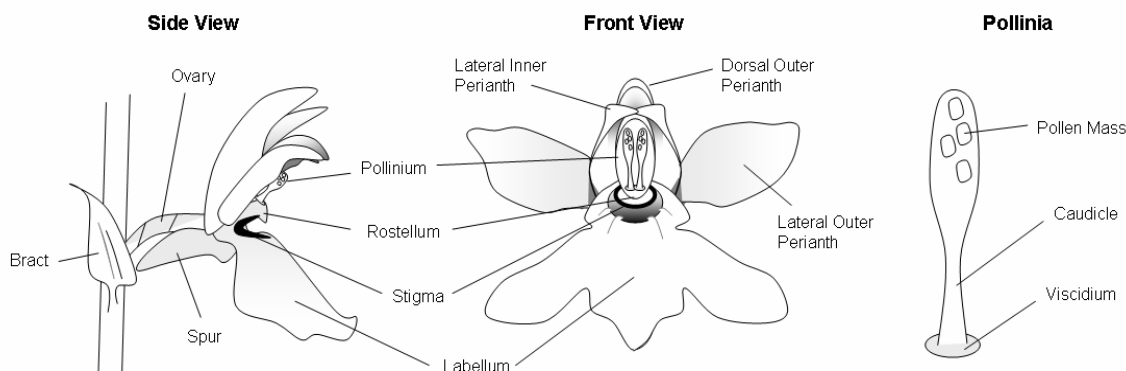


Figure 1.1. Generalised structure of Orchid Flowers. Diagrams adapted from Lang, 1980.

Historically, orchids have been classified according to qualitative descriptions of their morphological differences. This has led to the development of an extremely complicated system of nomenclature, with plants often being moved from genus to genus depending on the details and interpretation of their form.

In the last decade modern phylogenetic molecular techniques have allowed both the nuclear and chloroplastic DNA of our orchid flora to be examined in great detail. These techniques have helped to resolve some of the long-standing phylogenetic uncertainties in orchid taxonomy and have helped the classification of the many spontaneous hybrids that can form between different orchid species (Bateman *et al.*, 2001; Bateman, 2004). In addition, these advances have also facilitated the study of orchid population genetics, both locally and across Britain and Europe. By examining the genetic structure of orchid populations an understanding can be gained of seed and pollen dispersal, the demographic origins of populations and detrimental effects resulting from inbreeding can be quantified (Machon *et al.*, 2003).

To this end, a recent genetic study of the endangered autumn lady's tresses orchid (*Spiranthes spiralis*) conducted in France revealed that the decline of the species was the result of a lack of gene flow through pollen dispersal (Machon *et al.*, 2003). The authors conclude that the re-introduction of the species to suitable habitats in the region would result in the re-establishment of a long-lived metapopulation connected by pollen flow.

Orchid Pollination

The highly specialised mechanisms by which orchids are pollinated have been the subject of many studies, with perhaps the most well known being the paper *The Various Contrivances by which Orchids are Pollinated by Insects* by Charles Darwin (1862). Most orchids are dependant on insects to effect cross-pollination as their pollen is borne in sticky masses and so cannot be dispersed by the wind. Self pollination is also prevented in most species by the protruding *rostellum* (see Figure 1.1), which separates the pollinia from the stigma. Orchid pollination mechanisms, which are highly dependant on specialised adaptation to their insect pollinators, are regulated by the mode of pollinator attraction, the form of the pollen and the geographic location of the plant.

The generalised mechanism of orchid pollination is shown in Figure 1.2 (Proctor *et al.*, 1996). An insect is attracted to an orchid by the colour and/or scent of the flower, which they interpret to represent an offer of nutritional reward or, in the case of species such as those in the *Ophrys*

group, a mate. The insect lands on the labellum, which forms a specialised landing platform, and when it attempts to either feed on the flowers nectar or mate with the flower (pseudo-copulation), the cement of the viscidium attaches the pollinia to its head (Figure 1.2i). After the insect departs from the flower a rapid reaction in the caudicle causes the pollinia to fall forward and adopt a horizontal rather than vertical position (Figure 1.2ii). Thus, when the insect visits a second flower the forward pointing pollinia is aligned below the rostellum and comes in to contact with the stigma (Figure 1.2iii). Pollination of the same plant is avoided as successful it can only occur in plants at a later stage of flowering than those presenting their pollinia.

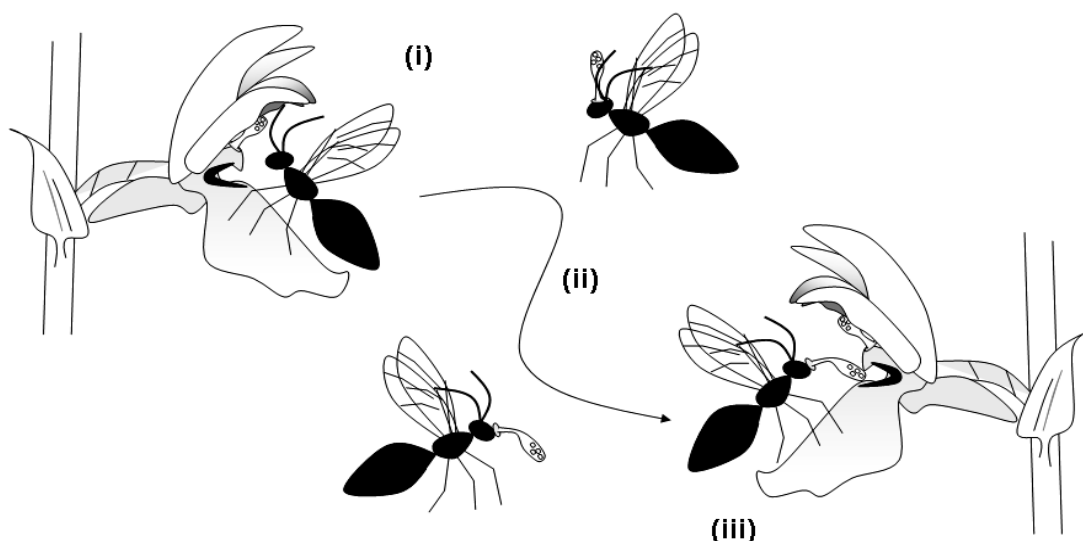


Figure 1.2. Generalised Mechanism of Insect-Medated Orchid Pollination. For full details of the mechanism refer to text.

Recent studies of orchid pollination have focused on the mechanisms that orchids, and in particular the *Ophrys* genus, use to attract their insect pollinators (Schiesti, 2005; Raguso, 2004). These have revealed that many orchid species rely on deception through mimicry of insects and through the production of chemo-attractant fragrances, such as monoterpenes, sesquiterpenes and aliphatic hydrocarbons, which induce feeding or mating behaviour in their target insects (Borg-Karlson, 1990).

Orchid Reproduction and Lifecycle

Orchids can reproduce through either vegetative multiplication or sexual reproduction, but the degree to which different species are dependant on these processes varies greatly. In Britain the former process occurs primarily in woodland species, such as the helleborines, where conditions are disadvantageous to the production of seed (Lang, 1980). However, while all orchid species can multiply in this way, the majority are dependant on sexual reproduction to proliferate.

Orchid seed germination, as with other plants, requires the correct combination of moisture, oxygen and light and warmth, but in almost every case there is also a requirement for the seed to also become infected with a mycorrhizal fungus (Lang, 1980; Rasmussen, 1995). As the orchid seed carries no food reserves within its structure, this fungus provides the seeds with the nutrients they require to germinate and grow. The germinated seed, infected with the mycorrhizal fungus, forms an undifferentiated ball of cells termed a protocorm, or mycorrhizome, which gradually matures to form a fibrous tuber from which the leaf and flower bearing stems subsequently grow.

The maturation of the mycorrhizome is a slow process and varies greatly between species. In most species it takes around four years before the first leaf is produced, but in others, such as the Burnt Orchid (*Orchis ustulata*) it may take as long as fifteen years (Lang, 1980). The mycorrhizal infection of the developing orchid is at first parasitic, but as the plant matures its dependence on the fungus is reduced. The degree to which the mycorrhizal infection continues once the plant has reached maturity also varies greatly depending on the species in question. Some species, such as the Bee orchid (*Ophrys apifera*), eventually expel the fungus, while others retain the infection. In the most extreme case, the saprophytic species such as the Birds nest orchid (*Neottia nidus-avis*), are entirely dependant on the nutrients they derive from the fungus throughout their lives.



Once the orchid plant reaches maturity the tuber produces a rosette of often long and narrow leaves, which are fleshy, un-stalked, un-divided and have parallel venation. The leaves of the saprophytic species are reduced to membranous sheaths at the base of the flower stem. These leaves then continue to feed the developing tuber for several growing seasons before producing a flower one or more times. Plants which flower once, such as the bee orchid and the early purple orchid are termed monocarpic.

In recent years there has been a huge effort to elucidate the reproductive mechanisms of orchids, which has been driven by a need to cultivate orchids, *ex-situ*, to both aid re-introduction programmes and to supply the horticultural market. The best example of this in Britain is the highly successful programme of *ex situ* cultivation and re-introduction undertaken for the Lady's Slipper Orchid, *Cypripedium calceolus* (Ramsay, 1998), which had been reduced to just a single plant before the programme was initiated. Programmes, such as the one implemented for the lady's slipper orchid, have adopted a systematic approach to elucidate the species reproductive mechanisms and life-history before using this information to inform the cultivation of large numbers of plants for re-introduction (Ramsay, 1998; Stewart, 1993).

In summary, the initial stage in the process is the hand pollination of wild plants, the harvest of the resulting seed pods and the preservation of the seed by drying and refrigeration. Alongside this the specific mycorrhizal fungus for the species under study must be isolated and expanded in culture. The seed and fungus are then combined in a tissue culture germination system carefully tailored to the species in question. Numerous studies have attempted to optimise the tissue culture of orchid seedlings, for example by the addition of growth factors and nutrients, to ensure the development of robust plants for re-introduction (e.g. Debeljak, 2002). Finally the cultivated plants are re-introduced into habitat regarded as being suitable and the developing populations monitored both in terms of their population dynamics and their genetics (Stewart, 1993, McKendrick, 1994).

In addition to facilitating re-introduction programmes, the *ex situ* cultivation of orchid plants has also allowed further research into the underground phase of the orchid life-cycle, something that can no longer be examined in the wild because of their legal protection. In a recent study, with the specific aim of informing conservation, *in vitro* techniques were used to examine the optimal substrate requirements for orchid seed germination and the dependence of germination and development on fungal availability (Rasmussen, 1995).

Orchid Population Dynamics

Another traditional activity of naturalists and orchid enthusiasts has been the censusing of orchid populations. This activity, conducted over many years, has resulted in the accumulation of long and precise historical records primarily of the rarest and most iconic British species. Recently, this huge resource has been used to analyse the population dynamics of these species and the precision of the records for some sites has allowed the life histories of individual plants to be examined.

The major studies of this type undertaken are shown in Table 1, but perhaps the best example is the ten year study of the rare early spider orchid (*Ophrys sphegodes*) reported in two parts by Hutchings (1987a and 1987b). Over a ten year period the behaviour of individual plants in the population were recorded and the demography and temporal variations in behaviour analysed. As a result, the author was able to determine that winter grazing of the site and the protection of plants from grazing during the flowering season had helped the population to recover. In addition, the data revealed that conservation of this species was dependent upon the creation of conditions conducive to flowering, seed setting and seedling establishment.

Table 1 – Orchid Population Studies

Species	Duration (years)	Analyses Performed	Reference
Early spider Orchid <i>Ophrys sphegodes</i>	10	Plant morphology, flowering dynamics and life history.	Hutchings, 1987a; Hutchings, 1987b
Autumn Lady's Tresses <i>Spiranthes spiralis</i>	3	Flower morphology, variation in population size, climatic effects, grazing impacts.	Wells, 1967
Green-Winged Orchid <i>Orchis morio</i>	18	Flowering dynamics, climatic effects.	Wells <i>et al.</i> , 1998
Musk Orchid <i>Herminium monorchis</i>	18	Flowering dynamics, climatic effects.	Wells <i>et al.</i> , 1998
Green-Winged Orchid <i>Orchis morio</i>	25	Variation in flowering abundance, risk of extinction.	Gillman and Dodd, 1998
Military Orchid <i>Orchis militaris</i>	18	Population flux, age structure, effects of management.	Hutchings, 1998
Lizard Orchid <i>Himantoglossum hircinum</i>	16	Modelling dispersal, population dynamics.	Carey, 1998

Orchid Habitat and Landscape Ecology

Our understanding of terrestrial orchid habitat requirements has largely come from qualitative observation of where they occur and so definitions are often broad and vague. This is illustrated in the reviews of McKendrick *et al.* (1994), who present perhaps the most detailed habitat definitions we have for several native British orchids, and Farrell (1985) who presents a comprehensive review of military orchid (*Orchis militaris*) biology.

The habitat definitions presented in these reviews, which were compiled a group of some of our most knowledgeable orchid experts, are still largely qualitative and vague. For example, Farrell describes the degree of shade required by military orchid as varying from, 'slight...to considerable' (Farrell, 1985).



Close-up of a Military Orchid *Orchis Militaris*

In recent years attempts have been made to characterise orchid habitat, and the environmental determinants that regulate orchid abundance, with a more empirical approach. For example, Silvertown *et al.* (1994) have reported the devastating effects on orchid populations of environmental contamination with agricultural chemicals, and Wheeler *et al.* (1998) have presented an elegant study of how vegetation, environmental characteristics and management were related to the population dynamics of the fen orchid (*Liparis loeselii*).

Areas of Deficiency in Orchid Research

Despite the expansion of empirical studies of terrestrial orchids there remain a number of deficiencies in the approach to orchid research in Britain.

The first is that very few studies have addressed the key question of how orchids fit into the ecosystems in which they occur and so do not provide us with the kind of insight into their ecology that will allow us to manage those ecosystems such that orchids and the other species on which they depend are benefited. Furthermore, there has been little quantitative research into the habitat requirements of orchids to identify why they occur where they do and to aid identification of habitats to which they could be introduced. Therefore, although our understanding of terrestrial orchid reproductive biology is now comprehensive for many species, the applicability of this knowledge is still limited by our largely qualitative and anecdotal understanding of optimum habitat for the establishment of the different orchid species and the optimal performance of the underground phase of their life-cycles. These limitations mean that orchid habitat management, conservation and re-introduction programmes are laborious and often inefficient (Ramsay, 1998).

Furthermore, as with conservation of many taxa, in orchid research there remains a huge emphasis on the study and conservation of the most endangered species. This reactive approach, which often focuses only on the rarest or most iconic species, overlooks the fact that several other species are also in decline and are likely to become the endangered species of the future without proactive intervention now.

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