

## Host range and specificity of *Orobanche minor* Sm. on Crymlyn Burrows

C. R. HIPKIN

*School of Biological Sciences, University of Wales, Swansea, SA2 8PP*

### ABSTRACT

A survey of hosts reported for the broomrape *Orobanche minor* Sm. (Orobanchaceae) in Britain and Ireland, indicates a very wide range for this species with most hosts recorded from the Leguminosae and the Compositae. Results from an investigation of the host range of a large coastal population of *O. minor* Sm. var. *minor* (sensu Rumsey & Jury) on Crymlyn Burrows, West Glamorgan, confirm 15 host species by observation of direct root contact between host and parasite. Some individual broomrapes were noted to parasitise more than one (up to three) host, each a different species. Seeds of *O. minor* var. *minor* taken from plants parasitising *Eryngium maritimum* germinated to produce plants that were able to parasitise *Hypochoeris radicata*, *Trifolium hybridum* and *T. pratense*.

### INTRODUCTION

Of the 45 species of *Orobanche* L. recognised in Europe by Webb & Chater (1972), seven were assigned to the *Orobanche minor* group and two of these, *O. minor* Sm. and *O. loricata* Reichenb., are in the British flora (Clapham *et al.* 1987). Both these species have predominantly south-eastern distributions in Britain, with *O. minor* extending discontinuously west and north-west, more or less along the coast. Taxonomically, the *O. minor* group is rather problematic, a situation which is exacerbated by the great intraspecific variation exhibited by *O. minor* itself. In a recent account of *Orobanche* L. in Britain and Ireland, Rumsey & Jury (1991) divide *O. minor* into four varieties, (var. *minor*, *compositarum*, *flava* and *maritima*), and describe a number of features which aid their identification including a guide to their host ranges.

Correct identification of the host can be helpful in the identification of several species of *Orobanche*. Unfortunately, however, although host specificity within the *O. minor* group may be of some significance taxonomically, it is confusing for at least two reasons. Firstly, some taxa appear to have rather wide, overlapping host ranges. Secondly, it is usually difficult to identify the host unequivocally in the field (Chater 1986) and it is likely that several hosts reported in the literature have been recorded in error. Nevertheless, some taxa may parasitise a well defined, narrow spectrum of hosts, e.g. *O. minor* var. *maritima* (Rumsey & Jury 1991), and the concept of physiological races with very specific host requirements (Musselman & Parker 1982) has often been suggested. Comments in county Floras indicate that coastal populations have frequently caused difficulties and this appears to be, in part, a consequence of an incomplete understanding of the host ranges of *O. minor* and *O. maritima* Pugsley (Pugsley 1940) in particular. Recent exchanges in the literature (e.g. Hamblen 1991; Rumsey 1991) underline the controversial nature of this problem.

In this account, the host range of a large population of *O. minor* growing in mobile and partially fixed sand dune communities on Crymlyn Burrows in West Glamorgan (v.c. 41) is described. These studies exemplify the problems associated with coastal populations of *O. minor* and confirm a number of hosts, unequivocally.

### MATERIALS AND METHODS

A large sand dune population of *Orobanche minor* was studied on Crymlyn Burrows (GR SS/710.930). In recent years the size of this broomrape population has usually numbered more than

TABLE 1. HOSTS FOR *OROBANCHE MINOR* RECORDED IN BRITAIN AND IRELAND

Host	Reference	Host	Reference
CARYOPHYLLACEAE		<i>Daucus carota</i>	
<i>Honkenya peploides</i>	Rumsey & Jury (1991)	(including subsp. <i>gummifer</i> )	Ravenshaw (1860) <sup>#</sup>
GERANIACEAE			Grose (1957)
<i>Geranium columbinum</i>	White (1912)		White (1912) <sup>#</sup>
<i>G. rotundifolium</i>	White (1912)		McClintock (1975) <sup>§</sup>
<i>Erodium cicutarium</i>	Petch & Swann (1968)		Davey (1909) <sup>#</sup>
<i>Pelargonium</i> spp.	Lousley (1976)		Margetts & David (1981) <sup>§</sup>
	Murphy (1972)		Holland <i>et al.</i> (1986)
	Jones (1985)		Jones (1985)
LEGUMINOSAE		Garden spp.	
<i>Clianthus puniceus</i>	Margetts & David (1981)	(e.g. carrot, caraway)	Lousley (1976)
<i>Vicia faba</i>	Jones (1985)	BUDDLEJACEAE	
<i>Ononis repens</i>	Savidge <i>et al.</i> (1963)	<i>Buddleja davidii</i>	Jones (1985)
	White (1912)	POLEMONIACEAE	
	Jones (1985)	<i>Polemonium caeruleum</i>	Patrick & Hollick (1975)
	Rumsey & Jury (1991)	CONVOLVULACEAE	
<i>Medicago arabica</i>	McClintock (1975)	<i>Calystegia soldanella</i>	Rumsey & Jury (1991)
<i>M. lupulina</i>	Bowen (1968)	SOLANACEAE	
	Jones (1985)	<i>Nicotiana</i> cultivar	Jones (1985)
<i>Trifolium arvense</i>	Trimen & Thiselton-Dyer (1869)	SCROPHULARIACEAE	
		<i>Parahebe catarrhactae</i>	Margetts & David (1981)
<i>T. campestre</i>	McClintock (1975)	LABIATAE	
	Jones (1985)	<i>Salvia verbenaca</i>	White (1912)
<i>T. hybridum</i>	Grose (1957)	<i>Glechoma hederacea</i>	Murray (1896) <sup>##</sup>
	Jones (1985)		Grose (1957)
<i>T. medium</i>	Savidge <i>et al.</i> (1963)		White (1912)
<i>T. pratense</i>	Ravenshaw (1860)		Jones (1985)
	Salmon (1863)	PLANTAGINACEAE	
	Archer Briggs (1880)	<i>Plantago coronopus</i>	Ravenshaw (1860)
	Grose (1957)		McClintock (1975)
	Savidge <i>et al.</i> (1963)		Davey (1909) <sup>#</sup>
	Bowen (1968)		Jones (1985)
	Messenger (1971)	<i>P. major</i>	Grose (1957)
	McClintock (1975)	<i>P. maritima</i>	McClintock (1975) <sup>§</sup>
<i>T. repens</i>	Kent (1975)	CAMPANULACEAE	
	White (1912)	<i>Campanula</i>	
	Murray (1896)	<i>portenschlagiana</i>	Murphy (1972)
<i>Lotus corniculatus</i>	Grose (1957)	<i>C. poscharskyana</i>	Jones (1985)
<i>Onobrychis viciifolia</i>	Grose (1957)	DIPSACACEAE	
ARALIACEAE		<i>Dipsacus fullonum</i>	Jones (1985)
<i>Hedera hibernica</i>	Jones (1985)	COMPOSITAE	
UMBELLIFERAE		<i>Brachyglottis</i>	
<i>Eryngium maritimum</i>	Wolley-Dod (1970) <sup>#</sup>	cv. 'Sunshine'	Bowen (1968)
	White (1912) <sup>#</sup>		Swann (1975) <sup>*</sup>
	McClintock (1975) <sup>##</sup>		Lousley (1976)
	Bevis <i>et al.</i> (1978) <sup>§§</sup>		Margetts & David (1981)
	Davey (1909) <sup>#</sup>		Jones (1985)
	Margetts & David (1981) <sup>§§</sup>		Rumsey & Jury (1991) <sup>*</sup>
	Allen (1984)	<i>Olearia macrodonta</i>	Jones (1985)
	Jones (1985)	<i>Achillea millefolium</i>	Grose (1957)
	Rumsey & Jury (1991)	<i>Tripleurospermum</i>	
<i>Anthriscus sylvestris</i>	Grose (1957)	<i>inodorum</i>	Rumsey & Jury (1991) <sup>*</sup>
<i>Pastinaca sativa</i>	Grose (1957)	<i>Matricaria</i> spp.	Kent (1975)
	Holland <i>et al.</i> (1986)	<i>Carduus nutans</i>	Rumsey & Jury (1991) <sup>*</sup>
	Jones (1985)	<i>Cirsium arvense</i>	Grose (1957)
		<i>C. vulgare</i>	Jones (1985)

TABLE 1. *cont.*

Host	Reference	Host	Reference
COMPOSITAE <i>cont'd</i>			
<i>Hypochoeris radicata</i>	Bowen (1968)* Petch & Swann (1968)* McClintock (1975) Jones (1985) Rumsey & Jury (1991)*		Petch & Swann (1968)* Jones (1985) Holland <i>et al.</i> (1986) Rumsey & Jury (1991)* Dony (1953)
<i>Leontodon autumnalis</i>	McClintock (1975)	<i>C. vesicaria</i>	
<i>Picris echioides</i>	Dony (1953)	GRAMINEAE	
<i>Crepis capillaris</i>	Linton (1919) Grose (1957) Grose (1957)*	<i>Elymus farctus</i> <i>Ammophila arenaria</i>	Rumsey & Jury (1991) Murray (1896) Murphy (1972)

\* = recorded as var. *compositarum*; # = recorded as *O. amethystea*; ## = recorded as *O. amethystea* but queried by author(s) as *O. minor*; § = recorded as *O. maritima*; §§ = recorded as *O. maritima* but queried by author(s) as *O. minor*.

5,000 individuals. This presented opportunities to sample a relatively small number of specimens with minimal disturbance to a thriving population. Plants rooted in sand were excavated carefully (usually with ease and minimal disturbance to the rooting systems of host and parasite) and examined for host-parasite root connections. Hosts were traced via their root systems and identified. Often, it was possible to replace plants with little disturbance after substantiating host root contact.

Plants were also cultivated in containers using as hosts *Trifolium hybridum* (cv. 'Alyske', Elsom's Seeds Ltd, Spalding, England), *T. pratense* and *Hypochoeris radicata* (both grown from local stock). Seeds of *O. minor* were collected from individuals parasitising *Eryngium maritimum* on Crymlyn Burrows. Host plants were established in pots before inoculation with broomrape seeds which were applied in suspension directly on to the host roots.

#### REPORTED HOST RANGE OF *OROBANCHE MINOR* SM.

A cursory glance at the literature would reveal that *O. minor* has been recorded most frequently as a parasite of *Trifolium* spp., often as a weed in clover fields. It became well known, however, that other (often exotic) species were also parasitised by this broomrape and enthusiastic observations have led to a number of reports of largely unsubstantiated hosts. Table 1 lists a representative selection of hosts that have been reported over the last 130 years, and includes reports referring to all varieties of *O. minor* as well as *O. amethystea* Thuill. which has been recorded in error for *O. minor* in Britain (Clapham *et al.* 1987; Rumsey & Jury 1991). It is not a definitive list and, undoubtedly, many species that have been recorded as hosts for *O. minor* are missing from it.

#### HISTORY AND IDENTIFICATION OF *OROBANCHE MINOR* SM. ON CRYMLYN BURROWS

The accurate records of Rev. J. Lightfoot describing his visit in 1773 to "Breton Sands", in the vicinity of Crymlyn Burrows (Carter 1954), do not mention any broomrapes. One of the first records of *O. minor* in the region was made by A. M. Barnard at Swansea in 1853 and nearly a hundred years later, in 1943, J. A. Webb, a very active, local botanist, recorded it at nearby Aberavon West Burrows (Hyde & Wade 1957) where it still grows today. During this period, this species would have been regarded as a local rarity and its presence would have attracted the attention of active recorders. It is possible that *O. minor* was present in small numbers on Crymlyn Burrows at that time but, if so, it remained unrecorded until 1970 when a small population of about 100 individuals was noted. By 1979, the population had increased markedly to approximately 6000 plants (author's own records). It appears that *O. minor* is either a relatively recent arrival at Crymlyn Burrows (within the last 50 years) or was present in small numbers until the 1970s but had been overlooked by a number of recorders. Similar, but smaller, populations of *O. minor* now occur elsewhere in West

Glamorgan, e.g. on the sand dune systems of Swansea Bay, South Gower and Margam Burrows and in Mid Glamorgan, on Kenfig Burrows.

Several casual recorders have visited Crymlyn Burrows in the last ten years and named the *Orobanche* population there tentatively as *O. maritima* Pugsley. However, the morphological features of this population conform strongly with *O. minor* var. *minor* as described by Rumsey & Jury (1991).

Thus:

1. Plants varied greatly in size, up to 60 cm in height, with the largest individuals usually found in association with *Eryngium maritimum* and then often in large clumps. Plants associated with other hosts were rarely as vigorous.

2. The bases of stems were not obviously bulbous.

3. The sizes and densities of inflorescences were variable. For example, inflorescence lengths varied from 5 cm to 50 cm with overall flower densities varying between 1.4 and 3.2 flowers/cm. Some individuals had inflorescences which were lax below and dense above and some were relatively lax throughout. Other plants exhibited inflorescences which were relatively dense throughout their length.

4. Bracts were 14–18 mm, similar in length to the flowers but often slightly shorter in upper flowers.

5. Calyces were 11–13 mm and unequally bifid.

6. Corollas were 15–18 mm, suffused purple, glandular pubescent, the lower lip with subequal crisped lobes.

7. Flower diameters were always greater than 5 mm.

8. Filaments were hairy below and inserted 2 mm above the corolla base.

9. Stigma lobes were purple and united at base.

A small number of pigment-less individuals were noted in the Crymlyn Burrows populations during the study; similar albino forms have been noted by Rumsey & Jury (1991).

It should also be noted that *Daucus carota* subsp. *gummifer* is not a host for *O. minor* on Crymlyn Burrows.

#### HOST RANGE OF *OROBANCHE MINOR* SM. ON CRYMLYN BURROWS

*O. minor* var. *minor* has been observed to parasitise a number of hosts on Crymlyn Burrows. So far, 15 species of host have been identified and these are indicated in Table 2. Each host was substantiated by direct observation of contact between the host root and the distinct, swollen haustorial region of the parasite. Where indicated, root specimens were taken, sectioned and examined under the light microscope. When this was done, microscopic examination confirmed physical interaction between host and parasite vascular systems.

The most commonly recorded host was *Eryngium maritimum*. On Crymlyn Burrows, this species is very common in open mobile sand communities behind the foredunes, where there are often high densities of broomrape spikes (up to 25 spikes/m<sup>2</sup>). Other plants recorded with broomrapes in this type of community are listed in Table 2(a). Many broomrape spikes were noted in the vicinity of Marram Grass (*Ammophila arenaria*) in this community. Indeed, several plants were noted growing in the middle of marram tufts. All such plants were investigated; none made any apparent contact with marram roots, but did make contact with the extensive root systems of *E. maritimum*. Parasitism of hosts other than *E. maritimum* appears to be relatively rare in this community but a single broomrape individual was observed to parasitise *Pastinaca sativa*.

More species were parasitised by broomrapes in partially fixed sand communities where *E. maritimum* is rare but legumes and composites are conspicuous. Typical species in these communities are listed in Table 2(b). The most commonly recorded hosts here were *Ononis repens*, *Lotus corniculatus* and *Hypochoeris radicata*. In addition, the composites *Leontodon taraxacoides*, *Crepis capillaris*, *C. vesicaria*, *Senecio jacobaea*, *Erigeron acer* and *Tragopogon pratensis* were also recorded as hosts. There was only one substantiated record of root contact with the legume *Anthyllis vulneraria*, although this species dominates large areas of partially fixed-dune on Crymlyn Burrows. Other minor hosts recorded were the crucifers *Arabis hirsuta* and *Coincya monensis* subsp. *recurvata*, and the plantain, *Plantago lanceolata*.

TABLE 2. HOSTS FOR *OROBANCHE MINOR* VAR. *MINOR* IN MOBILE AND PARTIALLY FIXED SAND COMMUNITIES ON CRYMMLYN BURROWS  
+ root contact with *O. minor* observed.

(a) Mobile sand communities		(b) Partially fixed sand communities	
CRUCIFERAE		CRUCIFERAE	
<i>Coincya monensis</i> subsp. <i>recurvata</i>	-	<i>Arabis hirsuta</i>	+
<i>Matthiola sinuata</i>	-	<i>Coincya monensis</i> subsp. <i>recurvata</i>	+
CRASSULACEAE		VIOLACEAE	
<i>Sedum acre</i>	-	<i>Viola canina</i>	-
ONAGRACEAE		<i>V. tricolor</i> subsp. <i>curtisii</i>	-
<i>Oenothera cambrica</i>	-	CARYOPHYLLACEAE	
UMBELLIFERAE		<i>Cerastium diffusum</i>	-
<i>Eryngium maritimum</i> *	+	<i>C. fontanum</i>	-
<i>Pastinaca sativa</i>	+	<i>Arenaria serpyllifolia</i>	-
EUPHORBIACEAE		GERANIACEAE	
<i>Euphorbia paralias</i>	-	<i>Geranium molle</i>	-
CONVOLVULACEAE		LEGUMINOSAE	
<i>Calystegia soldanella</i>	-	<i>Ononis repens</i> *	+
COMPOSITAE		<i>Trifolium arvense</i>	-
<i>Senecio jacobaea</i>	-	<i>Lotus corniculatus</i>	+
<i>S. squalidus</i>	-	<i>Anthyllis vulneraria</i>	+
<i>Hypochoeris radicata</i>	-	UMBELLIFERAE	
<i>Leontodon taraxacoides</i>	-	<i>Pastinaca sativa</i>	-
<i>Crepis capillaris</i>	-	GENTIANACEAE	
CYPERACEAE		<i>Centaurium erythraea</i>	-
<i>Carex arenaria</i>	-	PLANTAGINACEAE	
GRAMINEAE		<i>Plantago lanceolata</i>	+
<i>Vulpia fasciculata</i>	-	COMPOSITAE	
<i>Ammophila arenaria</i>	-	<i>Senecio jacobaea</i>	+
<i>Phleum arenarium</i>	-	<i>S. squalidus</i>	-
		<i>S. vulgaris</i>	-
		<i>Erigeron acer</i>	+
		<i>Carlina vulgaris</i>	-
		<i>Hypochoeris radicata</i>	+
		<i>Leontodon taraxacoides</i>	+
		<i>Tragopogon pratensis</i>	+
		<i>Crepis capillaris</i>	+
		<i>C. vesicaria</i>	+
		<i>Taraxacum officinale</i> agg.	-
		GRAMINEAE	
		<i>Festuca rubra</i>	-
		<i>Aira praecox</i>	-
		<i>Ammophila arenaria</i>	-
		<i>Phleum arenarium</i>	-

\* Haustoria-root connections of some plants were sectioned and examined under the light microscope.

In transitional areas between mobile and partially fixed sand communities, *Eryngium maritimum* often grows in close proximity to *Ononis repens*, *Lotus corniculatus* and *Hypochoeris radicata*. In those places, broomrapes were observed making root contact with each of these species.

On four separate occasions, single specimens of *O. minor* were observed making root contact with two separate hosts. The following dual-host combinations were noted: (a) *Hypochoeris radicata* and *Ononis repens* (in partially fixed sand); (b) *Eryngium maritimum* and *Lotus corniculatus* (transitional areas); (c) *Crepis capillaris* and *Ononis repens* (in partially fixed sand); (d) *Crepis capillaris* and *Plantago lanceolata* (partially fixed sand).

On one occasion a triple-host combination of *Arabis hirsuta*, *Hypochoeris radicata* and *Lotus corniculatus* was noted in a partially fixed sand community.

Minor hosts such as *Arabis hirsuta* and *Erigeron acer* often appeared greatly weakened by the

parasite and supported smaller broomrape specimens with lax inflorescences. In contrast, common hosts such as *Eryngium maritimum*, *Ononis repens* and *Lotus corniculatus* often showed normal vigour and the roots of leguminous hosts that were investigated always bore abundant nodules. *E. maritimum* often supported large broomrape specimens with dense inflorescences in clusters of 20 or more individual spikes.

Seeds of *O. minor* var. *minor* taken from specimens parasitising *Eryngium maritimum* in mobile sand communities were sown into separate pots containing *Hypochoeris radicata* (grown from seed taken from an individual in a typical partially fixed-dune community), *Trifolium hybridum* (cv. 'Alyske') or *T. pratense* (transplanted from a local meadow) as potential hosts. All three species were able to act as hosts and supported specimens of *O. minor* that flowered and set seed.

*O. minor* on Kenfig Burrows (GR SS/796.812) appeared to parasitise *Eryngium maritimum* and *Ononis repens*, mostly, whereas a small and short-lived population which occurred on a roadside verge in Swansea (GR SS/652.912) appeared to be parasitising *Trifolium pratense* and *T. repens*. However, none of these plants was excavated and investigated for root contact.

#### DISCUSSION

Positive verification of host species for *O. minor* in the field is difficult, particularly when specimens are growing in compacted soil, due to the fragile connections between parasite and host roots. Moreover, in some areas, *O. minor* is a rare or local species and potentially destructive sampling should not be attempted. Under these circumstances the observer has to rely on a judgement based on the presence and proximity of suitable hosts. Most records of host species, such as those in the survey shown in Table 1, are probably based on such observations. However, significant patterns emerge from this survey and a number of relevant points may be deduced from it as follows:

1. Dicotyledonous perennials predominate as hosts for *O. minor*, whereas woody perennials are rarely reported.

2. Certain families such as Leguminosae and Compositae appear to contain several species which are suitable hosts for *O. minor* and there are many reports in the literature of parasitism on members of these families.

3. Other families also appear to be well represented in the survey such as Umbelliferae, Plantaginaceae, Geraniaceae and Labiatae.

4. Reports of the parasite on grasses (Murray 1896; Murphy 1972; Rumsey & Jury 1991) are infrequent and of interest. Parasitism of grasses (or other Monocotyledons) is rare in the genus *Orobancha* although it is a feature of other genera such as *Aeginetia* and *Striga* (Stewart & Press 1990).

The study described here verified a number of the hosts given in Table 1 and underlines the importance of certain families such as Umbelliferae, Leguminosae and Compositae (see Table 2). Nevertheless, although Leguminosae was well represented in the study area, it was notable that certain species such as *Anthyllis vulneraria*, *Lathyrus pratensis*, *L. tuberosus*, *Medicago sativa* subsp. *falcata*, *M. lupulina*, *Melilotus alba*, *M. officinalis*, *Trifolium arvense*, *T. fragiferum*, *Vicia cracca* and *V. sativa* were rarely or never parasitised. In contrast, a much higher proportion of the composites represented were parasitised. Interestingly, two crucifers, *Arabis hirsuta* and *Coincya monensis* subsp. *recurvata*, were recorded as hosts although members of Cruciferae have rarely been reported as hosts before.

One novel feature that emerged from this study was the occasional observation of *O. minor* var. *minor* individuals parasitising more than one host, each one a representative of a separate family. Presumably, this happens during establishment on a primary host when a haustorium also makes contact with the root of another compatible, secondary host in the near vicinity.

Parasitism of more than one host at the same time may occur commonly with other populations of *O. minor* var. *minor*, a consequence of its very wide host spectrum. However, there is evidence that *O. minor* has developed host specific strains (Musselman & Parker 1982) and, clearly, populations of these would be limited in this respect.

From the outset, it seemed possible, but intuitively unlikely, that the Crymlyn Burrows population was composed of more than one physiological strain, each with a limited set of hosts. For example, it could be argued that the mobile dune population which appeared to parasitise *Eryngium*

*maritimum* almost exclusively, was physiologically distinct from the partially fixed dune population which appeared to parasitise a wider spectrum of hosts. However, *O. minor* var. *minor* also occurs in transitional areas between well-defined mobile and partially fixed sand communities, where *E. maritimum* and other hosts are parasitised. Furthermore, it was shown that seed taken from a specimen parasitising *E. maritimum* in a mobile dune community germinated to produce vigorous specimens in pots containing *Hypochoeris radicata*, *Trifolium pratense* or *T. hybridum*. This evidence, together with observations of individuals parasitising multiple, unrelated hosts (including the combination of *E. maritimum* and *Lotus corniculatus*), does not support the argument that there are a number of host specific strains of *O. minor* var. *minor* on Crymlyn Burrows.

The broomrape population of Crymlyn Burrows has become a striking feature of this actively accreting coastal dune system in recent years. However, although it is likely that a small population of *O. minor* was established there about 50 years ago, it seems probable that only in the last 20 years or so has it spread so conspicuously into mobile and partially fixed dune areas. Indeed, the establishment and spread of this population on Crymlyn Burrows resemble colonisations there by a number of non-native colonists such as *Coincya monensis* subsp. *recurvata*, *Hirschfeldia incana*, *Senecio squalidus* and *Conyza canadensis*. It is notable, therefore, that Rumsey & Jury (1991) suggest that *O. minor* var. *minor* may not be native in the British Isles.

#### ACKNOWLEDGMENTS

I am grateful to Mr Ian Tew for his invaluable help in the histological preparation of specimens and to Mrs Hilary Hipkin for her assistance in the field. Thanks also to Quentin Kay for allowing me access to his collection of county Floras.

#### REFERENCES

- ALLEN, D. E. (1984). *Flora of the Isle of Man*. Douglas.
- ARCHER BRIGGS, T. R. (1880). *Flora of Plymouth*. London.
- BEVIS, J., KETTLE, R. & SHEPHARD, B. (1978). *Flora of the Isle of Wight*. London.
- BOWEN, H. J. M. (1968). *The Flora of Berkshire*. Oxford.
- CARTER, P. W. (1954). Some account of the history of botanical exploration in Wales. *Trans. Cardiff Nat. Soc.* **82**: 5–31.
- CHATER, A. O. (1986). *Orobanche* hosts – a cautionary tale. *B.S.B.I. News* **42**: 10.
- CLAPHAM, A. R., TUTIN, T. G. & MOORE, D. M. (1987). *Flora of the British Isles*, 3rd ed. Cambridge.
- DAVEY, F. H. (1909). *Flora of Cornwall*. Penryn.
- DONY, J. G. (1953). *Flora of Bedfordshire*. Luton.
- GROSE, D. (1957). *Flora of Wiltshire*. Devizes.
- HAMBLER, D. J. (1991). *Orobanche maritima*: an overlooked feature? *B.S.B.I. News* **58**: 18–19.
- HOLLAND, S. C., CADDICK, H. M. & DUDLEY-SMITH, D. S. (1986). *Supplement to the Flora of Gloucestershire*. Bristol.
- HYDE, H. A. & WADE, A. E. (1957). *Welsh flowering plants*. Cardiff.
- JONES, M. (1985). *Orobanche* hosts. *B.S.B.I. News* **41**: 29.
- KENT, D. H. (1975). *The historical Flora of Middlesex*. London.
- LINTON, E. F. (1919). *Flora of Bournemouth*. Bournemouth.
- LOUSLEY, J. E. (1976). *Flora of Surrey*. London.
- MARGETTS, L. J. & DAVID, R. W. (1981). *A review of the Cornish Flora 1980*. Redruth.
- MCCLINTOCK, D. (1975). *The wild flowers of Guernsey*. London.
- MESSINGER, K. G. (1971). *Flora of Rutland*. Leicester.
- MURPHY, D. P. (1972). *Orobanche* hosts at Glasnevin. *Ir. Nat. J.* **17**: 279.
- MURRAY, R. P. (1896). *Flora of Somerset*. Taunton.
- MUSSELMAN, L. J. & PARKER, C. (1982). Preliminary host ranges of some strains of economically important broomrapes (*Orobanche*). *Econ. Bot.* **36**: 270–273.
- PATRICK, S. & HOLLICK, K. M. (1975). *Supplement to the Flora of Derbyshire*. Derby.
- PETCH, C. P. & SWANN, E. L. (1968). *Flora of Norfolk*. Norwich.
- PUGSLEY, H. W. (1940). Notes on *Orobanche* L. *J. Bot., Lond.* **78**: 105–116.
- RAVENSHAW, T. F. (1860). *Flowering plants and ferns of Devonshire*. London.
- RUMSEY, F. J. (1991). *Orobanche maritima* revisited. *B.S.B.I. News* **59**: 9–10.

- RUMSEY, F. J. & JURY, S. L. (1991). An account of *Orobanche* L. in Britain and Ireland. *Watsonia* **18**: 257–295.
- SALMON, J. D. (1863). *Flora of Surrey*. London.
- SAVIDGE, J. P., HEYWOOD, V. H. & GORDON, V., eds. (1963). *Travis's Flora of South Lancashire*. Liverpool.
- STEWART, G. R. & PRESS, M. C. (1990). The physiology and biochemistry of parasitic angiosperms. *Ann. Rev. Plant Physiol.* **41**: 127–151.
- SWANN, E. L. (1975). *Supplement to the Flora of Norfolk*. Norwich.
- TRIMEN, H. & THISELTON-DYER, W. T. (1869). *Flora of Middlesex*. London.
- WEBB, D. A. & CHATER, A. O. (1972). *Orobanche* L., in TUTIN, T. G. *et al.*, eds. *Flora Europaea* **3**: 286–293. Cambridge.
- WHITE, J. W. (1912). *Flora of Bristol*. Bristol.
- WOLLEY-DOD, A. H. (1970). *Flora of Sussex*. Bristol.

(Accepted October 1991)