6. Fungal species of conservation concern (SoCC): taxonomic relationships

6.1 Selection of species of conservation concern (SoCC)

Of all the fungi, the ascomycete and basidiomycete macrofungi (Section 3) are the most conspicuous and have understandably received most attention from field mycologists and general naturalists. Even though the macrofungal inventory for any site in the world is far from complete (Section 5), a groundbreaking attempt was made by Ing (1992) to produce a provisional red data list of over 580 British fungi (including some microfungi). The criteria for inclusion on this list were not detailed but due regard was given to selecting species which were relatively well-understood and could be identified with some confidence. Some plant pathogenic microfungi were included on the basis that their host plants were themselves endangered species. Although this pioneering compilation of species of conservation concern was not strictly based on mapped distribution data, it was nevertheless informed by expert opinion and studies of major foray lists, herbarium catalogues and literature sources.

This achievement was followed by a decision made at the third quinquennial review of protected species to extend full legal protection to a few species of fungi which do not form lichen partnerships. The resulting 1998 revision of the Wildlife and Countryside Act (1981) included 30 named lichens *and* four non-lichen fungi comprising a bolete, bracket, puffball and tooth fungus as listed below. The provisional red data list conservation status (Ing 1992) follows each name.

- *Battarrea* (*Battarraea*) *phalloides* sandy stilt puffball now known as sandy stiltball. Endangered.
- *Boletus regius* royal bolete. Endangered.
- *Hericium erinaceum* hedgehog fungus now known as bearded tooth. Vulnerable.
- *Piptoporus quercinus* (*Buglossoporus pulvinus*) oak polypore. Endangered.

The next milestone in recognition of SoCC was the inclusion of fungi in the UK Government Biodiversity Action Plan (BAP). Action plans or species statements were published for the above four species together with a further 23 fungi and all 27 are listed in Table 1. Fourteen of the listed tooth fungi in the genera *Bankera*, *Hydnellum*, *Phellodon* and *Sarcodon* were grouped together in a single action plan.

Table 1 The 27 fungal species with Biodiversity Action Plans (BAP species) or species statements published prior to the 2005 BAP review

Scientific name	English name	Status (Ing 1992)
Armillaria ectypa	marsh honey fungus	Vulnerable
Bankera fuligineoalba	drab tooth	Endangered
Battarrea (*Battarraea*) *phalloides*	sandy stiltball	Endangered
Boletopsis leucomelaena	black falsebolete	Vulnerable
Boletus regius	royal bolete	Endangered
Boletus satanas	devil's bolete	Rare
Hericium erinaceum	bearded tooth	Vulnerable
Hydnellum aurantiacum	orange tooth	Endangered
Hydnellum caeruleum	blue tooth	Vulnerable
Hydnellum concrescens	zoned tooth	Vulnerable
Hydnellum ferrugineum	mealy tooth	Endangered
Hydnellum peckii	devil's tooth	Endangered
Hydnellum scrobiculatum	ridged tooth	Endangered
Hydnellum spongiosipes	velvet tooth	Rare
Hygrocybe calyptriformis	pink waxcap	Vulnerable
Hygrocybe spadicea	date waxcap	Vulnerable
Hypocreopsis rhododendri	hazel gloves	Rare
Microglossum olivaceum	olive earthtongue	Vulnerable
Phellodon confluens	fused tooth	Endangered
Phellodon melaleucus	grey tooth	Vulnerable
Phellodon tomentosus	woolly tooth	Endangered
Piptoporus quercinus (*Buglossoporus pulvinus*)	oak polypore	Endangered
Poronia punctata	nail fungus	Endangered
Sarcodon glaucopus	greenfoot tooth	Not listed in Ing (1992)
Sarcodon imbricatus	scaly tooth	Vulnerable
Sarcodon scabrosus	bitter tooth	Endangered
Tulostoma niveum	white stalkball	Vulnerable

Current conservation concern centres on these 27 species, although authors of several BAP-related species reports have advocated additional related species as worthy of as much, if not more, concern. Examples of these include *Phellodon niger*, whose omission was presumably accidental, and the following species:

- *Boletus pseudoregius* the pretender. Not listed in Ing (1992).
- *Hericium* (*Creolophus*) *cirrhatum* tiered tooth. Vulnerable.
- *Hericium coralloides* coral tooth. Vulnerable.
- *Hypocreopsis lichenoides* willow gloves. Endangered.
- *Sarcodon squamosus* no English name. Not listed in Ing (1992). Previously not distinguished from *Sarcodon imbricatus*.

The above 33 SoCC are also listed alphabetically by scientific name in Appendix I with a guide to where each is covered in the ecological groupings in Section 7. Undoubtedly the periodic BAP reviews and release of updated species checklists and red data lists will trigger further revisions of fungi regarded as SoCC. Taxonomic studies may also necessitate reviews of current species concepts and historical records which will have consequences for SoCC lists. Mention should also be made of another 33 fungi which were to be proposed by the Swedish Environmental Protection Agency for inclusion in Appendix 1 of the Bern Convention as deserving of strict protection in Europe. However, in late 2003 this was withdrawn "for the time being" pending further consultations with Parties to the Convention.

A gradual shift in emphasis has continued to occur from individual species-based action plans (SAPs) to a consideration of suites of BAP species with similar habitat requirements as advocated, since the production of the devil's bolete *Back from the Brink* report, by Marren (1997, 1998 & 2000a,b). This welcome shift was reviewed at the 7th International Mycological Congress in Oslo (Duckworth, Evans & Fleming 2002). There is still a need to relate SoCC to different habitat types and then to individual sites and their management plans. Progress is now being made towards the goal of formulating lists of the less ephemeral and more easily recognisable fungi which are fairly consistently associated with declining habitats in order to set conservation priorities based on, or at least including, fungi.

Interestingly, a very similar agenda was set out over a decade ago as one of the original goals underlying the production of the provisional red data list of British fungi (Ing 1992). However, the link between the provisionally listed species and declining habitats such as Caledonian pine forests, beechwoods on chalk, oak wood pastures, Atlantic hazelwoods, alder woods, nutrient poor grasslands, sand dunes, alpine habitats, bogs, fens etc was not made explicit. Nevertheless, an ecologically diverse subset was later identified as a useful nucleus of species groups relevant for evaluating the fungal interest of ancient woodland habitats (Ing 1996). Looking to the future, the development and expansion of this approach should yield useful sets of fungal indicators of habitat quality which can then be accorded due protection within designated sites, monitored and may be of value in highlighting sites deserving of future SSSI designation.

6.2 Taxonomy of ascomycete SoCC

Although the ascomycetes (Section 3) are the largest group of fungi, relatively few of them produce conspicuous (macrofungal) fruit bodies and this is reflected in the small number of species currently considered to be of conservation concern. Although ascomycetes are not represented amongst the listed Schedule 8 fungi, there are three BAP ascomycete species representing three different taxonomic orders (Table 2, with English names as recommended in Holden 2003).

Table 2 Ascomycete species listed in BAP

Hypocreopsis rhododendri	hazel gloves (order Hypocreales)
Microglossum olivaceum	olive earthtongue (order Helotiales)
Poronia punctata	nail fungus (order Xylariales)

In ascomycete fruit bodies, asci are usually formed in a dense layer lining the inside of a relatively open or closed structure or coating the outside of a fruit body. Perhaps the most familiar and conspicuous ascomycetes are the cup fungi and morels in which a layer of asci lines the inside of the relatively open hollows of the fruit bodies. Fruit bodies with asci on the outside include the bog beacon *Mitrula paludosa* (Figure 16) and the earthtongues such as the BAP species *Microglossum olivaceum*.

In other ascomycete groups the asci are more protected and line tiny cauldron-shaped chambers known as perithecia submerged just below the surface of a cushion of sterile tissue known as a stroma. The asci discharge by the usual violent squirting mechanism but emerge through a small opening, the ostiole, situated in the roof of the chamber (perithecium). Usually the only external signs of spore-producing structures in these fungi are the ostioles which appear as minute, often darker, dots on the stromatal surface. This dotted pattern is seen on the surface of the fruit bodies of *Cordyceps gracilis* (Figure 16) and BAP species such as the nail fungus *Poronia punctata* (Section 7.8) and hazel gloves *Hypocreopsis rhododendri* (Section 7.6). The English names of these BAP species refer to the form of the supporting stromatal cushion which in *Poronia* resembles a buff flat-headed nail protruding from herbivore dung, whereas in *Hypocreopsis* it resembles a reddish-brown glove with "fingers" encircling twigs and branches, usually of hazel. There is a lookalike with fewer British records called willow gloves *Hypocreopsis lichenoides* which is therefore also regarded as a SoCC (Ainsworth 2003b).

Figure 16 Club-shaped ascomycete fruit bodies with contrasting arrangements of asci. The head of the bog beacon *Mitrula paludosa* (left) is coated in a microscopic layer of asci whereas that of *Cordyceps gracilis* (right) has asci submerged in chambers with only the exit holes (ostioles) visible as dark dots on the surface. Photographs © Dr Martyn Ainsworth

6.3 Taxonomy of basidiomycete SoCC

All four listed Schedule 8 fungi and most BAP fungi are basidiomycetes. The five basidiomycete taxonomic groups represented by BAP species are discussed below.

6.3.1 Agarics and allies

The term agaric has traditionally been applied to those species which produce a mushroom-shaped fruit body having a stem (stipe) supporting a cap (pileus) bearing gills (lamellae). However, a number of variations exist in which the stem and/or gills are considerably reduced and some agaric fruit bodies lack stems altogether and are described as sessile (Figure 17). Historically, the taxonomic order Agaricales approximately corresponded to the group of species producing a recognisable agaric fruit body. More recently the underlying evolutionary relationships have been investigated by molecular studies which have revealed the agaric affinities of fungi with strikingly different fruit bodies. The Agaricales have now been expanded to include, for example, some puffballs and their relatives (a group also known as gasteromycetes or stomach-fungi) now interpreted as having highly modified caps, stems and gills. Hence the taxonomic order of many fungi can no longer be determined by a cursory examination of the overall fruit body form.

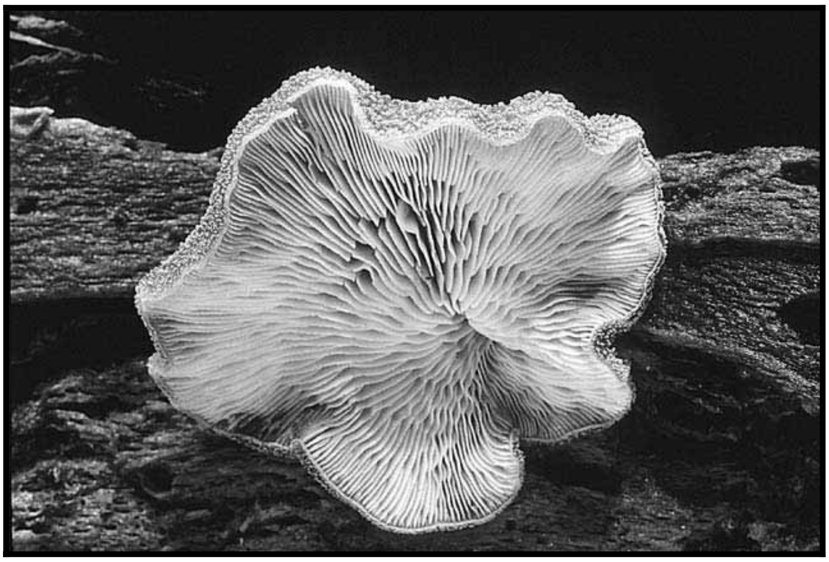


Figure 17 An example of a sessile agaric fruit body (woolly oyster *Hohenbuehelia mastrucata*), ie it has a cap (pileus) but no stem (stipe), viewed from below showing gills radiating from the point of attachment to the wood. Photograph © Dr Martyn Ainsworth

The BAP species assigned to the modern order Agaricales (Kirk and others 2001) are listed below (Table 3, with English names as recommended in Holden 2003).

Table 3 Agaricales listed in BAP

Armillaria ectypa	marsh honey fungus
Battarrea phalloides	sandy stiltball (Schedule 8)
Hygrocybe calyptriformis	pink waxcap
Hygrocybe spadicea	date waxcap
Tulostoma niveum	white stalkball

Of these, *Battarrea* and *Tulostoma* are puffball relatives and the others are traditionally recognisable agarics. Microscopically, it is also noteworthy that puffball basidia are distinguished by lacking a forcible basidiospore discharge mechanism. Instead, the fertile tissue is initially protected within a bag-like structure (peridium) and spores are released when this subsequently ruptures irregularly (eg *Battarrea*) or develops an apical outlet pore (eg *Tulostoma* and the earthstars). In most puffballs and their relatives, spore dispersal is promoted by a bellows-mechanism. This operates when raindrops and other items land on the peridium and results in the rapid expulsion of visible clouds containing millions of basidiospores.

6.3.2 Boletes

Traditionally this term has been used to describe species producing a frequently stout, mushroom-shaped shaped fruit body on the ground (rarely on wood) having a stem or stipe (ie they are stipitate) supporting a cap which differs from that of an agaric in bearing tubes not gills beneath (Figure 18). The tubes terminate in tiny pores which give a sponge-like (poroid) appearance to the undersides of bolete caps. Historically, the taxonomic order Boletales approximately corresponded to the group of species producing a recognisable bolete fruit body. More recently however, the underlying relationships have been clarified with molecular studies leading to a modified concept of this order which currently includes some species with puffball- and agaric- shaped fruit bodies. On the other hand, it is noteworthy that some fungi, eg the BAP genus *Boletopsis* (see below), which have a bolete or boletoid fruit body form are not thought to be closely related and are not classified in the Boletales.

Figure 18 An example of a bolete fruit body (iodine bolete *Boletus impolitus*) showing the sponge-like tube layer beneath the cap. Photograph © Dr Martyn Ainsworth

Of the currently recognised BAP species, two are assigned to the order Boletales (Kirk and others 2001) and are listed below (Table 4, with English names as recommended in Holden 2003).

Table 4 Boletales listed in BAP

Boletus regius	royal bolete (Schedule 8)
Boletus satanas	devil's bolete

As discussed in the species report for the royal bolete (Marren 1998), there has been considerable confusion between the records and identification of this Schedule 8 species and of the pretender *Boletus pseudoregius*. The latter should therefore be included as a SoCC and research undertaken to clarify the species concepts.

6.3.3 Polypores

This is the traditional term for bracket fungi bearing pores beneath their bracket-shaped fruit bodies and is also used for some stipitate forms fruiting directly on wood. Historically, the taxonomic order Polyporales approximately corresponded to the group of species producing a recognisable polypore fruit body until recent revisions and molecular studies expanded the concept to include many non-poroid genera. The only BAP species currently assigned to the order Polyporales (Kirk and others 2001) is the oak polypore (Figure 19 and Table 5, with the English name as recommended in Holden 2003).

Figure 19 An example of a polypore fruit body (oak polypore *Piptoporus quercinus*) showing the sponge-like tube layer beneath the bracket-shaped cap. Photograph © Dr Martyn Ainsworth

Table 5 Polyporales listed in BAP

Buglossoporus pulvinus *Piptoporus quercinus*	(Schedule 8) but now usually referred to as: oak polypore

Naming note (Roberts 2002): According to the current nomenclatural rules governing the naming of fungi, the epithet *quercinus* is the only valid epithet. However the acceptance of the genus *Buglossoporus* is currently a matter of taxonomic opinion and while both generic names are equally valid, the forthcoming Checklist of British Basidiomycetes will retain the oak polypore within *Piptoporus*. The genera are currently separated by examination of the microscopic construction of the basidiospore-producing tubes. Future comparative DNA sequencing work may further illuminate the relationships between the two genera.

6.3.4 Russulales

Originally proposed as an order to accommodate such distinct agaricoid genera as the brittlegills *Russula* and milkcaps *Lactarius*, recent molecular studies have shown similarities exist with genera possessing grossly dissimilar fruit bodies which may even have spines (Figure 20), pores or a relatively smooth surface from which the basidiospores are dispersed in the place of gills.

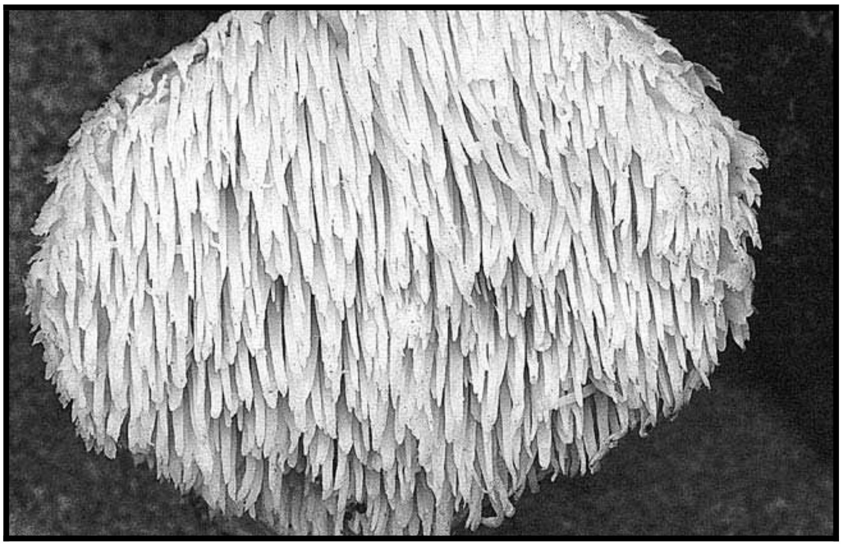


Figure 20 An example of a spiny 'russuloid' fruit body (tiered tooth *Hericium cirrhatum*) showing the tooth-like surface beneath the cap, each 'tooth' is coated with a layer of basidia. Photograph © Dr Martyn Ainsworth

An example of a spiny form currently assigned to the order Russulales (Kirk and others 2001) is the BAP species listed below (Table 6, with the English name as recommended in Holden 2003).

Table 6 Russulales listed in BAP

Hericium erinaceum	bearded tooth (Schedule 8)

The species report for the bearded tooth (Boddy & Wald 2002) included the related species coral tooth *Hericium coralloides* and tiered tooth *Hericium cirrhatum* (Figure 20), also known as *Creolophus cirrhatus*. All three are justified for inclusion as SoCC. On the evidence of the accumulated fruit body records assessed by Boddy & Wald (2002), coral tooth seemed to be the rarest of the three and was therefore recommended for promotion to priority BAP status.

6.3.5 Thelephorales

This is predominantly an order whose species produce basidiospores from spines projecting downwards beneath the cap. However it also includes related species with smooth crust-like fruit bodies and the boletoid genus *Boletopsis*. Most of the BAP-listed fungal species are currently assigned to the order Thelephorales (Kirk and others 2001). With the notable exception of *Boletopsis*, they produce fruit bodies with stipes (stipitate) bearing irregular caps with basidiospores dispersed from spines and are usually described as stipitate hydnoids or tooth fungi (Figure 21 and Table 7, with English names as recommended in Holden 2003).

Figure 21 An example of a spiny 'thelephoroid' fruit body (blue tooth *Hydnellum caeruleum*) showing the tooth-like surface beneath the cap, each 'tooth' is coated with a layer of basidia. Photograph © Dr Martyn Ainsworth

Table 7 Thelephorales listed in BAP

Boletopsis leucomelaena	black falsebolete
Bankera fuligineoalba	drab tooth
Hydnellum aurantiacum	orange tooth
Hydnellum caeruleum	blue tooth
Hydnellum concrescens	zoned tooth
Hydnellum ferrugineum	mealy tooth
Hydnellum peckii	devil's tooth
Hydnellum scrobiculatum	ridged tooth
Hydnellum spongiosipes	velvet tooth
Phellodon confluens	fused tooth
Phellodon melaleucus	grey tooth
Phellodon tomentosus	woolly tooth
Sarcodon glaucopus	greenfoot tooth
Sarcodon imbricatus	scaly tooth
Sarcodon scabrosus	bitter tooth

Naming note: This provides an example where the recommended English names highlight the visual similarities in overall fruit body form rather than reflect the current molecular-based taxonomic approaches. As a result, the suffix 'tooth' is applied to most of the BAP Thelephorales and also to the wood-decomposing genus *Hericium*, which is currently accommodated in the order Russulales (Kirk and others 2001).

As noted in the status assessments of Scottish conifer-associated species (Newton and others 2001, 2002) and the species report for the English stipitate hydnoids (Marren 2000b), there is much confusion surrounding the records and identification of a number of these species, including the species pairs *Hydnellum concrescens/scrobiculatum*, *H. spongiosipes/ferrugineum*, *H. aurantiacum/auratile*, the quartet *Sarcodon imbricatus/*

squamosus/glaucopus/scabrosus and within the genus *Phellodon*. If confirmed as British, *H. auratile*, *Sarcodon squamosus* and *S. versipellis* should be included as SoCC. Fruiting of British *Phellodon* spp. not referable to any of the known species has been suspected by several workers and taxonomic clarification within this genus would greatly benefit from the development of a robust and reliable DNA sequence-based technique.

7. Fungal species of conservation concern (SoCC): ecological groups, sites and management

In this section BAP species and a few other species of conservation concern are grouped according to the ecological considerations discussed in Section 4. The grouping is based on habitats and resource relations insofar as they are known.

To some extent, this approach has already been followed in the grouping of 14 BAP stipitate hydnoid fungi under a single joint Species Action Plan on the basis that they are ecologically similar. However this may require some revision on the basis that some of these are more or less Scottish pinewood species. It is often difficult to ascertain the mycorrhizal tree associated with a particular stipitate hydnoid fruit body unless one is in a pure stand of a single tree species. Nevertheless, there does seem to be a subgroup that is almost exclusively associated with native and planted Scottish pinewoods in central and eastern regions of Scotland, and a second less geographically restricted group associated with both broadleaved trees (mostly of the oak/beech/sweet chestnut family) and conifers. Occasional reports exist of the 'Scottish pine' group fruiting outside Scotland (and with broadleaved trees) but, until evidence to the contrary is forthcoming, it is tentatively assumed that these are largely introductions with planted non-native trees that are rarely likely to persist. The 'broadleaved/conifer' group is fully represented in Scotland, with varying degrees of selectivity towards conifers or broadleaved trees, but south of Scotland it occurs predominantly with broadleaved trees. Some of the 'broadleaved/conifer' group seem to be found with conifers or broadleaved trees regardless of geography, eg *Phellodon melaleucus* and *P. niger*, whereas the records suggest that *Sarcodon scabrosus* associates with pine in Scotland and broadleaved trees in England (Marren 2000b; Newton and others 2002).

Overall, it was thought to be desirable to recognise two groups of stipitate hydnoids for the purposes of future assessments of fungal interest and ranking of sites by their species diversity. In this respect, the 'Scottish pine' group may be of little relevance in assessing the 'best' English sites whose complement of around six species might be half that possible in some Caledonian pinewoods. To refine and increase confidence in placing species in ecologically-based groups or suites, major gaps in our taxonomic knowledge need to be addressed, in particular with regard to the ectomycorrhizal genera *Hydnellum*, *Phellodon*, *Sarcodon* and *Boletus*. In tandem with this, much remains to be revealed regarding the mycorrhizal ecology of all these species.

The proposed ecological groups represented by BAP species are summarised in Table 8. For ease of searching for information on a particular species, these are arranged alphabetically with a listing of the appropriate handbook sections covering each ecological group in Appendix I.

Data sheets consisting of brief species profiles have been prepared from available data and are included for the members of each ecological group except for those characteristic of Scottish habitats. In time it is hoped that this list will be augmented by addition of Scotttish species, red data list species, nationally rare and scarce species, habitat quality indicators and other species of conservation concern. This could then form the basis of an inventory of fungal key habitats and their characteristic species as has already been produced for woodland key habitats in Estonia (Andersson and others 2003) and Sweden (Nitare 2000; Anon 2002).

Table 8 Suggested ecological grouping of BAP species

Section	Ecological grouping	Genera represented
7.1	'Scottish pine' stipitate hydnoids (incl. a boletoid close relative)	*Bankera, Boletopsis, Hydnellum, Phellodon, Sarcodon*
7.2	'Broadleaved/conifer' stipitate hydnoids	*Hydnellum, Phellodon, Sarcodon*
7.3	Thermophilous boletes	*Boletus*
7.4	Bulky deadwood species	*Hericium, Piptoporus*
7.5	Litter/woody debris species	*Battarrea*
7.6	?Parasitic on fungi or saprotrophic on wood	*Hypocreopsis*
7.7	Waxcap grassland species	*Hygrocybe, Microglossum*
7.8	Lowland heath species	*Poronia*
7.9	Wetland species	*Armillaria*
7.10	Scottish montane species	*Tulostoma*

It should be clear from Section 4 that fungi are so ecologically diverse that it is no more feasible to provide generic guidelines for management of 'fungi' than it is to provide such guidelines for management of 'plants' or 'animals' (other than the self-evident avoidance of fungicides). Nevertheless, there are still some extra steps that can be taken to safeguard some groups of fungi on wildlife sites. To this end, the Fungus Conservation Forum (Anon 2001) produced a leaflet entitled *Managing your land with fungi in mind* (see Appendix II) and an expanded version is in Borges & Rotheroe (2002).

It is true that fungi, however poorly studied, living on sites protected for other wildlife interest receive some general 'umbrella' protection by default. Major habitat changes, such as pollution, eutrophication, invasive species, changes in water availability and other destructive or enrichment disturbances, are likely to be as deleterious for organisms and habitats of priority interest as for the fungi. However, it is important to encourage fungal recording, ecologically-based observation and research to enable site management to consider the different ecological groups of fungi, their requirements and locations within site boundaries. Coupled with efficient communication between recorders, ecologists, site managers and contractors, this would help to minimise the destruction of important fungal habitat through lack of awareness of fungal distribution and ecology. Even where the welfare of other wildlife takes priority, there are usually small concessions that can be made to safeguard keystone mycorrhizal and recycling fungi of conservation concern. Some preliminary management guidelines are included for each ecological suite of SoCC (Scottish guidelines in prep.).

Given the oft-repeated bottleneck issues of taxonomy, standardising surveys, fungal distribution, data quality/usage, ecology and the paucity of resources directed at their resolution and elucidation, it would seem unsound at this stage confidently to rank sites according to indicator-based measures of quality. Nevertheless this is a worthy and challenging goal and would finally address a question that has remained unanswered for over 15 years; "How should we judge which sites should be conserved for their fungi?" (Kirby 1988).

Major progress in this regard has been made with waxcap grassland assessments, although the choice of systems now available could lead to some uncertainty in making comparisons (see below). The stipitate hydnoid species are so well-represented in the BAP list that site ranking should be initiated on this basis as suggested by Marren (2000b). Furthermore, there is evidence that members of this suite of species have existed, at least at some of their sites, for a very long time. Examples of this include the recording of stipitate hydnoids since the 1800s in pinewoods near Forres and on Speyside (Newton and others 2002), with oak in the New Forest (Dickson & Leonard 1996) and in sweet chestnut formerly managed as coppice near Ascot (Green 2001). Of the other well-circumscribed groups, the boletes probably require further taxonomic work and survey to gain a clearer picture of the numbers of accepted species at each site and further progress is believed to be possible with indicator selection and testing for ranking bulky deadwood sites. A preliminary attempt at site ranking has been made herein for those species suites where some site-based information has recently become available.

Many other fungal habitats are of conservation interest and in need of some flagship species. Some habitats are in need of additional flagships, for example the fungal interest of coastal and montane habitats stretches well beyond their value as waxcap grasslands and that of Scottish pinewoods beyond their complement of stipitate hydnoids. In dunes and alpine habitats, there are clear threats from grazing and visitor pressures but further generic guidelines and an indicator-based approach to site ranking would be greatly beneficial. In Scottish pinewoods the relaxation of sheep and deer grazing is expected to diminish the fruiting of ectomycorrhizals (Orton 1986) versus deadwood saprotrophs and thereby prompt decisions on ground flora management (E.M. Holden pers. comm.). Fortunately, the agarics and boletes characteristic of such Caledonian pinewoods have been relatively well-studied. A list of 32 indicator species found after 21 years of detailed recording over 3000 h of woodland at Abernethy was produced by Tofts & Orton (1998) based on a previous series of 16 lists (Orton 1986). In addition, Tofts and Orton (1998) mentioned a further three potential indicators which had not been recorded at Abernethy. This list of indicators is currently being revised in the light of recent recording and taxonomic changes (Holden in prep.).

Attention should also be directed towards the fungi of less well-worked habitats, for example by appropriate BAP species revision, Bern inclusion or compilation of site-based species dossiers, to raise their profile and status within the conservation community.

7.1 'Scottish pine' stipitate hydnoids

7.1.1 'Scottish pine' stipitate hydnoids and relatives: group members

These thelephoroid fungi (mainly stipitate hydnoids) are exclusively or predominantly associated with living pine roots and a Scottish distribution in the UK (Table 9). They may have been introduced or are possibly native outside Scotland where populations or individuals may persist, but generally seem prone to dying out. It should be noted that members of both this and the 'broadleaved/conifer' group of stipitate hydnoids can be found coexisting in Scottish pinewoods.

Table 9 'Scottish pine' group of stipitate hydnoids and a close relative

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	Yes	ectomycorrh.	Stipitate hydnoid	*Bankera fuligineoalba*	drab tooth
No	Yes	ectomycorrh.	Boletoid	*Boletopsis leucomelaena*	black falsebolete
No	Yes	ectomycorrh.	Stipitate hydnoid	*Hydnellum aurantiacum*	orange tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Hydnellum caeruleum*	blue tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Hydnellum ferrugineum*	mealy tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Hydnellum peckii*	devil's tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Hydnellum scrobiculatum*	ridged tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Phellodon tomentosus*	woolly tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Sarcodon glaucopus*	greenfoot tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Sarcodon imbricatus*	scaly tooth
No	No	ectomycorrh.	Stipitate hydnoid	*Sarcodon squamosus*	none

The status of *Phellodon tomentosus* outside Scotland is uncertain and, due to doubt surrounding taxonomy, ectomycorrhizal associates and determination of records (many lacking voucher material), the national status of the following pairs is also uncertain: *Sarcodon imbricatus/squamosus*, *Hydnellum scrobiculatum/concrescens* and *H. ferrugineum/spongiosipes*.

7.2 'Broadleaved/conifer' stipitate hydnoids

7.2.1 'Broadleaved/conifer' stipitate hydnoids: group members

This group of stipitate hydnoids is associated with living broadleaved tree roots, usually of oak, sweet chestnut and beech, and some can also associate with coniferous trees. Members of this group (Table 10) occur in Scotland where there is an overlap of distribution with the conifer-favouring group. However, south of Scotland, this is the group regularly associated with broadleaved woodland.

Table 10 'Broadleaved/conifer' stipitate hydnoids

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	Yes	ectomycorrh.	Stipitate hydnoid	*Hydnellum concrescens*	zoned tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Hydnellum spongiosipes*	velvet tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Phellodon confluens*	fused tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Phellodon melaleucus*	grey tooth
No	No	ectomycorrh.	Stipitate hydnoid	*Phellodon niger*	black tooth
No	Yes	ectomycorrh.	Stipitate hydnoid	*Sarcodon scabrosus*	bitter tooth

7.2.2 'Broadleaved/conifer' stipitate hydnoids: species data sheets

Species data sheets follow for *H. concrescens*, *H. spongiosipes*, *P. confluens*, *P. melaleucus*, *P. niger* & *S. scabrosus*.

Hydnellum concrescens zoned tooth

Synonyms in recent use: *Hydnellum zonatum*, *H. velutinum* var. *zonatum*, *H. scrobiculatum* var. *zonatum.*

Known distribution before 1960

Known distribution 1960 onwards

Description: fruiting singly or in fused groups Aug-Nov. Cap 2-10 cm diam., flat or depressed, with radial ridges, irregular nodules and concentric zones, finely velvety and pinkish becoming smoother and darkening with age, bruising and rain to reddish-brown, darker towards the centre. Spines 2-4 mm long, pinkish becoming brownish. Stem 2-5 cm long, buried in litter, reddish brown, velvety. Flesh reddish brown, often darker towards stem base, often zoned with darker lines in section with floury smell. Spores brown, knobbly (at high magnification many ‘knobbles’ end in two ‘peaks’), ellipsoid, 4.5-6.0 x 3.0-4.5 µm.

Distinguishing features: often confused with *H. scrobiculatum*, both were once distinguished merely as varieties and intermediate forms are recorded. *H. scrobiculatum* usually has thin fruit bodies, is mainly (?always) associated with pine and, at high magnification, many of the ‘knobbles’ on the slightly larger spores end in a single ‘peak’.

Ecology: mycorrhizal with coniferous and broadleaved trees, often on banks/ditches at sites noted for more unusual stipitate hydnoid fungi.

Distribution & Status: Europe, North America and Asia. UKRDL (1992) and BAP vulnerable.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Eutrophication and removal of mycorrhizal tree associates should be minimised. Some sites require management of bracken and rhododendron, indicating that control of light levels is very important, and some are threatened by recreational pressures (eg mountain biking). Pilot trials of selective *Castanea* coppicing and bank and ditch creation in suitable oak and *Castanea* habitat are suggested. In formal parks, leaf blowers are recommended for removal of fallen leaves to prevent litter build-up. Research needed on taxonomy, population structure and colonisation.

Published illustrations: in Breitenbach & Kränzlin (1986), Maas Geesteranus (1975), Marren (2002), Marren & Dickson (2000), Pegler, Roberts & Spooner (1997), Phillips (1981) and Ryman & Holmåsen (1984).

Additional published information: in Dickson (2000), Ewald (2000, 2002), Hrouda (1999), Stalpers (1993). Species reports for stipitate hydnoid fungi in England by Marren (2000b) and in Berkshire/Surrey by Green (2001).

Young dry fruit body in sweet chestnut coppice

Mature wet fruit bodies in sweet chestnut coppice

Hydnellum spongiosipes velvet tooth

Synonyms in recent use: *Hydnellum velutinum* var. *spongiosipes*.

Description: fruiting singly or in fused groups Aug-Nov. Cap 2-10 cm diam., domed and lumpy, becoming flatter, without strong radial ridges, velvety, pinkish buff darkening with age, bruising and rain to reddish-brown, darker towards the centre. Spines 2-6 mm long, lilac buff becoming brownish. Stem 2-9 cm long, buried in litter, reddish brown, velvety. Flesh reddish brown, often darker towards stem base, often zoned with darker lines in section with floury smell. Spores brown, knobbly, shortly ellipsoid, 6.0-7.0 x 5.0-6.0 µm.

Known distribution before 1960

Known distribution 1960 onwards

Distinguishing features: distinguished from *H. scrobiculatum* and *H. concrescens* by the lack of radial ridges and less concentric zonation on the cap. Distinguished with difficulty from *H. ferrugineum*, which is reddish brown and more associated with conifers.

Ecology: mycorrhizal with broadleaved trees, often oak, beech and *Castanea*, on mossy banks/ditch sides etc in glades, wood pasture and old chestnut coppice, often with more unusual stipitate hydnoid fungi.

Distribution & Status: Europe and North America. UKRDL (1992) rare, BAP vulnerable.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Eutrophication and removal of mycorrhizal tree associates should be minimised. Some sites require management of bracken and rhododendron, indicating that control of light levels is very important, and some sites are threatened by recreational pressures (eg mountain biking). Pilot trials of selective *Castanea* coppicing and bank and ditch creation in suitable broadleaved habitat are suggested. In formal parks, leaf blowers are recommended for removal of fallen leaves to prevent litter build-up. Research needed on taxonomy, population structure and colonisation.

Published illustrations: in Breitenbach & Kränzlin (1986), Maas Geesteranus (1975), Marchand (1976), Pegler, Roberts & Spooner (1997) and Phillips (1981).

Additional published information: in Dickson (2000), Ewald (2000, 2002), Hrouda (1999), Stalpers (1993). Species reports for stipitate hydnoid fungi in England by Marren (2000b) and in Berkshire/Surrey by Green (2001).


Young dry fruit body in sweet chestnut coppice


Rain darkening fruit bodies under sweet chestnut

Phellodon confluens fused tooth

Synonyms in recent use: *Phellodon amicus*

Description: fruiting singly or in fused groups Aug-Nov. Cap 2-9 cm diam., flat or depressed, finely velvety and whitish becoming roughly woolly, pitted and darker brown towards the centre with age and very dark after rain (then causing confusion with other *Phellodon* species). Pale margin relatively wide. Spines 2-3 mm long, whitish becoming lilac-brownish. Stem 2-4 cm long, when sliced in dry condition there is a pale brown soft outer layer (tomentum) and darker central core (duplex flesh). Cap flesh whitish becoming darker brown towards the stem, can be duplex. Strong smell of fenugreek (curry powder) on drying. Spores white, spiny, shortly ellipsoid, 3.5-4.5 x 3.0-4.5 µm.

Known distribution before 1960

Distinguishing features: distinguished from *P. melaleucus,* which can also have brown cap tints, by the duplex stem tissue. *P. niger* stem is also duplex, but has a grey-black-blue tinted cap and a narrower pale margin that darkens faster than that of *P. melaleucus* and *P. confluens*.

Ecology: mycorrhizal with broadleaved trees, often southern with oak and *Castanea*, on mossy banks/ditch sides etc in glades, wood pasture and old chestnut coppice, often with other stipitate hydnoid fungi.

Distribution & Status: Europe, North America and Asia. UKRDL (1992) endangered, BAP vulnerable.

Known distribution 1960 onwards

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Eutrophication and removal of mycorrhizal tree associates should be minimised. Some sites require management of bracken and rhododendron, indicating that control of light levels is very important, and some sites are threatened by recreational pressures (eg mountain biking). Pilot trials of selective *Castanea* coppicing and bank and ditch creation in suitable broadleaved habitat are suggested. In formal parks, leaf blowers are recommended for removal of fallen leaves to prevent litter build-up. Research needed on taxonomy, population structure and colonisation.

Published illustrations: in Breitenbach & Kränzlin (1986), Marchand (1976), Maas Geesteranus (1975), Pegler, Roberts & Spooner (1997) and Phillips (1981)

Additional published information: in Dickson (2000) Ewald (2000, 2002), Hrouda (1999) and Stalpers (1993). Species reports for stipitate hydnoid fungi in England by Marren (2000b) and in Berkshire/Surrey by Green (2001).


Dry fruit body with oak by marl pit

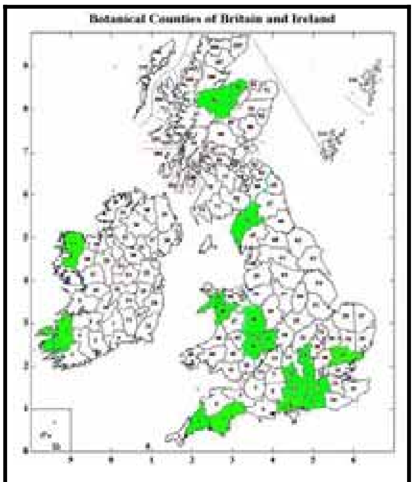

White fruit body darkened by rain shower


Dry stem (from fungus in photo on left) sliced to show darker core region within (duplex flesh)

Phellodon melaleucus grey tooth

Synonyms in recent use: *Phellodon graveolens*

Description: fruiting singly or in fused groups Aug-Nov. Cap 2-8 cm diam., flat or depressed, finely velvety and whitish becoming smoother, radially wrinkled, concentrically zoned with reddish-brown and black-brown towards the centre with age. Pale margin relatively wide. Spines 2-3 mm long, whitish becoming grey-brownish. Stem 2-3 cm long, relatively narrow, dark brown and smooth, when sliced in dry condition there is no contrasting paler softer outer zone (flesh not duplex). Cap flesh slate-brown becoming darker brown towards the stem. Strong smell of fenugreek (curry powder) on drying. Spores white, spiny, shortly ellipsoid, 3.5-5.0 x 3.0-4.5 µm.



Known distribution before 1960

Known distribution 1960 onwards

Distinguishing features: distinguished from *P. confluens,* which can also have brown cap tints, and *P. niger* by the lack of duplex stem tissue. *P. niger* has a grey-black-blue tinted cap and usually a margin that darkens faster than that of *P. melaleucus* or *P. confluens* and is therefore relatively narrow.

Ecology: mycorrhizal with pine, spruce and broadleaved trees related to oaks, often on mossy banks/ditch sides etc in glades, wood pasture and old chestnut coppice, often with other hydnoids.

Distribution & Status: Europe, North America, Asia and Australasia, UKRDL (1992) and BAP vulnerable.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Eutrophication and removal of mycorrhizal tree associates should be minimised. Some sites require management of bracken and rhododendron, indicating that control of light levels is very important, and some sites are threatened by recreational pressures (eg mountain biking). Pilot trials of selective *Castanea* coppicing and bank and ditch creation in suitable broadleaved habitat are suggested. In formal parks, leaf blowers are recommended for removal of fallen leaves to prevent litter build-up. Research needed on taxonomy, population structure and colonisation.

Published illustrations: in Breitenbach & Kränzlin (1986), Maas Geesteranus (1975), Pegler, Roberts & Spooner (1997), Phillips (1981) and Ryman & Holmåsen (1984).

Additional published information: in Dickson (2000), Ewald (2000, 2002), Hrouda (1999), Marchand (1976) and Stalpers (1993). Species reports for stipitate hydnoid fungi in England by Marren (2000b) and in Berkshire/Surrey by Green (2001).

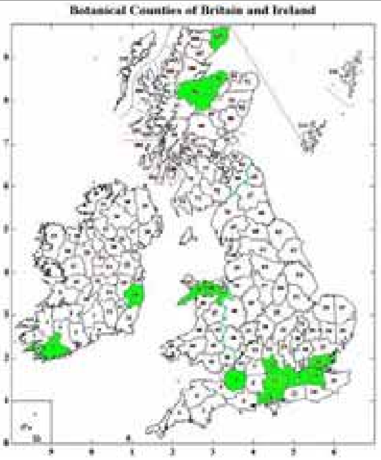

Fruit bodies from partial rings on mossy ditch banks

© Martyn Ainsworth

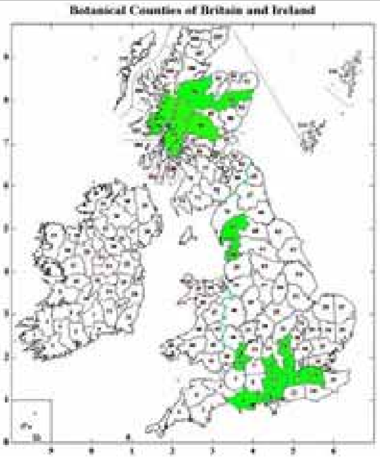
Damp fruit bodies in sweet chestnut coppice

© Martyn Ainsworth

Phellodon niger black tooth



Known distribution before 1960



Known distribution 1960 onwards

Synonyms in recent use:

Description: fruiting singly or in fused groups Aug-Nov. Cap 2-7 cm diam., flat or depressed, finely velvety and whitish then roughly pitted and/or radially ridged and/or concentrically zoned, rapidly becoming greyer (can develop violet or olive tints) then blue-black towards the centre with age. Pale margin relatively narrow. Spines 2-4 mm long, whitish becoming grey. Stem 2-5 cm long, when sliced in dry condition there is a dark grey spongy outer layer (tomentum) and black harder central core (duplex flesh). Cap flesh grey becoming black towards the stem, can be duplex. Strong smell of fenugreek (curry powder) on drying. Spores white, spiny, shortly ellipsoid, 3.5-5.0 x 3.0-4.5 µm.

Distinguishing features: distinguished from *P. melaleucus* by the duplex stem tissue. *P. confluens* stem is also duplex, but has a paler browner cap with a pale margin that is often wider than that of *P. niger*.

Ecology: mycorrhizal with pine, spruce and broadleaved trees related to oaks, on mossy banks/ditch sides etc in glades, wood pasture and old chestnut coppice, often with other stipitate hydnoid fungi.

Distribution & Status: Europe, North America, Asia and Australasia, UKRDL (1992) rare, no BAP (recommended for BAP).

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Eutrophication and removal of mycorrhizal tree associates should be minimised. Some sites require management of bracken and rhododendron, indicating that control of light levels is very important, and some sites are threatened by recreational pressures (eg mountain biking). Pilot trials of selective *Castanea* coppicing and bank and ditch creation in suitable broadleaved habitat are suggested. In formal parks, leaf blowers are recommended for removal of fallen leaves to prevent litter build-up. Research needed on taxonomy, population structure and colonisation.

Published illustrations: in Bon (1987), Breitenbach & Kränzlin (1986), Marchand (1976), Maas Geesteranus (1975), Pegler, Roberts & Spooner (1997), Phillips (1981) and Ryman & Holmåsen (1984).

Additional published information: in Dickson (2000), Ewald (2000, 2002), Hrouda (1999), Stalpers (1993). Species reports for stipitate hydnoid fungi in England by Marren (2000b) and in Berkshire/Surrey by Green (2001).


Immature violet-tinted fruit bodies


Maturing damp fruit body


Mature dry fruit bodies under chestnut

Sarcodon scabrosus bitter tooth

Known distribution before 1960

Synonyms in recent use:

Description: fruiting singly or in groups, Aug-Oct. Cap 5-15 cm diam., cap domed becoming flat or depressed, chestnut brown, often with reddish-purple tinges, smooth then splitting into darker coarse scales, erect at centre and flatter at the margin. Spines 4-10 mm long, greyish lilac becoming brownish with paler tips. Stem 3-10 cm long, pinkish brown with small scales, darker towards the base and often dark greenish at the base. Flesh whitish with pinkish or lilac tinges, grey-green in the stem base. Smell floury. Whole fruit body blackening with age. Spores brown, knobbly, shortly ellipsoid, 6.0-7.5 x 5.0-6.0 µm.

Distinguishing features: distinguished from the very similar *S. regalis*, (discovered and restricted to single UK site before habitat destruction, now presumed extinct in UK), in having central cap scales which are more erect and stem base and flesh with fewer violet tinges. Familiarity with variation in *S. scabrosus* may promote rediscovery of *S. regalis*.

Known distribution 1960 onwards

Ecology: mycorrhizal mainly with Scottish conifers and English broadleaved trees, often oak, and *Castanea*, on mossy banks/ditch sides etc in glades, wood pasture and old chestnut coppice, often with more unusual stipitate hydnoid fungi. Fruiting recorded on one mossy mound (see photo* below) for 40 y.

Distribution & Status: Europe, North America and Asia. UKRDL (1992) and BAP endangered.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Eutrophication and removal of mycorrhizal tree associates should be minimised. Sites may require management of bracken and rhododendron, indicating that control of light levels is very important, and some sites are threatened by recreational pressures (eg mountain biking). Pilot trials of selective *Castanea* coppicing and bank and ditch creation in suitable broadleaved habitat are suggested. Research needed on taxonomy, population structure and colonisation.

Published illustrations: in Breitenbach & Kränzlin (1986), Maas Geesteranus (1975), Pegler, Roberts & Spooner (1997) and Phillips (1981).

Additional information: in Dickson (2000), Hrouda (1999) and Stalpers (1993). Species reports for stipitate hydnoid fungi in England by Marren (2000b) and in Berkshire/Surrey by Green (2001).


Maturing fruit bodies on ditch side with sweet chestnut


*Drying fruit bodies on mossy mound with sweet chestnut

7.2.3 'Broadleaved/conifer' stipitate hydnoid sites: generic management guidelines

This fungal group serves to highlight that site management for a specific fungal component of biodiversity may require some amendments to the existing management regime aimed at other organism groups. On most sites managed for nature conservation, a frequent key objective is to remove alien species which for England would include introduced conifers and sweet chestnut. The outstanding English sites in Berks/Surrey and West Kent, and some of those in the New Forest cluster of sites are habitats for BAP fungi that are dependent on sweet chestnut for carbon nutrition.

From the standpoint of conservation status, the year of introduction of a tree species is important. *Castanea* was probably introduced by the Romans (Mitchell 1974) and having been naturalised since well before 1500 is considered as an archaeophyte (Preston, Pearman & Dines 2002). The associated stipitate hydnoids are native species and therefore, unless contradictory evidence is forthcoming, they could have colonised the tree roots from other British populations associated with native trees. In the light of this and discussions following Cheffings' (JNCC) paper *Aliens: to be conserved, eradicated or ignored?* delivered at the BMS Autumn Taxonomy Meeting held at Kew in 2003, it would seem that the '*Castanea*/native BAP stipitate hydnoids' partnership should be recognised as conferring an enhanced conservation status on an already 'nearly native' tree. It is felt that this deserves wider publicity and recognition, especially in view of the fact that *Castanea* trees supporting stipitate hydnoids have, for various reasons, been felled on SSSIs and one of the English chestnut sites supporting all species in the 'broadleaved/conifer' group remains just outside the boundary of a nearby SSSI. It is hoped that further damage can be minimised once the lifestyle and importance of these BAP fungi becomes more widely publicised and their locations are mapped and communicated to managers and contractors.

The 'best' sites for 'broadleaved/conifer' stipitate hydnoid fruit bodies are:

- Relatively nutrient poor patches in open woodland with visible bare mineral soil or at least areas with relatively little build up of leaf litter.
- Often on slopes, banks, ditches, burrows, cuttings, mounds, earthworks, path and track edges. One roadside bank is known to be under 50 years old.
- Often with mosses and lichens but without, or with only sparsely grassy, vascular plant cover.
- Usually associated with oak, beech and sweet chestnut family of trees, occasionally with conifers. Sweet chestnut associates may be maiden trees or coppiced with current management or not.
- Not necessarily associated with the oldest trees.
- Acid, neutral or alkaline, ranging from alkaline clay (old marl pit surrounds) to well-drained acidic sand/gravel based soils.
- Often in sunny windswept locations.

Consideration of various reports on their English status (Ewald 2000, 2002; Green 2001; Marren 2000b) suggests the following management guidelines (subject to revision by the Fungus Conservation Forum):

- Minimal destruction of mycorrhizal tree partners, particularly with regard to *Castanea*. Harmonisation required between potentially conflicting management plans for forestry, recreation, conservation (eg heathland restoration) and stipitate hydnoid mycorrhizas. If trees have to be felled, eg for safety reasons or because they are damaging ancient monuments, trunks should preferably be removed to adjacent woodland for benefit of saprotrophs and not left across the site of fruiting or dragged across it during extraction.
- Prevent spread of and, where appropriate, eradicate invasive plants such as bracken and *Rhododendron*, ensuring accompanying trampling and extraction avoids fruiting sites. Mechanical removal of *Rhododendron* roots should be avoided within fruiting areas (extensive damage to mycelium), instead chemical control of cut stumps should be considered (E.E. Green pers. comm.)
- Coppicing of traditionally managed *Castanea* should be maintained in the traditional manner avoiding undue compaction of, and fires on, the main fruiting sites.
- Where invasive plants pose a threat, avoid major removal of nearby canopy which increases light levels favouring spread of invasives. Any felling of neighbouring tree cover and/or large-scale coppicing should be accompanied by appropriate planting and/or leaving some trees uncut and retention of marginal shelter belts to keep dappled shade. Invasive plants suppress fruiting and could lead to the death of the the mycelium and loss of the fungi.
- Maintenance of stand species composition and continuity of appropriate mycorrhizal partner (by regeneration and/or planting).
- Prevention of damage to fruiting sites by road/track/path widening, vehicles, forestry, recreational activities, eg mountain biking, trampling, horse riding.
- Ensure nutrient levels are not raised, eg by seepage, spray drift, bonfires and creation of nearby site access points for dogs.
- Where appropriate, eg formal landscape, autumnal leaf litter should be removed by mechanical blowers not rakes.
- Collection of fruit body material for microscopic examination is important but should be restricted to minimal amounts and preferably cut with minimal aesthetic impact.

Some stipitate hydnoid fruiting sites are on streambanks, walls of abandoned burrows and other naturally-occurring earth exposures, but many are associated with historic man-made disturbance. The time elapsing from such disturbance to fruiting is not known, but it would be of interest to try to create a few suitable mounds, banks, ditches in areas of suitable trees near to, but without damage to, fruiting populations. Traditional sweet chestnut coppice management, such as the 12 year rotation currently operated at the hydnoid site at Pembury Walks, Kent, should be monitored throughout the cycle to investigate the effects on the fungal community. It would also be useful to compile data on the historic management of such sites.

7.2.4 'Broadleaved/conifer' stipitate hydnoids: ranking of sites

Pending further taxonomic studies, especially with regard to *H. scrobiculatum* and its presence outside Scotland, the six listed 'broadleaved/conifer' stipitate hydnoid species can be used as a preliminary guide to the 'best' sites in England. At least 12 sites are currently believed to have five or six species each. Most of the sites are in the well-surveyed New

Forest with two on the Crown Estate in the Ascot/Bracknell area (formerly Windsor Forest) and two in West Kent. The evidence strongly supports the enlargement of an existing SSSI on Crown Estate land to include Buttersteep, Berkshire, a top English site for stipitate hydnoid fungi. This site is in an area that has been well known for this group of fungi since the 1800s; unfortunately the only known UK site and type locality for *Sarcodon regalis* was in this area and has already been destroyed by housing development near Bracknell.

Table 11 has been compiled from data in Ewald (2002) and from the records of Weightman (in Marren 2000b) and those of Ainsworth, Lucas, Green and Pitt (unpubl.). 'IFA' denotes that the site is listed as an Important Fungus Area (applying criteria A-C) in Evans, Marren & Harper (2001). Although the New Forest as a whole is listed as an IFA, only those sites individually listed as IFA 'hotspots' are recorded as IFAs in the table. This list is by no means exhaustive, particularly with reference to the continuing finds of good sites in the New Forest. There are issues surrounding the interpretation of hydnoid records and the definition of site boundaries within the New Forest in continuous woodland series such as Mark Ash, Church Moor and Knightwood Inclosure. Use of GPS data would greatly enhance the accuracy of recording and standardisation of boundaries for site names. Further survey is anticipated to reveal several additional New Forest sites with five or six stipitate hydnoid species. Pembury Walks (Table 11) is also known as a site for *Sarcodon imbricatus/squamosus* associated with pine (M. Allison pers. comm.).

Table 11 Provisional top 12 English 'Broadleaved/conifer' stipitate hydnoid sites

				Sarco	*Phellodon*			*Hydnellum*	
Site	**Total**	**SSSI**	**IFA**	***scabr***	***confl***	***mela***	***niger***	***conc***	***spong***
Buttersteep, (*Castanea*), Berkshire. SU 9166	6	No	No	X	X	X	X	X	X
*Rapley 2-4, (*Castanea)*, Berkshire. SU 8865	6	Yes	No	X	X	X	X	X	X
Vinney Ridge B, (various*)*, New Forest. SU 263051	6	Yes	No	X	X	X	X	X	X
Holidays Hill Inclosure, (*Quercus*), New Forest. SU 2607	6	Yes	No	X	X	X	X	X	X
Mark Ash boundary, (various), New Forest. SU 248067	6	Yes	?	X	X	X	X	X	X
Set Thorns, (*Castanea*), New Forest. SU 2600	6**	Yes	Yes	X	X	X	X	X	X
Knightwood East, (various), New Forest. SU 264061	5	Yes	No		X	X	X	X	X
Worts Gutter, *(Quercus*), New Forest. SU 3602 etc	5	Yes	No		X	X	X	X	X
Stubbs Wood, *(Quercus*), New Forest. SU 3603	5	Yes	Yes		X	X	X	X	X
East End, (*Quercus*), New Forest. SZ 3697	5	Yes	Yes	X		X	X	X	X
Hosey Common, (*Quercus* and *Castanea*), West Kent. TQ 4552/53	5		No		X	X	X	X	X
Pembury Walks, (*Castanea*), West Kent. TQ 6143 etc	5	No	Yes	X	X		X	X	X

Notes for Table 11:
* Site name as in Green (2001)
** Current status of this site unknown following tree-felling operations across main fruiting area. Only two species have been recorded subsequently (A. Lucas pers. comm.). Potential recovery of hydnoid community should be monitored.

7.3 Thermophilous boletes

7.3.1 Thermophilous boletes: group members

This group of BAP species is associated with living broadleaved tree roots, often of oak and beech but the Schedule 8 royal bolete *B. regius* can also associate with sweet chestnut (Table 12). They have a predominantly southern distribution and are generally regarded as warmth-loving since peak fruiting follows hot weather in late summer. The term 'thermophilic' has been used in the mycological literature specifically for fungi whose mycelial growth has a relatively elevated temperature range (Kirk and others 2001). For this group of boletes however, summer warmth may just stimulate fruiting rather than signify true thermophily. Until this is investigated further, the term 'thermophilous' (as used in Marren 1998) is adopted herein. Some historical confusion exists in the recording of *B. regius* and *B. pseudoregius* and this may also extend to *B. fechtneri*, a species which may also develop pinkish tones in the mature cap.

Table 12 Thermophilous boletes

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	No	ectomycorrh.	Bolete	*Boletus pseudoregius*	the pretender
Yes	Yes	ectomycorrh.	Bolete	*Boletus regius*	royal bolete
No	Yes	ectomycorrh.	Bolete	*Boletus satanas*	devil's bolete

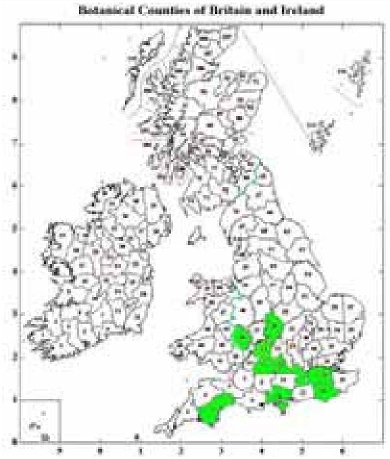
7.3.2 Thermophilous boletes: species data sheets

Species data sheets follow for *B. pseudoregius*, *B. regius* & *B. satanas*.

Boletus pseudoregius the pretender

Synonyms in recent use: *B. appendiculatus* var. *pseudoregius* (also historic confusion with *B. regius*, *B. speciosus* and *B. aemilii*).

No known distribution before 1960



Known distribution 1960 onwards

Description: fruiting singly or in small groups Aug-Oct. Cap 5-15(20) cm diam., domed becoming flatter, finely velvety, dull smoky pink or rose becoming dull copper-red or brown in sun, often remaining pinkish near the overhanging margin. Browning with handling. On cutting, good blueing reaction gives deep sky blue tint in the cap. Pores bright yellow, may redden with age, with bright greenish-blue bruising reaction fading to fawn. Stem variable, tapering or bulbous, apex bright yellow with network pattern, duller towards the base, often with reddish pink zone at the middle or base. Flesh yellowish but becoming more pinkish brown towards the stem base. Spores pale yellow-brown, slightly tapered at both ends, 10-14(15) x 4.0-5.5 µm.

Distinguishing features: distinguished from *B. regius* in blueing reaction when cut and less intense reddish tones of young cap.

Ecology: mycorrhizal with broadleaved trees, especially in parks, wood pasture etc in warm places noted for other unusual boletes, ?more likely in calcareous soils than *B. regius*.

Distribution & Status: predominantly central Europe (members of this species complex also in America). UKRDL (1992) not listed, no BAP. Since Marren's species report, Hills has concluded that the **only** reliable British herbarium material of *B. regius* that he has seen is from VC11 collected in 1987 (as "1967" in editor's note in Marren, 2000a). Hence other records currently mapped for *B. regius* would become extra records of *B. pseudoregius*.

Conservation management advice: one of a group of species in need of molecular-based studies and taxonomic revision which, with more surveys and monitoring, will lead to realistic distribution maps and better understanding of fruit body variation and ecology of the related species. Management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Soil eutrophication and felling of associated trees should be minimised, eg during scrub clearance around New Forest marl pits. Encourage collection of minimal quantities of material for research.

Published illustrations: in Courtecuisse & Duhem (1995), Marren (2000a). Probably illustrated as *B. speciosus* in Breitenbach & Kränzlin (1991).

Additional published information: Species report for *B. pseudoregius* by Marren (1998).

Young fruit body on woodbank beneath oak

© Martyn Ainsworth

Young fruit body with cap fading in strong sunlight

© Martyn Ainsworth

Localised blueing reaction of cut flesh and tubes

© Martyn Ainsworth

Boletus regius royal bolete

Synonyms in recent use: (historic confusion with *B. pseudoregius*).

Description: fruiting singly or in small groups Aug-Oct. Cap 5-15(20) cm diam., domed becoming flatter with overhanging margin, finely velvety, rich blood-red or deep reddish-pink becoming browner in sun. Pores bright yellow, no bruising reaction. Flesh of cap and stem apex pale yellow, unchanging or showing faint blueing reaction above pores, below cap skin and in stem apex when cut or bruised. Stem usually cylindrical, bright yellow with prominent network pattern, sometimes flushed pinkish below. Spores pale yellow-brown, slightly tapered at both ends, 10-16 x 3.5-5.0 µm.

Known distribution before 1960

Distinguishing features: distinguished from *B. pseudoregius* in absence of, or hardly any, blueing reaction when flesh is cut or bruised and more intense red colour of young fresh cap.

Ecology: mycorrhizal with broadleaved trees, especially oak and *Castanea* in wood pasture in warm places noted for other unusual boletes, ?more likely in acidic soils than *B. pseudoregius*.

Known distribution 1960 onwards

Distribution & Status: central and southern Europe (members of this species complex also in America). UKRDL (1992) and BAP endangered. On Schedule 8 of the Wildlife and Countryside Act 1981. Since Marren's species report, Hills has concluded that the **only** reliable British herbarium material of *B. regius* that he has seen is from VC11 collected in 1987 (as "1967" in editor's note in Marren, 2000a). Hence other records currently mapped for *B. regius* would become extra records of *B. pseudoregius*. Regarded as endangered in Austria, Czech Republic, Germany, The Netherlands (thought to be extinct), Poland and Spain.

Conservation management advice: one of a group of species in need of molecular-based studies and taxonomic revision which, with more surveys and monitoring, will lead to realistic distribution maps and better understanding of fruit body variation and ecology of the different taxa. Management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Soil eutrophication should be minimised. Ecological research needed to study population structure and colonisation process. Encourage collection of minimal quantities of material for research. Modern records urgently needed.

Published illustrations: in Bon (1987), Courtecuisse & Duhem (1995), Engel and others (1983), Kibby (1992) and Marchand (1971).

Additional published information: in Courtecuisse (1999) and Watling (1970). Species report for *Boletus regius* by Marren (1998).

Mature fruit body with oak and *Castanea*

Boletus satanas devil's bolete

Synonyms in recent use:

Known distribution before 1960

Known distribution 1960 onwards

Description: fruiting singly or in large groups Jul-Oct. Cap 5-30 cm diam., domed then undulating, sticky-velvety becoming smoother and shiny, whitish-buff becoming grey-brown with age and handling. Pores yellow then blood red but more orange at the overhanging margin and with age, bruising greenish, tubes yellowish-green with blueing reaction when cut or bruised. Flesh of cap and stem pale yellow, showing faint blueing reaction. Stem short swollen, yellow-saffron at apex, redder below (completely or just a belt) with red network pattern, sometimes flushed yellow-brownish below. Smell becoming unpleasant. Spores pale yellow-brown, slightly tapered at both ends, 11-14(16) x 4.5-6.0(7.0) µm.

Distinguishing features: distinguished from *B. legaliae* (=*B. satanoides*) which has a much pinker darker flattening cap, less swollen stem and is usually in less base-rich soil.

Ecology: mycorrhizal with broadleaved trees, especially beech and oak in glades, wood pasture, parks, verges, downland and on woodbanks in warm places, usually in calcareous soils, often with other unusual boletes.

Distribution & Status: throughout Europe but predominantly southern, N. Africa, N. America and Asia. UKRDL (1992) and BAP rare. Regarded as endangered in Denmark, Finland, Germany, The Netherlands, Poland (thought to be extinct) and Sweden.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore or mycorrhizal colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community. Careful clearance of invasive ivy, brambles etc from former sites, avoiding potential mycorrhizal tree saplings, may lead to resurgence of fruiting. Soil eutrophication should be minimised. Ecological research needed to study population structure, colonisation process and role of beetles attracted to fruit bodies.

Published illustrations: in Bon (1987), Breitenbach & Kränzlin (1991), Bresinsky & Besl (1990), Courtecuisse (1999), Courtecuisse & Duhem (1995), Garnweidner (2000), Jordan (1995), Marchand (1971), Marren (2000a), Pacioni (1985), Ryman & Holmåsen (1984) and Svrcek (1999).

Additional published information: in Phillips (1981) and Watling (1970). Species report for *Boletus satanas* by Marren (1997) with additions in Appendix 2 in species report for *B. regius* & *B. pseudoregius* by the same author (1998).

Young clustered fruit bodies in bare soil between beech roots

Mature fruit body in stony soil beneath beech

7.3.3 Thermophilous bolete sites: generic management guidelines

There are sites well-known for their long history of bolete fruiting, some of which are also important for other ectomycorrhizal species and deadwood organisms of conservation interest. The guidelines for bulky deadwood saprotrophs (Section 7.4) should also apply to bolete sites if there is also plenty of deadwood present. In addition to safety and aesthetic considerations regarding management of standing and fallen deadwood, particularly in popular and highly formal settings, there may be extra pressures to remove fallen bulky deadwood from ectomycorrhizal hotspots to nearby denser cover. However, the older trees should be retained *in situ* for as long as possible. In parkland, some of the best sites for thermophilous boletes may be with trees (often oaks) in their first few centuries of life, perhaps even with planted trees. However the presence of much older trees in the vicinity suggests a source of late-stage mycelial inoculum that should be preserved for as long as possible. Therefore, the management of these species is basically similar to that for bulky deadwood saprotrophs, but with special attention directed to management of the ground flora. In the short term, in order to see the fruiting presence of bolete species, the sward or ground cover should be kept short, whereas in order to secure fruiting presence in the longer term, there should be sufficient tree regeneration or planting. Until management strategies are informed to the contrary by laboratory-based studies, they should cater for both short-term and long-term demands whilst paying due regard to the associated saprotrophs.

The flagship conservation species for this group are the two BAP boletes but, as has been suggested by Marren (1998), conservation effort may be better directed towards a larger group of rare boletes (particularly within *Boletus* itself). Concern should certainly be broadened to include other thermophilous species, not least because this group may also usefully serve as indicators of climate change. Examples of other related boletes or bolete groups (with some attendant taxonomic and naming issues) include the following species. Numbers of BMSFRD records at September 2004 are listed in brackets for each.

Aureoboletus gentilis gilded bolete (132)
B. aereus (119)
B. appendiculatus oak bolete (232)
B. luridiformis var. *discolor* (*B. erythropus* ssp. *discolor*) (25)
B.fechtneri pale bolete (21)
B. impolitus iodine bolete (155)
B. legaliae (*B. satanoides*, *B. splendidus*)
B. pseudoregius the pretender (22)
B. pseudosulphureus (*B. junquilleus* of some authors) yellow bolete (12)
B. queletii deceiving bolete (184)
B. radicans (*B. albidus*) rooting bolete (350)
B. regius royal bolete (1 currently accepted record A. Hills pers. comm.)
B. reticulatus summer bolete (247)
B. rhodopurpureus/torosus group (number of species unknown)
B. satanas devil's bolete (135)
Gyroporus castaneus chestnut bolete (194)
Leccinum pseudoscabrum (*L. carpini*) hazel bolete (113)
L. crocipodium saffron bolete (164)
Rubinoboletus (*Chalciporus*) *rubinus* (76)

The thermophilous boletes are also likely to be good indicators for a taxonomically much wider community of mycorrhizal species whose distribution is more restricted to southern and warmer regions. Luxuriant vegetation cover is not conducive to maximal ectomycorrhizal fruiting, hence the best sites are in naturally open woodland, perhaps with thin soils, or in woodland managed as parkland or wood pasture by grazing and/or mowing and/or bracken control. The Fungus Conservation Forum also intends to consider some general management guidelines for habitats with ectomycorrhizal interest, meanwhile the following points have arisen from field observations.

The best thermophilous bolete sites:

- Have good continuity of old trees hence should aim for all age classes of trees.
- Are lightly wooded with naturally short, grazed or mown grassy ground flora.
- Are nutrient poor and may be on clay or thin soils overlying rock or gravel.
- Are often in sunny locations.
- May be rich in epiphytic lichens and mosses but poor in flowering plants.

Some thermophilous boletes, eg *Boletus satanas*, may be found on downland well away from trees and it has been suggested common rockrose might also be a woody mycorrhizal partner (Mattock 2003).

Consideration of the ground flora aspects suggests the following guidelines:

- Maintain ground flora management at current richly fruiting sites, preferably with mowing regimes relaxed at times of peak fruiting to allow fruit body maturation.
- Mechanical treatment of bracken invasion is useful but should also avoid peak fruiting period as fruit bodies can be destroyed.
- Overgrown wood pasture with more luxuriant ground flora should be considered for re-introduction of light grazing to return to conditions favouring fruit body production.
- Some areas should be left ungrazed and unmown to allow regeneration of mycorrhizal partner trees for the future. Planting creates more disturbance and is second best option.
- Contractors removing planted conifers should be made aware of, and avoid, any thermophilous bolete hotspots which may require prior summer survey.
- Collection of fruit body material for microscopic examination is important but should be restricted to minimal amounts and preferably cut with minimal aesthetic impact. Unauthorised picking of Schedule 8 species *B. regius* is illegal.

7.3.4 Thermophilous boletes: ranking of sites

The taxonomy of several members of this group is currently under review and therefore this should be allowed to stabilise before a preliminary ranking of sites is attempted. Nevertheless the Windsor and New Forest clusters of sites are already well-known for their outstanding bolete diversity. Of these, Wormstall Wood and the copse near East End Pond (New Forest) and Bishopsgate and Cranbourne (Windsor Great Park, partly private) deserve special mention. However some sites are of outstanding bolete interest, not necessarily for their species diversity, but for the sheer numbers of fruit bodies which can be produced, eg over 100 fruit bodies of *B. satanas* seen during a single visit to Blenheim Park, Oxon (Marren 1997).

7.4 Bulky deadwood species

7.4.1 Bulky deadwood species: group members

These are saprotrophs living on the deadwood of broadleaved trees (standing, fallen, felled, or attached to living trees) and usually fruiting on larger diameter, bulky elements (Table 13).

Table 13 Bulky deadwood species

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	No	saprotroph	Toothed bracket	*Hericium cirrhatum*	tiered tooth
No	No	saprotroph	Toothed bracket	*Hericium coralloides*	coral tooth
Yes	Yes	saprotroph	Toothed bracket	*Hericium erinaceum*	bearded tooth
Yes	Yes	saprotroph (oak heartwood)	Poroid bracket	*Piptoporus quercinus* (=*Buglossoporus pulvinus*)	oak polypore

7.4.2 Bulky deadwood species: species data sheets

Species data sheets follow for *H. cirrhatum*, *H. coralloides*, *H. erinaceum* & *P. quercinus*.

Hericium cirrhatum tiered tooth

Synonyms in recent use: *Creolophus cirrhatus*

Description: fruiting in Jul-Nov. Fruit bodies are irregular fused masses of rubbery whitish warty-spiky caps, browning with age, 5-40 cm diam. No distinct stem. Spines hanging below caps are whitish, 5-15 mm long, browning with age. Spores ellipsoid, smooth, 3.0-4.5 x 2.5-4.0 µm.

Distinguishing features: distinguished from other *Hericium* species in fruiting as fused tiers of bracket-like caps without coralloid branches.

Ecology: saprotrophic on wood of broadleaved trees, usually on fallen trunks and detached branches. Most frequently seen on beech and often fruiting in sites with long continuity of tree cover and noted for dead-wood fungal diversity. Can fruit on relatively undecayed wood.

Distribution & Status: throughout Europe, N. America, Asia. UKRDL (1992) vulnerable, no BAP.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore colonisation. Essential to leave dead wood *in situ* or remove from highly formal landscapes to safety of nearby woodland. Has fruited on felled turkey oak trunks when fungus already present at a site. Ecological research needed to study population structure, colonisation process and competitive behaviour. Research required to investigate how fungus responds to availability of freshly fallen or cut wood placed in vicinity of fruit bodies.

Published illustrations: in Bon (1987), Breitenbach & Kränzlin (1986), Jordan (1995), Marchand (1976), Pegler, Roberts & Spooner (1997), Phillips (1981) and Ryman & Holmåsen (1984).

Additional published information: in Dickson (2000), Stalpers (1996) and Wicks (1999). Species report for *H. cirrhatum* in England by Boddy & Wald (2002).

Known distribution before 1960

Known distribution 1960 onwards

Immature on felled turkey oak trunk in deer park

© Martyn Ainsworth

Mature on felled turkey oak

© Martyn Ainsworth

Hericium coralloides coral tooth

Synonyms in recent use: *H. clathroides*, *H. ramosum*.

Description: fruiting in Aug-Dec. Fruit bodies are irregular masses of rubbery whitish coralloid branches on main stem, browning with age, 5-40 cm diam. No distinct caps. Spines hanging below branches are whitish, 5-10 mm long. Spores ellipsoid, finely roughened, 3.5-5.0 x 3.0-4.0 µm.

Distinguishing features: distinguished from other *Hericium* species in fruiting as a mass of comb-like branches without any bracket-like caps. *H. alpestre* (*H. flagellum* group) is similar but occurs on coniferous wood with slightly larger spores. Photos with caption *H. coralloides* in Breitenbach & Kränzlin (1986) and Marchand (1976) are probably of a member of the *H. flagellum* group of species.

Ecology: saprotrophic on standing or fallen dead parts of trunks and branches of broadleaved trees, most frequently seen on fallen trunks and logs of beech and often fruiting in sites with long continuity of tree cover and noted for deadwood fungal diversity. Wood supporting annual flushes of fruit bodies usually disintegrates within a few years.

Distribution & Status: Europe and N. America. UKRDL (1992) vulnerable, no BAP.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore colonisation. Essential to leave dead wood *in situ* or remove from highly formal landscapes to safety of nearby woodland. Ecological research needed to study population structure, colonisation process and competitive behaviour. Research required to investigate how fungus responds to availability of freshly fallen or cut wood placed in vicinity of fruit bodies.

Known distribution before 1960

Known distribution 1960 onwards

Published illustrations: in Bon (1987), Courtecuisse (1999), Garnweidner (2000), Marren & Dickson (2002), McCarthy (1996), Pegler, Roberts & Spooner (1997), Phillips (1981) and Ryman & Holmåsen (1984).

Additional published information: in Dickson (2000), Stalpers (1996) and Wicks (1999). Species report for *H. coralloides* in England by Boddy & Wald (2002).


Immature on fallen beech trunk
© Martyn Ainsworth


On fallen beech trunk
© Martyn Ainsworth


On fallen beech trunk in bracken
© Martyn Ainsworth

Hericium erinaceum bearded tooth

Synonyms in recent use:

Description: fruiting in Aug-Dec. Fruit bodies are irregular rubbery whitish bulbous rounded masses, browning with age, 5-40 cm diam. Thick stemmed but no distinct caps or coralloid branches. Crowded hanging spines dominate the fruit body and are whitish, 10-40 mm long. Spores ellipsoid, finely warted, 5-7 x 4-6 µm.

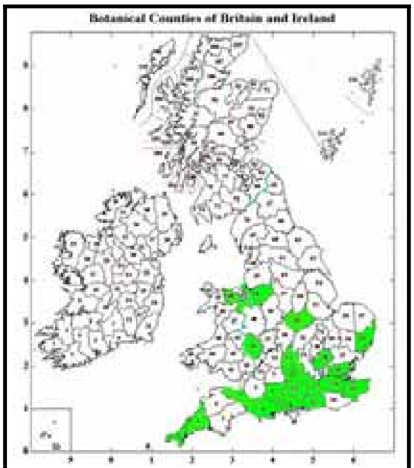
Distinguishing features: distinguished from other *Hericium* species in fruiting as a rounded mass without obvious branches or bracket-like caps. It has longer spines than the other British species.

Ecology: saprotrophic on broadleaved trees and often fruiting on damaged parts (wounds, broken branch stubs etc) of old standing beech, sometimes high up, but also persisting on fallen branches, in sites with long continuity of tree cover and noted for dead-wood fungal diversity. Some trees have supported intermittent fruiting over several decades.

Known distribution before 1960

Distribution & Status: Europe, Asia and N. America. UKRDL (1992) vulnerable, BAP endangered. On Schedule 8 of the Wildlife and Countryside Act 1981. Regarded as endangered in Armenia, Austria, Bulgaria, Denmark, Germany, Greece, Holland, Macedonia, Poland, Sweden, Switzerland.

Conservation management advice: management largely depends on devising ways of ensuring continuity of suitable trees for spore colonisation. Essential to leave dead wood *in situ* or remove from highly formal landscapes to safety of nearby woodland. Ecological research needed to study population structure, colonisation process and competitive behaviour. Research required to investigate how fungus responds to availability of freshly fallen or cut wood placed in vicinity of fruit bodies. Tests also required to evaluate effect of re-erecting colonised trunks (or upper parts thereof) after windthrow to attempt to maintain existing moisture regime and delay competitive fungal colonisation from woodland litter.



Known distribution 1960 onwards

Published illustrations: in Bowen (2000), Courtecuisse (1999), Jordan (1995), Marchand (1976), Marren & Dickson (2002), McCarthy (1996), Pacioni (1985), Pegler, Roberts & Spooner (1997), Phillips (1981) and Ryman & Holmåsen (1984).

Additional published information: in Dickson (2000), Stalpers (1996) and Wicks (1999). Species report for *H. erinaceum* in England by Boddy & Wald (2002).

On standing live beech
© Martyn Ainsworth

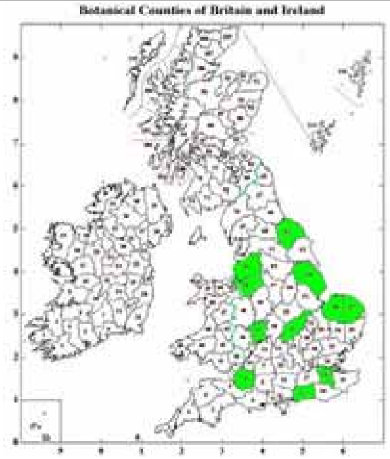
On standing live beech
© Martyn Ainsworth

On standing live beech
© Martyn Ainsworth

Piptoporus quercinus oak polypore

Synonyms in recent use: *Buglossoporus quercinus* and *B. pulvinus*.

Description: fruiting singly or clustered Jun-Aug, usually lasting for a few weeks but rarely dried remnants visible for 1 y. Bracket or cushion shaped <20 cm diam. and <5 cm thick. Initially white, soft and juicy, bruising lilac then rusty brown, with age becoming drier and tougher with gold then browner concentric zones on upper surface of cap which is finely velvety becoming smooth and skin-like. Lower surface is whitish developing pores, 2-4 per mm., becoming yellow-brown after maturity. Narrow point of attachment, rarely a stem. Flesh whitish flushed magenta and/or yellow. Spores whitish, curved cylindrical, 6-9 x 2.5-4.0 µm.



Known distribution before 1960

Known distribution 1960 onwards

Distinguishing features: easily identified when accessible and in good condition in July, but if young it can resemble several bracket fungi (eg *Ganoderma resinaceum*) and should be revisited later. Aborted or decaying remnants require microscopy to eliminate possibility of chicken of the woods *Laetiporus sulphureus* and beefsteak fungus *Fistulina hepatica*.

Ecology: saprotroph causing a brown cubical heartwood rot in dead or live oaks, fruiting on exposed heartwood (sawn, standing or fallen), root plates, buttresses or through cracked bark of live or dead trunks and branches. Can fruit inside hollow trees, in log piles and on trunks that have fallen decades ago. Usually seen in sites with good populations of veteran oaks and long continuity of oak presence especially parkland, deer parks and wood pasture.

Distribution & Status: Europe, mostly southern, and Asia. UKRDL (1992) and BAP endangered. On Schedule 8 of the Wildlife and Countryside Act 1981. Stronghold in Windsor of 80+ oaks. Regarded as endangered in Germany, Norway and Poland.

Conservation management advice: management largely depends on retaining as many old oaks and as much dead wood on or as near to the tree as possible and devising ways of ensuring continuity of suitable trees for spore colonisation (by regeneration &/or planting) whilst minimising threats to existing fungal community (eg mycorrhizal species). Ecological research needed to study population structure and colonisation process. Encourage authorised collection of minimal quantities of material for research, a 1cm wide sliver of mature fruit body with pores is sufficient for microscopic confirmation of identification.

Published illustrations: in Dagley (2001), Ellis & Ellis (1990), Green (1993, 2000), Ryman & Holmåsen (1984), Vesterholt & Knudsen (1990) and Wöldecke (1998).

Additional published information: in Evans (2001), Ryvarden & Gilbertson (1994) and Stalpers (1978). Species report for *P. quercinus* by Roberts (2002).

Immature on fallen oak branch

On dead standing oak trunk

Post-mature on seasoned fallen oak trunk

7.4.3 Bulky deadwood species: generic management guidelines

The primary conservation focus is *not* on common pioneer communities of twigs and small branches, but on the scarcer inhabitants of the scarcer microhabitats which exist in larger diameter (older) deadwood elements. In some of the relevant literature these are described as coarse woody debris (CWD). Although this terminology seems justified when applied to fallen branches and even trunks, it is felt that it is less appropriate for standing dead trees and the *in situ* dead parts of living trees. The saprotrophs of interest are found in all deadwood locations including the central deadwood cylinder of living trees, with or without distinct heartwood. Hence CWD seems too narrow a concept and is perhaps better regarded as a subset of the wider range of deadwood microhabitats under consideration. Moreover, the connotations associated with the term 'debris' are unlikely to enhance the conservation profile of ancient trees and their recycling fungal partners.

'Old-growth' has also been used in the context of large diameter wood, unfortunately it has not been restricted to the woody elements themselves. It has confusingly been applied to entire woodlands, their characteristic fungi and even used to characterise woodlands with such fungi. One issue arising from this imprecision, as discussed in Section 4 in relation to ectomycorrhizas, is that the some so-called late-stage ('old growth'-associated) species are also found fruiting in plantations where no 'old growth' currently exists. Although care should therefore be taken in application of 'old growth' in a mycorrhizal context, not enough is known of the timing of the establishment phase of deadwood saprotrophic SoCC to comment on the possibility of associations between young trees and 'old growth' decay fungi.

The deadwood species of interest fruit on larger diameter wood which is more abundant on and near older trees and in older woodlands with long continuity of uneven aged tree cover. Since these species also eventually eat themselves out of a habitat, a saprotrophic diversity hotspot will inevitably subside into a mere epicentre of spore dispersal unless the fungi are provided with a suitable supply of bulky wood. In Western Europe, natural deadwood supply is subjected to major periodic fluctuations following catastrophic storm damage. Larger sites may therefore have a long term advantage in having a greater pool of woody resources to buffer against the 'feast and famine' which might befall saprotrophs in smaller isolated sites. In large sites, or a mosaic of sufficiently close sites, hotspots of saprotrophic fruiting may be a naturally transient feature, moving around the site over the centuries.

Evidence from the BMS database and personal experience supports the view that there are indeed sites which have a long wooded history, diversity of tree age classes, plenty of bulky dead wood and continued presence of their associated saprotrophs. These sites should be located, inventoried, mapped, assessed for existing protection and prioritised for conservation action. This would be greatly facilitated by compilation of site-based dossiers.

Conservation of fungi in habitats as complex and diverse as woodlands highlights the potential for ecologically-based conflicts of interest. These might arise unless there is clarity regarding the fungal interest across a site. Even within a mycological context, different ecological demands may require some compromise and accommodation. For example, is a woodland area to be managed for saprotrophic, ectomycorrhizal or a combination of fungal interests? A substantial build-up of fallen deadwood and other litter may promote fruiting of saprotrophs but suppress that of ectomycorrhizals. In the absence of laboratory-based sampling, we still need to see fruiting to know that a species is present. There is an inherent danger that this approach might easily develop into fungal management based entirely on the promotion of visible fruiting without due regard for the mycelium and its dynamics. Indeed studies of the below-ground consequences of chronic fruiting suppression or promotion would be very interesting topics of ecological research with direct conservation relevance.

There are varying degrees of selectivity shown by macrofungi towards the bulky wood of particular tree species. For example, oak has a small number of characteristic species, some of which may also be found on sweet chestnut, whereas beech has a greater diversity, many of which will also be found on other species such as hornbeam, ash and elm. Conservation effort should be directed towards a larger suite of fungi characteristic of bulky deadwood substrata and a suggested list for beech has recently been formulated with some preliminary validation in Ainsworth (2004).

The Fungus Conservation Forum intends to prepare a leaflet outlining some general management guidelines, meanwhile the following points have arisen from field observations.

The best bulky deadwood species sites:

- Have good continuity of old trees and representatives of all age classes.
- Have plenty of standing and fallen deadwood of all age and decay classes.
- Often have good deadwood (saproxylic) invertebrate interest.
- May be open and rich in epiphytic lichens and mosses but not necessarily rich in flowering plants.

The requirement for continuity indicates that good sites would be expected to include ancient woodlands and hunting forests, medieval deer parks, wood pasture, wooded commons, estate/monastic woodlands and wooded scarps or other agriculturally intractable land such as willow swamps and alder carrs. In addition, avenues, clumps and individual trees are also important for saprotrophs, whether in hedgerows or more isolated in fields and on roadsides. Read (2000) has produced a guide to good management of veteran trees which considers trees as ecosystems rather than individuals and therefore includes conservation of associated fungi. The basic principle is to conserve as much of an old tree in the living state as possible because this will ultimately provide the greatest diversity of habitat for saprotrophs. Of course, any management guidelines to look after trees for their saprotroph interest should also include prevention of damage to their mycorrhizal partners and might include:

- Allow trees to grow old, become hollow, die and collapse *in situ* if possible. In formal or other settings popular with visitors, the second best option is proactively to keep as much of the tree standing for as long as possible by reduction of canopy weight (with removal of fallen and cut branches and eventually the unsafe or collapsed remnants to nearby woodland if not acceptable to leave near the tree).
- Gradual phased release (not by clear-felling) of old open-grown trees from competition from invasive or planted neighbouring trees whilst avoiding destruction of deadwood and compaction of mycorrhizas during extraction. If possible leave felled broadleaved trees, eg turkey oak, to decay on site. Work should avoid very dry and very wet periods (avoids desiccation damage and creation of flooded ruts which may facilitate waterborne spread of pathogenic *Phytophthora* spp. including the sudden oak death organism). No fires near old trees.

- *Rhododendron* stump removal should avoid tearing through fruiting patches of ectomycorrhizal species (see Section 7.2).
- Avoid widespread major disturbance and soil compaction from heavy plant and vehicle ruts, car parks, machinery, construction, dumping and digging.
- Consider restoration pollarding to increase life expectancy of standing trees.
- Respect exclusion zone surrounding trees in or at margins of arable fields. Ideally this is an uncultivated island stretching to 5m beyond the extent of the canopy or to 15 times the diameter of the trunk away from the centre of the trunk (Read 2000). Similar zones of rough grass to surround trees on amenity land.
- Reduce likelihood of fires by bracken management. If mechanically bruising fronds, this should avoid peak fruiting period for thermophilous boletes (often August, but variable) and destruction of concealed deadwood.
- If possible, divert well-used paths and tracks away from immediate vicinity of ancient trees.
- Ensure regeneration (and planting where more appropriate) can occur with protection from grazing to try to maintain age structure of trees.
- Collection of fruit body material for microscopic examination is important but should be restricted to slivers about 1cm wide and preferably cut with minimal aesthetic impact. Unauthorised picking of Schedule 8 species *Hericium erinaceum* (edible) and *Piptoporus quercinus* is illegal.

7.4.4 Bulky deadwood species: ranking of sites

This resource provides a habitat for a wide range of species from several genera and to some extent each tree species provides a different resource. Hence it would not be meaningful to compare the species diversity of large diameter wood in an alder carr with that in a beech or oak woodland. Preliminary work has been carried out using a proposed list of fungal indicators for assessing the quality of beech deadwood sites in England (Ainsworth 2004). This study also uses a European-based list of indicator species to compare sites from various countries on a presence or absence basis. The top ten beech deadwood sites currently known are shown in Table 14. Although England has some of the youngest post-glacial beechwoods in Europe, nevertheless several well-known beech-dominated sites compared favourably with less degraded and fragmented beech forest sites in the central European core regions for beech.

Table 14 English beech sites ranked with other European sites according to presence of 21 European saprotrophic indicators showing top site for each country in grey and number of sites surveyed (from Ainsworth 2004)

No. of sites surveyed per country (Total = 126)	Ranked by European score	Country	Site name	European score from 21 possible
4	1=	Slovakia	Stuzica	16
	1=	Slovakia	Rozok	16
1	3=	Czech Republic	Zofin	15
1	3=	France	Fontainebleau (Tillaie and Gros Fouteau)	15
25	5	Denmark	Jægersborg Dyrehave	14
	6=	Slovakia	Havesová	13
14	6=	England	Wood Crates, New Forest	13
	6=	Denmark	Strødam	13
	9=	Denmark	Suserup	12
	9=	England	Denny Wood area, New Forest	12

Since these sites vary considerably in extent and duration of survey, it is also of interest to combine the results for some of the English habitat mosaics, such as the five New Forest sites and two Windsor Forest sites analysed since 1970. The New Forest quintet produced a combined score of 15 and the Windsor pair yielded a score of 12. It should be borne in mind that of the 21 indicators chosen in this pan-European list, the maximum possible score for an English site is currently 16. The remaining five species are currently excluded on the grounds that they are not on the British list, have not been recorded on British beech or have many records requiring careful interpretation. Nevertheless, the results clearly bolster the assertion that England has internationally important deadwood sites for fungi.

7.5 Litter/woody debris species

7.5.1 Litter/woody debris species: group members

One species (Table 15) has been identified as of high conservation value and is probably associated with dead wood fragments in litter (but details unknown) usually hedgerow, roadside or parkland trees. It has a southern distribution in the UK.

Table 15 Litter/woody debris species

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
Yes	Yes	saprotroph	Stalked puffball	*Battarrea phalloides*	sandy stiltball

7.5.2 Litter/woody debris species: species data sheet

A species data sheet follows for *B. phalloides*.

Battarrea phalloides sandy stiltball

Synonyms in recent use: several spelling variations exist eg *Battarraea* (also historic confusion with *B. stevenii*, a synonym for some authors).

Description: fruiting singly or in groups with autumn peak production but can fruit in any season. Initially egg-like, buried, brownish, 3-4 cm diam., splitting to form basal bag with gelatinous lining and apical cap on emergence of 9-35 cm high stem. Stem initially with gelatinous coat, becoming dry, scaly, woody and persistent with buff-orange brown tint. Apical cap and membrane rupturing to expose domed head bearing powdery rusty brown spore mass. Spores subglobose with warts and ridges, 5-6.5 µm diam. eventually coating surrounding vegetation.

Distinguishing features: *B. stevenii* is distinguished by some authors by the larger fruit body and absence of gelatinous structures when young.

Ecology: usually in sandy or other warm dry soil, in southern and eastern England near various species of roadside, hedgerow and parkland trees, sometimes in debris within base of hollow trees. Saprotrophic, but details of materials colonised are still required. Reliably fruiting at some sites.

Distribution & Status: Europe, the Americas, Africa and Australia although some records are of *B. stevenii*. UKRDL (1992) and BAP endangered. On Schedule 8 of the Wildlife and Countryside Act 1981. Regarded as endangered in Austria, Germany and Poland.

Conservation management advice: occurrence on banks and verges indicates main threats are from road and building works. Associated hedge/verge cutting may stimulate fruiting provided the ground is not disturbed. Overgrowth by vegetation may suppress fruiting. Successfully managed on roadside nature reserve by Suffolk Wildlife Trust. Ecological research needed to study population structure, colonisation process and effects of roadside management on mycelium. Taxonomic research required to clarify species concepts and improve knowledge of distribution.

Known distribution before 1960

Known distribution 1960 onwards

Published illustrations: in Bon (1987), Courtecuisse (1999), Courtecuisse & Duhem (1995), Fortey (1998), Jordan (1995), Pegler, Læssøe & Spooner (1995) and Phillips (1981).

Additional published information: in Ellis & Ellis (1990), Evans (2001), Marren (1995), Telfer, Lambdon & Gurney (2000) and Viney (1999).

Roadside habitat showing thick brown spore deposit coating surrounding plants and litter

Suffolk roadside verge habitat

7.5.3 Litter/woody debris species: generic management guidelines

Hedge and verge sites inhabited by *Battarrea phalloides* should be protected from destruction during road and building works. Verges should not be allowed to get overgrown with tall vegetation and fruiting bodies should not be destroyed by maintenance works (if avoidable). More information is required on the types of resources required by this fungus in order to devise more prescriptive guidelines. The unauthorised picking of Schedule 8 species *B. phalloides* is illegal.

7.6 Species ?parasitic on fungi or saprotrophic on wood

7.6.1 Species ?parasitic on fungi or saprotrophic on wood: group members

These species (Table 16) are associated with dead wood of broadleaved trees such as hazel, blackthorn, and willows with a predominantly western distribution (at least for *H. rhododendri*). *Hypocreopsis* may (?always) be parasitic on wood-rotting fungi of the basidiomycete genus *Hymenochaete*, but further study is required.

Table 16 Species ?parasitic on fungi or saprotrophic on wood

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	No	?	Stromatic asco	*Hypocreopsis lichenoides*	willow gloves
No	Yes	?	Stromatic asco	*Hypocreopsis rhododendri*	hazel gloves

7.6.2 Species ?parasitic on fungi or saprotrophic on wood: species data sheets

Species data sheets follow for *H. lichenoides* & *H. rhododendri*.

Hypocreopsis lichenoides willow gloves

Synonyms in recent use:

Description: fruiting within conspicuous lumpy orange-brown radiating patches (stromata) resembling crustose lichen, <10 cm diam., with paler margins, becoming increasingly lobed with strap-like fingers. When fruiting, stromatal centre becomes dotted with minute darker ostioles (pores leading to microscopic spore-producing chambers in flesh below). Ascospores, ejected from ostioles into the air, are white, finely roughened, relatively narrow, tapered at both ends, 2-celled, 16-30 x 6-9 µm.

Known distribution before 1960

Known distribution 1960 onwards

Distinguishing features: very similar to *Hypocreopsis rhododendri* usually seen on hazel, but microscopy of mature spores is required.

Ecology: stromata found all year round on and sometimes girdling branches and woody stems, predominantly of *Salix*, but also seen on hazel. Associated with (?parasitic on) the brown bracket/crust fungus *Hymenochaete tabacina* (not frequently recorded in UK). May favour damper woods, but UK distribution not as oceanic as *H. rhododendri*.

Distribution & Status: Canada, USA, predominantly northern and central Europe. UKRDL (Ing 1992) endangered, no BAP.

Conservation management advice: all likely woodland habitats and certainly those with known *Hymenochaete tabacina* records should be surveyed to produce a realistic distribution map as this species may be on the brink of extinction. Originally described from English material collected in 1790, but no English records since 1968. Welsh site, although recently damaged, should continue to be monitored and old sites and environs surveyed to try to rediscover it and gain more ecological data. Sampled material could be saved for use in molecular study of *Hymenochaete* association and population structure. Encourage collection of minimal quantities of material for research, a 1cm wide sliver of mature fruit body with ostioles is sufficient for microscopic confirmation of identification. Management should focus on protecting *Salix* at and near known sites from shading and damage from forestry/woodland management operations. Cutting of *Salix* and dead wood removal should be avoided.

Published illustrations: in Candoussau (1990), Courtecuisse (1999), Dennis (1975, 1981), Ellis & Ellis (1997), Niemelä & Nordin (1985), Rossman and others (1999), Ryman & Holmåsen (1984) and Seaver (1910).

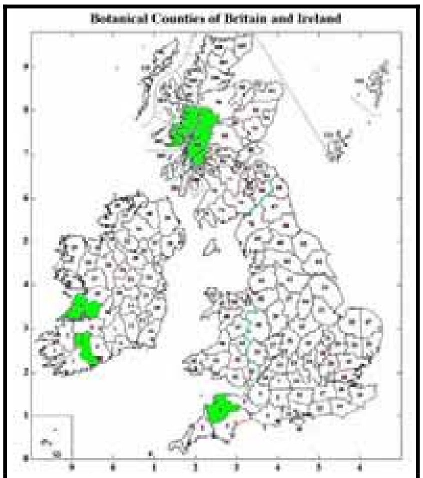
Additional published information: in Cauchon & Ouellette (1964) and Hansen & Knudsen (2000). Noted in species report for *H. rhododendri* in England by Ainsworth (2003b).

Hypocreopsis rhododendri hazel gloves

Synonyms in recent use:

New British record in 1973

Description: fruiting within conspicuous lumpy orange-brown radiating patches (stromata) resembling crustose lichen, <20 cm diam., with paler margins, becoming increasingly lobed and component strap-like fingers reaching <5 mm width. When fruiting, stromatal centre becomes dotted with minute darker ostioles (pores leading to microscopic spore-producing chambers in flesh below). Ascospores, ejected from ostioles into the air, often adhere in short chains and are white, coarsely warty, shortly ellipsoid, usually 2-celled, 12-17(25) x 12-13.5(17) µm.



Known distribution 1960 onwards

Distinguishing features: very similar to *Hypocreopsis lichenoides* usually seen on *Salix*, but microscopy of mature spores is required.

Ecology: stromata found all year round on and sometimes girdling branches and woody stems, predominantly of hazel, but also seen on blackthorn, rose and *Salix.* Associated with (?parasitic on) the brown crust fungus *Hymenochaete corrugata.* Oceanic distribution with strongholds in undisturbed Atlantic hazelwoods of W. Scotland (>200 stromata seen Mar-May 2000) and Eire. Indicator of high-quality old-growth hazelwoods supporting important lichen assemblages in W. Scotland.

Distribution & Status: Eire, France and USA. UKRDL (Ing 1992) rare, BAP vulnerable.

Conservation management advice: all likely Atlantic (western) hazel and blackthorn habitats should be surveyed to produce a realistic distribution map. N. Devon/Cornwall border and surrounding area requires detailed surveying/monitoring to provide ecological data, sampled material could be saved for use in molecular study of *Hymenochaete* association and population structure. Encourage collection of minimal quantities of material for research, a 1cm wide sliver of mature fruit body with ostioles is sufficient for microscopic confirmation of identification. Management should focus on balancing site grazing intensity and hazel regeneration, possibly requiring temporary fencing. Reinstating lapsed coppice cycles and dead wood removal should be avoided.

Published illustrations: in Candoussau (1990), Candy & Webster (1988), Coppins, Coppins & Quelch (2002), Dennis (1975) and Watling and Ward (2003).

Additional published information: in Cauchon & Ouellette (1964) and Coppins & Coppins (1997). Species report for *H. rhododendri* in England by Ainsworth (2003b) and in Scotland by Coppins and Coppins (2000).

Immature stroma on hazel branch in spring

7.6.3 Species ?parasitic on fungi or saprotrophic on wood: generic management guidelines

Little progress can be made with guidelines until more is known about the ecology and distribution of these species. However it is known that Atlantic (western oceanic) hazelwoods are one of their important habitats.

Hazel coppicing is often regarded as a positive conservation management tool for many organisms and yet it would undoubtedly impact negatively on *H. rhododendri*. This fungus is found predominantly in Atlantic hazel and blackthorn woodland in Scotland and Eire. This habitat is also known for its lichenological interest but is a hitherto neglected habitat from a conservation perspective (Coppins & Coppins 2000). In England, the ecology of this species and its distribution around known sites near the Devon/Cornish border remains unclear. The Scottish experience would indicate that hazel coppicing and grazing inhibition of hazel regeneration are major threats. It is important to investigate the resource relations of this species (and of *H. lichenoides*), ie parasitic on a saprotrophic fungus or saprotrophic on wood.

7.7 Waxcap grassland species

7.7.1 Waxcap grassland species: group members

These are members and relatives of the agaric genera *Hygrocybe*, *Camarophyllopsis*, *Dermoloma*, *Entoloma*, *Porpoloma*; the earthtongue family Geoglossaceae; and the coral and club family Clavariaceae (Table 17). They are associated with short turf of unimproved grassland which may be floristically species-poor and are becoming popularly known as waxcap grasslands. Their mode of nutrition is currently assumed to be saprotrophic. This is under investigation at University of Wales, Aberystwyth, with preliminary results in Griffith, Easton & Jones (2002).

Table 17 Waxcap grassland species

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	Yes	?saprotroph	Waxcap	*Hygrocybe calyptriformis*	pink waxcap
No	Yes	?saprotroph	Waxcap	*Hygrocybe spadicea*	date waxcap
No	Yes	?saprotroph	Earthtongue	*Microglossum olivaceum*	olive earthtongue

7.7.2 Waxcap grassland species: species data sheets

Species data sheets follow for *H. calyptriformis*, *H. spadicea* & *M. olivaceum*.

Hygrocybe calyptriformis pink waxcap

Synonyms in recent use: *Hygrophorus calyptriformis* (epithet is also in literature as *calyptraeformis*).

Description: fruiting singly or in groups Aug-Dec. Cap 3-7 cm diam., 5-8 cm tall, narrow, pointed and conical then splitting from the margin, slightly greasy at first becoming silky, rose pink fading with age. Gills pinkish, rather widely spaced, not or barely attached to the stem. Stem 6-15 x 0.5-1.5 cm without any ring, dry, whitish (cap colour in var. *domingensis*), fibrous, hollow and brittle. Flesh whitish or pink. Spores white shortly ellipsoid, 6-9 x 4.5-7.0 µm.

Distinguishing features: distinctive and unlikely to be misidentified.

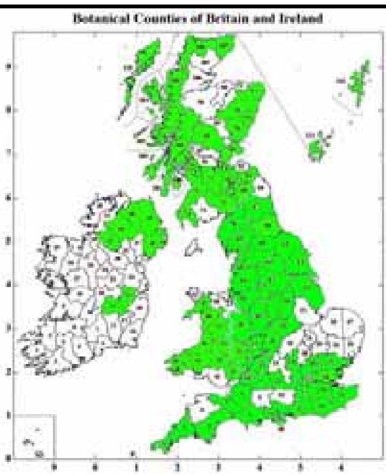
Ecology: fruiting in old, undisturbed, unfertilised grassland (cemeteries, churchyards, lawns and meadows), currently assumed to be saprotrophic on grasses and/or mosses.

Known distribution before 1960

Distribution & Status: Europe, North America and Asia. UKRDL (Ing 1992) vulnerable, BAP low risk. Regarded as endangered in Austria, Denmark, Germany, Italy, Poland, Switzerland and former Yugoslavia.

Conservation management advice: pending results of ecological research, management advice is based on conservation of fruiting populations. Fruiting requires maintenance of low nutrient levels and a short sward by grazing or frequent mowing (clippings removed if possible) and avoidance of fertilisers (no applications of any chemicals). Maintain current drainage patterns and avoid physical disturbance, eg excavation, ploughing. Invasive non-grazed plants may require removal or mowing if practicable.

Published illustrations: in Arnolds (1990), Boertmann (1995), Bon (1987), Breitenbach & Kränzlin (1991), Courtecuisse (1999), Courtecuisse & Duhem (1995), Fortey (2000) and Phillips (1981).



Known distribution 1960 onwards

Additional published information: in ECCF (2001). Species report in assessment of waxcap-grasslands in England by Evans (2004).

Fruit bodies showing the highly distinctive and characteristically conical pink cap

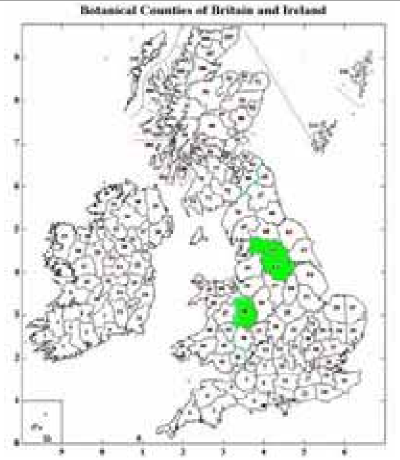
Hygrocybe spadicea date waxcap

Synonyms in recent use: *Hygrophorus spadiceus*

Description: fruiting singly or in small groups Aug-Dec. Cap 3-8 cm diam., conical then flattening with central hump, slightly greasy at first becoming silky and splitting from the margin, pale to chestnut or olive brown. Gills bright yellow, rather widely spaced, not or barely attached to the stem. Stem 4-9 x 0.5-1.2 cm without any ring, dry, bright yellow, fibrous, solid but brittle. Flesh whitish or pale yellow. Spores white, shortly ellipsoid, 9-12.5 x 4.5-8 µm.

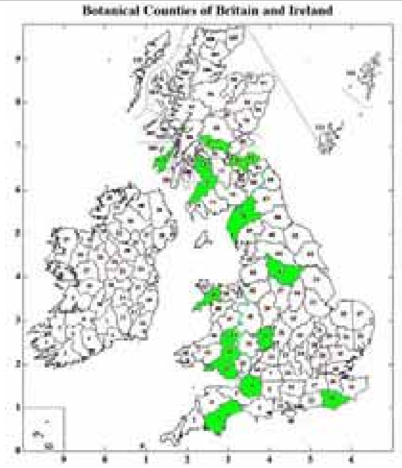
Distinguishing features: distinctive and unlikely to be misidentified.

Ecology: fruiting in old, undisturbed, unfertilised, dry, limy or neutral grassland (pastures, dunes, commons), currently assumed to be saprotrophic on grasses and/or mosses.



Known distribution before 1960

Distribution & Status: Europe, North America, Asia and New Zealand. UKRDL (Ing 1992) and BAP vulnerable. Regarded as endangered in Denmark, Germany, Poland and Sweden.



Known distribution 1960 onwards

Conservation management advice: pending results of ecological research, management advice is based on conservation of fruiting populations. Fruiting requires maintenance of low nutrient levels and a short sward by grazing or frequent mowing (clippings removed if possible) and avoidance of fertilisers (no applications of any chemicals). Maintain current drainage patterns and avoid physical disturbance, eg excavation, ploughing. Invasive non-grazed plants may require removal or mowing if practicable. Some dune turf populations with public access may require protection from trampling and destruction.

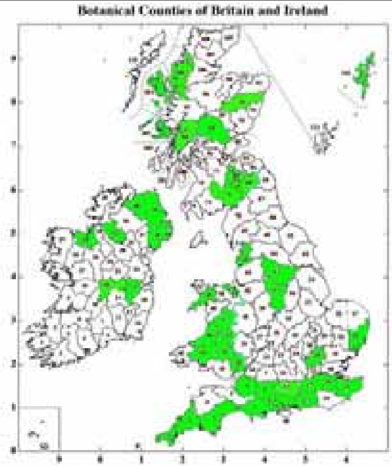
Published illustrations: in Arnolds (1990), Boertmann (1995), Bon (1987), Courtecuisse (1999), Courtecuisse & Duhem (1995) and Pacioni (1985).

Additional published information: Species report in assessment of waxcap-grasslands in England by Evans (2004).

Fruit bodies with distinctive yellow stipes and gills

Microglossum olivaceum olive earthtongue

Known distribution before 1960



Known distribution 1960 onwards

Synonyms in recent use: brown and pink variants may be respectively *M. fuscorubens* and *Geoglossum carneum.*

Description: fruiting singly or in clusters as slender, cylindrical, club-shaped or spatula-shaped 'tongues', smooth or slightly furrowed, Sep-Nov. 1-5 cm high, variable shades of olive greenish but can be more blue-green, brown, purple or pink. The smooth or shiny sterile stem supports a fertile, spore-producing head. Stem can be brighter than head and green when the head is brown. Flesh whitish or brownish, faintly scented on cutting. Spores pale, narrow, tapered at both ends, sometimes curved, with inconspicuous or no crosswalls within, 14-21 x 4-5 µm.

Distinguishing features: green variants distinguished from *Microglossum viride* by smooth stipe (beware of young *M. viride* before stem becomes scurfy), but colour variants require microscopy and experience of genus for accurate identification.

Ecology: fruiting in old, undisturbed, unfertilised, grassland (cemeteries, churchyards, lawns and pastures), currently assumed to be saprotrophic on grasses and/or mosses. Sites usually well-drained and sometimes calcareous to some extent. May favour fruiting on thinner soils on rocky outcrops in undisturbed grassland. Rarely fruiting in limestone woodland. May not fruit every year and fruiting enhanced during wet mild autumns.

Distribution & Status: Europe, North America, Asia and Australasia. UKRDL (Ing 1992) and BAP vulnerable.

Conservation management advice: all likely grassland habitats (including shell-sand machair) should be surveyed to produce a realistic distribution map. Pending results of ecological research, management advice is based on conservation of fruiting populations. Fruiting requires maintenance of low nutrient levels and a short sward by grazing or frequent mowing (clippings removed if possible) and avoidance of fertilisers (no applications of any chemicals or additional dung). Maintain current drainage patterns and avoid physical disturbance, eg excavation, ploughing. Invasive non-grazed plants may require removal or mowing if practicable. May benefit from some past localised disturbance, perhaps as a result of looser soil or more open vegetation, as judged from fruiting density associated with moderate trampling (human or sheep), roadside turf, ancient trackway banks, and limestone quarry edges/spoil heaps. Populations subjected to adverse impacts (eg fertiliser application) should be monitored to assess fruiting decline and any recovery potential in the years following impact.

Published illustrations: in Dennis (1981) and Ryman & Holmåsen (1984).

Additional published information: Species report in assessment of waxcap-grasslands in England by Evans (2004) and report on *M. olivaceum* by Silverside (2000).

Earthtongue cluster showing smooth stipe (left)

© Martyn Ainsworth

Glossy olive fertile heads

© Gordon Dickson

7.7.3 Waxcap grasslands: generic management guidelines

Some habitats may be rich in fungi and yet receive little if any 'umbrella' protection by association with other organism groups with high conservation profiles. An outstanding example of this is the British and Irish traditionally managed waxcap grassland habitat, important in a European context, but often of relatively low botanical and zoological interest. In recognition of this priority, the first leaflet dedicated to a managing a particular habitat type for its fungi was produced by the Fungus Conservation Forum (Anon 2003) and was entitled *Grassland gems: managing lawns and pastures for fungi* (see Appendix III). Quoting from this leaflet, "the best grassland fungi sites:

- Are often well drained.
- Have a short turf.
- Are poor in nutrients and usually unfertilised.
- Often have plenty of moss present.
- Are not necessarily rich in flowering plants".

The leaflet also lists some management guidelines which are expanded in Evans (2004) and are summarised and incorporated in the list below:

- Maintain short sward (helps to keep nutrient-poor status) by established methods of grazing or mowing (removal of clippings if practical). Relaxation of mowing frequency in autumn will allow fruit body development, spore dispersal and rapid assessment of fungal community. Accurate assessments require sampling of mycelium below ground.
- Maintain low nutrient status by avoiding agricultural 'improvement', eg avoid ploughing, reseeding and applications of fertiliser, lime and increased amounts of farmyard manure. Minimise nutrient enrichment from activities on neighbouring land.
- Maintain existing drainage.
- Avoid herbicides and fungicides.
- Avoid widespread major disturbance and compaction from vehicle ruts, horse riding, construction, dumping and large crowds of visitors, eg public events.
- Find out if a grassland site is important for its waxcap grassland fungi. This is especially important if contemplating the creation of wild-flower, bird and butterfly rich habitats. To assist with this, the British Mycological Society maintains a database of fungal records. Evans (2004) has compiled existing data for England and produced preliminary lists of the most important waxcap grasslands (see below). Similar compilations are documented for Scotland (Newton and others 2003) and Wales (Evans & Holden 2003).

7.7.4 Waxcap grasslands: ranking of sites

Rald (1985) produced a rapid scoring system for ranking sites based on the numbers of *Hygrocybe* taxa (species, varieties, subspecies) recorded on a single site visit. Inevitably some of the best sites will remain undetected by this method unless the visit coincides with peak fruiting. The system was adapted by Vesterholt, Boertmann & Tranberg (1999) to include the total numbers of recorded taxa and used by Evans (2004) to produce a preliminary assessment of English sites based on a compilation of existing data. According to this adapted system, sites with 17 or more *Hygrocybe* taxa are regarded as of national importance and those with over 22 taxa are of international importance. Although there has not been a systematic survey in England, Evans (2004) has already identified 12 English sites of international importance (Table 18) and 32 others of national importance. She also ranked sites according to the numbers of taxa recorded from other important, but much more taxonomically challenging, groups of waxcap grassland fungi (see below) using the CHEG abbreviation such that:

C = No. of Clavariaceae. H = No. of *Hygrocybe* taxa. E = No. of *Entoloma* taxa. G = No. of Geoglossaceae.

Table 18 Provisional top 12 English sites for *Hygrocybe* from data in Evans (2004)

Site	SSSI	IFA	C	H	E	G
Longshaw Estate, Derbyshire. SK 2579	in part	No	**8**	**33**	**24**	**4**
Goodmans, East Devon. ST 2705 etc		No	0	**29**	**24**	0
The Patches, West Gloucestershire. SD 6308		Yes	1	**29**	14	1
Kerridge Hill, Cheshire. SJ 9476		Yes	7	**29**	10	0
Crimsworth Dean, S.W. Yorkshire. SD 9829 etc		Yes	5	**28**	**29**	3
Smalley's Farm, M.W. Yorkshire. SD 7134		No	**11**	**25**	**15**	**4**
Roecliffe Manor, Leicestershire. SK 5312	Yes	Yes	**13**	**24**	**28**	**4**
Windsor Great Park, Berkshire. SU 9672 etc	Yes	Yes	5	**23**	6	3
Brookwood Cemetery, Surrey. SU 9556	Yes	Yes	4	**23**	5	2
Blencathra, Cumbria. NY 3025 etc		Yes	5	**22**	6	1
Danehill Church, East Sussex. TQ 4027		No	5	**22**	8	0
Slaugham Church, West Sussex. TQ 2528		No	2	**22**	1	0

Notes overleaf.

In Table 18, IFA denotes that the site is listed as an Important Fungus Area (applying criteria A-C) in Evans, Marren & Harper (2001) and bold underlined data indicate numbers of taxa which were sufficiently high to warrant inclusion of site in other CHEG tables (Tables 19-21). Longshaw Estate, Roecliffe Manor and Smalley's Farm are the only sites listed in all four tables.

Analysis of Scottish waxcap grassland survey data by Newton and others (2003) revealed that a poor correlation existed between the different grassland taxa such that a site recognised as important for *Hygrocybe*, for example, would not necessarily be one of the best *Entoloma* sites. Furthermore these authors estimated that over 16 visits spread over several years could be required for adequate characterisation of site diversity taking into account the different periods of optimal fruiting and differing responses to weather conditions. The use of waxcap recording on its own is therefore not sufficient to assess waxcap grassland fungal diversity, a property often equated with conservation value.

Attempts have been made to assign members of the different fungal groups to different categories of rarity for use as indicators of habitat quality, for example, high, medium and low categories were used by Rotheroe (1999) and then converted to a score by McHugh and others (2002) to produce weighted scores for Irish grasslands. Such an approach is one of a number being evaluated as a potential tool in site monitoring in Northern Ireland (Bataille & Wright in prep.) but was not used in the assessments of Evans (2004) or Newton and others (2003). One potential pitfall of this approach would seem to be the potential for equivalent scores arising from the presence of either a few high-scoring rarities or an abundance of low-scoring commoner species. Evans (2004) opted to list the top sites for each CHEG group separately to highlight the lack of currently perceived overlap and these are reproduced in Tables 19-21 using the same format as for Table 18.

Table 19 Provisional top 11 English sites for grassland Clavariaceae from data in Evans (2004)

Site	SSSI	IFA	C	H	E	G
Roecliffe Manor, Leicestershire. SK 5312	Yes	Yes	**13**	**24**	**28**	**4**
Mulgrave Woods, N.E. Yorkshire NZ 8311 etc		No	**13**	17	11	**4**
Smalley's Farm, M.W. Yorkshire. SD 7134		No	**11**	**25**	**15**	**4**
Bedgebury, Kent. TQ 7333 etc		Yes	**11**	21	**21**	3
Moccas Park, Herefordshire. SO 3442	Yes	Yes	**11**	17	7	1
Baslow area, Derbyshire. SK 2572 etc		No	**11**	17	11	2
Ashburnham Place, E. Sussex. TQ 6914		No	**9**	18	6	0
Longshaw Estate, Derbyshire. SK 2579	in part	No	**8**	**33**	**24**	**4**
Down House, Kent. TQ 4361		Yes	**8**	20	9	3
Fishpool Valley, Herefordshire. SO 4565 etc	in part	Yes	**8**	14	6	1
Savernake, Wiltshire. SU 2266 etc	Yes	Yes	**8**	16	10	2

Table 20 Provisional top 11 English sites for grassland *Entoloma* from data in Evans (2004)

Site	SSSI	IFA	C	H	E	G
Crimsworth Dean, S.W. Yorkshire. SD 9829 etc		Yes	5	**28**	**29**	3
Roecliffe Manor, Leicestershire. SK 5312	Yes	Yes	**13**	**24**	**28**	**4**
Back Fields, Walton-in-G'dno. N. Somerset. ST 4273		Yes	4	19	**28**	0
Longshaw Estate, Derbyshire. SK 2579	in part	No	**8**	**33**	**24**	**4**
Goodmans, East Devon. ST 2705 etc		No	0	**29**	**24**	0
Kiberick Cove, E. Cornwall SW 9239		No	3	15	**22**	3
Bedgebury, Kent. TQ 7333 etc		Yes	**11**	21	**21**	3
Walton Common, N. Somerset. ST 4273		No	1	9	**16**	0
Broadhead Clough, S.W. Yorkshire. SE 0024		No	2	13	**15**	1
Smalley's Farm, M.W. Yorkshire. SD 7134		No	**11**	**25**	**15**	**4**
St. Dunstan's Farm, E. Sussex. TQ 3031		Yes	2	20	**15**	0

Table 21 Provisional top 10 English sites for Geoglossaceae (data in Evans 2004)

Site	SSSI	IFA	C	H	E	G
Nices Hill, S. Hampshire. SU 1911	Yes	Yes	5	16	10	**5**
Upper Dunsop Valley, Lancashire. SD 6551 etc		Yes	4	13	4	**5**
Gear Sands, W. Cornwall. SW 7755		No	3	10	1	**5**
Elmer Sands, W. Sussex. SZ 9899		No	0	3	0	**5**
Roecliffe Manor, Leicestershire. SK 5312	Yes	Yes	**13**	**24**	**28**	**4**
Longshaw Estate, Derbyshire. SK 2579	in part	No	**8**	**33**	**24**	**4**
Smalley's Farm, M.W. Yorkshire. SD 7134		No	**11**	**25**	**15**	**4**
Mulgrave Woods, N.E. Yorkshire NZ 8311 etc		No	**13**	17	11	**4**
Minions, E. Cornwall. SX 2671		No	3	12	1	**4**
Ilkley Moor, M.W. Yorkshire. SE 1046 etc		No	1	7	1	**4**

7.8 Lowland heath species

7.8.1 Lowland heath species: group members

Currently the only SoCC from this habitat is more directly associated with the diet and movements of grazing herbivores (Table 22). It is saprotrophic and almost always on pony dung (coprophilic).

Table 22 Lowland heath species

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	Yes	saprotroph	Stromatic asco	*Poronia punctata*	nail fungus

7.8.2 Lowland heath species: species data sheets

A species data sheet follows for *P. punctata*.

Poronia punctata nail fungus

Synonyms in recent use:

Description: fruiting within conspicuous whitish-buff discs (stromata) resembling heads of large nails, <1.5 cm diam., with <2 cm high pale grey to black stalk beneath arising within pony dung, all seasons but mainly autumn to spring. When fruiting, the stromatal disc becomes dotted with minute darker ostioles (pores leading to microscopic spore-producing chambers in flesh below). Margin of disc remains sterile and often as a slightly raised rim. Ascospores, ejected from ostioles into the air, are dark brown, smooth, bean-shaped, 17-28 x 6-13 µm and have a gelatinous coat.

Distinguishing features: an unmistakeable fungus.

Ecology: dung saprotroph whose spores adhere to vegetation and are eaten by, and then germinate in the deposited dung of, horses and ponies. Physico-chemical composition and microstructure of dung probably very important to the success of this species which is now rarely found away from rough acidic and heathy grazing land. It is hardly ever found in limed or fertilised grassland.

Distribution & Status: Declining across Europe (also reported on cow dung in Europe and USA). UKRDL (1992) and BAP endangered. Widespread in Britain until early 1900s but recent records mainly from its last UK stronghold in the New Forest with potential resurgence on Dorset heaths.

Conservation management advice: undoubtedly this species would benefit from more traditional grazing of rough and heathy grassland by ponies with a more natural diet, particularly of areas with historic records. Research is required into the effects of pony diets supplemented with different types of fodder, feed additives and veterinary products on spore germination, colonisation and competitive success in dung. The effects of dung deposition in different habitats and weathering also deserve further study.

Known distribution before 1960

Known distribution 1960 onwards

Published illustrations: in Dennis (1981), Dickson & Leonard (1996), Ellis & Ellis (1998), Phillips (1981), Ryman & Holmåsen (1984) and Whalley & Dickson (1986).

Additional published information: in Cox & Pickess (1999), Hansen & Knudsen (2000) and Reid (1986).

Mature stroma (left) dotted with black fruit bodies and 3 immature stromata on pony dung

7.8.3 Lowland heaths: generic management guidelines

Poronia puncata is one of the few fungi for which records unequivocally show a dramatic decline in the number of sites in England. Reintroductions would be expected to follow reinstatement of grazing of rough and heathy grassland by ponies on a fairly natural diet which includes the spores of *Poronia*. The types, amounts and combinations of supplemental feedstuffs and veterinary products tolerated by *Poronia* and their detrimental indirect effects in the dung microcosm are unknown. Management of lowland heath by tree felling, eg of sweet chestnut, should also take into account the needs of the associated ectomycorrhizal fungi, particularly when these are BAP species.

Additions to this suite should be made following further study of species characteristic of heaths.

7.9 Wetland species

7.9.1 Wetland species: group members

Currently the only SoCC from this habitat is poorly known and surveyed but seems to be mainly (?always) associated with fen or with base–rich flushes, eg on moors, coasts etc. It is assumed to be saprotrophic but lives on undetermined elements of vegetation (Table 23).

Table 23 Wetland species

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	Yes	saprotroph	Agaric	*Armillaria ectypa*	marsh honey fungus

7.9.2 Wetland species: species data sheets

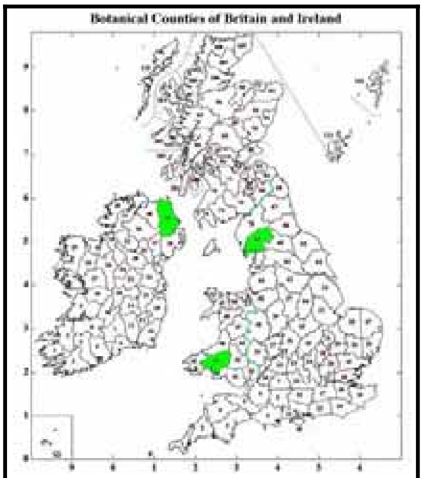
A species data sheet follows for *A. ectypa*.

Armillaria ectypa marsh honey fungus

New British record in 1995

Synonyms in recent use: *Clitocybe ectypa*

Description: fruiting singly or in small clusters Jul-Oct. Cap 3-6(10) cm diam., domed becoming flat and sometimes wavy at the striate margin, yellowish brown sometimes with rosy tints, darker at centre where slightly scaly. Darker when wet and then translucent at margin. Gills cream or pinkish sometimes arching downwards at point of attachment forming ridges on stem apex. Stem 6-10 x 0.6-1.3 cm without any ring and only slightly thickened at base, similar colour to cap, coated with minute scales. Spores white or creamy, subglobose to ellipsoid, 6.7-9.5 x 5.5-6.5 µm.



Known distribution 1960 onwards

Distinguishing features: other *Armillaria* species may fruit in wet habitats, but can usually be distinguished by presence of a ring on the stem. *A. tabescens* is ringless but, like the other species, fruits in dense tufts on wood.

Ecology: saprotrophic on vegetation of wet places, either in fens or associated with localised base-rich flushes in bogs, from coastal reedbeds to upland moor or alpine. Reports of more acidic boggy sites in continental Europe warrant further investigation.

Distribution & Status: central and northern Europe and Japan. UKRDL (Ing 1992) vulnerable, BAP endangered. Regarded as endangered in Austria, Czech Republic (also protected by law), Slovakia, Denmark, Finland, Germany, Sweden, Switzerland (extinct) and The Netherlands.

Conservation management advice: all likely habitats should be surveyed to produce a realistic distribution map. Known sites (3) require detailed surveying/monitoring to provide ecological data, preferably in concert with lab-based studies. Managing site hydrology expected to be of major importance. Known sites already have conservation interest so awareness of local threats (pollution and nearby land-use changes) expected. Existing management regimes (grazing, reed and scrub clearance) should take this species into account to avoid destroying best fruiting populations. Investigations into effects of fen/flush management and plant succession (eg drying effects of *Salix* scrub) are required.

Published illustrations: in Bon (1987), Evans (2002), Marchand (1986) and Termorshuizen (1995).

Additional information: in ECCF (2001), Pegler, Roberts & Spooner (1999) and Ramsbottom (1953). Species report for *A. ectypa* by Ainsworth (2003a).

Coastal reedy fen habitat with *Salix*

Young fruit body in grazed reedbed

Mature fruit body in mossy reedbed near *Salix*

7.9.3 Wetland species: generic management guidelines

Little useful generic management guidance is currently available beyond preservation of habitat for other characteristic organisms, eg prevention of eutrophication, pollution, drying and habitat destruction. Suitable wetlands should be surveyed to locate *A. ectypa* fruiting sites and more information is required on the ecology of this species and the impacts of different wetland management regimes. In particular, the effects of cattle grazing, reed cutting, *Salix* invasion/control and creation of open water should all be assessed with regard to impact on the best fruiting sites for the fungus.

7.10 Scottish montane species

7.10.1 Scottish montane species: group members

Currently the only SoCC from this habitat is associated with mossy lime-rich rocks and assumed to be saprotrophic (Table 24). A list of at least 18 further taxa (some lichenised) is in preparation (Holden in prep.). Corresponding lists of English and Welsh taxa, all of which will be relatively rare, are also required.

Table 24 Scottish montane species

Sched 8	BAP	Nutrition	Description	Scientific Name	English Name
No	Yes	saprotroph	Stalked puffball	*Tulostoma niveum*	white stalkball

8. Acknowledgements

I would like to acknowledge the British Mycological Society, English Nature, Scottish Natural Heritage, Countryside Council for Wales, Northern Ireland Environment Heritage Service, Plantlife International, Fungus Conservation Forum, Royal Botanic Gardens Kew and the Joint Nature Conservation Committee for their involvement in, commitment to and support for fungal conservation work at all levels. I am very grateful to all those who contributed to the growing portfolio of BAP fungal species status reports and assessments which not only improved our scanty knowledge of wild fungi and their distribution, but also stimulated further recording and research upon which syntheses such as this heavily rely. I would like to thank all field mycologists and recorders who shared their enthusiasm and knowledge with me and everyone who has contributed records to the national database, the foundation upon which fungal conservation increasingly depends. My thanks go to Paul Kirk for access to this resource. Thanks are also due to Alan Rayner and Lynne Boddy for their insight and ecological work, which directly and indirectly fuelled much of the underlying fungal biology herein (errors and omissions are all mine), and to Martin Allison, Gordon Dickson, Ted Green, Alan Hills, Philip Jones, Alan Lucas and Joyce Pitt for time spent in the field sharing their knowledge of BAP fungi. Last, but not least, my thanks to Carl Borges, Ian Slater and Jill Sutcliffe of English Nature and to Ted Green who helped to improve my early drafts and to Gordon Dickson, Rob Dryden, Alan Hills, Richard Sholtbolt and Dave Shorten who kindly provided me with some of their copyright images as colour transparencies or digital files.

9. Appendices

Appendix I

Alphabetical listing of scientific names (with English names) of fungal species of conservation concern. Individual species data sheets (if available) can be located by reference to the numerals in the first column which refer to the handbook sections covering each ecological group. Species are also assigned to taxonomic orders (Kirk and others 2001) and to Basid (= Basidiomycete) or Asco (= Ascomycete) group**s.**

Section	Scientific name	English name	Taxonomic order	Asco or Basidio
7.9	***Armillaria ectypa***	marsh honey fungus	Agaricales	Basid
7.1	***Bankera fuligineoalba***	drab tooth	Thelephorales	Basid
7.5	***Battarrea phalloides***	sandy stiltball	Agaricales	Basid
7.1	***Boletopsis leucomelaena***	black falsebolete	Thelephorales	Basid
7.3	***Boletus pseudoregius***	the pretender	Boletales	Basid
7.3	***Boletus regius***	royal bolete	Boletales	Basid
7.3	***Boletus satanas***	devil’s bolete	Boletales	Basid
7.4	***Hericium cirrhatum***	tiered tooth	Russulales	Basid
7.4	***Hericium coralloides***	coral tooth	Russulales	Basid
7.4	***Hericium erinaceum***	bearded tooth	Russulales	Basid
7.1	***Hydnellum aurantiacum***	orange tooth	Thelephorales	Basid
7.1	***Hydnellum caeruleum***	blue tooth	Thelephorales	Basid
7.2	***Hydnellum concrescens***	zoned tooth	Thelephorales	Basid
7.1	***Hydnellum ferrugineum***	mealy tooth	Thelephorales	Basid
7.1	***Hydnellum peckii***	devil’s tooth	Thelephorales	Basid
7.1	***Hydnellum scrobiculatum***	ridged tooth	Thelephorales	Basid
7.2	***Hydnellum spongiosipes***	velvet tooth	Thelephorales	Basid
7.7	***Hygrocybe calyptriformis***	pink waxcap	Agaricales	Basid
7.7	***Hygrocybe spadicea***	date waxcap	Agaricales	Basid
7.6	***Hypocreopsis lichenoides***	willow gloves	Hypocreales	Asco
7.6	***Hypocreopsis rhododendri***	hazel gloves	Hypocreales	Asco
7.7	***Microglossum olivaceum***	olive earthtongue	Helotiales	Asco
7.2	***Phellodon confluens***	fused tooth	Thelephorales	Basid
7.2	***Phellodon melaleucus***	grey tooth	Thelephorales	Basid
7.2	***Phellodon niger***	black tooth	Thelephorales	Basid
7.1	***Phellodon tomentosus***	woolly tooth	Thelephorales	Basid
7.4	***Piptoporus quercinus***	oak polypore	Polyporales	Basid
7.8	***Poronia punctata***	nail fungus	Xylariales	Asco
7.1	***Sarcodon glaucopus***	greenfoot tooth	Thelephorales	Basid
7.1	***Sarcodon imbricatus***	scaly tooth	Thelephorales	Basid
7.2	***Sarcodon scabrosus***	bitter tooth	Thelephorales	Basid
7.1	***Sarcodon squamosus***	? tooth	Thelephorales	Basid
7.10	***Tulostoma niveum***	white stalkball	Agaricales	Basid

Appendix II

FCF leaflet *Managing your land with fungi in mind*

Appendix III

FCF leaflet *Grassland gems: managing lawns and pastures for fungi*

Appendix IV (reproduced from Ing's *2002 English Nature Research Reports*, No. 466, 'The endangered myxomycetes of the British Isles')

Conservation of myxomycetes

Habitats of importance

The majority of myxomycetes are to be found on decaying wood or herbaceous litter in woodland. Ancient woodland tends to be richer in species, with a number of indicators, such as *Lycogala conicum* and *Physarum psittacinum*. Although there is a well documented decline in ancient woodland this has not resulted, as far as can be determined, in the loss of any myxomycete species. It is not possible to conclude why certain woodland species have declined or become, apparently, extinct. The occurrence of myxomycetes is essentially opportunistic, although there is evidence to show that some species, such as *P. psittacinum*, recur on the same log at the same time of year, for decades.

In Atlantic woodland the presence of ravines and waterfalls, or the combination of high rainfall and close canopy, ensures a consistently high humidity. The rocks and boulders have a rich and important bryophyte covering and this is the habitat for several rare and attractive myxomycetes, eg *Diderma lucidum, D. ochraceum, D. sauteri, Lamproderma columbinum* and *Lepidoderma tigrinum*. This assemblage is especially well represented in the oak woodlands of Snowdonia.

The myxomycetes associated with persistent snow cover on mountains – ie areas with late snow bed vegetation – are well represented in the Cairngorms and several of the commoner species are found throughout the Scottish Highlands. Species of *Diderma, Didymium, Lamproderma* and *Physarum* are well represented. Recently an addition to the British list, *Trichia sordida*, has been found to be common on the moorlands around Sheffield. This is a much smaller group than in the Alps, where there is more, longer-lasting snow-lie and a wider range of vegetation units, including forest, in which snow accumulates. The loss of many species may therefore have occurred when the montane forest was cleared. It is intriguing to speculate whether they might return as higher level plantations mature. The highest areas of native pine forest in the Cairngorms have not yielded these species because in the last ten years the snowfall has not persisted for long enough in the Spring at these lower altitudes. The only recognisable risk to these snowline species is destruction of the vegetation on which they sporulate as a result of activities associated with skiing and snowboarding, such as construction of roads, mountain railways, chair-lifts, and the preparation and grooming of pistes. There is insufficient evidence to implicate any of these in species decline.

Coastal dunes and shingle beaches have a small, but most interesting group of species, particularly associated with *Cladonia* heaths, such as *Listerella, Diacheopsis mitchellii* and *Trichia fimicola*. There are also a number of predominantly woodland species, which are found under and within the mats of shingle plants such as *Silene, Beta* and *Atriplex*. Marram and other grasses carry a few grass-litter species, including some which are characteristic of straw heaps (see below.) The well-grazed mossy dune grasslands are the major habitat in the British Isles of a Mediterranean species, *Diderma spumarioides.* The major threat to all these species is increased disturbance by visitors, and especially damage caused by vehicles of all kinds.

Surprisingly, agricultural land has, at least in the past, been a rich source of myxomycetes. Many litter species are, in reality, soil species, and may be found sporulating on any vegetable material left around arable fields. In the early part of the 20^{th} C cornfields were significant for the piles of wheat straw left along the margins after harvest. After suitable periods of rain these were inhabited by a number of species, notably *Badhamia apiculospora, Didymium vaccinum, Physarum didermoides, P. lividum P. straminipes, Fuligo cinerea*, plus many common species. Nearly all the straw heap specialists have declined markedly with the loss of their habitat. The use of straw bales, which are more compact, take longer to become waterlogged and are poorly ventilated, are less effective at supporting this group of species. However, some *have* been found in recent years. Attempts to 'trap' these species on straw bales is a worthwhile, and inexpensive, future project.

Farmland also provides another myxomycete substrate – herbivore dung. Many of the species found on dung are also found on other plant remains but several are more or less confined to dung, especially of rabbit, hare, goat and deer. Domestic cattle and sheep dung is utilised by a number of myxomycetes but it is stable manure and dung heaps, which traditionally have been a favoured substrate. The decline in these features of the rural scene has been mirrored by the decline in *Fuligo cinerea.*

Conservation management

Maintenance of the *status quo* is the main requirement, on the basis that the organisms surviving in a particular site know best! Woodland management should involve leaving piles of cut timber, such as coppice, and fallen trunks be allowed to rest on the ground, thus remaining damp enough. In general, coppice woodlands are less rich in myxomycetes than high forest, partly through the encouragement of ground and field layer vegetation and also because of drying out. Leaf litter should not be collected or burned as it provides a major habitat for common as well as rare species. Litter of holly and brambles is especially rich in myxomycetes and maintenance of the appropriate light regime is essential. In Atlantic woodlands it is important to regulate grazing so that there is little or no woody plant regeneration in the neighbourhood of bryophyte boulders, especially in the oak woodlands of Snowdonia. Myxomycetes may be encouraged simply by providing adequate fallen wood and leaf piles.

Apart from the specific points included in the discussion on habitats and woodland management there is little that can be usefully done to protect myxomycetes. They are very small, averaging one millimetre in height, and mostly inconspicuous, requiring specialised methods of collecting. Moreover, they are not easy to identify. There is little to be gained from legal protection by including them on any schedules. The only worthwhile conservation activity is monitoring of the important key sites mentioned in the next section.

Changes in patterns of distribution are being researched by the author and the results of this work will be published. When the impact of climate change is taken into account the problems become even more complex, as myxomycetes react rapidly to improved conditions. Several species of corticolous (tree-bark) species are known to be increasing their range northwards at the present time. Whether this trend will also affect lignicolous and foliicolous species is not yet known. In particular it is not yet possible to predict the effect of climate shift on the snowline species of the Scottish Highlands.

It is possible to make these comments because of the intensive studies made over the past forty years on the distribution and ecology of myxomycetes in the British Isles.

Important sites for myxomycetes

England

Dungeness NNR, Kent (especially TR 0619,0620,0717,0718) - important colonies on *Cladonia* heaths, in litter under bushes and on vegetation and woody debris around the pits. Notable species include: *Listerella paradoxa* and *Physarum lateritium.*

Management suggestions: maintenance of Cladonia heath, shingle scrub and, especially the wooded margins of the Open Pits; monitoring.

Ashdown Forest, Sussex (especially TQ 4130,4132,4133,4329,4332,4832) - wide range of woodland species, including rarities in mature conifer plantations, such as *Cribraria splendens, Physarum confertum* etc. The area is well studied by a local specialist, D.W. Mitchell.

Management suggestions: more sympathetic forestry practices with provision of fallen wood, less clear felling and more thinning to allow terrestrial mosses to flourish; monitoring.

Epping Forest, Essex (especially TQ 4095,4096,4193,4196,4197,4299,4399) – wide range of woodland species, including old records of many rarities, eg *Stemonitopsis microspora*, and the type locality of *Didymium laxifila*, a Mediterranean evergreen forest species which is frequent in the London area.

Management suggestions: maintenance of status quo, with plenty of fallen wood and deep leaf litter; monitoring.

The Mens and The Cut, W. Sussex (especially TQ 0223) – wide range of ancient woodland species, many rare species, including *Didymium pertusum.*

Management suggestions: maintenance of status quo, with plenty of fallen wood and deep leaf litter; monitoring.

The New Forest, Hampshire (especially SU 2005,2006,2215,2402,2506,3305, 3306,3307,3309,3805) – impressive list of species of ancient forest, with the largest assemblage of species associated with conifers outside Scotland.

Management suggestions: maintenance of high forest, with abundant fallen wood and leaf litter; monitoring.

Slapton Ley LNR, Devon (especially SX 8143,8144,8243,8244,8344,8345) – good range of woodland and wetland species, including *Didymium applanatum*.

Management suggestions: woodland – maintenance of high forest, with some thinning to reduce terrestrial ivy; marsh – maintenance of status quo; shingle back-slope – reduction of scrub woodland to allow marsh-side vegetation to survive.
Because of the complexity of the site it needs frequent monitoring.

Wyre Forest, Worcs/Shropshire (especially SO 7576) – wide range of ancient woodland species, including old records of *Diderma treveylanii* and recent records of *Leptoderma iridescens.*

Management suggestions: maintenace of high forest, with fallen wood and leaf litter, especially in the damper areas; monitoring.

Holme Fen NNR, Huntingdonshire (especially TL 2089) – a rich area of damp woodland with over fifty recorded species including the largest known colony of *Diachea subsessilis* and the only British site for *Ceratiomyxa porioides*, discovered in 2001.

Management suggestions: maintenance of status quo, especially fallen wood; monitoring.

Surlingham Wood and Fen, Norfolk (especially TM 3207) - classic locality for fenland species and rich assemblage of carr species; long studied by E.A. Ellis.

Management suggestions: maintenance of fen, carr and marginal woodland as at present; monitoring.

Esher Common/Oxshott Heath, Surrey (especially TQ 1261,1262,1263,1361,1362) – well studied area of oak woodland, heath and spontaneous pine with over 100 species of myxomycetes recorded in recent years, including the rare bark species *Licea tenera*.

Management suggestions: maintenance of mixed forest, leaving plenty of dead wood; avoidance of too much tidying-up! This complex site needs regular monitoring.

Royal Botanic Gardens, Kew, Surrey (TQ 1776,1876,1877) – intensively studied area with over 100 species of myxomycetes including the following very rare bark species: *Licea erddigensis, L. cristallifera, L. margaritacea, L. tenera* and *Clastoderma debaryanum.*

Management suggestions: maintenance of status quo; monitoring.

Wales

Snowdonia oak woodland NNRs – classic site of studies on Atlantic myxomycetes, with many rare species and typical sites of the Atlantic ravine association – *Fuligo muscorum, Diderma lucidum, D. ochraceum, Lamproderma columbinum* and *Lepidoderma tigrinum.* All the oakwood NNRs have been studied and all are included as significant sites. Coed Dolgarrog has ancient woodland indicators such as *Lycogala conicum* and is the type locality for *D. lucidum.*

Afon Pumrhyd, Bryn, Llanymawddwy, Merioneth – this is the only SSSI designated for myxomycetes and is the type locality for the ravine association (see previous site.) It is also one of the last recorded sites for *Physarum muirinum*.

Alyn Valley woodlands, Denbighshire and Flintshire – includes the Loggerheads Country Park and has a wide range of ancient woodland myxomycetes, including *Physarum psittacinum* and *Lycogala conicum* as well as the very rare bark species *Trabrooksia applanata*.

Scotland

Cairngorms NNR – includes the best sites in the British Isles for snowline myxomycetes, with 18 species currently recorded, including several for which this is the only extant site. The species are *Dianema nivale, Diderma alpinum, D. lyallii, D. meyerae, D. microcarpon, D. niveum, Didymium dubium, D. nivicola, Lamproderma atrosporum, L. carestiae, L. cribrarioides, L. ovoideum, L. sauteri, Lepidoderma aggregatum, L. carestianum, L. chailletii, Physarum alpestre* and *P. vernum.*

Glas Maol NNR – an excellent site for snowline myxomycetes with two species not found in the Cairngorms, viz. *Lepidoderma chailletii* and *Physarum albescens,* the latter in its only British station.

Kindrogan Field Centre, Perthshire – a much studied area with over 100 species recorded, including some of the most recent records of rare species, such as *Diacheopsis insessa, Diderma asteroides, D. trevelyanii, Physarum citrinum* and *P. penetrale*.

Northern Ireland

Drumlea Wood NNR, Co. Tyrone – a fine example of Atlantic woodland with a rich diversity of bryophilous myxomycetes including *Craterium muscorum* and *Diderma sauteri*.

Florence Court, Co. Fermanagh – a rich assemblage of woodland species, including *Diachea leucopodia* in its only site in the whole of Ireland.

10. Glossary of mycological terms

agaric applied to most mushroom-shaped **fruit bodies** with a cap bearing gills underneath.

ascomycete a **higher fungus** sexually producing **spores** in an **ascus**, or close relative of such fungi.

ascospore an **ascomycete spore** produced in an **ascus.**

ascus (pl. **asci)** an **ascomycete hyphal** tip, often sausage shaped, in which **ascospores** develop, often in a row of eight (Figure 10).

basidiomycete a **higher fungus** sexually producing **spores** in a **basidium**, or close relative of such fungi.

basidiospore a **basidiomycete spore** produced by a **basidium.**

basidium (pl. **basidia)** a **basidiomycete hyphal** tip with prongs (**sterigmata**) at the end, usually four, each of which produces a **basidiospore** (Figure 11).

bolete applied to most mushroom-shaped **fruit bodies** with a cap bearing sponge-like tubes beneath and usually growing on the ground.

chitin structural material giving strength to **hyphal** walls and the external coats or shells of insects and crabs.

chlamydospores asexually produced **spores** with thick walls which are not dispersed far and can withstand conditions which are unfavourable for **mycelial** growth.

component-restricted ecological strategy whereby **mycelium** of a **saprotroph** is constrained within the physical boundaries of the favoured resource such as within dead leaves, cupules, catkins, cones etc.

ectomycorrhiza partnership in which a fungus sheaths the finest roots of a plant and penetrates *between*, but not *inside*, their outer cells and absorbs plant nutrients while the root absorbs fungal nutrients obtained from the surrounding soil.

endomycorrhiza partnership in which a fungus forms structures *inside* the root cells of a plant and absorbs plant nutrients while the root absorbs fungal nutrients obtained from the surrounding soil.

endophyte a fungus occurring inside a plant without causing any visible symptoms whose existence is usually demonstrated by sterilizing the plant surface and cultivating any remaining living fungi associated with the plant under sterile laboratory conditions.

fruit body conspicuous reproductive structure of a fungus sexually producing **spores** (**ascospores** and **basidiospores**) and commonly known by such names as mushrooms, boletes, brackets, chanterelles, puffballs, earthstars, stinkhorns, cramp balls, earthtongues, morels and truffles.

higher fungus a **true fungus** belonging to the **ascomycetes** or **basidiomycetes** or their asexual relatives.

hypha (pl. **hyphae)** fine filament or tube which is the basic building block from which fungi are constructed. Hyphae are divided into compartments which correspond to the cells of plants and animals.

IFA important fungus area as defined in Evans, Marren & Harper (2001).

latency ecological strategy whereby **endophytes** may be relatively inactive (as if inside a Trojan horse) until triggered to become pathogenic and kill plant tissues or triggered to become **saprotrophic** and obtain nutrients from surrounding dead plant tissue.

latent invasion see **latency**

lichen dual organism formed from the partnership between fungi and algae or cyanobacteria (blue-green algae) whose scientific name is based on the main fungal partner

lower fungus a fungus of relatively simple construction and usually a **true fungus** which is neither an **ascomycete** nor a **basidiomycete**

macrofungi fungi which have conspicuously visible **spore**-producing structures and are almost all **ascomycetes** and **basidiomycetes**

macromycetes see **macrofungi**

microfungi fungi which remain inconspicuous throughout their lives and have microscopic **spore**-producing structures. They are loosely termed moulds.

micromycetes see **microfungi**

mycelium (pl. **mycelia)** inconspicuous 'feeding body' of a fungus composed of **hyphae**

mycelial cord a bundle of **hyphae** which are aligned in parallel to form a rope-like structure which is often white and can be seen beneath leaf litter exploring for items of deadwood

mycorrhiza partnership between living plant roots and fungal hyphae to form dual organisms (see **ectomycorrhiza** and **endomycorrhiza**)

ostiole a small opening situated in the roof of a **perithecium** through which **ascospores** are discharged and often visible as darker dots on the surface of a **perithecial stroma**

perithecium (pl. **perithecia)** a type of **ascomycete fruit body** in which the **asci** are protected and line tiny cauldron-shaped chambers

polypore applied to most bracket-shaped **fruit bodies** with sponge-like tubes beneath and usually growing on wood

rhizomorph a type of **mycelial cord** which develops a UV-protective and waterproof crust (involving the human skin pigment melanin) perforated with recently discovered air pores to allow it to 'breathe'. They are characteristically produced by the honey fungus genus *Armillaria*, when these fungi are exploring soil and litter layers as **saprotrophs** and pathogens, and are also known as 'bootlaces'

saprotroph a fungus that obtains carbon compounds from surrounding dead tissues, usually of plants, and also known as decay fungi, decomposers or recyclers

spore dust-like propagule of a fungus with dispersal and survival roles similar to those of plant seeds

sterigma (pl. **sterigmata)** prong-shaped **basidiomycete** structures which produce **basidiospores** and occur in a group of four, more rarely one to three, six or eight, at the end of **basidia** (Figure 11)

stipe the stem of a **fruit body**

stipitate having a **stipe**

stipitate hydnoids a group of **ectomycorrhizal basidiomycetes** of conservation concern with spines, not gills, below the caps of their **stipitate fruit bodies** and part of the group commonly known as **tooth fungi**. Members of the genera *Bankera*, *Hydnellum*, *Phellodon* and *Sarcodon*

stroma (pl. **stromata)** visible cushion of sterile **ascomycete** tissue in which **perithecia** can develop

thermophilous used here to describe **boletes** tending to fruit in summer and distinguished from thermophilic fungi which are defined as fungi with **mycelia** that thrive in relatively hot conditions such as compost

tooth fungi English name given to **stipitate hydnoids** and unrelated wood-decaying *Hericium* species

true fungus a fungus classified within the Eumycota and characterised by walls containing **chitin**

unit-restricted see **component-restricted**

11. References

AINSWORTH, A.M. 2003a. Report on the marsh honey fungus *Armillaria ectypa*, a UK BAP species. Peterborough: *English Nature Research Reports*, No. 540.

AINSWORTH, A.M. 2003b. Report on hazel gloves *Hypocreopsis rhododendri*, a UK BAP ascomycete fungus (with reference to willow gloves *H. lichenoides*). Peterborough: *English Nature Research Reports*, No. 541.

AINSWORTH, A.M. 2004. Developing tools for assessing fungal interest in habitats 1: beech woodland saprotrophs. Peterborough: *English Nature Research Reports*, No. 597.

AINSWORTH, A.M. & RAYNER, A.D.M. 1990. Aerial mycelial transfer by *Hymenochaete corrugata* between stems of hazel and other trees. *Mycological Research*, 94, 263-288.

ANDERSSON, L., and others. 2003. *Woodland key habitat inventory in Estonia 1999-2002*. Tartu: Regio Publishing.

ANON, 2001. *Managing your land with fungi in mind*. Fungus Conservation Forum.

ANON, 2002. *The Swedish woodland key habitat survey*. Jönköping: Skogsstyrelsen (Swedish National Board of Forestry).

ANON, 2003. *Grassland gems: managing lawns and pastures for fungi*. Fungus Conservation Forum.

ARNOLDS, E. 1990. *Hygrocybe*. *In*: C. BAS, T.W. KUYPER, M.E. NOORDELOOS and E.C. VELLINGA, eds. *Flora Agaricina Neerlandica* 2. Rotterdam: A.A. Balkema.

BODDY, L. & GRIFFITH, G.S. 1989. Role of endophytes and latent invasion in the development of decay communities in sapwood of angiospermous trees. *Sydowia*, 41, 41-73.

BODDY, L. & WALD, P. 2002. *Creolophus (= Hericium) cirrhatus*, *Hericium erinaceum* and *H. coralloides* in England. Peterborough: *English Nature Research Reports*, No. 492.

BOERTMANN, D. 1995. *The Genus Hygrocybe (Fungi of Northern Europe – 1).* Danish Mycological Society.

BON, M. 1987. *The mushrooms and toadstools of Britain and north-western Europe*. London: Hodder & Stoughton.

BORGES, C. & ROTHEROE, M. 2002. Managing land with fungi in mind. *Enact*, 10, 17-22.

BOWEN, H.J.M. 2000. *The flora of Dorset*. Newbury: Pisces Publications.

BRASIER, C.M. & RAYNER, A.D.M. 1987. Whither terminology below the species level in the fungi? *In*: A.D.M. RAYNER, C.M. BRASIER and D. MOORE, eds. *Evolutionary biology of the fungi*. Cambridge: Cambridge University Press.

BREITENBACH, J. & KRANZLIN, F. 1986. *Fungi of Switzerland vol 2*. Lucerne: Verlag Mykologia.

BREITENBACH, J. & KRANZLIN, F. 1991. *Fungi of Switzerland vol 3*. Lucerne: Verlag Mykologia.

BRESINSKY, A. & BESL, H. 1990. *A colour atlas of poisonous fungi*. London: Wolfe Publishing.

BULLER, A.H.R. 1909. *Researches on fungi*. London: Longmans, Green & Co.

BULLER, A.H.R. 1922. *Researches on fungi*, 2. London: Longmans, Green & Co.

CANDOUSSAU, F. 1990. *Hypocreopsis rhododendri* in southern France. *Mycologist*, 4, 170-171.

CANDY, B. & WEBSTER, J. 1988. *Hypocreopsis rhododendri*, a rare conspicuous fungus. *Mycologist*, 2, 18-21.

CAUCHON, R. & OUELLETTE, G.B. 1964. Association of *Stromatocrea cerebriforme* and *Hypocreopsis* species with *Hymenochaete* species. *Mycologia*, 56, 453-455.

CLAY, K. 1988. Fungal endophytes of grasses: a defensive mutualism between plants and fungi. *Ecology*, 69, 10-16.

COOKE, R.C. & RAYNER, A.D.M. 1984. *Ecology of saprotrophic fungi.* London: Longman.

COPPINS, A.M. & COPPINS, B.J. 1997. Ballachuan Hazelwood, Argyll Main (VC 98): Lichen survey. Unpublished report for Scottish Wildlife Trust.

COPPINS, A.M. & COPPINS, B.J. 2000. Species dossier - *Hypocreopsis rhododendri*. Unpublished report for Scottish Natural Heritage.

COPPINS, A.M., COPPINS, B.J. & QUELCH, P. 2002. Atlantic hazelwoods, some observations on the ecology of this neglected habitat from a lichenological perspective. *British Wildlife*, 14, 17-26.

COURTECUISSE, R. 1999. *Collins guide to the mushrooms of Britain and Europe*. London: HarperCollins.

COURTECUISSE, R. & DUHEM, B. 1995. *Collins field guide to mushrooms and toadstools of Britain & Europe*. London: HarperCollins.

COX, J.H.S. & PICKESS, B.P. 1999. Observations concerning the ecology of nail fungus *Poronia punctata*, recently rediscovered in Dorset. *Dorset Proceedings*, 121, 129-132.

DAGLEY, J. 2001. (photo only). *Field Mycology*, 2, (4) back cover.

DENNIS, R.W.G. 1975. New or interesting British microfungi, III. *Kew Bulletin*, 30, 345-365.

DENNIS, R.W.G. 1981. *British Ascomycetes*. Vaduz: J. Cramer.

DICKSON, G. 2000. A field key to British non-resupinate hydnoid fungi. *Field Mycology*, 1, 99-104.

DICKSON, G. & LEONARD, A. 1996. *Fungi of the New Forest: a Mycota*. BMS.

DIGHTON, J. & MASON, P.A. 1985. Mycorrhizal dynamics during forest tree development. *In*: D. MOORE, L.A. CASSELTON, D.A. WOOD and J.C. FRANKLAND, eds. *Developmental biology of higher fungi*. Cambridge: Cambridge University Press.

DOWSON, C.G., RAYNER, A.D.M. & BODDY, L. 1986. Outgrowth patterns of mycelial cord-forming basidiomycetes from and between woody resource units in soil. *Journal of General Microbiology*, 132, 203-211.

DUCKWORTH, J.C., EVANS, S.E. & FLEMING, L.V. 2002. Fungi within the UK Biodiversity Action Plan (abstract). *In*: *The 7th International Mycological Congress Book of Abstracts*. Oslo: IMC7.

DUDDRIDGE, J.A. 1985. A comparative ultrastructural analysis of the host-fungus interface in mycorrhizal and parasitic associations. *In*: D. MOORE, L.A. CASSELTON, D.A. WOOD and J.C. FRANKLAND, eds. *Developmental biology of higher fungi*. Cambridge: Cambridge University Press.

ECCF. 2001. Datasheets of threatened mushrooms of Europe, candidates for listing in Appendix 1 of the [Bern] Convention. Bern: ECCF Doc T-PVS(2001)34.

ELLIS, M.B. & ELLIS, J.P. 1990. *Fungi without gills, an identification handbook*. London: Chapman & Hall.

ELLIS, M.B. & ELLIS, J.P. 1997. *Microfungi on land plants*. Slough: Richmond Publishing.

ELLIS, M.B. & ELLIS, J.P. 1998. *Microfungi on miscellaneous substrates*. Slough: Richmond Publishing.

ENGEL, H., KRIEGLSTEINER, G., DERMEK, A. & WATLING, R. 1983. *Dickröhrlinge: Die Gattung* Boletus *in Europa*. Weidhausen.

EVANS, S. 2001. Conservation corner. *Field Mycology*, 2, 116-117.

EVANS, S. 2002. Conservation corner. *Field Mycology*, 3, 143-145.

EVANS, S. 2004. Waxcap-grasslands - an assessment of English sites. Peterborough: *English Nature Research Reports,* No. 555.

EVANS, S. & HOLDEN, E. 2003. Collation of data and information on mycologically important semi-natural grasslands in Wales. Bangor: *Countryside Council for Wales Contract Science Report* No. 565.

EVANS, S., MARREN, P. & HARPER, M. 2001. Important fungus areas. London: *Plantlife Report*.

EWALD, N. 2000. *Survey of the New Forest for the stipitate hydnoid fungi*. Unpublished: Hants & IOW Wildlife Trust.

EWALD, N. 2002. *Stipitate hydnoid fungi in the New Forest*. Unpublished: Hants & IOW Wildlife Trust.

FLEMING, L.V. 1983. Succession of mycorrhizal fungi on birch: infection of seedlings planted around mature trees. *Plant and Soil*, 71, 263-267.

FORTEY, R. 1998. *Battarraea* in Oxfordshire. *Mycologist*, 12, 159-160.

FORTEY, R. 2000. Old churchyards as fungal conservation areas. *Field Mycology*, 1, 121-123.

GARNWEIDNER, G. 2000. *Mushrooms and toadstools of Britain and Europe*. London: HarperCollins.

GREEN, E.E. 1993. Correspondence: *Inonotus hispidus* on apple trees. *Mycologist*, 7, 80-83.

GREEN, E.E. 2000. A rare fungus and rare trees. *Field Mycology*, 1, 133-134.

GREEN, E.E. 2001. Survey of stipitate hydnoid fungi in Berkshire. Peterborough: *English Nature Research Reports*.

GRIFFITH, G.W., EASTON, G. L. & JONES, A.W. 2002. Ecology and diversity of waxcap (*Hygrocybe* spp.) fungi. *Botanical Journal of Scotland*, 54, 7-22.

HANSEN, L. & KNUDSEN, H. 2000. *Nordic Macromycetes Vol 1 Ascomycetes*. Copenhagen: Nordsvamp.

HAWKSWORTH, D.L. 1991. The fungal dimension of biodiversity: magnitude, significance, and conservation. *Mycological Research*, 95, 641-655.

HELFER, S. 1993. Rust fungi – a conservationist's dilemma. *In*: D.N. PEGLER, L. BODDY, B. ING and P.M. KIRK, eds. *Fungi of Europe: investigation, recording and conservation*. Kew: Royal Botanic Gardens.

HENDRY, S.J., LONSDALE, D. & BODDY, L. 1998. Strip-cankering of beech (*Fagus sylvatica*): pathology and distribution of symptomatic trees. *New Phytologist*, 140, 549-565.

HOLDEN, E.M. 2003. *Recommended English names for fungi in the UK.* Salisbury: Plantlife.

HROUDA, P. 1999. Hydnaceous fungi of the Czech Republic and Slovakia. *Czech Mycology*, 51, 99-155.

ING, B. 1992. A provisional Red Data List of British fungi. *Mycologist*, 6, 124-128.

ING, B. 1996. The importance of ancient woodlands in the conservation of larger fungi. *In*: H.J. READ, ed. *Pollard & veteran tree management II (incorporating proceedings of Corporation of London meeting at Epping Forest 1993)*. Slough: Richmond Publishing.

ING, B. 2002. The endangered myxomycetes of the British Isles. Peterborough: *English Nature Research Reports*, No. 466.

JORDAN, M. 1995. *The encyclopedia of fungi of Britain and Europe*. Newton Abbot: David & Charles.

KIBBY, G. 1992. *An illustrated guide to mushrooms and other fungi of Britain and northern Europe*. Limpsfield: Dragon's World.

KIRBY, K.J. 1988. The conservation of fungi in Britain. *The Mycologist*, 2, 5-7.

KIRK, P.M., and others. 2001. *Dictionary of the Fungi 9th edn*. Wallingford: CAB International.

LANDEWEERT, R., and others. 2002. Weathering, a new role of ectomycorrhizal fungi in ecosystems (abstract). *In*: *The 7th International Mycological Congress Book of Abstracts*. Oslo: IMC7.

LEWIS, D.H. 1987. Evolutionary aspects of mutualistic associations between fungi and photosynthetic organisms. *In*: A.D.M. RAYNER, C.M. BRASIER and D. MOORE, eds. *Evolutionary biology of the fungi*. Cambridge: Cambridge University Press.

MAAS GESTERANUS, R.A. 1975. *Die terrestrischen stachelpilze europas (The terrestrial hydnums of Europe)*. Amsterdam: North-Holland Publishing.

MARCHAND, A. 1971. *Champignons du Nord et du Midi* 1. Perpignan: Société Mycologique des Pyrénées Méditerranéennes.

MARCHAND, A. 1976. *Champignons du Nord et du Midi* 4. Perpignan: Société Mycologique des Pyrénées Méditerranéennes.

MARCHAND, A. 1986. *Champignons du Nord et du Midi* 9. Perpignan: Société Mycologique des Pyrénées Méditerranéennes.

MARREN, P. 1995. Stinkhorns, earthstars and fungal flowers: the strange world of gasteromycete fungi. *British Wildlife*, 6, 366-376.

MARREN, P. 1997. Back from the brink project on the Devil's bolete, *Boletus satanas* Lenz. London: *Plantlife*.

MARREN, P. 1998. Species action programme project on *Boletus regius* Kromb., the royal bolete and the pretender *Boletus pseudoregius* Estades. London: *Plantlife Report*, No. 111.

MARREN, P. 2000a. Surveying the royal and devil's boletes. *Field Mycology*, 1, 94-98.

MARREN, P. 2000b. Stipitate hydnoid fungi in England. Peterborough: *English Nature Research Reports*, No. 420.

MARREN, P. 2002. Stipitate hydnoid fungi in England. *Field Mycology*, 3, 120-123.

MARREN, P. & DICKSON, G. 2000. British tooth-fungi and their conservation. *British Wildlife*, 11, 401-409.

MATTOCK, G. 2003. *Boletus satanas* mycorrhizal with *Helianthemum*? *Field Mycology*, 4, 78-79.

McCARTHY, G. 1996. *The wild mushroom*. Kingston-upon-Thames: Fountain Press.

McHUGH, R., and others. 2002. The fungi of Irish grasslands and their value for nature conservation. *Biology and Environment: Proceedings of the Royal Irish Academy*, 101B, 225-243.

MITCHELL, A. 1974. *A field guide to the trees of Britain and Northern Europe*. London: Collins.

NEWTON, A.C., and others. 2001. Progress towards implementing the Biodiversity Action Plan for stipitate hydnoid fungi in Scotland. *Botanical Journal of Scotland*, 54, 89-110.

NEWTON, A.C., and others. 2002. Status and distribution of stipitate hydnaceous fungi in Scottish coniferous forests. *Biological Conservation*, 107, 181-192.

NEWTON, A.C., and others. 2003. Status, distribution and definition of mycologically important grasslands in Scotland. *Biological Conservation*, 111, 11-23.

NIEMELA, T. & NORDIN, I. 1985. *Hypocreopsis lichenoides* (Ascomycetes) in North Europe. *Karstenia*, 25, 75-80.

NITARE, J. (ed) 2000. *Signalarter*. Jönköping: Skogsstyrelsen (Swedish National Board of Forestry).

ORTON, P.D. 1986. Fungi of northern pine and birch woods. *Bulletin of the British Mycological Society*, 20, 130-145.

PACIONI, G. 1985. *The Macdonald encyclopedia of mushrooms and toadstools*. London: Macdonald.

PAREEK, M., ASHFORD, A.E. & ALLAWAY, W.G. 2002. *Armillaria* air pores and rhizomorphs really do conduct oxygen (abstract). *In*: *The 7th International Mycological Congress Book of Abstracts*. Oslo: IMC7.

PEGLER, D.N., LÆSSØE, T. & SPOONER, B.M. 1995. *British puffballs, earthstars and stinkhorns*. Kew: Royal Botanic Gardens.

PEGLER, D.N., ROBERTS, P.J. & SPOONER, B.M. 1997. *British chanterelles and tooth fungi*. Kew: Royal Botanic Gardens.

PEGLER, D.N., ROBERTS, P.J. & SPOONER, B.M. 1999. New British Records. *Mycologist*, 13, 19-22.

PHILLIPS, R. 1981. *Mushrooms and other fungi of Great Britain & Europe*. London: Pan.

PRESTON, C., PEARMAN, D. & DINES, T. (eds) 2002. *The new atlas of the British & Irish flora*. Oxford: Oxford University Press.

RALD, E. 1985. Vokshatte som indikatorarter for mykologisk værdifulde overdrevslokaliteter. *Svampe,* 11, 1-9.

RAMSBOTTOM, J. 1953. *Mushrooms and toadstools*. London: Collins.

RAPER, C.A. 1978. Control of development by the incompatibility system in basidiomycetes. *In*: M.N. SCHWALB and P.G. MILES, eds. *Genetics and morphogenesis in the basidiomycetes*. London: Academic Press.

RAYNER, A.D.M. 1976. Dematiaceous hyphomycetes and narrow dark zones in decaying wood. *Transactions of the British Mycological Society*, 67, 546-549.

RAYNER, A.D.M. 1991. The challenge of the individualistic mycelium. *Mycologia*, 83, 48-71.

RAYNER, A.D.M. & BODDY, L. 1988. *Fungal decomposition of wood: its biology and ecology.* Chichester: John Wiley.

RAYNER, A.D.M., GRIFFITH, G.S. & AINSWORTH, A.M. 1994. Mycelial interconnectedness. *In*: N.A.R. GOW and G..M. GADD, eds. *The growing fungus*. London: Chapman & Hall.

RAYNER, A.D.M., WATLING, R. & FRANKLAND, J.C. 1985. Resource relations – an overview. *In*: D. MOORE, L.A. CASSELTON, D.A. WOOD and J.C. FRANKLAND, eds. *Developmental biology of higher fungi.* Cambridge: Cambridge University Press.

READ, D.J. 1984. The structure and function of the vegetative mycelium of mycorrhizal roots. *In*: D.H. JENNINGS and A.D.M. RAYNER, eds. *The ecology and physiology of the fungal mycelium*. Cambridge: Cambridge University Press.

READ, H. 2000. *Veteran trees: A guide to good management*. Peterborough: English Nature.

REID, D.A. 1986. A collection of *Poronia punctata* from Surrey. *Bulletin of the British Mycological Society*, 20, 58-59.

ROBERTS, P. 2002. Report on the oak polypore *Piptoporus quercinus* (syn. *Buglossoporus quercinus*; *B. pulvinus*) a UK BAP priority species and Schedule 8 species. Peterborough: *English Nature Research Reports*, No. 458.

ROSSMAN, A.Y., and others. 1999. Genera of Bionectriaceae, Hypocreaceae and Nectriaceae (Hypocreales, Ascomycetes). *Studies in Mycology*, 42, 1-248.

ROTHEROE, M. 1999. Mycological survey of selected semi-natural grasslands in Carmarthenshire. Bangor: *Countryside Council for Wales Contract Science Reports* No.340.

RYMAN, S. & HOLMASEN, I. 1984. *Svampar*. Stockholm: Interpublishing.

RYVARDEN, L. & GILBERTSON, R.L. 1994. *European polypores part 2*. Oslo: Fungiflora.

SCHULZE, B., and others. 2002. Endophytic fungi: a source of novel biologically active secondary metabolites. *Mycological Research*, 106, 996-1004.

SEAVER, F.J. 1910. The Hypocreales of North America III. *Mycologia*, 2, 48-92.

SILVERSIDE, A. J. 2000. Species dossier: *Microglossum olivaceum*. Unpublished report.

STALPERS, J.A. 1978. Identification of wood-inhabiting aphyllophorales in pure culture. *Studies in Mycology*, 16, 1-248.

STALPERS, J.A. 1993. The aphyllophoraceous fungi I, keys to the species of the Thelephorales. *Studies in Mycology*, 35, 1-168.

STALPERS, J.A. 1996. The aphyllophoraceous fungi II, keys to the species of the Hericiales. *Studies in Mycology*, 40, 1-185.

SVRCEK, M. 1999. *Mushrooms*. Leicester: Bookmart.

TELFER, M.G., LAMBDON, P.W. & GURNEY, M. 2000. Recent discoveries among the gasteroid fungi of Norfolk. *Field Mycology*, 1, 30-32.

TERMORSHUIZEN, A.J. 1995. *Armillaria*. *In*: C. BAS, T.W. KUYPER, M.E. NOORDELOOS and E.C. VELLINGA, eds. *Flora Agaricina Neerlandica* 3. Rotterdam: A.A. Balkema.

TOFTS, R.J. & ORTON, P.D. 1998. The species accumulation curve for agarics and boleti from a Caledonian pinewood. *Mycologist*, 12, 98-102.

VESTERHOLT, J., BOERTMANN, D. & TRANBERG, H. 1999. 1998 – et usædvanlig godt år for overdrevssvampe. *Svampe,* 40, 36-44.

VESTERHOLT, J. & KNUDSEN, H. 1990. *Truede storsvampe I Danmark - en rødliste*. Copenhagen: UFSF.

VINEY, D.E. 1999. The 'Donkey Fungus' of North Cyprus - a prime location for *Battarraea stevenii*. *Mycologist*, 13, 24-25.

WATLING, R. 1970. *British Fungus Flora* vol 1. Edinburgh: HMSO.

WATLING, R. & WARD, S. 2003. *Fungi: Naturally Scottish*. Edinburgh: Scottish Natural Heritage.

WEBSTER, J. 1980. *Introduction to fungi 2nd edn*. Cambridge: Cambridge University Press.

WHALLEY, A.J.S. & DICKSON, G.C. 1986. *Poronia punctata*, a declining species? *Bulletin of the British Mycological Society*, 20, 54-57.

WICKS, D. 1999. *Survey of the New Forest for the tooth fungi* Hericium erinaceum *and* Hericium coralloides. Unpublished: Hants & IOW Wildlife Trust.

WÖLDECKE, K. 1998. *Die Großpilze Niedersachsens und Bremens*. Hildesheim: NLÖ.

English Nature is the Government agency that champions the conservation of wildlife and geology throughout England.

This is one of a range of publications published by:
External Relations Team
English Nature
Northminster House
Peterborough PE1 1UA

www.english-nature.org.uk

Cover printed on Character Express, post consumer waste paper, ECF.

ISSN 0967-876X

Cover designed and printed by Status Design & Advertising, 2M, 5M, 5M.

Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888

Awarded for excellence