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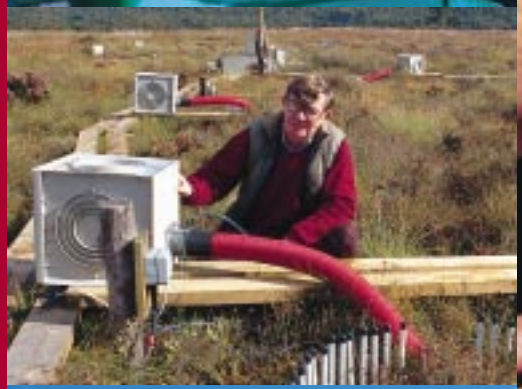

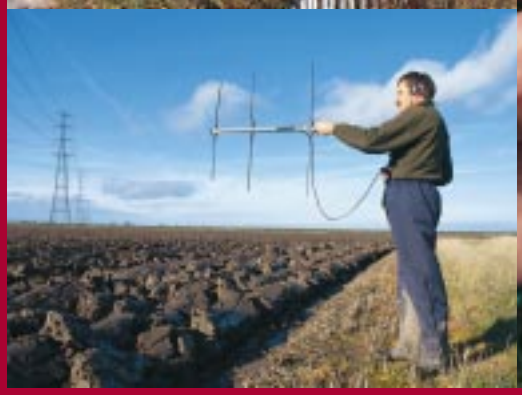

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Report on the marsh honey fungus *Armillaria ectypa*, a UK BAP species

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Summary

Marsh honey fungus *Armillaria ectypa* was added to the British list in 1995. Two more records were made in 2002 (an old record for Minsmere needs confirmation). It is also extant in Austria, Czech Republic, Slovakia, Denmark, Finland, Germany, Japan, Sweden and The Netherlands but is believed to be extinct in Switzerland. It is ranked as *Endangered* in the UK BAP, but as *Vulnerable* in *A provisional Red Data List of British fungi* (Ing 1992).

A. ectypa forms small-medium brown mushrooms in July-October. Ecological data are minimal. We do not know what this fungus lives on. A synthesis of all three UK locations suggests a theme of wet, botanically interesting habitats, probably with low nitrogen availability, with at least localised base-rich microhabitats, even when in predominantly boggy terrain. These sites encompass coastal reedy fen and base-rich flushes in upland moor. If reports of more acidic, boggy, habitats are verified then DNA sequence comparisons would be required.

Conservation management should focus on maintaining the appropriate site hydrology. Fen management to manipulate structural diversity should avoid the destruction of good fruiting populations.

The information and advice contained in this report is based on the best information available to the author at the time. If the conservation of *Armillaria extypa* is to be ensured the following survey work, research and publicity is urgently required.

Survey, monitoring and publicity needs

- Conservation bodies already involved in managing likely sites throughout the country need to be informed about the fungus and its conservation needs.
- Sites with records for *A. ectypa* need further survey and monitoring.
- Sites where *A.ectypa* has not been recorded, but where it may occur because they have suitable habitat conditions should be surveyed.
- Genetic individuals should be mapped and overall levels of genetic variation assessed.

Research

There should be a European collaboration to investigate the ecology of this fungus with UK involvement, including, but not limited to, answering the following questions:

- How does it colonise resources?
- How does it compete for resources?
- What is its breeding system?
- What triggers its exit by the elaboration of fruit bodies?

Contents

1. Accepted scientific name and synonyms

At the time of writing in March 2003 a new checklist of accepted names for the British basidiomycete fungi is nearing the final stages of preparation. The BMSFRD (the online British Mycological Society Fungus Records Database) has the following entry for this species:

Armillaria ectypa (Fr.) Lamoure

Family: Marasmiaceae

Order: Agaricales

This name was published in 1965 and there are a number of earlier synonyms, however all these names predate the first UK record and therefore are not encountered when researching the UK-based documentation. In the BMSFRD the synonyms are listed as:

Clitocybe ectypa (Fr.) Sacc.

Armillariella ectypa (Fr.) Singer

Agaricus ectypus Fr.

2. Established English name

The BAP refers only to the scientific name noting that this is an agaric fungus. Indeed this is such a recent addition to the British list, and subsequently rarely recorded here, that there has been neither the time nor familiarity for it to acquire a truly established English name. However the proposal to include this species on the Bern Convention (ECCF 2001) gives the French name as:

armillaire des marais

and the similarly derived English name as:

marsh honey fungus

The attention of field mycologists has recently been drawn to this species by Evans (2002) with the aim of encouraging more searches, in likely habitats, at the right time of year, to increase our knowledge of its distribution and biology. This initiative was called the "marsh honey fungus (*Armillaria ectypa*) challenge", a name previously used in Evans, Marren & Harper (2001). Consequently it is quite likely that this English name will now become increasingly established, at least in field mycological and conservation-related contexts.

If further research shows that the fungus causes bioluminescence in natural substrata, as is the case with other *Armillaria* spp., we are then faced with the exciting speculation that *A. ectypa* may have generated at least a few manifestations of the wetland phenomenon traditionally known as "will-o'-the-wisp" (S. Evans pers. comm.)

3. Description and distinguishing features

3.1 Fruit body characters

A. ectypa forms mushroom shaped fruit bodies bearing gills on the underside of the cap - it is an agaric fungus. It is not regarded as an edible species. Fruit body characters compiled mainly from Marchand (1986) and Termorshuizen (1995) are as follows:

Fruiting singly or in small clusters in wet ground (see Ecology section).

Fruit bodies have been recorded from July-October in UK and overseas.

Cap diam 3-6 cm (and up to 10 cm according to Termorshuizen 1995).

Cap shape initially domed with a downwards curved margin becoming flat and possibly developing a central depression and wavy margin.

Cap flesh is relatively thin, particularly towards the striate margin where it may become translucent when wet. The flesh is without a distinctive odour and is hygrophanous, ie becoming significantly darker when wet and paler on drying.

Cap colour is yellowish brown, possibly with rosy tints, and darker brown at the centre where the texture becomes slightly more scaly or at least fibrillose.

Gills cream coloured or developing pinkish tints and may be slightly decurrent (arching downwards at the point of attachment forming ridges on the stem apex).

Spore print white or creamy. Spores 6.7-9.5 x 5.5-6.5 µm subglobose to ellipsoid, no reaction in Melzer's reagent.

Stem 6-10 x 0.6-1.3 cm, cylindrical or laterally compressed, without any ring and only slightly thickened at the base.

Stem colour similar to that of the cap and coated with minute scales or fibrils.

Marchand (1986) and Termorshuizen (1995) noted the stem base did not seem to be connected to a system of rhizomorphs, ie the bootlace-like dark structures consisting of bundles of fungal hyphae ensheathed in a waterproof melanised coat characteristic of many species in this genus (see below).

3.2 Vegetative characters

The genus *Armillaria* is notorious amongst gardening circles as the genus accommodating the honey fungus, a group of closely-related species showing different degrees of root-pathogenicity and dead wood recycling behaviour. Wood containing actively growing honey fungus may be bioluminescent and the fungus exits from one woody resource to explore for fresh sources of food in the form of rhizomorphs. These structures protect the foraging fungal mycelium from drying and UV damage and ultimately connect the various food items discovered by the fungus in an extensive underground web. Over its lifetime, a network of honey fungus rhizomorphs may become broken into several physically separated units (many

physical individuals or ramets, but one genetic individual or genet). Should any of these re-encounter each other, they have the ability to recognise their similarity and fuse together to pool resources and subsequently behave as one physical entity again. Tracing the area of woodland inhabited by a single genet (detected using molecular markers) has led to more publicity for *Armillaria* species because surprisingly vast territorial areas (500-1,000 ha) were revealed. The fruit bodies of *A. ectypa* are generally smaller but nevertheless resemble those of a honey fungus. The important suite of characters distinguishing *A. ectypa* are its wetland habitat, lack of ring on the stem and apparent lack of rhizomorphs (Marchand 1986).

The ability of *A. ectypa* to form a rhizomorph web is a subject worthy of further research, not least because it has recently been shown in *A. luteobubalina* that oxygen can enter cultured rhizomorphs from tufts of aerial hyphae termed 'air pores' (Pareek, Ashford & Allaway 2002). Similar structures were then seen in a Norwegian *Armillaria* where rhizomorphs had entered a very waterlogged tree which had fallen into a ditch (A.M. Ainsworth & A. Ashford unpubl.). It is likely therefore that *Armillaria* can oxygenate its rhizomorphs when they enter waterlogged conditions facilitating colonisation of very wet substrata. The question remains whether *A. ectypa* can form rhizomorphs experimentally or *in situ*, or whether its watery habitat ensures that it remains in the diffuse mycelial mode seen when *Armillaria* is deep within colonised wood. If rhizomorphs are simply not produced, the next question centres on the molecular phylogeny of this species. In other words, has the ability to form rhizomorphs been lost over evolutionary time, or does *A. ectypa* occupy a basal position in the *Armillaria* evolutionary tree?

In Britain, there is one other ringless species, *A. tabescens*, but this is characterised by dense tufts of fruit bodies associated with dead trees or shrubs. It is perhaps most frequently found in the heavy wet soils of SE England and it does have some ability to forage with rhizomorphs (this species is usually found in recycling rather than pathogenic mode). Occasionally some of the other species are found fruiting on the ground in very wet habitats, particularly the highly rhizomorphic *A. gallica* (=*A. bulbosa*) (Rishbeth 1985; R. Watling pers. comm.). In such cases the detection of a ring on the stipe and rhizomorphic connections to nearby *Salix* or other shrubs should quickly preclude the possibility of *A. ectypa*.

4. Published illustrations and other information

Colour photographs of *A. ectypa* are on p35 in Marchand (1986), on p33 in Benkert (1997) and, courtesy of Prof. W. Winterhoff, in Evans (2002).

A colour painting appears on p142 in Bon (1987).

Line drawings of fruit body and spores are on p38 in Termorshuizen (1995)

The first British record was confirmed in 1995 and documented as New British Record No. 156 in Pegler, Roberts & Spooner (1999).

5. Status and distribution

5.1 Conservation status in British documents

A. ectypa is classified as *Endangered* in its BAP. It receives general protection under the Wildlife and Countryside Act 1981.

This species is classified as *Vulnerable* in *A provisional Red Data List of British fungi* (Ing 1992).

It is classified in *Group B* in a provisional Red List of endangered European macrofungi (Ing 1993).

5.2 Conservation status in other national and regional documents

It is included in the national lists of endangered fungi in:

Austria, Czech Republic (also protected by law), Slovakia, Denmark, Finland, Germany, Sweden, Switzerland (extinct) and The Netherlands (ECCF 2001).

It is included in the German regional lists of endangered fungi in:

Baden-Württemberg, Bayern, Brandenburg, Mecklenburg-Vorpommern and Rheinland-Pfalz (ECCF 2001).

5.3 Distribution outside UK

This fungus is evidently rare across its range in central, western and northern Europe although much more targeted searching is required to get an accurate picture of its distribution. In addition to the list of countries given above, it has also been reported in Japan (Termorshuizen 1995) and some example site details are available for France, Sweden and The Netherlands:

- **France:** at 1,300 m altitude amongst *Sphagnum* and *Drosera*, Lac Luitel, near Chamrousse, Isère, 31 August 1978 (Marchand 1986). This site seems to have been revisited by D. Lamoure who also found *A. ectypa* amongst *Sphagnum* at Lac Luitel (Alpes massif de Belledone) and cultured material was deposited in the CBS culture collection, The Netherlands, in 1987. Material originating from the Tourbière de Limagne, Haute-Loire, recorded as fruiting on soil, was sent to the MUCL culture collection, Belgium, by J.J. Guillaumin.
- **Sweden:** a few fens in Västergötland and Uppland but more recently reported from acid bogs in the more northerly Västernorrland (Ola Bengtson pers. comm).
- **The Netherlands**: Termorshuizen (1995) reported that it was only known from Kortenhoef and De Wieden. Material originating from Zwartluis, Overijssel, described as associated with a floating tussock of *Carex caespitosa*, was deposited in the CBS culture collection, The Netherlands, in 1998.

5.4 Distribution within the UK

There are only three recorded sites for *A. ectypa* in the UK with associated collections of dried voucher material. These sites are widespread and two of them are very recent discoveries (2002) so it must be concluded that our knowledge of its UK distribution is at a very preliminary stage. All vouchers have been deposited in the Herbarium of the Royal Botanic Gardens, Kew. All three sites are logged on the BMSFRD but, at the time of writing, there is no programme to update the associated dot maps and only the English site is currently displayed.

5.4.1 England

- Westmorland, VC 69, Sunbiggin Tarn SSSI near Tebay, Grid Ref NY6707 (Figures 1-5), collected on 3 Oct 1995 by D.W. Jefferies on BMS Foray, determined by A. Henrici & B. Ing, voucher at Kew as K(M) 36368. Only a relatively short time was spent at the site and so much of the site was not surveyed. This and the following site are described as Important Fungus Areas (Evans, Marren & Harper 2001).
- Suffolk, Minsmere RSPB, Compartment 38. A list of fungi on this reserve compiled by M.B. Ellis (up to end of Feb 1995) was discovered by RSPB staff in 2001. It included *A. ectypa* as new to the county, but there was no voucher material or habitat details. By the time the record and its significance came to light, the compartment's water level had been raised and the existing reed fringe habitat destroyed. M. Allison, RSPB, organised a BMS day foray covering Compartment 38 and likely habitat nearby in Oct 2002 but no records of *A. ectypa* were made.

Figure 1 Wet fen habitat of *Armillaria ectypa* at Sunbiggin Tarn photographed in May showing sedges and *Primula farinosa* in flower

Photograph © Martyn Ainsworth

Figure 2 Location of M6/A685 junction

Figure 3 Location of M6/A685 and Raisbeck

Figure 4 Location of Raisbeck and Sunbiggin Tarn NY6707

Figure 5 Location of Sunbiggin Tarn within

5.4.2 Wales

- Carmarthenshire, VC 44, Ffrwd Fen SSSI near Pembrey, Grid Ref SN419023 (Figures 6-7), collected on 24 Jul 2002 by P. Jones who observed fruiting occurring into Aug, determined by P. Jones, voucher at Kew as K(M) 101332. Dozens of fruit bodies, singly or in small clusters, were seen on these visits and an estimated 50 fruit bodies seen over the recording period. However, at this site, reed stems require parting to observe the fungus and only a fragment of the likely habitat has been surveyed in this manner.

Figure 6 Location of Pembrey near Burry Port

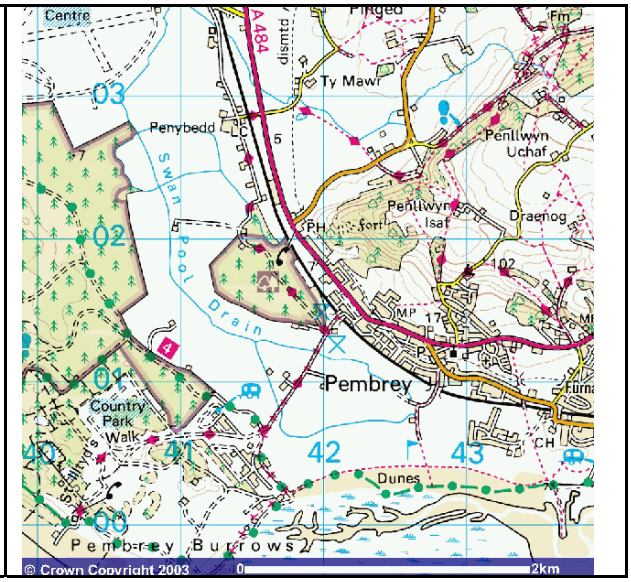

Figure 7 Location of Pembrey and Ffrwd Fen within SN4102

5.4.3 Northern Ireland

Co. Antrim, Garron Plateau ASSI, cSAC, near Ballymena, Grid Ref D218175 (Figures 8-9), collected on 5 September 2002 by M. Wright, determined by M. Wright, voucher at Kew as K(M) 103967. Fruit bodies were single or in small clusters and around 10-15 in all were noted.

Figure 8 Fenced-off base-rich flush habitat of Armillaria ectypa on Garron Plateau

Photograph © David Mitchel

Figure 9 Garron Plateau site is located in the central region of the map

5.4.4 Scotland

There are no authenticated records from Scotland, however Watling (1999) noted "there is evidence of this species in bogs near Peterhead". The evidence comprises a photograph of an *Armillaria* in moorland sent to R. Watling (pers. comm.) who thought it a possible candidate for *A. ectypa*. Unfortunately, there was no material collected and no further reports received from the original contact to verify this possibility.

6. Ecology

6.1 Ecology of A. ectypa at British sites

It must be stressed at the outset that our picture of the ecology of *A. ectypa* is at the pencil-sharpening stage. There are only three authenticated sites to consider so the following interpretations are based on observations made in the UK and discussions with A. Henrici, B. Ing, P. Jones and M. Wright, who were present at the time of the first discoveries in England, Wales and Northern Ireland.

If the general area surrounding each site is considered, there seems little to connect Pennine and Antrim moorland blanket bog with a south Wales low-lying coastal reedy fen. All are of botanical interest however and this led to the discovery of *A. ectypa* in two of the three sites during late July and early September, just before the peak time for general field mycological activity. The botanical interest also supplies a strong clue to an ecological link between the sites. Some details about each follow:

6.1.1 Ffrwd Fen, Wales

The fen has formed on an old estuary and coastal dune system and consists of a mosaic of open water, ditches, pools, relict dunes, areas cut for hay and reedbeds with some willow and alder. There is typical fen vegetation indicative of its base-rich status, including the nationally scarce marsh pea *Lathyrus palustris*. Monitoring the pea population led to the discovery of *A. ectypa* associated with *Phragmites* in an area subjected to waterlogging in winter. The proximity of *Salix* showing premature leaf-browning prompted P. Jones to send some root samples for analysis by A. Pérez-Sierra (RHS, Wisley) who has adopted a molecular approach to *Armillaria* identification (Pérez-Sierra & Henricot 2002). No evidence to support the hypothesis that *A. ectypa* was present in the root tissues has yet emerged (P. Jones, pers. comm.). Hence the substrata of *A. ectypa* remain unidentified and it has generally been assumed to be a saprotroph of plant debris.

6.1.2 Sunbiggin Tarn, England

The tarn and surrounding wetland is situated in upland moor where upwellings of calcareous water exert a localised influence on the otherwise acidic soils. Consequently a mosaic of microhabitats has developed such that the characteristic moorland flora is interspersed with the nationally scarce bird's-eye primrose *Primula farinosa* (Figure 1) and other indicators of base rich flushing such as grass-of-Parnassus *Parnassia palustris*. Interestingly, small tussocks of acid peat can form even in base rich drainage, developing from communities of, for example, *Sphagnum* and *Drosera* raising themselves above the surrounding water level (Gilmour & Walters 1954). Hence a complex picture emerges of tiny islands of plants indicative of acidic conditions within small base rich flushes within vast expanses of acidic blanket peat.

Undoubtedly it was just such habitat complexity that led to the site being included on the BMS Foray and hence to the first British record of *A. ectypa* fruiting amongst moss and grass. One of the two records made on the same day and documented in the BMSFRD stated that there was an association with fallen wood, but it is not clear whether this resource was colonised by *A. ectypa* mycelium.

6.1.3 Garron Plateau, Northern Ireland

The site shows remarkable similarity to Sunbiggin Tarn in that it is a well-known botanical 'oasis' in blanket peat bog. One of its inhabitants is the RDB yellow marsh saxifrage *Saxifraga hirculus*, a plant whose presence at this site has been thought to be "something to do with the availability of rather base-rich drainage water from the volcanic rocks" (Raven & Walters 1956). This is echoed in the advice for those seeking this plant in the Pennines "wherever a flush of water breaks through the peat blanket bringing up with it some dissolved limestone from below" (Fisher 1991). Conservation action in support of *Saxifraga hirculus* led to the discovery of *A. ectypa* at the edge of this flushed site and to its enclosure within a sheep-proof fence (Figure 8). Other plants indicative of base-rich flushing were also noted here, eg *Carex dioica*, but *C. limosa* was also present and *A. ectypa* was recorded fruiting in *Sphagnum papillosum*/*S. capillifolium*.

A synthesis of the UK data would suggest that a theme is emerging of a wet habitat, probably with low nitrogen availability, with at least localised base-rich microhabitats, even when in predominantly boggy terrain.

6.2 Ecology of A. ectypa at other sites

There is much less habitat detail currently easily available for overseas sites of *A. ectypa*. Nevertheless, in Germany, Benkert (1997) records a preference for fens. The French record in Marchand (1986) of fruiting amongst *Sphagnum* and *Drosera* initially suggests a lower pH than usually implied by fen. However this site is at 1,300 m altitude in the French Alps and so the scenario of localised base-rich influence within a boggy matrix cannot be discarded without further investigation. The reports of sites in acid bogs in northern Sweden (Ola Bengtson pers. comm) together with the acceptance that local base-rich flushes may also be present (Stig Jacobsson pers. comm.) further emphasise the uncertainty surrounding the pH tolerance and preferences of this fungus. These are topics which are certainly readily amenable to investigation. If there are verified reports of truly acidic local conditions then molecular comparisons of DNA sequence data may provide insights into the relatedness of potential bog and fen variants. Nevertheless, even if *A. ectypa* is confirmed as fruiting in completely acid bog conditions, the truncated habitat description of "bogs, usually among *Sphagnum*" (eg ECCF 2001) seems to be in need of amendment. Indeed, the BAP itself includes such a description and actions to undertake surveys of *Sphagnum* bogs in northern Britain. It is suggested that, until evidence to the contrary is overwhelming, the target areas for UK surveys should be coastal/inland fens and other areas with localised base-rich flushes.

7. Conservation management advice

In the UK, *A. ectypa* has only been found in three sites, Sunbiggin Tarn, FFrwd Fen and Garron Plateau, all of which represent unusual habitats already recognised for their wildlife of conservation importance. All three ecosystems are sensitively dependent on local hydrology and any major changes to this would be expected to trigger conservation concern, even without detailed knowledge of *A. ectypa* biology and requirements. In general, therefore, *A. ectypa* conservation is occurring under the general umbrella of habitat conservation at these sites. Whether it has requirements conflicting with other conservation interests remains to be seen.

The English and NI sites are islands in blanket bog terrain and therefore any actions leading to a drying of the surrounding area may have deleterious effects. Examples that spring to mind include peat extraction, ditch digging, extensive forestry plantations and any other uses of the groundwater itself. Changes in the quality of the groundwater may also have a negative impact on an ecosystem established under nitrogen poor conditions. Given the unknown substrata inhabited by *A. ectypa*, the effects of nitrogenous enrichment are not predictable but would ultimately negatively impact on the site value. Any agricultural toxic discharges or run-off would be relatively rapidly deleterious, but more long- term and gradual increases in nitrogen inputs from rain, dogs and gull colonies (Sunbiggin area) may influence species recruitment to, or loss from, the site. Such base-rich foci are also subject to sheep grazing which keeps the rank vegetation in check ensuring a good show of specialist plants such as *Primula farinosa* and *Saxifraga hirculus*. It is likely that botanical concern would guard against the possibility of grazing pressure reaching mycelium-threatening levels. At the other extreme, the NI experience of completely fencing the site should be monitored to see the floral and fungal response to a total absence of sheep grazing.

The Welsh site consists of a much more widespread fen habitat, but there are the same concerns about continuity of groundwater quantity and quality. Indeed, the site is effectively bounded on three sides by a road, disused canal and disused railway line and water enters at just two points. Water enters the site via an area of light industry or from a ditch near to a road, hence both are potentially sources of pollution. Attempts have been made in the past to drain and either agriculturally improve the site or industrially develop it as has occurred in surrounding areas of former fen.

The largest number of fruit bodies recorded at any UK site occurred in the vicinity of willows in what is probably a relatively dynamic ecosystem. Any coastal habitat with open pools, reedbeds and willow encroachment requires management to maintain such a varied structure. Conflict of interest may arise if it was suggested that willows in the vicinity of good fruiting sites of *A. ectypa* fruit bodies should be felled to check scrub encroachment. However, encroachment by willow is likely to have an impact on water levels through transpiration and we just do not know how *A. ectypa* fares as reedbed becomes dominated by willow, or if the willow is pollarded as a compromise. It is imperative that the extent of *A. ectypa* territory should be determined as far as possible (in practice this may just be fruiting areas) and future management plans take these into account. It would also be useful to investigate the history of management in the exact locations currently favoured by fruiting *A. ectypa*, particularly if, as expected, records begin to accumulate from similar reedy fens around the country.

The immediate priority is to raise awareness of this fungus and stimulate searches to be made for its fruit bodies in July-Oct. A start has recently been made within the field mycological community (Evans 2002), but funding is urgently required to produce leaflets to alert the networks of conservation bodies already involved in managing likely sites throughout the country. Funding should be made available to carry out surveys of suitable sites as stated in the BAP. Given the locations documented herein, a start could be made in the following nature reserves: Kenfig NNR, Ainsdale NNR, Cothill NNR, Leighton Moss RSPB (and nearby Hawes Water where *Primula farinosa* occurs) and any East Anglian fen. We need to keep track of unproductive visits to sites as well as successes. We need to know the extent of fruiting populations at each site and lab work could reveal the number of genetic individuals and overall level of genetic variation present. We need to know almost everything about the ecology of this fungus from observations of naturally colonised substrata and detection of mycelia by molecular methods to its responses to laboratory manipulation. How does it

colonise and enter resources, how does it compete for them, what is its breeding system and what triggers its exit by the elaboration of fruit bodies? In short, we know its name but very little about how and where it lives.

8. Acknowledgements

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Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
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Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
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