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# THE SLAPTON FUNGAL (INCLUDING LICHEN) SURVEY: INVENTORYING AND DOCUMENTING CHANGES IN THE MYCOBIOTA

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ABSTRACT

The Slapton Fungal Survey has involved at least 64 mycologists since 1969 and, in mid-October 1995, the number of species identified stood at 2,344—of which 449 were added in the two years 1994–95 as a result of three particularly intensive periods of study. In view of the habitats and groups remaining to be studied, the estimate of the total fungal inventory of the Reserve is increased (conservatively) to 3,000 species, 6.1 times the number of plants known to be native to the Reserve.

Particular attention is paid to changes in the lichen flora, at least 25 species of which have become extinct in the period, due to changes in habitat and, it is suggested, small increases in ambient sulphur dioxide pollution. Some mycorrhizal fungi also fruit less frequently, but other macromycetes have been found to reappear, often after extended periods, in the same areas. The richness and level of novelty of species revealed in this one site (64 new for the British Isles, including 21 described as new to science) has implications for inventories of fungi in other sites.

## INTRODUCTION

The fungi, including lichen-forming species, slime moulds, yeasts, and various other groups of organisms traditionally studied by mycologists, remain imperfectly known throughout the world, perhaps with an even smaller proportion having been named than in the case of the insects (Hawksworth, 1991; Heywood, 1995). A protected area with varied habitats, and almost adjacent accommodation and laboratory facilities, come together at Slapton to provide an opportunity to inventory in depth the fungi of a single site. This article describes how the inventorying has been undertaken and the results to date, draws attention to some of the changes documented in the case of lichens and macromycetes, and considers the wider implications of the results.

A full account of the survey, including observations of species in different habitats, a comprehensive checklist, and also host/substrate indices is to be published as the first paper in *Field Studies* **9** (1996) with the support of the Centenary Committee of the British Mycological Society.

## INVENTORYING THE MYCOBIOTA

### *Conducting the Inventory*

In-depth systematic recording in the, then, Slapton Ley Nature Reserve and its immediate vicinity started in 1969. In that year, D.L.H. had visited in April, during the

British Lichen Society spring field meeting based in Totnes, and was so impressed by the richness of the site that he needed little persuading to return in the September to run a course on lichens. Dr (now Professor) D. H. Richardson, then at the University of Exeter, had been scheduled to teach the course but had left to take up an appointment at Laurentian University in Canada.

D.L.H. has recorded in the reserve at least once (and sometimes up to four times) in all but one year since 1969. Visits were most extensive and frequent in 1969–75, leading to the first accounts of the lichenised (Hawksworth, 1972) and other fungi (Hawksworth, 1976). From 1975, his visits were more sporadic and mainly in the summer, as a course tutor. F.S.D. succeeded D.L.H. in running courses on lichens at the Field Centre from 1988. However, the achievements to date would not have been realised without inputs from numerous other mycologists.

Additional records were contributed by several other workers in the late 1970s to mid-1980s, most notably by Dr B. Ing (Ing, 1976) and the late Mr M. C. Clark, specialising in slime moulds and discomycetes respectively. Additions up to 1985 are compiled in Hawksworth (1986).

Since 1990, frequent visits have been made by Mr P. J. Roberts formerly of Torquay, but now at the Royal Botanic Gardens Kew. A specialist in basidiomycetes, especially resupinate groups, he has made numerous additions to the inventory during weekend courses conducted at the Field Centre and on independent visits.

Dr B. J. Coppins and Ms A. M. O'Dare made a detailed survey of the lichenised fungi in the Higher Start Farm area in February 1991.

The British Mycological Society has visited Slapton on four occasions: for single days in May 1968 (Holden, 1969) and September 1978 (Greenhalgh, 1980), and seven days based at the Field Centre in both May 1990 and October 1995. Numerous specialists participate in Society field visits ("forays") and they have all made major contributions to the current level of knowledge.

As a result of a small contract from English Nature, soil and water samples were collected from different habitats for dilution-plate and selective-isolation work during September 1993, which have been reported on by Hall *et al.* (1995). Several specialists from IMI and Glaxo Research Ltd conducted an intensive study in May 1994, yielding around 180 additional species; including three genera new to science. Mr A. Weir recorded Laboulbeniales on insects for the first time in the Reserve in June 1995, adding 18 species, and Professor J. Webster has been culturing additional fungi from rabbit dung collected the same month.

To date, not less than 64 mycologists have been involved in the collection and critical identification of material from Slapton. The results of their work are incorporated into a database maintained at the International Mycological Institute (IMI). Voucher specimens of critical and representative material are mostly deposited in the collections of IMI and Royal Botanic Gardens Kew (K), with other material at The Natural History Museum London (BM), Royal Botanic Garden Edinburgh (E).

*The Inventory to Date*

The recording area used in the survey embraces the Slapton Ley National Nature Reserve, and also Battleford Wood, Duck Marsh, Higher Start Farm, Slapton Village, Southgrounds, Slapton Church, Strete Gate, and parts of Torcross at the level with the Reserve.

TABLE 1. *Total numbers of species of fungi recorded from the Slapton Ley National Nature Reserve and adjacent regions.*

| Group | Number of Species Recorded 1976 | 1986 | 1994 | 1995 (not analysed by group) |
|---|---|---|---|---|
| Myxomycota | 87 | 88 | 95 | — |
| Oomycota | 4 | 7 | 19 | — |
| Chytridiomycota | 0 | 0 | 0 | — |
| Zygomycota | 14 | 14 | 30 | — |
| Ascomycota | 612 | 717 | 829 | — |
| Basidiomycota | 336 | 384 | 609 | — |
| Mitosporic fungi | 239 | 266 | 333 | — |
| Total | 1,292 | 1,476 | 1,915 | 2,344 |

The total number of fungal species reliably recorded from the Slapton Ley Nature Reserve and its immediate vicinity had reached 2,344 in mid-October 1995 (Table 1). That figure allows for anamorphs (asexual, mitosporic states) named separately from their teleomorphs (sexual, meiosporic states) and excludes about 80 currently unnamed collections at IMI, and much of the critical material collected during the British Mycological Society's October 1995 needing further study.

*Completing the Inventory*

While the number of species known from Slapton has been increased at an average rate of 55 each year since 1976 when the initial surveys were published (see above), recording rates have been far from equal. For example, 449 species were added during 1994 and 1995 as a result of concerted visits by IMI scientists, the British Mycological Society, other specialists. That so many species can be found in so short a period after 25 years of recording raises the question of how many species remain to be discovered.

Hawksworth (1976) estimated that the total number of species of fungi at Slapton might be as many as 1,800, but ten years on, when the total had swelled to 1,476 species, Hawksworth (1986) considered that "a few years of concerted fieldwork . . . . would take the total to over 2000". In February 1994 the estimate was raised to 2,500 (Hawksworth, 1994). The 2,000 barrier was crossed in May 1994, and with 2,500 now in sight, 3,000 species seems far from unrealistic. Some support for that hypothesis can be derived from the comparison of the proportions of the fungi in different groups found in Slapton compared with the general estimates prepared by Dennis (1973) presented as Table 2. If the ascomycetes are assumed to be the best-studied group at Slapton and should reflect about 25% of the total species, then this would give a figure for 3,316 for the species to be expected at Slapton. As Dennis did not allow for lichenised species, such a figure could be an over-estimate and 3,000 can be accepted as a conservative estimate at this time.

The larger fungi, particularly seasonal agarics and boleti, are certainly proportionately still underrepresented at Slapton, mainly due to a lack of intensive recording opportunities in autumn "flushes". Various other fungal habitats and groups also remain

TABLE 2. *Proportions of fungi recorded from Slapton up to February 1994 in different phyla compared with the generalised estimates of Dennis (1973).*

| | Dennis (1973) | Slapton |
|---|---|---|
| Myxomycota | 1–5 % | 5 % |
| Oomycota and Zygomycota | 2–6 % | 3 % |
| Ascomycota | 24–27 % | 43 % |
| Basidiomycota | 47–57 % | 32 % |
| Mitosporic fungi | 12–20 % | 17 % |

not at all or scarcely studied; for example, aquatic oomycetes, bryophilous fungi, chytrids, coprophilous fungi, endomycorrhizal fungi, entomogenous fungi, fungicolous fungi, keratinophilic fungi, soil fungi, marine fungi, dung fungi, fungi in bird's nests, bark cultures, and yeasts). Specialists are currently being sought to address as many of these gaps as possible for the 1996 synthesis publication.

## CHANGES IN THE LICHENS AND MACROMYCETES

In an extended survey of a particular site, changes due to both natural and human agencies in the species present are to be expected. In this section, we wish to draw attention to some of the more dramatic changes that have been revealed by the survey in the case of species forming lichens and macromycete fungi.

### *Lichens*

One consequence of the perennial nature of most lichen thalli is that they are especially suitable for the detection of change, without the complications of periodicity in fruiting and seasonality seen in many larger and plant-related fungi. To date, 323 lichenised species have been recorded from the Reserve and its immediate vicinity; this is one of the highest numbers for an area of this size in England and Wales (Hawksworth, 1994). This is even more remarkable considering that it contains few natural substrates for saxicolous lichens. Old forest species (Rose, 1976) are also poorly represented as, except in the marshes, almost all the trees have been clear-felled at some time; the highest Revised Index of Ecological Continuity (RIEC) value reached is 30 (maximum 100) in the carr (F1) at the base of Slapton Wood (Hawksworth, 1986). It is here that the old forest species such as *Dimerella lutea, Nephroma laevigatum* and *Sticta* species are most frequently found, and the valley-bottom also support *Leptorhaphis maggiana* (on hazel). Luxuriant growths of *Evernia prunastri* exceed 5 cm in length here, and provide one of the few sites in England and Wales where this species is found fertile. *Degelia plumbea*, not seen in the Reserve this century, probably formerly occurred along the ancient ash-elm line than formerly ran from Deer Bridge to the northern edge of the Lower Ley; this is the site for some more "Mediterranean" species such as *Cryptolechia carneolutea* and *Parmelia quercina* (Dobson & Hawksworth, 1976) favoured by the Reserve's mild climate.

The relatively clean air also contributes to the site's richness in lichens. The mean winter concentration of the main airborne pollutant affecting lichens, sulphur dioxide ($SO_2$), remains low. Nevertheless there has been a marked decline in some especially sensitive species since 1969 when *Usnea articulata*, indicative of really "pure" air

(Hawksworth and Rose, 1970), was abundant. The lichen vegetation suggests that levels of this pollutant in the Reserve are probably now around 30–35 μg $m^{-3}$; zones 8–9 rather than 10 of Hawksworth and Rose (1970). While mean daily figures recorded in 1988 were very much lower, a maximum of 49 μg $m^{-3}$ has been reported (Bates *et al.*, 1993). It would be of interest to have further measurements for the moist winter periods over several years as it is then that the lichens are physiologically most vulnerable to this pollutant.

In 1970, only a single thallus of the pollution tolerant species *Lecanora conzaeoides* was found on the Reserve but this species is now much more widely distributed around the Field Centre, especially on sawn wood of its perimeter fences.

These fences have become an important habitat for *Parmelia soredians*, a species found apothecia on the seat opposite the Centre, seen for the first time in the British Isles in 1995 by D.L.H.. Other interesting colonists on new fences here and elsewhere in the area are *Pseudevernia furfuracea* and *Strangospora moriformis*.

Since about 1975 there has been a decline in the lichens of the Reserve with at least 26 species having been lost (Hawksworth, 1986). The area around Duck Marsh has noticeably suffered. In 1970, F.S.D. photographed a specimens of *Usnea ceratina* measuring almost 50 cm in length. It is now difficult to find specimens of that species measuring more than 5 cm, and *Usnea articulata* which formed thalli to 24.5 cm long in that site (Hawksworth, 1972) has not been seen at all in the Reserve since at least 1990. The dense cover of *Usnea* and *Ramalina* species that was common on trees in Duck Marsh and on the Causeway has been reduced mainly to isolated specimens. This decline appears to have been caused by a combination of rising air pollution and the loss of mature willow trees (due to a fall in the level of the water table and possibly by an increase in pollution from agriculture and fish farming, and severe attacks by *Phyllodecta* beetles).

Aquatic lichens are present in Slapton Wood stream, but the high turbidity and nutrient levels in the Ley prevent its colonisation by these species. The western seaward shore (C) consists of a low shingle bank that used to be an important lichen site when constantly replenished by fresh shingle from the beach during severe winter storms and the unstable nature of the shingle bank prevented vascular plants from dominating the ridge. An interesting lichen community was found on the more stable shingle in the open areas. Many of these pebbles had colonies of crustose species such as *Buellia punctata, Micarea erratica* and *Rhizocarpon obscuratum,* together with foliose and fruticose species such as *Evernia prunastri*, and *Ramalina cuspidata*. With the building of the new sea defences at Torcross following the destructive storms of 1979, (the new concrete providing a habitat for species such as *Caloplaca thallincola*), and further the building of the central car park on the site of the former Slapton Sands Hotel, the storms no longer deposit fresh shingle on the ridge. The resultant prolific growth of vigorous herbaceous plants has led to the loss of several lichens, including six species of *Cladonia*, from the Reserve.

Another important factor has been the occurrence of Dutch Elm Disease (*Ophiostoma novo-ulmi*). This first reached the Reserve in 1978, and by 1980 almost all the mature elms had died. This not only eliminated species such as *Anaptychia ciliaris, Caloplaca flavorubescens* and *Collema furfuraceum* that were only found on these trees, but opened up habitats along Marsh Lane (by Duck Marsh) and along the northern edge of the Lower Ley, dramatically reducing more photophobous species. *Cryptolechia carneolutea* still persists with some other rare lichens (notably *Opegrapha prosodea* and

*Wadeana dendrographa*) on mature ash (*Fraxinus*) but they are not colonising younger trees and can be expected to become extinct in the Reserve when the last large ash dies.

Some species have also been lost from man-made substrates in recent years. For example, *Acarospora smaragdula* following cleaning to remove graffiti from the memorial on the beach (B), and *Peltigera horizontalis* from the wall-top at the front of the Centre (due to a heavy growth of ivy and repair work).

Over 30 years of recording and monitoring the lichens on the Reserve, from the early Field Courses run by Dr K. L. Alvin (from 1961–66) has shown a number of changes, many of them for the worse. They show how precarious is the balance of the environment for some of the more interesting species in the area, and we fear further losses in future as ancient trees die and ambient air pollution increases insidiously.

*Macromycetes*

Macromycetes are generally fleshy fungi with macroscopic fruit bodies; this includes mushrooms and their relatives, bracket fungi, larger cup-fungi, and also gasteromycetes. As in the case of lichens, these do not form a monophyletic group, but as large fruit bodies are most easily seen, these fungi are those most commonly featured in identification guides and most likely to be recorded. Although it is still early days to comment authoritatively on changes in most non-lichenised fungi, the following preliminary observations are of particular interest.

Mycorrhizal fungi are especially poorly represented in the Slapton inventory. While this is partly due to the pattern of recording (see above), it is unlikely to be the whole answer. That the woods are mostly secondary and the soils are rather shallow and rich may be particularly relevant factors. The fruiting of some mycorrhizal species is also much less abundant than in the 1970s, for example in *Amanita rubescens, Russula nigricans* and *R. ochroleuca*. The chanterelle, *Cantharellus cibarius*, which on occasion used to be collectable in sufficient quantities from France Wood and Slapton Wood for student breakfasts at the Field Centre in the late 1970s has not been reported at all for at least 5 years although almost invariably present in J3 at least from 1970–85 (Hawksworth, 1986). Dramatic declines of this fungus in continental Europe have been linked with acid rain (Arnolds, 1991).

The absence of some other common macromycetes may be due to the rarity of poor development of their host trees in the Reserve. For example, the fly agaric *Amanita muscaria* and the razor strop fungus *Piptoporus betulinus*, both associated with birch are both yet to be discovered at Slapton.

One aspect of studying macromycetes over a long period is that seeming random and rare occurrences of fruit bodies are found to be far from that. Examples of species with very localised occurrences in the Reserve are *Cortinarius decipiens, Gyroporus cyanescens, Helvella elastica, Hydnum rufescens, Lentinus tigrinus, Marasmius hudsonii,* and *Pholiota squarrosus.*

Amongst the gasteromycetes, the spectacular and perhaps introduced *Clathrus ruber* on a stump in the Field Centre grounds occurred only in 1965 and 1967–69. Surprisingly, the giant puffball, *Langermannia gigantea*, was first found in the Reserve in 1992 but has been seen repeatedly since. *Geastrum lageniforme*, a Red List species previously considered extinct in the British Isles has also been collected in Marsh Lane (Duck Marsh) and the lower part of Slapton Wood (J2)[1] from 1991 onwards.

[1] The 38 sites used for biological recording in and around Slapton Ley National Nature Reserve are explained by Bates, Perry & Proctor (1993). Ed.

Interestingly, a few macromycetes have flourished as a result of the demise of the Slapton elms, particularly *Peziza micropus* and *Rhodotus palmatus* on rotting elm trunks.

## Implications of the Slapton Survey

Slapton currently has the largest number of species published as occurring in an area of its size anywhere in the British Isles, and probably the world. Slapton is therefore becoming a classic site for the recording of fungi. The only potential rival, to our knowledge, is Esher Common in Surrey, which has had fungi recorded there since the 1880s but for which no synthesis has yet been made available.

The Slapton fungal survey has shown that a sustained effort involving numerous specialists and extending over several decades is likely to be necessary to fully inventory the fungi of a single site. Involving new specialists even after two decades of recording results in significant increases in species numbers.

Further, the Slapton survey has to date yielded about 64 species new to the British Isles, of which 21 have been formally described as new to science. In addition, many others await more critical study or have only been named to the level of genus (or in some cases family). This means that strong systematic support is essential if all collections are eventually to have species names.

That so many novelties can occur in a single, largely secondarily-vegetated site, suggests that our knowledge of fungi in the British Isles remains most inadequate in comparison with other "botanical" groups. The extent to which the particular climatic situation of Slapton may contribute to this situation cannot, however, be ascertained at our currently level of ignorance of the distribution of most groups of fungi in the British Isles.

Finally, it has been suggested elsewhere (Hawksworth, 1991) that the number of fungi (of all groups) in a particular geographical area can be expected to exceed the total of native vascular plants by about a factor of six. It is, therefore, of interest to note that the revised estimate of 3,000 species for Slapton is 6.1 times the 490 species of plants listed for the Reserve by Brookes & Burns (1969).

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