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# Survey of Sand Dune Macrofungi Assemblage, Merthyr Mawr Warren NNR 2020

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Evidence Report No 534

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## 1. Crynodeb Gweithredol

Mae twyni'n amgylchedd cymharol elyniaethus ac eithafol i ffyngau, gan gynnal niferoedd llawer is o rywogaethau na chynefinoedd eraill. Mae llawer ohonynt yn arbenigol iawn ac nad ydynt i'w cael yn unman arall; dyma pam mae mor bwysig eu gwarchod. Am y tro cyntaf, mae'r canllawiau ar gyfer dewis Safle o Ddiddordeb Gwyddonol Arbennig (SoDdGA) yn cynnwys casgliad twyni o ffyngau (yn seiliedig ar Evans a Roberts 2018).

Yn ystod pum ymweliad yn hydref 2020 â Gwarchodfa Natur Genedlaethol Tywyn Merthyr Mawr, cofnodwyd 17 o rywogaethau o ffyngau casgliad twyni, yr oedd 10 ohonynt yn newydd i'r safle, gan greu cyfanswm hanesyddol o 23. Deg yw'r trothwy ar gyfer ystyriaeth yn SoDdGA ac nid oes unrhyw system dwyni Brydeinig (ar sail 2018) â chyfanswm o fwy na 27 o rywogaethau. Yr elfen bwysicaf o ran hyn yng Ngwarchodfa Natur Genedlaethol Tywyn Merthyr Mawr yw casgliad ffwngaid llac twyni'r gorchelygen *Salix repens* a geir yno, sef un o'r goreuon yng Nghymru. Bellach dylid diweddarau disgrifiad SoDdGA Merthyr Mawr i gydnabod y diddordeb ffwngaid eithriadol hwn gan sicrhau rheolaeth wedi'i thargedu a phriodol.

Nid yn unig yw Gwarchodfa Natur Genedlaethol Tywyn Merthyr Mawr ymysg y deg safle twyni gorau yng Nghymru am ei ffyngau unigryw ac arbenigol, mae ymhlith y rhai mwyaf adnabyddus ym Mhrydain, ac o bosibl yn Ewrop. Mae'n hollbwysig diogelu eu dyfodol.

## 2. Executive Summary

Dunes represent a relatively hostile, extreme environment for fungi supporting much lower numbers of species than other habitats. Many are highly specialised and not found anywhere else which is why their conservation is so important. Guidelines for selection of a Site of Scientific Interest (SSSI) for the first time include a dune assemblage of fungi (based on Evans & Roberts 2018).

During five visits in autumn 2020 to Merthyr Mawr Warren NNR 17 species of dune assemblage fungi were recorded of which 10 were new to the site giving a total historic count of 23. The threshold for consideration as a SSSI is 10 and no British dune system (as of 2018) has a total higher than 27 species. The most important element of this at Merthyr Mawr Warren NNR is its *Salix repens* creeping willow dune slack fungal assemblage which is one of the best in Wales. Merthyr Mawr's SSSI description should now be updated to recognise this outstanding fungal interest ensuring targeted and appropriate management.

Merthyr Mawr Warren NNR is not only one of the top ten dune sites in Wales for its unique and specialised fungi but also amongst the very best known in Britain, possibly in Europe. Safeguarding their future is paramount.

### 3. Aim

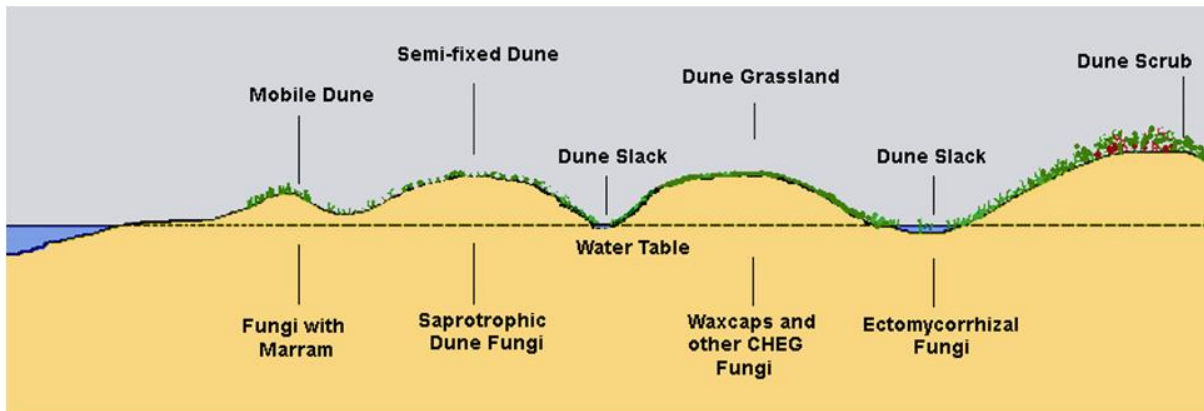
The aim of the survey was to establish the presence of dune assemblage macrofungi of conservation concern at Merthyr Mawr Warren National Nature Reserve (NNR) including their location and population.

### 4. Introduction

Dunes represent a relatively hostile and extreme environment for non-lichenised macrofungi and they tend to support a much lower number of species than other habitats such as woodlands. However, some of the species they do support are so highly specialised they are not found anywhere else which is why their conservation is so important.

These specialist dune fungi can occur in specific zones of the dune ecosystem so it is important when conducting a survey to search a representative sample of each of these zonal ecosystems (see cross section below).

**Figure 1 Cross-section of a representative coastal dune, showing zonations and their typical macrofungi**



Typical macrofungi of mobile (yellow) foredunes are saprotrophs on marram grass often occurring at the base of clumps and then appearing to arise from bare sand. Representative species include the fairly ubiquitous *Psathyrella ammophila* dune brittlestem and the more restricted *Coprinopsis ammophila* dune inkcap.

Semi-fixed and fixed (grey) dunes typically support a greater variety of saprotrophic macrofungi and many (but not all) are dune specialists, e.g. *Bovista pusilla* least puffball and *Tulostoma brumale* winter stalkball.

Dune slacks are important for ectomycorrhizal fungi typically associating with *Salix repens* creeping willow and some of these associates are dune specialists, e.g. *Inocybe dunensis* dune fibre-cap. This is often the most mycologically rich part of the dune system (Vincenot *et al.* 2008).



The dune grassland of fixed (grey) dunes is important for fungi of unimproved grasslands, including waxcaps and other CHEG species (the assemblage of Clavarioid fungi-*Hygrocybe* s.l.-*Entoloma*-Geoglossoid fungi, restricted to old, untreated pastures and short-sward grasslands), a few of which are dune specialists, e.g. *Hygrocybe conicoides* dune waxcap. Dune scrub, also in the fixed dunes, is the least important zone for dune specialist fungi often giving rise to macrofungi typical of similar scrub habitats inland though it may host specialist microfungi.

## 5. Methods

### 5.1. Site visits

Site visits were made on five occasions in the autumn and early winter of 2020 on 1<sup>st</sup> Sept, 8<sup>th</sup> October, 16<sup>th</sup> October, 5<sup>th</sup> November and 19<sup>th</sup> November. This was at agreed variance from the project specification which suggested regular visits from late August to late October.

### 5.2. Timing

Mycological field observation surveys such as this are based on the identification of visible fruiting bodies arising from the organisms' underground mycelial networks. The fruiting of macrofungi such as the target dune fungi for this survey is limited by the vagaries of prevailing fruiting conditions principally determined by the weather. In August and September 2020 there was a lack of any significant rainfall and after an initial visit on 1<sup>st</sup> September it was deemed best to extend the survey and visit at surveyor discretion when fruiting conditions appeared more favourable.

Careful on-line monitoring of the onsite weather station was used to inform these dates. It is well established (Evans & Roberts 2015b) that, if the weather is sufficiently wet, dune fungi can often continue fruiting well into December and even January or February in mild winters. During this survey in 2020 the weather conditions in late November were once again very dry so a late winter December visit was not deemed likely to add further records. This should not prevent any future dune surveys from doing so if fruiting conditions are favourable.

### 5.3. Survey methodology

Survey methodology was based on the method proposed by Rotheroe *et al.* (1996) for waxcap-grassland fungi but modified to suit sand dune system needs. The initial visit on 1<sup>st</sup> September included scoping the extent and challenges of the terrain and tailoring a survey approach suitable for Merthyr Mawr Warren NNR that would maximise best use of time and include all micro dune habitats likely to have target species (mobile foredune, grey dune, dune slack, dune scrub, and dune grassland). A series of potential areas deemed most likely to hold these was identified to maximise effective use of surveyor time. In general, a methodical walkover approach in these areas was adopted, with both linear and circular sweeps to best suit the individual topography and to reflect interest found.

#### 5.4. Field records

Field records were made on site and were supported by additional notes and photographs where possible of as many potential dune target species as feasible. GPS map readings were also taken for recognised dune target species together with subsequent map extrapolations for other collections.

#### 5.5. Relative frequency

Relative frequency notes were made of occurrence of individual dune assemblage species based on fruitbody observations during each visit rather than population figures as stated in the initial survey specification. It is not possible to assess population figures for fungi in the way that it is for plants and other organisms, since an individual mycelium may produce one or many fruitbodies over a small or extensive area. The science does not yet allow for the definition of the number of fungal individuals which constitute a viable population nor is there any standard method of assessment in the field (Bosanquet *et al.* 2018). Not enough is known about individual species ecology and the extent of their underground mycelium to make such inferences without advances in DNA analysis. However, observations of relative frequency of individual fruitbody or small groups of fruitbody occurrence do provide some guidance as to how relatively common each species is likely to be at a site and are listed throughout the report in place of population figures.

#### 5.6. Collections

Collections of specimens were made for most of the fungi encountered as nearly all dune assemblage species require further microscopic identification work. These specimens were described on the day of collection and in some cases dried for later lab-based microscopic identification in combination with the use of specialist monographs. Time was not spent unnecessarily on the identification of taxa deemed to be widespread in non-dune habitats. It is proposed in line with best practice that any retained notable material will in due course be offered for curation to the UK national fungus collections held in the Fungarium at the Royal Botanic Gardens, Kew.

#### 5.7. Records

Records were made for all target dune assemblage species as well as other non-lichenised macrofungi encountered. All species observed have been databased in an electronic format and provided in an Excel spreadsheet which accompanies this report as well as listed in summary format in Table 7 in this report. These records include data fields recommended as a minimum for best practice by the Fungal Records Database of Britain and Ireland (FRDBI) (British Mycological Society 2009). Survey records should normally be shared with the FRDBI which itself feeds data into the National Biodiversity Network (NBN).

#### 5.8. Scientific names

Scientific names for basidiomycetous fungi follow those used in the Royal Botanic Gardens, Kew's *Checklist of the British and Irish Basidiomycota* (Legon & Henrici 2005), updated at [www.basidiochecklist.info](http://www.basidiochecklist.info), and for ascomycetous fungi (for which there is no current checklist) the Fungal Records Database of Britain and Ireland

(British Mycological Society 2009). English names follow those recommended by the British Mycological Society at [www.britmycolsoc.org.uk/library/english-names/](http://www.britmycolsoc.org.uk/library/english-names/).

## 5.9. Limitations

Limitations on a field observation fungus survey such as this are inevitable given they are based on the identification of visible fruiting bodies. Apart from a very few perennial bracket fungi on trees or shrubby plants, the fruitbodies of larger fungi are ephemeral and may not appear every year. The mycelium of fungi, in sand or plant substrates, is continually present but remains below the surface and cannot be identified visually. So, any survey of this kind will always provide a species list limited by the vagaries of prevailing fruiting conditions principally determined by the weather. A one year survey such as this at Merthyr Mawr Warren NNR, can only reflect a minimum snapshot assessment of the species actually present at the site.

## 5.10. Best practice

Best practice for survey should as a minimum include 3-5 visits per year (timed at the mycologist's discretion for maximum fruiting) ideally over a period of at least three years (Evans & Roberts 2018). Analysis has shown that successive surveys year on year will continue to add new species of macrofungi to a site list even after 20 years, albeit under the rule of diminishing returns (Tofts & Orton 1998). Further surveys are therefore recommended, both to better establish fungal diversity and to monitor long term site management.

# 6. Results

## 6.1. SSSI dune assemblage fungi

Before this survey 13 dune fungal assemblage species listed in JNCC's 'Guidelines for the Selection of Biological SSSIs' (Bosanquet *et al.* 2018) had been recorded from Merthyr Mawr Warren NNR over approximately 60 years of predominantly occasional or ad hoc recording. This is the first targeted dune fungi assemblage survey.

During the course of these five targeted site visits during the autumn of 2020 this survey recorded a total of 17 dune fungal assemblage species of which 10 were new assemblage records for the site giving a new total of 23 fungal dune assemblage species at Merthyr Mawr Warren NNR.

Prior to this survey Merthyr Mawr Warren NNR ranked equal 15<sup>th</sup> amongst Welsh dune sites for the number of dune assemblage fungi recorded (Evans & Roberts 2015b & 2018). The addition of these further ten dune assemblage species during the 2020 survey raises Merthyr Mawr to 7<sup>th</sup> ranking in Wales. For comparison, as of 2018 the highest ranking Welsh dune site, Aberffraw on Anglesey, had a total of 27 species (Evans & Roberts 2018) which is not a substantially higher figure. On a British scale Merthyr Mawr now ranks equal 11<sup>th</sup>, alongside Braunton Burrows in Devon, and no British dune system (as of 2018) has a total higher than 27 species. All of these assessments suggest Merthyr Mawr Warren NNR is not only one of the

top ten dune sites in Wales for its unique and specialised fungi but also amongst the very best known in Britain.

All of the 17 species found during the 2020 survey (including grid references, specific dune habitat and relative frequency encountered) are detailed below in Table 1. A map (Figure 2) shows the broad extent of the area surveyed, within which are three smaller areas (foredunes, slack with *Salix repens* creeping willow, and species-rich grey dunes) deemed of highest target interest during the 2020 survey.

Brief profiles together with photographs and location maps of all 17 dune assemblage species recorded during the 2020 survey are given below. It should be stressed that all these fungi require microscopic examination for identification purposes with the probable exception of *Melanoleuca cinereifolia* dune cavalier, *Phallus hadriani* sand stinkhorn, *Psathyrella ammophila* dune brittlestem, and *Tulostoma brumale* winter stalkball, each of which should be sufficiently distinct to be recognisable in the field by an experienced mycologist.

**Table 1 Dune assemblage species recorded in 2020 survey.** Species highlighted in red are new records for the site, first recorded in the 2020 survey. Frequent = found at 10 or more locations; occasional = 4 to 9 locations; infrequent = 2 or 3 locations; single = one location (with a single fruitbody or a single group of fruitbodies)

Scientific Name	English Name	Date	SS Grid Ref.	Habitat	Frequency
<i>Bovista pusilla</i>	least puffball	16/10	87133 76873	grey dunes	single
<i>Clitocybe barbularum</i>	(a funnel)	05/11	87133 76873	grey dunes	single
	(a funnel)	05/11	86282 76256	grey dunes	single
<i>Coprinopsis ammophilae</i>	dune inkcap	05/11	85753 76465	foredunes with <i>Ammophila arenaria</i>	single
<i>Hebeloma dunense</i>	(a poisonpie)	16/10	86380 76629	slack with <i>Salix repens</i>	infrequent
<i>Hebeloma vaccinum</i>	willow poisonpie	08/10	86492 76701	slack with <i>Salix repens</i>	infrequent
	willow poisonpie	16/10	86371 76633	slack with <i>Salix repens</i>	infrequent
	willow poisonpie	05/11	86349 76622	slack with <i>Salix repens</i>	infrequent
	willow poisonpie	19/11	86489 76702	slack with <i>Salix repens</i>	single
<i>Hygrocybe aurantiolutescens</i>	(a waxcap)	05/11	87185 76965	grey dunes	single

Scientific Name	English Name	Date	SS Grid Ref.	Habitat	Frequency
<i>Hygrocybe conicoides</i>	dune waxcap	08/10	86518 76635	grey dunes	frequent
	dune waxcap	16/10	86318 76642	slack	frequent
	dune waxcap	05/11	87197 76980	grey dunes	frequent
	dune waxcap	19/11	86897 76773	grey dunes	occasional
<i>Inocybe agardhii</i>	(a fibrecap)	01/09	86153 76601	slack with <i>Salix repens</i>	single
	(a fibrecap)	08/10	86362 76617	slack with <i>Salix repens</i>	occasional
	(a fibrecap)	16/10	86187 76601	slack with <i>Salix repens</i>	occasional
<i>Inocybe dunensis</i>	dune fibrecap	01/09	86153 76601	slack with <i>Salix repens</i>	single
	dune fibrecap	08/10	86368 76634	slack with <i>Salix repens</i>	infrequent
<i>Inocybe serotina</i>	(a fibrecap)	08/10	86502 76701	slack with <i>Salix repens</i>	single
<i>Inocybe vulpinella</i>	foxy fibrecap	08/10	86493 76712	slack with <i>Salix repens</i>	single
<i>Melanoleuca cinereifolia</i>	dune cavalier	16/10	85693 76519	foredunes with <i>Ammophila arenaria</i>	occasional
	dune cavalier	05/11	86070 76176	foredunes with <i>Ammophila arenaria</i>	frequent
<i>Melanoleuca pseudoluscina</i>	(a cavalier)	16/10	86482 76696	slack	infrequent
	(a cavalier)	05/11	86550 76335	grey dunes	infrequent
<i>Phallus hadriani</i>	sand stinkhorn	19/11	85529 76698	foredunes with <i>Ammophila arenaria</i>	single
<i>Psathyrella ammophila</i>	dune brittlestem	01/09	85981 76152	foredunes with <i>Ammophila arenaria</i>	infrequent
	dune brittlestem	08/10	85965 76192	foredunes with <i>Ammophila arenaria</i>	frequent

Scientific Name	English Name	Date	SS Grid Ref.	Habitat	Frequency
	dune brittlestem	16/10	85688 76529	foredunes with <i>Ammophila arenaria</i>	frequent
	dune brittlestem	05/11	85734 76563	foredunes with <i>Ammophila arenaria</i>	frequent
<i>Rhodocybe popinalis</i>	(a pinkgill)	08/10	87160 76988	grey dunes	single
<i>Tulostoma brumale</i>	winter stalkball	05/11	87143 76985	grey dunes	occasional
	winter stalkball	19/11	86538 76744	grey dunes	occasional

**Figure 2 Map of Merthyr Mawr Warren NNR.** The yellow boundary shows the full extent of the area surveyed in 2020. The red boundaries indicate approximate areas of particular interest for target species: 1. foredunes with *Ammophila arenaria* marram grass; 2. slack with *Salix repens* creeping willow; and 3. species-rich grey dunes.



## 6.2. Profiles of SSSI dune assemblage fungi recorded in 2020 at Merthyr Mawr Warren NNR

All 17 dune assemblage species recorded during the 2020 survey period are profiled here. The maps indicate the approximate location of the specimens found (more precise grid references are given in Table 1). Note, however, that two species (*Hygrocybe conicoides* dune waxcap and *Tulostoma brumale* winter stalkball) are common and widespread throughout the dunes and only a few sample locations are mapped. The same applies to *Melanoleuca cinereifolia* dune cavalier and *Psathyrella ammophila* dune brittlestem, which are also common but restricted to the foredunes.

**Figure 3** *Bovista pusilla* least puffball NEW RECORD



This small (under 20 mm diam.) puffball, formerly called *Bovista limosa* in the UK, is restricted to dune sites, where it typically occurs in grey dunes. It is superficially similar to several more widespread species, such as small specimens of *Lycoperdon lividum* grassland puffball, but is microscopically distinctive. The species is classed as “endangered” on the most recent British red list (Smith *et al.* 2016). The least

puffball has previously been recorded from eight Welsh sites (Evans & Roberts 2015b). The 2020 collection from Merthyr Mawr Warren NNR is a new record for the site.

**Figure 4** *Clitocybe barbularum* (a funnel cap) **NEW RECORD**



A small, grey-brown agaric, *Clitocybe barbularum* (a funnel cap) is a saprotrophic species probably living on dead, buried plant matter in the grey dunes. It is markedly hygrophanous, dark blackish brown in damp weather but drying much paler often with a two-tone appearance. The species has previously been recorded from 13 Welsh sites (Evans & Roberts 2015b). The 2020 collections from Merthyr Mawr Warren NNR are new records for the site.



Figure 5 *Coprinopsis ammophilae* dune inkcap NEW RECORD



A small, ephemeral agaric, this inkcap occurs in sand alongside *Ammophila arenaria* marram grass in the foredunes. *Coprinopsis ammophilae* dune inkcap is a saprotroph, possibly living on decaying roots. It is classed as “vulnerable” on the most recent British red list (Evans *et al.* 2006) and is a “key species” on the Local Biodiversity Action Plan for Bridgend (Bridgend Biodiversity Partnership 2002). The species has previously been recorded from 11 Welsh sites (Evans & Roberts 2015b). The 2020 collection from Merthyr Mawr Warren NNR is a new record for the site.

Figure 6 *Hebeloma dunense* (a poisonpie) NEW RECORD



This pale, brown-spored agaric is an ectomycorrhizal species that forms a mutually beneficial relationship with the roots of *Salix repens* creeping willow, typically in dune slacks. *Hebeloma dunense* (a poisonpie fungus) can only be distinguished microscopically from other *Hebeloma* species, all of which tend to look similar in the field. The species has previously been recorded from five Welsh sites (Evans & Roberts 2015b). The 2020 collection from Merthyr Mawr Mawr NNR is a new record for the site.

Figure 7 *Hebeloma vaccinum* willow poisonpie NEW RECORD



This is another ectomycorrhizal *Hebeloma* species that forms a mutually beneficial relationship with the roots of *Salix repens* creeping willow, typically in dune slacks. It can be distinguished microscopically from the superficially similar *H. dunense* above. *Hebeloma vaccinum* willow poisonpie has previously been recorded from eight Welsh sites (Evans & Roberts 2015b). The 2020 collections from Merthyr Mawr Warren NNR are new records for the site.

Figure 8 *Hygrocybe aurantiolutescens* (a waxcap) NEW RECORD



The waxcap *Hygrocybe aurantiolutescens* was first described from dunes in Cornwall and appears to be restricted to dune habitats, where it is found in grey dunes and dune grassland. Recent DNA sequencing (Cannon 2012) has shown it to be distinct from the superficially similar *H. acutoconica* persistent waxcap which also occurs at Merthyr Mawr Warren NNR, but is not restricted to dunes. The two species can be distinguished microscopically. *Hygrocybe aurantiolutescens* has been verified by DNA analysis from dune sites in five Welsh vice-counties (Cannon 2012). The 2020 collection from Merthyr Mawr Warren NNR is a new record for the site.

Figure 9 *Hygrocybe conicoides* dune waxcap



This conspicuous waxcap is widespread in grey dunes, dune slacks, and dune grassland, occasionally occurring in bare sand. As with the common *Hygrocybe conica* blackening waxcap, the brightly coloured fruitbodies gradually blacken with age. Both species occur at Merthyr Mawr Warren NNR, but *H. conicoides* dune waxcap differs by sometimes (but not always) having reddish gills and microscopically by the shape and size of its spores. *Hygrocybe conicoides* is one of the commonest specialist dune fungi in Great Britain and has been recorded from 24 Welsh sites (Evans & Roberts 2015b), including Merthyr Mawr Warren NNR where it was previously recorded in 2019.

Figure 10 *Inocybe agardhii* (a fibrecap)



This rusty brown, slightly scaly, fibrecap agaric is an ectomycorrhizal species that forms a mutually beneficial relationship with the roots of *Salix repens* creeping willow, typically in dune slacks. The species has been recorded from 13 Welsh sites (Evans & Roberts 2015b), including Merthyr Mawr Warren NNR where it was previously recorded in 1973 and 2019.

Figure 11 *Inocybe dunensis* dune fibre-cap NEW RECORD



*Inocybe dunensis* dune fibre-cap is another ectomycorrhizal, fibre-cap agaric that forms a mutually beneficial relationship with the roots of *Salix repens* creeping willow, typically in dune slacks. It lacks the distinctly rusty appearance of *I. agardhii* and is microscopically distinct. The species has previously been recorded from nine Welsh sites (Evans & Roberts 2015b). The 2020 collections from Merthyr Mawr Warren NNR are new records for the site.

Figure 12 *Inocybe serotina* (a fibrecap) NEW RECORD



One of ten fibrecap agarics on the fungal dune assemblage list, *Inocybe serotina* is ectomycorrhizal, forming a mutually beneficial relationship with the roots of *Salix repens* creeping willow, typically in dune slacks. Like most fibrecaps, it requires microscopic investigation in order to identify it with certainty. The species has previously been recorded from eight Welsh sites (Evans & Roberts 2015b). The 2020 collection from Merthyr Mawr Warren NNR is a new record for the site.



Figure 13 *Inocybe vulpinella* foxy fibrecap NEW RECORD



Fox-coloured with brown spores, this is another ectomycorrhizal fibrecap agaric that forms a mutually beneficial relationship with the roots of *Salix repens* creeping willow, typically in dune slacks. It can be distinguished from other fibrecaps microscopically. The species has previously been recorded from nine Welsh sites (Evans & Roberts 2015b). The 2020 collection from Merthyr Mawr Warren NNR is a new record for the site.

Figure 14 *Melanoleuca cinereifolia* dune cavalier



A large and comparatively conspicuous agaric having greyish gills below the cap, *Melanoleuca cinereifolia* dune cavalier occurs in sand alongside *Ammophila arenaria* marram grass in the foredunes. It is a saprotroph, probably living on decaying roots, and is one of the commoner specialist dune fungi, having been recorded at 16 Welsh sites (Evans & Roberts 2015b), including Merthyr Mawr Warren NNR where it was previously recorded in 2019.

Figure 15 *Melanoleuca pseudoluscina* (a cavalier) NEW RECORD



Only recently recognised as British, *Melanoleuca pseudoluscina* (a cavalier) is a saprotrophic agaric growing in grey dunes, dune slacks, and dune grassland. It is variable in colour, but can be distinguished from similar species microscopically. It has previously been recorded at just two Welsh sites (Harries 2014). The 2020 collections from Merthyr Mawr Warren NNR are new records for the site.

Figure 16 *Phallus hadriani* sand stinkhorn



A saprotrophic species, the sand stinkhorn grows amongst *Ammophila arenaria* marram grass in the foredunes, probably arising from decaying roots. Young fruitbodies are soft and egg-like, often buried in sand, but at maturity they split and the evil-smelling, slimy spore mass arises, attracting flies that spread the spores. *Phallus hadriani* sand stinkhorn has been recorded at eight Welsh sites (Evans & Roberts 2015b) and was previously recorded at Merthyr Mawr Warren NNR in 2019.

Figure 17 *Psathyrella ammophila* dune brittlestem



One of the commonest specialist dune fungi, *Psathyrella ammophila* dune brittlestem is a saprotrophic species growing amongst *Ammophila arenaria* marram grass in the foredunes where it can occur in quantity. The buff to brown caps, blackish-brown gills, and stem extending deeply into the sand are distinctive. It has been recorded at 28 Welsh sites (Evans & Roberts 2015b), including Merthyr Mawr Warren NNR where it was previously recorded in 1973 and 2019.

Figure 18 *Rhodocybe popinalis* (a pinkgill)



This is a rather squat, chunky, grey to brown, medium-sized agaric with greyish gills that extend partway down the stem and pinkish spores. It is a saprotrophic species typically found in grey dunes and dune grassland. It has been recorded at 12 Welsh dune sites (unpublished data), including Merthyr Mawr Warren NNR where it was previously recorded in 1992.

Figure 19 *Tulostoma brumale* winter stalkball



Resembling a tiny puffball on a stick, *Tulostoma brumale* winter stalkball is a saprotrophic species adapted to arid conditions and is typically found amongst mosses and lichens in grey dunes, particularly late in the year. The rarer *T. melanocyclum* scaly stalkball is very similar but can be distinguished by its darker, scaly stem. *Tulostoma brumale* winter stalkball has been recorded at 21 Welsh sites (Evans & Roberts 2015b), including Merthyr Mawr Warren NNR where it was previously recorded in 2019.

## 6.3. Discussion of SSSI dune assemblage fungi

### 6.3.1. Relative frequency

Not all dune assemblage species are equal in terms of how frequently they are recorded from dune sites across Wales. Table 2 below gives some context by listing the number of known Welsh dune sites for each species recorded at Merthyr Mawr Warren NNR. The table also lists the number of known English and Scottish dune sites, for additional comparison.

This helps highlight key conservation dune assemblage species at Merthyr Mawr Warren NNR as well as where best to concentrate conservation management efforts.

Of the 11 species that have been recorded at ten or fewer sites in Wales, six species of *Hebeloma* poisonpie and *Inocybe* fibre-cap occurred in this survey exclusively in dune slack with *Salix repens* creeping willow. In a Welsh context, this is clearly a key habitat at Merthyr Mawr Warren NNR for dune assemblage fungi.

Merthyr Mawr Warren NNR also has a wider UK importance for the cavalier *Melanoleuca pseudoluscina*, recorded during the survey in both grey dune and slack, which has only been found at one other site in Wales and none at all in England or Scotland. The waxcap *Hygrocybe aurantiolutescens* which occurs in grey dune at Merthyr Mawr Warren NNR is also very rarely recorded in Wales and in the UK.

By contrast, some dune assemblage species are almost ubiquitous in dune sites. *Hygrocybe conicoides* dune waxcap and *Tulosoma brumale* winter stalkball which mainly occur in grey dune, together with *Psathyrella ammophila* dune brittlestem in foredune, are three of the most commonly recorded dune assemblage species both in Wales and in England & Scotland.

**Table 2 Dune assemblage species recorded in 2020 survey: number of sites where each species has been recorded in Wales and in England/Scotland.** The figures are from data collated for Evans & Roberts (2018), except for *Hygrocybe aurantiolutescens* which is from Cannon (2012). 1-5 sites = very rare, 6-10 sites = rare, 11-20 sites = uncommon, >21 sites = common

Scientific Name	English Name	Welsh Sites	English/Scottish Sites
<i>Bovista pusilla</i>	least puffball	8 – rare	5 – very rare
<i>Clitocybe barbularum</i>	(a funnel)	10 – rare	10 – rare
<i>Coprinopsis ammophila</i>	dune inkcap	11 – uncommon	8 – rare
<i>Hebeloma dunense</i>	(a poisonpie)	5 – very rare	1 – very rare
<i>Hebeloma vaccinum</i>	willow poisonpie	5 – very rare	8 – rare
<i>Hygrocybe aurantiolutescens</i>	(a waxcap)	5 – very rare	3 – very rare



Scientific Name	English Name	Welsh Sites	English/Scottish Sites
<i>Hygrocybe conicoides</i>	dune waxcap	26 – common	54 – common
<i>Inocybe agardhii</i>	(a fibre-cap)	7 – rare	18 – uncommon
<i>Inocybe dunensis</i>	dune fibre-cap	6 – rare	10 – rare
<i>Inocybe serotina</i>	(a fibre-cap)	8 – rare	7 – rare
<i>Inocybe vulpinella</i>	foxy fibre-cap	3 – very rare	9 – rare
<i>Melanoleuca cinereifolia</i>	dune cavalier	16 – uncommon	31 – common
<i>Melanoleuca pseudoluscina</i>	(a cavalier)	2 – very rare	0 – absent
<i>Phallus hadriani</i>	sand stinkhorn	8 – rare	27 – common
<i>Psathyrella ammophila</i>	dune brittlestem	28 – common	65 – common
<i>Rhodocybe popinalis</i>	(a pinkgill)	13 – uncommon	25 – common
<i>Tulostoma brumale</i>	winter stalkball	23 – common	41 – common

### 6.3.2. SSSI dune assemblage fungi not re-found in 2020

It should be noted that a further six species have previously been recorded from Merthyr Mawr Warren NNR, but were not seen during the survey visits in 2020. They are: the spring-fruiting *Helvella leucopus* palefoot saddle (last recorded 2006) normally found in dune slacks; two additional fibre-cap species, *Inocybe heimii* and *I. impexa* (last recorded in 2019 and 2003 respectively) which grow in association with *Salix repens* creeping willow; *Agaricus devoniensis* sandy mushroom (last recorded in 1994) and *Lepiota erminea* dune dapperling (last recorded in 2019), both normally found in grey dunes or dune grassland; and *Tulostoma melanocyclum* scaly stalkball (last recorded in 2019) normally found in grey dunes.

Species only represented by historical records should be regarded as extinct at site level if, despite searching, the species has not been recorded in the last 50 years. This timeframe might be shortened when a site or the fungal habitat has been substantially altered or degraded during this period (Evans & Roberts 2018).

**Table 3 Dune assemblage species previously recorded at Merthyr Mawr Warren NNR, but not re-found in 2020: number of sites where each species has been recorded in Wales and in England/Scotland.** The figures are from data collated for Evans & Roberts (2018). 1-5 sites = very rare, 6-10 sites = rare, 11-20 sites = uncommon, >21 sites = common

Scientific Name	English Name	Dune Habitat	Welsh Sites	English/Scottish Sites
<i>Agaricus devoniensis</i>	sandy mushroom	grey dune	12 – uncommon	22 – common
<i>Helvella leucopus</i>	palefoot saddle	slack, with <i>Salix repens</i> / <i>Populus</i> spp	2 – very rare	0 – absent
<i>Inocybe heimii</i>	(a fibrecap)	slack, with <i>Salix repens</i>	2 – very rare	1 – very rare
<i>Inocybe impexa</i>	(a fibrecap)	slack, with <i>Salix repens</i>	4 – very rare	3 – very rare
<i>Lepiota erminea</i>	dune dapperling	grey dune	14 – uncommon	45 – common
<i>Tulostoma melanocyclum</i>	scaly stalkball	grey dune	8 – rare	7 – rare

### 6.3.3. SSSI dune assemblage fungi not yet recorded from Merthyr Mawr Warren NNR after 2020 survey

As an indication of which dune assemblage fungi are most likely to be added to the records for Merthyr Mawr Warren NNR if further surveys were undertaken, Table 4 (below) lists the remaining species with their frequency at other Welsh sites and at English & Scottish sites.

None of the remaining species is “common” in other Welsh dune sites and the majority are “very rare” or absent. The latter includes several species (such as *Laccaria maritima* sand deceiver) only recorded from northern or eastern dune sites in Britain.

Two species listed as “uncommon” in Wales, the parachute *Marasmius anomalus* and *Peziza ammophila* dune cup, together with three “rare” species, *Conocybe dunensis* dune conecap, *Geastrum schmidelii* dwarf earthstar, and the cup fungus *Geopora arenicola*, are among the most likely to occur at Merthyr Mawr Warren NNR since all five have been recorded at nearby Kenfig NNR (Evans & Roberts 2015b). The parachute *Marasmius anomalus* is a small species growing on decaying herbaceous remains in grey dunes and as such is difficult to target and easy to overlook. *Peziza ammophila* dune cup and *Conocybe dunensis* dune conecap occur in foredunes with *Ammophila arenaria* marram grass and should be more visible. They seem, however, to prefer shallow embryo dunes that extend onto the beach, a microhabitat that was not present at Merthyr Mawr Warren NNR during the 2020 survey.

Additional species recorded at other dune sites in the vice county of Glamorganshire are *Campanella caesia* marram oysterling and *Hohenbuehelia culmicola* marram oyster (both growing on *Ammophila arenaria* marram grass) at Oxwich and Whiteford, *Entyloma eryngii* sea holly smut at Oxwich. *Leucoagaricus barssii* smoky dapperling at Oxwich, *Omphalina galericolor* dune navel at Ogmore, Oxwich, and Whiteford, and *Inocybe arenicola* sand fibrecap (a *Salix repens* creeping willow associate) at Whiteford (Evans & Roberts 2015b).

**Table 4 Dune assemblage species not yet recorded at Merthyr Mawr Warren NNR: number of sites where each species has been recorded in Wales and in England/Scotland.** The figures are from data collated for Evans & Roberts (2018). 1-5 sites = very rare, 6-10 sites = rare, 11-20 sites = uncommon, >21 sites = common

Scientific Name	English Name	Dune Habitat	Welsh Sites	English/Scottish Sites
<i>Bovista aestivalis</i>	summer puffball	grey dune	3 – very rare	19 – uncommon
<i>Campanella caesia</i>	marram oysterling	foredune, on marram	4 – very rare	10 – rare
<i>Chrysomyxa pyrolata</i>	wintergreen rust	slack, on wintergreen	4 – very rare	4 – very rare
<i>Conocybe dunensis</i>	dune conecap	foredune, with marram	7 – rare	28 – common
<i>Cortinarius ammophilus</i>	a webcap	slack, with <i>Salix repens</i>	0 – absent	1 – very rare
<i>Cyathus stercoreus</i>	dung bird's nest	grey dune, on rabbit dung	9 – rare	2 – very rare
<i>Entoloma nigellum</i>	a pinkgill	grey dune	1 – very rare	3 – very rare
<i>Entoloma phaeocyathus</i>	a pinkgill	grey dune	2 – very rare	2 – very rare
<i>Entyloma eryngii sensu auct. Brit.</i>	sea holly smut	grey dune, on sea holly	4 – very rare	1 – very rare
<i>Geastrum elegans</i>	elegant earthstar	grey dune	2 – very rare	4 – very rare
<i>Geastrum marginatum</i>	tiny earthstar	grey dune	0 – absent	2 – very rare
<i>Geastrum schmidelii</i>	dwarf earthstar	grey dune	9 – rare	24 – common
<i>Geoglossum littorale</i>	an earthtongue	slack	0 – absent	1 – very rare
<i>Geopora arenicola</i>	a cup fungus	grey dune	6 – rare	20 – uncommon
<i>Hebeloma ammophilum</i>	a poisonpie	slack, with <i>Salix repens</i>	0 – absent	3 – very rare
<i>Hebeloma psammophilum</i>	a poisonpie	slack, with <i>Salix repens</i>	0 – absent	5 – very rare

Scientific Name	English Name	Dune Habitat	Welsh Sites	English/Scottish Sites
<i>Hohenbuehelia bonii</i>	an oyster fungus	foredune, on marram	2 – very rare	3 – very rare
<i>Hohenbuehelia culmicola</i>	marram oyster	foredune, on marram	4 – very rare	6 – rare
<i>Hygrocybe olivaceonigra</i>	a waxcap	grey dune	1 – very rare	0 – absent
<i>Inocybe arenicola</i>	sand fibre-cap	slack, with <i>Salix repens</i>	7 – rare	3 – very rare
<i>Inocybe heimiana</i>	a fibre-cap	slack, with <i>Salix repens</i>	3 – very rare	0 – absent
<i>Inocybe inodora</i>	a fibre-cap	slack, with <i>Salix repens</i>	1 – very rare	4 – very rare
<i>Inocybe pruinosa</i>	a fibre-cap	slack, with <i>Salix repens</i>	5 – very rare	7 – rare
<i>Laccaria maritima</i>	sand deceiver	slack, with <i>Salix repens</i>	0 – absent	2 – very rare
<i>Lepiota brunneoilacea</i>	star dapperling	grey dune	0 – absent	1 – very rare
<i>Leucoagaricus barssii</i>	smoky dapperling	grey dune	4 – very rare	6 – rare
<i>Marasmius anomalus</i>	a parachute	grey dune	11 – uncommon	6 – rare
<i>Mycocalia duriaeana</i>	dune cannon	grey dune	0 – absent	1 – very rare
<i>Omphalina galericolor</i>	dune navel	grey dune	4 – very rare	7 – rare
<i>Omphalina subhepatica</i>	a navel fungus	grey dune	6 – rare	6 – rare
<i>Peziza ammophila</i>	dune cup	foredune	16 – uncommon	37 – common
<i>Peziza boltonii</i>	a cup fungus	grey dune	3 – very rare	0 – absent
<i>Peziza pseudoammophila</i>	a cup fungus	foredune	0 – absent	1 – very rare
<i>Poronia erici</i>	dung button	grey dune, on rabbit dung	0 – absent	4 – very rare
<i>Psathyrella dunensis</i>	a brittlestem	grey dune	0 – absent	1 – very rare
<i>Psathyrella flexispora</i>	a brittlestem	grey dune	1 – very rare	5 – very rare
<i>Sabuloglossum arenarium</i>	sandy earthtongue	grey dune	1 – very rare	4 – very rare
<i>Simocybe centunculus var. maritima</i>	a twiglet	foredune, on marram	3 – very rare	0 – absent
<i>Stropharia halophila</i>	dune roundhead	foredune, with marram	1 – very rare	3 – very rare
<i>Trichoglossum rasum</i>	dune earthtongue	grey dune	1 – very rare	1 – very rare

Scientific Name	English Name	Dune Habitat	Welsh Sites	English/Scottish Sites
<i>Tulostoma simulans</i>	a stalkball	grey dune	0 – absent	1 – very rare

#### 6.3.4. Conservation assessments of non-dune assemblage fungi

Table 5 (below) comprises all species listed in red data lists for Britain and Wales that were recorded during the 2020 survey at Merthyr Mawr Warren NNR. Several different red data lists exist for non-lichenised fungi in Britain and Wales, the more recent only covering a limited range of genera (Smith *et al.* 2016) with an earlier list detailing all threatened British fungi (Evans *et al.* 2006) and an even earlier list for Wales (Rotheroe 2003).

With the exception of three grassland species (*Clavaria incarnata* skinny club, *Clavulinopsis laeticolor* handsome club, and *Ramariopsis tenuiramosa*), all those listed are dune assemblage fungi. The red list for Wales (Rotheroe 2003) was compiled at a time when field recording was much less prevalent, especially in grassland habitats, and is now only of limited relevance. All three of the grassland species listed are now known to be common to very common both in Wales and Britain and likely to be assigned to the category “Least Concern”. This emphasises the urgent need in Wales for the compilation of an up-to-date, IUCN compliant red list for non-lichenised fungi.

During the 2020 survey no fungi listed as priority species in Section 7 Environment (Wales) Act 2016 were recorded, although it should be noted that *Tulostoma melanocyclum* scaly stalkball (which is on the Section 7 list) has previously been recorded from Merthyr Mawr Warren NNR.

**Table 5 Species of conservation concern recorded during the 2020 survey. Dune assemblage species are highlighted in red.**

Scientific Name	English Name	Reference	Category
<i>Bovista pusilla</i>	least puffball	GB Red List (2016)	Endangered
<i>Clavaria incarnata</i>	skinny club	British Red Data List (2006)	Near Threatened
<i>Clavulinopsis laeticolor</i>	handsome club	Welsh Red Data List (2003)	Vulnerable
<i>Coprinopsis ammophilae</i>	dune inkcap	British Red Data List (2006)	Vulnerable
	dune inkcap	Bridgend LBAP (2002)	Key Species
<i>Hebeloma dunense</i>	(a poisonpie)	Welsh Red Data List (2003)	Vulnerable
<i>Inocybe vulpinella</i>	foxy fibrecap	British Red Data List (2006)	Vulnerable
<i>Ramariopsis tenuiramosa</i>	(a coral fungus)	Welsh Red Data List (2003)	Vulnerable

### 6.3.5. Waxcap-grassland fungi

The JNCC SSSI dune fungus assemblage lists eight waxcap-grassland species that are dune specialists and not listed on the separate JNCC grassland assemblage (Bosanquet *et al.* 2018). Two species *Hygrocybe aurantiolutescens* and *H. conicoides* dune waxcap were recorded during the 2020 survey at Merthyr Mawr Warren NNR.

JNCC SSSI guidelines for grassland fungi (Bosanquet *et al.* 2018) give the following threshold counts for a site to be considered for notification if it equals or exceeds: 7 species of Clavariaceae (C), 19 species of *Hygrocybe* s.l. (H), 15 species of grassland *Entoloma* (E), or 5 species of Geoglossaceae s.l. (G). Based on records made during the 2020 survey, this cumulative species count for Merthyr Mawr Warren NNR was only C3 H8 E4 G1. However, it is generally accepted that dune grasslands do not feature amongst the top-ranking sites in Britain for their waxcap-grassland fungi (Evans & Roberts 2018) but their additional grassland assemblage interest should still be assessed as Wales is considered to have the best waxcap-grasslands in Europe with an unprecedented level of international conservation responsibility for them (Evans & Roberts 2015a)

This conservation responsibility has been further confirmed recently with the inclusion of a remarkable 25 species of waxcap-grassland fungi that occur in Britain on the IUCN Global Red List of Threatened Species (see Table 8) which in nature conservation terms is like having most of the world's giant pandas, elephants, and polar bears in Wales.

Although no globally threatened waxcap-grassland fungi have yet been recorded at Merthyr Mawr Warren NNR this may well change with future survey work and should be borne in mind.

The Global Fungal Red List initiative (IUCN 2019) is an ongoing project and all 46 species which have been evaluated and published as of December 2020 that are threatened or near threatened and that are known to occur in Britain are included in Table 8. British species have been extrapolated from the IUCN website and cross-referenced for relevance to assemblages listed in JNCC's SSSI guidelines for fungi (Bosanquet *et al.* 2018).

JNCC SSSI guidelines suggest all such taxa on a red list with threat categories, whether listed as part of an assemblage or not, should be taken into consideration when assessing a site and that any assessed as critically endangered (CR) should be given SSSI status.

Two species on the Global Red List for fungi, *Laccaria maritima* sand deceiver and *Lepiota brunneolilacea* star dapperling, are part of the dune assemblage although neither have yet been recorded at Merthyr Mawr Warren NNR.

### 6.3.6. Other notable non-dune assemblage species

There are a further eight species recorded during the 2020 survey at Merthyr Mawr NNR which require mention as they have been recorded from five or fewer sites in Wales. They are: *Calocybe ionides* violet domecap, *Calocybe obscurissima* obscure domecap, *Entoloma rhodocylix* (a pinkgill), *Galerina praticola* (a bell), *Hebeloma salicicola* (a poisonpie), *Melanoleuca friesii* (a cavalier), *Mycena luteovariegata* (a bonnet), and *Psathyrella fatua* (a brittlestem).

Most represent difficult-to-identify or obscure species which are therefore likely to be under-recorded in Wales, though *Calocybe ionides* violet domecap has a distinctive, not easily overlooked appearance and is straightforward to identify so is deemed genuinely rare in Wales.

Two species, *Hebeloma salicicola* (a poisonpie) and *Mycena luteovariegata*, are of more significant conservation importance. The recently described *Hebeloma salicicola* (a poisonpie) is only found in association with *Salix repens* in dune slacks so is a good candidate species for any future revisions of dune assemblage fungi in JNCC's 'Guidelines for the Selection of Biological SSSIs' (Bosanquet *et al.* 2018). Also recently described is *Mycena luteovariegata*. More data are needed on its preferred habitat but the species has been recorded from grassland and inner dunes in continental Europe and is only known from dunes in Wales.

**Figure 20** *Calocybe ionides* violet domecap



An attractive violet-coloured agaric with contrasting cream gills, found once in the grey dunes. The species was previously recorded at Merthyr Mawr Warren NNR in 1973, but is only otherwise known in Wales from five sites, three of which are also dunes. It is known from at least 40 sites in England and one in Scotland, mostly in woodland. It is a saprotrophic (litter-decaying) species said to prefer base-rich substrates and its predominance in dune sites in Wales may well be related to this factor. Given its distinctive appearance and relative ease of identification it is likely to be genuinely relatively rare rather than under-recorded.

**Figure 21** *Calocybe obscurissima* obscure domecap



A brown agaric with cream gills, found once during the survey in *Salix repens* slack. The species is only otherwise known in Wales from four sites, all of which are also dunes. It has been recorded from at least 20 sites in England, mostly in woodland, and one dune site in Scotland. Also saprotrophic, it is said to prefer base-rich substrates.

***Entoloma rhodocylix* (a pinkgill)**

A small, pinkish-brown agaric with gills running down the stem, found once during the survey in *Salix repens* slack. The species is only otherwise known in Wales from a single site. It has been recorded from at least 25 sites in England and Scotland, mostly in woodland. It is saprotrophic and is said to prefer sandy soils with mosses.

**Figure 22** *Galerina praticola* (a bell)





A small, brown agaric with a ring on the stem, found three times during this survey in both grey dunes and *Salix repens* slack. The species is only otherwise known in Wales from a single site, also a dune. It has, however, been recorded from at least 50 sites in England and Scotland, mainly in grassland or dunes. It is saprotrophic and is said to be associated with mosses.

**Figure 23** *Hebeloma salicicola* (a poisonpie)



A pale agaric with clay-coloured gills, found three times in *Salix repens* slack during this survey. It is only otherwise known in Wales from a single site, also a dune, but the species was only described in 2015 and any earlier collections would have been referred to as other *Hebeloma* species. *Hebeloma salicicola* is ectomycorrhizal, forming a mutually beneficial association with *Salix repens*. As such it is a strong candidate for any future revisions of JNCC's 'Guidelines for the Selection of Biological SSSIs' dune assemblage fungi.

***Melanoleuca friesii* (a cavalier)**

A greyish agaric with white gills found four times in grey dunes and dune grassland during this survey. There are no other Welsh records for this species, but it has long been considered a synonym of a widespread species (*M. polioleuca* common cavalier) and only recently recognised as distinct. There are four recent English and Scottish records under this name, but all are from woodland.

**Figure 24** *Mycena luteovariegata* (a bonnet)



An agaric with pale yellow and lilac tones, found twice during this survey in *Salix repens* slack. It was previously recorded at Merthyr Mawr Warren NNR in 2019, but is only otherwise known in Wales from a single site, also a dune. It has not been recorded in England or Scotland. The species was, however, only described in 2013 and would formerly have been considered a yellowish colour form (f. *lutea*) of the common *Mycena pura* lilac bonnet. There is a further Welsh record of such a colour form from dunes, together with three from grassland, and additional English and Scottish records from dunes, grassland, and woodland. It is not clear whether all or any of these are referable to *M. luteovariegata*. The distribution and ecology of the species are not well understood but it has been described as occurring ‘in seminatural grassland and inner dune areas’ (Aronsen & Læssøe 2016).

#### ***Psathyrella fatua* (a brittlestem)**

A fragile, ephemeral agaric with a buff cap and brown gills, found once during this survey in the grey dunes. It is only otherwise known in Wales from a single site, but is easily overlooked and likely to be under-recorded. It is known from at least 20 sites in England and Scotland, mostly in woodland, but once in dunes. It is saprotrophic and is said to prefer base-rich substrates.

#### **6.3.7. Conservation Implications for fungi at Merthyr Mawr SSSI**

New online guidelines for the selection of SSSIs were published for fungi in July 2018 by JNCC which for the first time (based on work by Evans & Roberts 2018) includes a dune assemblage of fungi (Bosanquet *et al.* 2018). This assemblage incorporates species from mobile dune, slack & dune scrub but not grassland on the landward side of dunes which should be assessed separately using the waxcap grassland SSSI assessment guidelines (Bosanquet *et al.* 2018). The new guidelines propose that dune sites be recommended for notification for their fungi if the recorded number of dune assemblage species reaches or exceeds 10 species.

The total number of JNCC dune assemblage fungi at Merthyr Mawr Warren NNR is now 23 (prior to the survey it was only 13). The report (Evans & Roberts 2018) that informed the JNCC dune assemblage species list detailed those sites exceeding 10 species across Britain that should be considered for notification as a SSSI. There were 5 such sites in Scotland, 12 in England, and 16 in Wales, giving Wales the highest currently known number of qualifying sites and significant responsibility for their protection. Merthyr Mawr Warren NNR now more than doubles the qualification threshold, ranking as the 7th best site in Wales and equal 11th in Great Britain. The majority of the NNR was declared a SSSI in 1950 and the current description includes its special interest for sand dune fungi, mentioning as important species *Tulostoma melanocyclum* scaly stalkball, *Russula cessans* tardy brittlegill, *Suillus fluri* (a bolete whose current name is now *Suillus collinitus*) and *Rhodotus palmatus* wrinkled peach, as well as morels and *Helvella* spp (saddle fungi).

Very few SSSIs have included any mention of fungi and Merthyr Mawr SSSI, whose boundary lies mainly within Merthyr Mawr Warren NNR, is one of only five dune systems in Wales which does. JNCC guidelines indicate that historically many sites important for fungi were designated on the basis of habitat or vegetation type which resulted in incidental rather than targeted conservation for fungal interest. The updated JNCC guidelines (Bosanquet *et al.* 2018) also aim to ensure fungi receive adequate protection through their recognition as features within proposed and existing SSSIs. Merthyr Mawr SSSI was a pioneering exception in its mention of fungi but, with the publication of a specific SSSI dune assemblage of fungi and as a result of this survey, there is not only an opportunity but also a need to revise the current Merthyr Mawr SSSI description. This will best ensure targeted and appropriate fungal protection and management for this outstanding site for dune fungi especially as NRW's management lease has now ended and management returned to Merthyr Mawr Estate.

It is strongly recommended that all the SSSI dune assemblage fungi that are restricted to dune slack with *Salix repens*, i.e. the *Hebeloma* poisonpie and *Inocybe* fibrecap species listed in Tables 1 and 3, should now be included in Merthyr Mawr's SSSI description. Consideration should also be given to including *Hebeloma salicicola* (a poisonpie), a candidate species for any future revision of the JNCC SSSI dune assemblage list (as noted under the heading 'Other notable non-dune assemblage species' above).

This will help ensure a balanced management approach to actively target these dune slack fungi alongside management for other important dune slack species at Merthyr Mawr SSSI, notably *Petalophyllum ralfsii* petalwort which is already highlighted in the current SSSI description.

At the same time it would also be timely to re-evaluate all the fungi already mentioned on the SSSI description. The following are some notes and suggestions.

**Helvella** is a non-specific generic term and most *Helvella* species (saddle fungi) are not restricted to dunes (including *H. macropus* felt saddle recorded from Merthyr Mawr Warren NNR). It would be more appropriate to instead specifically name the spring-fruiting (April-May) *Helvella leucopus* palefoot saddle on the SSSI description as this is not only on the JNCC SSSI dune assemblage list but is also known from

just two dune sites in the UK: Merthyr Mawr and Pembrey. It is ectomycorrhizal with *Salix repens* creeping willow and *Populus* spp poplars and has been assessed as “Vulnerable” on the 2006 British red list (Evans *et al.* 2006).

It is recommended that the genus *Helvella* should be replaced by the species *Helvella leucopus* palefoot saddle in the SSSI description.

**Morels** are a non-scientific description for spring-fruiting *Morchella* species. Although two *Morchella* species have been recorded at Merthyr Mawr, they are not restricted to dunes, are not uncommon across Wales or Britain, and are not deemed to be of conservation concern. They are also sought-after edible fungi and as such it may be prudent not to publicise their presence since it may encourage illegal picking.

It is recommended that morels should be removed from the SSSI description.

***Rhodotus palmatus*** wrinkled peach is a saprotrophic wood-rotting species growing mainly on fallen trunks, logs, and stumps of broadleaved trees. Its principal host is elm, but it can also occur on ash and (less commonly) other broadleaved trees. It was last recorded at Merthyr Mawr on elm in ‘dune woodland’ (Rotheroe 1993) but without a specific grid reference. It is uncommon throughout the UK (with circa 250 post-2000 UK records) but only five in Wales. Although it is not linked specifically to dune sites it is listed on the Global Red List of Fungi (IUCN 2019) as “Near Threatened” because of the disappearance or decline of its main host trees. Dune woodland was not searched during the 2020 survey and it is not clear if *Rhodotus palmatus* still persists at Merthyr Mawr at least on elm though it may still be present on a different host. It is a very distinctive species, possible to identify in the field without microscopic examination, and should be searched for actively.

It is recommended that *Rhodotus palmatus* should remain in the SSSI description.

***Russula cessans*** tardy brittlegill is ectomycorrhizal with pines (*Pinus sylvestris*, *P. nigra*, and *P. radiata*), none of which are native in Wales. In Wales it seems to be typical of pines planted in dunes with records from Pembrey Country Park, Morfa Harlech, and Newborough Warren, but it has also been recorded from one inland site. *Russula cessans* tardy brittlegill is present with native pine in Scotland where it is listed in the JNCC SSSI Caledonian pinewoods fungal assemblage (Bosanquet *et al.* 2018) as one of the additional species of interest (so not counted in the site assemblage score but to be mentioned in SSSI citations).

As a non-native species, it is recommended that *Russula cessans* tardy brittlegill should be considered for removal from the SSSI description.

***Suillus fluryi*** (current name *Suillus collinitus* a bolete) is ectomycorrhizal with pines (*Pinus sylvestris*, *P. nigra*, and *P. radiata*), none of which are native in Wales. In Wales it seems to be typical of pines planted in dunes with records from Whiteford, Pembrey Country Park, and Newborough Warren, but it has also been recorded in two inland sites.

As a non-native species, it is recommended that *Suillus fluryi* should be considered for removal from the SSSI description.

***Tulostoma melanocyclus*** scaly stalkball is on the JNCC SSSI dune assemblage list, is found in grey dunes, and is known from eight dunes in Wales and a further seven in England & Scotland. It is also assessed as “Vulnerable” on the most recent British red list (Smith *et al.* 2016) and is a priority species in Section 7 Environment (Wales) Act 2016.

It is recommended that *Tulostoma melanocyclus* remain in the SSSI description.

## 7. Conservation Management and Monitoring

Natural Resources Wales (NRW) lease to manage the conservation of Merthyr Mawr Warren NNR and its special features came to an end on 31<sup>st</sup> December 2020. In the short term NRW will continue involvement through the Sands of LIFE project, running until December 2022, with additional contribution by Bridgend County Borough Council with its ‘Dunes 2 Dunes’ project. The site’s future management will be taken forward with Merthyr Mawr Estate under a new Nature Reserve Agreement with NRW and it is hoped that key findings from this report will help inform the site’s management to best conserve and benefit its outstanding dune assemblage of fungi, one of the best in the UK.

Conservation of the dune assemblage fungi recorded at Merthyr Mawr Warren NNR entails the conservation of the three key broadly defined habitats that support them, together with their associated plants. These three habitats are:

- Foredunes with *Ammophila arenaria* marram grass
- Dune slacks with *Salix repens* creeping willow
- Grey dunes, comprising a mosaic of semi-fixed, fixed dune and dune grassland with low herb and grass cover

Some SSSI dune assemblage fungi typical of grey dunes can also occur in short-sward dune grassland, a micro-habitat that is only present in a few small patches at Merthyr Mawr Warren NNR. Dune scrub and woodland, which are extensive at the site, are not preferred habitats for any dune assemblage fungi and are not covered in this survey report.

For each key micro-habitat the dune assemblage fungi associated with them are outlined and management concerns discussed with key action points suggested that are specific to Merthyr Mawr Warren NNR.

The development of JNCC’s SSSI dune assemblage fungi list is relatively recent (Evans & Roberts 2018; Bosanquet *et al.* 2018) and until now no specific guidelines for their management have ever been compiled despite their importance in the Welsh and wider UK landscape. Based on current ecological understanding and management strategies for other groups of fungi like those of waxcap-grasslands,

Table 6 outlines for the first time best general management strategies to benefit dune assemblage fungi.

### 7.1. Management for foredune fungi with *Ammophila arenaria* marram grass

Ten or so species of dune assemblage fungi (as listed on the JNCC website, Bosanquet *et al.* 2018: para 3.7) are restricted to foredunes with *Ammophila arenaria* marram grass, either growing at the base of decaying grass tussocks or arising in open sand from buried roots. Of these, just four species (*Coprinopsis ammophilae* dune inkcap, *Melanoleuca cinereifolia* dune cavalier, *Phallus hadriani* sand stinkhorn, and *Psathyrella ammophila* dune brittlestem) have so far been recorded at Merthyr Mawr Warren NNR, a rather smaller number than anticipated. At least two of these species (*Melanoleuca cinereifolia* dune cavalier and *Psathyrella ammophila* dune brittlestem) were found to be widespread and frequent throughout the foredunes.

It is difficult in a one year snapshot survey such as this to definitively explain this relative paucity of foredune assemblage fungi but, given that it was a relatively good fruiting year in 2020 for other species at Merthyr Mawr Warren NNR, it is reasonable to assume they may be under-represented here.

This might be as a result of the 2013-2014 dune rejuvenation works which involved mechanically clearing vegetation and creating notches and corridors through the southern section of the foredunes, increasing the area of bare sand from 2.6 ha to 8.5 ha (Pye & Blott 2015) thereby reducing the potential habitat for these as well as grey dune fungal assemblage species.

More probably, the apparently poor foredune fungal assemblage results from the truncated cliff-like appearance of the foredunes as observed during the 2020 survey, though it is not clear whether this appearance is the result of recent successive storm damage, or is a more long term pattern. Several species of dune assemblage fungi (such as *Peziza ammophila* dune cup and *Conocybe dunensis* dune conecap, both known from other sites in South Wales) are often present in gently sloping mobile embryo dunes with marram grass, but have not been recorded at Merthyr Mawr Warren NNR where the transition from beach to foredune is abrupt. Their precise ecology has never been studied, but it is possible that the cliff-like, fixed foredunes may have become too high and dry for such species. Ideally, the creation of embryo tapering dunes should be encouraged on the seaward side to promote a greater diversity of dune assemblage fungi in the foredunes.

The ongoing Sands of LIFE dune restoration project at Merthyr Mawr Warren NNR involves creating one or more further notches in dunes along the beach and stripping vegetation from the tops of some. Essentially this will in the short term be detrimental to any dune assemblage foredune fungi in the areas affected. Of the four species recorded *Psathyrella ammophila* dune brittlestem and *Melanaleuca cinereifolia* dune cavalier are least likely to be adversely affected as they occur extensively throughout the foredune areas of marram. However *Phallus hadriani* sand stinkhorn and *Coprinopsis ammophila* dune inkcap are both more localised at Merthyr Mawr Warren NNR as well as being less commonly recorded across dunes in Wales. If possible, the broad locations where these two species have been recorded should be left undisturbed.

Unfortunately, no specific research is available on the long-term effects on dune assemblage fungi where such dune restoration projects have been undertaken. It would be hoped that in the long term the greater dune mobility and habitat diversity the project aims to create would benefit both foredune and grey dune assemblages of fungi, provided that sufficient areas of stabilised *Ammophila arenaria* marram grass are left undisturbed for their associated specialist fungi to continue flourishing.

It is worth noting that these semi-stabilised areas of foredune *Ammophila arenaria* marram grass are the preferred habitat for *Hohenbuehelia culmicola* marram oyster and the recently described *H. bonii* which are both priority species in Section 7 Environment (Wales) Act 2016, as well as on the SSSI dune assemblage of fungi, and are known to be rare across Europe (Dahlberg & Croneborg 2006). Although not yet known from Merthyr Mawr Warren NNR, they have both been recorded in South Wales from Pembrey and Whiteford and their occurrence at Merthyr Mawr Warren NNR is entirely possible. Further active search for them is advised.

Footpaths and bridlepaths through the foredunes are only causing minor degradation, not currently at a level to create great concern.

- The key conservation management strategy for these species consists of maintaining the majority of the existing foredunes in their current state.
- This involves avoiding (if possible) any mechanical destruction during dune rejuvenation projects in the vicinity of those dune assemblage fungi with the most restricted distribution
- Developing (if possible) an area or areas of the foredune with a more tapered profile on the seaward side should also be an aim

## 7.2. Management for dune slack fungi with *Salix repens* creeping willow

Some sixteen species of dune assemblage fungi (as listed on the JNCC website, Bosanquet *et al.* 2018: para 3.7) form mutually beneficial ectomycorrhizal associations with *Salix repens* creeping willow and are thus only found with their partner plant, typically in dune slacks.

Six of these species in the genera *Hebeloma* poisonpies and *Inocybe* fibrecaps, plus the potential dune assemblage species *Hebeloma salicicola*, were recorded at Merthyr Mawr Warren NNR during the 2020 survey, all of them in a single extensive area of low-growing *Salix repens* creeping willow in what appears to be a dry or damp (but not wet or inundated) slack (outlined in Figure 2). Two additional *Inocybe* species with *Salix repens* were previously recorded, quite probably in the same slack. With a total of 6-8 dune assemblage species, this relatively small area of dune slacks with *Salix repens* is thus the most important fungal dune assemblage habitat at Merthyr Mawr Warren NNR as well as one of the best dune slack assemblages in Wales (after Newborough and Aberffraw).

Figure 25 *Salix repens* creeping willow dune slack at Merthyr Mawr Warren NNR



Cattle and rabbit grazing was noted in this *Salix repens* slack at Merthyr Mawr Warren NNR during the 2020 survey and the area was also mown very short prior to the final survey visit on November 5th. Both grazing and mowing with clipping removed are beneficial to dune slack assemblage fungi in keeping scrub encroachment in check. However mowing should not be so short as to compromise the viability or vigour of the *Salix repens* and its associated fungi. Some encroaching *Betula* birch was observed, particularly at the eastern end of this slack area where fungal interest was possibly best during 2020 survey. Active removal of young birch saplings in this eastern area is recommended as a priority as it is also the location of one of only two known British sites for the cavalier *Melanoleuca pseudoluscina*.

Based on the 2020 survey, this relatively small area of *Salix repens* creeping willow appears to be the sole hotspot for dune assemblage species at Merthyr Mawr Warren NNR. As such it is a priority that its extent and quality should be preserved and a careful balance in management strategies maintained. Particular attention should be given in respect of potential conflicts with management for *Petalophyllum ralfsii* petalwort which focuses on mowing to keep *Salix repens* in check creating bare areas. Clearly too much checking the extent of *Salix repens* to create bare areas is not a favourable strategy for dune assemblage fungi. Mosaic mowing at different heights is one possible solution with low mowing along the borders of the *Salix repens* area and path edges but leaving slightly taller areas in the middle. Leaving mowing as late as possible into November is also recommended as this ensures the majority of fungal fruiting and spore dispersal has taken place for these key fungi.

Research elsewhere, based on DNA analysis of soil samples as well as field observations (Geml *et al.* 2014), indicates that *Salix repens* slacks are species-rich in both ectomycorrhizal and other fungi. It is therefore extremely likely that further surveys will reveal additional dune assemblage species in this area.



*Salix repens* was not observed in other slack or low-lying areas elsewhere at Merthyr Mawr Warren NNR, though a few scattered plants (without visible signs of their associated fungi) were seen amongst other vegetation in the grey dunes.

Encouraging further areas of *Salix repens* to colonise or be actively introduced into other slacks at Merthyr Mawr Warren NNR would safeguard and extend the area available to the benefit of their associated dune assemblage fungi.

The ongoing Sands of LIFE dune restoration project aims to scrape and lower the levels of some dune slacks as well as mow some areas. All these actions are potentially very beneficial to dune assemblage fungi especially if more areas of *Salix repens* are encouraged. The hotspot dune slack assemblage area should not however be subject to any scraping.

- The key conservation management strategy for these species consists as a minimum of maintaining this slack area in its current condition and extent.
- This will require active management (grazing and mowing) to retain low growth and avoid scrub encroachment to ensure that the area of *Salix repens* slack does not diminish in extent or quality.
- Rejuvenation and encouraging extension of *Salix repens* in other areas should also be an aim.

### 7.3. Management for grey dune fungi

Most of the dune assemblage fungi found in grey (semi-fixed and fixed) dunes are saprotrophs, growing on the buried remains of vegetation and organic matter in the soil. Many (such as species of *Tulostoma* stalkballs) are adapted to arid, open and sandy conditions. Most if not all require areas of stable, fixed dune but with a relatively low density covering of mosses, lichens, and sparse, low-growing grasses and herbs.

There are a total of 21 species of dune assemblage fungi associated with grey dunes, nine of which have been recorded from Merthyr Mawr Warren NNR (six during the 2020 survey). The most rarely recorded in Wales are *Bovista pusilla* least puffball, *Clitocybe barbularum* (a funnel cap), *Melanoleuca pseudoluscina* (a cavalier), and *Tulostoma melanocyclum* scaly stalkball (last recorded in 2019) which is listed as “Vulnerable” on the most recent British red list (Smith *et al.* 2016) and is a Section 7 Priority Species.

Grey dune covers by far the largest proportion of dune assemblage fungal habitat at Merthyr Mawr Warren NNR and these species are scattered throughout but mainly concentrated at the more landward parts least subjected to recent disturbance by dune renovation works or *Hippophaë rhamnoides* sea buckthorn clearance.

Based on the 2020 survey, one of the best areas for grey dune assemblage fungi at Merthyr Mawr Warren NNR is close to the main entrance of the reserve, as marked in Figure 2. This area appears relatively undisturbed with less recent mechanical disturbance than other parts of the reserve, allowing a greater diversity of fungi to develop.

It was noticeable that large areas of the reserve, particularly in a wide band behind the foredunes, contained very few dune assemblage fungi and rather more ruderal species such as *Panaeolus acuminatus* dewdrop mottlegill. This is probably in part the result of the 2013-2014 dune rejuvenation works and, more especially, the extensive clearance of some 37 ha of *Hippophaë rhamnoides* sea buckthorn scrub between 1996 and 2006 which involved both herbicides and mechanical digging (Rooney *et al.* 2011). The presence of ruderal species may also be the result of the previous presence of the sea buckthorn scrub which has nitrogen fixing nodules and increases soil nitrogen levels in what would normally be a nutrient deficient dune habitat (Packham and Willis 1997).

No research has been undertaken on how long fungal communities might take to recolonise disturbed or nitrogen enriched sites in dunes, but for unimproved grasslands the estimated time span for recolonisation following disturbance is “several decades” (Griffith *et al.* 2013). Time and further survey will tell at Merthyr Mawr Warren NNR .

- The key conservation management strategy for these species consists of maintaining an open patchwork of semi-fixed and stable areas.
- This will require adequate grazing and some regular active management to retain low growth and avoid scrub encroachment

**Table 6 Management strategies to maintain and benefit dune assemblage fungi**

<b>AVOID</b>
<ul style="list-style-type: none"> <li>• <b>Turf and surface layer removal</b> or large-scale disturbance through change of land use</li> <li>• <b>Application of herbicides</b>, including runoff from adjacent areas</li> <li>• <b>Increasing nutrient levels</b>, especially in slacks, by:               <ul style="list-style-type: none"> <li>○ fertilisers/nitrates, including runoff from adjacent areas</li> <li>○ supplementary feeding of cattle or other livestock</li> <li>○ failure to remove grass/herbaceous clippings when mowing</li> </ul> </li> <li>• <b>Under-grazing or neglect</b> of grey dunes and slacks, leading to rank sward and scrub encroachment</li> <li>• <b>Rutting and destruction of the surface layer</b> of grey dunes and slacks by recreational and other vehicles, heavy machinery, horse-riding off bridlepaths, wild boar, excessive trampling, barbecues and bonfires, etc.</li> <li>• <b>Substantial changes to drainage or runoff patterns</b>, especially in slacks</li> </ul>

## ENCOURAGE

- **Maintenance of a low sward or herb layer** in grey dunes and slacks: ideally through grazing by rabbits or other light-grazing animals, alternatively by mowing (with the removal of clippings)
- **Scrub control especially in *Salix repens* slacks**, if necessary hand cutting birch and willow saplings and preventing any recolonisation by *Hippophaë rhamnoides* sea buckthorn
- **Reclamation of overgrown and neglected grey dunes and slacks** by grazing or hand-clearance (avoiding soil/turf disturbance or herbicides)
- **Promotion of embryo dunes** on the seaward edge of the existing foredunes by encouraging some mobile areas of foredune

### 7.4. Future Monitoring

The unstable shifting nature of sand dunes and the rapid drying out after periods of rainfall mean that dune systems are amongst the most fleeting and unpredictable of mycological habitats when it comes to fruiting of fungi. They can remain without any fungi fruiting for long periods of time but then respond rapidly to sufficient rainfall and temperature to give a flush of fungi which can disappear equally rapidly if the weather dries out and becomes hot. So timing of visits is critical and it is well documented that successive surveys year on year will continue to add new species of macrofungi to a site list even after 20 years (Tofts & Orton 1998). For survey purposes it is strongly suggested that more visits to dunes are required to achieve meaningful results than for other habitats.

Monitoring surveys at an important dune fungal assemblage site like Merthyr Mawr Warren NNR should be carried out at regular intervals and as a minimum at least once every five years (Evans & Roberts 2018). Such monitoring should be undertaken by experienced mycologists with a good working knowledge of dune macrofungi and the ability to check identifications using a microscope and specialist literature. Monitoring and survey priority should be given to SSSI sites like Merthyr Mawr where there have been substantive changes. These include the chemical or physical removal of sea buckthorn or other vegetation, introduction of grazing and similar management changes, and any large-scale alterations such as the Sands of LIFE project dune rejuvenation works.

The optimal time for surveys is between late September to mid-November (and if weather is mild December) when the great majority of species produce visible fruiting bodies (monitoring the spring-fruiting species *Helvella leucopus* palefoot saddle would require an additional visit in April-May). Such surveys are necessarily weather-dependent and a dry autumn or early frost may limit the number of species found, so surveys should have the flexibility to postpone or run over into a subsequent year.

Recent advances in DNA sequencing allow many fungi to be identified by soil/substrate or root-tip sampling, a technique that is usually combined with a traditional fruitbody survey. Such substrate sampling has the advantage of not being weather-dependent and typically identifies a large number of species that are not visible above-ground at the time of the survey (Van der Heijden *et al.* 1999; Geml *et al.* 2014; Høiland & Botnen 2016). The main disadvantages, at present, are the costs involved in DNA sequencing and analysis and, more importantly, a lack of sufficient data allowing the majority of sequences to be matched to a named species. Both, however, are improving with time so that in the next decade or two monitoring that includes the analysis of soil/substrate samples may be the most cost-effective and accurate means of conducting a survey of dune assemblage fungi.

Merthyr Mawr Warren NNR is not only one of the top ten dune sites in Wales for its unique and specialised fungi but also amongst the very best known in Britain possibly in Europe. This makes safeguarding its management and monitoring its fungi in the future of huge importance.

## 8. Acknowledgments

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## 9. References

Aronsen A, Læssøe T. 2016. *The genus Mycena s.l. Fungi of Northern Europe Vol. 5*. Danish Mycological Society

Bosanquet SDS, Ainsworth AM, Cooch SP, Genney DR, Wilkins TC. 2018. *Guidelines for the selection of Biological SSSIs. Part 2: detailed guidelines for habitats and species groups. Chapter 14 Nonlichenised Fungi*. Joint Nature Conservation Committee. Available from: <https://data.incc.gov.uk/data/d1fcb171-8086-4f5b-ade5-a34c5edc78c5/SSSI-Guidelines-14-Non-lichenisedfungi-2018a.pdf>

Bridgend Biodiversity Partnership 2002. *Local Biodiversity Action Plan for Bridgend County Borough Volume 1*. Available from: <https://www.bridgend.gov.uk/media/2036/sd95.pdf>

British Mycological Society 2009. *Fungal Records Database of Britain and Ireland*. Available from: <http://www.frdbi.info/> [accessed Feb. 2021]

Cannon P. 2012. *Systematics, barcoding and ecology of fungi from waxcap grasslands in Britain*. Project report to DEFRA 4: April 2012. Available from: <http://fungi.myspecies.info/sites/fungi.myspecies.info/files/Project%20report%20to%20DEFRA%204.pdf>

Dahlberg A, Croneborg H. 2006. The 33 threatened fungi in Europe. *Nature & Environment* 136. Council of Europe

Evans SE, Henrici A, Ing B. 2006. *Red Data List of threatened British fungi*. Available from:

[https://www.britmycolsoc.org.uk/application/files/2013/3537/5755/RDL\\_of\\_Threatened\\_British\\_Fungi.pdf](https://www.britmycolsoc.org.uk/application/files/2013/3537/5755/RDL_of_Threatened_British_Fungi.pdf)

Evans SE, Roberts PJ. 2015a. Mycological survey of Mynydd Epynt Ranges, Sennybridge, Powys. *Natural Resources Wales Report* (in press)

Evans SE, Roberts PJ. 2015b. Welsh Dune Fungi: data collation, evaluation and conservation priorities. *Natural Resources Wales Evidence Report* 134. Available from: <https://cdn.cyfoethnaturiol.cymru/media/685004/report-134-welsh-dune-fungi-data-priorities.pdf>

Evans SE, Roberts PJ. 2018. Developing British fungal assemblage scoring systems for SSSI selection guidelines. *Natural England Report* (in press)

Geml J, Gravendeel B, van der Gaag KJ, Neilen M, Lammers Y, Raes N, Semenova TA, de Knijff P, Noordeloos M E. 2014. The contribution of DNA metabarcoding to fungal conservation: diversity assessment, habitat partitioning and mapping red-listed fungi in protected coastal *Salix repens* communities in the Netherlands. *PLoS ONE* 9(6), e99852. doi:10.1371/journal.pone.0099852

Griffith GW, Gamarra JGP, Holden EM, Mitchel D, Graham A, Evans DA, Evans SE, Aron C, Noordeloos ME, Kirk PM, Smith SLN, Woods RG, Hale AD, Easton GL, Ratkowsky DA, Stevens DA, Halbwachs H. 2013. The international conservation importance of Welsh 'waxcap' grasslands. *Mycosphere* 4(5), 969-984. Mycosphere online edition [www.mycosphere.org](http://www.mycosphere.org)

Harries D. 2014. *Melanoleuca pseudoluscina* – a dune species with an interesting history. *Field Mycology* 15, 135–136

Høiland K, Botnen S. 2016. A comparison of aboveground sporocarps and belowground ectomycorrhizal structures of Agaricales, Boletales and Russulales in a sand dune ecosystem on Lista, South-western Norway. *Agarica* 37, 67–77

IUCN 2019. *The global fungal red list initiative*. Available from: <http://iucn.ekoo.se/en/iucn/welcome> (accessed Feb. 2021)

Legon N, Henrici A. 2005. *Checklist of the British and Irish Basidiomycota*. Royal Botanic Gardens, Kew (updated at <http://basidiochecklist.science.kew.org/index.htm>)

Packham JR, Willis AJ. 1997. *Ecology of dunes, salt marsh, and shingle*. Chapman & Hall, London

Pye K, Blott SJ. 2015. Merthyr Mawr dune rejuvenation works topographic survey report. *Natural Resources Wales Report* 99. Available from:

<https://cdn.cyfoethnaturiol.cymru/media/685924/eng-report-099-merthyr-mawr-dune-rejuvenation-report-march-2015.pdf>

Rooney P, Houston J, Weaver G. 2011. The conservation and management of Sea Buckthorn (*Hippophaë rhamnoides*) in the UK. *Sand Dune and Shingle Network Occasional Paper* 3. Available from: . <https://www.asharrison.com.au/wp-content/uploads/2017/05/sea-buckthorn-in-uk.pdf>

Rotheroe M. 1993. The larger fungi of Welsh sand dunes. *Countryside Council for Wales Report*. Available from: <https://www.aber.ac.uk/waxcap/downloads/rotheroe93-welshsanddunefungi.pdf>

Rotheroe M. 2003. The rare mushrooms of Wales II: A revised red data list of Welsh macrofungi. *Countryside Council for Wales Report*. Available from: <https://www.aber.ac.uk/waxcap/downloads/rotheroe03-raremushrooms2.pdf>

Rotheroe M, Newton A, Evans S, Feehan J. 1996. Waxcap-grassland survey. *Mycologist* 10, 23–25

Smith JH, Suz LM, Ainsworth AM. 2016. *Red List of Fungi for Great Britain: Bankeraceae, Cantharellaceae, Geastraceae, Hericiaceae and selected genera of Agaricaceae (Battarrea, Bovista, Lycoperdon & Tulostoma) and Fomitopsidaceae (Piptoporus)*. Available from: <http://fungi.myspecies.info/sites/fungi.myspecies.info/files/Smith%20et%20al.%20%282015%29.pdf>

Tofts RJ, Orton PD. 1998. The species accumulation curve for agarics and boleti from a Caledonian pinewood. *Mycologist* 12, 98–102

Van der Heijden EW, de Vries FW, Kuyper TW. 1999. Mycorrhizal associations of *Salix repens* communities in succession of dune ecosystems. I. Above-ground and below-ground views of ectomycorrhizal fungi in relation to soil chemistry. *Canadian Journal of Botany* 77, 1821–1832

Vincenot L, Tedersoo L, Richard F, Horcine H, Kõljalg U, Selosse M-A. 2008. Fungal associates of *Pyrola rotundifolia*, a mixotrophic Ericaceae, from two Estonian boreal forests. *Mycorrhiza* 19, 15–25

## 10. Annex 1

**Table 7 All fungi recorded in 2020 survey.** Associated plants are only noted where the relationship is obligate. Frequent = found at 10 or more sites; occasional = 4 to 9 sites; infrequent = 2 or 3 sites; single = one site (with a single fruitbody or a single group of fruitbodies)

Scientific Name	English Name	First Survey Record	Location and Association	Frequency
<i>Agrocybe pediades</i>	common fieldcap	01/09/2020	slack	single
<i>Arrhenia baespora</i>		16/10/2020	slack	single
<i>Bovista pusilla</i>	least puffball	16/10/2020	grey dunes	single
<i>Calocybe ionides</i>	violet domecap	08/10/2020	grey dunes	single
<i>Calocybe obscurissima</i>	obscure domecap	19/11/2020	slack	single
<i>Clavaria incarnata</i>	skinny club	05/11/2020	grey dunes	infrequent
<i>Clavulinopsis laeticolor</i>	handsome club	16/10/2020	slack	single
<i>Clitocybe agrestis</i>		08/10/2020	grey dunes	occasional
<i>Clitocybe barbularum</i>		05/11/2020	grey dunes	infrequent
<i>Clitocybe rivulosa</i>	fool's funnel	19/11/2020	grassland	single
<i>Conocybe tenera</i>	common conecap	19/11/2020	slack	single
<i>Coprinopsis ammophila</i>	dune inkcap	05/11/2020	foredunes with <i>Ammophila arenaria</i>	single
<i>Cortinarius saturninus</i>		08/10/2020	slack with <i>Salix repens</i>	occasional
<i>Crucibulum laeve</i>	common bird's nest	08/10/2020	slack	single
<i>Cuphophyllus virgineus</i>	snowy waxcap	08/10/2020	grey dunes & grassland	frequent
<i>Cystoderma amianthinum</i>	earthy powdercap	05/11/2020	grey dunes	single
<i>Entoloma longistriatum</i>		05/11/2020	slack	single

Scientific Name	English Name	First Survey Record	Location and Association	Frequency
<i>Entoloma rhodocylix</i>		16/10/2020	slack	single
<i>Entoloma sericeum</i>	silky pinkgill	05/11/2020	grey dunes & grassland	occasional
<i>Entoloma undatum</i>		16/10/2020	grey dunes	single
<i>Galerina graminea</i>	turf bell	05/11/2020	grey dunes	occasional
<i>Galerina praticola</i>		05/11/2020	slack & grey dunes	infrequent
<i>Galerina vittiformis</i>	hairy leg bell	08/10/2020	slack & grey dunes	occasional
<i>Geastrum sp.</i>		01/09/2020	grey dunes	single
<i>Geoglossum cookeanum</i>		08/10/2020	slack & grey dunes	frequent
<i>Gliophorus psittacinus</i>	parrot waxcap	16/10/2020	slack	infrequent
<i>Gymnopus dryophilus</i>	russet toughshank	16/10/2020	grey dunes	single
<i>Hebeloma dunense</i>		16/10/2020	slack with <i>Salix repens</i>	infrequent
<i>Hebeloma hiemale</i>		16/10/2020	slack with <i>Salix repens</i> or <i>Betula sp.</i>	single
<i>Hebeloma salicicola</i>		08/10/2020	slack with <i>Salix repens</i>	infrequent
<i>Hebeloma vaccinum</i>	willow poisonpie	08/10/2020	slack with <i>Salix repens</i>	occasional
<i>Hebeloma velutipes</i>		16/10/2020	slack with <i>Salix repens</i>	single
<i>Hemimycena crispula</i>		19/11/2020	foredunes	single
<i>Hygrocybe acutoconica</i>	persistent waxcap	08/10/2020	slack & grey dunes	occasional
<i>Hygrocybe aurantiolutescens</i>		05/11/2020	grey dunes	single
<i>Hygrocybe calciphila</i>	limestone waxcap	19/11/2020	slack	single
<i>Hygrocybe conica</i>	blackening waxcap	05/11/2020	grey dunes & grassland	occasional



Scientific Name	English Name	First Survey Record	Location and Association	Frequency
<i>Hygrocybe conicoides</i>	dune waxcap	08/10/2020	slack & grey dunes	frequent
<i>Hygrocybe insipida</i>	spangle waxcap	08/10/2020	slack	infrequent
<i>Hygrocybe mucronella</i>	bitter waxcap	05/11/2020	grey dunes & grassland	infrequent
<i>Hygrocybe reidii</i>	honey waxcap	08/10/2020	slack	single
<i>Inocybe agardhii</i>		01/09/2020	slack with <i>Salix repens</i>	occasional
<i>Inocybe dunensis</i>	dune fibre-cap	01/09/2020	slack with <i>Salix repens</i>	infrequent
<i>Inocybe salicis</i>		08/10/2020	slack with <i>Salix repens</i>	single
<i>Inocybe serotina</i>		08/10/2020	slack with <i>Salix repens</i>	single
<i>Inocybe vulpinella</i>	foxy fibre-cap	08/10/2020	slack with <i>Salix repens</i>	single
<i>Lactarius pubescens</i>	bearded milkcap	08/10/2020	slack with <i>Betula</i> sp.	occasional
<i>Lepiota oreadiformis</i>		08/10/2020	grey dunes	frequent
<i>Lepista irina</i>	flowery blewit	16/10/2020	grey dunes	single
<i>Lepista nuda</i>	wood blewit	05/11/2020	slack & grey dunes	infrequent
<i>Leucoagaricus leucothites</i>	white dapperling	01/09/2020	grey dunes & grassland	occasional
<i>Lycoperdon lividum</i>	grassland puffball	08/10/2020	slack, grey dunes, & grassland	frequent
<i>Lycoperdon pratense</i>	meadow puffball	08/10/2020	slack & grassland	frequent
<i>Macrolepiota mastoidea</i>	slender parasol	16/10/2020	grey dunes	single
<i>Marasmius oreades</i>	fairy ring champignon	01/09/2020	grey dunes & grassland	occasional
<i>Melanoleuca cinereifolia</i>	dune cavalier	16/10/2020	foredunes with <i>Ammophila arenaria</i>	frequent
<i>Melanoleuca friesii</i>		16/10/2020	grey dunes & grassland	occasional

Scientific Name	English Name	First Survey Record	Location and Association	Frequency
<i>Melanoleuca pseudoluscina</i>		16/10/2020	slack & grey dunes	infrequent
<i>Mycena acicula</i>	orange bonnet	05/11/2020	grey dunes	infrequent
<i>Mycena epipterygia</i>	yellowleg bonnet	16/10/2020	grey dunes	single
<i>Mycena flavoalba</i>	ivory bonnet	19/11/2020	grassland	single
<i>Mycena luteovariegata</i>		08/10/2020	slack	infrequent
<i>Omphalina pyxidata</i>	cinnamon navel	08/10/2020	slack & grey dunes	frequent
<i>Panaeolus acuminatus</i>	dewdrop mottlegill	01/09/2020	grey dunes	frequent
<i>Phallus hadriani</i>	sand stinkhorn	19/11/2020	foredunes with <i>Ammophila arenaria</i>	single
<i>Psathyrella ammophila</i>	dune brittlestem	01/09/2020	foredunes with <i>Ammophila arenaria</i>	frequent
<i>Psathyrella fatua</i>		19/11/2020	grey dunes	single
<i>Psilocybe montana</i>	mountain brownie	19/11/2020	slack	single
<i>Ramariopsis tenuiramosa</i>		05/11/2020	grassland	single
<i>Rhodocybe popinalis</i>		08/10/2020	grey dunes	single
<i>Stropharia coronilla</i>	garland roundhead	16/10/2020	grey dunes	single
<i>Tubaria confragosa</i>	ringed twiglet	08/10/2020	slack	single
<i>Tubaria conspersa</i>	felted twiglet	05/11/2020	slack	infrequent
<i>Tulostoma brumale</i>	winter stalkball	05/11/2020	grey dunes	occasional
<i>Xylodon sambuci</i>	elder whitewash	16/10/2020	foredunes	occasional

## 11. Annex 2

**Table 8 IUCN Global Fungal Red List species in the British Isles (excluding lichens & species of 'Least Concern') as of December 2020**

Scientific Name	English Name	IUCN Global Red List threat category	JNCC SSSI fungi assemblage
<i>Armillaria ectypa</i>	marsh honey fungus	NT	
<i>Boletopsis grisea</i>		NT	
<i>Bovista paludosa</i>	fen puffball	VU	
<i>Buchwaldoboletus lignicola</i>	wood bolete	VU	
<i>Clavaria zollingeri</i>	violet coral	VU	grassland
<i>Cortinarius atrovirens</i>	olive webcap	NT	
<i>Cuphophyllus canescens</i>	felted waxcap	VU	grassland
<i>Cuphophyllus colemannianus</i>	toasted waxcap	VU	grassland
<i>Cuphophyllus lacmus</i>	grey waxcap	VU	grassland
<i>Cuphophyllus lepidopus</i>		VU	grassland
<i>Entoloma bloxamii</i>	big blue pinkgill	VU	(grassland)
<i>Entoloma excentricum</i>	excentric pinkgill	NT	(grassland)
<i>Entoloma griseocyaneum</i>	felted pinkgill	VU	(grassland)
<i>Entoloma porphyrophaeum</i>	lilac pinkgill	VU	(grassland)
<i>Entoloma prunuloides</i>	mealy pinkgill	VU	(grassland)
<i>Gastrosporium simplex</i>		NT	
<i>Geoglossum difforme</i>	slimy earthtongue	NT	
<i>Gliophorus euoperplexus</i>	butterscotch waxcap	VU	grassland
<i>Gliophorus reginae</i>	jubilee waxcap	VU	grassland
<i>Gloioxanthomyces vitellinus</i>	glistening waxcap	EN	grassland
<i>Hydnellum gracilipes</i>	graceful tooth	VU	
<i>Hygrocybe citrinovirens</i>	citrine waxcap	VU	grassland
<i>Hygrocybe coccineocrenata</i>	bog waxcap	NT	
<i>Hygrocybe punicea</i>	crimson waxcap	VU	grassland
<i>Hygrocybe spadicea</i>	date waxcap	VU	grassland
<i>Hygrocybe splendidissima</i>	splendid waxcap	VU	grassland
<i>Laccaria maritima</i>	sand deceiver	NT	dune
<i>Lepiota brunneolilacea</i>	star dapperling	VU	dune
<i>Microglossum atropurpureum</i>	dark-purple earthtongue	VU	grassland
<i>Neohygrocybe ingrata</i>	dingy waxcap	VU	grassland
<i>Neohygrocybe nitrata</i>	nitrous waxcap	VU	grassland
<i>Neohygrocybe ovina</i>	blushing waxcap	VU	grassland
<i>Perenniporia medulla-panis</i>		NT	

Scientific Name	English Name	IUCN Global Red List threat category	JNCC SSSI fungi assemblage
<i>Porpolomopsis calyptriformis</i>	pink waxcap	VU	grassland
<i>Pseudotracheloma metapodium</i>	mealy meadowcap	EN	(grassland)
<i>Rhodotus palmatus</i>	wrinkled peach	NT	
<i>Rubinoboletus rubinus</i>	crimson bolete	VU	
<i>Rubroboletus rhodoxanthus</i>	ruddy bolete	NT	
<i>Sarcodon joeides</i>	violet tooth	VU	tooth fungi with oak
<i>Sarcodontia crocea</i>	orchard toothcrust	VU	
<i>Stereopsis vitellina</i>	roothole rosette	VU	
<i>Trichoglossum walteri</i>	short spored earthtongue	VU	grassland
<i>Tricholoma acerbum</i>	bitter knight	VU	
<i>Tricholoma apium</i>	scented knight	VU	
<i>Tricholoma matsutake</i>	spicy knight	VU	
<i>Tulostoma niveum</i>	white stalkball	VU	

## Data Archive Appendix

Data outputs associated with this project are archived in [NRW to enter relevant corporate store and / or reference numbers] on server-based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word format.

[B] A worksheet named “Merthyr Mawr Warren NNR Records of Fungi 2020” in Microsoft Excel format

Metadata for this project is publicly accessible through Natural Resources Wales’ Library Catalogue <https://libcat.naturalresources.wales> (English Version) and <https://catllyfr.cyfoethnaturiol.cymru> (Welsh Version) by searching ‘Dataset Titles’. The metadata is held as record no [NRW to insert this number]



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