

Introduction to Lichenicolous Fungi

Introduction to the resources on the BLS Lichenicolous Fungi webpage

The aim of this webpage is to give some support to the growing number of people who have an emerging interest in lichenicolous fungi – fungi that always, or frequently, grow on lichens. Many readers will be lichenologists who have had their interest piqued by the odd growths and black dots that they've found on the lichens that they look at. Other readers may be mycologists who have ventured into mycology on a new substrate.

The needs of lichenologists and mycologists are different. Fungi from a wide range of taxonomic groups, and with a very wide range of different structures, occur on lichens. However, lichens themselves mostly belong to the form groups that mycologists sometimes refer to as discomycetes and pyrenomycetes – in other words, those having apothecia and perithecia. Lichenologists will, therefore, often lack the understanding of the terminology used in other fungal groups and may also lack the skills used to investigate them. Mycologists, on the other hand, will often struggle to identify the lichen substrate to genus or species.

The materials on this webpage are written primarily for lichenologists but the following literature may be particularly useful to those coming from a strong mycological background.

Where the host is uncertain, mycologists may be more comfortable using keys that concentrate on the characteristics of the lichenicolous fungus. The following are available:

- Hawksworth DL, Atienza V, Coppins BJ (2010) Artificial Keys to the Lichenicolous Fungi of Great Britain, Ireland, the Channel Islands, Iberian Peninsula, and Canary Islands – Fourth draft edition. http://www.ascofrance.com/uploads/forum_file/LichenKeys2010-0001.pdf
- Ihlen PG, Wedin M (2008) An annotated key to the lichenicolous Ascomycota (including mitosporic morphs) of Sweden. *Nova Hedwigia* **86**: 275-365.

There is no modern key to the lichenicolous basidiomycetes. The following work lists the lichenicolous basidiomycetes that are known as well as listing all other genera and species of lichenicolous fungi.

- Diederich P, Lawrey JD, Ertz D (2018) The 2018 classification and checklist of lichenicolous fungi, with 2000 nonlichenized, obligately lichenicolous taxa. *The Bryologist* **121**: 340-425.

Lichenicolous fungi

Lichenicolous fungi are fungi that grow on lichens. **Obligate** lichenicolous fungi are unable to grow on any other substrate. **Facultative** lichenicolous fungi occur on lichens but can also occur on other substrates.

There are also some species of lichenised fungi that grow on lichens. These are usually referred to as **lichenicolous lichens**.

The relationship between a lichenicolous fungus (or a lichenicolous lichen) and the lichen it is growing on, varies enormously.

Saprotrophic lichenicolous fungi feed on dead lichen material. Many of these are also able to feed on other dead organic material.

Parasitic lichenicolous fungi feed on living lichen material and take their nutrients from the lichen, with or without causing damage to the host lichen. Many parasitic lichenicolous fungi are host specific, either restricted to a particular lichen species or to a group of closely related lichens.

Pathogenic lichenicolous fungi are parasitic lichenicolous fungi that cause damage to the host lichen, sometimes leading to the death of the host.

Endolithic lichenicolous fungi appear to live in harmony with a living lichen. It is unclear in many cases whether they are merely taking nutrients from the lichen they are living with (making them parasites) or whether they are contributing something to the health of the lichen (making them parasymbiotic). Some endolithic fungi reproduce only when the host lichen is dying and, therefore, can easily be mistaken for pathogens.

Morphology

Lichenicolous fungi show a wide range of morphological characteristics. Some produce apothecia or perithecia that are very similar to those produced by lichens. Other lichenicolous fungi reproduce by forming basidiospores on a layer of exposed fungal tissue. Still others produce non-sexual spores protected in closed structures called pycnidia or exposed on the ends of specialised hyphae.

Although specialist terminology has been kept to a minimum in the resources on this webpage, the use of some terms has been necessary and observers who wish to consult more detailed literature will need to learn more.

A detailed glossary of mycological terms can be found here: <https://www.environment.gov.au/science/abrs/online-resources/glossaries/fungi>

Fungi are composed of long cells that join into threads known as **hyphae** (singular: hypha). These are the main feeding structures. Fungi can also form specialised cells which can take different shapes and have different functions.

Fungal reproductive structures

As with the majority of living organisms, the reproductive features of fungi are extremely useful for providing reliable identification characteristics.

Spores can be produced in two ways:

- The “budding off” of small cells (spores) which contain a copy of the ‘parent’ DNA. This is described as an **asexual** process.
- The combination and re-organisation of the DNA from two different ‘parents’, followed by the production of spores. This is a **sexual** process.

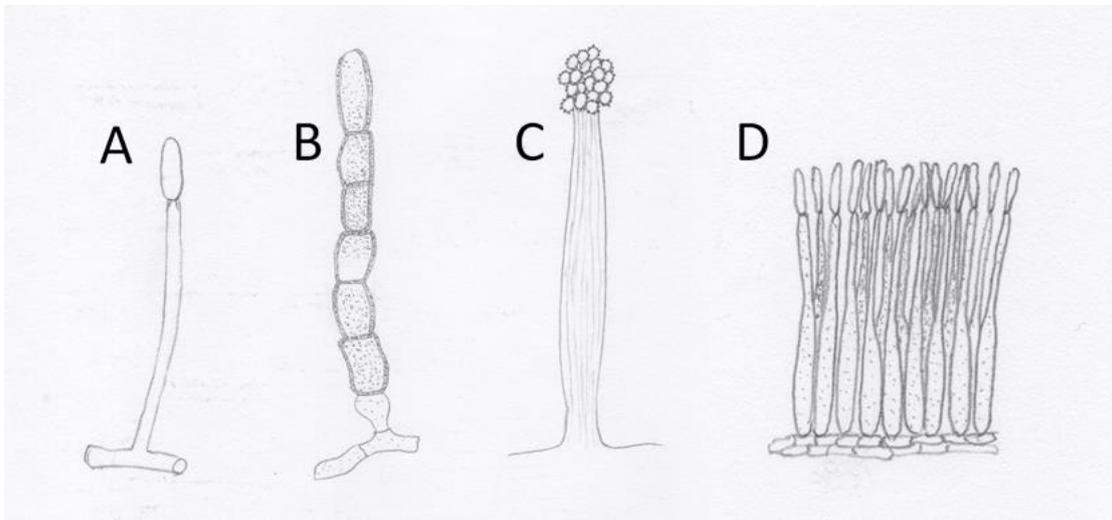
Although lichens often produce both asexual and sexual spores on the same individual thallus, in non-lichenised fungi the two processes can occur on different forms of the fungus. These forms are the **anamorph** which produces spores asexually and the **teleomorph** which produces spores sexually. In the past, these two forms have often been given different names although they belong to the same biological entity. Standardisation is gradually resulting in a single name being used but either name will identify the species that is meant.

When submitting records, it is good practice to record in the ‘Notes’ field whether the anamorph or the teleomorph was seen, for fungi where both forms are known to occur.

Anamorph reproductive morphology

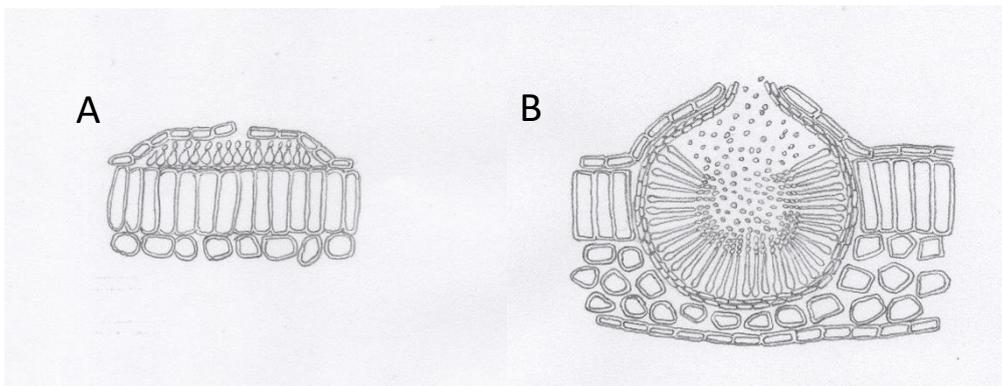
Conidia (asexually produced spores; singular: conidium) are formed by the “budding off” of a cell at the tip of a specialised fungal hypha. The specialised hypha is called a **conidiophore** and the cell at the tip of this hypha is called the **conidiogenous cell**. Conidiophores can be simple or branched.

When the conidiophores and conidia are exposed to the air, they are totally exposed to environmental conditions and can be easily damaged by dehydration, UV radiation or predation. The formation of thicker cell walls, and/or the additional of dark pigments to cell walls, offers more protection. The arrangement of the conidiophores into more complex structures also offers increasing levels of protection to the conidia.



Relatively simple arrangements of conidiophores and conidia: **A** – A spore-bearing hypha with a single thin-walled conidium. Conidia occur in chains in some species. **B** – A spore-bearing hypha with dark, melanised walls and thick-walled spores formed in a chain. **C** – Spore-bearing hyphae joined together to form a stalk – a **synnema** (plural: synnemata). **D** – Spore-bearing hyphae packed tightly together for protection – a **sporodochium** (plural: sporodochia).

Anamorphic fungi with these reproductive structures are known as **hyphomycetes**. This is a morphological grouping (equivalent to using crustose or foliose to group lichens) and does not necessarily imply any taxonomic relationship.



More complex structures that protect conidiophores and conidia - drawn here developing in plant leaf tissues. **A** – Spore-bearing hyphae packed tightly together to protect against dehydration and protected further by their development beneath a layer of host tissue – an **acervulus** (plural: acervuli). **B** – Spore-bearing hyphae forming a layer on the inside wall of a flask-shaped structure – a **pycnidium** (plural: pycnidia). Pycnidia are usually either partially or totally immersed in the host tissue. The walls are often dark due to melanisation which gives extra protection. The small pore through which the spores are shed is called an ostiole.

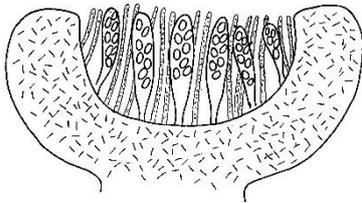
Anamorphic fungi with these reproductive structures are known as **coelomycetes**. This is a morphological grouping (equivalent to using crustose or foliose to group lichens) and does not necessarily imply any taxonomic relationship.

Teleomorph reproductive morphology

Two different types of sexual spores (ascospores and basidiospores) are produced by the fungal groups that are likely to be found on lichens. These are named after the structures that form them and represent two taxonomic groups.

Ascomycetes produce **ascospores** in sacs known as **asci** (singular: ascus). The reproductive structures in which the asci occur are called **ascomata**.

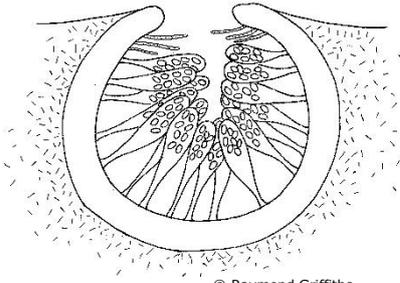
Types of ascomata:



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Asci arranged in a layer exposed to the air, usually with distinct tissues beneath and around the sides of the layer – an **apothecium** (plural: apothecia).

Teleomorphic fungi which produce apothecia have previously been known as **Discomycetes**. This is a morphological grouping (equivalent to using crustose or foliose to group lichens) and does not necessarily imply any taxonomic relationship.

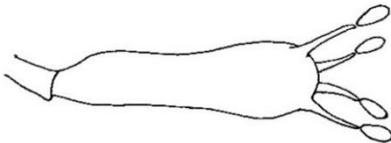


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Asci arranged in a layer on the inside wall of a flask-shaped structure – a **perithecium** (plural: perithecia). The small pore through which the spores are shed is called an ostiole.

Teleomorphic fungi which produce perithecia have previously been known as **Pyrenomycetes** (or pyrenocarps). This is a morphological grouping (equivalent to using crustose or foliose to group lichens) and does not necessarily imply any taxonomic relationship.

Basidiomycetes produce **basidiospores** on specialised cells called **basidia** (singular: basidium).



A **basidium** with four extensions called **sterigmata** (singular: sterigma). Each sterigma bears a single **basidiospore**.

Basidia can be arranged in a specialised layer called the **hymenium**. Basidia with four sterigmata are most common.

Identifying lichenicolous fungi

There are now hundreds of lichenicolous fungi known to occur in Britain and Ireland. The simplest way for a lichenologist to narrow down the group of fungi that need to be considered is by identifying the host lichen and referring to a key for lichenicolous fungi known on the host genus.

However, new fungi are being discovered on lichens every year, so keys quickly become out-dated. For this reason, keys may not contain the species of fungus that is being examined. In order to prevent mistakes in identification, answers from keys should be checked against the information available in the species descriptions on this website and, where possible, in the references given or against detailed descriptions sourced elsewhere.

In the species descriptions on this website, only lookalikes likely to occur on the same host, or on closely related lichens, have been included. This paragraph in each species description will, therefore, not be reliable if the identification of the host lichen is uncertain. It may also lack mentions of similar fungi not yet found in the UK at the time of writing.

Some collected specimens will lack the characteristics required for an accurate identification, such as mature spores. In these cases, the fungus must simply remain un-named.

Members of the British Lichen Society are encouraged to make use of the society's referees for lichenicolous fungi. Names of referees and their contact details can be found on the British Lichen Society website.

It is good practice to contact a referee before sending material for identification or verification. All specimens should be clearly labelled with collector's name, date of collection, place collected, notes on habitat and numbers present. They should also be accompanied by identification notes that describe characteristics observed and progress made towards an identification. Sending as much of this information as possible in an email in the first instance, may help the referee to decide if they are the best person to examine the material.

Making records

The distributions of lichenicolous fungi are changing, so even records of common and easily recognised lichenicolous fungi can be useful. For example, in recent years *Marchandiomyces corallinus* has been replaced by *Erythrium aurantiacum* and *Illiosporiopsis christensenii* in some habitats.

When recording it is good practice to state the information source(s) that have been used and to list the characteristics that were observed which led to the identification, such as 'Ascospores 10-12 x 3-4 µm". This information can be placed in the Notes field in most recording systems.

The British Lichen Society maintains a database of lichen records. This also includes records of lichenicolous fungi and of some small fungi that grow on bark. Over two million records have been gathered during the last 50 years.

The most efficient method for contributing records to this database is by using the British Lichen Society's spreadsheet. The latest version of this can be accessed on the British Lichen Society webpage. Search for 'spreadsheet'.

Records can also be submitted through the society's project on iRecord but these records are presently much more difficult for the BLS to integrate into their main database. iRecord is, however, the best place to make records when a recorder is not certain of the accuracy of their identification. Adding photos and as much information as possible, may allow records on iRecord to be verified in the future, so that only reliable records are integrated into the BLS database. iRecord will safely store these records until the British Lichen Society has the manpower to check the identification given.

Literature sources

These resources have been developed using primary scientific literature whenever possible but extensive use has also been made of the information and images available on the *Fungi of Great Britain and Ireland* website (<http://fungi.myspecies.info/>). This website gives more complete, and more technical, descriptions of fungi, often accompanied by a series of images. When no readily available literature has been found, descriptions have been added to the *FGBI* website.

How to search the Fungi and Lichens of Great Britain and Ireland website.

Type the name of a genus or species of fungus (lichenised or non-lichenised) into the search box, select Taxonomy and click on Search. This will open an overview page for the genus or species. This gives a summary of some of the information available on the other tabs situated just below the fungus name.

If a genus is selected, a list of species that have pages available can be seen in the taxonomic list in the left-hand sidebar by expanding the genus using the plus symbol. The current page has its taxon highlighted in bold in the taxonomic list for ease of use.

It is also possible to search by host lichen. Below the search box there is a series of brown tabs. Select the 'Host lists' tab. Select the appropriate letter under 'Fungal hosts'. This gives an alphabetical list of fungal hosts (including lichens) and under each species there is a list of fungi that grow on that host and have descriptions available on the website. These lists are, therefore, incomplete.

All of the references mentioned in the resources on this webpage were freely available through the internet when this introduction was written, with the exception of works published by the British Lichen Society. These can be accessed cost-effectively by members of the BLS:

- *The BLS Bulletin* is published twice-yearly and is free to BLS members. Older copies are available on the BLS website <https://www.britishlichensociety.org.uk/bulletins>
- *The Lichenologist* is a scientific, refereed journal published in conjunction with Cambridge University Press. A small annual fee, paid in addition to the BLS membership fee, gives BLS members online access to all issues of *The Lichenologist*.
- *The Lichens of Great Britain and Ireland – 2009 edition*. This heavy volume includes descriptions of lichenicolous fungi in cases where at least one closely related species is a lichen. The book is available to all but can be purchased at a substantial discount by BLS members from Richmond Publishing Co. Ltd., The Cottage, Allerds Road, Slough, SL2 3TJ (refer to the BLS website for prices).
- *Revisions of British and Irish Lichens*. This is a free access, serial publication that will eventually replace *The Lichens of Great Britain and Ireland*. Each volume covers a taxonomic family. All volumes can be accessed from <https://www.britishlichensociety.org.uk/content/lgbi3>

The references are given on this webpage in a consistent style.

Example: Brackel (2008) *Sauteria* **15**: 103-120

In this case:

- “Brackel” is either the only author of the article or the first-mentioned author.
- “2008” is the year that the article was published.
- “Sauteria” is the name of the scientific journal that the article appeared in.
- “15” is the volume of the journal which contained the article.
- “103-120” are the page numbers that the article appeared on in the journal.

Journal articles available in the scientific literature can often be sourced by using Google Scholar. This search engine highlights free pdf versions of papers by listing them on the right-hand side of the results page.

Many of the articles are available (sometimes in a less-well laid out format) through a scientific community called Researchgate. Membership of Researchgate is free and is not restricted to formally trained or employed scientists.

How to find an article on Researchgate

Join Researchgate. Follow the instructions at <https://www.researchgate.net/>

Use Google Scholar to find the full details of the paper you require.

Search for any one of the authors.

On the author’s home page, scroll down to ‘Research’ and click on ‘Research items’. These appear in chronological order, newest first.

Scroll down to find the paper you require and click on ‘Full-text available’, ‘Download’ or ‘Request full-text’.

Some additional information

Using Scientific names

Scientific names are given in italics in typeface or are underlined when written by hand. The scientific name of a living organism usually has two parts: the name of the genus that the organism belongs to followed by a name that is unique to the species. Thus, *Taeniolella punctata* belongs to the genus *Taeniolella*. Its unique name is *Taeniolella punctata*. All organisms (in this case fungi) that have a name beginning with *Taeniolella* are closely related and will share many characters. The two parts of a scientific name should not be split onto different lines of text.

When taxonomists write about living organisms, they often shorten the genus name of an organism to a single letter followed by a full stop. This should always (and only) be done for the last organism referred to that has a genus beginning with the used letter. The practice should be avoided if two or more organisms are being discussed that come from different genera with the same starting letter. The shortened form is also used when multiple species from a single genus are being discussed.

For example:

Xanthoria parietina is a yellow foliose lichen with broad lobes. The apothecia of *X. parietina* have a yellow margin and a slightly more orange disc.

Erythricium aurantiacum occurs on *Physcia adscendens*, *P. aipolia*, *P. caesia*, *P. leptalea*, *P. tenella* and *Xanthoria parietina*.

Xanthoriicola physciae is a lichenicolous fungus that grows on *Xanthoria parietina*. *X. physciae* causes a black soot-like growth on the host's apothecia. INCORRECT because the *X.* here would be taken to refer to *Xanthoria*.

Xanthoriicola physciae is a lichenicolous fungus that grows on *Xanthoria parietina*. The discs of *X. parietina* become covered in a black soot-like layer of fungal spores. CORRECT but BAD PRACTICE since two different genera beginning with *X.* are being discussed.

Sensu stricto and sensu lato

Sensu stricto is Latin for 'in the narrow sense'. It can be shortened to sens. str. or s.s.

Sensu lato is Latin for 'in the broad sense'. It can be shortened to sens. lat. or s.l.

These terms are used to indicate the degree of certainty with which a name has been applied. The measure of certainty here is connected to the science behind the taxonomy rather than to the level of certainty/uncertainty felt by the identifier.

For example:

The lichen *Hypotrachyna revoluta* is now known to be two species: *H. revoluta* and *H. afrorevoluta*. Old records, where no effort would have been made to separate these, are given the name *H. revoluta* sens. lat. to indicate a broad-brush identification while new records, that fit only the description of *H. revoluta*, are given the name *H. revoluta* sens. str.

The name *Didymocyrtis epiphyscia* has been applied to a lichenicolous fungus that grows on *Physcia aipolia*, *P. adscendens*, *P. tenella* and *X. parietina*. Its description has been formally updated by Ertz (2015) *Fungal Diversity* **74**: 53-89 who believe that this species only occurs on *P. aipolia*. They have observed that spores previously assigned to this name on the other three hosts are consistently more narrow. However, work using DNA does not support an argument for two different species. At the moment, *Didymocyrtis epiphyscia* sens. str. is used to describe the fungus on *P. aipolia* and *D. epiphyscia* sens. lat. is used to describe the fungus on the other hosts.

Anamorphs and teleomorphs

Some anamorph forms of fungi were originally given different names to their teleomorph forms. This was necessary before the use of DNA characteristics, as it was often impossible to know that the two forms were the same fungus. When both anamorph and teleomorph forms of a fungus are known, one name usually 'takes priority' and is used for both forms. The BLS Taxon Dictionary (see <https://www.britishlichensociety.org.uk/resources/lichen-taxon-database>) can be used to find the presently preferred name. Any name typed into the search box will return a database row that includes the 'Current Taxon Name' once the Apply button is pressed. Other recently used names for the fungus will be given in the 'Synonyms' column. Synonyms are names that refer to the same fungus. Whenever records are made, the Current Taxon Name should be used if possible.

Insect frass

Many lichenicolous fungi occur as 'black dots'. These are usually reproductive structures such as pycnidia, apothecia and perithecia. Insect frass is often mistaken for these 'black dots'. Under a low power microscope, insect frass can often be seen to be a cylindrical shape. When mounted on a slide it usually starts to disintegrate into the liquid used for making the slide. The small particles released have no regular shape, form or colour.

Google translate and papers written in languages other than English

Google Translate is available as both a website and also as a phone app. The phone app is particularly useful for reading papers written in languages other than English. It can scan a page and offer a translation extremely quickly. It lacks knowledge of the specialist terminology for lichens and fungi but, when combined with some imagination, can lead to some accurate and useful information.