Fungi of Temperate Europe

VOLUME 1

Thomas Læssøe
Jens H. Petersen

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Preface

"I am lost – I cannot fathom nature anymore . . ." exclaimed one of the authors to the other after having experienced parts of a forest completely devoid of fungal fruitbodies bordering other parts with thousands. The longer you are in the game, the more you realize how little you understand. We have now been engaged in mycology and fungal identification for more than 40 years and a synthesis of our combined experience would seem desirable. It would have been easier if mycological knowledge had stabilized and many of the problems had been settled. Instead, we experience a period with constant change and much confusion. Our ignorance still appears to be monumental.…

We have both worked on the dissemination of mycology for our entire mycological careers: from teaching evening classes, through courses organized by, *e.g.,* the Danish Mycological Society, to courses at university level in Denmark and abroad. At all levels we have felt that well-written and well-illustrated teaching material was lacking and we have, to our best ability, tried to provide such over the years. We have published basic fungal identification guides, advanced mycological textbooks, coffee table books, fungal keys and manuals. At the end of the nineties we realized that we had to go one step further.

Advanced fungal identification is often hampered by the difficulties of finding the right genus, so we initiated the MycoKey project: digital keys to fungal genera. Digital keys can be constructed as synoptic keys, whereby the user only enters characters that are absolutely certain. The computer analyzes these data and displays matching genera. When carefully constructed, such keys can be very accurate and highly useful. Unfortunately, however, a major part of the mycological community still preferred books, with their relative easy overview, to digital flexibility. So, again, we had to rethink.

An ambitious 5-volume publication dealing with all the Danish fruitbody-forming *Basidiomycota* was planned by Jan Vesterholt, Jacob Heilmann-Clausen, Thomas Læssøe and Jens H. Petersen in connection with the ´Atlas of Danish fungi´ (2009–13). However, partly due to the premature death of Jan Vesterholt in 2011, this plan was abandoned. As a result, the large image library, collated in part for that publication, was archived. In 2014, Axel Kielland (Gyldendal Publishing) approached Jens hoping he would revise Jan Vesterholt's out of print book *Danmarks Svampe* (The Fungi of Denmark). This hefty book, which covers 1,000 species, stands as a very important and lasting contribution to Danish mycology and Jens felt it would be wrong to rewrite it. Instead, Jens came up with the idea of publishing a completely new work that had a larger geographical coverage. The concept was to base the layout and communication ideas on MycoKey. Some of the graphics had been tested at a small scale in other books by Jens and collaborators, but the idea was to present and key out more or less the whole fungal kingdom as a series of so-called 'fungal wheels'. Thomas agreed to join the project and the result is this two-volume publication with more than 80 fungal wheels, about 2,800 species accounts and almost 10,000 illustrations and photographs.

The fungal kingdom is, at present, being 'split' at an unprecedented rate, largely as a result of molecular studies. Indeed, even while this publication was on its way to the printer it is likely that new genera will have been introduced. Many species are being split based solely on molecular characters and can no longer be identified using standard keys. Nevertheless, we hope that the concept applied in this publication will help the enthusiast to better understand the complexities and not feel completely at a loss when faced with an unfamiliar fungus.

Thomas Læssøe and Jens H. Petersen

Acknowledgements

First and foremost, we owe our gratitude to the many photographers that have allowed us to use their images. Pia Boisen Hansen/Jan Vesterholt (†) and Jens Maarbjerg have given us free access to their extensive archives. Many other mycologists with large image archives have allowed us to use images without any compensation other than the credits given under each image. We are honoured and grateful to be able to present their splendid pictures. Especially generous contributions were made by Enrique Rubio Domínguez, Jean-Marc Moingeon, Lucie Zíbarová, Michal Mikšík, Thomas Stjernegaard Jeppesen and Thomas Kehlet. Without these contributions, the result would have been a much less visually appealing publication. Credits are given under each image and a list of all contributing photographers is given on page 1714.

Our colleagues from the Danish fungal atlas, Jacob Heilmann-Clausen, Tobias Frøslev and Jan Vesterholt are thanked for allowing us to use their atlas texts for individual species written during the atlas project period (2009–2013) as templates for this work. In return, all the edited texts are now available within the online atlas project.

The illustrations of fungal structures, notably the microscopical ones, were drawn by Jens H. Petersen using the following main sources as templates: *Funga Nordica* (agarics and boletes), Ryvarden & Gilbertson (polypores), Eriksson *et al.* (corticioids), Hans-Otto Baral (inoperculate discomycetes), www.ascofrance.com (various other groups of *Ascomycota*), and various specialized papers and photographs from the internet.

We owe a huge thanks to Kirsten Bjørnsson and Mogens Holm for proof reading the Danish text and to Andy and Gill Swash for copy editing the English version.

Finally, we want to thank 15. Juni Fonden for financing work with the Danish text.

From the top Jan Vesterholt, Jens Maarbjerg, important source books, a plate from Hans Otto Baral's online archive and a photo-troll by Rolf Lidberg dedicated to Jens H. Petersen.

Scope and design

In this two-volume publication we have attempted to give a broad and deep overview of the fungi in the temperate zone of Europe. More than 2,850 fungal species from about 1,000 genera are depicted with approximately 10,000 illustrations (photographs of fruitbodies and other structures and drawings of microscopical characters). More than 1,500 additional species are discussed as potential look alikes. These figures may seem high but it is important to realize that the real fungal diversity in temperate Europe is probably in the range 15,000–20,000 species (see the discussion under the fungal kingdom p. 10). This publication is therefore nowhere near complete in terms of species coverage, and for accurate identification it may be necessary to use more specialized literature or perform DNA-sequencing of difficult material.

We have defined temperate Europe as extending from northern Norway down to the Alps, northern France and northern Spain (see the map, p. 20). We have not covered the fungi from arctic-alpine habitats that occur in parts of Scandinavia and in the Alps or Pyrenees. Towards the east we cover the Baltic states and Poland, but only in part the steppe regions of Hungary and Ukraine.

The fungi covered in this publication have been organized according to fungal phyla. The major groups are the fruitbody-forming *Basidiomycota* (spores on basidia) and *Ascomycota* (spores in asci), p. 12, 24. and 42. At the end of Volume 2, fungi without fruitbodies (p. 1622, 1626) and non-fungal groups traditionally studied by mycologists are outlined (p. 1646).

Most importantly, however, we have divided the fungi into manageable 'form groups' (see p. 42), *e.g.* gilled fungi, polypores, corticioids, pyrenomycetous fungi. Within the gilled fungi we have attempted to cover almost all the genera known from temperate Europe, while in some ascomycote groups only examples of characteristic, spectacular species are given (see more on coverage in the box below).

Individual species are treated with a short description of the most important characters, including spore measurements and ecological details, a section covering confusion species and, at the end, a section summarizing distribution and frequency within temperate Europe. Species mentioned in the discussion are marked with arrows or page references indicating where they are treated

Examples of the coverage in various groups

Agarics (gilled fungi)
Temperate Europe > 2,500; FTE 1,285 species.
Nearly all genera so far described are included. For many small genera the coverage is 100%, but for large genera, such as *Cortinarius* with 125 species included, the coverage is about 20%.

Boletes
Temperate Europe > 100; FTE 74 species. Nearly all genera are covered and species coverage is high.

Polypores
Temperate Europe > 400, FTE 192 species.
Most genera are covered and species coverage is fairly high.

Clavarioid fungi
Temperate Europe > 200; FTE 104 species.
Almost all genera are covered and species coverage for small genera is high, but rather poor in, *e.g.,* the large genus *Ramaria*.

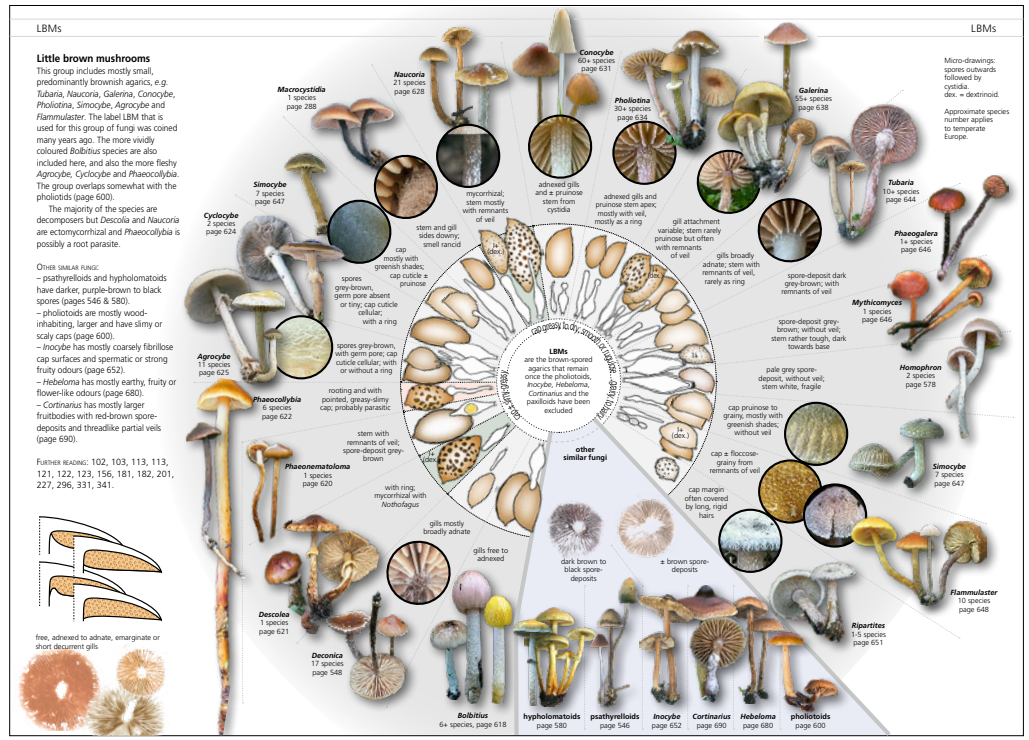
Corticioid fungi and jelly fungi
Temperate Europe > 800; FTE 217 species.
All very common and easily recognizable genera and species are included. Species coverage is moderate.

Operculate cup-fungi
Temperate Europe > 650; FTE 136 species.
The majority of the genera are covered, but species coverage is rather poor.

Inoperculate cup-fungi
Temperate Europe > 1,000; FTE 257 species.
Very common or spectacular genera and species are included. Species coverage is rather poor.

Pyrenomycetous fungi (true and false flask fungi)
Temperate Europe > 1,000; FTE 209 species.
A selection of common and spectacular species are included; coverage is poor.

Rusts, smuts, lichens, powdery mildews, *Laboulbeniales*, asexual fungi (hyphomycetes, coelomycetes) and slime moulds (Mycetozoa)
These groups are only covered by examples and identification of such fungi from this publication should not be attempted.



An example of a fungal wheel, one of the key features of this publication. The outer part of the wheel shows cut-out images of fruitbodies and enlarged details or tiny fruitbodies in inset circles. The inner part shows spores at approximately the same scale relative to each other. Green and red backgrounds indicate whether the groups are mutualists (mycorrhizals or lichens) or parasites.

or with a ⋉, indicating that they are not included elsewhere in the publication. Recommended edibles have a specific symbol attached, as do highly poisonous fungi (see box below).

We have not included detailed descriptions of the morphology of each species, partly because such descriptions are hard to follow and take up considerable space, and partly because images convey the message better than words. This has allowed room for more pictures showing the details that we consider to be diagnostic.

All the chapters in the systematic part of this publication start with one or more identification wheel introducing the group in question. Contrary to dichotomous, analytical keys, these wheels are not very rigid but should, by means of pictures and small texts, point the user in the right direction. We recommend starting at the bottom left of the wheel and working clockwise. The user can, depending on individual inclination, follow the pictures, or try to follow the internal logic of the wheel. This will hopefully provide a good lead that will make an identification possible when turning to the relevant species page. Several leads may have to be followed before an identification is confirmed.

The individual species accounts are presented in approximately the same order as in the wheels, and the page headings can be used as a guide to the contents of the page spreads.

In the process of writing and designing this publication, Jens H. Petersen has constructed the wheels, designed the entire work, photographed and processed the majority of the images and written some of the texts. Thomas Læssøe has written the majority of the texts and provided some of the images.

Edibility symbols – only important edible and seriously/deadly poisonous species are marked.

- ● acceptable edible after proper cooking
- ●● high quality edible after proper cooking
- †? presumed seriously poisonous
- † seriously poisonous
- †† deadly poisonous

References to presentation of the species

- △ = found above on the same page
- ▽ = found below on the same page
- ◁ & ▷ = found on opposite page
- ◁◁ = earlier in the chapter
- ▷▷ = later in the chapter
- ⋉ = not treated further

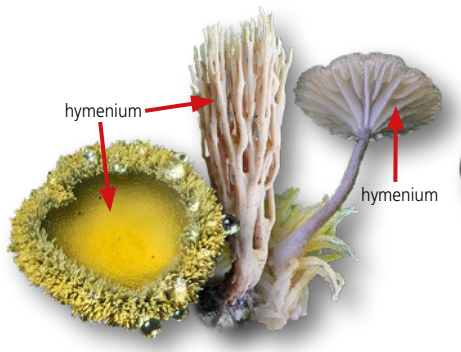
Form groups and fungal wheels

The fungi that are included in the two volumes of this publication have been organized into groups of morphologically similar fungi, which we have called 'form groups'. With some experience, these groups can be recognized with the naked eye or with a hand lens. It is important to remember that form groups do not necessarily reflect natural relationships, since morphology only reflects such relationships to a certain degree. For example, fungi with polypore morphology have evolved multiple times and, as a result, many of the taxa concerned are not closely related – even though they may look similar. The section on polypores in this book therefore covers all the species with polypore morphology, regardless of their current classification.

There is one major exception to this general rule. We have divided the fungi, irrespective of their macroscopic appearance, into the two major phylogenetic groups: the *Basidiomycota* and the *Ascomycota*. At the end of Volume 2, we have also included sections on asexual fungi, and organisms that belong in other kingdoms but resemble true fungi, *e.g.* the slime moulds.

The fungal wheels are the key feature of this publication. We have adopted a highly pragmatic approach when preparing these wheels, so that, for example, even if you find yourself looking at the wheel that covers cyphelloids (*Basidiomycota*) (p. 1076), you will find cross-references to similar discoid fungi in the *Ascomycota* (p. 1372). For this reason, prior knowledge of fungal systematics is not a prerequisite.

The wheels on this and the following page spread are organized based on how the sexual spores are produced. In order



Fruitbodies with external spore production on an exposed hymenium, see also page 31.

corticioids
page 960

rosette fungi and the like
page 952

clavarioids
page 1092

cyphelloids
page 1076

Dacrymycetales
page 1154

jelly fungi
page1162

hydnoids
page1054

tongue-shaped or with flattened branches; smooth under/upperside

clavate or coralloid

with hanging, tiny discs or tubes

± rubbery; basidia like tuning-forks; spores often septate

rusts and smuts
page 1198

flat or effused-reflexed; smooth, warty, wrinkled or spiny

often gelatinous; spores repeating

parasitize plants

basidiomycotes

stem and spines

basidia one-celled, 'normal'

without fruitbodies

with deviating basidia

fruitbodies (when present) **with external spore production** and active spore (meiospore) release

ascomycotes

discoid to clavate apothecia; asci with lids

operculate discomycetes
page 1278

tubes firmly attached

polypores
page 824

with tubes that can be loosened from the flesh

discoid, slit-like to clavate apothecia; asci without lids

inoperculate discomycetes
page 1348

boletes
page 760

with gills

fruitbodies with internal spore production, with or without active spore release

without fruitbodies

thalli with enclosed algae and/or cyanobacteria

without fruitbodies

asci on living host tissue; on leaves and fruits

funnel-shaped, hymenophore smooth or veined

asexual

agarics
page 56

chanterelles
page 46

see next page spread

asexual fungi
page 1626

lichens
page 1484

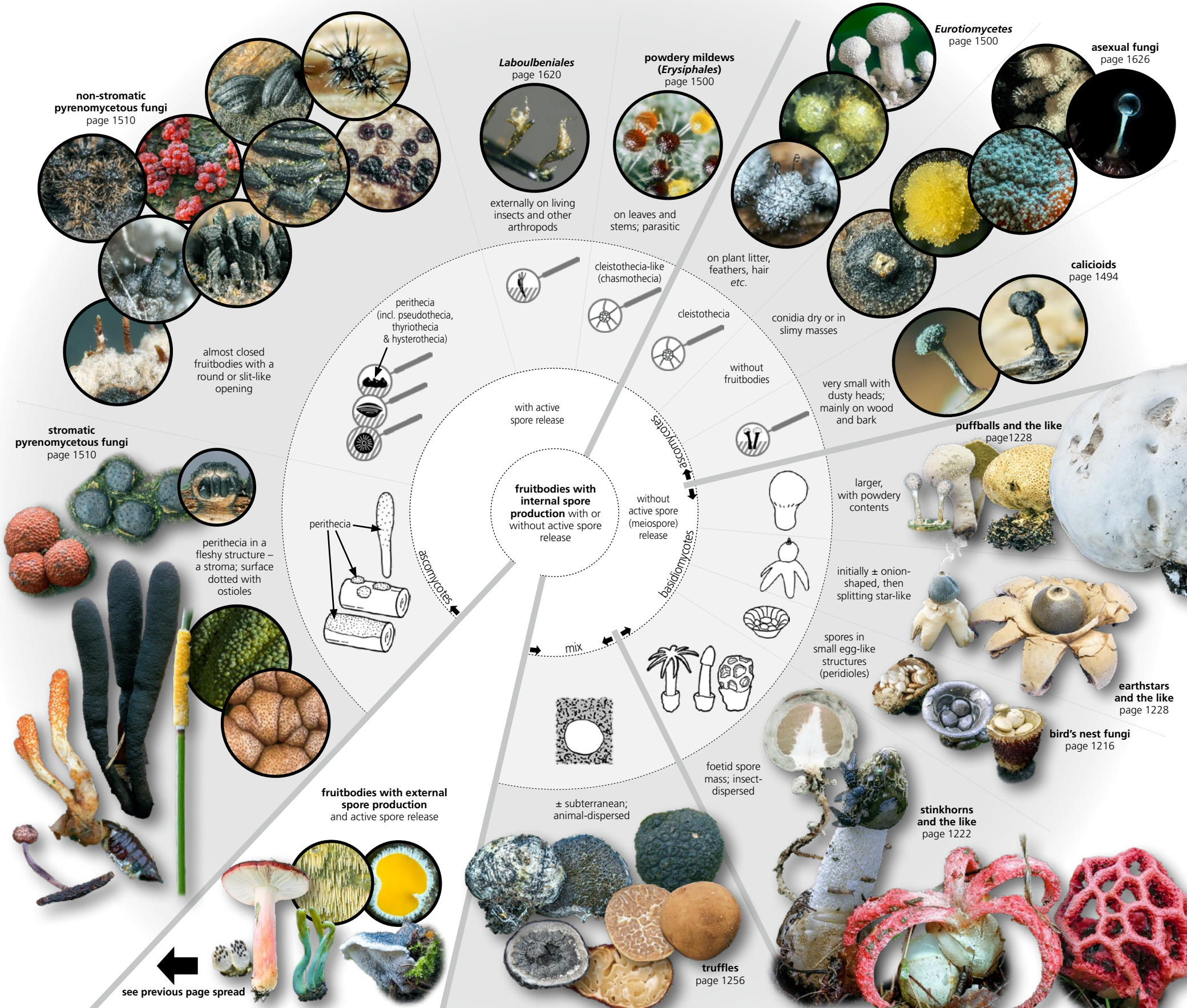
Taphrina
page 1622

to decide which wheel to use, you will first have to determine whether your chosen fungus produces spores from an external hymenium (see p. 31 and the illustration p. 42 bottom left). The hymenium consists of a palisade of basidia or asci, and typically forms a smooth surface on the fruitbody. Fruitbodies with internal spore production do not display such a surface. Instead, you may find small openings (ostioles), through which the spores can be ejected. Form groups with external production and active dispersal of the sexual spores (meiospores) from hymenia are found on the previous page spread, and groups with internal spore production are covered on this page spread.

On this page spread, the groups with spores that are actively released are shown at the upper/left side; the groups with fruitbodies that have passive spore dispersal, or have a powdery or slimy inner spore mass, are represented in the lower/right side of the wheel. For passive spore dispersal to take place an external force is often required, *e.g.* rain drops or animal activity.

The wheels here and throughout this publication can be used in various ways. By checking the images in the outer 'rim', a quick overview can be obtained of the variation in the fungal groups covered. Images in the pale blue sections (see, *e.g.,* the wheel on page 46) represent fungi that in some way recall species from the form group covered by the wheel, and which are treated in other wheels in this publication; the relevant page number is given for ease of cross-referencing. The inner part of the wheel shows other features that could be considered, particularly microscopic characters such as spore morphology (see, *e.g.,* the wheel on page 60 and 176).

We recognize that the wheel approach to fungal identification will never reach the same level of accuracy as a traditional analytical key. The distinguishing features of some fungi are not always clear-cut, and several wheels and species accounts may need to be consulted in order to reach a satisfactory conclusion. However, we hope that the approach taken in this publication will be easier to use than trying to follow the often highly technical keys found in other identification guides.



Hygrocyboids

The hygrocyboid agarics (waxcaps and others) are recognized by their thick, wax-like and mostly rather distant gills, and many species have very vivid colours. Microscopically, most hygrocyboids have unusually long and slender basidia, typically 6–9 times as long as wide. The spore-deposits are whitish and the spores smooth and inamyloid; as a general rule cystidia are lacking.

Most hygrocyboids are thought to be biotrophic, with a poorly understood symbiosis with herbs. Using DNA-analysis techniques, living hyphae have been detected inside tissues and seeds of *Plantago*. Species of *Hygrophorus* are also proven to be biotrotrophic, but they form ectomycorrhiza with a number of woody partners. One species (*Hygrophorus exiguus* ⋉) appears to be associated with *Tricholoma* mycorrhiza.

Most hygrocyboid agarics have very demanding habitat requirements. They are particularly sensitive to fertilizers and many favour habitats with a long continuity. The hygrocyboids share the same habitats and have similar preferences to a number of clavarioids, entolomatoids and earthtongues; they are all good indicators of sites of special nature conservation value.

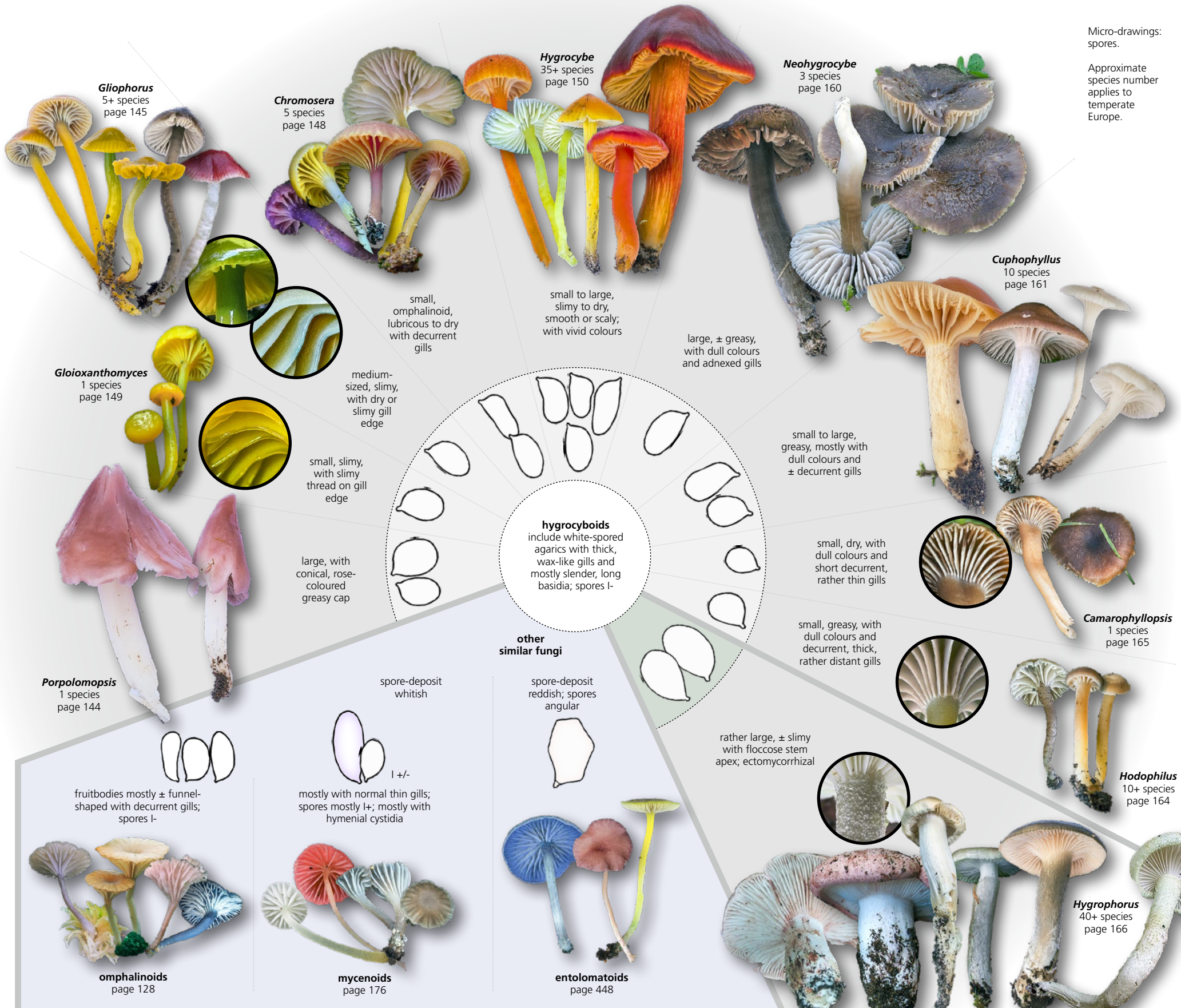
In most of Europe the typical habitat for hygrocyboids, except *Hygrophorus* and *Hodophilus*, is old, unfertilized grassland – a habitat that has declined dramatically over the past 50 years. In other parts of the world, the hygrocyboid agarics are predominantly to be found in forests with long continuity. Species of *Hodophilus* tend to prefer thorny thickets on clay soils.

Other similar fungi:
– omphalinoids may also have thick, fleshy gills; many are parasites on mosses or are lichenized, but some are saprotrophs (page 128).
– mycenoids generally have 'typical' gills and most have cystidia and amyloid spores. They are all believed to be saprotrophs (page 176).
– entolomatoids may be colourful, but have angular, pinkish spores (page 448).

Litteratur: 1, 2, 3, 43, 57, 156, 172, 178, 183.

Micro-drawings: spores.

Approximate species number applies to temperate Europe.



Jacob Heilmann-Clausen

Porpolomopsis calyptriformis is a large, acutely conical, rose-coloured, ± dry waxcap with a whitish or somewhat rose stem and a radially split margin. The fruitbodies are very fragile and do not blacken, but the colours may wash out with age. The smooth spores measure 6–9 × 4–7 µm. Occurs in older, mostly clay-rich or calcareous grasslands, including old churchyards.

Distinctive and unlikely to be misidentified, since the combination of colour and shape is unique. It can be found in a rare, pure white form. *Gliophorus reginae* ▷▷ may have similar colours, but is slimy on both cap and stem.

A rather rare and local species that tends to be more common in the Atlantic areas, especially in the British Isles; mainly August–November.

The hygrocyboid fungi in the genus ***Gliophorus*** are slimy on both cap and stem and some are very brightly coloured. One is even slimy on the gill edge. They may have strange smells.

Gliophorus laetus is a medium-sized waxcap with somewhat dull colours, decurrent, pale greyish gills with a slimy edge, and a strange smell like burnt rubber. The stem apex is mostly greyish-violet or olive and below is brass-yellow. The smooth spores measure (5–)6–7 (–8.5) × (3.5–)4–4.5(–5) µm. It is also found in an almost pure yellow form. Occurs in unfertilized grasslands, mostly on somewhat acidic soils, or on heathlands.

This species is also known as *Hygrocybe laeta*. *Gloioxanthomyces vitellinus* ▷▷ also has a slime-thread on the gill edge, but is ± odourless, smaller and bright yellow. *Gliophorus psittacinus* ▷▷ does not have decurrent gills, and likewise no slime-thread on the gill edge; it is mostly greener.

A rather common and widespread species; mainly August–November.

Gliophorus irrigatus is a medium-sized, very slimy, grey to grey-brown, rarely almost white, waxcap with pale, somewhat decurrent gills. It does not have a distinctive smell, and the gill edge is not slimy. The spores measure (5–)6.5–8(–9) x (3.5–)4.5–5(–6) µm. Occurs in unfertilized grasslands, mostly with other hygrocyboids, clavarioids and earthtongues, and occasionally also in forests.

Distinctive and unlikely to be misidentified.

A widespread, rather common species; mainly July–November.

Thomas Læssøe

Gliophorus psittacinus is a spectacular, very slimy, variegated green-yellow waxcap with ± emarginate gills without a slimy edge, and without a distinct smell. The colours are very variable, often in response to exposure – specimens shielded from the sun are mostly a deep bottle-green and those exposed are more yellowish. Yellow versions can change back to green when kept in the shade. The smooth spores measure 7–9.5 × 5–6 µm. Occurs in unfertilized grasslands and in moist forests on clay-rich soils with scattered mosses.

Gliophorus perplexa ▷is similar, but has brownish-red colours, and *G. reginae* ▷ has almost brownish-violet colours. *Gliophorus laetus* ◁◁ has a slimy gill edge, decurrent gills and a strong, rubbery smell.

A widespread and rather common species; mainly June–January.

Jan Vesterholt

Gliophorus perplexus is a brownish-red version of *G. psittacinus* completely without green colours, but with similar gill attachment and thick slime layers on cap and stem. The spores measure 7–9.5 × 5–6 µm. In unfertilized grasslands with long continuity, *e.g.* in old deer parks and other old grasslands.

Gliophorus reginae ▽ has more reddish-violet colours. *Gliophorus laetus* ◁◁ has distinctly decurrent gills with a slimy edge.

Widespread but rather rare; mainly May– November.

Gliophorus reginae is a reddish-violet to greyish-purple, medium-sized, slimy waxcap with emarginate gills and a pale stem. The gills are greyish without a slimy edge. The spores measure 7–9.5 × 5–6 µm. Occurs in unfertilized grasslands with other hygrocyboids, clavarioids *etc*.

Gliophorus perplexus △ is more brownish-red on the cap and stem.

Described from the British Isles with a few additional records from continental Europe; mainly July–November.

David Boertmann

Boletes

The boletes is a group of fungi that form rather soft-fleshed fruitbodies that have tubes rather than gills below the cap and a sturdy central stem. The tubes are generally not joined firmly to each other, or to the cap flesh, from which the entire tube layer can easily be loosened. The spores form inside the tubes and are mostly brown. Many boletes change colour when bruised or sectioned. These colour changes, the colour of the pores (the visible part of the tubes) and the cap surface structure are very important characters.

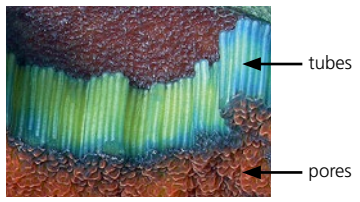
The boletes constitute a monophyletic entity and are classified in the order *Boletales*. The order also includes some false truffles (*e.g. Rhizopogon*), some corticioids (*e.g. Serpula*) and some species with gills (*e.g. Paxillus* and the gomphidioids).

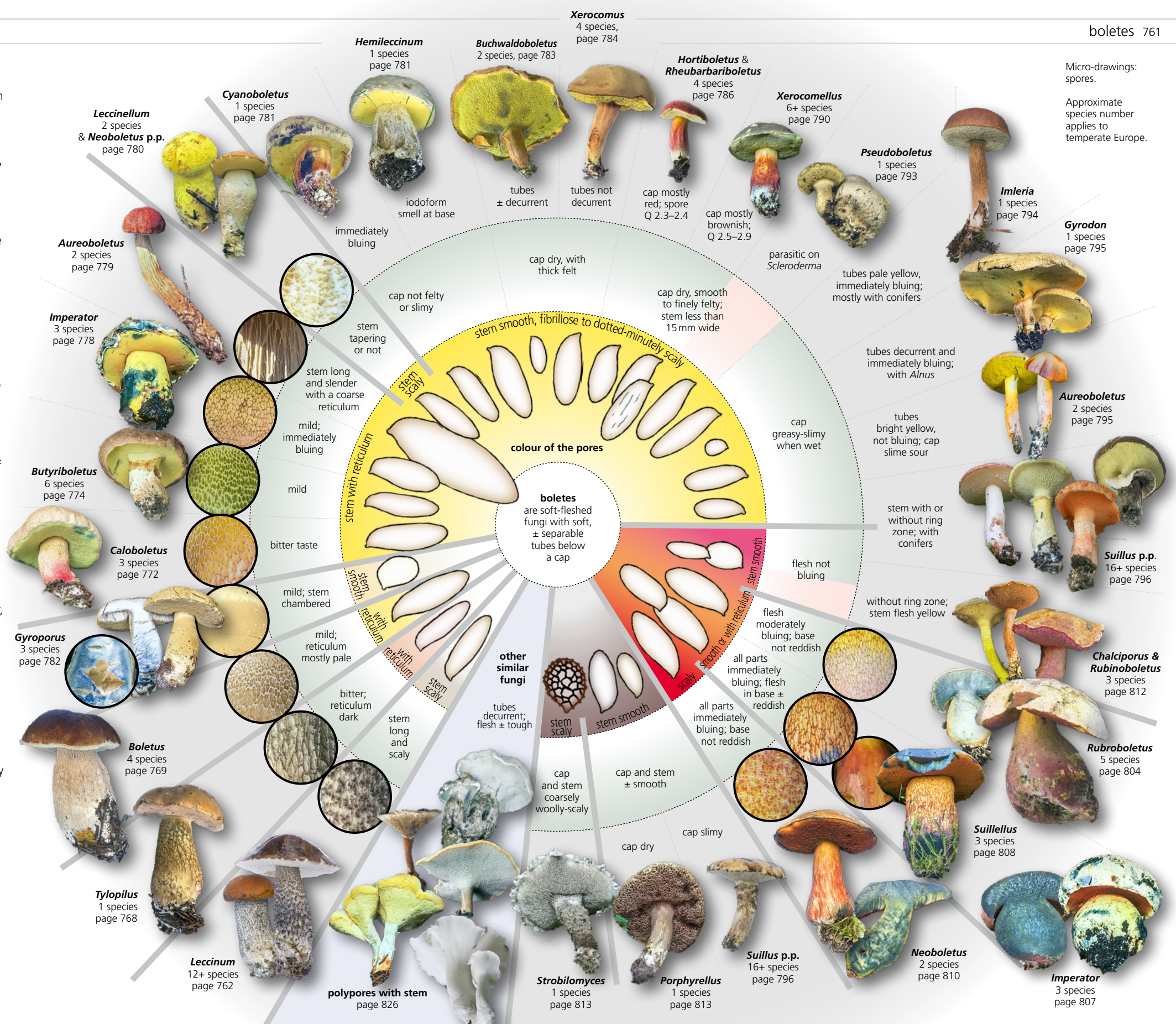
Almost all boletes are ectomycorrhizal with deciduous trees or conifers. The genus and sometimes the species of the host is important for identification, especially in the genera *Leccinum* and *Suillus*. A few species are parasitic: *Pseudoboletus* parasitize *Scleroderma*; *Buchwaldoboletus* is probably parasitic on *Phaeolus;* and *Chalciporus* perhaps parasitizes *Amanita muscaria*.

There are many choice edibles among the boletes, but also a few bitter, inedible species (*e.g. Tylopilus felleus*, *Caloboletus radicans* and *C. calopus*) and most species of *Rubroboletus* and *Imperator* are moderately poisonous.

Other similar fungi:
– polypores with a stem (*e.g. Albatrellus* and *Boletellus*) may look very similar. They have tubes that are firmly joined – both with each other and the flesh. They also often have decurrent tubes and tough flesh – see page 826.

Further reading: 71, 150, 156, 170, 194, 205, 228.





Michal Mikšík

Patrice Tanchaud

Patrice Tanchaud

† ***Rubroboletus rhodoxanthus*** is a large *Rubroboletus* with orange pores and a ± pale rose cap. The stem has an orange reticulum and yellowish flesh. Stains moderately blue in the cap flesh but not in the stem. The basal stem hyphae have amyloid walls. Spores 10–14 × 4–5.5 µm. With deciduous trees in warm forests and parks.

The stem flesh in *R. legaliae* ◁◁ stains entirely blue; *R. satanas* ◁◁ has a pale cap that lacks rose colours and a nauseous smell; *R. rubrosanguineus* ⋉ occurs with *Abies* and the stem stains entirely blue.

A rare southern species that reaches the Netherlands and south-eastern Sweden; late summer–autumn.

Rubroboletus dupainii is a medium-sized *Rubroboletus* with orange pores and a ± red, shiny cap. The stem has predominantly small, orange scales, but may also have a rather narrow zone with a fine reticulum at the top. The flesh stains moderately blue and a more monochrome pale blue towards the stem base. The spores measure 11–12 × 4.5–5.5 µm. Occurs with *Quercus* in warm habitats.

The stem scales recall the dots/scales on the stem surface of *Neoboletus luridiformis* ▷▷, but that species has a brown cap. The other *Rubroboletus* species all have a prominent reticulum on the stem and never have a shiny red cap surface.

A southern species, which only reaches as far north as southern Germany, rare; late summer–autumn.

Gianluigi Boerio/Jens H. Petersen

† ***Imperator rhodopurpureus*** is a large, extremely strongly blue-staining *Imperator* with a pale grey, yellow, vinaceous-brown to purple-flamed cap and varying yellow and orange colours on the stem surface and reticulum. The pores vary from reddish orange to pure yellow (see page 778). The spores measure 12–13.5 × 5–5.5 µm. Occurs with deciduous trees (mostly *Quercus* and *Fagus*) in warm habitats.

Fruitbodies with yellow pores may be confused with *I. torosus* ◁◁. *Suillellus* ▷▷ and *Neoboletus* ▷▷ stain blue almost as strongly but have ± brown caps. The southern *I. luteocupreus* ⋉ has distinctly yellow colours on the cap. *Neoboletus luridiformis* var. *junquilleus* ◁◁ may recall yellow forms of *I. rhodopurpureus*, but lacks a reticulate stem. *Cyanoboletus pulverulentus* ◁◁ also lacks a reticulum. Pale-capped species of *Rubroboletus* ◁ stain much less strongly.

A rare southern species that reaches as far north as southern nemoral Scandinavia; mainly July–October.

Jan Vesterholt

Suillellus is characterized by fleshy fruitbodies with fine orange to red pores, strong and fast blue staining on all parts, and wine-red flesh in the stem base. When old, dry or attacked by moulds, the blue reaction may be partly absent. Somewhat poisonous as raw.

●● ***Suillellus luridus*** is a rather large to large, strongly bluing bolete with a honey-yellow, cinnamon-brown to yellow-brown, dry cap, sometimes with purple-red 'flames', and orange-red or very rarely yellow pores on a red surface (in section a red line is seen above the tubes). The stem has an orange-red reticulum almost to the base. The flesh in the base reacts blue with iodine reagents. The spores measure 11–15 × 5.5–7 µm, Q 2.1–2.4. Occurs with deciduous trees on clay soils, mostly in open forests, parks, *etc.*

The slender *S. mendax* ▽ only has a reticulum on the upper part of the stem and has red spots below. It is mostly more carmine-red to purple-red on the cap, pores and stem and should have wider spores (Qav. 2.6–2.8). Species of *Rubroboletus* ◁◁ stain less strongly blue and have paler caps. Species of *Imperator* ◁◁ stain very blue, including on the cap surface, but mostly have yellower pores and paler caps.

Widespread and common, but ± absent from the boreal zone; May–October, peaking early in the season.

Michal Mikšík

●● ***Suillellus mendax*** is similar to a rather purple version of *S. luridus* △, and in section a red line can be seen above the tubes. The reticulum quickly turns into dots down the stem. The spores measure 12.5–15.5 × 4.5–5.5 µm, Qav. 2.6–2.8. Occurs with deciduous trees in warm habitats.

Almost inseparable from *S. luridus* that usually is more orange and has a more pronounced reticulum; it should also have narrower spores. *Suillellus comptus* ⋉ has a reticulum as in *S. mendax* and spores as in *S. luridus*, but usually lacks a red zone between the tubes and cap flesh – a southern species.

Distribution and frequency not clear but widespread; summer–autumn.

Thomas Læssøe

●● ***Suillellus queletii*** is a medium-sized, strongly bluing *Suillellus* with a cinnamon-brown, red-brown to brownish-orange, ± felty cap and apricot-orange to brownish-orange, rarely more yellow pores. When kept, the whole fruitbody may discolor wine-red. The stem is finely dotted and ± tapering towards the base. The flesh in the base is wine-red. The spores measure 10–14 × 5.5–7 µm, Q 1.9–2.3. Occurs with deciduous trees on mostly clay-rich soils in warm habitats.

Neoboletus xanthopus and *N. luridiformis* ▷▷ have similar, but more distinctly punctate stems, usually ± scarlet pores and do not normally have wine-red flesh at the stem base; they also have a higher Q value (2.7–3.3). Other, similar *Suillellus* species have ± reticulate stems. *Cyanoboletus pulverulentus* ◁◁ is strongly blue staining and smooth-stemmed, but has yellow pores and lacks wine-red flesh in the stem base.

Widespread and locally common, rare in the hemiboreal zone and absent from the boreal zone; June–October.

Jan Vesterholt/Jens H. Petersen

Perennial polypores

All polypores where the fruitbodies continue to produce new tube layers in successive years belong here. The growth periods can often be seen as raised concentric zones on the caps. The group includes most polypores with hard fruitbodies. In general, the fruitbodies have one growth period per year, but *Fomes fomentarius* has two growth periods: a strong one in the spring and a weaker one the autumn; this creates two zones of growth per year.

Some species are borderline perennial. For example, species of *Trametes*, *Cerrena* and *Antrodia* may, during a mild spring, continue to grow and thus produce two-layered fruitbodies. However, these fruitbodies typically rot away during the summer.

Most perennial polypores have a complicated hyphal system with both generative hyphae with septa, and branched binding hyphae and/or thick-walled skeletal hyphae without septa (page 35).

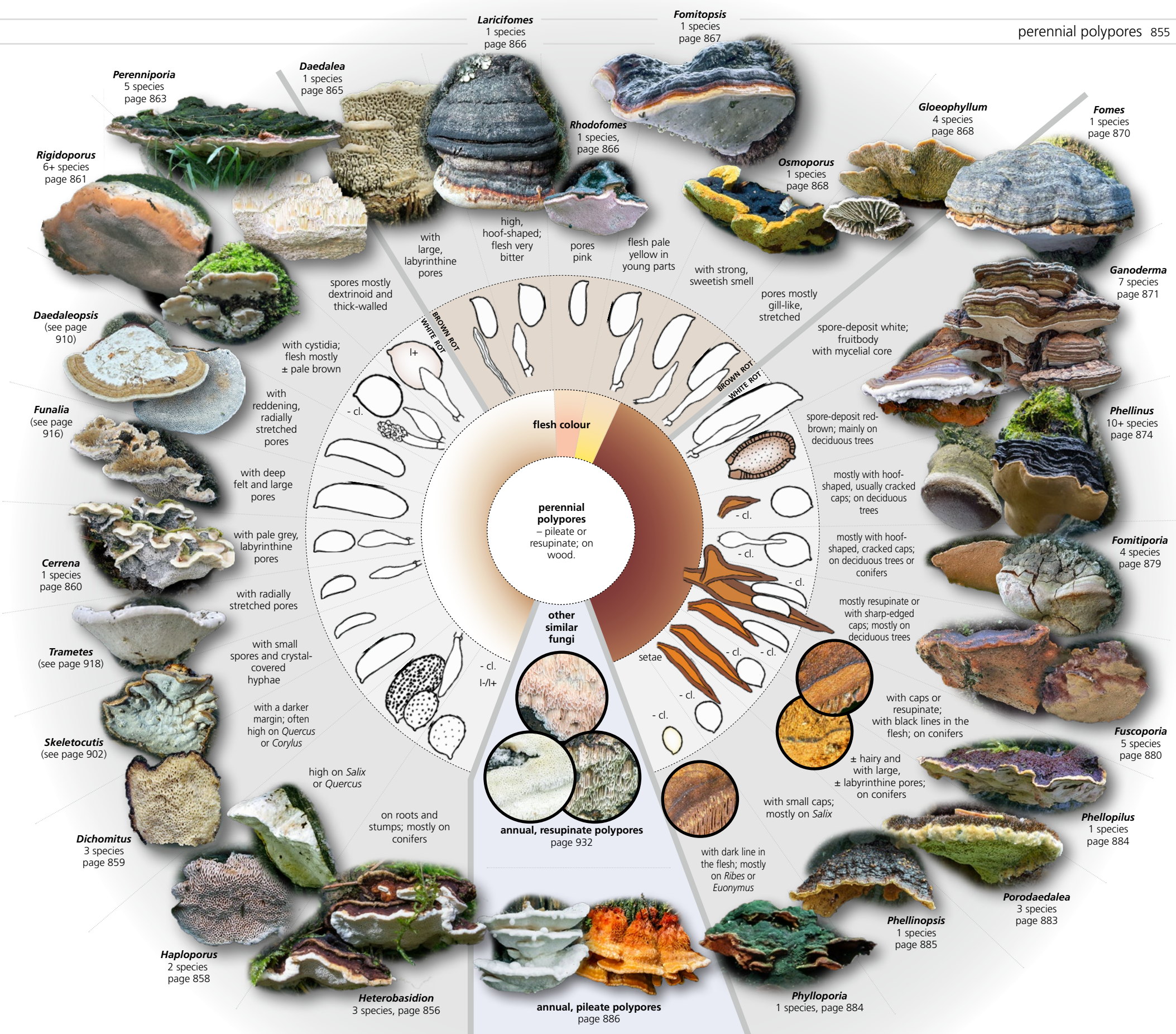
The species can be divided into white- and brown-rotters; although the two types may look surprisingly similar, they are not closely related.

Other similar fungi:
– similar but annual species of polypore are divided into two groups: those with caps (pileate) and those without (resupinate) (pages 886 & 932).

See also the overview and the references to further reading on page 824.

Micro-drawings: spores outwards, followed on the inside by cystidia and setae. cl. = clamps.

Approximate species number applies to temperate Europe.



Thomas Læssøe

Fomes fomentarius is a large, hoof-shaped, hard, grey to almost black, mostly distinctly zonate perennial polypore. The cap crust mostly has a reddish-brown zone close to the finely felty margin and it is not meltable with a flame. Pores rounded, pale grey, 4–5 per mm. The flesh is yellow-brown with an aberrant, marbled area (a mycelial core) where the fruitbody started (see arrow). Individual pore layers are mostly more than 6 mm thick. Spore-deposit white (middle image). The smooth spores measure 12–20 × 4–7 µm. A white-rotter. Found on a number of deciduous trees but *Fagus* and *Betula* are the dominant hosts; occurs both on standing dying trees and fallen trunks.

Fomitopsis pinicola ◁◁ has paler flesh and yellowish tinges on the pores, a strong smell and a meltable crust. *Ganoderma* ▷ has no mycelial core and a more obvious 'lacquered' crust that is usually powdered by brown spores. *Phellinus* ▷▷ typically has a cracking surface, narrower pore layers and much smaller spores.

Widespread and common in most of the area, although less so in southern UK; all year.

Ganoderma includes both, pale-fleshed annual polypores with ± stipitate fruitbodies (page 840) and broadly adnate, dark-fleshed perennial polypores. The double-walled, brown, ornamented spores are mostly easily detectable by rubbing a wet finger on the cap surface. White rotters.

Ganoderma pfeifferi is a rather large to very large, ± hoof-shaped, hard, mostly zonate perennial polypore with an apricot-orange, resinous, finely wrinkled-veined surface that cracks and can be melted with a flame. Has 5–6 pores per mm. During winter the tube layer is covered by a yellow wax (lower image). The odour is pleasantly sweetish. Spores are double-walled, cinnamon-brown (see below the upper fruitbody) and measure 9–12 × 6–9 µm. Occurs at the base of large living trees, mostly *Fagus*, or on stumps; rarely on smaller trees, *e.g. Prunus*.

No other dark-fleshed *Ganoderma* species has a meltable cap crust. *Fomitopsis pinicola* ◁◁ has a meltable cap crust, but pale flesh and white spores.

Widespread and occasional in the nemoral zones, very rare in the hemiboreal zone; all year.

Yellow, orange, red to pink operculate cup fungi

Fungi with cup- to goblet-shaped or flattened apothecia, yellow, orange, red or pinkish hymenium, and asci with a lid (an operculum) or, in the genus *Coprotus*, with a slit-like opening mechanism. All genera, apart from *Iodophanus* and *Peziza*, have inamyloid asci.

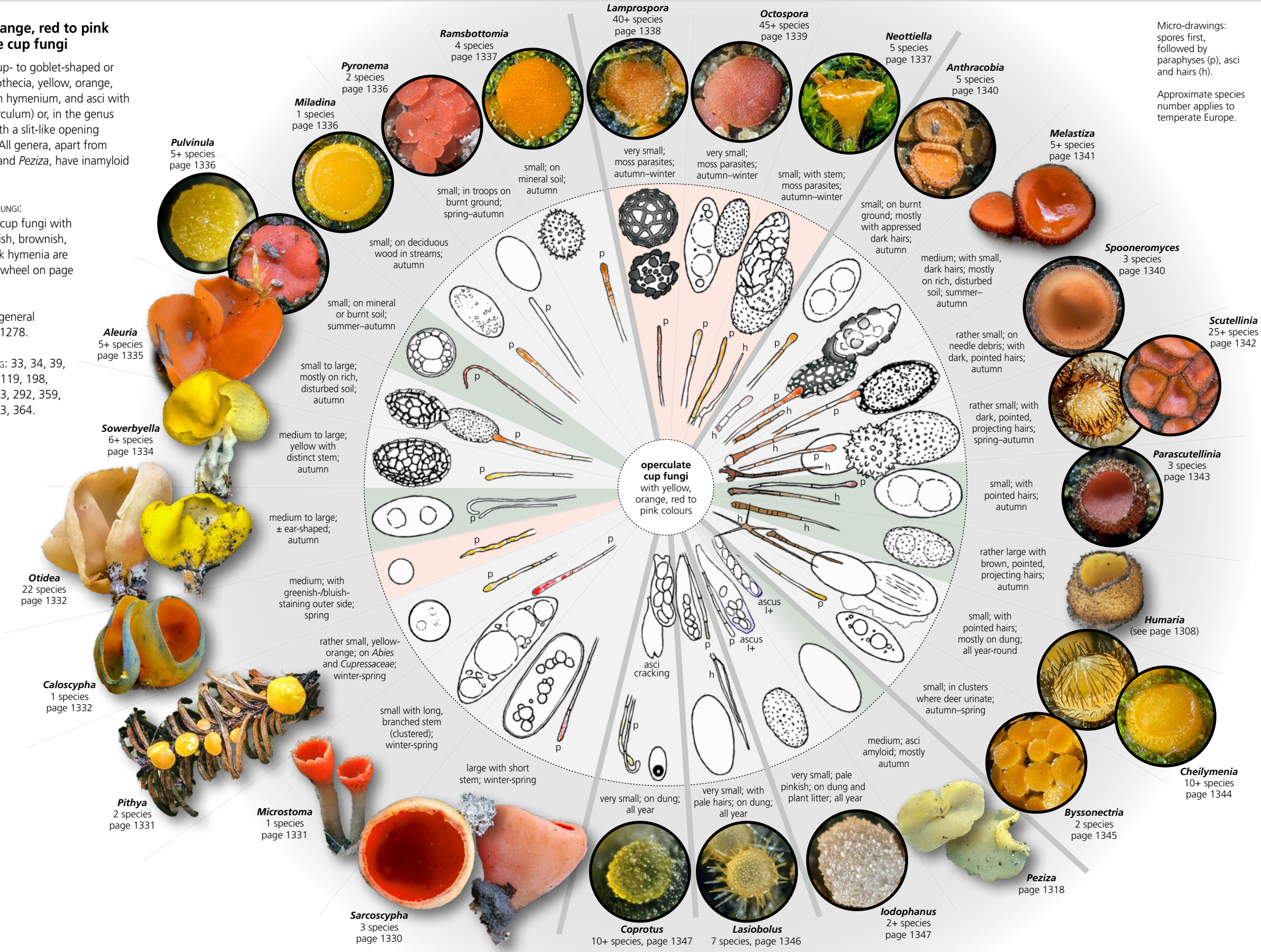
Other similar fungi:
– operculate cup fungi with whitish, greyish, brownish, violet or black hymenia are found in the wheel on page 1290.

See also the general wheel, page 1278.

Further reading: 33, 34, 39, 49, 73, 101, 119, 198, 199, 200, 233, 292, 359, 360, 361, 363, 364.

Micro-drawings: spores first, followed by paraphyses (p), asci and hairs (h).

Approximate species number applies to temperate Europe.



Morten Christensen

Thomas Læssøe

Sarcoscypha form large, bright scarlet or rarely orange fruitbodies with large, smooth, almost cylindrical spores in 8-spored, inamyloid asci. All fruit in winter–spring and are decomposers on wood.

Sarcoscypha austriaca is a large, cupulate, scarlet, tough-fleshed *Sarcoscypha* with a somewhat paler, dense felt on the outside; can also rarely occur in an orange form. The outside hairs are corkscrew-curled (microscope required). The living spores have many internal small drops, are concave at the ends and measure (22–)26–40(–50) × (11.5–)12–15 (–16) µm. Occurs on wood of deciduous trees (*e.g. Salix*), mostly on wood buried in ± moist soil in damp woodlands and scrub.

Sarcoscypha coccinea ▽ has ± straight hairs on the outer side. The living spores also have multiple drops but are rounded at the ends (may be slightly concave in dead spores); it prefers drier, highly calcareous habitats and the main host is *Fagus*. *Sarcoscypha jurana* ⋉ also has straight hairs but the spores have two drops and truncate or somewhat concave ends; it has a preference for *Tilia*.

Widespread in the nemoral–hemiboreal zones, occasional; (November–)January–April(–May).

Sarcoscypha coccinea is a scarlet, ± stemmed, tough *Sarcoscypha* with a paler, somewhat hairy outer side. The hairs are ± straight. The spores have many small drops, are typically rounded at the ends (may be slightly concave in dead spores) and measure (24.5–) 27–43(–51) × (10–)11–14 (–14.5) µm. Occurs on dry, calcareous soil, mostly on *Fagus* wood, but also on other hard woods.

Sarcoscypha austriaca △ has corkscrew-like hairs and *S. jurana* ⋉ has spores with two drops. Both have truncate or somewhat concave spore ends.

Widespread, nemoral, uncommon to locally common; (September–) February–April.

Microstoma protractum is a spectacular, long-stemmed, almost tulip-shaped, scarlet, operculate cup fungus with a dentate, somewhat hairy apothecial margin. Occurs mainly in clusters, with the upper parts joined to a common, deeply rooting stem. The spores are thick-walled and measure 40–45 × 15–20 µm. Occurs on ± buried sticks on rich soils in temporarily flooded riverbeds, *Alnus* carrs, *etc*.

A highly distinctive species that is easy to identify.

Found mainly in continental parts of Europe, absent from oceanic parts of the nemoral zones; spring.

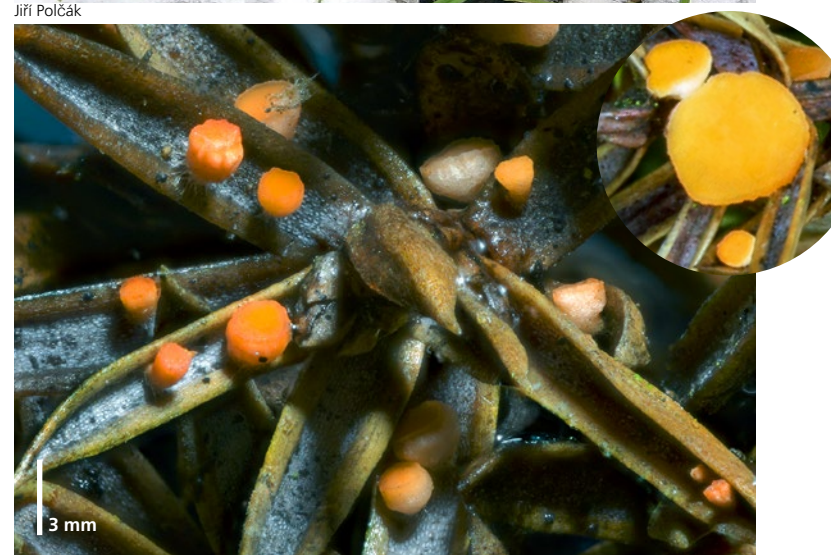
Jiří Polčák

Pithya form rather small, ± orange apothecia and the asci have spherical spores. Decomposers on conifers.

Pithya cupressina is a small, orange, ± sessile, operculate cup fungus with a smooth margin and a ± downy, paler outer side. The spherical, double-walled, smooth spores measure 10–11 µm. On attached, dead twigs of mostly introduced *Juniperus* species in gardens, but also on *J. communis* and other members of the *Cupressaceae*.

Pithya vulgaris ▽ has larger apothecia, larger spores and occurs mainly on *Abies*.

Mainly nemoral–hemiboreal, occasional; mostly October–May.



Pithya vulgaris is rather small, yellow-orange, disc-shaped, tough-fleshed operculate cup fungus with a smooth margin. The outside is paler and minutely hairy at the base. The asci are inamyloid and 8-spored. The paraphyses have yellow contents. The spherical, smooth, double-walled spores measure (11–)13–14(–15) µm; outer wall dissolves in KOH. Occurs mostly on recently dead *Abies* branches (sometimes also attached), rarely on other conifers.

Pithya cupressina △ has smaller apothecia, smaller spores and occurs mainly on *Juniperus*.

Mostly nemoral, common to rare; December–May.

Hypocrealean pyreno-mycetous fungi and others

A form group of fungi with small, mostly globose to flask-shaped perithecia (page 30). The perithecia are typically relatively soft (leathery) and often brightly coloured or whitish; they may be free, sit on a soft, often brightly coloured stroma or immersed in a stroma (page 30). The dots on the surface of the stromata represent the ostioles (perithecial openings). The spores are typically hyaline, or nearly so, and vary from multicelled, thread-like (some split into part-spores) to one-celled; 2-celled spores are common and may split into two at maturity.

Many species are parasitic on plants, animals or fungi. Species of *Hypomyces* may replace parts of the living fruitbodies of larger fungi with perithecia. *Cordyceps* and *Ophiocordyceps* are predatory fungi that kill insects and spiders, later producing stromata from the carcasses. *Epichloë* and *Claviceps* live as endophytes in grasses and other monocots; they are well known due to their toxic alkaloids (ergotism is caused by *Claviceps*).

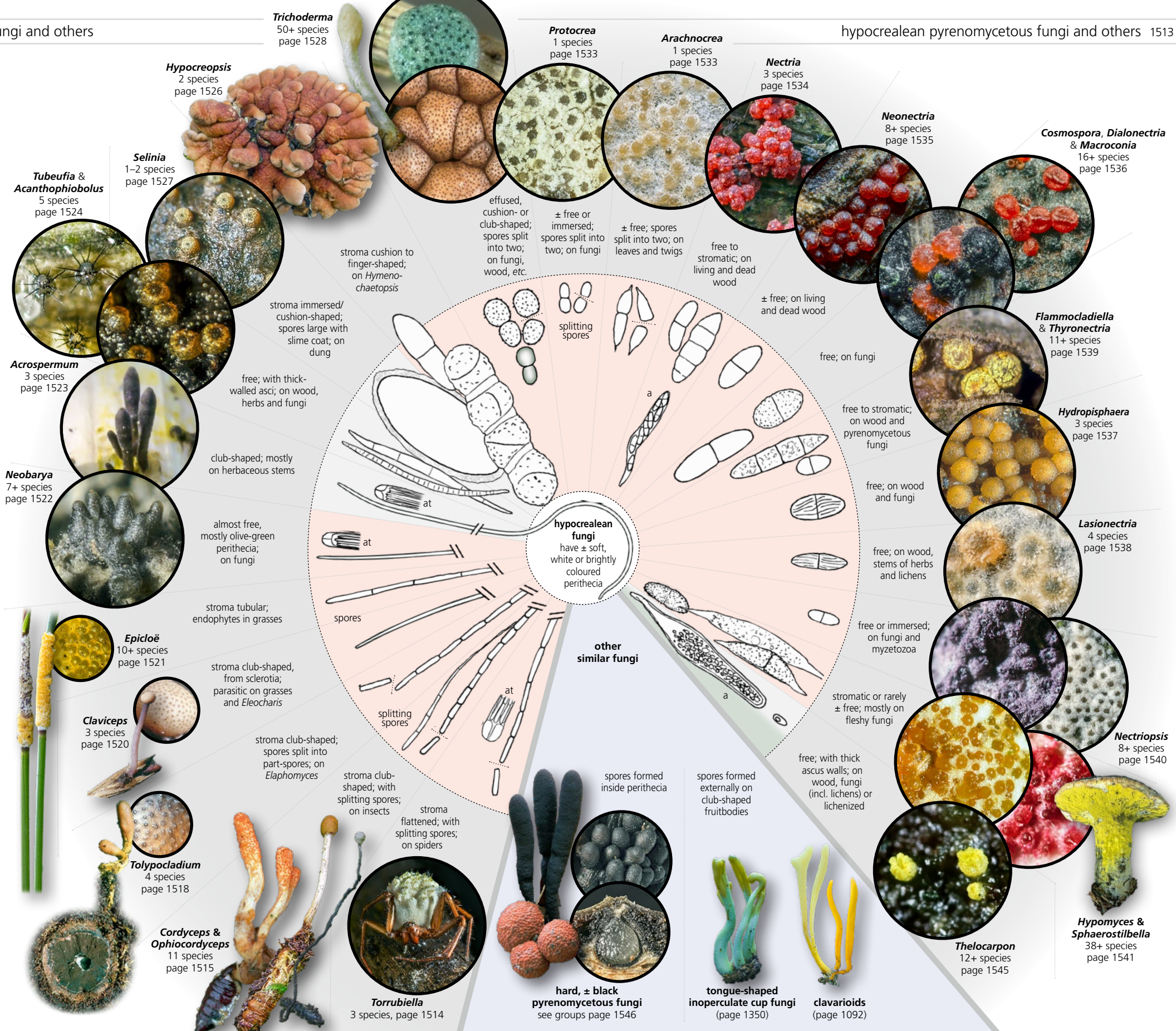
Other similar fungi:
– hard, ± black pyrenomycetous fungi are more carbonous (page 1546).
– clavarioid basidiomycotes and tongue-shaped inoperculate cup fungi, have external hymenia, and thus no dots from immersed perithecia (pages 1092 & 1350).

See also the general wheel, page 1510.

Further reading: 48, 55, 60, 96, 106, 107, 128, 129, 131, 132, 175, 248, 274, 275, 278, 279, 280, 284, 302, 311.

Micro-drawings: spores first, followed on the inside by asci (a) and ascus tops (at).

Approximate species number applies to temperate Europe.



Torrubiella albolanata has white, almost chimney-like stromata on top of the host's body. The pale yellow perithecia are ± immersed, and all are positioned vertically. The conical ostioles are clearly visible on top of the fluffy stroma. The asci measure up to 340 × 5.5 µm and have a cap-like, pierced, refractive top. The thread-like spores are ± twisted within the asci and split into part-spores that measure 8.4–9.8 × 1.4–1.5 µm. Occurs on tiny spiders (possibly exclusively members of *Linyphiidae*) in swampy habitats with tall grass vegetation, *e.g.* reedbeds.

Torrubiella aranicida ⋉ occurs on somewhat larger spiders and the perithecia are more scattered. The most commonly encountered fungi on dead spiders belong to the asexual genus *Gibellula*, particularly *G. pulchra* (page 1630); these hyphomycetes are closely related to *Torrubiella*.

Mainly nemoral, rarely reported, but probably overlooked; mostly June–October.

Cordyceps and ***Ophiocordyceps*** form club-shaped stromata from insects that they have killed and devoured. The spores are ± thread-like and split into part-spores after having been released. Both genera have asexual states with morphologies corresponding to the asexual genera *Lecanicillium* ⋉, *Hirsutella* ⋉, *Isaria* (page 1631), *Paraisaria* ⋉ and *Septofusidium* ⋉.

Cordyceps militaris is an apricot-orange to reddish-orange, club-shaped *Cordyceps* with reddish-orange immersed perithecia that have conical ostioles at the surface. Several stromata may emerge from the same cadaver. The asci are cylindrical, measure about 300 × 3–6 µm, and have a cap-like, pierced, refractive top. The thread-like spores split into part-spores that measure 4.5–5(–7) × 1.5 µm. The asexual state is a hyphomycete with *Lecanicillium* characters. Occurs on pupae and larvae of moths, both in forests and in open habitats, *e.g.* non-fertilized grasslands.

Distinctive and unlikely to be misidentified. *Cordyceps bifusispora* ▽ is yellower, and *C. memorabilis* ⋉ appears from beetle larvae cadavers.

Widespread and rather common, becoming scarcer towards the north; mainly July–December.

Cordyceps bifusispora is a sulphur-yellow to lemon-yellow, simple or forked *Cordyceps* with semi-immersed perithecia that have projecting conical ostioles on the upper part and a rather prominent, pale, sterile lower part. The asci are cylindrical, about 200–220 × 3–11.5 µm. Spores thread-like, with fusiform, swollen ends (bola-shaped): main part about 145–220 µm, end parts 3-septate and measure about 30 × 1.6 µm. The asexual state has *Septofusidium* characters. Occurs on moth pupae/larvae in *Alnus* carrs, *etc.*

A distinctive species, both macro- and microscopically.

Widespread, very rare, but possibly somewhat overlooked; mainly August–October.

Erik Arnfred Thomsen/Jens H. Petersen

Fungi of Temperate Europe is one of the most comprehensive mycological guides ever published. Featuring more than 7,000 photographs, this lavish two-volume set treats more than 2,800 species of fungi across the region.

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Thomas Læssøe is a mycologist and senior researcher at the Natural History Museum of Denmark. He has previously been a senior scientific officer at the Royal Botanic Gardens, Kew and associate professor at the University of Copenhagen. He is the author of several guide books.

Jens H. Petersen is a mycologist, graphic designer and photographer. He taught mycology at Aarhus University for more than 20 years and is the author of _The Kingdom of Fungi_ (Princeton). Petersen and Læssøe created the online identification tool MycoKey (www.mycokey.com).

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