

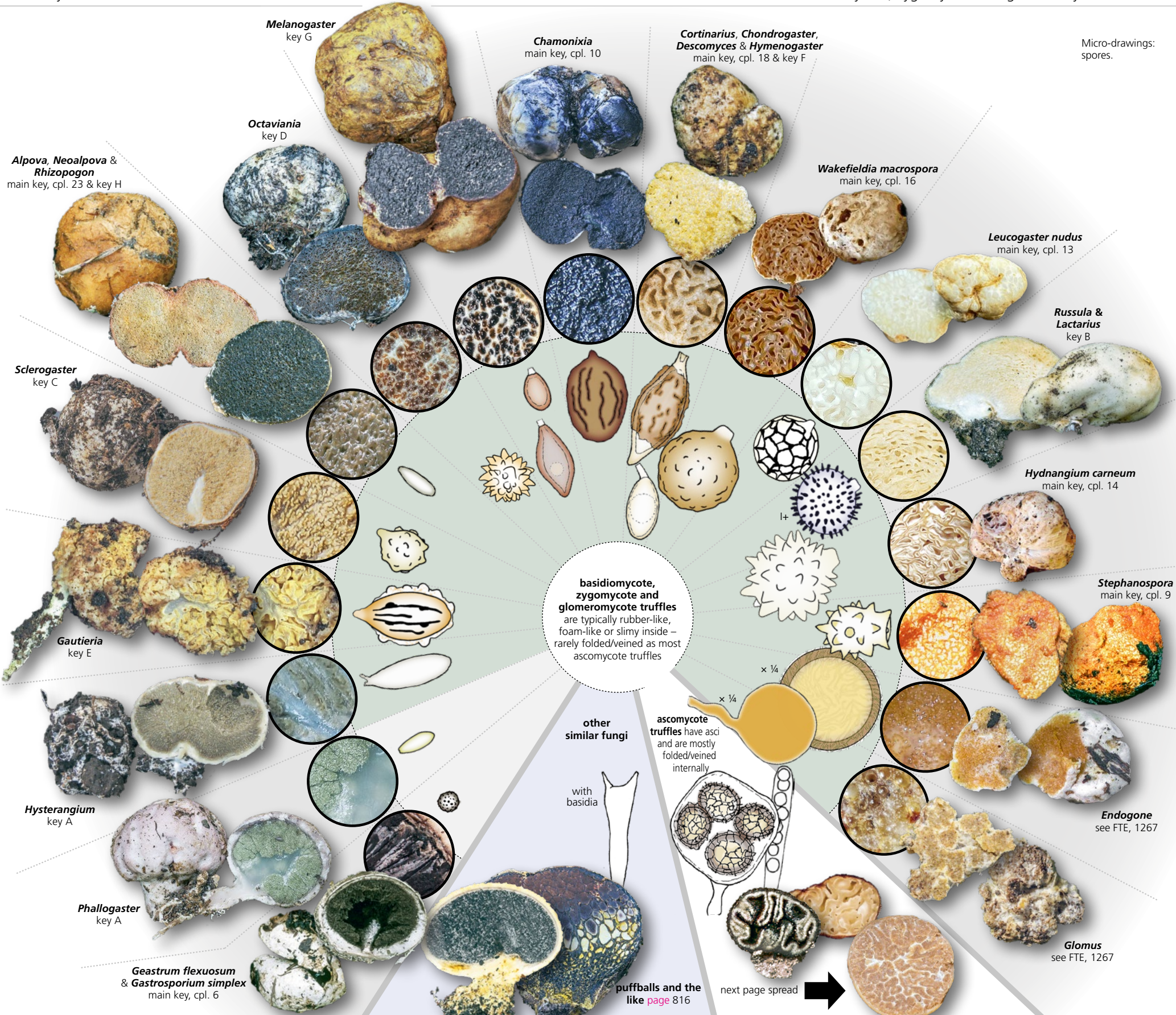
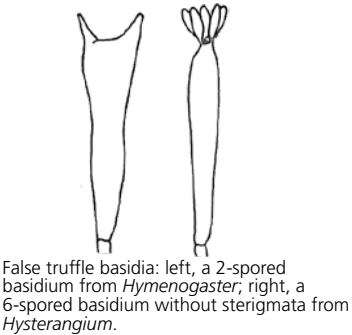
Truffles

Truffles constitute a form group where the tuber-like fruitbodies are formed ± underground (hypogaeus) and spore dispersal is passive via digging animals. This strategy has arisen multiple times during the evolution of the fungal kingdom, both amongst the *Ascomycota*, *Basidiomycota* and *Zygomycota* and within the *Glomales* (A-mycorrhiza-forming fungi), where truffle-like asexual structures can be found. The fungal wheels shown here have the basidiomycote and other non-ascomycote truffles on the first page spread and the ascomycotes (the “true truffles”) on the second.

Almost all truffles are ectomycorhizal. They are dispersed by animals, and various mammals are attracted by their often pungent odours. Boar, deer, mice, and other mammals dig up the fruitbodies to feed on them. Some rodents hoard truffles. Spores from some of the species tolerate passage through the gut.

The odours vary from species to species, and some may resemble mammal pheromones. It is probably compounds of the latter nature that make true truffles an exclusive ingredient in fine cuisine.

The spores are formed internally and the mechanism for active release has been lost. Within the basidiomycote truffles this means that the sterigmata on the basidia and the apiculus on the spores are absent or have changed, and that the spores are typically more symmetrical than in basidiomycotes with active dispersal. Within the ascomycotes the cylindrical ascus has typically evolved into a ± balloon-like shape, but in some species the cylindrical shape has been maintained. The ascospores tend to be extremely large (20–50 µm long).





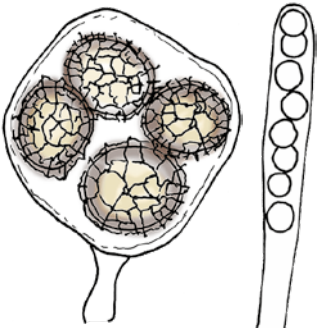
How to find truffles (truffling)

Some truffles may form fruitbodies at soil level with the top clearly visible; this is often the case with, for example, species of *Rhizopogon* and *Choiromyces*. However, as the majority form fruitbodies completely immersed in litter or rotten wood, or in soil down to 10–15 cm, sometimes deeper, they have to be dug out, e.g. with a small hand rake. Successful truffling requires a certain “feel” for the ecology of the species. One simple prerequisite is the presence of suitable ectomycorrhizal partners, mainly trees and shrubs, e.g. *Corylus*, *Tilia*, *Fagus*, *Quercus* or ectomycorrhizal conifers. Relatively light mull soils can often be rewarding to rake through, mainly in places with a warm microclimate. Rake the surface and keep an eye out for any tuberous object (alas, many will be fungal primordia, pebbles, old nuts, etc.). Some truffles form potato-sized fruitbodies, but many are small, down to the size of a pea. If you think you have found a truffle, cut it through with a sharp blade and check the internal structure with a hand lens; if veined or spongy you are in luck.

A shortcut can be taken by looking out for animal scrapes, e.g. from deer or squirrels – or, even better, train a dog!

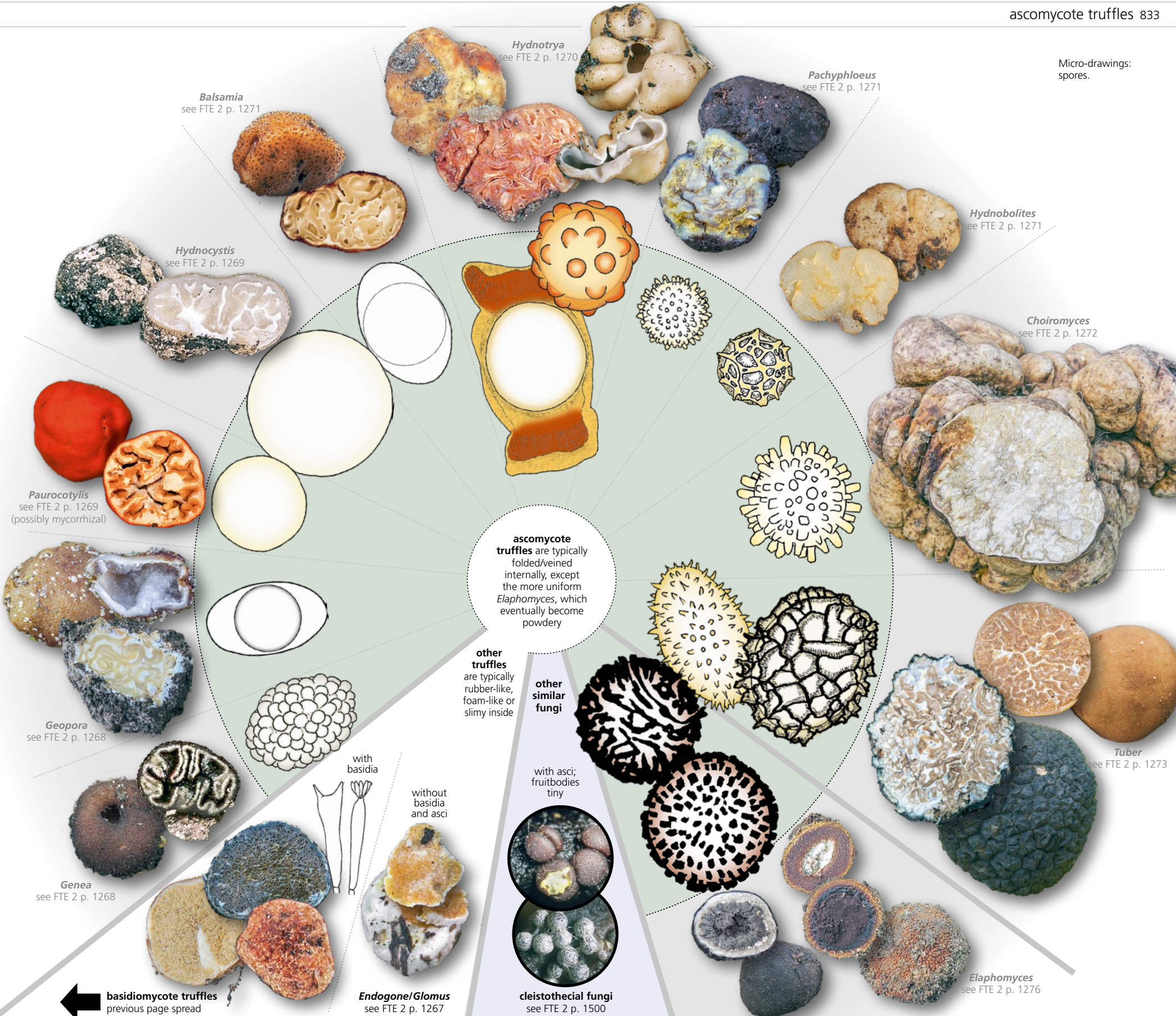
OTHER SIMILAR FUNGI:

- witch’s eggs may look similar but mature above ground (page 814).
- puffballs and the like typically become dusty at maturity and normally mature above ground (page 816).
- cleistothelial fungi produce tiny fruitbodies with tiny asci (see FTE 2 page 1500).



Types of truffle asci: left, a balloon-shaped type from *Tuber aestivum*; right, a cylindrical ascus from *Hydnocystis*.

basidiomycote truffles  
previous page spread



Micro-drawings:  
spores.

ascomycote  
truffles are typically  
folded/veined  
internally, except  
the more uniform  
*Elaphomyces*, which  
eventually become  
powdery

other  
truffles  
are typically  
rubber-like,  
foam-like or  
slimy inside

other  
similar  
fungi

with asci;  
fruitbodies  
tiny

cleistothelial fungi  
see FTE 2 p. 1500

with  
basidia

without  
basidia  
and asci

Endogone/Glomus  
see FTE 2 p. 1267

Elaphomyces  
see FTE 2 p. 1276

Tuber  
see FTE 2 p. 1273

Choiromyces  
see FTE 2 p. 1272

Hydnobolites  
see FTE 2 p. 1271

Pachyphloeus  
see FTE 2 p. 1271

Hydnotrya  
see FTE 2 p. 1270

Balsamia  
see FTE 2 p. 1271

Hydnocystis  
see FTE 2 p. 1269

Paurocotylis  
see FTE 2 p. 1269  
(possibly mycorrhizal)

Geopora  
see FTE 2 p. 1268

Genea  
see FTE 2 p. 1268



Key to groups of basidiomycote truffles

Spore measurements are without ornament.

1. Spores globose and more than 42 µm wide (sometimes with stringlike appendages) ..... *Endogone* and *Glomus* – see FTE 2 p. 1267  
Spores different ..... 2
2. Spores formed in asci; fruitbody typically strongly internally folded ..... ascomycote truffles – see p. 1268
- Spores formed on basidia or spore formation unknown; fruitbody interior usually more uniform, e.g. foam-rubber-like ..... 3
3. Spore mass (gleba) powdery at maturity ..... 4  
Spore mass not powdery at maturity ..... 7
4. Spores globose and more than 15 µm wide, with a dark ornament ..... *Elaphomyces* – see FTE 2 p. 1276  
Spores different ..... 5
5. Spores more than 9 µm wide, with a spiny or netlike ornament ..... see *Scleroderma*, p. 819  
Spores smaller, warty ..... 6
6. In warm, calcareous scrub and forests; fruitbodies with a thick peridium; with many thin, white hyphal cords. Spores globose, dark greyish brown, 4–6 µm, densely warty; rare (Sweden) ..... *Gastrum flexuosum*  
In dry, steppe-like vegetation; fruitbodies with a pale outer peridium and a greyish inner; with a thick, white hyphal cord. Spores subglobose to drop-shaped, pinkish buff, finely warty (3.5–) 4–5 µm; rare (S, reaching S Sweden) ..... *Gastrosporium simplex*
7. Cut fruitbodies resemble a cut witch's egg in colour and texture; base with hyphal cords; spores smooth and hyaline under the microscope ..... *Hysterangium* and *Phallogaster*, key A  
Not like a witch's egg-like when cut; with or without white hyphal cords; spores different ..... 8
8. Fruitbodies orange or bluish (orange blue), sometimes only when bruised ..... 9  
Fruitbodies whitish, pinkish, yellowish or brown, but sometimes reddening (pink red) when bruised ..... 11
9. Both surface and spore mass orange; spores with triangular spines and a truncate end. Fruitbody 10–40 mm wide; spore mass ± chambered; spores 10–16 × 7.5–12 µm; in warm calcareous forests; rare (S, including UK) ..... *Stephanospora caroticolor*  
Surface blueing or reddening; spores different ..... 10
10. Surface deep blue when bruised and at maturity; spores brown, longitudinally wrinkled. Fruitbody 10–30 mm wide; spore mass labyrinthine-chambered, greyish brown with a short, white columella; spores 18–20 × 12–15 µm; in ± calcareous conifer forests, usually in rotten stumps; rare (N–NW) ..... *Chamonixia caespitosa*  
Surface moderately blueing or reddening; spores warty or with large spines, which can fuse to crests ..... *Octaviania*, key D
11. Spores with an amyloid, spiny ornament ..... *Russula* & *Lactarius*, key B  
Spore ornament not amyloid ..... 12
12. Spores globose to subglobose ..... 13  
Spores elongated ..... 17



13. Spores with a smooth, loosening outer layer, surrounding a net-ornamented inner layer. Fruitbody 10–30 mm wide, pinkish buff to clay-buff; spore mass solid, but chambered, whitish; smell caramel-like; spores 10–14 (–18) µm; with deciduous trees; rare, reaching Denmark from S ..... *Leucogaster nudus*  
Spores different ..... 14
14. Spores hyaline to buff-yellow. Fruitbody 10–25 mm wide, flesh pink; spore mass ± foam-rubber-like, flesh pink; spores 12–17.5 × 11.5–16.5 µm; with *Eucalyptus*, mostly in pots and greenhouses; rare (S–W) ..... *Hydnangium carneum*  
Spores ± yellowish brown ..... 15
15. Spores smaller than 8 µm in diameter; spore mass slightly gelatinous ..... *Sclerogaster*, key C  
Spores more than 10 µm in diameter; spore mass not gelatinous ..... 16
16. Surface unchanged or yellowing; spores with low, wide warts. Fruitbody 5–20 mm wide, whitish; spore mass foam-rubber-like, brownish; smell potato-like; spores 12–19 × 8–13 µm; with *Fagus* and *Quercus*; rare (S–SW, including UK) ..... *Wakefieldia macrospora*  
Surface rather quickly discoloured greenish, reddish, bluish to black; spores warty or with large spines, which can fuse to crests, dextrinoid ..... *Octaviania*, key D
17. Spores ornamented or with a loosening outer wall, which curls around the spore ..... 18  
Spores smooth ..... 20
18. Fruitbodies enclosed in a compact mat of roots and hyphae; with *Eucalyptus*. Fruitbody 8–25 mm wide, pale buff, reddish brown when bruised; spores brown, with irregular crests, 10–15 × 5–10 µm; rare (UK) ..... *Chondrogaster pachysporus*  
Fruitbodies different; not with *Eucalyptus* ..... 19
19. Spore mass somewhat cauliflower-like with rather large cavities and a stemlike centre (columella); surface usually folded-pitted like a tiny *Sparassis* ..... *Gautieria*, key E  
Spore mass uniform and foam-rubber-like; surface continuous and ± plane ..... *Cortinarius*, *Descomyces* and *Hymenogaster*, key F
20. Spores 18–22 µm long ..... *Hymenogaster*, key F  
Spores shorter than 18 µm ..... 21
21. Spores brown under the microscope; spore mass slimy ..... *Melanogaster*, key G  
Spores hyaline, yellow or greyish under the microscope; spore mass not distinctly slimy ..... 22
22. Spore mass spongy and porous, usually without large contrasts ..... *Rhizopogon*, key H  
Spore mass chambered, usually with pale chamber walls and dark contents ..... 23
23. Spores 8–15.5 × 4–4.5 µm. Fruitbody 15–60 mm wide, glabrous, surface cinnamon to reddish brown; spore mass gelatinous, blackish; spores hyaline to yellowish green, (9–) 10–13.5 (–14) × 4–5 µm, Q ca. 2.6; with *Fagus*; rare, but apparently widespread ..... *Neolpova rubescens*  
Spores 5–6.5 × 2–3 µm. Fruitbody 10–25 mm wide, glabrous to finely felty, yellow-brown to reddish brown, reddening, surface yellowish brown; spore mass gelatinous, yellowish brown to blackish; spores hyaline to yellowish, 5–6.5 × 2–3 µm, Q 2.1–2.5; with *Alnus*; rare (Sweden) ..... *Alpova larskersii*





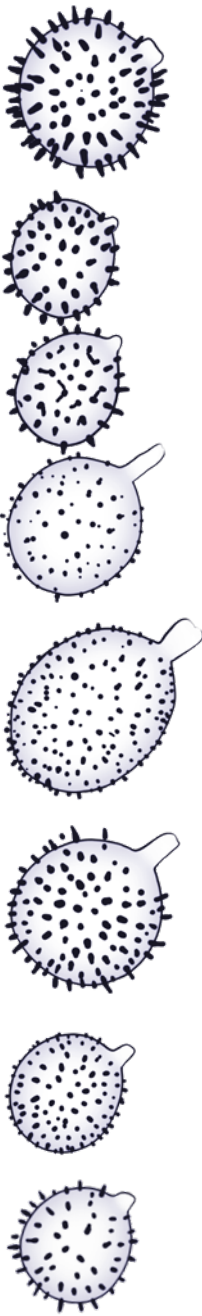
Key A – *Hysterangium* and *Phallogaster*

1. Spores ± globose and warty ..... see *Sclerogaster*, key C  
Spores ellipsoid to spindle-shaped, smooth, but sometimes with a loosening outer wall ..... 2
2. Spores 4–5.5 × 1.5–2.5 µm; fruitbody very witch’s-egg-like. Fruitbody up to 15 mm wide, pale; stem 10–20 mm high; spore mass gelatinous, greenish; on debris with much dead wood; rare (S) ... *Phallogaster saccatus*  
Spores larger; fruitbody less witch’s-egg-like ..... 3
3. Spore mass quickly ± cinnamon (■ ■ ■). Fruitbody 10–20 mm wide, whitish, later with brown spots; spore mass ± gelatinous; smell strong and acidic; spores (11.5–) 15–16.5 × 6–6.5 (–7.5) µm, almost hyaline under the microscope, with ± wrinkled outer wall; with *Fagus* in humus-rich soils; rare, but apparently widespread ..... *Hysterangium pompholyx*  
Spore mass olivaceous buff, glaucous green to brownish olive (■ ■ ■) ..... 4
4. Spores 9–12 µm long ..... 5  
Spores longer than (11–) 12 µm ..... 6
5. With *Eucalyptus*; spores with an outer wall that loosens crest-like; the outer layer of the fruitbody (peridium) exclusively of narrow hyphae. Fruitbody 10–25 mm wide, whitish, immediately clay-pink when touched, later brownish; spore mass ± gelatinous, glaucous green; smell radish- to melon-like; spores 9–12 × 3–4 µm; rare (S) ..... *Hysterangium inflatum*  
With deciduous and coniferous trees; spores with a wrinkled outer layer; the outer layer of the fruitbody with a layer of globose cells. Fruitbody 20–25 mm wide, initially whitish, but soon orange-brown; spore mass ± gelatinous, ± olivaceous buff; spores 9–12 × 4–6 µm; rare, but widespread ..... *Hysterangium coriaceum*
6. Outer layer of the fruitbody (peridium) exclusively of narrow hyphae. 7  
Outer layer with a layer of globose cells ..... 8
7. Fruitbody wrapped in a thick layer of thin, white hyphal cords; spores on average 12–15 µm long. Fruitbody 10–30 mm wide, whitish, later with brown spots; spore mass ± gelatinous, glaucous green; spores spindle-shaped and with a slightly wrinkled outer wall, 12–15 × 5–7 µm; in calcareous soil with deciduous trees; rare, but widespread ..... *Hysterangium calcareum*  
Fruitbody with a thick basal hyphal cord and with rather few surface cords; spores on average 16–20 µm long. Fruitbody 5–15 mm wide, whitish, later with brown spots; spore mass ± gelatinous, dark olivaceous buff; spores spindle-shaped with a uneven outer wall, 15–22 × 5–7 µm; in mixed forest; rare, but widespread ..... *Hysterangium clathroides* ss. auct.
8. Spores up to 16 µm long. Fruitbody 20–25 mm wide, initially whitish, but soon orange-brown; with a thick hyphal cord; spore mass ± gelatinous, glaucous green; smell fruity; spores ± spindle-shaped with distinctly longitudinally wrinkled outer wall, 11–16 × 3–5.5 (–7) µm; in mixed forests; rare, but widespread ..... *Hysterangium crassum*  
Spores longer than 16 µm ..... 9
9. Spores 17–26 × 5–7 µm. Fruitbody 10–30 mm wide, initially whitish, later ± orange-brown, with numerous white hyphal cords, including a thicker basal; spore mass ± gelatinous, olivaceous buff to brownish olive; spores spindle-shaped; with deciduous trees; rare, but widespread ..... *Hysterangium stoloniferum*  
Spores 16–17 × 4.5–6.5 µm. Fruitbody 10–20 mm wide, whitish; spore mass ± gelatinous, glaucous green; spores spindle-shaped, outer wall wrinkled; in deciduous forests, rare, but widespread ..... *Hysterangium nephriticum*<sup>1</sup>

1. *Hysterangium thwaitesii* should have a hyphal, hyaline lower layer in the peridium and a rather smooth outer wall on the spores, while *Hysterangium nephriticum* should have a lower layer of more globose, brown cells and a more wrinkled outer spore wall.

Key B – *Lactarius* and *Russula*

1. With a stem or a remnant of one (a columella) internal in the fruitbody ..... 2  
Without any traces of a stem ..... 4
2. With a well-developed stem and curled remnants of gills; spores on average wider than 11 µm. Fruitbody 12–38 mm wide, brownish orange with browner spots; spore mass labyrinthine, buff-yellow; smell absent; taste mild; spores (9–) 10.5–15.5 (–18) × (8–) 10–15 (–17) µm, Q 1–1.15, with up to 2.5 (–3) µm long, isolated spines; with *Abies* and *Picea*; rare (S) ..... *Russula mattirolana*  
Only with inner traces of a stem; spores on average narrower than 11 µm ..... 3
3. Spores with entirely isolated spines, 8–11 (–12.5) × 7–9 (–11) µm. Fruitbody 5–35 mm wide, cream; spore mass buff-yellow, foam-rubber-like; spore Q 1.1–1.3, with up to 1.5 µm high spines; in nutrient-rich deciduous forests and parks; rare, but widespread ..... *Russula candida*  
Spores with somewhat connected spines, 9.5–12.5 (–15) × (8–) 8.5–10.5 (–13) µm. Fruitbody 14–28 mm wide, cream; spore mass buff-yellow, foam-rubber-like; spore Q 1.1–1.3, with up to 2 µm high spines; with deciduous trees and *Abies*; rare (S) ..... *Russula candidissima*
4. With white milk. Fruitbody 10–30 mm wide, reddish; spore mass foam-rubber-like, whitish, later cinnamon; milk hot; spores (11.5–) 12–14.5 (–15) × (10–) 11–13 µm, Q 1.1–1.2, with up to 2 µm long, isolated spines; basidia 1-spored; with deciduous trees; rare, but widespread, reaching S Scandinavia ..... *Lactarius stephensii*  
Without white milk, but sometimes with water-clear milk ..... 5
5. With sparse, water-clear milk; flesh with lactiferous hyphae (milk-hyphae); spores broadly ellipsoid, Q 1.2–1.3. Fruitbody 10–20 mm wide, ± reddish brown; spore mass foam-rubber-like, reddish brown; taste mild; smell fruity; spores 14–18.5 × 12–15 µm, with up to 2 µm long, isolated or slightly connected spines; with deciduous and coniferous trees; rare (S) ..... *Lactarius soehneri*  
Without milk; flesh without lactiferous hyphae; spores usually globose to subglobose (Q 1–1.2) ..... 6
6. Basidia 1-spored; spores 13–15 (–15.5) × 12.5–14.5 (–15) µm. Fruitbody 10–20 mm wide, whitish to yellowish brown, later brownish; spore mass foam-rubber-like ± yellowish brown; smell and taste unknown; spore Q 1.0–1.1, with up to 3 µm long, isolated spines; rare (Germany) ..... *Russula bavarica*  
Basidia mostly 2-spored; spores smaller than 13 µm ..... 7
7. Spores with 0.5–1 µm long spines. Fruitbody 10–30 mm wide, ± yellowish brown, later with darker brown spots; spore mass foam-rubber-like, ± yellowish brown; taste mild; spores 9.5–12.5 × 8.5–11 µm, Q 1.0–1.1; with deciduous trees; rare (Czech Republic, Germany) ..... *Russula neuhoffii*  
Spores with 1–3 µm long spines. Fruitbody 10–30 mm wide, ± clay-buff, later with brown spots; spore mass foam-rubber-like, ± cinnamon; smell fruity; taste mild; spores (8–) 9.5–12.5 (–14) µm, Q 1; with deciduous and coniferous trees; scattered (S–SE, reaching S Germany) ..... *Russula cerea*







Key C – Sclerogaster

- 1. Spore mass initially pale glaucous green (■), later olivaceous buff (■); peridium of only elongated hyphae. Fruitbody 5–15 mm wide, whitish, wrapped in lots of white mycelium; spore mass gelatinous, with a columella; smell strong and unpleasant; spores 4–5 µm, somewhat irregular in shape, with an up to 0.5 µm high ornament of cyanophilous warts; in deciduous and coniferous forests, usually embedded in thick litter; rare, but apparently widespread . . . *Sclerogaster hysteroangioides*  
Spore mass ± yellowish (■ ■ ■ ■ ■); peridium of two layers, the inner with globose cells . . . . . 2
- 2. Spores 4–7 µm; in deciduous and coniferous forests. Fruitbody 5–10 mm wide, white, later pale buff to cinnamon-buff; spore mass gelatinous, clay-buff to cinnamon-buff, with a columella; spores warty; rare, but widespread . . . . . *Sclerogaster compactus*  
Spores 8–12.5 µm; in steppe-like vegetation. Fruitbody 5–10 mm wide, whitish, wrapped in lots of white mycelium; spore mass rubber-like and densely labyrinthine, yellowish brown, with a columella; smell fruity; spores with large warts or spines; rare (SE) . . . . . *Sclerogaster gastrosporoides*



Key D – Octaviania

- 1. Spore ornament of low, 0.8–1 (–1.3) µm high, ± regular warts. Fruitbody with a pale surface, which blackens when touched; spore mass marbled to chambered with white chamber walls, brownish to greyish brown; smell fruity; spores subglobose, yellowish brown, (10.5–) 11.5–13 (–14) × (9.5–) 10–11.5 (–12) µm; with deciduous trees, rare (S) . . . . . *Octaviania arbucalensis*  
Spore ornament higher and more spiny or crested . . . . . 2
- 2. Peridium with more layers, including ± globose cells. Fruitbody 15–30 mm wide; surface reddening and blackening when touched; spore mass foam-rubber-like to chambered with white chamber walls, brownish to blackish brown; smell fruity; spores ellipsoid to subglobose, yellowish brown, 11–14 × 9.5–11 µm, with 2.3–4 µm high ornament, up to 6 µm in unripe spores; in deciduous forests; probably rare (confused with other species) . . . . . *Octaviania asterosperma*  
Peridium with only ± elongated hyphae . . . . . 3
- 3. The spore ornament forms a ± regular pattern of conical spines . . . 4  
The spore ornament forms a more striped, irregular pattern . . . . . 5
- 4. Peridial hyphae with many swellings; spore ornament 1.7–3.7 µm high. Fruitbody 15–45 mm wide, with a pale surface, reddening and blackening when touched; spore mass foam-rubber-like to chambered with white chamber walls, brownish to blackish brown; smell fruity; spores globose, yellowish brown, 8–15.5 × 7.5–15 µm; with deciduous trees; scattered . . . . . *Octaviania mutabilis*  
Peridial hyphae without swellings; spore ornament 2.5–5 µm high. Fruitbody 20–40 mm wide, with pale surface, yellowing, reddening and blackening when touched; spore mass foam-rubber-like to chambered with white chamber walls, brownish to blackish brown; smell fruit- or cocoa-like; spores globose, yellowish brown, 12–14.5 × 10–14 µm; with various deciduous trees; rare (?) . . . *Octaviania lutea*



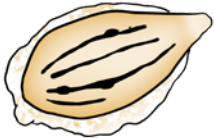
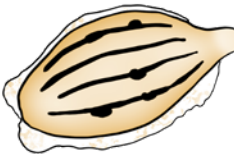
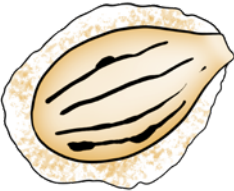
Key E – Gautieria

- 1. Spores up to 10 µm wide . . . . . 2  
Spores wider . . . . . 4
- 2. Spores (12–) 12.5–15.5 (–16.5) µm long; with deciduous trees. Fruitbody 20–50 mm wide, surface initially whitish, later yellowish brown; spore mass folded-pitted, somewhat gelatinous, ± cinnamon; smell fruity to onion-like; spores (12–) 12.5–15.5 (–16.5) × (7.5–) 8–9.5 (–10) µm, Q 1.5–1.8 (–1.9); rare (S) . . . . . *Gautieria persimilis*  
Spores on average longer than 15.5 µm; with conifers . . . . . 3
- 3. Fruitbodies with a vanishing peridium; inner structures ± jelly-like; spore Q 1.5–1.8 (–2). Fruitbody 15–50 mm; surface whitish, later somewhat folded-pitted, yellowish to yellowish brown; spore mass folded-pitted, ± cinnamon; smell fruity, later onion-like; spores (14–) 15–18 (–19) × (8–) 8.5–10 (–11) µm; rare, but widespread . . . . . *Gautieria otthii*  
Peridium persistent; inner structures not jelly-like; spore Q 1.7–2. Fruitbody 20–50 mm wide; surface whitish, sometimes slightly rose when bruised; spore mass folded-pitted, cinnamon; smell of fish or garlic; spores 16–19 (–21.5) × 8.5–10 µm, rare (S) . . . . . *Gautieria pityophila*
- 4. Spore Q 1.15–1.3. Fruitbody 15–35 mm wide; surface initially whitish, later folded-pitted and yellowish brown; spore mass folded-pitted, ± cinnamon; smell fruity; spores (14–) 15–18 (–19) × (11.5) 12–15 (–15.5); with conifers; rare (alpine) . . . . . *Gautieria subglobispora*  
Spore Q higher . . . . . 5
- 5. Fruitbodies with a rather robust peridium . . . . . 6  
Fruitbodies with a quickly vanishing peridium . . . . . 7
- 6. Spores with crests with coarse warts in stripes; spore Q 1.6–2; with conifers on calcareous soil. Fruitbody 15–30 mm wide; surface initially whitish, later translucently brownish rose; spore mass folded-pitted, ± cinnamon; smell onion-like; spores (16–) 16.5–20 (–21) × 9.5–11 (–12) µm; rare (alpine) . . . . . *Gautieria queletii*  
Spores with crests without coarse warts; spore Q 1.3–1.5; with deciduous trees. Fruitbody 15–40 mm wide; surface initially whitish, later folded-pitted and reddening, then light reddish grey; spore mass folded-pitted, ± cinnamon; smell unpleasant; spores (14.5–) 15–17.5 (–19) × (10–) 10.5–12.5 (–13) µm; rare, but widespread . . . . . *Gautieria graveolens*

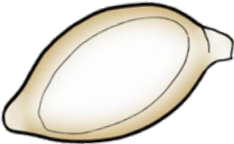




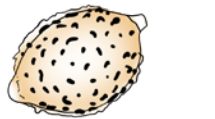
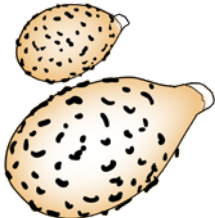
7. Spores (13–) 14–17 (–18)  $\mu\text{m}$  wide. Fruitbody 20–65 mm wide; surface initially whitish, later folded-pitted and yellowish brown, reddening when touched; spore mass folded-pitted,  $\pm$  cinnamon; smell strongly pear- or peach-like; spores 19–24 (–26)  $\times$  (13–) 14–17 (–18)  $\mu\text{m}$ , Q 1.3–1.6; with deciduous trees on calcareous soils; rare (S) ..... *Gautieria macrocoila*  
Spores 10–14.5  $\mu\text{m}$  wide ..... 8
8. Spore crests largely without prominent nodules and transverse ribs. Fruitbody 20–45 mm wide; surface initially whitish, soon folded-pitted and yellowish brown,  $\pm$  reddening; spore mass folded-pitted,  $\pm$  cinnamon; smell strong of seafood or onion; spores (15–) 16–21.5 (–23)  $\times$  (10–) 10.5–12.5 (–14)  $\mu\text{m}$ , Q 1.4–1.7 (–2); with deciduous trees and *Abies*; rare (southern, alpine) ..... *Gautieria fenestrata*  
Spore crests with many nodules and transverse ribs ..... 9
9. Apiculus 4–8  $\mu\text{m}$  wide at the tip; with deciduous trees on calcareous soils. Fruitbody 15–55 mm wide; surface initially whitish, soon folded-pitted and yellowish brown, reddening; spore mass folded-pitted,  $\pm$  cinnamon; smell strongly of seafood or onion; spores (18–) 19–24 (–27)  $\times$  12–14.5  $\mu\text{m}$ , Q 1.4–1.8 (–2); rare, but apparently widespread ..... *Gautieria morchelliformis*  
Apiculus 2.5–4.5  $\mu\text{m}$  wide at the tip; with conifers. Fruitbody 15–65 mm wide; surface initially whitish, later folded-pitted and yellowish brown, reddening when touched; spore mass folded-pitted,  $\pm$  cinnamon; smell initially fruity, later of seafood or onion; spores (15–) 16–22.5 (–23)  $\times$  10–13.5  $\mu\text{m}$ , Q 1.3–2; rare, but apparently widespread ..... *Gautieria villosa* s.l.<sup>2</sup>



- Key F – Cortinarius, Descomyces and Hymenogaster**  
Sequence studies on European material have shown that *Hymenogaster* is far more species rich than normally assumed, and the key is a simplification.
1. Spores smooth or almost so ..... 2  
Spores with a wrinkled-warty,  $\pm$  loosening outer wall ..... 3
2. Spore mass buff-yellow (■ ■ ■). Fruitbodies 5–20 mm wide, whitish, pale buff to clay-pink; spore mass compact labyrinthine, buff-yellow to cinnamon-buff; smell aromatic, pleasant; spores 18–22  $\times$  7–11  $\mu\text{m}$ , mostly narrowly lemon-shaped, many deformed, pale greyish yellow; with deciduous trees; rare, but widespread ..... *Hymenogaster luteus* s.l.  
Spore mass  $\pm$  cinnamon (■ ■ ■). Fruitbodies 20–40 mm wide, whitish, later  $\pm$  brown; spore mass very compact labyrinthine with branched veins, cinnamon to dark brownish rose; smell unpleasantly pungent; spores 20–22  $\times$  12.5–15  $\mu\text{m}$ , lemon- to pear-shaped; smooth to almost so, brownish yellow; with deciduous trees; rare (S) ..... *Hymenogaster bulliardii*
3. Spores mostly with a broad, rounded end opposite the apiculus ..... 4  
Spores with an  $\pm$  obvious papilla opposite the apiculus, but the papilla can be partly covered by the loosening outer layer ..... 5



4. Spores 8–14  $\mu\text{m}$  long. Fruitbodies 20–60 mm wide, partly above ground, whitish; spore mass brownish red; smell strong and fruity; spores 8–14  $\times$  5–9  $\mu\text{m}$ ; with conifers; rare, but apparently widespread ..... *Cortinarius olens*  
Spores 18–22  $\mu\text{m}$  long. Fruitbodies 20–30 (–40) mm wide, whitish, later  $\pm$  brown; spore mass compact labyrinthine,  $\pm$  brown; smell faint; spores 18–22  $\times$  11–14  $\mu\text{m}$ ; with deciduous trees; rare (?), but widespread ..... *Hymenogaster muticus*
5. Spore Q lower than 2; spores  $\pm$  warty. Fruitbodies 5–20 mm wide, whitish, later  $\pm$  clay-buff; spore mass compact labyrinthine, clay-buff to cinnamon; smell  $\pm$  mealy to rancid, radish-like; spores spindle-shaped with a distinctly developed papilla, 13–17  $\times$  8–12  $\mu\text{m}$ ; with deciduous and coniferous trees; common ..... *Hymenogaster niveus* s.l.<sup>3</sup>  
Spore Q higher than 2; spores  $\pm$  wrinkled ..... 6
6. Spores 13–20  $\mu\text{m}$  long; with *Eucalyptus*. Fruitbody up to 60 mm wide, whitish, when bruised yellowish to brownish; spore mass  $\pm$  clay-buff; spores spindle-shaped to lemon-shaped, 13–20  $\times$  7–11  $\mu\text{m}$ , with a warty to netlike, loosening outer wall; rare, mainly SW ..... *Descomyces albus*  
Spores on average longer than 20  $\mu\text{m}$ ; with other hosts ..... 7
7. Spores on average longer than 25  $\mu\text{m}$  ..... 8  
Spores on average shorter than 25  $\mu\text{m}$  ..... 9
8. Spores 23–35  $\times$  10–15  $\mu\text{m}$ ; fruitbody surface initially yellowish, when bruised reddish brown to almost blackish. Fruitbodies 10–30 (–60) mm wide; spore mass compact labyrinthine, soon dark greyish brown; smell fruity to more acidic; with deciduous trees; scattered ..... *Hymenogaster citrinus* s.l.<sup>4</sup>  
Spores 35–50 (–90)  $\times$  12–15  $\mu\text{m}$ ; fruitbody surface initially whitish, when touched pale buff, browning to blackish. Fruitbody 10–30 mm wide; spore mass compact labyrinthine,  $\pm$  clay-buff; smell unknown; with deciduous and coniferous trees; rare (?), apparently widespread ..... *Hymenogaster calosporus* ss. auct.
9. Spores brownish yellow to yellowish brown, usually obliquely spindle-shaped. Fruitbody 10–30 (–40) mm wide, whitish, later olivaceous buff; spore mass compact labyrinthine, pale vinaceous brown to greyish brown; smell rancid, earthy; spores 18–27  $\times$  9–12  $\mu\text{m}$ ; with deciduous and coniferous trees; scattered ..... *Hymenogaster vulgaris* s.l.  
Spores dark brown, mostly symmetrically spindle-shaped. Fruitbody 10–15 mm wide, whitish, later greyish brown to dark greyish brown; spore mass compact labyrinthine, soon dark greyish brown; smell flowerlike; spores 18–27  $\times$  10–13  $\mu\text{m}$ ; with deciduous and coniferous trees; common ..... *Hymenogaster griseus* s.l.<sup>5</sup>



2. *Gautieria convoluta* and *Gautieria confusa* are very similar and can probably not be safely identified without molecular data.

3. Including *Hymenogaster thwaitesii*.  
4. Including *Hymenogaster olivaceus*. Gross 1969 (Über *Hymenogaster*-Funde mit Sporen von 25–35  $\mu$  mittlerer Länge. *Zeitschrift für Pilzkunde* 35(3–4): 157–178) describes a number of species with spores up to 35  $\mu\text{m}$  in length.  
5. *Hymenogaster hessei*, *Hymenogaster decorus* and *Hymenogaster rehsteineri* are included here.



Key G – *Melanogaster*

1. Spores on average shorter than 10 µm ..... 2  
Spores on average longer than 11 µm ..... 4
2. Spores on average shorter than 6 µm. Fruitbody 10–15 mm wide, ± curry yellow; spore mass chambered, black; spores 5.5–6.5 × 2.8–3.3 µm; with deciduous and coniferous trees; rare, but widespread ..... *Melanogaster luteus*  
Spores on average longer than 7 µm ..... 3
3. Spores almost cylindrical; spore Qav. 1.8–2.0. Fruitbody 20–60 mm wide, ± yellowish brown; spores 6.5–11 × 3.5–5 µm; in mull soil with *Fagus*, *Tilia* or other deciduous trees, both in parks and forests; scattered ..... *Melanogaster broomeanus*  
Spores ± egg-shaped; spore Qav. 1.4–1.7. Fruitbody 20–60 mm wide, ± yellowish brown; spores 6–9 × 3–6 µm; in deciduous forests; scattered ..... *Melanogaster variegatus*
4. Spores almost lemon-shaped with an obvious papilla, 14–18 (–20) × 7–9 (–12) µm. Fruitbody 20–50 × 10–30 mm, greyish brown; with *Fagus*, *Corylus* or other deciduous trees; scattered ..... *Melanogaster ambiguus*  
Spores without an obvious papilla ..... 5
5. Spores egg-shaped to ellipsoid, broadly rounded at one end, Q 1.4–1.6. Fruitbody 20–60 mm wide, ± reddish brown; spores 9–15 × 6–8.5 µm; mostly with *Fagus*; rare, but apparently widespread ..... *Melanogaster tuberiformis*<sup>6</sup>  
Spores ± spindle-shaped, Q 1.9–2.2. Fruitbody 20–60 mm wide, ± reddish brown; spores 12–16 × 6–7 µm; with *Fagus* or other deciduous trees; rare (?), mainly S ..... *Melanogaster macrosporus*

Key H – *Rhizopogon*

1. Fruitbody covered by adpressed hyphal cords ..... 2  
Fruitbody at most with scattered adpressed hyphal cords ..... 6
2. Spores mostly with a truncate attachment end ..... 3  
Spores with convex ends ..... 4
3. Surface with reddening hyphal cords, turning muted rose (■) with KOH. Fruitbody 18–27 mm wide, curry yellow to pinkish buff with dark spots; spore mass foam-rubber-like, ± pinkish buff to reddish brown; spores 5–8 × 2–3.8 µm; with *Pinus*; rare (?), but widespread ..... *Rhizopogon verii*<sup>7</sup>  
Surface ± curry yellow, turning glaucous green or clay-buff (■) with KOH. Fruitbody 10–50 mm wide, pale buff, curry yellow to cinnamon-buff; spore mass foam-rubber-like, ± clay-buff to brownish olive; smell slightly fruity; spores 5–8.5 (–11) × 2–4 µm; with *Pinus*; common ..... *Rhizopogon luteolus*<sup>8</sup>
4. Surface reddening (■ ■ ■), especially after addition of KOH. Fruitbody 20–40 mm wide; initially whitish, later curry yellow, when bruised muted rose; spore mass foam-rubber-like, glaucous green to olivaceous buff; smell fruity; spores 5–8 × 2–3.5 µm; with *Pinus*; rare (?), but widespread ..... *Rhizopogon occidentalis*  
Not reddening, not even with KOH, but sometimes browning ..... 5

6. *Melanogaster intermedius* is sometimes regarded as a distinct species with slightly larger spores.

7. *Rhizopogon subolivascens* is very similar or identical, and if so, it is the correct name.

8. *Rhizopogon subalpinus* can possibly be separated by a peridium of narrow hyphae mixed with wider cells. *Rhizopogon ochraceorubens* is very similar, but should have more slender, 30–40 × 4–4.5 µm sized basidia.

5. Surface dark brown (■ ■ ■) with KOH. Fruitbody 12–30 mm wide, initially whitish, later yellowish to orange; spore mass foam-rubber-like, ± greenish yellow; smell fruity; spores 5.5–6.5 (–8.5) × 2.5–3.5 µm; with *Pinus*; apparently rare ..... *Rhizopogon aurantiacus*  
Surface unchanged with KOH ..... see *Rhizopogon luteolus*, cpl. 3
6. Spores with convex ends ..... 7  
Spores mostly with a truncate attachment end ..... 10
7. Spores 3.5–5 µm wide, on average wider than 4 µm. Fruitbody 9–35 mm wide, yellowish to clay-pink with dark spots, flesh pink when bruised and with KOH; spore mass foam-rubber-like, pinkish buff to brownish rose; smell not distinct; spores (6.5–) 7–11 × 3.5–5.2 µm; with *Pinus*; rare (?), apparently mainly S ..... *Rhizopogon marchii*  
Spores narrower ..... 8
8. Surface when bruised dark vinaceous brown (■ ■ ■), with KOH often greenish to brownish (■ ■ ■). Fruitbody 7–40 mm wide, initially pinkish buff, later dark reddish brown; spore mass foam-rubber-like, initially whitish, later yellowish green; spores 5.5–7 × 2–3 µm; with *Pseudotsuga* and rarely also with other conifers; rare, but widespread up to Denmark ..... *Rhizopogon villosulus*  
Surface when bruised ± muted rose (■ ■ ■), with KOH muted rose to wine red (■ ■ ■) ..... 9
9. Spores on average wider than 2.8 µm. Fruitbody 7–40 mm wide, initially whitish, later yellowish to dark brownish rose; spore mass foam-rubber-like, initially whitish, later greenish yellow to olivaceous buff; smell initially fruity, later onion-like; spores (5–) 6–8 (–10) × (2–) 2.5–4 (–4.5) µm; mostly with *Pinus* on calcareous soils; scattered ..... *Rhizopogon roseolus*  
Spores on average narrower than 2.8 µm. Fruitbodies as *R. roseolus*; spores 5.5–8 × 2.2–2.8 µm, sometimes with quite small scars at the attachment end; with conifers; rare (?), mainly N ..... *Rhizopogon evadens*
10. Spores with a deeply indented end, ca. 5 µm wide on average. Fruitbody up to 18 mm wide, pinkish buff, pale buff to cinnamon, in places pitted; spore mass foam-rubber-like, whitish marbled; spores 7.5–10 × (4–) 4.5–6.5 µm; with *Pinus*; rare (S–SE) ..... *Rhizopogon melanogastroides*  
Spores with a flat, truncate end ..... 11
11. Spores 2.5–3 µm wide; spore Qav. 2.7–3. Fruitbody up to 15 mm wide, brownish; spore mass foam-rubber-like, brownish; spores 7–9 × 2.5–3 µm, usually with a ± flat side; with conifers; rare (?) ..... *Rhizopogon angustisepta*  
Spores 2.5–4 µm wide; spore Qav. lower than 2.7 ..... 12
12. Spores 5–7.5 µm long; peridium with parallel hyphae, with KOH peach (■ ■ ■), with FeSO<sub>4</sub> unchanged. Fruitbody 8–15 mm wide, whitish to clay-pink to peach with wine-red spots; spore mass foam-rubber-like, ± peach to brown; spores 5–7.5 × 2.5–4 µm; with *Pinus*, *Picea* and *Pseudotsuga*; rare (?) ..... *Rhizopogon vinicolor*  
Spores 7–10 µm long; peridium with somewhat interwoven hyphae, with KOH muted rose to rose (■ ■ ■), with FeSO<sub>4</sub> dark brownish olive. Fruitbody 7–35 mm wide, initially whitish, later pinkish buff, clay-pink to muted rose, when bruised dark clay-pink; spore mass foam-rubber-like, initially whitish, later ± clay-pink; smell not distinct; spores 7–10 × (2.5–) 3–4 (–6) µm; with various conifers, including *Pinus* and *Pseudotsuga*; rare (?), but apparently widespread ..... *Rhizopogon pseudoroseolus*<sup>9</sup>

9. *Rhizopogon abietis* is probably a synonym.