

Identification key to *Hymenogaster*

Identification key to the Central European species of the genus *Hymenogaster*

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1. Background information

This key is published as supplementary material to the paper "Species delimitation in taxonomically difficult fungi: The case of *Hymenogaster*". It is useful as a stand-alone document for the identification of the many taxonomically difficult *Hymenogaster* species occurring in Central Europe. The key is specifically excluding all Mediterranean species. A broad overview including more than 100 pictures and a detailed key is provided, necessary for the identification of every considered species based on macro- and micromorphological characters. The specimens IDs for all images are listed in chapter four. The complete collection data are available in Table 1 of the full paper.

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2. Addresses of the authors



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3. Identification key to the Central European *Hymenogaster* species

- (1) a. Spores smooth, yellow, whitish-yellowish, yellowish-brownish, transparent; perisporium absent.....2
- (1) b. Spores verrucose, wrinkled, warted, thorny, dark coloured, blackish-brownish, reddish-brownish, greenish-yellowish; perisporium always present.....4
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- (9) a. Peridia yellow-brown; basidiospores (10-)21(-29) x (7-)13(-24),
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mucronate-fusoid spores always present.....*H. thwaitesii* (p. 41)
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Note: *H. pruinatus* is an ultra-rare taxon that could be falsely determined as *H. griseus*. However, *H. griseus* can probably only distinguished from *H. pruinatus* by DNA sequence analysis. *H. griseus* and *H. rehsteineri* are more common taxa and more likely to be found. *H. pruinatus*, as the only taxon, is not present in part 5, species descriptions, as no images are available of this species.

(12)b. Basidiospores strongly verrucose; basidiomata extremely variable in colouration from light to dark (yellow-)brown to whitish-brown to entirely grey; odour of basidiomata unpleasant to pleasant.....
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Notes: Always compare with macro- and micromorphological images of both taxa as *H. rehsteineri* and *H. griseus* are the two most variable *Hymenogaster* taxa.

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54	<i>Hymenogaster arenarius</i> (<i>pusillus</i>)	Basidiomata	it1_2
55	<i>Hymenogaster arenarius</i> (<i>pusillus</i>)	Basidiomata	it1_2
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57	<i>Hymenogaster arenarius</i> (<i>pusillus</i>)	Basidiospores	it1_2
58	<i>Hymenogaster arenarius</i> (<i>pusillus</i>)	Basidiospores	it1_2
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87	<i>Hymenogaster griseus</i> (<i>vulgaris</i>)	Basidiomata	not in dataset
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5. Species descriptions

Hymenogaster citrinus Vittad. 1831 emend. Stielow et al. 2010

Spores: (10-) 26 (-50) x (7-) 13 (-23) µm in diameter; broad to elongated, citriform, fusoid.

Ornamentation: Verrucose to wrinkled (or entirely smooth; sometimes only one type is present), many different graduations and intermediate forms.

Basidiomata: Regularly roundish, oval, silky-shiny appearance, ca. 1-7 cm in diameter.

Peridia: Surface smooth, wrinkled, colouration whitish-brownish-greyish-yellowish when juvenile, turning dark black-brown, sometimes with predominant white-yellow-orange tones at maturity.

Gleba: Consistency compact, enduring, not compressed, strongly chambered, labyrinthoid; whitish-ochraceous-greyish when juvenile, becoming very dark coloured, with blackish-brownish but alternatively also with bright yellowish-orange tones at maturity; trama plates whitish-yellowish-lemon (an unstable character which is not always present).

Odour: Sweet to rancid, reminding of fruits and nuts.

Ecology: The species can be found in various soils and associated with a wide range of deciduous trees; when associated to coniferous trees, than only with *Pinaceae*.

Images:

Basidiomata: No. 1-7. Basidiospores: No. 8-13. Montecchi & Sarasini 2000, p. 468, 490.

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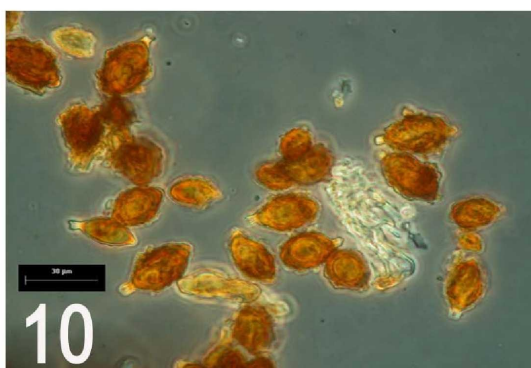
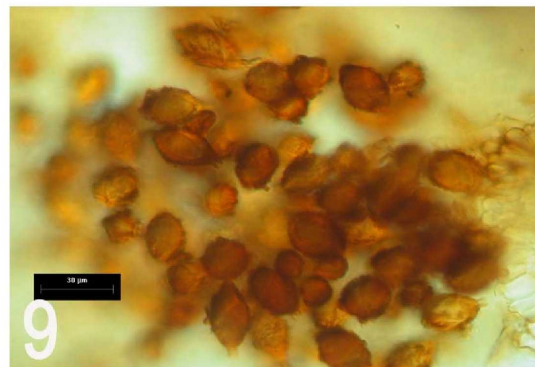
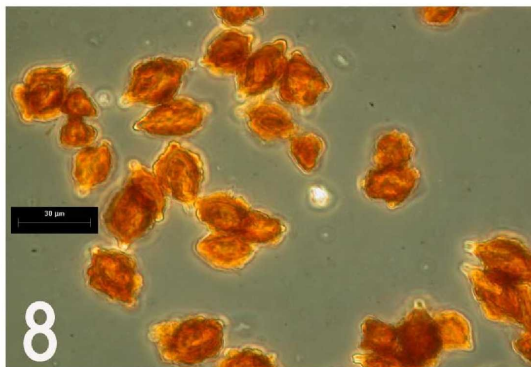
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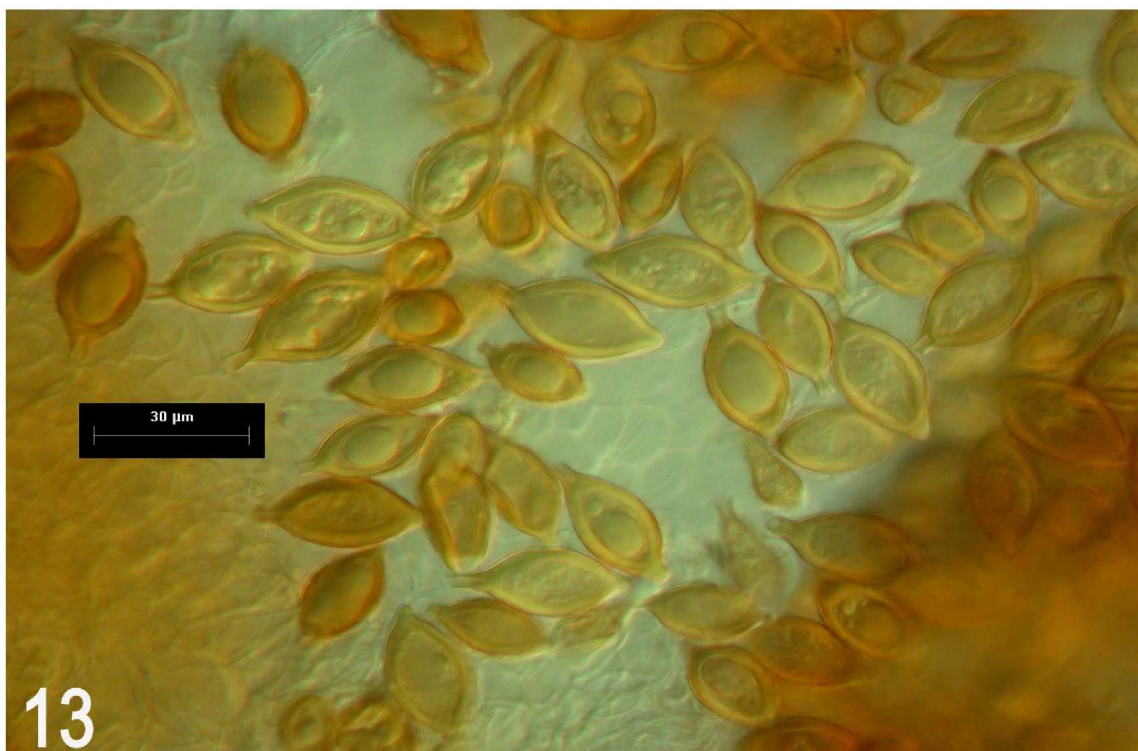
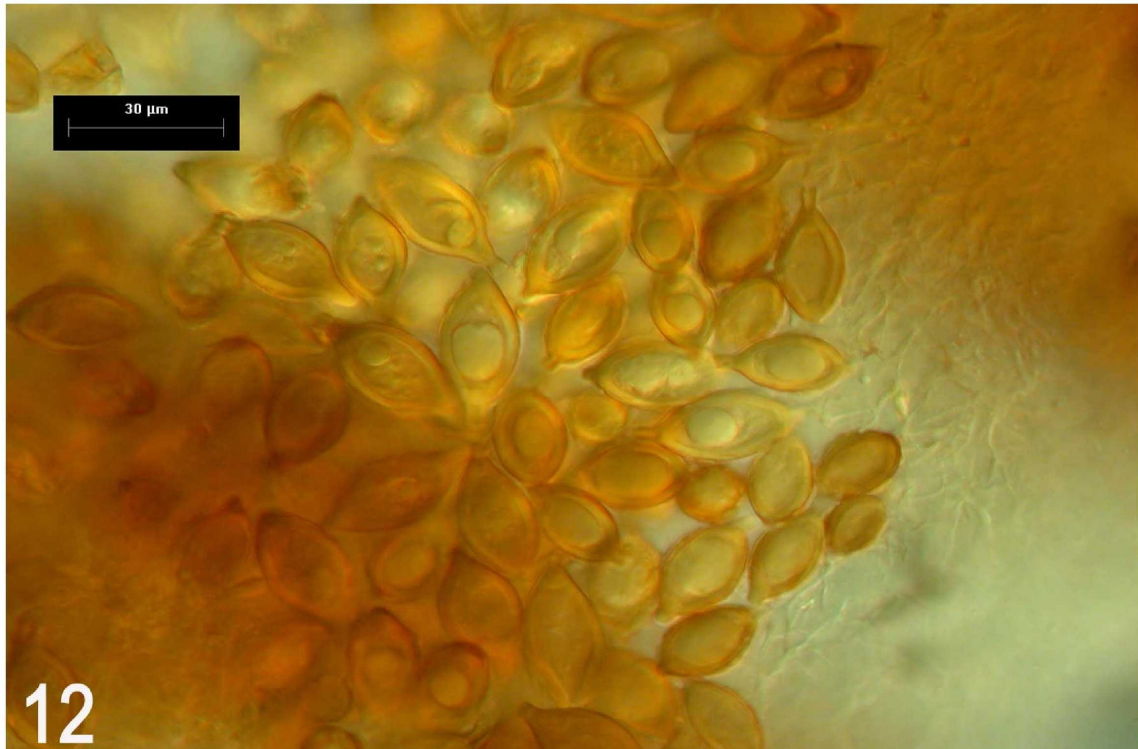
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Hymenogaster bulliardii Vittad. 1831

Spores: (12-) 20 (-31) x (7-) 11 (-19) μm in diameter; smooth surface, not ornamented; transparent; fusoid, elongated to ovoid. Spores with distinct abnormalities (secondary spores) always present and a distinct species character for *H. bulliardii*, often triangle- or cup-shaped.

Basidiomata: Roundish, knotted, partially wrinkled, ca. 1.5-4 cm in diameter.

Peridia: Yellowish-brownish, ochraceous coloured, smooth, thin, slightly furrowed.

Gleba: Consistency very compact and compressed; composed of small roundish cells; very constantly brownish-reddish(-black) coloured at maturity, yellowish-(whitish) coloured when juvenile, shimmied by reddish tones (Images 14-15).

Odour: Very unpleasant, reminding of putrescent vegetables.

Ecology: The species is always associated with deciduous trees in habitats on calcareous soils (can be confounded with *H. luteus* var. *berkeleyanus*).

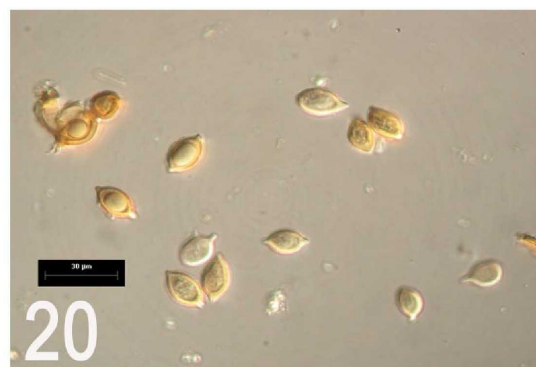
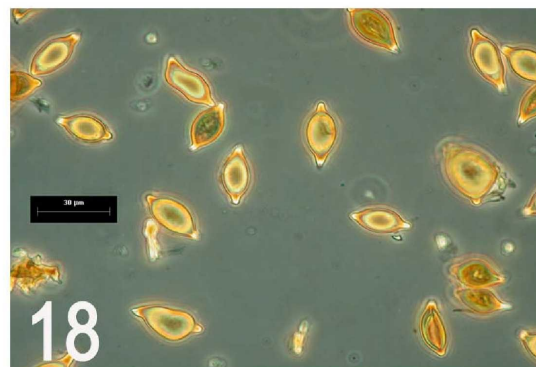
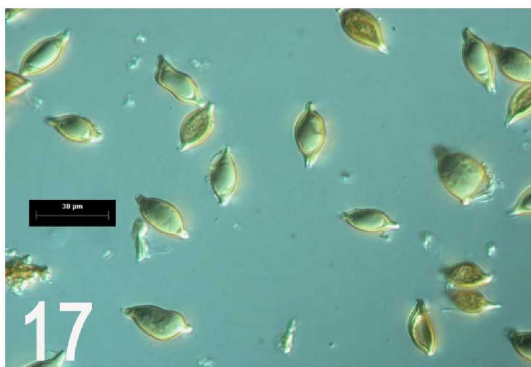
Images:

Basidiomata: No. 14-16. Basidiospores: No. 17-20 (secondary spores: No. 17-19 or Montecchi & Sarasini 2000, p. 463)

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Hymenogaster luteus Vittad. 1831

Spores: (14-) 20 (-36) x (6-) 9 (-14) μm in diameter; fusoid, elongated to ovoid; spores with distinct abnormalities rarely present.

Ornamentation: None, spore surface smooth. (The opinion of Montecchi & Sarasini regarding the brownish ornamentation of spores can not be confirmed; see Montecchi & Sarasini 2000, p. 479.)

Basidiomata: Globose or subglobose, ca. 0.2 - 2 cm in diameter.

Peridia: Pale white to grey-white, fluffy-smooth, very thin. Whitish-greyish at maturity but entirely whitish when juvenile.

Gleba: Consistency very compact and compressed; composed of small roundish cells; very constant characters are the bright predominant yellow to pale yellowish-ochre-brownish colouration at maturity. *H. luteus* var. *subfuscus* contains more distinct reddish-ochre tones according to Soehner (1962) (see image 23); differentiation from *H. luteus* var. *luteus* is ambiguous. The varieties of *H. luteus* can easily be confounded with *H. bulliardii* (compare image 23, most likely *H. luteus* var. *subfuscus*, with image 24, representing *H. bulliardii*).

Odour: Pleasant, reminding of fruits and flowers.

Ecology: A species that is only found on calcareous soils and under deciduous trees, from late October to early spring time, a typical winter species.

Images: Basidiomata: No. 21-26. Basidiospores: No. 27-31.

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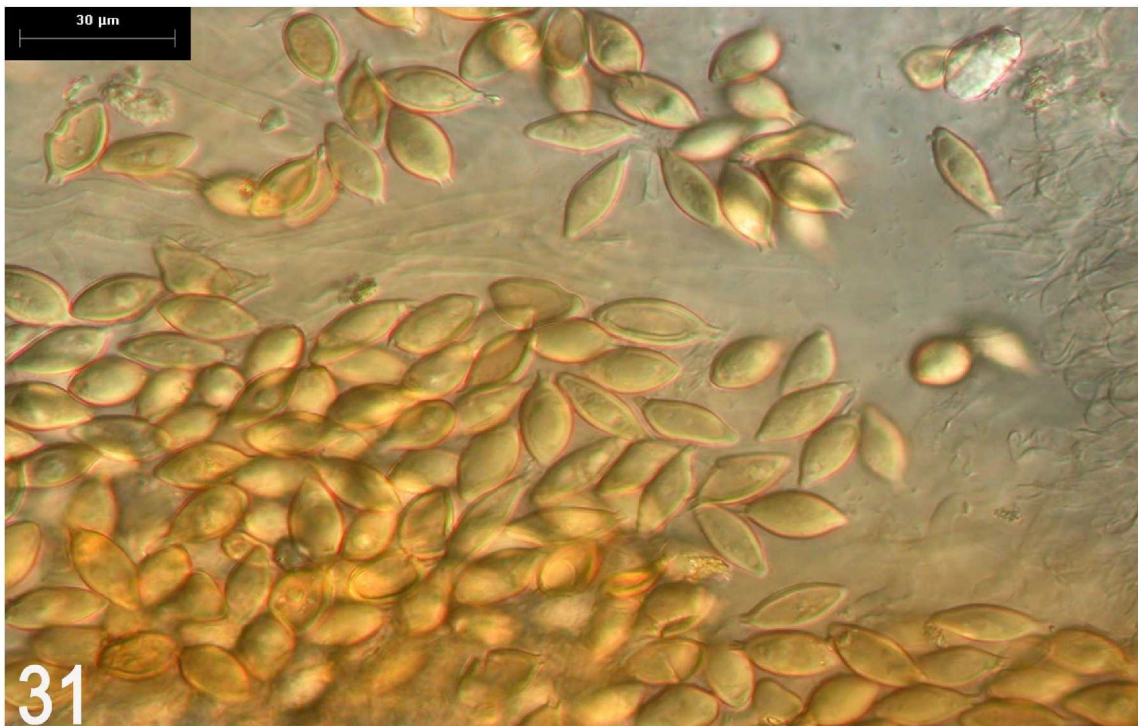
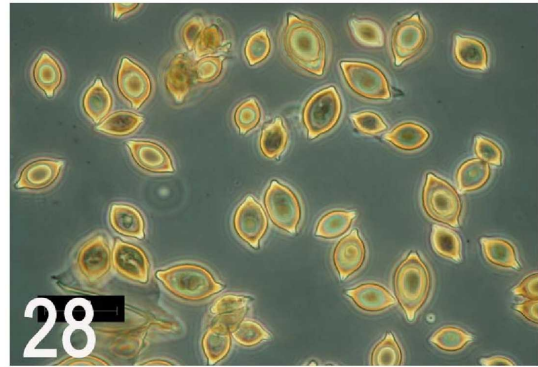
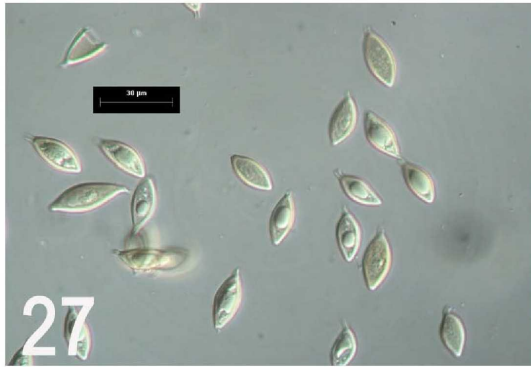
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Hymenogaster tener Berk. & Broome 1844

Spores: (13-) 14 (-16) x (8-) 9 (-11) μm in diameter; broad, ovoid to slightly citriform.

Ornamentation: Pronouncedly thorny-spiny; important species-delimitating character (when compared to *H. arenarius*, *H. niveus* or *H. intermedius*).

Basidiomata: Globose or subglobose, sometimes strongly wrinkled; gouges and cavities present, often with pronounced yellowish dehiscent apex, ca. 0.5 - 4 cm in diameter.

Peridia: Brilliant white in juvenile and intermediate stage (image 32), with distinctive yellowish spots at the apex; surface strongly wrinkled; kidney-like at maturity, entirely even when juvenile; colour at maturity turning to pale yellow-brownish-ochraceous.

Gleba: Juvenile to intermediate stages brilliant white; turning grey-brown to rose-brown at full maturity.

Odour: Pleasant, strong floury, *H. tener*-like.

Ecology: The species is strictly found in Central European spring time (Late Jan. – Mar.) under various deciduous trees and soils.

Images: Basidiomata: No. 32. Basidiospores: No. 33.

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Hymenogaster niveus Vittad. 1831 emend. Stielow et al. 2010

Spores: (9-) 14 (-18) x (6-) 8 (-10) µm in diameter; broad-ellipsoid, citriform, ovoid.

Ornamentation: Warty, spiny, never verrucose.

Basidiomata: Globose or subglobose; often with a pronouncedly dark coloured dehiscent apex contrasting *H. tener*; ca. 0.5-2.5 cm in diameter.

Peridia: Smooth, very thin, even, with cavities; colouration predominantly shiny snow-white to pale white (images 34-35); in most cases not changing and present in both juvenile and mature fruiting bodies.

Gleba: Consistency compact, elastic, with small chambers, labyrinthoid; whitish when juvenile, greyish-brownish to dark reddish-black at maturity.

Odour: Rancid, floury but not strikingly unpleasant.

Ecology: Found under various deciduous and coniferous trees in many soil types, from early summer till autumn.

Taxonomic notes: *H. niveus* sensu stricto was found to be genetically very heterogeneous but stable regarding its morphological characters. *H. niveus* consists of at least six cryptic species that require a more detailed analysis and verification. The insufficient number of exsiccates analysed in our dataset did not allow to further separate this very difficult species complex. In the future, morphological differences between the cryptic species might be found regarding spore shape (quotient Q of spore length and width).

Images:

- Basidiomata: No. 34-35. Basidiospores: No. 36-42.

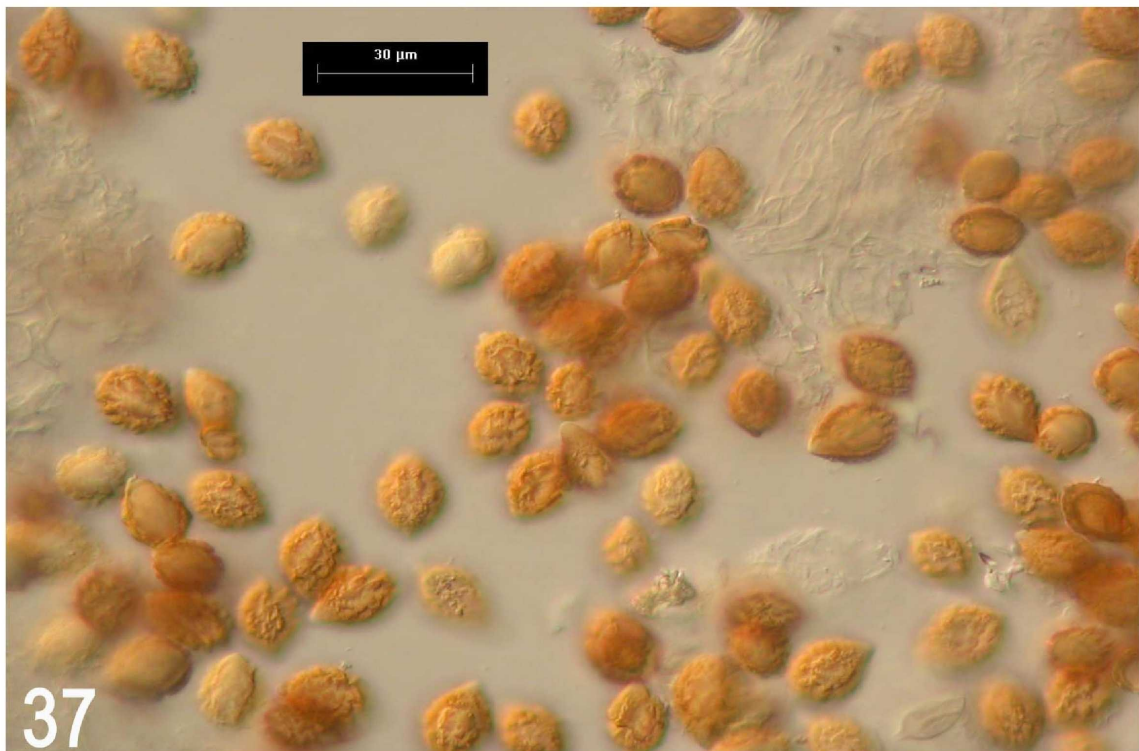
Identification key to *Hymenogaster*

- Cryptic species one (= cluster 0): spores (9-) 14 (-18) x (6-) 10 (-13), Q = 1.4 (images 36-37, 40-41).
- Cryptic species two (= cluster 15): spores (10-) 13 (-16) x (6-) 9 (-11), Q = 1.44
- (image 43).
- Cryptic species three (cluster 3): spores (15-) 16 (-18) x (10-) 11 (-12), Q = 1.45.
- Cryptic species four (cluster 22): spores (10-) 14 (-17) x (8-) 11 (-15), Q = 1.27
- (images 38-39).
- Cryptic species five (cluster 21): spores (9-) 12 (-14) x (7-) 9 (-12), Q = 1.33.
- Cryptic species six (cluster 7): spores (10-) 12 (-14) x (7-) 9 (-10), Q = 1.33.

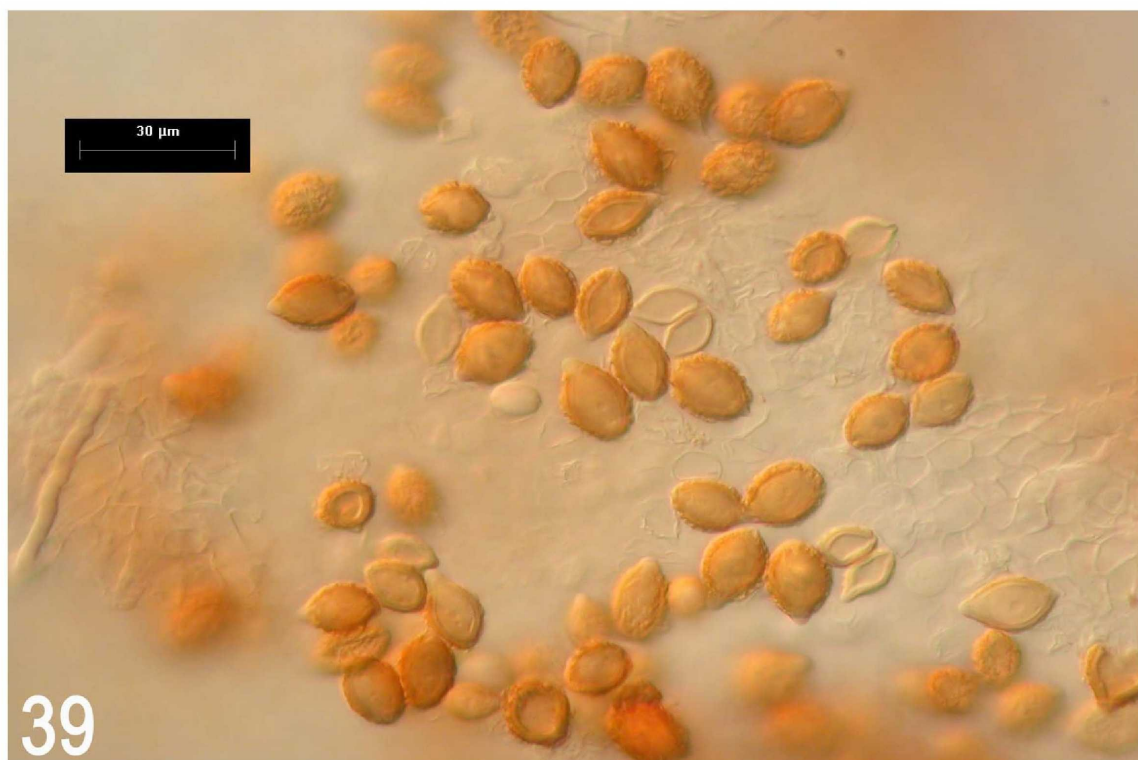
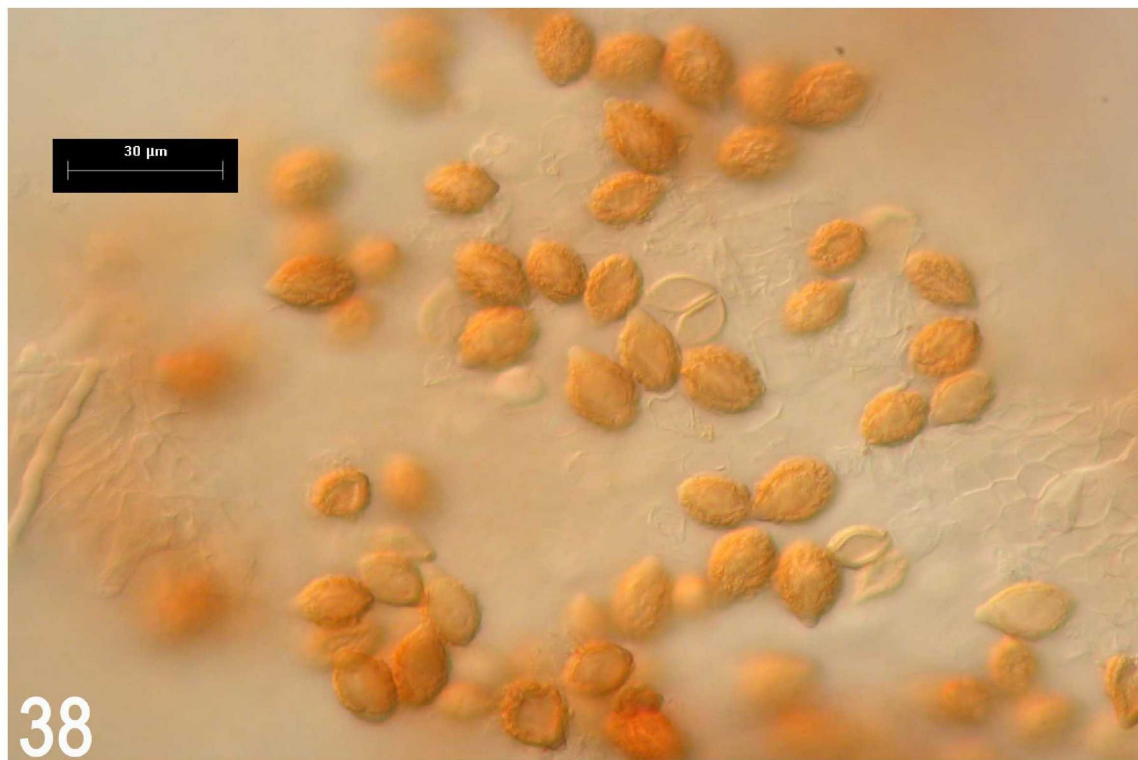
Identification key to *Hymenogaster*



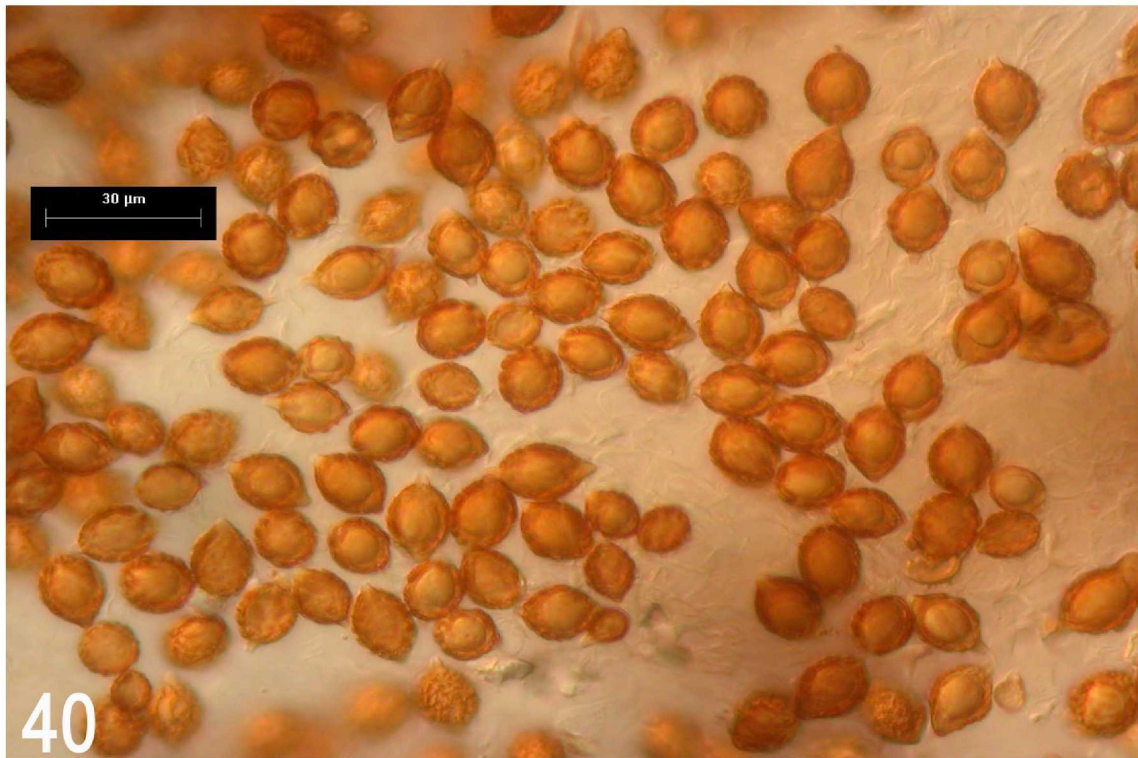
Identification key to *Hymenogaster*



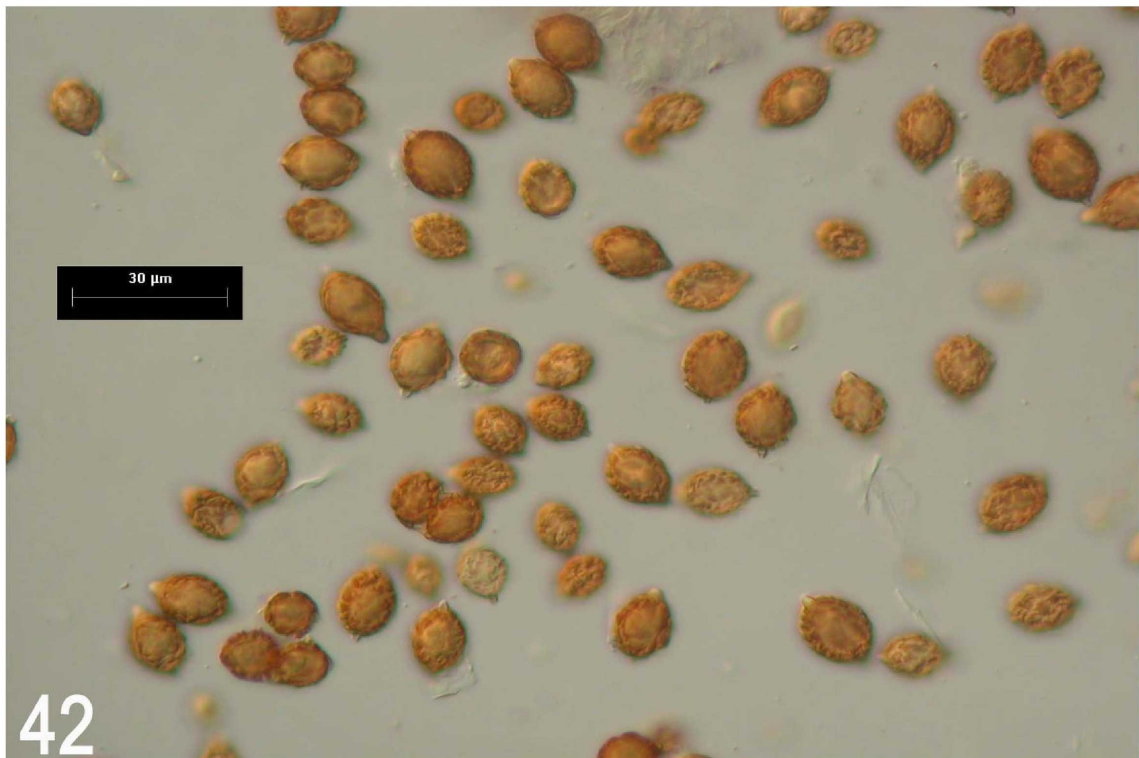
Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

Hymenogaster arenarius Tul. & C. Tul. 1844

Spores: (10-) 14 (-17) x (6-) 10 (-13) μm in diameter; broad, ovoid-citriform; fusoid deviations present.

Ornamentation: Warty, thorny, never verrucose.

Basidiomata: Globose, subglobose, wrinkled, ca. 0.5-2.5 cm in diameter.

Peridia: Pale grey-whitish when juvenile, with brown tones, surface greasily-waxy-shiny.

Gleba: Consistency compact; composed of small chambers, labyrinthoid; emerging radially from a sterile base; greyish-whitish to rose-greyish when juvenile; brownish-carmine and rusty-red tones at maturity; trama appears waxy.

Odour: Very unpleasant, reminding of putrescent garlic or onion.

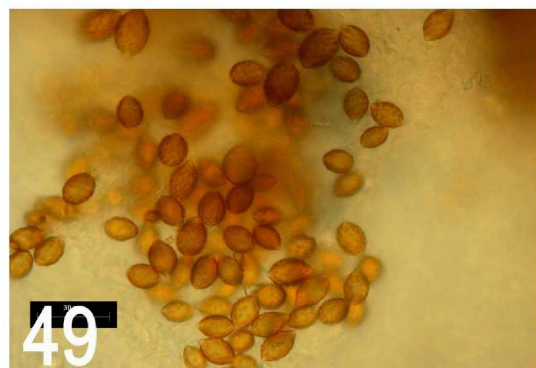
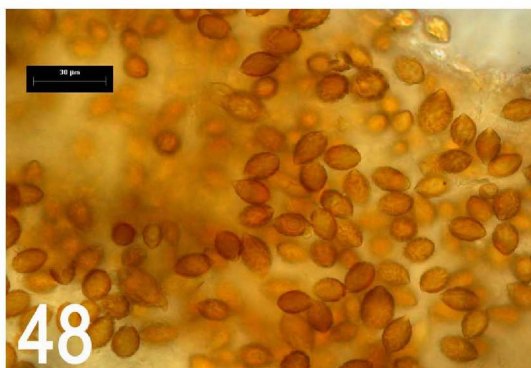
Ecology: The species is found under various deciduous trees, often in park-like habitats; it prefers loose sandy soils. Typical *Hymenogaster* species in Central European late spring time, never grows in the summer season.

Images: Basidiomata: No. 44-47, 54-55. Basidiospores: No. 48-53, 56-61.

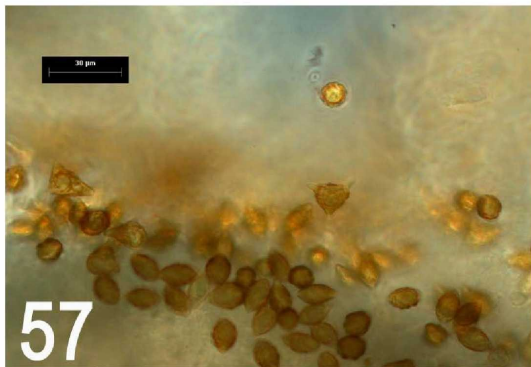
Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

Hymenogaster intermedius Stielow et al. 2010, sp. nov.

Spores: Spores (10-) 12 (-14) x (6-) 8 (-9) µm in diameter; globose to subglobose or ovoid, spores yellow-brown.

Ornamentation: Very similar to *H. arenarius* and *H. niveus*, not spiny but rather thorny-verrucose.

Basidiomata: Tuberous, globose to subglobose; ca. 1 - 1.5 cm in diameter.

Peridia: Plain white when young, turning to pale-ochraceous in mature basidiomes, very similar to the typical colouration of *H. rehsteineri*; change of colouration very slow.

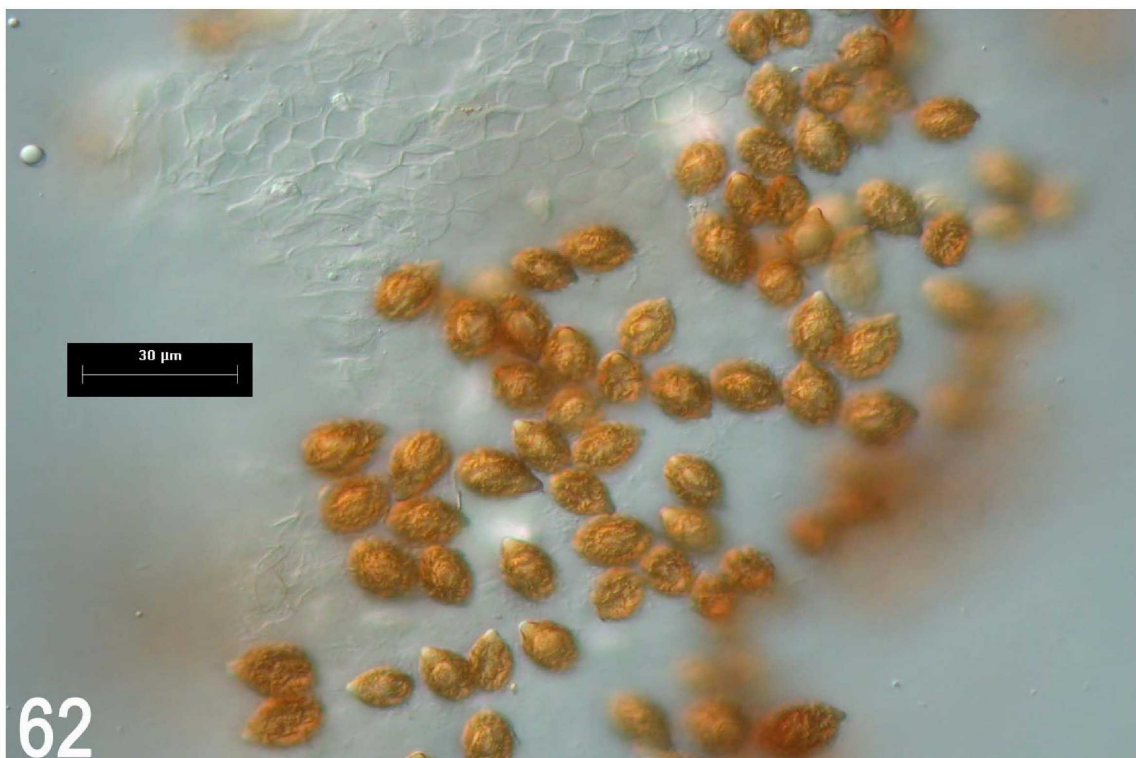
Gleba: White when juvenile, passing through gentle lilac tones, turning to brilliant warm-brown at maturity, but remaining more light-coloured than in typical *H. rehsteineri* specimens. Columella present, with mycelial cord at the base.

Odour: Floury- or cucumber like, pleasant.

Ecology: Present under various deciduous trees, so far reported from northern and eastern Germany to be only associated with *Fagus sylvatica*, in Hungary with various host trees. Very rare taxon.

Images: Basidiomata: No. 62. Basidiospores: No. 63-65.

Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

Hymenogaster thwaitesii Berk. & Broome 1846

Spores: (10-) 21 (-29) x (7-) 13 (-24) μm in diameter; predominantly globose-subglobose to ovoid ($Q= 1.6$), but mucronate-fusoid spores always present.

Ornamentation: Verrucose to wrinkled.

Basidiomata: Globose, knotted, lobated; usually very small, ca. 0.5 - 1 cm in diameter.

Peridia: Uneven, surface wrinkled; whitish-yellowish when juvenile, yellowish-brownish at maturity, with all possible brown tones during the ripening process.

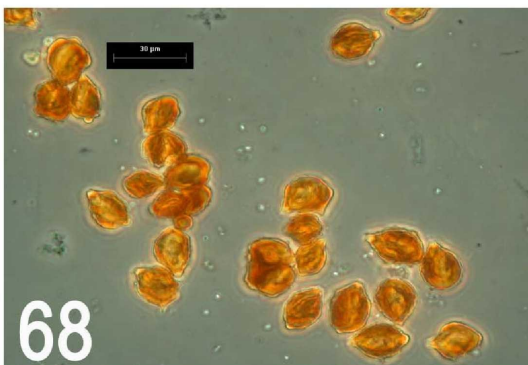
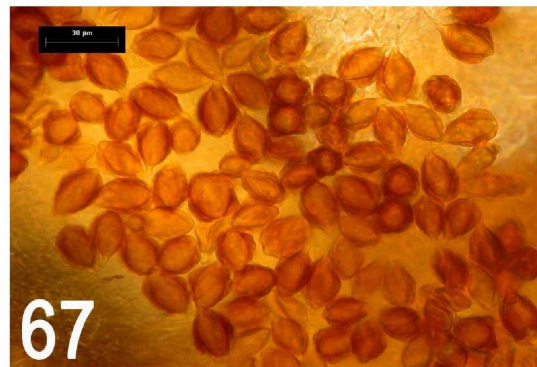
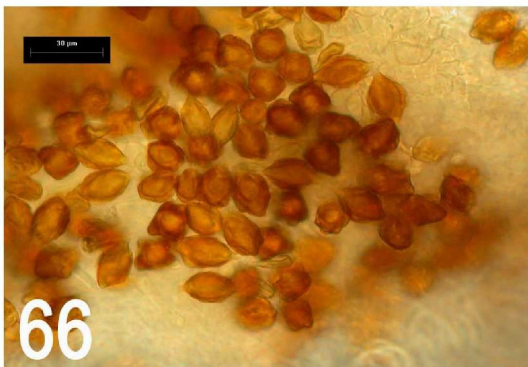
Gleba: Compact, not compressed; enduring small chambers, labyrinthoid; yellowish-beige when juvenile, dark-brown to cinnamon at maturity.

Odour: Soil- or swamp-like.

Ecology: Under deciduous and coniferous trees and in various soils, also in montane habitats. Often at wet, shady sites. Very rare taxon across Europe.

Images: Basidiomata: No. 66. Basidiospores: No. 67-70.

Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

Hymenogaster megasporus Soehner 1952

Spores: (15-) 25 (-37) x (6-) 13 (-18) μm in diameter; elongated, fusoid-lanceolate, spores unusually large on average in some exsiccates > 35 μm .

Ornamentation: Vigorously verrucose (similar to *H. griseus*).

Basidiomata: Globose, roundish; ca. 0.5 -1 cm in diameter.

Peridia: Surface slightly uneven, but not wrinkled, furrowed or with cavities; whitish-grey when juvenile turning grey-brown-purple with predominant lilac tones at maturity.

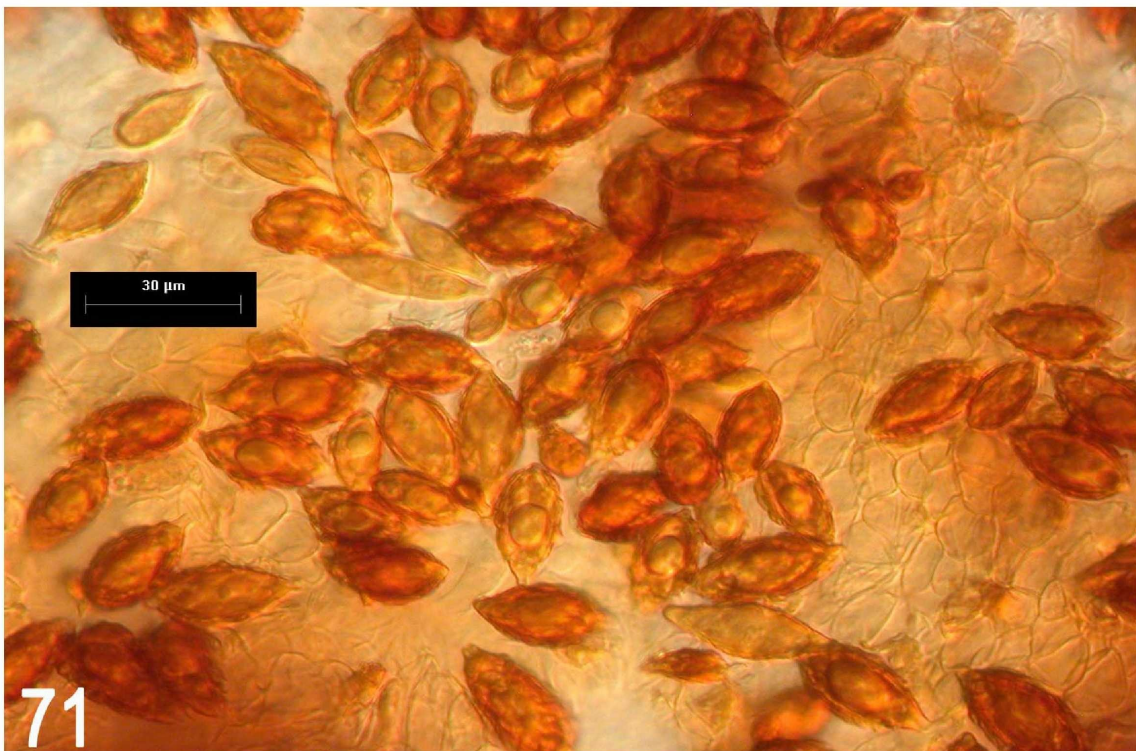
Gleba: Consistency very compact, with large chambers, not compressed, labyrinthoid orientation; with constant and predominant lilac and blue purple tones during ripening (rare character state in other *Hymenogaster* species); this distinct colouration is independent of the degree of maturity; juvenile gleba whitish-purple.

Odour: Insignificant.

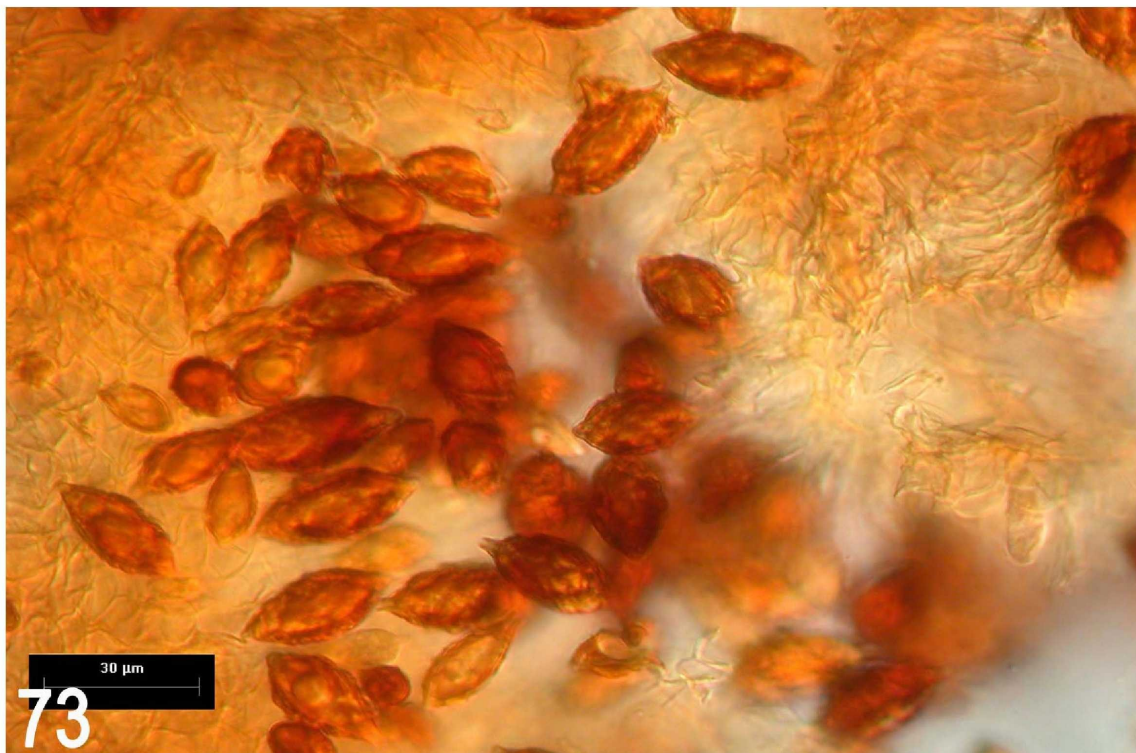
Ecology: A species found under various deciduous trees, ultra rare taxon or rarely found across Europe.

Images: Basidiomata: No. 71. Basidiospores: No. 72-74.

Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

Hymenogaster huthii Stielow et al. 2010, sp. nov.

Spores: (16-) 22 (-29) x (9-) 13 (-21) μm in diameter; lanceolate, elongated, broadly fusoid, papillate, rounded at the apex (similar to *H. griseus* group like basidiospores).

Ornamentation: Verrucose, strongly wrinkled, infolded inwards; dark rusty-brown.

Basidiomata: Wrinkled, globose to subglobose, with cavities leading to the inner side in mature basidiomes; gouges present; ca. 1.5-2.5 cm in diameter.

Peridia: Plain brilliant white when young, reminding of *H. niveus* and *H. tener* basidiomata, with irregularly dispersed brownish spots in young and mature basidiomes.

Gleba: White, turning grey-brown, becoming brown-black at full maturity, columella absent.

Odour: Pleasant, cucumber like.

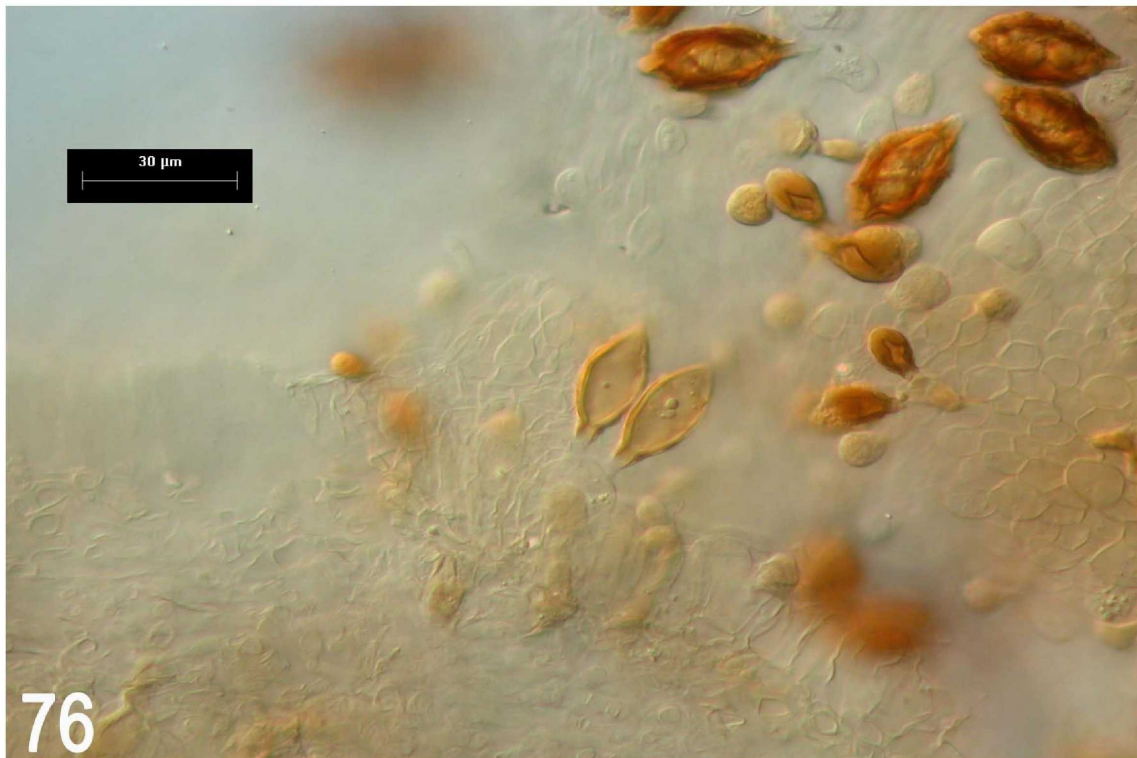
Ecology: The species is so far only known to be associated with *Tilia* species, *Corylus avellana* and *Alnus glutinosa* in habitats with limestone and basic soils.

Images: Basidiomata: No. 75. Basidiospores: No. 76-78. Two-spored-basidia: No. 77. Three-spored-basidia: No. 78

Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

Hymenogaster griseus Vittad. 1831 emend. Stielow et al. 2010

Spores: (11-) 21 (-36) x (7-) 11 (-21) μm in diameter (quotient = 1.9); fusoid, mucronate, predominantly ellipsoid, but ovoid and lanceolate deviations are present.

Ornamentation: Verrucose, warted, wrinkled; colour brownish-yellowish to reddish, greenish tones absent.

Basidiomata: Globose to subglobose, tuberiform, lobated; ca. 1 - 4 (-6) cm in diameter.

Peridia: Variable in coloration, from pale brown to greyish-brownish-whitish in all possible graduations.

Gleba: Compressed, composed of irregularly arranged, labyrinthoid, small chambers; extremely variable in colouration, from distinct brown tones to black and to grey-white to brown-yellow, irrespective of the degree of maturity.

Odour: Variable, pleasant (reminding of lily) to unpleasant, from slightly unspecific to predominantly raphanoid with many graduations (often reminding of *Cortinarius*) to mature onions and garlic, like putrescent vegetables.

Ecology: The species is present under various deciduous and coniferous trees and soils, also in montane habitats.

Images: Basidiomata: No. 79-88. Basidiospores: No. 89-96.

Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



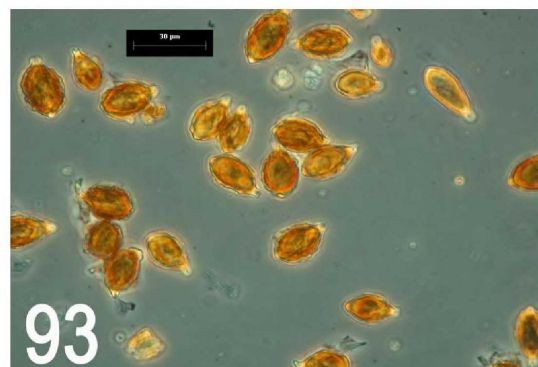
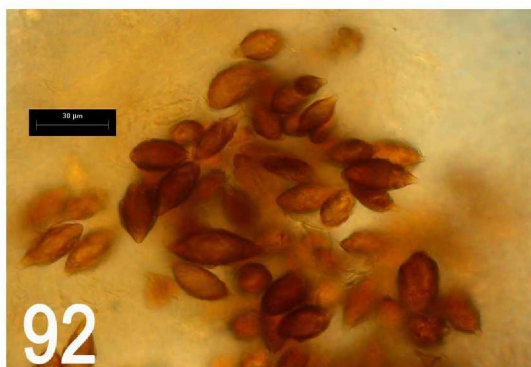
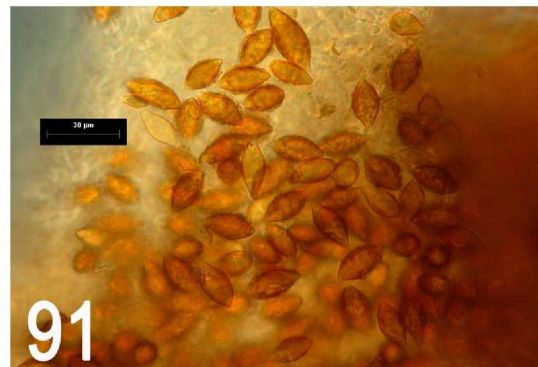
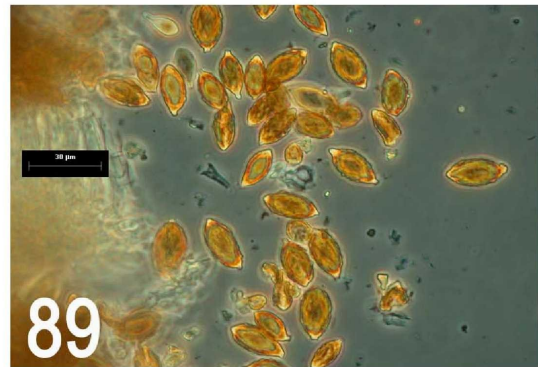
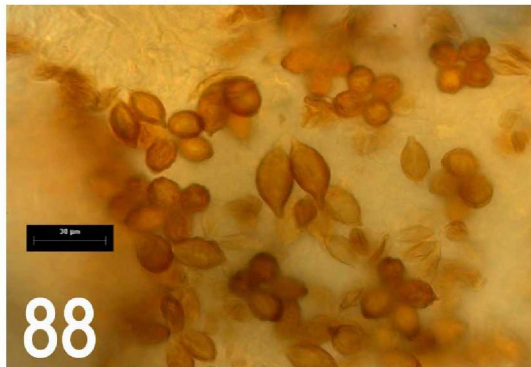
Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

Hymenogaster rehsteineri Bucholtz 1901 emend. Stielow et al. 2010

Spores: (13-) 20 (-30) x (8-) 11 (-15) µm in diameter; papillate to lanceolate shape predominant, but fusoid deviations always present.

Ornamentation: Verrucose, warted; colour brownish-yellowish, sometimes with very weak but distinct greenish tones (similar to *H. niveus*); loose perisporium constitutes two parallel walls, not always very evident but constantly present.

Basidiomata: Globose to tuberiform, sometimes elongated; ca. 1.5 -2 cm in diameter.

Peridia: Surface even, partially wrinkled, with visible hyphae; surface smooth, pale whitish-greyish when juvenile, turning ochraceous-yellowish-brownish at maturity

Gleba: Fragile, not compact, with small roundish chambers; greyish-brownish when juvenile, turning dark cinnamon-brown at maturity.

Odour: Pleasant in early juvenile stages, very unpleasant at maturity; rancid; when dry reminding of mature *Marasmius* species.

Ecology: The species is found under various deciduous trees and in different soils, often park-like habitats, also in montane habitats.

Taxonomic notes: *H. rehsteineri* is like *H. niveus* a difficult species complex with at least three cryptic species. One *H. rehsteineri* cryptic species could not be subjected to an intensive morphological analyses, as only two specimens were available. The second cryptic species represents the typical *H. rehsteineri*, with the main characters begin a pale ochraceous, yellowish or brownish basidiomata and lanceolate, strongly verrucose-thorny basidiospores.

Identification key to *Hymenogaster*

Images: Basidiomata: No. 97, 99. Basidiospores: No. 43, 98, 100, 101.

- Cryptic species one (= cluster 14): spores (13-) 21 (-24) x (7-) 12 (-15) μm
- (images 99-101).
- Cryptic species two (= cluster 8): spores (14-) 20 (-30) x (8-) 10 (-15) μm
(images 43, 97, 98).

Identification key to *Hymenogaster*



Identification key to *Hymenogaster*



Identification key to *Hymenogaster*

