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Cantharellus quercophilus sp. nov. and its comparison to other small, yellow or brown American chanterelles

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Abstract – *Cantharellus quercophilus.* is described and illustrated from a post-oak savannah in Texas, USA. Morphological differences with other, small yellowish brown American *Cantharellus* species are discussed, mainly *C.tabernensis, C.appalachiensis, C.septentrionalis* and *C.minor*. The type specimens for all these *Cantharellus* have been reexamined to verify the currently applied species concepts. Some of the examined types of *Cantharellus* clearly belong in the *Craterellus tubaeformis* species complex and these are here transferred to the latter genus: *Craterellus convolvulatus* (A.H.Sm.) Eyssart. & Buyck comb. nov., *Craterellus flavobrunneus* (R.H.Petersen) Eyssart. & Buyck comb. nov., *Craterellus pallidipes* (R.H.Petersen) Eyssart. & Buyck comb. nov., *Craterellus sphaerosporus* (R.H.Petersen) Eyssart. & Buyck comb. nov., *Craterellus subperforatus* (A.H.Sm.) Eyssart. & Buyck comb nov. are introduced.

Résumé – *Cantharellus quercophilus* est décrite et illustrée d'une savane à *Quercus stellata* au Texas, USA. Une comparaison morphologique de cette espèce avec les chanterelles américaines les plus similaires complète la discussion, notamment *C.tabernensis, C.appalachiensis, C.septentrionalis* et *C.minor*. Les holotypes de toutes ces espèces ont été examinés pour vérifier le concept couramment appliqué. Pour d'autres chanterelles, notre examen des holotypes indique clairement qu'elles sont proches de *Craterellus tubaeformis*, genre dans lequel ces espèces sont donc transférées : les recombinaisons *Craterellus convolvulatus* (A.H.Sm.) Eyssart. & Buyck comb. nov., *Craterellus flavobrunneus* (R.H.Petersen) Eyssart. & Buyck comb. nov., *Craterellus pallidipes* (R.H.Petersen) Eyssart. & Buyck comb. nov., *Craterellus sphaerosporus* (R.H.Petersen) Eyssart. & Buyck comb. nov., *Craterellus subperforatus* (A.H.Sm.) Eyssart. & Buyck comb nov. sont introduites.

Cantharellus tabernensis / C. appalachiensis / C.minor / C.septentrionalis / Craterellus / taxonomy / Cantharellales

INTRODUCTION

Cantharellus is the type genus of the Cantharellales or "cantharelloid clade" as recently delimited by Montcalvo *et al.* (2007). Early American species of *Cantharellus* s.s. were described by Peck (1887, 1898, 1903) and contemporary mycologists. Since then, Ronald Petersen (1969, 1971a-b, 1975, 1979a-b, 1986; Petersen & Mueller 1992, Petersen & Ryvarden 1971) made the largest contribution to the knowledge of American *Cantharellus* with several morphological papers on this genus, including type revisions of Peck's species (Petersen 1976). Occasional papers presenting new taxa were also published by Smith & Morse (1947), Smith (1968), and in the past 15 years by Redhead *et al.* (1997), Feibelman *et al.* (1996), Dunham, O'Dell & R. Molina (2003) and Arora & Dunham (2008).

Petersen (1976) already disposed of some of the older names given to cantharelloid taxa that do not belong in *Cantharellus*. On the other hand, quite a number of American *Cantharellus* species that are clearly closely related to *Cantharellus tubaeformis*, a species now transferred to the genus *Craterellus* on the basis of molecular evidence (Feibelman *et al.*, 1997; Dahlman *et al.*, 2000) still await transfer to the latter genus.

The study and identification of *Cantharellus* in North America remains nevertheless very difficult because of the rarity of synthetic efforts such as regional revisions (Bigelow 1978, Smith 1968, Smith & Morse 1947, Thiers 1985) or comprehensive identification keys. A general revision of the genus for North America has never been tempted. This paper is the first of a series of publications aiming at a much needed, modern update on worldwide *Cantharellus* in general (Buyck & Hofstetter, 2008; Tibuhwa *et al.*, 2008; Eyssartier *et al.*, 2009) and American *Cantharellus* in particular. This first part discusses and illustrates in detail the smaller, yellowish brown chanterelles described from the USA.

MATERIAL AND METHODS

The color notations indicated in the descriptions are from Kornerup and Wanscher (1978). Microscopic features were examined and sketched by B. Buyck. All microscopic observations and measurements – except for basidiospores – were made in ammoniacal Congo red, after a short aqueous KOH pretreatment to improve tissue dissociation and matrix dissolution. Original drawings for all elements of the hymenium or pellis were made at × 2400. Measurements of basidiospores give mean values (underlined) accompanied – between brackets – by minimum and maximum values measured and are based on 20 spores. The mean length/width ratio (Q) gives minimum, mean, and maximum values in the same format. References to infrageneric placements follows Eyssartier & Buyck (2001).

TAXONOMY

Cantharellus quercophilus spec. nov. Figs 1-3, 28-29

Basidiomatis 24-35 mm altis carnosis habitu Cantharello cibario simile; pileo usque ad 35 mm diam., sicco, brunneo; hymenio lamellis moderate distantibus crassis pallide cremeis constituto, stipite 13-18 × 6-10(15) *mm, subcilindraceo vel ad basim attenuato Basidiis cum (2-4)5-6 sporis, 60-85 × 7-9 µm. Basidiosporis (6.3) 7.6 (8.3) × (4.4) 4.9 (5.6) µm, Q = (1.3) 1.5 (1.8), n = 20,, ellipsoideis vel leviter reniformibus laevibus, hyalinis, inamyloideis, acyanophilis. Cystidiis nullis. Pileipelle hyphis 4-5 µm latis cylindricis raro ramosis tenuitunicatis composita. Fibulis ubique abundantibus.*
Holotypus: *America borealis, prope Caldwell (TX), Burleson Co., sub Quercu stellata, Buyck & Lewis leg., Buyck 07.097, in herbario PC conservatus.*

Basidiome 24-35 mm high**. Pileus** small, < 35 mm diam., irregular in outline, subplane with an involuted margin in the very young stages, very soon depressed in the center, then infundibuliform with an irregular and often deeply lobed margin; margin slightly incurved, smooth, brown.; the surface dull, smooth, continuous, not yellow but pale brown (5D5-6) to greyish yellow or blond (4B3-5, 4CD4-6), sometimes with a darker, concentrical zone towards the margin. **Hymenophore** cream to pale yellowish (2A2-3), of rather well-developed, thick and relatively spaced gill folds, decurrent, not interveined, ca. 2-3 mm high, sparsely forking. **Stipe** 13-18 × 6-10(15) mm, irregularly subcylindrical or rapidly widening upwards and conical to almost triangular, massif and fleshy, concolorous to or paler than cap. **Context** grayish buff (but water-soaked) and with a faint but distinct lilac tinge, when handled or on injury yellowing, then rapidly reddish brown to rusty brown. **Smell** very weak. **Taste** slightly acrid. **Spore print** not obtained.

Spores (6.3) 7.6 (8.3) × (4.4) 4.9 (5.6) µm, Q = (1.3) 1.5 (1.8), n = 20, ellipsoid to egg-shaped, sometimes slightly reniform in side view, smooth. **Basidia** (2-4)5-6 spored, 60-85 × 7-9 µm, slightly undulate-sinuose and narrowly clavate. **Cystidia** none. **Suprapellis** a cutis made up of cylindrical hyphae, mostly 4-5 µm wide, with extremities near the surface remaining thin-walled, having somewhat more densely disposed septa and some branched at the 2 to 4th subterminal cell, but otherwise hardly differentiated; the terminal cell cylindrical or slightly widening near the tip, 30-60(70) × (5) 6-7 (8.5) µm, mostly obtuse-rounded, some subapically slightly constricted. Pileocystidia none. **Clamp connections** abundant in all parts of the basidiome.

Holotype: UNITED STATES. **Texas**: Burleson Co., Jackson's farm near Caldwell, 30 33.630N 96 50.099W, on sandy soil in a Post oak savannah, 27 July 2007, Buyck & Lewis leg., Buyck 07.097 (PC holotype).

Habitat and ecology: In grass under Post oak (in this case *Quercus stellata* Wangenh. var. *margaretta* (Ashe) Sarg), an ectomycorrhizal, native tree of the Beech family (Fagaceae) that is abundant throughout the Southeastern and South Central United States. It forms extensive pure stands known as "Cross timbers" in the prairie transition area of central Oklahoma and Texas and likes well drained, sandy soils that are often low in organic matter and deficient in nutrients (Bray 1904).

Additional material examined for comparative reasons:
– ***Cantharellus appalachiensis***: UNITED STATES. **Tennessee**: Great Smoky Mountains National Park, "Le Conte Creek Trail", 22 VII 1968, R. H. Petersen 3433 (TENN holotype). **Texas**: Montgomery Co., Conroe, in oak-pine woods, 28 VII-2007, Buyck 07.123.

– ***Cantharellus septentrionalis*** UNITED STATES. **Michigan**: Luce Co., Tahquamenon Falls State Park, 7-VIII 1963, A.H.Smith 67052 (MICH holotype).

– ***Cantharellus tabernensis***: UNITED STATES. **Mississippi**: "Hancock Co., Stennis Space Center, Stennis Space Center Recreation Area, latitude 30° 21' 13.0515'' N, longitude 89° 38' 39.5103'' W", 8 IX 1993, *T. Feibelman* 1897 (F holotype); **Texas**: Newton Co., Bleakwood, along highway 87, D.Lewis' property, on sandy soil under mixed broadleaf forest bottomlands, 4 VII 2002, Buyck 02.094, ibid.; 20 VII 2007, Buyck 07.040, ibid.; 24 VII 2007, Buyck 07.054, 07.056, 07.064; Forest Lake experimental plots, water oak (*Q.nigra* L.), plot near *Taxodium* swamp, 8 VII 2002, Buyck 02.168; Site 7, Toledo Bay Reservoir, on sandy soil in hickory-oak-pine forest, 30-VII-2007 Buyck 07.166. Hardin Co., Big Thicket national reserve, near Seratoga, Land's Rosier Unit, on sandy-loam in oak-pine forest, 19 VII 2007, Buyck 07.020; Montgomery Co., near Conroe, in oak-pine woods, 28 VII 2007, Buyck 07.118, 07.119, 07.124.

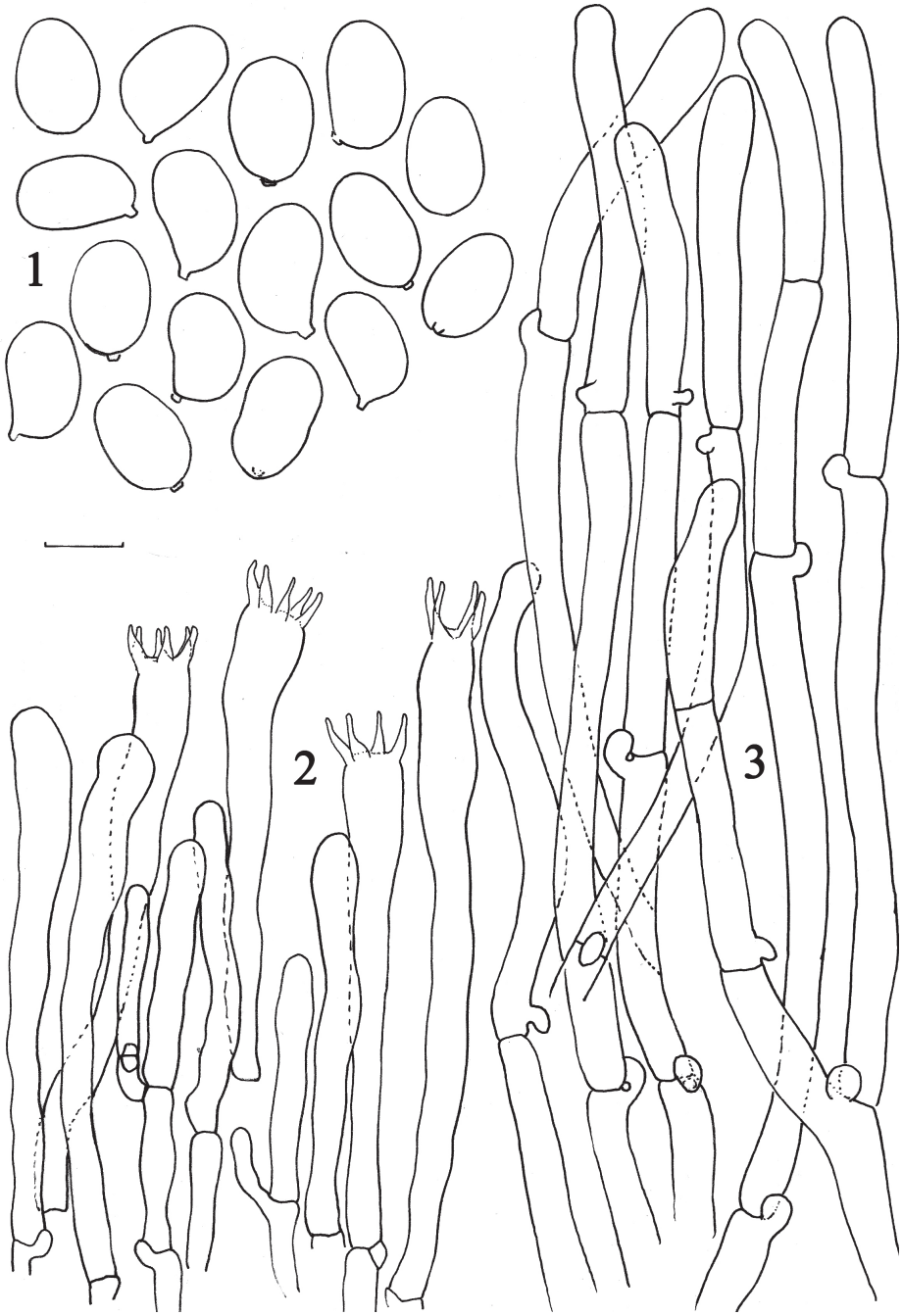
– ***Cantharellus minor***: UNITED STATES. **Texas**: Newton Co., Bleakwood, along highway 87, D.Lewis property, mixed bottomlands swamp with dominance of water oak (*Q.nigra* L.), laurel oak (*Q. laurifolia* Michx.) and swamp chestnut oak (*Q michauxii* Nutt.), 4 VII 2002, Buyck 02.092, ibid., 18 VII 2007, Buyck 07.002, ibid., 24 VII 2007, Buyck 07.057, 07.059; Forest Lake, water oak plot near *Taxodium* swamp, 8 VII 2002, Buyck 02.157 (all PC).

DISCUSSION

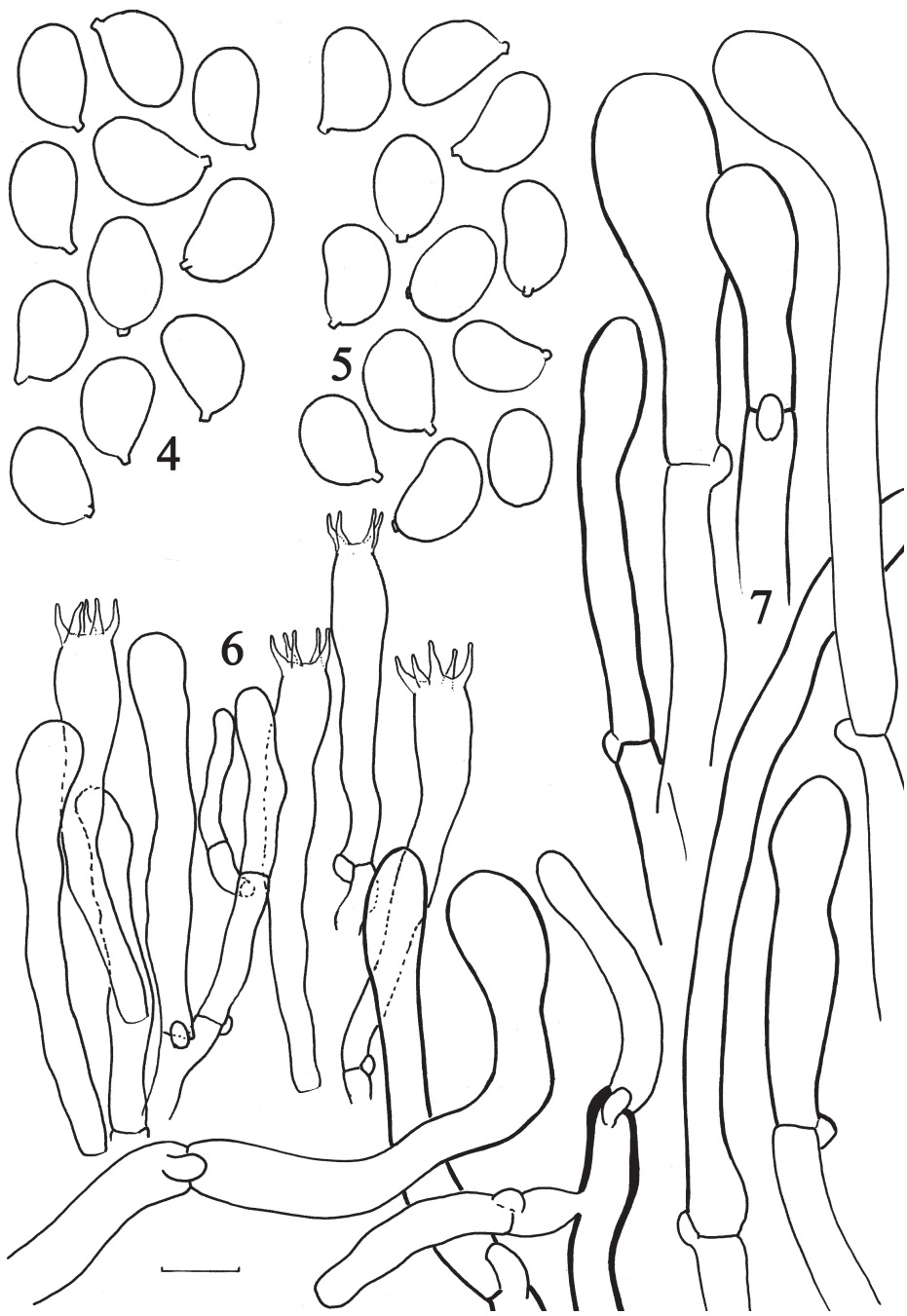
Our description of this species is based on a single collection, but there is no doubt that it represents an undescribed taxon as evident from sequence data for two ribosomal and two protein-coding genes (Buyck & Hofstetter unpubl.). These sequences will be published in a forthcoming phylogeny of the genus *Cantharellus* (for an abstract see Buyck & Hofstetter 2008) and place *C. quercophilus* firmly in subgenus *Cantharellus*, thereby considerably widening the gap with other small, yellowish brown American chanterelles, such as *C. appalachiensis* R. H. Petersen and *C. tabernensis* Feib. & Cibula, two extremely close sister species that definitely belong in a different subgenus.

Because of its general, robust habit this species reminds somewhat of a very dark, small *C. cibarius*. It differs nevertheless from the latter by several important features, such as the strong contrast between the pale hymenophore and the darker pileus and stipe and particularly by the exclusive presence of thin-walled, hyphal extremities at the pileus surface. Another distinctive feature is the strong and rapid yellowing of the context when handled or injured. Future collections of *C. quercophilus* will allow to document the variability of the pileus color, the eventual variation in hymenophore configuration, as well as the amplitude of the basidiome size, all of these characters being known to vary considerably in many species of the genus.

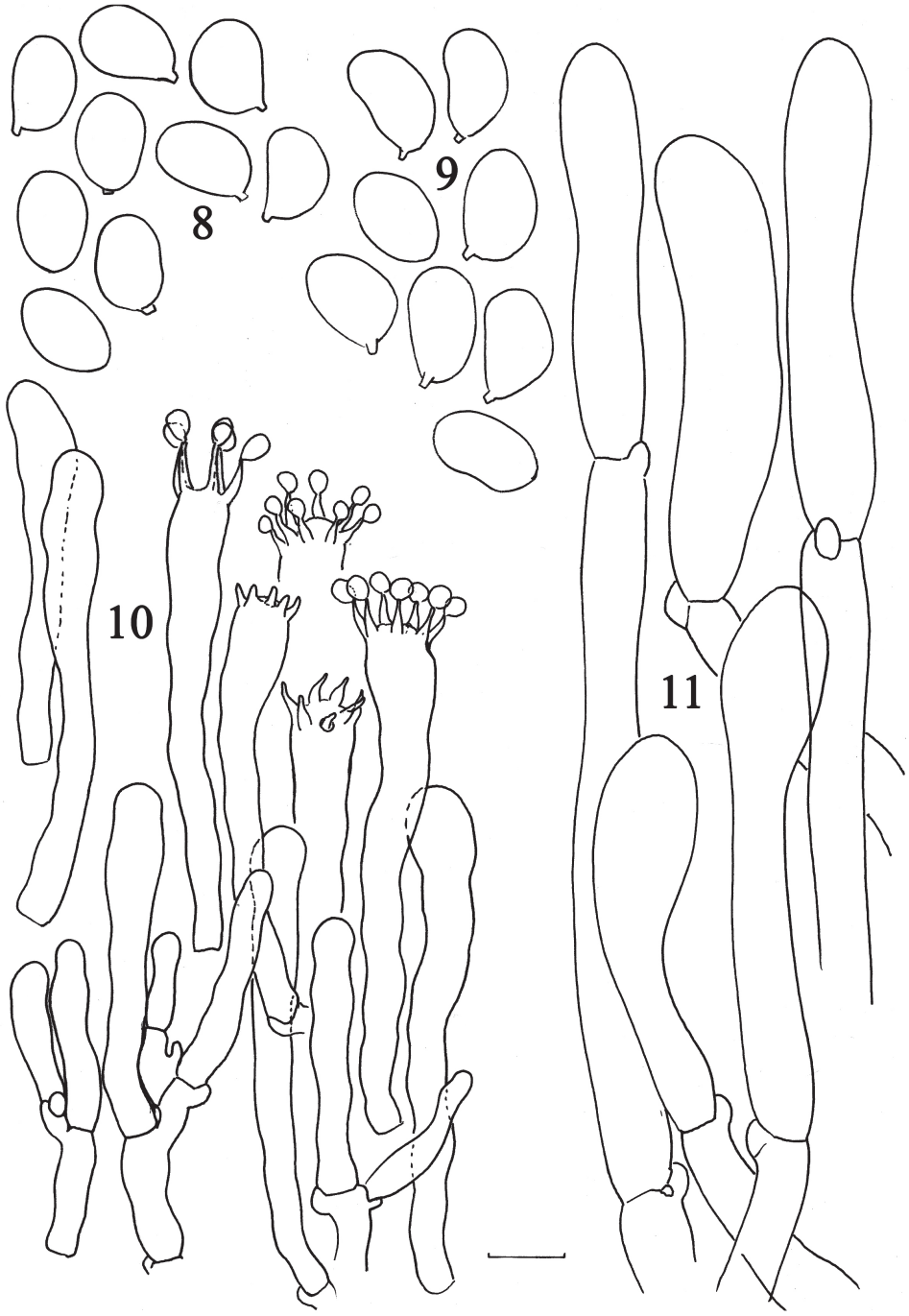
When making a section through the fruitbody of *C. quercophilus*, we noticed a distinct pinkish-lilac tinge in the context. As it happens, this was cited as a prominent feature of the otherwise enigmatic *C. septentrionalis* A.H.Sm., another small species that, as far as its presence in the US is concerned, remains still only known from the type locality in Michigan (Smith 1968). Our examination of the type collection of Smith's species revealed very different microscopic features (figs 12-14) and it is clearly unrelated. Other important characters for Smith's species include the minutely but distinctly squamose cap, reddening context upon bruising and lemon yellow spore print.



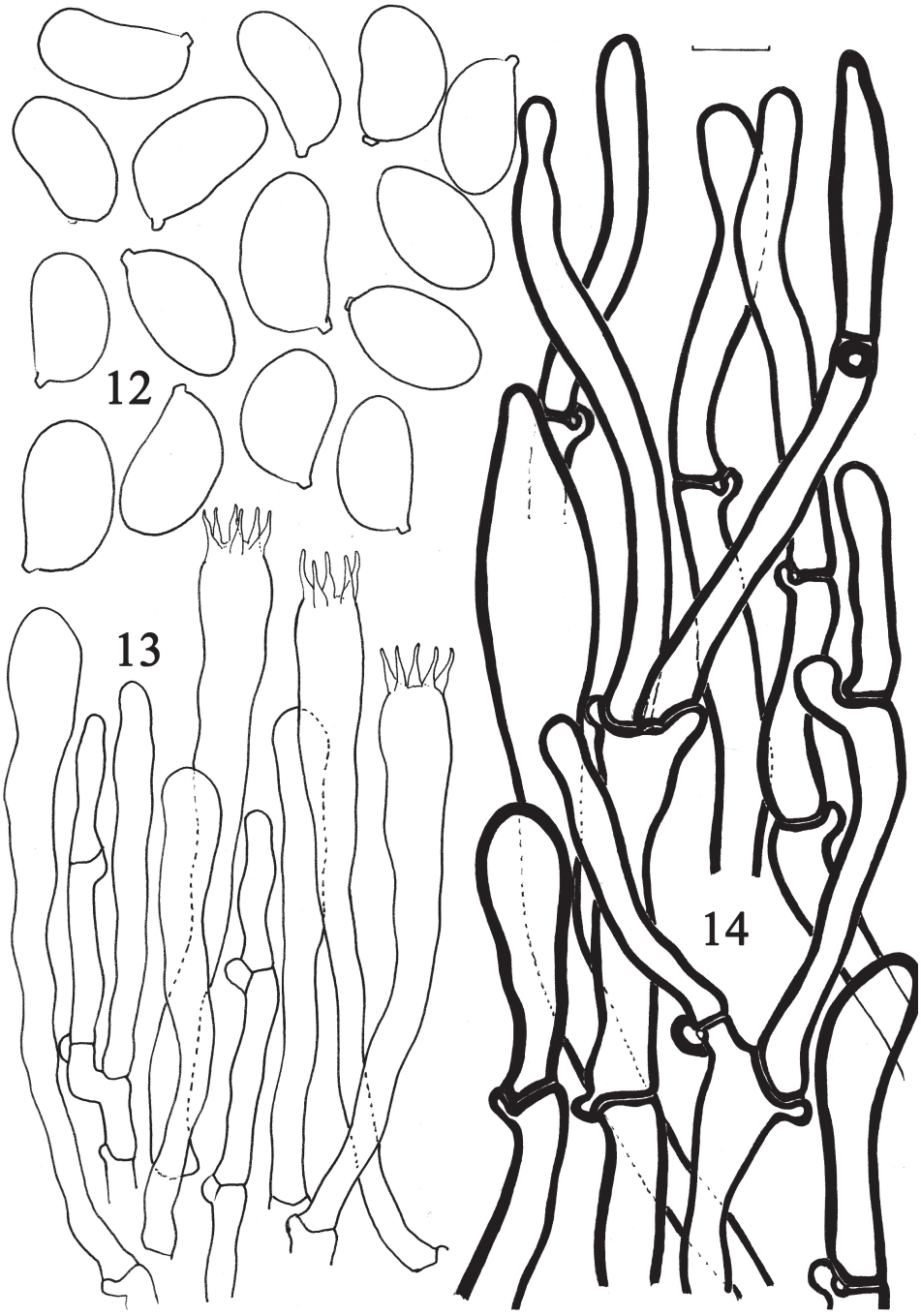
Figs 1-3. *Cantharellus quercophilus*. **1**. Spores. **2.** Basidia and basidiola. **3**. Hyphal extremities at the cap surface. Scale bar = 10 µm, 5 µm for spores (all from holotype, drawings B. Buyck).



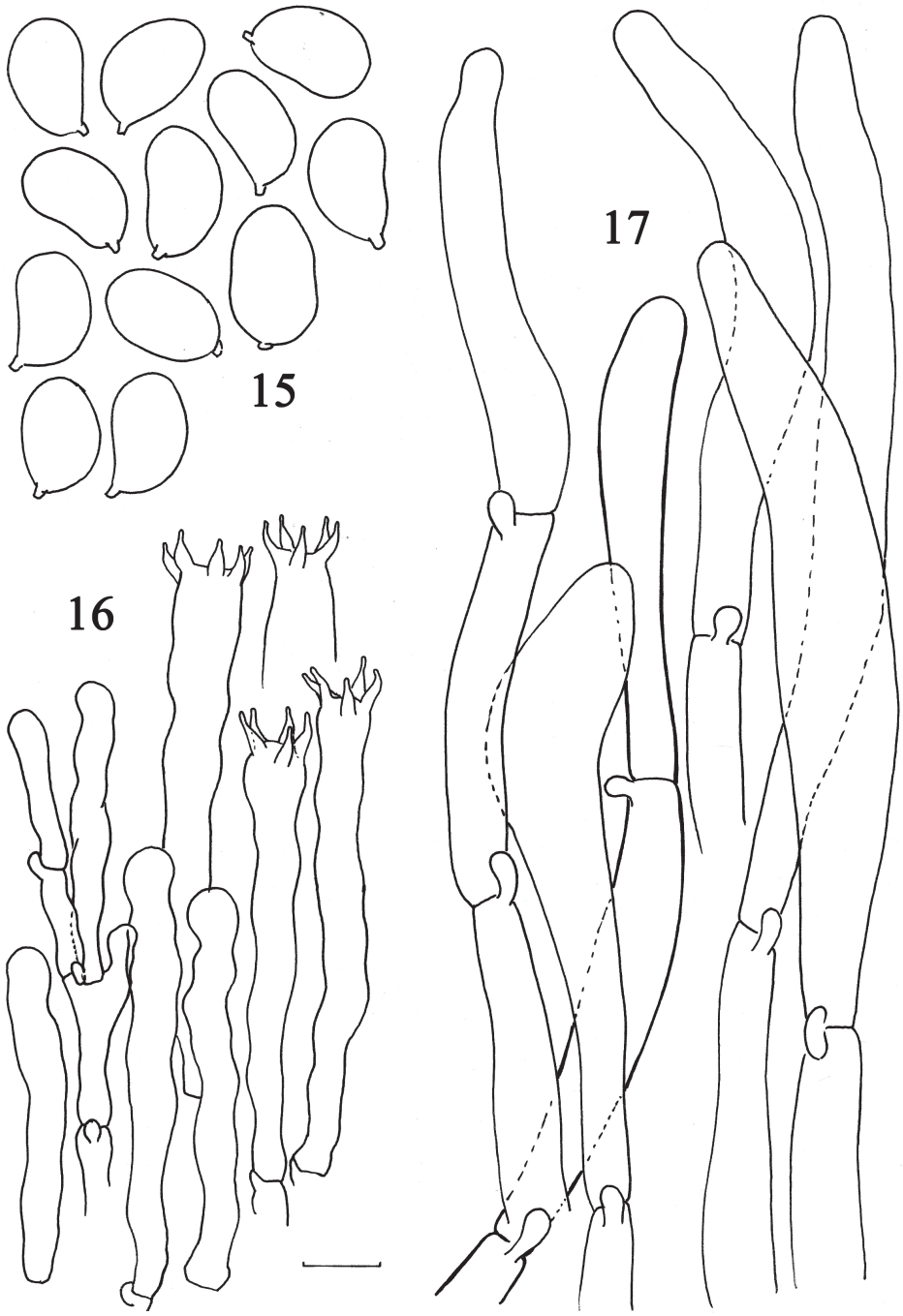
Figs 4-7. *Cantharellus tabernensis*. **4-5**. Spores. **6**. Basidia and basidiola. **7**. Hyphal extremities at the cap surface. Scale bar = 10 µm, 5 µm for spores (all from BB 07.040, except 4 from holotype, drawings B. Buyck).



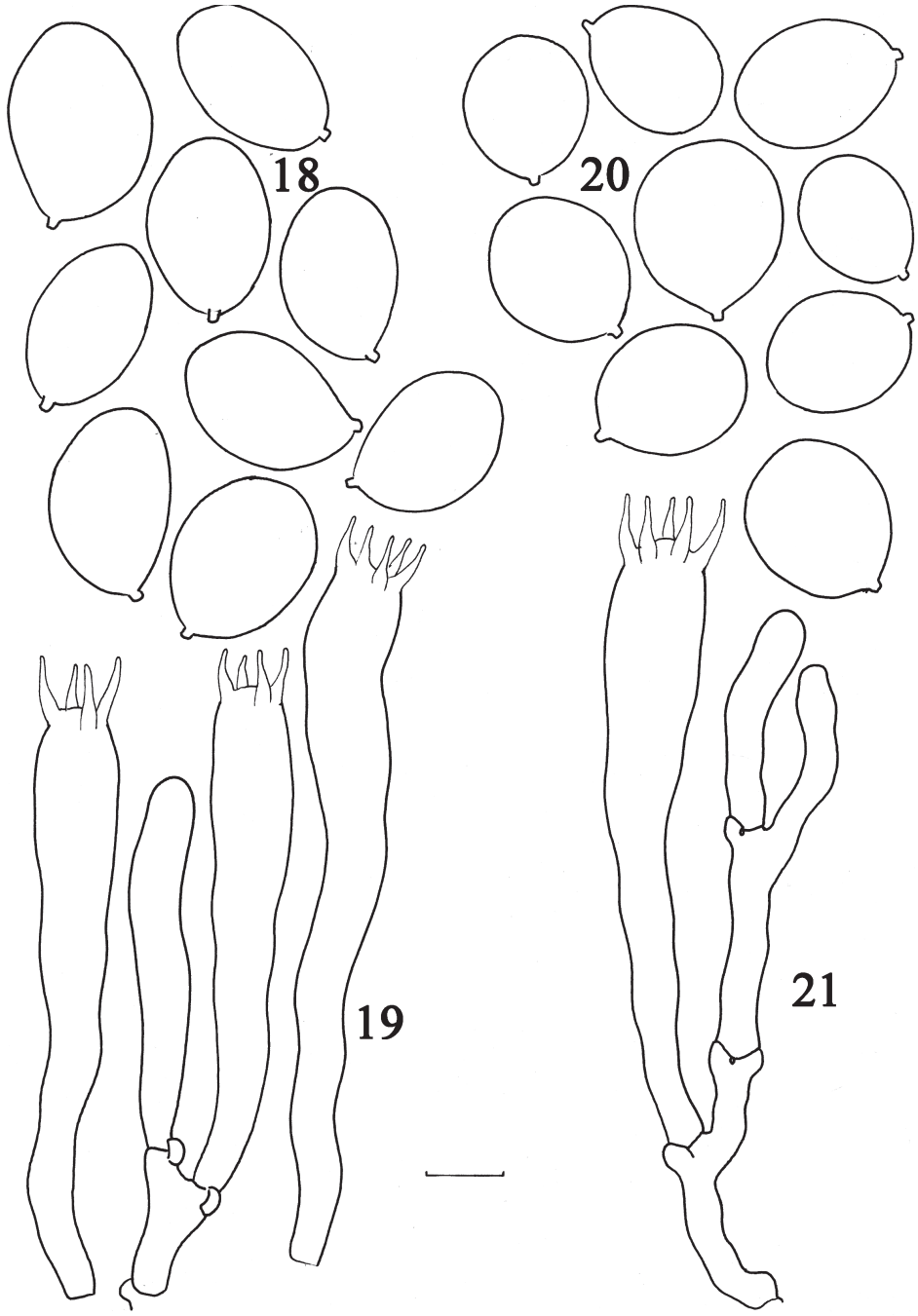
Figs 8-11. *Cantharellus appalachiensis*. **8-9**. Spores.**10.** Basidia and basidiola. **11**. Hyphal extremities at the cap surface. Scale bar = 10 µm, 5 µm for spores (all drawings from BB 07.123, except 8 from holotype, drawings B. Buyck).



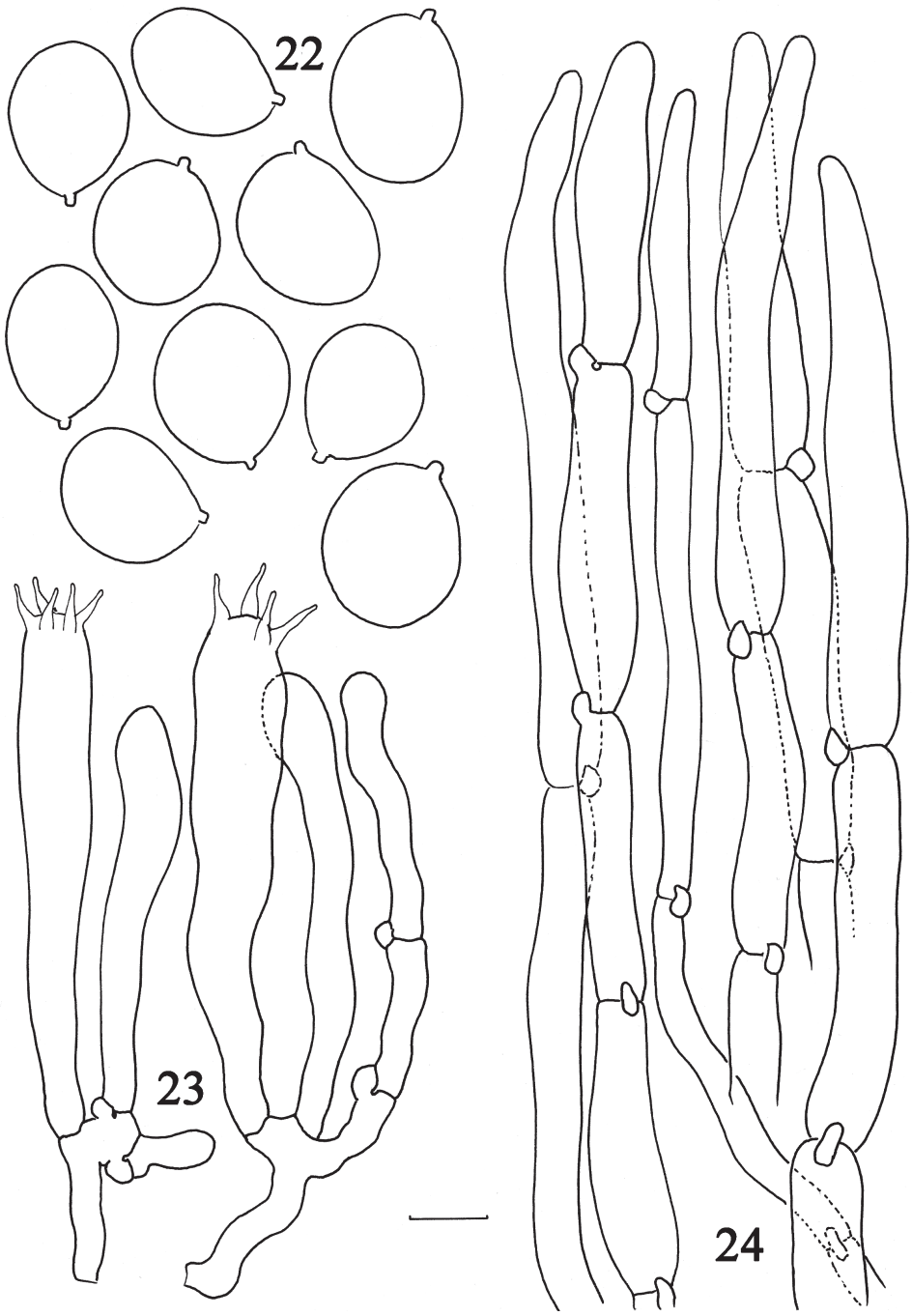
Figs 12-14. *C. septentrionalis.* **12**. Spores. **13**. Basidia and basidiola. **14**. Hyphal extremities at the cap surface. Scale bar = 10 µm, 5 µm for spores (all from holotype, drawings B. Buyck).



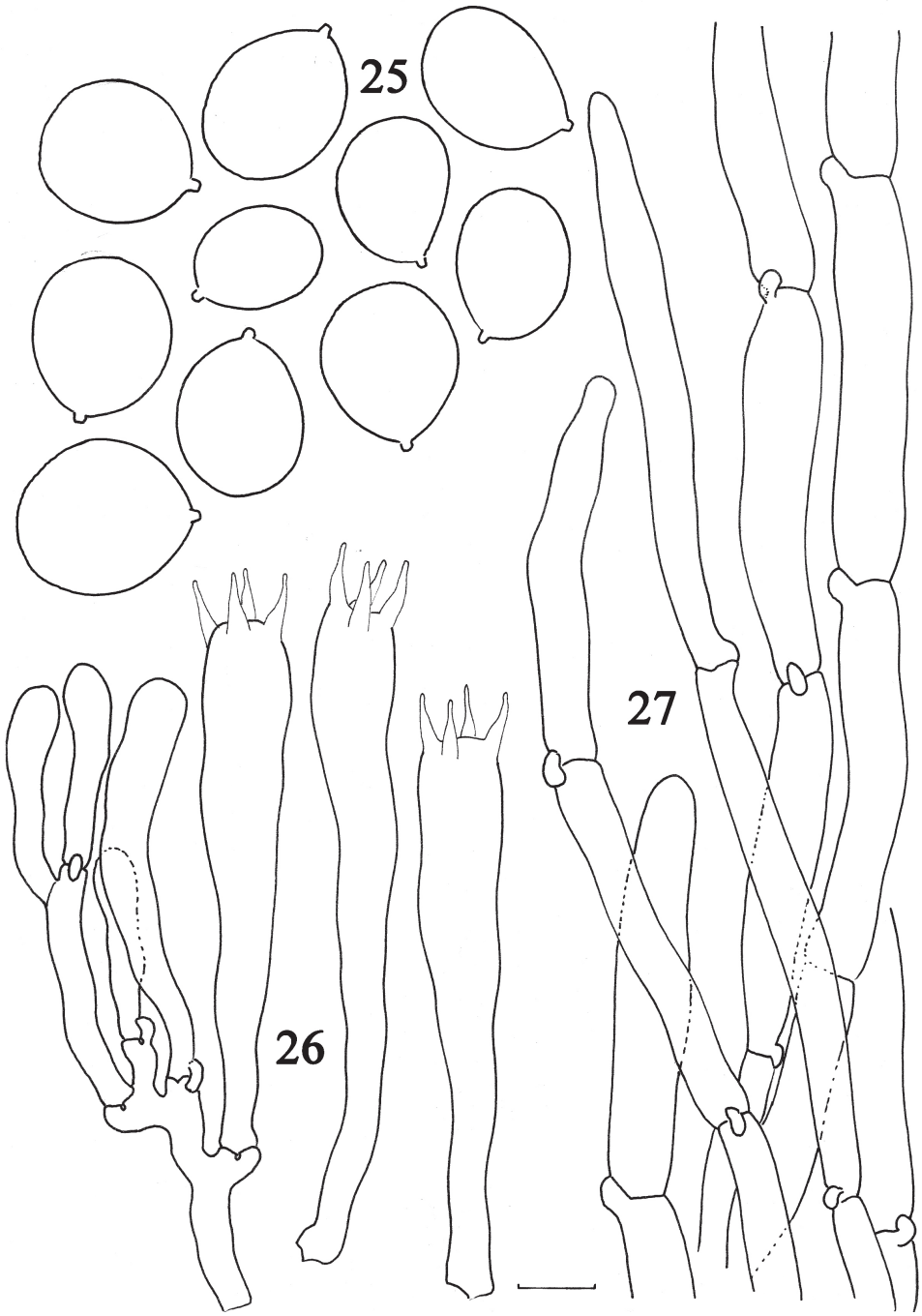
Figs 15-17. *C. minor*. **15**. Spores. **16**. Basidia and basidiola. **17**. Hyphal extremities at the cap surface. Scale bar = 10 µm, 5 µm for spores (all from BB 07.042, drawings B. Buyck).



Figs 18-21. *C. convolvulatus*. **18**. Spores. **19**. Basidia and basidiola. *C. subperforatus*. **20**. Spores. **21**. Basidia and basidiola. Scale bar = 10 µm, 5 µm for spores (all from holotype, drawings G. Eyssartier).



Figs 22-24. *C. flavobrunneus.* **22**. Spores. **23**. Basidia and basidiola. **24**. Hyphal terminations at cap surface. Scale bar = 10 µm, 5 µm for spores (all from holotype, drawings G. Eyssartier).



Figs 25-27. *C. pallidipes*. **25**. Spores. **26**. Basidia and basidiola. **27**. Hyphal terminations at cap surface. Scale bar = 10 µm, 5 µm for spores (all from holotype, drawings G. Eyssartier).

As mentioned above, the overall color and small size of *C. quercophilus* are shared with several other, small, yellowish to brown *Cantharellus*. On the east coast, this concerns more specifically *C. tabernensis,* and in particular *C. appalachiensis* which shares the almost identical coloration and has an equally weak smell and faintly acrid taste (Petersen & Ryvarden, 1971). Both *C. appalachiensis* and *C. tabernensis* are nevertheless much more slender, less compact in habit, with the stipe length exceeding the pileus diameter and neither of the two species displays a noticeable yellowing of the context upon handling. From our own limited field experience (the senior author collected *C. appalachiensis* only once) and from images on the internet, it is possible to conclude that the overall color of *C. appalachiensis* is more grayish brown as opposed to the brownish yellow color of *C. tabernensis*. The stipe of *C. appalachiensis* also tends to inflate slightly towards the base (never so in *C. tabernensis*) and the basidiomes are stouter and more "fleshy" than in *C. tabernensis.* Unfortunately, microscopical features offer little or no help to distinguish among these three chanterelles and this notwithstanding quite important differences in their genomic sequences and systematic placement. *C. quercophilus* is quite unrelated to the other two (in so far that we repeated extraction, amplification and sequencing of its DNA to exclude handling errors from our part): but spores are nearly identical, hyphal endings at the cap surface are – although very similar – somewhat less voluminous, less clavate and more constantly thin-walled in *C. quercophilus.*

There exist, however, indications for ecological and distributional differences among the three above-mentioned species. *C. quercophilus* is possibly a very rare or ecologically restricted taxon. We have never found it in other vegetation types during the past 7 years of collecting in the eastern US and Canada. On the other hand, we have never collected in a post-oak savannah before. It may therefore possibly correspond to a strictly southern taxon with a distribution range that parallels the one for *Quercus stellata* woodland. The other two chanterelles are more common but differ in their distribution area. Indeed, *C. appalachiensis*, although originally described from the Great Smoky Mts. in N Carolina and Tennessee, has a much larger distribution. It was later reported from Massachusetts (Bigelow 1978), Pennsylvania, Illinois, Indiana, Missouri, Kentucky (Kuo 2006), and there have been clearly recognizable pictures posted on the web from Ohio, Georgia and Arkansas (web site www.hsu.edu/content.aspx?id= 48146 as "*tabernensis*"). It also occurs much more to the North, in Québec (Lamoureux & Despres, 2004). Down south in the Gulf States, however, *C. appalachiensis* is apparently a rarity and after several years of collecting around the Gulf, the senior author has found it only once (in Texas – this is the second collection for the State after the one, in exactly the same area, made at the NAMA 2000 Foray at Beaumont, TX). *C. tabernensis,* on the other hand, is a very common and abundant chanterelle around the Gulf and we collected it frequently in Texas, Louisiana and Mississippi, where it occurs on well drained (sandy) soil, in mixed woods, especially near slash pine (*Pinus elliottii* Engelm.) as noted in the original description (Feibelman *et al.*, 1996). This species becomes quickly much rarer in more northern states. To our knowledge, there are no published records of this species from other States than those around the Gulf.

For completeness, we can cite here also *C. minor*, the smallest of all North American chanterelles which can hardly be mistaken for any of the above-mentioned species, except perhaps for some smaller forms of *C. tabernensis*. Notwithstanding its hollow stipe and "hygrophoroid" habit, *C. minor* is a good species of the genus *Cantharellus* (Feibelman *et al.*, 1997) of which it possesses also the stichic basidia (Wakayama 1932). In contrast to its very small size in the

Fig. 28. *C. quercophilus* (holotype) *in situ*. (© B. Buyck)

Fig. 29. *C. quercophilus* (holotype). Details of context and external parts. (© B. Buyck)

field, observation under the microscope (figs 15-17) reveals large spores and also very voluminous, terminal cells at the cap surface that are wider than those of the other chanterelles discussed above.

Finally, a number of other small, brownish *Cantharellus* have been described from more northern areas, in casu Michigan and Nova Scotia (Canada). Our examination of the type specimens confirms that they all belong in the *Craterellus tubaeformis* complex. All of these species differ from the aforementioned *Cantharellus* by their large and more globose spores and quickly hollowing stipes. We transfer these taxa here to *Craterellus*:

Craterellus convolvulatus (A.H.Sm.) Eyssart. & Buyck comb. nov. Figs 18-19
Basionym: *Cantharellus convolvulatus* A. H. Sm., *Michigan Bot.* 7: 161 (1968)

Original description: *"Pileus 3-7 cm latus, irregulariter infundibuliformis, ad marginem lobatus et convolvulatus, perforatus, glaber; hygrophanus, luteo-brunneus demum ochraceus, deinde ochraceo-griseus. Contextus fragilis, sapor mitis; odor nullus. Lamellae decurrentes angustae (venosae), vinaceo-griseae. Stipes 2-5 cm longus, 6-12 mm crassus, fragilis, cavus, glaber, sordide aurantiacus. Sporae in cumulo albidae, 9-13 × 6.5-8.5 µm, late ellipsoideae. Typus*: *Shaffer 2518 (MICH)"*
Holotype: United States: Michigan "Pinckney recreation area, Washtenay County, gregarious at edge of a bog in an oak-hickory woods, august 5th, 1960", L. Shaffer 2518 (MICH).
Iconography: SMITH (1968, fig. 13).

Re-examination of the type: **Spores** (9) 10-*10.8*-11.5 (12) × (6.5) 7-*7.5*-8.5 (9) µm, Q = 1.25-1.43-1.69, strictly oval in lateral view, ellipsoïd to broadly ellipsoid, smooth, hyaline. **Basidia** 66-100 × 8-10 µm, 4(-5)-spored, clavulate to subcilindrical. **Cystidia** absent. **Lamellar trama** well differentiated, composed of relatively short hyphae measuring (8) 10-20 (30) µm diam. **Cap surface** of repent, thin-walled hyphae (6) 10-15 (20) µm diam. **Clamps** abundant in all tissues.

Craterellus flavobrunneus (R.H.Petersen) Eyssart. & Buyck comb. nov. Figs 22-24
Basionym: *Cantharellus flavobrunneus* R. H. Petersen, *Nova Hedwigia* 31: 14 (1979a)

Original diagnosis: *"Ut* Cantharellus infundibuliformis*, sed*: *a) pileus immaturus flavus; b) sporae 8.9- 10.4 × 7.8-8.9 (Em = 1.17)"*
Holotype: **Canada**. Nova Scotia, Kings Co., Black Hole near Baxter's Harbor, under *Picea* and *Betula*, august 30th 1973, leg. & det. R. H. Petersen, *R. H. Petersen* 38030 (TENN holotype).
Iconographie: PETERSEN (1979a, fig. 13).

Re-examination of the type: **Spores** 9-*9.82*-10.5 (11) × (7) 7.5-*8.33*-9 (9.5) µm, Q = 1,1-*1.18*-1.29, broadly ellipsoid to subglobose, smooth, hyaline or faintly yellowish, not amyloïd. **Basidia** mostly 66-90 × (8.5) 10-11 µm, (1) 2-5 (6)-spored, clavulate to subcilindrical. **Cystidia** absent. **Cap surface** composed of repent, thin-walled hyphae of 5-10 (15) µm diam., with free extremities that are sometimes slightly refringent. **Clamps** abundant in all tissues.

Craterellus pallidipes (R.H.Petersen) Eyssart. & Buyck comb. nov. Figs 25-27
Basionym: ***Cantharellus pallidipes*** R. H. Petersen, *Nova Hedwigia* 31: 7 (1979a)

Original diagnosis: *"Ut* Cantharellus infundibuliformis*, sed*: *a) stipes ad basim cremeo; b) stipes aurantiacus vel tangerinus; c) pulvis sporis "cartridge buff"; d) sporae 8.9-12.2 × 7.0-10.5 (Em = 1.18)"*
Holotype: Canada, "Nova Scotia, Kings Co., vic. Kentville, 10 IX 1973", leg. & det. R. H. Petersen, *R. H. Petersen* 38224 (TENN).
Iconography: PETERSEN (1979a, fig. 10, 11).

Re-examination of the type: **Spores** (8) 8.5-*9.45*-10.23 (11) × (6.5) 7-*8.06*-9 (10) µm, Q = 1.05-*1.18*-1.28, broadly ellipsoid to subglobose, smooth, hyaline or faintly yellowish, not amyloïd. **Basidia** mostly 70-85 (100) × 10-11 µm, (2) 3-4 spored, clavulate to subcilindrical. **Cystidia** absent. **Cap surface** of repent to ascendant, thin-walled hyphae with frequent free terminations, 5-8 (10) µm diam., containing a distinct intracellular, pale brown pigment. **Clamps** abundant in all tissues.

Craterellus subperforatus (A.H.Sm.) Eyssart. & Buyck comb nov. Figs 20-21
Basionym: *Cantharellus subperforatus* A. H. Sm., *Michigan Bot.* 7: 160 (1968)

Original diagnosis: *"Pileus 2.5-6 cm latus, plano-depressus ad marginem recurvatus, demum infundibuliformis, atrospadiceus demum sordide luteobrunneus, glaber, rugulosus. Contextus tenuis. Odor fragrans. Sapor mitis. Lamellae angustae, decurrentes, distantes, caeruleofuscae demum ochraceotinctae. Stipes 4-6 cm longus, 4-8 mm crassus, cavus, sursum subfuscus, deorsum sordide aurantiaco-ochraceus. Mycelium laete olivaceoluteum. Sporae 8-11 × 7-9 µm. Typus: Smith 62936 (MICH)"*
Holotype: **United States**: MICHIGAN: Burt Lake, Cheboygan County, gregarious on moss and duff in a cold *Abies-Thuja* bog, 18 VIII 1960, A. H. Smith 62936 (MICH).

Re-examination of the type: **Spores** (8.5) 9-*9.53*-10 (11) × (7) 7.5-*8.16*-9 (9.5) µm, Q = 1.05-*1.14*-1.36, broadly ellipsoid to subglobose, smooth, hyaline. **Basidia** 62-80 × 10-12 µm, (4-)5-6-spored, clavulate to almost cilindrical. **Cystidia** absent. **Cap surface** composed of repent to ascending, thin-walled hyphae of (4)5-10 (15) µm diam., with free extremities that are sometimes slightly refringent. **Clamps** abundant in all tissues.

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