

## STUDIES IN THE GENUS *GASTROBOLETUS*

HARRY D. THIERS & JAMES M. TRAPPE

Thiers, H. D. (Dept. of Ecology & Systematic Biology, San Francisco State College, San Francisco, Calif. 94132) & J. M. Trappe (Pacific Northwest Forest & Range Experiment Station, Corvallis, Oregon 97330). Studies in the genus *Gastroboletus*. *Brittonia* **21**: 244-254. 1969.—The following species of *Gastroboletus* are described as new: *G. subalpinus*, *G. xerocomoides*, *G. suilloides*, *G. imbellus*, and *G. amyloideus*. All of these species have been found in the western portion of the United States. Comments on two previously known species from this region are included. Brief statements are also presented on the possible origin and evolution of this taxon of fungi.

The numerous recent contributions of Smith & Singer to the study of gastromycetoid and secotioid fungi have focused renewed attention on the systematics and taxonomy of these organisms as they occur in North America. *Gastroboletus*, one of the genera studied by them (1959, 1964), closely resembles the boletes in gross appearance. It is readily distinguished by the hymenophore, which, although distinctly tubulose, is developed so as to preclude deposition of spores. The "tubes" are often not vertically oriented, and may be covered by a well-developed, persistent peridial membrane or blocked by outgrowths of wall tissue. Spore deposits have never been observed from any of these fungi on either the adjacent substrate or on the inner surface of the peridial membrane.

Until recently only one species, *Gastroboletus turbinatus* (Snell) Smith & Singer, was known from North America. Smith & Singer (1959) later reported a variety of this species from the Northwest. More recently Mazzer & Smith (1967) described *G. scabrosus* from Michigan. Descriptions of five additional species are presented in this paper.

Most, if not all, of these organisms appear to form mycorrhizae, and a majority seem to be associated with conifers. The outstanding exception to this latter characteristic is *G. scabrosus*, which was collected in an oak-hickory association and has not yet been found with conifers. In the western United States, where most of our field work was done, the species are typically montane to subalpine but may also occur in mesic coastal forests. In subalpine regions *Abies* and *Pinus* species are perhaps the most common associates. Conclusive evidence to support this observation is lacking, however, and other conifers are probably involved.

Although possession of the characters enumerated earlier has resulted in all species being placed in *Gastroboletus*, critical comparisons make it evident that they might have arisen from ancestral types so distinct as to cause them to be placed in different genera of present-day boletes. *G. turbinatus*, for example, appears similar in morphology and anatomy to members of the genus *Boletus*. *G. scabrosus* shows obvious similarities to members of *Leccinum*. *Gastroboletus suilloides* Thiers & Trappe, and *G. imbellus* Trappe, chiefly because of the highly characteristic cystidia, are strongly suggestive of species of *Suillus*. Further comparisons with taxa in the genus *Boletus* reveal gastrobolete species that appear closely related to representatives of the various evolutionary lines within that genus. *G. turbinatus* is strongly suggestive of *B. luridus* Fries. *G. xerocomoides* Trappe & Thiers, as the name implies, shows distinct similarities to the *Xerocomus* species complex; and *G. subalpinus* Trappe & Thiers appears very similar to the species centered around *B. edulis* Bull. ex Fries.

Detailed comment on the possible phylogenetic relationships between the gastro-

boletes and boletes does not seem feasible at this time. It is tempting, however, to speculate that the gastroboletes represent a transition to a hypogeous and gastro-mycetoid habit after having arisen from epigeous boletoid ancestors. Furthermore, since hymenophores of the two groups are so remarkably similar, it seems probable that gastroboletes were derived from boletes by initially losing forcible spore discharge, then the loss of the regular, vertical orientation of hymenophore dissepiments. This supposition is based on the presumption that loss of forcible spore discharge would remove any selective pressure that might have preserved a regular, vertical arrangement of the hymenophore.

In the following descriptions, colors keyed by the Color Atlas of Kornerup & Wanscher (1962) are designated "K. & W.," those keyed by Ridgway (1912) are designated "R." Much of the field work by the senior author was made possible by Grants No. G5845 and No. GB2760 from the National Science Foundation and by Faculty Research Grants from San Francisco State College. Herbaria in which examined collections are deposited are abbreviated as SFSC for San Francisco State College, OSC for Oregon State University, and MICH for the University of Michigan.

The following taxonomic key is presented to encourage study of this challenging group of fungi and does not represent an exhaustive study of the genus for any given region. We have not studied *G. turbinatus* var. *flammeus* Smith in Smith & Singer (1959), *G. boedijnii* Lohwag, nor *G. fascifer* Singer & Smith, but have included them in the key on the basis of the descriptions by Smith & Singer (1959) and Singer & Smith (1964). The latter two species are known only from Asia and Africa respectively.

1. Peridial membrane white, enclosing gleba, persistent, well differentiated from the epicutis of the "cap" 1. *G. subalpinus*
1. Peridial membrane either absent or not as above. 2. *G. scabrosus*
  2. Stipe scabrous, similar to stipe surface of *Leccinum*
  2. Stipe not scabrous but may be glabrous, striate, floccose or tomentose, occasionally reticulate or glandular dotted at the apex. 3. *G. xerocomoides*
  3. About half of the spores truncate and with small germ pore 3. *G. xerocomoides*
  3. Truncate spores with germ pores absent
  4. Cystidia clustered and staining dark brown in KOH as in *Suillus*. 4. *G. suilloides*
    5. Spores brown and subgleba ochraceous in KOH 4. *G. suilloides*
    5. Spores hyaline and subgleba vinaceous to lilac in KOH. 5. *G. imbellus*
  4. Cystidia lacking or not as above. 6. *G. amyloideus*
    6. Context not turning blue where exposed; spores noticeably amyloid in mass 6. *G. amyloideus*
    6. Context quickly turning blue when exposed or spores not amyloid.
      7. Spores 6.5–9.5  $\mu$  broad. 7. *G. turbinatus*
      8. Spores 13.5–18.0  $\mu$  long var. *turbinatus*
      8. Spores 11–14  $\mu$  long 8. *G. turbinatus*
      8. Spores 11–14  $\mu$  long var. *flammeus*
    7. Spores 4–5.5  $\mu$  broad.
      9. Peridial surface fasciculate-squamose shaggy 9. *G. fascifer*
      9. Peridial surface smooth, unpolished 10. *G. boedijnii*

### 1. *Gastroboletus subalpinus* Trappe & Thiers, sp. nov.

Pileus 60–100 mm latus, exoperidium bulbalinum vel subbrunneum, siccum, glabrum vel subtomentosum; peridium inferum tenue, album, subtomentosum, persistens; gleba tubulosa, lutea demum olivaceo-brunnea; stipes 20–50 mm longus, 20–45 mm latus, subventricosus vel bulbosus, albus vel bulbalinus, siccus, apice reticulatus; sporae 4.5–6  $\times$  10–16  $\mu$ , laeves, ellipsoideae; cuticula innexa.

Gastrocarp 60–100 mm broad, convex, becoming plane to deeply depressed to plano-convex at maturity, boletoid in overall appearance, frequently highly pitted and wrinkled and irregular in outline.

Peridium: Upper surface dry to moist, glabrous to velutinous to subtomentose, typically covered with adherent soil and debris; when young "warm buff" to "light buff" to "pale olive buff" (R) (K & W 4A2) to "pinkish cinnamon" (R) (K & W 5A4), unchanging with age or darkening to near "clay color" to "buckthorn brown" (R); peridium on lateral and undersides of gleba white, thin, velvety, persistent except for scattered, circular ruptures over mouths of occasional glebal tubes in age, dirty from copious, adherent soil.

Context: 3–15 mm thick at disc, tapering gradually to margin of upper surface, soft, white or on some with sordid yellowish to olivaceous zones, in some gastrocarps slowly staining pinkish to grayish lavender when cut.

Odor of context mild to farinaceous; taste mild, pleasant.

Gleba: Tubulose, the tubes 10–30 mm long, but markedly diminished in length in both directions from the broadest point of the hymenophore. In youth grayish yellow (K & W 3B4) = "dark olive buff" to "pale olive buff" (R), with age becoming olive brown (K & W 4D5) = "buffy citrine" to "citrine drab" (R). Gleba depressed to seceded from stipe-columella, strongly projecting beyond upper peridium but then covered by the thin, pallid, lateral peridium. Tubes occasionally oriented vertically near the stipe-columella, but mostly curved and oriented 20° from vertical to horizontal, or angled upwards near edges of the hymenophore. Pores small, less than 1 mm broad, concolorous with tubes, unchanging when bruised.

Stipe-columella: 20–50 mm long, 20–45 mm thick at apex, subventricose or tapering downward, occasionally equal to bulbous at the base, base up to 3–4 cm broad in some gastrocarps; surface dirty white to "warm buff" to "light buff" (R) in some, the base orange yellow (K & W 4A6 = (R) "apricot yellow"); dry, but typically covered with adherent soil and debris; glabrous to velutinous to subtomentose with the apex reticulate when the gleba has seceded. Context white, unchanging.

Spores: 4.5–6 (8) × 10–16 (18)  $\mu$ , smooth, ellipsoid, oblong to subovate, occasionally irregularly constricted near middle, light yellow to ochraceous in KOH and Melzer's, moderately thick-walled, sterigmatal appendages oblique.

Hymenium: Basidia 8–13 × 40–48  $\mu$ , thin walled, hyaline and guttulate in KOH, clavate, evenly attenuating from above the middle to a narrow base, with 4 sterigmata, 3–4  $\mu$  long. Brachybasidioles 7–12 × 25–40  $\mu$ , similar in shape and appearance to basidia. Cystidia often abundant when young, especially on the pores, apparently collapsing and appearing infrequently with age, single or sometimes clustered, hyaline in KOH and Melzer's thin walled, subcylindric to clavate to tapered, 7–10 × 24–75  $\mu$ .

Tissue: Clamp connections lacking. Epicutis of peridium on top of gastrocarp composed of densely interwoven, much branched hyphae 4–15  $\mu$  broad, with erect, tapered, blunt-tipped terminal cells 7–12 × 25–45  $\mu$ , sparsely scattered over the surface. In KOH all hyphae hyaline; in Melzer's hyphae pallid to pale yellow to bright reddish brown (intensity of color reaction in Melzer's varies directly with degree of coloration of epicutis). The more darkly colored areas of epicutis contain intercellular deposits of dextrinoid debris. Peridial epicutis over lateral and undersides of gleba when young a trichodermium that collapses with age, of blunt-tipped, cylindrical to tapered to occasionally subcapitate cells 8–12 × 27–65  $\mu$ . Subtrichodermial hyphae interwoven, 4–10  $\mu$  broad, confluent with glebal trama and stuffing the mouths of glebal tubes through maturity, hyaline in KOH except for localized pale golden brown areas, in Melzer's uniformly pale yellow. Oleiferous hyphae abundant. Context of upper peridium of thin-walled, often inflated, loosely interwoven hyphae (3) 8–25  $\mu$  broad. Hyaline oleiferous hyphae 12–20  $\mu$  broad and with walls thickened to 1  $\mu$  are scattered throughout. Cutis of stipe-columella when young a palisade of hyaline clavate cells 6–15 × 22–35  $\mu$ , with occasional fertile basidia, collapsing in age and

then present only at remnant patches. Context of stipe-columella of subparallel to interwoven hyphae 4–15  $\mu$  broad, hyaline in KOH and pale yellow in Melzer's. Oleiferous hyphae abundant. Trama of glebal tubes 60–80  $\mu$  wide, consisting of hyaline, parallel hyphae 4–6 (8)  $\mu$  broad, not divergent. Subhymenium interwoven of hyphae similar to trama but with inflated cells 5–15  $\mu$  broad scattered throughout.

Solitary to gregarious, hypogeous or partially erumpent, under and probably mycorrhizal with *Pinus albicaulis* Engelm. or *Abies magnifica* A. Murr. and possibly other conifers of montane and subalpine forests in Oregon and California. Commonly found in late spring and summer.

TYPE: OREGON: Hood River County: Cloud Cap, *Trappe 607* (HOLOTYPE: OSC).

Additional material examined:

CALIFORNIA: Calaveras County: Calaveras Big Trees State Park, *Thiers 21270* (SFSC); Camp Connell, *Thiers 21266* (SFSC). Tuolumne County: Yosemite National Park, *Thiers 21017* (SFSC); Pinecrest, *Thiers 21292* (SFSC). Sierra County: Yuba Pass, *Thiers 21151* (SFSC). Fresno County: Huntington Lake, *Thiers 13422, 13436* (SFSC). OREGON: Clackamas County: Clackamas Lake, *Goetz 30* (SFSC).

*Gastroboletus subalpinus* is readily distinguished from the other known species of the genus by its smooth, generally whitish-pallid peridium and stipe. It is distinctly gastroid in having a gleba whose tubes are curved, not vertically oriented, and mostly closed by peridial tissue through maturity. The hypogeous habit of the type collection has been noted in other gatherings but may not be typical as many spore-shedding agarics [e.g., *Amanita muscaria* (L. ex Fr.) Pers. ex Hook.] mature without breaking through the surface in timberline habitats.

When first collected in California, the specimens were thought to be abnormal carpophores of *Boletus edulis*, although the tubes were more or less enclosed and disorganized in orientation. Subsequent collections made it apparent, however, that these were carpophores of a species of *Gastroboletus*. In the case of each collection careful search was made for normal-appearing carpophores of *B. edulis*, but none was found.

2. *GASTROBOLETUS SCABROSUS* Mazzer & Smith, Michigan Botanist **6**: 60. 1967.

This species has not been collected by either of the authors and is apparently reported only from Michigan. The taxon is considered significant since it is the only one known that is apparently related to and possibly derived from *Leccinum*. *G. scabrosus* is most readily distinguished from other gastroboletes by the scaly covering on the stipe-columella and is one of the few species known exclusively from hardwoods.

3. *Gastroboletus xerocomoides* Trappe & Thiers, sp. nov.

Pileus 30–60 mm latus; peridium siccum, tomentosum, luteum vel olivaceum; gleba tubulosa, lutea, caerulea ubi secta; stipes obscurus, saepe nullus siccus, glaber vel furfuraceus, pallidus vel bulbalinus; sporae 6.4–8  $\times$  12.8–18  $\mu$ , laeves, ellipsoideae, saepe truncatae porosae; cystidia nulla; cuticula innexa.

Gastrocarp 30–60 mm broad, convex to plano-convex; margin incurved, entire.

Peridium: Dry, tomentose, occasionally somewhat rimose, suggestive of *Xerocomus subtomentosus* (Fr.) Quel., colored near "isabella color" or "tawny olive" to as dark as "Saccardo's umber" (R), not covering underside of gleba.

Context: Up to 15 mm thick at disc, whitish but staining brown in some areas and blue in others when exposed.

Gleba: Tubulose, the tubes up to 15 mm long, not vertically oriented, near "old gold" (R), staining blue where cut or bruised. Mouths concolorous but staining brownish to ochraceous where bruised.

Stipe-columella: Poorly developed, 10–25 mm long, 4–8 mm broad, occasionally much shorter or lacking, equal or tapered downward, surface dry, glabrous to furfuraceous, pallid to “warm buff” (R), staining brown with age or where bruised. Context pallid at apex, grading to distinctly reddish at the base, staining blue in irregular areas when exposed.

Spores:  $6.4\text{--}8 \times 12.8\text{--}18$  (21)  $\mu$ , smooth, ellipsoid to subcylindric, inequilateral, pyriform, or slightly constricted in the middle, about half being truncate; in KOH yellowish singly, yellowish brown in mass, guttulate, in Melzer’s somewhat browner but neither amyloid nor dextrinoid at any stage of development.

Hymenium: Basidia  $10\text{--}12 \times 30\text{--}38$   $\mu$ , clavate, yellow in KOH from refractive cytoplasmic content, with 1 to 4 subcylindric sterigmata  $1\text{--}1.5$   $\mu$  broad and 3  $\mu$  long. Brachybasidioles  $6\text{--}10 \times 16\text{--}25$   $\mu$ , subcylindric, hyaline. No cystidia noted.

Tissue: No clamp connections found. Peridial epicutis a turf of erect hyphal tips with subcylindrical to tapered terminal cells arising from a subcutis of interwoven hyphae  $5\text{--}10$   $\mu$  broad; hyphal surfaces irregularly encrusted with bands or patches of golden yellow material which slowly dissolves in KOH or Melzer’s. Cuticular tissue golden brown in KOH, orange-brown to reddish brown in Melzer’s. Peridial context of interwoven hyphae  $3\text{--}10$   $\mu$  broad; scattered oleiferous hyphae present. Tissue hyaline to pale yellowish in KOH; in Melzer’s pale to deep reddish near subcutis grading to dull yellowish below. Epicutis of stipe-columella a hymenium of fertile basidia; brachybasidioles and fusoid-ventricose cystidia deep yellow in Melzer’s. Subcutis dull grayish-yellow in KOH, deep orange in Melzer’s, the hyphae  $3\text{--}10$   $\mu$  broad, oleiferous hyphae abundant. Context of stipe-columella similar to subcutis but hyaline in KOH. Glebal trama of parallel to subparallel hyphae  $4\text{--}8$   $\mu$  broad, hyaline to pale yellowish in KOH and light yellow in Melzer’s. Subhymenium of similar hyphae, tightly interwoven to obscurely divergent.

Gregarious in humus in coniferous forest usually in vicinity of *Abies magnifica* at higher elevations in the Sierra Nevada of California. Found only in late summer.

TYPE: CALIFORNIA: Sierra County: Yuba Pass, *Thiers 13163* (HOLOTYPE: SFSC).

Additional material examined:

CALIFORNIA: Sierra County: Yuba Pass, *Thiers 21116* (SFSC).

This gastrobolete, showing obvious affinities with the xerocomoid group of boletes, is the only known species with truncate spores. The structure of the apical pore is similar to those in *Xerocomus truncatus* Singer, Snell, & Dick. The erratic bluing of the context and the dry tomentose peridium are macroscopic characters similar to species of *Xerocomus*. Microscopically, similarities are seen in the structure of the cutis including the encrustations on the cuticular hyphae.

#### 4. *Gastroboletus suilloides* Thiers, sp. nov.

Pileus 2.5–5 cm latus; peridium siccum, glabrum demum tomentosum vel fibrillosum, ochraceum vel cinnamomeum; gleba tubulosa, flavovirens vel olivacea, immutabilis; stipes obscurus, 0.5–1 cm longus, 3–5 mm latus, siccus, brunneus; sporae  $3.5\text{--}4.5 \times 6.4\text{--}12$   $\mu$ , ellipsoideae; cystidia gregaria, fusca in KOH; cuticula apressa vel innexa.

Gastrocarp 2.5–5 cm broad at maturity; convex to subglobose to plano-convex during all stages of development.

Peridium: Surface dry, glabrous when young, often becoming fibrillose to tomentose to appressed fibrillose scaly with age, sometimes becoming areolate with age; colored “ochraceous buff” to “cinnamon brown” to “buckthorn brown” to occasionally as dark as “mikado brown” to “sayal brown” (R) when older, unchanging when bruised.

Context: 3–7 mm thick, “ochraceous buff” to pale “cream color” (R), unchanging when exposed. Taste and odor not distinctive.

**Gleba:** Distinctly tubulose; tubes arranged so as to make a spore deposit impossible; typically exposed at maturity; greenish yellow to olive-yellow, unchanging when bruised or exposed; pores small, irregular, concolorous with the tubes.

**Stipe-columella:** Typically poorly developed, 5–10 mm long, 3–5 mm broad; surface dry, tomentose to appressed fibrillose; more or less concolorous with the pileus during all stages of development.

**Spores:**  $3.5\text{--}4.5 \times 6.4\text{--}12 \mu$ , brown to dark brown in KOH and Melzer's, ellipsoid to inequilateral, some appearing ovoid or occasionally more or less constricted at the midportion, smooth, walls slightly thickened, sterigmatal appendages oblique.

**Hymenium:** Basidia  $6\text{--}8 \times 20\text{--}37 \mu$ , narrowly clavate to subcylindric, clavate to depressed at the center, hyaline in KOH, with four sterigmata; brachybasidioles  $4\text{--}8 \times 15\text{--}23 \mu$ , clavate. Cystidia abundant to numerous, typically clustered and staining dark brown in KOH and Melzer's as in *Suillus*, clavate to cylindrical to subcylindric,  $5\text{--}11 \times 35\text{--}55 \mu$ .

**Tissue:** Clamp connections absent. Peridial epicutis of appressed, interwoven to subparallel to sometimes tangled hyphae,  $5\text{--}12 \mu$  broad, yellow to dark brown in KOH and Melzer's, not gelatinous. Peridial subcutis of hyphae  $6\text{--}25 \mu$  broad, tissue yellow-brown in KOH and dark orange in Melzer's. Peridial context interwoven, hyphae  $5\text{--}30 \mu$  broad, staining bright ochraceous in KOH, deep orange in Melzer's. No oleiferous hyphae present. Stipe-columella without distinctive epicutis, of loosely subparallel hyphae  $7\text{--}30 \mu$  broad and having some inflated cells up to  $50 \mu$  broad, grayish yellow in KOH. Glebal trama a central stratum of hyaline, parallel hyphae  $4\text{--}9 \mu$  broad, with abundant oleiferous hyphae, diverging from a central stratum toward the cellular hymenium.

Solitary to gregarious, hypogeous to partially emergent, under conifers including *Abies magnifica* and *Pinus murrayana* Grev. & Balf. Known only from higher elevations in the Sierra Nevada of California. Found only in late summer.

**TYPE:** CALIFORNIA: Inyo County: Mammoth Mountain, *Thiers 20991* (HOLOTYPE: SFSC).

Additional material examined:

CALIFORNIA: Inyo County: Mammoth Mountain, *Thiers 20990* (SFSC). Fresno County: Huntington Lake, *Thiers 13412* (SFSC).

This species shows considerable affinity with the genus *Suillus*, especially in the presence of fascicled, darkly staining cystidia, which are highly characteristic of that genus. This close relationship is further substantiated by the similarity of shape and size of the spores of the two taxa. Although both characters often occur in *Suillus*, neither a viscid pellicle nor an annulus was observed in any collections of *G. suilloides*.

##### 5. *Gastroboletus imbellus* Trappe, sp. nov.

Pileus 50 mm latus; peridium humectum, fibrillosum, griseolum vel flavidum; gleba tubulosa, olivacea; stipes 30 mm longus, 15 mm latus, lateralis, luteus vel roseus; sporae  $2.5\text{--}5 \times 7\text{--}10 \mu$ , ellipsoideae; cystidia gregaria, fusca in KOH; cuticula innexa.

Gastrocarp 50 mm broad, convex, expanded, boletoid in appearance except for the lateral attachment of the "pileus" to the stipe-columella.

Peridium: Moist but not viscid, the ground color grayish yellow (K & W 4B3) overlain by dark olivaceous fibrils to produce an overall sordid grayish appearance. Cutis ruptured by a few broad cracks that extend deeply into the context, which is rose-blushed where thus exposed. Margin raggedly membranous-appendiculate from a 2–3 mm broad extension of the peridium.

Context: 20 mm thick at attachment of stipe-columella, soft, white with scattered

pale yellow stained areas, a rosy zone above the gleba and a 2 mm thick olive-hygrophanous zone under the cutis, slowly and erratically staining light sordid brownish where cut. Where wetted with 5% KOH context quickly turns deep lilac adjacent to the peridium.

Odor of context pungent-farinaceous. Taste slightly bitter.

Gleba: Exposed, tubulose, the tubes decurrent, readily separable from context, very short (not exceeding 2 mm in length), pale grayish olive. Pores rotund,  $\frac{1}{4}$ –1 mm broad, mostly blocked by folds and outgrowths of wall tissue. Tubes oriented at about 40° from vertical. When wetted with 5% KOH, tube mouths become dark brown, bases deep lilac.

Stipe-columella: 30 mm long, 15 mm thick at apex, equal except for a slight attenuation at the base, laterally attached to pileus; apical surface dry, dull yellowish, the color grading to sordid creamy in the midportion to pale salmonaceous with copious dark brown stains at base; upper half with dark brown to blackish glandular dots which are minute singly but often coalesced into patches up to one-half mm broad; no trace of peridial remnants remaining on stipe; context pallid with a vinaceous blush near the base, slowly sordid when cut.

Spores:  $2.5 \times 7$ –10  $\mu$ , thin walled, smooth, narrowly to broadly ellipsoid to obovate, slightly inequilateral in profile, mostly with one or two large guttules and often with several smaller ones, hyaline in KOH and pale yellow in Melzer's (the few fertile basidia scattered in the glandular dots of the stipe produced spores that were pale to dark vinaceous in KOH).

Hymenium: Basidia 3–5 (7)  $\times$  20–30  $\mu$ , thin walled, hyaline and guttulate in KOH, sterigmata inconspicuous. Brachybasidioles similar to basidia but shorter. Cystidia fasciated, 4–6  $\times$  25–60  $\mu$ , hyaline to vinaceous to dark brown in KOH with much brown, amorphous material deposited at the base of the clusters, cylindrical to fusoid-ventricose or irregularly constricted.

Tissue: Clamp connections lacking. Epicutis of peridium in KOH of granulated, pale brownish, thin walled hyphae 3–6  $\mu$  broad; subcutis similar except that hyphae are 5–12  $\mu$  broad and much yellowish to pale vinaceous debris is present. In Melzer's epicutular hyphae are yellowish and subcuticular hyphae more or less vinaceous stained; orange-brown pigment balls scattered throughout. Context of interwoven, hyaline, thin walled hyphae 5–20  $\mu$  broad, with sparsely scattered vinaceous debris; in Melzer's, the hyphae yellowish but obscured by abundant, orange-brown pigment balls. Hyphae of stipe-columella similar to those of peridial context but more or less parallel; glandular dots are palisades of dark brown, much encrusted elements 5–9  $\mu$  broad, including scattered fertile basidia. Subglebal tissue bright lilac in KOH when fresh and diffusing a lilac pigment into the mounting medium, merely vinaceous when revived in KOH; in Melzer's deep yellow with many brown, amorphous deposits; hyphae thin walled, 3–8  $\mu$  broad, oleiferous hyphae present. Trama of tubes parallel, hyaline, thin-walled hyphae 4–14  $\mu$  broad, oleiferous hyphae few.

Solitary under *Tsuga mertensiana* (Bong.) Carr and *Abies amabilis* (Dougl.) Forbes. Known only from the type collection. Collected in midsummer.

TYPE: OREGON: Lane County: Olallie Ridge Trail, East Fork McKenzie River, 5000 ft, *Trappe 1703* (HOLOTYPE: OSC).

Because of the drab coloration and rather unpleasant odor and taste, *G. imbellus* resembles *Suillus pungens* Thiers & Smith. Although suilloid in most macroscopic and microscopic characters, no spores were deposited, and the tubes were mostly blocked at maturity by folds and outgrowths of the walls. It is distinct from other known *Gastroboletus* or *Suillus* species because of the combination of very short glebal tubes, the persistently membranous-appendiculate margin of the "pileus," and

the distinctive reactions of subcutis, context, and especially subgleba in KOH. The lateral stipe attachment is novel for *Gastroboletus* or the Boletaceae. For this very reason, more collections are needed to confirm the constancy of this feature.

6. ***Gastroboletus amyloideus*** Thiers, sp. nov.

Pileus 40–80 mm latus; peridium siccum, glabrum vel subtomentosum, luteum vel rubellum; gleba tubulosa, lutea; sporae 13.5–18 × 6–7  $\mu$ , amyloideae in cumulo; cuticula innexa.

Gastrocarp 4–8 cm broad at maturity; convex to broadly convex when young, becoming flattened to depressed to plano-convex at maturity.

Peridium: Surface dry, dull, glabrous to subtomentose during all stages of development; colored yellow (“colonial buff” to “old gold”) (R) to reddish (“ochraceous buff” to “ochraceous tawny”) (R), or at least with reddish areas scattered throughout. No gastrocarps were entirely red.

Context: 1–2 cm thick, colored pale yellow, unchanging when exposed. Taste and odor not distinctive.

Gleba: Tubulose, tubes 1–2.5 cm long, highly disoriented and appearing to radiate at various angles from the peridium; characteristically colored near “colonial buff” to “chamois” (R) during all stages of development, unchanging when bruised or exposed; pores small, less than 1 mm broad, concolorous with the tubes occasionally reddish.

Stipe-columella: Very reduced and sometimes apparently lacking, 10–20 mm long, 5–15 mm broad; surface dry, dull, glabrous, colored near “chamois” to “old gold” to as pale as “warm buff” (R) during all stages of development; with a characteristic red band at the apex; solid; context yellow, unchanging upon exposure.

Spores: 6–7 × 13.5–18.8  $\mu$ , brown in KOH, strongly amyloid when seen in mass in Melzer’s; fusoid to subcylindric, thick walled, smooth, sterigmata terminal.

Hymenium: Basidia 7–10 × 26–32  $\mu$ ; hyaline, clavate, 4-spored; cystidia apparently not present; brachybasidioles hyaline, clavate, similar to basidia but smaller.

Tissue: Clamp connections absent. Epicutis of upper peridium interwoven to tangled, pale ochraceous to dark yellow in KOH and Melzer’s, hyphae 5–7  $\mu$  broad; peridial trama homogeneous to interwoven, up to 15  $\mu$  broad, septations in Melzer’s highly differentially stained, becoming conspicuous and giving either a dextrinoid or amyloid reaction. Tube trama hyaline, more or less homogeneous, weakly divergent, at least in young gastrocarps.

Hypogeous under *Pinus murrayana* and *Abies magnifica* in higher elevations in Sierra Nevada in California. Known only from the type collection. Collected only in late summer.

TYPE: CALIFORNIA: Sierra County: Yuba Pass, *Thiers 21117* (HOLOTYPE: SFSC).

As the name indicates, the most striking characteristic of this fungus is the conspicuous amyloid reaction of the spores and the interesting feature of the differential staining of the septations. Mounts were made from all carpophores in the collection, and all showed similar reactions. Both reactions were typically strong enough to be seen clearly with the low-power objective. In most other features this fungus is somewhat suggestive of *G. turbinatus*, although the exposed flesh did not immediately change to blue.

7. **GASTROBOLETUS TURBINATUS** (Snell) Smith & Singer var. *turbinatus*. Brittonia **11**: 208. 1959.

In studying collections of this species from Oregon and Idaho, Trappe noted that the spores fit the description by Smith & Singer (1959) but not their illustration of

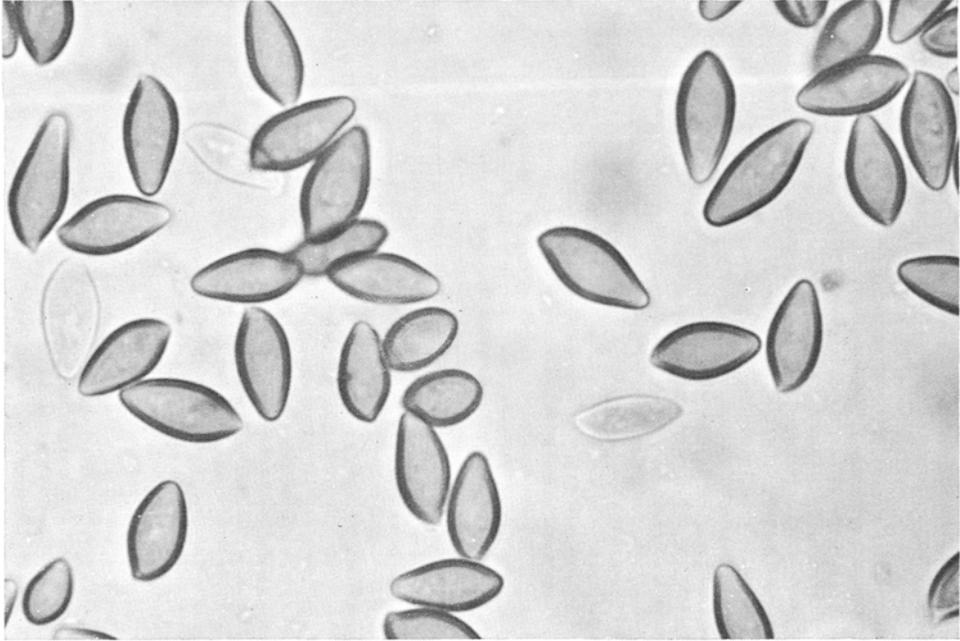


FIG. 1. Basidiospores of the type of *Gastroboletus turbinatus* [D. H. Linder (Snell Herb. 345)].  
 × 2000.

spores of Snell's type. Through study of the type, as kindly loaned by Prof. Snell, the accuracy of Smith & Singer's illustrations was reconfirmed, as well as the difference in spores between the type, collected in Missouri, and the far western collections.

The spores of the type are generally broadly sublenticular, inequilateral in profile, and have an apical pore (Fig. 1). Those of far western collections, in contrast, are predominantly ellipsoid to oblong to subovate or occasionally constricted about the middle, equilateral in profile, and lacking an obvious apical pore (Fig. 2). The type coincided with far western collections in all other features, however, and there was some similarity in spore shape. The difference in spores is accordingly judged to be an expression of the wide variation reported as characteristic of *G. turbinatus* by Smith & Singer.

In all collections examined, spores produced by caulobasidia ranged  $5-7 \times 10-12 \mu$  in size, quite smaller on the average than those produced by glebal basidia.

In the course of these studies, the dried context of collections was noted to blacken immediately when touched with Melzer's but this color faded to bluish in about 15 minutes. Sections of all tissue except the peridium, when cut from dried material and mounted in Melzer's, immediately turned faint to dark blue. The color faded quickly and in many cases was not detectable microscopically, no matter how little time elapsed between mounting and examination.

Other frequent but not universally consistent reactions of tissue revived in Melzer's were as follows: pink hues in occasional cells of the peridial context; scattered deposits of deep brown to black crystalline debris in context of the stipe-columella; occasional patches of deep red stain in the hymenium of the stipe-columella; and a pale to intense pinkish brown color of immature spores (dextrinoid).

At the time of Smith & Singer's (1959) treatment of *G. turbinatus*, the species was



FIG. 2. Basiospores of *Gastroboletus turbinatus* (Trappe 848) from Oregon.  $\times 2000$ .

known to range from the Cascade Mountains of Oregon and Washington eastward to Missouri, and also was reported from near Mexico City (Gispert de Imaz, 1958). Since then, collections have been made by Trappe in the Coast Range of Oregon, as well as on the northern Oregon coast, and Thiers has made collections in the Sierra Nevada of California. On Marys Peak at an elevation of ca. 4000 ft in the Oregon Coast Range, it occurred as a probable mycorrhizal associate of *Abies procera* Rehd. On the coast it was found under mixed stands of *Picea sitchensis* (Bong.) Carr. and *Tsuga heterophylla* (Raf.) Sarg. at elevations of 50 to 100 ft. Whether only one or both of these conifers served as mycorrhizal hosts could not be determined for these collections, but in all likelihood both did; other collections by Trappe in the Cascade Mountains were specifically associated with *Tsuga heterophylla* and *Picea engelmannii* Parry, respectively. The single collection from California was found under *Abies magnifica* and *Pinus murrayana* at an elevation of approximately 6000 ft.

TYPE: MISSOURI: Valley Park, *D. H. Linder* (HOLOTYPE: *Snell Herb.* 345).

#### Additional material examined:

CALIFORNIA: Calaveras County: Camp Connell, Highway 4, *Thiers* 21256 (SFSC). IDAHO: from the northern panhandle in June and August, 1962 and 1964, *Thiers* 11326, 11344, 11370, 11391, 11493, 11494 (all SFSC). OREGON: Tillamook County: Oswald West State Park, *Trappe* 189 (MICH). Clatsop County: Ft. Clatsop National Monument, *Trappe* 190 (MICH). Wasco County: Devils Half Acre, Barlow Creek, *Trappe* 191 (MICH). Benton County: Marys Peak, *Trappe* 729, 848 (OSC). WASHINGTON: Whatcom County: U. S. Cabin, Chilliwack River, *Trappe* 188 (MICH). Mt. Rainier National Park: Ohanepecosh, *Trappe* 1630 (OSC).

#### LITERATURE CITED

- Gispert de Imaz, M.** 1958. Especies del género *Boletus* de la Sierra de las Cruces y del Desierto de los Leones, D.F. *Bol. Soc. Bot. México* **22**: 28-40.
- Kornerup, A. & J. H. Wanscher.** 1962. *Reinhold Color Atlas*. New York: Reinhold Publishing Corp. 224 pp.

- Mazzer, S. J. & A. H. Smith.** 1967. New and interesting boletes from Michigan. *Michigan Botanist* **6**: 57-67.
- Ridgway, R.** 1912. *Color Standards and Color Nomenclature*. Washington, D. C.: Published by the author. 44 pp. + 53 *pl.*
- Singer, R. & A. H. Smith.** 1964. Studies on secotiaceous fungi. X. Additional data on *Gastroboletus*. *Mycologia* **56**: 310-313.
- Smith, A. H. & R. Singer.** 1959. Studies on secotiaceous fungi.—IV. *Gastroboletus*, *Truncolumella*, and *Chamonixia*. *Brittonia* **11**: 205-223.