SECOTIACEOUS FUNGI FROM WESTERN UNITED STATES

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It is always pleasing to obtain good material of any unfamiliar fleshy basidiomycete but particularly material of species which are at the center of discussion and conjecture, whose name is based on some obscure collection or whose name is based on collections inadequately described. These conditions apply for most any secotiaceous fungus, for it appears that collections are so irregularly made that affinities are always in dispute. So much of our knowledge of the bolbitiaceous and strophariaceous gastromycetes is based on single collections that Singer (1963) considers only one species of *Galeropsis, G. andina,* has been obtained in enough quantity to study it really extensively. When several collections of two species of so-called *Galeropsis* from widely separated areas came to hand, the opportunity was taken to critically review their taxonomy. The two fungi can be assigned to *Galeropsis cucullata* and *G. polytrichoides.*

A note on recent collections of another secotioid fungus, *Setchelliogaster,* appends the discussion.

Smith has recently (1965) described *Weraroa coprophila* (figs. 1–3) from Payette National Forest, Idaho, which is distinguished primarily by the lack of a spore-print, the color of the gleba, carpophore coloration, the spore dimensions and spore attachment to the basidium. He drew attention in his account of the similarity of his fungus to *Bolbitius cucullatus* Seaver & Shope, the type of which was examined by one of us (R.W.) during the tenure of a National Science Foundation Grant (G 13282–03779, made available to me while at the University of Michigan). The hymenial color of the type approaches "bone brown" of Ridgway and thus closely resembles that of many dark-spored agarics, i.e., *Psilocybe* spp. and *Stropharia spp.* Even under the microscope the spores have a slight purplish flush, and do not approach the gill colors found in either *Agrocye* or, as indicated by Singer (1963), in *Conocybe.*

Opportunities have been taken over several years by one of us(R.W.) to examine the types of many so-called bolbitiaceous fungi, both agaricoid and secotioid. *Bolbitius cucullatus,* it seems, is unique in this group in some of its anatomical details. The cheilocystidial shape (fig. 8), pore characters and gill color lead one to place this species along with Smith's fungus in the strophariaceous genus *Weraroa* as it is presently understood. *Galeropsis* (type species—*G. destertorum* Vel.), the genus to which *Bolbitius cucullatus* was transferred by Singer (1936), differs

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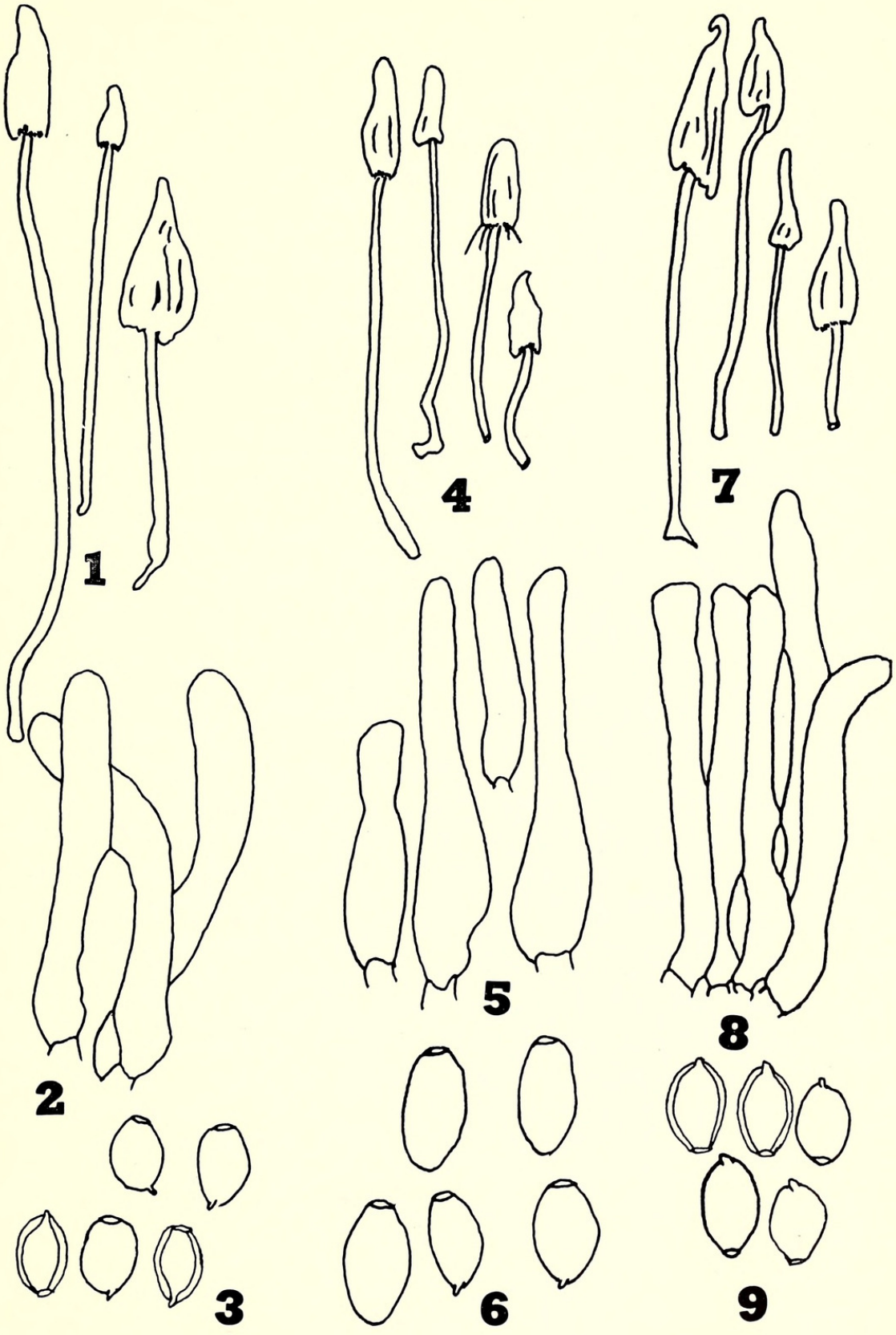
markedly in gill and spore color; moreover it is considered by us (Watling, 1964), as it stands at present, to be an artificial assemblage of secotiaceous fungi, and a revision is being prepared.

The following new combination is proposed:

Weraroa cucullata (Seaver & Shope) Thiers & Watling, comb. nov. Bolbitius cuculattus Seaver & Shope, Mycologia 27:649. 1935. *Galeropsis cucullata* (Seaver & Shope) Singer, Beih. Bot. Centralb. 56:137. 1936. *Secotium longpipes* Zeller, Mycologia 33:209. 1941.

Pileus 9–35 mm high, 4.5–15 mm broad at the base, not or hardly expanding, typically conic often ending in a long, relatively sharp point which may curl on drying (fig. 7), wrinkled, fibrillose to fibrillose-scaly from remains of a floccose, "mustard yellow" (Color terms defined in Ridgway (1912) are placed in quotes.) to "ochraeous tawny" veil, dry, almost "apricot yellow" to "mustard yellow" when young becoming rich "chrome yellow" at the base, finally more "old gold" or "buffy citrine" at the base and "tawny" or near "buckthorn brown" toward the apex; margin incurved and tightly fitted around the stipe, joined in the young specimens to the stipe by a distinct, although fugacious, veil which leaves distinct flecks and which can be seen even in the most mature pilei upon careful examination; sometimes becoming free and expanded but retaining a frill of velar flecks. Stipe columella 50–110 × 1–4 mm, equal or slightly swollen at the base in larger specimens, dry with appressed fibrils at the apex or fibrillose toward the base from velar remnants, "pale ivory yellow" at apex and near "Saccardo's umber" to "sepia" downwards, then "ochraceous buff" to "clay color" at the apex with hint of cinnamon yellow but base unchanging. Gills fusing and anastomosing to form elongate compartments, "Verona brown" at first then becoming flushed with "warm sepia," finally "bone brown" except for white or pale yellow margin. Flesh soft, yellowish in pileus, more buff in stipe, particularly in the base, and drying bright yellow; odor and taste not unpleasant, mild.

Basidia 4-spored, hyaline to slightly colored in KOH, clavate or constricted about the middle, 25–35 × 10–12 μ, pedicellate. Basidiospores (fig. 9) 11.5–13 (14.5) × 6.5–7.5 (8) μ, elliptic to slightly amygdaliform, flattened in side view with a low shoulder over a prominent, although not large, apiculus, thick-walled, truncate by a slightly eccentric or apical pore, deep honey with a bister tint in water and KOH. Pleurocystidia rare, up to 25μ long, langeniform and slightly mucronate, mixed with more vesiclulose cells up to 15μ broad, described by some as pseudoparaphyses. Cheilocystidia (fig. 8) numerous, forming a distinct fringe on the gill, filamentous-cylindric, hyaline or slightly yellowish, 35–70 × 5–7.5 μ; caulocystidia lageniform, up to 30 μ long and 5–8 μ broad at apex. Hymenophoral trama of irregularly arranged, ± enlarged cells some of which have yellow contents. Pileus trama of irregularly arranged, ± swollen cells and up to 16 μ in width with some colored con-



FIGS. 1–9: 1–3, *Weraroa coprophila;* 1, carpophores, × 1; 2, cheilocystidia, × 400; 3, basidiospores, × 900; 4–6, *Galeropsis polytrichoides;* 4, carpophores, × 1; 5, cheilocystidia, × 400; 6, basidiospores, × 1000; 7–9, *Weraroa cucullata;* 7, carpophores, × 1; 8 cheilocystidia, × 400; 9, basidiospores, × 800.

tents and covered in a distinct filamentous pellicle of ± colored, ± faintly colored granulose cells 2–3 μ in diam. and up to 35 μ long. Clamp connections infrequent but present.

On ground among grass and sedges, elev. 9,600 ft, University of Wyoming Summer Camp, near Laramie, Wyoming, 2 July 1929, *F. J. Seaver* a *F. Shope* (Type: MICH, ex herb. Univ. Colorado No. 249. A permanent slide is also in NY).

Gregarious, often in large troops, in boggy or marshy areas; elev. 7,500 ft., Haskner Creek, Sierra Madre, Carbon Co., Wyoming, June, 1950, *Smith 36246* (MICH); Hot Lake Area, elev. 6,300 ft., Lassen Volcanic Nat. Park, Shasta Co., California, 8 June, 1965, *Thiers 12923* (E, San Francisco State College); Silver Lake, elev. 7,200 ft., Amador Co., California, 6 June, 1966, *Thiers 16904* (E, San Francisco State College).

This fungus is very close to *Weraroa coprophila* as already indicated, and it may be necessary to reassess the position of the Idaho fungus when more material is collected. When the type collections of the two species are compared one gets the impression that *W. coprophila* (fig. 1) is a much more robust fungus. Smith (1965), however, has indicated three main differences between his taxon and *W. cucullata;* namely, the darkening stipe, the smoky grey to pale fuscous gills when fresh and the narrow spores (fig. 3). The first difference still applies, however the stipe is very dark at the base from the beginning in *W. cucullata;* the gills of *W. cucullata* are nearer "Verona brown" than has been indicated earlier and, after comparing the types of both species directly, one besides the other, the colors are indeed very close. The spores are slightly narrower but one must treat this with some caution for the statement is based on only a single collection. Similarities are also seen in cheilocystidial shape. Although Smith did not observe cheilocystidia, they are present in the type material of *W. coprophila* and resemble those of the type of *W. cucullata;* the contents are much more yellow in KOH in *W. coprophila.* Now that more and more collections are being made of gastromycetoid fungi, the full range of differences between individuals, which belong to the same taxon, are becoming evident.

Galeropsis polytrichoides was described by Zeller (1941) from collections made by W. B. Cooke on Mount Shasta, and, although not found for several years it has appeared in the last few collecting seasons in several localities elsewhere in California. A full description based on these fresh collections and subsequent microscopic examination is given.

GALEROPSIS POLYTRICHOIDES (Zeller) Zeller, Mycologia, 35:410. 1943. Figs. 4–6. *Secotium polytrichoides* Zeller, Mycologia 33:211. 1941.

Pileus 5–15 mm high, 3–10 mm broad at the base, narrowly to acutely conic, subacute or ellipsoid or pinched in at the top, attenuate or becoming truncate at the base at maturity, moist or slightly lubricous when fresh and immature but soon becoming dry; glabrous to silky

appressed fibrillose, becoming rimose, tan on the disc, darker towards the margin, becoming "sudan brown" to "bone brown" at maturity, drying with distinctly paler disc and in herbarium material the disc is "ochraceous tawny" to "yellow ochre" and the margin "date brown" to almost "umber"; margin joined to the stipe when young with white fibrils which darken slightly with age becoming very pale tan to ochraceous and separate at maturity, forming a fimbriate fringe with long dangling "ciliae" up to 10 mm long. Veil consisting of parallel hyphae 25–42 (68) μ long and 4.5–7 μ wide, fused or adhering tightly together. Stipe columella 30–90 mm $\times$ 1–2 mm, equal or slightly enlarged at the base, glabrous to silky fibrillose often showing a twisted pattern of fibrillosity, tan to "buckthorn brown", finally "Verona brown" and in dried material with a peculiar steel blue at the very base when seen in certain light. Gills joined by a few thin, anastomosing lamellar partitions, pale brown, on drying becoming "buckthorn brown" to "Prout's brown" to "raw umber" in dried material. Flesh pale tan in pileus and upper stipe, darker brown in lower stipe.

Basidia (1-, 2-) 4-spored 25–29 $\times$ 7–8 μ, short pedicellate, usually hyaline in KOH although some are distinctly yellow-brown. Basidiospores (fig. 6) 10–13 $\times$ 5–6 $\times$ 6–6 μ, ellipsoid, slightly flattened in side view and swollen upwards in face view (obovate of Zeller), slightly tapered, with an apical germ-pore, although fairly thick-walled not strongly pigmented. Pleurocystidia not found; cheilocystidia (fig. 5) lageniform to slightly subcapitate with apex 5–6 (8) μ broad and up to 25 μ long. Caulocystidia similar to cheilocystidia, although more variable in shape and often with a tapered apex, 20–42 $\times$ 18–12 μ (apex 8.5–10 μ or 1.5–2 μ). Hymenophoral trama consisting of interwoven, swollen hyphae up to 8.5 μ broad. Pileus trama filamentous, consisting of interwoven, swollen cells up to 17 μ broad with a distinctly filamentum cutrill of hyphae 2–4 μ in diameter. Clamp connections present.

Gregarious on moist ground, in boggy areas about streams, and in open seepage areas in conifer woodlands; Lassen Volcanic National Park, elev. 6,000 ft., Shasta Co., California, 3 July, 1965, *Thiers 12912* (E, San Francisco State College); Big Meadows Campground, elev. 7,000 ft., Calaveras Co., California, 30 May, 1966, *Thiers 16874, 16875,* and *16878* (E, San Francisco State College); Sagehen, California, 29 May, 1966, *D. McLaughlin* (E).

It must be pointed out that in all the collections examined the basidiospores are slightly larger than those indicated in the original description. However, authentic material collected on 24 July, 1941, by W. B. Cooke from a site only a few yards from the type locality and now in MICH under No. 136 Mycobiota of North America, Mycobiota of Mt. Shasta, California, is similar to our collections in every way. The type material has not been examined.

A very interesting observation which needs further ecological examina-

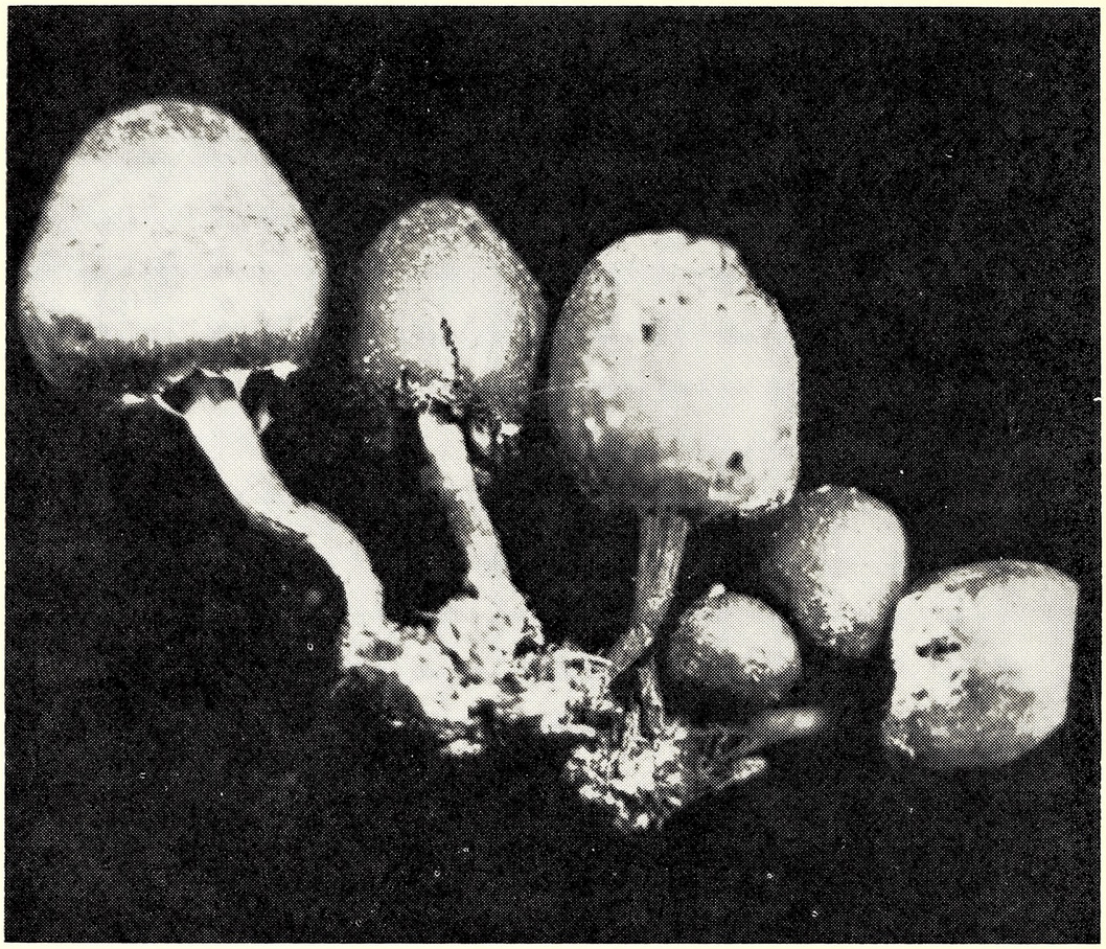


FIG. 10. *Setchelliogaster tenuipes,* × 1.

tion is that on these different occasions *Werarora cucullata* and *Galeropsis polytrichoides* have been found at the same localities, in Lassen National Park, in Silver Lake area and in the type locality for *G. polytrichoides* (from which the type of *Secotium longipes,* =*W. cucullata* fide Singer, was also described).

We believe that all *Galeropsis*-like fungi are xerophytic derivatives, many of which are, perhaps, quite restricted in distribution, of a whole series of familiar agaric groups. It does not follow, however, that we think all secotiaceous fungi exhibit convergance in this way and are such end-products. We envisage these gastromycetes as paralleling the aquatic mammals; although the latter are all adapted to water and live successfully there, they can be quite unrelated, except that they are all mammals.

Several factors convince us that they are end-products: particularly the well-developed stipe, the well-developed cheilocystidia, the well-developed cuticular structure of the stipe and pileus, and the lamellar nature of the "gleba." It has been shown by one of us (R.W.) that in *Conocybe farinacea* dye entering a water column maintained in the stipe finally finds its way into the cheilocystidia and then into external, apical droplets. It is postulated that the cystidia which develop on the most exposed parts of the gill have developed in response to water uptake

phenomena. This will be expanded in greater detail elsewhere but the question must be posed here, if this is so what would be the part played by the cheilocystidia in such a fungus as *Galeropsis cucullata* and when would they begin to play a part in the economy of the gill-edge if evolved within the fruit body.

Should, therefore, the Secotiaceae or the majority of its members be placed alongside the units to which they are closest? Martin (1956) has already expressed similar ideas on the subject but from a more general point of view. Also should not *Weraroa* and *Galeropsis* be reorganized into genera which show some relationship to the geophiloid agarics and separate out the bolbitiaceous element, if one exists?

There is little doubt that these questions will cause much discussion and possibly disagreement and we sincerely hope it does, so that, when further material is available to us, it can be examined with new thoughts in mind; we are anxious to see more material to support our present approach.

Pouzar (1958) described the genus *Setchelliogaster* in 1958 basing the taxon on *Secotium tenuipes,* a fungus originally described by Setchell (1907) who collected it on the University of California campus at Berkeley, California. As early as 1950 Heim discussed the possible connection between this fungus and the bolbitiaceous agarics mainly on the basis of the cellular cuticle and spore color, but its affinities are still problematic. It is always difficult to make convincing comparative studies from limited herbarium material; we are, for example, ignorant of how the cuticle of this fungus actually develops. The development of such carpophore tissues is considered by Reijnders (1963) and Watling (1963) to be very important in the understanding of relationships between different groups of higher fungi. After examination of several herbarium collections it appears that the cuticular structure, although cellular, does not, in fact, develop in the same way as that of typical members of the Bolbitiaceae, e.g., *Conocybe farinacea, Bolbitius vitellinus,* or *Agrocybe praecox.* The cells of the outer layer are not pyriform with the pedicels developing from an active zone as described by Watling (1964), but more studies are required.

All the studies so far carried out were based on material from the small area embraced by Alameda and Santa Clara counties, California, although Singer and Smith (1959) mention a collection in the New York Botanical Garden from Oregon. The material described below is from San Francisco State College Campus and adjacent Marin Co. and are the only recent collections with full field notes made by one of us (H.T.).

Grateful appreciation is extended to Mrs. Alix Wennekens for transmitting the collections from Marin Co.

SETCHELLIOGASTER TENUIPES (Setchell) Pouzar, Ceska Mykol. 12:34. 1958. Fig. 10. *Secotium tenuipes* Setchell, J. Mycol. 13:239. 1907. Gastro-

carp 5–25 mm high, 10–20 mm broad at maturity; convex to somewhat cylindric to globose when fully developed, never completely expanding, dry to moist, glabrous, colored near "Hessian brown" to "carob brown" when young, unchanging with age or becoming near "hazel" to "Kaiser brown" to "chestnut brown"; unchanging when bruised; margin typically incurved during all stages; when young typically attached to the stipe columella by white veil fragments, usually breaking free with age, but always remaining incurved to straight, entire to often eroded. Stipe-columella distinct, well-developed and apparent in all gastrocarps, 5–20 mm long, 3–4 mm broad, solid, extending through the entire gleba, more or less concolorous with the gleba or peridium, surface dry, more or less appressed fibrillose; white mycelium at the base. Gleba distinctly lamellose to broadly and highly irregular lacunose; lamellae plates very thin and fragile but not becoming pulverulent with age or when dried, typicallly folded, convolute and irregular, strongly intervenose with numerous, large air spaces interspersed, "ochraceous tawny" to "hazel" during all stages of development. Peridium less than 1 mm thick, fragile, concolorous with the surface, unchanging when exposed; taste and odor mild.

Basidia 27–38 × 8–12 μ, typically 2-spored with the sterigmata often large and strongly developed. Basidospores 15–17.6 × 9–11.2 μ, ovoid to subellipsoid, with well-developed sterigmal appendage, germ-pore typically present but often poorly differentiated and difficult to interpret, bright ochraceous to "tawny" in KOH and Melzer's, surface roughened, episporium with numerous small canals extending from inner-wall to surface and sometimes causing an obscure reticulation on the surface. Cystidia not seen, but often large, ± cylindric to fusoid cells with obtuse apices present in hymenium (possibly undeveloped basidia). Trama of lamellae plates irregular to subparallel, staining pale ochraceous to yellow in KOH and Melzer's. Peridial trama typically loosely interwoven; cutis differentiated as a layer of globose to vesiculose cells, "ochraceous tawny" in KOH and Melzer's, wall not incrusted, 12–18 μ in diam.

Gregarious in soil under *Eucalyptus globulus* and *Cupressus macrocarpa*. All collections except one made by Mrs. Alix Wennekens in vicinity of Mill Valley, Marin Co., California, *Thiers 21893, 21911, 29112, 21913, 21914,* and *21924*. An additional collection was made on the campus of San Francisco State College, San Francisco, California, *Thiers 12413*. All collections are deposited in the herbarium of San Francisco State College.

Setchell (1907) noted this fungus growing under *Eucalyptus globulus,* and *Quercus* spp. in the vicinity of *Eucalyptus* spp.. Our more recent collections are from under *Eucalyptus globulus* and *Cupressus macrocarpa;* the latter, although native to California, has presumably been planted in Marin Co. *Eucalyptus* spp. are mainly native of Australia, a few extending into the East Indies, and it is interesting to speculate

as to the habitat of Setchell's fungus. Various *Eucalyptus* spp. are widely planted now for ornament in Mexico, South Africa, the southern states of the United States, India, S.E. Asia, etc., and it is possible that native species of fungi have taken up association (mycorrhizal or not) with *Eucalyptus* when once introduced, e.g., *Scleroderma* in India (Thayer, et al., 1967), *Pisolithus tinctorius* in S. Africa (Thayer, et al., 1967). The qeustion arises as to whether *Setchelliogaster* is an endemic western North American fungus or has it been introduced along with the *Eucalyptus* trees? It has not been found in Australia yet, but there is every possibility that a fungus can exist for very long periods as a mycorrhizal associate simply reproducing vegetatively or being distributed along with seedlings of mature trees and rarely producing fruit bodies. The climate offered by California may be more favorable to the fungus than its native area, and so regular fruiting can be accomplished in its new environment.

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