

New and Interesting Hypogeous and Secotiid Fungi from California

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Hypogeous basidiomycetous fungi are those which, as the name indicates, initiate basidiocarp formation below the surface of the soil and usually do not become erumpent at maturity. The secotiid fungi which in many instances appear closely related are similar except the basidiocarps at maturity are either completely or partially epigeic. Both groups show close affinity with the true gilled or boletoid fungi. The fruit bodies are typically putrescent, but are readily distinguished from the agarics or boletes by the failure to forcibly discharge their basidiospores from the basidium.

HARKNESS (1880) of the California Academy of Sciences of San Francisco was the first to publish extensively on the taxonomy of hypogeous fungi in California. Most of the species studied by him were found in the coastal areas, particularly in the vicinity of the San Francisco Bay Area, and his reports included few, if any, species now known to occur in the montane regions of the state. Later ZELLER and DODGE (1931, 1941, 1948) began their highly significant contributions to the taxonomy of these organisms. Their contributions were extensive and included descriptions of several species which are commonly encountered in the subalpine zones of California at the present time. SINGER and SMITH (1958, 1962) and, later, SMITH (1963, 1965, 1966) have published the results of more recent monographic studies of hypogeous and secotiid fungi. Their papers included numerous species which continue to constitute a conspicuous element of the California flora.

The hypogeous and secotiid fungi seem to be much more abundant and occur in greater variety in the western part of the United States than elsewhere, and are particularly common from the Rocky Mountains to the Pacific Coast at higher elevations. For the most part they appear to be mycorrhizal-forming and are found associated with both hardwoods and conifers, perhaps more commonly, in California at least, with the cone-bearing hosts. In California they occur in the coastal forests, but they are far more abundant, and there is a greater variety of genera and species in the forests of the Sierra Nevada and other

mountain ranges. They are found at all elevations up to timberline but appear to be more common at elevations varying from 4,500 to 8,000 feet. Fruiting is usually from August until the winter temperatures preclude further fruit-body development, then they reappear to a much lesser extent in May and June as the snow melts and the temperature increases.

Numerous California collections, particularly in such genera as *Rhizopogon*, *Gautieria*, *Melanogaster*, *Hysterangium* and *Martellia*, await correct determination at the species level. The species included in this paper represent a few of the more interesting and unusual ones found in the subalpine and lower regions of California during the past few years. All collections cited in the paper are deposited in the herbarium at San Francisco State University (SFSU), and all colors in quotations are from RIDGWAY (1912).

1. *Arcangeliella tenax* SMITH & WIEBE

Gastrocarps 4–8 cm in diameter, 2–6 cm high, stipitate-capitate. Pileus plano-convex to convex when young becoming plane to shallowly depressed to highly irregular and uneven in outline when mature. Peridium more or less evenly colored near “pinkish buff” to “pale pinkish buff” when young, unchanging or darkening to “cinnamon buff” when old, unchanging when bruised, dry to moist or sometimes subviscid, dull, glabrous or obscurely appressed fibrillose on the disc. Context 1–2 cm thick on the disc, thinner toward the margin, firm, white to “pinkish buff”, unchanging upon exposure. Taste immediately acrid. Odor strong, unpleasant. Latex scant, white, unchanging upon exposure, not staining the gleba or peridium.

Gleba typically completely enclosed by the peridium, rarely becoming exposed when old, lamelliform but plates completely folded and convoluted, often anastomosed and lacunose; colored near “ochraceous buff” to “pinkish buff”, unchanging when exposed.

Stipe-columella often obscure and poorly developed, 0.5–1.5 cm long, 0.5–1 cm broad, often eccentric, solid or often hollow at maturity, concolorous with the peridium, dry, glabrous.

Spores $7.5-10 \times 5.5-7.2$ μm , ellipsoid, walls ornamented with a strongly amyloid, complete to more commonly, broken reticulum, with a rather large, smooth plage. Basidia clavate, 4-spored, thin-walled, $35-47 \times 9-15$ μm . Cystidia embedded in hymenium and often not easily detected, ventricose to fusoid to subclavate, moderately thick-walled, hyaline in KOH and MELZER's, $35-50 \times 8-15$ μm . Hymenophoral trama interwoven, lacking sphaerocysts, pale yellow in KOH and MELZER's. Pileus trama interwoven, with numerous conspicuous masses of sphaerocysts. Epicutis composed of a narrow,

compact layer of closely appressed, interwoven hyphae, pale yellow in KOH and MELZER's, non gelatinous. Clamp connections absent.

SMITH and WIEBE (1963) described this species from material collected in Oregon. Their description was apparently based upon a very small, single collection. Subsequent collecting, however, in the mountain ranges of California has shown this species to be common under red firs. It is characterized by the relatively large size of the basidiocarp, its pale buff color, white latex, acrid taste, poorly developed stipe-columella and basidiospores which have a strongly amyloid ornamentation and a large smooth plate.

2. *Arcangeliella variegata* THIERS sp. nov.

Gastrocarpia distincte stipitato-pileata. Pileus 4—8 cm latus, e convexo plano-convexus vel planus, humidus vel siccus, glaber vel subvelutinosus, pallide olivaceo-bubalinus vel olivaceo-bubalinus, maculis luteis vel subluteis. Contextus albus, immutabilis. Sapor acer, odor mitis. Latex albus, immutabilis. Gleba lamellata vel alveolata, subochraceo-bubalina, tactu immutabilis. Stipes 3—5 cm longus, 2—4 cm crassus, aequalis, siccus, glaber, albus, tactu brunescens. Sporae $8.4-9.6 \times 7.8-9.6$ μm , globosae vel subglobosae, ornamentis amyloideis reticulum fractum vel perfectum formantibus. Epicutis ex hyphis intertextis. Gregaria vel dispersa in humo in silvis littoralibus. Holotypus: Thiers 21738 (SFSU), Dunlap Campground, Jackson State Forest, Mendocino Co., California, December 21, 1967.

Gastrocarps distinctly stipitate-pileate. Pileus 4—8 cm broad, convex to plano-convex to plane, russuloid in appearance, sometimes shallowly depressed to highly irregular to undulating in outline; surface moist to dry, not viscid, dull, glabrous to obscurely velutinous, colored "pale olive buff" to "olive buff" when young, usually with noticeable yellow to pale yellow spots with age. Margin strongly incurved, highly irregular when old. Context white, unchanging upon exposure. Taste distinctly acrid; odor mild. Latex copious, white to whitish or sometimes almost clear, unchanging upon exposure; not staining the gleba or context.

Gleba somewhat lamellate to highly alveolate and irregular; color near "pale ochraceous buff", unchanging when bruised; not enclosed by the peridial layer at any stage of development.

Stipe-columella 3—5 cm long, 2—4 cm broad at the apex, well developed; more or less equal; surface dry, glabrous, white, staining brown when bruised. Context white, unchanging when exposed.

Spores $8.4-9.6 \times 7.8-9.6$ μm , globose to subglobose, hyaline in KOH, surface ornamented with a broken reticulum or with a complete, well-formed reticulum, ornamentations strongly amyloid. Cystidia rare, deeply embedded in the hymenium, inconspicuous, hyaline, thin-walled, clavate to subfusoid to obscurely fusoid ventricose, $35-40 \times 13-17$ μm . Basidia 2—4-spored, hyaline, clavate, sterigmata

strongly developed, $30-37 \times 10-15 \mu\text{m}$. Trama of glebal plates with a distinct central strand, subparallel, sphaerocysts absent, laticiferous hyphae present. Trama of the peridium interwoven, with scattered sphaerocysts and laticiferous hyphae; cuticle tightly interwoven, composed of non gelatinous, filamentous hyphae. Hypodermis composed of loosely interwoven filamentous hyphae, sphaerocysts rare. Clamp connections absent.

Habit, habitat and distribution. Gregarious to scattered in humus in mixed coastal forests.

Material studied. Mendocino County: THIERS 21567, 21737, 21738 — holotype, 21739, 21740, 24184. San Mateo County: THIERS 35396.

Observations. So far as can be determined this is the only gray-buff colored *Arcangeliella* that has been described. This color is often rather strongly developed in the young basidiocarps but may fade with age. The yellow spots or regions may become rather pronounced and noticeable as the pilei mature or they may always remain small and inconspicuous. *Arcangeliella tenax*, the only other common species occurring in California, has a pinkish pileus, a noticeable smooth plage on the spore walls and a poorly developed stipe-columella. *Arcangeliella crassa* is colored pinkish buff and has thickwalled sphaerocysts in the trama and *A. lactarioides* has a gelatinous cuticle.

3. *Gastroboletus citrinobrunneus* THIERS sp. nov.

Gastrocarpia stipitato-pileata. Pileus 4—7 cm latus, convexus, undulatus vel rugosus, siccus, in statu humectato lubricus, glaber praeter fibrillas appressas marginem versus, costis fuscis et sulcis citrinis, tactu caerulescens. Contextus luteus, tactu caerulescens dein tarde fuscans. Sapor et odor mites. Gleba tubulosa. Stipes 2.5—4 cm longus, 0.7—1.5 cm crassus, bulbosus, demum clavatus, siccus, glaber, luteus, tactu fuscus vel ater. Sporae $10.8-15 \times 5.4-6.6 \mu\text{m}$, fusoidaeae vel subellipsoideae, aliquae apice truncatae, parietibus glabris. Cystidia fusioidea vel clavata, $18-26 \times 7-10 \mu\text{m}$. Epicutis ex hyphis intertextis. Gregaria vel dispersa in humo subter *Abies concolor*. Holotypus: SHOWERS 2901 (SFSU), Mineral, Lassen National Forest, Tehama County, California, September 29, 1975.

Gastrocarps stipitate-pileate. Pileus 4—7 cm broad when mature, generally convex but typically highly irregular in outline, usually undulating or rugose to wrinkled; surface dry, lubricous when wet, colored dark brown to sepia on the ridges, changing to bright yellow to lemon yellow in the spaces between the ridges, glabrous except appearing somewhat appressed fibrillose near the margin; margin incurved to inrolled when young, remaining inrolled at maturity, entire, becoming noticeably eroded with age, staining blue-green immediately upon bruising. Context 0.2—0.8 cm thick, colored bright yellow to pale lemon yellow, changing to dark blue immediately upon exposure, gradually changing to fuscous. Taste and odor mild.

Gleba tubulose, not enclosed or surrounded by a sterile peridial membrane during any stage of development, 0.6—1.7 cm long, more or less vertically oriented when young, curving to a 45 degree angle from the stipe-columella at maturity, colored pale yellow to yellow when young, changing to olive yellow at maturity, becoming blue-black immediately upon injury or exposure. Pores small, 1—3 per mm, colored bright yellow when young, changing to olive-yellow to pale olive-brown with age, changing to blue-green immediately upon bruising. Stipe-columella 2.5—4 cm long, 0.7—1.5 cm broad at the apex, bulbous when young, becoming clavate with age, somewhat pinched at the base. Surface dry, glabrous, colored bright yellow when young fading to buffy yellow with age, becoming fuscous to black when bruised. Context yellow, changing to blue immediately upon exposure then slowly fading to pale fuscous.

Spores $10.8-15.0 \times 5.4-6.6 \mu\text{m}$, fusoid to subellipsoid, bright brown in KOH, inamyloid except for a small region near the germ pore and at the apicular region near the base, often noticeably truncate, walls smooth, moderately thick. Basidia 4-spored, clavate, hyaline, $21-25 \times 8-10 \mu\text{m}$ in diameter. Pileus trama interwoven, homogeneous. Cuticle differentiated as a trichodermium of more or less upright hyphae with terminal cells slightly differentiated, individual hyphae hyaline but yellowish in mass. Clamp connections absent.

Habit, habitat and distribution. Scattered to gregarious in humus under white firs (*Abies concolor*). Known only from the type locality.

Material studied. Tehama County: SHOWERS 2901 — holotype.

Discussion. The curious mixture of brown and yellow colors in the pileus of *Gastroboletus citrinobrunneus* is highly distinctive. *Gastroboletus turbinatus* (THIERS & TRAPPE 1969; THIERS 1975) often has a somewhat similar coloration in the pileus but red or reddish pigments are also present and frequently predominate. Another highly distinctive characteristic of *G. citrinobrunneus* is the unusual deposition of the amyloid material in the spore wall. These amyloid areas are seen only in those spores having a truncate apex and may not be present in all of them. The only other gastrobolete known to have truncate spores is *G. xerocomoides* (THIERS & TRAPPE 1969; THIERS 1975) which has a differently colored pileus, stains blue only erratically and none of the basidiospores are amyloid.

4. *Hydnangium soederstroemii* LAGERHEIM

Gastrocarps 0.5—3 cm in diameter, ovoid to ellipsoid to subglobose in outline, frequently becoming highly irregular in shape with age and sometimes flattened or compressed. Surface pitted or wrinkled and uneven. Surface dry, dull, fibrillose to submentose, typically colored "light vinaceous cinnamon" to "light pinkish cin-

namon" to occasionally as pale as "pale pinkish buff", sometimes with spots as dark as "vinaceous tawny". Some gastrocarps whitish to "pale olive buff" when young. Unchanging when bruised. No rhizoids. Peridium up to 1 mm thick, fragile. Gleba dry, finely lacunose to occasionally more or less labyrinthine, sometimes with large air spaces, lacking sterile veins or a columella. Colored "light vinaceous cinnamon" to "vinaceous cinnamon" to "pinkish cinnamon" to occasionally as dark as "testaceous", unchanging when bruised or exposed.

Spores $13.5-18 \times 13.5-16.5 \mu\text{m}$, globose to subglobose, with large conic to pyramidal shaped warts or spines, inamyloid, hyaline to yellowish in KOH. Basidia 1-2spored, $30-50 \times 10-14 \mu\text{m}$, elongate-clavate. Cystidia absent. Hymenophoral trama interwoven, yellowish in KOH. Peridial trama interwoven, reddish in MELZER's, yellowish in KOH. No sphaerocysts. Oleiferous hyphae inconspicuous. Epicutis of peridium interwoven, hyaline to pale yellow in KOH and MELZER's. Clamp connections present.

Hydnangium soederstroemii was originally reported by SINGER & SMITH (1960) under the name of *H. roseum*, however, recently SINGER (1962) has shown that it should be correctly named *H. soederstroemii*. It is apparently a very rare hypogeous fungus and, so far as is known, California is the only place in the United States where it has been found. It has been placed in the Astrogastrales but the spores do not possess amyloid ornamentations and sphaerocysts are lacking in the tramal tissues. It seems, therefore, as Singer and Smith have intimated, this species is much more closely related to the genus *Laccaria* in the *Tricholomataceae*. This species was reported by SINGER and SMITH and later by SMITH and SMITH (1973) from under oaks in the San Francisco Bay Area; however, none apparently saw fresh material and took their distribution and habitat data from herbarium labels. I have yet to find a single basidiocarp under any member of the genus *Quercus*. Instead, until very recently, it was found consistently and often abundantly, either under Australian tea (*Leptospermum* spp.), a common cultivated shrub, or *Eucalyptus* spp. Recently a large collection of an interesting variant was made under beach pine, *Pinus contorta* ssp. *murrayana*, with no hardwoods in the immediate vicinity. In addition to the significant difference in mycorrhizal host, the basidiospores of these basidiocarps were $2-3 \mu\text{m}$ larger and clamp connections were exceedingly rare. Additional material is needed before final disposition of this variant can be made.

5. *Protogautieria substriata* THIERS sp. nov.

Gastrocarpia 1.5-2.5 cm diametro, ovoidea vel subglobosa. Peridium album vel albidum demum fuscum, siccum, glabrum vel subtomentosum, tactu immutabile. Rhizoidea nulla. Gleba lacunosa vel alveolata, alba vel albida demum flava, ubicumque fracta sectave immutabilis vel subrufescens. Sporae

12.4—17.1×7.5—9.5 μm , ovoideae vel subglobosae, solutione kalii hydroxidi hyalinae, solutione Melzeri pseudo-amyloideae et striatae vel rugulosae. Peridium vix effectum, hypharum intertextarum compositum. Hypogaea, subalpina, solitaria vel gregaria. Holotypus: THIERS 13405 (SFSU), Huntington Lake, Fresno Co., California. October 5, 1965.

Gastrocarps 1.5—2.5 cm in diameter, ovoid to subglobose in general outline, but often with irregular pits or undulations. Peridium white to whitish when young, becoming dark brown or discolored when old; surface dry, dull, glabrous to subtomentose; peridium up to 1 mm thick, not changing color when bruised; no rhizoids present. KOH black on the peridium, all other chemical tests negative. Gleba lacunose to wrinkled and alveolate, somewhat suggestive of the folding seen in the hymenium of the Tuberales; white to whitish, typically becoming pale yellow to yellow with age; unchanging when bruised or exposed or sometimes showing pale reddish tints when exposed. All chemical tests on the gleba negative.

Spores 12.4—17.1×7.5—9.5 μm , ovoid to obovate to sometimes nearly subglobose, hyaline to pale yellow and smooth in KOH, strongly dextrinoid and showing distinct longitudinal folds or striations in MELZER's, walls 1—2 μm thick; basidia 4-spored, hyaline in KOH, clavate, 32—40×10—12 μm ; cystidia absent; trama of plates hyaline in KOH, yellowish in Melzer's, interwoven, homogeneous, hyphae 3—5 μm in diameter, thin-walled. Peridium not strongly apparent, composed of more or less interwoven hyphae, hyaline in KOH, hyaline to pale yellow in MELZER's.

Habit, habitat and distribution. Solitary to gregarious. Buried in soil under firs and mixed conifers. Found only in subalpine habitats.

Material studied. Fresno County: THIERS 13403, 13405 — holotype. Sierra County: THIERS 34890.

Discussion. Only one other species, *Protogautieria lutea* (SMITH 1965), has been placed in this genus. It has cystidia which stain red and a yellow peridium which turns purple in KOH. The peridium of *P. substriata* is perhaps better developed than in *P. lutea* and the basidiocarps do not strongly resemble *Gautieria morchelliformis* as reported for *P. lutea*.

6. *Sedecula pulvinata* ZELLER

Gastrocarps 4—9 cm in diameter, usually ovoid to ellipsoid to pulvinate in outline, with coarse, cord-like rhizoids extending from the gleba in the basal region. Peridium 2—3 mm thick, whitish to pale olive buff, sometimes with slight yellowish tints when young and fresh, darkening to gray or blackish with age. Surface dry, dull, somewhat glabrous when young, often appearing tomentose to fibrillose with age; characteristically appearing lacunose and pitted or

split with age, not changing color when bruised or exposed. Taste not distinctive, odor when old and moist unpleasant and strong. Chemical tests negative. Gleba black, becoming somewhat powdery at maturity, cord-like cartilaginous veins ramifying through out and remaining intact during all stages, veins compactly and closely interwoven in upper portion becoming loosely interwoven to free in the basal portion and extending beyond the peridium as coarse rhizoids.

Spores (12) $13.3-14.3 \times (22) 25.5-28.5 \mu\text{m}$, ovoid to elliptical to occasionally subglobose to citriform, brown in KOH and MELZER's; walls smooth, $1-2 \mu\text{m}$ thick, with germ pore at apex, hyaline apiculus present. Basidia hyaline in KOH, not reviving in KOH to permit accurate measurements, 2-spored. Glebal trama hyaline in KOH, interwoven. Cystidia absent. Peridium differentiated as a tangled interwoven, repent, compact trichodermium, hyaline in KOH, hyphae $5-7 \mu\text{m}$ in diameter, smooth, thin-walled. Clamp connections absent.

This highly distinctive fungus is characterized by the strange glebal configuration of large, dark-colored, cartilaginous veins outlining irregularly shaped cavities. The coarse, black rhizoidal-like extensions of the veins from the base of the gastrocarp are also unusual. The peridial layer is equally difficult to interpret and appears to be perforated with pits or openings. So far as known, this is only the second report of its occurrence. The type was collected by W. B. COOKE from Mt. Shasta in Siskiyou County, California. COOKE sent his collection to ZELLER who first placed it in the Sclerodermataceae (ZELLER 1941), but later transferred it to its own family the Sedeculaceae (ZELLER 1948).

Other interesting hypogeous and secotioid fungi which have been collected by me or my students but not previously reported from the state include the following species:

Brauniellula nancyae SMITH. Abundant throughout the Sierra Nevada where it is commonly associated with lodgepole pines (*Pinus contorta* ssp. *murrayana*). Less common but widespread and associated with the same mycorrhizal host in other mountain ranges within the state. All collections, when fresh, showed the characteristic reddish discoloration of the cystidia in KOH, however, recent examination of these same collections after having been in the herbarium for several years revealed the disappearance of any staining reaction of the cystidia when mounted in KOH or, at most, a very faint change.

Endoptychum depressum SINGER & SMITH. Relatively common in compacted soil in the vicinity of campsites in the National Forests in the various mountain ranges within the state.

Gymnomycetes ferruginascens SINGER & SMITH. Known only from two collections, both of which were made in the Sierra Nevada Range at elevations of 5 to 6 thousand feet.

Hymenogaster brunnescens SMITH. Known most commonly from the Sierra Nevada Range where it occurs in pine-fir stands. One collection, tentatively identified as this species, has been made under planted pines on the campus of San Francisco State University, San Francisco.

Hymenogaster diabolus SMITH. Known only from a single locality (Silver Lake, Amador Co.), where it was found under lodgepole pines at approximately 7,000 feet elevation.

Hymenogaster sublilacinus SMITH. Known from two different localities within the state where it was associated with lodgepole pines at approximately 7,000 feet elevation.

Hymenogaster subolivaceus SMITH. Known from only one locality situated at approximately 6,000 feet elevation where it appeared to be associated with lodgepole pines.

Macowanites americanus SINGER & SMITH. Known from the northern coastal forests and the Sierra Nevada. In both areas it was apparently associated with pines.

Macowanites iodiolens SMITH & WELLS. Known from only a single collection made under lodgepole pines at an elevation of approximately 6,000 feet in the Sierra Nevada.

Macowanites luteolus SMITH & TRAPPE. Known from the coastal forests of northern California where it has been found in mixed conifers (pines, Douglas firs and lowland firs).

Macowanites subolivaceus SMITH. Known from the higher elevations in the Sierra Nevada Range where it occurs under conifers (pines and firs).

Macowanites subrosaceus SMITH. Known from Huntington Lake (elevation approximately 6,000 feet), Fresno County where it was found under lodgepole pines.

Mycolevis siccigleba SMITH. Known from only a single collection made at Yuba Pass, Sierra County under red firs at an elevation of approximately 7,000 feet.

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