

## Studies on Secotiaceous Fungi. VIII. A New Genus in the Secotiaceae Related to Gomphidius

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# STUDIES ON SECOTIACEOUS FUNGI. VIII. A NEW GENUS IN THE SECOTIACEAE RELATED TO GOMPHIDIUS.<sup>1, 2</sup>

ALEXANDER H. SMITH AND ROLF SINGER

(WITH 9 FIGURES)

The fungi here described are interesting because they clearly indicate a connection between the genus *Gomphidius* of the Agaricales and the Secotiaceae of the Gastromycetes. Also, all the species have been found in a single geographic area, the western United States. This area is of considerable general interest because of the large number of other secotioid Gastromycetes known to occur in it.

The species described in the following account could be placed easily in the two main subgenera of Singer's (1949) classification of *Gomphidius* were it not for the fact that the spores are not discharged from the basidia in the manner typical of Hymenomycetes, and the hymenophore does not become oriented for spore discharge. In addition, the hymenophore has many chambers, lined by hymenium containing fertile basidia, which do not open to the outside, so that spores could not possibly escape from them. In other words, the morphology of the fructification is that of the Secotiaceae. Because of these gastromycete features, we are describing the two new species in the Gastromycetes but recognizing that their relationships are with *Gomphidius*.

The name *Brauniellula* was selected to indicate the resemblance of this genus to *Brauniella* in certain microscopic characters. This does not necessarily imply that we believe the two genera are intimately related. As we pursue the evolutionary lines of development evident in the Agaricales into the Gastromycetes (or vice versa depending on one's views in the matter) we hope to shed more light on this problem.

The field work during 1958 was financed by the University of Michigan Herbarium. Previous work in the area, which laid the ground work for the 1958 expedition, was financed jointly by the Faculty Research Fund of the University of Michigan and the Na-

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tional Science Foundation. With the continued destruction of our virgin forests in the United States and the removal of this set of characteristic habitats from our land, it is highly desirable to inventory their entire flora at the earliest possible date because of the possible extinction of many species. The agencies which sponsor this type of work are thus filling an urgent need at a critical time.

### **Brauniellula gen. nov.**

Gastrocarpio obtuse companulato vel convexo aut centro depresso, peridio glabro vel fibrilloso; gleba sublamellari vel lacunosa, loculis frequenter elongatis irregularibusque, columellae adnata variabiliterque decurrente vel libera (columella haud attingente); columella percurrente; velo praesente vel absente; sporis eis *Gomphidiorum* analogis; cystidiis eis *Gomphidiorum* simillimis vel ab eis paulum distinctis magnitudine, forma, reactionibus. SPECIES TYPICA *B. nancyae*.

Gastrocarp obtuse to campanulate or convex, at times depressed, surface glabrous to fibrillose; gleba sublamellate to lacunose, the cavities often elongate and irregular in shape, attached to columella and attachment extending various distances down it, at times an opening produced by slight expansion of the peridium freeing the lower margin of the peridium from its attachment to the stipe-columella or free from columella; columella percurrent; veil present or absent.

Spores large and resembling those of species of *Gomphidius*, cystidia resembling those of *Gomphidius* in size, shape, and color reactions or deviating only slightly from this pattern.

#### KEY TO SECTIONS AND SPECIES

1. Flesh white at first; stipe with lemon-yellow base; spores remaining dark smoky brown in KOH.....Sec. *Gomphidius* (*B. leucosarx* only species known)
1. Flesh ochraceous to mineral red at first; stipe ochraceous to vinaceous throughout; spores becoming pale brownish to melleous in KOH.....  
.....Sec. *Brauniellula*
2. Cystidia as revived in KOH with a vinaceous-red content.....*B. nancyae*
2. Cystidia with hyaline content as revived in KOH.....*B. albipes*

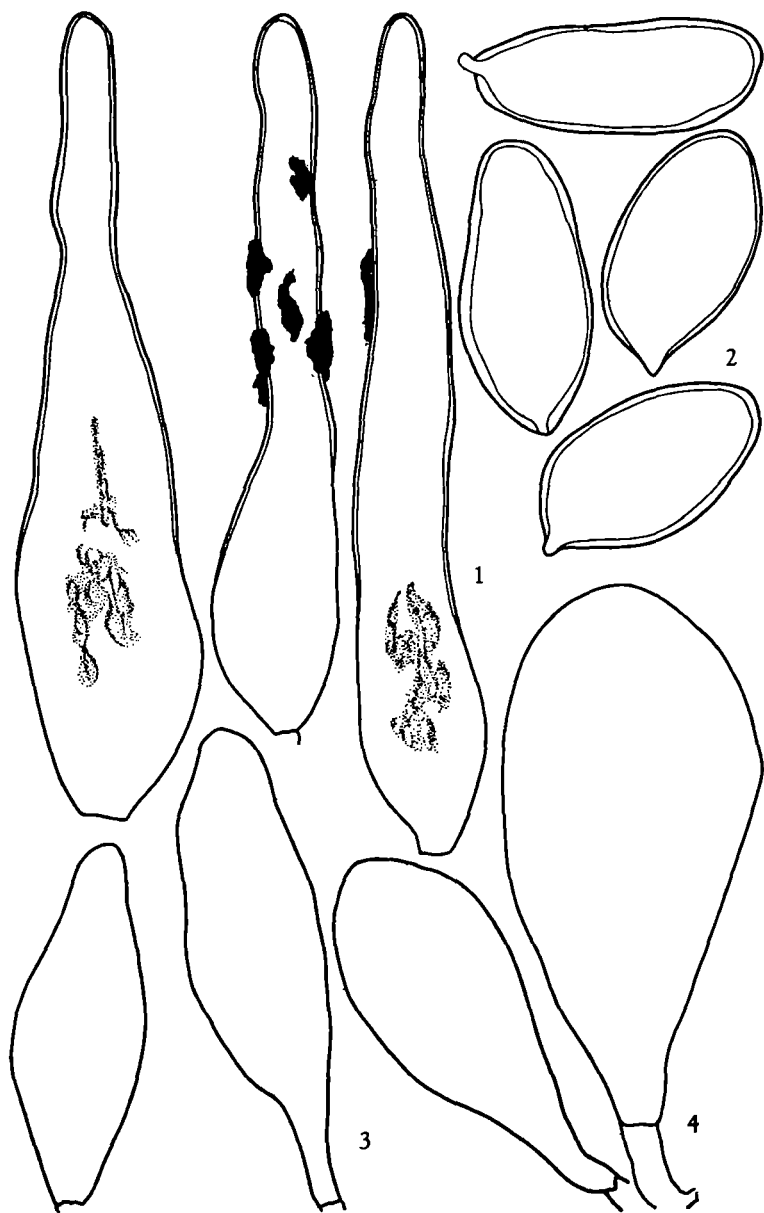
### Section **Gomphidius** sec. nov.

Sporis non-pseudoamyloideis, stipite deorsum citrino, peridio tenui, intus albo. SPECIES TYPICA: *B. leucosarx*.

### **Brauniellula leucosarx** sp. nov.

FIGS. 3, 4, 6 and 8

Gastrocarpio 15 mm lato, pallide vinaceo, mox atro-maculato; peridio tenui, intus albo, in aere exposito vinaceo-alutaceo; gleba griseola, loculata, libera; stipite cum columella 12 × 6 mm., intus alba, solida, laesa tarde pallide purpurascens, basi intus extusque citrino; sporis 15-19.8 × 7-9  $\mu$ , atrofumosis KOH iodique ope;



FIGS. 1-4, spores and cystidia. FIG. 1, pleurocystidia of *B. nancyae*; FIG. 2, spores of *B. nancyae*; FIGS. 3-4, pleurocystidia of *B. leucosarx*.

cystidiis  $65-90 \times 18-35 \mu$ , clavatis vel fusoido-ventricosis, statu vivo saepe purpurascens-incrustatis; hyphis haud gelatinascentibus, defibulatis.

Gastrocarp 15 mm broad, convex-depressed, surface with debris adhering to it but apparently not viscid, shape irregular, margin lobed, ground color pale vinaceous but surface soon blackish spotted; peridium thin, interior white but slowly becoming tinged vinaceous buff when cut, odor and taste not distinctive; gleba drab-gray, oval in longitudinal section, consisting of minute chambers, no gill-structure visible, *free from columella to apex of gastrocarp*, peridium curved in around the gleba at the lower edge so that the latter is not truly exposed to the outside but no veil is present; stipe-columella  $12 \times 6$  mm, solid, white within but slowly becoming pale vinaceous, base lemon yellow inside and out, slowly dark grayish-violet in Melzer's sol. (but individual hyphae not amyloid under microscope).

Spores  $15-19.8 \times 7-9 \mu$ , smooth, smoky brown in both KOH and Melzer's sol., walls slightly thickened, with no apical discontinuity but occasional spores with bifid apex, oval to elliptic in face view, obscurely inequilateral in profile view, apex rounded; basidia mostly 4-spored, a few 2-spored,  $50-60 \times 10-14 \mu$ , clavate, when fresh the content nearly lemon yellow in Melzer's sol., dull yellow as revived in Melzer's, hyaline in KOH; cystidia  $65-90 \times 18-35 \mu$ , clavate to fusoid-ventricose, apex rounded to obtuse, wall thin or with slight irregular thickenings, when fresh often incrustated with amorphous material which is vinaceous red in KOH, dingy yellowish as revived in KOH; tramal plates of hyphae  $5-9 \mu$  in diam. and with short cells, floccose, interwoven, subhymenium absent—the basidia originating in the tissue of the tramal plate; peridium of loosely arranged floccose hyphae  $4-9 \mu$  in diam., the cells not much inflated but many heavily incrustated with yellowish to brown material (in KOH), no gelatinous hyphae seen anywhere; clamp connections none.

Solitary under *Pinus contorta*, Louie Lake Trail, Payette National Forest, Idaho, July 31, 1958, Sm-59316, TYPE; *Nancy Jane Smith* collector.

Near the lower edge of the gleba sections of the latter show a slight lamellar structure, but the main glebal body is truly lacunose. Although known from only a single fructification, the latter was in perfect condition and there is no reason to doubt the data taken from it. These positive data are exceedingly important since it is the first gastroid type connecting up the *Gomphidii* of the subgenus *Gomphidius* with secotioid types. The fruiting body was found in an area where *Rhizopogon rubescens* and *Brauniellula nancyae* also occurred, both typical members of the lodgepole-pine flora of central Idaho. Hence we consider it very

probable that *B. leucosarx* forms mycorrhiza with lodgepole pine. It is interesting to note that the cystidia are less cylindric than in the related species of *Gomphidius*, but that the color of the spores is typical of that group. The characters which relate this species to *Gomphidii* of the subgenus *Gomphidius* are: the yellow base of the stipe which turns dark in Melzer's, but, as in *G. glutinosus*, no amyloid reaction is visible under a microscope, the typical gomphidioid spores, the vinaceous incrustation of the cystidia in KOH on fresh material, and the white flesh of the peridium and stipe-columella above the yellow base. If one chooses to disregard the gastromycete nature of the fruiting body, it still does not fit any species of *Gomphidius*. It would seem to be, in some respects, a connection to *G. septentrionalis*, in which a glutinous veil is only slightly developed, but the cystidia and lack of a veil amply distinguish it. A similar relationship to *G. maculatus* is suggested by the white flesh and lack of a veil, but in that species the cap is viscid, the spores are larger and its cystidia give different color reactions.

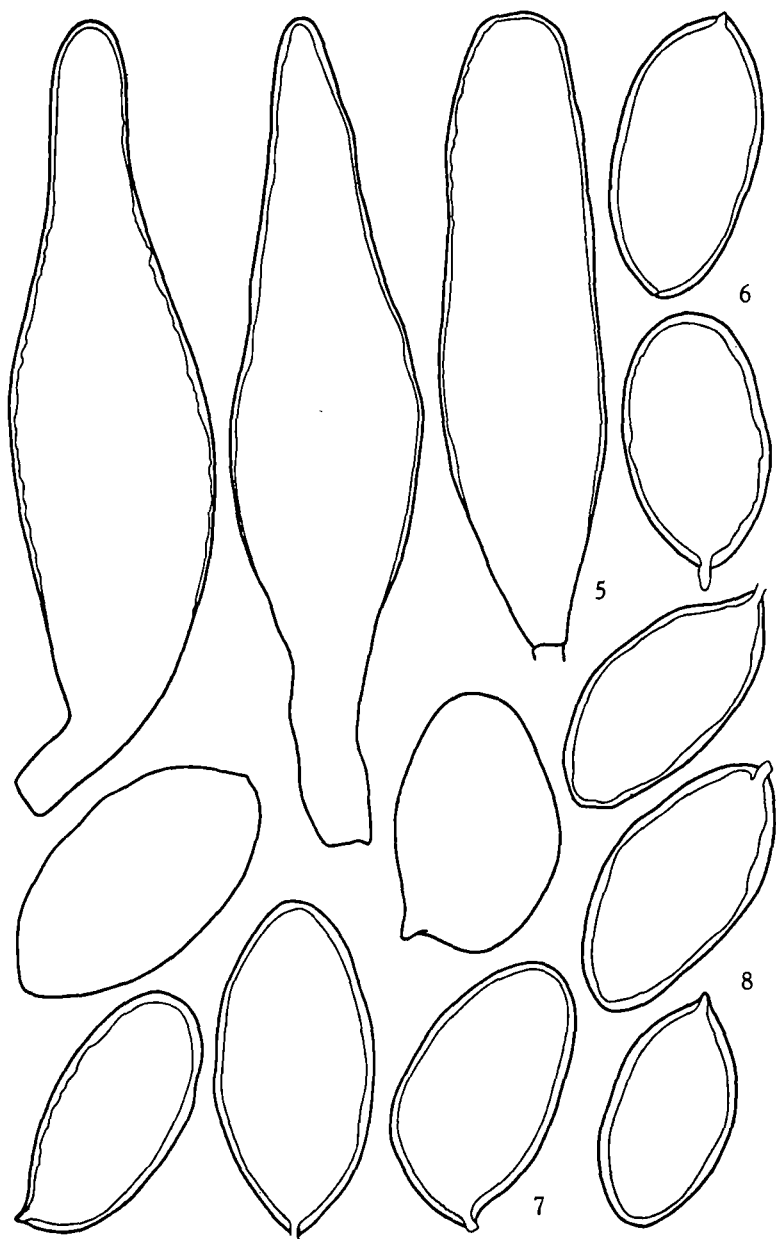
### Section *Brauniellula*

*Brauniellula nancyae* Smith sp. nov.

FIGS. 1, 2 and 9

Gastrocarpio (5-)10-50 mm lato, margine demum a stipite-columella separato sed constanter decurvato; peridio appresse fibrilloso, sublubrico ut in *Incocybe geophylla* sed pellicula gelatinosa destituto, fibrillis griseolis supra fundamentum ochraceum, aetate vinaceo-purpurascens, crasso et ex eo agrificiformi (ut pileus *Gomphidii* cuiusdam); gleba convoluta-loculato vel sublamellari ochracea, dein grisea, plerumque velo fibrilloso ochraceo vel vinaceo margineque peridii oblecta; stipite-columella 3-15 × (5-)8-10 mm aequali vel ad basin attenuata, ochracea, demum vinoso-rubra, et velo fibrilloso-striato; sporis 16-20 × 6.5-9  $\mu$ , ellipsoideis vel oblongis, levibus, in aqua fumoso-flavo-brunneis, in KOH pallide melleis; cystidiis 100-150 × 14-26  $\mu$ , subventricosis vel subcylindraceis, apice attenuatis obtusis vel subacutis, in statu vivo purpureo-incrustatis; fibulis nullis.

Gastrocarp (5-)10-50 mm broad, obtusely campanulate to convex or depressed, margin irregular and often lobed and at first connected to stipe-columella by a thin fibrillose veil of ochraceous to vinaceous fibrils—i.e., a true veil—margin of peridium becoming free from the stipe-columella in age but remaining decurved, surface dry and appressed fibrillose or when wet merely subviscid to the touch as in *Incocybe geophylla*—no gelatinous pellicle present—fibrils grayish to dark drab, ground color ochraceous and in age slowly changing from ochraceous to vinaceous to purplish red; peridium thick and resembling the context of an agaric cap, ochraceous to ochraceous-orange in young fresh fruiting bodies, bluish black in Melzer's sol. fresh, in  $\text{Fe}(\text{SO}_4)$  very quickly turning black, in KOH becoming red or darker purplish red, odor and



FIGS. 5-8, spores and cystidia. FIG. 5, pleurocystidia of *B. albipes*; FIGS. 6 and 8, spores of *B. leucosarx*; FIG. 7, spores of *B. albipes*.

taste not distinctive; gleba a convoluted mass of loculate to lamellate-intervenose tissue, the portion of the gleba becoming exposed usually appearing somewhat lamellate, very few of the interior cavities actually opening to the outside and hence spore discharge non-functional if it actually does occur, typically remaining completely covered by the veil and the incurved margin of the peridium but in a few gastrocarps opening out slightly to expose the lower portion of the gleba, color ochraceous at first but in age drab from the spores; stipe-columella 3–15 mm long, (5–)8–10 mm thick at apex, equal or narrowed below, solid, ochraceous over all but in age finally vinaceous red, streaked with ochraceous to vinaceous fibrils from the dry veil, base often reddish from these fibrils.

Spores  $16\text{--}20 \times 6.5\text{--}9 \mu$ , in face view elliptic to narrowly elliptic, in profile showing a slight suprahilar flattening, smooth, wall thickened slightly (less than  $1 \mu$  thick), smoky yellow-brown in  $\text{H}_2\text{O}$  mounts of fresh material, *pale melleous* in KOH either in fresh or revived material, strongly pseudo-amyloid (dark red-brown) in Melzer's sol. in either fresh or revived material, no apical differentiation observed; basidia 4-spored,  $44\text{--}52 \times 9\text{--}12 \mu$ , dull orange-brown to yellowish in Melzer's sol., hyaline and with "granular" content fresh; cystidia abundant,  $100\text{--}150 \times 14\text{--}26 \mu$ , subventricose to subcylindric, more or less tapered to an obtuse or subacute apex, walls flexuous toward apex, thin-walled, when fresh with vinaceous-red incrustations around medial area in age, when revived in KOH, content vinaceous red, yellowish-hyaline in Melzer's sol.; hyphae of tramal plates  $4\text{--}8 \mu$  in diam., subparallel and curving out slightly to an interwoven subhymenium, the hyphae thin-walled, with scattered incrusting particles some of which are reddish as revived in KOH, *some hyphae distinctly though weakly amyloid* (with blue to lilac walls) in fresh material treated with Melzer's sol., reaction very erratic in dried material and appearing absent on some specimens; hyphae of the "cuticle"  $4\text{--}5 \mu$  in diam., radially arranged, much incrusting material present and this reddish in KOH on revived sections; hyphae of context hyaline but in sections revived in KOH the section showing a pinkish tint, mostly not incrustated; clamp connections none.

Solitary to cespitose under *Pinus contorta*, throughout central Idaho, TYPE collected at Pen Basin, Payette National Forest, Idaho, Aug. 5, 1958, *Nancy Jane Smith*, Sm-59644.

Additional Material: The following collections were made during the summer of 1958 from Heaven's Gate Ridge, Nez Perce National Forest roughly on a line extending southeast to Stanley, Idaho, at the northeast edge of the Sawtooth Mountains. Sm-58838; 58977; 58978; 58979; 58992; 59194; 59310; 59326; 59335; 59448; 59480; 59644; 59794; 59867; 59944; 60083; 60219; 60441; 60477; 60511.



Our first experience with this fungus was a single collection by Smith from Iron Creek, near Stanley, Idaho, in late August 1954, from under lodgepole pine. The gastrocarps were so contorted, however, that the detailed structure was not clearly evident. During the season of 1958 an expedition to the same area was made and a detailed search made for additional collections. The 1958 season was apparently very favorable for the development of this species, for, thanks largely to the efforts of Miss Nancy Jane Smith, we found it at Stanley as well as in nearly every stand of lodgepole pine visited after the 10th of July until late August. The collecting data indicate conclusively that the species is associated with *Pinus contorta*, very likely as a mycorrhizal associate. Its pattern of occurrence is interesting. Very frequently it occurs in or next to clusters of carpophores of *Rhizopogon rubescens*, which is also very abundant in the association, and like the *Rhizopogon*, development is hypogeous until near maturity when the fructifications at times become partly exposed. In most fructifications the development is angiocarpic, the gleba never becoming exposed, but during the height of the fruiting period some specimens were observed in which the veil had broken and the gleba had become partly exposed by a slight expansion of the "cap." No spore deposits were obtained from such specimens though several attempts were made.

The gleba varies from truly lamellate to truly lacunose and all intermediate stages are readily found in large fruitings. However, the most erratic character is the amyloid reaction of the hyphae of the peridium and tramal plates. In fresh material a weak but distinct blue reaction is observed on some hyphae. These are numerous enough to be easily seen and cause the dark appearance resulting from the application of Melzer's sol. to the cut surface of the flesh. This can be readily reversed by the application of bases or even weakly alkaline tap-water, so that it often appears to be easy to "wash out" the reaction with several changes of water. When sections of material which has been dried are revived directly in Melzer's sol., one gets, especially if the mount is crushed by pressure on the cover glass, a reaction *in places* in both context and tramal plates, to bluish or bright or dull lilac. If the sections are not crushed a few hyphae may turn blue or there may be no reaction whatever. About the only really distinctive feature of this behavior is that with the technique used the color change took place, but one could not be sure which hyphae would react. Actually it closely resembles, both in its pattern of behavior and the color produced, that found in *Gomphidius* among some of the species of the subgenus *Chroogomphus* Singer, as described by Smith and Dreisinger (1954).

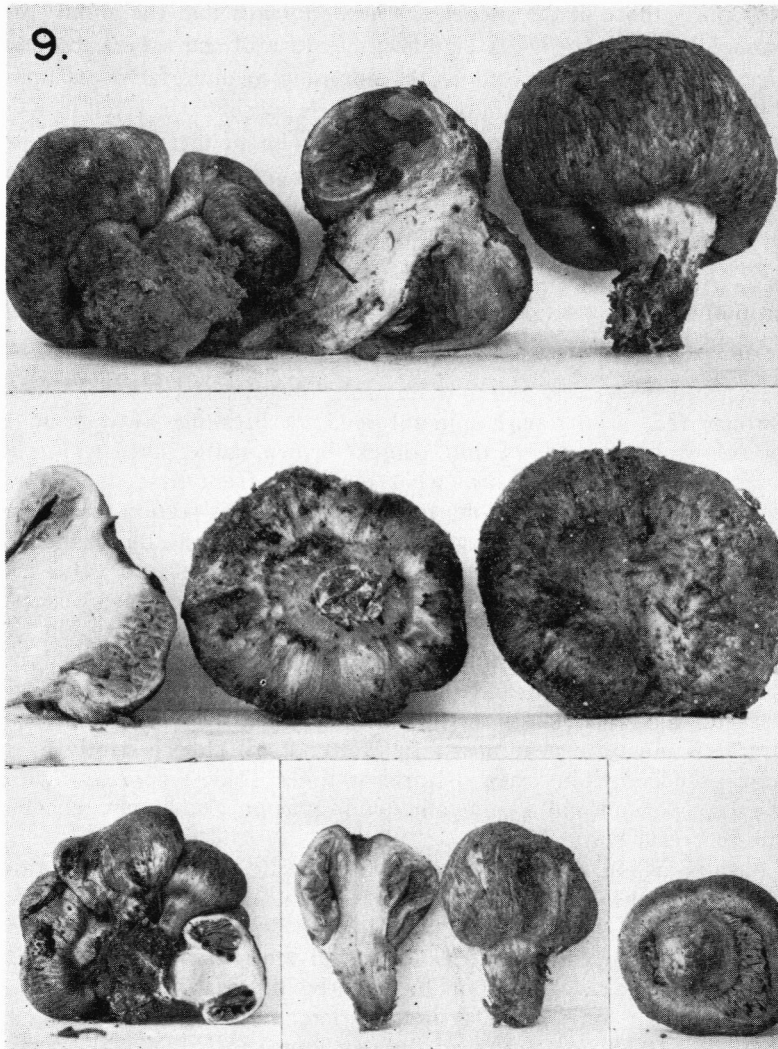


FIG. 9. Fruiting bodies of *B. nancyae*, about natural size.

This gastromycete is perhaps most closely related to *Gomphidius leptocystis* and *G. helveticus* by virtue of its dry, fibrillose pileus, the red reaction in KOH of the incrustations of the hyphae and the content of the revived cystidia, the shape of the cystidia and the fact that these structures have thin walls, and the gradual change to purplish red as the fructification ages. All of its characters, including the spores, are

so obviously those of the subgenus *Chroogomphus* that the affinity with it cannot be questioned. A significant feature of the spores, however, is that the color in 3 per cent KOH mounting medium fades out appreciably. Hence, one studying only herbarium specimens revived in KOH might be inclined to question whether the color of the spores ever was typical of *Gomphidius*. The strong pseudoamyloid reaction is a constant character for mature spores but immature ones remain yellow to pale yellow-brown.

**Brauniellula albipes** (Zeller) comb. nov.

FIGS. 5 and 7

*Secotium albipes* Zeller, Mycologia 40: 675. 1948.

Gastrocarp up to 50 mm in diam., subglobose, surface viscid, smooth, glabrous; red, drying dark mineral red, not breaking away from the stipe below; peridium very thin, context brown, rather hard (?); gleba loculate, chambers small, somewhat dehiscent from base of columella leaving at maturity a small ring-hole, broad in cross section, pale ocher-stramineous; stipe-columella turbinate, tapering to a thin acute base from a broad apex, 10–15 mm long, solid, percurrent; no volva seen.

Spores  $14.5\text{--}20 \times 7.5\text{--}10 \mu$ , ovate to elliptic in face view, obscurely inequilateral in profile view, with a short eccentric basal apiculus and a slight suprahilar depression, wall slightly thickened and pale brown in KOH, content hyaline and slightly reticulate, no apical differentiation observed, smooth to faintly wrinkled (not completely revived?), pale ochraceous tawny to near tawny in Melzer's sol. (hence faintly to distinctly pseudoamyloid when mature, at times (oldest spores?) with a darker episporium and a subhyaline endosporium visible, not metachromatic in cresyl blue.

Basidia  $34\text{--}48 \times 10.5\text{--}12 \mu$ , cylindric-clavate, with 2, 3, or rarely 4 sterigmata, the latter unequal in size, some small, some large, some almost straight, others curved and thicker below; cystidia scattered,  $80\text{--}140 \times 15\text{--}25 \mu$ , subcylindric to fusoid-ventricose with an obtuse to rounded apex, walls thin to slightly thickened (up to  $1.5 \mu$ ), smooth or with some granular incrustation, not reddish in KOH; hymenophoral trama and trama of the peridium consisting of filamentous to rather broad hyphae mixed with occasional oleiferous elements, frequently regular in the tramal plates but sometimes with lateral stratum of arcuate-diverging hyphae, and in some places somewhat gelatinized although not showing a well differentiated external gelatinized layer or a gelatinized lateral stratum but filaments often wavy; hyphae of the external layer of the peridium partly (not all) incrustated by an epicellular amyloid (blackish violet) or amylaceous mass which tends to disappear gradually after repeated hydrolization (reduction); some hyphae near

the cap surface with granular amyloid contents; hyphae with clamp connections, but these not readily demonstrated in all mounts.

In rich forest duff, Merrimac, Butte County, California, Nov. 9, 1932, leg. *Thelma Norman*, det. E. E. Morse as *Secotium erythrocephalum* (NY, ex Zeller Herb., two portions of TYPE).

We have used Zeller's original description for the macroscopic details but have added our own observations on the type material. Morten Lange has annotated the type, and his observations agree with ours. In the first place, the gleba is not dark brown and the spores are not truly ornamented, and the gelatinization is less extensive than the diagnoses would make one think. The similarity with *Weraroa erythrocephala* is only in the color of the peridium, and even so the color is quite a different red. Whether the surface material on the stipe, which makes it appear white, is an artifact, we cannot decide but think it is entirely possible. Unfortunately neither of us nor Zeller has or had seen this material or any other of this species in the fresh condition, and it is possible that the stipe is colored when fresh. There seems to be a fibrillose "partial veil."

In spite of the fact that the species epithet may be a misnomer, the fungus is most interesting in the light of the two species previously described. We place it beside *B. nancyae* in the subgenus *Brauniellula* because of the following characters: 1) Spore characters, such as the large size, thickened wall with no other apical differentiation, the pale color in KOH and the pseudoamyloid reaction; 2) the large cystidia similar in size and shape to many of those found in subg. *Chroogomphus* of *Gomphidius*; 3) the vinaceous-red color of the peridium; and 4) the amyloid reactions of the tramal and peridial hyphae. Microscopically it is at once distinguished from *B. nancyae* by not having the content of the cystidia red as revived in KOH. As compared in the dried state the characters of the stipe also separate them but here no real comparison can be made because of lack of data on *B. albipes*.

In *B. albipes* the spores are less pseudoamyloid than in *B. nancyae* or in species of *Gomphidius* of the subgenus *Chroogomphus*, the cystidia lack the chemical reaction in KOH of *B. nancyae* and hence are less "gomphidioid," and the characters of the stipe in dried material are not comparable to those of *B. nancyae* or of *Gomphidius*. These features taken together indicate that *B. albipes* is farther removed, in the evolutionary scale, from *Gomphidius* than is *B. nancyae*. In fact, *B. albipes* might also be compared with *Brauniella* (Singer 1953, 1955). At this time, however, especially in view of the data presented in this series of

papers, we believe the relationships of the Secotiaceae need not be re-discussed before the situation has been studied on a monographic level.

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