

The Genus *Calvatia* in North America

SANFORD M. ZELLER AND ALEXANDER H. SMITH¹

(University of Michigan Herbarium, Ann Arbor)

The genus is defined along classical lines following the works of Lloyd (3) and Coker and Couch (1). Hence no review of its taxonomic features is given here. I have introduced the category of stirpes (sing. stirps) as this has been used in other mycological works, as a category for grouping related species when the characters of the groups are intergrading to the point of confusion to the taxonomist. Briefly, a stirps is a central species with its satellites. This grouping is particularly useful in *Calvatia* since so many of the features such as the color of the gleba, the thickness of the inner peridium, and the degree of powderiness of the mature gleba are relative, and in addition, vary some according to the age of the basidiocarp at the time it was dried. The category of stirps is without status in the International Rules of Botanical Nomenclature. The name of a stirps is the species epithet of the central species, and no authority for the name is ever used. I feel certain that this method of dividing the genus would have appealed to C. G. Lloyd were he alive today.

As represented in North America the genus is divided into seven stirpes and contains 32 species. The present account is not intended to be an exhaustive study of *Calvatia* based on the anatomy and hyphal details of the peridial layers of the basidiocarps. Rather it is an attempt to bring the classification up to date on the basis of the gross morphology of the basidiocarp and the microscopic details of the gleba. This should set the stage for a systematic study of hyphal types and detailed anatomical observations on the hyphae of the peridial walls. Such a study must necessarily be based both fresh (immature and mature) as well as dried specimens, as the changes which take place in the maturation of the basidiocarp are certain to be of critical importance in such investigations. This means the investigator must locate mycelia of the various species and make collections of many stages in the development of the fruiting bodies. This will be a slow and tedious process, but it needs to be done in order to clarify, if possible, species as well as generic concepts in the Lycoperdales as a whole.

CALVATIA Fries

Summa Vegetabilium Scandinaviae Sect. 2: 442. 1849. Emend.

Morgan, J. Cinc. Soc. Nat. Hist. 12: 165. 1890.

Hippoperdon Montagne, Ann. Sci. Nat. Ser. 2. 17: 121. 1842, and in Ramon d. I. Sagra, Hist. fis., pol. y nat. Cuba 9: 319. 1845.

Langermannia Rostkovius, in Sturm, Deutschl. Fl. 3. Abt. 5: 23. 1839.

Globaria Quélet, in Mémoires de la Soc. d'Émulation de Montbéliard, 2 sér., 5: 366. 1871-75.

Utrario Quélet in Mémoires de la Soc. d'Émulation de Montbéliard, 2 ser. 5: 370. 1871-75.

Lasiosphaera Reichardt in Reise de Osterreich. Fragtte Novara um die Erde 1: 135 (Wien). 1870.

¹Dr. Zeller died Nov. 4, 1948. He left manuscripts on the Gastromycetes of North America in various states of completion. His herbarium and papers were obtained by the New York Botanical Garden, and late in 1962 I was asked by the Garden to finish the project. One of the genera which Zeller had nearly completed was *Calvatia*, which is here finished in general accord with his outline. Some species have been added, mostly from my own field work in our Western States. I am to be held responsible for the comments following each species, new species as indicated in the text, and any errors detected in the published account.—Alexander H. Smith.

Fructifications medium to very large, globose, depressed, or pyriform, with or without a thick stalk-like sterile base; exoperidium a thin membranous layer or a very thick layer, becoming rimose; endoperidium usually thin, fragile, at or after maturity breaking up into fragments and gradually falling away; sterile base with upper surface concave or convex above, long-persistent, sometimes poorly developed or absent; capillitium attached to inner peridium or diaphragm of sterile base, of long much-branched threads which at maturity in most species break into fragments; spores globose to subglobose, small, smooth to punctate, verruculose or echinulate, rarely reticulate.

Type species: *Calvatia craniiformis* (Schw.) Fries

KEY TO STIRPES OF CALVATIA

- 1. Gleba distinctly violaceous at maturity Stirps *Cyathiformis*
- 1. Gleba reddish brown, umber brown, olive brown to ochraceous 2
 - 2. Peridial wall hard and Scleroderma-like at maturity Stirps *Pachyderma*
 - 2. Peridial wall disintegrating completely or remaining as a cup-like wall around the margin of the sterile base 3
- 3. Peridial wall more or less persistent around margin of sterile base: subgleba cellular and violaceous or purplish tinged Stirps *Tatrensis*
- 3. Not as above 4
 - 4. Peridium breaking up into conspicuous polygons or cones; sterile base usually present Stirps *Sculpta*
 - 4. Not as above 5
- 5. Basidiocarp large (8-40 cm); sterile base reduced to absent Stirps *Gigantea*
- 5. If large the sterile base prominent 6
 - 6. Gleba powdery at maturity Stirps *Bovista*
 - 6. Gleba a cottony mass, more or less persistent Stirps *Craniiformis*

STIRPS CYATHIFORMIS

KEY TO SPECIES

- 1. Peridium becoming spotted with red; spores strongly verruculose in Melzer's sol 1. *C. rubrotincta*
- 1. Not as above 2
 - 2. Sterile base inconspicuous *Calvatia cyathiformis* f. *fragilis*
 - 2. Sterile base distinct and typically well-developed 3
- 3. Spores smooth or practically so 4
- 3. Spores distinctly ornamented 2. *C. cyathiformis* f. *cyathiformis*
 - 4. Spores with a long pedicel; endoperidium subcoriaceous and with a ferruginous brown lining 4. *C. sigillata*
 - 4. Spores with only a stump of a pedicel or none; endoperidium ochraceous and velvety 3. *C. leiospora*

1. CALVATIA RUBROINCTA Zeller, Mycologia 39: 303. 1947.

Basidiocarps depressed-globose, 4-7 cm broad, 3-4 cm high, sulcate below, the base with several white cordlike rhizomorphs; surface smooth to felty or furfuraceous below, areolated above by reticulations, "Hay's brown" (dark reddish umber) when covered with spores, whitish where exoperidium has not disappeared, staining red in spots. Peridium duplex; exoperidium white, very thin, evanescent or a merely flaky cover; endoperidium somewhat thicker, brittle, easily broken up along the ridged reticulations. Sterile base about one tenth of fructification, convex above, soft, large-celled, white to purplish brown, with a metallic luster where torn. Gleba very powdery, dull lilac (benzo brown to dark "vinaceous drab").

Capillitium of threads 2.2-5.5 μ in diam; branched occasionally, the branches fork-like, interwoven and somewhat elongate; becoming attenuated to subacute tips, septate, walls up to 1 μ thick, pitted, the pits round, abundant and small, threads breaking readily, dark olive brown in KOH and nearly hyaline to tawny brown in Melzer's sol. Spores (5-)5.5-6.6(-7.7) μ in diam, globose to subglobose, strongly verruculose, the verrucae rounded and up to 1 μ high, uniguttulate usually, dark olive brown in KOH and dextrinoid (russet) in Melzer's sol., pedicel obscure.

Under *Pinus ponderosa*, south of Silver Lake near Mt. Hager, Lake County, Oregon. Type examined. More data are needed to determine whether the red spots of the type collection represent a true color change or are the result of a bacterial infection. The spores in Melzer's sol., however, are darker than those of *C. cyathiformis* and this should be a reliable species distinction.

2. *CALVATIA CYATHIFORMIS* (Bosc) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 168. 1890.

Lycoperdon cyathiforme Bosc, Ges. Nat. Freunde Berlin Mag. 5: 87. 1811.

Bovista lilacina Berk. & Mont. in Hooker, Lond. Journ. Bot. 4: 64. 1845.

Lycoperdon lilacinum (Berk.) Masseur, Mongr. Lyc. p. 10. 1887.

Calvatia lilacina (Berk. & Mont.) Hennings, Hedwigia 43: 205. 1904.

Lycoperdon bovista Vittadini, Fung. Manger. p. 264. 1835 (non Persoon, non Fries)

Lycoperdon pseudo-lilacinum Speg., Fungi Guaran. p. 45. 1886.

Hippoperdon crucibulum Mont., Syll. Crypt. no. 1057. 1856.

f. *cyathiformis*

Illustration: Plate IA.

Basidiocarps 7-16 cm in diam, 9-20 cm high, depressed, globose to turbinate or subpyriform, tapering abruptly into a large well-developed thick, stout, rooting base, often sulcate to deeply wrinkled from the base upward to the broadest dimension: exoperidium smooth or floccose, slightly scaly, very thin and fragile, the upper part often cracking into broad, flat areas, white, becoming pale brownish, often sordid purplish from the spores; endoperidium thin and delicate, as maturity is reached scaling away with the exoperidium gradually from the apex to expose the gleba. Sterile base chambered, remaining intact as a persistent dark cup-like structure which may remain in place over winter. Gleba at first white, then changing through yellow shades to deep purplish brown toward maturity.

Capillit threads 2.2-8.8 μ in diam, flexuous or straight, sparsely branched, slightly attenuated to the more or less pointed tips, slender, loosely interwoven; septa common, joint-like or square, occasionally breaking at the septa; walls thin, usually less than 1 μ thick, mostly even or slightly undulating, pitted; the pits small and abundant, round, occasionally up to 1 μ across; color pale livid gray to purplish in KOH, pale tawny in Melzer's sol. Spores (3.3-)4.4-7.7 μ in diam, globose to subglobose, echinulate to echinate, ornamentation up to 1 μ high, hyaline envelope evident or collapsed on the ornamentation, pale purplish in KOH, pale tawny in Melzer's sol.

Fruiting during the later summer and fall on ground in grassy places like pastures, often in the prairie and near-desert communities, across the United States.

Material examined: Idaho, *Trueblood* 1953. Michigan, *Potter* 3835, 6512, 6520, 6525, 6545, 6546, 6552, 6822, 8042; *A. H. Smith* 7176, 14933, 20544, 20740, 20801, 22276; *Imshaug* 4545, 4546. California, *Rea* 30; *Leach* 3. North Dakota, *Brenkle*, Fungi Dakotenses, 172, 1911 (as *C. lilacina* var. *occidentalis* Lloyd). Oklahoma, *Bulmer* 2034, 2109a, 2112. Pennsylvania, *Rea* 859. Texas, *E. A. Smith* numerous collections (MICH). Washington, Oct. 1956. West Virginia, *L. W. Nuttall*, no. 324, Greenbrier county, 1890-98.

This is one of our most common puffballs and shows tremendous variation in the degree of development of the sterile base. The spore ornamentation should be studied on mature spores from gastrococarps collected when mature. Basidiocarps allowed to "mature" in the laboratory show all degrees of spore ornamentation from that which is typical down to practically none at all.

- 2a. *Calvatia cyathiformis* f. *fragilis* (Vitt.) Smith comb. nov.

Lycoperdon fragile Vittadini, Monogr. Lycop. p. 80. 1842.

Calvatia fragilis (Vittadini) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 168-169. 1890.

Calvatia lilacina (Berk. & Mont.) Lloyd, var. *occidentalis* Lloyd, Myc. Writ. 6: 1097. 1921. nom. nud.

Illustration: Plate IB.

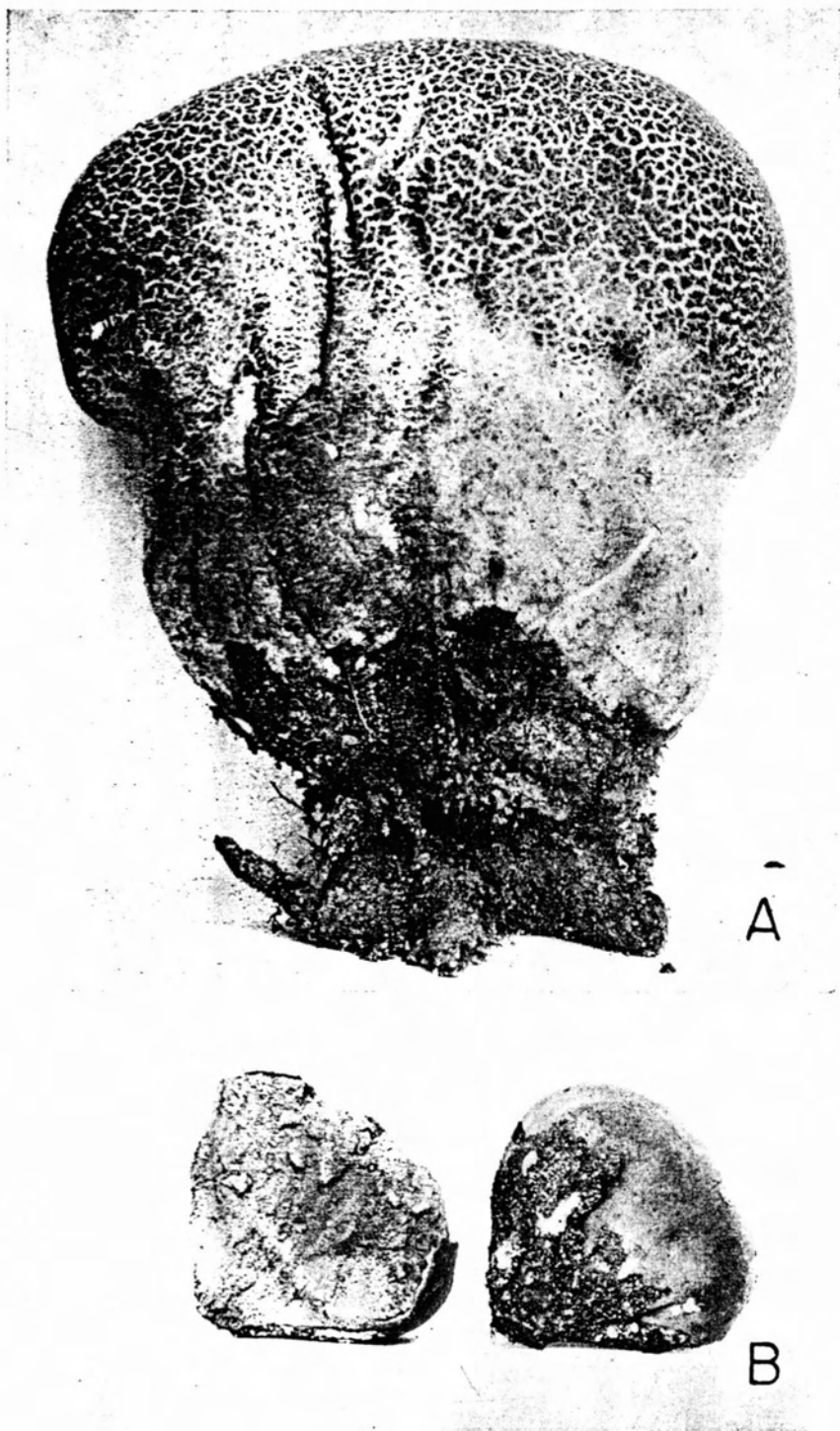


PLATE I

A, *Calvatia cyathiformis* f. *cyathiformis* $\times 2\frac{2}{3}$. B, *Calvatia cyathiformis* f. *fragilis* $\times 1$.

Basidiocarps up to 9.5 cm broad and 2-5 cm high, obovoid, pulvinate or subglobose, plicate below, base abruptly contracted to a blunt point. Exoperidium thin, separable, areolate and breaking into scales or plates, brownish to straw color, or light violet to purplish, the surface minutely felted to smooth and usually with the larger depressions having a central flat purplish brown scale whose edges are more or less free and turned up; endoperidium thin (about 0.7 mm thick), brittle and breaking away by degrees in fragments, purplish brown. Sterile base almost absent or obscure, cup-shaped when present, occasionally fairly well developed but not stalklike. Gleba violet to pale purple, sometimes deep purplish brown at maturity, not very powdery, at least not falling out readily.

Capillitial threads 2.2-8.8 μ diam (rarely up to 11 μ thick), elongate, occasionally branched, Y-branches present, extremities attenuated and slender, tips subacute; septate, septa common to occasional, often joint-like or square, breaking readily at septations; walls even to slightly undulate, about 0.5 μ thick; pitted, pits round, very small, about 1 μ or less in diam, abundant; color livid gray to faintly purplish in KOH, pallid ochraceous tawny in Melzer's sol. Spores 3.9-4.4-7(12) μ in diam, often very variable in size, globose to subglobose, usually distinctly echinulate or asperulate, echinules up to 1 μ high and abundant, sometimes finely verrucose to nearly smooth, 1-guttulate, purplish to gray in KOH, pale tawny in Melzer's sol., obscurely pedicellate.

Growing scattered to gregarious on the open prairies or in pasture land, generally throughout the United States and southern Canada, late summer and fall.

Material examined: Alabama, *A. H. Povah*, Auburn, Feb. 1921. California, *Rea* 220, 246; *Leach* 3. Idaho, *Trueblood* 544, 895, 1953; *A. H. Smith* 64916 and numerous other collections. Louisiana, Baton Rouge, 1927. Michigan, *Potter* 9276; *A. H. Smith* 36136. New Mexico, *Barrows* 162. Oklahoma, *Bulmer* 2118. South Dakota, *Sydow Fungi Exotici* no. 941, 1928. Texas, *E. A. Smith* 1201, 1206, 1207, 1212, 1222, 1226, 1230, 1231, 1233, 1236, 1250. Utah, *Beck* F212. Wyoming, *A. H. Povah*, Tower Falls, Yellowstone National Park, May 1931.

Zeller was inclined to recognize this species and I also recognized it ($\bar{5}$) at that level, but in the ensuing years so much variation has been found that I have here relegated it to the rank of a form. The younger the spores the less conspicuous is the ornamentation in both this and the type form.

3. CALVATIA LEIOSPORA Morgan, Journ. Cinc. Soc. Nat. Hist. 18: 39. 1895.

Basidiocarps 6-9 cm tall and 4-6 cm in diam, oblong to obovoid, with a thick plicate base and a cord-like root; exoperidium smooth, continuous, very thin, fragile, reticulately marked, whitish; endoperidium thickish, fragile, velvety, ochraceous, at maturity breaking into fragments and falling away; sterile base about one half the fructification, convex above, ochraceous, cellular. Gleba violaceous to livid at maturity. Capillitium threads long, scarcely as wide as the spores, sparingly branched. Spores spherical, smooth, 3.5-4 μ in diam.

Growing in prairie habitats, South Dakota.

This species needs to be redefined from fresh material. It appears to have smooth spores but this is a somewhat questionable character in this stirps—especially in view of the small number of collections available.

4. CALVATIA SIGILLATA (Cragin) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 169. 1890.

Lycoperdon sigillatum Cragin, Bull. Washb. Coll. 1(2): 27. 1885.

Basidiocarps 10-14 cm in diam, turbinate, depressed above, narrowed below into a stem-like base; exoperidium very thin, fragile, white, easily rubbed off; endoperidium subcoriaceous, with a fragile ferruginous brown lining, marked off above into polygonal areas by lines of depression, at length breaking into fragments and falling away. Gleba violet to dark purple. Capillitium light brownish purple, threads long, branched slightly, rather sinuous, very occasionally

pitted. Spores spherical, smooth, with a long pedicel, 1-guttulate, 3.5–4.5 μ in diam.

Growing on the ground in meadows or open prairie, Kansas.

As for the preceding species, this one needs to be restudied in all stages of development to clearly separate it from *C. cyathiformis*.

STIRPS PACHYDERMA

Mycenastrum corium with spiny capillitium will key out here.

KEY TO SPECIES

1. Pits of capillitium threads slit-like..... 2
1. Pits of capillitium \neq isodiametric..... 4
2. Spores (mature) smooth to indistinctly ornamented..... 3
2. Spores distinctly verrucose to echinulate..... 7. *Calvatia fumosa* var. *fumosa*
3. Peridial surface even..... 6. *Calvatia hesperia*
3. Upper surface of gastrocarp soon broken into cones or warts with gray to fuscous tips..... 8. *Calvatia subcretacea*
4. Many spores ellipsoid to ovate; gastrocarps large (3–17 cm broad)..... 5. *Calvatia pachyderma*
4. Spores regularly globose; gastrocarps 2–6 cm broad..... 7a. *Calvatia fumosa* var. *idahoensis*
5. CALVATIA PACHYDERMA (Peck) Morgan, Journ. Cinn. Soc. Nat. Hist. 12: 167. 1899.

Lycoperdon pachydermum Peck, Bot. Gas. 7: 54. 1882.

Calvatia primitica Lloyd, Puffball Letters, no. 1: 2. 1904 (nom. nud.).

Basidiocarps 7–12 cm high, (3)7–17 cm broad, pulvinate or turbinate or irregularly ovate, peridial wall hard and thick, 2–4 mm in thickness, rarely thinner; exoperidium: smooth to lightly furfuraceous, white to pale brownish, thin and rind-like, about 1 mm thick, adherent to endoperidium or scaling away as small furfuraceous plaques or separate areas; endoperidium 2–3 mm or more thick, hard and rigid (*Scleroderma*-like), tan to dark brown, or shining and white when long weathered, dehiscence about the upper part of the peridium as irregular cracks and splits, these large plates then falling away exposing the gleba. Gleba dark olive-brown to umbrinous with faint purplish tints at the base, when mature very powdery, tending to blow away leaving an empty endoperidial shell, subgleba not developed, fertile tissue present to the basal attachment, base prolonged into a subradicating rhizomorph on occasion and the basidiocarp distinctly narrowed toward the base.

Capillitial threads (3.3–)4.4–9.9(–13.2) μ in diam, abundantly branched flexuous interwoven, branches Y-shaped or more acutely angled, threads usually rather thick, attenuated slender branches very rare, walls most irregular and often constricted, occasionally septate and thread breaking at septa readily, walls up to 2 μ thick in places, pitted, the pits rare to occasional, partially perforating the wall or perforating it; pits round to elliptical in shape, small not slit-like; the walls of the thread yellowish to pale olive (rarely dark olive-brown) in KOH, tawny to ochraceous tawny in Melzer's sol. Spores(3.3)3.9–6.6(–7.7) \times 3.3–5.5 μ , subglobose, broadly elliptical to broadly ovate, finely warted to seemingly smooth, with a hyaline envelope, yellowish to yellowish tawny in Melzer's sol. and KOH, pedicel present, small, some with an oil droplet.

Growing in open places in arid regions, Southwest and southern California, type examined. It is reported from Colorado, Arizona and California.

This appears to be a western species closely related to *C. fumosa*. Both have the same dark powdery gleba and a hard shell which is left as the only indication of the basidiocarp after it opens out and the spores escape. It is probably not as rare as the records indicate, but has probably been misidentified in the young stages as *C. gigantea*. Paul Marshall Rea collected this species a number of times in the vicinity of Santa Barbara, California. The empty peridial shell reminds one of *Mycenastrum corium*.

6. *CALVATIA HESPERIA* Morgan, Journ. Cinc. Soc. Nat. Hist. 18: 39. 1895.

Basidiocarps 4-8 cm broad, subglobose, depressed, white to pearly gray; peridium even, of two layers closely knit together, hard, coriaceous (*Scleroderma*-like); exoperidium hyaline, 180-200 μ thick, a rind of small periclinal cells; endoperidium 580-620 μ thick, of loosely woven hyphae which are larger than the exoperidial cells; dehiscence by the breaking up of the very persistent peridium. Gleba entirely fertile, clay-color to greenish yellow, then becoming olivaceous or even chocolate brown, pulverulent.

Capillitium continuous with the hyphae of the peridium, threads 4.4-7.7 μ thick, more or less flexuous and interwoven with occasional branches, Y-shaped branches present, tips not attenuated (instead rather blunt), septate; septa occasional; walls up to 2 μ thick, pitted; the pits slit-like or only partially perforating the wall, very occasional; walls yellowish to tawny brown in KOH and Melzer's sol. Spores 4.4-5.5(-6.6) \times 4-5 μ in diam, subglobose or somewhat ovoid, very indistinctly warted (almost smooth), hyaline envelope present, tawny brown in KOH, tawny in Melzer's sol., with an evident pedicel.

Found along a street in sandy soil, Pasadena, California, and known only from the type locality. Type examined.

7. *CALVATIA FUMOSA* Zeller, Mycologia 39: 300-301. 1947.

var. *fumosa*

Illustrations: Plate II A, B.

Basidiocarps 3-8(-10) cm in diam, irregularly subglobose to depressed globose or pulvinate, having a white cordlike rhizomorph: surface smooth to slightly furfuraceous at first, becoming irregularly wrinkled to plicate in drying, sometimes in dry situations rimose or areolate, the areolae small and flat-topped, white when in the duff, then smoke gray to hair brown to "sepia" to "Saccardo's umber" after exposure to light: peridium thick (1-2 mm), of two layers almost inseparable but sometimes quite apparent, very hard and persistent, chalky white throughout except for the darker surface cutis. Subgleba lacking or rudimentary. Gleba becoming very powdery and completely falling away at maturity, passing through colors from "Saccardo's olive" to "mummy brown."

Capillitial threads 2.2-18 μ in diam, mostly 4-11 μ thick, usually in long segments, sparsely branched and not much interwoven, branches Y-shaped or acutely angled, some attenuated into very slender subacute tips, aseptate; walls even, irregular or with knob-like projections, about 1-1.5 μ thick, breaking into segments with jagged edges, dark olive-brown to dark reddish brown in KOH, ochraceous tawny in Melzer's solution; pits slit-like, occasional to abundant. Spores (4.4-)5-7.7 μ in diam, globose to subglobose, echinate to verruculose (usually strongly ornamented when mature), often 1-guttulate, dark olive-brown in KOH and ochraceous tawny in Melzer's sol., pedicel evident.

Solitary or gregarious under spruce and fir in the mountains during the summer and early fall in Oregon, Washington Idaho (common) and Wyoming.

Material examined: Oregon: July 22, 1943, Crater Lake National Park, Type. Washington: *Smith* 29017, 29030, 29033, 29681, 30047, 30074, 30345, 30716, 30937, 31368, 31371, 31373, 31378, 31381. Idaho: *Smith* 44308, 44634, 45066, 45236, 45358, 45416, 45590, 45720, 46012, 58473, 58609, 58763, 58844, 59455, 60019, 64958, 64963, 65086, 65306. Wyoming: *Smith* 34596, 34815, 35591; *Solheim* 3389, 3390.

I have collected this species and *C. subcretacea* in quantity in Idaho and the two seldom intergrade. It is only during dry weather when *C. fumosa* has developed slowly that the peridium becomes deeply cracked. Rodents frequently gnaw on the peridia. Most collectors who find this species for the first time think they have found a *Scleroderma* because of the hard peridium. When one considers

the line of species in *Calvatia* distinguished by the hard peridium, and the tendency of the capillitium in the genus to become bumpy or develop short processes, one wonders if *Mycenastrum* should be maintained as a distinct genus.

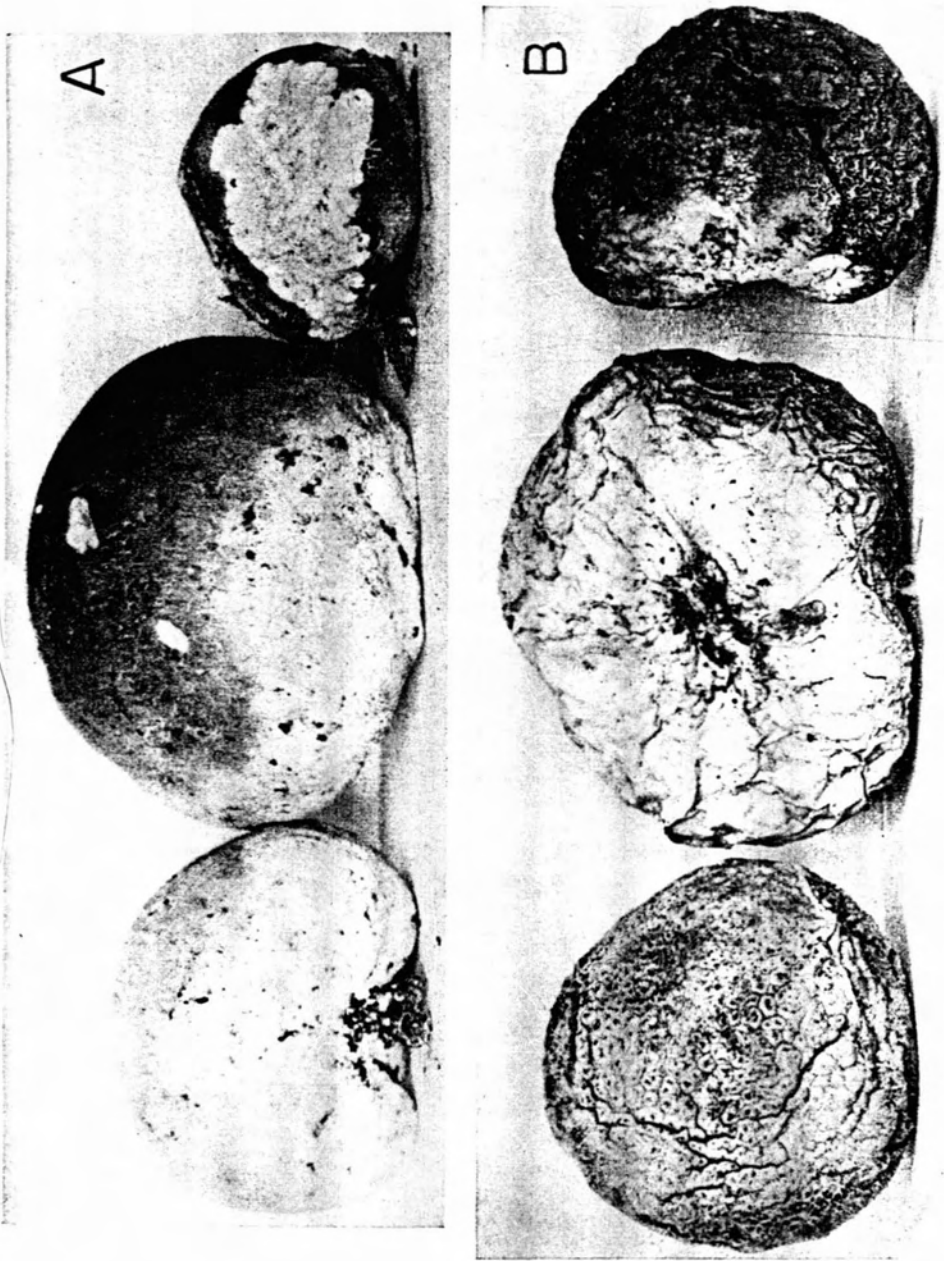


PLATE II A, *Calvatia fumosa* (fresh basidiocarps) $\times 2\frac{1}{2}$. B, *Calvatia fumosa* (dried basidiocarps) $\times 2\frac{1}{2}$.

7a. *Calvatia fumosa* var. *idahoensis* Smith var. nov.

Fructificationes 3-6 cm crassae, globosae vel ellipsoideae, glaber, demum furfuraceae vel subareolatae, avellaneae demum ligno-brunneae. Peridia dura, crassa. Gleba pulverulenta, olivaceo-brunnea. Subgleba nulla. Sporae 4.5-6.5 μ , globosae, verrucosae. Capillitium olivaceo-brunneum, perforatum; perforationes subrotundata. Typus: Smith 45279.

Basidiocarp 3-6 cm broad, globose to ellipsoid, glabrous or the epicutis of the outer layer thin and floccose and separating into minute areolae or warts and becoming avellaneous to wood brown in color, whitish over all at first and not darkening much in areas not exposed to light (color and surface markings much as in var. *fumosa*); inner peridium and exoperidium together forming a hard wall (*Scleroderma*-like). Gleba pallid when immature, when mature very powdery and soon completely dispersed, near "bister" to "Dresden brown" in dried material (not as reddish as in var. *fumosa*). Subgleba none.

Capillitium of thick-walled threads 3-10 μ diam., bister in KOH and tawny in Melzer's sol.; pitted and pits isodiametric, the edges pushed outward and ragged (as if pit had been produced by a minute explosion), walls 0.5-1.5 μ thick, smooth (except where pits are present), mostly aseptate, Y-branching rather frequent and segments not breaking up readily into short pieces, ultimate branches tapered to subacute points, outline straight to flexuous. Spores 4.5-6.5 μ , globose, with a hyaline narrow stump of a pedicel or in a few spores the pedicel tail-like, distinctly verruculose to echinulate from plugs extending into a hyaline outer matrix, bister in KOH, paler and tawny in Melzer's sol.

Under conifers, Hell's Canyon, East Rim near Kinney Point, Idaho, July 23, 1954, Bigelow & Smith 45279-type.

This variety differs from var. *fumosa* in the more yellow brown gleba as dried, in the isodiametric to irregular shape of the pits, and the more frequent branching of the capillitial threads.

STIRPS SCULPTA

Calbovista subsculpta with antler-like capillitium branches will key out here.

KEY TO SPECIES

1. Pits of capillitium slit-like; spores smooth or nearly so..... 8. *Calvatia subcretacea*
1. Pits of capillitium more or less rounded or if some are slit-like then a distinct subgleba present..... 2
2. Threads of capillitium with walls 1-2 μ thick; exoperidial spines very elaborate—sometimes curved or coiled; subgleba typically well developed..... 9. *Calvatia sculpta*
2. Not as above..... 3
3. Spores appearing practically smooth; warts on gastrocarp neither coarse nor ornamented by lines..... 11. *Calvatia owyheensis*
3. Spores distinctly ornamented..... 4
4. Basidiocarps 10-12 cm broad; threads of capillitium often encrusted..... 12. *Calvatia cretacea*
4. Basidiocarps up to 6 cm broad; threads of capillitium not encrusted..... 10. *Calvatia arctica*

8. CALVATIA SUBCRETACEA Zeller, Mycologia 39: 298-299. 1947.

Illustrations: Plate III.

Basidiocarp 2-7 broad, 1.5-4 cm high, depressed globose to pulvinate, base tapering to a point when young, lobed and broad to almost flat when older, slightly attached by white mycelium; exoperidium chalky white, conspicuous because of the polygonal warts the tips of which are often smoky gray, the sides of the warts may be marked by lines which converge at the apex, sometimes with parallel lines at various heights around the warts, warts 7 mm or less across, mostly pointed, never connivent, breaking away individually at maturity, sometimes discolored yellowish tawny when old: endoperidium thin, firm, furfuraceous, dull chamois

to honey yellow, breaking irregularly above. Subgleba rudimentary to lacking. Gleba powdery at maturity, passing through colors from olive buff to burnt umber.

Capillitial threads 2.2-13.2(-22) μ in diam, elongate, flexuous, or nearly straight, sparsely to abundantly branched, occasional Y-shaped branches present,



PLATE III - *Calvatia subreticulata* $\times 1$.

becoming attenuated and having subacute apices, aseptate or the septa very rare, breaking readily leaving jagged-edged segments; walls even to sinuous, or tortuous where the threads are very slender, about $1(2) \mu$ thick, dark olive brown in KOH when mature, tawny to ochraceous tawny in Melzer's sol., pitted; the pits slit-like or as jagged tears, often abundant. Spores $(3.3)3.9-6.6 \mu$ in diam, globose to subglobose, nearly smooth to asperulate, not truly verrucose (almost smooth in the type), ornamentation about 0.25μ high or less in the most heavily ornamented spores, hyaline envelope often evident, often 1-guttulate, cinnamon-brown to dark olive-brown in KOH, tawny to ochraceous tawny in Melzer's sol., pedicel evident.

Growing solitary to scattered in forests of spruce and alpine fir, summer and fall, California, Oregon and Idaho.

Material examined: California: *Gibbons* 184 (as *C. cretacea*); *Zeller*, 1947, from Mt. Shasta. Oregon: Mt. Hood, July 1938, type. Idaho: *Smith* 15825, 44728, 44865, 44877, 44903, 45279, 45248, 45256, 45278, 45321, 45322, 45323, 45347, 45419, 58781, 58782, 58910, 59060, 65169, 65264, 65426, 66143.

This is a common species in the mountains around McCall, Idaho, but its pattern of fruiting is typically scattered to solitary. It reaches the height of its season at about the same time as *C. fumosa*, from which it is readily distinguished by the characters in the key. Young specimens are white overall, but the scales darken as they become exposed to light. In the type of *C. cretacea* the pits are not distinctly slit-like, the spores have a hyaline envelope up to 0.7μ thick, and the basidiocarp is much larger.

9. *CALVATIA SCULPTA* (Harkn.) Lloyd, *Myc. Writ.* 1: 203. 1904.
Lycoperdon sculptum Harkness, *Calif. Acad. Sci. Bull.* 1(3): 160. 1885.

Illustrations: Plate IV A, B.

Basidiocarps obovate, turbinate, or pyriform, 8-15 cm in diam and in height, pure white: exoperidium very thick, spongy to coriaceous, rimose when young and cracking into warts that become pyramidal, the pyramidal masses 2-35 mm broad at the polygonal bases and 5-30 mm high, often coiled and tapering to more or less pointed apices and longitudinally or horizontally grooved by parallel lines, in age dividing vertically into several segments which usually remain attached at their apices, the segments falling away separately first over the upper surface of the basidiocarp and then more tardily downward to the base, usually leaving a few scaly remnants on the sides: endoperidium thin, membranous, fragile, breaking up, along with the exoperidium, along the lines between the warts or separately after the exoperidial layer has fallen away, often the upper surface of the endoperidium breaking up exposing the gleba through a broad irregular mouth. Subgleba weakly to well developed, occupying about one fourth or up to one half of the basidiocarp, interior chambered, often slightly purplish within base not truly radicating. Gleba yellow to olive brown, at maturity dark olive brown and somewhat powdery.

Capillitial threads $2.2-7.7 \mu$ in diam typically long and sparsely branched, interwoven, ultimate branches markedly attenuated to subacute apices, abundantly septate, breaking at septa readily; walls even to sinuous, up to 2μ thick, pitted; the pits occasional to abundant, round and like those of *C. craniiformis*; threads yellowish to tawny in KOH and in Melzer's sol. Spores $3.3-5.5(6.6) \mu$ in diam, globose to subglobose, rarely very broadly elliptical, at times with one oil drop, yellowish to pale brown in KOH and in Melzer's sol, very minutely spiny, the spines 0.25μ or less high, pedicel short.

Growing on the duff in conifer forests at high altitudes in the summer and fall in California, Oregon, Washington and Idaho.

Material examined: California: *Rea* 1186, 427, 1184, 1114, 1209. Copeland Butte Meadows, Butte County. Idaho: *Smith* 65158.

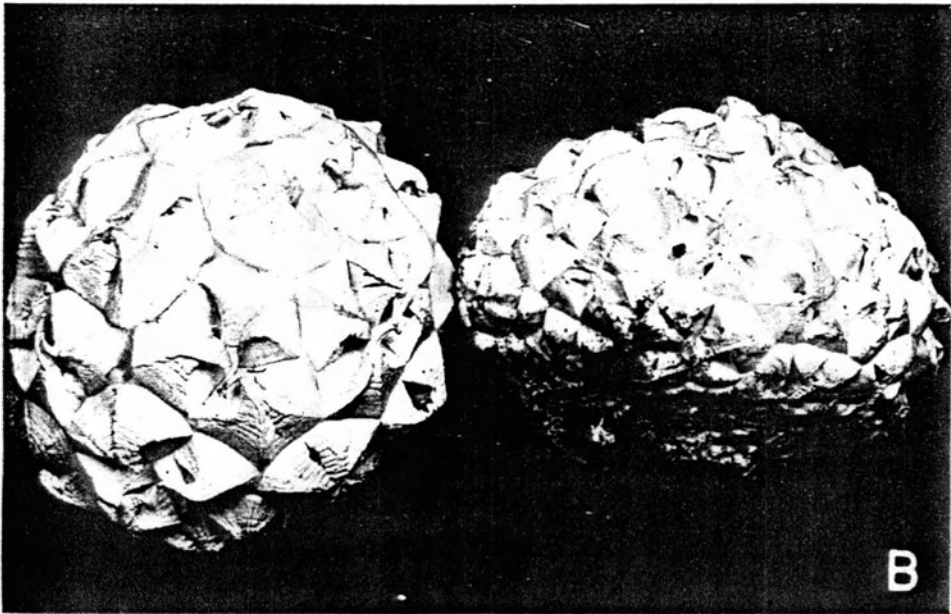
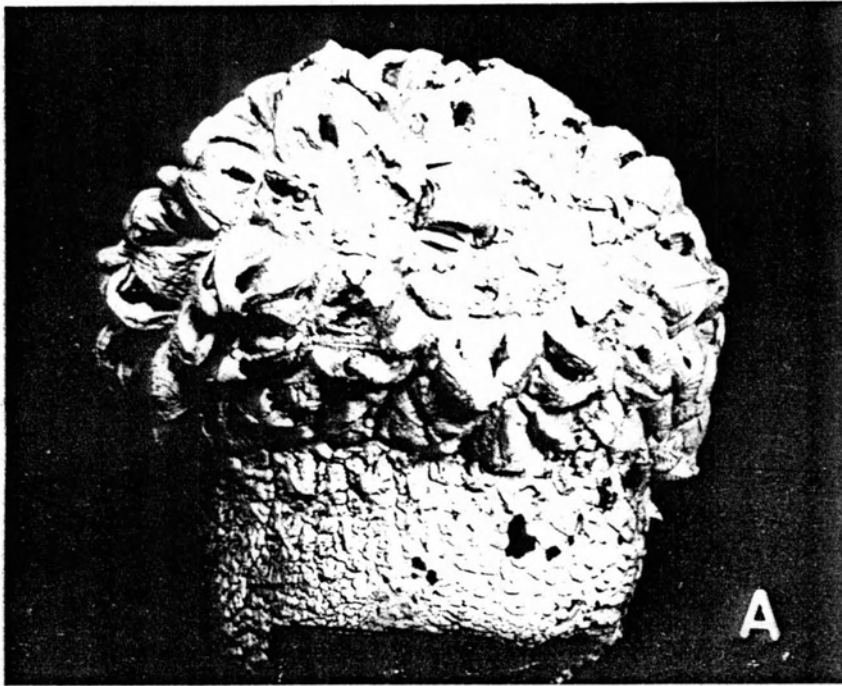


PLATE IV

A, *Calvatia sculpta* $\times 1$. B, *Calvatia sculpta* $\times \frac{2}{3}$.

This species is the most elaborately ornamented of any North American *Calvatia*. The manner in which the spines become curved or coiled gives the basidiocarp a rather outlandish appearance. In the slightly purplish interior of the sterile base it resembles *C. latrensis* but the exoperidial features of the latter are totally different. It appears to be closely related to *C. cretacea* but the latter, according to Lloyd's illustration of the type, does not have the elaborate spines.

10. *CALVATIA ARCTICA* Ferdinandsen & Winge, Medd. om Grønl. XLIII, p. 142-145. 1910.

Basidiocarps about 6 cm broad and 3 cm high, subreniform to depressed-globose, base plicate, protracted, acuminate, rooting by a mycelial cord: exoperidium white at first, cinnamon when mature, the part covering the upper surface remaining much paler, breaking into conspicuous pyramidal warts up to 7 mm broad and 2.5 mm high, these ornamented by lines parallel with the base and another set converging to the pointed apex, points of spines only rarely connivent, usually slightly darker than the rest of the spine, exoperidium less spinose on sides and lower side of basidiocarp where it may form merely a rather thick crust, or be only slightly sculptured with inconspicuous granules; warts falling away from upper surface first (singly or in groups) leaving the rather thick endoperidium smooth, polished to slightly floccose, and "Pale Olive-Buff" in color. Gleba rather pulverulent, becoming "Snuff Brown." Subgleba very inconspicuous, occupying only the protracted part of the base of the basidiocarp, consisting of minute chambers with pallid walls.

Capillitium pale "Honey Yellow," fragmented, branched, thin-walled (rarely with wall more than 0.7μ thick), with some round pits, main threads $3-8 \mu$ diam, outer ends $3-4 \mu$. Spores $(4.7)5.2-6 (-6.3) \mu$, pale "Honey Yellow," with blunt low hyaline warts about 0.4μ high, often with a hyaline envelope and a rather short hyaline pedicel. (Description adapted from that of Morten Lange).

Found in arctic regions of North America. Its detailed distribution is not clear but it was described from Greenland.

Lange (2) has given the best account to date of this species. Following his characterization, the species has the warts of the exoperidium ornamented by lines as in *C. sculpta*, it has distinctly ornamented spores at maturity, thinwalled capillitial threads with rounded pits, and a weakly developed subgleba. *C. subcretacea* has slit-like pits in the capillitium and practically smooth spores.

11. *Calvatia owyheensis* Smith sp. nov.

Fructificationes circa 5 cm latae, 3 cm altae, areolato-squamulosae, pallidae; subgleba incospicua; gleba olivaceo-brunnea, pulverulenta. Sporae $3.5-6 \mu$, globosae, punctatae. Filamenta capillitorum elongata. Typus Smith 65001 (Mich).

Basidiocarp about 5 cm broad and 3 cm high, with a more or less mycelioid rooting base, surface evenly areolate-warty with the warts more or less polygonal and smooth except for a central very small secondary wart or spine, or surface cracked into areas with 2-4 such secondary spines or warts, the whole effect is that of an embossed surface rather than distinct warts as in *C. subcretacea*, lower half of basidiocarp merely furfureaceous and pallid, color of upper surface dingy pallid as dried including the warts but with some areas stained brown: endoperidium thin and adhering to exoperidium. Subgleba reduced to a small area of chambers at the top of the rooting mycelium-and-direct column, avellaneous as dried. Gleba olive brown, more or less powdery.

Capillitium dull yellow brown in KOH, walls $1-1.5(2) \mu$ thick, $1.5-8 \mu$ in diam, cross walls scattered to numerous, branching fairly numerous and often nearly at right angles to main trunk, pitted with minute holes but narrower

branches often unpitted, walls flexuous to straight, some narrow threads quite contorted, and a fair number of branches ending in a needle-like point 5-9 μ long. Spores globose, 3.5-6 μ , minutely punctate-ornamented, more or less cinnamon brown in KOH (rather dilute) pedicel short, wall slightly thickened.

On soil, Owyhee County, Idaho, June 22, 1962, Ellen Trueblood (Smith 65001, MICH).

This species in many respects is like a small *C. bovista* var. *hungarica* but has rather frequently septate capillitium with scattered small holes as pits, and rather frequent right-angle branching. The outer layer of the basidiocarp becomes blocked out into polygons with secondary ornamentation at their tips, a feature distinguishing the species from *C. candida* and placing it closest to *C. artica* from which it is separated by the characters used in the key.

STIRPS GIGANTEA

KEY TO SPECIES

1. Basidiocarp smooth to near maturity; capillitium with isodiametric pits often abundant; spores nearly smooth to slightly punctate.....16. *Calvatia gigantea*
1. Characters not combined as above.....2
2. Spores smooth or practically so; basidiocarp soon coarsely areolate squamulose, the polygons and cones up to 2 cm high at times.....14. *Calvatia booniana*
2. Spores distinctly verruculose at maturity.....3
3. Surface of gastrocarp embossed but not scaly; capillitium not pitted to any extent; exoperidium corky and about 2 mm thick as dried.....15. *Calvatia lepidophora*
3. Not as above.....4
4. At least some capillitial threads encrusted with debris.....12. *C. cretacea*
4. Capillitium smooth.....13. *C. polygonia*

12. CALVATIA CRETACEA (Berk.) Lloyd, Mycol. Notes no. 46, pp. 650-652. 1917.
Lycoperdon cretaceum Berkeley, Ann. Sci. Nat. 12: 160. 1839.

Basidiocarp up to 10-12 cm broad and high, subglobose, depressed, or more oval varying to pear-shaped; exoperidium white at first, at maturity brownish gray (some of the spines remaining white), in most cases very thick and breaking up (especially near the apex) into more or less prominent polygons or warts, with clusters of spines of variable size and shape; towards the base remaining nearly smooth with inconspicuous spines, peeling off in rather large flakes together with the upper part of the endoperidium, and leaving the lower part of the endoperidium glabrous, polished and horn-gray. Gleba rather dark brown when fully ripe (Prout's Brown to Burnt Umber). Subgleba rudimentary to rather prominently developed (in more long-stemmed specimens), chambered, dark olive brownish, often with a lilaceous tint.

Capillitium thick-walled, tawny in KOH, walls flexuous, threads 3-13 μ thick, equal or tapered to extremities but not with thorns though a few aborted branches were seen, Y-shaped branches not infrequent, septate but septa rare (the threads break up into relatively short segments, apparently at the septa); walls rather heavily incrustated with adhering debris, pitted, the pits puncture-like as though the pressure was applied from the inside (hence the opening irregular in shape from a slight tearing effect. Spores globose, 4-7.5 μ diam, ornamented with a hyaline envelope 0.5-0.8 μ thick into which denser plugs project, spores pale cinnamon brown in KOH and more dingy yellow-brown in Melzer's sol.; pedicel present as a short stump and broken pedicels numerous in the mount.

On grassy areas and dry heaths in open arctic areas, Greenland, northern Canada, and Scandinavia.

Dr. Derek Reid, Royal Botanic Garden, Kew, Surrey, England, very kindly made observations on the type for me and sent a pinch of the gleba for observation. The microscopic features in the present description are from the type. It is obvious from Lloyd's illustration of the type that it is a large *Calvatia* much like *C. polygonia*. For a comparison of the two see that species. In my estima-

tion the encrusted capillitium and the way the threads break up into segments are sufficient to justify the recognition of both species. *C. subretucea* has practically smooth spores and generally smaller basidiocarps.

13. ***Calvatia polygonia*** Smith sp. nov.

Calvatia polygonia Lloyd in Shantz & Piemeisel, Journ. Agric. Res. XI, no. 5: 202. 1917 (Nom. nud).

Illustrations: Plate V, VI.



PLATE V

Calvatia polygonia ×1. Holotype.

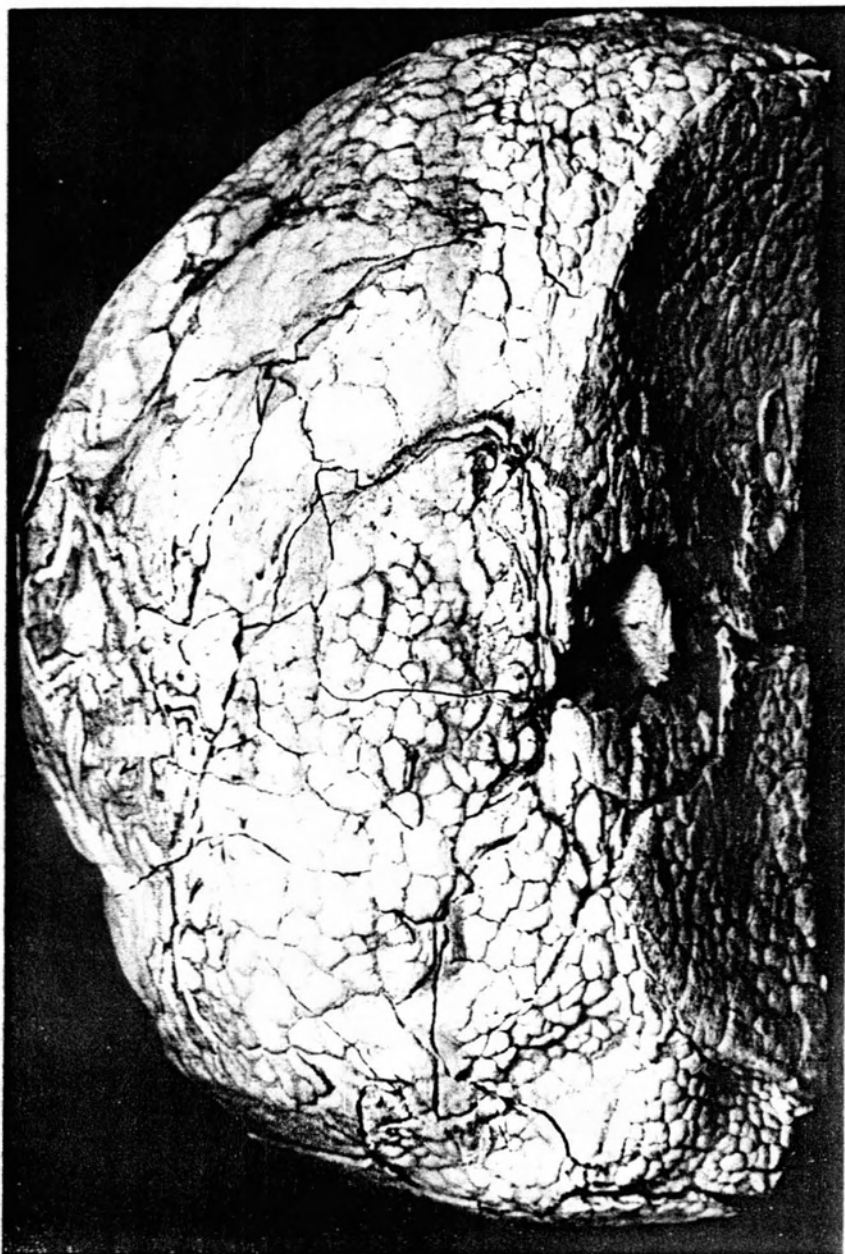


PLATE VI
Calvatia polygonia X1. Paratype.

Fructificationes 8-16 cm latae, globosae vel subglobosae demum areolato-squamulosae. Gleba sordide brunnea, non-pulverulenta. Sporae globosae, 3.5-6.5 μ crassae, verruculosae. Filamenta capillitiorum 3-8 μ crassae, tenui-tunicatae (0.5-1.2 μ), flexuosa, septata. Typus Lloyd Herb. 31786.

Fructifications medium to large, 8-16 cm diam, globose to sub-globose; exoperidium white to brownish, continuous at first but soon breaking up into distinct

polygonal warts which in age may show some development of horizontal lines, finally falling away; endoperidium adhering to exoperidium as a thin lining and breaking up and falling away as part of the scale. Gleba cottony, dingy brown (an avellaneous brown, but not truly lilac or violaceous), maintaining its shape at least for a time after peridium falls away. Subgleba absent to rudimentary.

Capillitium of threads 3-8 μ diam, smooth, pale ochraceous brown in KOH and bright fulvous in Melzer's sol., walls rather thin (0.5-1.2 μ), narrower threads unpitted, larger threads with scattered roundish pits, threads often flexuous to crooked, rarely with short aborted branches but regular branching frequent, many of the branches Y-shaped, septa moderately abundant and thread usually creased clear around at the septa (the joint not swollen but rather marked by a narrow circular depression), ultimate branches tapered to a subacute apex, the threads not breaking up into short segments readily. Spores 3.5-6.5 μ , globose to subglobose, pale ochraceous in KOH, pale yellow (bright) to pale tawny in Melzer's sol., lacking a pedicel, strongly ornamented, the hyaline sheath 0.5-1 μ thick, denser plugs extending into it, walls not conspicuously thickened (many spores long remaining collapsed in Melzer's sol.).

On prairie sod, Colorado during the summer.

Calvatia booniana was mistaken for this species until the original material sent to Lloyd by Shantz and Piemeisel was studied. The two are readily separated by the difference in spore ornamentation. Even young spores of *C. polygonia* are distinctly ornamented. The difference in septation of the capillitial threads may also be important. Actually, *C. polygonia* is very close to *C. cretacea* (sensu the type, not the literature). However, *C. polygonia* lacks incrusting debris on the capillitium, the threads have thinner walls, and do not break up into the short segments as seen for *C. cretacea*. One would expect the gleba to be much more powdery in the latter. The spores of *C. polygonia* lack a pedicel whereas those of *C. cretacea* often have a short stem of a pedicel and broken pedicels are numerous in the mounts.

It is clear to me that the arctic species of *Calvatia* need to be restudied on the basis of what is now known of the species in our western states.

Material examined. Colorado: Lloyd Herb. 31786-type; 15574 (both collected by Shantz). Lloyd Herb. 31787 from New Mexico is *C. booniana*.

14. *Calvatia booniana* Smith sp. nov.

Illustrations: Plate VII, VIII.

Fructificationes 20-60 cm latae, 7-30 cm altae, demum areolato-squamulosae; sporae 3.9-6(-6.6) \times 3.3-5.5 μ , subgloboseae, subleves; filamenta capillitiorum 3.3-8.8 μ crassae. Typus, Smith 65191 (MICH).

Basidiocarp 20-60 cm broad, 7-30 cm high, flattened but circular more or less in outline: exoperidium thick and white, subfloccose, soon breaking up into 4-6 sided areolate squamules or polygones or patches of them, the polygones up to 2 cm deep and finally falling away exposing a whitish then pale buff thin to thick (1-2 mm) endoperidium which is slightly punky in texture, the exposed surface unpolished and felt-like, attached to substratum by a cord-like rhizomorph, entire peridium wall 2-4 mm thick. Gleba dingy olive when mature, olive brown as dried. Subgleba absent to rudimentary.

Capillitial threads 3.3-8.8 μ in diam, twisted and interwoven, branched, the branches Y-shaped or otherwise, extremities not truly attenuated, but rather bullet-shaped to subacute, rarely thorn-like, threads septate, septa scattered to abundant, square and thread breaking readily at the septa, walls even to sinuous or tortuous, thickened up to 2 μ , yellowish in Melzer's sol. and usually bright olive-yellow in KOH; pitted very occasionally, the pits often not extending clear through the wall. Spores 3.9-6(-6.6) \times 3.3-5.5 μ , globose to subglobose or broadly



PLATE VII
Calvatia booniana (dried) $\times 1\frac{1}{3}$. Holotype.

elliptical, seemingly smooth to very finely punctate, hyaline envelope evident, usually uniguttulate, yellowish olive in Melzer's sol. and olive-brown in KOH, pedicel usually evident.

Growing on soil under sage brush or in grassy places in arid regions. It is known from Idaho, Oregon, Utah and Colorado.

Material examined: Oregon: *Smith* 65191-type. Utah: *McKnight* F998. Idaho: *Truablood* 1614, 2183, 2193, 2248 (MICH). New Mexico: Lloyd Herb. no. 31787.



PLATE VIII

Calvatia booniana (fresh) $\times \frac{1}{4}$. Photo by Mrs. Ellen Trueblood.

This species has been misidentified for the last fifty years as *C. gigantea*, no doubt because of its large size. Dr. Wm. Judson Boone, the first president of the College of Idaho, who was keenly interested in the central Rocky Mountain mushroom flora, had some beautiful specimens which I saw in 1935. Hence, I take pleasure in dedicating this species to him. The smooth or practically smooth spores at once distinguish the species from *C. polygonia*, but there are many slight differences in addition, such as the size of the exoperidial warts, occasional short thorns on the capillitial threads reminding one of the capillitium of *Mycenastrum*, and the more tortuous outline of the threads, often appearing as a series of stretched out S-curves. In KOH the capillitium is often bright olive-yellow to nearly lemon color and some of this pigment may diffuse into the mounting medium.

15. CALVATIA LEPIDOPHORA (E. & E.) Coker and Couch, *Gastromycetes of Eastern United States and Canada*, p. 60. 1928.

Lycoperdon lepidophorum Ellis & Everhardt, *Journ. Myc.* 1: 88. 1885.

Hypoblema lepidophorum (E. & E.) Lloyd, *Myc. Writ.* 1: 140. 1903.

Basidiocarps large, 15 cm high, 20 cm broad, subglobose to obovate, stramineous to brownish; peridium very thick, duplex: exoperidium with a thin glazed rind inseparable from an almost corky brown layer 2 mm thick when dry, surface glossy but areolate or marked with inherent patches or rounded bosses which are darker and duller than the glazed surface, the whole separable from the endoperidium: endoperidium papery thin, dark brown. Gleba dull olive-brown, pulverulent.

Capillitial threads 2.2-5.5 μ in diam, elongate, slightly interwoven, branched, the branches forked or at right-angles and rather common, attenuated to slender pointed tips, septate; the septa abundant, square or joint-like; the walls even and thickened to some extent, often breaking at septa, thickened at septa and forming interiorly directed walls up to 1 μ thick, not pitted to any degree, yellowish in Melzer's sol. and KOH; where pits are present they are minute and widest to the interior and round. Spores (4.5)5.5-6.5 \times (5)-5.5-6 μ , subglobose to very broadly elliptical or broadly ovate, densely verruculose, the verrucae about 0.5 μ high, a definite hyaline envelope present, usually uniguttulate, olive-brown in KOH and ochraceous tawny in Melzer's sol., pedicel absent to inconspicuous.

Growing in prairie country, South Dakota. Lloyd listed it from Indiana and Ohio.

The strongly ornamented spores, thick peridium and relatively smooth outer surface appear to be the important diagnostic features. The distinctly ornamented spores separate it from *C. booniana*.

16. CALVATIA GIGANTEA (Batsch ex Pers.) Lloyd, *Myc. Writ.* 1: Note 269, p. 166. 1904.

Lycoperdon giganteum Batsch ex Pers., *Syn. Fung.* p. 140. 1801.

Bovista gigantea (Batsch ex Pers.) Bigeard et Guillemin, *Fl. Champ. super. de France* 1: 467. 1909.

Lycoperdon bovista Fries, *Syst. Myc.* 3: 29. 1829 (non Persoon).

Langermannia gigantea (Batsch ex Pers.) Rostk. in Sturm, *Deuts. Fl.* 44. Abt. 3 (5 vol): 23. 1844.

Globaria gigantea (Batsch ex Pers.) Quélet, *Champ. Jura et Vosges* p. 362 (370). 1873.

Calvatia maxima Morgan, *Journ. Cinc. Soc. Nat. Hist.* 12: 166. 1890.

Calvatia bovista (Fries) MacBride, *Lab. Nat. Hist. Univ. Iowa Bull.* 4: 41. 1896.

Lasiosphaera fenzi Reichardt, *Novare expedit.* p. 135. 1870 (?).

Eriosphaera fenzi (Reichardt) Saccardo, *Syll. Fung.* 7: 96. 1888.

Illustration: Plate IX.

Basidiocarps very large, 20-50 cm in diam, subglobose, depressed-globose or obovate, with a thick cord-like root: exoperidium white or grayish but changing to yellowish and becoming olivaceous, at first subtomentose, smooth like a kid glove, very thin (about 1 mm when dry), fragile, ultimately breaking up and falling away in pieces from the inner layer: endoperidium thin fragile, after maturity

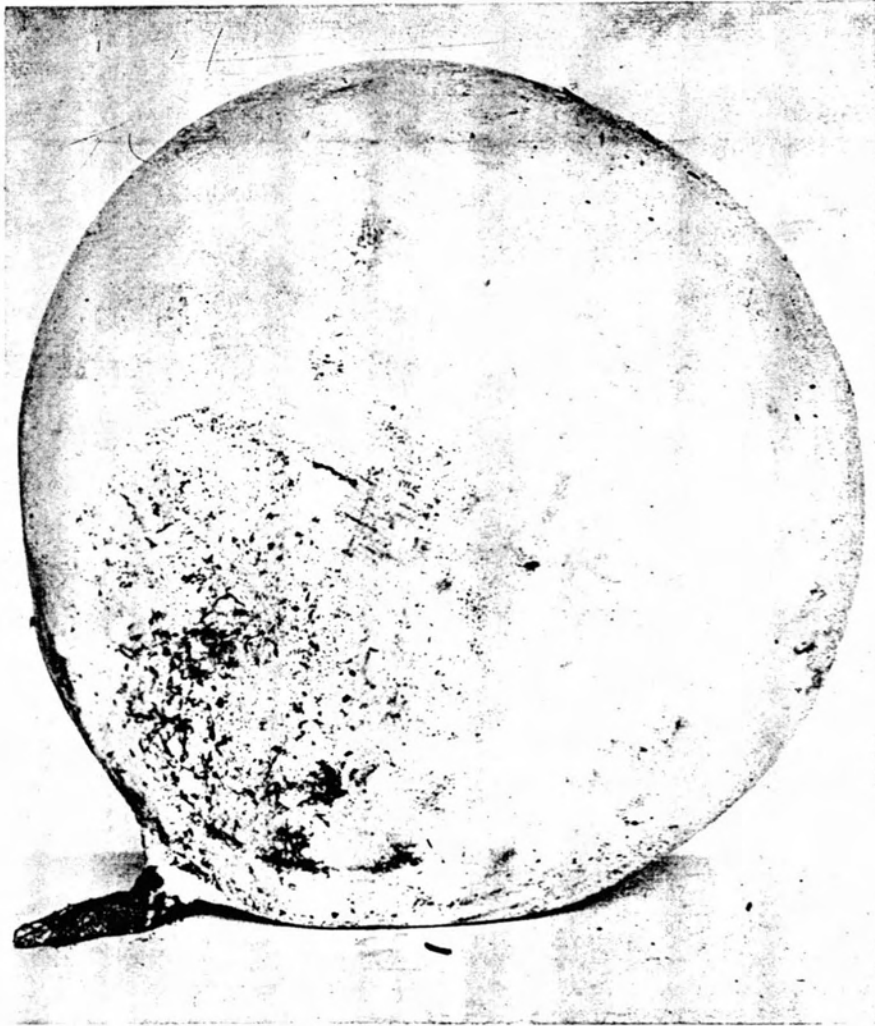


PLATE IX

Calvatia gigantea (young) $\times 1$.

gradually breaking up into fragments and falling away. Subgleba very shallow or almost wanting. Gleba white, then yellowish and finally olivaceous or greenish yellow.

Capititial threads 2.2-8.8 μ in diam, elongate, occasionally branched, branches Y-shaped or otherwise, becoming attenuated to the slender pointed tips, septate; septa abundant to occasional, threads of even diameter at septa or enlarged slightly causing a joint-like appearance; walls up to 1.5 μ thick, pitted, the pits round and often abundant, frequently widest on the interior side or not completely penetrating the wall, wall yellowish in Melzer's sol. and KOH. Spores 3.3-5.5 \times 3-5 μ , globose to subglobose, rarely very broadly elliptical, minutely and sparsely spiny-punctate to seemingly smooth, often uniguttulate, yellowish to pale olive-brown in KOH, yellowish to tawny in Melzer's sol., pedicel small.

Growing solitary to gregarious on low ground under brush and often bordering woodland pools, sometimes abundant along drainage ditches, late summer and

early fall. It occurs throughout eastern North America and into the Prairie States, but reports from the Pacific Coast all need further verification.

No attempt to give material cited is made for this common species which is frequently sold for human consumption in markets, and is treated in almost every book on edible mushrooms.

STIRPS TATRENSIS

KEY TO SPECIES

- | | |
|--|-------------------------------|
| 1. Spores 9-12 μ , globose, reticulate; capillitium breaking up into S-shaped fragments or fragments very sinuous..... | 18. <i>Calvatia paradoxa</i> |
| 1. Spores smaller and not reticulate..... | 2 |
| 2. Capillitial threads encrusted, very thick-walled, not pitted, the broken ends often lacerate-fibrillose..... | 20. <i>Calvatia lacerata</i> |
| 2. Capillitium not as above..... | 3 |
| 3. Capillitial threads not pitted..... | 19. <i>Calvatia depressa</i> |
| 3. Capillitium pitted..... | 4 |
| 4. Gleba a cottony mass of capillitium mixed with spores..... | 21. <i>Calvatia lloydii</i> |
| 4. Gleba powdery and soon completely dispersed..... | 17. <i>Calvatia tatrensis</i> |
17. CALVATIA TATRENSIS Hollos, Math. Termés. Ért. 19: 508. 1901.

var. TATRENSIS

Illustrations: Plate X.

Basidiocarp 4.5-9 cm broad, 5-7 cm high, turbinate to obovate: exoperidium white to cream colored, thick, cracking into low irregular plaques which are granular-furfuraceous and mostly deciduous, remnants remaining as small, floccose patches or large plate-like areas: endoperidium chamois to dull tawny or stained brownish from gleba, firm to somewhat papery in age, splitting irregularly and forming a broad, tattered mouth at times in age. Gleba powdery and chocolate brown to dark olivaceous brown at maturity. Subgl. occupying the lower fourth of the basidiocarp, strongly furrowed to plicate, interior chambered and the chamber walls purplish or in extreme age olivaceous.

Capillitial threads 2.2-10.8 μ in diameter, main axes mostly 7.7-10.8 μ , flexuous and elongate, branched frequently, branches becoming attenuated to subacute at the tip, breaking readily, lacking septa; walls nearly entire to pitted abundantly, the pits irregular and slit-like; walls up to 2 μ thick, olivaceous-brown to russet in KOH and russet to Prout's brown in Melzer's sol. Spores 4.4-7.7 \times 4.4-6.6 μ , subglobose to very broadly ovate, a thin, hyaline envelope present, minutely echinulate to almost smooth, often uniguttulate, Dresden brown in KOH and tawny brown in Melzer's sol. (weakly dextrinoid), pedicel inconspicuous. Peridial wall composed of somewhat swollen cells 6.5-12.5 μ in diam, collapsing readily, more elongate slender hyphae intermixed with the inflated ones, the tissue light yellowish in KOH.

Growing on waste land under sagebrush in North America, summer, rare. Known from Wyoming and Utah.

Material examined: Wyoming: *Smith* 34380. Utah: *Kelly*, summer of 1929.

The granular furfuraceous outer layer, the manner of dehiscence, the slit-like pits of the capillitium, weakly ornamented spores, and violaceous tinged chamber walls of the subgleba are distinctive.

17a. *Calvatia tatrensis* var. *gruberi* Smith var. nov.

Fructificationes circa 13.5 cm latae, pyriformes, sursum conico-squamulosae, squamulis in Bovistellis radicatis similis; sporae globosae, 4.5-6 μ to 4-5 μ , apedunculatae. Typus Gruber 754 (MICH).

Basidiocarps about 13.5 cm broad in expanded portion, about 6 cm deep, sterile base 6 cm long, 5 cm thick: outer peridium in the form of spines coating the surface as in *Bovistella radicata* (often in groups with connivent tips) over the upper portion, lower down furfuraceous to nearly smooth: inner peridium splitting

P. E. X. *Calvatia latronis* X1.

variously over the apex and breaking away backward to form a goblet containing the powdery gleba, the layer dull russet in color, thick over the sides and lower portion, thin over the disc (remining one of *Calvatia depressa* at maturity). Subgleba with moderately sized chambers and well developed into a short stipe-like structure with chamber walls avellanaceous to wood brown in color. Gleba

soon powdery and peridial shell soon nearly empty, when ripe gleba near umber brown ("warm sepia").

Capillitium of branched filaments 2-10 μ diam, dull brown in KOH, walls 0.5-1.5 μ thick, with copious slit or tear-like pits, breaking readily, rather sinuous in outline, tapered to acute apices. Spores 4.5-6 \times 4-5 μ , globose to subglobose or broadly ovate, smooth or practically so, sepia in KOH under the microscope, lacking a pedicel or with a short stump of one.

Under scattered conifers near Mt. Hood, Oregon, 1945, Wm. B. Gruber 754. Know only from the type collection.

This variety in many ways resembles *Bovistella radicata* closely but is distinguished by the pitted capillitium and lack of a pedicel on the spores. The ornamentation of the surface of the basidiocarp distinguishes it at once from *C. cretacea*. It is distinct from var. *latrensis* in lacking plications at the base and in heavier exoperidial ornamentation as well as much larger size.

18. *Calvatia paradoxa* Smith sp. nov.

Fructificationes 2-6 cm latae, 2-3.5 cm altae, glaber, radiato-laceratae, gleba pulverulenta, umbrino-lutea. Subgleba inconspicua. Sporae 9-12 μ , globosae, reticulatae. Filamenta capillitiorum fragmentata, sinuosa; tunicac 0.4-1 μ crassae. Typus Smith 51962 (MICH).

Basidiocarp 2-5 cm broad, 2-3.5 cm high, surface glabrous, dull brown when collected and outer layer smooth but rimose-cracked over apex (in the only unopened specimens available for study). Outer layer adherent to inner layer and both together forming a leathery spore case which opens widely by radial tears across the upper part in the manner of *Scleroderma flavida*. Subgleba none to rudimentary. Gleba powdery, dark sepia when mature (not purplish), soon completely dispersed leaving the empty spore case.

Capillitium abundant, tunicas ochraceous in KOH, walls 0.4-1 μ thick, smooth, readily breaking up into fragments which are S-shaped or compound S-shaped, but varying to merely wavy in outline (rarely). Spores 9-12 μ globose dark umber brown in KOH and closely reticulate, lacking a pedicel.

On soil in a mountain sheep pasture. Placerville, Colo. Aug. 6, 1956, Smith 51962-type.

The species has spores like a *Scleroderma*, capillitium much like that of *C. polygonia* and the over-all appearance of *Calvatia depressa*. The developmental stages of this species should be interesting. In the material seen to date the gleba was mature.

19. *Calvatia depressa* (Bon.) Zeller & Smith comb. nov.

Lycoperdon depressum Bonorden, Bot. Zeitg. p. 611. 1837.

Vascellum depressum (Bon.) F. Smarda, in *Gastromycetes*, A. Pilát, B-1, p. 305, 1958.

Lycoperdon subpratense Lloyd, Myc. Writ. 2: 231. 1905.

Calvatia subpratense (Lloyd) Coker & Zeller, Mycologia 39: 305. 1947.

Basidiocarp depressed-globose or turbinate, bowl- or urnshaped at maturity, 2.5-5 cm high, 2-4 cm broad; surface white, then pale ochraceous buff or flesh pinkish, becoming shades of olivaceous or finally a dark shining metallic brownish where the inner peridium is exposed: exoperidium composed of small soft spines somewhat united at the apex, mixed with tiny simple spines and furfureaceous granules which fall away from mature specimens: endoperidium thin, dark inner surface at first densely felted with bases of capillitium threads but becoming shiny and metallic in old specimens, dehiscing by more or less stellate lobes which break up and fall away until the upper portion of the peridium has disappeared. Subgleba prominent, of large chambers with whitish walls at first but these becoming brownish to purplish, often occupying the lower half of the basidiocarp, cupshaped, separated from the gleba by a definite diaphragm which is membranous and in old specimens is smooth and shining. Gleba white soft, becoming yellowish olivaceous, then light brownish olive.

Capillitial threads 3.3–6.6 μ in diam, scanty at maturity, attached to the inner surface of the peridium and the diaphragm, hyaline to pale brown in KOH and Melzer's sol., even or slightly irregular, abundantly septate, sparingly branched, the walls moderately thick, not pitted, breaking up into short sections. Spores 3–5.5 μ in diam, smooth to finely punctate, pale olivaceous in KOH, tawny in Melzer's sol., with one to several oil drops, pedicel short.

Growing on lawns and in pastures and other grassy areas in late summer and fall, known in the east from Massachusetts and from the Pacific Coast states where it is common.

Material examined: Oregon: *Smith* 55617. *Carpenter* 64C.

Because of its superficial resemblance to a *Lycoperdon*, the number of collections preserved in herbaria is in no way an indication of the abundance of the species.

20. *Calvatia lacerata* Smith sp. nov.

Fructificationes circa 7 cm latae, globosae, pallidae demum sordide brunneae, areolatae, stellate rimosae vel laceratae. Gleba flocculosa, umbrino-brunnea. Subgleba nulla. Sporae 3.5–5 μ , globosae, verruculosae. Filamenta capillitiorum 2–7 μ diam, crasso-tunicata, scabra. Typus *Smith* 19546 (MICH).

Basidiocarp about 7 cm diam, globose: exoperidium present as a thin felty layer pallid to whitish fresh but discoloring to brownish and sloughing off in patches leaving a thin pliant pallid to brownish inner peridium which finally dehisces by radial tears toward the base leaving segments of various widths roughly triangular in shape. Gleba not completely powdery, rather like a cottony mass not becoming completely dispersed, very dark brown at maturity. Subgleba none evident.

Capillitium of threads 2–7 cm diam, rarely septate, not pitted, thick-walled to the exclusion of the cell lumen at times, surface conspicuously encrusted with debris both in KOH and Melzer's sol., yellowish to dingy tan in KOH, practically the same color in Melzer's sol., branching rare to absent (in most mounts), threads often bent or curved as if elastic, but not sinuous or flexuous, broken ends lacerate-frayed to some extent (as if thread were made up of individual fibrils). Spores 3.5–5 μ , globose, strongly verruculose with plugs extending about 1 μ into an outer hyaline matrix, in KOH near snuff brown, dark bistre in Melzer's sol. lacking a pedicel.

Solitary in young Douglas fir area, Rhododendron, Oregon, Oct. 8, 1944. *Gruber & Smith* 19546-type.

The specimen reminded one of an old *Bovista pila* in which the peridium had become quite lacerated, but the resemblance ends there. The thick-walled, encrusted non-pitted capillitium is distinctive.

21. *CALVATIA LLOYDII* Zeller and Coker, *Mycologia* 39: 301. 1947.

Basidiocarp 3–8 cm in diam, depressed globose to subturbinate, rounded or flattened above, pinched below and attached by ample whitish rhizomorphs; surface at first creamy white, becoming stramineous to chamois or even reddish brown, dull or at times silky-areolated above becoming increasingly so, the areolae finally forming more or less prominent warts or obtuse spines, spines smaller and more or less furfureaceous surface smooth below; exoperidium rather thin and broken as described above, not readily separating from the endoperidium which is papery, thin and delicate, merging imperceptibly into the gleba on the inner side; dehiscence irregular. Gleba a cottony mass of capillitium and spores, light to dark olive buff to olive brown. Subgleba concave and extending somewhat upward in the form of a cup around the gleba, composed of small lacunae, the partitions thin and purplish brown, with a metallic luster.

Capillitium 2.2–8.8 μ in diam, uneven, fragmented, somewhat branched, aseptate, umbrinous in KOH, ochraceous tawny in Melzer's sol., walls about 1 μ thick, with abundant slit-like pits. Spores globose to subglobose, 3.9–5.5 μ in

diam, finely but distinctly echinulate, the spines projecting through a hyaline envelope, olive-brown in KOH and ochraceous tawny in Melzer's sol.

In dry coniferous woods, mountains of California and Idaho.

Material examined: California, *Zeller-type*. Idaho, *Trucloud 1514*.

STIRPS CRANIIFORMIS

KEY TO SPECIES

- | | |
|--|---|
| 1. Exoperidium dark brown to blackish; gleba dark cocoa-color at maturity | 22. <i>Calvatia umbrina</i> |
| 1. Not as above | 2 |
| 2. Sterile base absent or nearly so | 3 |
| 2. Sterile base well developed (distinct) | 4 |
| 3. Spores smooth; gleba ochraceous | 23. <i>Calvatia diguetii</i> |
| 3. Spores echinulate to verruculose; gleba dark olive brown | 24. <i>Calvatia lycoperdoides</i> |
| 4. Fresh gastrocarp quickly staining chrome yellow when injured, when dried ochraceous to orange red at least in some part | 25. <i>Calvatia rubroflava</i> |
| 4. Colors not as above | 5 |
| 5. Spores 5.5-7.7 x 5.5-7 μ, usually flattened on one side; threads of capillitium hyaline | 26. <i>Calvatia ochrogleba</i> |
| 5. Spores not as above | 6 |
| 6. Surface of gastrocarp before breaking up of peridium smooth or practically so; capillitial threads with numerous large pits | 27. <i>Calvatia craniiformis</i> |
| 6. Surface granular to furfuraceous | 7 |
| 7. Spores distinctly ornamented, plugs extending out 0.5-1 μ from the spore surface | 28. <i>Calvatia excipuliformis</i> var. <i>excipuliformis</i> |
| 7. Spores with indistinct ornamentation | 29. <i>Calvatia elata</i> |

22. CALVATIA UMBRINA Lloyd, Myc. Writ. 1: L. 1, p. 2. 1904.

Illustrations: Plate XI.

Basidiocarps 4-6 cm in diam, subglobose; exoperidium thin, smooth, dark brown or almost black, not easily separable from the endoperidium which is also very thin and fragile, dehiscing by breaking away above; sterile base none; gleba dark amber, without purple tints; capillitium branching, sinuous, smooth dark brown 4-6 μ in diam; spores spherical, smooth, with a short stub of a pedicel. 4 μ in diam.

On the ground Mountain View, California.

In order to present all the data on this species Lloyd's "original description" follows:

"Another plant, I think undescribed, reaches me from Edward M. Erhorn, Mountain View, California. It is globose, has no sterile base, but is much smaller than the previous species (*C. primitiva*). A have labelled it *Calvatia umbrina*, and if I do not find it in some of the collections of Europe, I will illustrate it in "Mycological Notes" under this name. Peridium very thin, smooth, dark brown, almost black. It reminds me somewhat of the peridium of *Bovista pila*, but dehisces evidently as a *Calvatia*. Gleba without sterile base, dark amber color, without hint of purple. Capillitium branching and intertwined, smooth, deeply colored, 4-6 μ thick, thicker than the diameter of the spores. Spores small, about 4 μ in diameter, globose, smooth, apiculate. The exact generic place of this plant is not assumed as yet. It is close to "*Calvatia hesperia*" from the same region, in form, size, internal characters and absence of sterile base. It differs entirely, however, in the color of the gleba."

Through the kindness of Dr. C. R. Benjamin of the National Fungus Collections, Beltsville, Maryland, I have examined the type. The data are as follows: Capillitium of threads 3-10 μ diam, reddish brown (dull vinaceous brown) in KOH, pale tawny in Melzer's sol.; walls about 1 μ thick, smooth over exterior, pitted, pits = isodiametric and many appearing as if punched in from the outside and showing a lens-shaped thickening (or nearly globose) on interior opening (almost like tyloses); outline of threads flexuous to rather crooked, septate, septa



PLATE XI *Calvatia umbriina* Lloyd (Type, about nat. size).

transverse, thread rarely enlarged at septa and when breaking, breaking clearly and squarely, tapering to blunt or subacute apices, lateral walls rarely with short projections or short lateral branches. Spores 4-9 μ , globose to subglobose, *smooth*, with a stump of a pedicel at most, in KOH, pale dingy cinnamon, in Melzer's sol. pale tawny, wall thickened somewhat. The gleba is about "warm sepia" (dark cocoa-color).

23. *CALVATIA DIGUETHI* Harkness & Pat. Bull. Soc. Mycol. France 20: 64. 1904.

Basidiocarps depressed globose, 4-6 cm broad, somewhat flattened below, about 2 cm high, short-stemmed, surface ochraceous, very minutely furfuraceous; peridium thin, less than 1 mm thick, rigid, dehiscing above by irregular fragments which fall away; sterile base wanting; gleba ochraceous, cottony; capillitium threads fragile, branched, light ochraceous, 3-6 μ in diam, spores subglobose, smooth, with a short stump of a pedicel, 3-4 μ in diam.

On sandy soil on the California coast. Known only from the type locality.

24. *Calvatia lycoperdoides* Smith sp. nov.

Illustrations: Plate XIII.

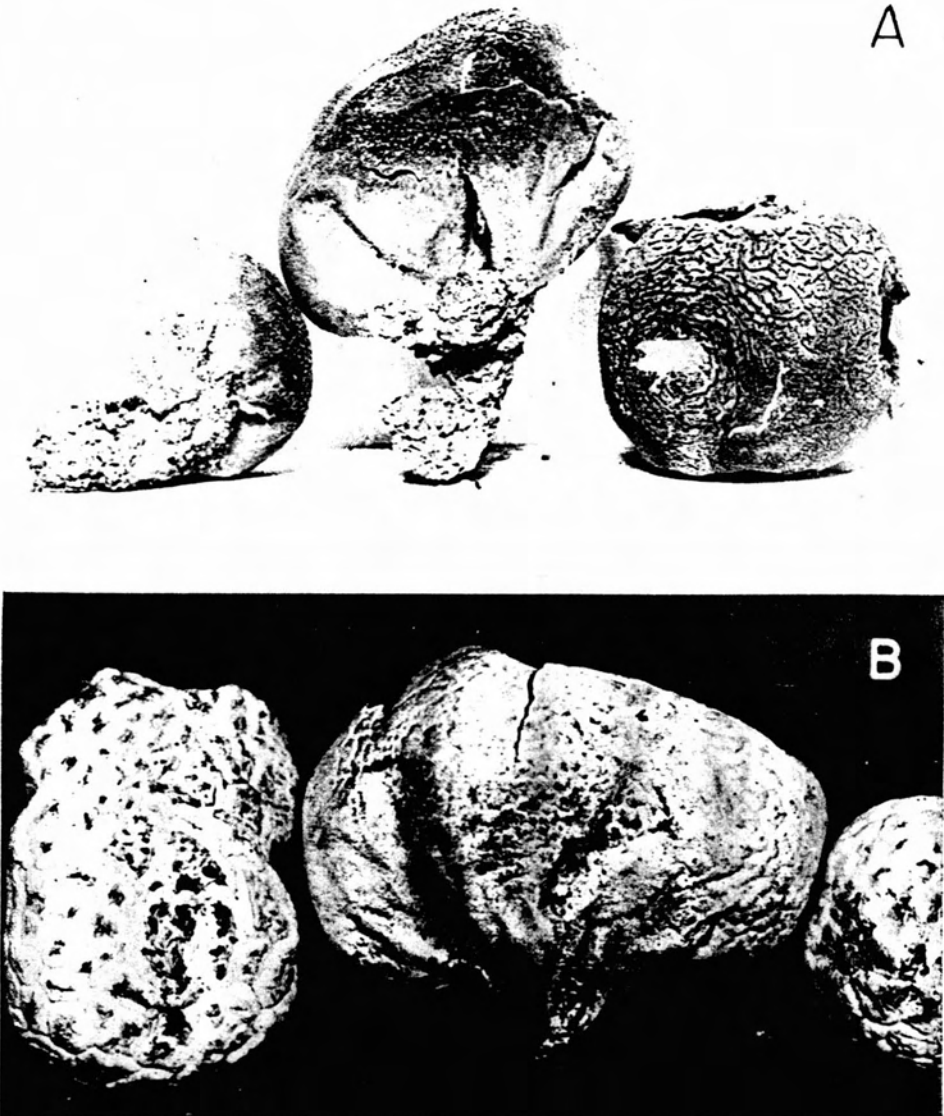


PLATE XII A, *Calvatia lycoperdoides* $\times 1$. Holotype. B, *Calvatia bovista* var. *hungarica* $\times 1$.

Fructificationes 1.5-4 cm altae, 1.7-5 cm latae, globosae, fragiles, subspinulosae vel subareolatae. Gleba flocculosa, olivaceo-brunnea. Subgleba nulla. Filamenta capillitorum 2.2-7.7 μ . ramosa sinuosa crasso-tunicata ($\approx 1 \mu$). Sporae 3.9-6.6 μ globosae, verruculosae. Typus Smith 30617 (MICH).

Basidiocarp 1.5-4 cm high, 1.7-5 cm broad, globose to pulvinate, peridial wall thin and cracking readily, the endo- and exoperidial walls long remaining firmly adherent, exoperidium delicately furfuraceous to spinulose over all, the upper surface of the gastrocarp occasionally also breaking into small areolae which are warted-polygonal and may be up to 3 mm across, these warts rounded, low and often abundant, occasionally the tips may be pointed and the surface is then spinose-warted, mostly merely furfuraceous to spinulose below and not areolately ornamented; dehiscence occurring by the peridial wall cracking into large plate-like areas, spines deciduous leaving a tan, thin endoperidium. Subgleba absent. Gleba cottony remaining intact at maturity, dark olivaceous brown to "Saccardo's umber," finally with a slightly purplish cast especially near the basal attachment.

Threads of capillitium: 2.2-7.6 μ in diam. rarely 11 μ , segments long, interwoven and frequently branched with many Y-shaped branches, threads attenuated to subacute tips, aseptate or sparsely septate, breaking readily and broken edges jagged; walls sinuous and thickened, up to 1 μ thick in places, pitted; the pits elongate and slit-like or irregularly roundish, often abundant; walls tawny olive to russet in Melzer's sol., yellow-brown in KOH. Spores 3.9-6.6 μ in diam, globose to subglobose, often uniguttulate, tawny-olive to ochraceous tawny in Melzer's sol., olive-brown in KOH, very finely echinulate to verruculose, the ornamentation about 0.6 μ high, pedicel inconspicuous.

In coniferous woods in open places, on the duff or occasionally on rotten wood, California, Washington and Idaho in the late summer and fall.

Material examined: California. *Collet.* 24, Idaho: *Trueblood* 920; *Smith* 58859. Washington: *Smith* 30617, 30935. '38.

This species is about the size of a *Lycoperdon* and would readily be mistaken for a member of that genus except for the fact that the gastrocarp does not dehisce by the formation of a pore. The lack of a subgleba distinguishes it from *C. lloydii*, in which the base is both distinct and chambered.

25. CALVATIA RUBRO-FLAVA (Cragin) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 171. 1890.

Lycoperdon rubro-flavum Cragin, Washburn Lab. Nat. Hist. Bull. 1(2): 36. 1885.

Calvatia aurea Lloyd, Myc. Writ. 1: 11. 1899.

Calvatia candida var. *rubro-flava* (Cragin) Cunningham, Proc. Linn. Soc. New South Wales 51: 368. 1926.

Illustrations: Plate XIII A, B.

Basidiocarp 2-10 cm broad, subglobose, flattened above, 1.5-5 cm high, usually with a short abruptly pointed stalk which is centrally attached by one or more slender rootlike rhizomorphs; surface nearly white when young with a faint tint of pink or lavender but varying to pinkish leather brown, all parts turning at once to about chrome yellow upon rubbing or cutting, drying orange to orange red or bay, at maturity becoming a metallic brown: peridium about 123-160 μ thick when fresh becoming very thin and papery on drying, practically single layered, the exoperidium being represented by only a delicate furfurescence, becoming smooth and shiny on exposure to weather, cracking into irregular areas or scales, and falling away after drying. Subgleba homogeneous (not cellular at maturity), usually less than one third of the fructification and extending up the sides as a thin layer, yellowish to chocolate brown. Gleba changing from white to honey yellow to "empire yellow" or Isabella color when ripe or even reddish ochre or olivaceous-orange.

Capillitial threads 2.2-6.6 μ in diam, elongate or slightly flexuous, sparsely or

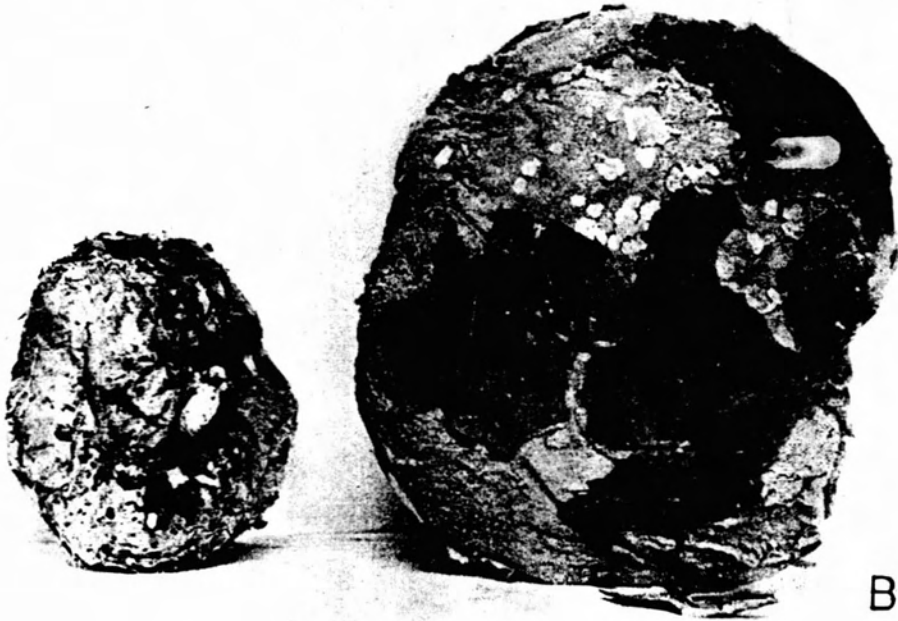


PLATE XIII

A, *Calvatia rubroflava* (young) $\times 1$. B, *Calvatia rubroflava* (mature) $\times 1$.

frequently branched, not much attenuated toward tips of branches, septate, breaking occasionally at septa, septa abundant, the latter joint-like or square; walls mostly even, thin (less than $1\ \mu$ thick), pitted the pits forming gapping discontinuities $1-3\ \mu$ in diam, nearly hyaline in KOH and Melzer's sol. Spores $(3-3.3-5(-5.5))\times 3-5\ \mu$, subglobose to very broadly and unequally ovate, weakly ornamented ($0.25\ \mu$ high), hyaline in KOH and faintly tawny in Melzer's sol., pedicel inconspicuous.

Usually on cultivated soil and widely distributed both throughout North America and the world (Japan, Australia, South America, Bolivia and Brazil).

Material examined: Iowa 2 collections. Maryland: *Kelley* 1659. Ohio: *W. B. Cooke* 33857. Tennessee: *Hesler* 5374. Texas: *E. A. Smith*, 2 collections.

This is one of the most distinctive species in the genus.

26. *CALVATIA OCHROGLEBA* Zeller, *Mycologia* 39: 302-303. 1947.

Basidiocarps 7-9 cm broad and high, turbinate to depressed-globose, somewhat misshapen and lobed at times, somewhat pointed below; surface smooth to furfuraceous, dull reddish brown; peridium duplex, outer very thin, not easily separable, the two layers breaking up together, inner layer medium thick, ochraceous. Subgleba about one fourth of the basidiocarp, convex above, cavities very small, whitish and bluish tints. Gleba of very fine texture but not very powdery and not falling out easily, pale yellow-orange to ochraceous buff.

Capillitium threads hyaline, fragmented, 2.2-6.6 μ in diam, slender, mostly not pitted but tiny rounded pits present on some threads, very sparsely branched, very loosely interwoven, yellowish in Melzer's sol., septate, septa abundant. Spores (5-)5.5-7.7 \times 5.5-7 μ , subglobose to rounded with one side slightly flattened, not truly spherical, aguttulate, hyaline in KOH and yellow to tawny in Melzer's sol., distinctly echinulate to asperulate, the ornamentation up to 1 μ high, a hyaline outer sheath present.

Known only from meadows near Aurora, Marion county, Oregon.

The color of the capillitium and spores relate this species to *C. rubrollava* from which the almost lack of pits in the capillitium and the lack of color changes on the fresh gastrocarp distinguish it. It is also close to *C. talrensis* but the pits of the capillitium are not slit-like.

27. *CALVATIA CRANIIFORMIS* (Schw.) Fried. *Summa Veg. Scand.* p. 442. 1849.

Bovista craniiformis Schw., *Am. Phil. Soc. Trans.* 11, 4: 256. 1832.

Lycoperdon missouriense Trelease, *Acad. Sci. St. Louis Trans.* 5: 240. 1891.

Lycoperdon delicatum B. & C. *North Amer. Fungi.* no. 337. (Not *L. delicatum* Berk. *Hook Jour. Bot.* p. 172. 1854.)

Illustrations: Plates XIV, XV.

Basidiocarps large, 8-19 cm broad, 6-20 cm high, obovoid to turbinate, the thick stalk-like base rounded below and attached by rhizomorphs: exoperidium very thin, papery, smooth to nearly glabrous or delicately furfuraceous, pale tan or grayish in color, scaling off very slowly as thin plates at maturity; endoperidium thin and fragile, yellowish to reddish, upper part cracking into plates and breaking away after the exoperidium peels off. Subgleba occupying the stalk-like base, of chambered structure, quite spongy, concave above and long persistent. Gleba long remaining intact, not powdery, white then greenish yellow or sordid ochraceous, finally yellowish brown.

Capillitial threads (1.1-) 2-5 (7.7) μ in diam, mostly narrow in long segments, sparsely branched, occasional Y-shaped branches present, extremities becoming slightly attenuated, septa numerous to occasional, threads round and joint-like or square at the septa, breaking at septa readily; walls thin, even, less than 1 μ thick, pitted; the pits small or rather wide and gaping (1-3 μ across), abundant, threads yellowish in KOH and Melzer's reagent. Spores (2.2)3.3-4.4 μ in diam, globose to subglobose, seemingly smooth to faintly punctate from fine projecting pegs immersed in the hyaline envelope, often 1-guttulate, yellowish in KOH and Melzer's sol., pedicel very small.

On the ground in open or brushy places in low areas, or in hardwood forests, common in North America from Texas and the southwest eastward and northward to New England.

PLATE XIV. *Calvatia craniiformis* (old) X1.

Material examined: Michigan: *Smith* 49518, 62337, 64357, 64643; *Kauffman*, Dec. 1926; Mains 31-460. Oklahoma: *Bulmer* 2008, 2045. Texas: *E. A. Smith* 7 collections in summer of 1938.

This species and *C. rubroflava* are closely related. The pale color of the gleba and spores under the microscope are quite similar, and in the Southwest many collections occur which when dry have somewhat the colors of a mature *C. rubroflava*. Both have the cottony gleba at maturity.



PLATE XV

Calvatia craniiformis (fresh) $\times 1$.

28. CALVATIA EXCIPULIFORME (Persoon) Perdeck. Blumea 6: 490. 1950.

Lycoperdon excipuliforme Persoon, Syn. Meth. Fung. p. 143. 1801.

Lycoperdon saccatum (Vahl) Fries, Syst. Myc. 3: 35. 1829.

Calvatia saccata (Fr.) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 171. 1890.

Utraria saccata (Fr.) Quél., Champ. Jura et Vosges p. 369. 1873.

Calvatia saccata (Vahl) Morgan var. *punctata* (Rostk.) Hollos, Gast. Ungarn. p. 88. 1904.

var. EXCIPULIFORME

Basidiocarps 6.5-8 cm high, the fertile heads 3.5-4.5 μ broad, sterile stalk widest toward the apex and narrowing downward, the fertile head broadly rounded and somewhat flattened on its upper surface, the basal part of the stalk costate to irregularly wrinkled, somewhat inserted in the substrate. Subgleba well developed (occupying the stalk), chambered, spongy in texture, upper surface concave and

forming a shallow cup in which rests the gleba; exoperidium thin, cracking into large irregular plates around the widest part of the head, falling away gradually, covered with a fine furfuraceous, granular material which is deciduous and has occasional punctate spinules scattered over the surface; endoperidium yellowish to chamois, very thin and papery, both peridia together about 1 mm thick. Gleba cottony, remaining intact at maturity, enclosed by the cup-like subgleba over lower part, when mature dingy purplish olive to purplish brown (but not violaceous or lilaceous drab).

Capillitial threads 1.1-7.7 μ diam, mostly very slender and elongate, with numerous Y-branched, ultimate branches strongly attenuated to pointed tips, aseptate or very rarely septate, walls up to 1 μ thick, somewhat undulating, pitting occasional, pits irregular-roundish, threads not readily breaking, walls yellowish to pale olive brown in KOH, in Melzer's sol. ochraceous tawny to russet. Spores 3.5-5.6 μ , globose, pale snuff brown in KOH, tawny in Melzer's sol., distinctly ornamented, the hyaline sheath 0.5-0.8 μ thick and with "plugs" extending to its outer surface; pedicel absent to very short.

On grassy waste ground, lawns, pastures, etc. Its distribution in North America remains to be accurately ascertained.

Material examined: Michigan: *Bulmer* 1374, 1386, 1388.

29. CALVATIA ELATA (Masse) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 172. 1890.

Lycoperdon elatum Masse, Jour. Roy. Micr. Soc. P. 710. 1887.

Calvatia saccata (Vahl) Morgan var. *elata* (Masse) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 172. 1890.

Illustration: Plate XVI.

Basidiocarp long-stipitate, the whole shaped more or less like a pestle, stalk up to 9 cm long and 4 cm diam, head 4-7 cm diam and 2.5-4.5 cm high, depressed globose, subumbonate; exoperidium pale brown to leather color when mature, thin, granular or powdery, persistent above, almost absent on the stalk; endoperidium thin and very fragile, at maturity soon breaking into fragments and falling away or held by the capillitium. Subgleba confined to the stalks composed of distinct empty chambers. Gleba brown or brownish olivaceous.

Capillitial threads (1.1)-2.2-5.5(-6.6) μ , diam, narrow, loosely interwoven, somewhat sinuous, frequently to occasionally branched, Y-shaped branches present, threads tapering to pointed extremities, aseptate to rarely septate, breaking readily; walls up to 1 μ thick, pitted, the pits irregularly roundish and rather large; threads yellowish to tawny in Melzer's sol., pale olive brown in KOH. Spores (3.3) 4-5.5 (-6.6) μ in diam, globose to subglobose, distinctly but minutely spinulose, ornamentation about 0.25 μ high, walls olive-brown in KOH, pale ochraceous tawny in Melzer's sol., pedicel short if present.

Growing among grass or mosses in low grounds and in shrubby places, New England, New York and Michigan southward, summer and fall.

Material examined: Connecticut: *V. S. White*, summer of 1900, 2 cols. Michigan: *C. H. Kaufman*, 3 cols.; *Smith* 5024, 20750, 31076. Canada, Ontario: *Kelley* 1593.

In much of the literature this is reported as *Calvatia saccata* var. *elata*. This is apparently a much more abundant and variable species in Europe, especially central Europe.

STIRPS BOVISTA

KEY TO SPECIES

- 1. Pits in walls of capillitial threads small and round; gleba white, becoming orange, then olivaceous; spores asperulate, ornamentation 0.5-1.1 μ high.....30. *Calvatia candida*
- 1. Pits in capillitial threads elliptic to slit-like.....2
- 2. Spores finely echinulate to densely verrucose.....31. *Calvatia pallida*
- 2. Spores smooth or nearly so.....3
- 3. Sterile base distinct (usually well developed).....32. *Calvatia bovista*
- 3. Sterile base greatly reduced to absent.....32a. *C. bovista* var. *hungarica*



PLATE XVI
Calvatia elata ×1.

30. *CALVATIA CANDIDA* (Rostk.) Hollos, *Gast. Ungarns* p. 89. 1904.

Basidiocarps 1.7-6 cm broad, 1.5-6 cm high, pulvinate to turbinate, white to chalky white or slightly grayish over upper surface, peridium thin to thick, composed of a firm exoperidium up to 1 mm thick and a papery velum-like endoperidium: exoperidium smooth to wrinkled or areolate, the areolae plaque-like, not raised up as cones or squamules, over the under surface finely granular to furfuraceous: endoperidium dehiscing by breaking into large plate-like areas or simply peeling away from the gleba. Subgleba evident at first, occupying about one fourth of the basidiocarp, composed of small chambers, less evident at maturity. Gleba white becoming distinctly orange, but finally olivaceous brown to umbrinous, powdery.

Capillitium of threads 2.2-6.6 μ in diam, elongate, sparsely interwoven, branching occasional, branches Y-shaped, ultimate tips attenuated and pointed; septa numerous, square, threads breaking at the septa and elsewhere; walls flexuous and

uneven, rarely up to $1\ \mu$ thick, pale yellowish to tawny in Melzer's sol. and KOH; pitted, pits minute, round as in *C. craniiformis* but not as abundant. Spores (5-)5.5-6.6(-7.7) μ in diam, globose to subglobose, a hyaline sheath evident, aguttulate, yellowish olive in KOH, ochraceous tawny in Melzer's sol. or when immature deep russet, strongly asperulate, ornamentation from 0.5 to 1.1 μ high when mature.

Growing in arid places under sage brush and in grassy places, summer and fall. The only collections I have seen were from southwestern Idaho: (Trueblood 871, 1804, 2049, 2285. Smith 65001).

In some respects this species resembles *C. rubroflava* but it does not stain and the gleba is powdery when mature.

31. *Calvatia pallida* Smith sp. nov.

Fructificationes 1.4-5.4 cm latae, 1-2.5 cm altae, subrugulosae, pallidae demum pallide argillaceae. Gleba pulverulenta, olivaceo-brunnea demum purpureo umbrina. Subgleba lacunosa, inconspicua. Filamenta capillitorum 2.2-8.8 μ crassa, perforatae, perforationes elongata vel elliptica. Typus Smith 30620 (MICH).

Basidiocarps 1.4-5.5 cm wide, 1-2.5 cm high, flattened, pulvinate or turbinate; exo- and endoperidium adherent, rather thin (less than 1 mm), brittle, upper surface finely but distinctly wrinkled, occasionally finely rivulose between the wrinkled areas, the endoperidium when discernible thin and papery: Base constricted and plicate much as in *C. tatrensis*, rooting in the substratum; color when mature pallid to pale pinkish buff overall or dusted umbrinous from the spores. Subgleba poorly developed (about one fourth to one eighth of the basidiocarp), of small cavities which become less evident by maturity, base usually attenuated into a small root-like rhizomorph. Gleba powdery and finally becoming completely dispersed, olive brown with a purplish tinge when mature.

Capillitium of ... ads 2.2-8.8 μ in diam, somewhat interwoven, sinuous to irregularly constricted or occasionally of equal diameter throughout, sparsely branched and Y-shaped branches present, breaking readily, attenuated to subacute tips, septa occasional to very rare; walls up to $1\ \mu$ thick, umbrinous to olive brown in KOH and tawny to ochraceous in Melzer's sol., usually pitted; the pits lenticular to elliptic or slit-like. Spores (4.4)5.5-7.7 μ , in diam, globose to subglobose, usually uniguttulate with a distinct hyaline envelope, finely echinulate to densely verrucose (both types may be present in a single gastrocarp), verrucae up to $1\ \mu$ high, pale yellowish to olive brown in KOH and tawny to ochraceous tawny in Melzer's sol., pedicel obscure to evident.

Open woods and in meadows in duff and soil at high elevations, summer and fall, Washington and Idaho.

Material examined: Washington: Smith 30618, 30620, 30934. Idaho: Smith 64933.

This species is very close to *C. candida* but is distinct in the slit-like to elongate capillitial pits. In addition to this the gleba does not pass through an orange stage in the process of maturation and the species does not occur in the same type of habitat, though we actually do not have much information on the ecology of *C. candida* here in North America. The plicate base of *C. pallida* appears to be an additional difference.

32. CALVATIA BOVISTA (Pers.) Kambly & Lee, Univ. of Iowa Stud. in Nat. Hist. 17(4): 138. 1936. (non Macbride, Bull. Lab. Nat. Hist. Univ. Iowa 4: 41. 1896.)

Lycoperdon bovista Pers., Syn. Fung. p. 141. 1801.

Lycoperdon caelatum Bull. ex DC, Flore Francaise 2: 264. 1805.

Bovista suberosa Rostk., in Sturm, Deutschl. Fl. Abt. 5: 7. 1831.

Bovista favosa Rostk., in Sturm, Deutschl. Fl. Abt. 3, 5: 9. 1831.

Lycoperdon fontanesii Dur. & Mont., Fl. Alg. 1: 381. 1849.

Lycoperdon favosum (Rostk.) Bon. Bot. Zeit. 15: 595. 1857.

- Utraria caelata* (Bull. ex DC) Quél., Champ. Jura et Vosges p. 369. 1873.
Lycoperdon sinclairii Berk. & Masee, Roy Micr. Soc. Journ. 11, 7: 711. 1890.
Calvatia caelata (Bull. ex DC) Morgan, Journ. Cinc. Soc. Nat. Hist. 12: 190. 1889.
Calvatia favosa (Rostk.) Lloyd, Myc. Writ. 1: Aus. Lye. p. 36. 1905.
Calvatia fontanesii (Dur. & Mont.) Lloyd, Myc. Writ. 1: Lye. Aus. p. 36. 1905.
Calvatia sinclairii (Berk.) Lloyd, Myc. Writ. 1: Lye. Aus. p. 37. 1905.
Lycoperdon caelatum (Bull. ex DC) Fries, Syst. Myc. 3: 32. 1829.

Illustrations: Plate XVII A, B.

Basidiocarps 5-15 cm in diam, subspherical to turbinate with a large stalk, stalk long-cylindric or short and tapered: exoperidium a thick floccose layer, usually areolate from more or less prominent truncate warts above, warts thinner downward but with a tendency throughout to form more or less stellate flattish areas, whitish then pallid yellowish to brownish: endoperidium thin, breaking up into fragments at the apex, then downward, exposing the gleba. Subgleba 5-10 cm thick, furrowed below and pinched to a point, chambers distinct and moderately large, extending up the sides for a short distance as a tapering margin of a cup. Gleba bright olivaceous to brownish olive and finally dark olive brown, fragile and powdery but more or less remaining intact.

Capillitial threads 2.2-12(-17.6) μ , in diam, elongate and sinuous, branching rare to frequent, Y-shaped branches present, strongly attenuated to very slender filaments with subacute apices; threads breaking readily, aseptate or occasionally septate; walls even to undulate, thick, 1 up to 1.6 μ thick, dark olive brown in

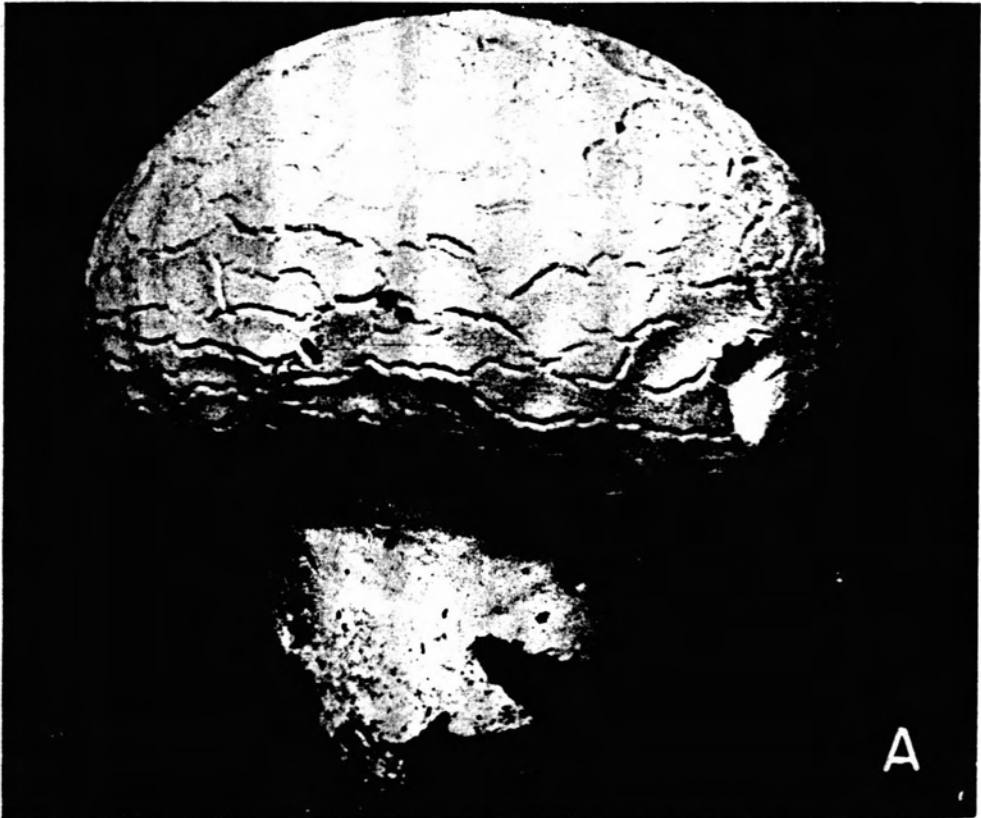


PLATE XVII

A, *Calvatia bovista* var. *bovista* $\times \frac{1}{2}$. B, *Calvatia bovista* var. *bovista* $\times \frac{1}{2}$.

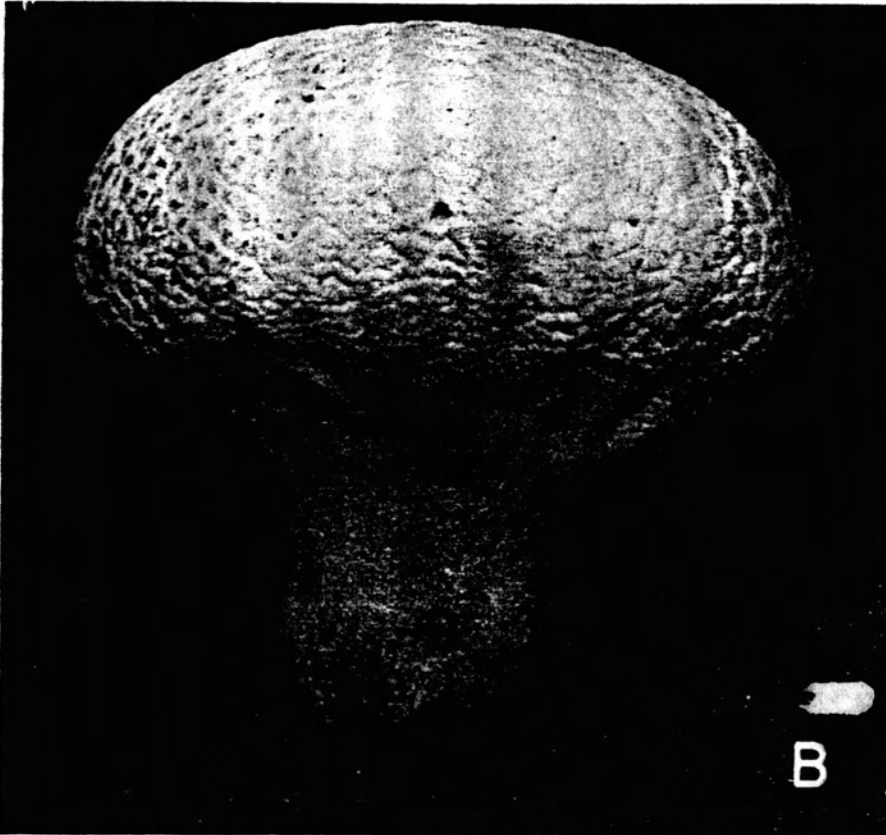


PLATE XVII (Continued)

KOH and ochraceous tawny in Melzer's sol., pitted; the pits occasionally irregularly rounded but more often slit-like, abundant. Spores $(3.3)4-6.6(-7.7) \times (3.3)4-6(-6.8) \mu$, globose to subglobose or most often broadly ovate, seemingly smooth, (actually faintly punctate), 1-guttulate, dark olive brown in KOH and tawny to ochraceous tawny in Melzer's sol., pedicel absent or inconspicuous.

On the ground in fields, lawns and along roadsides, throughout the United States and southern Canada.

Material examined: California, *Gruber* 754, *C. A. White*, Prairie Creek State Park; Idaho: *Trueblood* 887, 1080. Michigan: *Smith* 62176, 63540, 66484, 32824. North Dakota: *Brenckle Fungi Dakotenses* No. 171.

The gleba is more pulverulent than in *C. excipuliforme* and the subgleba usually much thicker.

- 32a. *CALVATIA BOVISTA* var. *HUNGARICA* (Hollos) Šmarda, *Flora CSR*, B-1, *Gastro*, p. 285. 1958.
Calvatia hungarica Hollos, *Gast. Ungarns* p. 84. 1904.

Illustration: Plate XII B.

Basidiocarp 4.3-9 cm broad, 0.3-5.5 cm high, pulvinate to turbinata in shape: exoperidium white to pale creamy at first, becoming tan to dark brown by maturity, the peridial wall about 1 mm thick, the upper surface breaking into low, flat to

slightly pointed areolate polygonal warts, the under surface merely furfuraceous to smooth: endoperidium yellowish, to olive brown, olive or dark yellow-brown, blocked out into areolate plaques corresponding to the position of the deciduous warts of exoperidium, very papery and brittle at maturity, dehiscence about the upper surface by irregular lines with the exoperidium promptly deciduous, then the endoperidium falling away leaving a broad irregular mouth with jagged and recurved edges, eventually the whole top of the basidiocarp open. Subgleba not stalk-like, lacking any appreciable sterile tissue, externally constricted and somewhat furrowed and plicate. Gleba light olive brown to dark umbrinous at maturity.

Capillitial threads 2.2–6.6 μ in diam, very flexuous, sparingly branched, rarely septate, breaking readily, walls undulate to even, entire or pitted with slit-like or lenticular perforations, the wall up to 1 μ thick and pale tawny brown in KOH and in Melzer's sol. Spores 4.4–7.7 μ usually subglobose nearly smooth, usually uniguttulate, olive to tawny brown in KOH, tawny to russet in Melzer's sol., dextrinoid when immature minutely punctate, pedicel inconspicuous.

In North America it has been found in arid regions under sage brush, not common.

Material examined: Wyoming: *Kaufman* 9–1923. *Smith* 34852. Colorado: *Baxter* 9–1920.

ACKNOWLEDGMENTS

It is always a delicate task to finish a work of this sort. An effort has been made to follow Zeller's ideas to the best of my knowledge and ability. However, it seemed pointless to limit the treatment to material Zeller had seen when I was in possession of much data that added to or changed some of his conclusions. In certain species some of the synonymy has been changed because of information coming to light in the interval since the death of Dr. Zeller. I am greatly indebted to the New York Botanical Garden for the opportunity to finish Zeller's project. The National Science Foundation (Grant G-23139) furnished financial support for the field work represented in my collections from the Western United States, and for research assistance in the laboratory. Mr. Bill Isaacs as the research assistant on the project made many pertinent contributions.

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