State of LA Fungi

February 28, 2023

Chlorophyllum rhacodes

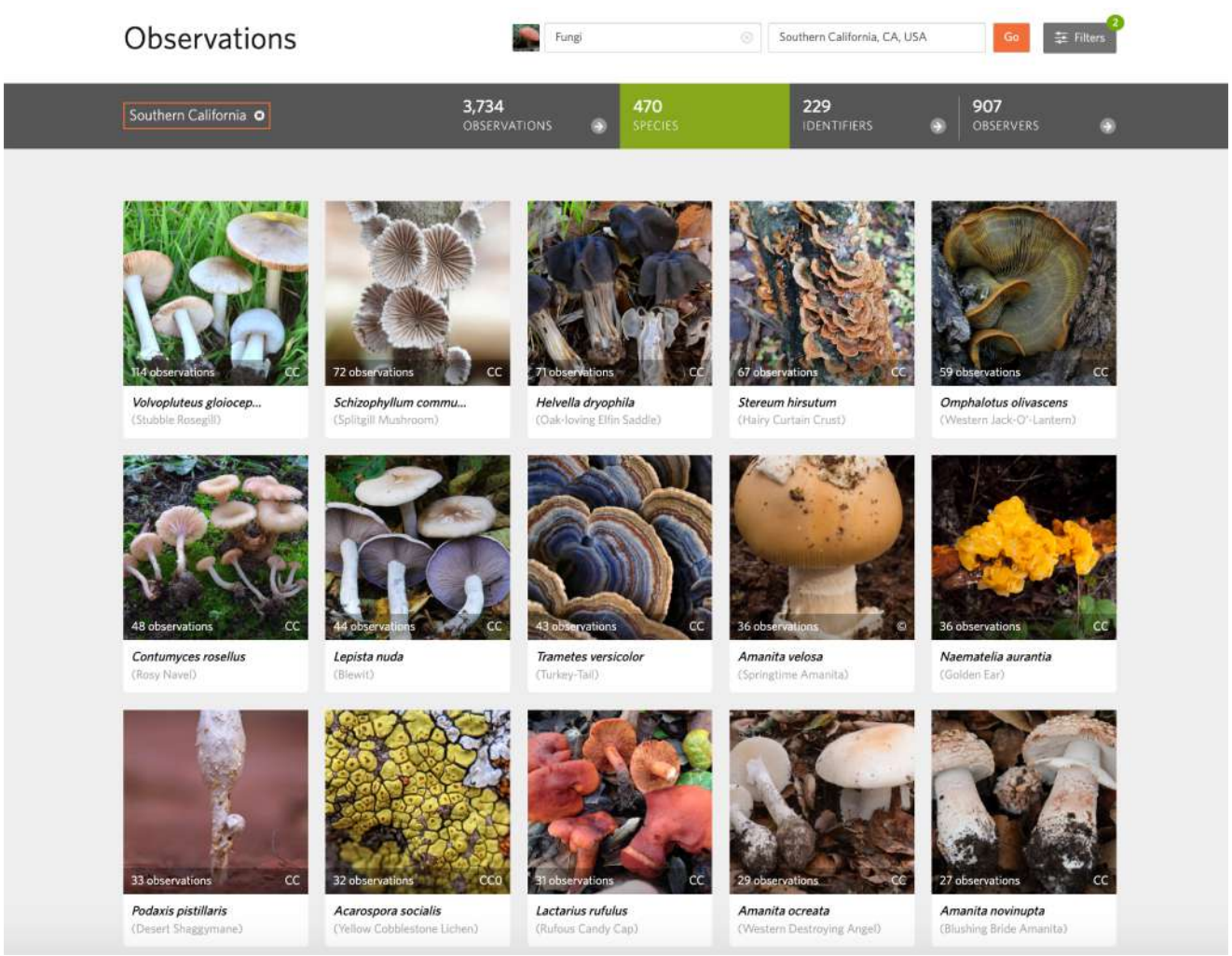
Los Angeles Mycological Society

I. Look back on February

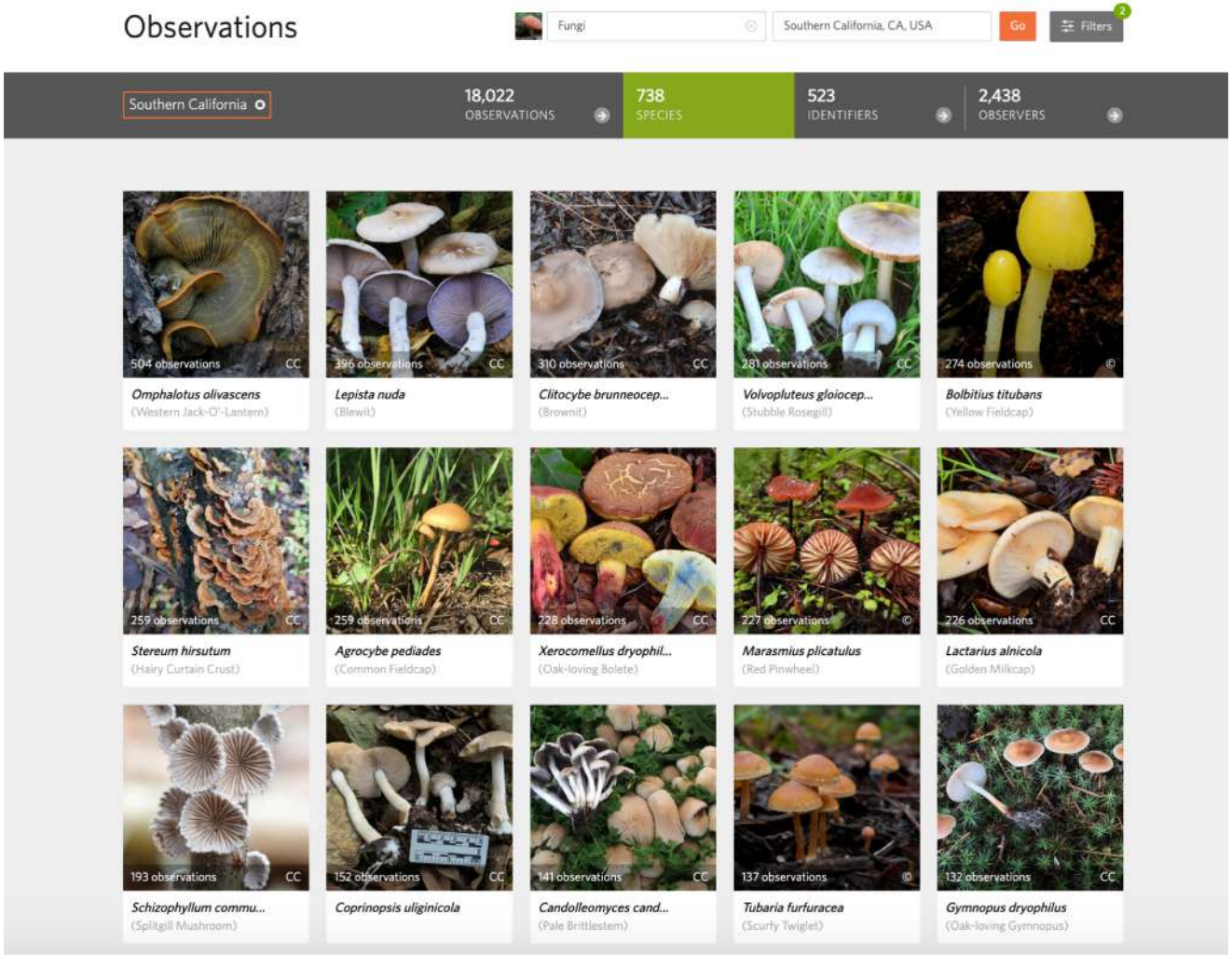
II. Describing mushrooms for identification and scientific study

III. The genus *Amanita* in Southern California

IV. New discovery on the death cap invasion in California



Most common fungal species observed on iNaturalist in Southern California, **February 2023**



Most common fungal species observed on iNaturalist in Southern California, **January 2023**

NATIONAL GEOGRAPHIC
PUBLISHED FEBRUARY 15, 2023

LAMS in National Geographic

ENVIRONMENT

Love mushrooms? California is having an epic 'supershroom' season

This mushroom season is one for the record books. Here's why—and how to start shroom-hunting.

More than 2,000 people showed up to Los Angeles Mycological Society's Wild Mushroom Fair in February. Many brought their finds from all over the region to show off and identify—like this mushroom in the *Amanita* genus, which looks dangerously similar to a toxic one.

BY **ALEJANDRA BORUNDA**

PHOTOGRAPHS BY **MICHAEL CHRISTOPHER BROWN**

https://www.nationalgeographic.com/environment/article/how-to-hunt-mushrooms-during-californias-epic-supershroom

Bob Cummings, a mycologist at Santa Barbara City College, has been mushroom hunting for 60 years. His first mind-blowing season was 1982 to 1983, when one of the most powerfully rainy seasons on record hit California. Chanterelles were practically popping out of the woodwork. Another epic season came along in 1997. But he'd almost given up hope for another exceptional year, since Southern California, along with much of the U.S. Southwest, has been stuck in a 20-year drought.

Those rainy years tend to come during an El Niño event, a climatic phenomenon that usually brings wet weather to the Pacific coast, from California to Chile. But recent years have seen the opposite, a La Niña pattern characterized by dry winters. "The last few years have been terrible," says Jess Starwood, a forager from the Los Angeles area. "I didn't see a single chanterelle."

Scientists forecast the dry pattern would prevail once again this winter. But instead, a series of remarkable atmospheric rivers streamed across the skies, dumping as much as 600 percent of the normal rainfall in some parts of California, overtopping dams and destroying homes.

https://www.nationalgeographic.com/environment/article/how-to-hunt-mushrooms-during-californias-epic-supershroom

latimesplants

Mushrooms are everywhere. Here's how to forage, eat and grow the mighty fungi in L.A.

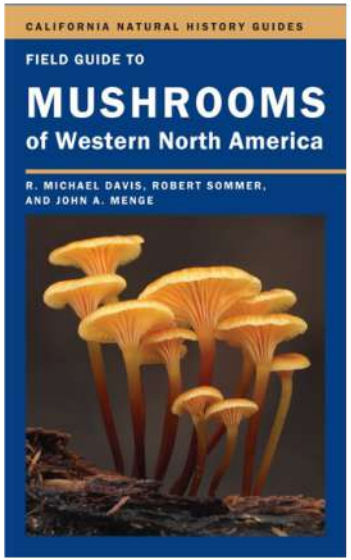
Photos by Jason Armond / Los Angeles Times; Alan Nakkash / For The Times; animated illustration by Danie Drankwalter / For The Times

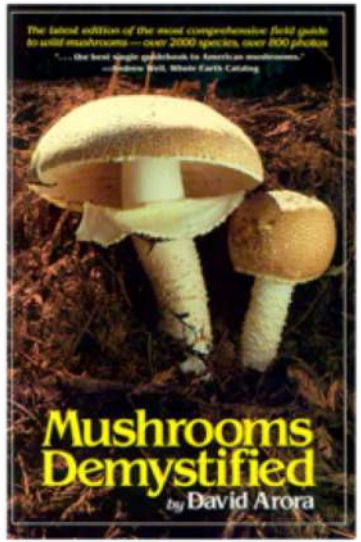
FEB. 1, 2023 5 AM PT

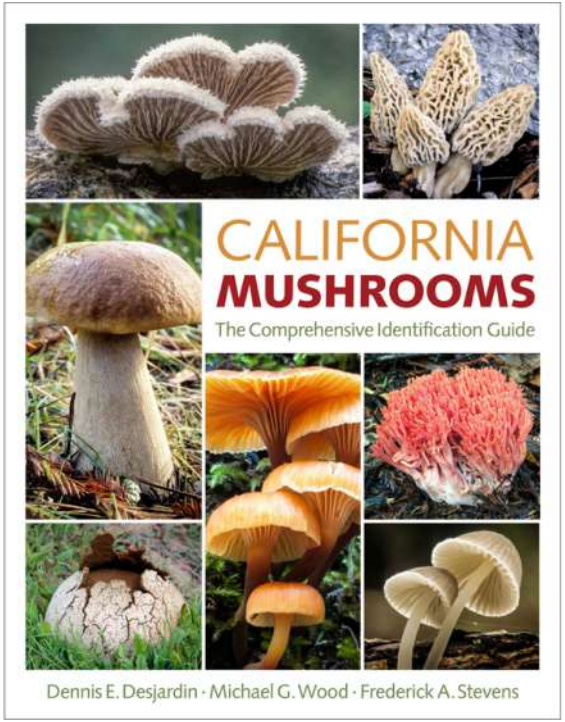
LAMS in The LA Times

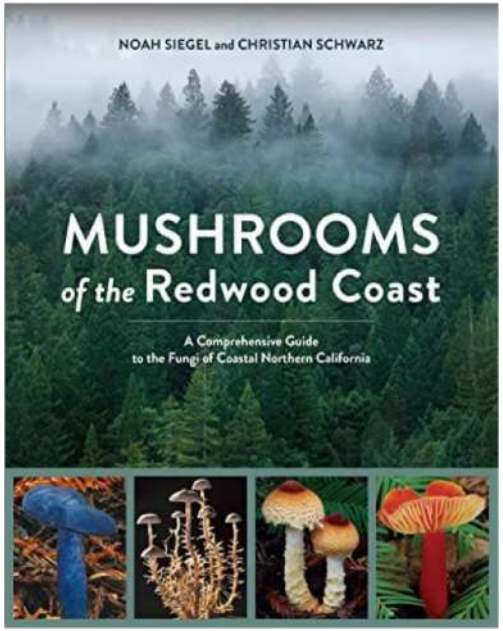
https://www.latimes.com/lifestyle/story/2023-01-31/mushrooms-in-california-shroom-boom

Describing mushrooms for identification and scientific study









Precise and consistent language enables the communication of specific scientific hypotheses. In the scientific recognition of species, technical language is linked to hypotheses for taxonomically-informative trait variation. When you identify a mushroom, you put forward a scientific hypothesis.

Agarics (gilled mushrooms)

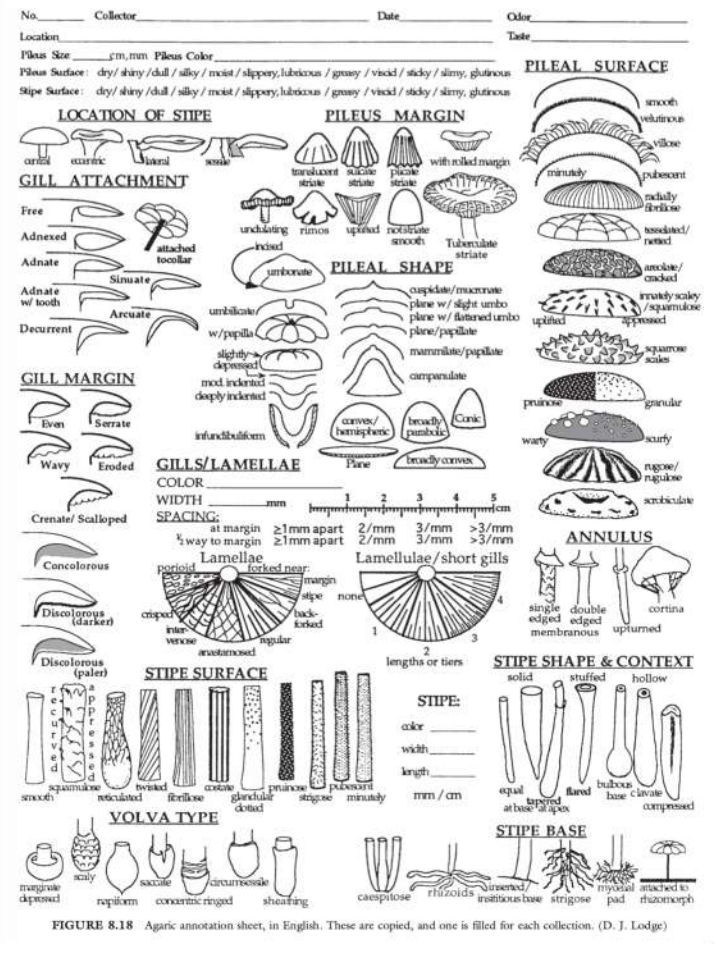


FIGURE 8.18 Agaric annotation sheet, in English. These are copied, and one is filled for each collection. (D. J. Lodge)

Boletes (spongy poroid mushrooms)

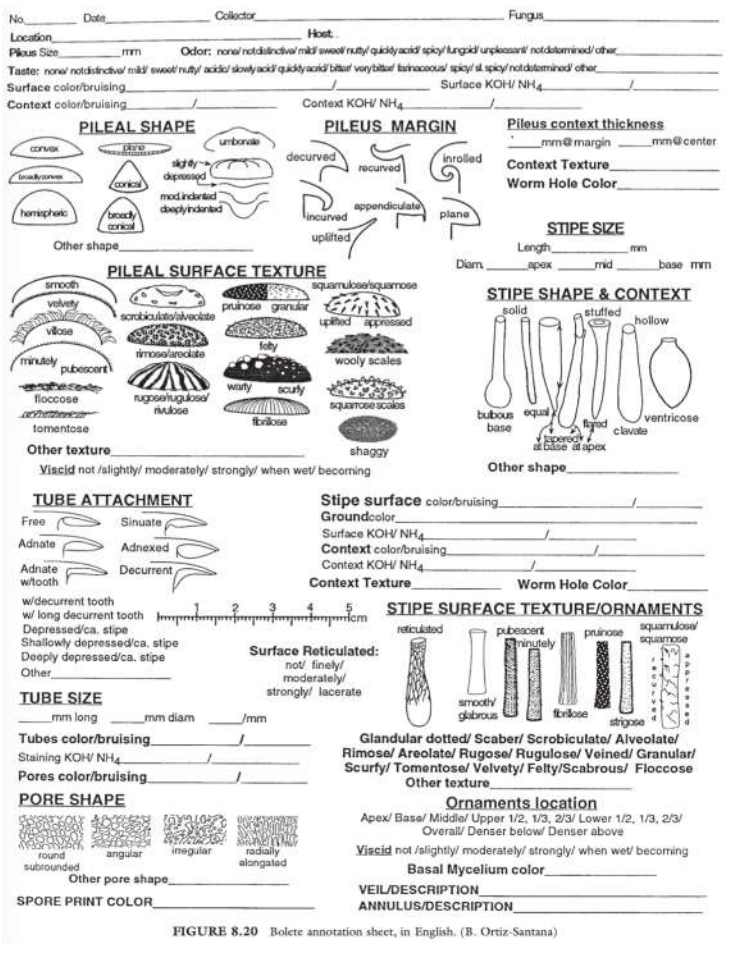


FIGURE 8.20 Bolete annotation sheet, in English. (B. Ortiz-Santana)

"Terrestrial and Lignicolous Macrofungi" (D. Lodge, et al., 2004)

https://moodle.ufsc.br/pluginfile.php/1311301/course/section/972329/Lodge%20et%20al.%202004%20-%208%20-%20Terrestrial%20and%20Lignicolous%20Macrofungi.pdf

DBG16467 Indeed! GH#147 Me-H

Hebeloma Wright 938:

Pileus 6.5-10 cm broad, convex becoming broadly convex to plane or at last shallowly depressed, margin inrolled at first, viscid (slimy), glabrous, not hygrophanous, pallid yellow to ± ochraceous or some with a flesh tinge (as dried, pallid with a pale dull brown disc), rarely rimose or lobed in age. Context white, thick in the disc, odor raphanoid, taste raphanoid becoming bitter and the aftertaste slightly acrid.

Lamellae off-white (pallid) becoming ± "snuff brown" (a medium yellow-brown), close to subdistant, sinuate, broad, finely serrate, with cinnamon brown stains near the edges.

Stipe about 10 cm long, 1-2 cm thick (above the bulb if one is present), white to yellowish (concolor with pileus), furfuraceous especially near the apex; veil absent.

Spores 10-13.5 × 6-7.5 µm, clay-color in KOH, not appreciably darker in Melzer's, minutely marbled, subelliptic to ovate in face view, inequilateral to only somewhat inequilateral in profile.

Basidia 4-spored, 8-9 µm broad. Pleurocystidia none. Cheilocystidia elongate-capitate to elongate-clavate, 53-74 × 4-5 × 6-12 µm (broadest at apex), soon agglutinated and in age forming a collapsed mass dingy ochraceous to ochraceous brown in color. Gill trama typical for the genus.

Cuticle of pileus a thick ixolattice (it may be an ixotrichodermium at first), the hyphae 1.5-2.5 µm diam, refractive, hyaline, sparsely branched, with clamps at the septa. Hypodermium not differentiated in young pilei, in old ones present as a yellow-brown hyphoid layer, the hyphae about like those of the trama proper. Tramal hyphae typical of the genus, hyaline in KOH in young pilei. Clamps present.

On a lawn with mixed pine and oak (both planted), Claremont, Los Angeles County, California, Feb. 11, 1978, coll. Greg Wright 938

Observations. The degree of agglutination of the cheeilocystidia is such that in old specimens they are difficult to study because of the numerous spores adhering to them and the fact that they can be separated from each other only after some difficulty if at all. Also, masses of adhering spores obscure ones vision of the details. Apparently, however, droplets are not exuded as in section Lacrymaria. The species is close to H. guttatum in the Smith, Mitchel & Svenson ms but differs in a number of characters.

We need: 1) $FeSO_4$ tests on the base of the stipe

2) Does the stipe discolor from the base upward as it develops and ages or is bruised.

3) Check again for hyaline droplets on young material.

Best practices.

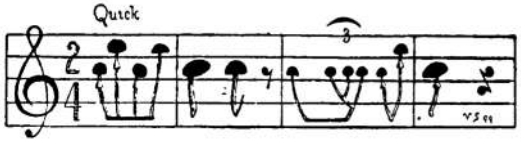
Mycological notes from a collection made by LAMS founding member Greg Wright in 1978.

ONE THOUSAND

AMERICAN FUNGI

CHARLES McILVAINE

1902



For twenty years my little friends—the toadstools—have been my constant companions. They have interested me, delighted me, fed me, and I have found much pleasure in making the public acquainted with their habits, structure, lusciousness and food value.

Download the whole book:
http://www.survivorlibrary.com/library/toadstools_mushrooms_fungi_edible_and_poisonous-one_thousand_american_fungi_1902.pdf

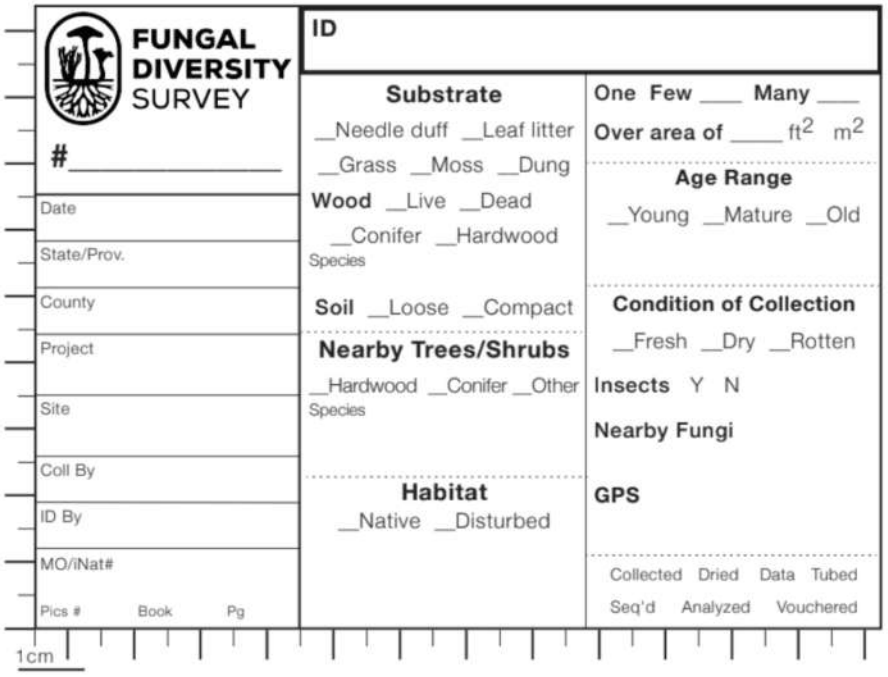
JOANNE SCHWARTZ 08 MAY 2021

Documenting macrofungi on a remote ocean island - The California Channel Islands FunDiS Project

Article:
https://fundis.org/resources/blog/140-documenting-macrofungi-on-a-remote-ocean-island-the-california-channel-islands-fundis-project

FUNGAL DIVERSITY SURVEY

98 Collections from one trip, ready for the Fungarium. Image credit: Joanne Schwartz.



FUNGAL DIVERSITY SURVEY

Download field data slips:
https://fundis.org/sequence/collect-dry/field-data-slips

Collecting and Documenting Macrofungi for Scientific Study

Los Angeles Mycological Society

Rudy Diaz & Justina Martelli

Fungi are an understudied kingdom of organisms distinguished by their absorptive mode of gaining nourishment and, in many species, filamentous growth. Despite their ubiquity in every environment, the diversity of fungal species remains poorly known. This is partly because many fungi only become visible at a macroscopic scale for short periods of time when environmental conditions are favorable for their reproduction. Fungi reproduce through spores, and their spore-bearing structures are called mushrooms. Be mindful that the term "mushroom" is not used exclusively for the gilled Basidiomycete morphology. "Mushroom" is often used to casually refer to a variety of other fungal spore-bearing structures, which include puffballs, corals, brackets, crusts, clubs, saddles, cups, and other Ascomycetes.

Knowledge of fungal species diversity and distributions improves through high-quality record-keeping. This has historically been done through fungaria and the publication of regional species lists, but online platforms — namely iNaturalist and Mushroom Observer — have provided the opportunity for public contribution to biodiversity research databases. This has been useful in the study of fungi, but failing to record key information from the fresh mushroom reduces the utility of an observation. This document describes steps for carefully documenting and preserving fungal specimens to maximize the scientific value of your observations and collections (Figure 1). A glossary is provided for words in bold.

Do not fear touching poisonous mushrooms. They are harmless unless ingested, with the exception of unique allergies. Breathing spores - something we do all the time - should not be a concern unless there are excessive amounts in an unventilated space; take regular precautions for those with reduced lung immunity.

Happy collecting!

Cortinarius flavofluorescens nom. prov. (G. virgatus Pk. ?) Greg Wright 2946

Volva membranous, light amber, compressed or the margin largely free, margin outline irregular, highest part 1.4-2.2 cm high, lowest part 1.1-1.9 cm high.

Partial veil not evident.

Cap yellowish "cinnamon" to "ochar" to light "ocher", with white mycelium, broadly convex to broadly concave, not umbonate, silky, 4.7-6.5 cm.

Gills yellowish where lacking mature spores, sienna where mature with spores, clave, sinuate at the stem, lamellulae attenuate.

Stem ecru-colored to pallid, silky, 4.8-6.4 cm x 8-11 at least 12 mm, equal or with a slightly colliquely marginate bulb, solid. Mycelium white, cottony.

Flesh in the cap ocher-buff, moderately thick; in the stem light ocher-brown. Odor moderately humusy when the mushroom is whole, rank when the flesh is crushed. Taste rank-humusy, astringent.

Spore print darkish "fulvous"; the mushroom leaving greenish yellow stains on the spore print card.

KOH (10%) staining the cap fulvous, not staining the cap flesh, staining the gills dark fulvous. UV light fluorescing the cap, stem, and cap and stem flesh bright yellow.

Spores (from a deposit) football-shaped, 6.6-8.2 x 4.4-4.9 um, apex not notified, Warts prominent. Basidia 4-spored. Gill cystidia absent; gill edges fertile. Caulocystidia absent.

Cap cuticle radial outside the center, narrow to broad filamentous, light greenish yellow in KOH. Cap trama radial, without oleifers. Gill trama parallel, ~~hyaline mixed with light greenish yellow in KOH~~. Clamps present.

Alvin Meadow, near the University of Southern California Idyllwild campus, San Jacinto Mtns., Riverside County, California, under manzanita and near Quercus chrysolepis and Pinus ponderosa, 2 fruitings, on dirt, March 12, 1983.

Figure 1. Description from a specimen collected in 1983 by Greg Wright, a founding member of LAMS and one of the most prolific amateur mycologists in Southern California.

https://www.lamushrooms.org/documents/Documenting_fungi_LAMS_2023.pdf

1. Equipment

Hardware: Large paper bag or basket, wax paper, tackle box, field data slips or notebook, pencil, digging tool (snow tent stakes are a LAMS tradition), pocket knife, hand lens, camera, scale bar, iNaturalist app.

Chemical reagents (optional): 3-10% aqueous KOH (Potassium Hydroxide)

2. Collection and description

Regarding hunting alone versus hunting with others, recognize that this is not a scavenger hunt. Make the effort for quality notetaking, subtle analysis, and individual reflection. See Additional Resources for ready-to-print field data slips.

You encounter a mushroom; what to do? Take a good look at it (Figure 2)! A high-quality collection is one that is morphologically-representative, carefully handled, and well-described. An individual fungal mycelium can produce many mushrooms in a given area. Collecting multiple mushrooms from the same mycelium counts as one collection. It can be difficult to determine the extent of an individual mycelium, but you can usually assume that mushrooms of the same kind that are within ten feet of each other come from the same fungal individual. If two mushrooms are of the same kind but are found much farther apart, they would count as two different collections. Keep collections wrapped separately to avoid cross-contamination and mix-ups.

It is strongly recommended that you study the technical vocabulary of mycology. Precise and consistent language enables the communication of specific scientific hypotheses. In the scientific recognition of species, technical language is linked to specific hypotheses for taxonomically-informative trait variation. When you identify a mushroom, you are putting forward a scientific hypothesis. In some cases, morphological evidence (macroscopic and microscopic) is enough to defend your hypothesis. However, some species can be indistinguishable with just their visible characters, and a confident identification cannot be made without chemical analysis or DNA sequencing. Do your best, and don't feel that you need to force a name to fit.

2.1.Describe the context for the observation.

2.1.1. Date and location: Record the month, day, and year, as well as the collectors. Describe the surroundings, starting with broader context (names of parks, trails, municipalities), then go into describing the environment and immediate habitat. Is it natural or disturbed? Along a busy trail? If in a forest, describe its composition. Are the trees mostly young or mature?

2.1.2. Ecology: What is the substrate? Is the mushroom growing from wood (may be buried), dung, vegetation, or directly from the soil? Was the substrate burned in a wildfire or burn pit? What other organisms are associated with the mushroom? What trees are nearby? List species if you can, otherwise indicate hardwood or conifer. Is it growing on another organism (an insect, another mushroom)? Are there other fungi in the vicinity?

2.2. Describe macroscopic features. It is important to examine several specimens at different stages of maturity, as the same species can look very different as it develops. It is also necessary to unearth entire mushrooms, ensuring that the base of the stipe (if there is one) is not broken off. Use a digging tool for this. As applicable, note the aspects below and how they vary across young to mature specimens.

2.2.1. Habit: Is the mushroom alone, or are there multiple? Is it common or uncommon? Are they scattered individually, or clustered?

2.2.2. Cap: Shape — Is it conic, broadly convex, plane, or funnel-shaped. Are the cap margins undulating, rolled in, uplifted,

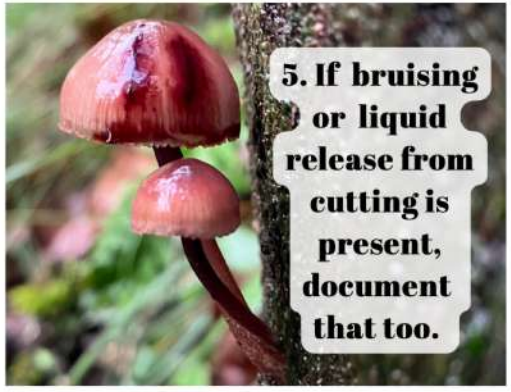
Figure 2. Mycena haematopus photographed in situ, growing from a log.

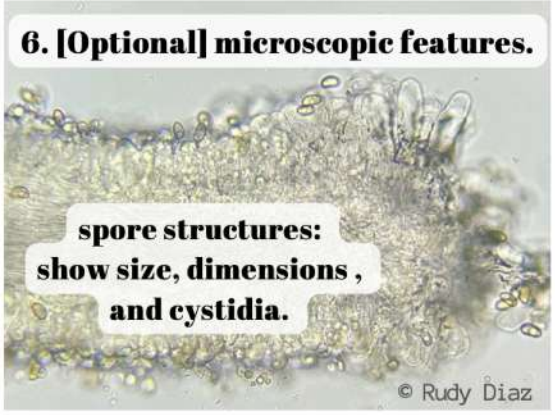

1. ZOOM OUT.
Show the habitat, and associated organisms.


2. From ABOVE:


3. From the SIDE, entirely unearthed.

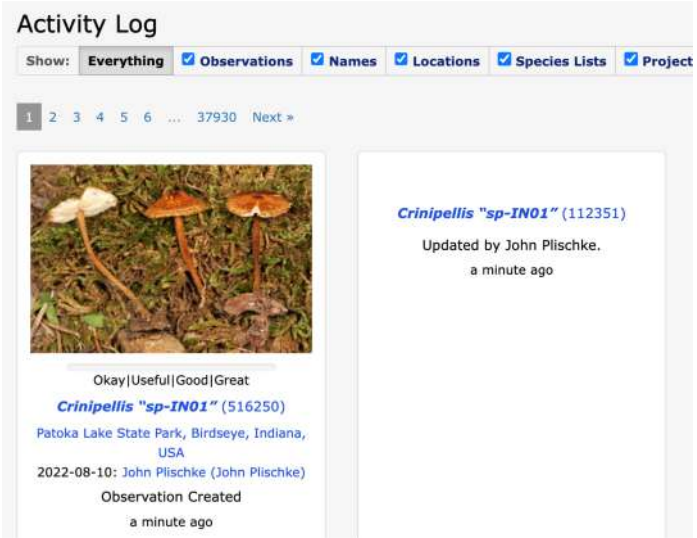

4. From BELOW: show the spore-bearing morphology.
A hand, coin, or ruler work well to scale.
© Justina Martelli


5. If bruising or liquid release from cutting is present, document that too.


6. [Optional] microscopic features.
spore structures: show size, dimensions , and cystidia.
© Rudy Diaz

Sharing your findings with the scientific community.

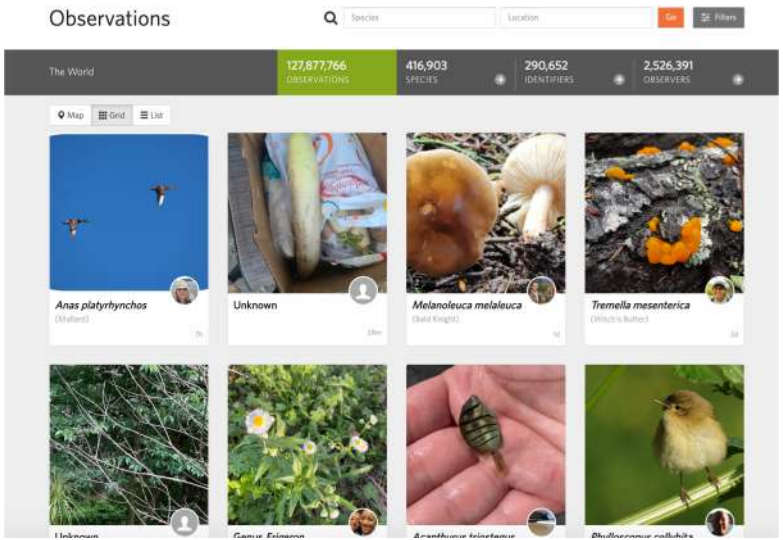
MUSHROOM OBSERVER



https://mushroomobserver.org/

– Specific to fungi.
– More “serious” high-quality data.
– Manage your own fungarium records (ready-to-print labels).

iNaturalist



https://www.inaturalist.org/pages/getting+started

– Bigger community; better chance at getting help with an ID.
– Convenient for casual *and* “serious” observations.
– More intuitive user interface.

The genus *Amanita* in Southern California

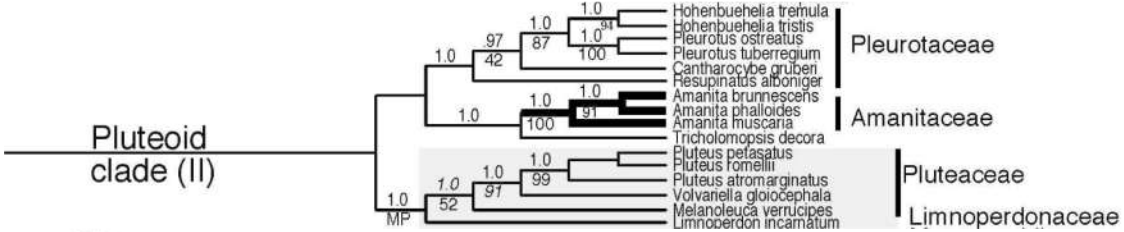
8-headed *Amanita ocreata* found by Joanne Schwartz on Santa Cruz island, 2021. https://mushroomobserver.org/362773?q=1oPmd

Rod Tulloss, lead taxonomist for North American Amanitaceae.

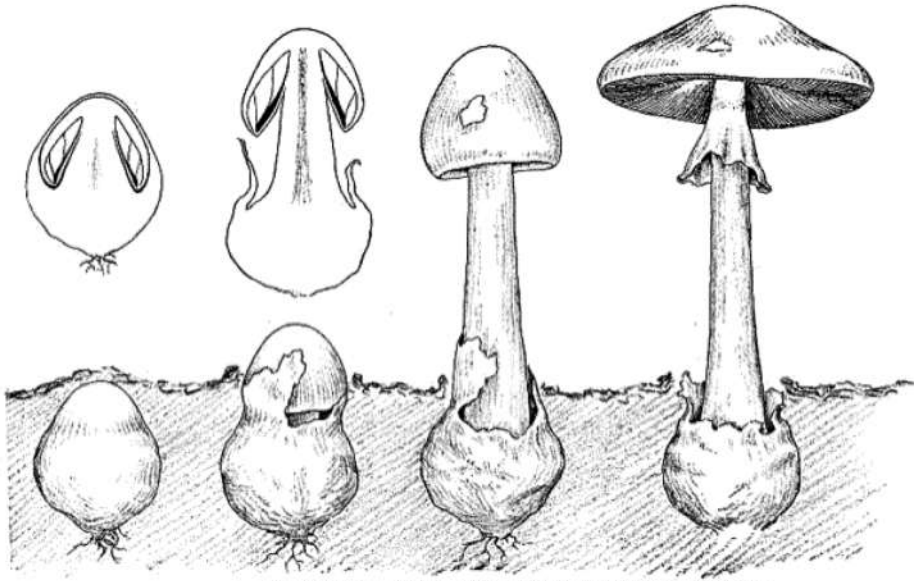
http://www.amanitaceae.org/?Identification+Tools

There is still a lot to be discovered in Southern California.

Characteristic development.



Matheny, P. B., Curtis, J. M., Hofstetter, V., Aime, M. C., Moncalvo, J.-M., Ge, Z.-W., … Hibbett, D. S. (2006). *Major clades of Agaricales: a multilocus phylogenetic overview. Mycologia, 98(6), 982–995.* doi:10.1080/15572536.2006.1183



The Deadly Amanita. From a drawing showing the fungus in several stages of development from the egg to the mature plant (Amanita phalloides).

Source: *Some Colorado mushrooms*, figure 14, by B.O. Longyear, published in 1914 by the Experiment Station at Fort Collins, Colorado.

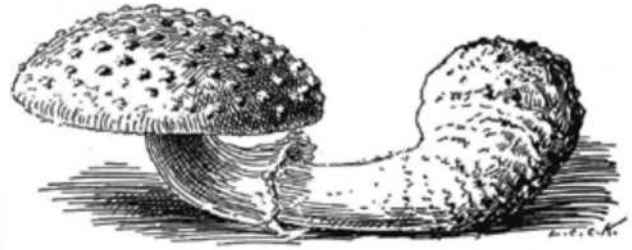
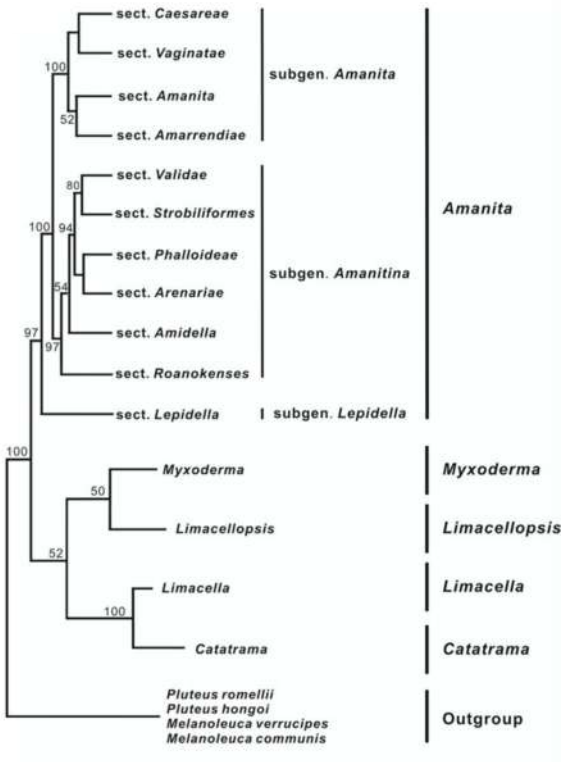


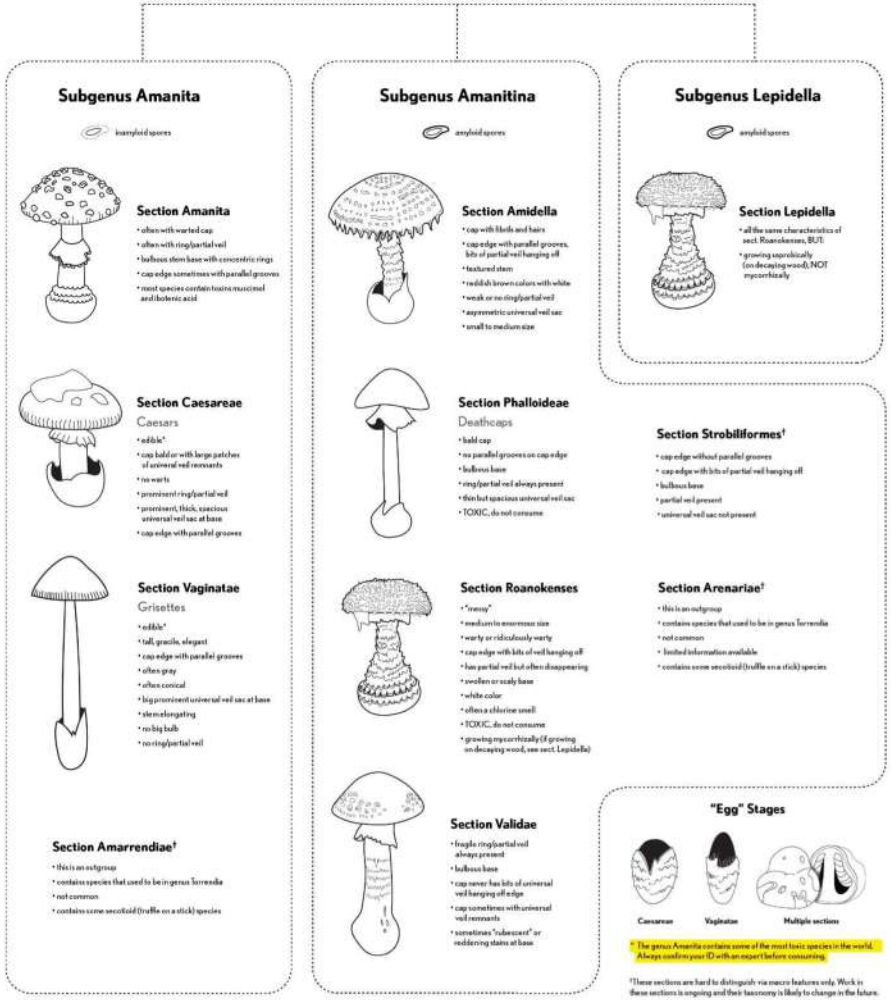
Figure 9 A specimen of *Amanita muscaria* that has lain in the horizontal position over night. Note the effect of gravity in causing the stem to bend so that the cap will again be horizontal

Krieger, Louis C.C. 1936. The Mushroom Handbook. The Macmillan Company, New York

Sections of the genus *Amanita*



Cui, YY., Cai, Q., Tang, LP. *et al.* The family Amanitaceae: molecular phylogeny, higher-rank taxonomy and the species in China. *Fungal Diversity* 91, 5–230 (2018). https://doi.org/10.1007/s13225-018-0405-9

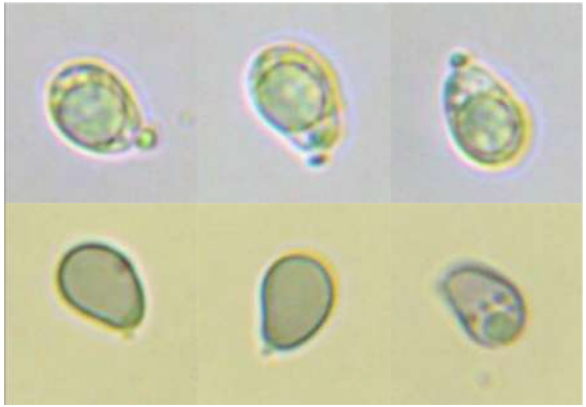


Created by Bethany Beech (NYMS). Free download: https://drive.google.com/file/d/1vMiRVXsPJ4RF-LCYSBMNq8Qvm2tpU9ha/view?fbclid=PAAaab3RZLRc5Ulu308aSE_8zDz2VPzJimLErU0mKIkc_6vE3vOBz4OIhLtcPw

Amyloid reaction

Water

Melzer's reagent

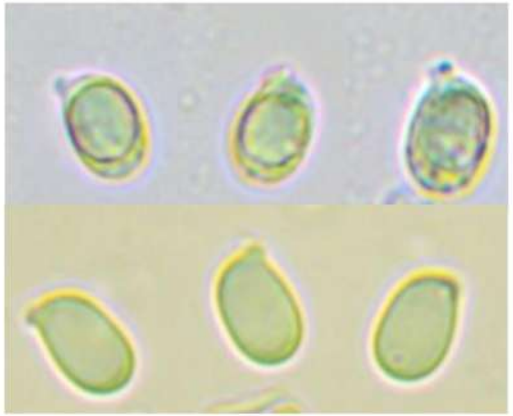


Amanita ocreata

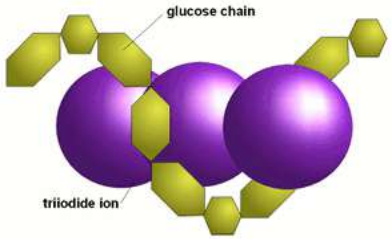
Inamyloid reaction

Water

Melzer's reagent

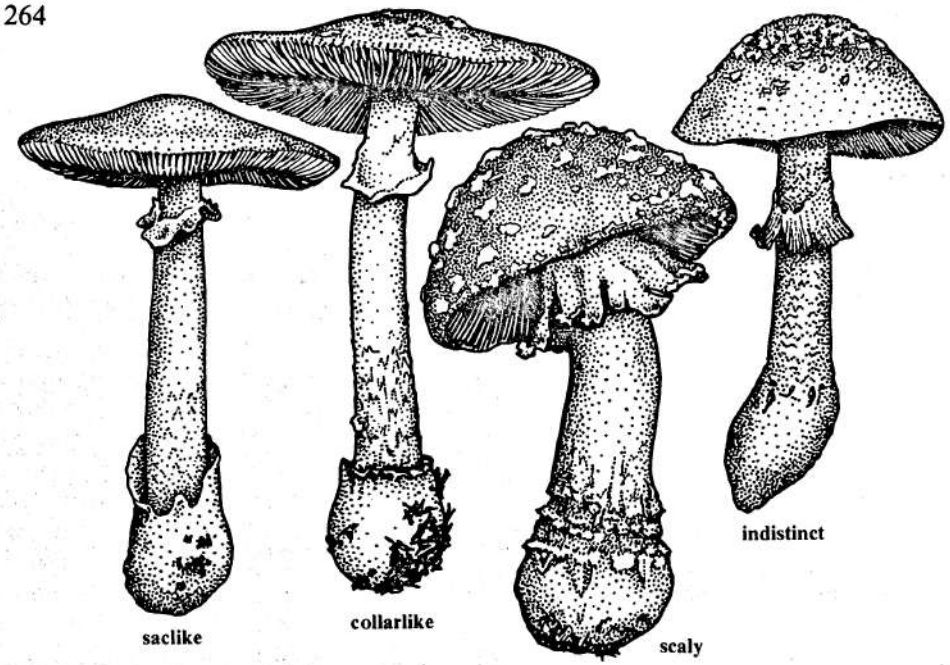


Amanita pantherina



https://braukaiser.com/wiki/index.php/Iodine_Test

Dig up the entire base of the mushroom.



Different types of volvas in *Amanita*. Left to right: *A. phalloides, A. pantherina, A. muscaria, A. rubescens.*

Arora, D. (1986). *Mushrooms demystified: a comprehensive guide to the fleshy fungi.* 2nd ed. Berkeley, Ten Speed Press.

Section Amanita

Found by Stu Pickell, Santa Monica Mts https://www.inaturalist.org/observations/148999861

Section Caesarae

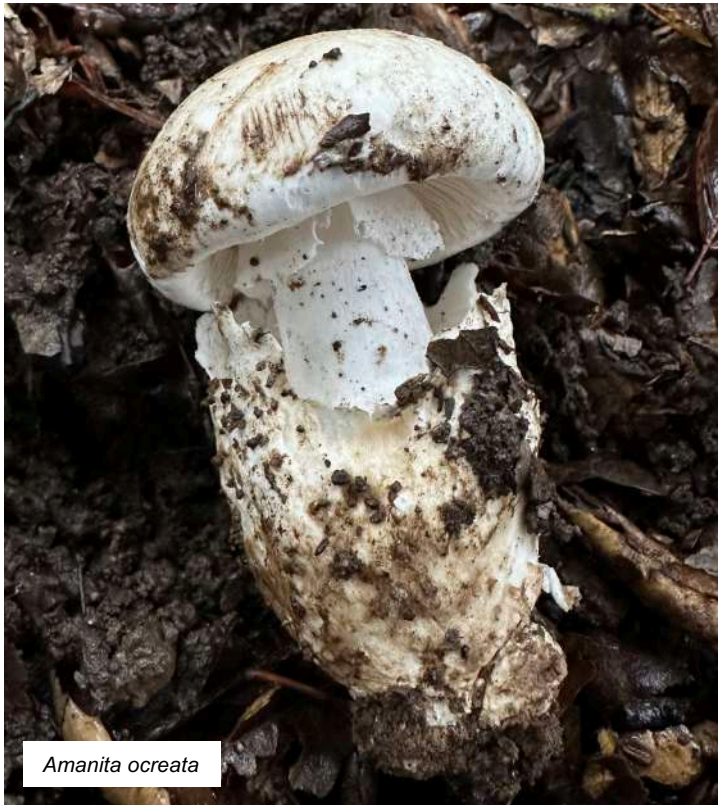
Dave Goodward, Cleveland National Forest Feb. 2023

Section Vaginatae

Amanita protecta Tulloss & G. Wright

Amanita velosa

Section Phalloides



Amanita ocreata

Santa Ana Mts Feb. 2023

Found by Sebastian and Dawn Urbont, West LA Jan. 2023

Amanita phallloides

Not *Amanita*. Spores pink.

Section Vaginatae

A. velosa

Section Validae

A. novinupta

Section Roanokenses

A. magniverrucata

Table at LAMS mushroom fair.

© CHRISTOPHER BROWN, NATIONAL GEOGRAPHIC 2023

Section Lepidella

The species in Southern California are not known.

Tim Martin, Santa Monica Mts Feb. 2023
https://www.inaturalist.org/observations/149862948

Dave Goodward, Santa Rosa Mts Sept. 2022
https://www.inaturalist.org/observations/133418612

Saproamanita sp.

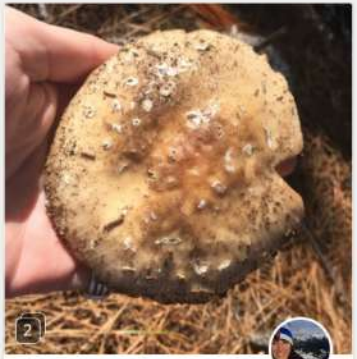
Christian Schwarz, Santa Cruz Island Jan. 2023 https://www.inaturalist.org/observations/146015210

Key to Amanita

1. Volva saclike (i.e., forming a true sack that sheathes base of stalk as shown on p. 264); cap usually bald or with a cottony or membranous patch of universal veil tissue or occasionally with several patches or non-friable warts 2
1. Volva collarlike (i.e., intergrown with base of stalk but with a free rim), scaly, warty, powdery, or indistinct but *not* saclike (see p. 264); cap often with many small pieces of universal veil tissue (warts), powder, etc., occasionally with larger pieces 15
2. Volva *tough*, thick, large; cap and/or stalk often shaggy, fibrillose, or with cottony patches of veil tissue; cap white or tinged brown (especially at center), often bruising brown or reddish, margin often striate in age; stalk similarly colored; annulus (ring) absent; spores *oblong or elliptical, amyloid;* fairly common in eastern North America, rare in West ***A. volvata*** & close relatives
2. Not with above features 3
3. Margin of cap distinctly striate (at least when mature); spores *not* amyloid 4
3. Margin of cap not striate or only faintly so (occasionally striate in age); spores amyloid .. 12
4. Partial veil present when young, usually (but not always!) forming an annulus (ring) on stalk 5
4. Partial veil and annulus absent or rudimentary (but stalk sometimes scaly) 8
5. Gills and stalk yellow to yellow-orange; cap bright red to orange (but may fade to yellow or paler in age or sunlight) ..... ***A. caesarea*** *group* & others, p. 284
5. Not as above; gills and stalk typically white to creamy or very pale yellow 6
6. Volva often small and inconspicuous; cap brown to gray or sometimes nearly white; growing in mixed woods and under hardwoods in eastern North America ..... ***A. spreta***
6. Not as above; known only from western North America 7
7. Cap brown to yellow or whitish, but if brown then usually with a yellow margin; partial veil typically (but not always!) forming a prominent skirtlike annulus on stalk ***A. calyptrata,*** p. 284
7. Cap variously colored, but the margin not yellow; annulus (ring) usually pressed closely to the stalk or poorly defined 48
8. Cap dark brown to gray or grayish-brown 9
8. Cap white to pale tan, beige, orangish, pinkish, orange-brown, or reddish-brown 10
9. Fruiting body medium-sized to large; cap dark gray to dark brown when young, often paler in age and often developing a darker band near inner edge of striations; gill edges usually brown; known only from the West ..... ***A. pachycolea,*** p. 290
9. Fruiting body medium-sized to rather small and slender; cap usually gray, but sometimes grayish-brown or brown; gill edges not brown; widely distributed 49
10. Cap white with *long* striations; widespread, but rare in West ***A. alba*** (see *A. vaginata*, p. 288)
10. Not as above; if cap white then with shorter striations and usually found near western oaks in winter and spring (or even summer); common 11
11. Cap pinkish-tan to orangish, beige, or paler ..... ***A. velosa*** & others, p. 286
11. Cap orange-brown to reddish-brown, tawny, etc.; common in eastern North America, infrequent in West ..... ***A. fulva***, p. 287
12. Cap greenish to yellow-green, brownish-olive, grayish-olive, or nearly white when young, often duller (dingy tan, etc.) or with a metallic luster in age ..... ***A. phalloides***, p. 269
12. Not as above; cap usually white or whitish when fresh (but may discolor by maturity) ... 13

Arora, D. (1986). *Mushrooms demystified: a comprehensive guide to the fleshy fungi.* 2nd ed. Berkeley, Ten Speed Press.

13. Cap white, but discoloring pinkish, brownish, or yellowish (at least centrally) in age; associated with oak; found in California and the Southwest and Texas ..... ***A. ocreata,*** p. 271
13. Cap usually remaining white or found elsewhere 14
14. Cap white; partial veil usually forming a distinct annulus (ring) on stalk (which may disappear in age!); very common in eastern North America, also found in the Pacific Northwest ..... ***A. virosa*** & others (see *A. ocreata,* p. 271)
14. Not as above; partial veil absent or evanescent; found in eastern North America (do not eat!) ..... ***A. peckiana*** & others
15. Universal veil remnants yellow to grayish-yellow (check cap for warts and base of stalk for volva); cap *not* whitish 16
15. Universal veil remnants not yellow; cap may or may not be whitish 22
16. Partial veil absent; gills yellow; found in eastern North America ..... ***A. parcivolvata*** (see *A. caesarea,* p. 284)
16. Not as above 17
17. Cap bright red to orange-red (but may fade in age); stalk white ..... ***A. muscaria,*** p. 282
17. Cap orange to yellow, yellow-brown, or dark brown; stalk white or yellow 18
18. Lower stalk sheathed with shaggy scales ..... (see ***Armillaria*** & **Allies,** p. 189)
18. Not as above 19
19. Cap salmon to salmon-pink when fresh; found in mountains of eastern U.S. ..... ***A. wellsii***
19. Not as above 20
20. Base of stalk staining reddish in age or where bruised; found in eastern North America ..... ***A. flavorubescens*** (see *A. aspera,* p. 278)
20. Not with above features (if staining as above, then found in West) 21
21. Cap yellow to yellow-brown to dark brown; stalk usually white; common along the Pacific Coast ..... ***A. aspera,*** p. 278
21. Cap yellow-orange to yellow; stalk often colored similarly; fruiting body rather small; common in eastern North America, rare in the West ..... ***A. flavoconia,*** p. 278
22. Cap pale yellow-green to pale yellow to nearly whitish with thin grayish, whitish-buff, or pinkish to lavender-gray warts (which may wash off); cap margin *not* striate; stalk with an abrupt, soft, rounded bulb at base; spores amyloid; common in eastern North America, especially under hardwoods but also with conifers ..... ***A. citrina*** (see *A. porphyria,* p. 279)
22. Not as above 23
23. Cap brown to olive-brown or paler; stalk lacking grayish patches, terminating in an abrupt basal bulb that is usually split or chiseled longitudinally; flesh usually staining reddish-brown; spores amyloid; common in eastern North America (especially under hardwoods); also reported from the Pacific Northwest (but rare) .. ***A. brunnescens*** (see *A. porphyria,* p. 279)
23. Not as above 24
24. Cap brightly colored (red, orange, or yellow); partial veil present, usually forming an annulus (ring) on stalk 25
24. Not as above (cap may be sordid reddish or reddish-brown, pinkish-tan, etc.) 26
25. Volva usually a series of concentric rings at apex of bulbous stalk base, but sometimes only a single ring or collar; cap medium-sized to large and bright red to orange, apricot, yellow-orange, or yellow (yellow form rare in coastal California, but common in the Sierra Nevada and most of eastern North America) ..... ***A. muscaria,*** p. 282
25. Volva usually a single collar at top of basal bulb or often indistinct, but sometimes consisting of several rings; cap small to medium-sized (occasionally large), usually pale yellow (but sometimes brighter), at times completely covered by veil material; widespread ***A. gemmata,*** p. 281
26. Partial veil absent (check young specimens if possible); cap margin distinctly striate; spores not amyloid 27
26. Partial veil present, or if absent, then cap margin *not* striate; spores amyloid or not 31
27. Cap gray to grayish-brown, brown, or darker 28
27. Cap pale yellow, orange-buff, salmon, pinkish, tan, or nearly white 30
28. Cap powdery-mealy; volva if present also mealy ***A. farinosa*** (see *A.* sp. (unidentified), p. 275)
28. Not as above 29
29. Cap gray or sometimes grayish-brown, with or without warts; upper limb of volva usually well-developed (but falls off easily); common in California ..... ***A. constricta,*** p. 289
29. Cap gray to brown to dark brown to nearly black, usually with warts; upper limb of volva not well-developed; widespread, but rare in California ...***A. inaurata*** (see *A. constricta,* p. 289)
30. Cap yellow to creamy to whitish; volva usually collarlike (with free rim) . ***A. gemmata,*** p. 281
30. Cap orange-buff to pale pinkish-orange to pinkish-tan, beige, or sometimes whitish; volva not typically collarlike; often growing in the open (but near trees) ..... ***A. velosa,*** p. 286
31. Cap entirely brown when young, breaking up into large brown scales in age; flesh in stalk usually staining orange or saffron (and eventually reddish) when cut (see ***Lepiota rachodes,*** p. 297)
31. Not as above 32
32. Cap with erect, often pyramidal brown warts which usually come off easily; stalk and/or underside of veil with similar warts; spores usually dextrinoid, *not* amyloid . (see ***Lepiota,*** p. 293)
32. Not with above features (but may have some of them); common 33
33. Some part of fruiting body usually with sordid reddish stains (especially the stalk); flesh *slowly* staining dingy reddish when bruised or cut; maggot tunnels also reddish ***A. rubescens,*** p. 276
33. Not as above 34
34. Fresh fruiting body white or whitish (but may age buff, yellowish, brownish, pinkish, etc.) 35
34. Not as above; cap distinctly colored or with colored veil material even when young 42
35. Stalk terminating in a fairly conspicuous bulb, *not* typically with a rooting portion below the bulb 36
35. Stalk without bulb, or if with a bulb, then also with a tapered rooting base below the bulb 40
36. Volva typically present as a distinct free rim (collar) or series of concentric rings at apex of basal bulb; spores *not* amyloid 37
36. Not as above; spores amyloid 38
37. Volva typically consisting of a single tight-fitting collar around bulb apex; cap often tinged yellowish or brownish at center; often rather slender ***A. cothurnata*** (see *A. pantherina,* p. 280)
37. Volva usually a series of concentric rings; cap white to grayish-white or tinged buff; not unusually slender ..... ***A. muscaria,*** p. 282
38. Cap surface with rather soft and cottony universal veil tissue, lacking conspicuous warts; known only from western North America ..... ***A. silvicola,*** p. 273
38. Not as above (if cap cottony, then found elsewhere) 39
39. Cap usually with brown warts; stalk often rather stout (up to 8 cm long); known only from California, associated with live oak ..... ***A.* sp. (unidentified)** (see *A. rubescens,* p. 276)
39. Not as above 40
40. Cap without warts or warts obscure; growing in sand ..... ***A. baccata,*** p. 273
40. Not as above; cap usually with distinct, well-developed warts 41
41. Cap covered with large, exaggerated warts; fairly common with oak and pine, known only from California ..... ***A. magniverrucata,*** p. 274
41. Found elsewhere, or if found in California then warts smaller and often concentrated at center of cap ..... ***A. cokeri*** & many others (the "Lepidellas") (see *A. magniverrucata,* p. 274)
42. Stalk arising from a well-developed cylindrical to jug-shaped, sometimes hollow, underground "tuber"; rare ..... (see ***Squamanita,*** p. 197)
42. Not as above (but stalk may root deeply or have a bulbous base) 43
43. Cap yellow to creamy, the margin usually striate or tuberculate-striate . . ***A. gemmata,*** p. 281
43. Not with above features 44
44. Volva indistinct, powdery, or scaly; cap margin not normally striate 45
44. Volva usually present as a free rim or collar on basal bulb *and/or* margin of cap striate in age 47
45. Found in California 46
45. Found in eastern North America (especially common in Southeast) 50
46. Usually found in open ground (pastures, etc.); partial veil often disappearing; cap grayish-white to gray to brownish-gray, small ..... ***A.* sp. (unidentified),** p. 275
46. Associated with oak; partial veil usually forming a persistent, prominent annulus; cap white to brownish ..... ***A.* sp. (unidentified)** (see *A. rubescens,* p. 276)
47. Warts gray *and/or* stalk gray or with grayish patches; spores amyloid .. ***A. porphyria,*** p. 279
47. Stalk white; warts usually white or pallid; spores not amyloid ..... ***A. pantherina,*** p. 280



Amanita pantherina
(Panthercap)
Research Grade 2 4y

Amanita pantherina
(Panthercap)
Research Grade 1 4y

Amanita pantherina
(Panthercap)
Research Grade 2 4y

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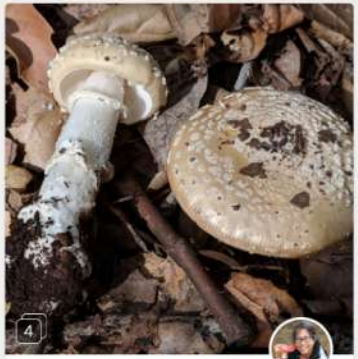
Amanita pantherina
(Panthercap)
Research Grade 1 Jan '19



Amanita pantherina
(Panthercap)
Research Grade 1 Jan '19

Amanita pantherina
(Panthercap)
Research Grade 2 May '18

Invasive Californian death caps develop mushrooms unisexually and bisexually

Yen-Wen Wang, Megan C. McKeon, Holly Elmore, Jaqueline Hess, Jacob Golan, Hunter Gage, William Mao, Lynn Harrow, Susana C. Gonçalves, Christina M. Hull, Anne Pringle

Abstract

Canonical sexual reproduction among basidiomycete fungi involves the fusion of two haploid individuals of different sexes, resulting in a heterokaryotic mycelial body made up of genetically different nuclei[1]. Using population genomics data, we discovered mushrooms of the deadly invasive *Amanita phalloides* are also homokaryotic, evidence of sexual reproduction by single individuals. In California, genotypes of homokaryotic mushrooms are also found in heterokaryotic mushrooms, implying nuclei of homokaryotic mycelia also promote outcrossing. We discovered death cap mating is controlled by a single mating-type locus (*A. phalloides* is bipolar), but the development of homokaryotic mushrooms appears to bypass mating-type gene control. Ultimately, sporulation is enabled by nuclei able to reproduce alone as well as with others, and nuclei competent for both unisexuality and bisexuality have persisted in invaded habitats for at least 17 but potentially as long as 30 years. The diverse reproductive strategies of invasive death caps are likely facilitating its rapid spread, revealing a profound similarity between plant, animal and fungal invasions[2,3].

Cold Spring Harbor Laboratory

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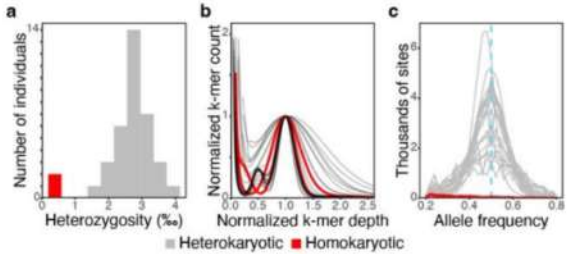

Fig. 1. Genomes of two putatively homokaryotic individuals collected in California bear signatures of a haploid or homozygotic genome. (a) Whole-genome heterozygosities of 37 individuals; note the cluster of two Californian individuals at left (in red). (b) Peaks of k-mer depths for Californian and Portuguese individuals; a secondary peak at 0.5 implies heterozygosity and is lacking for the two Californian individuals (in red). (c) Sequencing frequencies of variable SNPs within individuals; peaks at 0.5 indicate heterozygosity and are lacking for the two putative homokaryons.

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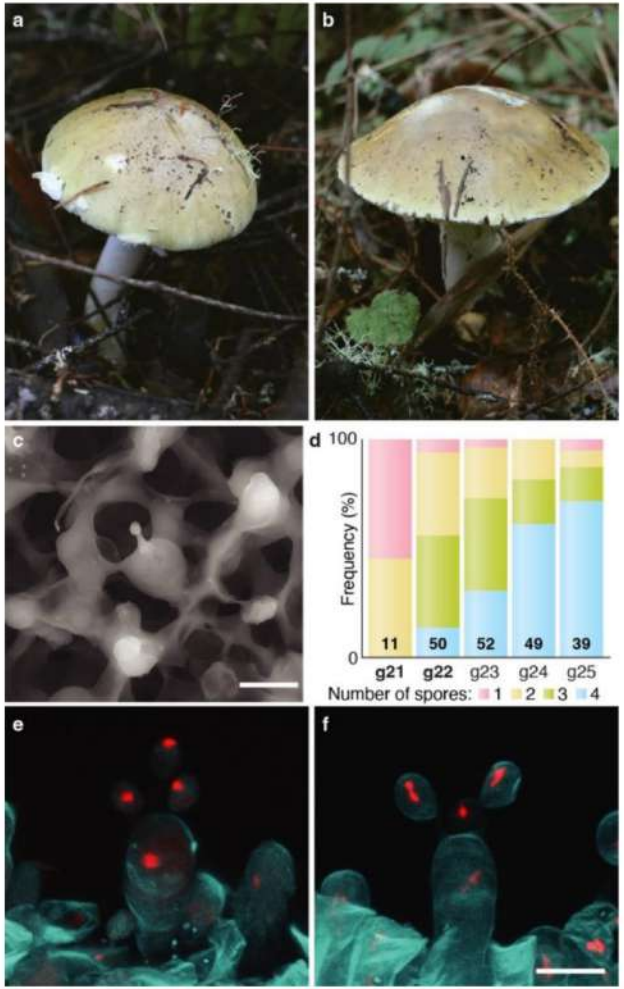
Fig. 3. Morphology of heterokaryotic and homokaryotic sporocarps. (a) Heterokaryotic sporocarp found in 2021. (b) Homokaryotic sporocarp found in 2021. (c) Scanning electron microscopy of a unisporic basidium from a homokaryotic sporocarp. (d) Frequency spectra of the number of spores per basidium among five individuals. Homokaryotic individuals are bold (g21 and g22). Number of basidia counted indicated within each column. (e–f) Z-stack composite image of confocal microscopy of trisporic basidia from heterokaryotic (e) and homokaryotic (f) sporocarps; in (f) the basidium was more mature and nuclei are dividing. Red: Vybrant Orange (nuclei); cyan: Calcofluor White (cell wall). Scale bars: 10 µm.



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