

## Phalloid Fungi in Hawaii<sup>1</sup>

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THE ORDER Phallales, as outlined by Cunningham (1942) and Zeller (1949), contains three families and approximately 20 genera of fleshy basidiomycetes, which, because of their usually stalked fruiting bodies and foetid odor, are commonly called "the stinkhorns." The group includes some of the most bizarre and unusual of the fungi.

The Phallales appear to be poorly represented in Hawaii, at least insofar as present records indicate. Five species, representing five genera in two families, have been collected in the Islands. It is the purpose of this report to summarize current knowledge of the group in Hawaii, in the hope that this will stimulate further collecting and reporting of these interesting fungi.

We are indebted to N. A. Cobb, formerly chief plant pathologist with the Hawaiian Sugar Planters' Association Experiment Station, for much of our knowledge of the phalloids in Hawaii. Cobb's observations on fruit body development and spore dispersal in these fungi are among the most detailed to be found in mycological literature (Cobb, 1906, 1909). Unfortunately, they appear to have been overlooked by many mycologists.

Because he associated these fungi with root disease in sugar cane, Cobb devoted much attention to them, and was particularly concerned with factors affecting their growth, dispersal, and survival in sugar cane fields. He very carefully studied the feeding habits of the sarcophagous flies which feed on the spores of these fungi, and which are the agents of spore dispersal, and demonstrated that the fungus spores can pass unharmed through the gut of the insect. In light of present knowledge of the behavior of many coprophilous fungi, this fact does not seem surprising, but it appears to be

one of the few documented observations of this phenomenon in the phalloids. Cobb (1906) showed that an adult fly could consume up to 80 percent of its body weight in fungal spores in a single day, and that a single "speck" of fly excrement could contain as many as 22,400,000 fungus spores.

Statements in current mycological literature (Ingold, 1965) indicate that the spores of the Phallales have never been observed to germinate; however, Cobb and his associate, L. Lewton-Brain, reported and illustrated germinating spores of *Phallus rubicundus* (Cobb, 1906).

The fruiting body of the phalloids is initially enclosed within a whitish, egg-shaped structure. Development of the sporophore takes place completely within the "egg," and when mature, the pressure caused by the enlargement of the internal structures causes the outer wall, or peridium, to break. The spongy, spore-bearing structure then emerges. Emergence of the sporophore usually occurs quite rapidly. Alexopoulos (1962) states that in *Dictyophora duplicata*, the stalk is fully expanded 5 hours after the peridium splits. Cobb (1906) illustrated the rapid development of *P. rubicundus* in a series of photographs, portrayed here as Figure 1.

The fruiting body is extremely ephemeral and wilts soon after its emergence from the "egg." Cobb (1906) stated that fructifications of *P. rubicundus* that were fully expanded by 6:30 A.M. had begun to wilt by 10:00 A.M.

A checklist of Hawaiian fungi published in 1940 (Parris, 1940) listed three species of phalloid fungi. Two additional species have been found in the Islands since the publication of that report. Phalloids now known to occur in Hawaii are discussed in the subsequent paragraphs.

*Anthurus javanicus* (Penzig) G. H. Cunningham. Proceedings of the Linnean Society of New South Wales, vol. 56, p. 186, 1931.

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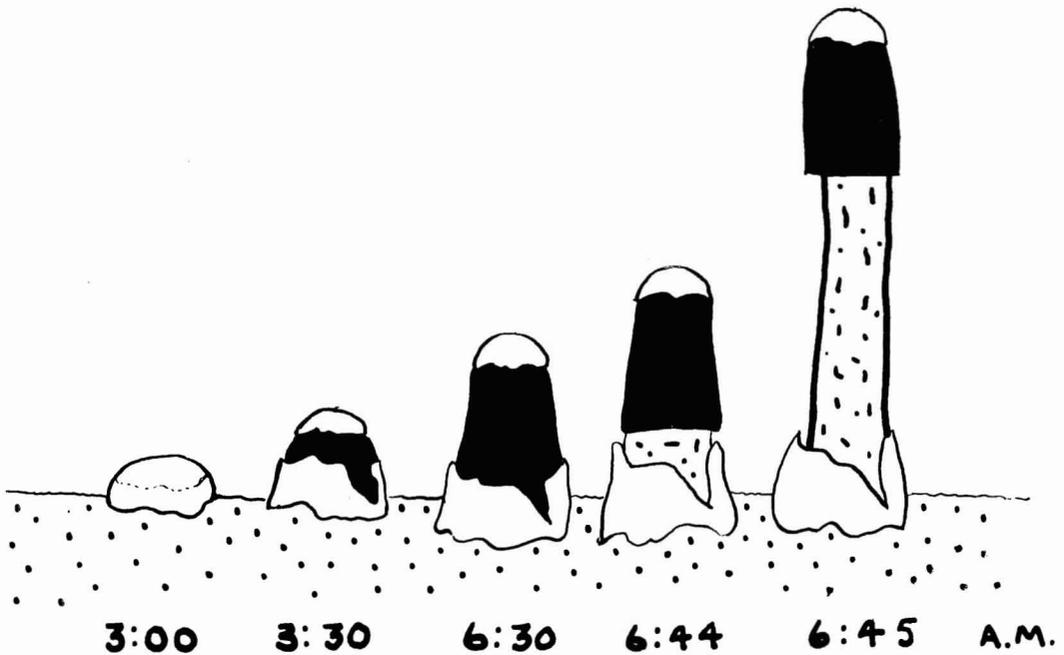


FIG. 1. *Phallus rubicundus*. Development from the "egg stage." (After Cobb, 1906).

Cunningham, G. H., *The Gasteromycetes of Australia and New Zealand*, p. 103, 1942.

The fungus upon which this record is based was collected near Punaluu, Oahu, on August 10, 1969, by D. Herbst, under a stand of *Eucalyptus*. The collection consisted of one expanded fructification and two "eggs," both of which subsequently developed to maturity in a moist chamber. Mature fructifications consisted of a short stalk subtended by a volva and bearing above two to four simple reddish arms, united at the apex (Fig. 2). Overall height of the fruiting bodies ranged from 3.0 to 4.0 cm; width at the base was 7 to 8 mm. Spore masses were produced in a greenish mucoid mass on the inner surface of the receptacle arms. The spores were elliptical, and measured  $4-5 \times 1.5-2\mu$ .

The fungus agrees fairly well with the description and illustration of *A. javanicus*, as given by Cunningham (1942), although there is a slight difference in spore size. Spores of the Hawaiian fungus measure  $4-5\mu$  in length, whereas Cunningham gives spore length as  $5-6\mu$ .

There is great confusion surrounding the

name *Anthurus*, making placement of a fungus in this genus less than satisfactory. Zeller (1948) treats *Anthurus* as a synonym of *Ly-*



FIG. 2. *Anthurus javanicus*. Two fully developed sporocarps and an "egg."

*surus*, and this treatment is accepted by Ainsworth (1961). By implication, Rea and Heidenhain (1955) also suggest that the two genera are synonymous, but an adequate taxonomic treatment is lacking in their paper.

Exact placement of the Hawaiian fungus is impossible without the examination of appropriate herbarium material and possibly a review of the several genera that may be involved, which is beyond the scope of the present investigation. Inasmuch as the fungus shows close agreement with *Anthurus javanicus*, it is provisionally assigned to that species.

*Aseroë rubra* La Billardiere ex Fries. Systema Mycologicum, vol. 2, p. 285, 1822. Cunningham, G. H., The Gasteromycetes of Australia and New Zealand., p. 107, 1942.

*Aseroë rubra* is one of the showiest of the phalloid fungi. The mature fruiting body consists of a basal volva (the ruptured peridium) subtending a spongy stalk, which bears at its apex an expanded, brightly colored receptacle from whose margin arise a number (5 to 9) of bifurcated arms (Fig. 3). The gloeoid, olivaceous spore mass is borne on the upper surface of the expanded receptacle. The stalk and volva are usually pale pinkish in color, while the receptacle may vary from pink to red. A definite foetid odor is usually detectable, and in fresh specimens may be pronounced.

According to Cunningham, *A. rubra* is common in Australia and New Zealand, and it has been reported from Tasmania, New Caledonia, the Malay Archipelago and Ceylon. There is a single report of it from England (Transactions of the British Mycological Society, vol. 1, p.



FIG. 3. *Aseroë rubra*. (After Ingold, 1965).

25, 1896–1901), where it was found in Kew Gardens, associated with plants introduced from Australia. It was concluded that the fungus also was "surely introduced."

The following records of *A. rubra* in Hawaii have been obtained: (1) Oahu, 1965; a single specimen found by D. E. Hardy; no other data available. (2) Oahu, 12/31/68; two specimens collected under *Eucalyptus* at an elevation of 1,800 feet, on the trail to Puu Hapapa, Waianae, Mts., by J. Obata. (3) Oahu, 1/16/69; remnants of two decaying sporophores found on decaying wood under *Eucalyptus*, Helemano Forest Reserve, by R. Goos. (4) Oahu, 4/12/69; single sporophore collected under *Eucalyptus*, Aiea Loop Trail, by Jane Mihata. (5) Maui, 12/18/67; specimen collected at an elevation of approximately 2,500 feet, under *Cytisus palmensis*, 2.3 miles east of the junction of highways 377 and 37, by D. Herbst. (6) Maui, 4/9/67; specimen collected at an elevation of 700 feet under bamboo, near the point where Oopuola stream intersects Hana Road, by J. Obata. (7) Molokai, 2/7/69; two sporophores collected in Palaaau State Park, one in an open grassy area used for campsites, the other on a foresters' road leading from the camp area, by B. K. H. Lee and R. Goos.

*Aseroë rubra* appears to be well established in Hawaii, and its occurrence on three of the principal islands suggests that it may occur throughout the Archipelago. Its distribution in Hawaii does not appear to be greatly affected by altitude, since it has been found at elevations ranging from 700 to 2,500 feet. Whether the fungus is indigenous to Hawaii or has been introduced with forest trees brought into the Islands from Australia or other South Pacific locations, is a matter of speculation. That such introduction could occur is evidenced by the single report of this fungus from England.

*Dictyophora indusiata* (Ventenat ex Persoon) Desvaux. Journal de Botanique, vol. 2, 1809. Cunningham, G. H., The Gasteromycetes of Australia and New Zealand, p. 96, 1942. Cobb, N. A., HSPA Experiment Station, Division of Pathology and Physiology, Bulletin 6, pp. 8–14, 1909.

The genus *Dictyophora* is, perhaps, one of the most attractive of all the fungi. The fruiting

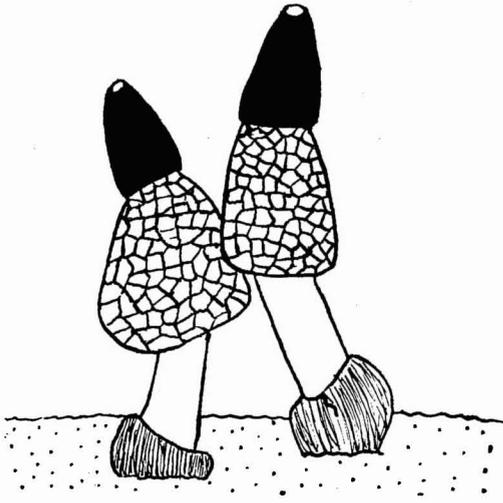


FIG. 4. *Dictyophora indusiata*. (After Cobb, 1909).

body consists of a pileus borne at the apex of a hollow cylindrical stem, which emerges, as in *Aseroë*, from a ruptured peridium that remains as a volva. The spore mass is olivaceous, mucilaginous, and foetid, and it covers the exterior of the pileus. The distinctive characteristic of the genus is the production of an elegant netlike skirt, the indusium, that subtends the pileus (Fig. 4).

*Dictyophora indusiata* was reported from Hawaii by Cobb, based on a collection made near Pepeekeo on the island of Hawaii in 1907 by J. W. Webster. The fungus was found on sugar cane trash. The description given by Cobb for these specimens agrees well with that given by Cunningham, and his illustrations (Fig. 4) leave no doubt regarding the identity of the fungus. In the words of Webster, as quoted by Cobb, "In this pile of trash we have the finest incubator of these 'potatoes' and fungus. 'Potatoes' 1½ inches diameter. Toadstools 8 to 10 inches in height with a large yellowish 'mosquito net' hung like an umbrella from under the head."

This fungus does not appear to have been recorded in Hawaii since Cobb's report. Parris (1940) cites only the single record, and no others have come to my attention.

*Linderiella columnata* (Bosc) G. H. Cunningham. New Zealand Journal of Science and

Technology, vol. 23, p. 171, 1942.

= *Clatrus trilobatus* Cobb, HSPA Experiment Station, Division of Pathology and Physiology, Bulletin 5, p. 209, 1906.

The receptacle of *Linderiella* consists of simple columns, united apically, but free and divided basally (Fig. 5). The spore mass is olivaceous and gloeoid as in the two preceding species, and is borne on the inner surface of the receptacle. There is no stalk in this genus, but the receptacle arms loop upward to form an upright fructification. Cunningham differentiates this genus from *Clatrus* on the basis of the basally free arms of the receptacle; in *Clatrus* they are attached. Zeller (1948) did not include *Linderiella* in his key to the Phallales, indicating that he probably did not consider the genus valid.

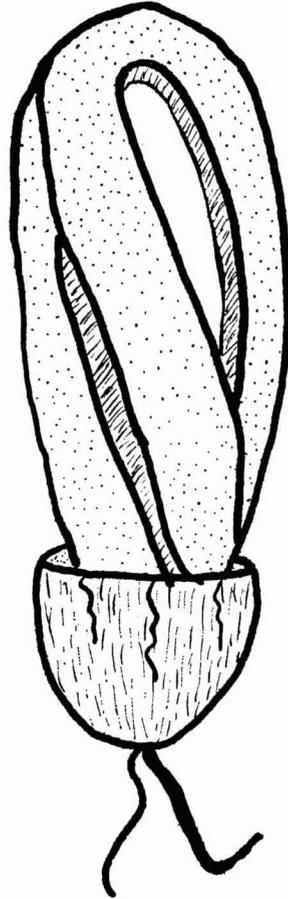


FIG. 5. *Linderiella columnata*. (After Cobb, 1909).

*Linderiella columnata* was reported from Hawaii by Cobb (1909), who described it as a new species in the genus *Clatbrus*. The fungus was found in sugar cane fields on Kauai, and was assumed by Cobb to be parasitic on the roots of the cane plants. According to Cunningham, the fungus is widely distributed, occurring in North and South America, the West Indies and New Zealand, as well as in Hawaii.

There are no additional records of this fungus in Hawaii since Cobb's report.

*Phallus rubicundus* (Bosc) Fries. Systema Mycologicum, vol. 2, p. 284, 1822. Cunningham, G. H., Gasteromycetes of Australia and New Zealand, pp. 94-95, 1942.

≡ *Ithyphallus coralloides* Cobb. HSPA Experiment Station, Division of Pathology and Physiology, Bulletin 5, p. 208, 1906.

The genus *Phallus* morphologically resembles *Dictyophora*, but lacks the conspicuous indusium. The sporophore consists of a hollow fusoid stem, bearing apically a pileus on which the mucilaginous, olivaceous spore mass is produced (Fig. 1).

Cobb (1906) reported this fungus as occurring on all of the principal islands of Hawaii, associated with root disease in sugar cane. There are no more recent records of it in Hawaii, but its apparently common and widespread occurrence in cane fields in 1906 suggests that the fungus must surely still be extant in the islands. Cunningham reports it as widely distributed in tropical and subtropical areas.

*Phallus rubicundus* was the fungus that stimulated Cobb's intense interest in the phalloid fungi associated with sugar cane in Hawaii. He was convinced that *P. rubicundus* and *Linderiella columnata* were parasitic on the roots of cane and were causing severe damage to the crop. This hypothesis did not prove valid however, and recent treatises on sugar cane diseases (Martin, 1938; Martin et al., 1961, 1964) make no mention of either fungus. *Dictyophora* is mentioned as the cause of root disease in cane in Australia by Martin et al., (1961), but the slight treatment accorded the fungus indicates that it is not considered a serious problem. While Cobb's opinion of the economic importance of these fungi may have been invalid,

it did provide the stimulus for some outstanding research, and we are indebted to him for some significant basic information about them.

It is of interest to mycologists to question why these rather conspicuous and unusual fungi, at one time of such concern to plant pathologists, have been recorded so infrequently in Hawaii. A part of the answer unquestionably lies in the ephemeral nature of their fruiting bodies. If not observed soon after they elongate, they will be overlooked. A further explanation may lie in the fact that there are simply not enough collectors in Hawaii, and also that those phalloids that are seen go unreported.

I would like to thank Dr. Gladys Baker for permission to include her distribution records of *Aseroë rubra*, for helpful suggestions, and for reviewing the manuscript.

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