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Species identification and chemical analysis of psychoactive fungi in the Hawaiian islands

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Abstract

Several fungi species collected in the Hawaiian Islands have been reported to be psychoactive. Previous chemical analyses together with the present study indicate that 5 coprophilous and one non-coprophilous species occurring in the islands are now known to contain psychoactive alkaloids. At least some of these species are consumed in the Hawaiian Islands, as well as elsewhere, for non-traditional, recreational purposes. These include *Copelandia cyanescens* (Berk. et Br.) Singer, *Copelandia tropicalis* (Ola'h) Singer and Weeks (syn. *Panaeolus tropicalis* Ola'h), *Copelandia anomala* Murrill, and *Panaeolus subbalteatus* (Berk. and Br.) Sacc., which have already been described from the Hawaiian Islands. Three more mind-altering fungi and one non-psychoactive species are reported from this archipelago for the first time. These psychoactive fungi include *Copelandia bispora* (Malençon et Bertault) Singer and Weeks from O'ahu, *Copelandia cambodginiensis* (Ola'h et Heim) Singer and Weeks from O'ahu, and *Amanita muscaria* (L.) Hooker from Kaua'i. *Panaeolus goossensiae* Beeli identified from O'ahu contains tryptamine compounds; however, the psychoactive alkaloids psilocybin and psilocin were not found in this dung species.

Key words: Hawai'i; *Copelandia* spp.; *Panaeolus* spp.; psilocin; psilocybin

1. Introduction

Non-traditional, recreational use of psychoactive fungi in the Hawaiian Islands has occurred for many years (Pollock, 1974; Allen, 1988; Allen and Merlin 1989). Previous research of any kind pertaining to these species in Hawai'i has been very limited.

Recent field work, botanical identification, and chemical analyses indicate that 6 species belonging to Coprinaceae are used for recreational, albeit illicit, purposes in the Hawaiian Islands. These include: *Copelandia cyanescens* (Berk. et Br.) Singer (Figs. 1,2), *Copelandia tropicalis* (Ola'h) Singer and Weeks, *Copelandia bispora* (Malençon et Bertault) Singer and Weeks (Figs. 3,4), *Copelandia cambodginiensis* (Ola'h et Heim) Singer and Weeks (Fig. 5), *Copelandia anomala* Murrill, and

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Fig. 1. *Copelandia cyanescens* (Berk. et Br.) Singer. Averagesized specimens from grass fed cattle. Photo.: Allen, Kualoa, O'ahu.

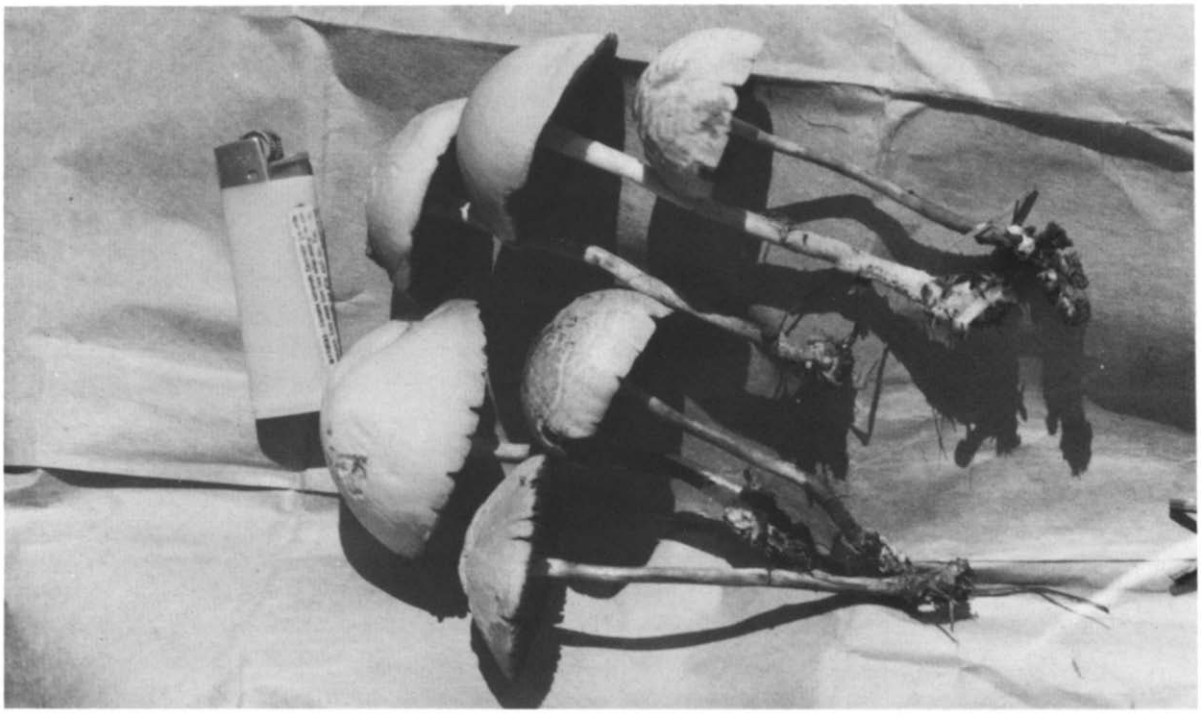

Fig. 2. *Copelandia cyanescens* (Berk. et Br.) Singer. Large specimens common in the dung of grain fed cattle. Photo.: Allen; Livestock and experimental farm, Kahuku, O'ahu.

Fig. 3. *Copelandia bispora* (Malençon et Bertault) Singer and Weeks. Observe the pitted and wrinkled cap resulting from sun exposure. Photo.: Allen; Livestock and experimental farm, Kahuku, O'ahu.

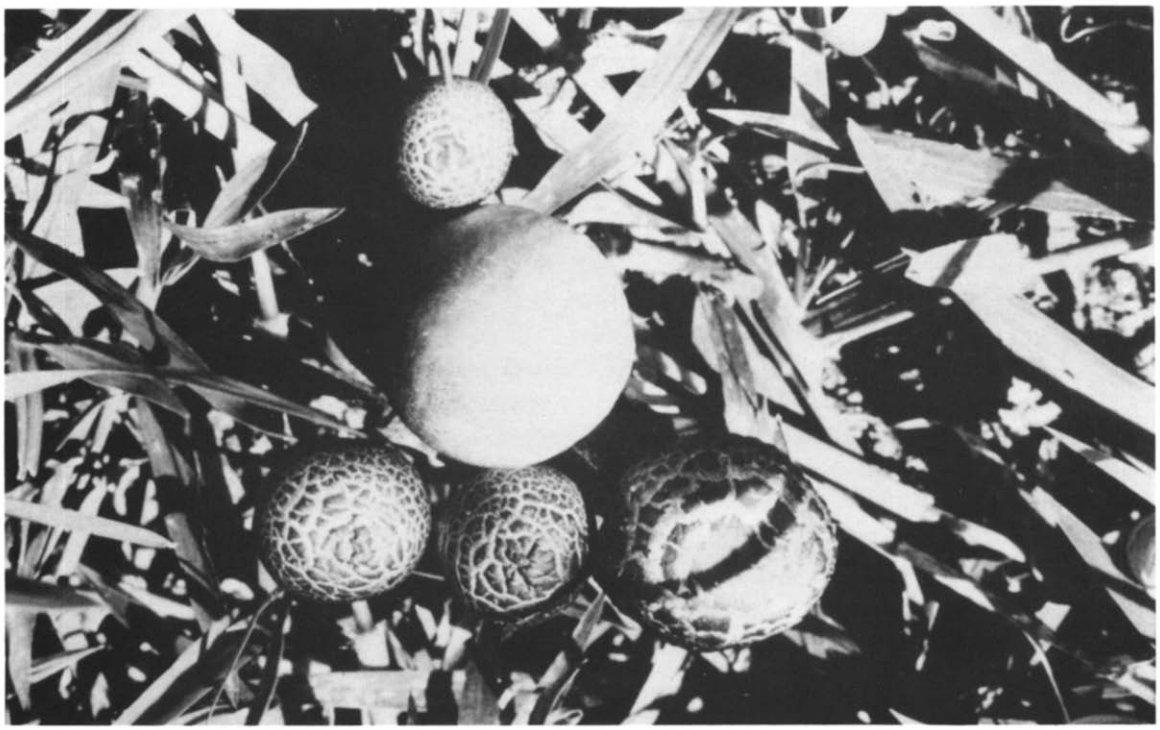

Fig. 4. *Copelandia bispora* (Malençon et Bertault) Singer and Weeks. Another collection from grain fed catttle. Photo.: Allen; Livestock and experimental farm, Kahuku, O'ahu.

Fig. 5. *Copelandia cambodginiensis* (Ola'h et Heim) Singer and Weeks. Typical morphology of *Copelandia* referred to as 'gold tops'. Photo.: Allen, Kahalu'u, O'ahu.

Panaeolus subbalteatus (Berk. et Br.) Saccardo (Figs. 6,7). Most of these melanosporous species, except *C. anomala*, are primarily coprophilous, found growing in ruminant dung, or occurring in grassy areas where manure had previously been deposited (Table 1). They all contain the hallucinogenic indole alkaloids psilocybin and psilocin (Weeks et al., 1979; Pollock, 1974).

Seven other coprophilous species recently collected and identified in the Hawaiian Islands (Hemmis, 1989, pers. commun.) are recognized as containing tryptamine derivatives, but have never been confirmed as psychoactive (Ola'h, 1970; Pollock, 1976; Lincoff and Mitchell, 1977; Stijve, pers. commun., 1987). These include *Anellaria sepulchralis* (Berk.) Singer (syn. *Panaeolus antillarum* (Fr.) Dennis *sensu* Dennis) (Fig. 8), *Panaeolus campanulatus* (L.) Quel., *Anellaria semiovata* (Sow.) Pearson and Dennis (syn. *Panaeolus semiovatus* (Sow.) Lundell et Nannfelt) (Fig. 9), *Panaeolus sphrinctrinus* (Fr.) Quel., *Panaeolus qoossensiae* Beeli (Fig. 10) and *Psilocybe coprophila* Guzmán (Fig. 11). Previous to this study, *P. goossensiae* had only been reported from Central West Africa (Stijve, pers. commun.). All of these species have been collected on O'ahu (Table 2); most, if not all, also occur on other volcanic islands of the archipelago in coprophilous association with alien hoofed mammals.

The Fly Agaric, *Amanita muscaria* (L.) Hooker (Fig. 12), which is known to have been used in the traditional rituals of several tribal societies (Wasson, 1968), is sometimes employed for recreational use in the Pacific Northwest of the United

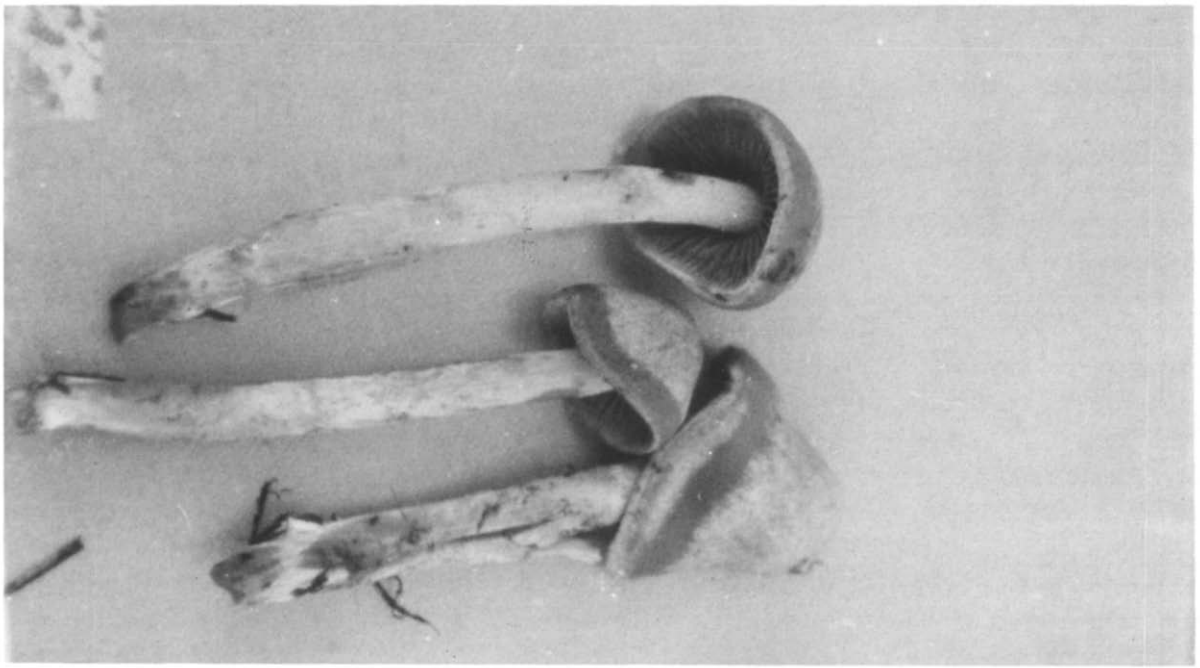

Fig. 6. *Panaeolus subbalteatus* (Berk. et Br.) Sacc. Youthful growth of freshly collected fruiting bodies. Photo.: Allen, Kula, Maui.

Fig. 7. *Panaeolus subbalteatus* (Berk. et Br.). Fruiting bodies in late stage of developement. Photo.: Allen; Livestock and experimental farm, Kahuku, O'ahu.

Table 1
Phychoactive fungi of Hawai'i

Species	Identified by	Location of species	Date collected	Where deposited
Copelandia cyanescens (Berk. et Br.) Sacc.	G. Guzmán E. Gerhardt	O'ahu, Hawai'i	Oct 5, 1987 July 3–24/1987	(XAL) México (BISH) O'ahu
Panaeolus tropicalis Ola'h (Syn. *Copelandia tropicalis*) (Ola'h)! Singer and Weeks	F. Rhoades	Hawai'i	1975	?
Copelandia anomala (Murr.) Sacc. et Trott	F. Rhoades	Hawai'i	1975	?
Copelandia bispora (Malençon et Bertault) Singer and Weeks	G. Guzmán	Livestock Farm, North Shore, O'ahu	Oct 25, 1987?	(XAL) México
Copelandia cambodginiensis (Ola'h et Heim) Singer and Weeks	E. Gerhardt	Kahalu'u O'ahu	July 17–22, 1990	Nestec Ltd.
Panaeolus subbalteatus (Berk. et Br.) Sacc.	G. Guzmán	Livestock Farm, North Shore, O'ahu	Oct 25, 1988	(XAL) México
	Don Hemmis John Allen	Hawai'i Island	Nov 1988	
Amanita muscaria (L.) Hooker	George Wong Don Hemmis	Koke'e, Kaua'i	1989	(NAT. TROP. BOT, GARD.) Kaua'i.
	Steve Montgomery	Palihale, Kaua'i	1992	(BISH) O'ahu

States and elsewhere (Weil, 1977; Ott, 1978). This agaric has been recently found growing in symbiosis with introduced pine tree plantations in the montane region of Kaua'i near Koke'e and Pelihale. All the coprophilous fungi species referred to above contain indole alkaloids; in contrast, *A. muscaria* contains ibotenic acid and muscimol, which have different physiological and mind-altering effects than psilocybin and psilocin (Schultes and Hofmann, 1980).

Both psilocybin and its dephosphorylated derivative psilocin were first detected in *C. cyanescens* by Heim et al. (1966), in *C. tropicalis* and *C. cambodginiensis* by Ola'h (1969, 1970), and in *P. subbalteatus* by Ola'h (1970). Baeocystin, a mono-analogue of psilocybin and psilocin, has also been detected in all 4 of the above mentioned species (Heim et al., 1966; Ola'h, 1970; Repke et al., 1977). Other tryptamines, such as norbaeocystin, *N,N*,dimethyltryptamine, 5-hydroxytryptamine (serotonin), 5-hydroxytryptophan, and other indole related compounds have also been detected in these four species (Hall, 1973; Repke et al., 1977; Stijve, pers. commun.).

Although no recent collections from Hawai'i of *C. anomala* and *C. tropicalis* have been reported in the scientific literature, and according to Weeks et al. (1979), no chemical analysis of *C. anomala* or *C. bispora* (*nomen confusum*) has been performed, the junior author of this paper (J.W.A.) bioassayed *C. bispora* in 1988 and experienced a mild psilocybian intoxication. It should also be noted that *Copelandia* spp. are known to bruise blue when handled. This bluing reaction in fungi is usually an indication of the presence of psilocybin and psilocin (Singer, 1975; Weeks et al., 1979).

2. Methodology

Fungi specimens referred to in this paper were collected from several locations in the Hawaiian Islands. These specimens were sun dried and later

Fig. 8. *Anellaria sepulchralis* (Berk.) Singer (syn. *Panaeolus antillarum*) (Fr.) Dennis *sensu* Dennis. Photo.: Allen. Kualoa, O'ahu.

deposited in 3 institutions listed below. The fungi species referred to in Tables 1-5 were identified by Ewald Gerhardt in Berlin, Germany, and Gastón Guzmán in Xalapa, Mexico. Some of these same species were later analyzed chemically for suspected psychoactive compounds using TLC and HPTLC techniques by T. Stijve in Vevey, Switzerland (Table 1).

3. Results

3.1. Specimens collected for herbarium deposit

Several specimens of Hawaiian fungi (primarily various collections of *Panaeolus* and *Copelandia* spp.) were collected from various locations on O'ahu island; including 2 collections from Maui. The specimens were sun-dried and deposited at the Herbarium Pacificum at the Bernice P. Bishop Museum, Honolulu, Hawai'i (*Burton, 626837, 626836*; *Allen, 616451, 626827, 626828, 626829, 626831, 616832, 626833, 626834, 626835, 626839*). Hawaiian specimens of *Panaeolus* spp. and *Copelandia* spp. deposited in the Bernice P. Bishop Museum previous to this study included collections by Neal (*498521, 498522, 615638*) and Puharich (*146101*).

Additional specimens collected in this study were deposited in the Instituto de Ecologia, Xalapa, Veracruz, Mexico (XAL) and the Institut für Biotechnologie, Leipzig, Germany.

Collected specimens of *A. muscaria* have been deposited at the National Tropical Botanical Gardens at Lawai, Kaua'i and at the Herbarium Pacificum at the Bernice P. Bishop Museum in

Fig. 9. *Anellaria semiovata* (Sow.) Pearson and Dennis (syn. *Panaeolus semiovatus*) (Sow) Lundell et Nannfelt. Photo.: Stijve, Vevey, Switzerland.

Fig. 10. *Panaeolus goossensiae* Beeli. Fruiting in cattle dung; macroscopically similar to *Panaeolus Sphrinctrinus* (Fr.) Quel. Photo.: Allen; Livestock and experimental farm, Kahuku, O'ahu.

Honolulu, Hawai'i (*Montgomery, 594747, 594748, 594749*).

3.2. Species identification

On 14 November 1989, Guzmán identified the following species based on specimens from Hawai'i: *C. cyanescens*, *C. bispora*, *P. subbalteatus*, *P. campanulatus*, and *Psilocybe coprophila*. The specimens were deposited at the Institut de Ecologia, Xalapa, Veracruz, Mexico (Table 3).

The specimens of *C. cyanescens* identified by Guzmán were collected on 25 October 1987 from

Fig. 11. *Psilocybe coprophila* Guzmán. Fruiting in horse dung. Photo.: Allen, Kualoa, Oah'u.

Table 2
Non-psychoactive species collected from O'ahu, Hawai'i

Species	Identified by	Location	Deposited	Chemical analyses
Panaeolus goossensiae Beeli	E. Gerhardt	O'ahu, Hawai'i	Nestec, Ltd.	T. Stijve
Anellaria semiovata (sow.) Pearson and Dennis (Syn. *Panaeolus semiovatus*) (Fr.) Lund. et Nann.	D. Hemmis	Hawai'i	U of H Hilo	?
Anellaria sepulchralis (Berk.) Sing. (Syn. *Panaeolus antillarum*) (Fr.) Dennis	E. Gerhardt	Hawai'i	Nestec, Ltd.	T. Stijve
Panaeolus campanulatus (L.) Quel.	E. Gerhardt	Hawai'i	U of H Hilo	?
Psilocybe coprophila Guzmán	G. Guzmán	O'ahu, Hawai'i	(XAL) México	?

Fig. 12. *Amanita muscaria*. Found on Kaua'i. Photo.: Allen, Astoria, OR.

Table 3
Specimens collected on O'ahu, Hawaii

Collection	Origin	Botanical identification	Identified by	Deposited
Psilocybe A	Kahalu'u O'ahu, Hawai'i 2 Sept. 1987	*Psilocybe coprophila* Guzmán	G. Guzmán	(XAL) Instituto de Ecologia, México
Copelandia B	Livestock Farm, North Shore, 25 Oct. 1987	*Copelandia cyanescens* (Berk. et Br.) Singer	G. Guzmán	(XAL) Instituto de Ecologia, México
Copelandia C	Livestock Farm, North Shore, O'ahu, Hawai'i 25 Oct. 1987	*Copelandia bispora* (Malençon et Bertault) Singer and Weeks	G. Guzmán	(XAL) Instituto de Ecologia, México
Panaeolus D	Livestock Farm, North Shore, O'ahu, Hawai'i 25 Oct. 1988	*Panaeolus subbalteatus* (Berk. et Br.) Sacc.	G. Guzmán	(XAL) Instituto de Ecologia, México

Table 4
Results of chemical analyses of fungi collected on O'ahu Island July 17–24, 1990. Analyses by T. Stijve, Nestec Ltd. (Plate 1–2, Fig. 13–14)

Collection	Origin	Botanical identity	Psilocin	Psilocybin	Tryptophan	Urea	Serotonin	Tryptamin
Copelandia A	Kahal'u, O'ahu 17 July 1990	*Copelandia cambodginiensis*	+	+	N/P	+	+	N/P
Copelandia B	Kahalu'u, O'ahu 22 July 1990	*Copelandia cambodginiensis*	+	+	N/P	+	+	N/P
Copelandia C	Livestock Farm in Olde Jail House, North Shore, O'ahu, 23 July 1990	*Copelandia cyanescens*	+	+	N/P	+	+	N/P
Copelandia D	Kahalu'u, O'ahu 23 July 1990	*Copelandia cyanescens*	+	+	N/P	+	+	N/P
Copelandia E	Kahalu'u, O'ahu Hawai'i, 23 July 1990	*Copelandia cyanescens*	+	+	N/P	+	+	N/P
Copelandia F	Kahalu'u, O'ahu Hawai'i, 23 July 1990	*Copelandia cyanescens*	+	+	N/P	+	+	N/P
Copelandia G	Kahalu'u, O'ahu, Hawai'i, 24 July 1990	*Copelandia cyanescens*	+	+	N/P	+	+	N/P
Copelandia H	Kahalu'u, O'ahu, Hawai'i, 24 July 1990	*Copelandia cyanescens*	+	+	N/P	+	+	N/P
Copelandia I	Kahalu'u, O'ahu, Hawai'i, 24 July 1990	*Copelandia cyanescens*	+	+	N/P	+	+	N/P

Table 5
Analytical results of non-psychoactive dung fungi from O'ahu, Hawaii.

Collected as	Identified as	Identified by	Location	Psilocybin	Psilocin	Tryptamin	Serotonin	Urea	5-OH-Tryptophan
Panaeolus sphrinctrinus (Fr.) Quel.	*Panaeolus goosensiae* Beeli	E. Gerhardt	Livestock Farm, North Shore, O'ahu	N/P[a]	N/P	+	+	+	+
Anellaria semiovata (Sow.) Pearson et Dennis	*Panaeolus semiovatus* (Fr.) Lundell et Nannfelt	D. Hemmis	Mauna Kea, Hawai'i	N/P	N/P	+	+	+	+
Panaeolus subbalteatus (Berk. et Br.) Sacc.	*Panaeolus antillarum* (Fr.) Dennis	CBS, Baarn, Netherlands	Livestock Farm, North Shore, O'ahu	N/P	N/P	+	+	+	+
Panaeolus subbalteatus (Berk. et Br.) Sacc.	*Panaeolus antillarum* (Fr.) Dennis	CBS, Baarn, Netherlands	Livestock Farm, North Shore, O'ahu	N/P	N/P	+	+	+	N/P

[a]N/P indicates not present.
Analysis by T. Stijve, Nestec Ltd. (Plates III-IV, Figs. 15–16).

cattle pastures on a livestock and experimental farm on the North Shore of O'ahu.

Copelandia cyanescens is known from the tropics of both hemispheres. It was originally reported and described from Sri Lanka by Berkeley and Broome in 1871 as *Agaricus cyanescens*. A few years later it was identified from the Philippines as *Copelandia papilionacea* by Bresadola (1881–92).

Copelandia cyanescens, one of 8 binomials published in the genus *Copelandia*, has also been classified as *Panaeolus* (subgenus *Copelandia*) *cyanescens* (Weeks et al., 1979; Allen et al., 1992). According to Guzmán (pers. commun.), *P. cyanescens* and *C. cyanescens* are the same species following 2 different taxonomic positions. Weeks et al. (1979) pointed out that '*Copelandia* has been reduced to an infragentic taxon by some authors who had preferred to include this *Copelandia* in *Panaeolus* (Fr.) Quel. (Ola'h, 1968, 1969, 1970)'. They argued that 'this treatment seemed to have some merit as long as only one species was believed to belong in *Copelandia* and a broader genus concept was thought to be desirable'. Weeks et al. (1979) asserted that this concept is not valid since each *Copelandia* specimen they studied were 'specifically different from one another and all showed the characteristic colored metuloid cystidia and bluing context, without any forms known intermediate between these and *Panaeolus*'. Therefore, in accordance with Horak (1968), Malençon and Bertault (1970), and Singer (1975), Weeks et al. maintained 'that a narrower genetic concept in the Panaeoloideae is warranted' (see Stijve, 1992).

Existing mycological literature describes various species of *Copelandia* from India, Indonesia, Thailand, Cambodia, Philippines, Australia, New Zealand, Samoa, Hawai'i, various areas of North America (including British Columbia, Washington, Oregon, California, and Florida), Jamaica, Mexico, various areas of Central and South America (including Colombia, Bolivia, Brazil, and Peru), Madagascar, France, and Italy (Ola'h, 1968, 1969, 1970; Pollock, 1974, 1976, 1977-1978; Lincoff and Mitchell, 1977; Guzmán, 1978; Weeks et al., 1979; Schultes and Hofmann, 1980; Cox 1981; Allen et al., 1991; Allen and Merlin, 1992).

Copelandia species are common in numerous cattle pastures on O'ahu. For example, species described in this paper were observed in or near various grassland areas of O'ahu including Mokule'ia, Haleiwa, Kahuku, La'ie, Kualoa, Kahalu'u and Kailua.

On Maui, *C. cyanescens* can be observed in many grassland locations throughout the island, e.g., near Pa'ia, Hana, Makawao, Kula, 'Ulupalakua, Ho'okipa and north-west of Wailuku. *Copelandia* fungi have also been observed fruiting from manure in pastures as high as 2000 m on the slopes of Haleakala volcano, East Maui. Another species, *Panaeolus subbalteatus*, is also common in several pastures and wooded areas on the slopes of Haleakala volcano at approximately 3000 feet (approximately 900 m) elevation.

On Hawai'i island, in November of 1988, one of the authors (J.W.A.), along with Don Hemmis, a professor of biology at the University of Hawai'i at Hilo, observed *C. cyanescens*, *P. subbalteatus*, *P. campanulatus*, *A. semiovata*, and *Psilocybe coprophila* at approximately 2000 m on the windward slopes of Mauna Kea volcano. *Copelandia* spp. and *P. subbalteatus* are also known to occur in dung found in the cattle pastures located in the northern region of Hawai'i Island, as well as in the grasslands of cattle ranches in the southern and western areas of that island. Recently, J.W.A. observed *Copelandia* fungi in the Paradise Park residential sub-division of Kea'ua on Hawai'i Island. These fungi were growing at 10–15 m above sea level in areas grazed by horses and cattle, and did not appear to be adversely affected by the salt spray from the ocean nearby.

Pollock (1974, 1976), reported *Copelandia* species from the island of Kaua'i. These fungi also probably occur in pastures on the islands of Moloka'i, Lana'i, and the privately-owned island of Ni'ihau. *Copelandia tropicalis* was originally reported as occurring on the dung of cattle and other wild or domesticated ruminants in Cambodia, the Republic of Central Africa, and Mexico (Pollock, 1976). Ola'h (1969), Rhoades (1975), and Pollock (1976) all reported this species from Hawai'i.

Specimens of *C. bispora* (Malençon et Bertault) Singer and Weeks were collected on 25 October

1987 from pastures of a livestock and experimental farm on the North Shore of O'ahu. They were identified in 1989 by Guzmán (pers. commun.). This species was previously recognized only from North Africa (Malençon et Bertault 1970), and is now reported for the first time from the Hawaiian Islands. *Copelandia anomala* was identified from Hawai'i in 1975 by F. Rhoades (Pollock, 1976).

Panaeolus subbalteatus (Berk. et Br.) Sacc., collected on 5 October 1988 (Isotypus in XAL, Mexico) and 4 November 1992 (Isotypus in BISH, *Allen, 626950*), were found in pastures of the same livestock and experimental farm on the North Shore, O'ahu referred to above. Specimens of this species were also identified by Guzmán.

Panaeolus subbalteatus, infrequently collected with *Copelandia* spp., is sometimes used as a recreational drug in Hawai'i. Although this fungi can be observed in large numbers in some areas on Maui, it is not as common as the *Copelandia* spp. found in many pastures of the Hawaiian Islands.

The geographical distribution of *P. subbalteatus* is cosmopolitan. It has been reported from Australia, Asia, India, North America, Central America, South America, Western Europe, Scandanavia, and Africa (Enos, 1970; Anonymous, 1972; Shepherd and Hall 1973; Pollock, 1976; Weil, 1977, 1980; Miller et al., 1982; Stijve and Kuyper 1985;). *Panaeolus subbalteatus* is not only coprophilous, but is also known to occur in lawns, grassy areas, compost heaps, and in rotted hay which has been left out to decay. It can also be found at horseback riding stables.

Psilocybe coprophila Guzmán was collected from horse manure on 2 September 1987 in cattle pastures near Kahalu'u, O'ahu. This species was identified by Guzmán. It has also been observed on the Hawai'i and Maui Islands.

In February 1991, Gerhardt identified *Panaeolus qoossensiae* Beeli from specimens which were collected in 1989 from a pasture also near Kahalu'u (Isotypus in BISH, *Allen, 626827*).

All of the dung-inhabiting species referred to in this paper were probably introduced into the Hawaiian Islands by cattle (*Bos taurus*) and/or horses (*Equus caballus*), or perhaps by other alien ruminant herbivores. Cattle were first introduced to Hawai'i by the British Captain, George Vancouver in 1793 and 1794; horses were first introduced to Hawai'i in 1803 aboard a merchant ship under the command of Captain William Shaler (Tomich, 1986).

3.3. Specimens collected for chemical analyses

Fungi specimens gathered in the field for chemical analyses included 9 collections of psychoactive mushrooms identified as either *C. cyanescens* or *C. cambodginiensis*. Three other non-psychoactive species belonging to the genus *Panaeolus* were also gathered for chemical analyses. The *Copelandia* collections were labeled A-I, while the *Panaeolus* collections were identified separately. All of these collections were forwarded to T. Stijve of Nestec Ltd., Vevey, Switzerland for chemical analyses (see Table 4 for results of chemical analyses of A-I; see Table 5 for results of chemical analyses of *Panaeolus*).

Species identification of these specimens was made by Ewald Gerhardt of Berlin. Duplicate collections of Hawaiian *Copelandia* spp. were deposited at the Institut für Biotechnologie, Leipzig, Germany. The collections analyzed chemically are described below.

A. Two specimens collected on 17 July 1990 near Kahalu'u, O'ahu were identified by Gerhardt in Berlin as *C. cambodginiensis*.
B. Numerous primordial size specimens collected on 22 July 1990 near Kualoa, O'ahu were identified in 1991 by Gerhardt in Berlin as *C. cambodginiensis*; this species has been reported previously from Cambodia, France, and Africa (Ola'h, 1968, 1969), Colombia (Pollock, 1975, 1976; Ott and Guzmán 1976), and in 1990 from México and Peru by Guzmán (pers. commun.); this is the first report of *C. cambodginiensis* from Hawai'i. Collections A and B differ from *C. cyanescens* (collections C-I) by having smaller spores and thin-walled metuloids; and in collection A the cystidia had a somewhat greenish color, which has an uncertain taxonomical value.

The other collections analyzed chemically, and labeled C-I, are described below. Specimens in

these collections were all identified by Gerhardt as *C. cyanescens*.

C. Fifty specimens were collected on 23 July 1990 in a pasture from a livestock and Experimental Farm on the North Shore of O'ahu (BISH, *Allen, 626839*);
D. Seven specimens were collected on 23 July 1990 in a pasture near Kahalu'u, O'ahu (BISH, *Allen, 626829*);
E. Four specimens with blue-green stained stems were collected on 23 July 1990 in a pasture near Kahalu'u, O'ahu (BISH, *Allen, 626831*);
F. One very large specimen and 7 other larger than average specimens were collected on 23 July 1990 near Kahalu'u, O'ahu;
G. Five specimens were collected on 24 July 1990 near Kahalu'u, O'ahu;
H. Eight specimens were collected on 24 July 1990 near Kahalu'u, O'ahu;
I. Thirteen specimens were collected on 24 July 1990 near the Coral Kingdom on Kahalu'u, O'ahu.

Several additional collections of *Copelandia* spp. and other dung-inhabiting fungi have been deposited in the Herbarium Pacificum at the Bernice P. Bishop Museum, Honolulu, Hawai'i.

3.4. Chemical analyses

Chemical analyses of collections A and B, comprised of specimens of *C. cambodginiensis*, revealed a higher percentage of psilocybin than collections C-I, comprised of specimens of *C. cyanescens*. This indicates that *C. cambodginiensis* may be a more potent psychoactive species than *C. cyanescens* or other *Copelandia* spp. Figs. 13 and 14 show the TLC analyses of collections A-I in the nano-cellulose/BAW system, using pDMCA as a chromogenic reagent, but Fig. 13 was taken a few minutes after spraying, and Fig. 14 a few hours later. The results of the analysis of *P. cambodginiensis* are presented in Table 6. The analytical results of *Panaeolus goosensiae* presented in Table 7 were obtained by TLC in the Nano-SiO^2/BAW system, using pDMCA-spray.

An unknown derivative (tryptamine?) commonly found in several TLC analysis of suspected psychoactive fungi was also present (but unquantified) in the *P. goossensiae* specimens analyzed in this study.

Figs. 15 and 16 show the analytical results of

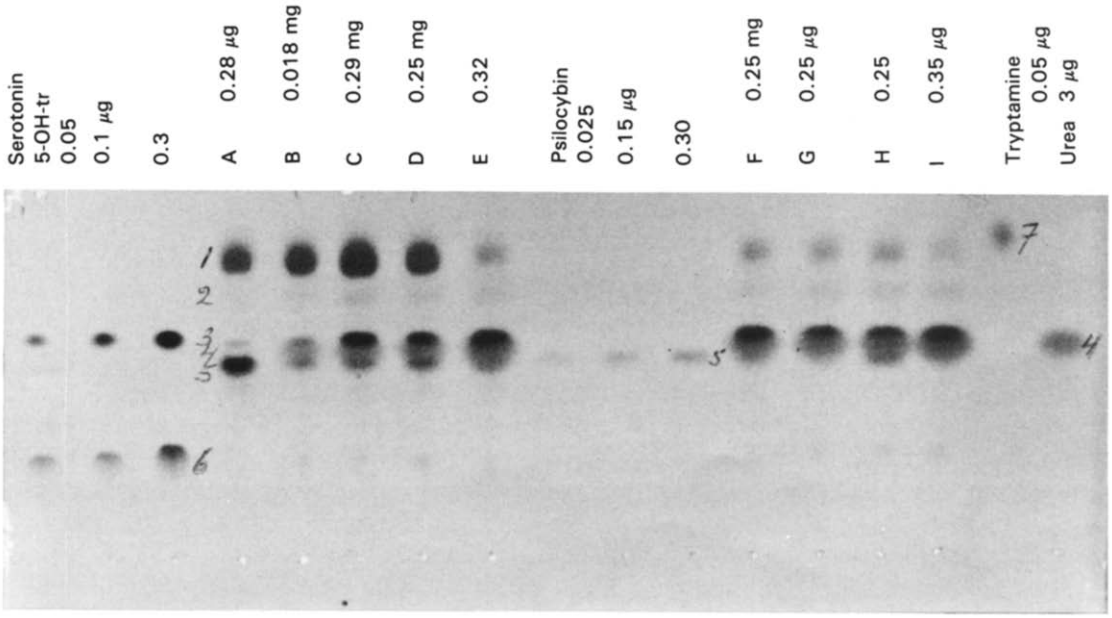

Fig. 13. TLC analysis of *Copelandia* collections A-I. Notice that all of the tryptamines can be seen clearly. 1, psilocin; 2, oxidation; 3, serotonin; 4, urea; 5, psilocybin; 6, 5-OH-tryptophan (absent); 7, tryptamine (absent).

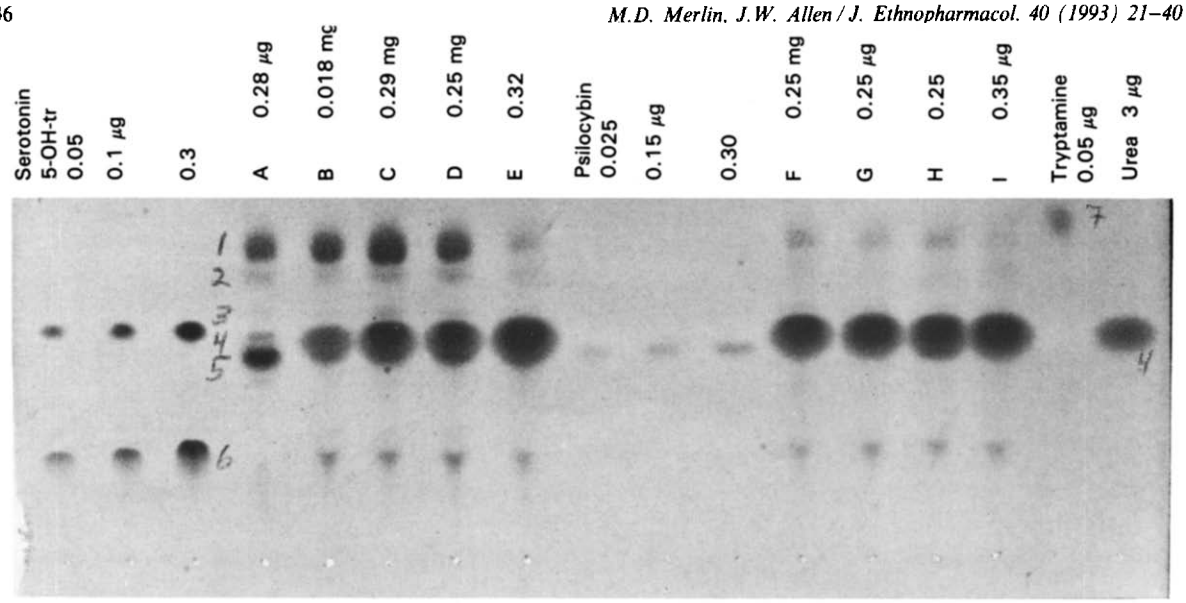

Fig. 14. TLC analysis of *Copelandia* collections A-I. Taken a few hours after plate I. Observe that all the tryptamines have become fairly obscure when the urea has reached its maximun intensity. 1, psilocin; 2, oxidation; 3, serotonin; 4, urea; 5, psilocybin; 6, 5-OH-tryptophan (absent); 7, tryptamine (absent).

Anellaria sepulchralis (syn. *Panaeolus antillarum*) performed by TLC. Fig. 15 shows the TLC analysis in the same nano-cellulose/BAW-pDMCA system. Fig. 16 was performed by TLC, nano/SiO^2/BAW. (See Table 5 for analytical results of Figs. 15 and 16.)

Three collections of *Copelandia* species from different locations (O'ahu, Hawai'i, 1989 and 1990; Australia, 1989; and Thailand, 1990) were sent to Dr. T. Stijve of Nestec Ltd., Vevey, Switzerland for chemical analyses. Stijve forwarded carpophores of the collections to Dr. Ewald Gerhardt of the Botanische Museum in Berlin for botanical identification. Gerhardt identified all three collections as *Panaeolus cyanescens* (Bk. and Br.) Sacc. (syn. *Copelandia cyanescens* (Bk. and Br.) Sing). Subsequent chemical analyses by Stijve (1992) in the TLC cellulose/BAW system revealed that the collections from Australia and Thailand were virtually devoid of psilocybin. On the other hand, the Hawaiian collections contained considerable amounts of psilocybin.

Clinical research involving human subjects who bioassayed Hawaiian specimens from the above

Table 6
Results of analysis of *Panaeolus cambodginiensis* Ola'h

	A	B
Psilocin	0.5–0.6%	0.3–0.5%
Psilocybin	0.55%	0.13%
Baeocystin	0.02%	<0.005%
Tryptophan	<0.005%	0.008%
Tryptamine	<0.005%	0.005%
Urea	0.1%	0.56%

(All values above are in percentage of dry matter.)
Collection A: 17 July 1990, Kahalu'u, O'ahu; two mature specimens.
Collection B: 22 July 1990, Kahalu'u, O'ahu; numerous primordial size specimens.

Table 7
Results of analysis of *Panaeolus goosensiae* Ola'h

Psilocin/psilocybin	<0.01%
5-OH-Tryptophan	<0.005%
Urea	0.6%
Serotonin	0.01%

(All values above are in percentage of dry matter.)
Collected October 1989, Kahalu'u, O'ahu

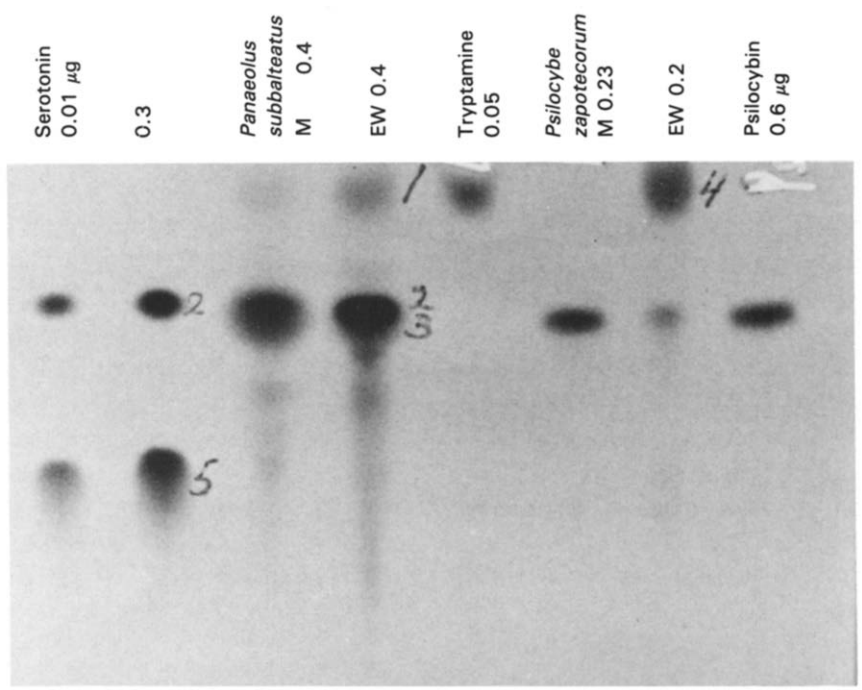

Fig. 15. TLC analytical results of *A. sepulchralis* (syn. *P. antillarum*). M, methanol extract; EW, ethanol water extract. 1, tryptamine; 2, serotonin; 3, urea; 4, psilocin extract in *Psilocybe zapotecorum* Heim; 5, 5-OH-tryptophan.

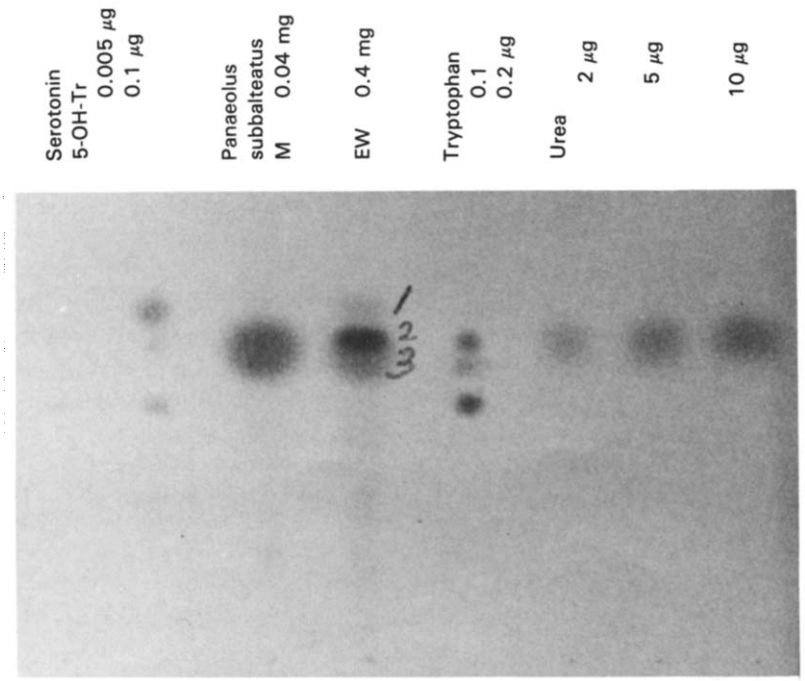

Fig. 16. TLC analytical results of *A. sepulchralis* (syn. *P. antillarum*). M, methanol extract; EW, ethanol water extract. 1, tryptophan; 2, serotonin; 3, urea.

mentioned collections indicated that the fungi consumed in the experiment produced a greater psychoactive effect than a similar dry weight dosage of *Psilocybe semilanceata* (Fr.: Secr.) Kumm. According to Stijve, 'four volunteers reported that [the ingestion of] 1 g of powdered pooled Hawaiian carpophores (contain[ing] 0.6% psilocin and 0.2 percent psilocybin) produced a most powerful psychotropic effect'. Stijve also noted that 'no disagreeable side effects were reported by the four volunteers'.

4. Discussion and conclusions

While illicit use of psychoactive dung fungi is widespread throughout the populated high islands of the Hawaiian archipelago, relatively few serious social or medical problems have been reported regarding the consumption of these mushrooms in non-traditional settings (see Allen and Merlin, 1989). However, the illegal aspects of their use notwithstanding, it should be noted that, occasionally, some individuals experience adverse psychological reactions, especially those who have a problematic mental set or are in unfavorable environmental settings (see Allen et al., 1991 for a comparative review of illicit psilocybian mushroom use in Australia and New Zealand). Amateur mushroom foragers, especially those in search of psychoactive fungi, have rarely acquired any knowledge of the scientific names of those species which they often haphazardly ingest for mind-altering purposes. Most collectors of psychoactive fungi create original epithets or utilize others which are already in use. In Hawai'i, the same epithet may be used to refer to all of the psychoactive fungi species which are collected for illicit consumption. Worldwide, the most common epithets in use appear to be "magic mushrooms" and "shrooms".

Recreational users of psychoactive mushrooms in Australia, New Zealand, and the Pacific northwest United States often refer to their favorite species by commonly known epithets (Allen et al., 1991). Among the English speaking people who ingest these fungi, the most common nicknames are "magic mushrooms" and "shrooms"; however, in Australia, *C. cyanescens* is often referred to as "blue meanies" whereas, in Hawaii, all *Copelandia* spp. are commonly referred to as "gold caps" or "golden tops". On the other hand, in Mexico, south-eastern areas of the United States, and some regions of Australia, these latter two epithets usually refer to the macroscopic coloration of the pileus of *Psilocybe cubensis*. On the island of Hawai'i, *C. cyanescens* has been referred to as "cone heads" (Stapleton, 1981). Furthermore, a mushroom identification guide published on the mainland, identifies small specimens of the genus *Copelandia* by the common epithet "dimple tops" (Stevens and Gee, 1977).

It should be noted that numerous informants have reported the occurrence of *Psilocybe cubensis* (Earle) Singer in grazing areas on the islands of Hawai'i and Kaua'i. Although *P. cubensis* is a very widely recognized, mind-altering coprophilous fungus (Badham, 1984; Allen et al., 1991), there is no botanical verification that this species is naturalized in Hawai'i. While *P. cubensis* may not reproduce on its own, in some areas of the Hawaiian Islands it is reportedly grown in vitro and most likely has been sold on the illicit market. For example, an entrepreneur, who advertizes licit mushroom growing kits from the mainland U.S., informed one of the authors of this paper (J.W.A.) that his company sells from 5 to 10 complete *P. cubensis* growing kits each month to residents of Hawai'i.

It should also be noted that another spore entrepreneur ('Sun Magic' company) in Seattle, WA, advertises spores and growing kits for 'Hawaiian' strains of psychoactive fungi referred to as 'Hawaiian Cyan' and '*Psilocybe cubensis*'. The fungi kits with the so-called 'Hawaiian Cyan' probably contain spores of *C. cyanescens*. As noted previously, *P. cubensis* probably does not occur in Hawai'i, except clandestinely under artificial conditions.

While the authors of this present paper refer to these dung fungi as being psychoactive rather than entheogenic (see Ruck et al., 1979), we would like to clarify the ethnomycological associations of these modifying terms for the reader. We use the word psychoactive in reference to psilocybian fungi and/or other drug plants used in non-traditional settings for mind altering purposes.

The term entheogenic generally refers to sacred drug plants consumed traditionally to experience a spiritual state of consciousness.

Although this study demonstrates that several psychoactive fungi species occur naturally in Hawai'i, and that most of these species are known to be ingested illicitly for recreational purposes, we believe that further research should be conducted in the Hawaiian Islands regarding the distribution and use of such fungi in these islands. Surveys of such illicit fungi use in non-traditional settings should be also undertaken; and the results of the statistical analysis concerning ingestion should be presented for scrutiny by both the public and scientific community.

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6. References

Allen, J.W. (1988) A private inquiry into the circumstances surrounding the 1972 death of John Gomilla Jr., who died after allegedly consuming ten magic mushrooms while residing in Hawaii. *Journal of Psychoactive Drugs* 20(4), 456–459.

Allen, J.W. and Merlin, M.D. (1989) *Copelandia* and other psychoactive fungi in Hawai'i. *Newsletter of the Hawaiian Botanical Society* 28(2), 27–31.

Allen, J.W. and Merlin, M.D. (1992) Psychoactive fungi use in Koh Samui and Koh Pha-ngan, Thailand. *Journal of Ethnopharmacology* 35(3), 205–228.

Allen, J.W., Merlin, M.D. and Jansen, K.L.R. (1991) An ethnomycological review of psychoactive agarics in Australia and New Zealand. *Journal of Psychoactive Drugs* 23(1), 39–69.

Allen, J.W., Gartz, J. and Guzmán, G. (1992) Index to the botanical identification and chemical analysis of the known species of the hallucinogenic fungi. *Integration: the Journal of Psychoactive Plants and Culture* 2-3, 91–97.

Anonymous (1972) Magic mushrooms of British Columbia. *British Columbia Access* 3rd Catalogue: 58–67.

Badham, E.R. (1984) Ethnobotany of psilocybin mushrooms, especially *Psilocybe cubensis*. *Journal of Ethnopharmacology* 10, 249–254.

Bresadola, G. (1881-92) *Fungi Tridentini novi vel nondum delineati descripti et iconibus illustrati*. Trento.

Cox, P.A. (1981) Use of an hallucinogenic mushroom in Samoa. *Journal of Ethnopharmacology* 4(1), 115–116.

Enos, L. (1970) *Key to the North American Psilocybe*. Youniverse, Lemon Grove, CA.

Guzmán, G. (1978) Nuevos hongos (Agaricales) de la zona tropical de México. *Boletin de la Sociedad Mexicana de Micologia*. 12, 27–31.

Hall, M.C. (1973) Problems in legislating against abuse of hallucinogenic fungi in Australia. *Bulletin on Narcotics* 25, 27–36.

Heim, R., Hofmann, A. and Tscherter, H. (1966) Sur une intoxication collective a syndrome psilocybien causee en France par un *Copelandia*. *Comptes Rendus de l'Academie des Sciences* 262, 519–523.

Horak, E. (1968) Sinopsis generum agaricalium. *Beitraege zur Kryptogamenflora der Schweiz* 13, 1.

Lincoff, G. and Mitchell, D.H. (1977) *Toxic and Hallucinoqenic Mushroom Poisoning*. Van Nostrand Reinhold, New York.

Malençon, G. and Bertault, R. (1970) *Flore des Champignons Superieurs du Maroc*. Rabat, Paris, pp. 301–304.

Miller, O.K., Laursen, G. and Farr, D.F. (1982) Notes on *Agaricales* from Arctic Tundra in Alaska: *Panaeolus subbalteatus*. *Mycologia* 74(4), 576–591 (see pp. 578–588).

Ola'h. G.-M. (1968) Etude chimiotaxinomique sur les *Panaeolus*, recherches sur la presence des corps indoliques psychotropes dans ces champignons. *Comptes Rendus de l'Academie des Sciences* 267, 1369–1372.

Ola'h, G.-M. (1969) A taxonomic and physiological study of the genus *Panaeolus* with the latin description of the new species. *Revue de Mycologie* 33(4), 284–290.

Ola'h, G.-M. (1970) Le Genre *Panaeolus*: essai taxinomique et physiologique. *Revue de Mycologie Ser. 10. Musee National d'Histoire Naturelle Paris*. 274 pp.

Ott, J. (1978) Recreational use of hallucinogenic fungi in the United States. In: B.Rumack and E. Saltzman (Eds.), *Mushroom Poisoning: Diagnosis and Treatment*. CPR Press. Cleveland.

Ott, J. and Guzmán, G. (1976) Detection of psilocybin in *Psilocybe*, *Panaeolus*, and *Psathyrella*. *Lloydia* 39(4), 258–260.

Pollock, S.H. (1974) A novel experience with *Panaeolus*: a case study from Hawaii. *Journal of Psychedelic Drugs* 6(1), 85–89.

Pollock, S.H. (1975) The psilocybin mushroom pandemic. *Journal of Psychedelic Drugs* 7(1), 73–84.

Pollock, S.H. (1976) Psilocybin mycetisms with special reference to *Panaeolus*. *Journal of Psychedelic Drugs* 8(1), 43–57.

Pollock, S.H. (1977-1978) Psychotropic mushrooms and the alteration of consciousness I: the ascent of psilocybian consciousness. *Journal of Altered States of Consciousness* 3 (1), 15–35.

Repke, D.B., Leslie, D.B. and Guzmán, G. (1977) Baeocystin in *Conocybe*, *Psilocybe* and *Panaeolus*. *Lloydia* 40(6), 566–578.

Rhoades, F. (1975) Personal Communication to Steven H. Pollock. Cited in: *Journal of Psychedelic Drugs* 8(1), 43–57.

Ruck, Carl A.P., Bigwood, J., Staples, D., Ott, J. and R. Gordon Wasson. (1979) Entheogens. *Journal of Psychedelic Drugs* 11(1-2), 145–146.

Schultes, R.E. and Hofmann, A. (1980) *Botany and Chemistry of the Hallucinogens*. Charles C. Thomas, Springfield, IL. 2nd Edition.

Shepherd, C.J. and Hall, M.C. (1973) Australian hallucinogenic fungi-taxonomic, pharmacological and legal aspects. *Anzaas*. Paper read to the Australian and New Zealand Association for the Advancement of Science, Section 11:5 pp. Mimeographed.

Singer, R. (1975) *The Agaricales in Modern Taxonomy*. Cramer, Lehre, Germany.

Southcott, R.V. (1974) Notes on some poisonings and other clinical effects following the ingestion of Australian fungi. *South Australian Clinics* 6(5), 441–478.

Stapleton, F. (1981) The other side of magic mushrooms. *Hawaiian Tribune-Herald* Vol. 68, pp. 1 and 16. Sunday, 22 March.

Stevens, J. and Gee, R. (1977) *How To Grow and Identify Psilocybin Mushrooms*. Sun Magic, Seattle.

Stijve, T. (1987) Verkommen von Serotonin, psilocybin und Harnstoffe in *Panaeoloideae*. *Beiträge zur Kenntnis der Pilze Mitteleuropas* III, 229–234.

Stijve, T. (1992) Psilocin, psilocybin, serotonin and urea in *Panaeolus cyanescens* from various origin. *Persoonia* 15(1), 117–121.

Stijve, T. and Kuyper, Th.W. (1985) Psilocybin in various higher fungi from several European countries. *Planta Medica* 51(5), 385–387.

Tomich, P.Q. (1986) *Mammals in Hawai'i: a synopsis and notational bibliography*, 2nd edn. B.P. Bishop Museum Special Publication 76. Bishop Museum Press, Honolulu.

Wasson, R.G. (1968) *Soma: Divine Mushroom of Immortality*. Harcourt Brace and World, New York.

Weeks, R.A., Singer, R. and Hearns, W.L. (1979) A new species of *Copelandia*. *Journal of Natural Products (Lloydia)* 42(5), 469–474.

Weil, A. (1977) The use of psychoactive mushrooms in the Pacific Northwest: An ethnopharmacological report. *Botanical Museum Leaflets of Harvard* 25(5), 131–148.

Weil, A. (1980) Mushrooms I, II, III. *Marriage of the Sun and Moon*. Houghton Mifflin, Boston.