Six Genera of Physaraceae (Myxomycetes) in Taiwan

Chin-Hui Liu(1) and Jong-How Chang(1)

1. Institute of Plant Science, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 106, Taiwan.
* Corresponding author: Email: hlhl4931@ntu.edu.tw

(Manuscript received 12 March 2011; accepted 9 April 2012)

ABSTRACT: Species of six genera Badhamia, Craterium, Fuligo, Leocarpus, Physarella, and Willkommlangea (Physaraceae) reported from Taiwan are critically revised. Two new records, Craterium concinnum and Leocarpus fragilis and an unknown species of Craterium are described and illustrated in this paper. Keys to the species of Badhamia, Craterium, and Fuligo, and a key to the genera of Physaraceae from Taiwan are also provided.

KEY WORDS: Myxomycetes, Physaraceae, Taiwan, taxonomy.

INTRODUCTION

The fruiting bodies of all members in Physaraceae are often limy, with non-crystalline lime granules and dark-colored spore mass. Their capillitia are typically composed of calcareous nodes connected by slender and hyaline threads (physaroid), or of calcareous tubes and thickened nodes (badhamioid). In Taiwan, 7 genera out of the 10 world records are known. The distinct characteristics separating the genera from each other are shown in the key to the genera provided. In this paper we compile data of six genera: Badhamia, Craterium, Fuligo, Leocarpus, Physarella, and Willkommlangea, leaving the largest genus Physarum to a separate paper. Characteristic examination for the fruiting bodies of these specimens were made by light and scanning electron microscopy as described previously (Liu et al., 2002a).

TAXONOMIC TREATMENTS

Key to genera of Physaraceae in Taiwan

1. Capillitium of two morphologically distinct systems ........... 2
2. Fruiting body plasmodiocarpous, peridium opaque, encrusted with red spots and white lime granules on the surface ......................................................... Willkommlangea
2. Fruiting body sporangiate, if plasmodiocarpous, then usually accompanied by sporangia ......................................................... 3
3. Sporangia ovate; outer peridium yellowish brown, cartilaginous, smooth, shining; capillitium a limy network, connected with and interpenetrating a limy net of flattened tubules .......... Leocarpus
3. Sporangia cylindrical, deeply perforated from above, appearing as a hollow cup, rarely plasmodiocarpous; peridium rough; capillitium composed of stout calcareous spines and a net work of slender threads bearing a few calcareous nodes ........................................ Physarella
4. Capillitium a network of calcareous tubes of nearly uniform diameter; limy connecting tubules few or none ................................................................. Badhamia
4. Capillitium a network of limeless tubes with connected calcareous nodes at many or all the junctions ........................................ 5
5. Fruiting body an aethalium; pseudocapillitium present .... Fuligo
5. Fruiting body sporangiate or plasmodiocarpous, rarely approaching aethaloid; pseudocapillitium lacking ........................................... 6
6. Fruiting body plasmodiocarpous, cylindrical, pendent, often anastomosing to form a 3-dimensional network, ......................................................... Fuligo aurea (= Erionema)
6. Fruiting body sporangiate or plasmodiocarpous, rarely pendent; never forming a 3-dimensional network in the plasmodiocarpous fruiting body ......................................................... 7
7. Sporangiate or plasmodiocarpous, rarely somewhat aethaloid; dehiscence irregular or lobate, never circumscissile; the lower portion of peridium persisting as at most as a shallow or irregular cup ................................................. Physarum
7. Sporangiate or plasmodiocarpous, rarely somewhat aethaloid; dehiscence often circumscissile or by a preformed lid, the lower portion always persisting as a deep cup ......................................................... Craterium

Key to species of Badhamia in Taiwan

1. Spores in clusters; peridium double; sporangia usually yellow, greenish yellow, or dull yellow, rarely iridescent ........ B. nitens
1. Spores free; peridium single; sporangia white, grayish or pale gray ......................................................... 2
2. Usually stalked ................................................................. 3
2. Usually sessile or shortly stipitate ........................................... 4
3. Spores angular in profile, with large reticulum, 1–6 in a hemisphere on the surface; stalk pale straw-colored, weak ........ B. gracilis
3. Spores not angular in profile, without large reticulum on the surface; stalk white, limy throughout ....................... B. formosana
4. Spores minutely punctate, usually ovoid; stalk, if present, red ........................................................................ B. panicea
4. Spores densely spinulose or warty, usually globose; stalk, when present, yellowish brown or nearly black ....................... 5
5. Capillitium radiating from the base to the periphery of sporangia; stalk, when present, dark, nearly black ................. B. affinis
5. Capillitium reticulate; stalk, when present, yellowish or brown, only dark at the base ......................................... B. macrocarpa

Badhamia affinis Rostaf., Sluzowce monogr. 143. 1874.

It was reported as a new record without any description and illustration (Wang et al., 1981).
As pointed out in the reference (Nennenga-Bremekamp, 1991), it is difficult to distinguish this species from B. macrocarpa. The capillitium is radiated from the base of the sporangium in B. affinis, not reticulate as that in B. macrocarpa, and is rarely branched and not or hardly interconnected.


Description and illustration: Liu et al. (2002b).


Description and illustration: Liu (1990).

**Badhamia macrocarpa** (Ces.) Rostaf., Sluzowce monogr. 143. 1874.

It was reported in a list by Nakazawa (1929), but no specimen was deposited in Taiwan.


It was reported in a list by Nakazawa (1929), but no specimen was deposited in Taiwan.

**Badhamia panicera** (Fr.) Rostaf., in Fuckel, Jahrb. Nassauischen Vereins Naturk. 27-28: 71. 1873

It was reported as a new record without any description and illustration by Wang et al. (1981). A species very close to B. macrocarpa, but it has smoother and usually ovoid spores (Nennenga-Bremekamp, 1991).

**Key to species of Craterium in Taiwan**

1. Fructification sessile or rarely short-stalked .................................................. 2
2. Fructification stalked ................................................................. C. reticulatum
3. Sporangia reddish brown ......................................................... C. leucocephalum var. sessile
4. Sporangia not bright yellow (if globose, then white or grayish white), obconical or deep cup-like, with a preformed lid of dehiscence .................................................. 4
5. Sporangia bright yellow .......................................................... 5
6. Sporangia turbinate or funnel-shaped, brownish, peridium double, thick .................................................. 5
7. Sporangia deep cup-like or globose, white, grayish; peridium single .................................................. C. leucocephalum
8. Lime nodes small, ochraceous or brownish .......... C. concinnum
9. Lime nodes large, white ......................................................... C. minutum
10. Sporangia oboviod or turbinate, lime node yellow, dehiscence often irregular from the top .................................................. C. aurum
11. Sporangia globose or prolate, lime node white, dehiscence petaloid at the upper part .................................................. Craterium sp.,

**Craterium aureum** (Schumach.) Rostaf., Sluzowce monogr. 124. 1874.


It was reported as a new record without any description and illustration (Wang et al., 1981). There are some differences in our specimens from the typical C. aureum. The pseudocolumella is not observed and our spores are smaller (7.0-8.5 μm), which are 8-10 μm in diameter in the references (Martin and Alexopoulos, 1969; Nennenga-Bremekamp, 1991).


Fructification sporangiate, loosely gregarious, (0.15-) 0.38-0.68 mm in total height. Sporangia obovate or goblet-shaped, pale reddish brown to brown, stipitate, 0.12-0.38 mm in diameter, with a paler and convex operculum. Peridium double, the outer layer cartilaginous, thick, closely attached to the membranous inner layer; dehiscent along the rim of the lid as a whole. Stalk about half the total height or often a little shorter, brownish, furrowed. Capillitium abundant, consisted of small, rounded or angular, brownish lime nodes connected by short and transparent threads. Spores nearly black in mass, dusky brown by transmitted light, globose, 8.5-10.5 μm in diameter, minutely and densely warted.

Specimen examined: TAIWAN, Taipei City: Peitou, Yangmingshan National Park, on decayed twigs and leaves, Y.F. Chen504, Aug. 7, 1995.

Distinguished by its small fruiting bodies, the pale and convex operculum, and the small and brownish lime nodes, which separate it from C. minutum. In C. minutum the operculum is often sunken, the lime nodes are white and larger.


**Craterium leucocephalum** var. scyphoides (Cooke & Balf.) G. Lister, in List, Mycet. ed. 2. 97. 1911.

Description and illustration: Shi (1981).

Specimens examined: TAIWAN, Taipei City: main campus of National Taiwan Univ., on straw, CHL B357, Apr. 3, 1984; Peitou, Yangmingshan National Park, on twigs, CHL B2246, Nov. 30, 2000.

This is a common, distinctive species and easy to be recognized in the field by a hand lens. The distinctive character is the stalked, cylindrical, white sporangium with an operculum-like apex.
Fig. 1. A-H. Craterium concinnum. A-B: Fruiting bodies. C: One fruiting body, by SEM. D: Capillitial threads and lime nodes, by SEM. E: Surface markings of spore, by SEM. F: Surface view of spores. G: Marginal view of spores. H: Capillitial threads and lime nodes. I-M. Craterium sp. I-J: Fruiting bodies. K: Limeless basal part of peridium. L: Marginal view of spores. M: Surface markings of spore, by SEM. Scale bar: A = 130 μm; B, J = 320 μm; C = 91 μm; D = 3.8 μm; E = 0.95 μm; F, G, L = 5 μm; H = 25 μm; I = 210 μm; K = 70 μm; M = 0.84 μm.

Description and illustration: Liu et al. (2001).

**Craterium minutum** (Leers) Fr., *Syst. Mycol.* 3: 151. 1829.

Description and illustration: Chung and Liu (1997b).


This species is characterized by the deep, brownish cup, the cartilaginous outer peridium, and the lid which is often sunken or at least depressed at the margins. Specimen CHL B777 is a collection with larger and stalked sporangia (0.5-0.9 mm in diameter, 1.0-1.27 mm in total height) containing large spores of 10-11 μm in diameter.


Description and illustration: Chung and Liu (1997b).

Specimen examined: TAIWAN, Hualien County: Kuanyuan Forest Recreation Area, on plant debris, CHL B777, Jan. 7, 1988.

This species is characterized by the deep, brownish cup, the cartilaginous outer peridium, and the lid which is often sunken or at least depressed at the margins. Specimen CHL B777 is a collection with larger and stalked sporangia (0.5-0.9 mm in diameter, 1.0-1.27 mm in total height) containing large spores of 10-11 μm in diameter.

**Craterium leucocephalum var. rufum** G. Lister, *A monograph of the Mycetozoa* 3 ed. 78. 1925.


Description and illustration: Chung and Liu (1997b).


This species is characterized by the deep, brownish cup, the cartilaginous outer peridium, and the lid which is often sunken or at least depressed at the margins. Specimen CHL B777 is a collection with larger and stalked sporangia (0.5-0.9 mm in diameter, 1.0-1.27 mm in total height) containing large spores of 10-11 μm in diameter.

**Craterium sp.**

Fructification sporangiate, stipitate, gregarious, erect, or nodding in some, 0.9-1.0 mm in total height. Sporangium globose or prolate, 0.4-0.5 mm in diameter. Peridium membranous, the upper two-third deposited with bright yellow lime granules, the remaining part thickened, translucent, smooth, limeless, brown to pale brownish yellow under transmitted light, dehiscent lobately or irregularly from the top to about one third of the sporangium, below persistent as a deep cup. Stalk erect or curved in few, pale brownish yellow, wrinkled, limeless, about 1/2-2/3 times of total height in length. Hypothallus membranous, pale brownish yellow. Columella lacking. Capillitium dense, netted, lime nodes white, angular, abundant, capillitial threads hyaline, tubular. Spores dark brown in mass, brown under transmitted light, minutely warted, globose or subglobose, 8.5-11.5 (-13.5) μm in diameter. Plasmodium yellow.


The distinct characters are the prolate or globose sporangia, the membranous peridium covered by bright yellow lime granules on the upper two-third portion of the sporangium, and the petaloid dehiscence at the upper part, the remaining persistent as a deep cup which is a distinct feature of the genus *Craterium*. The above combined characters are not identical with any known species of *Craterium*.

**Key to species of *Fuligo* in Taiwan**

1. Fructification plasmodiocarpous, cylindric, pendent, often anastomosing to form a 3-dimensional net …………………. *F. aurea* 1. Fructification aethaloid ………………………………………2

2. Aethalium usually yellow, sometimes violet or white; spores 6-9 μm in diameter, lime nodes small, fusiform …………………. *F. septica* 2. Spores usually exceeding 10 μm in diameter; lime nodes large, angular or irregular in shape ………………………………………3

3. Cortex thick, lime nodes connected by hyaline threads; spores spinulose, spines usually connected by narrow ridges into a broken reticulum ………………………………………. *F. cinea* 3. Cortex thin, sometimes lacking; capillitium badhamioid, with a few hyaline threads; spores minutely warted …………………. *F. intermedia*

**Fuligo aurea** (Penzig) Y. Yamam., *Myxomycete Biota Japan* 390. 1998. *Figs. 2A-G*

**Erionema aureum** Penz., *Myxomyc. Fl. Buitenzorg* 37. 1898.

Fructification plasmodiocarpous, pendent, on the surface of substrate, composed of many tubular plasmodi carpors, each tube with one end adhering to the hypothallus, intertwined to form a 3-dimensional net, up to more than 5 cm in total length, more than 1.5 cm in total width. Plasmodi carpors bright yellow or greenish yellow, tubular, 0.22-0.32 mm in diameter, sometimes dichotomously branched. Peridium membranous, covered with a thick layer of yellow lime granules, usually forming a long crusted tail at the free end of the plasmodi carp. Hypothallus crust-like, yellowish or bright yellow. Capillitium netted, strongly elastic, the threads colorless, with few small, yellow, fusiform lime nodes. Spores dark brown in mass, brown under transmitted light, globose, subglobose, 6.5-8 (-10.5) μm in diameter, minutely warted, with clustered warts.

Fig. 2. A-G. *Fuligo aurea*. A & E: Fruiting bodies. B: Surface view of spores. C: Capillitial threads and lime node. D: Capillitium. F: Marginal view of spores. G: Surface markings of a spore, by SEM. H-J. *Willkommlangea reticulata*. H: Fruiting bodies. I: Dehiscent fruiting body. J: Spores. Scale bar: A = 320 μm; B, F = 4 μm; C = 10 μm; D = 210 μm; E = 0.77 mm; G = 1 μm; H = 1 mm; I = 350 μm; J = 5 μm.
The pendent tubular plasmodiocarps and the strongly elastic capillitium are the characteristics separating this species from other Fuligo species.

It was named under the genus Erionema as E. aureum. The three dimensional network of fruiting bodies resembles the small aethalia of Fuligo septica without a cortex, and it was then transferred to the genus Fuligo (Yamamoto, 1998).


Description and illustration: Chung and Liu (1997a).

**Fuligo intermedia** T. Macbr., N. Amer. Slime-Moulds ed. 2. 30. 1922.

It was reported in a list by Nakazawa (1929), but no specimen was deposited in Taiwan.

**Fuligo septica** (L.) F. H. Wigg., Prim. Fl. Holsat. 112. 1780.


Fuligo candida, F. septica var. flava, and F. septica var. rosea, previously reported from Taiwan (Chen et al., 2005) are distinguished from F. septica by colors of aethalia or lime nodes, but those varieties do not have other characteristics to separate them from the type var. septica. According to Martin and Alexopoulos (1969), the three should be confined in the synonyms under F. septica.

**Leocarpus fragilis** (Dickson) Rostaf., Sluzowce monogr. 132. 1874.

Fructification sporangiate, crowded in clusters, 1.2-1.6 mm in total height. Sporangia shortly stipitate or sessile, ovoid to subglobose, 0.8-1.2 mm in diameter, yellowish brown. Peridium triple, the outer cartilaginous, smooth, shining, the middle thick and calcareous, the inner membranous, hyaline. Stalk weak, whitish or pale ochraceous. Hypothallus prominent, pale yellow, wrinkled. Capillitium reticulate, duplex, composed of a network of rigid, calcareous nodes (badhamioid), particularly toward the outside, connected with a network of slender, colorless tubules. Spores blackish brown in mass, brown by transmitted light, minutely warted, 10-13 (-15) μm in diameter. Plasmodium not observed.

Specimens examined: TAIWAN, Hualien County: Kuanyuan Forest Recreation Area, on fallen twig, CHL B398, CHL B399, Nov. 14, 1994.

It is a very distinctive species. The crowded and often clustered sporangia, the fragile, smooth and shining outer peridium, and the rigid, limy capillitium are the distinctive characters of this species.


Description and illustration: Liu (1980).


Cienkowskia reticulata (Alb. & Schwein.) Rostaf., Sluzowce monogr. 91. 1874.


The duplex capillitium is very conspicuous after the capillitium ruptured. This species is distinctive on the net-like plasmodiocarp, the limy peridium, and the scattered red spots on the peridium. It was first recorded (as Cienkowskia reticulata) from Taiwan in a list by Nakazawa (1929), and the species description here is based on the examination of the specimen CHL M336 (Liu, 1982).

**LITERATURE CITED**


Fig. 3. A-H. *Leocarpus fragilis*. A-B: Fruiting bodies. C: Capillitium. D: Badhamioid network of capillitium, by SEM. E: Spores. F: Peridium of 3-layered, with spores and capillitium on the inside, by SEM. G: Broken sporangium, by SEM. H: Surface markings of one spore, by SEM. I-K. *Physarella oblonga*. I-J: Fruiting bodies. K: Surface markings of spores, by SEM. Scale bar: A = 0.53 mm; B = 0.77 mm; C = 40 μm; D = 29 μm; E = 9 μm; F = 19 μm; G = 265 μm; H = 1.4 μm; I = 1.8 mm; J = 0.9 mm; K = 1.1 μm.
Myxomycetes of Taiwan XIV. Three new records of Trichiales. Taiwania 47: 97-105.
Myxomycetes of Taiwan XVI. One new species and one new record of Physaraceae. Taiwania 47: 290-297.

台灣產絨泡黏菌科的六個屬
劉錦惠(1*)、張仲豪(1)

1. 國立台灣大學生命科學院植物科學研究所，臺北市羅斯福路四段一號，台灣。
* 通信作者。Email: huil4951@ntu.edu.tw

(收稿日期：2012年3月12日；接受日期：2012年4月9日)

摘要：本文重新整理台灣產絨泡黏菌科的六個黏菌屬，並且報導淨潔高杯黏菌（Craterium concinnum）和光果黏菌（Leocarpus fragilis）為兩個台灣新紀錄種；另外Craterium sp.疑為新種。內文並提供台灣已紀錄的鈣絲黏菌屬、高杯黏菌屬與煤絨黏菌屬的物種檢索表，與台灣已紀錄的絨泡黏菌科各屬的檢索表。

關鍵詞：真黏菌綱、絨泡黏菌科、臺灣、分類。