

# The merosporangiferous fungi from Taiwan (X): A new species and new record of *Syncephalis*

Chen-Ju Liu, Hsiao-Man Ho\*

Department of Science Education, National Taipei University of Education, No. 134, Sect. 2, He-Ping E. Rd., Taipei, 10671, Taiwan

(Accepted: March 19, 2020)

## ABSTRACT

Two species of *Syncephalis* were found during a survey of zygomycetes fungi in Taiwan. *Syncephalis collaris* is described as new in uniquely forming a collar-like structure beneath the apical vesicle when aged. *Syncephalis intermedia* is newly recorded in Taiwan. Both species are described and illustrated.

**Key words:** merosporangiferous fungi, Piptocephalidaceae, Taiwan

## Introduction

The genus *Syncephalis* Tiegh. & G. Le Monn. is a member of Piptocephalidaceae (Zoopagales, Zoopagomycotina), containing obligate haustorial mycoparasites mostly growing on Mucoromycotina and Mortierellomycotina fungi. They are usually isolated from soil or dung of herbivores and small rodents. *Syncephalis* is characterized by forming straight or recurved sporangiophores with basal rhizoids and terminal vesicles that bear cylindrical, simple or branched merosporangia with one to several merospores. The merosporangia are initially dry, but merospores are released into droplets of fluid when mature (Benny and Smith, 2018; Ho and Benny, 2008). Up to date, sixty-five accepted species have been described (Lazarus et al. 2017) and thirteen—*S. cornu* van Tieghem & Le Monnier, *S. clavata* HM Ho et Benny, *S. depressa* van Tieghem & Le Monnier, *S. formosana* HM Ho et

Benny, *S. nodosa* Van Tieghem, *S. obconica* Indoh, *S. obliqua* HM Ho et Benny, *S. parvula* Gruhn, *S. pyriformis* SC Chuang, HM Ho & Benny, *S. sphaerica* van Tieghem, *S. tenuis* Thaxter, *S. cf. ventricosa* van Tieghem, and *S. vivipara* Mehrotra & Prasad—have been found in Taiwan (Ho, 2000, 2001, 2002, 2003; Ho and Benny, 2007, 2008; Ho and Chen, 2013; Benny et al., 2016 ).

In this study, soil and dung samples were collected from country road sides, forests, houses, national parks and arboretums in Taiwan. Among the isolated *Syncephalis* species, *S. collaris* was found from soil and is described as a new species, and *S. intermedia* Van Tieghem was found from rat dung and is newly recorded in Taiwan.

## Materials and Methods

### Isolation and purification of fungi

Species of *Syncephalis* were isolated from soil or

\*Corresponding author, e-mail: [ho@tea.ntue.edu.tw](mailto:ho@tea.ntue.edu.tw)

dung. Soil samples were collected from the roadsides, forests, national parks and school campus, brought back to laboratory in plastic bags. Two to three milligrams of soil particles were placed on the surface of 1.7 % corn meal agar (Becton Dickinson) plates. For the dung samples, dung of herbivores, small omnivorous rodents or amphibians were collected from forests, national parks, school campuses and houses, and then carried back to the laboratory in clean containers. Each sample was placed on moist filter paper in a Petri dish. The plates were left on a bench at room temperature, incubated for nearly one week, and then observed using a dissecting microscope. Sporangioophores of *Syncephalis* along with its host were transferred to a fresh corn meal agar plate and incubated at 24 C.

### Light microscopy (LM)

Materials to be observed were selected under a stereomicroscope and mounted in a drop of tap water or lactic acid-cotton blue (cotton blue, 0.5 g; 90% lactic acid, 1 L) as the mounting media (Kurihara et al., 2000). Specimen observation was carried out with a Leitz DMRB light microscope equipped with differential interference contrast optics (DIC) and photographed by using Leica DFC420 charge coupled device (CCD).

### Scanning electron microscopy (SEM)

Pertinent specimens were selected using a dissecting microscope, fixed for 1 h with 2.5% glutaraldehyde in distilled water, then washed with distilled water and dehydrated in a graded acetone series. Specimen were dried in a critical point dryer, coated with gold and observed with a Hitachi S-520 scanning electron microscope at 20 KV (Ho and Benny, 2008).

### Identification

Identification of species was based on morphological characters of sporangiophore, merosporangium, spore no. per merosporangium, spore size and shape, and followed the keys of Zycha et al. (1969) and Ho and Benny (2007).

### Taxonomy

*Syncephalis collaris* H. M. Ho, C. J. Liu & G. L. Benny, sp. nov. Fig. 1A–F

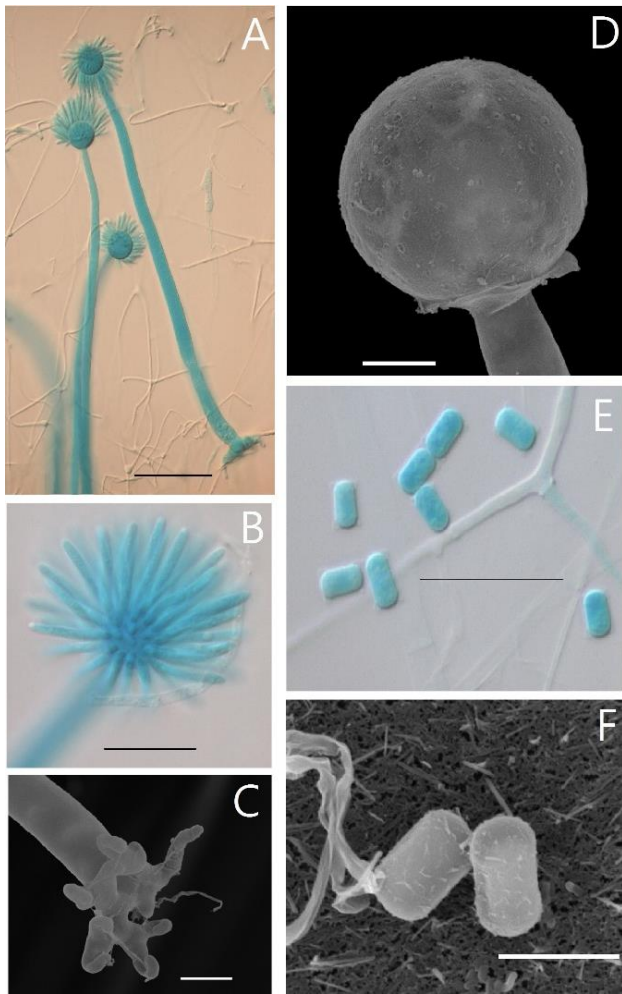
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**Diagnosis.** This is the only species forming collar-like structure beneath apical vesicle when aged.

**Typification.** TAIWAN. New Taipei City, Tucheng District, Heping Rd., bamboo farmland, parasitizing *Mortierella* sp. from soil, 22 Feb 2015, Liu, C.J. *SNTTa* (TNMF F29288 HOLOTYPE), living culture deposited at BCRC FU30580.

**Etymology.** For the collar-like structure beneath vesicle in age.

Vegetative hyphae slender, 1 µm wide, growing over the host hyphae. Sporangioophores simple, erect, solitary, arising from media, 190.5–404.5 µm high, 5–14.5 µm wide at the base, tapering upwards 2.5–7 µm wide below apical fertile vesicles. Rhizoids branched dichotomously once or twice, with several septa. Fertile vesicles spherical, 12–20.5 µm diam, bearing cylindrical merosporangia on the upper two-thirds of vesicle surface. In age, a collar-like structure appearing on the base of vesicle. Merosporangia cylindrical, 17–24 × 1.5–2.5 µm, containing 5–6 merospores,



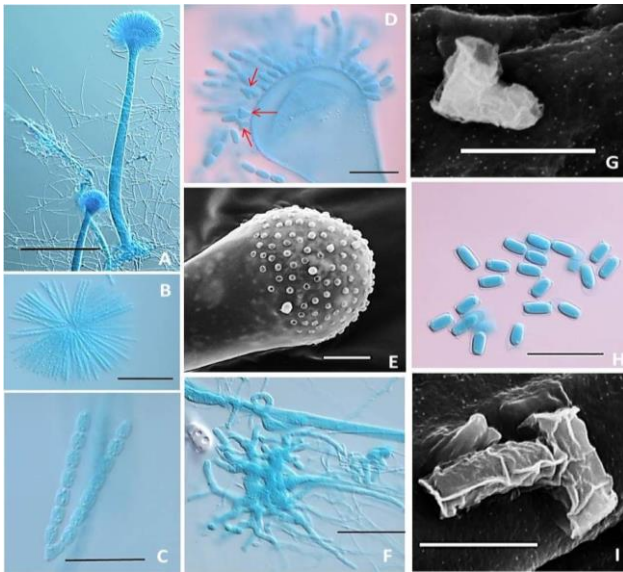
**Fig. 1.** *Syncephalis collaris* SNTTTBPb. A. Three young sporangiophores showing rhizoids, globose vesicles and nearly mature merosporangia on vesicles. B. Young merosporangia. C. Basal rhizoid. D. A terminal vesicle after merosporangia dropping and with collar-like structure beneath. E. Cylindrical merospores. F. Two merospores. A, B, E by LM; C, D, F by SEM. Bars in A = 50  $\mu\text{m}$ ; B, E = 20  $\mu\text{m}$ ; C = 10  $\mu\text{m}$ ; D, F = 5  $\mu\text{m}$ .

detached when mature, leaving inconspicuous scars on vesicle. Merospores cylindrical, smooth, rounded at both ends, 4–6.5  $\times$  3–3.5  $\mu\text{m}$ . Zygospores not observed. Host *Mortierella* sp.

**Other specimens examined.** TAIWAN: Chiayi County, Alishan National Scenic Area, from soil, Oct 2013, isolated by Liu, C.J. SCANSAe, living culture deposited at BCRC FU30579); Chiayi

County, Alishan National Scenic Area, from soil, Oct 2013, isolated by Liu, C.J. SCANSAc; Yunlin County, Xiyuan, from soil, Feb 2014, isolated by Liu, C.J. SYXEF; New Taipei City, Wulai, from soil, Apr 2014, isolated by Liu, C.J. SNTW; New Taipei City, Danlan Trail, from soil, Dec 2014, isolated by Liu, C.J. SNTDT; New Taipei City, Tucheng, farmland, from soil, Feb 2015, isolated by Liu, C.J. SNTTF; New Taipei City, Tucheng, Tung Blossom Park, from soil, Feb 2015, isolated by Liu, C.J. SNTTTBPa; New Taipei City, Tucheng, Tung Blossom Park, from soil, Feb 2015, isolated by Liu, C.J. SNTTTBPb.

**Notes.** The distinctive character of *S. collaris* is the spherical vesicle and collar-like structure forming beneath vesicle in age. *Syncephalis collaris* is similar to *S. bispora* Raciborski, *S. parvula* U. Gruhn and *S. sphaerica* Van Tieghem in having spherical vesicles, simple, erect merosporangiophores and multi-spored, unbranching merosporangia. However, *S. bispora* differs in having longer merosporangiophores (400–600  $\mu\text{m}$ ), larger vesicles (40–50  $\mu\text{m}$  diam) and with two-spored merosporangia (Raciborski, 1909). *Syncephalis parvula* differs in having shorter merosporangiophores (30–56.3  $\mu\text{m}$ ), smaller vesicles (10–17.5  $\mu\text{m}$  diam) and merosporangia containing less merospores (2–4)(Gruhn and Petzold, 1991; Ho, 2002). *Syncephalis sphaerica* differs in having longer merosporangiophores (420–720  $\mu\text{m}$ ), wider vesicles (40  $\mu\text{m}$  diam), and, after merospores detached, leaving prominent warts on vesicles (Indoh, 1962; Ho, 2001). Meanwhile, all these three species mentioned above lack a collar-like structure formed below the vesicle in age. In addition, Lazarus et al. (2017) conducted a phylogenetic analysis of *Syncephalis* species, showing that the type culture



**Fig. 2.** *Syncephalis intermedia* DTSTM. A. Two sporangiophores with nearly mature merosporangia. B. Nearly mature merosporangia. C. Branching merosporangia. D. Cylindrical merospores and heart-shape basal cells (arrows). E. A terminal vesicle showing prominent scars after merosporangia dropping. F. Stout rhizoid with branches. G. A basal cell. H. Cylindrical merospores. I. Merospores enveloped with merosporangia wall remnant. A–D, F, H by LM; E, G, I by SEM. Bars in A = 200  $\mu\text{m}$ ; B = 50  $\mu\text{m}$ ; C, D, F, H = 20  $\mu\text{m}$ ; E = 10  $\mu\text{m}$ ; G, I = 5  $\mu\text{m}$ .

*SNTTa* and the other isolate *SNTTF* clustered in one monophyletic clade. In conclusion, no described species of *Syncephalis* resembles *S. collaris*, which therefore is described as new.

***Syncephalis intermedia*** Van Tieghem, *Annales Sciences Naturelles, Botanique*, series 6, 1: 127. 1875.

Fig. 2. A–I

Vegetative hyphae slender, 1  $\mu\text{m}$  wide, growing over the host hyphae. Sporangiohores erect, arising from media or on host hyphae, 381–740  $\mu\text{m}$  high, slightly swollen at base, 24–43  $\mu\text{m}$  wide, tapering upwards and 14.5–24  $\mu\text{m}$  wide near vesicle. Rhizoids branched, with several septa and sometimes firmly grasping host mycelia. Fertile vesicles obovate, 41.5–68  $\times$  24.5–44

$\mu\text{m}$  diam, bearing merosporangia on the upper one-half of the vesicle. Merosporangia simple or dichotomously branched into symmetrical or slightly asymmetrical fork-shaped, branches cylindrical, 43.0–54.5  $\times$  1.5–3  $\mu\text{m}$ , containing 5–8 spores; basal cells cordate; detached when mature, leaving prominent scars on vesicle. Merospores cylindrical, often enveloped with transparent, wrinkled merosporangial wall remnants, 6–7.5  $\times$  2.5–3  $\mu\text{m}$ . Zygosporos not observed. Host *Mucor* sp.

**Specimens examined.** TAIWAN: New Taipei City, Beitou, from rat dung, Feb 2015, isolated by Ho, H.M. DTSTM; New Taipei City, Xindian, from rat dung, Mar 2015, Isolated by Ho, H.M. DNTXa; New Taipei City, Xindian, from rat dung, Mar 2015, isolated by Ho, H.M. DNTXb; New Taipei City, Xindian, from rat dung, Apr 2015, isolated by Ho, H.M. DNTXd.

**Notes.** *Syncephalis intermedia* resembles *S. asymmetrica* Van Tiegh. & Le Monn., *S. cordata* Van Tiegh. & Le Monn., *S. formosana*, and *S. ramosa* Van Tiegh. in having straight sporangiophores, V-shaped branching merosporangia, and heart-shaped basal cells. *Syncephalis asymmetrica* differs from *S. intermedia* by having longer sporangiophores (up to 1 mm) and less merospores (up to 7) in a merosporangium as opposed to up to 12 in *S. intermedia* (Zycha et al., 1969; Indoh, 1962). *Syncephalis cordata* is different by having longer sporangiophores (up to 3 mm) (Zycha et al., 1969). *Syncephalis formosana* is different by having larger merospores 13–15(–17)  $\times$  5–6  $\mu\text{m}$  and longer sporangiophores 700–790  $\mu\text{m}$  (Ho and Benny, 2007). *Syncephalis ramosa* is different by having merospores with variable size and shape (Van Tieghem, 1875).

**Key to the species of *Syncephalis* known in Taiwan**

1. Sporangiphores curved up to 270° .....*S. cornu*
1. Sporangiphores straight..... 2
  2. Sporangiphores with annual nodes, merosporangia branched ..... *S. nodosa*
  2. Sporangiphores not with annual nodes..... 3
3. Collar-like structure appearing beneath fertile vesicle when aged .....*S. collaris*
3. No collar-like structure appearing when aged..... 4
  4. Fertile vesicles indistinct, club-shaped; merosporangia branched, born on top of vesicle; merospores dolliform..... *S. clavata*
  4. Fertile vesicles distinct ..... 5
5. Merosporangia born obliquely on vesicle, merosporangia simple, containing 6 spores ....*S. obliqua*
5. Merosporangia born on vesicles not as above..... 6
  6. Fertile vesicles pyriform..... *S. pyriformis*
  6. Fertile vesicles not pyriform..... 7
7. Fertile vesicles more or less globose..... 8
7. Fertile vesicles obovoid to obclavate ..... 9
  8. Sporangiphores more than 200 µm high ..... *S. sphaerica*
  8. Sporangiphores less than 200 µm high..... 10
9. Merosporangia simple ..... 11
9. Merosporangia branched ..... 12
  10. Sporangiphores more than 80 µm high; vesicle in base..... *S. cf. ventricosa*
  10. Sporangiphores less than 80 µm high; no vesicle in base .....*S. parvula*
11. Merosporangia 2-spored, the upper one budding from the basal one..... *S. tenuis*
11. Merosporangia 3–4-spored, merospores germinating while merosporangia still attached to the vesicle.....*S. vivipara*
12. Fertile vesicles apex truncate; merosporangia arise in a circle on the upper edge of the vesicle ..... 13
12. Fertile vesicles apex convex; merosporangia formed over the upper portion of the vesicle ..... 14
13. Merosporangia initially grow horizontally and then produce several vertical branches .....*S. depressa*
13. Merosporangia grow more or less vertically, with a single branch ..... *S. obconica*

14. Merosporangia 4–5-spored, merospores cylindrical,  $13\text{--}15 \times 5\text{--}6 \mu\text{m}$  .....*S. formosana*  
 14. Merosporangia 5–8-spored, merospores cylindrical,  $6\text{--}7.5 \times 2.5\text{--}3 \mu\text{m}$  .....*S. intermedia*

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# 臺灣管狀孢子囊接合菌之研究 (X)：集珠黴屬一新種及一新紀錄種

劉貞汝、何小曼\*

國立臺北教育大學自然科學教育學系，臺灣

## 摘 要

本文報告兩種捕蟲黴目、頭珠黴科管狀孢子囊真菌：囊領集珠黴(*Syncephalis collaris*)，成熟時因具有獨特之囊領構造，鑑定為新種；另一中間集珠黴(*Syncephalis intermedia*)為臺灣新紀錄種。文中並提供描述、照相與對相似種類之比較。

**關鍵詞：**管狀孢子囊真菌、頭珠黴科、臺灣