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## Foliicolous hyphomycetes from Taiwan

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Kirschner, R. and Chen, C.J. (2007). Foliicolous hyphomycetes from Taiwan. *Fungal Diversity* 26: 219-239.

New species of *Cercospora* parasitic on *Thladiantha punctata* (*Cucurbitaceae*), of *Pseudocercospora* on *Nephrolepis auriculata* (*Nephrolepidaceae*), and of *Stenella* on *Myrsine seguinii* (*Myrsinaceae*), respectively, are described from Taiwan. *Periconiella rachidicola* is for the first time recorded from Asia on the new host plant *Angiopteris lygodifolia*, *Pseudocercospora sarcocephali* and *Stenella persicae* are new to Taiwan, *Merremia hederacea* is a new host genus and species for *Pseudocercospora timorensis*, and *Ageratum houstonianum* is a new host species for *Passalora perfoliati*. *Chromolaena odorata* is recorded as a new host plant for *Pseudocercospora eupatorii-formosani* in Taiwan. The newly proposed and recorded species are described and illustrated in detail.

**Key words:** anamorphic Ascomycota, cercosporoid fungi, *Mycosphaerella*, phytopathogenic fungi

### Introduction

Reviews and keys of cercosporoid taxa on living plants were provided by Braun (1995) and Crous and Braun (2003). Species of some genera of foliicolous hyphomycetes are treated in this study, namely *Cercospora*, *Passalora*, *Pseudocercospora*, and *Stenella*, all considered cercosporoid anamorphs of *Mycosphaerella* species (Dothideomycetes, Ascomycota). They have been studied fairly intensively in recent years (e.g. Ayala-Escobar *et al.*, 2006; Braun *et al.*, 2006; Crous *et al.*, 2006; Den Breeÿen *et al.*, 2006; Pereira and Barreto, 2006). Additionally, a species of *Periconiella* with uncertain anamorph-teleomorph connection is examined. *Cercospora* is characterized by hyaline conidiophores producing mostly hyaline conidia from refractive, unpigmented conidiogenous loci. In *Passalora* species conidiophores, conidia, conidiogenous scars, and conidial hila are all pigmented, whereas in

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*Pseudocercospora* species, conidiophores and conidia are pigmented, but without darkened scars or hila (Pereira and Barreto, 2006). *Stenella* species differ from *Passalora* species in having verruculose external hyphae. *Periconiella* can be distinguished from the cercosporoid genera mentioned above by conidiophores composed of a long stalk and a head formed by several short branches. *Periconiella*-like anamorphs are obtained when cultivating species of *Xylariales* (Hoog, 1979; Petrini-Klieber, 1985).

The cercosporoid taxa from Taiwan were monographed by Hsieh and Goh (1990). Parts of this work were updated and incorporated in the monograph of *Pseudocercospora* by Guo *et al.* (1998). Our recent studies on some plant pathogenic hyphomycetes in Taiwan resulted in additional new morphological and taxonomical findings (Kirschner *et al.*, 2002; 2004).

## Materials and methods

Plant pathogenic hyphomycetes were collected in different regions in Taiwan in 2004 to 2006, identified, and deposited in TNM. Host plants were in most cases identified with the “Flora of Taiwan”, 2<sup>nd</sup> edition, vol. 1-5, ed. by C.T. Huang, Taipei (1994-2000). Conidia of some species were aseptically transferred to 2% (w/v) malt extract agar (MEA) or water agar, with each medium containing 1.5% (w/v) agar agar. Resulting cultures were deposited in the Centraalbureau voor Schimmelcultures (CBS, Utrecht, the Netherlands). Microscopic characteristics were observed using leaf sections made with a razor blade and culture material grown on 2% MEA at approx. 23°C in diffuse daylight. Material was mounted in 5% KOH, with and without previous staining with 1% aqueous phloxine solution. Statistical treatments of the measurements are indicated by extreme values given in brackets and mean value  $\pm$  1 standard deviation of 30 measurements. If not stated otherwise in the following descriptions, hyphae are filamentous, septate, smooth, and thin-walled. For scanning electron microscopy, air-dried material was directly mounted and sputtered with gold for 60 seconds. Photographs were made with a Hitachi S 4500 scanning electron microscope (SEM).

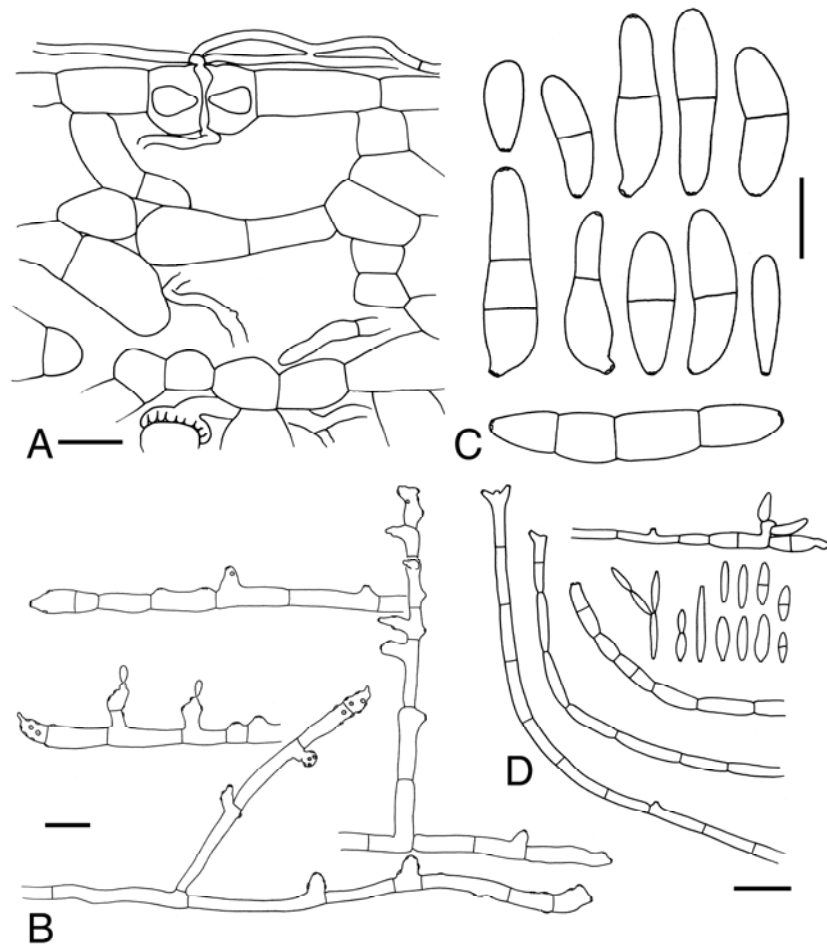
## Taxonomy

*Cercospora thladianthae* R. Kirschner, **sp. nov.** (Fig. 1)

Mycobank: 510578

*Etymology*: Referring to the genus of the host.

*Maculae* foliorum circulares vel irregulares, ochraceae vel albae, margine brunneo in superficie adaxiali, sine margine in superficie abaxiali, 1-10 mm diam. *Hyphae internae* intercellulares, hyalinae, laeves, 1.5-6  $\mu$ m latae, appressoriis disciformis. *Stromata* absentia.



**Fig. 1.** *Cercospora thladianthae* (from holotype). Bars = 10  $\mu$ m. **A.** Detail of a transversal section of a leaf showing internal and external hyphae and a discoid appressorium attached to a mesophyll cell. **B.** Conidiophores from the natural substrate. **C.** Conidia from the natural substrate. **D.** Conidiophores and conidia in culture.

*Hyphae externae* hypophyllae, per stomata apparentes, hyalinae, laeves, 1.5-4  $\mu$ m latae, anastomosibus. *Conidiophora* hypophylla, e hyphis externis vel conidiis germinantibus crescentia, prostrata vel erecta, ad ca. 200  $\mu$ m ascendunt, aggregata sine formatione fasciculorum separatorum, hyalina, laevia. *Cellulae conidiogenae* plerumque intercalares, interdum laterales vel terminales, cicatricibus aggregatis in protuberationibus lateralibus, ca. 1-1.5  $\mu$ m diam. *Conidia* singularia vel in catenis, hyalina, laevia, recta vel leviter curvata, forma variabili, obovata, obclavata, late ellipsoidea vel cum una parte conspicue latiori et una parte angustiori, 0-2-septata, (13-)15-22.5(-31)  $\times$  (2.5-)4-6(-7)  $\mu$ m, hilo basali et interdum hilo apicali incrassato, refractivo, 1-1.5  $\mu$ m diam.

*Leaf spots* circular or irregular, ochre or white, with irregular brown margin on the upper side, without distinct margin on the lower side, 1-10 mm diam. *Internal hyphae* intercellular, hyaline, smooth, 1.5-6 µm wide, forming plate-like appressoria attached to the mesophyll cells. *Stromata* absent. *External hyphae* hypophyllous, arising through stomata, hyaline, smooth, 1.5-4 µm wide, branched, with anastomoses. *Conidiophores* hypophyllous, arising from external hyphae and germinating conidia, creeping, prostrate, or erect, of the same width as the external hyphae and of the same height, but ascending up to approx. 200 µm, branched, not forming separate fascicles, but being densely aggregated, colourless, distances between septa approx. 5-30 µm. *Conidiogenous cells* in most cases intercalary, in some cases lateral or terminal, 5-30 × 1.5-4 µm, conidiogenous scars in most cases aggregated on lateral bulging outgrowths of the conidiogenous cells, with wall thickened compared to the thin wall of the conidiogenous cell, appearing conspicuously refractive in lateral view or as inconspicuous circle with central dot in top view, approx. 1-1.5 µm diam. *Conidia* solitary or catenate, hyaline, smooth, straight or slightly curved, variable in shape, obovate to obclavate, broadly ellipsoidal, or with one half conspicuously broader than the other one, 0-2-septate, (13-)15-22.5(-31) × (2.5-)4-6(-7) µm, with basal and in some cases with apical, thickened, refractive hilum, 1-1.5 µm diam., germinating conidia often longer, with up to 4 constricted septa.

*In culture*, colonies growing slowly on MEA, 4-5 mm in 14 days at room-temperature, flat, powdery, white on the upper surface, dark olive with a light olive margin on the reverse. Hyphae often constricted at the septa and breaking easily into parts, hyaline, smooth, 1-3 µm wide, forming minute, dark or refractive scars on lateral and terminal denticles giving rise to branched conidial chains. Conidia 1-3 µm wide, more variable in length and shape than those from leaves.

*Known distribution*: Taiwan.

*Habitat*: Living leaves of *Thladiantha punctata* (Cucurbitaceae).

*Material examined*: TAIWAN, Chia Yi County, Meishan, Taixingcun, approx. 700-900 m, on living leaves of *Thladiantha punctata* Hayata (Cucurbitaceae, det. C.-M. Wang), 10 March 2006, R. Kirschner & C.-J. Chen 2596 (TNM, **holotype**).

*Living culture*: ex type, R. Kirschner & C.-J. Chen 2596, CBS 120815.

*Notes*: The species appears somewhat intermediate between species of *Cercospora*, *Ramularia*, and *Ramulariopsis*, because of the shape of conidia and the thickened, but undarkened conidiogenous scars typical for *Cercospora* species, compared to the frequent intercalary conidiogenous cells which indicate a relationship to *Ramulariopsis* (Braun, 1995). Intercalary conidiogenous cells were illustrated for some *Cercospora* species by Deighton (1973). The production of conidiophores from external hyphae is not

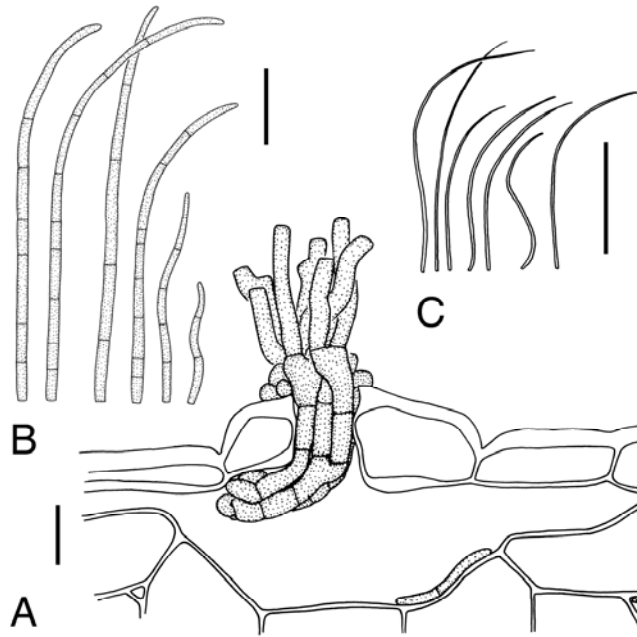
typical for members of *Cercospora* and *Ramulariopsis*, where conidiophores mostly arise in fascicles through stomata, but occurs in several species of the subgenus *Pseudovellosiella* of *Cercospora* and in many species of *Ramularia* (Braun, 1995; 1998). No species of *Cercospora* or *Ramulariopsis* is known from species of *Cucurbitaceae*. *Ramularia bonaerensis* Speg. is the single *Ramularia* species known from a member of *Cucurbitaceae* and is similar to *C. thladianthae*, because its conidiophores are predominantly formed as lateral branchlets of creeping hyphae and its conidiogenous scars are only slightly thickened and darkened (Braun, 1998). Conidia of *R. bonaerensis*, however, differ by not exceeding a width of 3.5  $\mu\text{m}$  and by minute hila (Braun, 1998). Conidiogenous scars are not blackened in *C. thladianthae*, especially when seen in top view, whereas they are darkened in species of *Ramularia* and *Ramulariopsis* (Braun, 1998). The plate-like appressoria found in *C. thladianthae*, were not found in species of *Ramularia*, but in *C. virgaureae* (Thüm.) Allesch. (R. Kirschner, in prep.), which additionally supports a placement of the new species in *Cercospora*. Microscopical characteristics of cultivated *Cercospora* species have previously only been described in *C. tinosporae* (Lacy & Thirum.) Deighton (Ajrekar and Oza, 1935, in Braun, 1993; Deighton, 1973). Pycnidia as described for this species were not found in *C. thladianthae*.

***Pseudocercospora nephrolepidis* R. Kirschner, sp. nov.** (Fig. 2)  
MycoBank: 510579

*Etymology*: Referring to the genus of the host.

*Maculae* foliorum amphigenae, 1-10 mm longae, ad 3-4  $\mu\text{m}$  latae, brunneae, irregulares. *Hyphae internae* intercellulares, pallide brunneae, laeviae, 1-4  $\mu\text{m}$  latae. *Hyphae externae* absentes. *Stromata* absentia vel minuta, pallide brunnea, irregularia, raro ad 35  $\mu\text{m}$  longa et 30  $\mu\text{m}$  alta. *Conidiophora* hypophylla, per stomata apparentia, pallide brunnea, laevia, ad 22 in fasciculo, recta vel leviter geniculata, simplicia, plerumque unice e cellula conidiogena formata, 0-1-septata, (7-)13-26(-35)  $\times$  2.5-3  $\mu\text{m}$ . *Conidia* curvata, interdum undulata, subhyalina vel pallide brunnea, laevia, cylindrica, apicem versus angustata, (32-)67-101(-113)  $\times$  2-3  $\mu\text{m}$ , 2-9 septis inconspicuis, hilo basali truncato, non angustato, non atrato.

*Leaf spots* amphigenous, 1-10 mm long, not passing the midrib of leaflets, restricted to a maximal width of 3-4 mm, medium brown, irregular, on just recently yellowing leaflets with thin, green margin. *Internal hyphae* intercellular, pale brown, smooth, 1-4  $\mu\text{m}$  wide. *External mycelium* absent. *Stromata* absent or small, within and just below the stomata, pale brown, irregular, rarely up to 35  $\mu\text{m}$  long and 30  $\mu\text{m}$  high. *Conidiophores* hypophyllous, arising through stomata, pale brown, smooth, up to 22 per fascicle, straight or slightly geniculate, simple, mostly comprising a single



**Fig. 2.** *Pseudocercospora nephrolepidis*. **A.** Fascicle of conidiophores arising through stoma (R. Kirschner 2315). **B.** Conidia (R. Kirschner 2315). **C.** Outlines of conidia representing the variability of size and curvature, septation and pigmentation not shown (R. Kirschner 2555). Bars: A = 10 μm; B = 20 μm; C = 50 μm.

*conidiogenous cell* only, 0-1-septate, (7-)13-26(-35) × 2.5-3 μm, conidiogenous loci broadly truncate, inconspicuous, unthickened, undarkened. *Conidia* curved, in some cases undulate, subhyaline to pale brown (paler than the conidiophores), smooth, cylindrical, narrowing to the apex, (32-)67-101(-113) × 2-3 μm, with 2-9 inconspicuous septa, basal hilum truncate, not narrowed, not blackened.

*Known distribution:* Taiwan.

*Habitat:* Living leaves of *Nephrolepis auriculata* (*Nephrolepidaceae*).

*Material examined:* TAIWAN, Taipei County, Yangmingshan, ca. 800 m, on *Nephrolepis auriculata* (L.) Trimen (*Nephrolepidaceae*, Pteridophyta) epiphytic on *Cyathea spinulosa* Wall., 2 March 2005, R. Kirschner 2315, (TNM); same locality and host plant species, 2 March 2006, R. Kirschner 2555 (TNM, **holotype**); Yilan County, Fushan Botanical Garden, ca. 600 m, on *Nephrolepis auriculata*, 15 March 2006, R. Kirschner & C.-C. Ko 2619 (TNM).

*Living culture:* ex R. Kirschner 2315, CBS 119121.

*Note:* In the type material (R. Kirschner 2555), external hyphae were found, but were traced to germinating two-celled conidia not belonging to a species of *Pseudocercospora*. The combination of absence of external hyphae,

small or absent stromata, short conidiophores (not exceeding 35  $\mu\text{m}$ ), and curved conidia not broader than 3  $\mu\text{m}$  distinguishes the species on *Nephrolepis auriculata* from *Pseudocercospora* species on other ferns. Since the single specimen of *Pseudocercospora phyllitidis* (H.H. Hume) U. Braun & Crous (as *Cercospora phyllitidis* Hume) on leaves of *Nephrolepis* ('*Nephrolepsis*') sp. from Myanmar, IMI 175733 (Thaung, 1984), was discarded (communication from IMI), its morphology could not be examined and its identity is doubtful. According to Chupp (1954), *Ps. phyllitidis* on other ferns than *Nephrolepidaceae* differs by its larger stromata (up to 75  $\mu\text{m}$ ), larger conidiophores measuring 10-75  $\times$  3-5  $\mu\text{m}$ , and straight to only mildly curved conidia. *Ps. nephrolepidis* is, therefore, the single known species on a member of the *Nephrolepidaceae*. *Ps. arachnioidis* Y.L. Guo on *Arachniodes* sp. (*Dryopteridaceae*) is similar by having small stromata and short conidiophores, but conidia are straight and only occasionally curved. Additionally, conidia can be narrower (1.5-3  $\mu\text{m}$ ) and conidiophores can be broader (up to 4  $\mu\text{m}$ ) than in *Ps. nephrolepidis* (Guo *et al.*, 1998).

***Stenella myrsines* R. Kirschner, sp. nov.**

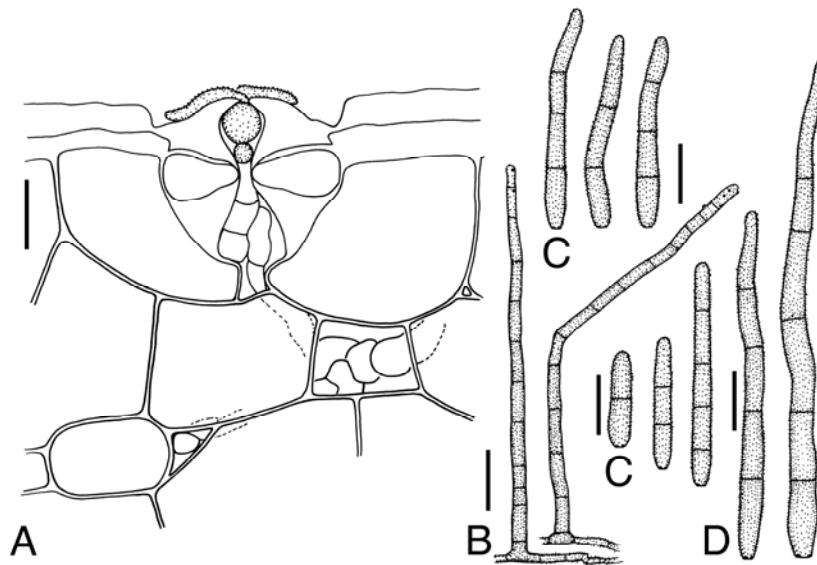
MycoBank, MB 510580

(Figs 3, 4)

*Etymology*: Referring to the genus of the host.

*Maculae* discolores foliorum absentes, colonia hypophylla, brunnea, ad 15 mm diam. *Hyphae internae* intercellulares, hyalinae, torulosae, 3-7  $\mu\text{m}$  latae. *Stromata* absentia. *Hyphae externae* per stomata apparentes, pallide brunneae, verruculosae, 2-3  $\mu\text{m}$  latae. *Conidiophora* hypophylla, per stomata vel ex hyphis externis apparentia, solitaria vel 2-3-aggregata, fusca, laevia, simplicia vel raro ramis apicalibus sparsis, (72-)125-230(-280)  $\times$  4-6(-7)  $\mu\text{m}$ . *Cellulae conidiogenae* terminales et subterminales, pluribus cicatricibus minutis atratis. Conidia singularia, cylindracea, apicem versus leviter angustata, pallide brunnea, verruculosa, 1-5-septata, (13-)16-44(-83)  $\times$  3-4(-5)  $\mu\text{m}$ , hilo basali atrati, 1.5-2  $\mu\text{m}$  diam.

*Leaf discolorations* absent, but indistinct, brown spots present on the abaxial side of living leaves because of the presence of conidiophores forming colonies up to 15 mm diam. *Internal hyphae* intercellular, hyaline, torulose, 3-7  $\mu\text{m}$  wide. *Stromata* absent. *External hyphae* arising through stomata, pale brown, verruculose, 2-3  $\mu\text{m}$  wide. *Conidiophores* hypophyllous, arising from stomata or external hyphae, single or in groups of 2-3 particularly at stomata, dark brown, smooth, simple, rarely with sparse apical branching, (72-)125-230(-280)  $\times$  4-6(-7)  $\mu\text{m}$ , distances between septa 5-17  $\mu\text{m}$ . *Conidiogenous cells* terminal and subterminal, with several minute, blackened, 1.5-2  $\mu\text{m}$  wide conidiogenous scars. *Conidia* solitary, cylindrical, slightly tapering to the apex, straight or very slightly curved, pale brown, verruculose, 1-5-septate, (13-)16-44(-83)  $\times$  3-4(-5)  $\mu\text{m}$ , basal hilum blackened, 1.5-2  $\mu\text{m}$  diam.



**Fig. 3.** *Stenella myrsines*. **A.** Detail of a transversal section of a leaf showing internal and external hyphae (from holotype, R. Kirschner 2558). **B.** Conidiophores (R. Kirschner 2331). **C.** Conidia (R. Kirschner 2331). **D.** Conidia from holotype (R. Kirschner 2558). Bars: A, C, D = 10  $\mu$ m; B = 20  $\mu$ m.

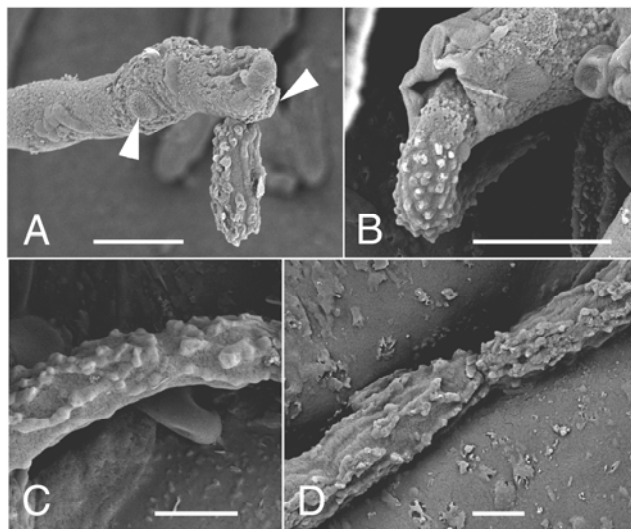
*Known distribution:* Taiwan.

*Habitat:* Living leaves of *Myrsine seguinii* (Myrsinaceae).

*Material examined:* TAIWAN, Taipei County, Yangmingshan, ca. 800 m, on living leaves of *Myrsine seguinii* H. Lév. (Myrsinaceae), 2 March 2005, R. Kirschner 2331 (TNM), same locality and host plant, 2 March 2006, R. Kirschner 2558 (TNM, **holotype**), Taipei County, Ergeshan, 450-700 m, on living leaves of *Myrsine seguinii*, 5 March 2007, R. Kirschner 2929 (TNM).

*Notes:* Attempts of cultivating failed in two collections. As it is shown in Fig. 4, hyphae and conidia show a verrucose ornamentation or, more frequently, a scattered rugose ornamentation interrupted by longitudinal smooth spaces. This ornamentation appears to be intermediate between the exclusively verrucose ornamentation known from species described in *Stenella*, like *S. iteae* R. Kirschner (Kirschner *et al.*, 2004) and the dense rugose ornamentation in *Verrucisporota* (David, 1997; Kirschner and Piepenbring, 2006) and supports the possible synonymy of both genera assumed by Crous and Braun (2003). The new species from Taiwan is, therefore, placed in *Stenella*. Three species names are known for *Stenella* parasitic on members of the Myrsinaceae: *S. embeliae* Rajak as well as *S. embeliae* Rai & Kamal from *Embelia* spp. in India, and *S. maesae* Crous & U.

Braun on *Maesa lanceolata* in South Africa. *S. embeliae* Rai & Kamal is illegitimate because it is a later homonym of the species described by Rajak (1981). Since hyphae are described as smooth in the illegitimate species (Rai and Kamal, 1989), its placement in *Stenella* is doubtful. Additional studies are necessary in order to clarify if both specimens described as *S. embeliae* represent one or two species. Both specimens, however, differ from *S. myrsines* by broader conidia (6-10  $\mu\text{m}$  in Rajak, 1981; 3.5-7  $\mu\text{m}$  in Rai and Kamal, 1989), and *S. maesae* differs by much shorter conidiophores not exceeding 15  $\mu\text{m}$  (Crous and Braun, 1994).

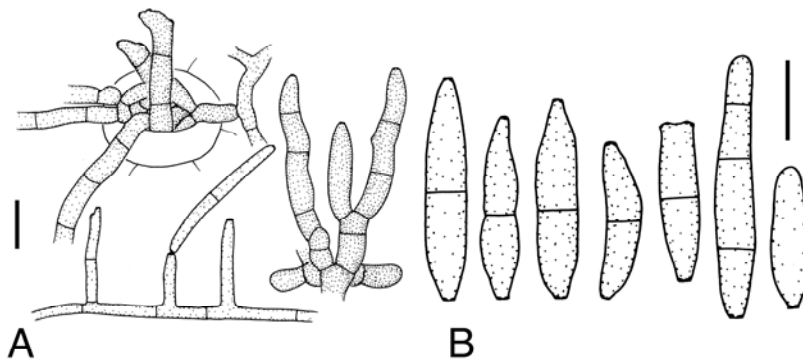


**Fig. 4.** *Stenella myrsines* (from holotype), SEM photographs. **A.** Apex of a conidiophore showing detachment scars (arrowheads) and a still attached conidium with scattered rugose surface ornamentation. **B.** Percurrently proliferating hyphae showing verrucose ornamentation. **C, D.** Hyphae with scattered rugose ornamentation. Bars: A, B = 5  $\mu\text{m}$ ; C, D = 2  $\mu\text{m}$ .

***Passalora perfoliati*** (Ellis & Everh.) U. Braun & Crous, in Crous and Braun, *Mycosphaerella* and its anamorphs: 1. Names published in *Cercospora* and *Passalora*, Utrecht, p. 314. (2003). (Fig. 5)

*Leaf spots* on the upper side indistinct, pale yellow to reddish brown, up to approx. 5 mm, with irregular margin, on the lower side densely covered by brown hyphae. *Internal hyphae* intercellular, hyaline to subhyaline, 1.5-2  $\mu\text{m}$  wide. *Stromata* absent. *External hyphae* subhyaline to pale brown, smooth, 2-5  $\mu\text{m}$  wide. *Conidiophores* hypophyllous, arising singly or in fascicles of 2-6 from stomata or singly from external hyphae, subhyaline (especially when arising from external hyphae climbing leaf hairs) to medium brown (especially

when arising from stomata), smooth, simple or rarely branched at the base,  $10-40 \times 2-5 \mu\text{m}$ , 0-4 septate. *Conidiogenous cells* terminal, rarely intercalary, with 1-3 darkened conidiogenous scars. *Conidia* catenate, cylindrical or obclavate, smooth, subhyaline to very pale brown, straight or very slightly curved, 0-4 septate (mostly 1 septate),  $(10-)16-33(-50) \times 3-5 \mu\text{m}$ , with basal and often additionally with apical darkened,  $1.5 \mu\text{m}$  wide hilum, giving rise to secondary conidia during germination.



**Fig. 5.** *Passalora perfoliati* (R. Kirschner & C.-J. Chen 2607). Bars =  $10 \mu\text{m}$ . **A.** Conidiophores. **B.** Conidia.

*Habitat:* Members of the *Eupatorieae*, *Asteraceae*: *Ageratum conyzoides*, *Chromolaena odorata*, *Eupatorium* spp. (Crous and Braun, 2003), *Ageratum houstonianum* (new host species).

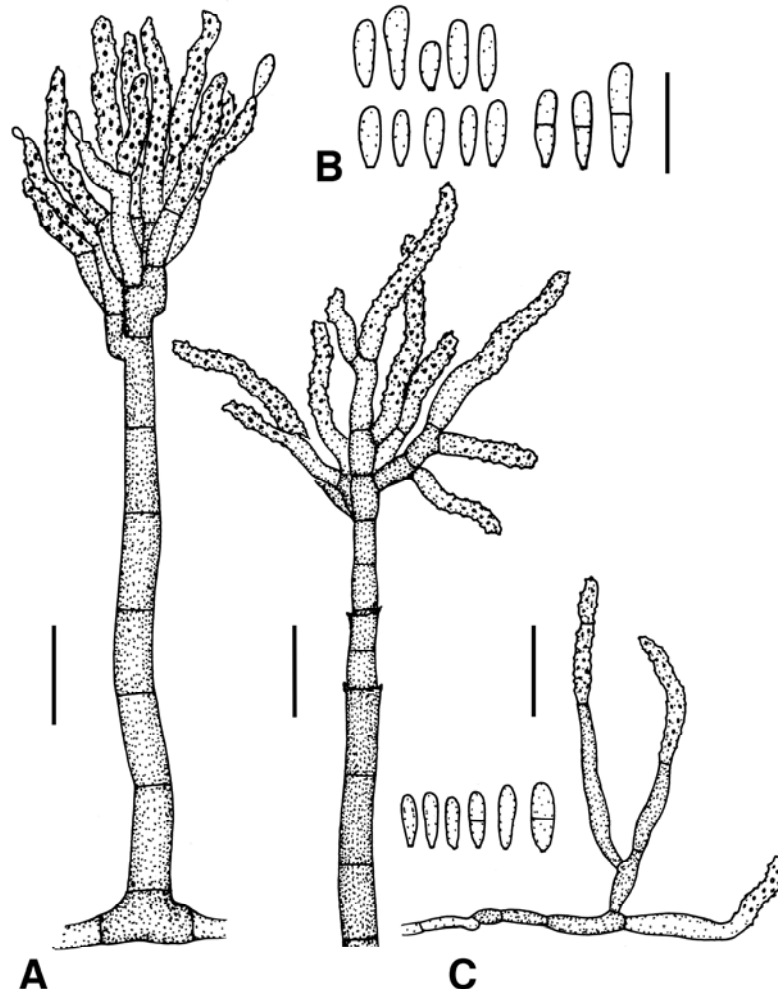
*Known distribution:* Taiwan (Hsieh and Goh, 1990), many other countries (Crous and Braun, 2003).

*Material examined:* TAIWAN, Chia Yi County, Meishan, Ruili, ca. 700 m, on living leaves of *Ageratum houstonianum* Mill. (*Asteraceae*), 10 March 2006, R. Kirschner & C.-J. Chen 2607 (TNM).

*Notes:* The fungus was hitherto known from *Ageratum conyzoides*, *Chromolaena odorata* and several *Eupatorium* species (Crous and Braun, 2003). In Taiwan, the species was recorded for *A. conyzoides* (Hsieh and Goh, 1990). Therefore, *A. houstonianum* is recorded here as a new host plant. Both *Ageratum* species have their origin in tropical America and are naturalized in Taiwan (Peng *et al.*, 1998).

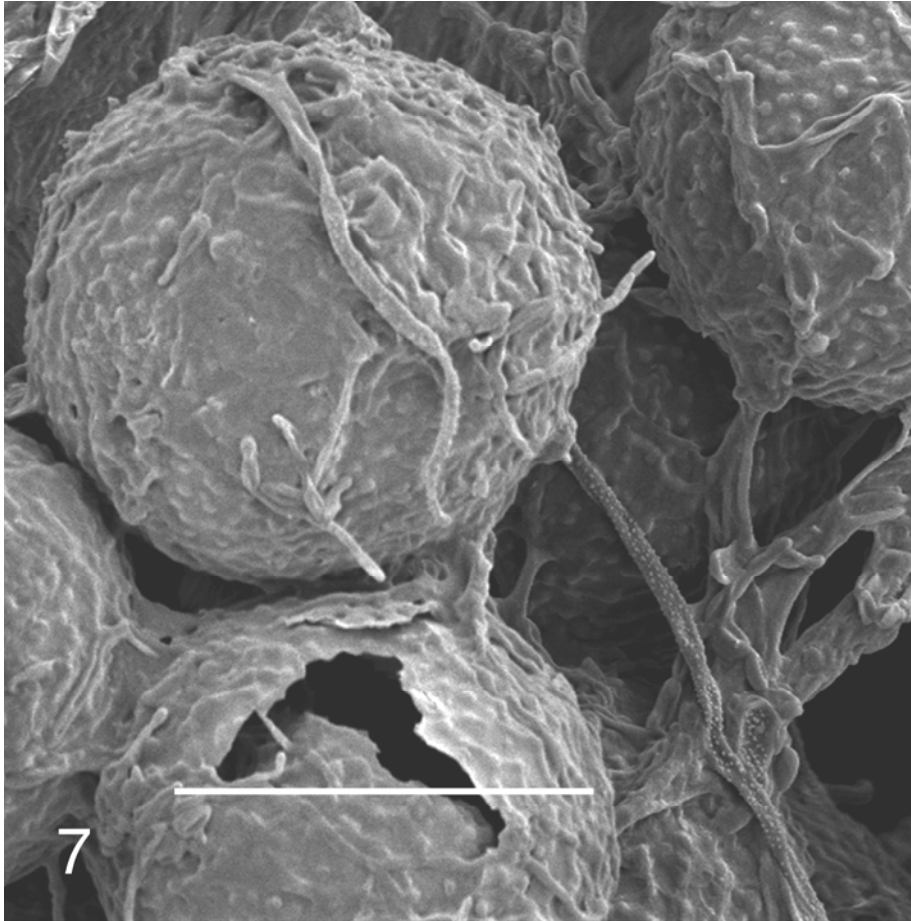
***Periconiella rachidicola*** U. Braun, Feddes Repert. 115: 53 (2004). (Figs 6, 7)

*Leaf spots* absent. *Stromata* absent. *Internal hyphae* not found, *external hyphae*, subhyaline to pale brown, smooth to verruculose in light microscopy, verruculose in SEM (Fig. 7),  $1-2 \mu\text{m}$  wide. *Conidiophores* arising from the superficial mycelium, confined to hyphae on the sporangial wall of the fern and



**Fig. 6.** *Periconiella rachidicola* (R. Kirschner & C.-J. Chen 2606). Bars = 10  $\mu\text{m}$ . **A.** Conidiophores from the natural substrate. **B.** Conidia from the natural substrate. **C.** Conidiophore and conidia from culture.

adjacent leaf epidermis, 36-280  $\mu\text{m}$  long, composed of a dark brown, smooth, pluriseptate stipe, 5-245  $\mu\text{m}$  long and 3-10  $\mu\text{m}$  wide, and a head composed of up to three times branched, in many cases divergent branches and conidiogenous cells, sterile cells of the head 5-10  $\times$  2-3  $\mu\text{m}$ , medium to pale brown, *conidiogenous cells* terminal and intercalary, delimiting septa of intercalary conidiogenous cells in many cases indistinct, cells pale brown, cylindrical, often geniculate, terminal conidiogenous cells (7-)11.5-21(-27)  $\times$



**Fig. 7.** SEM photograph of verruculose hyphae of *Periconiella rachidicola* among spores of the host fern *Angiopteris lygodifolia* (R. Kirschner & C.-J. Chen 2606). Bar = 20  $\mu\text{m}$ .

1.5-2  $\mu\text{m}$ , smooth, but densely covered by ca.  $1 \times 1 \mu\text{m}$  small, refractive conidiogenous scars. *Conidia* solitary, cylindrical or obclavate-cylindrical, straight or slightly curved, subhyaline to pale brown, smooth to indistinctly verruculose when seen with the light microscope,  $4.5-7.5(-11) \times 1.5-2 \mu\text{m}$ , 0-1-septate, with thickened, refractive basal hilum.

*In culture* on MEA, the stipes and number of conidiogenous cells of conidiophores were reduced, but the morphology of the conidiogenous cells was the same as in the material *in vivo*. Conidia were solitary, light brown, 0-1-septate, with a refractive basal hilum,  $(5-)-6-8(-10) \times 1.5-2.5 \mu\text{m}$ . The culture was lost due to infection by mites.

*Habitat:* Leaves of ferns: *Polypodium plesiosorum* (Braun, 2004), *Angiopteris lygodifolia* (new substrate).

**Known distribution:** Costa Rica (Braun, 2004), Taiwan (new record).

**Material examined:** Taiwan, Chia Yi County, Meishan, Taixingcun, ca. 700-900 m, on sporangia of *Angiopteris lygodiiifolia* Rosenst. (*Pteridophyta*, *Marattiaceae*), 10 March 2006, R. Kirschner & C.-J. Chen 2606 (TNM).

**Notes:** *Periconiella rachidicola* was described from the rachis of *Polypodium plesiosorum* Kunze in Costa Rica (Braun, 2004). According to the original description, stromata can be present or absent, whereas in the specimen from Taiwan stromata were not found, and conidiophores are mainly confined to the sporangia. The host fern from Costa Rica belongs to the leptosporangiate ferns and that from Taiwan to the eusporangiate. The host ferns are, therefore, distantly related. Since the morphological characteristics of conidiophores and conidia appear identical in the specimens from Costa Rica and Taiwan, they are considered conspecific.

***Pseudocercospora sarcocephali*** (Viennot-Bourgin) Deighton, Mycol. Papers 140: 152 (1976). (Fig. 8)

**Leaf spots** amphigenous, dark olive on the upper surface, pale to medium brown on the lower surface, up to 20 mm diam., margin inconspicuous, irregular. **Internal hyphae** intercellular, hyaline to pale brown, smooth, 1-2  $\mu\text{m}$  diam. **Stromata** few, brown, up to 30  $\mu\text{m}$  wide and 20  $\mu\text{m}$  high, cells 3-10  $\mu\text{m}$  wide. **External hyphae** copious, arising from internal hyphae or from stromata through stomata, pale brown, smooth, frequently anastomosing, 1-3  $\mu\text{m}$  diam. **Conidiophores** arising singly from external hyphae, frequently from those covering leaf hairs, with one to several septa, somewhat tortuose, simple or with 1-2 lateral branches, (21-)25-47(-59)  $\times$  3-4  $\mu\text{m}$ , with lateral and terminal, 1-2  $\mu\text{m}$  wide, undarkened conidiogenous scars or in some cases with terminal annellations, or conidiophores less frequently arising in fascicles of up to approx. 30 from stromata, darker brown, longer (up to 90  $\mu\text{m}$ ), and with more septa than those from external hyphae. **Conidia** straight or very slightly curved, pale brown, smooth, (23-)35-57(-65)  $\times$  3-4  $\mu\text{m}$ , basal hilum unthickened, undarkened, truncate, up to 2  $\mu\text{m}$  wide.

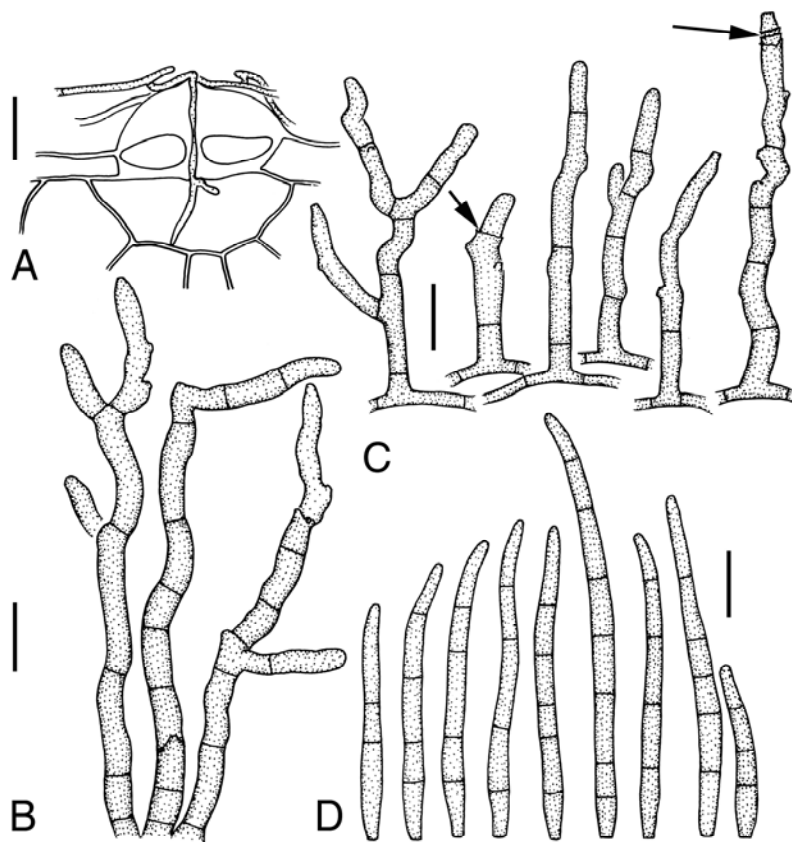
**Habitat:** *Sarcocephalus esculentus*, *Uncaria* spp. (*Rubiaceae*) (Guo *et al.*, 1998).

**Known distribution:** P.R. China, Guinea (Guo *et al.*, 1998), Taiwan (new record).

**Material examined:** TAIWAN, Taipei County, Wulai, on leaves of *Uncaria* sp. (*Rubiaceae*), 22 February 2005, R. Kirschner & C.-J. Chen 2275 (TNM).

**Living culture:** ex R. Kirschner & C.-J. Chen 2275, CBS 118759.

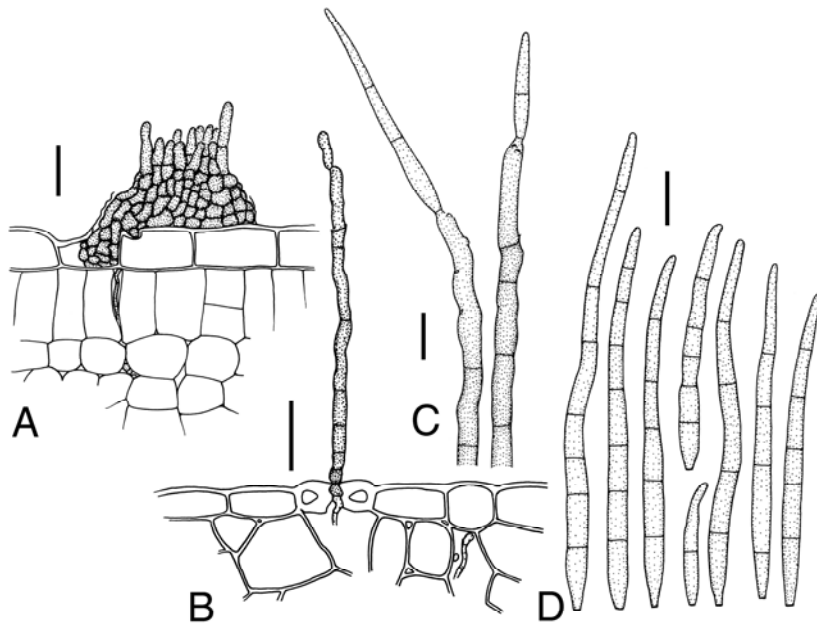
**Notes:** We preliminarily follow the species concept by Guo (1991). Studies of the type on *Sarcocephalus esculentus* might be necessary in order to confirm the conspecificity with the specimens on *Uncaria* spp.



**Fig. 8.** *Pseudocercospora sarcocephali* (R. Kirschner & C.-J. Chen 2275). Bars = 10  $\mu$ m. **A.** Detail of a transversal section of a leaf showing external hyphae penetrating from a stoma. **B.** Conidiophores from a fascicle arising through a stoma. **C.** Conidiophores arising from external hyphae, some of them showing percurrent proliferation (arrows). **D.** Conidia.

***Pseudocercospora subtorulosa*** (Syd. & P. Syd.) U. Braun & Crous, in Crous and Braun, *Mycosphaerella* and its anamorphs: 1. Names published in *Cercospora* and *Passalora*, Utrecht, p. 393 (2003). (Fig. 9)

*Leaf spots* amphigenous, pale ochre, 1-5 mm diam., margin inconspicuous, irregular. *Internal hyphae* intercellular, pale brown, smooth, 1-4  $\mu$ m wide. *Stromata* in the upper leaf surface almost subcuticular, in some cases extending into one epidermal cell, dark brown, pulvinate, 30-60  $\mu$ m broad and 20-43  $\mu$ m high, stromata in the lower leaf surface absent, consisting of few cells, or small (up to 20  $\mu$ m diam.) in the substomatal chamber, cells 2-10  $\mu$ m diam. *External hyphae* absent. *Conidiophores* up to approx. 20 arising from the stroma, erumpent through the cuticle on the upper leaf surface, simple, arising



**Fig. 9.** *Pseudocercospora subtorulosa* (R. Kirschner & C.-J. Chen 2012). **A.** Detail of a transversal section of a leaf showing internal hyphae and conidiophores on the adaxial leaf surface. **B.** Detail of a transversal section of a leaf showing a conidiophore penetrating from a stoma on the abaxial leaf surface. **C.** Apices of conidiophores with slightly darkened conidiogenous scars. **D.** Conidia. Bars: A, B = 20  $\mu\text{m}$ ; C, D = 10  $\mu\text{m}$ .

singly or in fascicles of up to 5 through the stomata of the lower leaf surface, simple, in some cases with a single lateral branch. Conidiophores medium brown, paler at the apex, erect, straight or geniculate, smooth, in some cases proliferating percurrently, 2-7-septate, septa 6-20  $\mu\text{m}$  apart, (42-)50-98(-154)  $\times$  4-6  $\mu\text{m}$ . *Conidiogenous cells* intercalary and terminal, with lateral and terminal, 1-1.5  $\mu\text{m}$  wide, darkened and undarkened conidiogenous scars. *Conidia* almost straight, pale brown, smooth, inconspicuously 1-7-septate, (23-)44-71(-91)  $\times$  (2.5-)3-4.5(-5)  $\mu\text{m}$ , basal hilum thickened, darkened, truncate, 1.5-2  $\mu\text{m}$  diam.

*Habitat:* *Melicope* sp., *M. triphylla* (*Rutaceae*) (Crous and Braun, 2006).

*Known distribution:* Philippines (Crous and Braun, 2006), Taiwan (new record).

*Material examined:* TAIWAN, Nantou County, Huisunlinchang, on living leaves of *Melicope* sp. (*Rutaceae*), 11 August 2004, R. Kirschner & C.-J. Chen 2012 (TNM).

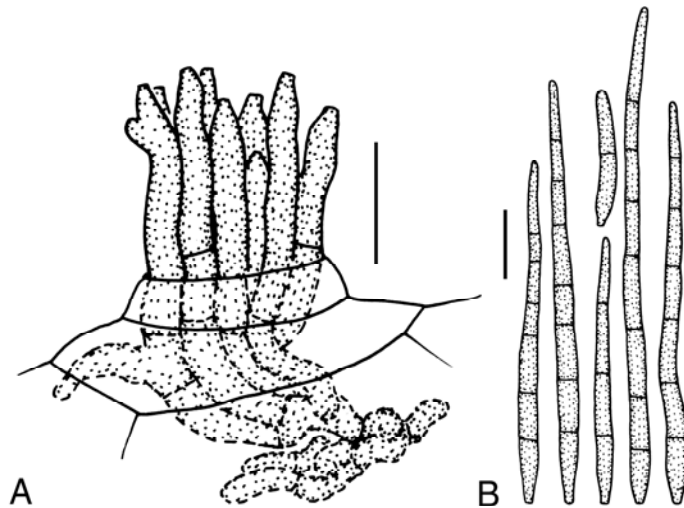
*Living culture:* ex R. Kirschner & C.-J. Chen 2012, CBS 117230.

*Notes:* Young distal conidiogenous scars of some conidiogenous cells appeared unthickened and undarkened, whereas more proximal scars of the

same cell were dark. Darkening of conidiogenous scars, usually considered diagnostic for *Cercospora* and *Passalora*, occasionally occurs during aging in conidiophores of *Pseudocercospora* species. The pigmentation and truncate base of the conidia of the specimen also indicates a placement in *Pseudocercospora* and not in *Cercospora* or *Passalora*. The amphigenous fascicles with morphology differing on both sides of the leaf found in the Taiwanese specimen is not mentioned in the original description of *Ps. subtorulosa* from the Philippines by Sydow and Sydow (1913).

***Pseudocercospora timorensis*** (Cooke) Deighton, Mycol. Pap. 140: 154 (1976).  
(Fig. 10)

*Leaf spots* amphigenous, brown, 3-10 mm diam., on the adaxial side with a yellow, ca. 1 mm wide irregular margin. *Stromata* mostly absent, consisting of few brown cells, rarely up to 40  $\mu\text{m}$  broad and 30  $\mu\text{m}$  high. *Internal hyphae* intercellular, subhyaline to pale brown, 1-3  $\mu\text{m}$ . *Conidiophores* amphigenous, arising through stomata in fascicles of approx. 8-35, pale brown, smooth, unbranched, with 0-1 septa, (12-)14-22.5(-30)  $\times$  2-3.5  $\mu\text{m}$ , with 1-2 terminal, undarkened, 1-1.5  $\mu\text{m}$  wide conidiogenous scars. *Conidia* cylindrical, slightly tapering to the apex, straight to very slightly curved, pale brown, smooth, with 0-7 septa, (17-)30-65(-74)  $\mu\text{m}$  long, 2.5-3  $\mu\text{m}$  at the broadest part, 1.5-2  $\mu\text{m}$  wide at the apex, basal hilum unthickened, undarkened, 1-1.5  $\mu\text{m}$  wide.



**Fig. 10.** *Pseudocercospora timorensis* (R. Kirschner 2689). Bars = 10  $\mu\text{m}$ . **A.** Fascicle of conidiophores penetrating through a stoma. **B.** Conidia.

*Habitat:* Members of the *Convolvulaceae*: *Calystegia* and *Ipomoea* species (Crous and Braun, 2003), *Merremia hederacea* (new host genus and species).

*Known distribution:* Taiwan (Hsieh and Goh, 1990), many other countries (Crous and Braun, 2003).

*Material examined:* TAIWAN, Tainan County, Nankunshen, 0 m, on leaves of *Merremia hederacea* (Burm. f.) Hall. f. (*Convolvulaceae*), 26 March 2006, R. Kirschner T2689 (TNM).

*Notes:* This is the first record of a *Merremia* species as host plant for *Ps. timorensis* which has hitherto been known only on species of *Calystegia* and *Ipomoea* (Crous and Braun, 2003; Hsieh and Goh, 1990). The distinction of the genus *Merremia* from other genera of the *Convolvulaceae* is not clearly resolved (Staples and Yang, 1998). The host plant was identified mainly because of the presence of yellow flowers and tubercles on the leaf petioles. The morphological characteristics of the fungus on *M. hederacea* are identical to those given by Hsieh and Goh (1990) and particularly with respect to stroma size and number of septa in the conidia by García *et al.* (1996).

***Stenella persicae*** Yokoyama & Nasu, Mycoscience 41: 91. 2000. (Fig. 11)

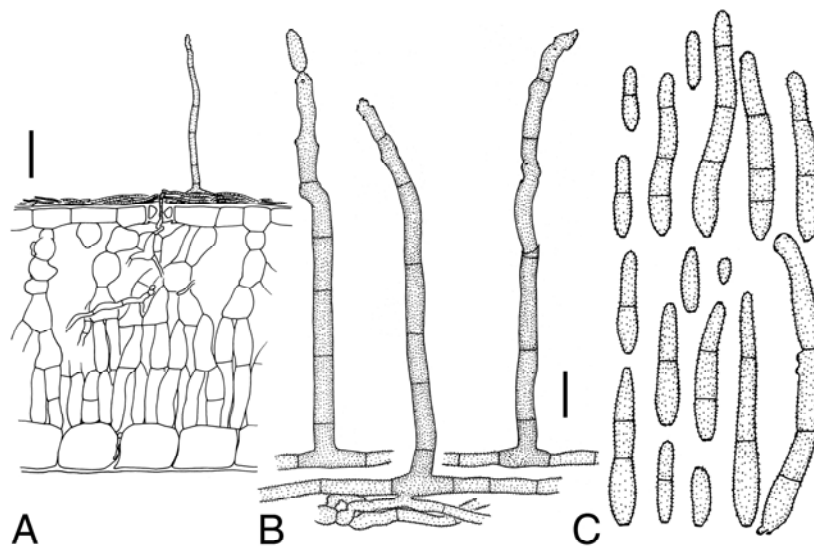
*Leaf discolorations* absent, olive colonies on the lower surface formed by conidiophores and external mycelium, approx. 2-6 mm diam., margin inconspicuous, irregular. *Internal hyphae* intercellular, hyaline, smooth, 1-4 µm wide. *Stromata* absent. *External hyphae* copious, arising from internal hyphae through stomata, pale brown, verruculose, frequently anastomosing, 2-3 µm wide. *Conidiophores* arising singly from external hyphae, erect, slightly geniculate towards the apex, simple, medium brown, smooth, in some cases with a percurrent proliferation, 3-8-septated, septa 10-17 µm apart, (20-)68-102(-111) × (3-)3.5-4 µm, with intercalary and terminal *conidiogenous cells*, conidiogenous scars scattered, 1-1.5 µm diam., darkened. *Conidia* catenate, straight or very slightly curved or sinuous, pale brown, verruculose, 0-3-septate, basal cell broader than the apical one, (4-)9-34(-55) × 2-4 µm, becoming longer (up to 85 µm) during germination and producing secondary conidia, basal hilum darkened, 1-1.5 µm diam.

*Habitat:* *Prunus persica* (Yokoyama and Nasu, 2000), *Prunus campanulata* (new host species).

*Known distribution:* Japan (Yokoyama and Nasu, 2000), Taiwan (new record).

*Material examined:* TAIWAN, Nantou County, Huisunlinchang, ca. 800 m, on living leaves of *Prunus campanulata* Maxim. (*Rosaceae*), 10 August 2004, R. Kirschner & C.-J. Chen 2006 (TNM),

*Living culture:* ex R. Kirschner & C.-J. Chen 2006, CBS 117229 (without sporulation on MEA, water agar).



**Fig. 11.** *Stenella persicae* (R. Kirschner & C.-J. Chen 2006). **A.** Transversal section of a leaf showing internal and external hyphae and a conidiophore arising from external mycelium on the abaxial leaf surface. **B.** Conidiophores arising from external hyphae. **C.** Conidia. Bars: A = 20 µm; B, C = 10 µm.

*Notes:* *Stenella persicae* was originally described as causing mold of peach fruits (*Prunus persica* Batsch var. *vulgaris* Maxim.) in Japan (Yokoyama and Nasu, 2000). The description of the Japanese specimen was based on material in culture on water agar and not from the natural substrate. The specimen from Taiwan was initially isolated on MEA and subsequently transferred to water agar, but sporulated on neither of both media. Cultural characteristics could, therefore, not be compared. The morphology of the conidiophores and conidia from the living host in Taiwan, however, is almost identical to that in culture on water agar in Japan according to the description by Yokoyama and Nasu (2000). Schubert and Braun (2007) described *S. persicae*, based on a Japanese herbarium specimen on leaves which was misidentified as '*Cladosporium persicum*', without giving information about internal hyphae, presence or absence of stomata and the connection with stomata. *Stenella anomoconis* de Hoog & Boekhout on *Prunus* sp. differs from *S. persicae* by longer (125-200 µm) conidiophores and not-catenate conidia (Hoog *et al.*, 1983). Another species on a members of the *Rosaceae*, *S. prinsepiae* M.K. Khan, Budathoki & Kamal on *Prinsepia utilis* Royle in India, differs by longer (up to 257 µm) and multiseptate conidia (Khan *et al.*, 1991).

***Additional records of cercosporoid species already known for Taiwan and identified with the monograph by Hsieh and Goh (1990):***

*Pseudocercospora abelmoschi* (Ellis & Everh.) Deighton

*Material examined:* TAIWAN, Taipei City, National Taiwan University, experimental field, on *Abelmoschus esculentus* Moench. (*Malvaceae*), 26 August 2004, R. Kirschner 2084 (TNM).

*Pseudocercospora cruenta* (Sacc.) Deighton

*Material examined:* TAIWAN, Pingtung County, Caopu, ca. 400 m, on *Phaseolus vulgaris* L. (*Fabaceae*), 4 September 2004, R. Kirschner & C.-J. Chen 2152 (TNM).

*Living culture:* ex R. Kirschner & C.-J. Chen 2152, CBS 117232.

*Pseudocercospora eupatorii-formosani* U. Braun & Bagyan

*Material examined:* TAIWAN, Tainan County, near Hsinhua, on *Chromolaena odorata* (L.) M.R. King (*Asteraceae*, new host for this fungus in Taiwan), 25 March 2006, R. Kirschner & C.-J. Chen T2682 (TNM).

*Pseudocercospora ixorae* (Solh.) Deighton

*Material examined:* TAIWAN, Taipei City, Peitou, on *Ixora* sp. (*Rubiaceae*), 3 March 2005, R. Kirschner 2345 (TNM); Tainan County, Yungkuang, Southern Taiwan University of Technology, campus, on *Ixora* sp. (*Rubiaceae*), 8 March 2005, R. Kirschner 2349 (TNM).

*Pseudocercospora stahliae* (F.L. Stev.) Deighton

*Material examined:* TAIWAN, Tainan County, Zuozhen, ca. 100 m, on *Passiflora foetida* L. (*Passifloraceae*), 1 September 2004, R. Kirschner & C.-J. Chen 2124 (TNM); Pingtung County, Caopu, ca. 400 m, same host species, 4 September 2004, R. Kirschner & C.-J. Chen 2151 (TNM).

*Living culture:* ex R. Kirschner & C.-J. Chen 2124, CBS 117549.

*Pseudocercospora oxalidis* (Goh & W.H. Hsieh) U. Braun

*Material examined:* TAIWAN, Taipei County, Wulai, on *Oxalis corymbosa* DC. (*Oxalidaceae*), 22 February 2005, R. Kirschner & C.-J. Chen 2258 (TNM).

*Living culture:* ex R. Kirschner & C.-J. Chen 2258, CBS 118758.

**Acknowledgements**

The study was supported by the National Science Council of Taiwan (NSC 94-2745-B-218-004-URD). We thank C.-M. Wang for identification of the host plant species in *Cercospora thladianthae*, C.-C. Ko and D.C. Chang for arrangement of a collection trip to the Fushan Botanical Garden, and M. Ruppel for assistance with SEM.

## References

- Ayala-Escobar, V., Yáñez-Morales, M.J., Braun, U., Groenewald, J.Z. and Crous, P.W. (2006). *Pseudocercospora opuntiae* sp. nov., the causal organism of cactus leaf spot in Mexico. *Fungal Diversity* 21: 1-9.
- Braun, U. (1995). *A monograph of Cercospora, Ramularia and allied genera (phytopathogenic hyphomycetes). Vol. 1*, IHW-Verlag, Eching, Germany.
- Braun, U. (1998). *A monograph of Cercospora, Ramularia and allied genera (phytopathogenic hyphomycetes). Vol. 2*, IHW-Verlag, Eching, Germany.
- Braun, U. (2004). *Periconiella* species occurring on ferns. *Feddes Repertorium* 115: 50–55.
- Braun, U., Hill, C.F. and Schubert, K. (2006). New species and new records of biotrophic microfungi from Australia, Fiji, New Zealand and Thailand. *Fungal Diversity* 22: 13-35.
- Chupp, C. (1954). *A monograph of the fungus genus Cercospora*. Published by the author, Ithaca, New York, USA.
- Crous, P.W. and Braun, U. (1994). *Cercospora* species and similar fungi occurring in South Africa. *Sydowia* 46: 204-224.
- Crous, P.W. and Braun, U. (2003). *Mycosphaerella and its anamorphs: 1. Names published in Cercospora and Passalora*. CBS, Utrecht, Netherlands.
- Crous, P.W., Groenewald, J.Z., Groenewald, M., Caldwell, P., Braun, U. and Harrington, T.C. (2006). Species of *Cercospora* associated with grey leaf spot of maize. *Studies in Mycology* 55: 189-197.
- David, J.C. (1997). A contribution to the systematics of *Cladosporium*. Revision of the fungi previously referred to *Heterosporium*. *Mycological Papers*: 172:1-157.
- Deighton, F.C. (1973). Studies on *Cercospora* and allied genera. IV. *Cercospora* Sacc., *Pseudocercospora* gen. nov. and *Pseudocercosporidium* gen. nov. *Mycological Papers* 133: 1-62.
- Den Breeÿen, A., Groenewald, J.Z., Verkley, G.J.M. and Crous, P.W. (2006). Morphological and molecular characterisation of *Mycosphaerellaceae* associated with the invasive weed, *Chromolaena odorata*. *Fungal Diversity* 23: 89-110.
- García C.E., Pons, N. and Rojas, C.B. de (1996). *Cercospora* y hongos similares sobre especies de *Ipomoea*. *Fitopatología Venezolana* 9: 22-36.
- Guo, Y.-L. (1991). Foliicolous hyphomycetes of Guniujiang in Anhui Province I. *Mycosystema* 4: 119-128.
- Guo, Y.L., Liu, X.L. and Hsieh, W.H. (1998). *Pseudocercospora*. *Flora Fungorum Sinicorum, Vol. 9*. Science Press, Peking (Beijing).
- Hoog, G.S. de (1979). Deductive classification – worked examples using anamorph and teleomorph data in the Ascomycetes. In: *The Whole Fungus, Vol. 1* (ed. W.B. Kendrick). Co-published by National Museum of Natural Sciences, National Museum of Canada and the Kananaskis Foundation, Ottawa, Canada: 215-237.
- Hoog, G.S. de, Rahman, M.A. and Boekhout, T. (1983). *Ramichloridium*, *Veronaea* and *Stenella*: Generic delimitation, new combinations and two new species. *Transactions of the British Mycological Society* 81: 485-490.
- Hsieh, W.H. and Goh, T.K. (1990). *Cercospora and similar fungi from Taiwan*. Maw Chang Book Company, Taipei, Taiwan.
- Khan, M.K., Budathoki, U. and Kamal (1991). New foliicolous hyphomycetes from Kathmandu Valley, Nepal. *Indian Phytopathology* 44: 21-29.

## Fungal Diversity

- Kirschner, R. and Piepenbring, M. (2006). New species and records of cercosporoid hyphomycetes from Panama. *Mycological Progress* 5: 207-219.
- Kirschner, R., Braun, U., Chen, Z.C. and Oberwinkler, F. (2002). *Pleurovularia*, a new genus of hyphomycetes proposed for a parasite on leaves of *Microstegium* sp. (*Poaceae*). *Mycoscience* 43: 5-20.
- Kirschner, R., Piepenbring, M. and Chen, C.-J. (2004). Some cercosporoid hyphomycetes from Taiwan, including a new species of *Stenella* and new reports of *Distocercospora pachyderma* and *Phacellium paspali*. *Fungal Diversity* 17: 57-68.
- Pereira, O.L. and Barreto, R.W. (2006). *Pseudocercospora palicoureae* sp. nov. associated with the toxic rubiaceae weed *Palicourea marcgravii* in Brazil, with observations on its mycobiota. *Fungal Diversity* 23: 243-253.
- Peng, C.-I., Chung, K.-F. and Li, H.-L. (1998). *Compositae*. In: *Flora of Taiwan. Vol. 4* (ed. T.C. Huang). 2nd edn. Department of Botany, National Taiwan University, Taipei: 807-1101.
- Petrini-Klieber, L.E. (1985). *Untersuchungen über die Gattung Hypoxylon (Ascomycetes) und verwandte Pilze*, Ph D thesis, Eidgenössische Technische Hochschule Zürich Nr. 7729, Switzerland.
- Rai, A.N. and Kamal (1989). A new *Stenella* species from India. *Mycological Research* 93: 398-399.
- Rajak, R.C. (1981). A new species of *Stenella* from India. *Acta Botanica Indica* 9: 132-133.
- Schubert, K. and Braun, U. (2007). Taxonomic revision of the genus *Cladosporium* s. lat. 6. New species, reallocations to and synonyms of *Cercospora*, *Fusicladium*, *Passalora*, *Septonema* and *Stenella*. *Nova Hedwigia* 84: 189-208.
- Staples, G.W. and Yang, S.-Z. (1998). *Convolvulaceae*. In: *Flora of Taiwan. Vol. 4* (ed. T.C. Huang). 2nd edn. Department of Botany, National Taiwan University, Taipei: 341-384.
- Sydow, H. & Sydow, P. (1913). *Novae fungorum species – X*. *Annales Mycologici* 11: 254-271.
- Thaung, M.M. (1984). Some fungi of *Cercospora* complex from Burma. *Mycotaxon* 19: 425-452.
- Yokoyama, T. and Nasu, H. (2000). Materials for the fungus flora of Japan (54). *Stenella persicae*, a new species from peach. *Mycoscience* 41:91-93.

(Received 1 March 2007; accepted 27 March 2007)