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**Taxonomy of *Dactylella* complex and *Vermispora*. III. A new genus *Brachyphoris* and revision of *Vermispora***

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According to morphology and phylogenetic analyses of the ITS region, a new genus *Brachyphoris* is established for the very short conidiophored species previously included in the genus *Dactylella*, viz. *D. helminthodes*, *D. stenomeces*, *D. oviparasitica*, *D. tenuifusaria* and *D. brevistipitata*. A detailed delimitation of the genus *Vermispora* is also proposed. Five species are accepted in *Vermispora* including *Vermispora leguminacea* sp. nov. and one new combination, *Vermispora spermatophaga*. *Vermispora obclavata* is excluded from the genus.

**Keywords:** *Brachyphoris*, key, *Vermispora*.

**Introduction**

In studies on the *Dactylella* complex and *Vermispora*, three major clades were distinguished based on analysis of ITS sequences data (Fig. 1, Chen *et al.*, 2007). Species with very short conidiophores constitute a distinct group adjacent to the *Dactylella* and *Vermispora* clades (Chen *et al.*, 2007). Considering the molecular and morphological analysis, we introduced a new genus, *Brachyphoris* gen. nov.

The genus *Vermispora* was established by Deighton and Pirozynski (1972) with the type species *V. grandispora*, a parasite of the leaf-inhabiting *Irenopsis aciculosae* (*Meliolaceae*) in Sierra Leone. *Vermispora grandispora* was described with micronematous, septate, colourless, simple, and almost straight conidiophores which are slightly geniculate above the old conidial scars. Conidia are colourless, long cylindrical-fusiform, slightly curved and usually slightly sigmoid, mostly 5-8-septate without constrictions at the septa.

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Since the genus was proposed without a clear delimitation, the limits of *Vermispora* have been increasingly widened by various workers to accommodate species resembling the type species. Four species have been assigned to *Vermispora* including *V. grandispora* Deighton & Pirozynski (1972), *V. obclavata* V. Rao & de Hoog (1986), *V. fusarina* Burghouts & W. Gams (1989) and *V. cauveriana* Rajashekhar, Bhat & Kaveriappa (1991). Gams (1989) compared *V. fusarina* with *Dactylella oviparasitica* G.R. Stirling & R. Mankau. Liu *et al.* (2005) provided further insight into the relationship of *Vermispora fusarina*, *Dactylella oviparasitica* and *D. brevistipitata* B. Liu, Xing Z. Liu & W.Y. Zhuang through phylogenetic analyses of ITS sequences. The complicated relationship revealed that this whole complex requires further revision.

## Materials and methods

Strains examined in this study were tabulated in Chen *et al.* (2007). The materials and methods are the same as those used by Chen *et al.* (2007).

### ***Brachyphoris* J. Chen, L.L. Xu, B. Liu & X.Z. Liu, gen. nov.**

MycoBank: 510641

*Etymology*: The epithet refers to the very short conidiophores.

*Conidiophora* inconspicua, conidio vix longiora, simplicia vel interdum ramosa, vulgo solitaria vel paucis aggregata. Conidium unum vel interdum duo gerentia. *Conidia* hyaline, fusiformia vel filiformia, recta vel leviter curvata.

*Conidiophores* simple or occasionally branched, hyaline, very short, scarcely longer than conidia. Conidiophore mostly produces a single conidium, sometimes with two conidia. *Conidia* hyaline, smooth-walled, spindle-shaped, filiform or elongate fusoid, straight or slightly curved.

*Teleomorph*: *Hyalorbilia*.

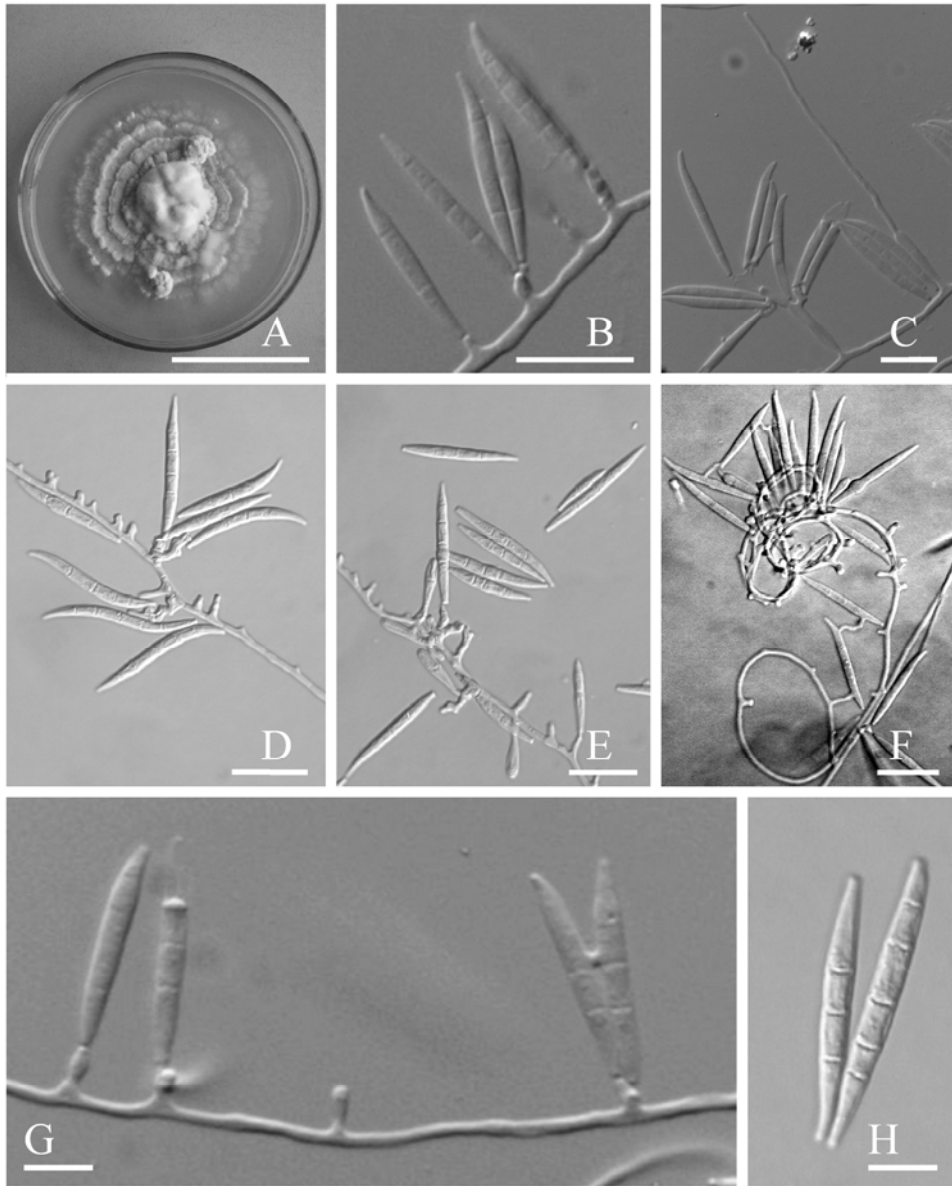
*Type species*: *Brachyphoris oviparasitica* (G.R. Stirling & R. Mankau) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu.

### ***Brachyphoris brevistipitata* (B. Liu, Xing Z. Liu & W.Y. Zhuang) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, comb. nov.** (Fig. 1)

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= *Dactylella brevistipitata* B. Liu, Xing Z. Liu & W.Y. Zhuang, Nova Hedwigia, 81: 145-155, 2005.

*Colonies* reaching 3.5 cm diam. after incubation at 25°C for 10 days on PDA, white, with irregular edge and aerial mycelium, reverse whitish; colonies reaching up to 4 cm diam. within 10 days on CMA, with sparser aerial mycelium than on PDA. *Hyphae* hyaline, septate, branched, 2.5-3 µm wide. *Conidiophores* simple or occasionally branched, hyaline, very short, 1.5-5 µm



**Fig. 1.** *Brachyphoris brevistipitata*. **A.** Colony on PDA. **B-G.** Conidiophores and conidia, conidia borne on short conidiophores. **H.** Conidia with 3 and 5 septa. Bars: A=5 cm, B-F = 20  $\mu$ m, G-H = 10  $\mu$ m.

long, 2-4  $\mu$ m wide at the base and 1.5-3  $\mu$ m at the apex. Conidiophores mostly producing a single conidium, sometimes with two conidia. *Conidia* occasionally aggregated, narrowly spindle-shaped, tapering evenly towards the

blunt apex and base, usually straight, occasionally slightly curved, especially at the apex, hyaline, smooth-walled, 3-5-septate,  $23\text{--}(39)\text{--}52 \times 3\text{--}(3.5)\text{--}4 \mu\text{m}$ .

**Habitat:** Decaying twigs of broad-leaved tree, rotten bamboo.

**Distribution:** China (Liu *et al.*, 2005).

**Material examined:** China, Beijing Province, Fragrance Mountain, 450 m altitude, on decaying twigs of broad-leaved tree, 24 June 2002, B. Liu 6167 (HMAS 86810, holotype).

**Notes:** *Brachyphoris brevistipitata* is similar to *B. oviparasitica* (G.R. Stirling & Mankau) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, *comb. nov.* and *B. helminthodes* (Drechsler) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, *comb. nov.*, while *B. oviparasitica* produces 5-9-septate conidia measuring  $40\text{--}(56)\text{--}65.5 \times 3.5\text{--}(4.5)\text{--}5 \mu\text{m}$  (Stirling and Mankau, 1978), *B. helminthodes* bears 7-septate and occasionally 8-septate conidia (Drechsler, 1952). Furthermore both *B. oviparasitica* and *B. helminthodes* are parasites, the former parasitizes eggs of *Meloidogyne*, and the latter subsists parasitically on oospores of *Pythium debaryanum* and zygospores of *Cochlonema megalosomum*. *Brachyphoris brevistipitata* did not show any capability of infecting nematode eggs or oospores. *Vermispora fusarina* is also similar to *Brachyphoris brevistipitata* in conidial shape, but its conidiophores are longer and conidia are more curved and slightly broader (Burghouts and Gams, 1989).

***Brachyphoris oviparasitica*** (G.R. Stirling & Mankau) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, **comb. nov.** (Fig. 2).

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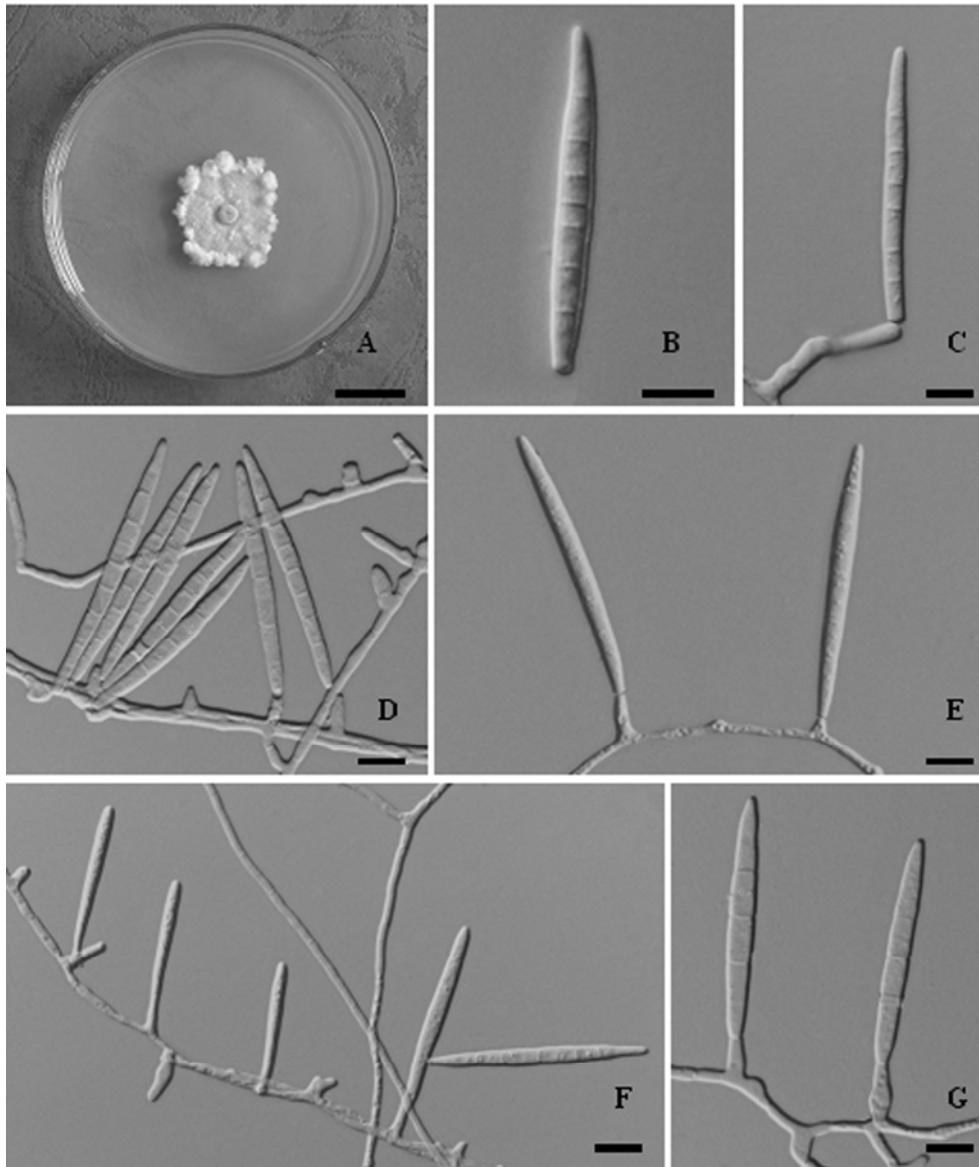
= *Dactylella oviparasitica* G.R. Stirling & Mankau, *Mycologia* 70: 777, 1978.

**Colonies** compact, fluffy or thickly cottony, reaching 2-2.5 cm diam. after incubation at 25°C for 15 days on PDA. Colonies on CMA produce sparser aerial mycelium than on PDA with the diam. of 5.5-6 cm. **Hyphae** hyaline, septate, flexuous and frequently branched, varying from 1.5-3.5  $\mu\text{m}$  in diam. **Conidiophores** hyaline, solitary, short, nonseptate, so that a single sporogenous cell functions as the conidiophore, 3-28  $\mu\text{m}$  long, 2.5-3  $\mu\text{m}$  wide at the base, tapering upwards to a width of 1-2  $\mu\text{m}$ . **Conidia** thin-walled, hyaline, fusiform, 5-9-septate,  $40\text{--}(56)\text{--}65.5 \times 3.5\text{--}(4.5)\text{--}5 \mu\text{m}$ .

**Habitat:** Eggs of *Meloidogyne*, eggs of *Globodera rostochiensis*.

**Distribution:** Netherlands, USA (Stirling and Mankau, 1978).

**Material examined:** Netherlands, Wageningen, Mierenbos, from eggs of *Globodera rostochiensis*, 9 June 1985, D. Hugo, CBS 347.85, CBS 348.85, CBS 349.85. USA, California, from nematode eggs, June 1984, R. Mankau, (BPI 418236, 418237, 418238); extype living culture in CBS 379.84.



**Fig. 2.** *Brachyphoris oviparasitica*. **A.** Colony on PDA. **B.** Conidia with 7 septa. **C-G.** Conidiophores and conidia, conidia borne on short conidiophores. Bars: A = 2 cm, B-G = 10  $\mu$ m.

*Notes:* Stirling and Mankau (1978) ascribed this species to *Dactylella* because *Dactylella* contained many species capable of utilizing nematodes as a food source. They considered however that the taxon lacked many characteristics of this group. According to our molecular analysis, species with

short conidiophores are quite different from other species in *Dactylella*, so we proposed a new genus *Brachyphoris* to accommodate them. It is interesting that species with parasitic ability interspersed among *Dactylella* and *Brachyphoris*, which partly accounts for the less taxonomic value of parasitic ability than trapping events.

Due to the rather special habitat, *Brachyphoris oviparasitica* requires relatively complex media for growth and sporulation. Stirling and Mankau (1978) tried a number of media including Czapek-Dox, Potato-dextrose, Soil-extract, Corn-meal, Glucose-peptone, YPSS and enriched YPSS for the culture of *B. oviparasitica*. Sporulation only occurred on Corn-meal and Enriched YPSS and on YPSS under the treatment of light. During our study, the fungus sporulated on Potato-dextrose agar after two weeks, and the CBS 347.85 culture sporulated better than others. May be the fungus has adapted to the saprotrophic life style after several transfers.

*Brachyphoris oviparasitica* resembles *Dactylella attenuata* R.H. Gao, Xing Z. Liu, L.P. Lei & T.F. Li, *B. helminthodes* and *B. brevistipitata*, however it differs from the former by its rather short conidiophores (Stirling and Mankau, 1978), the latter two species are more similar to *Brachyphoris oviparasitica* in conidial and conidiophore morphology, while conidia of *B. helminthodes* are longer and narrower (Drechsler, 1952). *Brachyphoris brevistipitata* produces conidia with less septum (Liu *et al.*, 2005).

***Brachyphoris tenuifusaria*** (Xing Z. Liu, R.H. Gao, K.Q. Zhang & L. Cao) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, **comb. nov.** (Fig. 3)  
MycoBank: 510643

= *Dactylella tenuifusaria* Xing Z. Liu, R. H. Gao, K.Q. Zhang & L. Cao, Mycological Research 100: 236, 1996.

*Colonies* on PDA buff to hazel, very slow-growing, extending to a diam. of 2 cm within 1 month at 25°C, producing sparse aerial mycelium. *Hyphae* hyaline, septate, creeping, rather scantily branched. *Conidiophores* usually in small groups or borne singly, hyaline, erect, branched, septate, 8-(35)-67 µm in length, 1-(2)-4 µm wide at the base, frequently with several branches, 4-34.5 × 1.5-3 µm. *Conidia* hyaline, elongate-fusoid, tapering toward the tail-like apex, 88-(102)-113 × 4-(5.5)-6 µm, frequently 10-13-septate.

**Habitat:** Soil. Capture and consume testaceous rhizopods.

**Distribution:** China (Liu *et al.*, 1996).

**Material examined:** China, Guizhou Province, Fanjing Mountain, 1770 m altitude, from forest soil, 25 June 1994, X.Z. Liu, (HMAS 70427, holotype); extype living culture in CBS 617.95.



**Fig. 3.** *Brachyphoris tenuifusaria* (HMAS 70427). **A, C.** Conidia. **B.** Hyphae with captured rhizopods. Bars: A-C = 20  $\mu$ m.

*Notes:* *Brachyphoris tenuifusaria* is a special species that can capture and consume rhizopods through outgrowth from the hyphae (Liu *et al*, 1996). Regrettably isolate CBS617.95 could not sporulate. So we can only get limited information through specimen. *Brachyphoris tenuifusaria* is similar to *B. helminthodes* and *B. oviparasitica* in conidial morphology, while *B.*

*helminthodes* and *B. oviparasitica* have shorter conidia, 40-(56)-65.5 × 3.5-(4.5)-5 μm (Drechsler, 1952) and 53-(67)-84 × 2.5-(3)-4 μm (Stirling and Mankau, 1978) respectively.

### Key to *Brachyphoris* species

1. Conidia less than 15-septate.....2
1. Conidia up to 22-septate .....*Brachyphoris stenomeces*
  
2. Conidia no more than 5-septate.....*Brachyphoris brevistipitata*
2. Conidia 5-15-septate .....3
  
3. Conidia foot-like at the base, capture and consume rhizopod.....*Brachyphoris tenuifusaria*
3. Conidia rounded at both end .....4
  
4. Conidia 4-9-septate, 40-(56)-65.5 × 3.5-(4.5)-5 μm .....*Brachyphoris oviparasitica*
4. Conidia mainly 7-septate, 53-(67)-84 × 2.5-(3)-4 μm.....*Brachyphoris helminthodes*

***Vermispora*** Deighton & Pirozynski, Mycological Papers 128: 87, 1972.

*Colonies* white to salmon. *Hyphae* colourless, septate, branched. *Conidiophores* borne as lateral branches of the mycelial hyphae, colourless, simple, smooth, thin-walled, slightly geniculate above the old conidial scars. Conidial scars inconspicuous, truncate, unthickened. *Conidia* colourless, long cylindrical to fusiform, obclavate or elongate fusoid, smooth, thin-walled, slightly curved and usually slightly sigmoid.

*Type species: Vermispora grandispora* Deighton & Pirozynski

***Vermispora fusarina*** Burghouts & W. Gams, Memoirs of The New York Botanical Garden 49: 58, 1989 (Fig. 4)

*Colonies* on PDA white to light yellow with abundant aerial mycelium, growing slowly, reaching 2.4 cm diam. after incubation at 25°C for 15 days. *Vegetative hyphae* hyaline, branched, 2-3 μm wide. *Conidiophores* not differentiated from the vegetative hyphae, arising mostly as lateral branches, proliferating repeatedly at some distance from the apex in a sympodial manner, 17-80 μm long, 2.5-3 μm wide near the base, ending in a broadly truncate scar 1.5-2.5 μm diam. *Conidia* hyaline, fusiform, curved and slightly beaked at the apex, 2-4 (mainly 3)-septate, 31-(41)-45 × 4-(4.5)-5 μm. *Chlamydospores* absent.

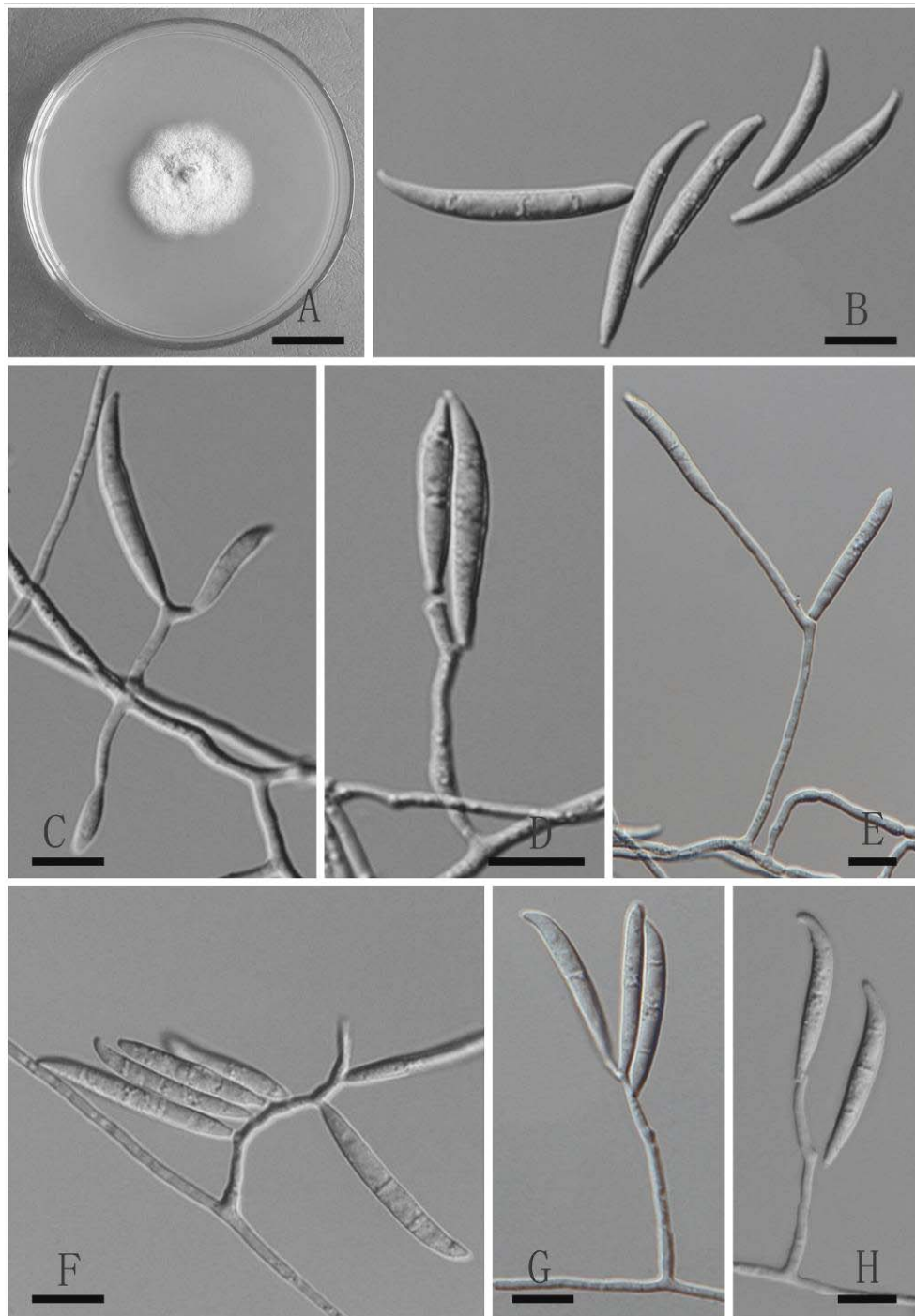
*Habitat:* Egg of *Globodera pallida*.

*Distribution:* Netherlands (Burghouts and Gams, 1989).

*Material examined:* Netherlands, Assen, from egg of *Globodera pallida*, January 1984, Th. Burghouts, CBS 382.84, CBS 383.84A, CBS 383.84B.

*Notes:* *Vermispora fusarina* resembles *Vermispora grandispora* Deighton & Pirozynski in its slightly curved, elongate fusiform conidia, while





**Fig. 4.** *Vermispora fusarina*. **A.** Colony on PDA. **B.** Conidia. **C-H.** Conidiophores and conidia. Bars: A = 2 cm, B-H = 10  $\mu$ m.

the conidia of *V. fusarina* appear shorter than those of *V. grandispora* (Deighton and Pirozynski, 1972).

***Vermispora grandispora*** Deighton & Pirozynski, Mycological Papers 128: 87, 1972 (Fig. 5)

*Conidiophores* borne as lateral branches of the mycelial hyphae, almost colourless, simple, smooth, thin-walled, substraight, slightly geniculate above at the old conidial scars, 22-55 µm long, 3.5-4 µm wide near the base diminishing gradually to about 2.5 µm wide towards the apex, septate and with a basal septum. Conidial scars about 1.5 µm diam., unthickened. *Conidia* almost colourless, long cylindrical-fusiform, smooth, thin-walled, slightly curved and usually slightly sigmoid, with an acute curved apex and a truncate unthickened hilum about 1.5 µm diam., when mature 5-8-septate, not constricted, 73-96 × 4.5-5 µm.

*Habitat:* Overgrowing *Irenopsis aciculosa* on *Sida urens*.

*Distribution:* Sierra Leone (Deighton and Pirozynski, 1972).

*Specimen examined:* Sierra Leone, Bumpe, overgrowing *Irenopsis aciculosa* on *Sida urens*, 30 October 1949, F.C. Deighton, IMI 40258b.

*Notes:* As type species of *Vermispora*, *V. grandispora* can be distinguished from other species in *Vermispora* through its much longer conidia (Deighton and Pirozynski, 1972).

***Vermispora leguminacea*** J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, **sp. nov.**  
Mycobank: 510346 (Fig. 6)

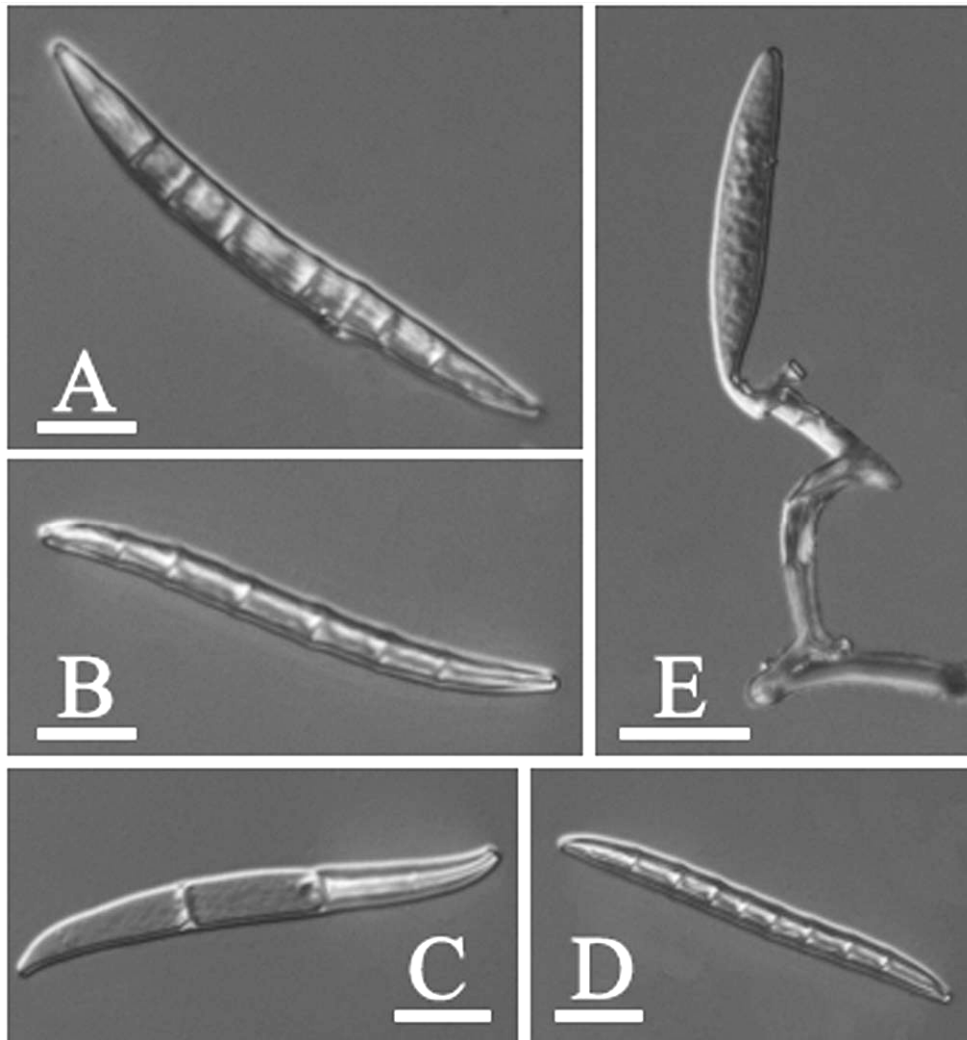
*Coloniae* lente crescentes, albae, copiose sporulantes, hyphae hyalinae, septatae, ramosae. *Conidiophora* erecta, flexuosa, ramosa vel non ramosa, hyalina, sursum geniculata, 26-(52)-104 µm longa, basi 1.5-3 µm crassa, apice 1-1.5 µm crassa. *Conidia* cylindrico-fusiformia, leniter curvata, 1-5-septata, plerumque 3-septata, 20-(17.5)-34 × 4-(4.5)-5 µm.

*Colonies* on PDA growing slowly, reaching 1.2-1.5 cm diam. after incubation at 25°C for 10 days, white, finely powdery due to conidium formation. After about 20 days, the colony slight brown, felty with sparse aerial mycelium. *Vegetative hyphae* hyaline, branched, 1.5-3 µm wide. *Conidiophores* simple, smooth, substraight, slightly geniculate, proliferate successively from the apex, 26-(52)-104 µm long, 1.5-3 µm wide near the base diminishing gradually to 1-1.5 µm wide towards the apex. *Conidia* hyaline, cylindrical-fusiform, pod-shaped, slightly curved, 1-5 (mainly 3)-septate, 20-(17.5)-34 × 4-(4.5)-5 µm.

*Habitat:* Soil.

*Distribution:* China.

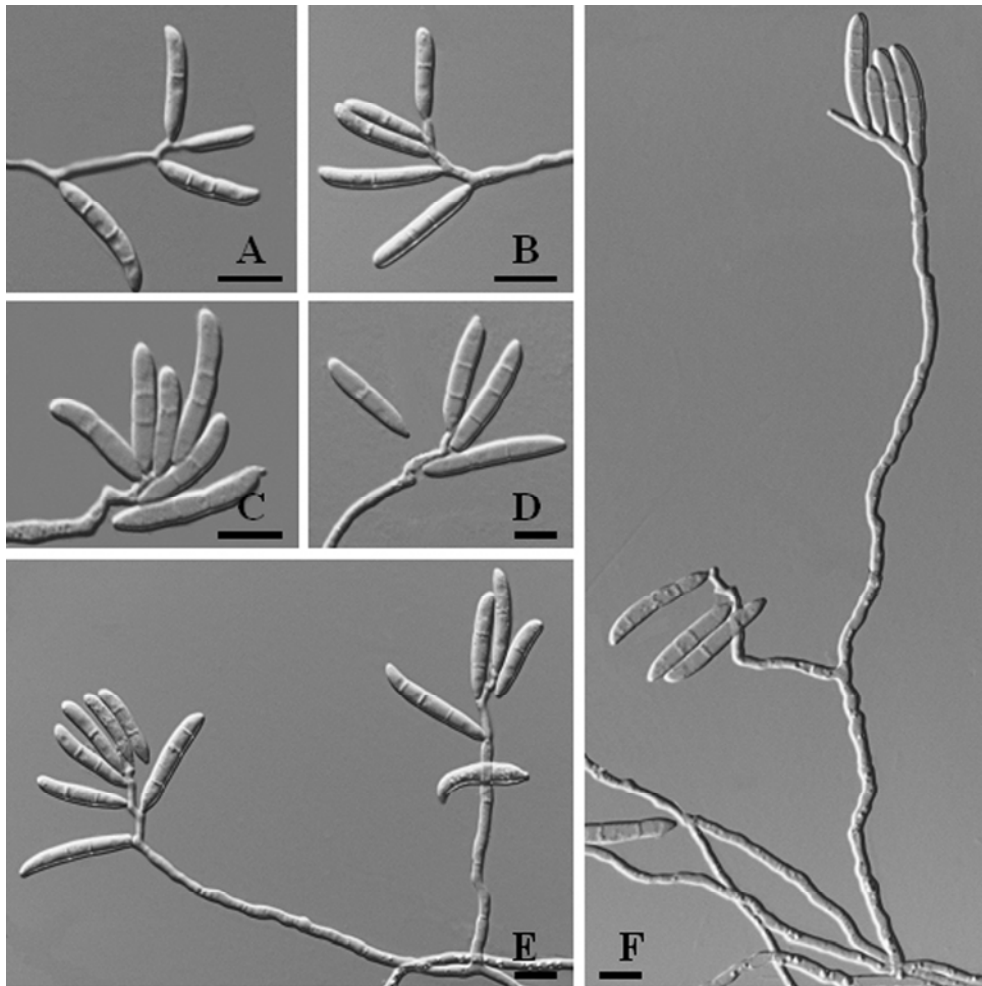
*Holotype:* China, Fujian Province, from Soil, 2003, X.Z. Liu, AS 6.0291. Specimen deposited in Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, HMAS 140512.



**Fig. 5.** *Vermispora grandispora*. **A-D.** Conidia. **E.** Conidiophore with a conidium. Bars: A-E = 15  $\mu$ m.

*Paratype:* China, Fujian Province, from Soil, 2003, X.Z. Liu, AS 6.0290. Specimen deposited in Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, HMAS 140513.

*Notes:* *Vermispora leguminacea* is characterized by its pod-shaped conidia. This species resembles *V. grandispora* (Deighton and Pirozynski, 1972), *V. fusarina* (Burghouts and Gams, 1989) and *V. spermatophaga* (Drechsler) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, comb. nov. (Drechsler, 1938) in conidial shape and septate, but can be distinguished via the smaller



**Fig. 6.** *Vermispora leguminacea* sp. nov.. **A-F.** Conidiophores and conidia. Bars: A-F = 10 µm.

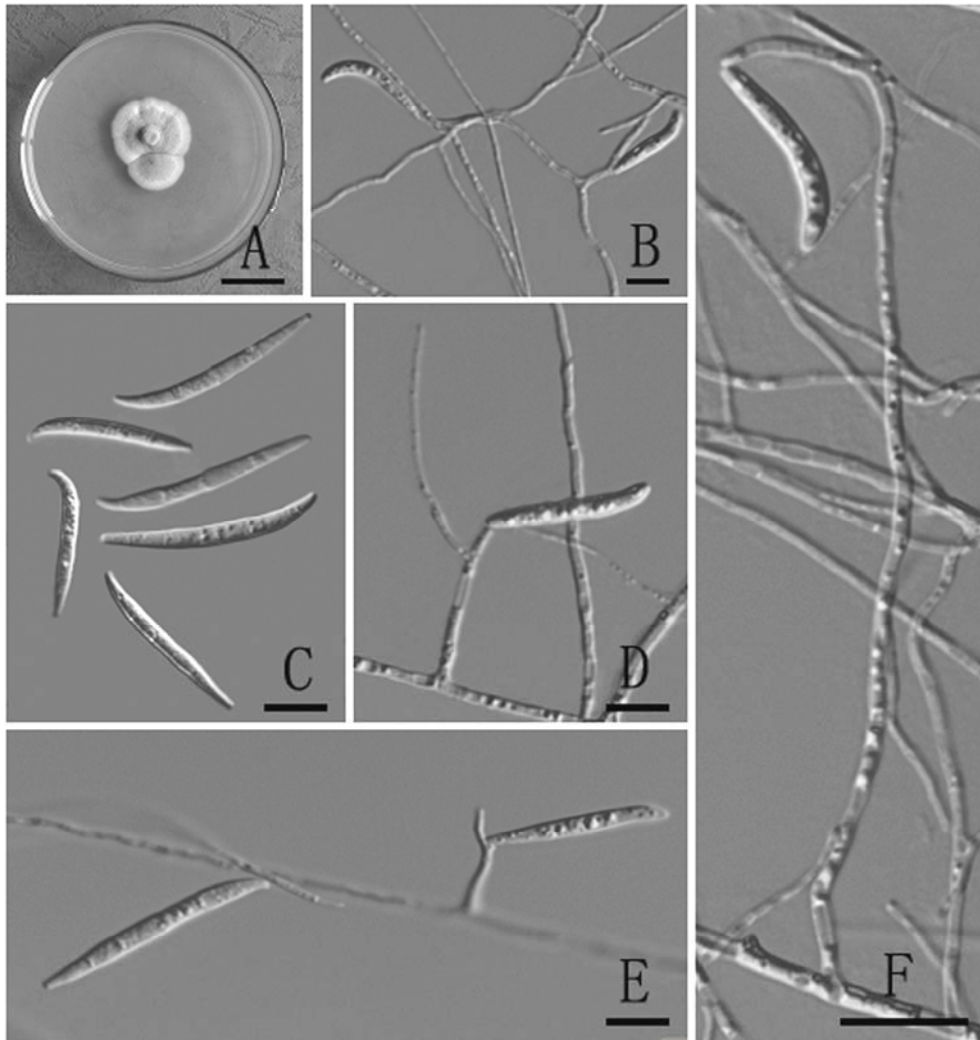
conidia 20-(17.5)-34 × 4-(4.5)-5 µm. The ITS region phylogeny also proved its difference with similar species (Fig. 1 Chen *et al.*, 2007).

***Vermispora spermatophaga*** (Drechsler) J. Chen, L.L. Xu, B. Liu & Xing Z. Liu, **comb. nov.** (Fig. 7)

MycoBank: 510645

= *Dactylella spermatophaga* Drechsler, *Phytopathology* 28: 91, 1938.

*Colonies* white to grey, compact with irregular edge, slow growing, reaching 1.5-2 cm in diam. after incubation at 25°C for 15 days. *Mycelium* abundantly branched. *Vegetative hyphae* hyaline, weak, 1-2 µm wide, flexuous,

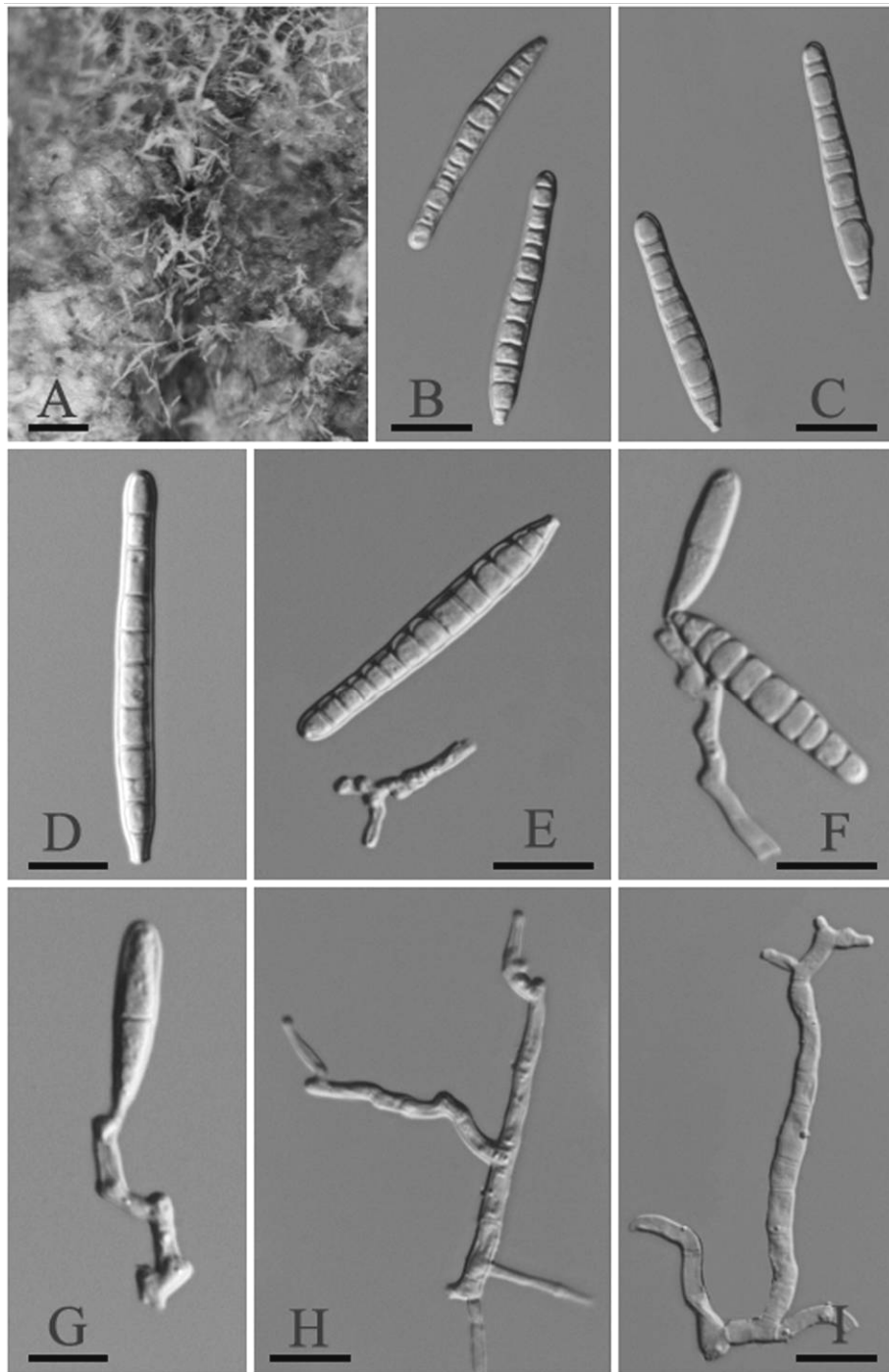


**Fig. 7.** *Vermispora spermatophaga* comb. nov.. **A.** Colony on PDA. **C.** Conidia. **B, D-F.** Conidiophores and conidia. Bars: A = 2 cm, B-F = 15  $\mu$ m.

septate. *Conidiophores* hyaline, septate, simple or somewhat branched, slightly geniculate, commonly 27-64  $\mu$ m high, 3-4  $\mu$ m wide at the base, tapering upwards to a width of 1-1.5  $\mu$ m at the apex. *Conidia* hyaline, elongate spindle-shaped, roundly truncate at the base, narrowly rounded at the apex, straight or slightly curved in the apex, 2-4 (mainly 3)-septate, 25-(45)-50  $\times$  3.5-(5)-5.5  $\mu$ m.

*Habitat:* Decaying plant remains, Soil.

*Distribution:* USA (Drechsler, 1938).



**Fig. 8.** *Vermispora obclavata*. **A.** Conidia and conidiophores on decayed wood. **B-D.** Conidia. **E-G.** Conidiophores and conidia. **H-I.** Conidiophores. Bars: A = 200  $\mu\text{m}$ , B-F, H-I = 20  $\mu\text{m}$ . G = 15  $\mu\text{m}$ .

*Material examined:* USA, Michigan, East Lansing, from oospore of *Phytophthora megasperma* var. *sojae*, 1976, B. Sneh, CBS 255.76.

*Notes:* *Dactylella spermatophaga* accommodate *Vermispora* well in elongate spindle-shaped, slightly curved conidia as well as geniculate conidiophores (Drechsler, 1938) so we included this fungus in *Vermispora* as *Vermispora spermatophaga*. *Vermispora spermatophaga* resembles *V. fusarina* in conidial morphology while conidia of *V. fusarina* slightly broaden at the hilum and gradually tapering to the beaked apex (Burghouts and Gams, 1989).

***Excluded species***

*Vermispora obclavata* V. Rao & de Hoog, Studies in Mycology 28: 53, 1985. (Fig. 8)

The subhyaline, usually irregularly verrucose conidiophores as well as conidia with rather firm walls do not agree with this genus.

***Key to Vermispora species***

- 1. Conidia more than 5-septate.....2
- 1. Conidia mainly 3-septate.....3
- 2. Conidia can produce small microconidia ..... *Vermispora cauveriana*
- 2. Microconidia absent, conidia 5-8-septate.....*Vermispora grandispora*
- 3. Conidia pod-shaped, 20-(17.5)-34 × 4-(4.5)-5 μm..... *Vermispora leguminacea*
- 3. Conidia fusiform or elongate fusiform.....4
- 4. Conidia slightly broaden at the hilum and gradually tapering to the beaked apex.....
- ..... *Vermispora fusarina*
- 4. Conidia roundly truncate at the base, ..... *Vermispora spermatophaga*

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