Two new species of *Stachybotrys*, and a key to the genus

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Stachybotrys palmae sp. nov. found on decaying petioles of *Licuala longicalycata* in a peat swamp forest, Thailand, and *S. cordylines* sp. nov. found on decaying leaves of *Cordyline banksii* in New Zealand are described and illustrated. The new species are compared with other species in the genus, and a key is provided to all accepted species of *Stachybotrys*. A new name, *S. thermotolerans*, is proposed for *S. ramosa* Udaiyan, a later homonym of *S. ramosa* Dorai & Vittal. A list of accepted *Stachybotrys* species with references is provided.

Key words: anamorphic fungi, hyphomycetes, monocotyledonous plants, palm fungi.

Introduction

We are studying fungi occurring on monocotyledonous plants (e.g. Hyde *et al*., 2002; McKenzie *et al*., 2002; Yanna *et al*., 2002; Zhou and Hyde, 2002). In this paper we describe two new species of *Stachybotrys*. The first species was found in Thailand on decaying petioles of *Licuala longicalycata* Furtado, a tropical palm species. The second species occurred on *Cordyline banksii* Hook. f., a New Zealand species of *Laxmanniaceae*. *Stachybotrys* species are saprobes, common in soil (Ellis, 1971, 1976), decaying plant material (Whitton *et al*., 2001) and wild fruits (Tang *et al*., 2003) and have also been recorded on submerged wood in mangroves (Maria and Sridhar, 2003). They produce single-celled conidia aggregated in slimy heads. The genus is worldwide in distribution although some species are restricted to the tropics and subtropics. More than 50 species of *Stachybotrys* are accepted, including those species formerly included in the genus *Memnoniella*. The new species are described and compared with similar species.

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Materials and methods

Decaying fronds of *Licuala longicalycata* were collected from Sirindhorn Peat Swamp Forest, Narathiwat, Thailand, and decaying leaves of *Cordyline banksii* were collected from the Waitakere Ranges, Auckland, New Zealand. The decaying tissues were returned to the laboratory and incubated in damp chambers. Single spore isolates of both fungi were obtained. Microscopic measurements for *S. palmae* were taken from specimens mounted in water while those for *S. cordylines* were taken from specimens mounted in lactophenol.

Taxonomy

Stachybotrys palmae Pinruan, **sp. nov.** (Figs. 1-5)

Etymology: referring to its association with palms.

Conidiophora macronematosa, mononematosa, solitaria vel fasciculata, eramosa, erecta, recta vel paulo flexuosa, laevia, 2-5 septata, brunnea, pallidae ad apicem, crassitunicata, (80-)110-230 µm longa, 6.3-10 µm crassa. *Cellulae conidiogenae* monophialidicae, discretae, 5-7 in verticillo dispositae, clavatae, 11-12.5 × 6-7.5 µm, laevae, hyalinae. *Conidia* in massis globosis aggregata, ellipsoidea, hyalina, verrucosa, 10-15 × 5-7.5 µm; apice et basi truncata.

Conidiophores macronematous, mononematous, single or in groups, unbranched, erect, straight or slightly flexuous, smooth, 2-5 septate, brown, apical cell hyaline, thick-walled, (80-)110-230 µm long, 6.3-10 µm wide. *Conidiogenous cells* monophialidic, discrete, determinate, clavate, smooth, hyaline, forming a whorl of 5-7 at the apex of the conidiophores, 11-12.5 µm long, 6-7.5 µm thick in the broadest part. *Conidia* aggregated in pale cream slimy heads, ellipsoidal or boat-shaped, truncate at the base and apex, hyaline, verrucose, non-septate, 10-15 × 5-7.5 µm ($\bar{x}$ = 13 × 7 µm, n = 20).

Habitat: Saprobic on *Licuala longicalycata*.

Distribution: Thailand.

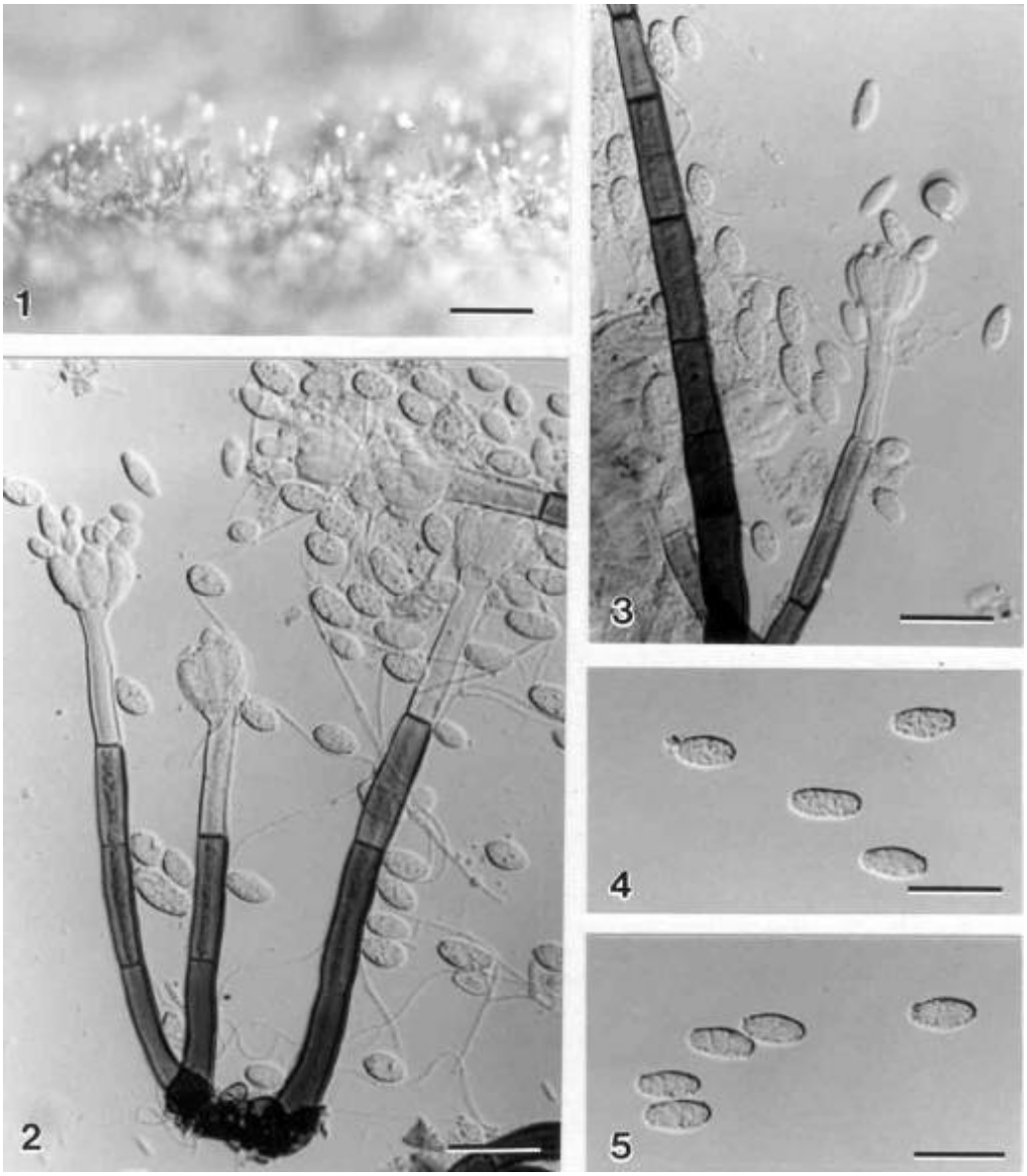
Material examined: THAILAND, Narathiwat, Sirindhorn Peat Swamp Forest, on decaying rachis of *Licuala longicalycata* Furtado, 12 May 2001, U. Pinruan (Wah 35) [BIOTEC Bangkok Herbarium (BBH), **holotype**].

Notes: *Stachybotrys palmae* is one of only five species of *Stachybotrys* that produce hyaline conidia. Of these, *S. palmae* is the only species with rough-walled conidia. Those of the other four species (*S. bambusicola* Rifai, *S. bisbyi* (Sriniv.) G.L. Barron, *S. guttulispora* Muhsin & Al-Helfi, *S. palmijunci* Rifai) are smooth-walled.

Stachybotrys cordylines McKenzie, **sp. nov.** (Figs. 6-13)

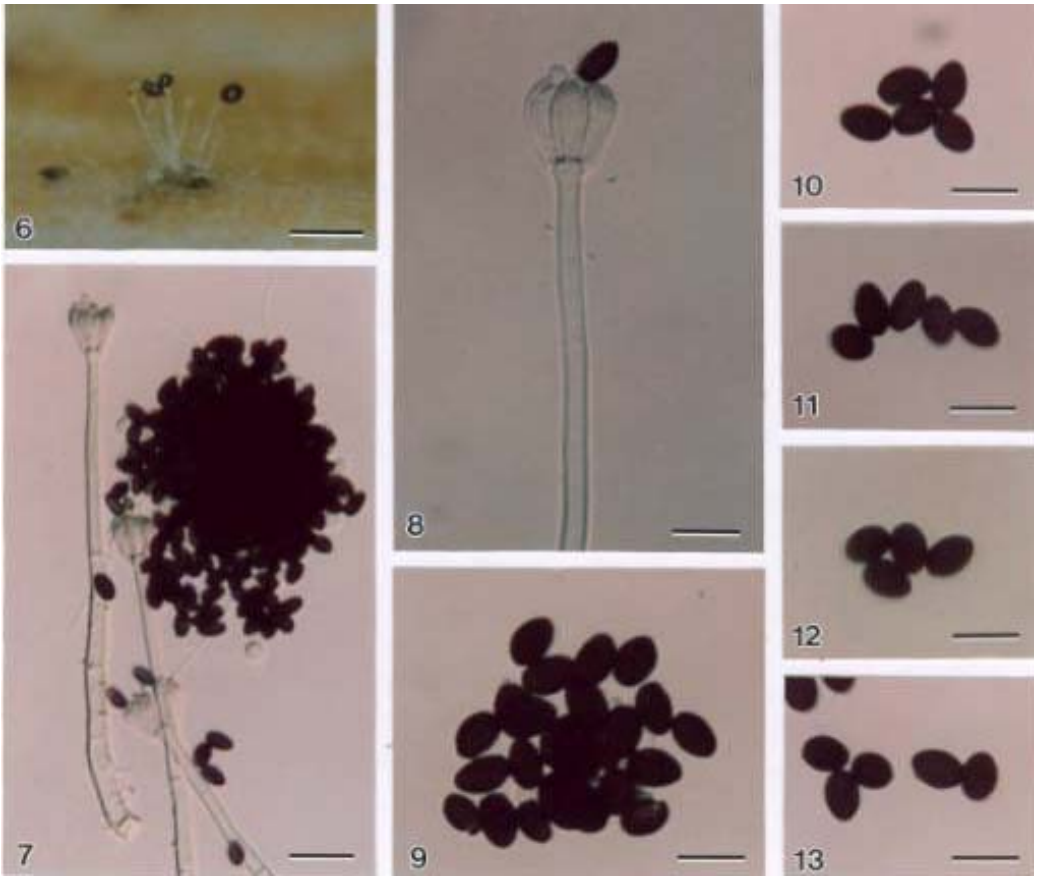
Etymology: referring to the host genus *Cordyline*.

Conidiophora macronematosa, mononematosa, solitaria, eramosa, erecta, recta vel paulo flexuosa, laevia, interdum granulis magnis tecta, 4-7 septata, hyalina, crassitunicata, 95-



Figs. 1-5. Light micrographs of *Stachybotrys palmae* (from holotype). **1.** Colonies on substratum. **2, 3.** Conidiophores with pale apical cell. **4, 5.** Conidia. Bars: 1 = 200 µm; 2-5 = 20 µm.

160 µm longa, basi 5.8-8 µm, prope apicem 3-4.2 µm, apice inflata 3.5-5.1 µm diam. *Cellulae conidiogenae* monophialidicae, discretae, 7-8 in verticillo dispositae, clavatae, 11-14(-16) × 3.8-5.4 µm, laevae, hyalinae. *Conidia* in massis globosis aggregata, ellipsoidea vel obovoidea, olivacea, rugulosa, eseptata, 7-8.3 × 3.2-5.1 µm.



Figs. 6-13. Light micrographs of *Stachybotrys cordylines* (from holotype). **6.** Colonies on substratum. **7, 8.** Conidiophores. **9-13.** Conidia. Bars: 6 = 150 µm; 7 = 20 µm; 8-13 = 10 µm.

Conidiophores macronematous, mononematous, single, unbranched, erect, straight or slightly flexuous, smooth or sometimes covered with a few large granules near the base, 4-7 septate, hyaline, thick-walled, 95-160 µm long, 5.8-8 µm thick near the base, tapering to 3-4.2 µm near the apex, slightly enlarged at the apex to 3.5-5.1 µm thick and bearing a whorl of 7-8 phialides. *Conidiogenous cells* monophialidic, discrete, clavate, 11-14(-16) µm long, 3.8-5.4 µm thick in the broadest part, smooth, hyaline. *Conidia* aggregated in slimy, black, glistening heads, ellipsoid or obovoid, olive green, rugulose, non-septate, 7-8.3 × 3.2-5.1 µm ($\bar{x}$ = 7.6 × 4.5 µm, n = 20).

Habitat: Saprobic on *Cordyline banksii*.

Distribution: New Zealand.

Material examined: NEW ZEALAND, Auckland, Waitakere Ranges, near Spraggs Bush, on dead leaves of *Cordyline banksii* Hook. f., 4 Aug 2003, R.E. Beever [PDD 78085, **holotype**]. Culture ex holotype [ICMP 15219].

The conidia of *S. cordylines* are similar in size and shape to those of *S. albipes*. However, the latter fungus has smooth conidia, whereas those of *S. cordylines* are rugulose. It differs from *S. chartarum* by having hyaline conidiophores; those of *S. chartarum* are dark olivaceous towards the apex.

Stachybotrys thermotolerans McKenzie, **nom. nov.**

≡ *Stachybotrys ramosa* Udaiyan, Journal of Economic and Taxonomic Botany 15: 641, 1991[1992], nom. illegit., non Dorai & Vittal, Transactions of the British Mycological Society 87: 642, 1986[1987].

Notes: Udaiyan (1991) described several new species of hyphomycetes that were isolated from water-cooling towers. The *Stachybotrys* was stated to have an optimum temperature for growth of 43ºC. Udaiyan (1991) called this fungus a 'thermophile', but gave insufficient data to equate to the definition of a thermophile (Mouchacca, 1997).

Discussion

Memnoniella and *Stachybotrys* have been considered distinct genera (e.g., Ellis, 1971, 1976). However, the only difference between these two genera is that the conidia are in long, dry chains in *Memnoniella* while they are in slimy masses in *Stachybotrys*. Some authors have considered this is not a valid generic distinction and have suggested the two genera be combined under the older name of *Stachybotrys* (e.g. Smith, 1962; Carmichael *et al*., 1980). This is supported by the molecular results of Haugland *et al*. (2001). All accepted species of *Stachybotrys* and *Memnoniella* are included in the following key. Synonyms have mainly followed those listed by Jong and Davis (1976). However, their synonymy of *S. sinuatophora* Matsush. with *S. nephrospora* Hansf. has not been accepted. A recently collected specimen (PDD 77554, on dead stems of *Abelmoschus esculentus*, Fiji) matched the description of *S. sinuatophora*. The conidiophores are distinctly sinuous, and quite unlike those of *S. nephrospora*. The four remaining species of *Memnoniella* (*M. indica*, *M. leprosa*, *M. longistipitata* and *M. levispora*) should probably be transferred to *Stachybotrys*, following molecular analysis.

Key to the accepted species of *Stachybotrys*

1. Conidia when mature roughened, or surface ridged or banded, or with delicate striations .2
1. Conidia when mature smooth 39

2. Conidial surface ridged, banded, striate or rugulose.....3
2. Conidia rough-walled 6

3. Conidia cylindrical, with delicate, oblique striations, 11-16 × 4-6 µm .....***S. cylindrospora***
3. Conidia ellipsoid.....4

4. Conidia with a ridged surface, 12-13 × 5-5.5 µm.....***S. virgata***
4. Conidia less than 12 µm long 5

5. Conidia with a ridged or banded surface, 7-12 × 4-6 µm .....***S. chartarum***
5. Conidia with a rugulose surface, 7-8.3 × 3.2-5.1 µm .....***S. cordylines***

6. Conidiophores synnematous.....7
6. Conidiophores mononematous 8

7. Conidia subglobose, 7-12 µm diam., apex black, base pale .....***Memnoniella leprosa***
7. Conidia globose, 4-5.5 µm diam .....***S. stilboidea***

8. Conidia produced in dry chains, sometimes also in slimy heads.....9
8. Conidia aggregated in slimy heads.....14

9. Conidia regularly of two kinds; catenate and globose, 5-5.5 µm diam.; non-catenate and cylindrical, 7-10 × 3.5-5 µm.....***S. zuckii***
9. Conidia mainly of only one kind 10

10. Conidiophores regularly branched, tapering to a slender, pointed apex; conidia globose, 5-6 µm diam.....***Memnoniella indica***
10. Conidiophores not tapering towards apex 11

11. Conidiophores (170-)260-460(-610) µm long, unbranched; conidia catenate and globose or subglobose, 5.8-8.5 × 6.3-8.3 µm; rarely producing cylindrical or ovoid conidia in slimy heads, 10.6-11.9 × 4.8-5.7 µm..... ***Memnoniella longistipitata***
11. Conidiophores shorter.....12

12. Conidia globose to subglobose, 3-5 µm diam.; rarely producing cylindrical conidia in slimy heads, 7-9 × 3-5 µm.....***S. echinata***
12. Conidia larger 13

13. Conidia globose, 5-7 µm diam .....***S. subsimplex***
13. Conidia globose, 7-8 µm diam .....***Stachybotrys* sp.** (Haugland *et al*., 2001)

14. Conidia mainly globose or subglobose.....15
14. Conidia mainly of other shapes 20

15. Conidia more than 10 µm diam 16
15. Conidia mostly less than 10 µm diam.....17

16. Conidia 11-12 µm diam.....***S. sphaerospora***
16. Conidia (15.4-)21-25.2(-28) µm diam..... ***S. nilagirica***

17. Conidiophores regularly sympodially branched; conidia 4.5-8 µm diam.....***S. globosa***
17. Conidiophores not regularly sympodially branched.....18

18. Conidia 5-6 µm diam.....***S. microspora***
18. Conidia more than 6 µm diam.....19

19. Conidia 6-8 µm diam.; conidiophores (40-)70-90 µm long.....***S. ruwenzoriensis***
19. Conidia 7.5-10.5 × 7-10.5 µm; conidiophores 58-272 µm long.....***S. kapiti***

20. Conidia reniform or curved.....21
20. Conidia not reniform.....25

21. Conidia tightly reniform, (11-)13-15(-15.5) × (10.5-)12-14 µm.....***S. nephrodes***
21. Conidia less than 10 µm wide.....22

22. Conidiophores distinctly sinuous, branched; conidia 8-12 × 6-7 µm.....***S. sinuatophora***
22. Conidiophores not sinuous.....23

23. Conidia strictly kidney-shaped, 10-13.5 × 6-9.5 µm; phialides 10-14 × 5-6 µm; conidiophores smooth, 86-137 µm long.....***S. reniverrucosa***
23. Conidia more variable, not strictly kidney-shaped.....24

24. Conidia reniform or comma-shaped, 8-12 × 4-6(-7) µm; phialides smooth, 10-12 × 5-6 µm; conidiophores smooth or roughened, up to 400 µm long.....***S. nephrospora***
24. Conidia ovoid to reniform, 9-12 × 4.5-8 µm; phialides smooth or verruculose, 10-21 × 4-7 µm; conidiophores smooth, up to 190 µm long.....***S. oenanthes***

25. Conidia usually more than 10 µm long.....26
25. Conidia usually less than 10 µm long.....32

26. Conidia more than 8 µm wide.....27
26. Conidia less than 8 µm wide.....28

27. Conidia ellipsoid or obovoid, 10-15 × 9.5-11(-12.5) µm; conidiophores 80-235 µm long.....***S. verrucispora***
27. Conidia ellipsoid to broadly ellipsoid, 14.5-19 × 8-11.5 µm; conidiophores 54-75 µm long.....***S. waitakere***

28. Conidia cylindrical or ellipsoid; conidiophores sometimes branched.....29
28. Conidia ellipsoid or navicular; conidiophores not branched.....30

29. Conidia cylindrical, (10-)11-13(-15) × (3.5-)4-4.5(-5.3) µm; conidiophores up to 320 µm long.....***S. freycinetiae***
29. Conidia ellipsoid or cylindrical, 10-19 × 5-6.5 µm; conidiophores 120-260 µm long.....***S. xanthosomae***

30. Conidia hyaline, ellipsoid or navicular, 10-15 × 5-7.5 µm; conidiophores smooth, 80-230 µm long.....***S. palmae***
30. Conidia dark-coloured.....31

31. Conidiophores warted, up to 100 µm long; conidia ellipsoid, 12-13 × 5-5.5 µm..***S. virgata***
31. Conidiophores smooth, up to 180 µm long; conidia ellipsoid, 10-15 × 6-8 µm..... .....***S. kampalensis***

32. Conidia more than 5 µm wide 33
32. Conidia usually less than 5 µm wide 34

33. Conidia ellipsoid or ovoid, 7.5-10(-14) × 5-7 µm; conidiophores up to 270 µm long ....***S. dichroa***
33. Conidia ellipsoid, 7-9 × 6 µm; conidiophores 45-50 µm long.....***S. klebahnii***

34. Conidia biguttulate, oblong, (5.5-)6-8 × 3-4 µm .....***S. queenslandica***
34. Conidia without guttules.....35

35. Conidiophores often branched, up to 130 µm long; conidia cylindrical or ellipsoid, 6.5-9.5 × 2-3.5 µm ..... ***S. breviuscula***
35. Conidiophores unbranched or rarely branched 36

36. Conidiophores smooth, up to 200 µm long; conidia ellipsoid, 3-6 × 2.5-3.5 µm; phialides 7-11 × 3-4 µm.....***S. parvispora***
36. Conidiophores less than 100 µm long 37

37. Conidia ovoid or ellipsoid, 5-8 × 2.5-3.5 µm; phialides 5.5-11 × 2.5-3 µm; conidiophores verrucose, 63-95 µm long.....***S. mangiferae***
37. Conidia usually wider.....38

38. Conidia ellipsoid, 7-9 × 3.5-4.5 µm; phialides 9-11 × 4-5 µm; conidiophores smooth, hyaline, 48-85 µm long..... ***S. zeae***
38. Conidia ellipsoid or cylindrical, 7-9 × 3-6 µm; phialides 7.5-11 × 3 µm; conidiophores smooth or verrucose, pale brown, darker towards apex, 48-94 µm long..... ***S. suthepensis***

39. Conidia produced in dry chains, subglobose, 4-6 µm diam.....***Memnoniella levispora***
39. Conidia aggregated in slimy heads 40

40. Conidia reniform or curved 41
40. Conidia not reniform or curved 43

41. Conidiophores not proliferating or branched; conidia 4.5-7 × 3-4.5 µm.... ***S. renisporoides***
41. Conidiophores proliferating or branched.....42

42. Conidiophores proliferating through apex; conidia 5.5-7 × 4-5 µm.....***S. proliferata***
42. Conidiophores sympodially proliferating or branching; conidia 5.2-7 × 3.5-5.2 µm..... .....***S. renispora***

43. Conidia usually more than 14 µm in length.....44
43. Conidia usually less than 14 µm in length.....46

44. Conidia broadly ellipsoid, 16-28 × 12-17 µm, with a basal apiculus .....***S. theobromae***
44. Conidia smaller, without an apical apiculus 45

45. Conidia cylindrical-clavate or ellipsoid, pale brown, 14.5-17.5 × 6.5-11 µm ..... ***S. cannae***
45. Conidia ellipsoid, hyaline, 13.8-18.4 × 4-5.8 µm ..... ***S. palmijunci***

46. Conidia fusiform or limoniform 47
46. Conidia of other shapes 48

47. Conidia limoniform or fusiform, hyaline, pink in mass, 8-14 × 6-9 µm or 10-16 × 3-6 µm ..... ***S. bisbyi***
47. Conidia fusoid, cylindrical or ellipsoid, grey to dark grey, black in mass, 7-10.2 × 2.5-3.5 µm ..... ***S. havanensis***

48. Conidia mostly more than 6 µm wide 49
48. Conidia mostly less than 6 µm wide 50

49. Conidia subglobose or ellipsoid, dark brown, 7-9 × 6-7 µm; conidiophore sympodially branched ..... ***S. ramosa***
49. Conidia obovoid, rarely ellipsoid, hyaline or pale pink, 10-15.5 × 6.5-8 µm ..... ***S. bambusicola***

50. Conidia cylindrical, 8.8-12 × 2-2.4 µm ..... ***S. longispora***
50. Conidia mainly other shapes, wider 51

51. Conidia distinctly biguttulate, 9-12 × 3.5-5 µm ..... ***S. guttulispora***
51. Conidia not guttulate 52

52. Conidiophores often sympodially branched; conidia ellipsoid, 8.5-15.5 × 3.5-5 µm; phialides 8.5-12 × 5-7 µm; conidiophores up to 68 µm long ..... ***S. thermotolerans***
52. Conidiophores not usually sympodially branched 53

53. Conidia ovoid, (4-)7-9(-12) × (3-)5-6(-7) µm; phialides 9-16 × 3-5 µm; conidiophores usually smooth, hyaline, up to 250 µm long ..... ***Melanopsamma pomiformis*** **(anamorph *S. albipes*)**
53. Conidia of other shapes, mostly less than 5 µm wide 54

54. Conidia cylindrical or subcylindrical, occasionally rough-walled, 7-11 × (2.5-)3.5-5 µm; phialides 8-13 × 3.2-5 µm; conidiophores grey to black, 70-120 µm long ..... ***S. yunnanensis***
54. Conidia of other shapes 55

55. Conidia navicular, dark brown, 6-9 × 3-4 µm; phialides 8-13 × 3-4 µm; conidiophores subhyaline to pale brown, up to 60 µm long ..... ***S. sansevieriae***
55. Conidia of other shapes 56

56. Conidia ellipsoid, olivaceous or dark, 5.9-10.2 × 2.2-5.2 µm; conidiophores hyaline ..... ***S. lunzinensis***
56. Conidia broadly ellipsoid to obovoid, blackish green, 8-10.5 × 4-5.5 µm; phialides 8-11 × 4-6 µm; conidiophores hyaline at base, darker towards apex, which is sometimes verrucose ..... ***S. chlorohalonata***

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