CHAPTER 21

AN ILLUSTRATED KEY TO THE COMMON TEMPERATE SPECIES OF AQUATIC HYPHOMYCETES

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1. INTRODUCTION

Aquatic hyphomycetes play a key role in the decomposition of allochthonous plant litter and food webs in lotic ecosystems (e.g. Suberkropp & Klug 1976, Bärlocher 1992, Hieber & Gessner 2002). Soon after colonizing a substrate, many species produce vast amounts of conidia that enter the water column and are transported downstream. Aquatic hyphomycetes can invest up to 80% of their production into sporulation and conidial production alone has been shown to account for up to 8—12% of leaf litter mass loss (Suberkropp 1991). Most aquatic hyphomycetes form tetraradiate, variously branched or scolecoid (worm-like) conidia that are adapted for dispersal in flowing water (Webster & Descals 1981). Since conidia are mostly characteristically shaped, it is often possible to identify them to species, count them and thus gain insight into the structure of the fungal community developing on submerged substrates (Bärlocher 2004). This facilitates ecological studies that link fungal biodiversity with functional aspects of ecosystems such as organic matter decomposition.

The objective of this chapter is to provide assistance for the fast identification of aquatic hyphomycete conidia in ecological studies carried out in temperate climates. Conidia can be sampled in transport (water, foam), from naturally colonized

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submerged substrates after inducing sporulation in the laboratory or from pure cultures (Gessner et al. 2003; Chapters 19 and 24).

It is important to acknowledge that the presented key includes only 64 of ca. 170 species of aquatic hyphomycetes occurring in temperate climate (over 300 species described worldwide). Along with common species we also included some less frequent ones, whose conidia may be confused with others. The key is primarily based on morphological characters of detached conidia; however, for species with similar or less differentiated conidia, their mode of conidiogenesis, which may also be diagnostic, is illustrated. Only typical conidia developed under submerged or semi-submerged conditions are considered. Even though we include drawings of conidia for all treated species, we encourage the reader to consult with taxonomic specialists and additional pertinent literature (e.g. Petersen 1962, 1963a,b, Nilsson 1964, Dudka 1974, Ingold 1975, Webster & Descals 1981, Marvanová 1997) as well as original species descriptions since some aquatic hyphomycetes (especially scolecosporous species) cannot be identified with certainty on the basis of detached conidia only. A glossary of some terms that may cause difficulties follows the key.

2. KEY TO THE COMMON TEMPERATE SPECIES OF AQUATIC HYPHOMYCETES (BASED ON CONIDIA)

1. Conidia variously branched or appearing tri-, tetra- or multiradiate 2

1a. Conidia of simple shape (scolecoid, globose, ellipsoid, fusiform, clavate, etc., some with short outgrowths or basal extensions) 50

2. Conidia appearing triradiate 3

2a. Conidia of different morphology 4

3. Conidia spanning 8—13 µm, 3-celled, ends obtuse ... *Tricellula aquatica* (Fig.1)

3a. Conidial span 20—46 µm, apices acute ..... *Ypsilina graminea* (Fig.2)

4. Conidia small, spanning up to 25 µm, outline triangular, with a short axis and 3 laterals ..... *Lateriramulosa uniinflata* (Fig. 3)

4a. Conidia of different shape 5

5. Conidia with a clamp connection on axis 6

5a. Clamp connections absent 7

6. Conidial elements cylindrical, axis gently curved or sigmoid, with an excentric basal extension, branch insertions unconstricted ..... *Taeniospora gracilis* var. *enecta* (Fig. 4a)

6a. Conidial elements long-fusoid, axis strongly curved or sigmoid, basal extension absent, branch insertions subconstricted ..... *Taeniospora gracilis* var. *gracilis* (Fig. 4b)

7. Conidia relatively large with typically numerous primary and secondary (sometimes tertiary) branches, elements cylindrical 8

7a. Conidia of different shape....11

8. Conidia resembling a fir tree with a more or less straight axis and perpendicular branches tending to aggregate near its base....9

8a. Conidial elements gently curved, branches distributed along the axis length, caducous (breaking off readily)....10

9. Conidia ca. 200 µm long, with more than 15 branches, elements 4—5 µm wide ....*Dendrospora erecta* (Fig. 5)

9a. Conidia with up to 14 branches, elements 3—4 µm wide.... ....*Dendrospora tenella* (Fig. 6)

10. Branches typically on one side of the axis, branch insertions abruptly constricted....*Varicosporium elodeae* (Fig. 7)

10a. Conidial elements delicate, gently constricted at septa, branches on both sides of the axis, insertions gradually narrowed.....*Varicosporium delicatum* (Fig. 8)

11. Conidia with an axis, 1—2 primary and one secondary branch, elements tapering distally....12

11a. Conidia of different shape....15

12. Conidial elements straight or nearly so, branching dorsal....13

12a. Conidial elements strongly curved or sigmoid, branching ventral....14

13. Axis 26—51 µm long, 3—4(—5) septa .....*Pleuropedium tricladioides* (Fig. 9)

13a. Axis 38—75(—100) µm long, elements multiseptate.... ....*Pleuropedium multiseptatum* (Fig. 10)

14. Conidia with one primary and one secondary branch.... ....*Gyoerffyella gemellipara* (Fig. 11)

14a. Conidia with two primary and one secondary branch.... ....*Gyoerffyella rotula* (Fig. 12)

15. Conidia with recurved axis and 2—3 branches (4—5 ends)....16

15a. Conidia of different shape....17

16. Conidia with up to 5 ends, stout .....*Tripospermum myrti* (Fig. 13)

16a. Conidia with up to 4 ends, more slender in appearance.... ....*Tripospermum camelopardus* (Fig. 14)

17. Conidia spanning over 70 µm, with 4 long filiform extensions, conidial body of 2 parts.....*Campylospora chaetocladia* (Fig. 15)

17a. Conidia of different shape....18

18. Conidia with a stalk bearing elements of 2 different shapes: filiform (subulate) and digitiform, filiform (subulate) and globose or only digitiform....19

18a. Conidia of different morphology....23

19. Conidia with 2 globose and 3 filiform (subulate) elements ..... *Tetracladium marchalianum* (Fig. 16)

19a. Conidia with filiform (subulate) and digitiform or only digitiform elements .. 20

20. Filiform (subulate) elements lacking, 2 digitiform elements furcate, conidia with 6 apices ..... *Tetracladium apiense* (Fig. 17)

20a. Both filiform (subulate) and digitiform elements present 21

21. Conidia with 2(—3) filiform (subulate) and 2 digitiform elements, basal extension absent..... *Tetracladium maxilliforme* (Fig. 18)

21a. Conidia with 5—6 apices, basal extension typically present 22

22. Conidia with 2 digitiform and 3 filiform (subulate) elements ..... *Tetracladium furcatum* (Fig. 19)

22a. Conidia with 3 digitiform and 3 filiform (subulate) elements ..... *Tetracladium setigerum* (Fig. 20)

23. Conidia with relatively broad body (clavate, fusoid, etc.) and 2—4 branches or if all elements are of similar width then conidia spanning up to 15 µm 24

23a. Conidia with all elements of similar width, spanning more than 25 µm 30

24. Conidial body clavate, with 3 coronate branches 25

24a. Conidial body long-clavate, navicular or obclavate with one terminal and 2—3 lateral branches 28

25. Conidial body 10—15 µm long, with 3 conoid branches, conidia appear stellate ..... *Heliscella stellata* (Fig. 21)

25a. Conidia larger, branches filiform 26

26. Conidial body 35—50 × 10 —12 µm ..... *Clavariopsis aquatica* (Fig. 22)

26a. Conidial body 3—5 µm wide 27

27. Conidial body 15—25 µm long..... *Clavatospora longibrachiata* (Fig. 23)

27a. Conidial body 45—70 µm long..... *Heliscus tentaculus* (Fig. 24)

28. Conidial body navicular to obclavate, straight, lateral branches 2—3, basal extension absent..... *Naiadella fluitans* (Fig. 25)

28a. Conidial body long-clavate, curved distally, lateral branches 2, basal extension percurrent, conidia have "mosquito" or "penguin" appearance 29

29. Conidial body hyaline, branches 40—80(—100) µm long..... *Culicidospora aquatica* (Fig. 26)

29a. Conidial body hyaline or subfuscous, branches less than 40 µm long..... *Culicidospora gravida* (Fig. 27)

30. Conidia tetraradiate in a broad sense, i.e. appearing as 4 arms radiating from a common point or from a central cell, or basiverticillate, or with terminal branches on a stalk, or with paired or subopposite laterals on a geniculate or curved axis 31

30a. Conidia with elongate axis and 2 alternate, not subopposite, branches 45

31. Conidia with a distinct globose central cell and 4 radiating arms 32

31a. Conidia of different shape 33

32. Arms as broad as central cell, long-obclavate, insertions constricted ..... *Lemonniera pseudofloscula* (Fig. 28)

32a. Arms thinner than central cell, cylindrical with subclavate ends, insertions unconstricted ..... *Lemonniera centrosphaera* (Fig. 29)

33. Conidia with 4 arms radiating from a common point, i.e. truly tetraradiate (indistinct central cell sometimes present) 34

33a. Conidia of different morphology 35

34. Arms cylindrical, 50—100 × 3—4 µm ..... *Lemonniera aquatica* (Fig. 30)

34a. Arms conoid or obclavate, 20—45 × 4—9 µm .. *Lemonniera terrestris* (Fig. 31)

35. Conidia basiverticillate 36

35a. Conidia with a stalk bearing terminal branches or with paired or subopposite laterals on a geniculate or curved axis 38

36. Conidial axis up to 105 µm long, elements cylindrical, branch insertions constricted ..... *Lemonniera filiformis* (Fig. 32)

36a. Conidial axis long-obclavate, up to 70 µm long 37

37. Axis 2-celled, lower cell often inflated, branches cylindrical, insertions subconstricted, septa indistinct or lacking ..... *Triscelophorus monosporus* (Fig. 33)

37a. Axis and branches long-obclavate, multiseptate, branch insertions abruptly constricted ..... *Triscelophorus acuminatus* (Fig. 34)

38. Conidia with 3 terminal branches (or 2, one of them forking again), elements constricted at insertions ..... *Articulospora tetracladia* (Fig. 35)

38a. Conidia with geniculate or curved axis and 2 branches attached near its middle 39

39. Branches subopposite, axis subconstricted at a septum between branch insertions 40

39a. Branches paired, axis not constricted 41

40. Axis typically over 90 µm long, elements cylindrical ..... *Fontanospora eccentrica* (Fig. 36)

40a. Axis less than 90 µm long, branches long-obclavate ..... *Fontanospora fusiramosa* (Fig. 37)

41. Conidia spanning over 90 µm 42

41a. Conidia spanning less than 70 µm 43

42. Branches submedian, insertions subconstricted, axis slightly swollen and bent at branch insertions ..... *Geniculospora inflata* (Fig. 38)

42a. Elements of equal length, branches gently curved backwards, insertions unconstricted ..... *Tetrachaetum elegans* (Fig. 39)

43. Conidial elements straight, axis bent at branch insertions, lower part of axis often subclavate, distal part thinner, cylindrical, branch-like, often twice as long ..... *Stenocladiella neglecta* (Fig. 40)

43a. Conidial elements gently curved 44

44. Lower element of axis cylindrical to subclavate, distal elements narrow-obclavate, branch insertions strongly constricted ..... *Alatospora pulchella* (Fig. 41)

44a. Elements cylindrical or long-fusoid or branches (0—2) subulate, insertions unconstricted to constricted ..... *Alatospora acuminata* (Fig. 42)

45. Branch insertions unconstricted or subconstricted 46

45a. Branch insertions abruptly constricted 48

46. Axis 150—200 µm long, elements gently curved, branch insertions subconstricted ..... *Tricladium chaetocladium* (Fig. 43)

46a. Axis up to 120 µm long 47

47. Axis 50—120 µm long, geniculate, branch insertions unconstricted ..... *Tricladium angulatum* (Fig. 44)

47a. Axis 40—60 µm long, often curved in lower part, base swollen, branch insertions subconstricted ..... *Tricladium curvisporum* (Fig. 45)

48. Axis geniculate or curved, elements cylindrical ... *Tricladium patulum* (Fig. 46)

48a. Axis fusoid or long-fusoid, straight or gently curved, branches long-obclavate .. 49

49. Axis 50—75 × 2.5—3.5 µm, apices acute ..... *Tricladium attenuatum* (Fig. 47)

49a. Axis 60—140 × 5—7 µm ..... *Tricladium splendens* (Fig. 48)

50. Conidia scolecoid or filiform, i.e. length to width ratio >10 51

50a. Conidia of different shape 58

51. Detachment scar lateral, dorsal (or basal extension integrated), conidia aseptate, lunate or sigmoid ..... *Lunulospora curvula* (Fig. 49)

51a. Detachment scar at the base of conidia, basal extension excentric, percurrent or absent, conidia septate, variously curved 52

52. Basal extension excentric 53

52a. Basal extension percurrent or lacking 55

53. Conidia filiform, 2.5—3.5 µm wide ..... *Anguillospora filiformis* (Fig. 50)

53a. Conidia 6—15 µm wide 54

54. Conidia hyaline, 110—190 × 6—13 µm, with 4—6 septa, one middle cell typically larger ..... *Mycofalcella calcarata* (Fig. 51)

54a. Conidia (or central cells) sometimes fuscous, 150—200 × 8—15 µm, with 7—11 septa, cells in the broad part of conidium of similar size ..... *Mycocentrospora acerina* (Fig. 52)

55. Conidia arcuate or sigmoid, 150—250 × 5—6 µm, 7—13 septate, basal extension growing through a frill (remnants of separating cell), which is usually difficult to observe ..... *Anguillospora longissima* (Fig. 53)

55a. Frill at the base of conidia absent 56

56. Conidia sigmoid, long-fusoid, over 5 µm wide 57

56a. Conidia filiform, 90—120 × 1.5—2.5 µm ..... *Flagellospora curvula* (Fig. 54)

57. Conidia 150—300 × 5—7 (—9) µm, 10—23 septate, base truncate or with a subulate extension ..... *Anguillospora furtiva* (Fig. 55)

57a. Conidia 120—180 × 8—14 µm, base truncate or with a blunt extension ..... *Anguillospora crassa* (Fig. 56)

58. Conidia isodiametric, clavate or fusiform to rhomboid, with short outgrowths 59

58a. Conidia ellipsoid to reniform, without outgrowths, aseptate, (13—16—20(—24) × 8—10 µm ..... *Dimorphospora foliicola* (Fig. 57)

59. Conidia globose, cubic to almost stellate in appearance, with 4—6 more or less equidistant, sometimes indistinct outgrowths 60

59a. Conidia clavate or fusiform to long-rhomboid 61

60. Conidia (10—)11—17(—21) µm in diam. ..... *Goniopila monticola* (Fig. 58)

60a. Conidia (8—)9—13(—14) µm in diam. (conidia can also be limoniform to fusiform with 0—2 septa) ..... *Margaritispora aquatica* (Fig. 59)

61. Conidia fusiform to long-rhomboid, 3-celled, central cell inflated, with short equatorial outgrowths ..... *Tumularia aquatica* (Fig. 60)

61a. Conidia clavate 62

62. Conidia curved, subclavate, 25—50 × 3—4 µm, outgrowths (1—)2 ..... *Heliscus submersus* (Fig. 61)

62a. Conidia straight, outgrowths 0—4 63

63. Distal cell swollen, outgrowths scattered over its surface, conidial body 25—40 × 10—12 µm..... *Tumularia tuberculata* (Fig. 62)

63a. Distal cell not inflated, outgrowths coronate 64

64. Conidia broadly clavate to obcampanulate, 13—25 × 7—13 µm, conidial base with a denticle..... *Heliscina campanulata* (Fig. 63)

64a. Conidia subclavate or clove-shaped, 20—45 × 4—6 µm, with 3(—4) conoid outgrowths or apex oblique..... *Heliscus lugdunensis* (Fig. 64)

3. GLOSSARY

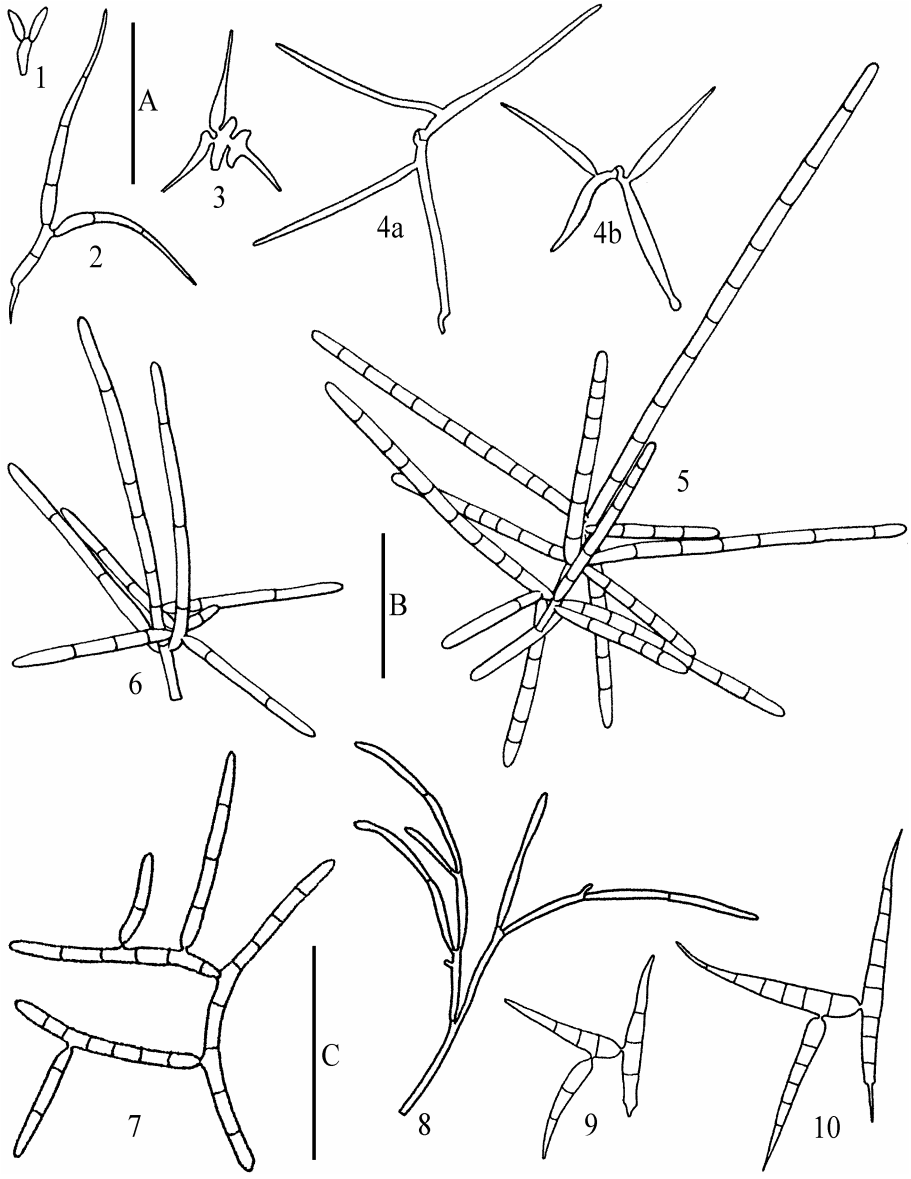
arcuate	curved like a bow or arch.
basiverticillate	having similar elements arranged in a whorl at the lowermost portion of parent element.
clavate	gradually broadening towards the distal part, club-shaped.
constricted	strongly and often abruptly narrowed.
coronate	having elements arranged in a crown-like fashion.
denticle	small tooth-like projection.
digitiform	finger-shaped.
excentric	located off the center (here refers to basal extensions on the side of conidial scar).
filiform	resembling a thread or filament.
furcate	divided into two elements, forked.
fuscous	having a brownish gray color.
fusiform, fusoid	tapering towards each end, spindle-shaped.
geniculate	bent abruptly at an angle like a knee joint.
navicular	resembling a boat.
obclavate	gradually broadening towards the proximal part, *cf.* clavate.
obcampanulate	shaped like an inverted bell.
percurrent	here refers to basal extensions growing through a scar, *cf.* excentric.
recurved	curved backwards.
reniform	kidney-shaped.
scar (conidial)	part of a septum involved in secession; it forms the base of conidium, but sometimes it is replaced by percurrent basal extension.
scolecoid	worm-like.
sigmoid	curved like the Greek letter sigma when standing at the end of a word (ς) or the Latin letter S.
stellate	star-shaped, consisting of short elements radiating from a common center.

sub	prefix signifying inferior position or degree: under, below, almost, not completely; *e.g. submedian* – situated below the middle, *subopposite* – arranged in pairs but not exactly on the same level.
subulate	tapering gradually to a point, awl-shaped.
tetraradiate	having four radiating elements.
triradiate	having three radiating elements.
truncate	terminating abruptly as if having the end cut off.

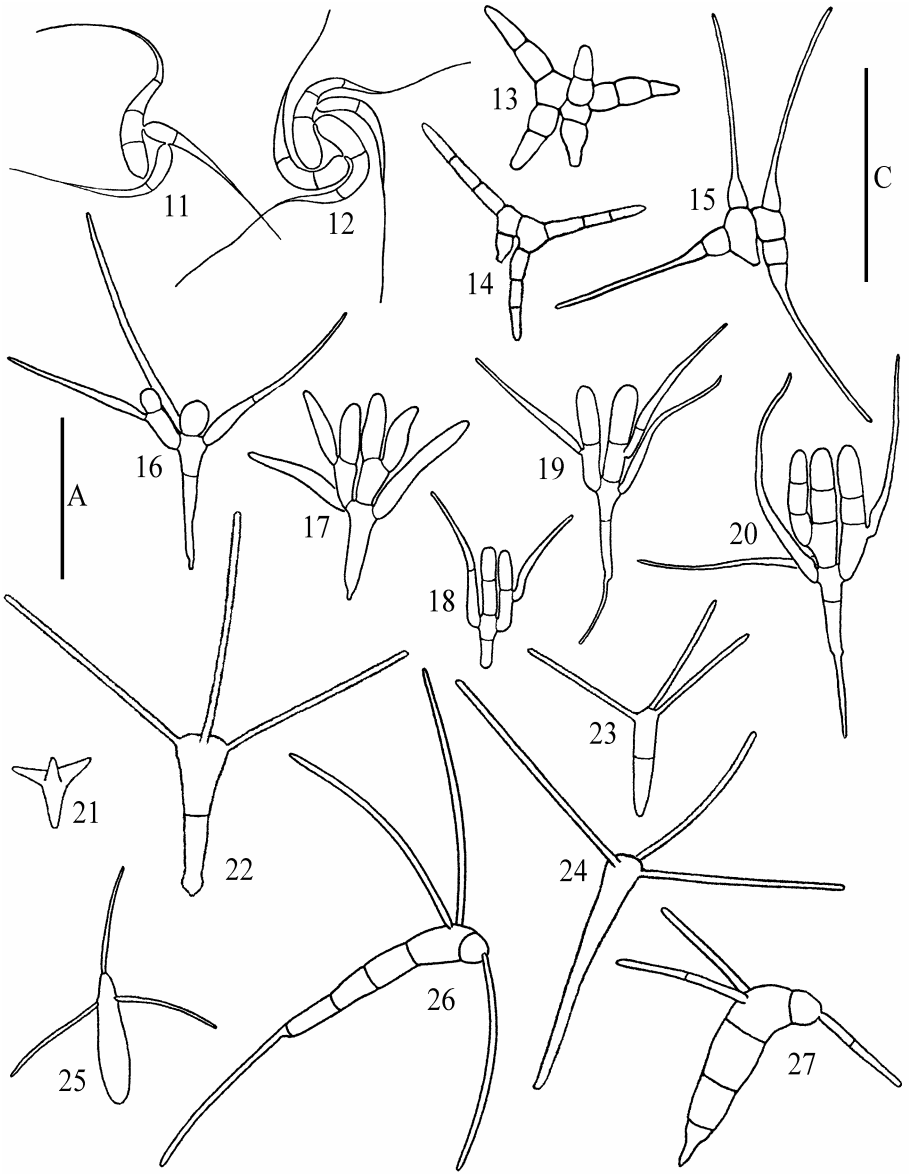
4. NOTES

Most of the drawings of conidia used in the key are by the authors (published or unpublished). Twenty-seven were taken from Bärlocher and Marvanová (2005). Illustrations of conidia from the genera *Dendrospora*, *Gyoerffyella* and *Tetracladium* are from Descals and Webster (1980), Marvanová (1975), and Roldán *et al.* (1989), respectively. *Anguillospora furtiva* is from the original description by Descals *et al.* (1998).

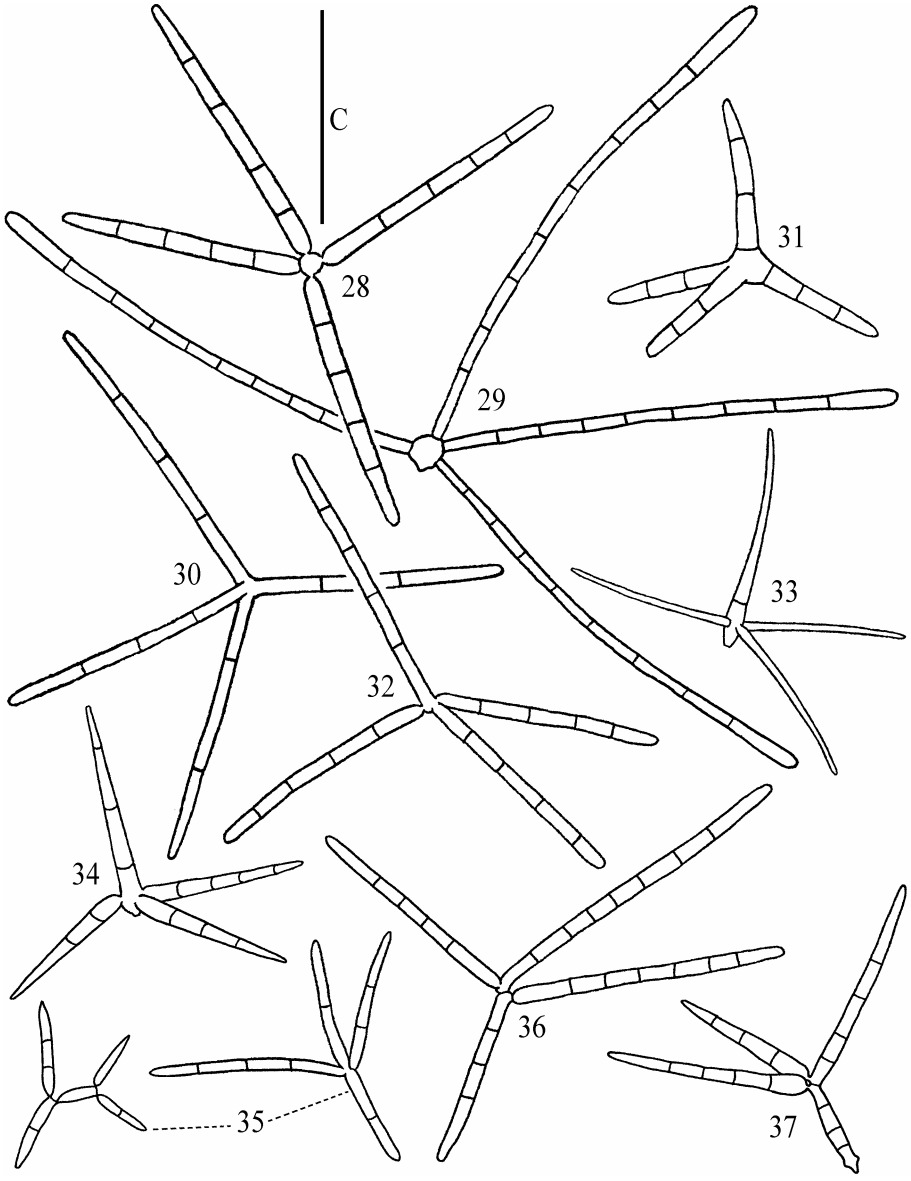
In order to identify species with conidia of simple shapes (e.g. *Dimorphospora foliicola, Goniopila monticola, Margaritispora aquatica,* many species with filiform conidia) details of conidiogenesis should be observed.



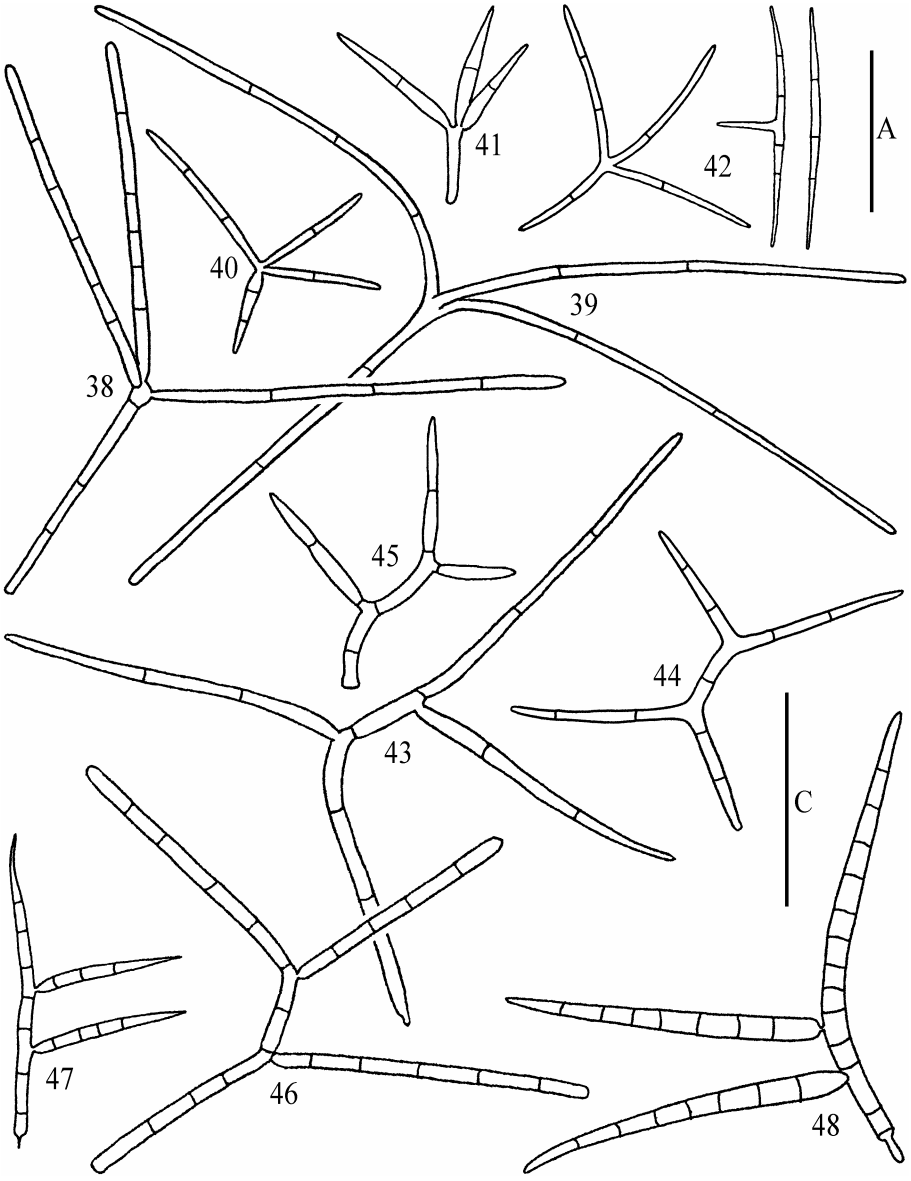
Figures 21.1—10. Conidia of aquatic hyphomycetes. 1. Tricellula aquatica*. 2.* Ypsilina graminea*. 3.* Lateriramulosa uniinflata*. 4a.* Taeniospora gracilis *var.* enecta*. 4b.* Taeniospora gracilis *var.* gracilis*. 5.* Dendrospora erecta*. 6.* Dendrospora tenella*. 7.* Varicosporium elodeae*. 8.* Varicosporium delicatum*. 9.* Pleuropedium tricladioides*. 10.* Pleuropedium multiseptatum*. Scale bar A (Figs. 1—4) = 25 µm, B (Figs. 5—6) = 50 µm, C (Figs. 7—10) = 50 µm.*



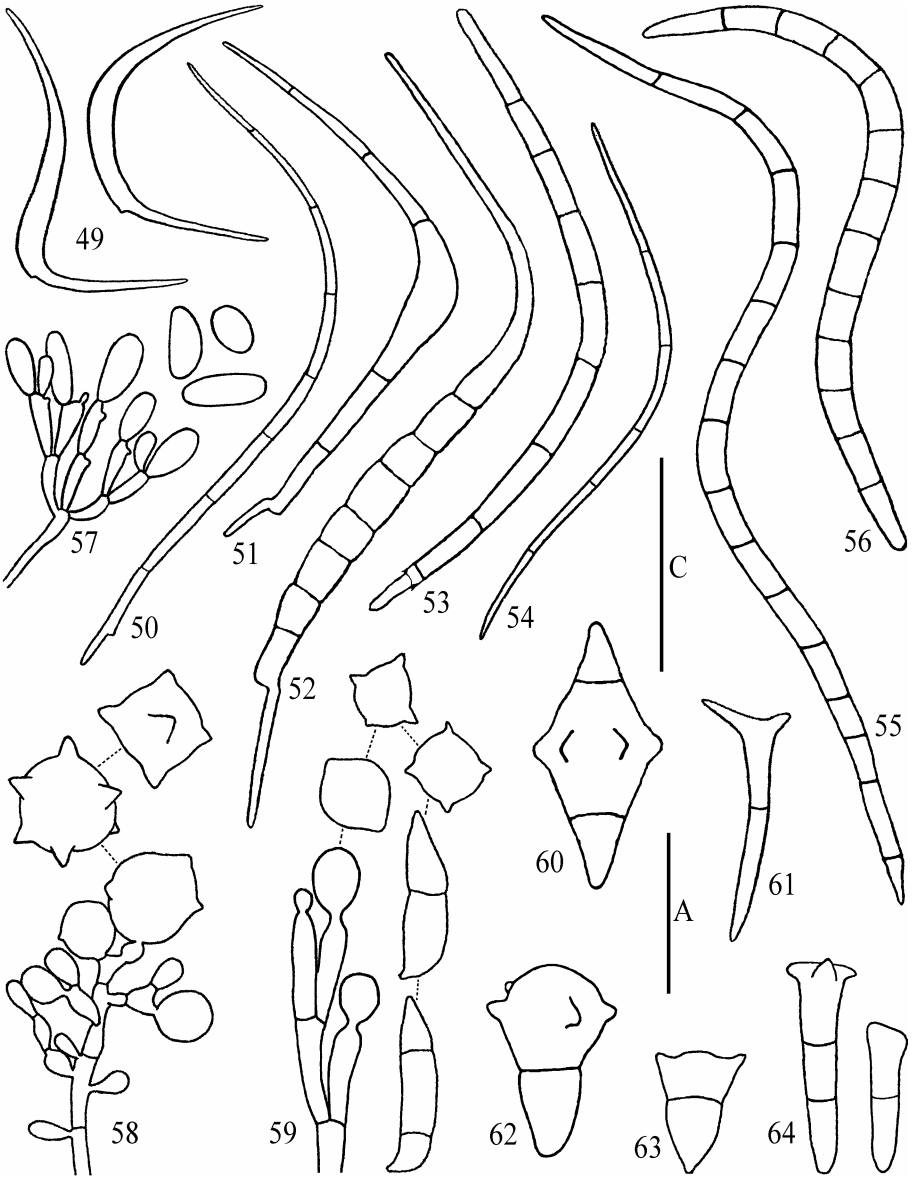
Figures 21.11—27. Conidia of aquatic hyphomycetes. 11. Gyoerffyella gemellipara. *12.* Gyoerffyella rotula. *13.* Tripospermum myrti. *14.* Tripospermum camelopardus. *15.* Campylospora chaetocladia. *16.* Tetracladium marchalianum. *17.* Tetracladium apiense. *18.* Tetracladium maxilliforme. *19.* Tetracladium furcatum. *20.* Tetracladium setigerum. *21.* Heliscella stellata. *22*. Clavariopsis aquatica. *23.* Clavatospora longibrachiata. *24.* Heliscus tentaculus. *25.* Naiadella fluitans. *26*. Culicidospora aquatica. *27*. Culicidospora gravida. *Scale bar A (Figs. 11, 12, 16—21, 23) = 25 µm, C (Figs. 13—15, 22, 24—27) = 50 µm.*



Figures 21.28—37. Conidia of aquatic hyphomycetes. 28. Lemonniera pseudofloscula*. 29.* Lemonniera centrosphaera*. 30.* Lemonniera aquatica*. 31.* Lemonniera terrestris*. 32.* Lemonniera filiformis*. 33.* Triscelophorus monosporus*. 34.* Triscelophorus acuminatus*. 35.* Articulospora tetracladia*. 36.* Fontanospora eccentrica*. 37.* Fontanospora fusiramosa*. Scale bar C (Figs. 28—37) = 50 µm.*



Figures 21.38—48. Conidia of aquatic hyphomycetes. 38. Geniculospora inflata*. 39.* Tetrachaetum elegans*. 40.* Stenocladiella neglecta*. 41.* Alatospora pulchella*. 42.* Alatospora acuminata*. 43.* Tricladium chaetocladium*. 44.* Tricladium angulatum*. 45.* Tricladium curvisporum*. 46.* Tricladium patulum*. 47.* Tricladium attenuatum*. 48.* Tricladium splendens*. Scale bar A (Figs. 40—42, 45) = 25 µm, C (Figs. 38, 39, 43, 44, 46—48) = 50 µm.*



Figures 21.49—64. Conidia of aquatic hyphomycetes. Some details of conidiogenesis are shown in Figs. 57—59. 49. Lunulospora curvula*. 50.* Anguillospora filiformis*. 51.* Mycofalcella calcarata*. 52.* Mycocentrospora acerina*. 53.* Anguillospora longissima*. 54.* Flagellospora curvula*. 55.* Anguillospora furtiva*. 56.* Anguillospora crassa*. 57.* Dimorphospora foliicola*. 58.* Goniopila monticola*. 59.* Margaritispora aquatica*. 60.* Tumularia aquatica*. 61.* Heliscus submersus*. 62.* Tumularia tuberculata*. 63.* Heliscina campanulata*. 64.* Heliscus lugdunensis*. Scale bar A (Figs. 58—64) = 25 µm, C (Figs. 49—57) = 50 µm.*

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