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Aquatic Hyphomycetes of Western Ghat Streams, India

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Aquatic hyphomycetes of three streams flowing through evergreen forests of the Western Ghat region in Karnataka were investigated by foam analysis during 1987–88. A total of 74 species were encountered. Twenty-six species were common to all streams and 21 species were restricted to one of the streams. The highest number of species, a total of 66, was found in the Sampaje stream. Fourteen species could not be assigned to a genus. Brief descriptions and drawings of the unknown conidia are provided.

Keywords: hyphomycetes, ecology, taxonomy.

Aquatic hyphomycetes constitute an important link of energy flow in lotic ecosystems between leaf litter and aquatic invertebrates (Bärlocher & Kendrick, 1981; Bärlocher, 1985). They produce characteristic multiradiate or sigmoid conidia. The branched or sigmoid conidia will be trapped by air bubbles in flowing waters (Iqbal & Webster, 1973a). Hence, the foam accumulated under waterfalls or beneath any obstruction in flowing waters generally represents most of the aquatic fungal flora of the stream/river (Willoughby & Archer, 1973; Ingold, 1975c; Wood-Eggenschwiler & Bärlocher, 1983). The present study reports the occurrence of some aquatic hyphomycetes in three major tropical streams flowing through evergreen forests of the Western Ghat region of Karnataka.

Materials and methods

Study area

The Sampaje stream is a tributary of the River Payaswini. It originates in the Western Ghat and flows through dense woodlands at high altitudes. The Kempu Hole stream is a fast flowing tributary of the River Nethravathi and flows through dense forest reserves. The Neriya stream is another tributary of the River Nethravathi and flows through forest reserves and plantations at the foot-hill of the Western Ghat (Fig. 1).

The physico-chemical parameters examined for the three streams are summarized in Tab. 1.

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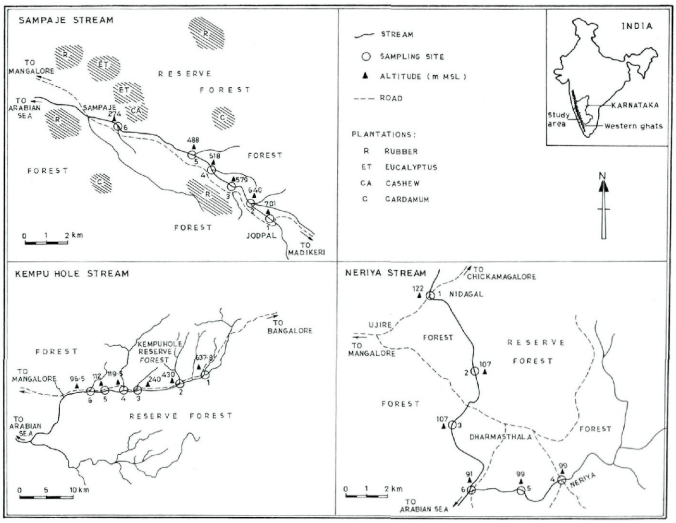

Fig. 1. – Maps of the study area with sampling stations.

Tab. 1. – Range of physico-chemical characters of the three streams investigated during 1987-1988.

	Sampaje	Kempu Hole	Neriya
Temperature (C)	17.9–26.9	20.0–28.0	23.0–28.8
pH	6.5–7.3	6.8–7.8	6.9–7.5
Dissolved oxygen (mg/l)	8.5–11.5	7.2–9.0	6.8–9.2
Altitude (MSL)	274–701	119.5–637.8	99–122

Sample collection

Foam samples were collected bimonthly from six sites in each stream for a period of one year, from September 1987 to September 1988. Freshly accumulated foam beneath the rocks/logs and under waterfalls were scooped up with a sterile plastic spatula and transferred to sterile wide-mouthed plastic jars. They were immediately fixed in formalin-acetic acid-alcohol (Iqbal & Webster, 1973b) and brought to the laboratory, where later they were screened for the presence of conidia of aquatic hyphomycetes. Each drop of foam was

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placed on a clean microslide, air dried, stained with cotton blue in lactophenol and examined under low power and subsequently under high power microscopy. Camera lucida drawings were made for the conidial propagules which were uncommon in earlier studies (Sridhar & Kaveriappa, 1989; Chandrashekar & al., 1990).

Results and discussion

A total of 74 species were recorded in the present survey (Tab. 2). The highest number of species (66 species) was recorded in the Sampaje stream. The Kempu Hole and Neriya streams had 44 and 43 species, respectively. Twenty-six species were common to all streams and twenty-one were restricted to one of the streams. Conidia identified only to genus, and unknown conidia are illustrated in Figs. 2-6. Fourteen kinds of morphologically distinct propagules could not assigned to any genera and are listed at the end of Tab. 2. The unknown conidia have the following features:

Tab. 2. – List of aquatic hyphomycetes encountered in three streams of Western Ghat forests. Citations in parentheses indicate illustration number.

Fungi	Sampaje	Kempu Hole	Neriya
1. *Actinospora megalospora* Ingold	x	x	
2. *Alatospora acuminata* Ingold	x	x	x
3. *Anguillospora crassa* Ingold	x	x	
4. *A. longissima* (De Wild.) Ingold	x	x	
5. *Articulospora inflata* Ingold	x	x	
6. *Articulospora* sp. (2A)	x		
7. *Brachiosphaera tropicalis* Nawawi	x		
8. *Campylospora chaetocladia* Ranzoni	x	x	
9. *C. filicladia* Nawawi	x	x	x
10. *C. parvula* Kuzuha	x		x
11. *Clavariana aquatica* Nawawi	x		x
12. *Clavariana* sp. (2B)			x
13. *Clavariopsis aquatica* De Wild.	x	x	
14. *C. azlanii* Nawawi	x	x	x
15. *C. brachycladia* Tubaki	x		
16. *Clavatospora tentacula* (Umphlett) Nilsson	x	x	x
17. *Condylospora spumigena* Nawawi	x		x
18. *Dactylella aquatica* (Ingold) Ranzoni	x	x	x
19. *D. oviparasitica* Stirling & Mankau	x	x	x
20. *Dendrospora erecta* Ingold	x		
21. *D. juncicola* Iqbal			x
22. *Erynia conica* (Nowakowski) Rem. & Henn.	x		x

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Fungi	Sampaje	Kempu Hole	Neriya
23. *Erynia rhizospora* (Thaxter) Rem. & Henn.	x	x	
24. *Erynia* sp. 1 (3B)	x		
25. *Erynia* sp. 2 (3C)	x		
26. *Flabellocladia tetracladia* (Nawawi) Nawawi	x		x
27. *Flabellospora crassa* Alasoadura	x	x	x
28. *F. multiradiata* Nawawi	x	x	x
29. *F. verticillata* Alasoadura	x	x	x
30. *Flagellospora curvula* Ingold	x	x	x
31. *F. penicillioides* Ingold	x	x	x
32. *Heliscella stellata* (Ingold & Cox) Marvanová	x		
33. *Ingoldiella hamata* Shaw	x	x	x
34. *Isthmotricladia gombakiensis* Nawawi	x	x	x
34. *I. laeensis* Matsushima	x	x	x
36. *Laridospora appendiculata* Nawawi		x	x
37. *Lateriramulosa uni-inflata* Matsushima	x	x	x
38. *Lunulospora curvula* Ingold	x	x	x
39. *L. cymbiformis* Miura	x	x	x
40. *Nawawia filiformis* (Nawawi) Marvanová	x	x	
41. *Phalangispora constricta* Nawawi & Webster	x	x	x
42. *P. nawawi* Kuthubutheen	x		
43. *Pyramidospora casuarinae* Nilsson	x		
44. *P. constricta* Singh	x		x
45. *Speiropsis hyalospora* Subramanian & Lodha	x	x	x
46. *S. irregularis* Petersen	x	x	
47. *S. pedatospora* Tubaki	x	x	x
48. *Taeniospora* sp. (2C) (?)	x	3	
49. *Tetracladium marchalianum* De Wild.	x	x	x
50. *T. setigerum* (Grove) Ingold	x	x	
51. *Tetracladium* sp. (2D)		x	
52. *Tricladiospora brunnea* (Nawawi) Nawawi & Kuthubutheen	x	x	x
53. *Tricladium* sp. 1 (2E)			x
54. *Tricladium* sp. 2 (2F)	x		x
55. *Tripospermum myrti* (Lind.) Hughes	x		x
56. *Triposporina* sp. (2G)	x		
57. *Triscelophorus acuminatus* Nawawi	x	x	x
58. *T. konajensis* Sridhar & Kaveriappa	x	x	x
59. *T. monosporus* Ingold	x	x	x
60. *Varicosporium elodeae* Kegel	x		
61. Unknown (4A)	x	x	
62. Unknown (4B)	x	x	
63. Unknown (4C)	x		
64. Unknown (4D)	x		
65. Unknown (4E)	x	x	
66. Unknown (5A)	x		x
67. Unknown (5B)		x	x
68. Unknown (5C)		x	x

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Fungi	Sampaje	Kempu Hole	Neriya
69. Unknown (5D)	x		
70. Unknown (5E)	x		
71. Unknown (5F)	x		
72. Unknown (5G)		x	x
73. Unknown (5H)	x	x	x
74. Unknown (6A, B)	x		x
Identified species	55	37	37
Unidentified species	11	7	6
Total	66	44	43

No. 61 Conidia sigmoid, hyaline, 6–8 septate, distinct separation between the terminal appendage with main body, 160–200 µm long, 6–8 µm broad at the widest region, terminal appendages 3 µm broad at the base, tapering to 1–1.5 µm at the tip (Fig. 4A).

No. 62 Conidia sigmoid, hyaline, 6–9 septate, 120–150 µm long, 2–2.5 µm wide (Fig. 4B.).

No. 63 Conidia sigmoid, hyaline, nonseptate, distinct attachment scar at the base, terminal part curved, 90–110 µm long, 2–2.5 µm broad (Fig. 4C).

No. 64 Conidia sigmoid, hyaline, 6–8 septate, 80–100 µm long, 5–6 µm broad at the widest region, tapering to 1.5–2 µm at the tip (Fig. 4D).

No. 65 Conidia slightly brown, 15–20 septate, zig-zag appearance, 180–200 µm long, 2 µm broad. Partially resembles the conidia of *Condylospora spumigena* Nawawi (Fig. 4E).

No. 66 Conidia branched, hyaline, one-septate, the main axis sickle-shaped, measuring 80–120 µm long, 2–2.5 µm broad. The lateral arm 30–40 µm long, 1.5–2 µm broad. These conidia were also seen on incubated leaf litter. They are tiny, hair-like, and floating on the water film (Fig. 5A).

No. 67 Conidia pentaradiate, hyaline, main axis 2-septate, 36–48 µm long, 2.5–3 µm wide, primary laterals two-septate, 25–35 µm long, 2–2.5 µm broad, secondary laterals one-septate, 20–30 µm long and 1.5–2 µm broad (Fig. 5B).

No. 68 Conidia tetraradiate, hyaline, main axis nonseptate, 15–20 µm long, 2–2.5 µm wide at the attachment region of the laterals, 3 laterals, 20–28 µm long, 1.5–2.5 µm broad and gradually tapering at the tip (Fig. 5C).

No. 69 Conidia tetraradiate, hyaline, main axis one–septate, 1–1.5 µm wide at the base and 2.5 µm wide at the bulbous region, 3 laterals, one–septate, 8–15 µm long, 2–2.5 µm broad, blunt at the tip. Partially resembles the conidia of *Flabellospora* spp. and *Triscelophorus* spp. (Fig. 5D).

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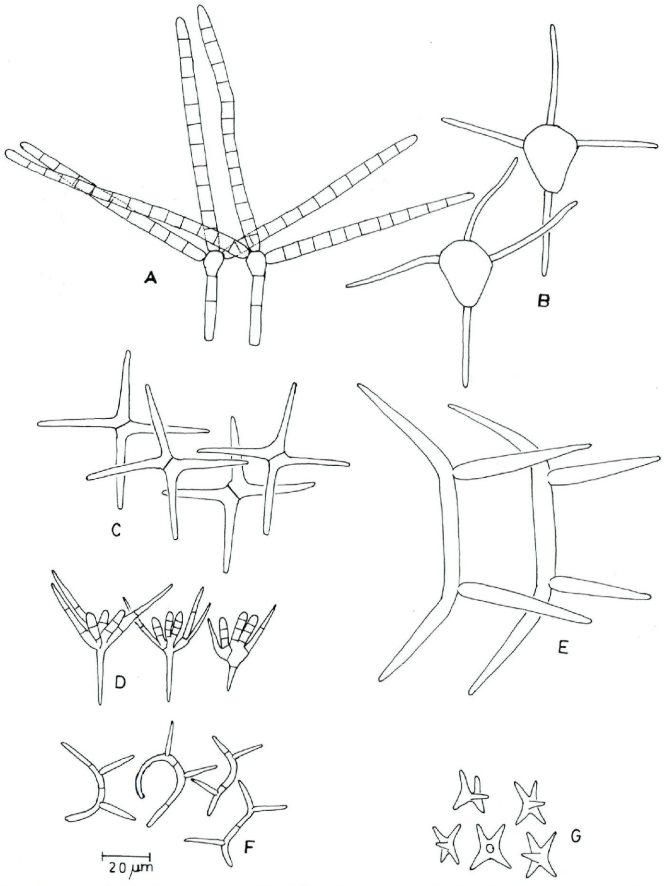

Fig. 2. – A: *Articulospora* sp. – B: *Clavariana* sp. – C: *Taeniospora* sp., clampless conidia(?). – D: *Tetracladium* sp. Similar conidia were described by Descals (1987). – E: *Tricladium* sp. 1. – F: *Tricladium* sp. 2. Similar conidia were recorded by Ingold (1975b). – G: *Triposporina* sp.

No. 70 Conidia triradiate, hyaline, non-septate, each arm 10–18 µm long and 2 µm broad (Fig. 5E).

No. 71 Conidia hyaline, five-septate, main axis curved, showing a clear attachment scar, 15–22 µm long, 10–12 µm broad at

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the widest region, 2 laterals, 10–20 µm long, 1–1.5 µm broad at the base and gradually tapering (Fig. 5F).

No. 72 Conidia tetraradiate, hyaline, main axis 3–6 septate, 35–45 µm long, 8–10 µm wide at the base, tapering to 2.5–3 µm at the tip, 3 laterals, 3–5 septate, 12–20 µm long, 4–5 µm broad at the base and tapering 2–2.5 µm at the tip (Fig. 5G).

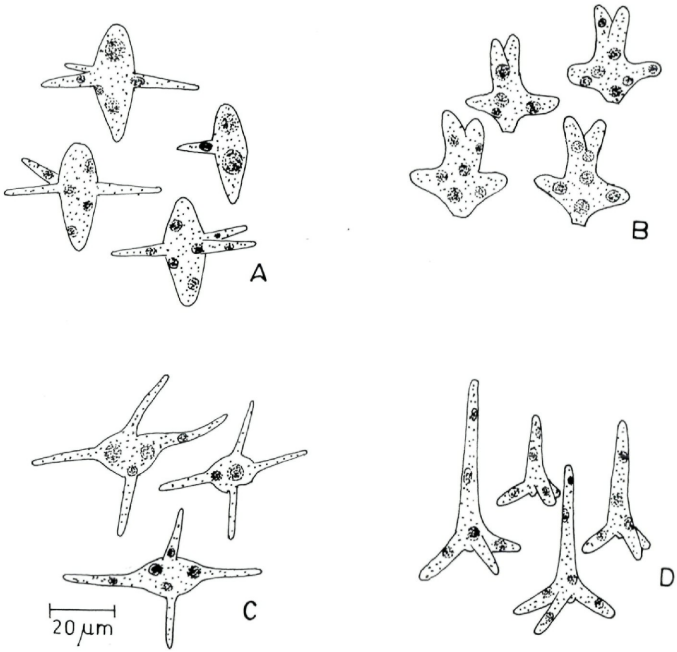

Fig. 3. – A: *Erynia rhizospora*. – B: *Erynia* sp. 1. – C: *Erynia* sp. 2. – D: *Erynia conica*.

No. 73 Conidia tetraradiate, pigmented, main body 6–10 µm broad, showing a clear attachment scar, main axis consisting of 4 projections, 5–8 µm long and 1.5–2 µm broad, the tip of the pigmented projections possessing hyaline appendages 10–30 µm long and 1 µm broad (Fig. 5H).

No. 74 Conidia tetraradiate, slightly brown in colour, main axis 2–3 septate, 220–240 µm long, 18–20 µm broad, 3 laterals,

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2–3 septate, 160–180 µm long, 18–20 µm broad, consisting of characteristic attachment of laterals of the main axis (Figs. 6A, 6C). The tip of the laterals of certain conidia were bulbous (Fig. 6B).

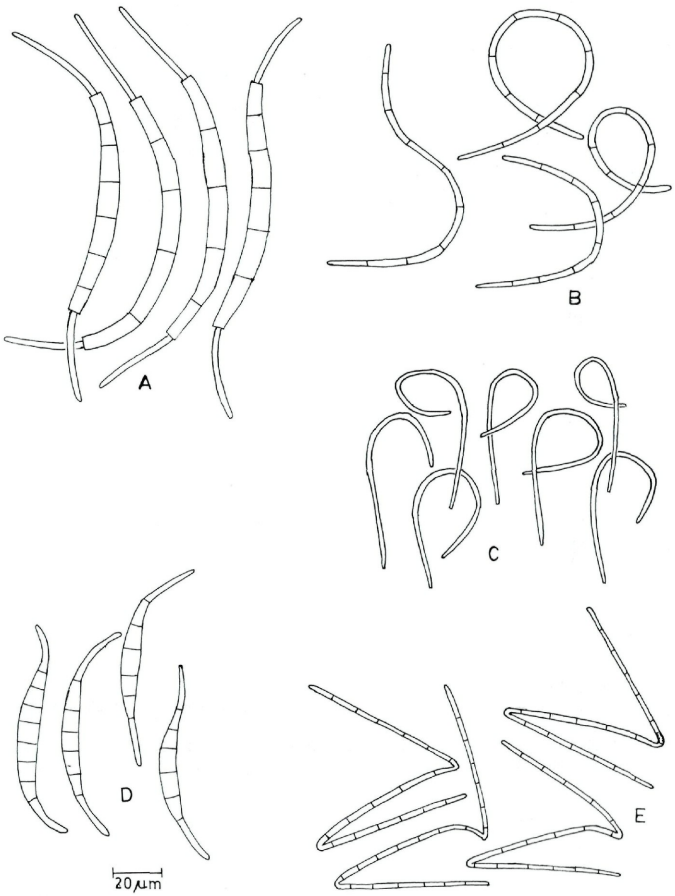

Fig. 4. – A-E: unknown sigmoid conidia. – E: conidia resembling *Condylospora spumigena* (Nawawi, 1976). Similar conidia were recorded by Nawawi (1985).

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There are several detailed studies on aquatic hyphomycetes, particularly in temperate parts of the world (Petersen, 1962; 1963a; 1963b; Nilsson, 1964; Ingold, 1967; Willoughby & Archer, 1973; Bärlocher & Rosset, 1981; Wood-Eggenschwiler & Bärlocher, 1983; Shearer & Webster, 1985; Bärlocher, 1987; Regelsberger & al., 1987). However, detailed studies on these communities in tropical regions are limited (Padgett, 1976; Subramanian & Bhat, 1981; Sridhar & Kaveriappa, 1989; Chandrashekar & al., 1990). A consolidated report on the occurrence and distribution in different geographical conditions was published by Webster & Descals (1981).

In the present survey the high species diversity in Sampaje stream may be attributed to the richness in forest litter, greater turbulence due to variation in altitude, obstructions such as woody vegetation and rocky basin, high rainfall and extremes of water temperature. In most investigations, including the present study, several morphologically distinct but unidentifiable conidial propagules were encountered. Based on the earlier and the present studies it is possible to conclude that there is a wide difference in the species composition of aquatic hyphomycetes of temperate and tropical regions. More detailed investigations are necessary specifically from different regions of the tropics to reach any firm conclusions concerning differences in species composition and geographic distributions.

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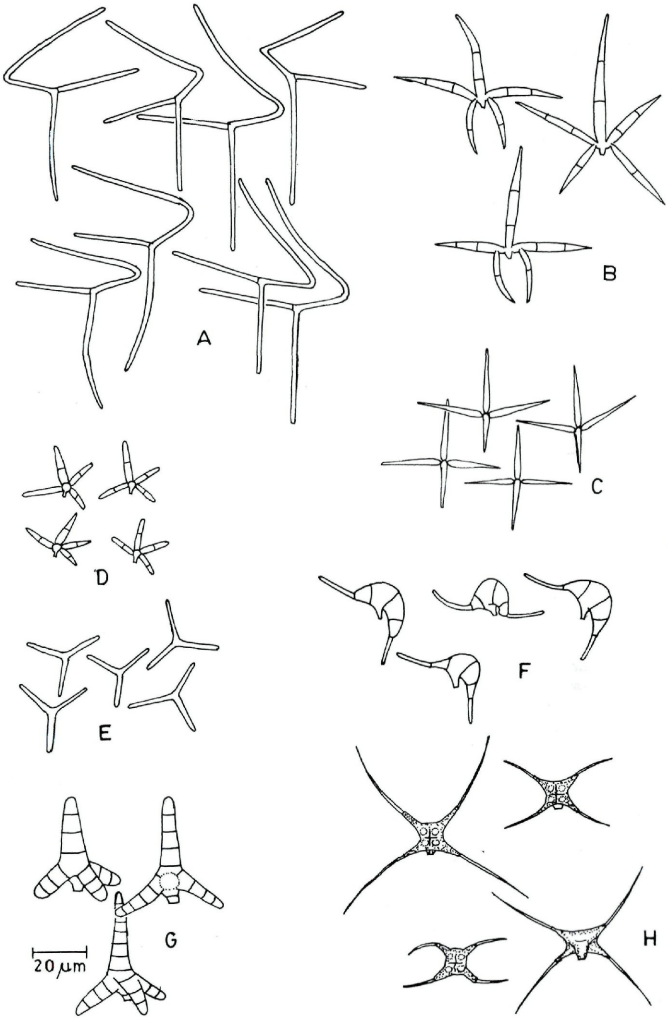

Fig. 5. – A-H: unknown multiradiate conidia. – D: conidia resembling those reported by Ingold (1958). – H: this kind of conidia was reported by Tubaki (1965), Subramanian & Bhat (1981) and Nawawi (1985).

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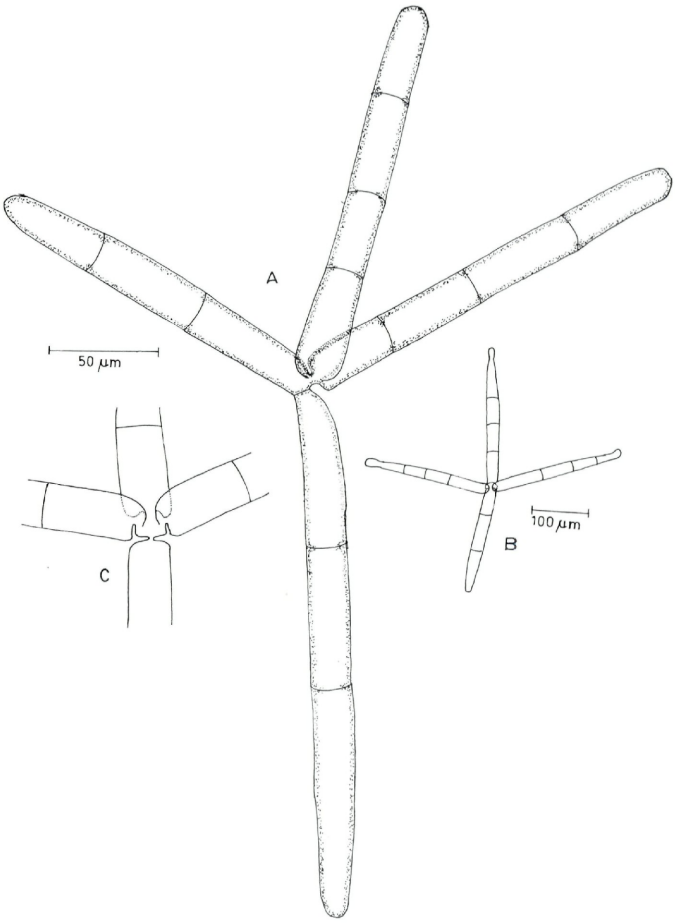

Fig. 6. – A-B: giant conidia (note the junction of arms). – C: junction of arms in one angle. This kind of conidia was recorded by Ingold (1975a), Subramanian & Bhat (1981), Sridhar & Kaveriappa (1985) and Nawawi (1985).

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