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## A MONOGRAPH OF *CYLINDROCLADIUM*, INCLUDING ANAMORPHS OF *CALONECTRIA*

PEDRO W. CROUS

*Department of Plant Pathology, University of Stellenbosch, 7600  
Stellenbosch, South Africa*

MICHAEL J. WINGFIELD

*Department of Microbiology and Biochemistry, University of the Orange  
Free State, P.O. Box 339, 9300 Bloemfontein, South Africa*

### ABSTRACT

The genus *Cylindrocladium* and respective teleomorphs in the holomorph genus *Calonectria* are treated. The genera are circumscribed, while morphological characters of conidia, vesicles, phialides, stipes, conidiophore branches and cultural characteristics are compared under standardized conditions. Species are described and illustrated with reference to their pathogenicity and distribution. Comparisons are also made of perithecia, asci and ascospores of the *Calonectria* spp. Comparisons with type specimens, cultures and additional collections of various species worldwide are included. In *Cylindrocladium*, 22 species and one variety, *C. colhounii* var. *macroconidialis*, are recognized. Microconidial states are newly described for *C. ilicicola*, *C. reteaudii* and *C. quinquesepatum*. Fifteen *Calonectria* species and one variety, *Calonectria colhounii* var. *macroconidialis*, are recognized. Dichotomous and synoptic keys are also provided.

### SPECIES TREATED

1. *C. avesiculatum* Gill, Alfieri & Sobers
2. *C. candelabrum* Viegas
3. *C. citri* (Fawcett & Klotz) Boedijn & Reitsma
4. *C. clavatum* Hodges & May
5. *C. colhounii* Peerally var. *colhounii*
6. *C. colhounii* var. *macroconidialis* Crous, Wingfield & Alfenas

7. *C. curvatum* Boedijn & Reitsma
8. *C. floridanum* Sobers & Seymour
9. *C. gracile* (Bugnicourt) Boesewinkel
10. *C. hawksworthii* Peerally
11. *C. heptaseptatum* Sobers, Alfieri & Knauss
12. *C. ilicicola* (Hawley) Boedijn & Reitsma
13. *C. naviculatum* Crous & Wingfield
14. *C. ovatum* El-Gholl, Alfenas, Crous & Schubert
15. *C. parasiticum* Crous, Wingfield & Alfenas
16. *C. pteridis* Wolf
17. *C. quinqueseptatum* Boedijn & Reitsma
18. *C. reteaudii* (Bugnicourt) Boesewinkel
19. *C. scoparium* Morgan
20. *C. spathiphylli* Schoulties, El-Gholl & Alfieri
21. *C. spathulatum* El-Gholl, Kimbrough, Barnard, Alfieri & Schoulties
22. *C. theae* (Petch) Subramanian
23. *C. variabile* Crous, Janse, Victor, Marais & Alfenas

#### INTRODUCTION

The genus *Cylindrocladium* Morgan was first described in 1892 for *C. scoparium* Morgan (Morgan, 1892). Boedijn & Reitsma (1950) recognized seven species, and in a recent review (Peerally 1991a), 26 species were accepted. *Cylindrocladium* spp. have been associated worldwide with numerous plant hosts, causing a wide range of disease symptoms. Disease development is generally more prevalent under humid conditions, and this explains why *Cylindrocladium* spp. are regarded as more important in tropical and subtropical areas (Crous *et al.*, 1991).

In the original description of *Cylindrocladium* (Morgan 1892), no mention was made of the stipe and characteristic terminal vesicle, now considered typical of this genus. In the first review of *Cylindrocladium*, Boedijn & Reitsma (1950) mentioned that all the species had a vesicle, and they also illustrated these structures as differing in shape. Although Peerally (1991a) distinguished one *Cylindrocladium* sp. by its apparent inability to form a stipe and vesicle, the concept of *Cylindrocladium sensu lato* is one of a fungus having a septate stipe and an apical vesicle (Crous *et al.*, 1993b).

Many species of *Cylindrocladium* are known to have teleomorphs in the holomorph genus *Calonectria* De Not. Rossman (1983) studied the various *Calonectria* spp. with *Cylindrocladium* anamorphs. She was

not able to distinguish all *Cylindrocladium* spp. by their teleomorphs, and therefore also rejected the vesicle as a criterion for distinguishing the various anamorph species. In some studies of *Cylindrocladium* (Sobers & Alfieri, 1972; Peerally, 1991a), vesicle morphology was found to be a reliable characteristic for species separation, while others (Zumpetta, 1976; Hunter & Barnett, 1978; Rossman, 1983) found it variable and unreliable, preferring to give preference to conidial characteristics. Recent studies (Crous *et al.*, 1992) have, however, shown that vesicle shape is influenced by the osmotic potential of the growing medium, and that it is a reliable criterion when examined on standardized media under prescribed growth conditions.

Boesewinkel (1982a) found that several of the small-spored *Cylindrocladium* species could be distinguished from the rest on the basis of cultural criteria, chlamyospore arrangement, two types of conidiophores, a *Nectria* (Fr.) Fr. holomorph, and a non-septate stipe. He accordingly transferred five species to a new genus, *Cylindrocladiella* Boesewinkel.

In his most recent review of *Cylindrocladium*, Peerally (1991a), treated the genus *Cylindrocladiella* as a synonym, and recognized 26 species. However, in our opinion, five species would be better accommodated in *Cylindrocladiella*, a genus we consider to be distinct from *Cylindrocladium* (Samuels *et al.*, 1991; Crous & Wingfield, 1993). Crous *et al.* (1991) found reference in the literature to six species of *Cylindrocladiella* and 34 of *Cylindrocladium*. In this study only the species of *Cylindrocladium* are considered in detail. *Cylindrocladiella* spp. have been treated elsewhere (Crous & Wingfield, 1993). Both teleomorph and anamorph characteristics are considered and illustrated. Keys to accepted species are also provided.

## MATERIALS AND METHODS

### *Material examined*

Standardization, both of media and conditions of incubation, are critical when studying and describing *Cylindrocladium* spp. (Crous *et al.*, 1992). Various media and different periods of incubation have previously been used by authors describing *Cylindrocladium* spp. Because of this variation, dried type specimens were inadequate for this study. Therefore, in addition to type specimens, type cultures (where available) and additional cultures were examined under standardized conditions.

Abbreviations used for herbaria are those cited by Holmgren & Kreuken (1974). Where type specimens were devoid of material, or depauperate, the original line drawings were redrawn, and the respective authors credited. All cultures and dried, colonized, pieces of carnation-leaf agar (CLA) (Fisher *et al.*, 1982; Crous *et al.*, 1992) were lodged at the National Collection of Fungi, Pretoria (PREM). A separate culture collection has been maintained at the Department of Plant Pathology, University of Stellenbosch (CPC), at 25 C on malt-extract agar (MEA) slants (20 g Oxoid malt extract, 15 g Difco agar, 1000 ml H<sub>2</sub>O), on sterile soil, and under H<sub>2</sub>O.

#### *Evaluation of anamorphs*

Single-conidial isolates were transferred to CLA, incubated at 25 C under near-ultraviolet lighting, and examined after 7 d. Only material occurring on the surface of the carnation leaves was examined. Material for microscopic examination was mounted in lactophenol containing cotton blue. Wherever possible, fifty examples of each structure were measured, means given, and extreme values placed in parentheses.

#### *Evaluation of teleomorphs*

Perithecia were derived from herbarium material as well as from fresh cultures. After material of anamorphs had been prepared for microscopic examination, plates were sealed and incubated until perithecia formed. Perithecia were examined before ascospores were released. This was because changes in spore length, septation and the degree of septal constriction were found to occur in older ascospores. Perithecia were placed in 5% KOH for 2-12 h, and fixed in 5% glutaraldehyde for 12-24 h. They were subsequently washed in H<sub>2</sub>O, and placed in a gelatine solution (12.5 g gelatine, 37.5 ml H<sub>2</sub>O, 0.5 g phenol). Longitudinal sections 10-15 µm thick were made using a Leitz Kryomat 1703 freezing microtome. Squash mounts were prepared in lactophenol cotton blue and 3% aqueous KOH.

#### *Cultural criteria*

*Growth studies.* To determine the maximum radial growth, agar plugs from 7-day-old colonies (3 mm diam.) of each fungus were placed at the centre of MEA plates and incubated at 25 C for 1 d to ensure active growth. After 1 d, the amount of growth was marked, and all isolates were incubated concurrently at 5, 8, 10, 15, 20, 25, 30, 33, and 35 C with three replicate plates of each culture at every temperature. It was

therefore necessary to include these temperatures to establish minimum and maximum temperature requirements for growth. Because most *Cylindrocladium* spp. have an optimum growth between 25 and 30 C, growth was also assessed after 3 d at these temperatures to determine the value of this rapid method in species differentiation. Radial growth was assessed after incubation for 6 d in the dark. Average growth was calculated as an average of four colony radii on each of the three plates. The experiment was repeated at least once for all isolates. Species that grew below 10 C were considered low temperature species, while those that grew above 30 C were regarded as high temperature species.

*Chlamydo-spores and colony colour.* This characteristic is of limited taxonomic value in *Cylindrocladium*, as most species form numerous, dense chlamydo-spore masses. There are, however, exceptions, which will be discussed for individual species. Chlamydo-spore measurements were found to be unreliable in this study, and were therefore excluded. Colony colours and chlamydo-spore formation were determined after 6 d. Colour designations used were those of Rayner (1970) and Methuen (Kornerup & Wanscher, 1967).

## EVALUATION OF MORPHOLOGICAL CHARACTERS

### *Anamorph*

*Vesicle shape and stipe length.* Vesicles in *Cylindrocladium* were measured and illustrated (Appendix 1) after cultures were incubated on CLA for 7 d at 25 C under near-ultraviolet light. Because stipes frequently branch in this genus, only terminal vesicles on primary stipes were considered. Only vesicles that were on stipes which had at least one primary and secondary branch with phialides, were included in measurements. Vesicles that showed signs of further proliferation were ignored. Vesicle length was found to be highly variable, but widths were reliable for taxonomic evaluation. Vesicles were often absent in microconidial states.

Although Boesewinkel (1982b) erected new species on the basis of stipe septation, there does not necessarily appear to be a relationship between length and septation of stipes. Species with longer conidia do, however, tend to have longer stipes. Vesicle shape and stipe length (from highest primary branch to the vesicle tip) should thus be seen as additional criteria of taxonomic value in *Cylindrocladium*.

*Microconidia.* At the outset of this study, five *Cylindrocladium* species, *C. pteridis*, *C. heptaseptatum*, *C. ovatum*, *C. parasiticum*, and *C. variabile* were known to have microconidial states (Sobers, 1968; El-Gholl *et al.*,

1987; Crous *et al.*, 1993b; Crous *et al.*, 1993e; El-Gholl *et al.*, 1993). Microconidial states are here reported for three more: *C. quinquesepatum*, *C. ilicicola* and *C. reteaudii*. The relationship between the microconidial and macroconidial state in *Cylindrocladium* is poorly understood. The microconidial state does, however, tend to have the same vesicle morphology as that of the macroconidial state.

**Phialides and collarettes.** *Cylindrocladium* spp. have only penicillate conidiophores. They rarely form collarettes (*sensu* Sutton, 1980) on macrophialides, although collars (*sensu* Booth & Murray, 1960) and channels (*sensu* Sutton, 1980) are often visible. We found that small-spored species have doliiform to reniform phialides. Species with conidia of medium length tended to have slightly elongate, doliiform to reniform phialides. In the large-spored species, phialides were cylindrical to allantoid (rarely doliiform) (Appendix 1, Table 1). Phialide shape in *Cylindrocladium* can therefore be related to conidium septation. A prediction concerning ascospore morphology can also be made (Table 1).

#### *Teleomorph*

**Ascocarp.** Ascocarps of *Calonectria* spp. range from yellow to orange, orange-red, red or red-brown, becoming blood-red in 3% KOH. In *C. colhounii*, only the lower part of the ascocarp changes colour. Ostioles are periphysate, and ascocarps generally become papillate with age.

*Calonectria* spp. have perithecia with a rough, warty outer layer. Although *Nectria* spp. also have walls consisting of two layers, the outer layer is generally not as rough as that of *Calonectria* spp. However, there appears to be considerable variation in this characteristic, as is evident from *Nectria* spp. recently described by Samuels & Brayford (1990).

Very few differences in stromatal morphology were observed among species of *Calonectria*. Ostiolar periphyses were also found in all perithecia. Ascocarps should be examined just before the ostiolar region becomes lighter in colour and more papillate, as this indicates the onset of ascospore discharge.

**Asci and ascospores.** Asci are unitunicate, and dissolve at maturity. Few distinct differences in ascospore size occur among species. Generally, species can be separated into those with small, medium or large ascospores. These can then be considered in conjunction with ascospore septation. Small ascospores tend to be 1-septate. Medium-sized ascospores are generally 1-3-septate, and large ascospores 3-septate. These characteristics can also be correlated with conidial septation. For

**Table 1.** Morphological characters of *Cylindrocladium* spp. with *Calonectria* teleomorphs

Species	Conidial septation <sup>a</sup>	Ascospore septation <sup>b</sup>	Phialide class <sup>c</sup>
<i>C. candelabrum</i>	1	1	1
<i>C. scoparium</i>	1	1	1
<i>C. floridanum</i>	1	1	1
<i>C. gracile</i>	1	1	1
<i>C. avesiculatum</i>	1	1	2
<i>C. pteridis</i>	1(-3)	1(-3)	2
<i>C. spathulatum</i>	1(-3)	1(-3)	2
<i>C. spathiphylli</i>	1(-3)	1(-3)	2
<i>C. ilicicola</i>	(1-)3	1(-3)	2
<i>C. crotalariae</i>	(1-)3	1(-3)	2
<i>C. colhounii</i> var. <i>colhounii</i>	(1-)3	(1-)3	2
<i>C. variable</i>	(1-)3(-4)	1(-3)	2
<i>C. colhounii</i> var. <i>macroconidialis</i>	(1-)3	(1-)3	3
<i>C. theae</i>	(1-)3	(1-)3	3
<i>C. reteaudii</i>	(1-)3(-6)	(1-)3	3
<i>C. quinquesepatum</i>	(1-)5(-6)	(1-)3	3

<sup>a</sup> Determined on carnation-leaf agar incubated for 7 d at 25 C under near-ultraviolet light.

<sup>b</sup> Determined before ascus dehiscence.

<sup>c</sup> 1 = Doliiform to reniform; 2 = elongate doliiform to reniform; 3 = cylindrical to allantoid.

example, species with 1-septate ascospores have 1-septate conidia, those with 1-3-septate ascospores have 1-3-septate conidia, and species with 3-septate-ascospores have 3- to multi-septate conidia (Table 1).

### KEYS

Both synoptic and dichotomous keys to species of *Cylindrocladium* are presented. In the synoptic key, numbers grouped with each character refer to the species that are alphabetically arranged in the text and in the table of contents.

#### Key to related anamorph genera

- 1 Conidia hyaline, 0-multi-septate, cylindrical with obtuse ends, in clear slimy masses, stipe extension present . 2
- 1 Conidia hyaline, 0-1-septate, cylindrical with obtuse ends, in yellowish slimy masses, stipe extension absent..... *Gliocladiopsis*
- 2 Stipe septate, microsclerotia common on MEA, cultures not slimy on MEA, phialide collarettes absent on CLA, associated ascocarp with warty outer layer .....*Cylindrocladium*
- 2 Stipe non-septate, microsclerotia uncommon on MEA, cultures mostly slimy on MEA, phialide collarettes present on CLA, associated ascocarp with smooth outer layer.....*Cylindrocladiella*

#### Synoptic key to *Cylindrocladium* species

1. Vesicle shape:
  - 1.1. avesciculate to clavate (Fig. 1B; Appendix 1)
    - 1
  - 1.2. clavate to spatulate (Figs 12A, 21A)
    - 12, 21
  - 1.3. clavate (Figs 4A, 6A)
    - 4, 5, 6, 9, 11, 16, 17, 22
  - 1.4. ellipsoidal to pyriform to obovoid (Figs 10A, 19A)
    - 3, 10, 19
  - 1.5. ellipsoidal to ovoid (Fig. 14C)
    - 14
  - 1.6. ellipsoid to obpyriform (Fig. 2B)
    - 2, 18
  - 1.7. sphaeropedunculate (Figs 8B, 15B)
    - 7, 8, 15, 23



- 1.8. globose (Fig. 20A)  
20
- 1.9. naviculate (Fig. 13B).  
13
2. Stipe length (mean in  $\mu\text{m}$ ):
  - 2.1. 120-150  
3
  - 2.2. 151-189  
2, 8, 12, 13, 15, 19, 21, 23
  - 2.3. 181-210  
4, 5, 10, 14, 18
  - 2.4. 211-240  
9, 16, 20
  - 2.5. 241-280  
1, 6, 17
  - 2.6. 381-650  
11, 22
3. Shape of phialides on penicillate conidiophores:
  - 3.1. reniform to doliiform (Figs 2, 3; Appendix 1)  
2, 3, 4, 8, 9, 10, 13, 14, 19
  - 3.2. elongate reniform to doliiform (Figs 16, 20)  
1, 5, 7, 12, 15, 16, 20, 21, 23
  - 3.3. cylindrical to allantoid (Figs 11, 17)  
6, 11, 17, 18, 22
4. Sporulation on aerial mycelium:
  - 4.1. slight to absent  
5, 6, 15, 17, 22
  - 4.2. moderate sporulation  
1, 2, 3, 4, 8, 9, 10, 11, 12, 13, 14, 16, 18, 19, 20, 21, 23
5. Conidium septation:
  - 5.1. 1-septate  
1, 2, 4, 7, 8, 9, 10, 13, 19
  - 5.2. 1(-3)-septate  
14, 16, 20, 21
  - 5.3. (1-)3-septate  
3, 5, 6, 12, 15, 22, 23
  - 5.4. (1-)3(-6)-septate  
18
  - 5.5. (1-)5(-6)-septate  
17

- 5.6. (1-)7(-8)-septate  
11
6. Conidium width (mean in  $\mu\text{m}$ ):
  - 6.1. 3-4  
2, 3, 7, 8, 10, 13, 19
  - 6.2. 4.5-5  
1, 4, 5, 9, 12, 14, 16, 21, 23
  - 6.3. 5.5-6  
15, 18, 20, 22
  - 6.4. 6.5-7  
6, 17
  - 6.5. above 7  
11
7. Conidium length (mean in  $\mu\text{m}$ ):
  - 7.1. 40-46  
2, 4, 7, 8, 13, 19
  - 7.2. 47-55  
3, 12
  - 7.3. 56-66  
1, 3, 5, 9, 10, 14, 15, 21, 23
  - 7.4. 67-75  
20
  - 7.5. 67-95  
16, 17, 18, 22
  - 7.6. above 96  
6, 11
8. Chlamydo spores on MEA:
  - 8.1. density medium (colonies light brown in colour)  
3, 6, 13, 18, 21
  - 8.2. extensive (colonies dark brown in colour)  
1, 2, 4, 5, 8, 9, 10, 11, 12, 14, 15,  
16, 17, 19, 20, 22, 23
9. Temperature requirement for minimum growth (C):
  - 9.1. below 5  
3, 21
  - 9.2. 5-8  
2, 10, 13, 19, 23
  - 9.3. 8-10  
1, 5, 6, 8, 12, 15, 18
  - 9.4. above 10  
4, 9, 11, 14, 16, 17, 20, 22

10. Temperature requirement for optimum growth (C):
  - 10.1. 25  
1, 3, 4, 5, 6, 11, 12, 13, 14, 15, 17, 18,  
20, 21, 22, 23
  - 10.2. 25-30  
2, 8, 19
  - 10.3. 30  
9, 10
  - 10.4. 30-33  
16
11. Maximum temperature permitting growth (C):
  - 11.1. below 33  
3, 5, 6, 11, 21
  - 11.2. below 35  
1, 4, 10, 12, 17, 18, 20, 22, 23
  - 11.3. above 35  
2, 8, 9, 13, 14, 15, 16, 19
12. Microconidial shape:
  - 12.1. curved (Fig. 16C)  
16
  - 12.2. straight (Fig. 17C)  
11, 12, 14, 15, 17, 18, 23
13. Microconidial length (mean in  $\mu\text{m}$ ):
  - 13.1. 10-20  
11
  - 13.2. 21-38  
12, 14, 15, 16, 23
  - 13.3. above 39  
17, 18
14. Collarettes on phialides of microconidiophores:
  - 14.1. present (Fig. 12B)  
11, 12, 14, 15
  - 14.2. absent (Fig. 16C)  
16, 17, 18, 23
15. Ascocarps:
  - 15.1. red-brown to red in colour, changing to  
blood-red in 3% KOH  
2, 9, 16, 19, 23
  - 15.2. orange to red in colour, changing  
to blood red in 3% KOH  
1, 8, 12, 15, 18, 20, 21, 22

- 15.3. orange to red-brown in colour,  
changing to blood red in 3% KOH  
17
- 15.4. yellow to orange in colour, only base  
and stroma changing to blood-red in KOH  
5, 6

*Dichotomous key to Cyliandrocladium species*

1. Conidia only 1-septate ..... 2
1. Conidia with more than one septum present ..... 10
2. Conidia mostly straight ..... 3
2. Conidia mostly curved ..... 4
3. Vesicles narrowly avesciculate to clavate,  
stipe thick-walled, conidia  
(57-)64(-77) x (4-)5(-7)  $\mu\text{m}$  ..... 1 *C. avesciculatum*
3. Vesicles not as above ..... 5
4. Conidia 40-46 x 3-4  $\mu\text{m}$ , vesicles  
sphaeropedunculate ..... 7 *C. curvatum*
4. Conidia (42-)56(-76) x (3-)4(-5)  $\mu\text{m}$ ,  
vesicles ellipsoidal to obovoid ..... 10 *C. hawksworthii*
5. Vesicles clavate ..... 6
5. Vesicles not as above ..... 7
6. Conidia (40-)56(-65) x (4-)5  $\mu\text{m}$ ,  
stipes (160-)220(-350)  $\mu\text{m}$  ..... 9 *C. gracile*
6. Conidia (38-)45(-52) x (4-)5(-6)  $\mu\text{m}$ ,  
stipes (140-)200(-260)  $\mu\text{m}$  ..... 4 *C. clavatum*
7. Vesicles sphaeropedunculate, conidia  
(35-)40(-50) x (3-)4(-5)  $\mu\text{m}$  ..... 8 *C. floridanum*
7. Vesicles not as above ..... 8
8. Vesicles ellipsoidal to pyriform  
(widest above the middle), conidia  
(40-)45(-55) x (3-)4(-5)  $\mu\text{m}$  ..... 19 *C. scoparium*
8. Vesicles not as above ..... 9
9. Vesicles ellipsoidal to obpyriform  
(widest below the middle), conidia  
(33-)45(-58) x (3-)4(-5)  $\mu\text{m}$  ..... 2 *C. candelabrum*
9. Vesicles naviculate, conidia  
(40-)43(-55) x (3-)4  $\mu\text{m}$  ..... 13 *C. naviculatum*
10. Average conidial septation, one ..... 11
10. Average conidial septation more than one ..... 14

11. Vesicles mostly globose, conidia (48-)68(-104) x (5-)6(-7)  $\mu\text{m}$  ..... 20 *C. spathiphylli*
11. Vesicles not as above..... 12
12. Vesicles ovoid, conidia (36-)65(-80) x (4-)5(-6)  $\mu\text{m}$  ..... 14 *C. ovatum*
12. Vesicles not as above..... 13
13. Vesicles clavate to spatulate, conidia (48-)58(-75) x (4-)5(-6)  $\mu\text{m}$  ..... 21 *C. spathulatum*
13. Vesicles narrowly clavate, conidia (62-)82(-121) x 5(-6)  $\mu\text{m}$  ..... 16 *C. pteridis*
14. Conidia (1-)3-septate..... 15
14. Conidia more than 3-septate ..... 21
15. Vesicles clavate ..... 16
15. Vesicles not as above..... 18
16. Phialides doliiform to reniform, conidia (45-)59(-70) x (4-)5(-6)  $\mu\text{m}$ , stipes (160-)210(-280)  $\mu\text{m}$ ..... 5 *C. colhounii* var. *colhounii*
16. Phialides cylindrical to allantoid..... 17
17. Conidia (65-)81(-96) x (5-)6(-7)  $\mu\text{m}$ , stipes (340-)380(-600)  $\mu\text{m}$  ..... 22 *C. theae*
17. Conidia (86-)97(-112) x (5-)7(-8)  $\mu\text{m}$ , stipes (240-)280(-320)  $\mu\text{m}$  ..... 6 *C. colhounii* var. *macroconidialis*
18. Vesicles uniformly sphaeropedunculate, conidia (45-)62(-90) x (4-)6(-7)  $\mu\text{m}$ ..... 15 *C. parasiticum*
18. Vesicles not as above..... 19
19. Vesicles sphaeropedunculate, ellipsoid to clavate, conidia (48-)60(-75) x (4-)5(-6)  $\mu\text{m}$ , frequently curved ..... 23 *C. variabile*
19. Vesicles not sphaeropedunculate, but clavate to spatulate to obovoid..... 20
20. Chlamydo spores in medium numbers, a low temperature species ..... 3 *C. citri*
20. Chlamydo spores extensive, a high temperature species ..... 12 *C. ilicicola*
21. Conidia (1-)3(-6)-septate, vesicles clavate to ellipsoidal to ovoid, conidia (60-)80(-105) x (5-)6(-7)  $\mu\text{m}$  ..... 18 *C. reteaudii*

21. Average conidial septation more than three ..... 22  
 22. Conidia (61-)84(-101) x (5-)7  $\mu\text{m}$   
 ..... 17 *C. quinquesseptatum*  
 22. Conidia (96-)118(-144) x (6-)8(-9)  $\mu\text{m}$   
 ..... 11 *C. heptaseptatum*

## CYLINDROCLADIUM

**Cylindrocladium** Morgan *Bot. Gaz.* **17**: 191 (1892).

*Candelospora* Hawley apud Rea & Hawley *Proc.*

*R. Irish Acad.* **31**: 11 (1912).

*Tetracytum* Vanderwalle *Parasitica* **1**: 145 (1945).

**Type species:** *C. scoparium* Morgan

Holomorph: *Calonectria* De Not. (*C. pyrochroa* (Desm.) Sacc.)

**Descriptions:** Boedijn & Reitsma, 1950; Hunter & Barnett, 1978; Rossman, 1983.

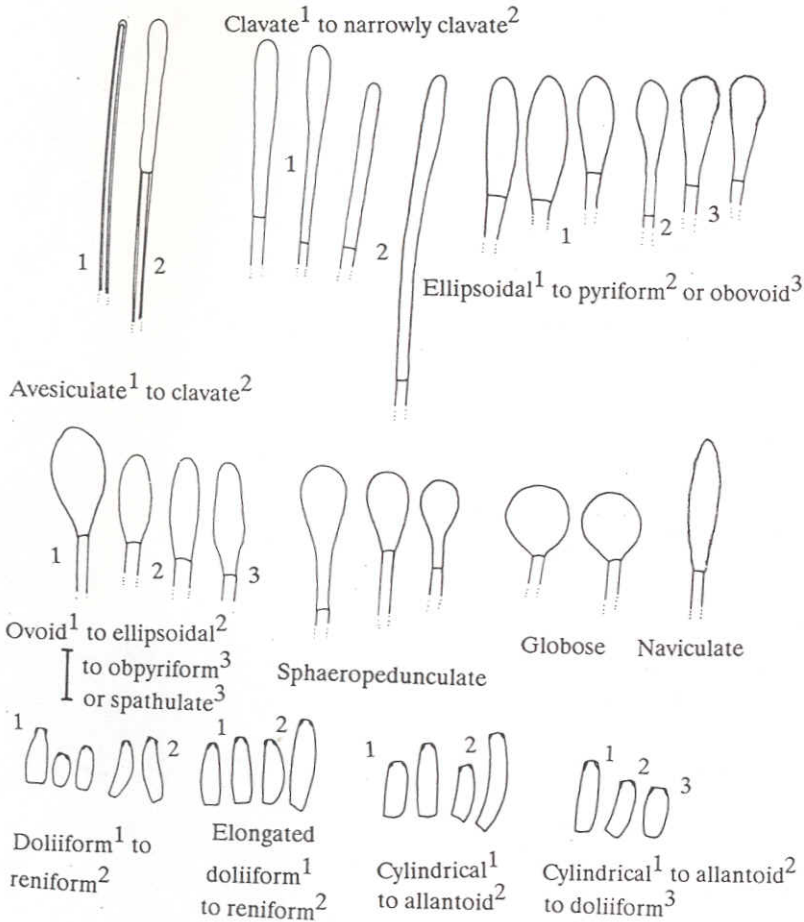
*Macroconidiophores* hyaline, penicillate, frequently with pigmented base, arising at right angles to the substrate. *Stipe* septate, hyaline, tapering towards apex, referred to as the stipe, frequently in the middle or to the side of the conidiophore, branched or unbranched, giving rise to a terminal, thin-walled structure of characteristic shape, called the vesicle. *Conidiophore branches* hyaline, penicillate, branching up to six times. *Monophialides* hyaline, with collars, doliiform or reniform to cylindrical or allantoid, occurring singly, or in groups of up to five on the ends of branches. *Conidia* hyaline, cylindrical, straight or curved, 1-8-septate with obtuse ends, mostly encased in an irregular mucilaginous matrix, arranged in cylindrical conidial clusters. *Chlamydospores* dark brown, thick-walled, occurring in clusters or chains, forming microsclerotia in soil, debris, host tissue and culture media.

*Microconidiophores* hyaline, penicillate or subverticillate, occurring mixed with macroconidiophores. *Stipe* hyaline, septate, cylindrical or with apical taper, terminating in a whorl of phialides or apical vesicle. *Conidiophore branches* hyaline, cylindrical, branching up to three times. *Monophialides* hyaline, cylindrical, frequently with conspicuous collarettes. *Conidia* hyaline, 1-septate, cylindrical with obtuse ends, curved or straight.

**Teleomorph.** Species either homothallic or heterothallic.

*Perithecia* solitary or gregarious, superficial, with periphysate ostiolar region, yellow to orange to red or red-brown, turning blood-red in 3 %

APPENDIX 1  
VESICLE AND PHIALIDE SHAPES



**Avesiculate to clavate vesicles**, *C. avesiculatum*; **Clavate to narrowly clavate vesicles**, *C. clavatum*, *C. colhounii*, *C. gracile*, *C. hawksworthii*, *C. heptaseptatum*, *C. ilicicola*, *C. pteridis*, *C. quinqueseptatum*, *C. spathulatum*, *C. theae*, *C. variabile*; **Ellipsoidal to pyriform or obovoid vesicles**, *C. hawksworthii*, *C. reteaudii*, *C. scoparium*, *C. variabile*; **Ovoid to ellipsoidal to obpyriform or spathulate vesicles**, *C. candelabrum*, *C. citri*, *C. ilicicola*, *C. ovatum*, *C. spathiphylli*, *C. spathulatum*; **Sphaeropedunculate vesicles**, *C. curvatum*, *C. floridanum*, *C. parasiticum*, *C. variabile*; **Globose vesicles**, *C. spathiphylli*; **Naviculate vesicles**, *C. naviculatum*.

KOH. *Ascocarp* wall consisting of two regions. The outer wall having large, globose cells, giving rise to a warty appearance. The inner layer consisting of hyaline, thin-walled elongate cells. *Asci* unitunicate, without apical mechanism, evanescent at maturity, clavate, tapering to a long thin basal stalk. *Ascospores* usually aggregated in upper third of ascus, bi- to multi-seriate, hyaline, straight to fusoid or ellipsoidal, one- to multi-septate, not or slightly constricted at septa, (1-4-)8 per ascus.

#### *Generic synonyms*

Boedijn & Reitsma (1950) reduced the genus *Candelospora* to synonymy with *Cylindrocladium*. They subsequently also made new combinations for two species, *Candelospora ilicicola* Hawley and *Candelospora citri* Fawcett & Klotz. Tubaki (1958) followed this decision by placing *Candelospora penicilloides* Tubaki in *Cylindrocladium*. Tubaki (1958) recognized the similarity between the genus *Moeszia* Bubak and *Cylindrocladium*. Later, Von Arx (1970) reduced *Moeszia* to synonymy with *Cylindrocarpon* Wollenw. *Tetracytum* Vanderwalle, with type species *T. laurii* Vanderwalle (1945) was recognized as a synonym of *Cylindrocladium* (Subramanian, 1971; Domsch *et al.*, 1980). *T. laurii* was thus synonymized with *C. ilicicola* (Meyer, 1959). The similarity of these two fungi was also recognized by Brayford & Chapman (1987).

Although *Diplocladium* Bonord. was never considered to be a synonym of *Cylindrocladium*, two species originally described in *Diplocladium* were later transferred to *Cylindrocladium*. These are *D. cylindrosporium* Ellis & Everh. (Ellis & Everhart, 1900) a synonym of *C. scoparium* (Boedijn & Reitsma, 1950) and *D. gregarium* Bres. (Bresadola, 1903), which was wrongly placed in *Cylindrocladium* by de Hoog (1978). The genus *Diplocladium* has, however, been synonymized with *Cladobotryum* Nees (Barron, 1968).

### SPECIES

#### 1. *Cylindrocladium avesiculatum* Gill, Alfieri & Sobers

*Phytopathology* 61: 60 (1971).

Holomorph: *Calonectria avesiculata* Schubert, El-Gholl, Alfieri & Schoulties *Can. J. Bot.* 67: 2415 (1989).

**Illustrations:** Figs 1, 24, 25; Gill *et al.*, (1971); Schubert *et al.* (1989).

**Descriptions:** Gill *et al.*, (1971); Schubert *et al.* (1989).

*Macroconidiophores.* *Stipe* septate, hyaline, terminating in an avesiculate to clavate vesicle, (1-)3(-4)  $\mu\text{m}$  diam.; *stipes* (190-)265(-360)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches



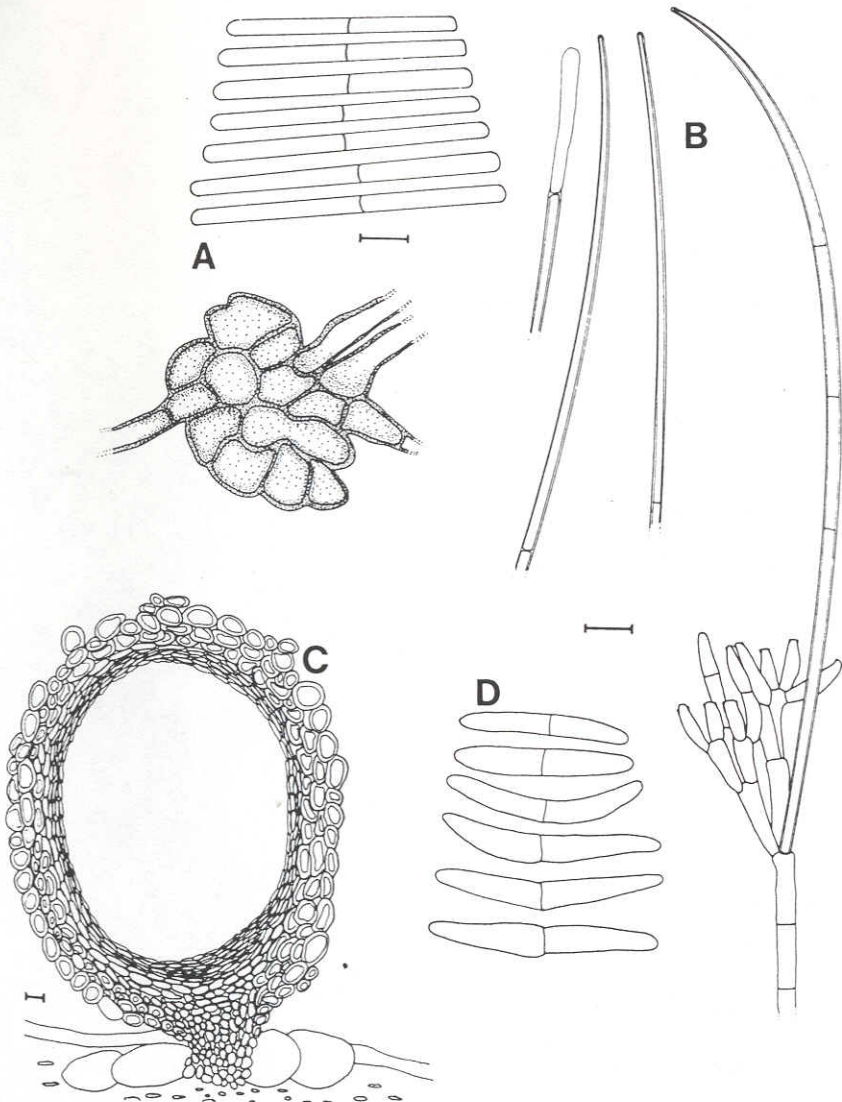


Fig. 1A-D. *Calonectria avesciculata* and its *Cylindrocladium avesciculatum* anamorph (bar = 10  $\mu$ m). A, conidia and microsclerotium; B, clavate vesicles, avesciculate stipes and conidiophore on CLA (ATCC 38226, ex type); C, v.s. through a perithecium; D, ascospores (F 55193, type).

non-septate or rarely 1-septate, (13-)17(-25) x (4-)5  $\mu\text{m}$ ; secondary branches non-septate, (10-)13(-15) x 4(-5)  $\mu\text{m}$ ; tertiary branches non-septate, rarely observed, (8-)12(-13) x (3-)4(-5)  $\mu\text{m}$ . *Phialides* elongate, doliiform to reniform, hyaline, non-septate, (9-)12(-16) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate, rounded at both ends, (57-)64(-77) x (4-)5(-7)  $\mu\text{m}$ . *Microconidiophores* unknown.

*Cultural characteristics.* Temperature min. above 8 C; max. below 35 C; opt. 25 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K amber brown (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydo-spores* extensive, dense, forming large microsclerotia.

*Teleomorph.* *Perithecia* globoid, red to orange-red in colour, 340-520 x 300-500  $\mu\text{m}$ , with warty outer wall and papillate ostiole, turning blood-red in 3 % KOH. *Asci* hyaline, clavate, 82-190 x 13-30  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, 1-septate, not or slightly constricted at central septum, (22-)40(-50) x (4-)6(-7)  $\mu\text{m}$ .

**Type:** USA: Georgia, Cairo, *Ilex cornuta* Lindl. & Paxt. leaves, D. Gill, 27 May 1969, BPI 414546 (isosyntyne of anamorph); Florida, Gainesville, *I. vomitoria* Soland. leaves, T. Schubert, Oct. 1986, FLAS F55193 (holotype of teleomorph).

**Symptoms:** leaf spotting, twig die-back and defoliation (Gill *et al.*, 1971).

**Hosts:** *Ilex* spp., *Pyranantha coccinea* M. Roem., *Rhododendron obtusum* Planch. (Gill *et al.*, 1971).

**Distribution:** U.S.A. (Georgia, Florida) (Schubert *et al.*, 1989).

**Specimens:** USA: Georgia, Cairo, *Ilex cornuta* leaves, D. Gill, 27 May 1969, BPI 414546 (isosyntyne of anamorph); Georgia, Cairo, *Ilex vomitoria* leaves, 27 May 1969, BPI 414547; Florida, Gainesville, *I. vomitoria* leaves, T. Schubert, Oct. 1986, FLAS F55193 (holotype of teleomorph).

**Culture:** USA: Georgia, Cairo, *Ilex vomitoria*, S.A. Alfieri, 1971, ATCC 38226.

**Notes:** *C. avesiculatum* is characterized by having large 1-septate conidia, and thick-walled avesiculate stipes. The nature of the stipe is unique to this species.

Gill *et al.* (1971) refer to *C. simplex* Meyer and *C. simplex* var. *microchlamydosporum* Meyer which are avesiculate, with stipes terminating in a slight swelling (Meyer, 1959). These two fungi are not

*Cylindrocladium* spp., and were transferred to *Gliocephalotrichum* Ellis & Hesselstine (Wiley & Simmons, 1971). Meyer (1959) illustrates a collection of *C. scoparium* from Zaire, which in spite of the slightly smaller conidia (40-48 x 3-4  $\mu\text{m}$ ), strongly resembles *C. vesiculatum*. No mention is made of any herbarium specimens, so this matter cannot be pursued further. Schubert *et al.* (1989) state that *Calonectria vesiculata* is heterothallic.

2. *Cylindrocladium candelabrum* Viegas *Bragantia* 6: 370 (1946).

Holomorph: *Calonectria scoparia* Ribeiro & Matsuoka *ex* Peerally (1991) *Mycotaxon* 40: 341.

*Calonectria scoparia* Ribeiro & Matsuoka (1978) Ribeiro, M. Sc. Thesis, Heterotalismo em *C. scoparium* Morgan p. 28. (*nom. nud.*).

Illustrations: Figs 2, 26, 27; Ribeiro (1978); Ferreira (1989); Botha & Crous (1992).

Descriptions: Ribeiro (1978); Botha & Crous (1992); Crous *et al.* (1993a).

*Macroconidiophores.* Stipe septate, hyaline, terminating in an ellipsoid to obpyriform vesicle (Hawksworth *et al.*, 1983), (6-)8(-10)  $\mu\text{m}$  diam; stipes (105-)180(-290)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate or rarely 1-septate, (13-)19(-27) x (3-)4  $\mu\text{m}$ ; secondary branches non-septate, (10-)15(-22) x (3-)4  $\mu\text{m}$ ; tertiary branches non-septate, (10-)14(-16) x (3-)4  $\mu\text{m}$ . *Phialides* arise from the ends of branches, in groups of 2, 3 or 4; phialides dolliiform to reniform, hyaline, (7-)13(-19) x (3-)4  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate, rounded at both ends, (33-)45(-66) x (3-)4(-5)  $\mu\text{m}$ . *Microconidiophores* unknown.

*Cultural characteristics.* Temperature min. above 5 C; max. above 35 C; opt. 25-30 C. This is a eurythermal species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) (13K-17I-15I), amber brown to buckthorn brown to sayal brown (Rayner, 1970), (5D6-6D8 or 5C6-6C7) pompeian yellow to light brown, or oak brown to reddish golden (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, in chains or clusters, forming microsclerotia in moderate numbers.

*Teleomorph.* *Perithecia* superficial, borne singly or in small groups, globose or subglobose, 280-520 x 280-400  $\mu\text{m}$ , red-brown to red, with rough warted outer wall and papillate ostiole. *Asci* hyaline, clavate, (72-)90(-120) x (6-)8(-15)  $\mu\text{m}$ , tapering to a long thin stalk,

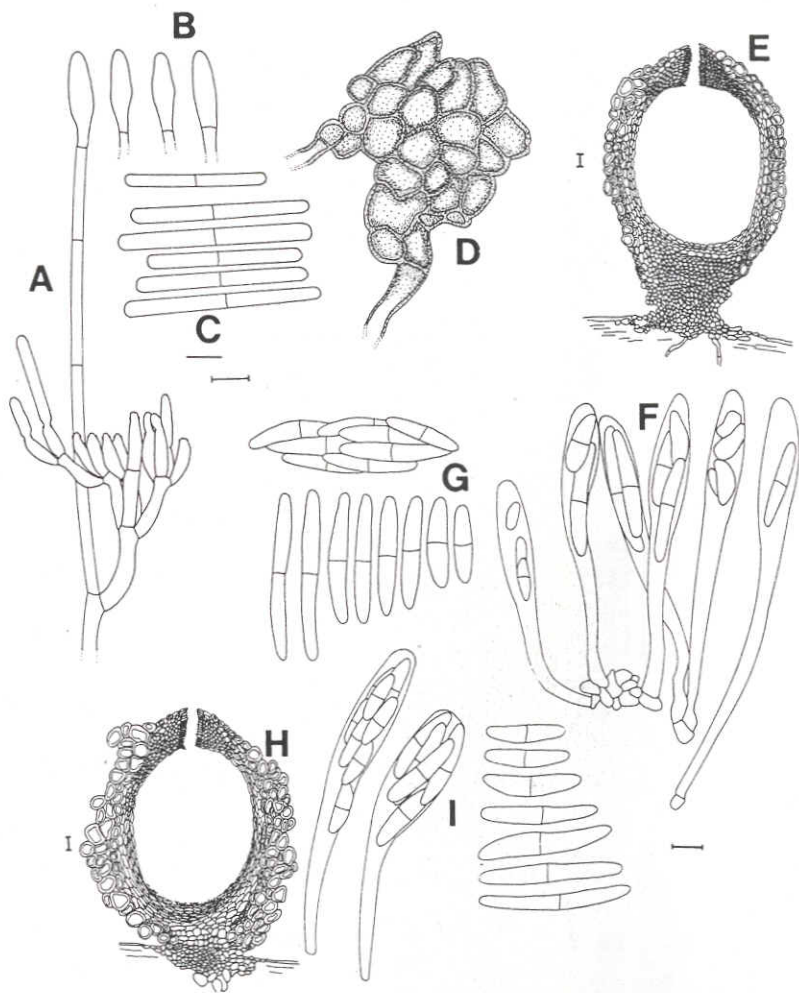


Fig. 2A-I. *Calonectria scoparia* and its anamorph *Cylandrocladium candelabrum*. A, conidiophore; B, obpyriform to ellipsoid vesicles; C, conidia; D, microsclerotium on CLA (PPRI 3989); E, v. s. through a perithecium (bar = 20  $\mu$ m); F, G, asci and ascospores; C, (Brazil X Brazil PPRI 4163 x PPRI 4153, bar = 10  $\mu$ m); H, v. s. through a perithecium (bar = 20  $\mu$ m); I, asci and ascospores (South African x South African PPRI 4202 x PPRI 4199, bar = 10  $\mu$ m).

containing 1-8 ascospores. *Ascospores* hyaline, straight to falcate, 1-septate, not or slightly constricted at central septum, (28-)41(-68) x (4-)5(-7)  $\mu\text{m}$ . Ascospores becoming 3-septate once discharged from ascus.

**Type:** Brazil: Copener-Bahia, *Eucalyptus* sp., A.C. Alfenas, PPRI 4153, PREM 51044 (neotype of anamorph); Brazil, BA Sul, Picadao, Conceicao da Barra, A.C. Alfenas & F.A. Ferreira, *Eucalyptus grandis* clone 172 (branch), 27 Apr. 1992, PREM 51045 (neotype of teleomorph).

**Symptoms:** damping off, root rot, cutting rot, stem cankers, leaf spotting, seedling and shoot blight (Ferreira, 1989).

**Hosts:** wide host range (Ferreira, 1989; Botha & Crous, 1992).

**Distribution:** Australia, Brazil, India, Kenya, Mauritius, South Africa.

**Specimens:** Africa: Kenya, *E. saligna* Sm., I. Gibson, 1966, IMI 123734; RSA, E. Tvl., Sabie, Frankfort, *E. grandis* cuttings, A.C. Alfenas, 24 Mar. 1992, PREM 51046 (teleomorph occurring naturally on cuttings); RSA, Natal, Cedara, *Syncarpia gummifera* (Smith) Niedz., M.J. Wingfield, 17 July 1978, PPRI 45419; PPRI 4202 (*E. macarthurii*) x PPRI 4199

(*Eucalyptus* sp.), July 1992, P.W. Crous, PREM 51050. **Brazil:** Luma sp., Campinas, Herbario da Seccao de Botanico IACM 440 (holotype of *C. candelabrum*); *Annona* sp., Campinas, Herbario da Seccao de Botanico, IACM 8155; PPRI 4163 (*Eucalyptus* sp.) x PPRI 4153 (*Eucalyptus* sp.), July 1992, P.W. Crous, PREM 51047; PPRI 4161 (*E. grandis*) x PPRI 4153 (*Eucalyptus* sp.), July 1992, P.W. Crous, PREM 51048; PPRI 4146 (*Eucalyptus* sp.) x PPRI 4153 (*Eucalyptus* sp.), July 1992, P.W. Crous, PREM 51049. **India:** *Eucalyptus* sp., C. Booth, 1964, IMI 108770 (as *C. theobromae*). **Mauritius:** unknown host, M.A. Peerally, IMI 167982 (as *C. sclerotiorum*).

**Cultures:** Africa: RSA: Swellendam, *Medicago truncatula*, S. Lamprecht, 16 March 1986, PPRI 3554; Natal, Seven Oaks, debris, 1 Feb. 1990, I. Rong, PPRI 3812; Natal, Kwambonambi, *E. grandis*, G. Kemp, May 1990, PPRI 3988; E. Tvl., Frankfort, *Eucalyptus* sp., S.H. Koch, 1988, PPRI 3989; E. Tvl., White River, *Rhododendron* hybrid, P.W. Crous, 11 May 1990, PPRI 4085; Natal, Pietermaritzburg, *E. nitens*, P.W. Crous, March 1991, PPRI 4189; Natal, Kwambonambi, *E. grandis*, P.W. Crous, Feb. 1990, PPRI 4191; Natal, Kwambonambi, *E. grandis*, P.W. Crous, Feb. 1990, PPRI 4192; E. Tvl., White River, *E. grandis*, P.W. Crous, Feb. 1990, PPRI 4193; Natal, Pietermaritzburg, *E. fastigata*, P.W. Crous, Feb. 1990, PPRI 4194; Natal, Kwambonambi, *Eucalyptus* sp., P.W. Crous, Feb. 1990, PPRI 4195; Natal, Kwambonambi, *Eucalyptus* sp., P.W. Crous, May 1990, PPRI 4196; E. Tvl., White River, *Eucalyptus* sp., P.W. Crous, 29 Sept.

1989, PPRI 4197; E. Tvl., Klipkraal, *E. grandis*, P.W. Crous, Feb. 1990, PPRI 4198; E. Tvl., Sabie, D.R. De Wet, *Eucalyptus* roots, P.W. Crous, Feb. 1990, PPRI 4199; N. Tvl., Tzaneen, *Eucalyptus* sp., P.W. Crous, 28 June 1990, PPRI 4201; Natal, Commondale, M.J. Wingfield, *E. macarthurii*, 5 Jan. 1987, PPRI 4202; E. Tvl., *E. nitens* (Deane et Maid.) Maid., M.J. Wingfield, ?, PPRI 4203; E. Tvl., Sabie, *E. grandis* roots, M.J. Wingfield, ?, PPRI 4204; E. Tvl., White River, *E. grandis* cuttings, P.W. Crous, 29 Sept. 1989, PPRI 4205; ?, *Acacia cyclops*, M. Morris, 10 July 1990, PPRI 4206; Natal, Kwambonambi, *Eucalyptus* leaves, P.W. Crous, May 1990, PPRI 4208. **Australia:** Queensland, from strawberry, D. Hutton, CPC 517, 518. **Brazil:** MG, Joao Pinheiro, *E. cloeziana*, A.C. Alfenas, PPRI 4151; MG, Virginopolis, *Eucalyptus* sp., PPRI 4146, IMI 354527; Copener-Bahia, *Eucalyptus* sp., PPRI 4148; UNB, J.C. Dianese, PPRI 4149; Viveiro, *Eucalyptus* sp., A.C. Alfenas, PPRI 4150; Copener-Bahia, *Eucalyptus* sp., A.C. Alfenas, PPRI 4152; Copener-Bahia, *Eucalyptus* sp., A. C. Alfenas, PPRI 4153, IMI 354517; ?, UNB, J.C. Dianese, PPRI 4155; CAF, *Eucalyptus* sp., A.C. Alfenas, PPRI 4156; MG, Ipatinga, *Eucalyptus* sp., A.C. Alfenas, PPRI 4158; MG, Ipatinga, *Eucalyptus* sp., A.C. Alfenas, PPRI 4159; Viveiro Florestas Rio Doce, *E. grandis*, A.C. Alfenas, PPRI 4161; MG, Coronel Fabricano, *Eucalyptus* sp., A.C. Alfenas, PPRI 4163 IMI 354518; PE, Recife, *Eucalyptus* sp., R.L.R. Mariano, PPRI 4165; ES, Aracruz, *Eucalyptus* sp., A.C. Alfenas, PPRI 4734.

**Notes:** this species is morphologically similar to *C. floridanum* and *C. scoparium*. It can, however, be distinguished by its ellipsoidal to obpyriform vesicles. Those of *C. floridanum* and *C. scoparium* are sphaeropedunculate and pyriform respectively (Appendix 1). Furthermore, the total protein electrophoresis banding pattern of *C. candelabrum* can be distinguished from that of *C. scoparium* (Crous *et al.*, 1993a).

Matings of single-conidial isolates from *C. scoparium* cultures have shown that this species does not cross with isolates of *C. candelabrum*. Moreover, isolates of *C. candelabrum* from South Africa and Brazil are sexually compatible, and pairings between and among them result in the formation of the teleomorph (Crous *et al.*, 1993a). The teleomorph is also frequently found associated with diseased *Eucalyptus* cuttings in forest nurseries in South Africa and Brazil.

3. *Cylindrocladium citri* (Fawcett & Klotz) Boedijn & Reitsma  
*Reinwardtia* 1: 57 (1950).

*Candelospora citri* Fawcett & Klotz *Mycologia* 29: 213 (1937).

*Cylindrocladium penicilloides* (Tubaki) Tubaki *Journ. Hattori Bot. Lab.* 20: 154 (1958).

*Candelospora penicilloides* Tubaki *Nagaoa* 2: 58 (1952).

**Illustrations:** Figs 3, 28, 29; Boedijn & Reitsma (1950).

**Descriptions:** Fawcett & Klotz, 1937; Boedijn & Reitsma (1950).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a obovoid to pyriform vesicle, (4-)7(-10)  $\mu\text{m}$  diam; stipes (115-)127(-170)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate to 1-septate, (10-)16(-26) x (3-)4(-5)  $\mu\text{m}$ ; secondary branches non-septate, (10-)11(-12) x (2-)3(-4)  $\mu\text{m}$ . *Phialides* doliiform to reniform, hyaline, non-septate, (8-)10(-11) x (3-)4  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3-septate, rounded at both ends, (50-)58(-65) x (3-)4(-5)  $\mu\text{m}$ . *Microconidiophores* unknown; *Teleomorph* unknown.

*Cultural characteristics.* Temperature min. below 5 C; max. below 33 C; opt. 25 C. This is a low temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13'I tawny (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydospores* in medium numbers, scattered throughout the medium or appearing in chains, forming microsclerotia.

**Type:** USA: Florida, *Citrus sinensis* Pers. fruit, H.S. Fawcett, 1937, CBS 186.36 (ex type culture).

**Symptoms:** decay of citrus fruits (Fawcett & Klotz, 1937).

**Hosts:** Citrus (Fawcett & Klotz, 1937).

**Distribution:** Florida, U.S.A. (Fawcett & Klotz, 1937).

**Cultures:** USA: Florida, *Citrus sinensis* fruit, H.S. Fawcett, 1937, CBS 186.36. Japan: Hatizyo, *Prunus* sp., M. Ookubu, 1952, CBS 174.55.

**Notes:** there have been no reports in the literature of this fungus other than that dealing with its type culture. The vesicles of this species are very variable, as was noted by Zumpetta (1976). Although Boedijn & Reitsma (1950) did not illustrate the exact nature of the vesicle, Sobers & Alfieri (1972) described it as "mostly ellipsoidal". On CLA, they are obovoid to pyriform in shape. However, young vesicles frequently resemble those of *C. ilicicola*. *C. citri* is distinguishable from *C. ilicicola* in being a low temperature species, while the latter is a high temperature species.

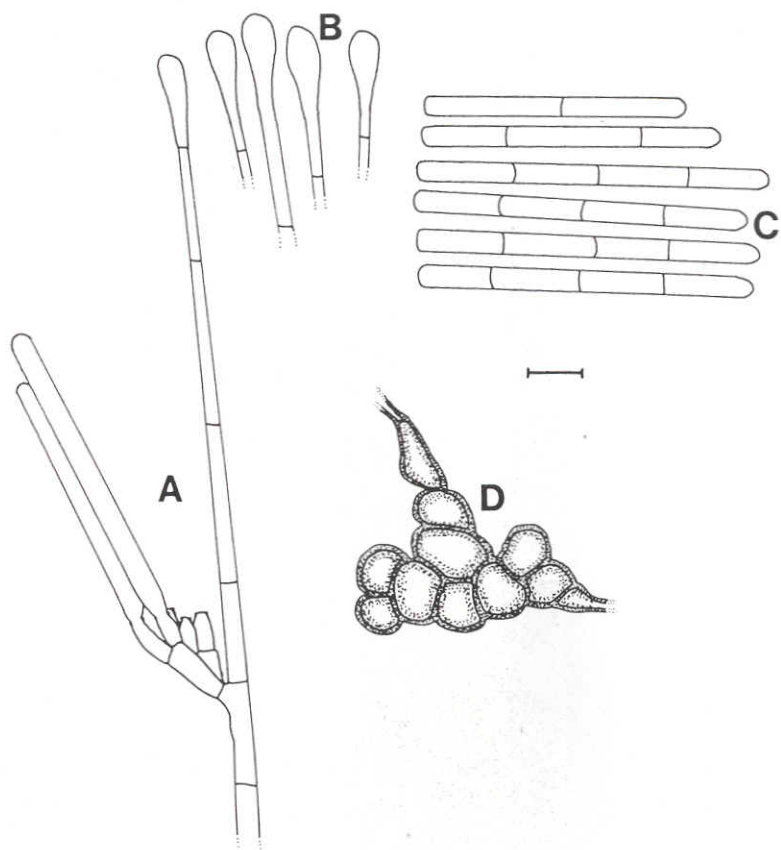


Fig. 3A-D. *Cyliandrocladium citri* (bar = 10  $\mu\text{m}$ ). A, conidiophore; B, obovoid to pyriform vesicles; C, conidia; D, microsclerotium on CLA (CBS 186.36, *ex type*).



The general morphology and cultural characteristics were found to be similar to that of *C. penicilloides* which was collected from a *Prunus* sp. in Japan in 1952. Further molecular study of the sterile type culture (CBS 174.55) (Crous *et al.*, 1993b), found that although the esterase zymograms showed differences from that of *C. citri* (CBS 186.36), the repetitive DNA polymorphisms using three restriction enzymes showed them to be very similar. Because of the similarities in their general morphology, chlamydospore formation, temperature requirements for growth and DNA banding patterns, *C. penicilloides* was reduced to synonymy with *C. citri*.

4. *Cylindrocladium clavatum* Hodges & May *Phytopathology* 62: 900 (1972).

*Cylindrocladium brassicae* Panwar & Bohra *Indian Phytopathology* 27: 425 (1974).

**Illustrations:** Figs 4, 30-32; Hodges & May (1972); Peerally (1974b).

**Descriptions:** Hodges & May (1972); Peerally (1974b).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a clavate vesicle, (3-)5(-6)  $\mu\text{m}$  diam.; stipes (140-)200(-260)  $\mu\text{m}$  long.

*Conidiophore branches:* primary branches non-septate or rarely 1-septate, (10-)16(-25) x (4-)5  $\mu\text{m}$ ; secondary branches non-septate, (10-)13(-18) x 4(-5)  $\mu\text{m}$ ; tertiary branches non-septate, (11-)13(-16) x 4(-5)  $\mu\text{m}$ ; quaternary branches non-septate, (10-)12(-13) x 4(-5); pentianary branches non-septate, (9-)10(-11) x 4(-5)  $\mu\text{m}$ . *Phialides* doliiform to reniform, hyaline, non-septate, (10-)12(-13) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate, rounded at both ends, (38-)45(-52) x (4-)5(-6)  $\mu\text{m}$ .

*Microconidiophores* unknown; *Teleomorph* unknown.

*Cultural characteristics.* Temperature min. above 10 C; max. below 35 C; opt. 25 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13 K - 17"K amber brown to Saccardo's umber (Rayner, 1970), 6D8 - 5E7 light brown to linoleum brown (Kornerup & Wanscher, 1967).

*Chlamydospores* extensive, dense, throughout medium, forming microsclerotia.

**Type:** Brazil: M.G., Horto Conceicao, near Itabira, *Pinus caribaea* E.

Murray roots, Hodges & May, 16 Mar. 1971, BPI 414550, 414551.

**Symptoms:** root rot, leaf spotting, stem infection, seedling blight, tuber rot and shoot blight. This fungus is possibly seed-borne (Bolkan *et al.*,

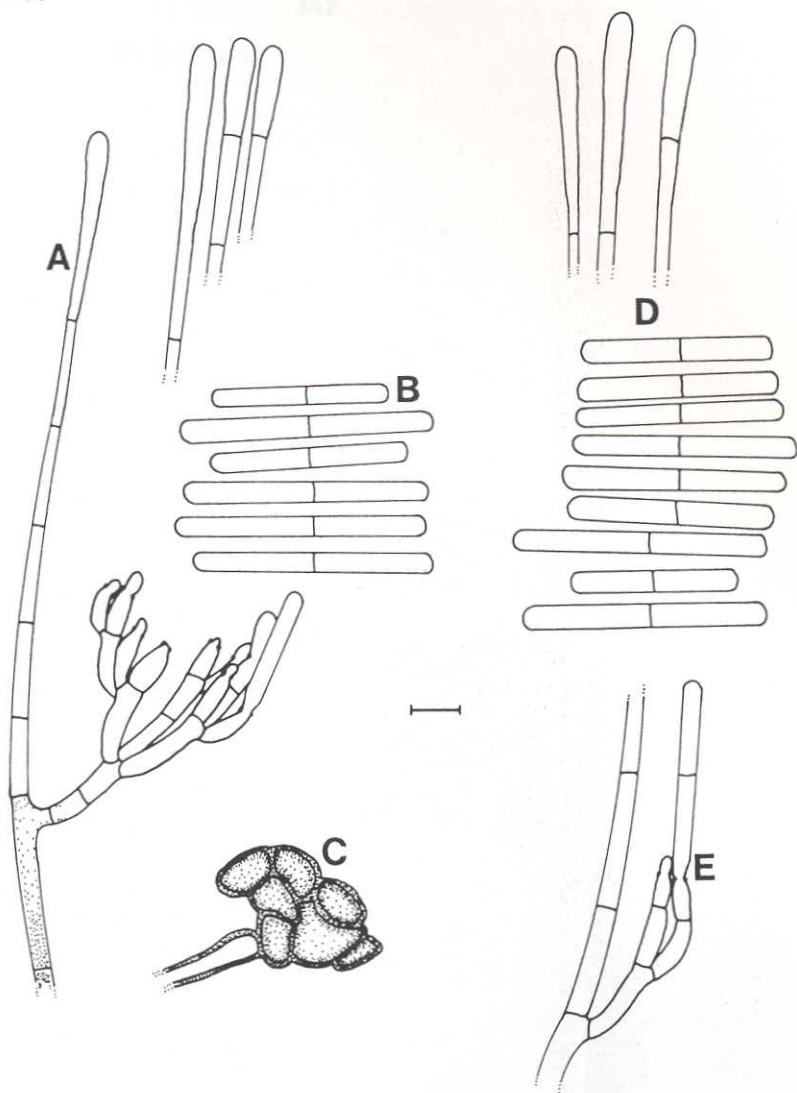


Fig. 4A-E. *Cyindrocladium clavatum* (bar = 10  $\mu\text{m}$ ). A, conidiophore and clavate vesicles; B, conidia; C, microsclerotium on CLA (PPRI 3997); D, clavate vesicles and conidia; E, conidiophore on agar (BPI 414550, type).

1981; Sharma *et al.*, 1984; Sharma *et al.*, 1985; Mohanan & Sharma, 1985a; Rattan *et al.*, 1983; Crous *et al.*, 1993c).

**Hosts:** *Arachis hypogaea* L., *Araucaria angustifolia* Bertol., *Brassica campestris* L., *Camellia sinensis* (L.) Kuntze, *Capsicum frutescens* Rodsch., *Cicer arietinum* L., *Eucalyptus* spp., *Glycine max* Merrill, *Pinus* spp., *Pisum sativum* L., *Solanum tuberosum* Bert., *Stylosanthes* sp. (Hodges & May, 1972; Bolkan *et al.*, 1981; Almeida & Bolkan, 1981; Lopes & Reifschneider, 1982; Mohanan & Sharma, 1985a; Dianese *et al.*, 1986; Dianese *et al.*, 1987).

**Distribution:** widely distributed including Brazil, Canada, India, Mauritius, South Africa (Peerally, 1974b; Crous *et al.*, 1993c).

**Specimens:** **Brazil:** M.G., Horto Conceicao, near Itabira, *Pinus caribaea* roots, Hodges & May, 16 Mar. 1971, BPI 414550, 414551 (holotype).

**India:** *B. campestris* roots, Panwar & Bohra, 1972, IMI 168400.

**Cultures:** **Africa:** R.S.A., N. Natal, Kwambonambi, Mondi nursery, *Eucalyptus* roots, P.W. Crous, Mar. 1990, PPRI, 3994, 3996; R.S.A., N. Natal, Kwambonambi, Sappi nursery, *Eucalyptus* roots, P.W. Crous, Mar. 1990, PPRI 3997. **Canada:** *Stylosanthes* sp., S.F. Hang, CPC 500.

**Mauritius:** *Camellia sinensis*, A. Peerally, 1970, IMI 167580.

**Notes:** *C. clavatum* is morphologically similar to *C. gracile*. The two species can, however, easily be distinguished, as *C. gracile* has longer stipes, narrowly clavate vesicles, and 1-septate conidia larger than those of *C. clavatum*. Cultures of *C. clavatum* have a yellowish aerial mycelium on MEA and PDA and are relatively slow growing when compared to other species with 1-septate conidia such as *C. scoparium*, *C. candelabrum* and *C. floridanum* and *C. gracile*.

Panwar & Bohra (1974) described *C. brassicae* from roots of *Brassica campestris* in India. The specimen of this species lodged at IMI (IMI 168400) is depauperate. The few conidia that were observed fell within the size range given by the authors, being 35-45 x 4-7  $\mu\text{m}$ . Vesicles were clavate, and phialides doliiform. This species fits the criteria of *C. clavatum*, having smaller conidia and shorter stipes than *C. gracile*.

El-Gholl *et al.* (1993) recently described the heterothallic holomorph of *C. clavatum* as *Calonectria clavata* Alfieri, El-Gholl & Barnard. However, the strains used to obtain the teleomorph are reported to have larger conidial dimensions than that of the type of *Cylindrocladium clavatum*. We therefore choose to not accept the teleomorph, pending the outcome of present molecular studies on *Cylindrocladium* species with 1-septate conidia and clavate vesicles.

5. *Cylindrocladium colhounii* Peerally var. *colhounii* *Trans. Br. mycol. Soc.* **61**: 92 (1973).

Holomorph: *Calonectria colhounii* Peerally var. *colhounii* *Calonectria colhounii* Peerally *Trans. Br. mycol. Soc.* **61**: 92 (1973).

Illustrations: Figs 5, 36; Peerally (1973, 1974i).

Descriptions: Peerally (1973, 1974i).

*Macroconidiophores*. Stipe septate, hyaline, terminating in a narrowly clavate vesicle, (3-)4  $\mu\text{m}$  diam.; stipes (160-)210(-280)  $\mu\text{m}$  long. *Conidiophore branches*: primary branches non-septate to 1-septate, (12-)21(-30) x (3-)5(-7)  $\mu\text{m}$ ; secondary branches non-septate to rarely 1-septate, (12-)16(-20) x (3-)4(-5)  $\mu\text{m}$ ; tertiary branches non-septate, (8-)11(-14) x (3-)4  $\mu\text{m}$ ; quaternary branches non-septate, (7-)10(-12) x (3-)4  $\mu\text{m}$ . *Phialides* elongate, doliiform to reniform, hyaline, non-septate, (7-)11(-16) x (3-)4  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3-septate, rounded at both ends, (45-)59(-70) x (4-)5(-6)  $\mu\text{m}$ . *Microconidiophores* unknown.

*Cultural characteristics*. Temperature min. above 8 C; max. below 33 C; opt. 25 C. This is a moderate temperature species, with no sporulation on aerial mycelium. *Colony colour* (reverse) 13'I tawny (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, in coarse chains throughout the medium, forming microsclerotia.

*Teleomorph*. *Perithecia* globose to subglobose, 350-500 x 320-400  $\mu\text{m}$ , with warty outer wall and papillate ostiole, yellow to orange, base and lower perithecial wall turning blood-red in 3% KOH. *Asci* hyaline, clavate, 80-180 x 15-30  $\mu\text{m}$ , tapering to a long thin stalk, containing four ascospores. *Ascospores* hyaline, straight or fusiform, (1-)3-septate, slightly constricted at septa, (30-)51(-70) x (4-)5(-8)  $\mu\text{m}$ .

**Type: Mauritius:** *Camellia sinensis*, A. Peerally, 1972, IMI 167581.

**Symptoms:** leaf spot, fruit rot (Peerally, 1974i; Siddaramaiah, 1988).

**Hosts:** *Annona* spp., *Arachis* spp., *Heuchera americana* Georgi, *Canavalia ensiformis* (L.) DC., *Callistemon lanceolatus* (Sm.) DC., *Camellia sinensis*, *Castanea vulgaris* Lam., *Centrosema* spp., *Carya* sp., *Eucalyptus robusta* Sm., *E. grandis*, *Eucalyptus* spp., *Eugenia caryophyllus* St. Lag., *Ficus carica* L., *Pinus strobus* L., *Thea sinensis* L., *Wistaria chinensis* DC. (Peerally, 1974i; Rossman, 1983; Siddaramaiah, 1988; Hutton & Sanewski, 1989; Lenné & De Alvarez, 1990).

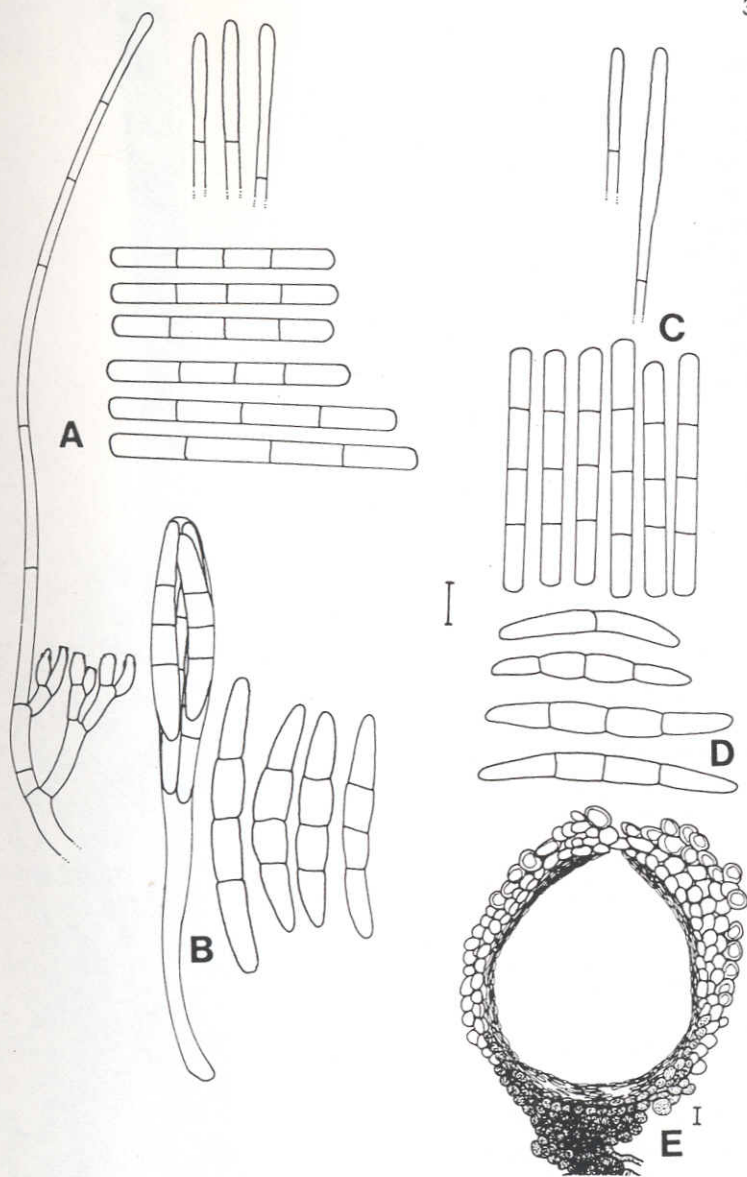


Fig. 5A-E. *Calonectria colhounii* var. *colhounii* and its *Cylindrocladium colhounii* var. *colhounii* anamorph (bar = 10  $\mu$ m). A, conidiophore, clavate vesicles and conidia; B, ascus and ascospores (PPRI 4183); C, clavate vesicles and conidia; D, ascospores; E, v.s. of a perithecium (IMI 167581, type) (bar = 20  $\mu$ m).

**Distribution:** Australia, India, Mauritius, Colombia, U.S.A. (Florida, Hawaii, Louisiana) (Peerally, 1974i; Rossman, 1983; Siddaramaiah, 1988; Lenné & De Alvarez, 1990).

**Specimens:** **India:** *Canavalia ensiformis*, 1986, IMI 308494. **Mauritius:** *Camellia sinensis*, M.A. Peerally, 1972, IMI 167581 (holotype).

**Cultures:** Australia: *Arachis pintoi*, D. Hutton, N8335, N8710, N9060, N9190, PPRI 4735-4738. **Colombia:** *Centrosema* sp., J.M. Lenné, 1990, PPRI 4748. **USA:** unknown hosts, A. Alfenas, (Viçosa, Brazil, UFV 4A, 22A, 51A, 52A, 53A, 65A), PPRI 4182-4187; Louisiana, *Ficus carica*, G.E. Holcomb, summer 1991, AR 2684, PPRI 4739; Virginia, Giles Co., Cascades Recreation site, 4 miles north of Pembroke, 37° 23 N, 80° 35 W, pericarp of *Carya* nut, G.J. Samuels, 18 Sept. 1991, GJS 91-117, PPRI 4740.

**Notes:** this species is easily recognized by its yellow perithecia which form readily in culture, and distinguish it from all other species in the genus. It is further characterized by having 3-septate conidia shorter than 70  $\mu\text{m}$ , and stipes shorter than 280  $\mu\text{m}$ , terminating in clavate vesicles. Only the perithecial stromata and bases turn red in 3 % KOH.

**6. *Cylindrocladium colhounii* Peerally var. *macroconidialis* Crous, Wingfield & Alfenas *Mycotaxon* 46: 222 (1993).**

**Holomorph:** *Calonectria colhounii* Peerally var. *macroconidialis* Crous, Wingfield & Alfenas *Mycotaxon* 46: 222 (1993).

**Illustrations:** Figs 6, 33-35.

**Descriptions:** Crous *et al.*, (1993d).

Morphologically similar to var. *colhounii*. *Macroconidiophores*.

*Stipe* septate, hyaline, terminating in a narrowly clavate vesicle, (3-)4(-5)  $\mu\text{m}$  diam.; stipes (240-)280(-320)  $\mu\text{m}$  long. *Conidiophore branches*: primary branches non-septate to 1-septate, (20-)31(-48) x (4-)5  $\mu\text{m}$ ; secondary branches non-septate to rarely 1-septate, (20-)25(-30) x (4-)5  $\mu\text{m}$ ; tertiary and quaternary branches non-septate, (18-)20(-30) x (4-)5  $\mu\text{m}$ . *Phialides* allantoid to cylindrical, hyaline, non-septate, (12-)20(-25) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3-septate, rounded at both ends, (86-)97(-112) x (5-)7(-8)  $\mu\text{m}$ . *Cultural characteristics* identical to var. *colhounii*. Isolates of var. *macroconidialis* do, however, grow faster than those of var. *colhounii*, and have medium numbers of chlamydospores.

*Teleomorph.* *Perithecia* morphologically and anatomically identical to those of var. *colhounii*.

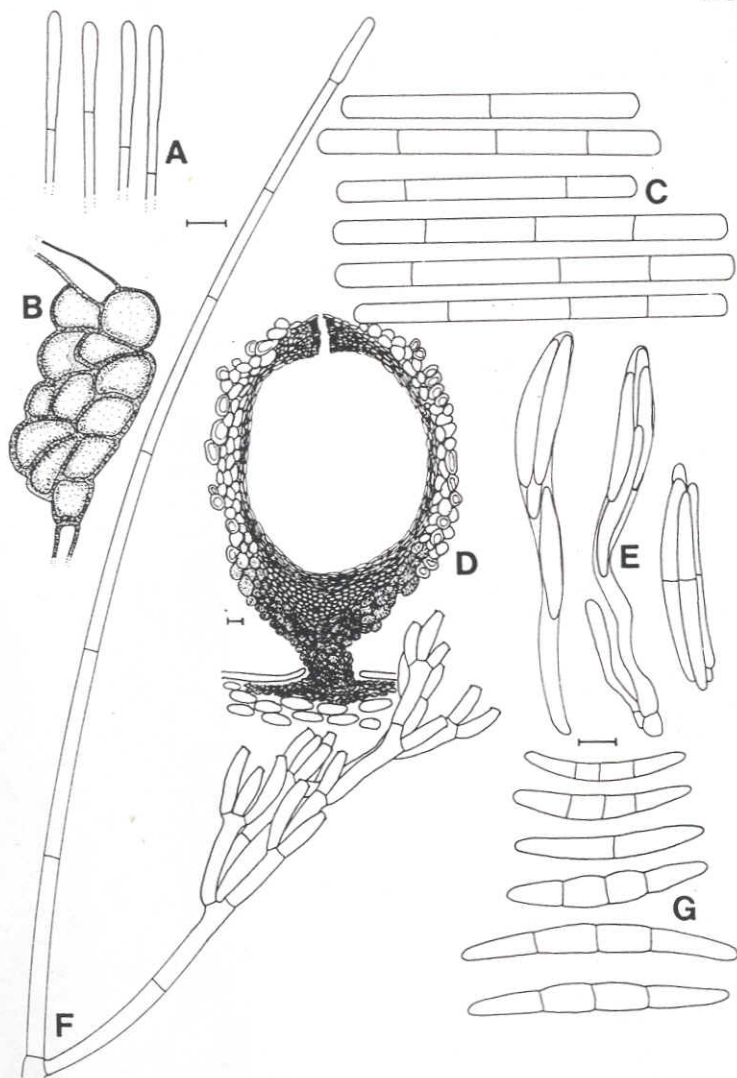


Fig. 6A-G. *Calonectria colhounii* var. *macroconidialis* and its *Cylindrocladium colhounii* var. *macroconidialis* anamorph (bar = 10  $\mu$ m). A, clavate vesicles; B, microsclerotium; C, conidia; D, v.s. of a perithecium; E, asci and ascospores; F, conidiophore; G, ascospores on CLA (PPRI 4000) (bar = 20  $\mu$ m).

**Type:** South Africa: E. Transvaal, Sabie, Frankfort, *Eucalyptus* cuttings, P.W. Crous, 16 Apr. 1991, PREM 51035, holotype of anamorph; E. Tvl., Sabie, Frankfort, *E. grandis* cuttings, P.W. Crous, March 1990, PREM 51036, holotype of teleomorph.

**Symptoms:** cutting rot, leaf spot, root rot, wilt.

**Hosts:** *Eucalyptus grandis*

**Distribution:** South Africa.

**Cultures:** Africa: RSA, E. Tvl., Sabie, Frankfort, *E. grandis* cuttings, P.W. Crous, March 1990, PPRI 4000; RSA, E. Tvl., Sabie, Frankfort, D.R. de Wet clone bank, *E. grandis* ramets (roots), P.W. Crous, 11 May 1990, PPRI 4001.

**Notes:** *C. colhounii* var. *macroconidialis* is characterized by larger conidia, longer stipes and cylindrical phialides than those of *C. colhounii* var. *colhounii*. These two varieties of *Cylindrocladium colhounii* belong to the only *Calonectria* sp. characterized by yellow perithecia and four-spored asci. Isolates of the two varieties are morphologically similar in culture, having the same temperature requirements and cultural pigmentation. However, isolates of var. *macroconidialis* grow faster than those of var. *colhounii*. Whereas all isolates obtained of var. *colhounii* were homothallic, no homothallic isolates have yet been found for var. *macroconidialis*.

*C. colhounii* var. *macroconidialis* causes a serious cutting rot disease of *Eucalyptus* cuttings in nurseries in the Eastern Transvaal of South Africa (Crous *et al.*, 1993c).

7. *Cylindrocladium curvatum* Boedijn & Reitsma *Reinwardtia* 1: 54 (1950).

**Illustration:** Fig. 7.

**Descriptions:** Boedijn & Reitsma (1950); Sharma *et al.* (1985).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a sphaeropedunculate vesicle, 5  $\mu\text{m}$  diam. *Conidiophore* branches: primary branches 25-31 x 2-4  $\mu\text{m}$ ; secondary branches 9-13 x 2-3  $\mu\text{m}$ . *Phialides* 7-10 x 2-3  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate, curved, rounded at both ends, 40-46 x 3-4  $\mu\text{m}$ . *Chlamydoconidia* formed in original culture. *Microconidiophores* unknown; *Teleomorph* unknown.

**Type:** none lodged.

**Symptoms:** leaf spot (Boedijn & Reitsma, 1950).

**Host:** *Hibiscus sabdariffa* L. (Boedijn & Reitsma, 1950).

**Distribution:** Java, India (Boedijn & Reitsma, 1950; Sharma *et al.*, 1985).



**Specimens and cultures:** none available.

**Notes:** this species is distinguished primarily by its curved conidia. Boedijn & Reitsma (1950) lost their type culture, and also did not lodge any type specimen. Sharma *et al.* (1985) reported this fungus from Kerala, India, where it caused a root rot on *Eucalyptus* spp. The conidial dimensions they reported were larger (35-60 x 3.2-5  $\mu\text{m}$ ) than those in the original description (40-46 x 3-4  $\mu\text{m}$ ). Because no material of this species has been maintained at either Kerala or IMI, the identity of the second collection from India cannot be confirmed.

8. **Cylindrocladium floridanum** Sobers & Seymour *Phytopathology* 57: 392 (1967).

Holomorph: *Calonectria kyotensis* Terashita, *Trans. Mycol. Soc. Japan* 8: 124 (1968).

*Calonectria uniseptata* Gerlach *Phytopath. Z.* 61: 379 (1968).

*Calonectria floridana* Sobers *Phytopathology* 59: 366 (1969).

**Illustrations:** Figs 8, 39, 40; Sobers & Seymour (1967); Terashita (1968); Sobers (1969).

**Descriptions:** Sobers & Seymour (1967); Sobers (1969).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a sphaeropedunculate vesicle, (6-)10(-12)  $\mu\text{m}$  diam.; stipes (100-)160(-200)  $\mu\text{m}$  long. Lateral stipes (90° to main axis) also present. *Conidiophore branches:* primary branches non-septate or rarely 1-septate, (16-)20(-25) x (4-)5(-7)  $\mu\text{m}$ ; secondary branches non-septate, (10-)16(-21) x (3-)4(-5)  $\mu\text{m}$ ; tertiary branches non-septate, (10-)14(-17) x (3-)4(-5)  $\mu\text{m}$ ; quaternary branches non-septate, (8-)12(-16) x (3-)4. *Phialides* doliiform to reniform, hyaline, non-septate, (9-)10(-13) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate, rounded at both ends, (35-)40(-50) x (3-)4(-5)  $\mu\text{m}$ . *Microconidiophores* unknown.

*Cultural characteristics.* Temperature min. above 8 C; max. above 35 C; opt. 25-30 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K - 17°B amber brown to cinnamon-buff (Rayner, 1970), 6D8 - 5B5 light brown to greyish orange (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, throughout medium, very dense, occasionally in chains, forming microsclerotia.

*Teleomorph.* *Perithecia* globose to ovoid, 280-550 x 210-425  $\mu\text{m}$ , with warty outer wall and flattened ostiole, red to orange in colour,

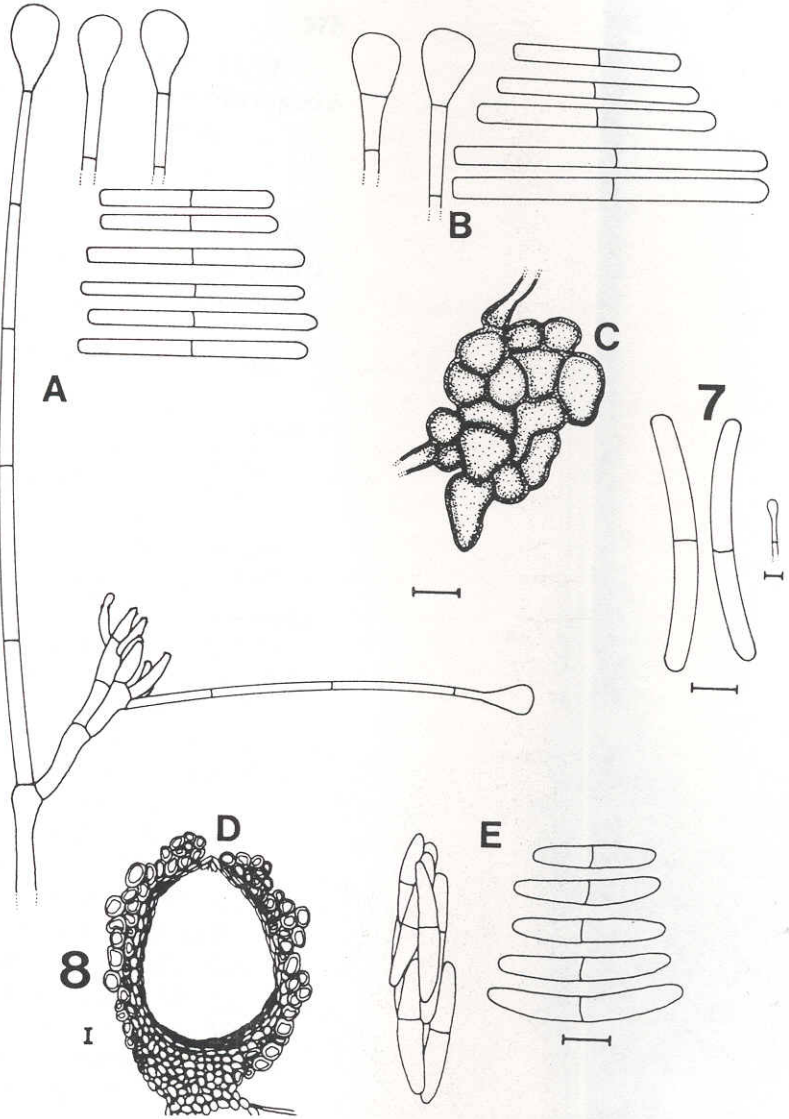


Fig. 7. Conidia and sphaeropedunculate vesicle of *Cyindrocladium curvatum* (redrawn from Boedijn & Reitsma, 1950) (bar = 10  $\mu\text{m}$ ). Fig. 8A-E. *Calonectria kyotensis* and its *Cyindrocladium floridanum* anamorph (bar = 10  $\mu\text{m}$ ). A, conidiophore with lateral branch, vesicles and conidia (PPRI 4140); B, sphaeropedunculate vesicles and conidia (BPI 414553, type of *C. floridanum*); C, microsclerotium; D, v.s. through a perithecium; E, ascospores (PPRI 4140) (bar = 20  $\mu\text{m}$ ).

turning blood-red in 3 % KOH. *Asci* hyaline, clavate, 70-140 x 13-22  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, 1-septate, not constricted at septum, (18-)35(-48) x (4-)5(-7)  $\mu\text{m}$ .

**Type:** USA: Florida, Monticello, *Prunus* sp., E.K. Sobers, 12 Apr. 1965, BPI 414553 (holotype of anamorph). Japan: Kyoto, Momoyama, Kansai Reg. For. Exp. Sta., on leaflet of *Robinia pseudoacacia* L., Terashita, Sept. 1963, (holotype of teleomorph, not examined).

**Symptoms:** root rot, leaf spots, wilting and death (Sobers & Seymour, 1967; French & Menge, 1978).

**Hosts:** *Callistemon rigidus* R. Br., *C. citrinus* Stapf., *Crotalaria spectabilis* Roth, *Eucalyptus camaldulensis* Dehnh., *E. robusta*, *E. rudis* Endl., *E. saligna*, *E. tereticornis* Sm., *Pinus palustris* Mill. Gard. Dict., *Prunus persica* Stokes, *Rhododendron obtusum*, *R. pseudoacacia*, *Rumohra adiantiformis*, *Trifolium pratense* L. (Sobers & Seymour, 1967; Cordell et al., 1971; French & Menge, 1978; Kuhlman et al., 1980; Forsberg, 1985).

**Distribution:** Brazil, Canada, U.S.A. (Florida, Georgia), Germany, Japan, India, New Zealand, Great Britain, Malaysia, Mauritius and Sri Lanka (Sobers & Seymour, 1967; Gerlach, 1968; Terashita, 1968; Sobers, 1972; Boesewinkel, 1974; Peerally, 1974a; Sharma & Mohanan, 1982).

**Specimens:** India: Sabah, *Pinus caribaea*, 1979, IMI 240406. USA: Florida, Monticello, *Prunus* sp., E.K. Sobers, 12 Apr. 1965., BPI 414553 (holotype); *Prunus* tree roots, R.H. Morrison, BPI 414554, 414555.

**Cultures:** Canada: *Pinus* seedlings, M. Dumas, UFV 75, CPC 509; Ontario, conifer roots, J. Juzwik, Oct. 1984, AR 2573, 2574, CPC 510, 511; Ontario, spruce seedling roots, S. Greifenhagen, 1992, CPC 512, 513.

USA: Florida, *Rumohra adiantiformis*, S.A. Alfieri, ATCC 42971; *R. adiantiformis*, El-Gholl, P88-5641, CPC 514; *Pinus palustris*, El-Gholl, P85-2179, CPC 515; Florida, *Prunus persica*, N.E. El-Gholl, (Viçosa, Brasil, UFV 7), PPRI 4140; Unknown hosts, A. Alfnas, (Viçosa Brazil, UFV 31, 33, 35), PPRI 4167, 4169, 4171; Florida, *Trifolium pratense*, N.E. El-Gholl, (Viçosa, Brazil, UFV 32) PPRI 4168; Georgia, peach tree roots, D.J. Weaver, AR 2600, ATCC 22677.

**Notes:** *C. floridanum* is frequently confused with *C. scoparium*.

Boesewinkel (1986) reports, however, that they can be distinguished by the shape of their microsclerotia and amount of pigmented mycelium. Although these differences have been observed in some cultures, they do not hold true for all isolates of *C. floridanum*. In this study, vesicle morphology in *C. floridanum* was found to be a sufficiently stable characteristic on which to separate this species from *C. scoparium*.

Vesicles of *C. floridanum* are always sphaeropedunculate, whereas those of *C. scoparium* are obovoid with a papillate apex, and those of *C. candelabrum* are obpyriform (Figs 2, 7, 19).

Branches that form on the stipe of *C. floridanum* are frequently produced at 90° to the main axis (Sobers & Seymour, 1967). Although branching of the stipe in *C. scoparium* and *C. candelabrum* is common, it never occurs at this angle.

**9. *Cylindrocladium gracile* (Bugn.) Boesewinkel** *Trans. Br. mycol. Soc.* 78: 554 (1982).

*Cylindrocarpon gracile* Bugnicourt *Encycl. Mycol.* 11: 162 (1939).

Holomorph: *Calonectria gracilis* Crous, Wingfield & Alfenas *Mycotaxon* 46: 224 (1993).

**Illustrations:** Figs 9, 41-43; Bugnicourt (1939); Booth (1966).

**Descriptions:** Bugnicourt (1939); Booth (1966); Crous *et al.* (1993d).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a narrowly clavate vesicle, (2-)4(-5)  $\mu\text{m}$  diam.; stipes (160-)220(-350)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate or rarely 1-septate, (14-)18(-25) x (3-)4(-5)  $\mu\text{m}$ ; secondary branches non-septate, (12-)15(-16) x (3-)4(-5)  $\mu\text{m}$ . *Phialides* doliiform to reniform, hyaline, non-septate, (10-)13(-15) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate, rounded at both ends, (40-)56(-65) x (4-)5  $\mu\text{m}$ . *Microconidiophores* unknown.

*Cultural characteristics.* Temperature min. above 10 C; max. above 35 C; opt. 30 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K - 17°K amber brown to Saccardo's umber (Rayner, 1970), 6D8 - 5E7 light brown to linoleum brown (Kornerup & Wanscher, 1967).

*Chlamydospores* extensive, dense, throughout medium, forming microsclerotia.

*Teleomorph.* *Perithecia* superficial, borne singly or in small groups, 350-400 x 330-380  $\mu\text{m}$ , with warty outer wall and papillate ostiole, red to red-brown, turning blood-red in 3% KOH. *Asci* hyaline, clavate, (75-) 90 (-100) x (8-) 10 (-15)  $\mu\text{m}$ , tapering to a long thin stalk, containing 8 ascospores. *Ascospores* hyaline, straight or falcate, guttulate, 1-septate, not constricted at median septum, (27-)37(-50) x (4-)5(-6)  $\mu\text{m}$ .

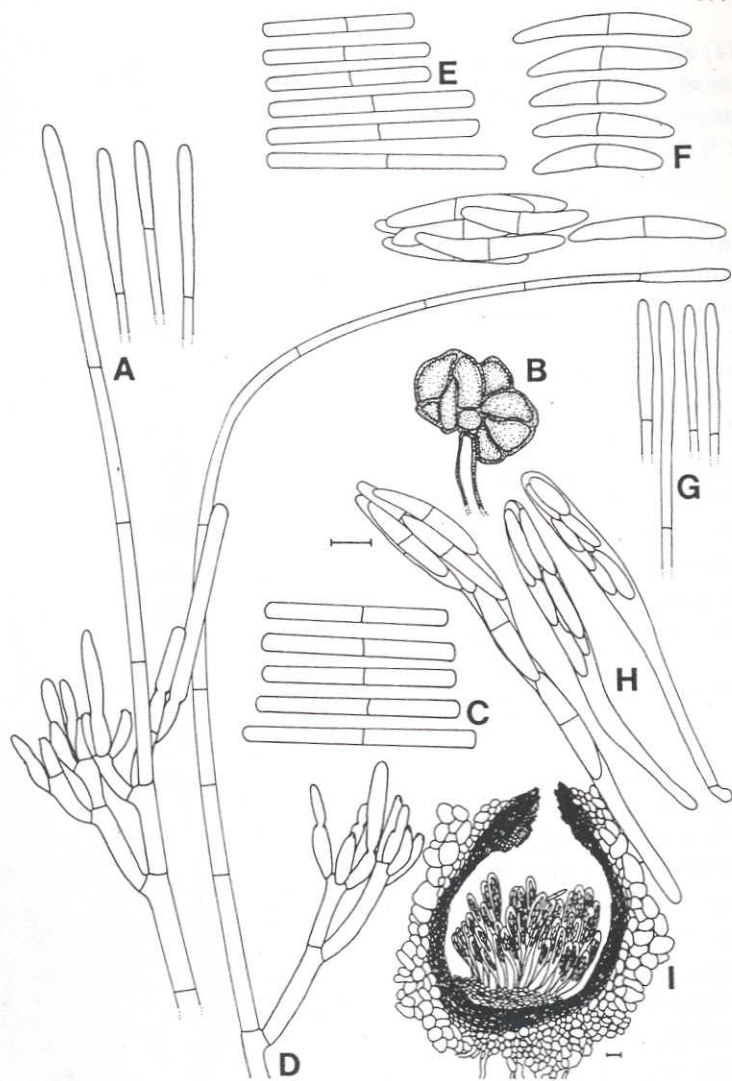


Fig. 9A-I. *Calonectria gracilis* and its anamorph *Cyndrocladium gracile* (bar = 10  $\mu$ m). A, conidiophore and clavate vesicles; B, microsclerotium; C, conidia on CLA (PC 551197, type); D, conidiophore (PREM 51031, type of teleomorph); E, conidia; F, ascospores; G, clavate vesicles; H, asci; I, v.s. of a perithecium (bar = 20  $\mu$ m).

**Type:** South East Asia (Vietnam): *Argyria splendens* Sweet, 1937, Bugnicourt, derived from Paris (PC) No. 551197, IMI 117577, PREM 51032 (holotype, anamorph). **Brazil:** Para, near Belem, *Manilkara zapota* (L.) van Royen, 1990, F. Carneiro de Albuquerque, PREM 51031 (holotype teleomorph).

**Symptom:** root rot.

**Hosts:** *Manilkara zapota*, *Argyria splendens*, *Pahudia cochinchinensis* Pierre, (Bugnicourt, 1939).

**Distribution:** Brazil, Canada, South East Asia (Indo China) (Bugnicourt, 1939).

**Cultures:** South East Asia (Vietnam): Herb. Paris (PC) No. 551197 (type culture). **Brazil:** PA, Belem, *Manilkara zapota* (L.) van Royen, F. Albuquerque, PPRI 4176, IMI 354519.

**Notes:** Among the 1-septate *Cylindrocladium* spp., *C. gracile* has a similar vesicle morphology to that of *C. clavatum*. An authenticated culture (Paris 551197) of this fungus was examined, and this species was distinct from *C. clavatum* in having longer stipes and larger conidia. There have also been recent reports of *C. gracile* from Canada (Chang & Blenis, 1987), and Brazil (Crous *et al.*, 1993d). Ascospores of the teleomorph are fusoid, 1-septate, and similar in size to those of *C. kyotensis* and *C. morgani*, but smaller than those of *C. scoparia* and *C. avesciculata*.

**10. *Cylindrocladium hawksworthii* Peerally *Mycotaxon* 40: 375 (1991).**

**Illustrations:** Figs 10, 44; Peerally (1991b).

**Description:** Peerally (1991b).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a ellipsoidal to pyriform or clavate vesicle, (6-)7(-9)  $\mu\text{m}$  diam.; stipes (150-)200(-250)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate or rarely 1-septate, (18-)30(-45) x (4-)5  $\mu\text{m}$ ; secondary branches non-septate, (13-)17(-25) x (4-)5  $\mu\text{m}$ ; tertiary and quaternary branches non-septate, (10-)12(-15) x 4(-5)  $\mu\text{m}$ . *Phialides* doliiiform to reniform, hyaline, non-septate, (10-)14(-16) x 4(-5)  $\mu\text{m}$  long. *Conidia* cylindrical, hyaline, curved, 1-septate, rounded at both ends, (42-)56(-76) x 4(-5)  $\mu\text{m}$ . *Microconidiophores* unknown; *Teleomorph* unknown.

*Cultural characteristics.* Temperature min above 5 C; max. below 35 C; opt. 30 C. This is a eurythermal species, with moderate sporulation on aerial mycelium. *Colony colour* (reverse) 13°K verona brown (Rayner, 1970), 5E7 linoleum brown (Kornerup & Wanscher, 1967).

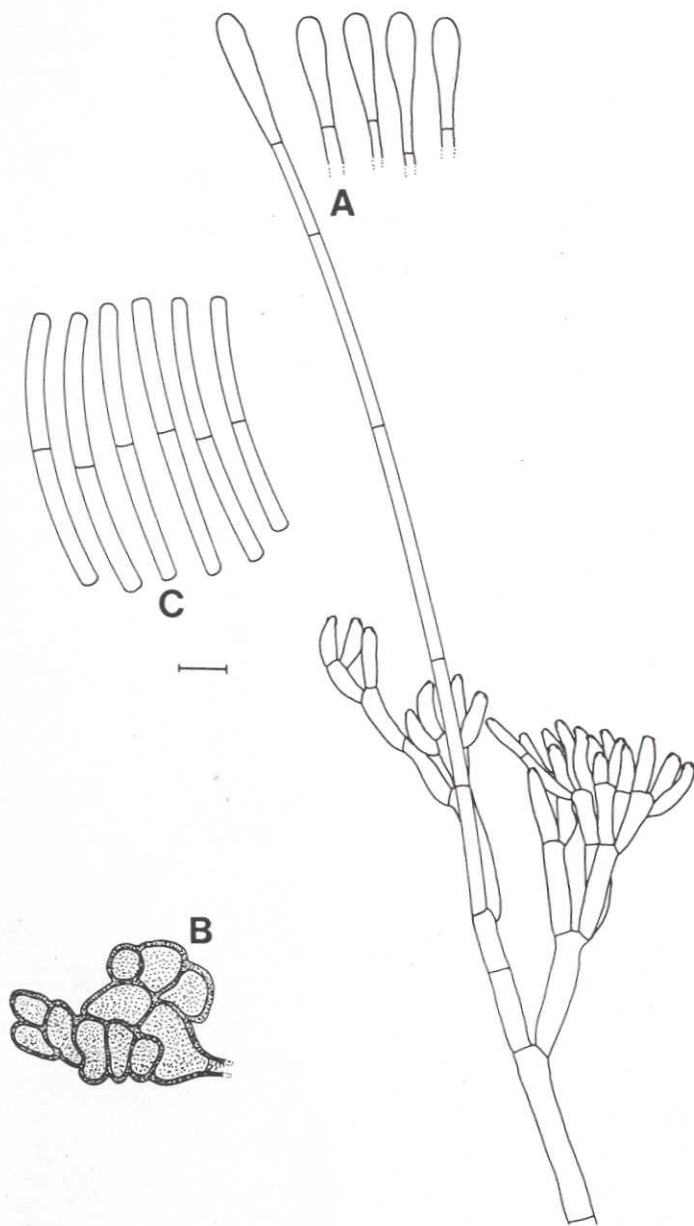


Fig. 10A-C. *Cylandrocladium hawksworthii* (bar = 10  $\mu\text{m}$ ). A, conidiophore and clavate to ellipsoidal vesicles; B, microsclerotium; C, conidia on CLA (MUCL 30866, type).

*Chlamydozores* extensive, dense, dispersed throughout medium, forming microsclerotia.

**Type: Mauritius:** Pamplemousses garden, leaves of *Nelumbo nucifera* Gaertn-Fuct., A. Peerally, 1990, MUCL 30866 (holotype).

**Symptoms:** leaf spots (Peerally, 1991b).

**Hosts:** *Nelumbo nucifera*, *Nymphaea lotus* L. (Peerally, 1991b).

**Distribution:** Mauritius (Peerally, 1991b).

**Specimens: Mauritius:** Pamplemousses garden, leaves of *Nelumbo nucifera*, A. Peerally, 1990, MUCL 30866 (holotype); Pamplemousses garden, *Nymphaea lotus*, A. Peerally, 1990, MUCL 30865 (paratype).

**Culture: Mauritius:** Pamplemousses garden, leaves of *Nelumbo nucifera*, A. Peerally, 1990, MUCL 30866 (ex holotype).

**Notes:** this species is morphologically very similar to *C. scoparium*, but has curved conidia. It is distinguished from *C. curvatum* by its larger conidia, and ellipsoidal vesicles.

**11. *Cylindrocladium heptaseptatum*** Sobers, Alfieri & Knauss *Phytopathology* **65**: 333 (1975).

**Illustrations:** Fig. 11; Sobers *et al.* (1975); El-Gholl *et al.* (1987).

**Descriptions:** Sobers *et al.* (1975); El-Gholl *et al.* (1987).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a narrowly clavate vesicle, (3-)4(-5)  $\mu\text{m}$  diam.; stipes (320-)420(-550)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate, (16-)22(-30) x (4-)5  $\mu\text{m}$ ; secondary branches non-septate, (14-)17(-25) x (4-)5  $\mu\text{m}$ . *Phialides* cylindrical to allantoid, hyaline, non-septate, (14-)17(-20) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)7(-8)-septate, rounded at both ends, (96-)118(-144) x (6-)8(-9)  $\mu\text{m}$ .

*Cultural characteristics.* Temperature min. above 10 C; max. below 33 C; opt. 25 C. This is a moderate temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K amber brown (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydozores* extensive, arranged as coarse chains, forming microsclerotia.

*Microconidiophores.* Stipe septate, hyaline, terminating in a clavate vesicle when present. *Conidiophore branches:* primary branches non-septate, (11-)19(-29) x (2-)3(-5)  $\mu\text{m}$ ; secondary branches non-septate, (9-)14(-20) x (2-)3(-4)  $\mu\text{m}$ . *Phialides* arise from the



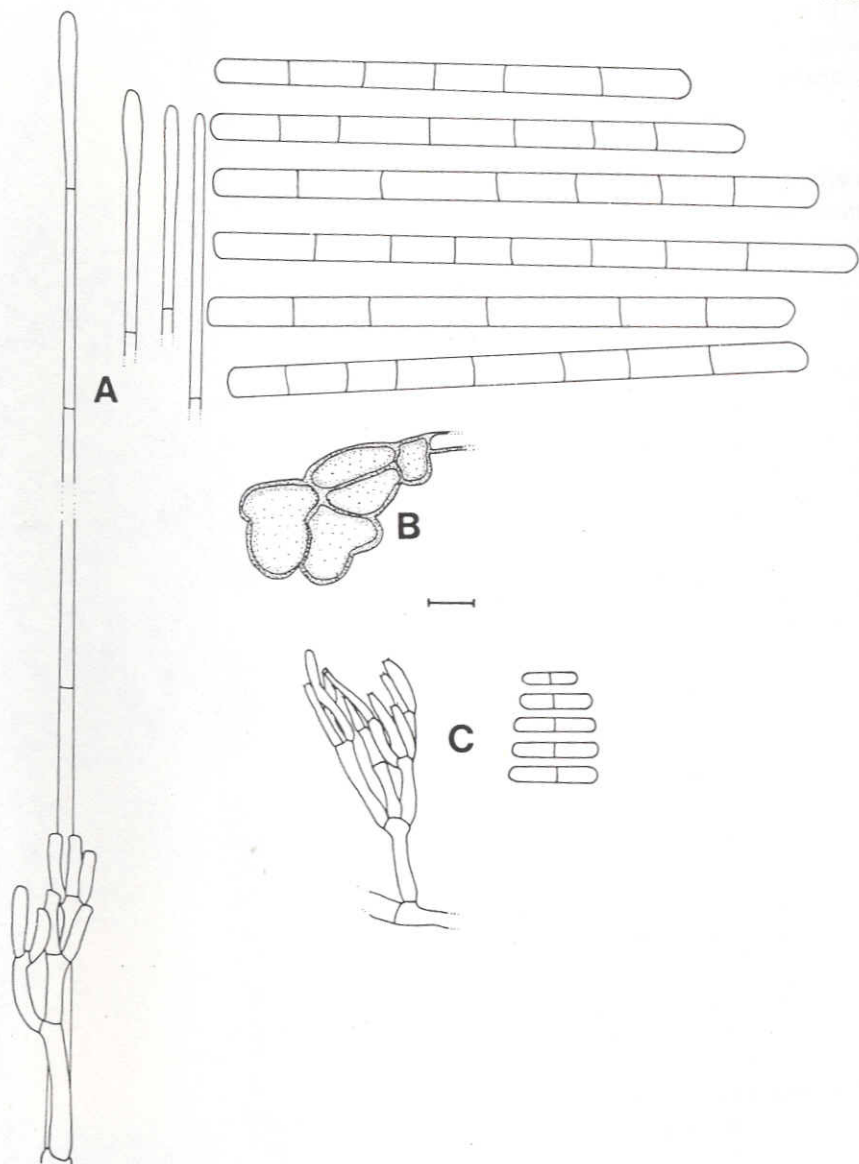


Fig. 11A-C. *Cylindrocladium heptaseptatum* (bar = 10  $\mu$ m). A, macroconidiophore, clavate vesicles and conidia; B, microsclerotium on CLA (ATCC 42972); C, microconidiophore and conidia on CLA (FTCC 1003).

ends of branches, in groups of 2-4, cylindrical, hyaline, non-septate, (7-)14(-17) x (2-)3(-4)  $\mu\text{m}$ , collarettes present. *Conidia* cylindrical, hyaline, 1-septate with obtuse ends, (12-)16(-22) x (2-)3(-4)  $\mu\text{m}$ . *Teleomorph* unknown.

**Type:** Brazil: Honduras, *Polystichum adiantiforme*, (NY), ATCC 38228.

**Symptoms:** leaf spots and stem lesions (Sobers *et al.*, 1975).

**Hosts:** *Polystichum adiantiforme* (Forst.) J.E. Sm., *Rumohra adiantiformis* (Forst.) Ching, (Sobers *et al.*, 1975; Marousky & Wildt, 1982).

**Distribution:** Honduras, Florida, U.S.A. (Florida), Thailand (Sobers *et al.*, 1975; Chase, 1984).

**Cultures:** USA: Florida, *Rumohra adiantiformis*, S.A. Alfieri, ATCC 42972; Florida, *R. adiantiformis*, N.E. El-Gholl, FTCC 1002 (macroconidial isolate), FTCC 1003 (microconidial isolate). Thailand: *Eucalyptus* sp., M.J. Wingfield, 3 Aug. 1992, CPC 516.

**Notes:** *C. heptaseptatum* has large multi-septate conidia and clavate vesicles. Other *Cylindrocladium* spp. with multi-septate conidia and clavate vesicles are *C. colhounii* var. *colhounii* & var. *macroconidialis*, *C. theae* and *C. quinquesepatum*. *C. heptaseptatum* is distinguished from these species by having 7-septate conidia. The other species mentioned above all have 3-septate conidia, except *C. quinquesepatum*, which has 5-septate conidia.

## 12. *Cylindrocladium ilicicola* (Hawley) Boedijn & Reitsma

*Reinwardtia* 1: 57 (1950).

*Candelospora ilicicola* Hawley *apud* Rea & Hawley *Proc. R. Irish Acad.* 31: 11 (1912).

*Tetracytum laurii* Vanderwalle *Parasitica* 1: 145 (1945).

Holomorph: *Calonectria pyrochroa* (Desm.) Sacc. *Michelia* 1: 308 (1878).

*Nectria pyrochroa* Desm. *Pl. Crypt. France* ed. 2: 372 (1856). Later, *Bull. Soc. Bot. Fr.* 4: 998 (1857).

*Calonectria daldiniana* De Not. *Comment. Soc. Crittogam. Ital.* 2: 477 (1867).

*Ophionectria puiggarii* Speg. *Bol. Acad. Nac. Ci.* 11: 532 (1889).

*Nectria abnormis* P. Hennings *Hedwigia* 36: 219 (1897).

**Illustrations:** Figs 12, 45-48; Peerally (1974e); Rossman (1979).

**Descriptions:** Peerally (1974e); Rossman (1979); Crous *et al.* (1993e).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a clavate to spatulate vesicle, (6-)8(-11)  $\mu\text{m}$  diam.; stipes (130-)175(-230)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate or rarely

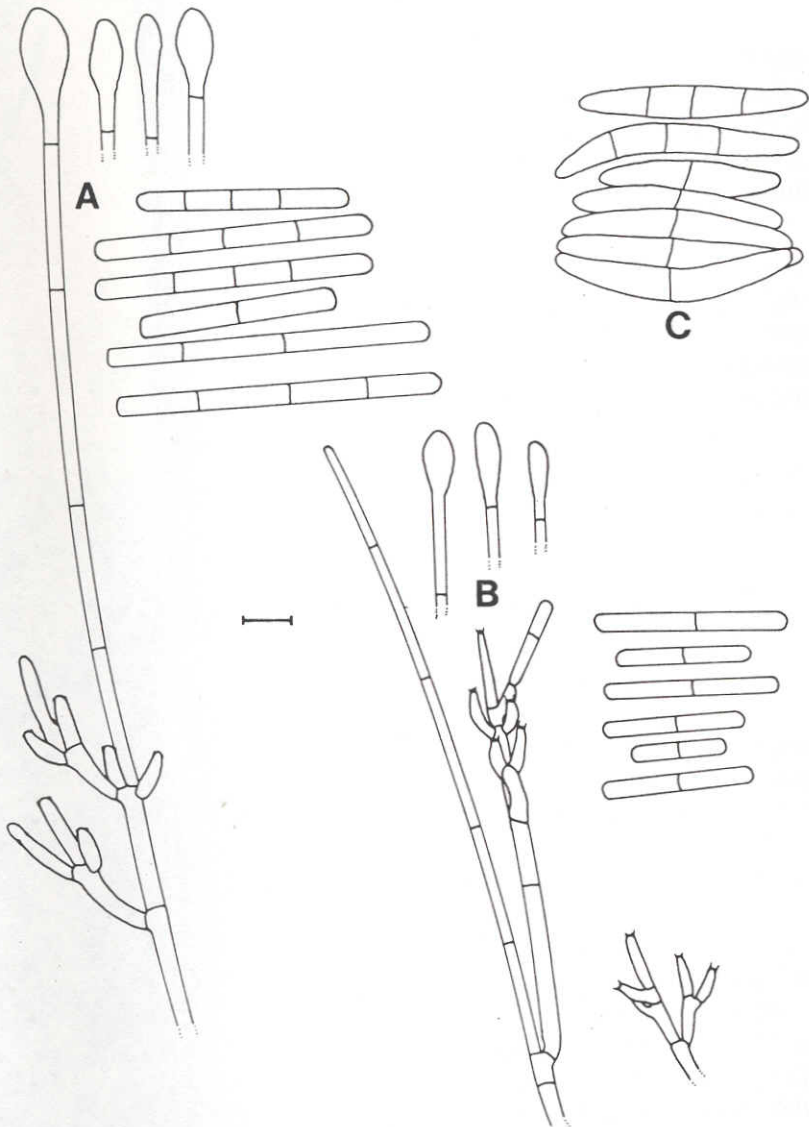


Fig. 12A-C. *Calonectria pyrochroa* and its *Cylindrocladium ilicicola* anamorph (bar = 10  $\mu\text{m}$ ). A, macroconidiophore, clavate to spathulate vesicles and conidia; B, microconidiophores, clavate to spathulate vesicles and conidia (PPRI 4151); C, ascospores, (PC, *C. pyrochroa*, type).

1-septate, (15-)18(-25) x (3-)4(-5)  $\mu\text{m}$ ; secondary branches non-septate, (11-)16(-20) x (3-)4(-5)  $\mu\text{m}$ ; tertiary branches rare, non-septate, (8-)12(-14) x (3-)4(-5)  $\mu\text{m}$ . *Phialides* elongate, doliiform to reniform, hyaline, non-septate, (10-)12(-15) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3-septate, rounded at both ends, (37-)53(-70) x (3-)5  $\mu\text{m}$ .

*Cultural characteristics.* Temperature min. above 8 C; max. below 35 C; opt. 25 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K amber brown (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, arranged in fine chains forming microsclerotia throughout substratum.

*Microconidiophores.* *Stipe* septate, hyaline, terminating in a clavate to spatulate vesicle when present. *Conidiophore branches:* primary branches non-septate, (10-)14(-15) x 3(-4)  $\mu\text{m}$ ; secondary branches non-septate, (9-)10(-12) x (2-)3(-4)  $\mu\text{m}$ . *Phialides* arise from the ends of branches, singly, or in groups of 2-4, cylindrical, hyaline, non-septate, (9-)12(-15) x (2-)3  $\mu\text{m}$ , collarettes present. *Conidia* cylindrical, hyaline, 1-septate with obtuse ends, (14-)24(-31) x (3-)4  $\mu\text{m}$ .

*Teleomorph.* *Perithecia* globose to ovoid, 400-500 x 320-370  $\mu\text{m}$ , with warty outer wall and papillate ostiole, orange to red, turning blood-red in 3 % KOH. *Asci* hyaline, clavate, 90-130 x 9-18  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, 1(-3)-septate, not or slightly constricted at septa, (28-)45(-66) x (4-)6(-7)  $\mu\text{m}$ .

**Type:** Ireland: Clare Island, *Ilex aquifolium* L., Hawley, IMI 76542 (holotype of anamorph); France: (PC), No. 372, leaves of *Platanus* sp. (lectotype of teleomorph).

**Symptoms:** damping-off, leaf and shoot blight, stem canker, die-back (Sharma & Mohanan, 1982).

**Hosts:** wide host range, including *Arbutus andrachnoides* Link, *Aesculus hippocastanum* L., *Betula* sp., *Buxus* sp., *Didymopanax morototoni* Dechne. & Planch., *E. alba* Reinw. : Bl., *E. robusta*, *E. tereticornis*, *E. grandis*, *E. globulus* Labill., *Gaultheria shallon* Pursh., *Ilex aquifolium*, *Magnolia grandiflora*, *Salix* sp., *Laurus nobilis* L., *Theobroma grandiflorum* K. Schum. (Rea & Hawley, 1912; Boedijn & Reitsma, 1950; Figueiredo & Cruz, 1963; Alfieri *et al.*, 1982; Sharma & Mohanan, 1982; Brayford & Chapman, 1987).

**Distribution:** Scilly Is., Brazil, Ireland, Europe (France, Switzerland), India, U.S.A. (Florida) (Boedijn & Reitsma, 1950; Figueiredo & Cruz, 1963; Peerally, 1974e; Reddy, 1974; Alfieri *et al.*, 1982; Sharma & Mohanan, 1982; Brayford & Chapman, 1987).

**Specimens:** Brazil: Sao Paulo, leguminous plant, Ule 2282, Feb.(?) 1896, (*Nectria leguminum*, holotype), (S); leaves of *Lauraceae*, Puiggarii 2562, March 1888, (ex type *Ophionectria puiggarii*), (FH); A. Möller, No. 52c, ex sheet 5350, (isotype, *Nectria abnormis*), (FH). France: (PC), leaves of *Platanus* sp., (type *Nectria pyrochroa*). Ireland: Clare Island, *Ilex aquifolium*, Hawley, IMI 76542 (type *C. ilicicola*). Switzerland: leaves of *M. grandiflora*, Daldini, (RO) (*Calonectria daldiniana*, holotype, not examined).

**Cultures:** Brazil: Bahia, *Eucalyptus* sp., (Viçosa, Brazil No. UFV 28), PPRI 4151, IMI 354525 (producing microconidial state).

**Notes:** *C. ilicicola* has a similar vesicle morphology to that of *C. spathulatum* and *C. citri*. The last two are, however, low temperature species, while *C. ilicicola* is a high temperature species.

Rossmann (1983) synonymized several early *Calonectria* collections under *C. pyrochroa*. Although that name is accepted for the holomorph *Cylindrocladium ilicicola*, not all the synonyms as listed by Rossmann (1983) are recognised here. *C. daldiniana*, *Ophionectria puiggarii* and *Nectria abnormis* are accepted as synonyms of *C. pyrochroa* from the morphology of their perithecia, asci and ascospores. However, *C. indusiata* Seaver includes the teleomorph of *Cylindrocladium theae*, while *Nectria leguminum* Rehm is accepted as representative of a new species (see section on doubtful and excluded species). In an *in vitro* evaluation of 22 fungicides against *C. quinquesepatum*, *C. floridanum* and *C. ilicicola*, the last proved to be more tolerant than the other species, only a few fungicides being effective (Sharma & Mohanan, 1991a).

13. *Cylindrocladium naviculatum* Crous & Wingfield *Mycotaxon* 48: 443-444 (1994).

**Illustrations:** Figs 13, 57; Crous *et al.* (1994).

**Descriptions:** Crous *et al.* (1994).

**Macroconidiophores.** *Stipe* septate, hyaline, terminating in a naviculate vesicle, (6-)8(-11)  $\mu\text{m}$  diam; stipes (150-)180(-200)  $\mu\text{m}$  long. **Conidiophore branches:** primary branches non-septate or rarely 1-septate, (12-)19(-25) x (4-)5(-6)  $\mu\text{m}$ ; secondary branches non-septate, (10-)12(-15) x (4-)5(-6)  $\mu\text{m}$ ; tertiary branches non-septate, (10-)12(-15) x (4-)5(-6)  $\mu\text{m}$ ; quaternary branches non-

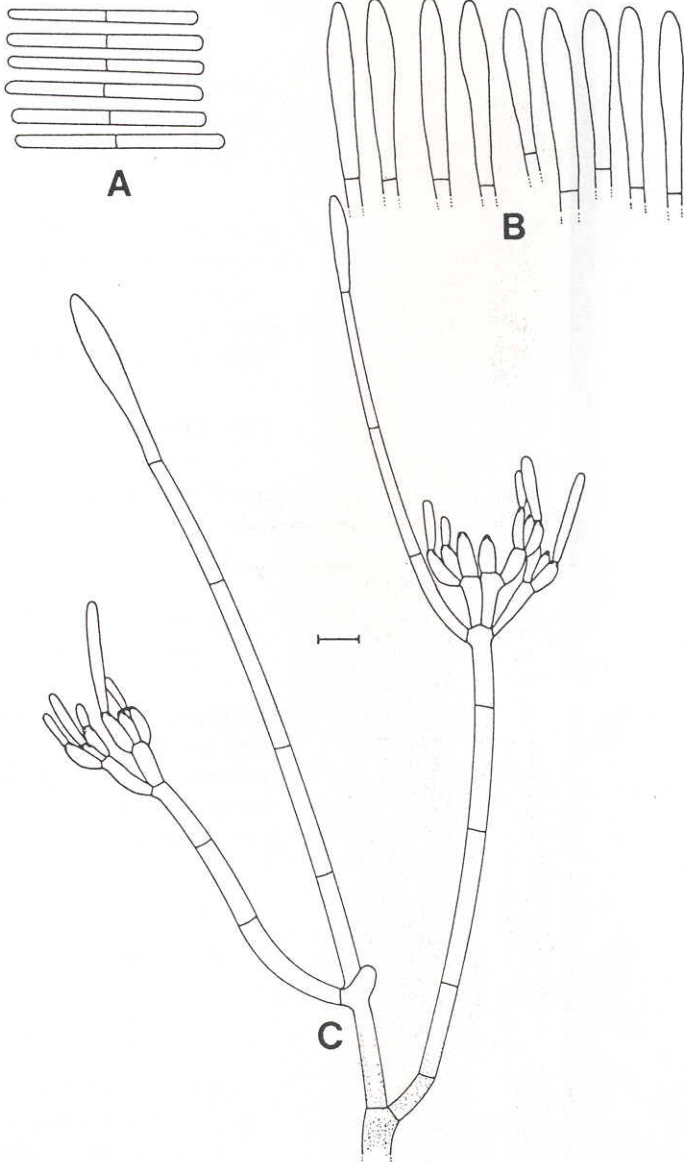


Fig. 13A-C. *Cylindrocladium naviculatum* (bar = 10  $\mu\text{m}$ ). A, conidia; B, naviculate vesicles; C, conidiophore (CPC 627).

septate, (10-)11(-14) x 4(-5)  $\mu\text{m}$ . *Phialides* arise from the ends of branches, in groups of 2-4, doliiform to reniform, hyaline, (9-)12(-15) x (3-)4  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate rounded at both ends, (40-)43(-55) x (3-)4  $\mu\text{m}$ . *Microconidiophores* unknown. *Teleomorph* unknown.

*Cultural characteristics.* Temperature min. above 5 C; max. above 35 C; opt. 25 C. This is a eurythermal species, with medium sporulation on the aerial mycelium. *Colony colour* (reverse) 13'I tawney (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydo-spores* in moderate numbers, forming fine chains with sparse microsclerotia.

**Type:** Brazil: Amazonia state, Manaus, soil, M.J. Wingfield, Apr. 1993; PREM 51542.

**Symptoms:** no disease symptoms are known, as this isolate was obtained from soil (Crous *et al.*, 1994).

**Hosts:** unknown, isolated from soil (Crous *et al.*, 1994).

**Distribution:** Brazil, Amazonia (Crous *et al.*, 1994).

**Cultures:** Brazil: Amazonia state, Manaus, soil, M.J. Wingfield, Apr. 1993, CPC 627 (culture of type); other collections from the same location, CPC 628, 629.

**Notes:** *C. naviculatum* can be distinguished from other 1-septate species of *Cylindrocladium* by the characteristic apical taper of its vesicles, the narrower conidia, moderate chlamydo-spore and slight microsclerotium formation. Other criteria characteristic of this species are the frequent multiple-stipes occurring in a conidiophore, as well as the very wide stipe diameter below the vesicle (Crous *et al.*, 1994).

**14. *Cylindrocladium ovatum*** El-Gholl, Alfenas, Crous & Schubert *Can. J. Bot.* 71: 469-470 (1993).

**Illustrations:** Fig. 14, 58; El-Gholl *et al.* (1993).

**Descriptions:** El-Gholl *et al.* (1993).

*Macroconidiophores.* *Stipe* septate, hyaline, terminating in an ellipsoid to ovoid vesicle, (8)10(-14)  $\mu\text{m}$  diam.; stipes (185-)205(-230)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate or rarely 1-septate, (15-)26(-40) x (3-)5  $\mu\text{m}$ ; secondary branches non-septate, (10-)20(-29) x (3-)5  $\mu\text{m}$ ; tertiary branches non-septate, (10-)18(-24) x (3-)5  $\mu\text{m}$ . *Phialides* arise from the ends of branches, in groups of 2, 3 or 4, doliiform to reniform, hyaline, (7-)15(-29) x (3-)5  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1(-3) septate, rounded at both ends,

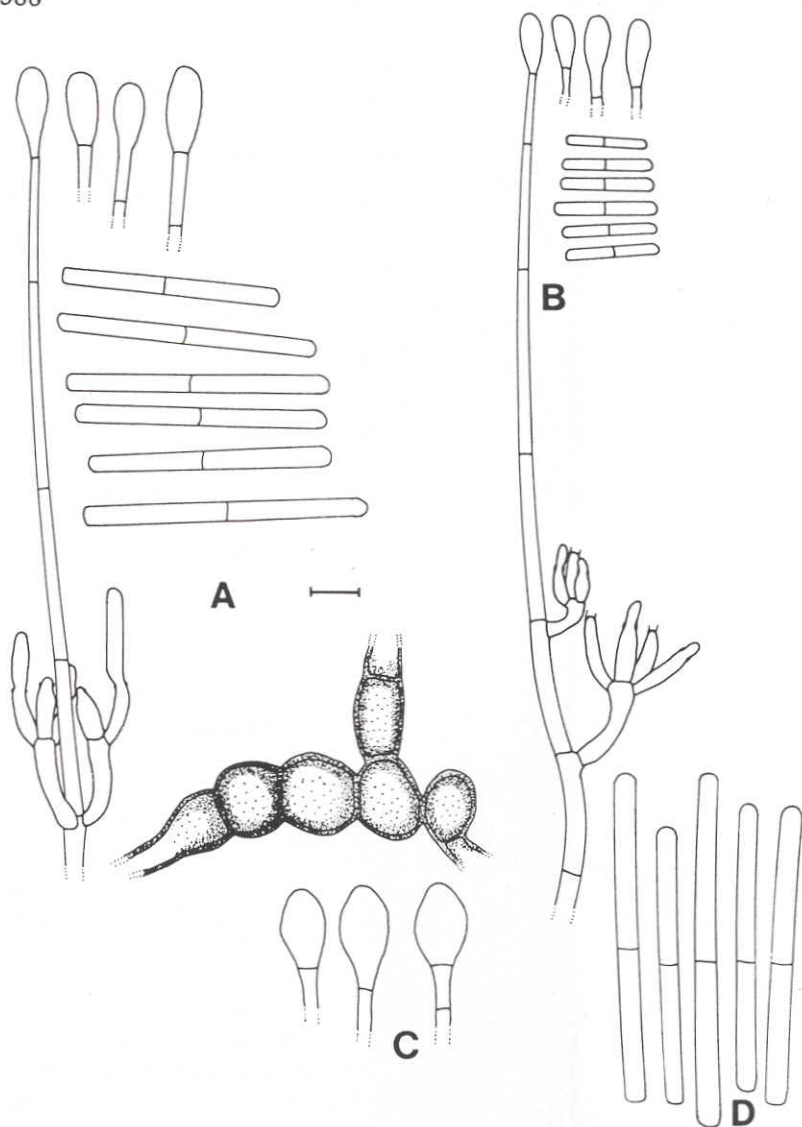


Fig. 14A-D. *Cylincladium ovatum* (bar = 10  $\mu\text{m}$ ). A, macroconidiophore, ovoid vesicles, conidia and chlamydozoospores; B, microconidiophore, ovoid vesicles and conidia (PPRI 4162); C, ovoid macrovesicles; D, conidia (PPRI 4147).



straight or slightly curved, (36-)65(-80) x (4-)5(-6)  $\mu\text{m}$ . *Teleomorph* unknown.

*Cultural characteristics.* Temperature min. above 10 C; max. above 35 C; opt. 25 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K amber brown (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, dense, forming microsclerotia throughout substratum.

*Microconidiophores.* *Stipe* septate, hyaline, terminating in an ellipsoid to ovoid vesicle when present. *Conidiophore branches:* primary branches non-septate or rarely 1-septate (9-)20(-30) x (2-)4  $\mu\text{m}$ ; secondary branches non-septate, (8-)10(-12) x (2-)4  $\mu\text{m}$ . *Phialides* arise from the ends of branches, in groups of 2-4, allantoid to navicular or doliiform, hyaline, with collarettes, (8-)15(-18) x (2-)3(-4)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate with obtuse ends, (11-)21(-28) x (2-)3(-4)  $\mu\text{m}$ .

**Type:** Brazil: Para, Monte Dourado, *Eucalyptus urophylla*, N.E. El-Gholl, Mar. 1990, FLAS F55638 (holotype).

**Symptoms:** leaf spots, blight and root rot (Blum *et al.*, 1992; El-Gholl *et al.*, 1993).

**Hosts:** *Eucalyptus* spp.

**Distribution:** Brazil, Amazonia (Blum *et al.*, 1992; El-Gholl *et al.*, 1993).

**Cultures:** Brazil: Pará, Monte Dourado, *E. urophylla*, N.E. El-Gholl, Mar. 1990, UFV 89, ATCC 76225, IMI 354515 (type), other single-conidial isolates from this collection UFV 90, 91; ?, *Eucalyptus*, J. Dianese, UFV 24, PPRI 4147 and UFV 55, PPRI 4162; Amazonia, *Eucalyptus*, J. Dianese, UnB 1026; UnB 1028, IMI 354516.

**Notes:** Conidia of *C. ovatum* are nearly always 1-septate. Vesicles are ovoid or ellipsoidal (widest in the middle), intermediate between those of *C. candelabrum* Viegas which are obpyriform (widest below the middle), and *C. scoparium* Morgan which are pyriform (widest above the middle). It is probable that this species is heterothallic, as is the case for *C. scoparium* and *C. candelabrum*. However, all available isolates of *C. ovatum* were paired, but only protoperithecia observed, indicating that the correct strains have not yet been collected to produce a teleomorph. As expected, pairings with mating types of *C. scoparium* and *C. candelabrum* were also unsuccessful. Not all isolates have the ability to form the microconidial state, and the majority can produce only

1-septate conidia (not curved as some in holotype), and generally do not have septate vesicles as illustrated in the original description.

A recent study in Brazil (Blum *et al.*, 1992) compared the damping-off ability of *C. clavatum* and *C. ovatum* (UnB-1026). Results showed that certain *Eucalyptus* provenances were more disease tolerant than others, and that *C. clavatum* has a wider host range and is more aggressive towards *Eucalyptus* spp. than *C. ovatum*.

**15. *Cylindrocladium parasiticum*** Crous, Wingf. & Alfenas *Mycol. Res.* **97**: 892 (1993).

*Cylindrocladium crotalariae* (Loos) Bell & Sobers *Phytopathology* **56**: 1364 (*nom. nud.*) (1966).

*Candelospora theae* (Petch) Wakefield: Gadd var. *crotalariae* Loos *Trans. Br. mycol. Soc.* **33**: 17 (*nom. nud.*) (1950).

Holomorph: *Calonectria ilicicola* Boedijn & Reitsma *Reinwardtia* **1**: 58 (1950).

*Calonectria theae* Loos var. *crotalariae* Loos *Trans. Br. mycol. Soc.* **33**: 18 (1950).

*Calonectria crotalariae* (Loos) Bell & Sobers *Phytopathology* **56**: 1364 (1966).

**Illustrations:** Figs 15, 37, 38; Bell & Sobers (1966); Peerally (1974h).

**Descriptions:** Bell & Sobers (1966); Sobers & Alfieri (1972); Nishijima & Aragaki (1973); Peerally (1974h); Crous *et al.* (1993e).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a sphaeropedunculate vesicle, (6-)8(-12)  $\mu\text{m}$  diam.; stipes (120-)175(-240)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate or rarely 1-septate, (16-)19(-25) x (4-)5  $\mu\text{m}$ ; secondary branches non-septate or rarely 1-septate, (11-)15(-20) x (4-)5  $\mu\text{m}$ ; tertiary branches non-septate, (9-)12(-14) x (4-)5  $\mu\text{m}$ . *Phialides* elongate, doliiform to reniform, hyaline, non-septate, (9-)13(-17) x 4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3-septate, rounded at both ends, (45-)62(-90) x (4-)6(-7)  $\mu\text{m}$ .

*Cultural characteristics.* Temperature min. above 8 C; max. above 35 C; opt. 25 C. This is a high temperature species, with slight to no sporulation on aerial mycelium. *Colony colour* (reverse) 11'D Salmon-buff (Rayner, 1970), 6A4 salmon (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, scattered throughout the medium, forming microsclerotia.

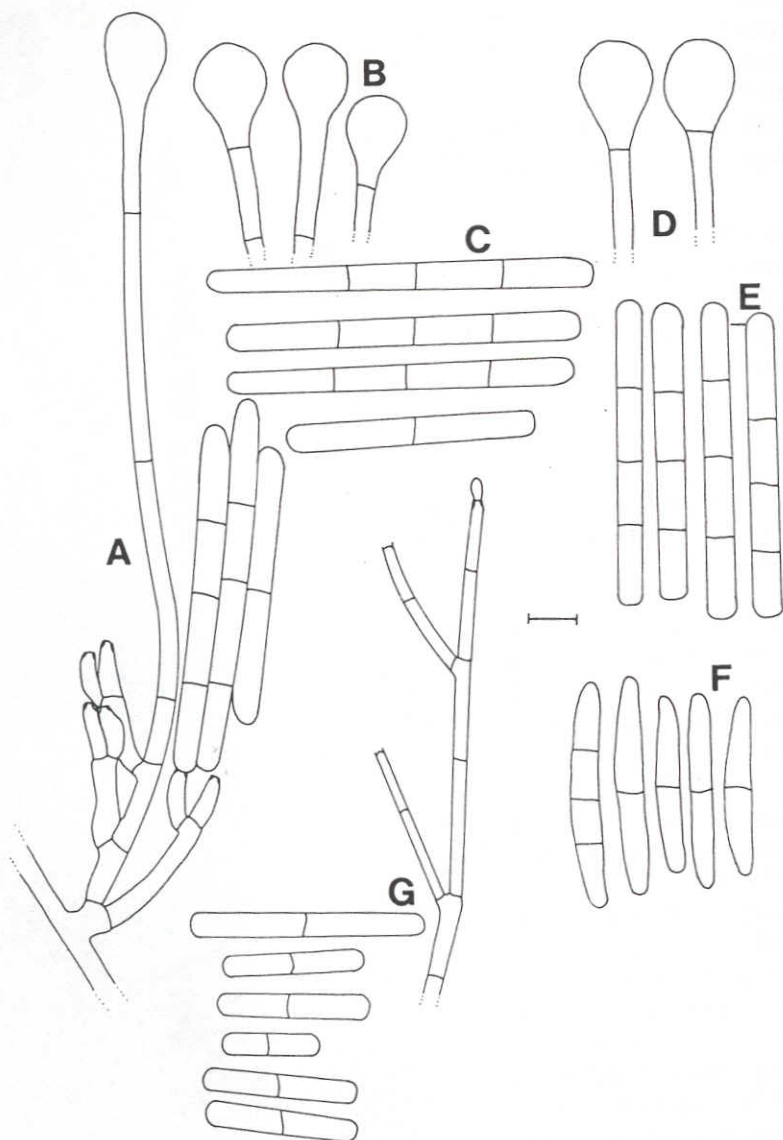


Fig. 15A-G. *Calonectria ilicicola* and its *Cyindrocladium parasiticum* anamorph (bar = 10  $\mu\text{m}$ ). A, macroconidiophore; B, sphaeropedunculate vesicles; C, conidia (IMI 122262); D, sphaeropedunculate vesicles; E, conidia; F, ascospores (IMI 264540); G, microconidiophore and microconidia (CBS 190.50).

**Microconidiophores.** *Stipe* septate, hyaline, terminating in a sphaeropedunculate vesicle, (4-)5(-6)  $\mu\text{m}$  diam. *Conidiophore branches*: primary branches non-septate, (19-)21(-26) x (3-)4  $\mu\text{m}$ ; secondary branches non-septate, (10-)12(-15) x (3-)4  $\mu\text{m}$ . *Phialides* arise from the ends of branches, in groups of 2-4, cylindrical, hyaline, non-septate, (10-)15(-19) x (3-)4  $\mu\text{m}$ . Collarettes present. *Conidia* cylindrical, hyaline, 1-septate with obtuse ends, (16-)30(-47) x 5(-7)  $\mu\text{m}$ .

**Teleomorph.** *Perithecia* orange to red, 300-500  $\mu\text{m}$  high, 280-400  $\mu\text{m}$  wide, with a warty outer layer and a papillate, periphysate ostiolar region; perithecia turn a blood-red colour in 3 % KOH. *Asci* are clavate, long-stalked, eight-spored, 90-140 x 12-19  $\mu\text{m}$ . *Ascospores* fusoid to falcate, 1-septate, slightly constricted at the septum, (30-)45(-65) x (4-)6(-7)  $\mu\text{m}$ ; ascospores are 1-septate before ascus dehiscence, and can eventually develop up to three septa.

**Type:** USA: Georgia, *Arachis hypogaea*, D.K. Bell, 1982, IMI 264540 (holotype specimen of anamorph). Indonesia: Java, Bogor, *Solanum tuberosum*, K.B. Boedijn & J. Reitsma, CBS 190.50 (type culture of teleomorph).

**Symptoms:** causes a peg, pod and root necrosis of peanuts, but also leaf spot and blighting (Sobers & Alfieri, 1972; Peerally, 1974h).

**Hosts:** *Acacia* spp., *Arachis hypogaea*, *Araucaria heterophylla* Salisb., *Camellia sasanqua*, *Caryota* sp., *Crotalaria anagyroides* H.B. & K., *Carica papaya* L., *Ceratonia siliqua* L., *Cinnamomum kanahirai* Hayata, *Cissus rhombifolia* Vahl., *Eucalyptus* spp., *Euterpe edulis* Mart., *Howeia forsteriana* Becc., *Indigofera hirsuta* L., *Leea coccinea* Planch., *Liquidamber* sp., *Liriodendron tulipifera* L., *Mandevilla* sp., *Medicago sativa* L., *Rivinia humilis* L., *Solanum tuberosum*, *Tephrosia* sp., *Vaccinium* sp. (Filer, 1970; Aragaki, Laemmlen & Nishijima, 1972; Sobers & Alfieri, 1972; Milholland, 1974; Peerally, 1974h; Sobers & Littrell, 1974; Alfenas *et al.*, 1979; Kuhlman *et al.*, 1980; Baxter & Segars, 1989).

**Distribution:** widely distributed *vide* Peerally (1974h).

**Specimens:** USA: Georgia, *Arachis hypogaea*, D.K. Bell, 1982, IMI 264540 (holotype of anamorph); *Ceratonia siliqua* (?), 1966, IMI 122262. Ceylon: *Crotalaria* stem, 1949, Loos, IMI 35028.

**Cultures:** Brazil: *Euterpe edulis*, isolated as endophyte, K. Rodrigues, 1991, PPRI 4527. Indonesia: Bogor, *Solanum tuberosum*, K.B. Boedijn & J. Reitsma, CBS 190.50. Taiwan: *Cinnamomum kanahirai*, M.J. Wingfield, June 1991, PPRI 4213. USA: Florida, *Rumohra adiantiformis*,

N.E. El-Gholl, (Viçosa, Brazil UFV 34) PPRI 4170; Hawaii, *Acacia koa*, M. Aragaki, 1970, ATCC 24023; ?, *Arachis hypogaea*, D. Griffin, PPRI 4540; ?, *A. hypogaea*, J. Beute, PPRI 4521-4524; ?, From soil, D.T. Krigsvold, 1975, ATCC 32832; Hawaii, *Carica papaya*, M. Aragaki, 1970, ATCC 24024; Hawaii, *Caryota* sp., M. Aragaki, 1991, PPRI 4525; Carolina, *Cissus rhombifolia*, C.S. Semer, PPRI 4526, PPRI 4541; ?, *C. rhombifolia*, S.A. Alfieri & C.L. Schoulties, ATCC 46133; Hawaii, *Howeia forsterana*, M. Aragaki, 1988, PPRI 4528; Florida, *Indigofera hirsuta*, N. El-Gholl, PPRI 4529; Hawaii, *Leea coccinea*, M. Aragaki, 1979, PPRI 4530; Hawaii, *Mandevilla* sp., M. Aragaki, 1987, PPRI 4531; Hawaii, *Medicago sativa*, M. Aragaki, 1981, PPRI 4532; Unknown host, J. Beute, PPRI 4533.

**Notes:** *C. parasiticum* is the only *Cylindrocladium* sp. to have 3-septate conidia and consistent sphaeropedunculate vesicles.

Boedijn & Reitsma (1950) collected a fungus which they identified as *Cylindrocladium ilicicola*, and subsequently described the teleomorph as *Calonectria ilicicola*. When Peerally (1974e) prepared the CMI description for *C. ilicicola*, he found the culture CBS 190.50 to be sterile. Because Boedijn & Reitsma (1950) had described the vesicle as globose (sphaeropedunculate), Peerally (1974e) did not acknowledge the name *Calonectria ilicicola*, finding stipes on the type specimen of *Cylindrocladium ilicicola* to have clavate to spatulate vesicles. Peerally (1974e) acknowledged, therefore, that *Calonectria ilicicola* was not the holomorph of *Cylindrocladium ilicicola*.

In a recent examination of the type culture of the teleomorph of *Calonectria ilicicola* (CBS 190.50) (Crous *et al.*, 1993e), vesicles were found to be sphaeropedunculate. Vesicle, conidium, ascus and ascospore morphology conformed perfectly with that found in the type of *Calonectria crotalariae* (IMI 264540). As the name *Calonectria ilicicola* predates *Calonectria crotalariae*, the latter is treated as a synonym.

The name *Cylindrocladium crotalariae* (Loos) Bell & Sobers had no accompanying Latin description, and was therefore not validly published. In a recent study (Crous *et al.*, 1993e), a Latin description has been provided, and the name *C. parasiticum* Crous, Wingf. & Alfenas proposed for this fungus. *C. parasiticum* is an important pathogen of peanuts, and is often regarded as more important than the notorious *Sclerotium rolfsii* Sacc. on this host (Sobers & Alfieri, 1972). There are several noteworthy articles dealing with the pathogenicity of *C. parasiticum* (Bell, 1967; Rowe *et al.*, 1973; Rowe *et al.*, 1974; Rowe & Beute, 1975; Hau *et al.*, 1982; Tomimatsu & Griffin, 1982; Johnson,

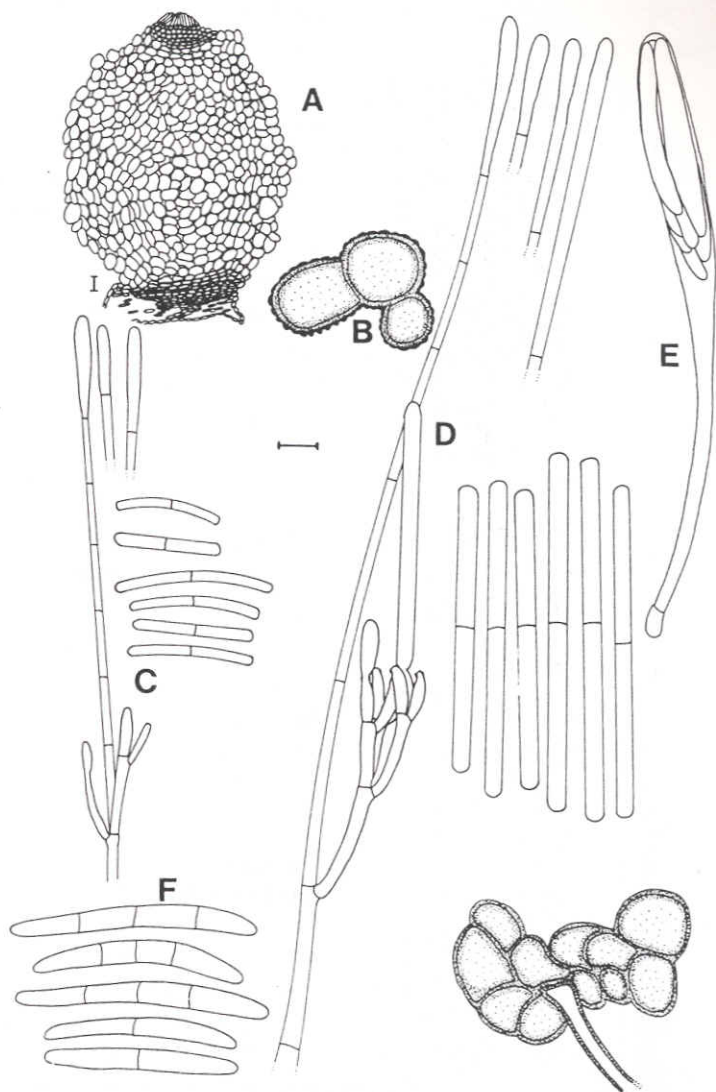


Fig. 16A-F. *Calonectria pteridis*, holomorph of *Cylindrocladium pteridis*. A, perithecium (PREM 51033, bar = 20  $\mu\text{m}$ ); B, chlamydoconidia on MEA after 7d; C, microconidiophore, vesicles and conidia on CLA; D, macroconidiophore, clavate vesicles, conidia and microscerotium on CLA after 7d (PPRI 4157); E, ascus; F, ascospores (PREM 51033) (bar = 10  $\mu\text{m}$ ).

1985). For synergism with nematodes see Diomande *et al.* (1980), and Culbreath *et al.* (1992).

**16. *Cylindrocladium pteridis*** Wolf *J. Elisha Mitchell Sci. Soc.* **42**: 59 (1926).

*Cylindrocladium macrosporum* Sherb. *Phytopathology* **18**: 222 (1928).

Holomorph: *Calonectria pteridis* Crous, Wingfield & Alfenas *Mycotaxon* **46**: 228 (1993).

**Illustrations:** Figs 16, 50; Wolf (1926); Sherbakoff (1928); Sobers (1968).

**Descriptions:** Wolf (1926); Sobers (1968); Crous *et al.* (1993d).

*Macroconidiophores.* *Stipe* septate, hyaline, terminating in a clavate vesicle, (4-)5(-6)  $\mu\text{m}$  diam.; stipes (150-)240(-300)  $\mu\text{m}$  long.

*Conidiophore branches:* primary branches non-septate or rarely

1-septate, (18-)28(-32) x (4-)5(-6)  $\mu\text{m}$ ; secondary branches

non-septate, (16-)20(-30) x (3-)4(-6)  $\mu\text{m}$ ; tertiary branches

non-septate, (14-)18(-22) x (3-)4(-5)  $\mu\text{m}$ . *Phialides* elongate,

doliiform to reniform, hyaline, non-septate, (12-)16(-22) x 4(-5)  $\mu\text{m}$ .

*Conidia* cylindrical, hyaline, 1(-3)-septate, rounded at both ends,

(62-)82(-121) x 5(-6)  $\mu\text{m}$ .

*Cultural characteristics.* *Temperature* min. above 10 C; max. above 35 C; opt. 30-33 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K - 13M amber brown to August Brown (Rayner, 1970), 6D8 - 6E7 light brown to cognac (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, dense clusters, forming very large microsclerotia.

*Microconidiophores.* *Stipe* septate, hyaline, terminating in a clavate

vesicle. *Conidiophore branches:* primary branches non-septate, rarely

1-septate, (20-)28(-50) x (3-)5  $\mu\text{m}$ ; secondary branches non-septate,

rarely 1-septate, (18-)20(-30) x (2-)3(-4)  $\mu\text{m}$ ; tertiary branches

non-septate, (16-)18(-23) x (2-)3  $\mu\text{m}$ . *Phialides* arise from the ends

of branches, in groups of 2-4, cylindrical, hyaline, non-septate,

(10-)15(-21) x (2-)3(-4)  $\mu\text{m}$ , collarettes absent in some isolates,

inconspicuous in others. *Conidia* cylindrical, curved or straight, hyaline,

1-septate with obtuse ends, (19-)30(-40) x (2-)4  $\mu\text{m}$ .

*Teleomorph.* *Perithecia* superficial, borne singly or in small groups,

400-500 x 300-350  $\mu\text{m}$ , with warty outer wall and papillate ostiole, red

to red-brown, turning blood-red in 3% KOH. *Asci* hyaline, clavate,

(100-)120(-180) x (9-)15(-27)  $\mu\text{m}$ , tapering to a long thin stalk,

containing 1-8 ascospores. *Ascospores* hyaline, straight or falcate,

1(-3)-septate, generally not constricted at septa, (30-)52(-75) x (4-)6(-7)  $\mu\text{m}$ . Ascospores develop up to six septa once discharged from the ascus.

**Type:** USA: Florida, Orlando, *Polystichum adiantiforme*, F.A. Wolf, Oct. 1926, BPI 414564 (holotype of anamorph); USA x Brazil: *Arachnoides adiantiformis*, USA, (?), F. Schickedanz, ATCC 34395 x *Eucalyptus grandis*, Brazil, A.C. Alfenas, PPRI 4180, PREM 51033 (holotype of teleomorph).

**Symptoms:** causing leaf spots and root disease (Sobers, 1968).

**Hosts:** *Arachis hypogaea*, *Arachnoides adiantiformis*, *Arecastrum romanzoffianum* (Cham.) Becc., *Asparagus plumosus* Baker, *Callistemon* spp., *Chamaedorea elegans* Schrad., *Cocos nucifera* L., *Collinia elegans* Liebm., *Dryopteris* sp., *Eucalyptus* spp., *Howeia* spp., *Lupinus* spp., *Melaleuca leucadendra* L., *Pinus caribaea* var. *hondurensis*, *Polystichum adiantiforme*, *Rhododendron obtusum*, *Rumhora adiantiformis*, *Strelitzia reginae* Banks and *Washingtonia robusta* Wendl. (Wolf, 1926; Sherbakoff, 1928; Sobers, 1967; Sobers, 1968; Sobers & Alfieri, 1972).

**Distribution:** Africa, Brazil, India, U.S.A. (Florida) (Sobers, 1968; Sobers & Alfieri, 1972; Bedendo & Krüger, 1987).

**Specimens:** Africa: *Pinus caribaea* var. *hondurensis*, 1972, Ivory, IMI 164169; *P. oocarpa*, Ivory, IMI 164168. India: *Cocos nucifera*, ?, 1973, IMI 174348. USA: *Washingtonia robusta*, C.D. Sherbakoff, Jan 1928, BPI 414558; Florida, near Sebring, *Washingtonia robusta*, C.D. Sherbakoff, Dec. 1927, BPI 414559; Florida, Orlando, *Polystichum adiantiforme*, F.A. Wolf, Oct. 1926, BPI 414564.

**Cultures:** Brazil: unknown host, J.C. Dianese, (Viçosa, Brazil, No. UFV 43), PPRI 4157; needles of a *Pinus* sp., T.L. Krüger, (Viçosa, Brazil, No. UFV 10) PPRI 4177, IMI 354524; needles of *Pinus caribaea*, T.L. Krüger, (Viçosa, Brazil, No. UFV 37) PPRI 4178; *Eucalyptus grandis* leaves, A.C. Alfenas, (Brazil, Viçosa, No. UFV 105) PPRI 4180, IMI 354530. USA: *Arachnoides adiantiformis*, F. Schickedanz, 1974, ATCC 34395; Florida, *Rumhora adiantiformis*, N.E. El-Gholl, (Brazil, Viçosa, No. UFV 50) PPRI 4179; *Eucalyptus* sp., C.S. Hodges, (Brazil, Viçosa, No. UFV 92) PPRI 4181, IMI 354532.

**Notes:** *C. pteridis* has the largest conidia of all 1-septate *Cylindrocladium* spp., its conidia frequently exceeding 100  $\mu\text{m}$  in length. Furthermore, it is the only *Cylindrocladium* sp. that produces curved microconidia.

Although *C. macrosporum* is a synonym of *C. pteridis*, many researchers continue to use the name *C. macrosporum* (Renard &



Viennot-Bourgin, 1973; Renard & Quillec, 1979; Ahmad & Ahmad, 1982) rather than the valid name *C. pteridis*.

Sobers (1968) showed that the original type culture of *C. macrosporum* could produce microconidia when cultured on WA. This was the first time that a microconidial state had been described in a species of *Cylindrocladium*. In the original description (Sherbakoff, 1928), microconidia are illustrated, but were not mentioned prior to the study in which Sobers (1968) synonymised *C. macrosporum* with *C. pteridis*. Sobers (1968) stated that microconidia did not give rise to both conidial types when single-spored. In contrast, in this study single microconidia from *C. pteridis* and other *Cylindrocladium* spp. could give rise to both conidial types in culture.

A heterothallic *Calonectria* teleomorph for *C. pteridis* was recently described (Crous *et al.*, 1993d). Fertile perithecia could be obtained only by incubating CLA plates at 15 C for 2 mo.

#### 17. *Cylindrocladium quinqueseptatum* Boedijn & Reitsma

*Reinwardtia* 1: 59 (1950).

Holomorph: *Calonectria quinqueseptata* Figueiredo & Namekata *Arch. Insti. Biol. Sao Paulo* 34: 93 (1967).

Illustrations: Fig. 17; Boedijn & Reitsma (1950); Figueiredo & Namekata (1967).

Descriptions: Boedijn & Reitsma (1950); Figueiredo & Namekata (1967).

*Macroconidiophores*. (Measurements of this species not obtained from CLA, but from specimens cited below). *Stipe* septate, hyaline, terminating in a clavate vesicle, (3-)5(-6)  $\mu\text{m}$  diam.; stipes (150-)275(-380)  $\mu\text{m}$  long. *Conidiophore branches*: primary branches non-septate or rarely 1-septate, (20-)28(-55) x (3-)5(-6)  $\mu\text{m}$ ; secondary branches non-septate, (15-)17(-20) x (3-)4(-5)  $\mu\text{m}$ ; tertiary branches (and other branches, up to six), non-septate, (12-)15(-19) x (3-)4(-5)  $\mu\text{m}$ . *Phialides* cylindrical to allantoid or slightly doliiform, hyaline, non-septate, (13-)17(-26) x 4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)5(-6)-septate, rounded at both ends, (61-)84(-101) x (5-)6(-7)  $\mu\text{m}$ .

*Cultural characteristics*. Temperature min. above 10 C; max. below 35 C; opt. 25 C. This is a high temperature species, with no or only sparse sporulation on aerial mycelium. *Colony colour* (reverse) 15'B ochraceous buff (Rayner, 1970), 5B6 apricot (Kornerup & Wanscher,

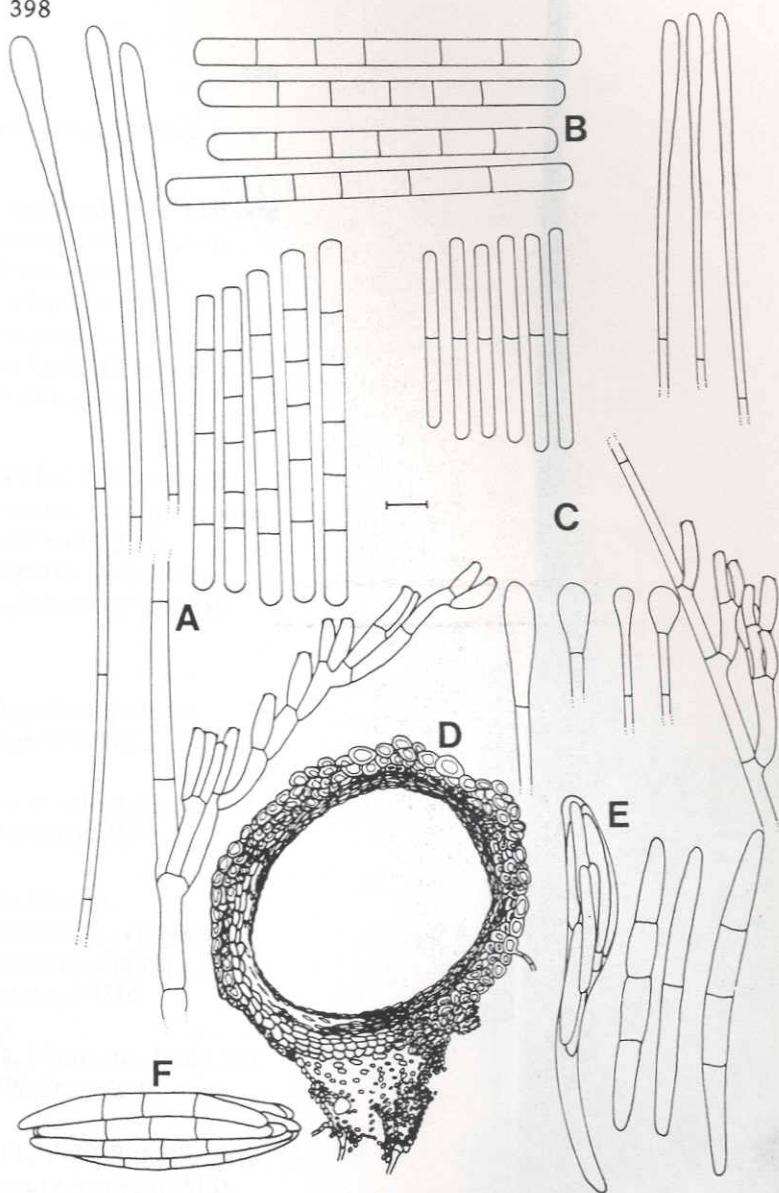


Fig. 17A-F. *Calonectria quinquesepata*, holomorph of *Cylindrocladium quinquesepatum*. A, macroconidiophore, clavate vesicles and conidia on PSA (IMI 114953); B, macroconidia and vesicles on PSA (IMI 201927); C, microconidiophore, clavate to sphaeropedunculate vesicles and conidia on PSA (IMI 114953) (bar = 10  $\mu$ m); D, v. s. through a perithecium (bar = 20  $\mu$ m); E, F, ascus and ascospores (NY 68-4, type) (bar = 10  $\mu$ m).

1967). *Chlamydozozoa* extensive, arranged in fine chains, forming microsclerotia.

*Microconidiophores*. Stipe septate, hyaline, terminating in a clavate to sphaeropedunculate vesicle when present. *Conidiophore* branches: primary branches non-septate, (15-)18(-24) x 3(-4)  $\mu\text{m}$ ; secondary branches non-septate, (8-)12(-18) x (2-)3(-4)  $\mu\text{m}$ . *Phialides* arise singly from the ends of branches, or are arranged in groups of 2-4, cylindrical, hyaline, non-septate, (11-)13(-15) x (2-)3  $\mu\text{m}$ , collarettes absent. *Conidia* cylindrical, hyaline, 1-septate with obtuse ends, (40-)46(-50) x 4(-5)  $\mu\text{m}$ .

*Teleomorph*. *Perithecia* globose to ovoid, 360-580 x 300-440  $\mu\text{m}$ , with warty outer wall and papillate ostiole, orange to red-brown, turning blood-red in 3% KOH. *Asci* hyaline, clavate, 76-126 x 13-22  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, (1-)3-septate, not or slightly constricted at septa, (54-)76(-100) x (4-)7(-8)  $\mu\text{m}$ .

**Type:** Brazil: Sao Paulo, Araruama farm, Jacupiranga, leaf spots on *Annona squamosa*, M.B. Figueiredo, 1965, C.T. Rogerson, NY 68-3 (holotype).

**Symptoms:** damping-off, seedling blight, root-rot, stem infection, leaf and shoot blights, tip blight, dieback (Sharma & Mohanan, 1982; Mohanan & Sharma, 1985b).

**Hosts:** *Ageratum* sp., *Annona squamosa* L., *Camellia sinensis*, *Clerodendron* sp., *Eucalyptus* spp., *Eugenia* sp., *Euphorbia* sp., *Hevea* sp., *Lucas* sp., *Malpighia* sp., *Manilkana* sp., *Scolopendrium* sp., *Sida* sp., *Synedrella* sp. and *Terminalia paniculata* Roth. (Peerally, 1974c; Sulochana *et al.*, 1982; Mohanan & Sharma, 1985b).

**Distribution:** Australia, Brazil, Indonesia, Malaysia, Mauritius, India, Sri Lanka, Hong Kong (Peerally, 1974c; Pitkethley, 1976; Sharma & Mohanan, 1982).

**Specimens:** Australia: *Eucalyptus phoenicea* F. Muell., 1976, Pitketh., IMI 201927. Brazil: Sao Paulo, June 1985, leaves of *Annona squamosa*, M.B. Figueiredo & T. Namekata, NY 68-3 (type of *Calonectria quinquesepitata*); Sao Paulo, leaves of *Eucalyptus* sp., M.B. Figueiredo & T. Namekata, Nov. 1979, NY 68-4 (paratype); *Annona* sp., Campinas, Herbario da Seccao de Botanico, IACM 2682; USA: *Scolopendrium* sp., 1965, IMI 114953.

**Culture:** USA: *Scolopendrium* sp., 1965, ATCC 16550.

**Notes:** of all the *Cylindrocladium* spp. that have multi-septate conidia and clavate vesicles, *C. quinqueseptatum* is the only species with primarily 5-septate conidia.

A collection lodged at IMI (IMI 114953) as *C. pteridis*, was found to represent *C. quinqueseptatum*. This collection produced microconidia, and single-spore isolations gave rise to both conidial types. The dried microconidial culture (representing both conidial types) is described above. Vesicles of the microconidial state varied from clavate to sphaeropedunculate, which is unusual, as vesicles of microconidiophores usually have exactly the same morphology as those of macroconidiophores. This variation is attributed to cultural conditions. There is no doubt, however, that the microconidiophores belong to *C. quinqueseptatum*, as the dried culture representing both states was derived from a single microconidium.

Sehgal (1983) reports *C. quinqueseptatum* to be widely distributed in India and regards it as a very serious pathogen of *Eucalyptus*. Anahosur *et al.* (1976) demonstrated the toxic effects of culture filtrates to *Eucalyptus* cuttings, while Sharma & Mohanan (1991b) found evidence of physiological strains in this species.

**18. *Cylindrocladium reteaudii* (Bugn.) Boesewinkel *Trans. Br. mycol. Soc.* 78: 554 (1982).**

*Cylindrocarpon reteaudii* Bugn., *Encycl. Mycol.* 11: 189 (1939) (described as *reteaudi*).

*Cylindrocladium macrosporum* var. *hederae* Arn. *Bull. Soc. mycol. Fr.* 68: 205 (1952) (*nom. nud.*).

*Cylindrocladium hederae* (Arn.) Peerally CMI Descriptions of Pathogenic fungi and Bacteria No. 426 (1974f) (*nom. nud.*).

*Cylindrocladium hederae* Arn. ex Peerally *Mycotaxon* 40: 335 (1991).

*Cylindrocladium leucothoes* El-Gholl, Leahy & Schubert *Can. J. Bot.* 67: 2530 (1989) (as *leucothoeae*).

Holomorph: *Calonectria reteaudii* (Bugn.) Booth *Mycol. Pap.* 104: 41 (1966).

*Neonectria reteaudii* Bugn. *Encycl. Mycol.* 11: 189 (1939) (as *reteaudi*).

*Calonectria hederae* Arnaud *Bull. Soc. Mycol. France* 68: 214 (1952) (*nom. nud.*).

*Calonectria hederae* Booth & Murray *Trans. Br. mycol. Soc.* 43: 70 (1960).

**Illustrations:** Figs 18, 49; Bugnicourt (1939); Booth (1966); Peerally (1974f); El-Gholl *et al.* (1989).

**Descriptions:** Bugnicourt (1939); Arnaud, 1952; Booth (1966); Peerally (1974f); El-Gholl *et al.* (1989); Crous & Wingfield (1992).

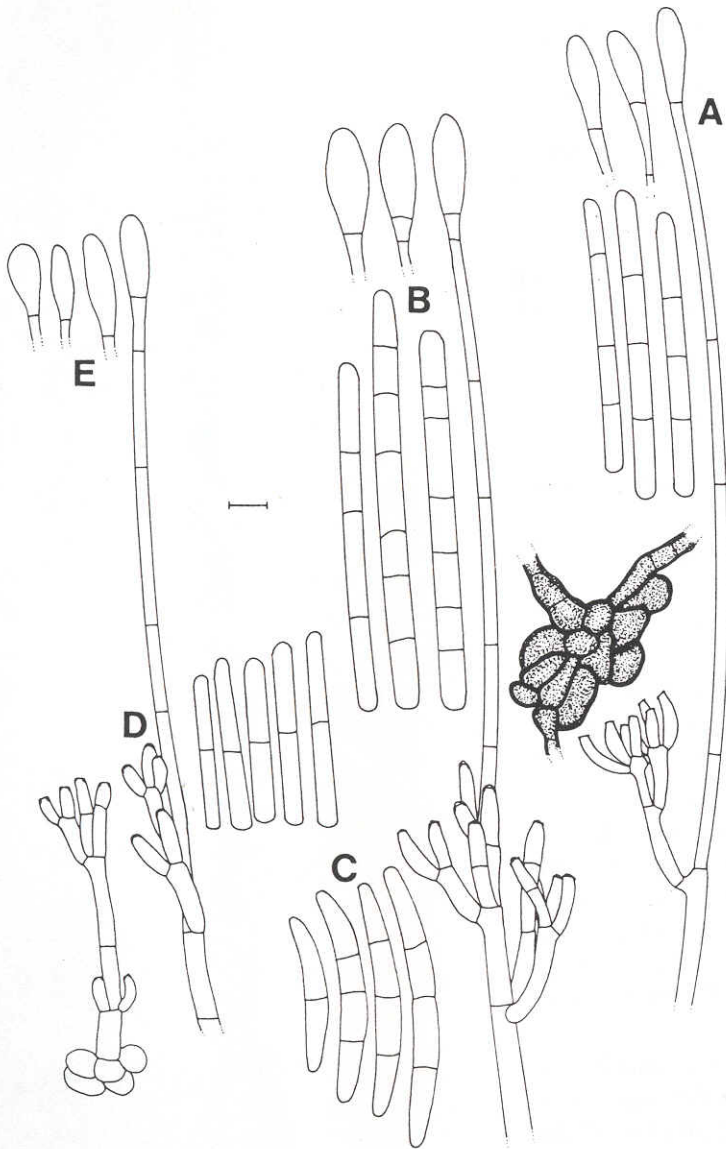


Fig. 18A-E. *Calonectria reteaudii* and its *Cylindrocladium reteaudii* anamorph (bar = 10  $\mu$ m). A, macroconidiophore, ellipsoidal vesicles, conidia and microsclerotium (ATCC 64824); B, macroconidiophore, ellipsoidal vesicles and conidia; C, ascospores; D, microconidiophores and microconidia; E, ellipsoidal microvesicles (CPC 599).

*Macroconidiophores.* Stipe septate, hyaline, terminating in an ellipsoidal or ovoid vesicle, (4-)6(-8)  $\mu\text{m}$  diam.; stipes (160-)185(-245)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate or rarely 1-septate, (11-)19(-36) x (3-)4(-5)  $\mu\text{m}$ ; secondary branches non-septate, (12-)15(-18) x (3-)4  $\mu\text{m}$ ; tertiary branches non-septate, (10-)14(-17) x (3-)4  $\mu\text{m}$ . *Phialides* cylindrical to allantoid or slightly doliiform, hyaline, non-septate, (10-)15(-20) x 3(-4)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3(-6)-septate, rounded at both ends, (60-)80(-105) x (5-)6(-7)  $\mu\text{m}$ . If incubated as outlined in the materials and methods section of this paper, conidia develop only three septa after 7 d. However, on older cultures, conidia develop up to six septa and are up to 105  $\mu\text{m}$  long.

*Cultural characteristics.* Temperature min. above 8 C; max. below 35 C; opt. 25 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 17B deep chrome (Rayner, 1970), 4B8 yolk yellow (Kornerup & Wanscher, 1967). *Chlamydospores* slight to medium in density, appearing scattered throughout medium, forming microsclerotia.

*Microconidiophores.* Stipe septate, hyaline, terminating in an ellipsoidal to ovoid vesicle when present. *Conidiophore branches:* primary branches non-septate, (10-)15(-20) x (4-)5(-6)  $\mu\text{m}$ ; secondary branches non-septate, (10-)15 x (4-)5  $\mu\text{m}$ . *Phialides* arising singly from the ends of branches, or are arranged in groups of 2-4, are cylindrical to doliiform, hyaline, non-septate, 10(-15) x 3(-4)  $\mu\text{m}$ , collarettes absent. *Conidia* cylindrical, hyaline, 1-septate with obtuse, frequently slightly swollen ends, (45-)47(-50) x (3-)5  $\mu\text{m}$ .

*Teleomorph.* *Perithecia* ovoid to globose, 200-400 x 250-380  $\mu\text{m}$ , with warty outer wall and papillate ostiole, orange to red, turning blood-red in 3 % KOH. *Asci* hyaline, clavate, 100-180 x 15-20  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, (1-)3-septate, not or slightly constricted at septa, (36-)60(-70) x (5-)6(-7)  $\mu\text{m}$ .

**Type:** South East Asia (Vietnam): *Smithia bequaertii* De Wild., F. Bugnicourt, IMI 55922 (dried culture, *ex holotype*). **France:** *Hedera helix* leaf, G. Arnaud, 1948, IMI 39232 (neotype of teleomorph). **Great Britain:** *H. helix* leaf, 1958, IMI 75300 (neotype of teleomorph). **Symptoms:** leaf spots and root discolouration (Peerally, 1974f).

**Hosts:** *Eucalyptus saligna*, *Hedera helix* L., *Smithia bequaertii*, *Leucothoe axillaris* (Bugnicourt, 1939; Peerally, 1974f; El-Gholl *et al.*, 1989).

**Distribution:** Brazil, France, Great Britain, U.S.A (Florida) (Peerally, 1974f; El-Gholl *et al.*, 1989).

**Specimens:** **France:** *Calonectria hederae*, *Hedera helix* leaves, G. Arnaud, 1948, IMI 39232. **Great Britain:** *Calonectria hederae*, *Hedera helix* leaf, 1958, IMI 75300; *H. helix* leaf, 1978, IMI 241261. **Indo China:**

*Cylindrocarpon reteaudii*, on *Smithia bequaertii*, F. Bugnicourt, IMI 55922 (dried culture derived from holotype, Herb Paris).

**Culture:** **USA:** Florida, *C. leucothoeae*, from *Leucothoeae axillaris* leaves, El-Gholl, Feb. 1988, ATCC 64824 (type culture). **Brazil:** Sao Paulo, leaf spots on young *E. saligna* trees, P.W. Crous, Apr. 1993, CPC 599.

**Notes:** Bugnicourt (1939) described *Cylindrocarpon reteaudii* and *Neonectria reteaudii* as a new holomorph from Indo China. Booth (1966) transferred the teleomorph to *Calonectria*, and Boesewinkel (1982a) the anamorph to *Cylindrocladium*. In a recent study (Crous & Wingfield, 1992), *C. reteaudii* was compared with *C. leucothoes* and *C. hederae*. These three species were shown to represent the same taxon, *C. reteaudii*, characterised by 1-(3)-6-septate conidia averaging 72  $\mu\text{m}$  in length, and ellipsoidal to ovoid vesicles. A recent collection from *E. saligna* (CPC 599) showed that this fungus is also present in Brazil.

19. ***Cylindrocladium scoparium*** Morgan Bot. Gaz. 17: 191 (1892).

*Cylindrocladium pithecolobii* Petch Ann. R. Bot. Gard. Peradeniya 6: 244 (1917).

*Diplocladium cylindrosporium* Ell. & Everh. Bull. Torrey Bot. Cl. 27: 58 (1900).

*Cylindrocladium scoparium* var. *brasiliensis* Batista & Ciferri Boletim da S.A.I.C. Pernamubco 18: 190 (1951).

*Cylindrocladium brasiliensis* (Batista & Ciferri) Peerally CMI Descriptions of Pathogenic Fungi and Bacteria No. 427 (1974).

*Cylindrocladium ellipticum* Alfieri, Seymour & Sobers *Phytopathology* 60: 1213 (1970).

Holomorph: *Calonectria morganii* Crous, Alfenas & Wingfield *Mycol. Res.* 97: 706 (1993).

**Illustrations:** Figs 19, 51-54; Booth & Gibson (1973); Alfieri *et al.* (1970); Crous *et al.* (1993a).

**Descriptions:** Booth & Gibson (1973); Crous *et al.* (1993a).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a obovoid to pyriform or ellipsoidal vesicle, (6-)(7-)(8)  $\mu\text{m}$  diam.; stipes

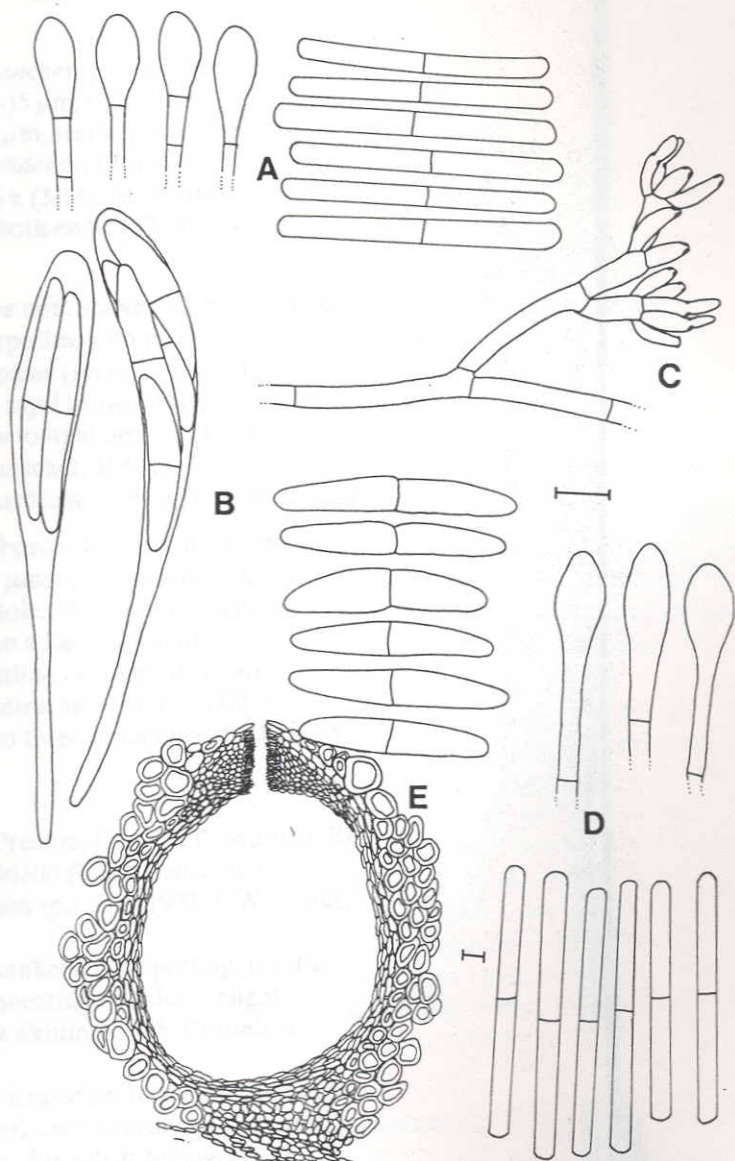


Fig. 19A-E. *Calonectria morganii* and its *Cylindrocladium scoparium* anamorph. A, pyriform to ellipsoidal vesicles and conidia (BPI 414576); B, asci and ascospores (PREM 51042, type); C, conidiophore; D, ellipsoidal vesicles and conidia on CLA (ATCC 46300, bar = 10  $\mu$ m); E, v. s. through a perithecium (PREM 51042, bar = 20  $\mu$ m).



(150-)173(-195)  $\mu\text{m}$  long. *Conidiophore branches*: primary branches non-septate or 1-septate, (11-)24(-40) x (4-)5  $\mu\text{m}$ ; secondary branches non-septate, (11-)16(-20) x 4(-5)  $\mu\text{m}$ ; tertiary branches non-septate, (10-)13(-15) x 4(-5)  $\mu\text{m}$ . *Phialides* doliiform to reniform, hyaline, non-septate, (9-)11(-15) x (3-)4  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1-septate, rounded at both ends, (40-)45(-66) x (3-)4(-5)  $\mu\text{m}$ . *Microconidiophores*, absent.

*Cultural characteristics*. Temperature min. above 5 C; max. above 35 C; opt. 25-30 C. This is a eurythermal species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K - 17I - 15I, amber brown to buckthorn brown to sayal brown (Rayner, 1970), 5D6 - 6D8, or 5C6 - 6C7, pompeian yellow to light brown, or oak brown to reddish golden (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, dense, distributed throughout medium, forming microsclerotia.

*Teleomorph*. *Perithecia* superficial, borne singly or in groups, globose or subglobose, 280-520 x 280-400  $\mu\text{m}$ , red-brown to red, with rough warted outer wall and papillate ostiole. *Asci* hyaline, clavate, (75-)80(-100) x (8-)10(-15)  $\mu\text{m}$ , tapering to a long thin stalk, containing 1-8 ascospores. *Ascospores* hyaline, straight to falcate, 1-septate, not or slightly constricted at central septum, (24-)37(-49) x (4-)7(-8)  $\mu\text{m}$ . *Ascospores* developing up to three septa once discharged from ascus.

**Type:** USA: *Gleditsia triacanthos* Hance, Preston, Ohio, A.P. Morgan, BPI 414576 (lectotype of anamorph); ATCC 46300 (USA, *Leucothoe catesbaei*) x PPRI 4731 (Brazil, *Anacardium* sp.), July 1992, P.W. Crous, PREM 51042 (holotype of teleomorph).

**Symptoms:** damping off, root rots, stem cankers, leaf spotting, needle blight, epicormic growth, death of trees, seedling and shoot blight (Batista, 1951; Peerally, 1974g; Cordell & Skilling, 1975; Cordell & Rowan, 1975).

**Hosts:** Booth & Gibson (1973) report *C. scoparium* to have a wide host range, infecting mainly woody plants (particularly eucalypts and pine), but also beet, strawberry and watermelon. French & Menge (1978) stated that it occurs on well over 66 plant genera.

**Distribution:** *C. scoparium* has been reported from numerous countries (Booth & Gibson, 1973). However, the establishment of another name for South African and Brazilian isolates previously referred to as *C. scoparium*, suggests that many of these reports might be of *C.*

*candelabrum*. An accurate representation of the distribution and host range of this fungus can, therefore, not be presented at this stage.

**Specimens:** **Brazil:** Recife, *Eucalyptus* seedlings, A.C. Batista, 11 Sept. 1950, IMI 43688 (ex holotype, *C. brasiliensis*); **USA:** ATCC 46300 (USA, *Leucothoe catesbaei*) x PPRI 4731 (Brazil, *Anacardium* sp.), July 1992, P.W. Crous, PREM 51042 (holotype specimen); ATCC 46300 (USA, *Leucothoe catesbaei*) x ATCC 38227 (USA, *Mahonia bealei*), July 1992, P.W. Crous, PREM 51043 (paratype specimen); Preston, Ohio, *Gleditsia triacanthos*, A.P. Morgan, 1893, BPI 414576 (Lectotype designated here), BPI 414577; Preston, Ohio, *Juglans nigra*, A.P. Morgan, 1893, BPI 414578.

**Cultures:** **Brazil:** CE, Fortaleza, *Anacardium* sp., D.O. Freire, PPRI 4731; T.R. Ciferri, CBS 230.51 Type of *C. brasiliensis*, (IMI 299576). **USA:** *Mahonia bealei*, S.A. Alfieri, 1970, ATCC 38227 (*C. ellipticum*, type); Florida, *Rhododendron* sp., C.R. Semer, (Viçosa, Brazil, No. UFV 11), PPRI 4144; unknown host, A. Rossman, (Viçosa, Brazil, No. UFV 39), PPRI 4154; North Carolina, *Leucothoe catesbaei*, D.M. Benson, 1981, ATCC 46300; *Rosa* sp., N. El-Gholl, P90.1445, PPRI 4732; Florida, *Ilex vomitoria*, N. El-Gholl, P90.1479, PPRI 4733.

**Notes:** *C. scoparium* is morphologically very similar to *C. floridanum*, *C. ovatum* and *C. candelabrum*. However, *C. scoparium* has ellipsoidal to obovoid vesicles, whereas vesicles are ovoid for *C. ovatum*, sphaeropedunculate for *C. floridanum*, and ellipsoidal to obpyriform for *C. candelabrum*. The teleomorph of *Calonectria kyotensis*, (the holomorph of *C. floridanum*), can be distinguished from the teleomorphs of the other two species by its smaller ascospores. Furthermore, *C. scoparium* isolates from North America can be distinguished from those of *C. candelabrum* through sexual incompatibility. Isolates of *C. scoparium* also have different electrophoretic protein profiles from those of *C. candelabrum* (Crous *et al.*, 1993a).

**20. *Cylindrocladium spathiphylli* Schoulties, El-Gholl & Alfieri** *Mycotaxon* 16: 268 (1982).

Holomorph: *Calonectria spathiphylli* El-Gholl, Uchida, Alfenas, Schubert, Alfieri & Chase *Mycotaxon* 45: 296 (1992).

**Illustrations:** Figs 20, 55, 56; Schoulties *et al.* (1982); El-Gholl *et al.* (1992).

**Description:** Schoulties *et al.* (1982); El-Gholl *et al.* (1992).

*Macroconidiophores.* Stipe septate, hyaline, terminating in a globose, ellipsoid or spatulate vesicle, (8-)12(-15)  $\mu\text{m}$  diam.; stipes

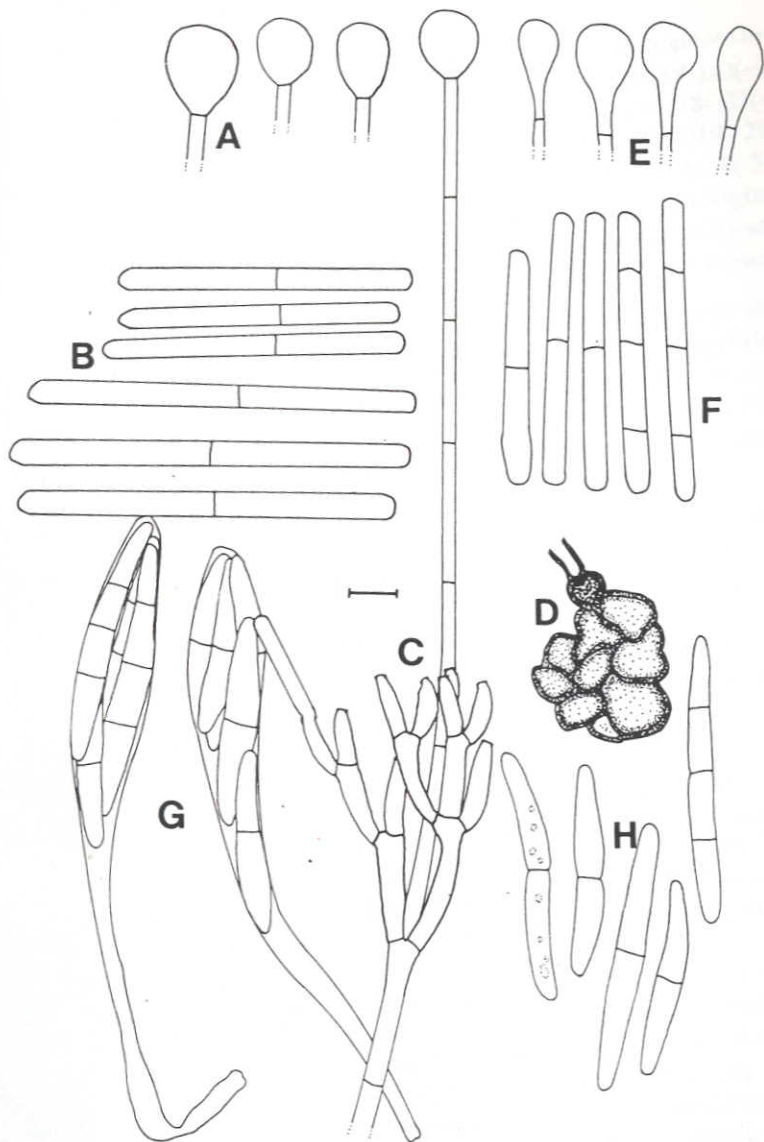


Fig. 20A-H. *Cyindrocladium spathiphylli* (bar = 10  $\mu$ m). A, globose to sphaeropedunculate vesicles; B, conidia; C, conidiophore; D, microsclerotium on CLA (ATCC 44730, *ex* type); E, globose to ellipsoid to sphaeropedunculate vesicles; F, conidia (Aragaki 1569); G, asci; H, ascospores (FLAS F55655, type).

(170-)217(-260)  $\mu\text{m}$  long. *Conidiophore* branches: primary branches non-septate or rarely 1-septate, (18-)30(-40) x (4-)5(-6)  $\mu\text{m}$ ; secondary branches non-septate, (18-)22(-30) x (4-)5(-6)  $\mu\text{m}$ ; tertiary branches non-septate, (16-)19(-25) x (4-)5  $\mu\text{m}$ ; quaternary branches non-septate, (11-)15(-20) x 4(-5)  $\mu\text{m}$ . *Phialides* elongate, doliiform to reniform, hyaline, non-septate, (12-)17(-21) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1(-3)-septate, rounded at both ends, (45-)68(-120) x (5-)6(-7)  $\mu\text{m}$ . *Microconidiophores* unknown.

*Cultural characteristics.* Temperature min. above 10 C; max. below 35 C; opt. 25 C. This is a high temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13°K verona brown (Rayner, 1970), 5E7 linoleum brown (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, dense, dispersed throughout the medium, forming microsclerotia.

*Teleomorph.* *Perithecia* superficial, borne singly or in groups, globose or subglobose, 380-655 x 340-650  $\mu\text{m}$ , orange to red, with rough, warty outer wall and papillate ostiole. *Asci* hyaline, clavate, (120-)172(-230) x (7-)15(-25)  $\mu\text{m}$ , tapering to a long thin stalk, containing (2-)8 ascospores. *Ascospores* hyaline, straight to falcate, 1(-3)-septate, slightly constricted at septa, guttulate, (22-)45(-65) x (3-)5(-7)  $\mu\text{m}$ .

**Type:** USA: Florida, *Spathiphyllum* sp., C.L. Schoulties, 1982, ATCC 44730 (holotype of anamorph); Florida, induced on leaf segment of *Howea forsteriana*, by mating P86-210 (from *Heliconia psittacorum*, K.I. Kavouras, Dover, Florida, 20 Jan. 1986) and P 87-167 (from *Heliconia* sp., C.L. Lippincott, Miami, Florida, 9 Jan. 1987, FLAS 55655 (holotype of teleomorph).

**Symptoms:** Root, stem and foliar disease (Schoulties *et al.*, 1982).

**Hosts:** *Araucaria heterophylla*; *Spathiphyllum* spp.; *Heliconia* spp.; *Strelitzia nicolai* Regel & Körn; *Ludwigia palustris* (L.) Elliott (Schoulties *et al.*, 1982; El-Gholl *et al.*, 1992).

**Distribution:** Australia, Italy, Florida, U.S.A (Florida, Hawaii) (Schoulties *et al.*, 1982; Forsberg, 1988; Carrai & Carribaldi, 1990).

**Cultures:** USA: Florida, *Spathiphyllum* sp., C.L. Schoulties, 1982, ATCC 44730; Hawaii, *Araucaria heterophylla*, M. Aragaki, 1987, No. 1568, IMI 354528; No. 1569, IMI 354529.

**Notes:** *C. spathiphylli* is currently the only known *Cylindrocladium* sp. with globose vesicles. In this study, however, we have found as reported by Uchida & Aragaki (1992) that some vesicles can be slightly ellipsoidal.

Furthermore, Hawaiian isolates studied also showed conidia to be 1(-3) septate, as observed by El-Gholl *et al.* (1992). This taxon is, however, primarily distinguished from *C. parasiticum* (sphaeropedunculate vesicles), by having mainly 1-septate conidia. Other *Cylindrocladium* spp. with 1-septate conidia and sphaeropedunculate vesicles are distinguished from *C. spathiphylli* by having curved conidia (*C. curvatum*) or lateral stipes and smaller conidia (*C. floridanum*).

21. ***Cylindrocladium spathulatum*** El-Gholl, Kimbrough, Barnard, Alfieri & Schoulties *Mycotaxon* **26**: 159 (1986).

Holomorph: ***Calonectria spathulata*** El-Gholl, Kimbrough, Barnard, Alfieri & Schoulties *Mycotaxon* **26**: 159 (1986).

Illustrations: Fig. 21; El-Gholl *et al.* (1986).

Description: El-Gholl *et al.* (1986).

*Macroconidiophores*. Stipe septate, hyaline, terminating in a clavate to spatulate vesicle, (3-)6(-9)  $\mu\text{m}$  diam.; stipes (105-)173(-225)  $\mu\text{m}$  long. *Conidiophore branches*: primary branches non-septate or rarely 1-septate, (12-)22(-37) x (3-)4(-5)  $\mu\text{m}$ ; secondary branches non-septate, (12-)18(-25) x (3-)4(-5)  $\mu\text{m}$ ; tertiary branches non-septate, (14-)16(-20) x 3(-4)  $\mu\text{m}$ . *Phialides* elongate, doliiform to reniform, hyaline, non-septate, (11-)14(-18) x (3-)4(-5)  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, 1(-3)-septate, rounded at both ends, (48-)58(-75) x (4-)5(-6)  $\mu\text{m}$ . When cultures are incubated under conditions other than that reported here, conidia are observed to have larger dimensions. *Microconidiophores* unknown.

*Cultural characteristics*. Temperature min. below 5 C; max. below 33 C; opt. 25 C. This is a low temperature species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13D - 15F cupucine orange to pale-yellow orange (Rayner, 1970), 5B6 - 4A5 apricot yellow to butter yellow (Kornerup & Wanscher, 1967). *Chlamydospores* in medium numbers (fewer than *C. ilicicola*), scattered to occurring in chains, forming microsclerotia.

*Teleomorph*. *Perithecia* globose to ovoid, 318-536 x 273-457  $\mu\text{m}$ , with warty outer wall and papillate ostiole, orange-red in colour, turning blood-red in 3% KOH. *Asci* hyaline, clavate, 87-162 x 10-24  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, 1(-3)-septate, not or slightly constricted at central septum, (25-)40(-48) x (4-)5(-7)  $\mu\text{m}$ .

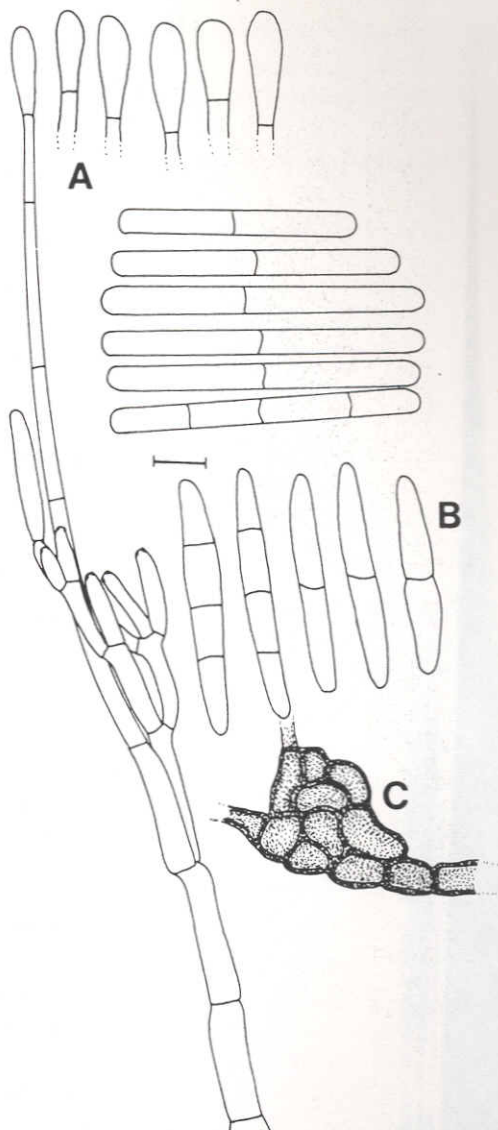


Fig. 21A-C. *Calonectria spathulata* and its *Cylindrocladium spathulanum* anamorph (bar = 10  $\mu$ m). A, conidiophore, clavate to spatulate and conidia on CLA (ATCC 62616, ex type); B, ascospores (FLAS F54257); C, microsclerotium (ATCC 62616).

**Type:** Brazil: Santa Catarina, leaves of *Eucalyptus viminalis* Labill., El-Gholl, 1983, FTCC 1001, FLAS F54257 (holotype).

**Symptoms:** leaf spots (El-Gholl, *et al.*, 1986).

**Hosts:** *E. viminalis*, *E. cloeziana*, *E. grandis* (El-Gholl, *et al.*, 1986).

**Distribution:** Brazil (El-Gholl, *et al.*, 1986).

**Cultures:** Brazil: Minas Gerais, *Eucalyptus grandis*, C. S. Hodges, (Beltsville, Maryland, AR 1844), PPRI 4173, IMI 354522; *E. viminalis* leaves, N.E. El-Gholl, 1985, ATCC 62616 (type culture); Minas Gerais, *Eucalyptus* sp., C.S. Hodges, 1974, PPRI 4742, IMI 354523; Minas Gerais, *Pteridium* sp., C.S. Hodges, 1974, PPRI 4743 IMI 354521; Minas Gerais, *Araucaria angustifolia*, C.S. Hodges, 1973, PPRI 4744 IMI 354520.

**Notes:** this species is morphologically similar to *C. ilicicola*. The two species have a similar vesicle, phialide and conidium morphology. In the original description of *C. spathulatum*, El-Gholl *et al.* (1986) compared this species with several *Cylindrocladium* spp. other than *C. ilicicola*. The original description also mentions that this species is homothallic, which is also true for *C. ilicicola*. Because of the similarities in their descriptions, Peerally (1991a) regarded the two species as synonyms.

In this study *C. spathulatum* and *C. ilicicola* are recognized as two distinct species. Conidia of *C. spathulatum* are 1-3-septate, (as *C. ilicicola*), but primarily 1-septate on CLA, and after 7 d hardly any 3-septate conidia can be found. *C. ilicicola*, however, has primarily 3-septate conidia on CLA. Furthermore, isolates of *C. spathulatum* can be distinguished from *C. ilicicola* by forming moderate, and not abundant chlamydospores, as is typical for *C. ilicicola*. *C. spathulatum* is also a low temperature species, as opposed to *C. ilicicola*, which is favoured by high temperatures. These species are clearly similar, but there is no justification in treating them as synonyms as proposed by Peerally (1991a). A recent study (Crous *et al.*, 1993b) also found the DNA banding patterns of *C. ilicicola* and *C. spathulatum* to be distinct.

El-Gholl *et al.* (1986) report asci to have 4-8 ascospores. This characteristic was observed in several collections, but in these cases asci were still immature. Mature asci of *Calonectria spathulata* had eight ascospores when grown on CLA.

**22. *Cylindrocladium theae*** (Petch) Subramanian, Hyphomycetes, an account of Indian species, except *Cercosporae*: 731 (1971).

*Cercospora theae* Petch *Annals of the Royal Botanic Gardens of Peradeniya* **6**: 246 (1917).

*Candelospora theae* (Petch) Wakefield: *Gadd Monographs on Tea Production in Ceylon* **2**: 59 (1949).

*Cylindrocladium theae* (Petch) Alfieri & Sobers *Phytopathology* **62**: 650 (1972) (*nom. nud.*).

Holomorph: *Calonectria indusiata* Seaver *Mycologia* **20**: 58 (1928).

*Calonectria theae* Loos *Trans. Br. mycol. Soc.* **33**: 17 (1950).

**Illustrations:** Fig. 22; Loos (1950); Alfieri *et al.* (1972).

**Descriptions:** Petch, 1917; Loos (1950); Alfieri *et al.* (1972).

*Macroconidiophores.* *Stipe* septate, hyaline, terminating in a narrowly clavate vesicle, (3-)4(-6)  $\mu\text{m}$  diam.; stipes (340-)380(-600)  $\mu\text{m}$  long. *Conidiophore branches:* primary branches non-septate to 1-septate, (18-)26(-47) x (3-)4(-5)  $\mu\text{m}$ ; secondary branches non-septate, (13-)19(-21) x (3-)4  $\mu\text{m}$ ; tertiary branches non-septate, (12-)16(-18) x 3(-4)  $\mu\text{m}$ ; quaternary branches non-septate, (10-)14(-18) x 3(-4)  $\mu\text{m}$ . *Phialides* cylindrical to allantoid, hyaline, non-septate, (11-)13(-16) x (3-)4  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3-septate, rounded at both ends, (65-)81(-96) x (5-)6(-7)  $\mu\text{m}$ . *Microconidiophores* unknown.

*Cultural characteristics.* *Temperature* min. above 10 C; max. below 35 C; opt. 25 C. This is a high temperature species, with only slight sporulation on aerial mycelium. *Colony colour* (reverse) 15'B ochraceous-buff (Rayner, 1970), 5B6 apricot (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, arranged in fine chains, forming microsclerotia.

*Teleomorph.* *Perithecia* globose to ovoid, 220-500 x 220-480  $\mu\text{m}$ , with warty outer wall and papillate ostiole, orange to red, turning blood-red in 3 % KOH. *Asci* hyaline, clavate, 80-145 x 16-26  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, (1-)3-septate, not or slightly constricted at septa, (35-)53(-70) x (4-)7(-8)  $\mu\text{m}$ .

**Type:** Sri Lanka: *Camellia sinensis*, Loos, 1949, (Tea Res. Inst. Herb. No. 435) IMI 35027 (holotype of anamorph). Trinidad: leaf of a *Micropolis* sp., Seaver 3176, 13 Mar. 1921, (NY) (holotype of teleomorph).  
**Symptoms:** leaf spots, defoliation, root rot, stem and petiole lesions (Peerally, 1974d; Mims *et al.*, 1981).



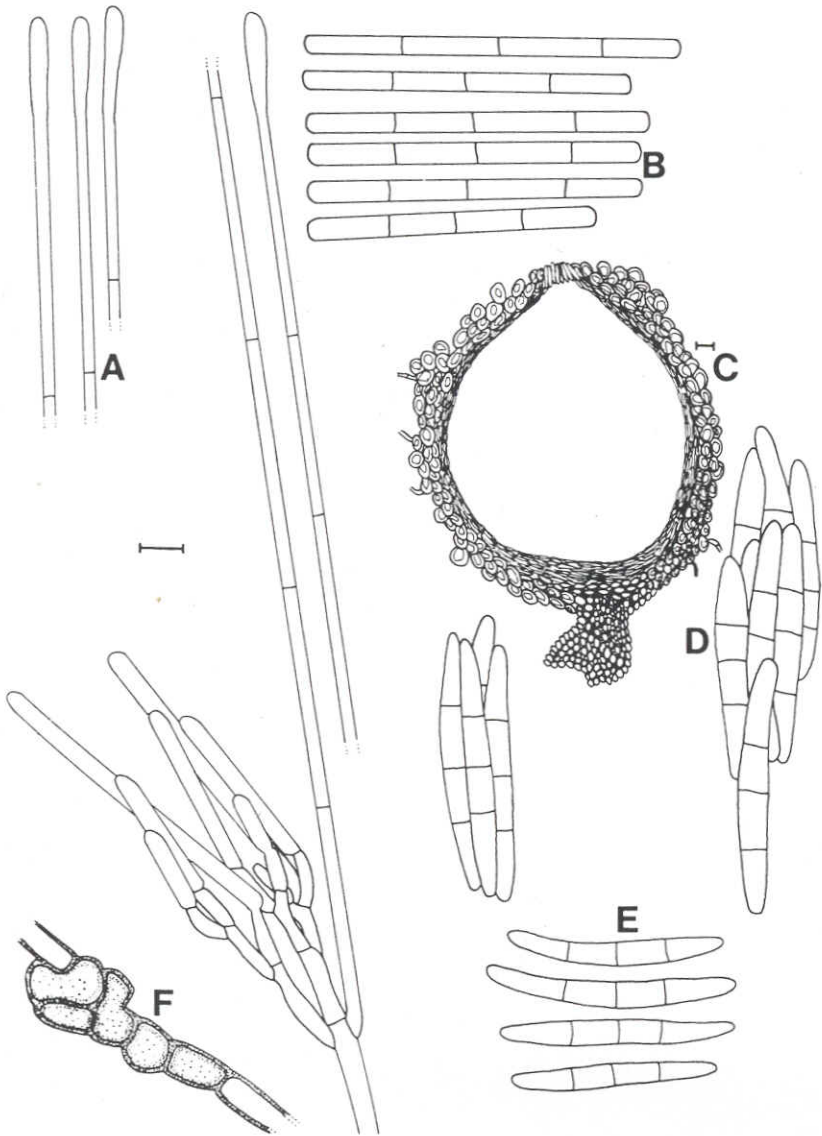


Fig. 22A-F. *Calonectria indusiata* and its *Cyliandrocladium theae* anamorph. A, clavate vesicles, conidiophore and chlamydospores; B, conidia (PPRI 4188, bar = 10  $\mu\text{m}$ ); C, v.s. of a perithecium (bar = 20  $\mu\text{m}$ ); D, ascospores (IMI 146970); E, ascospores; F, chlamydospores (PPRI 4188, bar = 10  $\mu\text{m}$ ).

**Hosts:** *Acacia* spp., *Albizzia* sp., *Camellia sinensis*, *Eucalyptus* spp., *Micropolis* sp. and *Rhododendron* spp. (Subramanian, 1971; Peerally, 1974d; Mims *et al.*, 1981; El-Gholl *et al.*, 1983).

**Distribution:** Brazil, India, Sri Lanka, U.S.A. (Florida), Mauritius (Peerally, 1974d; Ferreira, 1989).

**Specimens:** **India:** *E. gigantea* Hook. f., Reddy, 1970, IMI 146970.

**Trinidad:** a leaf of a *Micropolis* sp., Seaver 3176, 13 Mar. 1921, (NY).

**Australia:** *Eucalyptus* sp., S. Hoone, (?), IMI 55858, 55859.

**Cultures:** **USA:** Florida, *Rhododendron* sp., N.E. El-Gholl, ATCC 48895; Florida, *Rhododendron* sp., N.E. El-Gholl (Viçosa, Brazil, UFV 16) PPRI 4188.

**Notes:** *C. theae* is characterized by having 3-septate conidia and clavate vesicles. Of the other 3-septate *Cylindrocladium* spp. with clavate vesicles, *C. theae* is very similar to *C. colhounii* var. *macroconidialis*. These two species have almost identical phialides and vesicles, but the stipes of *C. colhounii* var. *macroconidialis* are much shorter than those of *C. theae*. The teleomorph of *C. theae* also has red to red-brown perithecia with 8-spored asci, and not yellow perithecia with 4-spored asci like those of *C. colhounii* var. *macroconidialis*.

*Calonectria indusiata* was collected from a *Micropolis* leaf in Trinidad (Seaver, 1928). Ascospores were described as 55-80 x 7-8  $\mu\text{m}$  in size and illustrated in the ascus as 3-septate. Although the illustration (Seaver, 1928) shows the ascospores as having very acute apices, they were found to be fusoid with rounded apices in this study. Ascospores (before discharge) in this collection were 3-septate, not constricted at septa, (35-)56(-70) x 6(-9)  $\mu\text{m}$ . Measurements of the asci, ascospores, as well as ascospore septation in young perithecia, indicate that this collection represents an earlier name for *Calonectria theae*. The name *Calonectria theae* is therefore reduced to synonymy with *Calonectria indusiata*.

**23. *Cylindrocladium variabile*** Crous, Janse, Victor, Marais & Alfenas *Syst. Appl. Microbiol.* **16:** 270 (1993).

**Holomorph:** *Calonectria variabilis* Crous, Janse, Victor, Marais & Alfenas *Syst. Appl. Microbiol.* **16:** 270 (1993).

**Illustrations:** Figs 23, 59, 60; Crous *et al.* (1993b).

**Description:** Crous *et al.* (1993b).

**Macroconidiophores.** Stipe septate, hyaline, terminating in a sphaeropedunculate or ellipsoid to clavate vesicle, (6-)9(-11)  $\mu\text{m}$  diam.; stipes (130-)180(-250)  $\mu\text{m}$  long. **Conidiophore branches:** primary

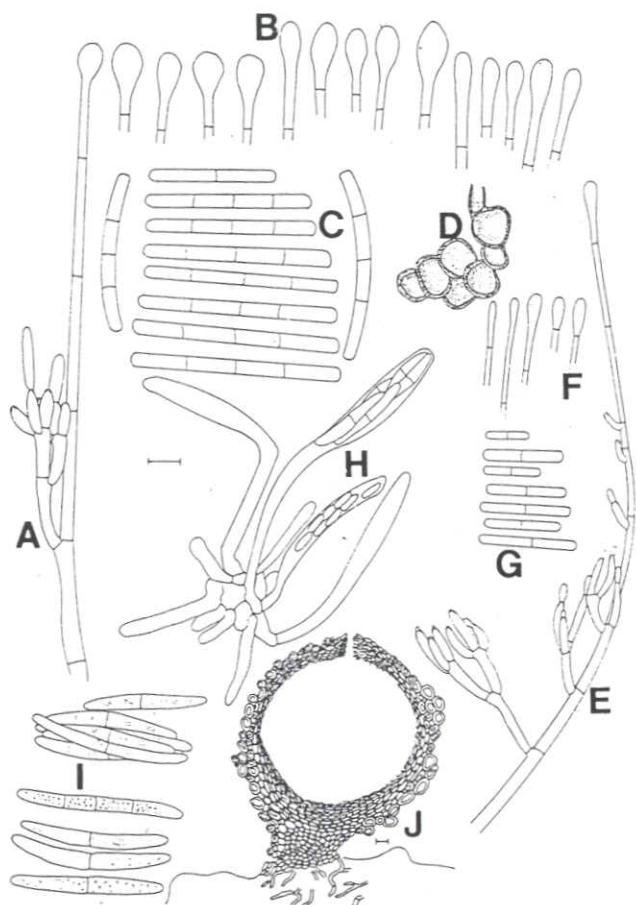


Fig. 23A-J. *Calonectria variabilis* and its anamorph *Cylindrocladium variabile* (PREM 51041) and its teleomorph (PREM 51039). A, macroconidiophore; B, sphaeropedunculate, ellipsoidal and clavate macrovesicles; C, cylindrical, straight or slightly curved (1-)3-septate macroconidia; D, chlamydospores; E, microconidiophore; F, clavate to ellipsoidal microvesicles; G, cylindrical 1-septate microconidia; H, developing asci with ascospores; I, immature guttulate, and mature, granular, 1-(3)-septate ascospores (PREM 51041, bar = 10  $\mu$ m); J, v. s. through a perithecium (PREM 51039, bar = 20  $\mu$ m).

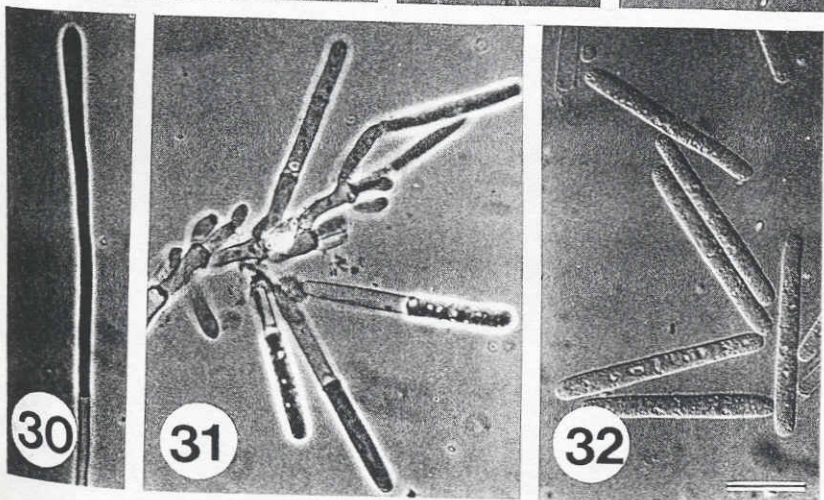
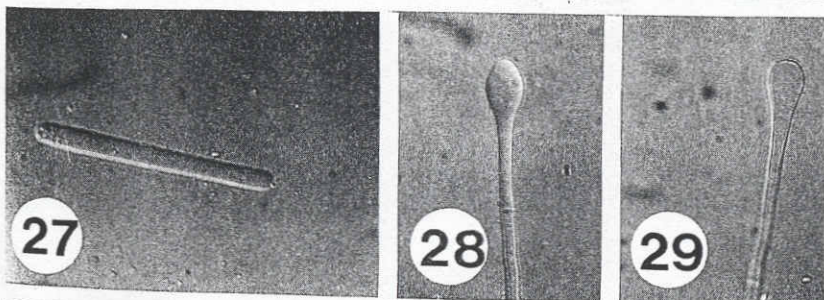
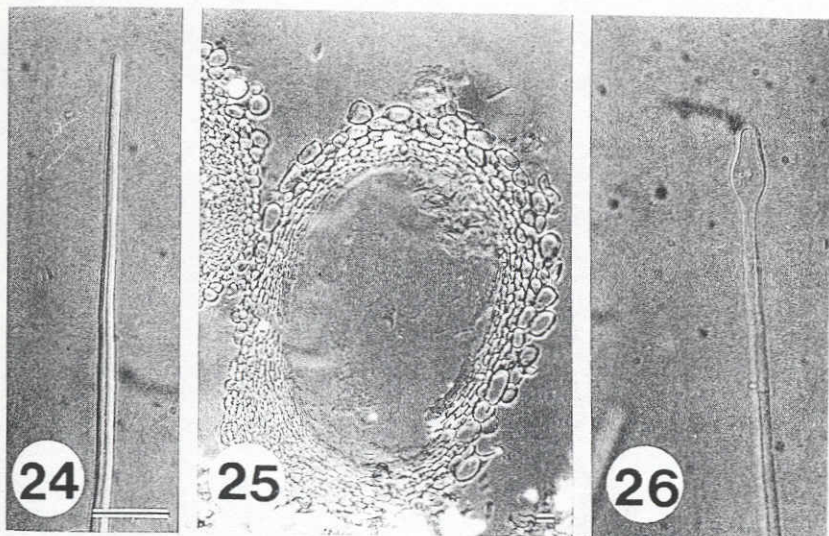
branches non-septate or rarely 1-septate, (15-)20(-30) x (3-)4(-5)  $\mu\text{m}$ ; secondary branches non-septate, (10-)13(-18) x (3-)4(-5)  $\mu\text{m}$ ; tertiary branches rare, non-septate, (8-)11(-14) x (3-)4(-5)  $\mu\text{m}$ . *Phialides* elongate, doliiform to reniform, hyaline, non-septate, (9-)13(-18) x (3-)4  $\mu\text{m}$ . *Conidia* cylindrical, hyaline, (1-)3(-4)-septate, rounded at both ends, straight but frequently curved, widest in the middle of the lower cell, which prominently tapers towards the base, (48-)60(-75) x (4-)5(-6)  $\mu\text{m}$ .

*Cultural characteristics.* Temperature min. below 8 C; max. below 35 C; opt. 25 C. This is a eurythermal species, with medium sporulation on aerial mycelium. *Colony colour* (reverse) 13K amber brown (Rayner, 1970), 6D8 light brown (Kornerup & Wanscher, 1967). *Chlamydospores* extensive, forming microsclerotia throughout substratum.

*Microconidiophores.* *Stipe* septate, hyaline, terminating in a clavate to ellipsoid vesicle when present. *Conidiophore branches:* primary branches non-septate, (12-)15(-20) x (3-)4  $\mu\text{m}$ ; secondary branches non-septate, (9-)10(-12) x (2-)3(-4)  $\mu\text{m}$ . *Phialides* arising from the ends of branches, singly or in groups of 2-4, cylindrical, hyaline, non-septate, (9-)14(-17) x (3-)4  $\mu\text{m}$ , collarettes absent. *Conidia* cylindrical, hyaline, 1-septate with obtuse ends, (12-)27(-36) x (3-)4  $\mu\text{m}$ .

*Teleomorph.* *Perithecia* superficial on substrate, solitary or in groups of 2-3, globose to ovoid, 260-450 x 220-350  $\mu\text{m}$ , with warty outer wall and papillate ostiole, red, turning blood-red in 3% KOH; perithecial wall two-layered: outer region 35-60  $\mu\text{m}$  wide, of elongate to angular cells (darkly pigmented), becoming globose at the surface (lighter pigmented), inner layer up to 20  $\mu\text{m}$  wide, of hyaline, thin-walled, elongate cells; perithecial base 100-150  $\mu\text{m}$  wide,

Figs 24, 25. *Calonectria avesiculata* (ATCC 38226). Fig. 24. Avesiculate stipe (bar = 10  $\mu\text{m}$ ). Fig. 25. V. s. of a perithecium (bar = 20  $\mu\text{m}$ ). Figs 26, 27. *Cylindrocladium candelabrum*. Fig. 26. Obpyriform vesicle. Fig. 27. One-septate conidium (PPRI 4162). Figs 28, 29. *Cylindrocladium citri* (CBS 186.36). Fig. 28. Spathulate vesicle. Fig. 29. Obovoid to pyriform vesicle. Figs 30-32. *Cylindrocladium clavatum* (PPRI 3997). Fig. 30. Clavate vesicle. Fig. 31. Conidiophore. Fig. 32. Conidia (bar = 10  $\mu\text{m}$ ).



consisting of angular cells, blackened around the point of attachment. *Asci* hyaline, clavate, 90-120 x 10-20  $\mu\text{m}$ , tapering to a long thin stalk, containing eight ascospores. *Ascospores* hyaline, straight or falcate, 1(-3)-septate, not or slightly constricted at septa, guttulate when young, becoming granular at maturity, (34-)42(-60) x (4-)5(-6)  $\mu\text{m}$ .

**Type:** Brazil: Pará, near Belém, on *Didymopanax morototoni*, F. C. de Albuquerque, 1990, PREM 51039 (holotype of teleomorph); PREM 51041 (holotype of anamorph).

**Symptoms:** leaf spots (Crous *et al.*, 1993b).

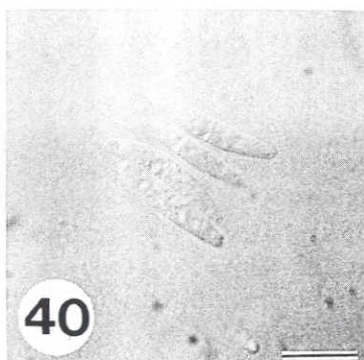
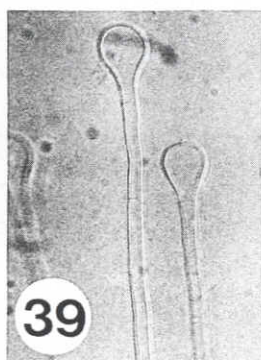
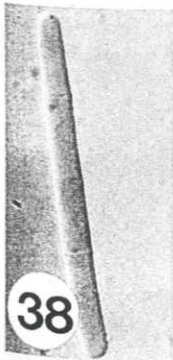
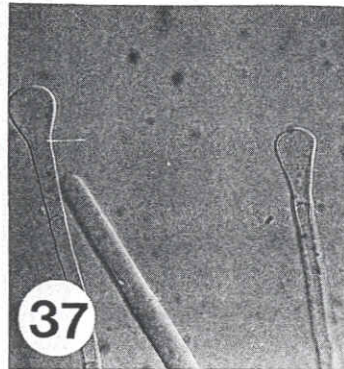
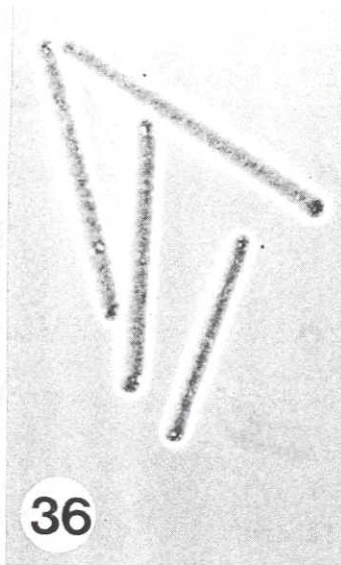
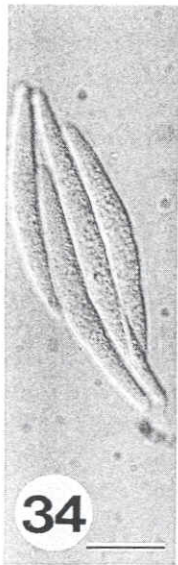
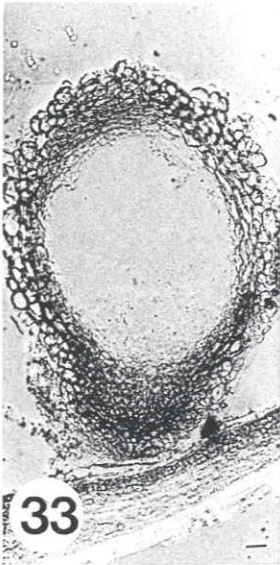
**Hosts:** *Didymopanax morototoni*, *Eucalyptus* spp., *Theobroma grandiflora* (Crous *et al.*, 1993b).

**Distribution:** Brazil (El-Gholl, *et al.*, 1986).

**Cultures:** Brazil: Pará, near Belém, on *Didymopanax morototoni*, F. C. de Albuquerque, 1990, (Beltsville, Maryland, AR 2675), PPRI 4174, CBS 339.92, IFO 32466, IMI 354513 (type culture); Pará, near Belém, on *Theobroma grandiflora* K. Schum., F. C. de Albuquerque, 1990, (Beltsville, Maryland, AR 2676), PPRI 4175, IMI 354514; ES, Aracruz nursery, on *Eucalyptus* cuttings, A.C. Alfenas, UFV 123, PPRI 4741; Teixeira de Freitas, large leaf spots on *Eucalyptus grandis* hybrid trees, Apr. 1993, P.W. Crous, CPC 593.

**Notes:** In a recent study *C. variabile* has been compared with morphologically similar species such as *C. citri*, *C. ilicicola*, *C. spathulatum* and *C. parasiticum* (Crous *et al.*, 1993b). *C. variabile* could easily be distinguished from the latter species by its esterase isozyme banding patterns and total DNA profiles, as well as vesicle and conidium morphology. The only species with a vesicle morphology similar to that of *C. variabile* is *C. parasiticum*. These two can, however, be distinguished by the range of variation found in the vesicle shape of *C. variabile*, which is not present in *C. parasiticum*, which has only sphaeropedunculate vesicles. All isolates thus far obtained of *C. variabile*

Figs 33-35. *Cylindrocladium colhounii* var. *macroconidialis* (PPRI 4000). Fig. 33. V. s. of a perithecium (bar = 20  $\mu\text{m}$ ). Fig. 34. Ascus with ascospores (bar = 10  $\mu\text{m}$ ). Fig. 35. Conidia. Fig. 36. Conidia of *Cylindrocladium colhounii* var. *colhounii* (PPRI 4183). Figs 37, 38. *Cylindrocladium parasiticum* (CBS 190.50). Fig. 37. Sphaeropedunculate vesicles. Fig. 38. Three-septate conidium. Figs 39, 40. *Calonectria kyotensis* (PPRI 4140). Fig. 39. Sphaeropedunculate vesicles. Fig. 40. Ascospores (bar = 10  $\mu\text{m}$ ).



consistently produced a microconidial state. Although the macroconidia are primarily 3-septate, they are distinct from others having similar dimensions in that they are frequently slightly curved. Furthermore, conidia of *Cylindrocladium* spp. are often observed to develop a basal swelling with age. In *C. variabile*, however, the swelling is not at the base of the conidium, but slightly higher, giving the base a subtruncate appearance (Fig. 60).

#### DOUBTFUL AND EXCLUDED SPECIES

*Cylindrocladium avesciculatum* var. *microspora* Nair & Nair *Curr. Sci.* 52: 1025 (1983).

This species is not validly published (Nair & Nair, 1983), since no type specimen was designated. Despite concerted efforts, no material of this species could be obtained.

*Cylindrocladium couratarii* Ram & Ram *Broteria* Ser 3, 41: 90 (1972) (as *couratariae*).

In the original description (Ram & Ram, 1972), conidia are described as being cylindrical, 1-septate, 15-20 x 4-6  $\mu\text{m}$  in size. The illustration shows them to be slightly attenuated at both ends, having 1-2 median septa (3  $\mu\text{m}$  apart), with conidia being widest in the middle, unlike any *Cylindrocladium* sp. No stipes or vesicles are illustrated. A type culture (ATCC 24711) of *C. couratarii* has been examined, and it appears to be neither a *Cylindrocladium* nor a *Cylindrocladiella*, but rather a *Gliocephalotrichum* sp.

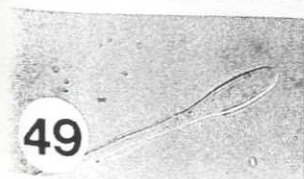
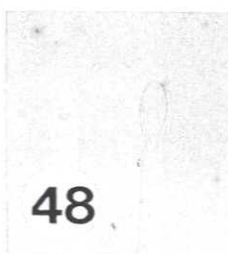
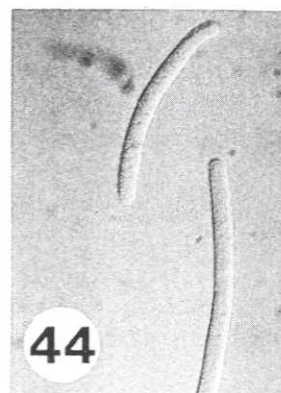
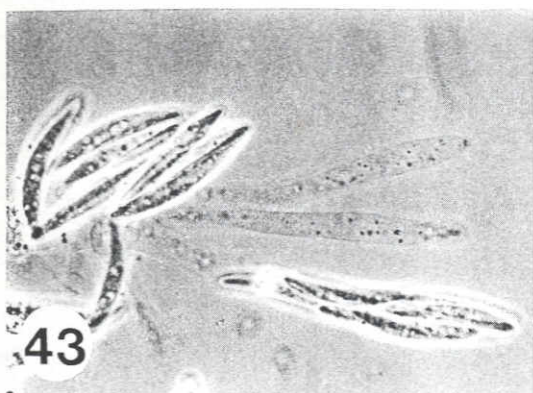
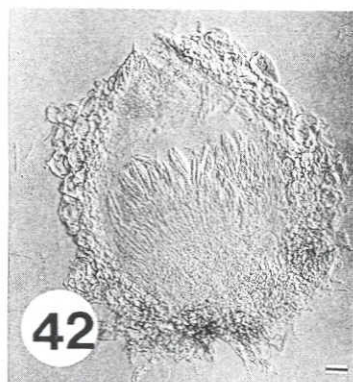
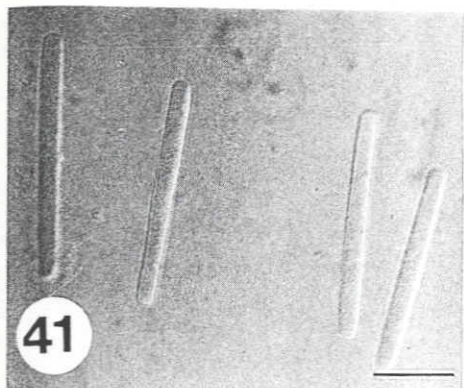
*Cylindrocladium gregarium* (Bres.) de Hoog *Persoonia* 10: 73 (1978).

*Diplocladium gregarium* Bres. *Annls mycol.* 1: 127 (1903).

Although the type specimen of this species has not been examined,

Figs 41-43. *Calonectria gracilis* (PREM 51031) (bar = 10  $\mu\text{m}$ ). Fig. 41. Conidia. Fig. 42. V. s. of a perithecium (bar = 20  $\mu\text{m}$ ). Fig. 43. Asci and ascospores. Fig. 44. Curved conidia of *Cylindrocladium hawksworthii* (MUCL 30866). Figs 45-48. *Cylindrocladium ilicicola* (PPRI 4151). Fig. 45. Three-septate macroconidium. Fig. 46. Microconidium. Fig. 47. Clavate vesicle. Fig. 48. Spathulate vesicle. Fig. 49. Ellipsoidal vesicle of *Cylindrocladium reteaudii* (IMI 39232). Fig. 50. Macroconidium and curved microconidia of *Cylindrocladium pteridis* (IMI 174348) (bar = 10  $\mu\text{m}$ ).





de Hoog's illustrations (de Hoog, 1978) show the conidia attenuated at their base, which is atypical of *Cylindrocladium* or *Cylindrocladiella*. The branching pattern also closely resembles that of *Leptographium* Lager. & Melin and *Phialocephala* Kendrick. It is thus doubtful that this collection is representative of either a *Cylindrocladium* or a *Cylindrocladiella* sp. The illustration shows a strong similarity with that of *Leptographium* spp.

***Cylindrocladium intermedium*** Matsushima *Microfungi of the Solomon Islands and Papua New Guinea*. p. 18 (1971).

In the original description of *C. intermedium*, Matsushima (1971) mentions that conidia are produced in yellow to hyaline conidial masses. This, together with the very uniformly cylindrical conidia, branch development, and the absence of a stipe suggests that *C. intermedium* would be better accommodated in the genus *Gliocladiopsis* Saksena (Saksena, 1954; Crous & Wingfield, 1993). It has thus far not been possible to obtain the type specimen of this species, which is lodged in Matsushima's own herbarium (MFC 2678).

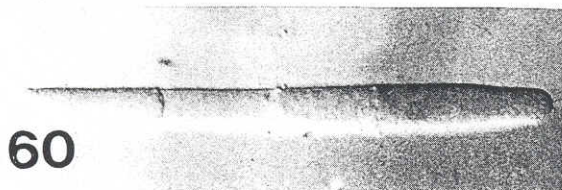
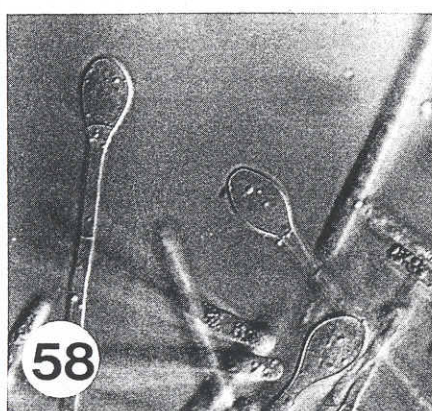
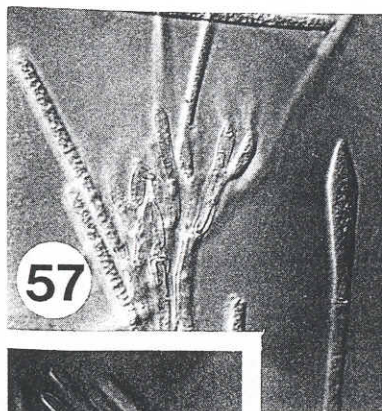
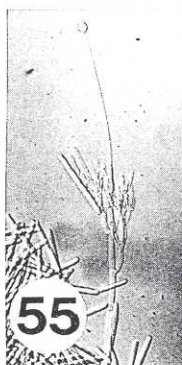
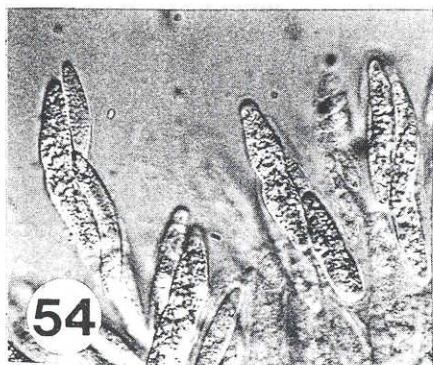
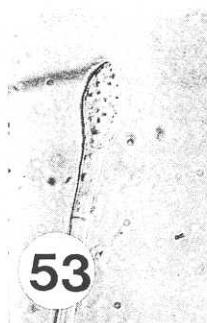
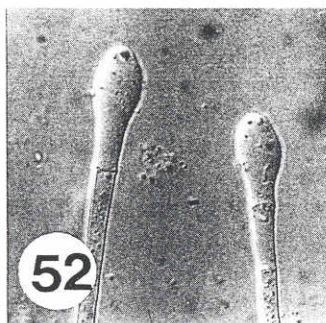
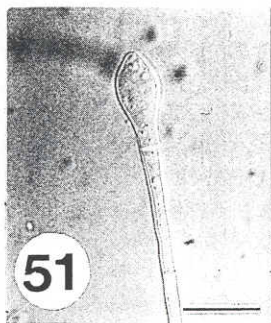
***Cylindrocladium terrestre*** Roy & Dwivedi *Proc. 56th Indian Sci. Congr.* 3: 308 (1969) (*Index of Fungi* 4(8): 242).

It has not been possible to locate the proceedings in which this species was described (Roy & Dwivedi, 1969). This species was, however, not validly published because it lacked a Latin diagnosis.

***Nectria leguminum*** Rehm *Hedwigia* 39: 221 (1900).

*N. leguminum* was treated by Rossman (1983) as a synonym of *Calonectria pyrochroa*. An examination of the type specimen lodged at S showed a *Cylindrocladium* sp. with 5-septate conidia to be present. The *Cylindrocladium* anamorph of *Calonectria pyrochroa* never has this number of conidial septa, but rather has (1-)3-septate conidia. For this reason it is not possible to concur with Rossman's treatment of this

Figs 51-54. *Calonectria morganii* (PREM 51042) (bar = 10  $\mu$ m). Figs 51-53. Ellipsoidal to obovoid or pyriform vesicles. Fig. 54. Asci with ascospores. Figs 55, 56. *Cylindrocladium spathiphylli* (ATCC 44730). Fig. 55. Conidiophore. Fig. 56. Globose vesicle. Fig. 57. Conidiophore with conidia and naviculate vesicle of *Cylindrocladium naviculatum* (CPC 627). Fig. 58. Ovoid vesicles of *Cylindrocladium ovatum* (UFV 89). Figs 59, 60. *Cylindrocladium variabile* (PPRI 4147). Fig. 59. Microconidiophore. Fig. 60. Three-septate conidium.



species, and we are of opinion that it represents an undescribed *Cylindrocladium* anamorph. Because the conidia on the type specimen of *N. leguminum* are 5-septate, this collection might be confused with *Calonectria quinqueseptata*. However, there are two reasons why this collection cannot be identified as *C. quinqueseptata*. Firstly, the ascospores are 1-septate, and much smaller (31-50 x 4-6) than the larger, 3-septate ascospores characteristic of *C. quinqueseptata*. Secondly, conidia were (1-)3(-6)-septate, 45-61 x 5-6  $\mu\text{m}$  in size, much smaller than those of *Cylindrocladium quinqueseptatum*, which are (1-)5-septate. *N. leguminum* is, therefore, not regarded as conspecific with either *Calonectria pyrochroa* or *C. quinqueseptata*. It is however probable that this collection represents an as yet undescribed *Cylindrocladium* and *Calonectria* sp. Further collections are required to sufficiently describe this holomorph as new.

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