Trans. Br. mycol. Soc. **87** (1), 45–76 (1986) *Printed in Great Britain*

A REVISION OF *ACHAETOMIUM*, *ACHAETOMIELLA* AND *SUBRAMANIULA*, AND SOME SIMILAR SPECIES OF *CHAETOMIUM*

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The species included in *Achaetomium*, *Achaetomiella* and *Subramaniula* are studied, particularly with regard to their relationships with *Chaetomium*. Where available, living cultures have been examined, but inevitably much of the study has had to be based on dried material; this means that a number of the conclusions as to taxonomic relationships which are advanced are only tentative. Various specialized techniques have been employed during the research, including SEM examination, and measurement of growth rates under carefully controlled conditions.

Achaetomium is restricted to three species, all having dark brown ascospores and apparently lacking periphyses; *Achaetomiella* is subsumed into *Chaetomium* in agreement with earlier authors; and the genus *Subramaniula* is expanded to include the new species *S. irregularis* P. Cannon & D. Hawksw. Three new combinations are proposed, *Chaetomium luteum* (Rai & Tewari) P. Cannon, *C. strumarium* (Rai *et al.*) P. Cannon and *C. virescens* var. *thielavioideum* (Chen) P. Cannon.

Comparisons are made with taxa from related genera, and particularly with the species of *Chaetomium* which have reduced or inconspicuous ascomatal hairs. A key to those species in addition to the accepted ones of *Achaetomium* and *Subramaniula*, along with a number of other taxa with which they might be confused, is included.

The genus *Achaetomium* was described by Rai *et al.* (1964) for fungi which were similar to *Chaetomium* Kunze but which were 'devoid of hairy ornamentation'. Three species were originally included, *A. globosum* Rai *et al.*, *A. luteum* Rai & Tewari and *A. strumarium* Rai *et al.*, with the first-mentioned designated as type. Although none of the species described by these authors have well-developed hairs typical of the genus *Chaetomium*, they all in fact have strongly tomentose ascomata. Most subsequent workers assumed from the descriptions provided by these authors that the three species were glabrous, and the resulting confusion meant that various species were inappropriately placed in *Achaetomium*. Most recent authors have been content to add species to the genus without critically reviewing those already there, and apart from the paper by von Arx (1985), there has been little thought as to the interrelationships of the constituent species.

Although Rai *et al.* (1964) noted similarities between their genus and *Chaetomium*, they could make no decision as to the familial placement of *Achaetomium*. This was largely the result of the grossly artificial concepts of ascomycete families of the day, many of them being based on single, supposedly overwhelmingly important characters rather than on a consensus of all available information about their constituent members. They were unwilling to include their genus in the Chaetomiaceae as that family was principally characterized by the presence of prominent ascomatal hairs. The difficulty of familial placement was elaborated on by Mukerji (1968), who advocated a separate family name (invalidly published) and order for the genus. His paper contained no significant advance in understanding of the genus and its relationships, and served only to underline the inadequacy of the then current concepts of ascomycete taxonomy. The separation of *Achaetomium* from *Chaetomium* at familial but not ordinal level was advocated by Rai *et al.* (1970) (who added a fourth species to the genus, *A. macrosporum*), and also in a paper by Mukerji & Saxena (1974). The family name Achaetomiaceae was finally validated by Mukerji (1978).

A number of species were described from India in the 1970s. Six were added in a series of papers by Rai & Chowdhery (1971, 1974*a*, *b*, 1978), a contribution was made by Kulshreshtha *et al.* (1977), and von Arx *et al.* (1978) described a species from Delhi Zoo (later transferred to the genus *Subramaniula*). Chowdhery & Rai (1980) described a further two taxa from mangrove swamps in eastern India. The first non-Indian taxon to be described was by Locquin-Linard (1980), based on

an isolation from arid soil in Egypt. Further species were also described, one from Japan by Udagawa (1982) and two from Nepal by Udagawa & Sugiyama (1982). The species placed in this genus are now known from a wide range of countries in Africa, Asia and Australasia.

There has been little revisionary work on this genus. Chowdhery (1980) produced a useful summary of the species known to him, but his work was a compilation, with no criticism of previous work or suggestions as to interrelationships of the species. The most recent work on the genus, by von Arx (1985), is primarily concerned with reviewing its generic limits, and a number of species names were transferred to other genera. Von Arx was apparently the first to realize that *Achaetomium* could not be distinguished from *Chaetomium* on the basis of the presence or absence of ascomatal hairs, but instead emphasized characters such as the colour of the ascospores, the composition of the fruit-body walls, and growth rates in culture.

The present study is an expansion of von Arx's work, with descriptions of a number of cultures and dried specimens not seen by him, and employing different techniques of observation. Many of von Arx's conclusions are confirmed, but the generic limits of *Achaetomium* are further tightened here. The genus can most easily be distinguished from *Chaetomium* by the colour of the ascospores, which are dark chocolate brown in *Achaetomium* and pale to mid brown or olivaceous in *Chaetomium*. In many species the colour does not develop fully until the ascospores are released from the fruit body, so care must be taken not to base observation of this character on immature specimens. The species of *Achaetomium* also appear to lack periphyses, whereas at least most species of *Chaetomium* possess them, and *Achaetomium* ascomata are thick-walled, and composed at least partially of loosely knit textura intricata, while in *Chaetomium* they are relatively thin-walled, and composed of well-ordered textura intricata or angularis.

Bearing in mind the difficulty in drawing a dividing line between *Achaetomium* and *Chaetomium*, the genera are most probably closely related. However, *Chaetomium* is poorly understood at present, and a firm decision on the relationships between the two taxa cannot be made. Carter (1984) went so far as to unite the two genera; I am unwilling to accept this because of the major morphological differences between the types of the two genera. With further work on the interrelationships of the species groups within *Chaetomium* (Dreyfuss, 1975; von Arx *et al.*, in press), a clearer picture of the two genera may emerge. There have been some suggestions (Hawksworth, pers. comm.) that *Achaetomium* might have been derived from ancestors of the Sordariaceae rather than the Chaetomiaceae, principally due to the colour of the ascospores in *Achaetomium*, which is reminiscent of the former family and unparalleled in the latter. A small-scale study of secondary metabolites was undertaken to try to obtain further evidence for this link, but it has so far proved inconclusive, largely due to the rudimentary knowledge of the chemistry of the groups concerned.

The genus *Achaetomiella* was erected by von Arx (1970) for a fungus which was to a certain extent intermediate between *Achaetomium* (as then understood) and *Chaetomium*. While the newly described species *A. virescens* v. Arx had distinct ascomatal hairs, they were simple in form, and evenly distributed over the fruit body, in contrast to *Chaetomium*, in which (for most species) the hairs on the upper part of the ascoma surrounding the ostiole are relatively complex in structure. Von Arx (1973) then transferred *Achaetomium macrosporum* Rai *et al.* to *Achaetomiella*.

A further species, *A. fusispora*, was added to the genus by Calviello (1974), and the species *Chaetomium megasporum* Sörgel ex Seth, described two years previously, was transferred to *Achaetomiella* by Hawksworth (1975) as an older name for Calviello's species.

Udagawa (1980) noted strong similarities between *Achaetomiella virescens* and *Chaetomium thielavioideum* Chen (1973), not only in morphological characteristics but also in colony characters and chemistry. As he found no convincing reason for the continued maintenance of *Achaetomiella* as separate from *Chaetomium*, he transferred *A. virescens* to *Chaetomium* and reduced *C. thielavioideum* to synonymy (the two taxa are recognized at varietal level in the present paper). The author of *Achaetomiella* now agrees with its reduction as a synonym of *Chaetomium* (von Arx *et al.*, in press).

The genus *Subramaniula* was described by von Arx (1985) to mark the 60th birthday of Professor C. V. Subramanian, and it contained the single species *Achaetomium thielavioides*, published by von Arx, Mukerji & Singh (1978). This fungus was recognized as atypical of *Achaetomium* when originally described, due to features of its ascomata, which are composed of thin-walled textura globulosa with a wide ostiole surrounded by a collar of hyaline cells. The genus is accepted in the present work, and a new species, *S. irregularis*, is added to it based on a collection from South Africa. The affinities of this genus are not clear; von Arx *et al.* (1978) and von Arx (1985) inferred a connexion with *Thielavia* Zopf, but the type of that genus differs in a number of ways from *Subramaniula*

thielavioides apart from the lack of an ostiole. The genus might be related to *Boothiella* Lodhi & Mirza, but the only species of that genus (*B. tetraspora*) has ascospores with rather different germ pores. Until more information can be gathered, it seems sensible to retain *Subramaniula* as an outlying member of the Chaetomiaceae.

MATERIALS AND METHODS

Where possible, living cultures were examined during this study. Living material is particularly important in investigations on this group of fungi, as the ascomata are delicate and are usually seriously damaged after a while in herbaria unless they are properly protected against physical damage. Features such as ascoma shape and morphology of terminal hairs are almost always impossible to determine accurately from dried material. In addition, the morphology and colouration of various parts of the fruit body, in particular the ascomatal hairs, change markedly with maturity, as does ascospore colour, and it is usually impossible to determine the state of maturity accurately in dried specimens.

Material for scanning was either air-dried or critical-point dried, coated with gold or platinum in a Polaron sputter coater and examined with an ISI-60 SEM.

For growth rate tests, cultures were inoculated using a *ca* 2 mm diam plug of agar containing mycelium and ascomata on to three different media, cornmeal agar (CMA), malt extract agar (MA) and potato-carrot agar (PCA). Details of the composition of the last two media are found in Johnston & Booth (1983); CMA was produced by dissolving 17 g of Oxoid powdered cornmeal and 20 g agar in 1 l of water. The cultures were incubated in the dark at 25 °C; measurement of growth occurred daily from the third to the fourteenth day after inoculation, or until the mycelium completely covered the agar surface.

The codes used in the text for the descriptions of colour derive from Kornerup & Wanscher (1967). In a number of cases the pigments produced were too localized to allow accurate comparison with the colour chart; in these instances the colours cited are used in their rough senses and not in the accurately defined senses used in the colour chart.

ANNOTATED KEY TO ACCEPTED SPECIES OF *ACHAETOMIUM* AND *SUBRAMANIULA*, AND TO THOSE SPECIES OF *CHAETOMIUM* WITH SHORT, INCONSPICUOUS OR NO ASCOMATAL HAIRS

Fungi from these genera are usually very delicate, and in many cases it is difficult to estimate the maturity of an ascoma without examining its development over a period. In particular, the morphology of the ascomatal hairs varies considerably with maturity; they generally become darker, more complex in form and more ornamented with age, and in the case of over-mature ascomata they frequently fragment, making observation very difficult. In addition, the pigmentation of the ascospores in these genera is not easy to assess without examining them over a period; in many species the colour does not develop fully until some time after they have been released from the asci. It is therefore important to examine the fungus over a period (which usually entails growing it in culture) before this key can be used with confidence.

The ascospore shape is particularly important for identification of many *Chaetomium* species. In many taxa the ascospores are not radially symmetrical, and it is crucial to observe them in all planes rather than simply taking the outline of a few spores as representative when using this key.

A few species from other genera have been included in the key, either where they are likely to be confused with members of the genera cited above, or where they have been mentioned in the text in contrast with the species described.

1. Ascospores with one germ pore 2
1. Ascospores with two germ pores 45
2. Asci cylindrical 3
2. Asci clavate 14
3. Ascospores roughly globose to ellipsoidal, without apiculae 4
3. Ascospores fusiform, limoniform or irregularly shaped, with at least one apicula 7
4. Ascospores more than 10 μm in length 5
4. Ascospores less than 10 μm in length 12
5. Ascomata composed of textura intricata, covered with dense to tomentose, thin, coloured hairs; usually ostiolate (ostiole sometimes inconspicuous); asci 8-spored (but see 6b). 6
5. Ascomata hyaline, $\pm$glabrous, composed of thin-walled textura angularis, non-ostiolate; asci 4-spored; ascospores 14–22 × 12–16 μm, with one apical, rather protuberant germ pore
Boothiella tetraspora Lodhi & Mirza (1962); see also von Arx & Tariq Mahmood (1968), von Arx (1975).

6. Ascomata pale yellow-tomentose; asci 8-spored; ascospores 12–15·5 × 10–13·5 × 8·5–10 μm, ± globose but flattened on two opposite lateral faces, with a lateral germ pore . . . *Achaetomium globosum* (p. 50)

6. Ascomata grey; asci probably 8-spored; ascospores 20–28·1 × 12·9–19·4 μm, ellipsoidal, with a single germ pore (position on ascospore unknown)
Chaetomium giga-nigrosporum Millner & S. Ahmad, in Millner (1975); material not seen.

7. Ascospores fusiform to limoniform, with two apiculae 8

7. Ascospores ovoid or irregularly shaped, with one apicula 10

8. Ascomatal hairs poorly developed; producing bright yellow pigments in culture; ascospores 12–17·5 × 7–10 μm, widely fusiform, circular in transverse section . . . . . *Chaetomium sulphureum* (p. 67)

8. Ascomata tomentose, without bright yellow pigments in culture; ascospores slightly smaller, fusiform-limoniform or rhomboid 9

9. Ascomata pale yellow-tomentose, rarely aggregated; ascospores 8·5–10 × 6·5–7·5 × 5–6 μm, limoniform to widely fusiform, laterally flattened . . . . . *Chaetomium luteum* (p. 60)
Areolospora bosensis (Das) D. Hawksw. is superficially similar but has minutely verrucose ascospores without germ pores (Hawksworth, 1980).

9. Ascomata pink-tomentose, often aggregated; ascospores 10–13·5 × 6–7·5 μm, widely fusiform to rhomboid, sometimes slightly inaequilateral . . . . . *Chaetomium strumarium* (p. 65)

10. Ascospores ovoid, hardly apiculate 11

10. Ascospores strongly apiculate 13

11. Ascospores 15–20 × 10–15 μm, almond-shaped, dark brown; ascomatal hairs thin, pale grey, weakly helically coiled . . . . . *Chaetomium uniapiculatum* (p. 69)

11. Ascospores less than 10 μm long, almost circular in face view, pale to mid brown; ascomatal hairs well developed 12

12. Ascomatal hairs not branched, helically coiled; not thermophilic
Chaetomium brasiliense Batista & Pontual (1948); see also Ames (1963), Skolko & Groves (1953) and Udagawa (1960).

12. Ascomatal hairs frequently branched, irregular in form, with numerous inflated and constricted regions; thermophilic
Chaetomium thermophile La Touche (1950); see also Ames (1963), Skolko & Groves (1953).

13. Ascomata glabrous, with a collar of hyaline thin-walled cells surrounding the ostiole
Subramaniula irregularis (p. 56)

13. Ascomata covered in delicate pale grey helical hairs; without a collar of hyaline cells
Chaetomium senegalense L. Ames (1963).

14. Ascospores markedly irregular in shape 15

14. Ascospores ± regular in shape (though not necessarily radially symmetrical) 25

15. Most ascospores less than 10 μm in length 16

15. Most ascospores greater than 10 μm in length 19

16. Ascomata ostiolate, with a hyaline collar around the ostiole; ascospores very irregular in shape, but usually with one end strongly apiculate . . . . . *Subramaniula irregularis* (p. 56)

16. Ascomata ostiolate or not, without a hyaline collar 17

17. Ascomata non-ostiolate, brown, with short ± straight hyaline hairs; ascospores 6·5–8 × 5–5·5 μm
Chaetomidium minutum Cain (1961); see also Malloch & Cain (1973), as *Thielavia*.

17. Ascomata ostiolate or not, ± hyaline to pale brown, ± glabrous 18

18. Ascomata non-ostiolate; ascospores 5–8 × 4–5 μm, usually ± ovoid
Thielavia australiensis Tansey (1975); see also von Arx (1975).

18. Ascomata ostiolate or not; ascospores 8–11 (–16·5) × 5·5–7·5 (–9) μm, very irregular in shape
Chaetomium hamadae (p. 58)

19. Ascomata non-ostiolate. 20

19. Ascomata ostiolate 21

20. Ascospores 10–18 × 7–10 μm, at least some triangular in section
Chaetomium deltosporum Krug, Carter & Tiwari (ined.).

20. Ascospores variable in shape, but always with rounded apices; 8–11 (–16·5) × 5·5–7·5 (–9) μm
Chaetomium hamadae (p. 58)

21. Ascospores pale to mid brown, less than 17 μm long 22

21. Ascospores dark brown, 17–21 × 9–13 μm, rhomboidal to limoniform (hardly irregular)
Achaetomium sphaerocarpum (p. 54)

22. Ascomata glabrous or nearly so; ascospores mostly less than 11 μm long 23

22. Ascomata with at least some hairs; ascospores mostly more than 11 μm long 24

23. Ascospores irregular, usually roughly oblong or ellipsoidal, 8–11 (–16·5) × 5·5–7·5 (–9) μm
Chaetomium hamadae (p. 58)

23. Ascospores ± fusiform with a prominent lateral bulge, 10–11 × 4–5 × 5·5–7·5 μm
Chaetomium microascoides Guarro, in Guarro *et al.* (1985).

24. Ascomatal hairs arcuate, unbranched; ascospores 10–12·5 × 6–10 μm
Chaetomium varisporum Udagawa & Horie (1973).
24. Ascomatal hairs delicate, yellow-brown, long, sometimes branched; ascospores 11–15 × 7–10 μm . .
Chaetomium irregulare Sörgel ex W. Gams (1967).
25. Ascospores globose to ellipsoidal, without apiculae 26
25. Ascospores fusiform to limoniform, with two apiculae 28
26. Asci 2-spored; ascospores globose, 11·2–20·8 μm diam; ascomata leathery, non-ostiolate
Thielavia bispora Lodha (1974); material not seen.
26. Asci 8-spored; ascomata membranous, ostiolate or not 27
27. Ascomata non-ostiolate, glabrous; ascospores globose, 16–20 μm diam, dark brown
Thielavia pseudomaritima Davidson (1976); see also von Arx (1975). No material seen.
27. Ascomata ostiolate, covered in thin hairs; ascospores irregularly ovoid, 19–24 × 11–14 μm
Chaetomium britannicum L. Ames (1963). The type now contains only ascospores, fide von Arx *et al.* (in press).
28. Ascospores 10–11 × 4–5 × 5·5–7·5 μm, with a prominent lateral bulge
Chaetomium microascoides Guarro, in Guarro *et al.* (1985).
28. Ascospores circular or ± elliptical in transverse section 29
29. Ascospores ellipsoidal to fusiform. 30
29. Ascospores limoniform, apiculate to umbonate 36
30. Germ pore of ascospore apical 31
30. Germ pore subapical or lateral 35
31. Ascomatal hairs shorter than the height of the ascoma 32
31. Ascomatal hairs significantly longer than the height of the ascoma, often very delicate. 33
32. Ascomatal hairs spine-like, thick-walled; ascospores 14–16 × 5–6 μm
Chaetomium dreyfussii v. Arx (ined.). See von Arx *et al.* (in press).
32. Ascomatal hairs hypha-like, thin-walled, inconspicuous; ascospores 18–23 × 9–12 μm
Chaetomium deceptivum Malloch & Benny (1973); see also Guarro *et al.* (1980).
33. Ascomatal hairs very pale brown, almost smooth, mostly terminal and arcuate; ascospores 12–16 × 6·5–8 μm, regularly fusiform; ascomata pale green . . . . *Chaetomium anatolicum* Karaca & Turhan (1973).
33. Ascomatal hairs thin, wavy, rather irregular in form, distributed fairly evenly over the brown or olivaceous peridium 34
34. Ascomata less than 150 μm diam, ± globose; ascomatal hairs dark olivaceous grey in reflected light; ascospores 13–15 × 6·5–8 μm, regularly widely fusiform
Chaetomium hispanicum Guarro & v. Arx (ined.); see von Arx *et al.* (in press).
34. Ascomata more than 150 μm diam, ± ellipsoidal; often producing green pigments in culture; ascomatal hairs black in reflected light; ascospores 10·5–16·5 × 4·5–8 μm, rhomboidal-fusiform to cylindric-fusiform, rather variable in shape . . . . . *Chaetomium virescens* (p. 70)
35. Germ pore only slightly subapical; ascomatal hairs dark olive brown, often arcuate; ascospores 10–13 × 5–7 μm
Chaetomium gracile Udagawa (1960).
35. Germ pore distinctly subapical, ascomatal hairs pale brown, flexuous, rather long; ascospores 12–16 × 6–8 μm
Chaetomium jodhpurense Lodha (1964).
36. Ascospores strongly apiculate to umbonate 37
36. Ascospores weakly apiculate 40
37. Ascospores more than 15 μm long, dark brown 38
37. Ascospores less than 15 μm long, mid brown 39
38. Ascospores limoniform, flattened laterally, strongly apiculate; ascomata greenish yellow
Achaetomium macrosporum (p. 53)
38. Ascospores irregularly rhomboidal, sometimes very widely umbonate; ascomata beige
Achaetomium sphaerocarpum (p. 54)
39. Asci 4-spored; ascospores 10·5–14 μm long
Chaetomium tetrasporum S. Hughes (1946); see also Ames (1963), Skolko & Groves (1953).
39. Asci 8-spored; ascospores 8·5–10 μm long . . . . . *Chaetomium umbonatum* Brewer (1974).
40. At least most ascospores more than 10 μm long. 41
40. Most ascospores less than 10 μm long 43
41. Ascomata glabrous, pale, with a hyaline collar around the ostiole; ascospores 22–26 × 11·5–14·5 μm, with a subapical germ pore . . . . . *Subramaniula thielavioides* (p. 57)
41. Ascomata hairy, peridium mid to dark brown, without a hyaline collar; ascospores less than 20 μm long, with an apical germ pore 42
42. Peridium dark brown at the base; ascospores 11–15·5 × 7–8·5 μm, limoniform
Chaetomium bangkokanum Gopal & Lodha (1982).
42. Peridium mid brown, concolorous; ascospores 10·5–16·5 × 4·5–8 μm, variable in shape; some flattened limoniform, others cylindric-fusiform . . . . . *Chaetomium virescens* (p. 70)
43. Ascomata pyriform, with a distinct neck; ascomatal hairs almost hyaline, closely septate 44
43. Ascomata globose to ellipsoidal, without a neck; ascomatal hairs various 45

44. Ascospores 7–9 × 6–7 μm; at least some ascomatal hairs longer than the height of the ascoma
Chaetomium sphaerale Chivers (1912); see also Ames (1963), Skolko & Groves (1953).
44. Ascospores 5·5–7 × 4–6 μm; ascomatal hairs all shorter than or equal to the height of the ascoma
Chaetomium homopilatum Omvik (1955); see also Ames (1963).
45. Ascomata with spine-like hairs; ascospores 3–5·5 μm wide . . *Chaetomium paucipilum* Carter (ined.).
45. Ascomata with hypha-like hairs; ascospores more than 6 μm wide 46
46. Ascomata more than 250 μm tall; ascomatal hairs long, hyaline or nearly so; ascospores very pale, pink en masse in reflected light
Chaetomium cruentum L. Ames (1963); an albino variant of *C. globosum* Kunze fide von Arx *et al.* (in press). *C. hyaloperidium* Carter (1983*b*) is almost identical but has bright yellow ascomatal hairs and pale brown ascospores.
46. Ascomata less than 200 μm tall; ascomatal hairs short, brown; ascospores brown
Chaetomium seminudum L. Ames (1949); = *Farrowia seminuda* (L. Ames) D.Hawksw. (1975*b*).
47. Most ascospores more than 15 μm long 48
47. Most ascospores less than 15 μm long 51
48. Germ pores subapical; ascospores 16–19 × 9–11 μm, widely limoniform to fusiform; growth rate very slow
Chaetomium retardatum Carter & Khan (1982).
48. Germ pores apical; growth rate fairly rapid 49
49. Ascospores dark brown, irregularly limoniform-ellipsoidal, 15–22 × 11–15 μm
Chaetomium nozdrenkoae Sergejeva (1961).
49. Ascospores pale brown, fusiform 50
50. Ascomata producing bright pinkish-purple pigments in culture; ascospores 15·5–21 × 9–11·5 μm
Chaetomium purpurascens (p. 64)
50. Ascomata not producing pigments; most ascospores more than 20 μm long, less than 10 μm wide, usually with inconspicuous germ pores. . . . . *Chaetomium megasporum* (p. 62)
51. Ascospores 12–15 × 10–13 μm, ± globose . *Chaetomium megalocarpum* Bainier (1910); see also Ames (1963).
51. Ascospores not of this shape, less than 10 μm wide 52
52. Ascospores very irregular in shape, 10–12·5 × 6–10 μm, with 1–2 germ pores; ascomata with pale brown closely septate arcuate hairs . . . . . *Chaetomium variosporum* Udagawa & Horie (1973).
52. Ascospores regular, or not very irregular, in shape; ascomata with dark hairs 53
53. Ascospores 8–12 × 4–7 μm, 2-pored, widely fusiform to limoniform, often curved; ascomatal hairs fairly robust; ascomata often with reddish exudates
Chaetomium aureum Chivers (1912); see also Ames (1963); Skolko & Groves (1953); Udagawa (1960).
53. Ascospores 10·5–16 × 4·5–8 μm, 1- to 2-pored, flattened limoniform to cylindric-fusiform; ascomatal hairs hypha-like; ascomata usually with green exudates. . . . . *Chaetomium virescens* (p. 70)

ACHAETOMIUM

Achaetomium J. N. Rai, J. P. Tewari & K. G. Mukerji, *Can. J. Bot.* **42**: 693 (1964).

Ascomata globose to pyriform, usually ostiolate, peridium rather thick, ill-defined, consisting at least principally of loosely knit textura intricata, covered in tomentose hyphae but without distinct (seta-like) hairs. *Periphyses* absent. *Asci* cylindrical to clavate, very thin-walled, without apical structures, evanescent, 8-spored. *Ascospores* dark chocolate brown, 1-celled, smooth, fairly thick-walled, with a single germ pore.

Type species: *A. globosum* Rai, Tewari & Mukerji

KEY TO SPECIES OF *ACHAETOMIUM*

1. Ascospores 12–15·5 μm long, globose to ellipsoidal with a lateral germ pore . . . . *A. globosum* (p. 50)
1. Ascospores over 16 μm long, bi-apiculate with a terminal germ pore 2
2. Ascospores limoniform, flattened on two opposite lateral faces; ascomata greenish-yellow
A. macrosporum (p. 53)
2. Ascospores irregularly rhomboid (to limoniform), sometimes widely umbonate; ascomata beige
A. sphaerocarpum (p. 54)

ACHAETOMIUM GLOBOSUM J. N. Rai, J. P. Tewari & K. G. Mukerji, *Can. J. Bot.* **42**: 693 (1964). (Fig. 1)

Thielaviella octospora Natarajan, *Proc. Ind. natn Sci. Acad.* B, **37**: 128 (*1971*) (1972) (as '*octosporus*').

Thielavia octospora (Natarajan) v. Arx, *Stud. mycol.* **8**: 6 (1975).

Thielavia octospora (Natarajan) Lodha, in C. V. Subramanian (ed.), *Taxonomy of Fungi* **1**: 248 (1978); comb. superfl.

Chaetomium spinigerum Sörgel ex Seth, *Beih. Nova Hedwigia* **37**: 102 (1972).

Achaetomium marinum H. J. Chowdhery & J. N. Rai, *Nova Hedwigia* **32**: 225 (1980).

Cultures. On CMA at 25° colonies > 85 mm diam after 7 d (60–75 mm after 5 d). Submerged mycelium inconspicuous, hyaline. Aerial mycelium almost absent. Ascomata variable in number, scattered to aggregated, developing after 2–3 weeks. On MA at 25° colonies > 85 mm diam after 7 d (65–80 mm after 5 d). Submerged mycelium obscured. Aerial mycelium very well developed, cream to yellowish grey (3A2–3B3). Ascomata variably developed, scattered to aggregated, developing after about 2 weeks. On PCA at 25° colonies > 85 mm diam after 7 d (50–70 mm after 5 d). Submerged mycelium inconspicuous, hyaline. Aerial mycelium poorly developed, hyaline to pale orange, lanose. Reddish exudates sometimes present. Ascomata variably developed, scattered to aggregated, developing after about two weeks.

Mycelium. Hyphae 1·5–5 μm diam, hyaline to pale brown, sometimes pustulate, frequently branched and nodular.

Anamorph. Not observed.

Teleomorph. *Ascomata* 150–260 μm diam, roughly globose, tending to aggregate in clusters, covered in conspicuous long thin sulphur-yellow hyphae. Neck absent, ostiole rather small and inconspicuous, not infrequently absent. Ascomatal hairs 2–4 μm diam, rather thick-walled, somewhat pustulate, sometimes branched. *Peridium* composed of loosely woven pale brown textura intricata several layers thick; hyphae 1·5–3 μm diam. *Periphyses* not seen. *Asci* 60–75 × 9–14·5 μm, ± cylindrical, short-stalked, very thin-walled, without apical structures, evanescent, 8-spored. *Ascospores* usually arranged uniseriately but with occasional irregularities, 12–14·5 (–15·5) × 10–13 (–13·5) × 8·5–10 μm, nearly globose but with two opposite faces slightly flattened, dark chocolate-brown when mature, aseptate, smooth, relatively thick-walled, with a single conspicuous lateral germ pore *ca* 1·5 μm diam usually towards one edge of a flattened face.

Typification. India: Lucknow, isol. ex soil soc. *Tamarindus indica* roots, Feb. 1960, J. N. Rai (IMI 82626 – holotype, ?BPI – isotype of *Achaetomium globosum*).

India: Madras University Botanical Garden, isol. ex rhizosphere of *Brassica juncea*, 15 Jun. 1968, K. Natarajan (MUBL 2250 – holotype of *Thielaviella octospora*).

China: Kunming, isol. ex unknown source, undated, G. Sörgel (IMI 73515 – holotype of *Chaetomium spinigerum*).

India: West Bengal: Kagh Islands, isol. ex mud of mangrove swamp (pH 7·8), undated, collector unknown (?LWU – holotype of *Achaetomium marinum*).

Distribution. China, Cyprus, India, Pakistan; Nepal (fide Udagawa & Sugiyama, 1982); Thailand (fide Udagawa & Sugiyama, 1981).

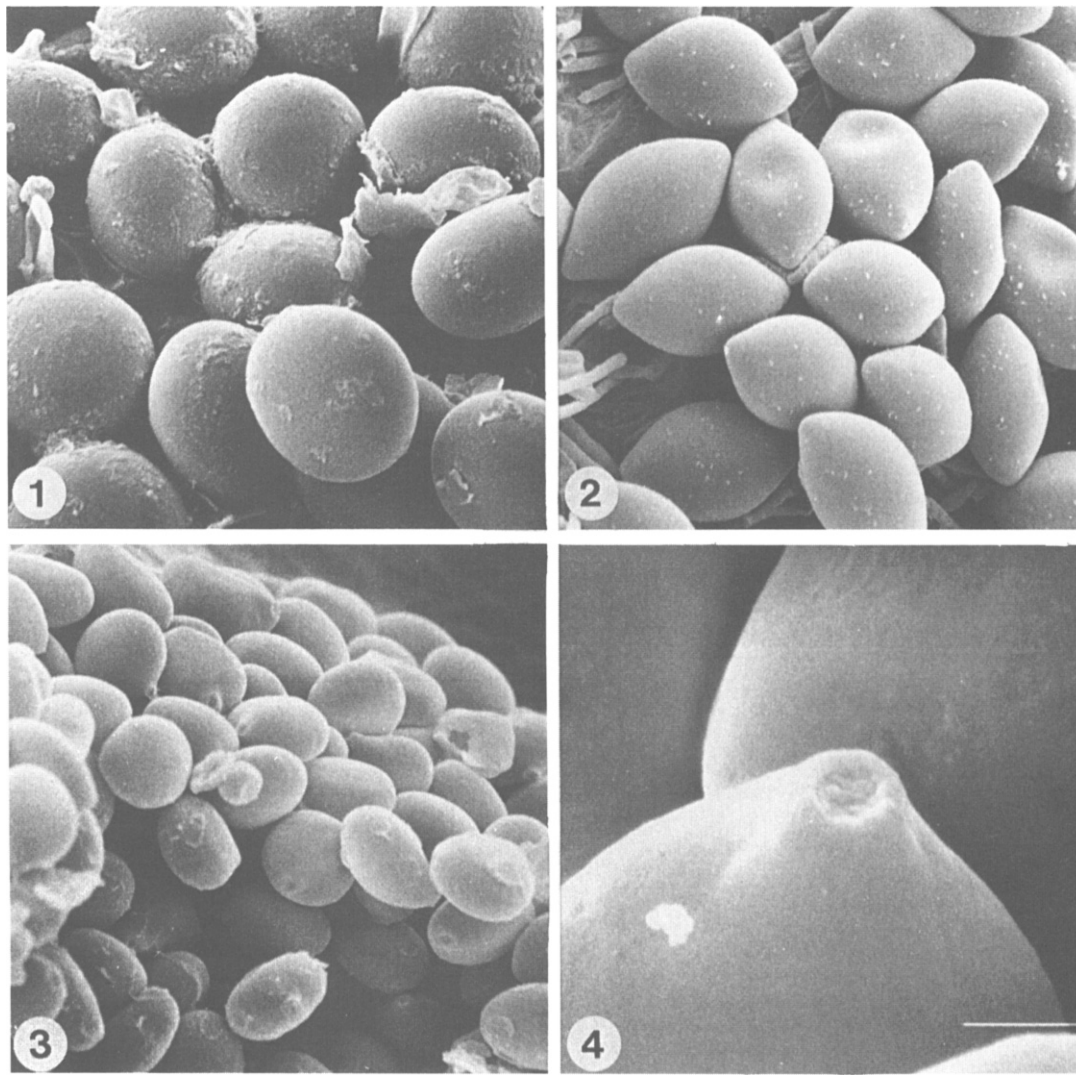
Illustrations. Chowdhery (1980: 477, 481), Chowdhery & Rai (1980: 227), Mukerji & Saxena (1974: 396), Natarajan (1972: 125, 127), Rai & Chowdhery (1974*a*: 31, 32), Rai *et al.* (1964: 695, 698), Seth (1972: fig. 110), Udagawa & Sugiyama (1981: 205).

Cultures examined. IMI 73515, from the holotype of *Chaetomium spinigerum*. IMI 169644, from the holotype of *Thielaviella octospora*. India: Allahabad, isol. ex *Mangifera indica*, comm. 28 Sep. 1972, M. P. Tandon 16 (IMI 169584); Jobner, isol. ex leaves of *Lasoda* sp., Nov. 1983, Rathore LL 18 (IMI 291366). Pakistan: unlocalized, isol. ex dead branch, undated, collector unknown (IMI 291729, = CBS 119.76).

The cultures of the type of *Achaetomium globosum* (IMI 82626) at IMI now produce only mycelium.

Specimens examined. IMI 82626, holotype of *Achaetomium globosum*. Cyprus: isol. ex *Prunus amygdalus*, comm. 20 Sep. 1969, J. Zyngas 873 (IMI 143106). India: Jodhpur, isol. ex *Arthrobotrys odoratissimus*, comm. 29 Oct. 1964, K. S. Bilgrami S 22 (IMI 109821); Agra, isol. ex unknown source, 15 Jul. 1965, M. N. Gupta S 608 (IMI 114515); Jaipur, isol. ex soil, comm. 5 Nov. 1965, R. L. Mathur D 59 (IMI 115916); Simla: Mashobra, isol. ex anthracnose of *Malus pumila*, comm. 1 Aug. 1967, R. K. Agarwala A 1–6 (IMI 128599); Jaipur, isol. ex *Vitis vinifera* leaf, comm. 3 Nov. 1969, V. N. Pathak 28VLI (IMI 142863); Jodhpur, isol. ex *Tecoma* sp., comm. 12 Nov. 1970, K. S. Panwar JU/BOT/D40 (IMI 152554); Varanasi, isol. ex soil, 15 Apr. 1972, L. S. Srivastava 4 (IMI 170104); Ludhiana, isol. ex soil of *Arachis hypogaea*, 28 Oct. 1972, J. S. Chohan 39 (IMI 170979); Jodhpur, isol. ex root surface of *Daucus* sp., comm. 26 Apr. 1973, Karan Singh Panwar JU/BOT/304 (IMI 174765); Bihar, isol. ex ? fruit or vegetable, comm. 6 Jun. 1973, Ranu Gupta 4 (IMI 176135); unlocalized, isol. ex unknown source, 26 June 1973, V. R. Nath 1688 (IMI 176776); unlocalized, isol. ex soil, 9 Mar. 1976, M. L. Sonar 128 (IMI 202239); Punjab Agricultural University, isol. ex *Lycopersicon esculentum*, 11 Aug. 1978, H. S. Khara II (IMI 230739); Aligarh, isol. ex unknown source, comm. 15 Sep. 1979; N. K. Agrawal 12 (IMI 241775); Aligarh, isol. ex unknown source, comm. 15 Sept. 1979, N. K. Agrawal 21 (IMI 241784); Kurukshetra University, isol. ex rhizosphere of gram, 7 Apr. 1981, R. S. Mehrotra 28 (IMI 257612); Gwalior, isol. ex unknown source, comm. 15 Apr. 1982, S. Chauhan 5 (IMI 266992). Pakistan: Pakistan Council of Scientific and Industrial Research, isol. ex stored grains, comm. 3 Nov. 1969, S. R. H. Rizvi 4 (IMI 144227).

Achaetomium globosum, the type species of the genus, is easily distinguished from the other taxa by the shape of its ascospores, which are flattened-globose rather than bi-apiculate. There are a few taxa in other genera with which it could possibly be confused; *Thielavia pseudomaritima* D. E. Davidson (1976) has similarly shaped dark ascospores with a single germ pore, but they are much larger



Figs 1–4. Ascospores of *Achaetomium* and *Subramaniula* species.

Fig. 1. *Achaetomium globosum* (air-dried material of IMI 82626, holotype); × 1800.

Fig. 2. *Subramaniula thielavioides* (critical-point dried material of IMI 288625, derived from the holotype); × 1000.

Figs 3, 4. *Subramaniula irregularis* (air-dried material of IMI 164251, holotype). Fig. 3; × 1500. Fig. 4, detail of ascospores showing germ pore; × 14200 (bar = 1 μm).

(16–20 μm diam) and are contained in apparently glabrous translucent ascomata. The type could not be examined. *Thielavia bispora* Lodha (1974) also has similar ascospores (12–20 μm diam) but in 2-spored asci within dark leathery ascomata. Probably neither of these two species is correctly placed in *Thielavia*. *Chaetomium megalocarpum* Bainier again has somewhat similar ascospores, but they are much larger and have two germ pores.

Thielaviella octospora was doubtless originally regarded as generically separate from *A. globosum*

because of its lack of an ostiole. However, this feature appears to be unstable, and the type culture in IMI now exhibits them. The ostioles, when they do occur, are very inconspicuous. The author of the name *T. octospora* (Natarajan, pers. comm.) is now convinced that his fungus is identical to *A. globosum*. The type of the genus *Thielaviella*, *T. humicola* v. Arx & Mahmood (= *Boothiella tetraspora* Lodhi & Mirza), is quite different from *Achaetomium*; it has thin translucent glabrous ascomata containing ascospores with large protuberant germ pores, in 4-spored asci.

A number of features of the description of *Chaetomium spinigerum* Sörgel ex Seth conflict with the type material available, suggesting that the description was based on a very old culture. There is no doubt of the synonymy of the two names when cultures are compared. Seth mentions the presence of 'jumbo-ascospores' up to 17·5 × 11·5 μm in size; giant spores have been seen occasionally in the material available, but not quite this size. They may well originate from asci with fewer than 8 ascospores.

No material of *A. marinum* was available for comparison, but there seems little doubt as to its affinities. The only difference cited between the two taxa is that *A. marinum* has very large ascomata, but the fruit bodies commonly coalesce in this species, as in *Chaetomium strumarium* (see below), and the measurements given for *A. marinum* may well be of compound ascomata.

The cytology of *A. globosum* has been studied by Ranga Rao & Mukerji (1971*a*). They reported a haploid chromosome number of 7 for this species, and stated that the ascospores were binucleate, there being two mitotic divisions within the ascus rather than the single one as normal.

ACHAETOMIUM MACROSPORUM J. N. Rai, K. Wadhwani & J. P. Tewari, *Indian Phytopath.* **23**: 54 (1970).

Achaetomiella macrospora (Rai *et al.*) v. Arx, *Proc. Konink. Nederl. Akad. Wet. Amsterdam, ser. C*, **76**: 292 (1973).

Achaetomium fusisporum J. N. Rai & H. J. Chowdhery, *J. Indian bot. Soc.* **52**: 310 (*1973*) (1974) (as '*fusisporus*').

A. thermophilum M. Basu, *Current Sci.* **51**: 524 (1982); ?nom. inval., Art. 9.5.

Cultures. On CMA at 25° colonies 70–75 mm diam after 7 d. Submerged mycelium hyaline, inconspicuous. Aerial mycelium very sparse, hyaline, lanose. Ascomata developing after about two weeks, covered in yellowish-green hypha-like hairs, scattered over the plate. On MA at 25° colonies 75–80 mm diam after 7 d. Submerged mycelium obscured. Aerial mycelium copious, hyaline, floccose. Ascomata developing after about 2 weeks, scattered over the agar surface, greenish yellow (2B5), eventually turning dark brown (4D5). On PCA at 25° colonies 70–75 mm diam after 7 d. Submerged mycelium inconspicuous, hyaline. Aerial mycelium hyaline, sparse, lanose. Ascomata developing abundantly after about 2 weeks, greenish yellow to beige (2C5), scattered over the agar surface, eventually turning dark brown.

Mycelium. Hyphae 1–6 μm diam, hyaline to mid brown, septate, frequently branched, sometimes nodulated, the older hyphae with a conspicuous brown gelatinous coating up to 2 μm thick, sometimes producing reddish soluble exudates.

Anamorph. None seen.

Teleomorph. *Ascomata* 140–290 × 110–210 μm, ellipsoidal to pyriform, sometimes with a short neck *ca* 50 μm diam and 30–50 μm in length; with an ostiole 30–50 μm diam. Ascomata composed of dark brown textura intricata with irregular hyphae to 3 μm diam, sometimes with an inner layer of dark brown textura epidermoidea with cells 3–8 μm diam. *Periphyses* not seen. *Asci* 55–80 × 12–19 μm, clavate, fairly long-stalked, very thin-walled, without apical structures, evanescent, 8-spored. *Ascospores* arranged biseriately, 16·5–21·5 × 10–13·5 × 9–11 μm, limoniform, flattened on two opposite lateral faces, sometimes curved along the longitudinal axis, the apices sometimes umbonate, dark chocolate brown, aseptate, rather thick-walled, with a single apical germ pore 0·5–0·75 μm diam.

Typification. India: Lucknow, isol. ex river bank soil (pH 8·5), September 1967, J. N. Rai (IMI 132137 – holotype of *Achaetomium macrosporum*).

India: Lucknow, isol. ex 'Usar' soils (pH 8·5), July 1971, collector not cited (?LWU – holotype of *A. fusisporum*).

India: Uttar Pradesh: Bhatni, isol. ex leaf litter, December 1977, collector not cited (?Allahabad University – holotype of *A. thermophilum*).

Distribution. India, Japan.

Illustrations. Basu (1982: 524), Chowdhery (1980: 481), Mukerji & Saxena (1974: 399), Rai & Chowdhery (1974*b*: 31, 32), Rai *et al.* (1970: 55).

Cultures examined. IMI 292262, from the holotype of *Achaetomium thermophilum*. Japan: Saitama, isol. ex compost, June 1982, S. Udagawa VA-F-1 (IMI 288464).

The cultures of the holotype of *Achaetomium macrosporum* at CMI (IMI 132137) now produce only sterile mycelium.

Specimens examined. IMI 132137, holotype of *Achaetomium macrosporum*. India: unlocalized, isol. ex soil, comm. 27 Aug. 1974, B. N. Johri T14 (IMI 188068); unlocalized, isol. ex soil, comm. 27 Aug. 1974, B. N. Johri

T 18 (IMI 188072); Jabalpur, isol. ex soil, comm. 30 Apr. 1977, D. P. Tewari A 106 (IMI 213348); Varanasi, isol. ex *Brassica nigra*, comm. 29 Feb. 1980, S. N. P. Chaurasia 5C3 (IMI 246274).

Achaetomium macrosporum is closely related to *A. globosum*, differing substantially only in ascospore size and shape, and in their arrangement within the ascus. *A. macrosporum* was described as having two germ pores per ascospore, but subsequent examinations by Chowdhery (1980) and myself establish that they have only one pore. There is frequently a small refractive area at the apex of the spore opposite from the germ pore, which no doubt led to the original error.

The type of *A. fusisporum* was not available for examination, but the taxon appears to differ from *A. macrosporum* only in the shape of the ascoma. The latter fungus was described as having considerably elongated ascomata, while *A. fusisporum* has more or less globose fruit bodies. Some of the IMI material has ascomata with short necks (no more than 50 μm long); the feature appears to be rather variable, and may be affected by environmental conditions. The two taxa are therefore regarded as synonymous.

Achaetomium thermophilum was described as similar to *A. macrosporum*, but was thermophilic in growth and had two rather than one germ pore in the ascospores. Examination of a type culture, however, shows that *A. thermophilum* has uniporate ascospores (the same misconception having occurred as when *A. macrosporum* was originally described), and it was found to grow and sporulate satisfactorily at 25°. There seems to be no reason to separate the two taxa. It is not clear from the original paper (Basu, 1982) whether *A. thermophilum* was validly published; the author stated that a culture was deposited at Allahabad University without making clear whether it was permanently preserved or maintained in a living state.

This fungus is most likely to be confused with *A. sphaerocarpum* (see below) but can be most easily distinguished by the shape of the ascospores, which are flattened limoniform in *A. macrosporum* but irregularly rhomboid (often flattened on one lateral face) in *A. sphaerocarpum*. It is thus obviously important to consider the three-dimensional shape of the ascospore rather than simply to observe its outlines under the light microscope.

There are a few species of *Chaetomium* with similarly shaped ascospores to *A. macrosporum*, but none is likely to be confused with it. *C. tetrasporum* S. J. Hughes (1946) has limoniform ascospores but they are smaller (10·5–14 μm long) and olivaceous brown, and are contained in four-spored asci within an ascoma with conspicuous coiled and branched terminal hairs. *C. flavum* Omvik (1955) is probably a synonym of *C. tetrasporum* (von Arx *et al.*, in press), and *C. umbonatum* Brewer (1974) also has limoniform ascospores with strongly apiculate ends but they are small (8·5–10 μm long) and chestnut rather than chocolate brown.

ACHAETOMIUM SPHAEROCARPUM J. N. Rai & H. J. Chowdhery, *Kavaka* 1: 29 (*1973*) (1974) (as '*sphaerocarpus*').

Chaetomium vitellinum A. Carter, *Mycologia* 75: 531 (1983).

Cultures. On CMA at 25° colonies > 85 mm diam after 7 d (55–60 mm after 5 d). Submerged mycelium inconspicuous, hyaline. Aerial mycelium sparse, pale beige, lanose. Ascomata developing after about 2 weeks, scattered abundantly over the agar. On MA at 25° colonies > 85 mm diam after 7 d (65–70 mm after 5 d). Submerged mycelium obscured. Aerial mycelium copious, hyaline to pale beige (4B2). Pinkish soluble exudates sometimes produced. Ascomata developing fairly sparsely, tending to aggregate, pale beige-tomentose. On PCA at 25° colonies > 85 mm diam after 7 d (60–65 mm after 5 d). Submerged mycelium hyaline, inconspicuous. Aerial mycelium fairly sparse, pale beige, lanose. Ascomata developing towards the edge of the plate, tending to clump together, tomentose, pale beige.

Mycelium. Hyphae 1–4 μm diam, hyaline to pale brown, often rather closely septate, frequently branching, sometimes nodular.

Anamorph. None seen.

Teleomorph. *Ascomata* 160–350 × 130–300 μm, globose to ellipsoidal. Neck absent, with an ostiole to *ca* 50 μm diam. Peridium 10–20 μm thick, composed of dark brown textura intricata with hyphae to 5 μm diam, sometimes nearly opaque. *Rhizoids* present, to 5 μm thick, reddish brown, septate, nodular, verrucose. *Peridial hairs* hyaline in transmitted light, 1·5–3 μm thick, branched, septate, somewhat irregular in form, very slightly roughened. *Periphyses* not seen. *Asci* 52–65 × (8–) 17–20 μm, clavate (rarely cylindric-clavate), relatively short-stalked, very thin-walled, without apical structures, evanescent, 8-spored. *Ascospores* arranged biseriately, 17–21 × 9–13 μm, somewhat irregular in shape, usually rhomboidal to slightly limoniform, the apices sometimes very widely umbonate, one lateral face sometimes flattened, dark chocolate brown, with a single apical germ pore *ca* 1 μm diam.

Typification. India: Lucknow, isol. ex 'Usar' soil (pH 9·0), September 1971, collector not cited (?LWU – holotype, IMI 189064 – isotype of *Achaetomium sphaerocarpum*).

Turkey: Anatolia: Kars: Sarikamis, isol. ex agricultural soil, s.d., I. Hasenekoglu (TRTC 48873 – holotype of *Chaetomium vitellinum*).

Distribution. India, Turkey.

Illustrations. Carter (1983: 532), Chowdhery (1980: 481), Rai & Chowdhery (1974*a*: 30, 32).

Cultures examined. IMI 283627 (= TRTC 48873), from the holotype of *Chaetomium vitellinum*.

India: Jabalpur: University campus, isol. ex *Bambusa* leaf litter, Dec. 1983–Mar. 1984, Nisha Singh NS/13 (IMI 287070).

Specimen examined: IMI 189064, isotype of *Achaetomium sphaerocarpum*.

This species is similar to *A. macrosporum*, but differs in ascospore shape (rhomboidal to limoniform rather than flattened-limoniform) and in the colour of the ascomata (beige as opposed to yellowish green).

The isotype of *A. sphaerocarpum* present in IMI is rather inadequate, containing only free ascospores and fragments of ascoma wall. Nevertheless, it seems identical to *Chaetomium vitellinum*, judging from the specimen and from the rather rudimentary description. No mention was made of the irregularity of the ascospore shape in the original publication. Carter's publication (1983) of *C. vitellinum* compared the new taxon with a number of *Chaetomium* species which had been described as having irregular spores, so it is likely that *A. sphaerocarpum* was not considered during his attempts to identify his fungus. The original publication of *A. sphaerocarpum* depicts a cylindrical ascus, but the shape of this organ appears to vary somewhat in the species, with a number of intermediates between the cylindrical and the clavate condition being observed; in these most of the ascospores were uniseriate, with only one or two being out of alignment. As the asci are evanescent in this group of fungi, the adaptive significance of the ascus shape is not very great.

Chaetomium nozdrenkoae Sergejeva (1961) (syn. *C. difforme* W. Gams) has similar ascospores to *A. sphaerocarpum*, but they are paler chestnut brown in colour and have two germ pores per spore. The other species of *Chaetomium* with irregular ascospores considered by Carter (1983) all have differently sized spores. *Chaetomium giga-nigrosporum* Millner & S. Ahmad (in Millner, 1975) sounds rather similar to *A. sphaerocarpum* but has larger ascospores (20–24 (–28) × 12·8–19·4 μm); material of this taxon has not been examined.

Dr A. B. Chandra (University of Madras, pers. comm.) reports this species as commonly isolated from soil of mine sites high in copper salts in southern India. I have not been able to examine material to confirm her identification.

ACHAETOMIUM RAII Locquin-Linard nom.nov., *Cryptogam. Mycol.* **1**: 239 (1980).

A. indicum J. N. Rai & H. J. Chowdhery, *Curr. Sci.* **47**: 23 (1978), *non A. indicum* Kulshreshtha, Raychaudhuri & Khan, *Acta Bot. Ind.* **5**: 16 (1977).

Typification. India: Lucknow, isol. ex 'usar' soil (pH 8·5), Nov. 1971, collector unknown (?LWU – holotype of *Achaetomium indicum* Rai & Chowdhery).

Illustrations. Rai & Chowdhery (1978: 24).

I have seen no material of this species, despite requests to the authors. The description and illustrations are not detailed enough to permit definite conclusions as to its affinities, but they seem not to fit any of the previously described species of *Achaetomium*. It was characterized by Rai & Chowdhery (1978) by its very large ascospores (19–25 (–29) × 10–12 (–15·3) μm), each with two germ pores. It seems closest to *Chaetomium megasporum* and *C. piluliferoides*, but these taxa have narrower ascospores and clavate rather than cylindrical asci. Without examining the type material, it would be premature to remove this taxon to the genus *Chaetomium*; a new name would be required in this genus due to the prior publication of *C. indicum* Corda (1840) and *C. raii* Malhotra & Mukerji (1976).

ACHAETOMIELLA v. Arx, *Genera of Fungi Sporulating in Pure Culture*: 247 (1970).

Type species: *A. virescens* v. Arx

Achaetomiella fusispora Calviello, *Darwiniana* **18**: 558 (1974).

See *Chaetomium megasporum* Sörgel ex Seth

Achaetomiella macrospora (Rai, Wadhwani & Tewari) v. Arx, *Proc. K. Ned. Akad. Wet.* C, **76**: 292 (1973).

See *Achaetomium macrosporum* Rai, Wadhwani & Tewari

Achaetomiella megaspora (Sörgel ex Seth) D. Hawksw., *Trans. Br. mycol. Soc.* **65**: 136 (1975).

See *Chaetomium megasporum* Sörgel ex Seth

Achaetomiella virescens v. Arx, *Genera of Fungi Sporulating in Pure Culture*: 247 (1970).

See *Chaetomium virescens* (v. Arx) Udagawa

SUBRAMANIULA v. Arx, *Proc. Indian bot. Soc.* **94**: 344 (1985).

Ascomata ± globose, urniform, with a very wide ostiole surrounded by a ring of hyaline cells; glabrous or nearly so, partially or wholly trans-

lucent. *Asci* cylindric-clavate to clavate. *Ascospores* brown, 1-celled, with a single germ pore.

Type species: *S. thielavioides* (v. Arx, Mukerji & Singh) v. Arx

KEY TO SPECIES OF *SUBRAMANIULA*

1. Ascospores 22–26 μm long, broadly fusiform with a subapical germ pore; whole of peridium ± hyaline . . . . . *S. thielavioides*
1. Ascospores 7–11 μm long, irregularly shaped but usually ± lacrimiform, germ pore apical or nearly so; peridium black at the base . . . . . *S. irregularis*

This genus, recently described by von Arx in honour of Professor C. V. Subramanian's 60th birthday, has some similarities to *Achaetomium*, but is easily distinguished by its ± glabrous urniform ascomata composed of pale textura epidermoidea, with a hyaline collar around the ostiole. Von Arx *et al.* (1978) regarded the type species of *Subramaniula* as an ostiolate counterpart of *Thielavia*, as they found occasional cleistothecia in their isolate which were very similar to *T. hyalocarpa* v. Arx (1975). Even in the restricted sense of von Arx, *Thielavia* is undoubtedly a heterogeneous assemblage, but the fruit bodies in this genus are so simplified that it is difficult to distinguish genuine relationships from convergent evolution. *Subramaniula* is probably not closely related to the type species of *Thielavia*, *T. basicola* Zopf.

Subramaniula irregularis P. Cannon & D. Hawksw., sp.nov. (Figs 3–5)

Achaetomiella irregulare D. Hawksw. ex Eicker, *Trans. Br. mycol. Soc.* **63**: 283 (1974); *J. S. Afr. Bot.* **42**: 129 (1976); nom. nud.

Ascomata perithecia, 200–300 × 150–275 μm, globosa vel subglobosa, cum ostiola lata, circumcincta a cellulis grandis hyalinis. Asci cylindrico-clavati, evanescenti, 8-spori. Ascosporae irregulariter lacrimiformes, brunneae, cum semel pora germinationi apicali.

South Africa: Transvaal: environs of Pretoria, isol. ex alkaline soil, comm. 23 Feb. 1972, A. Eicker UP 818 (IMI 164251 – holotype of *Subramaniula irregularis*).

Distribution. Only known from the type collection.

Cultures. 'Growing rapidly on PDA at 20°, producing abundant perithecia from a weakly

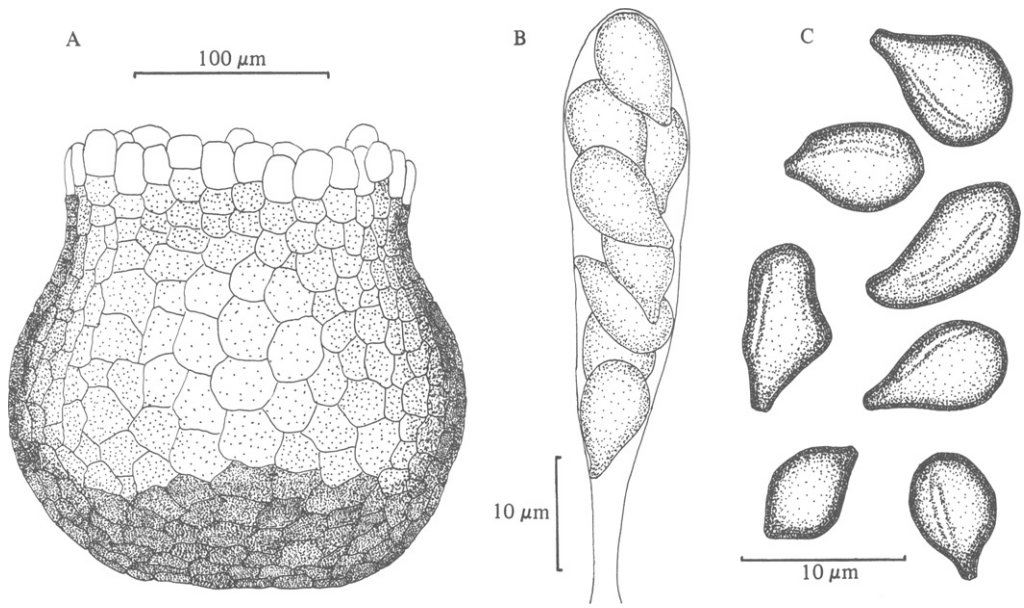


Fig. 5. *Subramaniula irregularis* (drawn from the holotype). (A) Ascoma; (B) ascus; (C) ascospores (note the irregular shape and the pale longitudinal stripe (probably a thinning of the ascospore wall from the interior).

developed hyaline mycelium' (Hawksworth, in litt.).

Mycelium. Hyphae 1·5–4 μm diam, hyaline to pale brown, irregular, frequently branched, septate, smooth-walled.

Anamorph. None seen.

Teleomorph. Ascomata 180–270 × 200–300 μm, globose to transversely ellipsoidal, urniform, at first orange-yellow, becoming black in reflected light, with a short neck 20–30 μm in length and 100–170 μm diam, and a very wide ostiole, to 150 μm diam. Peridium 5–8 μm thick, composed of an outer layer of large-celled ± hyaline textura angularis-epidermoidea with cells to 20 μm diam, with strongly darkened transverse walls, and an inner layer of similarly shaped cells with hyaline walls. The basal portion of the peridium (usually to ¼–⅓ and rarely to almost all its height) is strongly blackened and ± opaque. The neck is composed of ± hyaline textura angularis with cells to *ca* 12 μm diam, with a conspicuous ring of extremely thin-walled hyaline textura globulosa with cells to 20 μm diam, mostly without contents, around the ostiole. *Periphyses* not seen. *Asci* 40–55 × 6–8 μm, cylindric-clavate, very thin-walled, without apical structures, evanescent at an early stage, 8-spored. *Ascospores* 7–10 (–11) × 4–7 μm, irregularly shaped but most often lacrimiform (ellipsoidal with one apex conspicuously apiculate), mid-brown, aseptate, relatively thick-walled, smooth, with a minute germ pore (*ca* 0·5 μm diam) at or very near the apiculate apex, and a pale longitudinal band 1–1·5 μm wide running the length of the spore.

This new species is easily distinguished from *Subramaniula thielavioides* by the shape and size of the ascospores (7–11 × 4–7 μm; irregularly lacrimiform in *S. irregularis*, 22–26 × 11·5–14·5 μm; widely fusiform in *S. thielavioides*), and by the pigmentation of the ascomata, which are ± hyaline in *S. thielavioides* but with a black base in *S. irregularis*.

The new species is known only from a single collection from South Africa, and was only isolated once during protracted sampling of the soil under investigation (Eicker, 1974, 1976). The isolate was originally identified as a species of *Achaetomiella*, explaining the unpublished name referred to in the two ecological papers. Subsequent work has shown *Achaetomiella* (now recognized as a synonym of *Chaetomium*) to be an unsuitable generic placement. However, the epithet '*irregularis*' has been maintained to minimize the confusion arising from the invalidly published name. The new fungus has no nomenclatural connexion (or close taxonomic relationship) with *Chaetomium irregulare* Sörgel ex W. Gams (1967).

A number of *Chaetomium* species have broadly similar ascospores to *Subramaniula irregularis*, including *C. hamadae* (see p. 58), *C. irregulare* (mentioned above) and *C. senegalense* L. Ames (syn. *Kernia furcotricha* Tandon & Bilgrami), and these taxa in addition have few or inconspicuous ascomatal hairs. However, they can immediately be told from *S. irregularis* by the unusual ascomatal structure of the new species. *Chaetomidium minutum* Cain (1961) also has very similar ascospores to *S. irregularis*, but the former fungus has cleistothecia with conspicuous short hyaline hairs, and spherical asci.

Unfortunately, there is no living culture extant of this interesting species, and this means that the description of the fungus is not as detailed as for most of the other fungi treated in this paper.

SUBRAMANIULA THIELAVIOIDES (v. Arx, K. G. Mukerkji & N. Singh) v. Arx, *Proc. Indian bot. Soc.* **94**: 344 (1985). (Fig. 2)
Achaetomium thielavioides v. Arx, Mukerji & Singh, *Persoonia* **10**: 144 (1978).

Cultures. On CMA at 25° colonies 40–45 mm diam after 7 d. Submerged mycelium hyaline, very inconspicuous. Aerial mycelium very scanty, hyaline. Ascomata developing after about 7 days, scattered over the agar surface, fairly abundant. On MA at 25° colonies 40–45 mm after 7 d. Submerged mycelium copious, hyaline, radiating from the centre, the colony edge distinctly scalloped. Aerial mycelium well developed, hyaline, floccose. Ascomata developing after about 10 d, very few in number. On PCA at 25° colonies 45–50 mm diam after 7 d. Submerged mycelium inconspicuous, hyaline. Aerial mycelium very scanty, hyaline. Ascomata developing after about 6 d, scattered over the agar surface, abundant.

Mycelium. Hyphae 0·5–3·5 μm diam, hyaline, smooth-walled, septate, frequently branched.

Anamorph. A few hyphae were seen with chains of considerably swollen cells, producing thin-walled globose or ellipsoidal bodies to 8 μm diam, but they may well not function as propagules.

Teleomorph. Ascomata 130–200 × 110–160 μm, globose to widely ellipsoidal, with a short neck 10–20 μm in length and a large ostiole 40–60 μm diam (occasionally non-ostiolate, fide von Arx *et al.*, 1978). Ascomatal hairs absent, though with occasional narrow hyaline hyphae emanating from various points on the ascoma surface. Basal rhizoids absent. Peridium at first hyaline, becoming pale brown with age, 5–8 μm thick, composed of thin-walled textura intricata-epidermoidea, with a well-developed region of very thin-walled textura globulosa with cells to 20 μm diam surrounding the ostiole, this tissue degenerating in old specimens

into an amorphous mass. *Periphyses* not seen. *Asci* 45–69 × 18–31 μm, clavate, short-stalked, very thin-walled, without apical structures, evanescent at a very early stage, 8-spored. *Ascospores* 22–26 × 13–14·5 × 11·5–12·5 μm, widely fusiform to fusiform-limoniform, widely elliptical in transverse section, mid-brown, relatively thick-walled, with a conspicuous subapical germ pore 2–3 μm diam, round to nearly triangular in shape. In some conditions the extreme apices of the spores may become inverted, giving the impression of one or two apical germ pores.

Typification. India: Delhi: zoological garden, isol. ex dung of nilgai, 29 Dec. 1976, collector unknown (CBS 122.78 – holotype of *Achaetomium thielavioides*).

Distribution. India.

Illustrations. Von Arx *et al.* (1978: 145).

Culture examined: IMI 288625 (= CBS 122.68), from the holotype of *Achaetomium thielavioides*.
Specimen examined: India: Balaghat, isol. ex human nails, Dec. 1978, S. M. Singh 2 (IMI 244059).

This is the type species of the genus *Subramaniula*. The significance of the main diagnostic feature of that genus, the collar of thin-walled hyaline cells around the ostiole, is of uncertain significance; the cells may be ontogenetically periphyses. The translucent ascomatal walls and large ascospores might suggest a relationship with *Melanospora* Corda (Cannon & Hawksworth, 1982, 1983), but other features of the fungus suggest a fairly close relationship with the Chaetomiaceae. In this respect *Subramaniula* occupies a position between the Ceratostomataceae (syn. Melanosporaceae) and the Chaetomiaceae analogous to that of *Thielavia*, another genus over which there is disagreement about familial relationships.

Bearing in mind that one of the two collections of *S. thielavioides* is from human nails and the other from vertebrate dung, medical mycologists should be aware of its existence. However, the fungus is almost certainly an opportunist rather than a pathogen.

Subramaniula thielavioides is a very distinctive fungus, and unlikely to be confused with any other so far known. *Chaetomium retardatum* Carter & Khan (1982) has similar ascospores, but these have two subapical germ pores, and the peridium in this species is typical of *Chaetomium*, though with rather short simple ascomatal hairs. None of the *Chaetomium* species with single subapical germ pores has ascospores which approach *S. thielavioides* in size.

CHAETOMIUM Kunze, in Kunze & Schmidt, *Mykologisches Hefte* **1**: 15 (1817): Fr., *Syst. Mycol.* **3**: 253 (1829).

Only those species are treated which have synonyms in *Achaetomium* or *Achaetomiella*.

CHAETOMIUM HAMADAE (Udagawa) v. Arx, *Proc. Indian bot. Soc.* **94**: 343 (1985).
Achaetomium hamadae Udagawa, *Trans. mycol. Soc. Japan* **23**: 287 (1982).
Thielavia variospora Cain, *Can. J. Bot.* **39**: 1234 (1961), non *Chaetomium variosporum* Udagawa & Horie, *Repts Tottori mycol. Inst.* **10**: 430 (1973).
C. ecmelodes Krug & Carter, *Mycologia* **78** (in press) nom.nov.; = *T. variospora* Cain, non *C. variosporum* Udagawa & Horie

Cultures. On CMA at 25° colonies 35–40 mm diam after 7 d. Submerged mycelium hyaline, inconspicuous. Aerial mycelium absent. Ascomata developing after about 7 d, scattered over the agar surface, dark grey in reflected light. On MA at 25° colonies 30–35 mm diam after 7 d. Submerged mycelium hyaline, fairly well developed. Aerial mycelium copious in the centre of the plate, hyaline, floccose. Ascomata developing after about 7 d. On PCA at 25° colonies 30–35 mm diam after 7 d. Submerged mycelium hyaline, inconspicuous. Aerial mycelium very sparse, hyaline, lanose. Ascomata developing after about 7 d, scattered abundantly over the agar surface, dark grey.

Mycelium. Hyphae 1–4 μm diam, hyaline, becoming pale brown, rather thin-walled, septate, frequently branched.

Anamorph. None seen.

Teleomorph. Ascomata 80–210 × 80–170 μm, globose to pyriform, ostiolate or not, short neck present when ostiolate. Ostiole 50–60 μm wide (fide Udagawa, 1982). Peridium 5–15 μm thick, translucent, becoming pale brown, composed of several layers of textura angularis-epidermoidea with cells up to 10 μm in size. Ascomatal hairs numerous,

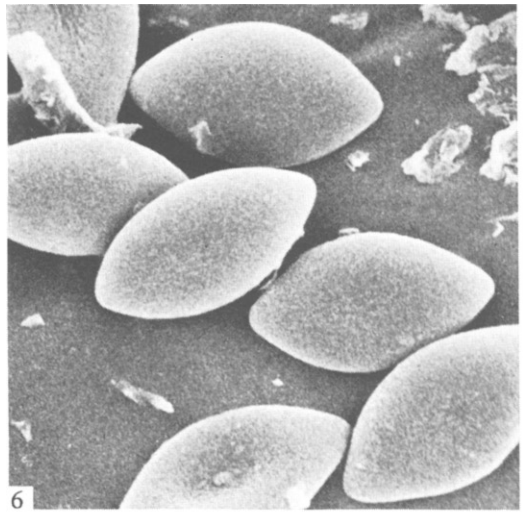
Figs 6–11. Ascospores of *Chaetomium* species (all of critical-point dried material).

Fig. 6. *C. nepalense* (IMI 288623, derived from the holotype); × 2200.

Fig. 7. *C. purpurascens* (IMI 288624, derived from the holotype); × 920.

Figs 8, 9. *C. megasporum* (IMI 210880, derived from the holotype of *C. piluliferoides*). Fig. 8; ascospores at ostiole of ascoma; × 1000. Fig. 9; × 1700.

Figs 10, 11. *C. virescens* (IMI 159035, derived from the holotype). Fig. 10; × 1900. Fig. 11; × 2200 (note the mixture of spore shapes; most are rhomboidal-fusiform, but the spore at the bottom left of the illustration is relatively elongated-fusiform).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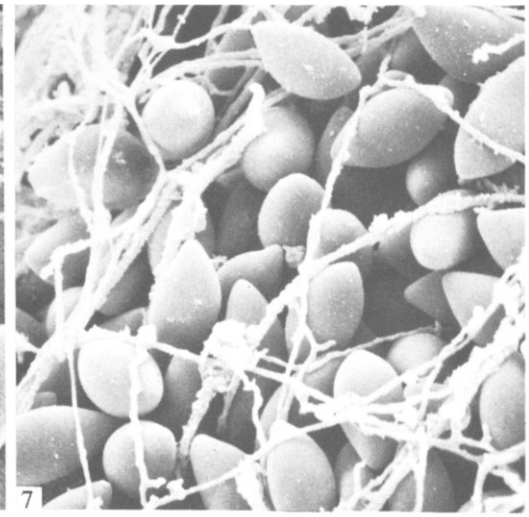
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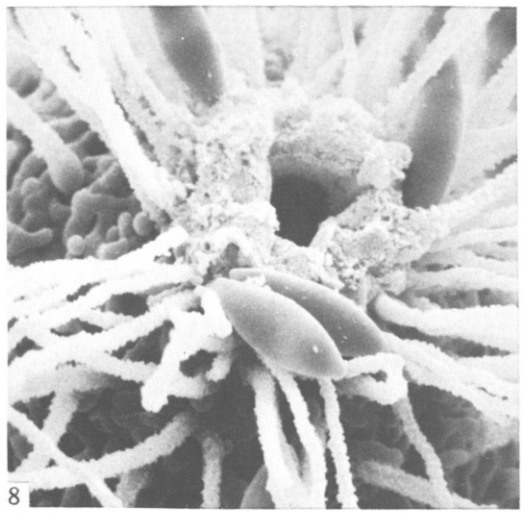
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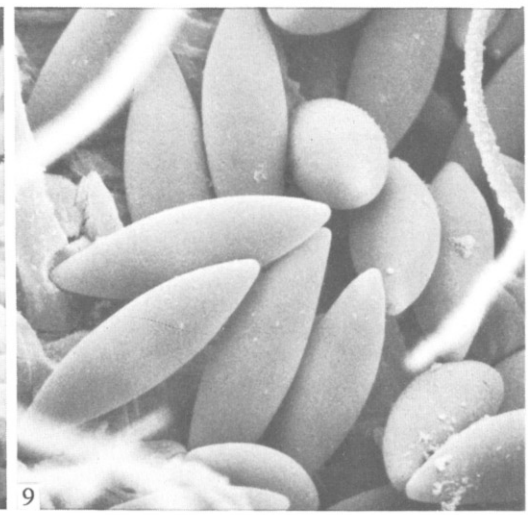
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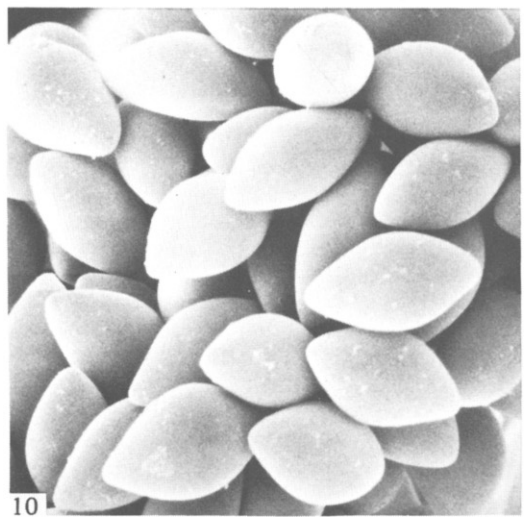
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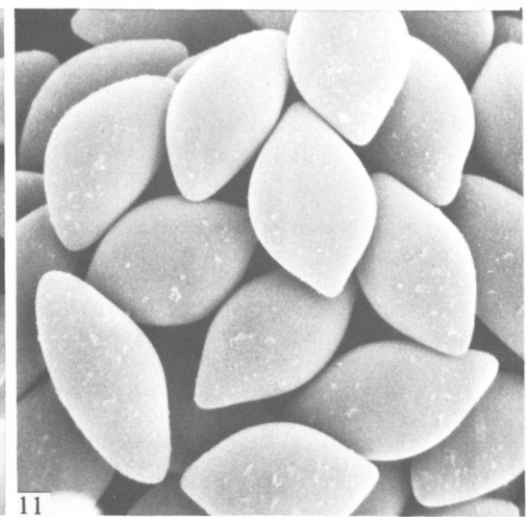
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hypha-like, hyaline to pale brown, 1–2·5 μm diam, sometimes very long. *Periphyses* present (fide Udagawa, 1982). *Asci* 32–42 × 12·5–19 μm, clavate, fairly short-stalked, very thin-walled, without apical structures, evanescent, 8-spored. *Ascospores* 8–11 (–16·5) × 5·5–7·5 (–9) μm, irregular in shape but usually roughly oblong or ellipsoidal, pale to mid brown, aseptate, thin-walled, with a single, usually ± apical, germ pore *ca* 1 μm diam, the surrounding spore wall sometimes darkened.

Typification. Japan: Kochi Pref.: Kami-gun: Tosayamada-cho, isol. ex paddy soil, March 1971, S. Udagawa (NHL 2910 – holotype of *Achaetomium hamadae*).

Papua New Guinea: near Madang, isol. ex forest soil, undated, J. H. Warcup A2/1 (TRTC 36863 – holotype of *Thielavia variospora*).

Distribution. Italy, Japan, Pakistan, Papua New Guinea, Sri Lanka, Thailand.

Illustrations. Cain (1961: 1239), Horie & Udagawa (1973: 49, 50), Udagawa (1982: 288, 290).

Cultures examined: IMI 288714 (= NHL 2910), from the holotype of *Achaetomium hamadae*.

Italy: Sardinia, isol. ex *Vitis* sp., comm. 10 Jul. 1984, U. Prota CN (IMI 287603).

Specimens examined: TRTC 36863, holotype of *Thielavia variospora*. Pakistan: Tandajam: Agricultural Research Institute, isol. ex fruit of *Musa sapientum*, 13 July 1962, A. Kamal T-47 (IMI 94515). Sri Lanka: Lunuwila, isol. ex coconut growing soils, comm. 1 Sept. 1982, B. Gown S93 (IMI 270248) (specimen in poor condition, identification tentative).

Udagawa (1982) commented on the similarity of *Achaetomium hamadae* to *Thielavia variospora* in the course of his description of the former, noting that the only easily appreciated difference between the two taxa was the presence or absence of an ostiole. As his culture consistently produced ostiolate ascomata he regarded the two fungi as different. However, a subculture of the type in IMI is producing non-ostiolate ascomata only, so there seems to be no reason to maintain the separation of these taxa.

Von Arx (1985) removed Udagawa's fungus to *Chaetomium*, recognizing it as another example of reduced vestiture in that genus rather than a genuine species of *Achaetomium*; it has the typical wall structure of *Chaetomium*, and the ascospores are pale brown in colour. A new combination is unnecessary despite the priority of the epithet '*variospora*' over '*hamadae*', due to the existence of the nomenclaturally unconnected taxon *Chaetomium variosporum* Udagawa & Horie (1973).

Chaetomium hamadae is very similar to *C. irregulare* Sörgel ex W. Gams (1967), but seems to be most easily distinguished by the ascomatal hairs, which are yellow-brown, delicate, long and wavy, and delicately verrucose in that species. In addition, the ascospores of *C. irregulare* tend to be larger, measuring 11·6–13·8 × 7–8·3 μm (Gams, 1967). *C. irregulare* produces yellow exudates in culture (von Arx *et al.*, in press); no exudates are produced by *C. hamadae*.

C. hamadae is also similar to *C. deltosporum* Krug, Carter & Tiwari (in press), both species having irregularly shaped ascospores, but the latter taxon has a proportion of spores which are triangular in face view. Other species of *Chaetomium* with irregular ascospores can be distinguished from *C. hamadae* by combinations of ascospore size and ascomatal hair characters (Carter, 1983).

Chaetomium luteum (J. N. Rai & J. P. Tewari) P. Cannon, comb.nov.

Achaetomium luteum J. N. Rai & J. P. Tewari, in Rai, Tewari & Mukerji, *Can. J. Bot.* **42**: 694 (1964).

?*A. indicum* D. D. Kulshreshtha, S. P. Raychaudhuri & A. M. Khan, *Acta bot. Indica* **5**: 16 (1977); ?nom.inval., Art. 9·5.

Chaetomium intermedium M. R. Tansey (1982), nom.nud. (listed in ATCC catalogue ed. 15).

Anamorph: *Scytalidium intermedium* M. R. Tansey, nom.nud. (*ibid.*).

Cultures. On CMA at 25° colonies 70–75 mm diam after 7 d. Submerged mycelium hyaline, very inconspicuous. Aerial mycelium ± absent. Yellow-brown exudates (4B4) colouring the agar produced in some cultures. Ascomata produced abundantly, scattered over the agar surface. On MA at 25° colonies 65–75 mm diam after 7 d. Submerged mycelium obscured. Aerial mycelium usually copious, sulphur-yellow to yellow-grey (3B5 to 3B3), floccose. Orange-brown exudates sometimes present in the agar. Ascomata produced abundantly, scattered. On PCA at 25° colonies 50–60 mm diam after 7 d. Submerged mycelium abundantly produced, hyaline to dark purplish brown (11F5) in reflected light. Aerial mycelium absent. Ascomata produced abundantly, scattered.

Mycelium. Hyphae 0·5–5 μm diam, hyaline to pale brown, septate, frequently branched, rarely producing pinkish exudates.

Anamorph. Some cultures produce *Scytalidium*-like resting spores; these are usually intercalary, up to 10 μm in size, very variable in shape but usually ellipsoidal or oblong, often curved, rather thick-walled, mid-brown. The occasional terminal resting spores are usually roughly spherical in form.

Teleomorph. Ascomata 130–220 (–250) × 100–190 (–220) μm, spherical to ovoid, neck absent, with a large ostiole 50–90 μm diam. Peridium dark brown,

composed of rather thick-walled textura intricata with hyphae 1·5–3 μm diam, often rather irregular, ? with an inconspicuous inner layer of brown thin-walled textura angularis. Peridium covered with a conspicuous layer of hyaline hyphae (pale grey in reflected light), the hyphae *ca* 1 μm diam, often branched and with frequent small knob-like swellings, smooth-walled or almost so. *Periphyses* present, hyaline, sometimes extruding from the ostiole for a short distance. *Basal rhizoids* 2–4 μm diam, mid-brown, much branched and contorted, smooth-walled. *Asci* 42–58 × 5–10 (–14) μm, cylindrical to clavate, very thin-walled, without apical structures, evanescent at an early stage, 8-spored. *Ascospores* usually arranged more or less uniseriately, 8·5–10 × 6·5–7·5 × 5–6 μm, dark chestnut brown to olivaceous, limoniform (to widely fusiform), flattened laterally, the ends ± apiculate, with a single apical germ pore *ca* 0·5 μm diam.

Typification. India: Harchandpur: Rae Barelli, isol. ex soil of sugarcane field, April 1960, J. N. Rai RUP-44 (IMI 96678 – holotype, ?BPI – isotype of *Achaetomium luteum*).

India: 'isolated from the rhizosphere of *Zea mays* L. growing in Delhi, Haryana, Hyderabad, Punjab, U.P., June 1967, D. D. Kulshreshtha', 'ITCC 1392', probably not extant.

Distribution. Australia, Ghana, India, Saudi Arabia; Japan (fide Udagawa & Muroi, 1979, isol. ex imported dill (*Anethum graveolens* L.) seed), Kenya and Pakistan (fide von Arx, 1985).

Illustrations. Chowdhery (1980: 477), Hawksworth (1980: 98), Mukerji & Saxena (1974: 397), Rai *et al.* (1964: 695, 698), Udagawa & Muroi (1979: 19).

Cultures examined: Australia: New South Wales: 21 miles NNW of Griffith: Pulletop Nature Reserve, isol. ex nesting material of *Leipoa ocellata* (Mallee Fowl), comm. 24 Mar. 1975, A. K. Morris (isol. by M. R. Tansey) (IMI 192493, = ATCC 34113, CBS 738.74, DAOM 147455; 'type' of *Chaetomium intermedium* Tansey and *Scytalidium intermedium* Tansey, nomina nuda). India: Delhi, isol. ex rhizosphere of *Cucurbita* sp., Jan. 1967, collector unknown DU/KR 78 (IMI 141563, = ATCC 18524, CBS 618.68); Jabalpur: Government Science College Botanic Garden, isol. ex *Bambusa* leaf litter, Apr. 1984, Nisha Singh NS/47 (IMI 287406).

The culture from the holotype present in IMI is now producing only sterile mycelium.

Specimens examined: IMI 96678, holotype of *Achaetomium luteum*. Ghana: Tajo, isol. ex soil of *Theobroma cacao*, 11 May 1971, H. C. Evans (IMI 158734). India: Jabalpur, isol. ex grassland soils, comm. 5 Sept. 1972, P. D. Agrawal 228 (IMI 169035); Ludhiana, isol. ex rotten ear of *Triticum* sp., comm. 13 June 1974, J. S. Chohan 6 (IMI 185646); Ludhiana, isol. ex wheat straw compost prepared for mushroom growing, comm. 3 July 1974, D. Singh Chahal II (IMI 185906); Jabalpur, isol. ex soil, comm. 30 Apr. 1977, D. P. Tiwari (IMI 213337); University of Jodhpur, isol. ex *Bauhinia purpurea*, comm. 4 June 1979, H. P. Srivastava JU/BD/H-9 (IMI 239476). Saudi Arabia: Riyadh, isol. ex soil, comm. 2 Feb. 1981, A. H. Abu-Zinada (IMI 255984).

This species is very similar to *Chaetomium strumarium* (Rai *et al.*) P. Cannon (see p. 65), but the ascomata are yellowish rather than pinkish brown, they are scattered over the agar surface in culture rather than aggregated in clumps, and the ascospores are slightly smaller, and tend to be limoniform and laterally flattened rather than rhombic.

C. luteum was described in the original publication (Rai *et al.*, 1964) as having ascospores with two germ pores, and this statement has been repeated in a number of subsequent publications. In some isolates the apex of the ascospore opposite the germ pore has a small refractive region, and this is doubtless the reason for the original misconception. Rai & Chowdhery (1974*a*) and von Arx (1974) suggested that this species be placed in *Achaetomiella* because of its clavate asci and twin germ pores, but the formal transfer was apparently never made.

Achaetomium indicum Kulshreshtha *et al.* (1977) is inadequately described, but probably belongs to this species. No material has been made available of this species. According to J. N. Kapoor (in litt.) the culture of this taxon deposited at ITCC was contaminated on arrival and had to be discarded. In any case, the name is in all probability invalidly published under Art. 9.5, as a type specimen was apparently never preserved. The locality of the 'type' isolate is also in doubt, as a number of different Indian states were cited in the original publication for its locality. The small drawing of the species included by Kulshreshtha *et al.* shows some very unusual features, which if genuinely present would certainly separate the taxon from *Chaetomium luteum* and indeed from the genus itself. These include ascospores apparently with subapical to lateral germ pores, and asci accompanied by what appear to be filiform paraphyses. However, the overall quality of the drawing is not such as to inspire confidence in its accuracy.

Achaetomium brevisemum Chowdhery & Rai was treated as a synonym of *C. luteum* by von Arx (1985), but its description seems more reminiscent of *C. strumarium*. The type is not available for examination.

Chaetomium luteum has now been reported from three continents, and is not infrequently encountered in relatively warm dry conditions, especially in soil isolations. It is interesting to note that the

only record to date of the species from temperate regions is an isolation from nesting material of the Mallee Fowl, which incubates its eggs at high temperatures generated by the anaerobic fermentation of the nesting material.

C. luteum has been investigated cytologically by Ranga Rao & Mukerji (1971*a*); a chromosome number of $n = 7$ was reported, and the ascospores were found to be binucleate, as the same authors had discovered for *Achaetomium globosum*.

CHAETOMIUM MEGASPORUM Sörgel ex Seth, *Nova Hedwigia Beih.* **37**: 82 (1970) (1972). (Figs 8–9, 12)

Achaetomiella megaspora (Sörgel ex Seth) D. Hawksw., *Trans. Br. mycol. Soc.* **65**: 136 (1975).

A. fusispora Calviello, *Darwiniana* **18**: 558 (1974), non *Chaetomium fusisporum* G. Smith, *Trans. Br. mycol. Soc.* **44**: 46 (1961).

Chaetomium piluliferoides Udagawa & Horie, *Trans. mycol. Soc. Japan* **16**: 337 (1975).

Cultures. On CMA at 25° colonies 55–65 mm diam after 7 d. Submerged mycelium hyaline, inconspicuous, radiating from the centre. Aerial mycelium absent. Ascomata developing after about 14 d, scattered, rather few in number. On MA at 25° colonies 55–65 mm diam after 7 d. Submerged mycelium hyaline, radiating. Aerial mycelium sparse, white, somewhat floccose, producing pale yellow exudates. Ascomata developing after 5–6 d, scattered, abundant. On PCA at 25° colonies 55–60 mm diam after 7 d. Submerged mycelium hyaline, radiating, inconspicuous. Aerial mycelium very sparse, hyaline. Ascomata developing after 5–6 d, scattered, abundant.

Mycelium. Hyphae 1–4 μm diam, hyaline to pale brown, smooth-walled, septate, frequently branched.

Anamorph. *Botryotrichum*-like. Resting spores 5–7 μm diam, spherical to widely obpyriform, hyaline, thick-walled, smooth or inconspicuously roughened, produced holoblastically from undif-

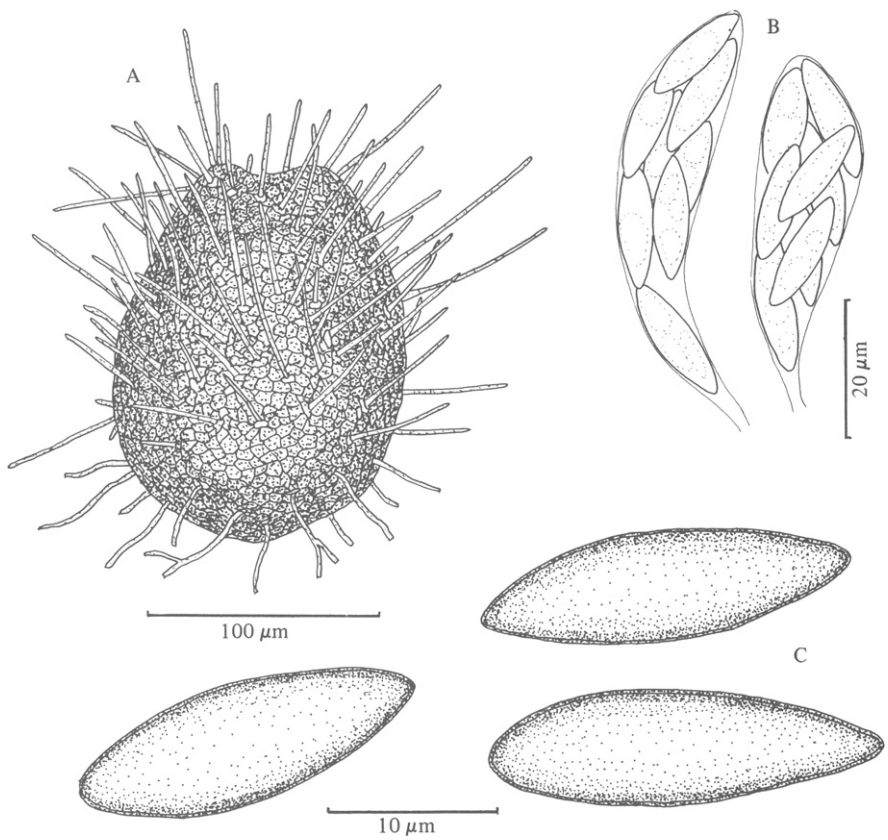

Fig. 12. *Chaetomium megasporum* (drawn from the holotype of *C. piluliferoides*). (A) Ascoma; (B) asci; (C) ascospores.

ferentiated hyphae, sometimes in clusters from closely branched hyphae.

Teleomorph. Ascomata 160–220 (–250) × 120–180 (–200) μm, ellipsoidal, neck absent, with an ostiole 25–80 μm diam. Peridium pale greenish to mid brown, composed of pale to brown relatively thick-walled textura intricata with irregular hyphae 1–2·5 μm diam, sometimes with an inner layer of textura angularis. Terminal and lateral hairs 50–150 (–250) μm long, very pale brown, becoming hyaline towards the tip, septate, 2–3 μm diam at the base, tapering gradually, delicately roughened. Basal rhizoids absent or very poorly developed, 5–10 μm in length, dark brown, irregular in form. *Periphyses* not seen. *Asci* 55–77 × 16–24 μm, the longer asci narrower, clavate, stalk 10–15 μm long, very thin-walled, without apical structures, evanescent, 8-spored. *Ascospores* biseriately arranged, (16–) 18–25 (–27) × 7–9 (–10) μm, narrowly fusiform but often rather irregular in shape and sometimes curved, pale grey-brown, becoming reddish-brown with age, smooth, aseptate, fairly thin-walled, with two apical germ pores 0·25–0·75 μm diam, these sometimes being extremely inconspicuous.

Typification. China: Chungking, isol. ex unknown source, undated, G. Sörgel (IMI 73514 – holotype of *Chaetomium megasporum*).

Argentina: Chubut: environs of Lake Futalaufquen, isol. ex moist bark of *Nothofagus* sp., Jan. 1973, B. O. Calviello (BA 23.431 – holotype of *Achaetomiella fusispora*).

Japan: Nagano Pref.: Chisagata-gun: Sanadamachi: Sugadaira, isol. ex grassland soil, 17–19 Oct. 1972, collector not cited (NHL 2738 – holotype of *Chaetomium piluliferoides*).

Distribution. Argentina, China, Japan, Spain.

Illustrations. Calviello (1974: 560, 561), Seth (1972: pl. 35, fig. 98), Udagawa & Horie (1975: 338, 346).

Cultures examined: IMI 187743 (= CBS 610.73), from the holotype of *Achaetomiella fusispora*. IMI 210880 (= NHL 2738, IFM 4531, IFO 30291), from the holotype of *Chaetomium piluliferoides*.

Spain: Cataluña: Sierra de Prades, isol. ex forest soil, Oct. 1982, J. Guarro (IMI 281202, = FMR 323).

Specimens examined: IMI 73514 – holotype of *Chaetomium megasporum*. Japan: Osaka Pref.: Habikino, isol. ex soil of rice paddy field, 22 Aug. 1977, T. Ito (IMI 247715, = IFO 30998). Same locality and substrate, 20 Nov. 1978, T. Ito (IMI 247716, = IFO 31000).

The synonymy of *Chaetomium megasporum* and *Achaetomiella fusispora* was reported by Hawksworth (1975*a*), who made a combination for the former name in *Achaetomiella*. There are however some differences between the types of the two names, which to a certain extent call into question the treatment of the two as synonymous. It is difficult to assess the significance of these differences, however, because the type of *Chaetomium megasporum* consists of a very meagre dried culture in poor condition, and no living subculture is extant. The peridium of *C. megasporum* is pale greenish and is composed of textura intricata only, while it is mid brown and made up of an inner layer of textura angularis covered by textura intricata in *A. fusispora*. There are also differences in ascospore form, *A. fusispora* having usually straight spores with almost indistinguishable germ spores, while in *C. megasporum* they are usually curved and slightly wider, and have distinct germ pores. Without better material of *C. megasporum* it is not possible to be sure of the relationship between these two taxa, but the differences in peridium might be a function of maturity of the ascomata, and as the ascospores of both taxa are very thin-walled, the wider spores and larger germ pores in *C. megasporum* might be the result of slight squashing of the ascospores during slide preparation.

The culture of *C. piluliferoides* examined seems identical with that of *C. megasporum* (s.l.), and Udagawa & Muroi (1981) regarded the two taxa as synonymous.

Judging from the scattered known distribution of *Chaetomium megasporum* (several collections from the Far East, one from Europe and one from South America), it is probably much more evenly distributed and common than the records indicate.

The possession of a *Botryotrichum*-like anamorph and (weakly developed) basal rhizoids suggests a relationship with *Farrowia* D. Hawksw. (Hawksworth, 1975*b*), but the species of this group have smooth ascomatal hairs and thick-walled apiculate ellipsoidal ascospores. Some recent authors, e.g. von Arx *et al.* (in press), have questioned the separation of this group from *Chaetomium* at generic level.

The development and cytology of *C. megasporum* have been described by Rai & Saxena (1979). They found that the pattern of development was similar to that in other species of *Chaetomium*, and they reported a chromosome number of $n = 5$.

CHAETOMIUM NEPALENSE (Udagawa & Sugiyama) v. Arx, *Proc. Indian Acad. Sci. (Plant Sci.)* **94**: 344 (1985). (Fig. 6)

Achaetomium nepalense Udagawa & Sugiyama, *Repts. cryptog. Stud. Nepal (Misc. Publ. natn. Sci. Mus. Tokyo)*: 11 (1982).

Cultures. On CMA at 25° colonies 45–50 mm diam after 7 d. Submerged mycelium hyaline, very inconspicuous. Aerial mycelium absent. Ascomata developing after 6–7 d, scattered abundantly over

the agar surface, black in reflected light. On MA at 25° colonies 60–65 mm diam after 7 d. Submerged mycelium hyaline, very inconspicuous. Aerial mycelium very sparse, hyaline, lanose. Ascomata developing after 6–7 d, very copiously produced, at first yellowish, then becoming black. On PCA at 25° colonies 45–50 mm diam after 7 d. Submerged mycelium hyaline, inconspicuous. Aerial mycelium absent. Ascomata developing after about 7 d, scattered over most of the agar surface, at first yellowish, then becoming dark grey in reflected light.

Mycelium. Hyphae 2–5 μm diam, hyaline to pale brown, septate, frequently branched.

Anamorph. None seen.

Teleomorph. *Ascomata* 190–230 (–250) × 170–200 (–220) μm, globose to globose-ellipsoidal, neck absent or almost so, with an ostiole 32–45 μm diam. Peridium 5–7 μm thick, translucent, composed of an outer layer of pale brown textura intricata with hyphae 2–3 μm diam, and an inner layer 2–3 cells thick of very thin-walled hyaline flattened textura globulosa 6–10 μm diam. The ostiole is lined with inconspicuous hyaline periphyses 1–1·5 μm diam, which may extrude to a length of 15–20 μm. Peridium covered with inconspicuous pale brown hypha-like hairs 1·5–3 μm diam, irregularly branched, delicately roughened. Paraphyses absent. *Asci* clavate, body 31–40 × 12–16·5 μm, the longer asci being narrower, stalk up to 30 μm long, very thin walled, without apical structures, evanescent, 8-spored. *Ascospores* biseriately arranged, (12·5–) 14–16·5 × 5–7 μm, fusiform, pale grey-brown when first discharged, becoming mid-brown with maturity, smooth, aseptate, with a single apical germ pore *ca* 0·5 μm diam.

Typification. Nepal: Central Development Region; Lalitpur; Godawari; Royal Botanic Garden, isol. ex soil, 10 Sept. 1980, S. Udagawa (NHL 2895 – holotype, TNS – isotype of *Chaetomium nepalense*).

Distribution. Nepal (only known from the type collection).

Illustrations. Udagawa & Sugiyama (1982: 12).

Culture examined: IMI 288623 (= NHL 2895), from the holotype of *Chaetomium nepalense*.

This species is only known from the original collection. Udagawa & Sugiyama (1982) report a reddish tinged colony colour for this species, but the subculture in IMI has not shown this feature. In other respects the descriptions are in agreement. The species was placed in *Achaetomium* by the publishing authors as it lacked well-developed terminal hairs, but it was noted by von Arx (1985) that the species had more in common with *Chaetomium*.

C. nepalense is one of a fairly large cluster of *Chaetomium* species with fusiform ascospores, and to identify it with certainty colony characteristics must be noted as well as such features as the shape and size of the ascospores and the position of the germ pore. The fungus is related to *C. murorum* Corda according to von Arx (1985), which has very long circinate ascomatal hairs; other similar species are *C. succineum* L. Ames with delicate coiled hairs, and *L. deceptivum* Malloch & Benny, which has very short inconspicuous ascomatal hairs but larger ascospores (18–23 × 7·7–9·8 μm, fide Malloch & Benny, 1973).

CHAETOMIUM PURPURASCENS (Udagawa & Sugiyama) v. Arx, *Proc. Indian Acad. Sci.* (*Plant Sci.*) **94**: 344 (1985). (Fig. 7)

Achaetomium purpurascens Udagawa & Sugiyama, *Repts. Cryptog. Stud. Nepal* (*Misc. Publ. natn. Sci. Mus. Tokyo*): 13 (1982).

Cultures. On CMA at 25° colonies 40–45 mm diam after 7 d. Submerged mycelium hyaline, very inconspicuous. Aerial mycelium ± absent. Ascomata developing abundantly after about 7 d, bright pinkish purple, scattered over the entire surface of the plate. On MA at 25° colonies 40–45 mm diam after 7 d. Submerged mycelium obscured. Aerial mycelium fairly well developed, hyaline to pinkish grey, lanose. Ascomata developing abundantly after about 7 d, bright pinkish-purple, later appearing dark purplish black due to the presence of extruded spores. On PCA at 25° colonies 25–30 mm diam after 7 d. Submerged mycelium inconspicuous, hyaline. Aerial mycelium very poorly developed, hyaline to pale pinkish brown. Ascomata developing after about 7 d, bright pinkish-brown, scattered over the agar surface.

Mycelium. Hyphae 1–2·5 μm diam, hyaline, often branched.

Anamorph. None seen.

Teleomorph. *Ascomata* (100–) 160–210 × (80–) 120–150 μm, pyriform, neck ± conical, with an ostiole 15–20 μm diam. Peridium translucent, composed of hyaline to pale brown textura angularis-epidermoidea with cells 2–5 (–8) μm diam. Whole surface of ascoma densely covered in pale brown unbranched nearly smooth-walled hypha-like hairs (bright pinkish-purple in reflected light), to 200 (–350) μm long and 2–3 μm wide. Periphyses very well developed, sometimes extruded through the ostiole for a short distance. *Asci* 40–50 × 16–23 μm, clavate, fairly long-stalked, very thin-walled, without apical structures, evanescent at an early stage, 8-spored. *Ascospores* arranged

fasciculately, 15·5–21 × 9–11·5 μm, widely fusiform to musiform, mid-brown to olivaceous, aseptate, smooth, with two apical germ pores *ca* 0·75 μm diam, one sometimes larger than the other, the spore wall sometimes darkened around the pores.

Typification. Nepal: Gandaki, between Birethanti and Ulleri, isol. ex paddy soil, 21 Aug. 1980, S. Udagawa (NHL 2896 – holotype, TNS – isotype of *Achaetomium purpurascens*).

Distribution. Egypt, India, Nepal, Zambia.

Illustrations. Udagawa & Sugiyama (1982: 14).

Cultures examined: IMI 288624 (= CBS 287.83, NHL 2896), from the holotype of *Achaetomium purpurascens*). Zambia: Lusaka, isol. ex soil, comm. 6 July 1983, J. N. Zulu SIR2 Cp5cm (IMI 279195).

Specimens examined: Egypt: Cairo, isol. ex *Petroselinum* sp., comm. 20 Mar. 1977, A. A. El Gindy 66 (IMI 212290). India: Assam, isol. ex soil, comm. 20 July 1977, A. K. Roy 5 (IMI 215267).

Although this species has only recently been described, it appears to be widely distributed in warm temperate and subtropical regions of the Old World. It is characterized particularly by its pinkish-purple hypha-like ascomatal hairs, prompting the choice of epithet, and the entire agar surface can appear pink when the ascomata are clustered.

Von Arx (1985) contrasted this species with *Chaetomium aureum* Chivers, which has smaller ascospores and much more extensively developed brown ascomatal hairs. There is a large group of *Chaetomium* species which has weakly developed terminal hairs and fusiform ascospores, distinguished from each other mostly by the number and position of the germ pores, the size of the ascospores, and the colour of the exudates produced in culture.

Udagawa & Sugiyama (1982) compared this species with *Achaetomium cristalliferum* Faurel & Locquin-Linard (a synonym of *Chaetomium strumarium*) as this was the only published species of *Achaetomium* described as possessing ascomatal hairs. It is probably not closely related to this taxon, differing in many characters of ascoma and ascospore.

Chaetomium strumarium (J. N. Rai, J. P. Tewari & K. G. Mukerji) P. Cannon, comb.nov.

Achaetomium strumarium Rai, Tewari & Mukerji, *Can. J. Bot.* **42**: 694 (1964).

Chaetomium spinulosum Sörgel ex Seth, *Nova Hedwigia Beih.* **37**: 103 (1972).

Achaetomium cristalliferum Faurel & Locquin-Linard, in Locquin-Linard, *Cryptogamie, Mycologie* **1**: 235 (1980).

?*A. brevisemum* H. J. Chowdhery & J. N. Rai, *Nova Hedwigia* **32**: 225 (1980).

Cultures. On CMA at 25° colonies > 85 mm diam after 7 d (55–70 mm after 5 d). Submerged mycelium inconspicuous, hyaline. Aerial mycelium absent or almost so. Ascomata developing after 6–7 d, sulphur yellow to greyish yellow, with a metallic appearance. On MA at 25° colonies > 85 mm diam after 7 d (70–80 mm after 5 d). Submerged mycelium obscured. Aerial mycelium copious, lanose, pale yellowish grey (3B1–3A2) to reddish orange (6B4). Ascomata developing after 6–7 d, sometimes aggregated, sulphur-yellow, often with conspicuous orange exudates. On PCA at 25° colonies > 85 mm diam after 7 d (55–65 mm after 5 d). Submerged mycelium inconspicuous, hyaline. Aerial mycelium hyaline, lanose, rather sparse. Ascomata developing abundantly in the centre of the plate, sulphur-yellow to pinkish, after 6–8 weeks brownish pink.

Mycelium. Hyphae 1–5 μm diam, hyaline, thin-walled, septate, frequently branched, sometimes slightly nodulose, smooth-walled.

Anamorph. Sporothrix-like, sparsely produced. Conidia formed holoblastically from short undifferentiated branches of the vegetative hyphae. Conidia 2–3 × 1·5–2·5 μm, roughly ellipsoidal, hyaline, aseptate, rather thick-walled.

Teleomorph. Ascomata (120–) 160–300 μm diam, ± spherical, tending to aggregate in clusters with common walls. Neck absent, ostiole 30–65 μm diam. Peridium dark brown in transmitted light, sulphur-yellow becoming brownish pink in reflected light, composed of thick-walled textura intricata, tending in some isolates towards textura epidermoidea. Peridium covered with irregular hypha-like hairs to 3 μm diam, pale brown, often branched. Basal rhizoids poorly developed, dark pinkish brown, 2–3·5 μm thick, usually covered with a conspicuous brown gelatinous coat to 4 μm thick. *Periphyses* present, sometimes extruding from the ostiole for a short distance. *Asci* 48–78 × 7–11 μm, ± cylindrical, very thin-walled, without apical structures, evanescent at an early stage, 8-spored. *Ascospores* arranged ± uniseriately, (10–) 11–13 (–13·5) × 6–7·5 μm, widely fusiform to rhomboid, sometimes slightly inaequilateral, circular in transverse section, olivaceous to chestnut brown, rather thick-walled, aseptate, smooth, with a single terminal germ pore *ca* 0·75 μm diam.

Typification. India: Lucknow, isol. ex soil, undated ('post annum 1958'), J. N. Rai (IMI 82624 – holotype, ?BPI – istotype of *Achaetomium strumarium*).

Spain: Tenerife, isol. ex unknown source,

undated, G. Sörgel (IMI 73517 – holotype of *Chaetomium spinulosum*).

Egypt: S.W. Egypt, Nouvelle Vallée, 32 km S of Kharga-Beris oasis, isol. ex arid, somewhat saline soil, 1969, L. Faurel (PC 3252 – holotype of *Achaetomium cristalliferum*).

India: West Bengal, Kagh Island, isol. ex mud in mangrove swamp (pH 7·5), undated, collector unknown (?LWU – holotype of *Achaetomium brevisemum*).

Distribution. Egypt, Gambia, India, Israel, Kenya, Kuwait, Namibia, Nigeria, Pakistan, South Africa, Spain (Canary Islands), Zaire; Algeria fide von Arx (1985); Nepal fide Udagawa & Sugiyama (1982); Thailand fide Udagawa *et al.* (1979). There is a collection in IMI reputedly from Great Britain, but the locality information is very doubtful.

Illustrations. Chowdhery (1980: 481), Chowdhery & Rai (1980: 226), Locquin-Linard (1980: 237), Mukerji & Saxena (1974: 398), Papendorf & Jooste (1974: 212), Rai & Chowdhery (1974*a*: 31, 32), Rai *et al.* (1964: 695, 698).

Cultures examined: IMI 82624 (= CBS 333.67, IMI 136213, NHL A10898), from the holotype of *Achaetomium strumarium*. IMI 285673 (= CBS 770.81), from the holotype of *Achaetomium cristalliferum*.

India: Muzaffarpur, isol. ex *Trichosanthes dioica*, comm. 8 June 1971, S. S. Prasad 87 (IMI 158086). Israel: locality unknown, isol. ex gazelle dung, Dreyfuss (IMI 291478, = CBS 826.71, ETH 7864). Kenya: Amboseli: Tukai Lodge, isol. ex antelope dung, 17 Aug. 1966, R. F. Cain, H. D. Griffin & J. C. Krug (IMI 291757, = TRTC 66.1765i); Lake Amboseli, isol. ex zebra dung, 18 Aug. 1966, R. F. Cain, H. D. Griffin & J. C. Krug (IMI 291758, = TRTC 66.1768u). Namibia: unlocalized, isol. ex brown sand, comm. 29 Nov. 1984, collector unknown (IMI 291726, = CBS 303.72). Nigeria: unlocalized, isol. ex *Capsicum annuum*, comm. 13 Mar. 1984, M. H. Gumel (IMI 285217); unlocalized, isol. ex *Mangifera indica*, comm. 19 Mar. 1985, M. H. Gumel (IMI 294496). Pakistan: Lahore, isol. ex unknown source, S. Ahmad (IMI 291725, = CBS 186.73). South Africa: Transvaal, Kempton Park, isol. ex leaf of *Protea* sp., March 1972, M. C. Papendorf (IMI 291727, = CBS 543.72, PUCC 1175). Zaire: Ruwenzori Mountains, Stulhman Pass, isol. ex antelope dung, 24 July 1966, R. F. Cain, H. D. Griffin & J. C. Krug (IMI 291759, = TRTC 66.2787f).

Specimens examined: IMI 73517, holotype of *Chaetomium spinulosum*. Gambia: Jundum Exp. Stn, isol. ex ?*Arachis hypogaea* kernels, 12 Feb. 1965, G. A. Gilman 574 (IMI 112672). Great Britain(?): locality unknown, isol. ex unknown source, 11 Aug. 1964, M. N. Okafor 5 (IMI 108484). India: University of Allahabad, isol. ex *Gardenia florida* leaves, comm. 29 Apr. 1964, S. Chandra N2 (IMI 105631); Jaipur, isol. ex soil, comm. 31 July 1965, B. L. Mathur (IMI 114711); Varanasi, Benares Hindu University Agric. Farm, isol. ex grain field soil, 12 Oct. 1966, Lallan Givi 1 (IMI 123951); unlocalized, isol. ex *Trichosanthes dioica*, comm. 3 Aug. 1971, S. S. Prasad 120 (IMI 159303); Jabalpur, isol. ex grassland soil, comm. 13 Oct. 1971, P. D. Agrawal 186 (IMI 161640); Varanasi, isol. ex soil, 15 Apr. 1972, L. S. Srivastava 5 (IMI 170105); unlocalized, isol. ex unknown source, comm. 26 June 1973, V. R. Nath 953 (IMI 176775); Delhi, isol. ex *Ficus* bark, 8 Nov. 1973, G. Mehrotra DU/KGM 287 (IMI 183995); Udaipur University, isol. ex *Corchorus tridens*, comm. 26 Apr. 1974, H. C. Dube 54 (IMI 184212); Udaipur University, isol. ex *Gossypium* leaf, comm. 26 Apr. 1974, H. C. Dube 61 (IMI 184219); unlocalized, isol. ex *Gossypium hirsutum*, comm. 6 Nov. 1974, H. C. Dube 141 (IMI 188111); unlocalized, isol. ex musk melon, comm. 10 Sept. 1974, J. S. Chohan M2 (IMI 188165); unlocalized, isol. ex *Vitex negundo*, comm. 1 July 1975, K. S. Bilgrami UN26 (IMI 195082); Banaras University, isol. ex unknown source, comm. 6 Dec. 1975, R. S. Dwivedi 15 (IMI 199525); unlocalized, isol. ex unknown source, comm. 12 Feb. 1976, R. N. Tandon 11 (IMI 201047); unlocalized, isol. ex *Dolichos biflorus*, comm. 15 June 1976, K. S. Bilgrami (IMI 204846); unlocalized, isol. ex *Dolichos lablab*, comm. 15 June 1976, K. S. Bilgrami SOR1 (IMI 204857); Gwalior, isol. ex ravine soil, comm. 18 Mar. 1978, R. K. S. Chauhan 683 (IMI 226563); Punjab Agricultural University, isol. ex *Lycopersicon esculentum*, comm. 11 Aug. 1978, H. S. Khara XII (IMI 230751); Amritsar, isol. ex camel dung, 20 Apr. 1979, Mira Madan 16 (IMI 238472); Jobner: S. K. N. School of Agriculture, isol. ex *Vigna aconitifolia* seeds, comm. 19 May 1979, J. R. Mathur M5-1 (IMI 239261); Bhagalpur University, isol. ex soil, comm. 18 Mar. 1980, K. S. Bilgrami B26 (IMI 246704); Varanasi: Banaras Hindu University, isol. ex *Lens esculenta* seeds, comm. 12 Aug. 1980, Rajendra Prasad PL-21 (IMI 250770); Warangal: Kakatiya University, isol. ex *Citrus sinensis*, comm. 9 Mar. 1981, S. M. Reddy 1386 (IMI 256284); unlocalized, isol. ex *Solanum tuberosum*, 23 May 1981, Babu Singh Siradhana 4 (IMI 259653). Kuwait: unlocalized, isol. ex moist soils, comm. 1 Aug. 1975, A. F. Moustafa 3 (IMI 195655). Nigeria: Garia, isol. ex *Triticum* seeds, comm. 10 Feb. 1975, O. H. Giha 2040 (IMI 191432); unlocalized, isol. ex cigarettes, comm. 23 June 1976, V. W. Ogundero C14 (IMI 204918).

Chaetomium strumarium is a common and widely distributed species, being found throughout Africa and southern Asia on a very wide range of substrates. The species is similar to *C. luteum*, but can be distinguished by its pinkish colonies with ascomata tending to aggregate, and by its ascospores, which are slightly larger than those of *C. luteum* and which are ± rhomboidal (biconical) rather than limoniform and flattened. Occasional isolates of *C. strumarium* have relatively large inaequilateral spores, approaching *C. purpurascens* in character, but there remains a fairly well-defined division between the ascospore size ranges of the two species.

The type specimen of *Chaetomium spinulosum* is more or less identical to *C. strumarium*; no culture is extant. In all probability the species of

Achaetomium were excluded from consideration in Seth (1972)'s attempts to identify his fungus because of the widely held misconception that *Achaetomium* species were glabrous.

Achaetomium cristalliferum was described as new on the basis of having crystalline deposits on its ascomatal hairs, but these are not a constant feature, and are absent from the culture in IMI. These deposits are apparently the only way of distinguishing the taxon from *C. strumarium*.

Ranga Rao & Mukerji (1971*b*) have investigated the cytology of this species, and report a chromosome number of $n = 7$. According to them, the ascus becomes septate as the ascospores are delimited, but it seems much more likely that the apparent transverse walls in the ascus are simply concentrations of stain accumulating between the developing ascospores.

Achaetomium brevisemum was described in reasonable detail by Chowdhery & Rai (1980), but no material has been made available for study by other workers. From the information available, the taxon seems more or less identical to *C. strumarium*, though von Arx (1985) thought that it most probably belonged to *C. luteum*.

Udagawa *et al.* (1979) reported that extracts from *C. strumarium* were toxic to HeLa cells (a human cancer tissue culture). The following compounds have been identified from *C. strumarium* (as *Achaetomium cristalliferum*; Turner & Aldridge, 1983); achaetolide; achaetolidone; isosclerone, 4,8-dihydroxytetralone; Me, 8-hydroxyl, 6-dimethoxy-3-methylanthraquinone and 1-hydroxy-6,8-dimethoxy-3-methyl-anthraquinone, 8-*O*-methylphyscion.

CHAETOMIUM SULPHUREUM Sörgel ex Seth, *Nova Hedwigia Beih.* **37**: 108 (*1970*) (1972). (Fig. 13)
Achaetomium macrocarpum J. N. Rai & H. J. Chowdhery, *Kavaka* **1**: 32 (*1973*) (1974) (as '*macrocarpus*').
?*A. sulphureum* Rai & Chowdhery, *J. Indian bot. Soc.* **52**: 310 (*1973*) (1974) (as '*sulphureus*').

Cultures. On CMA at 25° colonies > 85 mm diam after 7 d (*ca* 70 mm after 5 d). Submerged mycelium hyaline, inconspicuous, radiating from the centre. Aerial mycelium absent. Ascomata developing after about 10 d, scattered. On MA at 25° colonies > 85 mm diam after 7 d (*ca* 75 mm after 5 d), submerged mycelium not visible. Aerial mycelium copious, somewhat floccose, hyaline in the centre, with a conspicuous yellow (3A5–6) ring towards the edge of the plate. Occasional ascomatal initials present after about 14 d. On PCA at 25° colonies > 85 mm diam after 7 d (65–70 mm after 5 d). Submerged mycelium hyaline, well-developed. Aerial mycelium fairly sparse, hyaline, lanose. Ascomata developing abundantly in the centre of the plate after 9–10 d, giving the centre a yellow-grey metallic appearance.

Mycelium. Hyphae 1–6 μm diam, hyaline to brown, the wider brown hyphae with a conspicuous granular encrustation 1–1·5 μm thick of pale brown material, the hyphae frequently branched and septate.

Anamorph. One *Botryotrichum*-like resting spore was seen attached to a hyaline hypha. It was 6 μm diam, globose, very pale brown and strongly pustulate-verrucose.

Teleomorph. Ascomata 180–350 × 170–300 μm diam, globose to broadly ellipsoidal, neck absent, with an ostiole 50–80 μm wide developing at a late stage. Peridium dark olivaceous brown, composed of relatively thick-walled textura intricata with hyphae 2–4 μm diam. Terminal hairs consisting only of poorly developed and inconspicuous hyaline hyphae 1–1·5 μm diam, sometimes branched and irregularly curved. Lateral hairs absent, though the terminal hairs emanate from a wide region around the ostiole. Basal rhizoids 2·5–4 μm diam, well-developed, dark brown, encrusted. *Periphyses* present but inconspicuous, sometimes extruded from the ostiole for a short distance. *Asci* 50–65 × 7·5–10 μm (measured with immature ascospores), cylindrical, very thin-walled, without apical structures, evanescent at an early stage, 8-spored. *Ascospores* 12–14·5 (–17·5) × 7–8·5 (–10) μm, widely fusiform, circular in transverse section, hyaline when released but becoming dark olivaceous brown, with a single apical germ pore *ca* 1 μm diam, sometimes darkened around the pore, relatively thick-walled, without ornamentation.

Typification. Spain: Canary Islands, Tenerife, isol. ex unknown source, undated, G. Sörgel (IMI 73518 – holotype of *Chaetomium sulphureum*).

India: Lucknow, isol. ex 'Usar' soil (pH 9·0), July 1971, J. N. Rai & H. J. Chowdhery (?LWU – holotype, IMI 189062 – isotype of *Achaetomium macrocarpum*).

India: Lucknow, isol. ex 'Usar' soil (pH 9·0), July 1971, collector unknown (?LWU – holotype of *Achaetomium sulphureum*).

Distribution. Spain (Canary Islands), India.

Illustrations. Chowdhery (1980: 477), Rai & Chowdhery (1974*a*: 30, 32; 1974*b*: 311), Seth (1972: fig. 69).

Cultures examined: IMI 73518, from the holotype of *Chaetomium sulphureum*.

Specimens examined: IMI 189062, isotype of *Achaetomium macrocarpum*. India: Ludhiana, isol. ex *Solanum tuberosum*, comm. 24 Dec. 1979, H. Singh (IMI 244613).

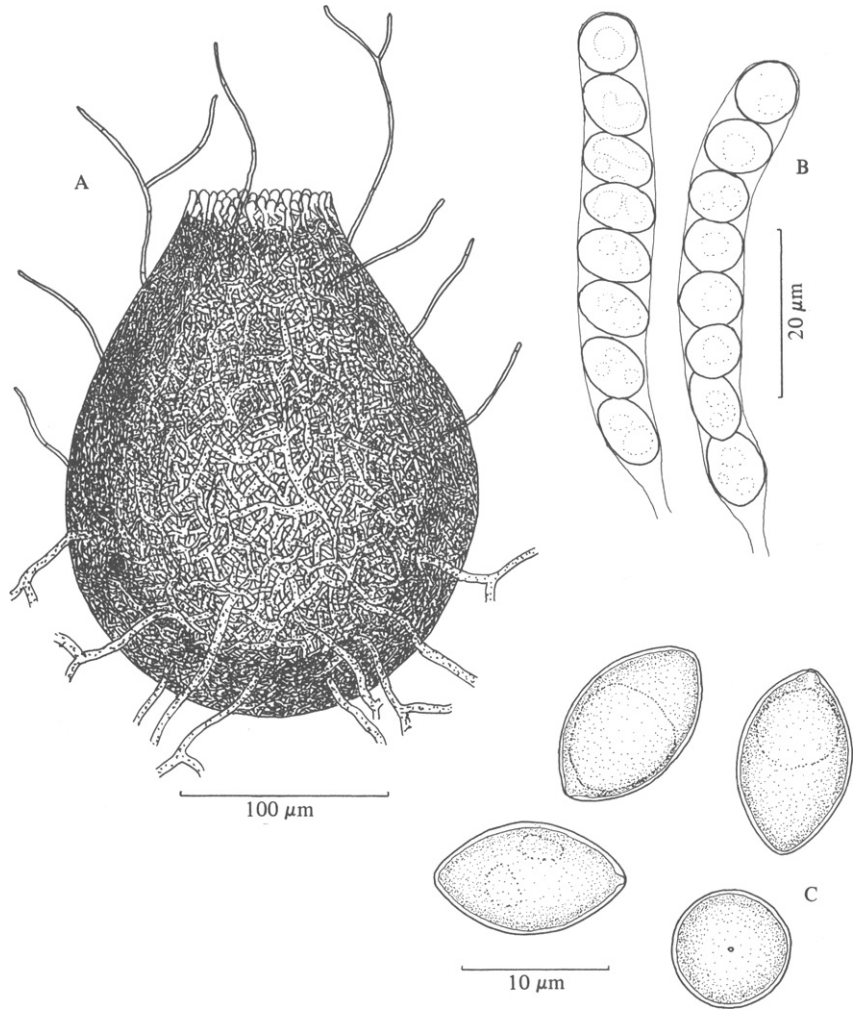

Fig. 13. *Chaetomium sulphureum* (drawn from the isotype of *Achaetomium macrocarpum*). (A) Ascoma; (B) asci; (C) ascospores.

Chaetomium sulphureum is one of a group of rather similar species which also includes *C. luteum*, *C. strumarium* and *C. virescens*. *C. sulphureum* has slightly larger ascospores than these species, and they are regularly widely fusiform rather than flattened limoniform in *C. luteum* or rhombic in *C. strumarium*. *C. sulphureum* is morphologically very similar to *C. virescens* var. *thielavioideum* (see below), but differs in its cylindrical rather than clavate asci, its ascospores which are thicker walled and more widely fusiform, and in a number of its colony characteristics.

Chaetomium sulphureum and *Achaetomium macrocarpum* seem identical to judge from the material available, as has been suggested by von Arx (1985). *Achaetomium sulphureum* (not nomenclaturally connected with *C. sulphureum*) is certainly similar to that species, but no type material has been made available to confirm or refute this hypothesis. The colony characteristics reported for *A. sulphureum* differ from those found in *C. sulphureum* during the present study, but the growth conditions were no doubt different. *A. sulphureum* was reported as having slightly larger ascospores (15·8–16 × 8·9–9·6 μm). IMI 244613 has ascospores corresponding to these figures, and the ascomata appear to be

slightly yellowish. However, the specimen consists only of a dried culture with a few ascomata in a considerably over-mature condition, and its cultural characters of course could not be properly assessed. More material (in a living state) is necessary before the taxonomic position of *Achaetomium sulphureum* can be unequivocally decided.

Achaetomium macrocarpum was described by Rai & Chowdhery (1974*b*) as having very large ascomata, measuring 504–720 × 288–360 μm. These figures are much larger than those of the isotype in IMI, and do not agree with those implied for the species in the drawing in Chowdhery (1980). It seems that either an error of calibration was made, or that the original authors measured a group of ascomata instead of a single fruit body.

Chaetomium sulphureum is probably a rare species, with only the one doubtful collection known apart from the type and that of *A. macrocarpum*. The known distribution of India and the Canary Islands suggests that it may be considerably more widespread than is known at present.

CHAETOMIUM UNIAPICULATUM (J. N. Rai & H. J. Chowdhery) v. Arx, *Proc. Indian Acad. Sci. (Pl. Sci.)* **94**: 345 (1985).

Achaetomium uniapiculatum Rai & Chowdhery, *Curr. Sci.* **40**: 412 (1971).

Chaetomium amygdalisporum Udagawa & Muroi, *Trans. mycol. Soc. Japan* **22**: 13 (1981).

C. subapiculatum Gopal & Lodha, *Trans. mycol. Soc. Japan* **23**: 261 (1982).

Cultures. On CMA at 25° colonies 20–25 mm diam after 7 d. Submerged mycelium well developed, hyaline, much-branched. Aerial mycelium almost absent. Ascomata developing after 7–14 d, scattered to abundant, but ascospore production almost nil. On MA at 25° colonies 25–30 mm diam after 7 d. Submerged mycelium obscured. Aerial mycelium well developed, white to pale grey, floccose. Ascomata developing sparsely to abundantly after about 7 d, but ascospore production very sparse. On PCA at 25° colonies 30–35 mm diam after 7 d. Submerged mycelium well developed, hyaline, much-branched. Aerial mycelium sparse but sometimes well developed in the centre of the plate, white to pale blue-grey (24B1–C2), lanose. Ascomata developing sparsely to abundantly over the agar surface, but ascospore production poor or nil.

Mycelium. Hyphae 0·5–3 μm diam, hyaline, septate, often branched, smooth-walled, sometimes funiculose.

Anamorph. *Acremonium*-like, abundantly produced. Conidia formed at the end of rather narrow fertile hyphae 5–30 × 0·5–1·5 μm in size (conidiogenous cells not morphologically delimited from the vegetative mycelium). Conidia 2–3·5 × *ca* 1 μm, ellipsoidal to cylindrical, sometimes curved, hyaline, aseptate, smooth, aggregating in gummy masses.

Teleomorph. *Ascomata* 250–400 × 140–320 μm, ellipsoidal to pyriform, neck absent to 30 μm long, ostiole up to 150 μm wide. Peridium composed of dark brown almost opaque textura intricata with hyphae to 5 μm wide. Ascomatal hairs rather variably developed, to 500 μm long, 1–2 μm wide, often weakly coiled, pale grey in reflected light, inconspicuously ornamented. Basal rhizoids to 5 μm thick, with pinkish exudates. *Periphyses* present, hyaline, often extruded from the ostiole for some distance. *Asci* 75–110 × 10–14 μm, cylindrical, short-stalked, very thin-walled, without apical structures, evanescent at an early stage, 8-spored. *Ascospores* 15–20 × (10–) 11·5–15 μm, usually widely ovoid but tending to be irregular, with some ellipsoidal or fusiform-cylindrical, dark brown, aseptate, smooth, with a single germ pore *ca* 1 μm diam at the acute apex.

Typification. India: Indore, isol. ex garden soil (pH 7·0), June 1970, collector unknown (?LWU – holotype, IMI 189063 – isotype of *Achaetomium uniapiculatum*).

Japan: Gunma, Kiryu-shi, isol. ex soil, 3 May 1978, S. Udagawa (NHL 2874 – holotype of *Chaetomium amygdalisporum*).

India: Haryana, Hisar, isol. ex horse dung, 26 Apr. 1979, K. Gopal (CBS 519.80 – holotype, HAU 70 – isotype of *Chaetomium subapiculatum*).

Distribution. India, Japan.

Illustrations. Chowdhery (1980: 481), Gopal & Lodha (1982: 261, 268), Rai & Chowdhery (1971: 412; 1974*a*: 31, 32, 34), Udagawa & Muroi (1981: 14, 23).

Cultures examined: IMI 291735 (= CBS 672.82, NHL 2874), from the holotype of *Chaetomium amygdalisporum*. IMI 293980 (= CBS 519·80, HAU 70), from the holotype of *Chaetomium subapiculatum*.

Specimens examined: IMI 189063, isotype of *Achaetomium uniapiculatum*. India: Warangal, Kakatiya University, isol. ex *Trichosanthes* sp., comm. 21 Feb. 1978, S. M. Reddy ASCO 32 (IMI 225777).

Chaetomium uniapiculatum is apparently a rather rare species, known only from three Indian collections and one from Japan. The species has not been investigated in exhaustive detail due to the lack of good material, the dried specimens in IMI being of rather poor quality, and the cultures available producing few or no ascospores. However, as far as can be ascertained there is no

significant difference between the three taxa listed above as synonyms. *C. uniapiculatum* proved to be particularly difficult to place in a genus, as while its ascospores are nearly as dark brown as those of *Achaetomium globosum*, it has well-developed periphyses and fairly conspicuous ascomatal hairs. The opinion of von Arx (1985), who combined *Achaetomium uniapiculatum* into *Chaetomium*, is tentatively followed here.

Udagawa & Muroi (1981) contrasted *C. amygdalisporum* with *C. mollicellum* L. Ames (1963), a synonym of *C. brasiliense* Batista & Pontual fide von Arx *et al.* (in press). *C. amygdalisporum* differed from this species most notably in its ascospores, which are much smaller, and in the characters of its ascomatal hairs. It is interesting to note that *C. amygdalisporum* was reported to produce the secondary metabolite mollicellin G (Sekita *et al.*, 1981), which has also been found in *C. mollicellum* by Stark *et al.* (1978). *C. amygdalisporum* also produced neocochliodinol, an isomer of cochliodinol, a purple pigment previously found in *C. cochliodes* Palliser and *C. globosum* Kunze.

Chaetomium subapiculatum Gopal & Lodha (1982) was contrasted by the authors with *C. amygdalisporum*, but the differences cited between the two taxa (width of ascomatal hairs, length of ascospores, growth rate, tolerance to high temperatures and presence/absence of an anamorph) either could not be demonstrated in the material available or are probably insignificant at the species level.

Rai & Chowdhery (1973) investigated the cytology and ascomatal development of *C. uniapiculatum*, and reported a chromosome number of $n = 5$.

KEY TO VARIETIES

1. Ascospores 10·5–13·5 – 16·5) μm long, rather irregular in shape but many of them rhomboidal . var. *virescens*
1. Ascospores 12–16·5 μm long, fusiform, ± regular in shape . . . . . var. *thielavioideum*

CHAETOMIUM VIRESCENS (v. Arx) Udagawa, *Trans. mycol. Soc. Japan* **21**: 34 (1980).

Achaetomiella virescens v. Arx, *Genera of Fungi Sporulating in Pure Culture*, p. 247 (1970).

var. VIRESCENS (Figs 10–11, 14)

Chaetomium cellulolyticum Chahal & D. Hawksw., *Mycologia* **68**: 602 (1976).

Cultures. On CMA at 25° colonies 35–45 mm diam after 7 d. Submerged mycelium hyaline, very inconspicuous. Aerial mycelium absent. Ascomata developing abundantly after about 7 d, black in reflected light, scattered over the entire agar surface. On MA at 25° colonies 40–45 mm diam after 7 d. Submerged mycelium inconspicuous, hyaline. Aerial mycelium abundant at the centre of the plate, hyaline, floccose. Ascomata developing abundantly over the entire agar surface after 5–6 d, black in reflected light. Lime-green soluble pigments produced after about 5 d. On PCA at 25° colonies 30–40 mm diam after 7 d. Submerged mycelium inconspicuous, hyaline. Aerial mycelium variably developed, present especially at the centre of the plate, hyaline, wispy to floccose. Ascomata developing abundantly over the entire agar surface after about 5 d, black in reflected light. Green soluble pigments produced after about 2 d.

Mycelium. Poorly developed, except on MA. Hyphae hyaline, septate, frequently branched, 1–3 μm diam, smooth-walled.

Anamorph. A number of *Acremonium*-like conidia (2–3 × 0·75–1 μm, hyaline, ellipsoidal, aseptate) were seen in one dried culture (IMI 224521); it is not clear whether this is evidence of an anamorph or a contaminant.

Teleomorph. *Ascomata* 110–250 (–300) × 100–200 μm, globose to ellipsoidal, neck absent, with an ostiole 20–30 μm diam. Peridium greenish to dark brown, composed of rather irregular relatively thick-walled textura angularis with cells 3–8 μm diam; up to 5 μm thick. Whole surface of peridium covered with pale brown hairs 30–100 × 2–3 μm in size, gradually tapered, the base sometimes slightly swollen, weakly verrucose. *Periphyses* present, often extruded from the ostiole for a short distance. *Asci* 25–40 × 9–14 μm, clavate, relatively short-stalked, very thin-walled, without apical structures, evanescent at an early stage, 8-spored. *Ascospores* arranged biseriately, 10·5–13·5 (–16·5) × 5·5–7 (–8) × (4·5–) 5–6 μm, rather irregular in shape, many rhomboidal-fusiform, some relatively elongate-oblong to fusiform, both widely elliptical in TS, mid-brown, aseptate, with one or two apical germ pores *ca* 0·5 μm diam, the opposite apex of those spores with one germ pore being thinned.

Typification. Pakistan: Lahore, isol. ex soil, 1968, collector unknown (CBS 148.68 – holotype of *Achaetomiella virescens*).

India: Punjab, Ludhiana, isol. ex fermenting wheat straw, comm. 3 July, D. S. Chahal (IMI 185905 – holotype, ATCC 32319, BPI, CBS

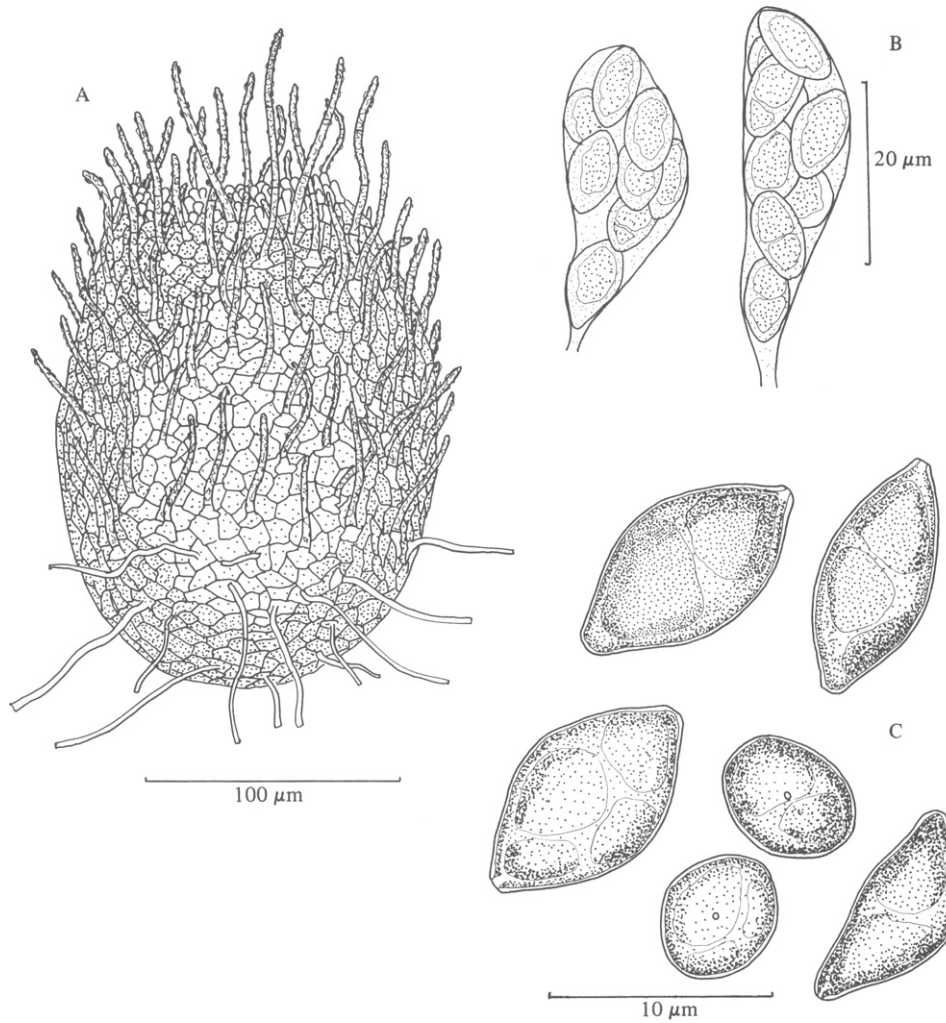

Fig. 14. *Chaetomium virescens* (drawn from the holotype). (A) Ascoma; (B) asci; (C) ascospores (note the variation in shape, and the shape in transverse section).

547.75, DAOM, H, K, LE, UPS – isotypes of *Chaetomium cellulolyticum*).

Distribution. India, Pakistan, Thailand.

Illustrations. Von Arx (1970: frontispiece), Chahal & Hawksworth (1976: 604), Ellis (1981: 767), Hawksworth & Wells (1973: pl. 6D), Udagawa (1980: 23e).

Cultures examined: IMI 159035 (= ATCC 32393, CBS 148.68, IMI 136212), from the holotype of *Achaetomiella virescens*. IMI 185905 (= ATCC 32319, CBS 547.75), from the holotype of *Chaetomium cellulolyticum*. Thailand: Prachinburi, isol. ex soil, 11 Sep. 1977, S. Udagawa (IMI 291733, = CBS 622.80, NHL 2829).

Specimens examined: India: Jabalpur, isol. ex grassland soil, comm. 13 Oct. 1971, P. D. Agrawal 160 (IMI 161617); Jabalpur, isol. ex grassland soil, comm. 5 Sep. 1972, P. D. Agrawal 252 (IMI 169057); Jabalpur, Government Science College, isol. ex unknown source, comm. 11 Jan. 1978, D. P. Tiwari N94 (IMI 224521).

Chaetomium virescens is a well-defined species, with a number of interesting characteristics. It is morphologically similar to the other species placed in *Achaetomiella* (see *Chaetomium megasporum*, p. 62), but differs from this taxon by the ascospore size and shape (10·5–16·5 μm and irregular in *C. virescens*, 16–27 μm and fusiform in *C. megasporum*). The asci and ascospores of *C. virescens* are rather

similar to those of *C. luteum* (p. 60), but this species has much thicker-walled ascomata with pale yellow tomentose, rather than brown ± straight, hairs. *C. virescens* has some similarities with *C. gracile* Udagawa (1960), but this species has fusiform ascospores and much thicker dark ascomatal hairs.

Chaetomium cellulolyticum Chahal & D. Hawksw., the basis for much interest in the field of biotechnology (see below), seems to be more or less identical to *C. virescens*. It was contrasted with this taxon by Chahal & Hawksworth (1976) who cited differences in the pigmentation of the ascomata as the reason for treating it as a new species. The pigmentation, however, varies with the age of the culture and also with the culture medium. Studies on the secondary metabolites of *Chaetomium* (Udagawa, 1984) showed that *C. cellulolyticum* and *C. virescens* produced identical compounds.

The ascospores of *C. virescens* var. *virescens* exhibit two unusual features. The first is that the number of germ pores per ascospore varies, certainly within the ascoma and possibly within the ascus; some have one and some two pores. Variation of this nature is most unusual in the genus *Chaetomium*; it is known otherwise only in *C. variosporum* (Udagawa & Horie, 1973) and *C. gracile* (von Arx *et al.*, in press). In *C. virescens*, those ascospores with a single germ pore have a thinner wall at the opposite apex from the germ pore, suggesting that the variation may be a matter of degree of development (and therefore probably environmentally induced) rather than directly genetically controlled. No study has been carried out on spore germination to decide whether both germ pores, when present, are functional.

The second unusual feature of the ascospores of *C. virescens* var. *virescens* is the variation in shape. Most ascospores seem to be either rhomboidal or roughly fusiform, with relatively few intermediates, and it is possible that there is a genetically controlled dimorphism of ascospore shape. It appears that the two morphs are present within individual ascomata, but that individual asci contain only one morph. However, a number of isolates would have to be examined using sophisticated mathematical techniques to demonstrate this dimorphism conclusively, and that work falls outside the remit of this investigation. No explanation for this phenomenon in terms of adaptive value can be advanced, though it is conceivable that they may germinate under different conditions. More work is needed.

Although this fungus is relatively infrequently encountered in isolations, a considerable amount is known about it. Its cytology and development have been investigated by Rai *et al.* (1979), who found that it had a chromosome number of $n = 6$ and normally uninucleate ascospores.

Chaetomium virescens var. *virescens* has been examined in detail for secondary metabolites, and several highly toxic compounds have been isolated from it (Ohtsubo, 1980; Sekita *et al.*, 1980, 1981; Udagawa, 1984; Udagawa *et al.*, 1979 as *Achaetomium* sp.). Chemicals identified include chaetocin, chaetochromin, eugenitin, sterigmatocystin, *O*-methyl sterigmatocystin and ergosterol; these cause cytotoxicity to HeLa cells, and such effects as delayed liver injuries, bone marrow aplasia and atrophy of lymphatic tissues in mice (Ito & Ohtsubo, 1982).

Strains of this fungus also have very considerable cellulolytic capability, and are being used in several industrial processes (mostly under the synonym *C. cellulolyticum*) converting waste materials into single-cell protein (SCP), mainly for use as animal feed. Sources of cellulose include sawdust and wood pulp wastes (Chahal *et al.*, 1981*a*; Moo-Young *et al.*, 1977, 1978; Pamment *et al.*, 1978*a*, *b*, 1979); wheat straw (Chahal *et al.*, 1977; Viesturs *et al.*, 1981); cattle and pig manure (Moo-Young & Chahal, 1980; Moo-Young *et al.*, 1981*b*); groundnut shells (Sedha *et al.*, 1982) and sag (*Brassica* sp.) waste (Ghai *et al.*, 1979). In view of the potential for injury due to the toxic metabolites produced by this fungus, extreme caution is needed when using it as part of a food production process.

var. **thielavioideum** (Chen) P. Cannon, comb. et stat.nov.

Chaetomium thielavioideum Chen, *Acta Microbiol. Sin.* **13**: 125 (1973).

Cultures. Identical to var. *virescens*, with similar growth rates. *Ascomata* as var. *virescens*, but ascospores usually slightly larger (12–16·5 × 5·5–7 μm), fusiform-cylindrical and roughly regular in shape, usually with one terminal germ pore.

Typification. China: Peking, isol. ex soil, 27 May 1959, K. T. Chen 331 (Institute of Microbiology, Academia Sinica, Peking – holotype of *Chaetomium thielavioideum*).

Distribution. China, Hong Kong, Thailand, Japan and Malaysia (Udagawa, 1980).

Illustrations. Chen (1973: 125), Udagawa (1980: 23a–d).

Cultures examined: China: Peking, isol. ex soil, undated, K. T. Chen 3-2775 (IMI 240609, authentic for the name *Chaetomium thielavioideum*). Hong Kong: New Territories, Little Tao Tung Shan Shatin, isol. ex soil, 3 Jan. 1981, K. Yung (IMI 291754, = TRTC 48938). Thailand: Nakhornratsima, isol. ex soil, 12 Dec. 1974, collector not known (IMI 240608, = CBS 623.80, IMI 291734, NHL 2827).

C. virescens var. *thielavioideum* is very similar to var. *virescens*, differing only on some ascospore characters. Udagawa (1980) regarded the two taxa as synonymous, though he noted the difference in ascospore shape. Von Arx *et al.* (in press) regard var. *thielavioideum* as a version of var. *virescens* having larger ascomata with distinct hairs and uniporate ascospores.

Studies on the toxic metabolites of *C. virescens* var. *thielavioideum* (Udagawa, 1980; Udagawa *et al.*, 1979) show that identical carcinogenic compounds were produced in this variety as in var. *virescens*.

The ascospores of var. *thielavioideum* are similar to the fusiform-spored morph of var. *virescens*, and it may be that var. *thielavioideum* simply represents a version of *C. virescens* with only one ascospore morph.

I have received valuable assistance from many sources during these investigations. First, I would like to thank Dr J. A. von Arx (CBS, Baarn) for many useful comments on the relationships of the species I studied, and for access to unpublished manuscripts on *Achaetomium* and *Chaetomium*. Useful suggestions were also made by Professor D. L. Hawksworth (CMI), who originally suggested the study, Dr J. C. Krug (University of Toronto) and Dr S. Udagawa (National Institute of Hygienic Sciences, Tokyo).

I received cultures from a number of collections during this study; my thanks to Dr M. A. A. Schipper (CBS), Dr S. Udagawa (NHL), Dr J. C. Krug (TRTC), Dr K. Furuya (Sankyo Co., Tokyo) and Miss M. Basu (Allahabad).

Finally, it is a pleasure to acknowledge the technical assistance that I had throughout the investigations. Miss T. S. Caine most capably prepared all the cultures for examination, and carried out the growth rate tests, and help in the photographic work was provided by Miss G. Godwin.

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(*Received for publication 2 January 1986*)