

A SYNOPTIC KEY TO SPECIES OF THE *ASPERGILLUS NIDULELLUS*-
EMERICELLA ASSEMBLAGE COMMON TO EGYPT

M.A. ISMAIL, M.A. ABDEL-SATER and A.A. ZOHRI

Botany Department, Faculty of Science,
Assiut University, Egypt

Abstract

A large number of isolates belonging to *Aspergillus nidulellus*-*Emericella* taxa were commonly isolated from a variety of substrates such as soil, spices, foodstuffs, seeds, grains, dust, air, pollen grains, etc. The number of isolates investigated for each species was as follows: *Emericella acristata* (3 isolates); *E. aurantiobrunnea* (2), *E. bicolor* (1), *E. dentata* (12), *Aspergillus egyptiacus* (6), *E. nidulans* (5), *E. parvathecica* (1), *E. quadrilineata* (44), *E. rugulosa* (8), *E. striata* (2), *E. sublata* (1), *E. unguis* (2) and *E. varicolor* (2). A synoptic key for the identification of these thirteen taxa is presented. The key uses definitive and readily observable features: colony appearance with specified growth conditions (using two cultural media and two incubation temperatures), stipe length, ascospore morphology and cleistothecia diameter. Brief descriptions are made for treated taxa. As no epithets are available for three anamorphs (treated here), we propose: *Aspergillus aurantiobrunneulus* st. nov., *Aspergillus dentatulus* st. nov. and *Aspergillus acristatulus* st. nov. for *Emericella aurantiobrunnea*, *E. dentata* and *E. acristata*, respectively.

Introduction

When Micheli (1729) introduced *Aspergillus* for anamorphic fungi, he also described taxa under the generic name *Eurotium* (The teleomorph of *Aspergillus reptans*). Subsequently other teleomorphs of *Aspergillus* species were described such as *Emericella* was introduced by Berkeley & Broome (1857) to accommodate *A. stellifer*. Benjamin (1955) compared the teleomorphs of *Aspergillus* taxa and on the basis of differences in cleistothecial development he selected the previously published generic names *Eurotium* Link (1809) for the *A. glaucus* group, *Emericella* Berkeley & Broome (1857) for *A. nidulellus* group and *Sartorya* Vuillemin (1927) for *A. fumigatus* group. Raper & Fennell (1965) considered that the use of different generic names for teleomorphs served no useful purpose, but Malloch & Cain (1972a) accepted the generic name *Emericella* for the

teleomorph of the *A. nidulellus* group and also they (1972a,b) introduced several new generic names for the other teleomorphs of different *Aspergillus* groups. Also Malloch & Cain (1972a, 1973) adopted the family name Trichocomaceae *E. Fischer* (Nat. Pflanzenfam. 1 (1): 310.1897) for cleistothecial Ascomycetes with *Aspergillus*, *Paecilomyces* and *Penicillium* imperfect states. However, Von Arx (1987) included *Emericella* in the order Eurotiales and the Family Eurotiaceae Clem. & Shear, (Gen. Fung. P. 50, 1931) stating that the Eurotiaceae are characterized by equally bivalvate, often saturn-shaped and ornamented ascospores and by ascoma with a well-developed peridium.

Emericella Berkeley & Broome, 1857, Berkeley's, Introduction to cryptogamic Botany, p. 340-341.
Type species: *E. variegata* Berkeley & Broome, 1857, Berkeley's Introduction to Cryptogamic Botany, p. 340-341.

Description: *Emericella* is characterized by ascocarps embedded in dense masses of thick-walled Hülle cells. The ascocarps globose, yellowish to red occurring singly or in groups. Asci irregularly disposed, subglobose to globose, evanescent. Ascospores bivalvate, orange to purple red or blue violet, smooth or roughened on the faces. Conidial stage *Aspergillus* with conidiophores bearing phialides on metulae. Hülle cells was considered to be the most significant characteristic of *Emericella* (Malloch & Cain 1972b).

Raper & Fennell (1965) discussed thoroughly the *Aspergillus nidulellus* group providing a dichotomous key to species and full descriptions for 23 taxa. Christensen & Raper (1978) included 7 new species described since 1965 (Baghdadi 1968, Mehrotra & Prasad 1969, Moubasher & Moustafa 1972, Samson & Mouchacca 1974, 1975, Christensen et al. 1978) in their synoptic key for the identification of the 30 taxa. *Aspergillus mellinus* described by Novobranova (1972) was considered to be indistinguishable from *A. unguis* (Samson 1979, Christensen & States 1982). *Emericella nivea* that was firstly described by Wiley & Simmons (1973) as the ascospore stage of *A. niveus* was rejected as a member of *Emericella* (Christensen & Raper 1978, Samson 1979) and included in the genus *Fennellia* (Samson 1979) because of the hyaline to pale yellow ascospores, elongate Hülle cells and white to buff heads. Also, Christensen & Raper (1978) have omitted *A. speluneus*, *A. caespitosus* and *A. silvaticus* from Raper & Fennell (1965)'s *A. nidulans* group. However, Kozakiewicz (1989) placed *A. silvaticus* in her new species group (*A. deflectus* group) and accepted *A. speluneus* in *A. versicolor* group and she believed that *A. caespitosus* is better placed in *A. nidulans* group. Horie (1980) published a beautiful scanning electron photomicrographs showing ascospore ornamentation in 22 taxa belonging to this assemblage together with certain colony features making a synoptic key for 26 (*Fennellia nivea* was included) taxa: the 21

ascosporic taxa included in Christensen & Raper (1978) and 4 newly described by Udagawa & Horie (1976), Horie (1978, 1979) and Udagawa & Muroi (1979). Christensen & States (1982) described a new *Emericella* species and revised their synoptic key to accommodate the 4 new species described since 1978. This key included 34 taxa (27 ascosporic and 7 nonascosporic). Since 1982, 4 new species have been described (3 ascosporic: *E. undulata* Kong & Qi 1986, *E. falconensis* Horie et al. 1989, *E. similis* Horie et al. 1990; and a non-ascosporic species *A. subunguis* Wadhvani et al. 1984). Thus, the assemblage now includes 38 (or 39) taxa (30 belonging to *Emericella* and 8 with *Aspergillus* anamorphs only or (9) if the opinion of Kozakiewicz (1989) that *A. caespitosus* is better placed in *A. nidulans* group, was considered).

Materials and Methods

Eighty-nine isolates of *Aspergillus nidulellus*-*Emericella* taxa commonly isolated from Egypt were investigated. For identification, isolates should be grown on Czapek Dox agar and 10% NaCl-Malt extract agar at 25°C and on Czapek Dox agar at 40°C in dark for 7 days. For cleistothecial maturation in some species, incubation for longer periods (more than 14 days) may be required. To use the synoptic key designed herein for the common Egyptian taxa, follow the method of either Korf (1972) or Christensen & Raper (1978). The virtues of a synoptic key as pointed out by Korf (1972) include (1) ease to entry, one begins at any point; (2) flexibility; the system is suited to modification and expansion by addition; (3) a means for accommodating disc-repancies.

The taxa treated in the present synoptic key are listed alphabetically in table (1). Before assuming that a selected name is correct for an unknown isolate, the user should compare salient features against both the brief descriptions given here (in the Brief Descriptions section of this paper) and the full description of the candidate taxon found in Raper & Fennell (1965) and the other publication appeared for new taxa of this assemblage since 1965 up to now.

Table 1: Alphabetical list of *Aspergillus nidulellus*-*Emericella* taxa treated in this study.

1-	<i>Emericella acristata</i> (Fennell & Raper) Horie
2-	<i>E. aurantio-brunnea</i> (Atkins, Hindson & Russell) Malloch & Cain
3-	<i>E. bicolor</i> Christensen & States
4-	<i>E. dentata</i> (Sandhu & Sandhu) Horie
5-	<i>Aspergillus egyptiacus</i> Moubasher & Moustafa
6-	<i>E. nidulans</i> (Eidam) Vuillemin
7-	<i>E. parvathecica</i> (Raper & Fennell) Malloch & Cain
8-	<i>E. quadrilineata</i> (Thom & Raper) C.R. Benjamin
9-	<i>E. rugulosa</i> (Thom & Raper) C.R. Benjamin
10-	<i>E. striata</i> (Rai, Tewari & Mukerji) Malloch & Cain
11-	<i>E. sublata</i> Horie
12-	<i>E. unguis</i> Emile-Weil & Gaudin
13-	<i>E. varicolor</i> Berkeley & Broome

Synoptic key to species treated
Colony features

- 1 - Restricted growth on Czapek agar: colony diam less than 20 mm after 7 days at 25°C 4, 5, 9, 13
Growth not restricted on Czapek agar: colony diam more than 20 mm 1, 2, 3, 4, 6, 7, 8, 10, 11, 12, 13
- 2 - Colony diam after incubation on Czapek agar at 40°C for 7 days:
No growth 3
Diam less than 25 mm 5, 9, 13
Diam from 25-40 mm 4, 6, 7, 8, 12
Diam more than 40 mm 1, 2, 6, 8, 10, 11
- 3 - Colony diam after incubation on 10% NaCl-MA at 25°C for 7 days:
Diam less than 25 mm 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13
Diam more than 25 mm 1, 5, 6, 8, 10, 11
- 4 - Colony colour on Czapek agar at 25°C:
- Gray to yellowish gray or grayish yellow 5
- Grass green-dark green 6, 7, 9, 11, 12
- Light yellow-beige 1, 3, 4, 6, 8, 9, 10
- Orange white, pale orange or orange gray to olive 2, 8
- Grayish yellow, grayish green, olive to olive brown 4, 8, 13
- 5 - Colony reverse on Czapek agar at 25°C:
- Grayish yellow-yellowish gray 5
- Grayish red, grayish brown to dark brown 1, 4, 6, 7, 8, 9, 11, 12

- Orange, brownish orange to deep brown 1, 2, 3, 4, 6, 8, 9, 10
- Light yellow to olive brown 13

6 Colony reverse diffusible on Czapek agar at 25°C
2, 3, 6, 8, 9, 12
Colony reverse not diffusible
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13

7 - Exudate colourless on Czapek agar at 25°C
1, 2, 4, 5, 6, 7, 8, 9, 10, 13
Exudate dark brown 2
Exudate orange white 9
Exudate not produced 3, 4, 8, 11, 12

8 - Colony profile raised on Czapek agar at 25°C
1, 2, 3, 4, 6, 8, 10, 13
Colony profile raised and lobed 4, 9
Colony profile flat 5, 11, 12
Colony profile spreading 1, 6, 7, 8

9 - Colony profile raised on Czapek agar at 40°C
4, 5, 9, 13
Colony profile spreading
1, 2, 4, 6, 7, 8, 9, 10, 11, 12

10- Sectors produced on Czapek agar at 25°C
1, 2, 3, 4, 6, 7, 8, 10
Sectors not produced
1, 2, 4, 5, 6, 8, 9, 11, 12, 13

11- Sectors produced on Czapek agar at 40°C
1, 2, 4, 7, 8, 9, 10, 11, 13
Sectors not produced
1, 2, 4, 5, 6, 8, 9, 10, 12, 13

Microscopic measurements

12- Cleistothecia diam less than 200 μm 7, 11
Cleistothecia diam 200 μm or more
1, 2, 3, 4, 6, 8, 9, 10, 13
Cleistothecia not produced 5, 12

13- Hülle cells produced
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13
Hülle cells not produced 5, 12

14- Stipe less than 50 μm long 5
Stipe less than 100 μm long 7
Stipe more than 100 μm long 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13

15- Stipe becoming brown-pigmented 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13

Stipe hyaline 5, 10

- 16- Ascospore convex wall smooth
1, 2, 3, 4, 6, 7, 8, 11, 13
Ascospore convex wall rugulose, ridged, not smooth
3, 9, 10
- 17- Ascospore crests lacking
1, 3, 10
Ascospore crests present, two in number
1, 2, 3, 4, 6, 7, 8, 9, 11, 13
Ascospore crests four or multiple and irregularly
arranged 8, 10
- 18- Ascospore crests well-developed, commonly extending
1.7 μm or more outward from spore body.
11, 13
Ascospore crests incised, spores stellate in pattern
13
Ascospore crests up to 0.8-1.5 μm wide
2, 4, 6, 8, 11
Ascospore crests 0.6 μm wide or less
1, 3, 4, 7, 8, 9, 10

Brief descriptions of included taxa

Brief descriptions of the most common taxa isolated from Egypt are given below, the complete description may be found in Raper & Fennell (1965), and for *Emericella bicolor* in Christensen *et al.* (1978), *A. egyptiacus* in Moubasher & Moustafa (1972) and Samson & Mouchacca (1974), and for *E. sublata* in Horie (1979).

- 1 - *Emericella acristata* (Fennell & Raper) Horie, 1980, Trans. mycol. Soc. Japan 21: 483-493.

Common Synonyms

- = *Emericella nidulans* (Eidam) Vuill. var. *acristata* (Fennell & Raper) Subramanian, 1972, Cur. Sci. 41:758
- = *Aspergillus nidulans* (Eidam) Wint. var. *acristatus* Fennell & Raper, 1955, Mycologia 47: 79.

Anamorph: *Aspergillus acristatulus*

Ismail, Abdel-Sater & Zohri, St. nov.

Colonies on Czapek agar at 25°C 24-31 mm diam in 7 da, with light yellow to beige colour (M: 4 A-D 3-4) (Kornerup & Wanscher 1989); deep orange, brown to dark brown reverse and colourless exudate. Growth enhanced at 40°C (43-51 mm diam in 7 da) with grayish yellow to olive yellow appearance (M: 2 C-D 4-6) and reddish orange to brown reverse. Colonies may form sectors on Czapek's agar either at 25° or 40°C. Stipe up to 150 μm long; conidia 2.5-4.5 μm ; Hülle cells up to 30 μm . Cleistothecia up to 375 μm diam; ascospore size is 3-3.5 μm ; crests lacking or 2 very narrow crests.

- 2 - *Emericella aurantio-brunnea* (Atkins, Hindson & Russell) Malloch & Cain, 1972, Can. J. Bot. 50: 61.
Common Synonyms:
= *Emericella nidulans* (Eidam) Vuill. var. *aurantio-brunnea* Atkins, Hindson & Russell, 1958, Trans. Br. mycol. Soc. 41: 501-504.
= *Aspergillus aurantio-brunneus* (Atkins, Hindson & Russell) Raper & Fennell, 1965, apud Raper & Fennell, The Genus *Aspergillus*: 511.
Anamorph: *Aspergillus auranticbrunneullus* Ismail, Abdel-Sater & Zohri, St. nov.
Colonies on Czapek agar at 25°C raised, with olive colour (M: 2 E-F 3-4) and orange white sectors (M: 6A2); reverse orange to dark brown. Colonies on Czapek agar at 25°C restricted (25-32 mm diam in 7 da) while enhanced spreading growth at 40°C (44-49 mm). Exudate on Czapek agar at 25°C colourless or dark brown. Stipe 20 to 175 µm long; conidia 2-3.5 µm diam and Hülle cells up to 25 µm. Maturation of cleistothecia (250 µm diam) requires more than 2 weeks.
- 3 - *Emericella bicolor* Christensen & States, 1978, Mycologia 70: 332-343.
Anamorph: *Aspergillus bicolor* Christensen & States, Loc. cit.
Colonies on Czapek agar raised, 25 mm in diam after 7 da at 25°C, light yellow to beige (M: 4 A-D 3-4) appearance with diffusing brownish orange to dark brown (M. 6 C-F 7) pigmentation; forming sectors with yellowish grey to greyish yellow colour (M: 4 B 2-3). No growth at 40°C. Reduced growth (14 mm in diam) was observed on Malt agar supplemented with 10% NaCl, giving raised, yellowish white to silver white (M: 2 A-B 2) colony with no reverse. Stipe 150 µm long; conidia subglobose to elliptical up to 4.5 µm size; Hülle cells up to 30 µm. Cleistothecia maturing tardily and up to 400 µm size; ascospores 4-5.5 µm with crests lacking or very low.
- 4 - *Emericella dentata* (Sandhu & Sandhu) Horie, 1980, Trans. mycol. Soc. Japan 21: 483-493.
Common Synonyms
= *Emericella nidulans* (Eidam) Vuill. var. *dentata* (Sandhu & Sandhu) Subramanian, 1972, Cur. Sci. 41: 758.
= *Aspergillus nidulans* (Eidam) Wint. var. *dentatus* Sandhu & Sandhu, 1963; Mycologia, 55: 297-299.
Anamorph: *Aspergillus dentatulus* Ismail, Abdel-Sater & Zohri, St. nov.
Colonies on Czapek agar raised mostly lobed forming sectors at 25°C with restricted growth 9-15 (-29) mm diam in 7 da; colour grayish yellow to olive brown (M: 4 B-D 4) and in other strains light yellow to beige (M: 4 A-D 3-4); reverse ranging from yellowish-, reddish-,

orange-, to brown dependant on strain; colourless exudate mostly produced. 40°C enhanced growth, 15-24 (-39) mm diam in 7 da. Stipe tall ranging from 11-125 (-180) μ m; conidia 2-4.5 μ m and Hülle cells 20-28 (-34) μ m. Cleistothecia up to 500 μ m (mostly 250-375 μ m) and ascospores 3-5 μ m with 2 crests conspicuously dentate.

- 5 - *Aspergillus egyptiacus* Moubasher & Moustafa, 1972, Egypt. J. Bot. 15: 153-154.

Colonies on Czapek agar at 25°C growing restrictedly attaining a diam of 11-17 mm within 7 da; gray to yellowish gray (M: 4 B 1-2) or gray to grayish yellow (M: 4 B 1-3) with grayish yellow (M: 4 B 3-4) or yellowish gray (M: 4 B 2) reverse; exudate colourless. 40°C enhanced growth slightly (17-23 mm) while MA amended with 10% NaCl gave twice growth or more (25-34 mm diam in 7 da at 25°C). Stipe hyaline, very short 5-35 μ m long, mostly not arranged in a typical *Aspergillus*-head but phialides solitary or occurring in little groups along the stipe resembling *Penicillium*-like structures. Conidia globose or subglobose, smooth 3-5 μ m. Hülle cells are produced in some strains, globose, subglobose or ellipsoidal up to 20 μ m. Non-ascosporic species.

- 6 - *Emericella nidulans* (Eidam) Vuillemin, 1927, Compt. rend. Acad. Sci. Paris 184: 137.

= *Aspergillus nidulans* (Eidam) Winter, 1884, Rab. Krypt.-Fl. 1 (2): 62.

= *Sterigmatocystis nidulans* Eidam, 1883, Cohn, Beitr. Biol. Pflanz. 3: 392-411.

Anamorph: *Aspergillus nidulellus* Samson & W. Gams, 1985, Apud Samson & Pitt, Adv. *Penicillium*, *Aspergillus* System.: 44.

Colonies on Czapek agar 25-34 mm in diam after 7 da at 25°C with grass green to dark green colour (M: 30 E-F 7) or light yellow to beige in some strains (M: 4 A-D 3-4); reverse reddish, or orange to brown; mostly diffusible pigmentation produced; sectors may be produced. Growth spreading and enhanced at 40°C, while reduced on MA amended with 10% NaCl at 25°C. Stipe up to 130 μ m; conidia 2.5-5 μ m; Hülle cells mostly 25 μ m but may reach 30 μ m. Cleistothecia size ranged from 250-450 μ m, ascospores 3.5-5.5 μ m with two equatorial crests.

- 7 - *Emericella parvathecica* (Raper & Fennell) Malloch & Cain, 1972, Can. J. Bot. 50: 62.

Common Synonym:

= *Aspergillus parvathecicus* Raper & Fennell, 1965, The Genus *Aspergillus*: 509-511.

Anamorph: *Aspergillus microthecicus* Samson & W. Gams, 1985, apud Samson & Pitt, Adv. *Penicillium*, *Aspergillus* System.: 46-47.

Colonies on Czapek agar spreading, 31 mm in diam after 7 da at 25°C, with grass green to dark green colour (M: 30 E-F 7); diffusible pigmentation and grayish red to reddish brown reverse (M: 8 C-E 4); exudate colourless. 40°C enhanced growth slightly (36 mm diam) with orange yellow reverse (M: 4 B 7-8). Sectors are formed either at 25°C or 40°C. Stipe short mostly 20-70 μ m long and conidia 2.5-4.5 μ m; Hülle cells up to 35 μ m diam. Cleistothecia small (100 μ m) and rarely up to 180 μ m, ascospores 4-4.5 μ m.

- 8 - *Emericella quadrilineata* (Thom & Raper) Benjamin, 1955, *Mycologia* 47: 680.

Common Synonym:

= *Aspergillus quadrilineatus* Thom & Raper, 1939, *Mycologia* 31: 660.

Anamorph: *Aspergillus tetrazonus* Samson & W. Gams, 1985 apud Samson & Pitt, *Adv. Penicillium Aspergillus System.*: 48.

Colonies on Czapek agar 20-33 (mostly 28 mm) in diam after 7 da at 25°C with shades of orange or reddish to dark brown colour; mostly diffusing pigmentation in the surrounding agar; colourless exudate mostly produced. Growth spreading and enhanced at 40°C, 31-51 (commonly above 45 mm diam) after 7 da. Stipe 20-100 μ m long but in some strains up to 200 μ m; conidia 2.5-5 μ m wide; Hülle cells up to 34 μ m but commonly 25 μ m. Cleistothecia about 250 μ m in diam (-500 μ m); ascospore body 3.5-6 μ m with four equatorial crests.

- 9 - *Emericella rugulosa* (Thom & Raper) Benjamin 1955, *Mycologia* 47: 680-681.

Common Synonym:

= *Aspergillus rugulosus* Thom & Raper, 1939, *Mycologia* 31: 660-663.

Anamorph: *Aspergillus rugulovalvus* Samson & W. Gams, 1985, apud Samson & Pitt, *Adv. Penicillium Aspergillus System.*: 49.

Colonies on Czapek agar at 25°C restricted (9-13 mm diam), raised and lobed with exudate in colourless or orange white droplets. Enhanced growth at 40°C (14-31 mm) was achedived and grayish yellow to olive (M1: B-E 5-6) or olive (M: 3 E-F 7-8) with light yellow (M: 1 A 4-5) or white edge; reverse dark brown. Diffusing pigmentation mostly produced into the medium. Stipe ranging from 20-200 μ m long; conidia 2.5-4.5 μ m; Hülle cells up to 35 μ m. Cleistothecia ripening quickly up to 400 μ m, ascospores with conspicuously rugulose convex walls and 2 narrow crests.

- 10- *Emericella striata* (Rai, Tewari & Mukerji) Malloch & Cain, 1972, *Can. J. Bot.* 50: 62.

Common Synonym:

= *Aspergillus striatus* Rai, Tewari & Mukerji, 1964, Can. J. Bot. 42: 1521-1524.

Anamorph: *Aspergillus striatulus* Samson & W. Gams 1985, apud Samson & Pitt, Adv. *Penicillium* *Aspergillus* System.: 50.

Colonies on Czapek agar raised, light yellow to beige (M: 4 A-D 3-4), 27-33 mm in diam after 7 da at 25°C; reverse light orange to yellowish brown; exudate colourless and sectors are formed. Colonies at 40°C spreading (48 mm diam), grayish yellow to olive brown colour; reverse grayish brown to violet brown. Stipe 45-140 µm tall; conidia 2.5-3.5 µm; Hülle cells subglobose to ovate up to 25 µm in diam. Cleistothecia up to 350 µm; ascospore with several low equatorial ridges continuous with striations in finger print-like patterns on the convex wall.

- 11- *Emericella sublata* Horie, 1979, Trans. mycol. Soc. Japan 20: 481.

Anamorph: *Aspergillus sublatulus* Horie, 1979; Trans. mycol. Soc. Japan 20: 481.

Colonies on Czapek agar at 25°C flat 29 mm diam, grass green to dark green (M: 30 E-F 7) in colour; reverse grayish brown. 40°C enhanced growth (44 mm diam in 7 da); colony colour grayish yellow to olive (M: 2 C-E 4-5); and with dark brown diffusing pigmentation. Stipe 20-125 µm long; conidia 4.5-6; Hülle cells 25 µm. Cleistothecia 175 µm wide, ascospores 5-6 µm, provided with two equatorial crests measuring 1-1.5 µm wide, commonly extending 1.7 µm or more outward from spore body, with convex surfaces smooth.

- 12- *Emericella unguis* Malloch & Cain, 1972, Can. J. Bot. 50: 62.

Anamorph: *Aspergillus unguis* (Emile-Weil & Gaudin) Thom & Raper, 1939, Mycologia 31 (6): 667-668
emended Fennell & Raper, Mycologia 17 (1): 78-79

Colonies on Czapek agar at 25°C flat, 22-28 mm diam with grass green to dark green (M: 30 E-F 7) colour; grayish brown reverse; and with diffusing pigmentation into the medium. Enhanced growth was achieved at 40°C (39 mm) and reduced at 25°C on MA amended with 10% NaCl. At 40°C colony dark green (M: 30 F 7-8) with greenish gray to dull green reverse (M: 30 D-F 2-3). Stipe up to 150 µm long; conidia 4-5 µm wide. A characteristic feature for this species is the presence of coarse spicular hyphae. Hülle cells not observed in our strains. Our strains non-ascosporic, in spite of the observation of a single isolate (WB 2392) with scattered cleistothecia in thin envelopes of globose Hülle cells (Christensen & Raper 1978).

- 13- *Emericella variegata* Berk. & Br., 1857; Berk., *Introd. Crypt. Bot.*; 340; Benjamin 1955, *Mycologia* 47: 679.

Common Synonyms:

= *Aspergillus variegata* (Berk. & Br.) Thom & Raper, 1939, *Mycologia* 31: 663-667; Raper & Fennell 1965, *The Genus Aspergillus*: 514.

= *Aspergillus stellatus* Curzi, 1934, *Rend. accad. nazl. Lincei* 19: 424-428.

Anamorph: *Aspergillus stellifer* Samson & W. Gams, 1985, *apud Samson & Pitt, Adv. Penicillium Aspergillus System.*: 52.

Colonies on Czapek agar at 25°C raised, 17-28 mm diam in 7 da; grayish yellow or olive to olive brown (M: 3-4 D-F 4); reverse light yellow to olive brown (M: 4 B-F 5); exudate colourless. It is worth to mention that this is the only species treated here that 40°C inhibited its growth (apart from *E. bicolor* which has no growth at 40°C). Colonies at 40°C with greenish white to greenish gray shades (M: 30 A-D 2) or white to gray (M: 18 A-C 1). Stipe up to 250 µm long; conidia globose to subglobose roughened 2.5-3.5 µm wide; Hülle cells globose, subglobose (17x20 µm) or elongate (15x26) or up to 38 µm. Cleistothecia measuring 400-575 µm, ascospore body 3-4.5 µm (crests not included), with convex wall smooth and two conspicuously pleated stellate equatorial crests, 3-4 µm wide.

Discussion

Christensen & Raper (1978) in addition to other authors such as Mains (1950), Bakshi (1951) and Zycha *et al.* (1969) strongly supported that morphologies for all reproductive states should be considered at the species level. In the *Aspergillus nidulans*-*Emericella* assemblage, morphological features, conidial structures together with those of cleistothecia, ascospores and hülle cells provide a ready means to species separation. Certain features may or may not be needed in the synoptic key, but in a few cases are either diagnostic or supportive. Thus for example: a) *Aspergillus egyptiacus* is the only species with gray to yellowish gray or grayish yellow colony appearance and reverse, consistently with colony diam more than 25 mm on 10% NaCl- Malt extract agar at 25°C, and stipe less than 50 µm long; b) *Emericella bicolor* does not grow at 40°C on Capek Dox agar and with subglobose to elliptical conidia, c) *E. variegata* is the only species (within species investigated) with light yellow to olive reverse and also with ascospores stellate in pattern, d) *E. parvathesia* with a stipe less than 100 µm long, e) *A. egyptiacus*, *E. rugulosa* and *E. variegata* are the only three species attaining colony diam less than 25 mm on Czapek Dox agar at 40°C; *E. parvathesia* and *E. sublata* produce small cleistothecia with diam less than 200 µm; *A. egyptiacus* and *E. unguis* were the only two species (in the

current study) lacking cleistothecia; only *A. egyptiacus* and *E. striata* produce hyaline stipes; and *E. sublata* and *E. varicolor* were the only two species producing ascospores with well-developed crests commonly extending 1.7 μm or more outward from spore body.

Many species of this assemblage were first described including both anamorph and teleomorph and most of these species were typified by Samson & Gams (1985). As *Aspergillus aurantio-brunneus* (Atkins, Hindson & Russell) Raper & Fennell, *A. nidulans* var. *acristatus* Fennell & Raper and *A. nidulans* var. *dentatus* Sandhu & Sandhu were first described inclusive of teleomorphs and as no epithets are available for them, we propose the following anamorphs: *Aspergillus aurantio-brunneulus* st. nov., *Aspergillus acristatus* st. nov. and *Aspergillus dentatus* st. nov. for *Emericella aurantio-brunnea*, *Emericella acristata*, and *Emericella dentata*, respectively.

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References

- Arx, J.A. von 1987: A re-evaluation of the *Eurotiales*. *Persoonia* 13 (3): 273-300.
- Baghdadi, V.C. 1968: De speciebus novis *Penicilli* Fr. et *Aspergilli* Fr. e terris Syriae isolatis notula. *Novosti Sistematiki nizshikh Rastenii* 5: 96-114.
- Bakshi, B.K. 1951: Studies on four species of *Ceratocystis* with a discussion on fungi causing sapstain in Britain. *Mycological Papers* 35, 1-16.
- Benjamin, C.R. 1955: Ascocarps of *Aspergillus* and *Penicillium*. *Mycologia* 47: 669-687.
- Berkeley, M.J. 1857: *Introduction to Cryptogamic Botany*. London: Bailliere.
- Christensen, M. & Raper, K.B. 1978: Synoptic key to *Aspergillus nidulans* group species and related *Emericella* species. *Trans. Br. mycol. Soc.* 71 (2): 177-191.
- Christensen, M. & States, J.S. 1982: *Aspergillus nidulans* group: *Aspergillus navahoensis*, and a revised synoptic key. *Mycologia* 74 (2): 226-235.

- Christensen, M.; Raper, K.B. & States, J.S. 1978: Two new *Aspergillus nidulans* group members from Wyoming soils. *Mycologia* 70: 332-342.
- Horie, Y. 1978: A new species of *Emericella* from Indian herbal drug. *Trans. mycol. Soc. Japan* 19: 313-317.
- Horie, Y. 1979: New or interesting *Emericella* from herbal drugs. *Trans. mycol. Soc. Japan* 20: 481-491.
- Horie, Y. 1980: Ascospore ornamentation and its application to the taxonomic re-evaluation in *Emericella*. *Trans. mycol. Soc. Japan* 21: 483-493.
- Horie, Y.; Miyaji, M.; Nishimura, K. & Udagawa, S. 1989: *Emericella falconensis*, a new species from Venezuelan soil. *Trans. mycol. Soc. Japan* 30: 257-263.
- Horie, Y.; Udagawa, S.; Abdullah, S.K. & Al-Bader, S.M. 1990: *Emericella similis*, a new species from Iraqi soil. *Trans. mycol. Soc. Japan* 31: 425-430.
- Kong, H. & Qi, Z. 1986: A new species of *Emericella*. *Acta Mycologica Sinica* 5 (4): 211-214.
- Korf, R.P. 1972: Synoptic key to the genera of the pezizales. *Mycologia* 64: 937-994.
- Kornerup, A. & Wanscher, J.H. 1989: *Methuen Handbook of colour*. Methuen London, Michelin House, 81 Fulham Road, London SW3 6RB.
- Kozakiewicz, Z. 1989: *Aspergillus* species on stored products. *Mycological Papers* No. 161 (pp. 188) C.A.B. International Mycological Institute, Ferry Lane, Kew, Surrey, England.
- Link, H.F. 1809: Observations in ordines plantarum naturales. *Gesellschaft Naturforschender Freunde zu Berlin, Magazin* 3: 1-42.
- Mains, E.B. 1950: The genus *Gibellula* on spiders in North America. *Mycologia* 42, 306-321.
- Malloch, D. & Cain, R.F. 1972a: New species and combinations of cleistothecial Ascomycetes. *Can. J. Bot.* 50: 61-72.
- Malloch, D. & Cain, R.F. 1972b: The Trichocomataceae: Ascomycetes with *Aspergillus*, *Paecilomyces* and *Penicillium* imperfect states. *Can. J. Bot.* 50: 2613-2628.
- Malloch, D. & Cain, R.F. 1973: The Trichocomaceae (Ascomycetes): synonyms in recent publications. *Can. J. Bot.* 51: 1647-1648.

- Mehrotra, B.S. & Prasad, R. 1969: *Aspergillus dimorphicus* and *Emericella cleistominuta* spp. nov. from Indian soils. Trans. Br. mycol. Soc. 52: 331-349.
- Micheli, P.A. 1729: Nova plantarum genera juxta Tournefortii Methodum Disposita. Florence.
- Moubasher, A.H. & Moustafa, A.F. 1972: *Aspergillus egyptiacus* sp. nov. Egypt. J. Botany 15 (1): 153-154.
- Novobranova, T.I. 1972: Species *Aspergilli* novae in fructibus mali ac Vitis inventis e regione Almaataënsi. Novosti Sistematiki nizshikh Rastenii 9: 171-180.
- Raper, K.B. & Fennell, D.I. 1965: The genus *Aspergillus*. Williams & Wilkins Co., Baltimore, 686 pp.
- Samson, R.A. 1979: A compilation of the *Aspergilli* described since 1965. Studies in Mycology, Baarn 18: 1-38.
- Samson, R.A. & Mouchacca, J. 1974: Some interesting species of *Emericella* and *Aspergillus* from Egyptian desert soil. Antonie van Leeuwenhoek 40: 121-131.
- Samson, R.A. & Mouchacca, J. 1975: Additional notes on species of *Aspergillus*, *Eurotium* and *Emericella* from Egyptian desert soil. Antonie van Leeuwenhoek 41: 343-351.
- Subramanian, C.V. 1972: The perfect states of *Aspergillus*. Curr. Sci. 41 (21): 755-761.
- Udagawa, S. & Horie, Y. 1976: A new species of *Emericella*. Mycotaxon IV (2): 535-539.
- Udagawa, S. & Muroi, T. 1979: Some interesting species of Ascomycetes from imported spices. Trans. mycol. Soc. Japan 20: 13-22.
- Vuillemin, P. 1927: *Sartorya*, nouveau genre de Plectascinées angiocarpes. C.r. hebdom. Séanc. Acad. Sci., Paris 184: 136-137.
- Wadhvani, K.; Dudeja, S.K. & Srivastava, M. 1984: *Aspergillus sub-unguis* spec. nov.: A new member of *A. nidulans* group. Current Science, 53 (8): 443-444.
- Wiley, B.J. & Simmons, E.G. 1973: New species and a new genus of Plectomycetes with *Aspergillus* states. Mycologia 65: 934-938.
- Zycha, H.; Siepmann, R. & Linnemann, G. 1969: Mucorales; eine beschreibung aller Gattungen und Arten dieser Pilzgruppe. Germany. J. Cramer.

Table 2: The mean, standard deviation and range of some measurements for taxa treated.

Taxon	Colony diameter (mm)		Microscopic measurements (μ m)			
	Cuspek	NaCl-NA				
	25°C	40°C	25°C	Cleistothecia	Ascospores	Stipe
<i>R. acviretata</i> (3)	27±3.6 (24-31)	40±4.4 (43-51)	24±3.6 (20-27)	312±63 (250-375)	5.2±0.58 (3-5.5)	130.3±12.6 (125-150)
<i>R. aureo- brunnea</i> (2)	20.5±4.9 (25-32)	46.5±3.5 (44-49)	21±4.2 (18-24)	250±0	(4.5-5)	145±42.4 (120-175)
<i>R. bicolor</i> (1)	25±3	0	14±3	400	(4.5-5)	75-150
<i>R. dentata</i> (12)	15.9±6.3 (9-29)	23.5±6.5 (15-39)	15.0±4.6 (9-25)	358±84 (250-500)	5.2±0.33 (3-5.5)	151.1±26.9 (11-180)
<i>A. egyptiacus</i> (6)	15±2.2 (11-17)	19.5±2.7 (17-23)	30.7±3.1 (25-34)	-	-	20±9.7 (5-35)
<i>R. nidulans</i> (5)	30.1±3.3 (25-34)	40.2±3.4 (35-43)	23±4.3 (16-27)	310±89 (250-450)	5.2±0.27 (3.5-5.5)	111±18.2 (12-130)
<i>R. parvathenia</i> (1)	31±2	36±9	21±4	100-180	4-5.5	20-70
<i>R. quadrifoveata</i> (44)	26.9±3.8 (20-33)	45.3±4.7 (31-53)	19.6±6.6 (8-29)	314±59 (250-500)	5.2±0.27 (3.5-6)	130.3±27.4 (1-200)
<i>R. regulosa</i> (8)	10.4±1.2 (9-13)	19.3±5.2 (14-31)	13.6±3.6 (8-18)	325±55 (250-400)	5.3±0.24 (3.5-5.5)	162.5±28 (20-260)
<i>R. striata</i> (2)	30±4.2 (27-33)	40±13 (16-26)	21±7.1 (16-26)	325±35 (300-350)	5.5±0 (3.5-5.5)	132.5±10.6 (45-140)
<i>R. subiate</i> (1)	29±2	44±8	25±1	175	(5-6)	20-125
<i>R. unguis</i> (2)	25±4.2 (22-28)	39±6 (18-19)	10.5±0.7 (10-19)	-	-	145±7.1 (5-150)
<i>R. variegator</i> (2)	22.5±7.8 (17-28)	16.5±7.8 (9-20)	19±5.7 (15-23)	400±124 (400-575)	4.5±0 (3-4.6)	220±42.4 -250
						4.5-6
						5±0 (4-5)
						3.5±0 (2.5-3.5)
						25
						25
						3.5±0 (2.5-3.5)
						32±0.5 (26-38)