

STUDIES ON THE GENUS EUPENICILLIUM LUDWIG

1. Taxonomy and nomenclature of *Penicillia* in relation to their sclerotoid ascocarpic states

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(With Plate 15 and four Text-figures)

The ascocarpic genus *Eupenicillium* Ludwig has been re-instated and reviewed taxonomically. It accommodates the perfect states of species characterized by pseudoparenchymatic or sclerotoid cleistothecia. The imperfect states belong to *Penicillium* Link ex Fries. Descriptions and synonymy of the genus and its type species *E. crustaceum* are presented. The generic name *Eupenicillium* has priority over the generic name *Carpenteles* Langeron. *Penicillium kewense* is reduced to the synonymy of *E. crustaceum*. The fungus misidentified by Shear as *C. asperum* is redescribed as *E. shearii* sp. nov. Species which had not previously been assigned to *Eupenicillium* are here so assigned.

Introduction

The first account of the development of a perfect state in a species of *Penicillium* was given by Brefeld in 1874. In "Die Entwicklungsgeschichte von *Penicillium*" he described and figured in great detail the formation of sclerotoid cleistothecia, slowly ripening from the centre outwards and producing bivalve ascospores. He identified the studied species as "*Penicillium crustaceum* Fries, *Penicillium glaucum* Link". It is, however, very questionable whether Brefeld's species represented the species described by Link and Fries. The illustrations of the conidial state strongly suggest that Brefeld dealt with mixed cultures. Brefeld stated that no new name for the Ascomycete he discovered is required, the name *Penicillium* should be used for both the perfect and the imperfect state.

Winter (1887) included the perfect state described by Brefeld in the Pyrenomycetes as *P. crustaceum* (L.) Fr. He gave an extract of Brefeld's paper together with a few of Brefeld's illustrations.

Based on the name in Winter's paper, which was thus founded on the perfect state reported by Brefeld, Ludwig (1892) introduced the new generic name *Eupenicillium*. The single species which typified the new genus was named *Eupenicillium crustaceum* (L.) Fr. (*P. glaucum*) and was described by the author. The correct citation of the name is *E. crustaceum* Ludwig.

Langeron (1922), unaware of Ludwig's genus, proposed the generic name

Carpenteles for ascus-producing *Penicillia*. As provisional type "*P. glaucum* (Link) Brefeld", rather '*P. glaucum*' Link sensu Brefeld, was indicated. Langeron stated that Brefeld presumably worked with a mixture of different species of *Penicillium* and with the term "provisional type" he meant to indicate that he considered the ascosporic portion of Brefeld's '*P. glaucum*' to be the type, but that the precise identity of the species thus singled out had not yet been established. He decided that only when Brefeld's ascosporic species is refound could the type species be defined more precisely.

Clements & Shear (1931) proposed as a new combination the name "*Carpenteles glaucum* (Link) Langeron" though Langeron never proposed this name.

In view of the uncertainty regarding the application of '*P. glaucum*' and the confusion which exists in its use, Shear (1934) introduced the new name *Carpenteles asperum*, nom. nov. for Brefeld's fungus. He thus gave a new specific name to that portion of '*P. glaucum*' described by Brefeld as ascosporic. Moreover, Shear reported the discovery of an ascosporic *Penicillium*, which he regarded as conspecific with Brefeld's species. The description of *P. asperum* (Shear) Raper & Thom published by Raper & Thom (1949: 263) and based on Shear's strain, shows that Shear's fungus is not identical with Brefeld's '*P. glaucum*.'

Thom (1930) and Raper & Thom (1949) rejected the assignment of the perfect *Penicillia* to ascomycetous genera. They adopted a classification with the emphasis on the conidial stage and treated all species as members of the single genus *Penicillium*, irrespective of whether or not an ascosporic state is present. Both *Eupenicillium* and *Carpenteles* were regarded as synonyms of *Penicillium*.

Benjamin (1956) reassigned the perfect *Penicillia* to ascomycetous genera. He considered *Carpenteles* to be the correct generic name for those species producing sclerotoid ascocarps.

Raper (1957) insisted, however, that in the case of *Penicillium* or *Aspergillus* it was "needlessly confusing to resurrect old and unused generic names or to construct new ones for the minority of isolates which succeed in developing an ascosporic stage."

Although there is much to say in favour of Raper's view, we feel obliged, in accordance with the "International Code of Botanical Nomenclature" (Art. 59), to assign the perfect *Penicillia* to ascomycetous genera and to acknowledge *Eupenicillium* as a legitimate generic name.

Generic diagnosis and specific descriptions

EUPENICILLIUM Ludwig

Eupenicillium Ludwig, Lehrb. nied. Krypt. 256, 257. 1892.

Carpenteles Langeron in C.r. Séanc. Soc. Biol. 87: 344. 1922.

Fungi ascomyceti plectascales. Cleistothecia globosa vel subglobosa, firma vel dura, textura pseudoparenchymatica vel sclerotioidea, e cellulis crassitunicatis polygonalibus composita, peridermio subcolorato et persistente sed ad maturitatum cellulis interioribus evanescentibus. Asci laterales, e hyphis ascogonicis nati, singuli vel catenati, globosi vel ellipsoidei, octospori,

evanescentes. Ascosporae lenticulares vel ellipsoideae, continuae, hyalinae, luteae, vel brunneae, cum vel sine cristis aequatorialibus, partibus convexis levibus vel spinulosis.

Status conidicus *Penicillium* Link ex Fries.

Species typica *Eupenicillium crustaceum* Ludwig.

Cleistothecia globose to subglobose, developing as a solid mass of pseudoparenchymatous or sclerotoid tissue, firm to hard, composed of thick-walled, polygonal cells; central part evanescent. Peridium persistent, hyaline or slightly coloured. Ripening occurs from the centre outwards. Asci arise as branches from ascogenous hyphae, developing singly or in chains, evanescent, globose to ellipsoid, 8-spored. Ascospores lenticular to ellipsoid, continuous, hyaline, yellow or brown, often showing equatorial ridges, with convex surfaces smooth or roughened. Cleistothecial initials consist of modified and undifferentiated cells in the crotch of an arborescent network of hyphae.

Conidial state: *Penicillium* Link ex Fries.

Type species: *Eupenicillium crustaceum* Ludwig.

The ultimate type material of the genus *Eupenicillium* consists of Brefeld's illustrations and description of '*P. glaucum*'. This material is in a measure heterogeneous.

The illustrations demonstrate clearly the existence of an ascosporic state connected with a conidial state (Brefeld's Figs. 10-51, cf. Pl. 15). In addition at least two other species are illustrated. His Figures 5, 8, 52 and 53-54 may even represent four different imperfect *Penicillium* species. Brefeld's description of the perfect state clearly applies to his Figures 10-51, they typify the species *E. crustaceum*. As a conidial state belonging to the described perfect state, Ludwig referred to "*Coremium glaucum* oder *vulgare*". This is one of the conidial states illustrated by Brefeld (cf. Brefeld's Figs. 53 and 54), but which we regard as belonging to another fungus.

Since Brefeld's description of '*P. glaucum*', many authors claim to have refound Brefeld's ascosporic species. Shear (1934) considered his isolate from Honduras soil (in this paper redescribed as *E. shearii*) identical with Brefeld's species. However, in *E. shearii* the asci are borne singly and not in chains like those figured by Brefeld.

Emmons (1935) stated *P. egyptiacum* to be more nearly Brefeld's fungus because of the disposition of the asci, which develop in a similar manner to those figured by Brefeld. However, the shape of the ascospores of *P. egyptiacum* differs markedly from Brefeld's fungus.

van Beyma (1940) considered his *P. euglaucum* to be the true representative of Brefeld's '*P. glaucum*', but the ascospores of this species are much smaller than the ascospore sizes indicated by Brefeld.

According to Raper & Thom (1949: 262) *P. baarnense* might better represent the fungus studied by Brefeld. *Penicillium baarnense* agrees reasonably well with Brefeld's description and Figures 10-51. Its cleistothecia are strongly sclerotoid, the asci are borne in helicoidal chains and the ascospores are rough-walled with two equatorial ridges.

In our opinion the fungus described by Smith (1961) as *P. kewense* resembles Brefeld's fungus even more. This species is closely related to *P. baarnense*; its cleistothecia are also strongly sclerotoid, asci are borne in chains and the ascospores

are rough-walled with two prominent, well-separated equatorial ridges, thus agreeing very well with Brefeld's figures of the perfect state. The dimensions of the ascospores of *P. kewense* ($4.2-5 \times 3-3.2 \mu$) are slightly smaller than the measurements given by Brefeld ($5-6 \times 4-4.5 \mu$). However, according to Neuhoﬀ (1924) and Donk (1966) the microscopical measurements given by Brefeld must be regarded as unreliable. In Brefeld's Figures 49, 50, and 51 mycelia are figured originating from ascospores and developing biverticillate-asymmetric penicilli consisting of branches, metulae and phialides with the composing elements closely appressed. The penicilli of *P. kewense* show exactly the same pattern, whereas those of *P. baarnense* are slightly different because the branches are lacking. Therefore we consider *P. kewense* to represent Brefeld's species.

EUPENICILLIUM CRUSTACEUM Ludwig—Text-fig. 1, Pl. 15

[*Penicillium crustaceum* (L.) Fr. *sensu* Winter in Krypt Fl. Deutschl., 2. Aufl., I (2): 64. 1887 (misapplied nomen anamorphosis)]. — *Eupenicillium crustaceum* Ludwig, Lehrb. nied. Krypt. 263. 1892 [“*Eupenicillium crustaceum* (L.) Fr. (*P. glaucum*)”]. — *Carpenteles glaucum* Langeron ex Clem. & Shear, Gen. Fungi 247. 1931 [“*Carpenteles glaucum* (Link) Langeron”]. — *Carpenteles asperum* Shear in Mycologia 26: 107. 1934 (name change).

Penicillium kewense Smith in Trans. Br. mycol. Soc. 44: 42. 1961.

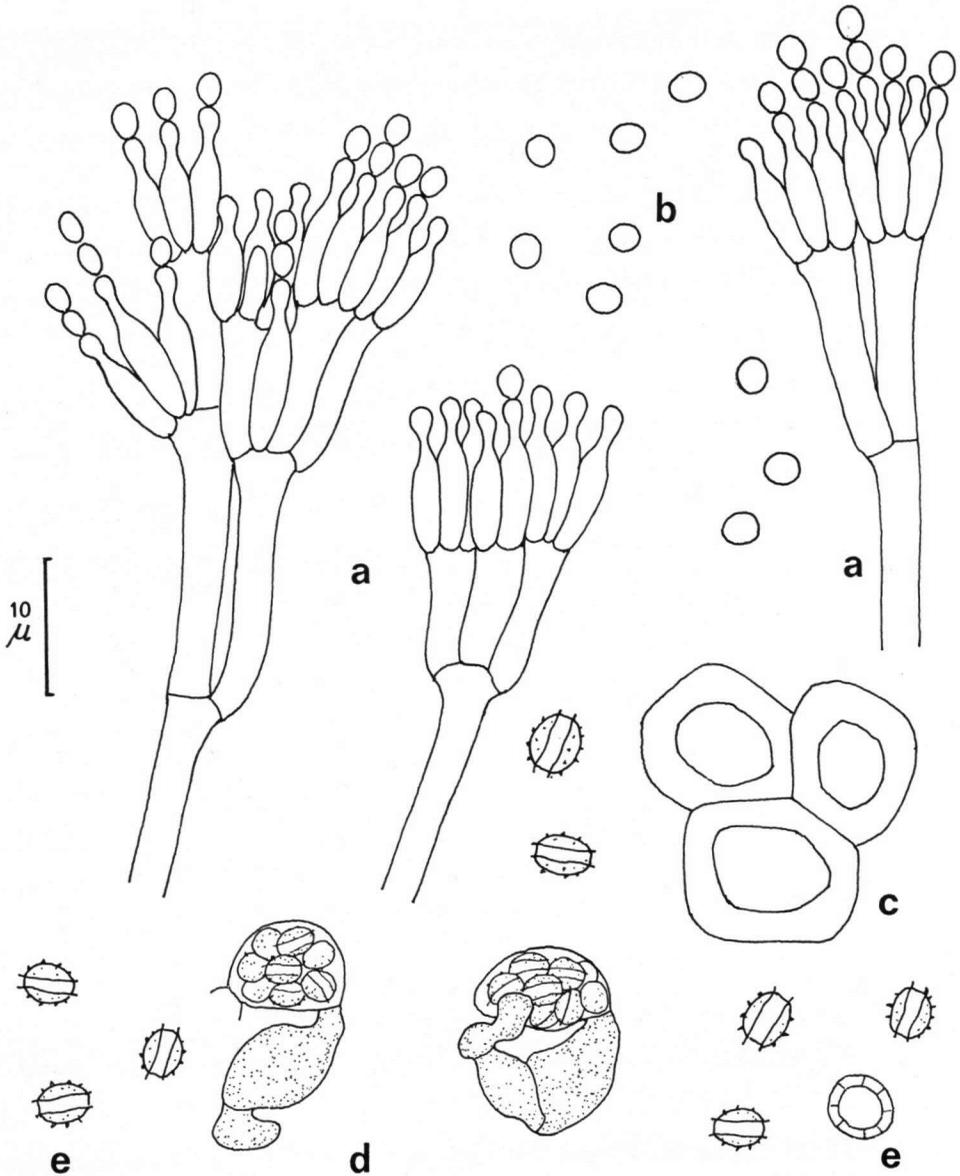
Status conid.: *Penicillium kewense* Smith, *ibid.* 44: 42. 1961; not *P. crustaceum* (L.) Fr., Syst. myc. 3: 407. 1829 (nomen ambiguum); not *P. glaucum* Link in Magazin Ges. naturf. Fr. Berl. 3: 17. 1809 (nomen ambiguum).

Colonies growing somewhat restrictedly on Czapek agar, attaining a diameter of about 3 cm within 14 days at 25° C, azonate, comparatively thin, showing buff shades near Avellaneous and Vinaceous Buff (Ridgway, Pl. 40) because of the development of abundant cleistothecia with surface growth slightly flocculent. Conidial structures limited in number, lending the colony margin a faintly bluish shade in very young colonies. Exudate clear, sometimes reddish. Reverses of colonies show brown shades approximating Kaiser Brown (Ridgway, Pl. 14) with the colour diffusing in the surrounding agar.

Colonies on malt agar and oatmeal agar generally agree with those on Czapek agar, being plane, thin, consisting of a dense layer of cleistothecia. On oatmeal agar growth is somewhat faster.

Cleistothecia avellaneous, globose to ovoid, 190–280 μ in diameter, sclerotoid, consisting of masses of thick-walled, polygonal cells (Text-fig. 1c), in their young stages resembling sclerotia, ripening slowly from the centre outwards after 4–5 weeks. Asci (Text-fig. 1d) borne in chains, ovoid, $9-10 \times 6-7 \mu$, containing 8 ascospores. Ascospores broadly lenticular, $4.2-5 \times 3-3.2 \mu$, with two prominent, well-separated equatorial ridges and with the convex surfaces coarsely roughened (Text-fig. 1e).

Conidiophores arising from the substratum and from aerial hyphae, smooth-walled up to 300 μ in length by 2–4 μ in diameter. Penicilli (Text-fig. 1a) biverticillate and asymmetrical, commonly showing one branch (rarely 4-verticillate) with all elements closely appressed and smooth-walled. Small penicilli consisting of 1 verticil of 2–4 metulae occur as well. Branches $20-22 \times 2.5-4 \mu$. Metulae in clusters of 2–4, $10-15 \times 2.5-3.5 \mu$ with apices slightly inflated. Phialides $8.5-10 \times 2-2.5 \mu$ showing definite conidium-bearing tubes. Conidia pear-shaped, smooth to slightly roughened, $2.5-3(-4) \times 2-2.5(-3.5) \mu$ (Text-fig. 1b).



Text-fig. 1. *Eupenicillium crustaceum*, CBS 344.61. — a. Different types of penicilli. — b. Conidia. — c. Thick-walled cleistothecial cells. — d. Asci produced in chains. — e. Ascospores.

The species is represented by CBS 344.61 sent to the CBS by G. Smith in 1961 as the type culture of *P. kewense*. The lectotype consists of Brefeld's description and Figures 10–51 of '*P. glaucum*' (1874).

***Eupenicillium shearii* Stolk & Scott, *sp. nov.*—Text-fig. 2**

Penicillium asperum (Shear) Raper & Thom, Man. Penicillia 263, 1949 (misapplied).

Status conid.: *Penicillium shearii* Stolk & Scott, *st. n.*

Coloniae in agar Czapekii tarde crescentes, mycelio basali coacto, cleistotheciis griseis involutis, penicillis restricte numerosis, reverso bubalino vel luteolo deinde fusciscente.

Cleistothecia globosa vel subglobosa vel ovoidea, usque ad 500 μ diam., sclerotioidea, tarde maturescentia. Asci octospori, singuli et laterales in hyphis ascogonicis, globosi vel ovoidei, 5–6 μ diam. Ascosporae 2.5–3 \times 2–2.5 μ , lenticulares, luteolae, partibus convexis spinulosis, cristis duabus aequatorialibus contiguis, 0.5 μ latis.

Conidiophora usque ad 500 μ alta, 2–2.5 μ lata, levia vel sublevia. Penicilli monoverticillati vel biverticillati, divaricati, quoque verticillio plerumque metulis 2–4 divaricatis instructo. Metulae leves, 10–15 \times 2–3 μ . Phialides 3–8 per metulam, 7–10 \times 2.2–2.8 μ ostio tubulari aperte angustato et elongato. Conidia ovoidea vel ellipsoidea, levia, 2.2–3 \times 2–2.5 μ , catenas intermixtas constituentia.

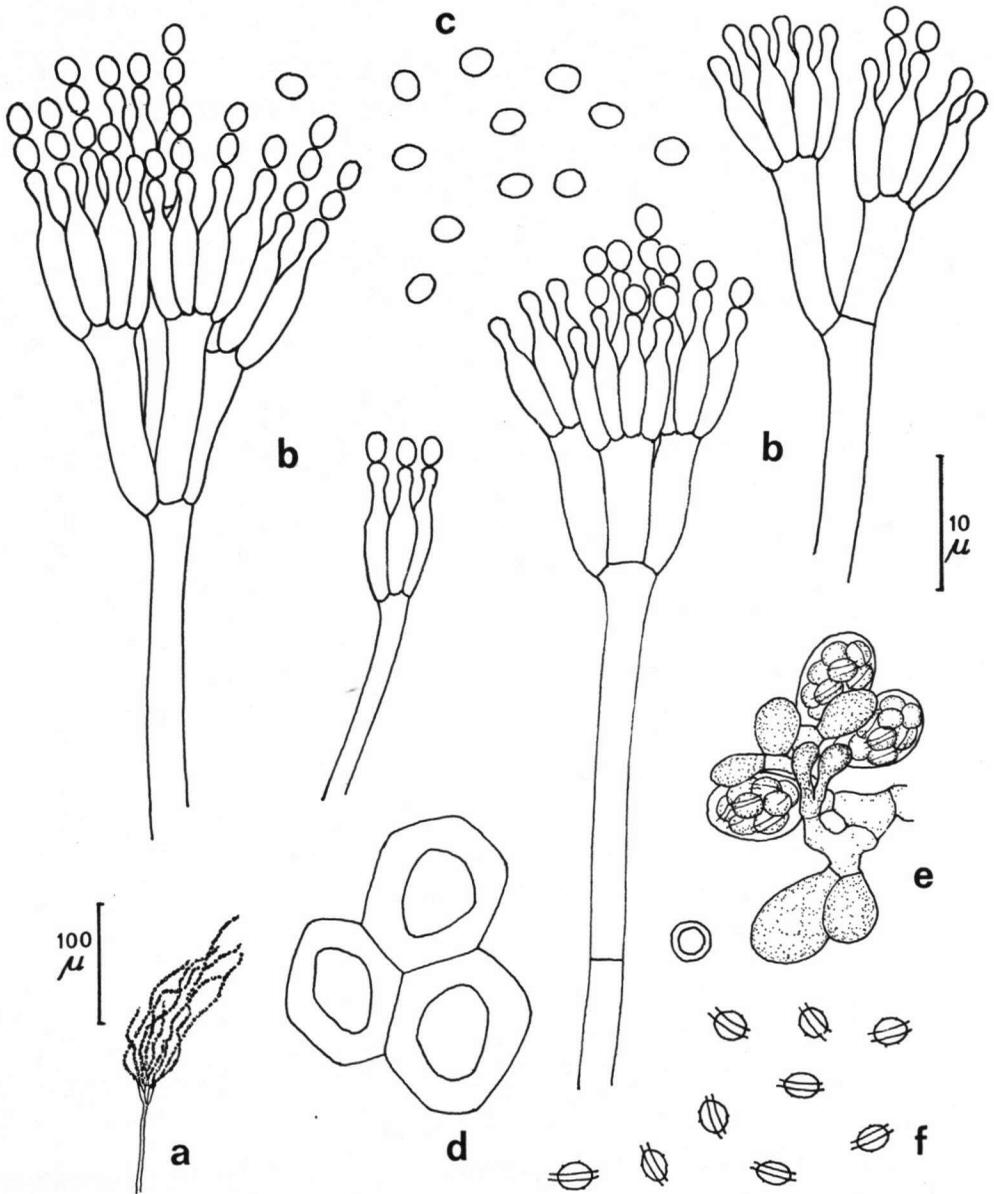
Typus: CBS 290.48 a Otto A. Reinking in 1931 e terra Tela, Honduras isolatus (cultura vivida et desiccata).

Colonies growing slowly on Czapek agar, attaining a diameter of 2.5–3 cm within 14 days at 25° C, zonate, showing grey shades near Mouse Gray (Ridgway, Pl. 51), consisting of an uncoloured mycelial felt, which is somewhat wrinkled and buckled in central areas and in which numerous greyish or almost black cleistothecia are embedded, the surface growth being somewhat flocculent. Conidial structures usually do not affect the colony appearance. The reverse of the colonies showing buff to yellowish shades, becoming dark brownish to fuscous, especially in central areas with age.

Colonies on malt agar attaining a diameter of 3–3.5 cm within 14 days at 25° C, thinner than those on Czapek agar, plane, becoming avellaneous from the development of abundant cleistothecia, with marginal areas grey-green, approximating Court Gray or Mineral Gray (Ridgway, Pl. 47). Colonies on oatmeal agar generally agree with those on malt agar, their growth being slightly faster and exudate occurring more abundantly, collecting in conspicuous, clear drops.

Cleistothecia globose, subglobose or ovoid, up to 500 μ in diameter, in their young stages very hard and resembling sclerotia, consisting of sclerotoid masses of thick-walled, polygonal cells (Text-fig. 2d), ripening slowly, producing ascospores after 4–5 weeks or more. Sometimes ascospores are never produced. Asci (Text-fig. 2e) borne singly, developing as branches from ascogenous hyphae, globose to ovoid, 5–6 μ in diameter. Ascospores lenticular, yellowish, 2.5–3 \times 2–2.5 μ , with convex surfaces more or less roughened, with two closely appressed equatorial ridges about 0.5 μ wide (Text-fig. 2f).

Conidiophores arising primarily from the substratum, but sometimes also from aerial hyphae, up to 500 μ or more in length by 2–2.8 μ in diameter, with walls smooth or nearly so. Penicilli (Text-fig. 2b) divaricate, consisting mostly of a terminal verticil of 2–4 slightly diverging metulae; usually monoverticillate structures occur as well. Metulae smooth-walled, 10–15 \times 2–3 μ ; metulae of different length may occur in one verticil. Phialides in clusters of 3–8, 7–10 \times 2.2–2.8 μ , their conidium-bearing tubes being definitely narrowed and fairly long. Conidia



Text-fig. 2. *Eupenicillium shearii*, CBS 290.48. — a. Habit sketch showing tangled conidial chains. — b. Different types of penicilli. — c. Conidia. — d. Thick-walled cleistothecial cells. — e. Development of asci. — f. Ascospores.

(Text-fig. 2c) ovoid to ellipsoid, $2.2-3 \times 2-2.5 \mu$, smooth-walled, forming tangled chains (Text-fig. 2a).

The type strain CBS 290.48 = NRRL 715 was isolated by Dr. Otto R. Reinking from soil at Tela, Honduras in 1931, and misidentified as *Carpenteles asperum* by Dr. C. L. Shear. The species is also represented by two additional strains: CBS 343.54 isolated from soil of the Congo by Dr. J. Meyer in 1954 and CBS 488.66 isolated from soil of the savanna near Abidjan (R.C.I.) at the 'Laboratoire de Phytopathologie', Abidjan in 1966. CBS 343.54 and CBS 486.66 differ slightly from the type strain in their cultural aspect. They produce more definite yellow and brown colours in reverse. The cleistothecia of these two strains on Czapek agar vary from tan to grey, whereas those of CBS 290.48 are grey or almost black.

In view of the confusion gathered around the name '*Penicillium glaucum*' Link, Shear (1934) introduced *Carpenteles asperum* as a new name for '*P. glaucum*' Link sensu Brefeld. At the same time Shear claimed to have refound Brefeld's ascosporic '*P. glaucum*'. However, the description of Shear's strain, given by Raper & Thom (1949) under the name *Penicillium asperum* (Shear) Raper & Thom, shows that Shear's claim is not correct. According to Brefeld, his fungus produces asci in chains, but in Shear's strain asci are borne singly. The fact that Shear proposed the name *C. asperum* as nom. nov. and not as spec. nov., and moreover that he reproduced Brefeld's illustrations (Brefeld's Figures 51, 34-39, 45-46) makes it clear that he intended not to create a new species based on Reinking's collection, but simply to rename Brefeld's fungus. Shear took the material collected by Reinking to represent the same species as Brefeld's fungus which is an error and, consequently, the recombination proposed by Raper & Thom and based on Shear's description is a misapplied name.

New combinations

A number of *Penicillium* species were described as perfect forms, but placed in the 'imperfect genus' *Penicillium*. These species are characterized by pseudoparenchymatous or sclerotoid cleistothecia as occurring in *Eupenicillium*. Some of them have been transferred to *Carpenteles* which is a later synonym of *Eupenicillium*. Since valid descriptions of the species under consideration, inclusive of their perfect states, were published, we propose the following new combinations:

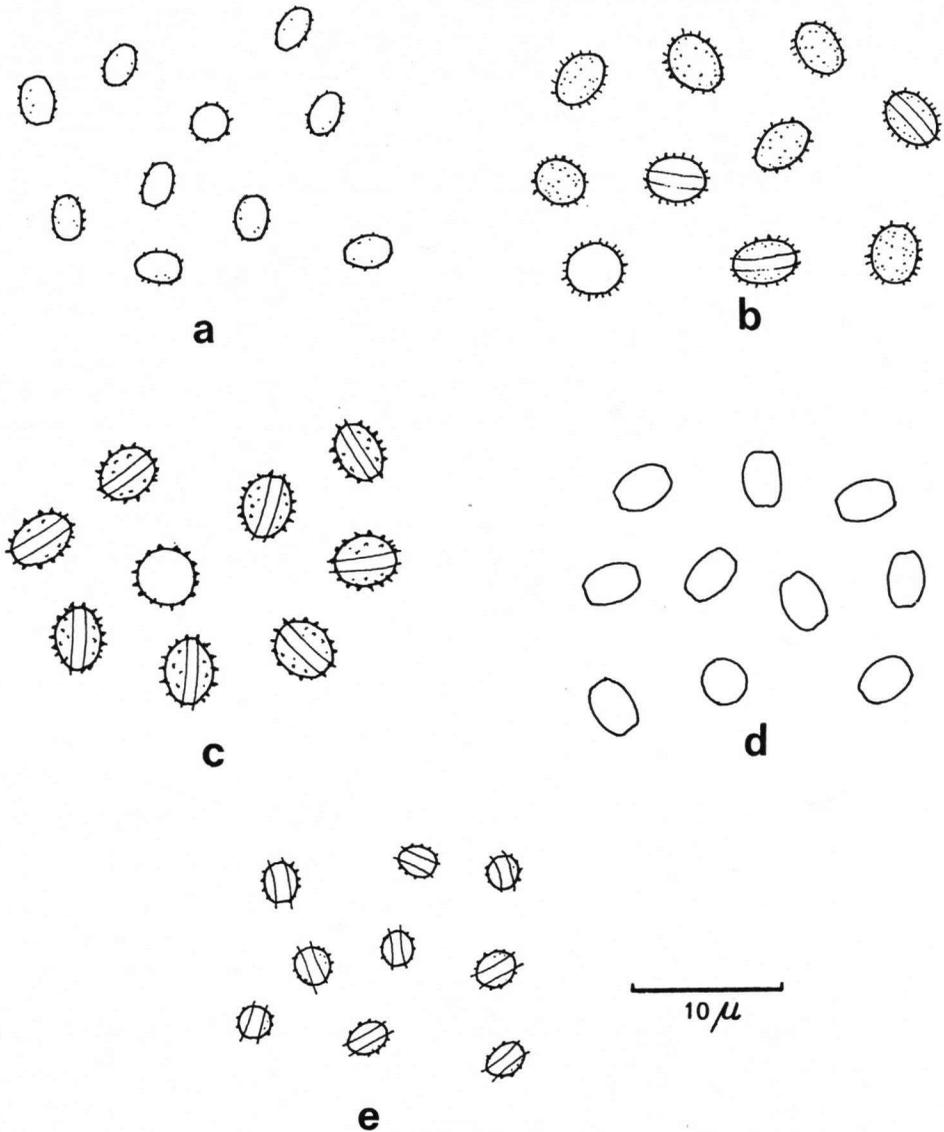
Eupenicillium javanicum (Beyma) Stolk & Scott, *comb. nov.*—Text-fig. 3a

Penicillium javanicum Beyma in Verh. K. Akad. Wet. Amst. (Natuurk., II) 26: 17. 1929 (basionym). — *Carpenteles javanicum* (Beyma) Shear in Mycologia 26: 107. 1934.

Penicillium oligosporum Saito & Minoura in J. Ferment. Technol., Osaka 26: 5. 1948 (Latin description lacking, not validly published).

Status conid.: *Penicillium javanicum* Beyma *ibid.* 26: 17. 1929.

SPECIAL LITERATURE: Raper & Thom (1949: 135).



Text-fig. 3. Ascospores. — a. *Eupenicillium javanicum*, CBS 341.48. — b. *E. brefeldianum*, CBS 298.48. — c. *E. ehrlichii*, CBS 324.48. — d. *E. egyptiacum*, CBS 244.32. — e. *E. parvum*, CBS 359.48.

Cleistothecia pseudoparenchymatous to slightly sclerotoid, yellow to brown, 100–150 μ in diameter, usually ripening within 2 or 3 weeks. Asci borne singly, 6–8 μ in diameter. Ascospores lenticular, 2.5–3 \times 2–2.5 μ , slightly roughened, with equatorial areas flattened, sometimes showing a trace of an equatorial furrow (Text-fig. 3a). Penicilli usually monoverticillate with an occasional branch. Phialides 8–13 \times 2–2.5 μ , with long, narrow conidium-bearing tubes. Conidia ellipsoid to pear-shaped, 2.2–3 \times 1.5–2 μ .

The type strain CBS 341.48 = NRRL 707 was isolated from tearroots coming from Java and described by van Beyma as *P. javanicum*. The species is also represented by CBS 349.51, described by Saito & Minoura (1948) as *P. oligosporum*. This type culture does not produce the red pigment characteristic of *E. javanicum* on Czapek agar. Notwithstanding this we regard it as a strain of *E. javanicum* because of the similarity of the ascospores and the conidial state.

Eupenicillium brefeldianum (Dodge) Stolk & Scott, *comb. nov.*—Text-fig. 3b

Penicillium brefeldianum Dodge in *Mycologia* 25: 92. 1933 (basionym). — *Carpenteles brefeldianum* (Dodge) Shear in *Mycologia* 26: 107. 1934.

Status conid.: *Penicillium brefeldianum* Dodge.

SPECIAL LITERATURE: Raper & Thom (1949: 141).

Cleistothecia pseudoparenchymatous to slightly sclerotoid, cream to light tan, 100–200 μ in diameter, ripening within 2 weeks. Asci borne singly, 7.5–9 μ in diameter. Ascospores broadly lenticular, finely echinulate, showing sometimes a trace of an equatorial furrow, 3–4 \times 2.5–3 μ (Text-fig. 3b). Penicilli monoverticillate with an occasional branch. Phialides 7–10 \times 2.5–3 μ , with conspicuous narrow conidium-bearing tubes. Conidia subglobose to ellipsoid, 2–3 \times 1.5–2 μ .

The species is represented by CBS 298.48 = NRRL 2083, isolated by Wm. I. Illman, University of Toronto, and described by Raper & Thom in 1949 as a characteristic representative of *P. brefeldianum*. *Eupenicillium brefeldianum* is closely related to *E. javanicum* and *E. ehrlichii*, the dimensions of the ascospores being in between these two species. Though *E. brefeldianum* sometimes produces a yellow pigment on Czapek agar, its colonies are less coloured than those of *E. javanicum* and *E. ehrlichii*, which may produce red or purplish pigments.

Eupenicillium ehrlichii (Klebahn) Stolk & Scott, *comb. nov.*—Text-fig. 3c

Penicillium ehrlichii Klebahn in *Ber. dt. bot. Ges.* 48: 374. 1933 (basionym)

Status conid.: *Penicillium ehrlichii* Klebahn.

SPECIAL LITERATURE: Raper & Thom (1949: 146).

Cleistothecia pseudoparenchymatous, yellow to brownish, 100–200 μ in diameter, ripening within 2 weeks. Asci borne singly, 8–10 μ in diameter. Ascospores lenticular, conspicuously roughened, 3.5–4.5 \times 3–3.5 μ , showing a shallow equatorial furrow and inconspicuous low marginal ridges (Text-fig. 3c). Penicilli fragmentarily monoverticillate. Phialides 10–15 \times 2.5–3.5 μ . Conidia ellipsoid 4–5 \times 3.5–4 μ .

The type strain CBS 324.48 = NRRL 708 was isolated by F. Ehrlich and described by Klebahn as *P. ehrlichii* in 1930.

Eupenicillium ehrlichii is closely related to *E. brefeldianum*, it differs from this species in producing more coloured colonies with yellow mycelium and showing bright yellow, purplish or orange-red reverses on Czapek- and oatmeal agar. The ascospores are slightly larger than those of *E. brefeldianum* with walls more conspicuously roughened and with two low equatorial ridges. Moreover the conidia are much larger than those of *E. brefeldianum*.

Eupenicillium egyptiacum (Beyma) Stolk & Scott, *comb. nov.*—Text-fig. 3d

Penicillium egyptiacum Beyma in Zbl. Bakt. ParasKde (Abt. 2) **88**: 137. 1933 (basionym).
Status conid.: *Penicillium egyptiacum* Beyma.

SPECIAL LITERATURE: Raper & Thom (1949: 269).

Cleistothecia pseudoparenchymatous, cream to pale avellaneous, 100–200 μ in diam., ripening within 3 weeks. Asci in chains, 7–8 μ in diam. Ascospores broadly lenticular, 3–3.5 \times 2–2.8 μ , smooth-walled with equatorial areas flattened, occasionally showing two rather widely separated low equatorial ridges (Text-fig. 3d). Penicilli usually biverticillate-divaricate, sometimes also monoverticillate, with all walls smooth. Rami rarely present. Metulae 2–5 in the verticil, 10–25 \times 2–2.8 μ . Phialides 8–10 \times 1.8–2.2 μ . Conidia globose to subglobose 2–3 μ .

The type strain CBS 244.32 = NRRL 2090 was isolated from soil by Y. S. Sabet, Cairo, Egypt, in 1932.

The species can be easily recognized by its characteristic barrel-shaped, smooth-walled ascospores. The colonies do not show conspicuous colours.

Eupenicillium baarnense (Beyma) Stolk & Scott, *comb. nov.*—Text-fig. 4

Penicillium (Carpenteles) baarnense Beyma in Antonie van Leeuwenhoek **6**: 271. 1940.

Status conid.: *Penicillium baarnense* Beyma *ibid.* **6**: 271. 1940.

SPECIAL LITERATURE: Raper & Thom (1949: 266).

Cleistothecia sclerotoid, buff, 100–200 μ in diameter, ripening after 4 weeks. Asci borne in chains, 10–12 μ in diameter (Text-fig. 4f). Ascospores lenticular, showing two prominent equatorial ridges (which are about 0.5–1 μ in width, usually close together, so that they sometimes appear as a single ridge) with convex surfaces rugulose to echinulate, 5–6.5 \times 3.4–4.5 μ (Text-fig. 4g). Penicilli (Text-fig. 4a) ranging from monoverticillate to divaricate. Metulae in clusters of 2–3(–4), appressed, smooth-walled, 10–20 \times 2–3 μ . Phialides 8–10 \times 2–2.5 μ . Conidia in very young cultures hyaline to slightly greenish, ellipsoid, smooth-walled, 3–3.5(–5) \times 2–2.5 μ (Text-fig. 4c). In older cultures also greenish, globose to subglobose, conspicuously roughened conidia occur, about 3–4 μ in diameter (Text-fig. 4d). Penicilli were observed with a few phialides producing smooth-walled ellipsoid conidia while the other phialides produced the rough-walled, globose type of conidium (Text-fig. 4b).

The rough-walled conidia were not mentioned in the descriptions given by van Beyma and Raper & Thom. However, they were observed in all three examined

strains of this species. Single spore cultures demonstrated both types of conidia to belong to *E. baarnense*.

The species is represented by CBS 134.41, type strain of *Penicillium (Carpenteles) baarnense* Beyma, isolated from soil collected near Baarn in 1939; CBS 339.61, originating from a culture labelled *Penicillium euglaucum* Beyma, and CBS 315.59 which was found as a contaminant in a Petridish culture. CBS 134.41 and CBS 339.61 are identical. The cultural aspect of CBS 315.59 differs slightly from the other two strains in producing a purple-red pigment in localized areas. Moreover, the cleistothecia of CBS 315.59 ripen somewhat more quickly than those of the other two strains.

The species is closely related to *E. crustaceum*. It differs from this species in the character of the ascospores, those of *E. baarnense* being definitely larger. Moreover they have two closely appressed equatorial ridges, whereas in *E. crustaceum* the ridges are widely separated. The penicilli of *E. crustaceum* are larger and more complicated than those of *E. baarnense*.

Eupenicillium levitum (Raper & Fennell) Stolk & Scott, *comb. nov.*

Penicillium levitum Raper & Fennell in *Mycologia* 40: 511. 1948 (basionym). — *Carpenteles levitum* (Raper & Fennell) C. R. Benj. in *Mycologia* 47: 685. 1955.

Status conid.: *Penicillium levitum* Raper & Fennell.

SPECIAL LITERATURE: Raper & Thom (1949: 148).

Cleistothecia pseudoparenchymatous, in light tan shades, 50–100 μ in diameter, ripening within 1 or 2 weeks. Asci borne singly, 8–10 μ in diameter. Ascospores broadly lenticular to ellipsoid, 3.5–4.5 \times 3–4 μ , smooth-walled, without any indication of an equatorial furrow or ridges. Penicilli fragmentarily monoverticillate. Phialides 7–12(–25) \times 2.2–3.5 μ . Conidia subglobose to pear-shaped, smooth-walled, 4.5(–7) \times 3–4.5 μ .

The type strain CBS 345.48 = NRRL 705 was isolated by B. O. Dodge from modelling clay.

Eupenicillium parvum (Raper & Fennell) Stolk & Scott, *comb. nov.*—Text-fig. 3c

Penicillium parvum Raper & Fennell in *Mycologia* 40: 508. 1948 (basionym). — *Carpenteles parvum* (Raper & Fennell) Udagawa in *Trans. mycol. Soc. Japan* 6: 79. 1965.

Status conid.: *Penicillium parvum* Raper & Fennell.

SPECIAL LITERATURE: Raper & Thom (1949: 138).

Cleistothecia sclerotoid, yellow to orange-brown, 80–150 μ in diameter, ripening after 3 to 4 weeks. Asci borne singly, 6–7 μ in diameter. Ascospores lenticular,

EXPLANATION OF FIGURE 4

Text-fig. 4. *Eupenicillium baarnense*, CBS 134.41. — a. Different types of penicilli. — b. Monoverticillate penicillus producing both smooth-walled, ellipsoid conidia and rough-walled, globose conidia. — c. Smooth-walled, ellipsoid conidia. — d. Rough-walled, globose conidia. — e. Ascogenous hyphae. — f. Asci produced in a chain. — g. Ascospores.

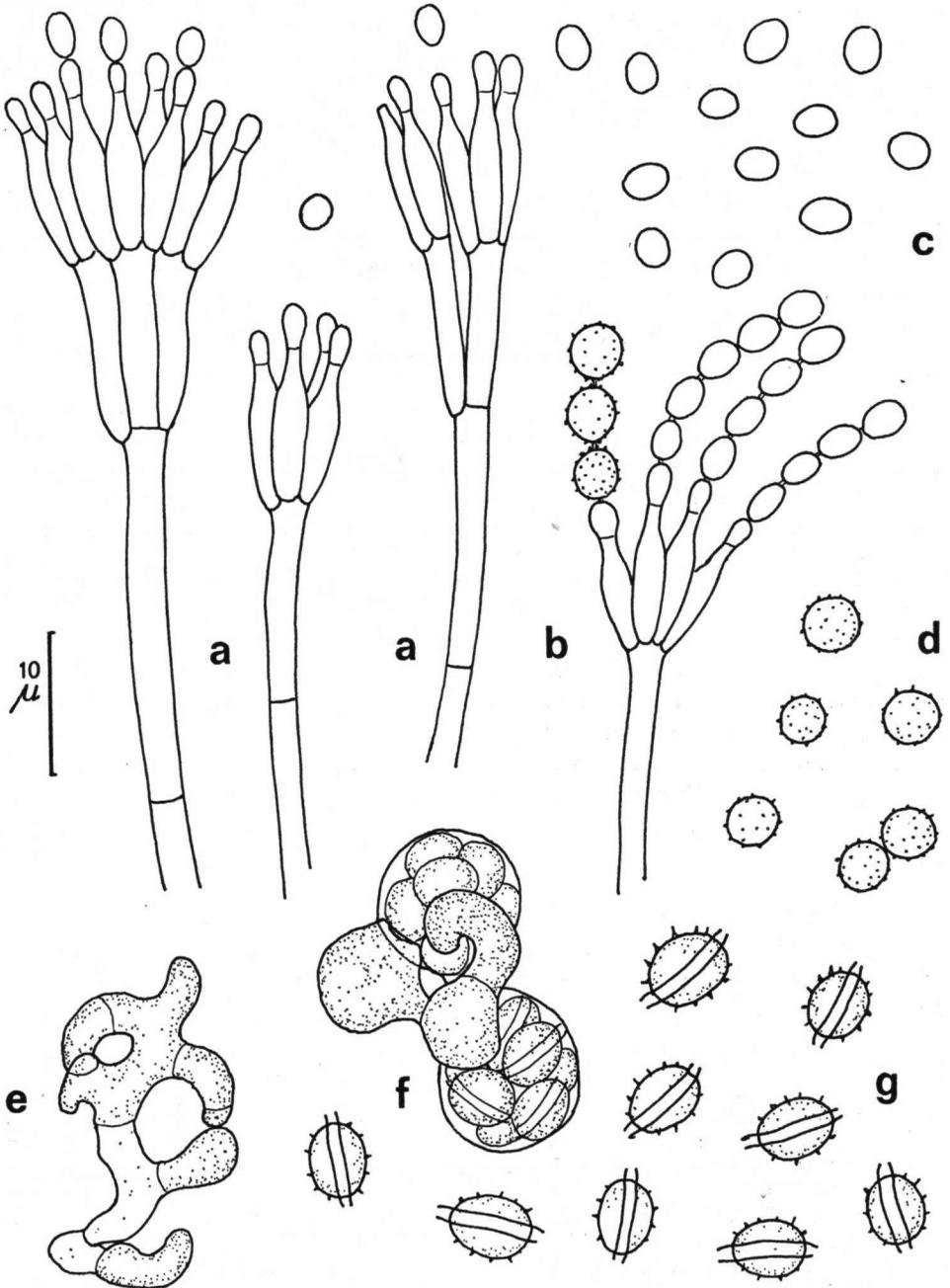


Fig. 4.

2.2–2.8 × 1.5–2 μ with walls conspicuously roughened and with two prominent, widely separated equatorial ridges (Text-fig. 3e). Penicilli monovercillate. Phialides 7–8 × 1.2–1.8 μ with conidium-bearing tubes slightly narrowed. Conidia subglobose to ellipsoid 1.5–2 × 1.2–1.5 μ.

The type strain CBS 359.48 = NRRL 2095 was isolated in 1945 from a sample of soil from Nicaragua.

The species is closely related to *E. javanicum*. Both species produce a reddish-brown pigmentation in reverse. They differ in the more delayed ripening of the cleistothecia and in the character of the ascospores. In *E. parvum* the ascospores are more conspicuously roughened and show more strongly developed equatorial ridges.

Doubtful species

PENICILLIUM EQUINUM Beyma in Zbl. Bakt. ParasKde (Abt. 2) 96: 423. 1937.

The type culture of *P. equinum* Beyma is lost. According to Raper & Thom (1949: 817) the strain they received in 1945 from the CBS under this name failed to produce perithecia and approximated *P. terrestre* Jensen. The perfect state of *P. equinum* was described by van Beyma in terms which place it near *E. brefeldianum*.

PENICILLIUM (CARPENTELES) EUGLAUCUM Beyma in Antonie van Leeuwenhoek 6: 267. 1940.

Penicillium euglaucum was described by van Beyma as a perfect *Penicillium* with sclerotoid perithecia, producing ascospores 3–4 × 3–3.3 μ, slightly roughened, and showing a definite equatorial band. Unfortunately, the culture CBS 339.61 labelled *P. euglaucum* does not agree any more with this species. It resembles *E. crustaceum* in all details. The notes and drawings van Beyma made of this species are still present at the CBS. They strongly suggest that the culture studied by van Beyma was different from *E. crustaceum*. We therefore presume that the type culture of *P. euglaucum* is lost.

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EXPLANATION OF PLATE 15

Brefeld's figures of "*Penicillium glaucum*, *Penicillium crustaceum*" reassembled in part, showing mature cleistothecium (Fig. 34), developing asci (Figs. 35-39), mature and germinating ascospores (Figs. 45-47) and penicilli which develop from germinated ascospores (Fig. 49).

