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A reappraisal of intrageneric classification of *Talaromyces* based on the ubiquinone systems

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Ubiquinone profiles of 25 strains of *Talaromyces* were determined using reversed-phase high performance liquid chromatography. Together with data of earlier authors, examination of the most recently described species allowed us to solve some taxonomic problems in the intrageneric classification. Ubiquinone Q-10(H_2) was found in the majority of *Talaromyces* species with a *Penicillium* anamorph, which are mostly placed in series *Flavi* and *Lutei* of section *Talaromyces*. *Flavi* and *Lutei* are closely related and homogeneous taxa based on their morphological characters used in the section. However, exceptional profiles were consistently shown by *T. trachyspermus* and the allied taxa of series *Trachyspermi* of the section *Talaromyces*, in which a mixture of ubiquinone Q-10(H_2) and ubiquinone Q-10(H_4) was found. Thus the accommodation of *T. trachyspermus* and the allied taxa in the section *Talaromyces* was not supported by their ubiquinone systems. *Trachyspermi* is distinguished from other taxa of *Talaromyces* by its production of white ascomata and rapid growth at 37°C. A new section, *Trachyspermus*, is proposed herein. Section *Emersonii* showed heterogeneity; the ubiquinone profiles (Q-10(H_2) or Q-10 and Q-10(H_2)) in *Talaromyces* with a *Geosmithia* anamorph were relatively homogeneous, whereas those of another group with a *Paecilomyces* anamorph were considerably variable. Only *Talaromyces* with a *Geosmithia* anamorph can be placed in the section *Emersonii*.

Key Words——Ascomycetes; intrageneric classification; section *Trachyspermus; Talaromyces*; ubiquinone system.

The ascomycetous genus *Talaromyces* C. R. Benjamin (Trichocomaceae, Eurotiales) is well known as one of teleomorphic states of *Penicillium, Paecilomyces* and *Geosmithia* (Stolk and Samson, 1972; Malloch and Cain, 1972; Pitt, 1979a, b). Most species in the genus are ubiquitous and cosmopolitan in soil (Domsch et al., 1980) and are important food-borne saprobes as spoilage agents and mycotoxin producers (Pitt and Hocking, 1985; Samson, 1989; Samson et al., 1992; Enigl et al., 1993). It is distinguished from *Eupenicillium*, another teleomorphic genus of *Penicillium*, by loose, hyphal, white to yellow ascomata that lack a pseudoparenchymatous peridium; asci are usually produced directly from ascogenous hyphae in short chains, whereas they arise singly from croziers in some species which were defined as the related genus *Hamigera* (Stolk and Samson, 1971). Pitt and Hocking (1979) synonymized *Hamigera* with *Talaromyces*, but introduced the new genus *Merimbla* for the anamorph of *Hamigera*. Thus *Talaromyces* species are associated with an anamorphic state characteristic of *Penicillium, Paecilomyces, Geosmithia* or *Merimbla*. Because of the anamorphic diversity in *Talaromyces* species, recent attempts have been made to apply chemotaxonomical and molecular biological data to species recognition and delimitation, and even to determine phylogenetic relationships between *Talaromyces* species and their related holomorphic fungi which have shared anamorphic characters (Frisvad et al., 1990; Taylor et al., 1990; LoBuglio and Taylor, 1993; LoBuglio et al., 1993).

The distribution of ubiquinone systems in *Penicillium* species and their teleomorphic genera including *Talaromyces* has been demonstrated by Kuraishi et al. (1991) and Schubert and Kreisel (1991) for taxonomic assessment of the species. These chemotaxonomic approaches are useful to clarify the relationship between most series of *Penicillium*. Kuraishi et al. (1991) found, for example, that the eight series of *Eupenicillium* are quite homogeneous in having the Q-9 system as a major ubiquinone. However, *Talaromyces* species, even those within the same series, were often heterogeneous in their ubiquinone systems. The discrepancy between the present *Talaromyces* systematics and the ubiquinone distribution represented a strong need for further assessment of the intrageneric assignment, grouping and classification.

Recently we have isolated several new species and varieties of *Talaromyces* from soil samples collected from Japan and overseas (Takada and Udagawa, 1993; Udagawa, 1993; Udagawa et al., 1993; Udagawa and Suzuki, 1994; Yaguchi et al., 1992, 1993a, b, 1994a, b). The accumulation of these additional taxa has led us to analyze their ubiquinone types in order to obtain new information on the relationship between the intrageneric

classification scheme of *Talaromyces* and the ubiquinone distribution.

Materials and Methods

Fungal isolates The 21 isolates of *Talaromyces* used in this study have been taken from our PF and SUM collections at the Pharmaceutical Research Center, Meiji Seika Kaisha, Ltd., Yokohama, Japan and are listed in Table 1. The following representative strains of *Talaromyces* were also tested: *T. ryukyuensis* (Ueda et Udagawa) von Arx NHL 2917, *T. assiutensis* Samson et Abdel-Fattah CBS 147.78, *T. gossypii* Pitt IMI 198365, and *T. unicus* Tzean, Chen et Shiu PPH16E.

Cultivation, ubiquinone extraction, purification and determination For production of mycelial felts, strains of *Talaromyces* species were each grown on five 9-cm Petri dishes containing 20 ml of potato-dextrose agar at 25°C for 10–14 d. Whole cultivated mycelia (10–20 g in wet weight) suspended in 20 ml of distilled water were saponified for 30 min at 90°C in the presence of 4 g of pyrogallol, 80 ml of ethanol and 17 g of potassium chloride. The crude ubiquinones were extracted twice with 100 ml of n-hexane and purified by preparative thin layer chromatography (silica gel $60F_{254}$ plates; 0.5 mm thick; M. Merck, Darmstadt, Germany) and benzene as a solvent system. The purified ubiquinones were identified by reversed-phase high performance liquid chromatography (RPHPLC) according to Katayama-Fujimura et al. (1982). The mobile phase was a mixture of methanol-isopropanol (7 : 3, v/v) running at a rate of 1 ml/min.

Results and Discussion

Ubiquinone profiles In the monographic treatment by Stolk and Samson (1972), *Talaromyces* comprised four sections with 18 species, most of which were described as having a *Penicillium* anamorph, but which also included two species with a *Paecilomyces* state. In his treatise on the genus *Penicillium*, Pitt (1979b) divided the 16 *Talaromyces* species with *Penicillium* anamorphic states into three sections and five series: Section *Talaromyces* (series *Flavi* Pitt, *Lutei* Pitt and *Trachyspermi* Pitt), section *Purpureus* Stolk et Samson (series *Purpurei* Pitt) and section *Thermophilus* Stolk et Samson (series *Thermophili* Pitt). Pitt (1979a) concurrently transferred the anamorphs of two *Talaromyces* species to *Geosmithia*, a segregate genus from *Penicillium* based on its differences in the colony color, penicilli with all elements roughened and cylindroidal conidia.

The ubiquinone systems in *Talaromyces* species in this study are summarized in Table 1. Ubiquinone Q-10 (H_2) was found in the majority of the investigated strains, i.e., in 20 of the 25 strains. A mixture of Q-10(H_2) and Q-10(H_4), an exceptional profile of the ubiquinone systems of the section *Talaromyces*, was found in *T. assiutensis* CBS 147.78 and *T. gossypii* IMI 198365, both recognized species of *Trachyspermi*. Frisvad et al. (1990) investigated the profiles of secondary metabolites in *Talaromyces* and found that *T. assiutensis* and *T. gossypii* are conspecific, not only in morphological characters but in chemical comparison. Furthermore, our ubiquinone analysis of the strains of these two taxa and atypical isolates of *T. trachyspermus* (Shear) Stolk et Samson (e.g., the strain PF 1124) concluded that *T. assiutensis* should be considered as a variety of *T. trachyspermus* (Yaguchi et al., 1994a). This is supported by phylogram based on rDNA sequence data showing a level of 100% in bootstrap analysis between *T. trachyspermus* and *T. gossypii* (LoBuglio et al., 1993).

Another exception is *T. spectabilis* Udagawa et S. Suzuki with a *Paecilomyces* anamorph, in which ubiquinone system was found to be a mixture of Q-9 and Q-10.

Taxonomic implication

Section *Talaromyces*

Series *Flavi* In this series are placed five species which produce colonies of more than 30 mm in diam on MEA (malt extract agar) at 7 d; in four of them, *T. flavus* (Klöcker) Stolk et Samson, *T. helicus* (Raper et Fennell) C. R. Benjamin, *T. stipitatus* (Thom) C. R. Benjamin and *T. panasenkoi* Pitt, ascomatal initials develop from a clavate or cylindrical cell, and mycelial and ascomatal colors are predominantly yellowish (Pitt, 1979b). Almost all species of the series produce Q-10(H_2) as the major ubiquinone (Kuraishi et al., 1991).

Talaromyces striatus (Raper et Fennell) C. R. Benjamin in the series produces rather white to cream-colored ascomata and coiled ascomatal initials (Pitt, 1979b). Asci of *T. striatus* are borne as lateral buds from ascogenous hyphae and in size, shape, and mode of origin bear a striking resemblance of *T. avellaneus* (Thom et Turesson) C. R. Benjamin. Stolk and Samson (1971) separated *T. avellaneus* and *T. striatus* from *Talaromyces* on the basis of asci produced singly from croziers, as the genus *Hamigera*. The ubiquinones of *T. avellaneus* (anam. *Merimbla ingelheimense* (J. F. H. Beyma) Pitt) and *T. striatus* (anam. *Penicillium lineatum* Pitt) were determined as Q-10 by Kuraishi et al. (1985, 1991). Thus *T. striatus* shows little relationship with other species in *Flavi*.

Talaromyces galapagensis Samson et Mahoney in the series *Trachyspermi* is characterized by spreading growth at 30°C, white to yellowish brown ascomata, large ascospores with irregularly disposed tubercles and ridges, biverticillate penicilli, and ellipsoidal conidia. According to Samson and Mahoney (1977), the ascomata of *T. galapagensis* develop from small simple initials. However, our examination of two Japanese strains of this species showed *T. flavus*-like initials composed of paired gametangia to be present. Ubiquinone Q-10(H_2) was found in the strain of *T. galapagensis*. Thus this species shows a general affinity with the representative species in *Flavi*.

Distinguishing characteristics and ubiquinone systems of members in the series *Flavi* are summarized in Table 2. *Talaromyces indigoticus* Takada et Udagawa, *T. macrosporus* (Stolk et Samson) Frisvad, Samson et Stolk and *T. muroii* Yaguchi, Someya et Udagawa obvi-

Table 1. Principal ubiquinone systems in *Talaromyces* examined.

Fungal isolate	Species	Source	Ubiquinone
PF 1117 ex type	*T. austrocalifornicus* Yaguchi et Udagawa (anam. *Penicillium*)	soil, USA	Q-10(H_2)
PF 1081 ex type	*T. barcinensis* Yaguchi et Udagawa (anam. *Penicillium*)	soil, Spain	Q-10(H_2)
PF 1102	*T. barcinensis* (anam. *Penicillium*)	soil, Japan	Q-10(H_2)
SUM 3013	*T. barcinensis* (anam. *Penicillium*)	soil, Nepal	Q-10(H_2)
SUM 3018 ex type	*T. convolutus* Udagawa (anam. *Penicillium*)	soil, Nepal	Q-10(H_2)
PF 1151 ex type	*T. eburneus* Yaguchi, Someya et Udagawa (anam. *Geosmithia*)	soil, Taiwan	Q-10(H_2)
SUM 3025 ex type	*T. emodensis* Udagawa (anam. *Penicillium*)	soil, Nepal	Q-10(H_2)
SUM 3019	*T. emodensis* (anam. *Penicillium*)	soil, Nepal	Q-10(H_2)
SUM 3028	*T. galapagensis* Samson et Mahoney (anam. *Penicillium*)	soil, Japan	Q-10(H_2)
PF 1103 ex type	*T. helicus* (Raper et Fennell) C. R. Benjamin var. *boninensis* Yaguchi et Udagawa (anam. *Penicillium*)	soil, Japan	Q-10(H_2)
SUM 3010 ex type	*T. indigoticus* Takada et Udagawa (anam. *Penicillium*)	soil, Nepal	Q-10(H_2)
PF 1134	*T. macrosporus* (Stolk et Samson) Frisvad, Samson et Stolk (anam. *Penicillium*)	soil, Japan	Q-10(H_2)
PF 1153 ex type	*T. muroii* Yaguchi, Someya et Udagawa	soil, Taiwan	Q-10(H_2)
PF 1152	*T. muroii*	soil, Taiwan	Q-10(H_2)
SUM 3032	*T. muroii*	soil, Japan	Q-10(H_2)
NHL 2917 ex type	*T. ryukyuensis* (Ueda et Udagawa) von Arx (anam. *Sagenomella*=*Paecilomyces* fide von Arx)	soil, Japan	Q-10(H_2)
SUM 3030 ex type	*T. spectabilis* Udagawa et S. Suzuki (anam. *Paecilomyces*)	soft beverage, Japan	Q-9(89%) Q-10(11%)
SUM 3031	*T. spectabilis* (anam. *Paecilomyces*)	soil, Nepal	Q-9(20%) Q-10(80%)
PF1113 ex type	*T. subinflatus* Yaguchi et Udagawa (anam. *Penicillium*)	soil, Japan	Q-10(H_2)
SUM 3017 ex type	*T. tardifaciens* Udagawa (anam. *Penicillium*)	soil, Nepal	Q-10(H_2)
CBS 147.78 ex type	*T. trachyspermus* (Shear) Stolk et Samson var. *assiutensis* (Samson et Abdel-Fattah) Yaguchi et Udagawa (anam. *Penicillium*)	soil, Egypt	Q-10(H_2)(70%) Q-10(H_4)(30%)
IMI 198365	*T. trachyspermus* var. *assiutensis*, as *T. gossypii* Pitt (ex type) (anam. *Penicillium*)	*Gossypium* sp., India	Q-10(H_2)(30%) Q-10(H_4)(70%)
PF 1124	*T. trachyspermus* var. *assiutensis* (anam. *Penicillium*)	soil, Japan	Q-10(H_2)(49%) Q-10(H_4)(51%)
PPH16E ex type	*T. unicus* Tzean, Chen et Shiu (anam. *Penicillium*)	soil, Taiwan	Q-10(H_2)
PF 1130 ex type	*T. wortmannii* C. R. Benjamin var. *sublevisporus* Yaguchi et Udagawa (anam. *Penicillium*)	soil, Japan	Q-10(H_2)

ously belong in this series (Frisvad et al., 1990; Takada and Udagawa, 1993; Yaguchi et al., 1994b).

Series *Lutei* There are four species in this series: *T. luteus* (Zukal) C. R. Benjamin, *T. wortmannii* (Klöcker) C. R. Benjamin, *T. rotundus* (Raper et Fennell) C. R. Benjamin and *T. udagawae* Stolk et Samson, which produce colonies of less than 30 mm in diam on MEA at 7 d and bright yellow mycelium (Stolk and Samson, 1972; Pitt, 1979b). Ascomatal initials of these species are less significant and variable in structure, but differ from those produced in *Flavi*. Ubiquinone Q-10(H_2) was found in these species by Kuraishi et al. (1991).

Due to such striking characters as their slow growth on MEA at 25°C, no or reduced growth at 37°C, yellow ascomata, well defined terminal biverticillate to diminutive penicilli, and Q-10(H_2) systems, *T. ohiensis* Pitt and *T. mimosinus* Hocking, which were formerly placed in the series *Trachyspermi*, are better assigned to this series.

Since 1979, more than 10 species interpreted as belonging to the section *Talaromyces* have been newly described. Among them, *T. austrocalifornicus* Yaguchi et Udagawa, *T. barcinensis* Yaguchi et Udagawa, *T. convolutus* Udagawa, *T. emodensis* Udagawa, *T. retardatus* Udagawa, Kamiya et Osada, *T. subinflatus* Yaguchi et Udagawa, *T. tardifaciens* Udagawa and *T. unicus* are regarded as belonging in *Lutei* (Tzean et al., 1992; Udagawa, 1993; Udagawa et al., 1993; Yaguchi et al., 1993a, b). Distinguishing characteristics and ubiquinone systems of members in the series *Lutei* are summarized in Table 3. *Talaromyces barcinensis* is somewhat exceptional in the appearance of relatively rapidly growing colonies on MEA (36–40 mm in diam in 7 d at 25°C and 25–34 mm in diam in 7 d at 37°C).

Section *Trachyspermus* Yaguchi et Udagawa, sect. nov.

Sectio in generis *Talaromycete* cum speciebus tarde crescentibus, minus quam 30 mm diam post 7 dies 25°C in agaro maltoso, et cum ascomatibus albis. Status

Table 2. Diagnostic characters and ubiquinones of members of series *Flavi* in section *Talaromyces*.

Diagnostic character	Colony diam on MEA at 25°C in 7 d: Exceeding 30 mm. Ascomata colored: Usually yellow. Growth at 37°C: Often good. Ascomatal initials: Clavate or cylindrical (mostly paired gametangia). Anamorph: *Penicillium*, usually well-defined biverticillate penicilli.
Ubiquinone	Major ubiquinones Q-10(H_2): *T. flavus*[a], *T. helicus* var. *helicus*[a], *T. helicus* var. *boninensis*, *T. stipitatus*[a], *T. galapagensis*, *T. indigoticus*, *T. macrosporus*, *T. muroii*. Ubiquinones not determined: *T. panasenkoi*.

a) Ubiquinone systems determined by Kuraishi et al. (1991).

anamorphus: *Penicillium*. Ubiquinona principalia: Q-10 (H_2) et Q-10(H_4).

Typus: *Talaromyces trachyspermus* (Shear) Stolk et Samson.

Pitt (1979b) subdivided the section *Talaromyces* into three series: *Flavi, Lutei* and *Trachyspermi*. The former two are closely related and relatively homogeneous taxa based on their shared characteristics such as production of colored ascomata and the Q-10(H_2) system. On the other hand, the ubiquinone system of *T. trachyspermus* was determined mostly to be a mixture of Q-10(H_2) and Q-10(H_4) by Kuraishi et al. (1991) and this supports a separation of the species from all taxa in both *Flavi* and *Lutei* as a section rank. Morphologically *T. trachyspermus* differs from the taxa of *Flavi* and *Lutei* in its white ascomata and rapid growth at 37°C. Stolk and Samson (1972) placed *T. trachyspermus* in the section *Talaromyces*, but stated that the species belonging to this section are mesophilic, with optimum temperatures of about 25°C and maximum temperatures not exceeding 40°C, with the exception of *T. trachyspermus*, which still grows slowly at 40°C. We propose that *T. trachyspermus* and its allied taxa should be considered as a new section.

Series *Trachyspermi* The series *Trachyspermi* sensu Pitt (Pitt, 1979b) contains six species, which are characterized by swollen, gnarled and profusely branched ascomatal initials, relatively large ascomata, and short conidiophores: *T. trachyspermus, T. gossypii* (=*T. trachyspermus* var. *assiutensis* (Samson et Abdel-Fattah) Yaguchi et Udagawa), *T. ohiensis, T. galapagensis, T. mimosinus* and *T. intermedius* (Apinis) Stolk et Samson. However, only two species placed in *Trachyspermi* sensu Pitt, *T. trachyspermus* and *T. gossypii* constitute the least homogeneous group in the section *Trachyspermus*. Phylogenetic analysis of *Talaromyces* species using sequence data from small subunit rDNA also suggested a heterogeneity among the four taxa in the series. LoBuglio et al. (1993) indicated that, within *Trachyspermi* sensu Pitt, a close statistically well-supported relationship is found only between *T. trachyspermus* and *T. gossypii*, while *T. intermedius* and *T. mimosinus* are found on different clades. Distinguishing characteristics and ubiquinone systems of members in the series *Trachyspermi*, the section *Trachyspermus*, are summarized in Table 4. *Talaromyces derxii* Takada et Udagawa, a heterothallic taxon, obviously belongs in this series (Takada and Udagawa, 1988).

Table 3. Diagnostic characters and ubiquinones of members of series *Lutei* in section *Talaromyces*.

Diagnostic character	Colony diam on MEA at 25°C in 7 d: Mostly less than 30 mm. Ascomata colored: Yellow, orange or reddish. Growth at 37°C: Lacking or restricted. Ascomatal initials: Variable but unlike those of *Flavi*. Anamorph: *Penicillium*, well-defined biverticillate penicilli to often diminutive ones.
Ubiquinone	Major ubiquinones Q-10(H_2): *T. luteus*[a], *T. wortmannii* var. *wortmannii*[a], *T. wortmannii* var. *sublevisporus*, *T. rotundus*[a], *T. ohiensis*[a], *T. mimosinus*[a], *T. udagawae*[a], *T. austrocalifornicus, T. barcinensis, T. convolutus, T. emodensis, T. retardatus*[b], *T. subinflatus, T. tardifaciens, T. unicus*.

a), b) Ubiquinone systems determined by Kuraishi et al. (1991) and by Udagawa et al. (1993), respectively.

Table 4. Diagnostic characters and ubiquinones of members of series *Trachyspermi* in section *Trachyspermus*.

Diagnostic character	Colony diam on MEA at 25°C in 7d: Often less than 30 mm. Ascomata colored: Usually white. Growth at 37°C: Very good. Ascomatal initials: Variable but unlike those of *Flavi*. Anamorph: *Penicillium*, well defined biverticillate penicilli to diminutive ones.
Ubiquinone[a]	Major ubiquinones Q-10(H_2) and Q-10(H_4): *T. trachyspermus* var. *trachyspermus, T. trachyspermus* var. *assiutensis* (=*T. gosspyii*), *T. derxii*.

a) Ubiquinone systems also determined by Kuraishi et al. (1991).

Table 5. Distribution of ubiquinone systems in section *Emersonii* Stolk et Samson.

Anamorph	Major Ubiquinone	Species
Geosmithia	Q-10 and Q-10(H_2) or only Q-10(H_2)	*T. emersonii*[a]
	Q-10(H_2)	*T. bacillisporus*[a]
		T. eburneus
Paecilomyes (incl. *Sagenomella*)	Q-9 and Q-10	*T. spectabilis*
	Q-10	*T. leycettanus*[a]
	Q-10 and Q-10(H_2) or only Q-10(H_2)	*T. byssochlamydoides*[a]
	Q-10(H_2)	*T. ryukyuensis*

a) Ubiquinone systems determined by Kuraishi et al. (1991).

Other sections

The section *Emersonii* has been previously recognized as a heterogeneous group based on variation in: the diverse peridial types from scanty and very inconspicuous (like *Byssochlamys*) to distinct and loose textured (telaperidium), and the type of anamorph produced, of which two are usually recognized (*Paecilomyces* or *Geosmithia*). The only character common to taxa in this section is that all are thermophilic or thermotolerant. As shown in Table 5, the analytical results of Kuraishi et al. (1991) and this study revealed that the taxa in the section have a heterogeneous distribution of ubiquinone systems: Q-9 and Q-10, Q-10, Q-10 and Q-10(H_2), and Q-10(H_2). Stolk and Samson (1972) subdivided the section *Emersonii* into two groups, depending on whether anamorphs were *Paecilomyces* or *Penicillium cylindrosporum* series (=*Geosmithia* Pitt). The ubiquinone profiles in *Talaromyces* with a *Geosmithia* anamorph are relatively homogeneous, whereas those in another one with a *Paecilomyces* anamorph are considerably variable. Thus only three species, *T. emersonii* Stolk, *T. bacillisporus* (Swift) C. R. Benjamin and *T. eburneus* Yaguchi, Someya et Udagawa, which are morphologically recognized by their *Geosmithia* anamorphs, can best be classified in the section *Emersonii*. A re-evaluation of classification of the remaining taxa must await conclusive evidence by multidisciplinary approaches, including the molecular perspective.

Stolk and Samson (1972) proposed the section *Purpureus* for accomodation of *T. purpureus* (E. Müller et Pacha-Aue) Stolk et Samson, which is distinguished by its production of a dark red mycelium, diminutive conidiophores with divergent metulae, and striate conidia. However, LoBuglio et al. (1993) stated that these distinctive characters are not reflective of a strongly divergent phylogenetic relationship to other *Talaromyces* species. *Talaromyces intermedius* in *Trachyspermi* (Pitt, 1979b) is readily recognized by the rapid growth on MEA, absence of growth at 37°C, pinkish mycelium and a poorly formed anamorph. This fungus is suggested to be more nearly related to *T. purpureus* of the section *Purpureus* than to the series *Trachyspermi*. Ubiquinone Q-10(H_2) was found in these two species by Kuraishi et al. (1991). Both are represented by the type strains only; it is hoped that additional isolates will be found which will clarify the true relationships of these disconcerting species.

Section *Thermophila* Stolk et Samson is a small and distinctive group with only one species: *T. thermophilus* Stolk (anam. *Penicillium dupontii* Griffin et Maubl.). This species is characterized particularly by its thermophilic growth, being the only known thermophile with a *Penicillium* anamorph, ascomata with well-developed, thick, plectenchymatous walls, and divergent penicilli composed of ampulliform-acerose phialides (Stolk and Samson, 1972; Pitt, 1979b). The ubiquinone of *T. thermophilus* was determined as Q-10 by Kuraishi et al. (1991). Based on the sequence analysis obtained from the mitochondrial small subunit rDNA, LoBuglio et al. (1993) stated that *T. thermophilus* and *T. luteus* were consistently the most divergent *Talaromyces* species and occupied a basal position on the major *Talaromyces* clade along with *Byssochlamys nivea* Westling and *Eupenicillium javanicum* (J. F. H. Beyma) Stolk et Scott. In view of the above facts the assignment of this unique species within the genus *Talaromyces* remains in doubt.

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