TAXONOMY OF THE FUNGI OCCURRING ON BAMBOOS

I. ASPERGILLUS

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The bamboo wares such as blinds, screens, baskets etc., which are now abundantly being exported to foreign countries have been made of the culms of *Phyllostachys reticulata*, *Phyll. nigra* var. *Henonis* and *Phyll. edulis* in our country. These wares are stained with various fungi occurring severely in humid condition, especially in warm climate, so that their market price comes down considerably.

A number of the fungi parasitic on culms and branches of *Phyllostachys* spp. have already been recorded by some mycologists, but the fungi occurring on bamboo wares or slates have scarcely been recorded yet. Various fungi occurring confusedly on bamboo wares or slates were collected at several localities in Osaka and Hyogo Prefecture (Province Kawachi, Settsu and Tamba) by the present authors..

These fungi were isolated by a single spore isolation method, and cultured on the culture media such as Czapek's solution agar, onion decoction agar and malt extract agar. From the results of studies made on the morphological and cultural characteristics, they could be separated into many species belonging to the genera of *Aspergillus*, *Penicillium*, *Cladosporium*, *Curvularia*, *Alternaria*, *Fusarium*, *Mucor* etc.

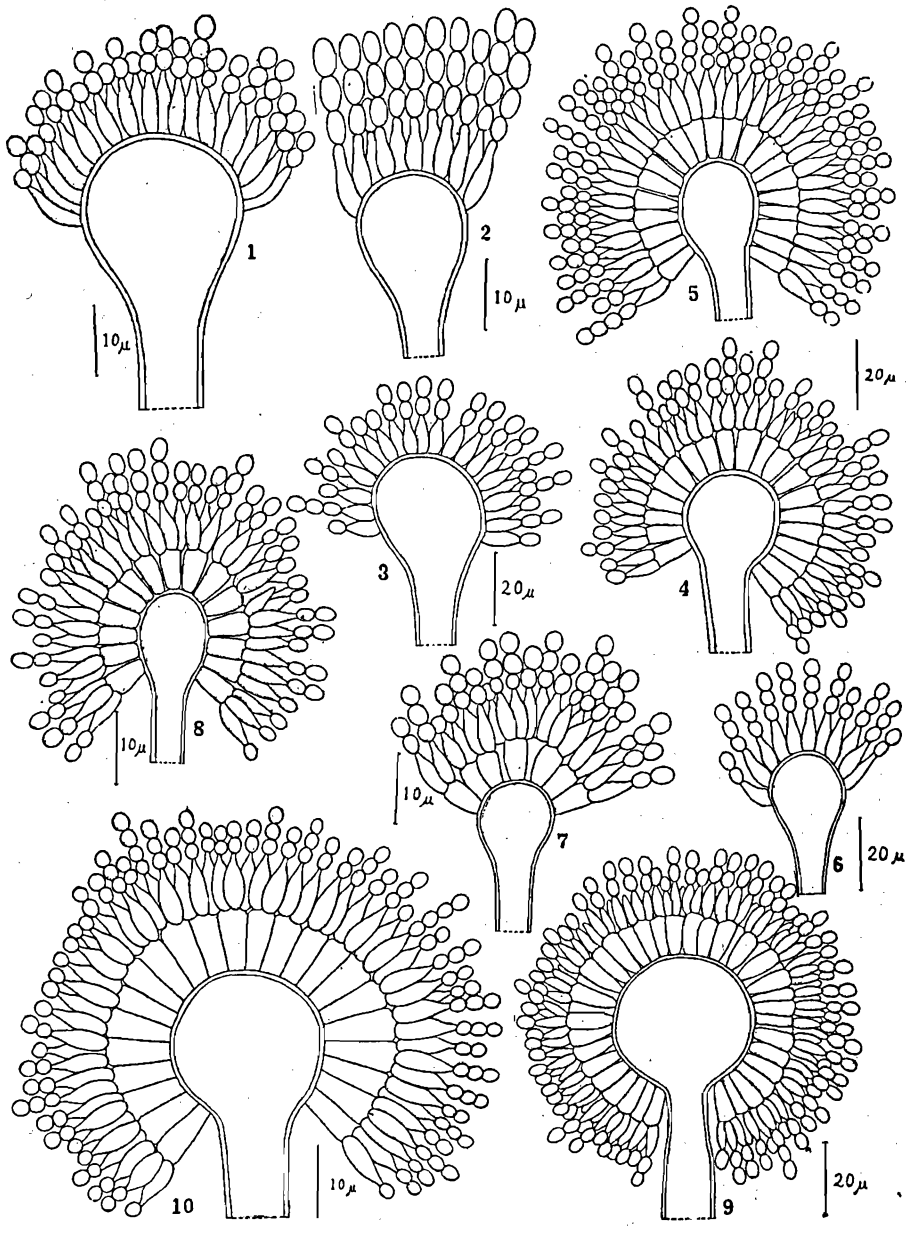
Among them, the nine species of *Aspergillus* were identified with *A. flavus*, *A. fumigatus*, *A. niger*, *A. nidulans*, *A. oryzae*, *A. quercinus*, *A. restrictis*, *A. versicolr* and *A. wentii*, respectively. The present paper deals with the diagnosis of these species of Aspergillus. The authors wish to acknowlege their indebtedness to Dr. T. HASEGAWA, Chief Researcher of the Institute for Fermentation, Osaka, for his kind advice.

Key to Species

A. Single sterigmata
  Conidiophore walls smooth
    1. Conidial heads dull green to dark green ..... 1. *A. fumigatus*
    2. Conidial heads dark green to olivaceous black ..... 2. *A. restrictis*
B. Single and (or) double sterigmata
  Conidiophore walls rough
    1. Conidial heads greenish yellow to olive..... 3. *A. oryzae*
    2. Conidial heads dull yellowish green ..... 4. *A. flavus*
C. Double sterigmata
  I. Conidiophore walls smooth
    a. Conidial chains in columns
      1. Conidial heads yellowish green to dark green.....5. *A. nidulans*
    b. Conidial chains usually in radiate heads
      1. Conidial heads dull yellow green to dull green..... 6. *A. versicolor*
      2. Conidial heads yellowish brown to brown ..... 7. *A. wentii*
      3. Conidial heads brownish black..... .....8. *A. niger*
  II. Conidiophore walls rough
    Conidial heads dull yellow to yellow..... ..... 9. *A. quercinus*

1. Aspergillus fumigatus FRESENIUS, in SACCARDO, Syll. Fung. **4** : 65. 1886 - THOM & CHURCH, Asperg. 129. 1926 - PAINE, Mycol. **19** : 254. 1927 - LECLERG, Mycol. **22** : 194. 1930 - CHANDHURI & SACHAR, Ann. Mycol. **32** : 93. 1934 - THOM & RAPER, Man. Asperg. 148. 1951 - GILMAN, Man. Soil Fung. 219. 1957 - HIRAYAMA & UDAGAWA, Bull. Fac. Agr. Mie Univ. **16** : 14. 1958.

Colonies on Czapek's solution agar growing very rapidly, becoming 7.5 cm. in diameter in 7 days at 25°C., velvety, greyish blue green to dark green near Gobelin Blue to Bottle Green, with margin thin and entire, sometimes more or less wrinkled in the central area; reverse and substratum pale yellow to pale orange. Conidial heads columnar, compact, dull green to dark green, 200~360 μ in length, 40~50 μ in diameter. Conidiophores arising directly from the submerged hyphae, crowded, somewhat sinuous, smooth, thin-walled, indistinctly septate or not septate, gradually enlarging toward the vesicle, pale brown in the upper part, 180~370 μ in length, 3~6 μ in diameter near the foot, increasing to 6~10 μ below the vesicle. Vesicles typically flask-shaped, bearing



Figs. 1~10. Conidial structures of the *Aspergillus* spp.

Fig. 1. *Aspergillus fumigatus.*
Fig. 2. *Aspergillus restrictis.*
Figs. 3~4. *Aspergillus oryzae.*
Figs. 5~6. *Aspergillus flavus.*
Fig. 7. *Aspergillus nidulans.*
Fig. 8. *Aspergillus versicolor.*
Fig. 9. *Aspergillus wentii.*
Fig. 10. *Aspergillus quercinus.*

sterigmata mostly on the upper half, 16～27 μ in diameter. Sterigmata in one series, crowded, 6.5 ～8×2～3 μ. Conidia globose to subglobose, dull green, delicately echinulate, 2.5～3.5 μ in diameter. (Fig. 1).

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Tamba, Sasayama-cho (Jan. 10, 1958, W. YAMAMOTO); Kasuga-cho (Feb. 4, 1958, N. OYASU).

2. Aspergillus restrictis SMITH, in THOM & RAPER, Man. Asperg. 141. 1951 - HIRIAYAMA & UDAGAWA, Bull. Agr. Mie Univ. **16** : 14. 1958.

Colonies on Czapek's solution agar growing very slowly, becoming about 1 cm. in diameter in 7 days at 25°C, but growing somewhat well on malt agar as well as onion agar, velvety, sometimes floccose, with margin thin and irregular, dark green, dark brown to olivaceous black in age; reverse dark green to dark brown. Conidial heads crowded, forming long, compact columns, dark green to olivaceous black, 120～450 μ in length, 17～33 μ in diameter. Conidiophores arising from the submerged or aerial hyphae, straight or slightly sinuous, smooth, rather thin-walled, colorless, indistinctly septate or not septate, broadening upward, 60～440 μ in length, 3～4 μ in diameter near the foot, increasing to 6～8 μ below the vesicle. Vesicles typically flask-shaped, bearing sterigmata on the upper part only, 8～19 μ in diameter, at times developing into secondary conidiophores bearing little heads. Sterigmata in one series, 8～12×3～3.5 μ. Conidia ellipsoid, ovoid, oblong or subglobose, delicately echinulate, olivaceous green to olivaceous brown, 4.5～9×3～4 μ. (Fig. 2).

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Tamba, Sasayama-cho (Jan. 5, 1958, W. YAMAMOTO).

3. Aspergillus oryzae (AHLBURG) COHN, in SACCARDO, Syll. Fung. **11** : 592. 1895 - THOM & CHURCH, Asperg. 198. 1926 - THOM & RAPER, Man. Asperg. 261. 1951 - HIRAYAMA & UDAGAWA, Bull. Fac. Agr. Mie Univ. **16** : 23. 1958.

Colonies on Czapek's solution agar growing rather rapidly, becoming 4 cm. in diameter in 7 days at 25°C., velvety, radially wrinkled, with margin thin and irregular, pale greenish yellow to olivaceous yellow near Moss Green to Citron Green, becoming yellowish brown in age; reverse pale orange to olive or olive grey. Conidial heads globose, later more or less elongated, radiate, greenish yellow to olive, 90～210 μ in diameter. Conidiophores arising from the submerged hyphae, straight, rather thick-walled, pitted, colorless, unseptate, 500～2300 μ in length, 11～21 μ in diameter. Vesicles globose, 30～50 μ in diameter, bearing sterigmata on the upper half or over the whole surface. Sterigmata in one to two series; in one series 8～19×3.5～5 μ, in two series with primaries 13～19×4～6 μ, secondaries 8～13×3～3.5 μ. Conidia ellipsoid, ovoid or globose, olivaceous green, smooth or slightly rough, 4～8×4～7 μ. (Figs. 3～4).

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Tamba, Kasuga-cho (Feb. 4, 1958, N. OYASU).

4. Aspergillus flavus LINK, in SACCARDO, Syll. Fung. **4** : 69. 1886 - THOM & CHURCH, Asperg. 204 : 1926 - LECLERG, Mycol. **22** : 196. 1930 - THOM & RAPER, Man. Asperg. 263. 1951 - GILMAN, Man. Soil Fung. 225. 1957 - HIRAYAMA & UDAGAWA Bull. Fac. Agr. Mie Univ. **16** : 24. 1958.

Colonies on Czapek's solution agar growing rapidly, becoming 6.5 cm. in diameter in 7 days at 25°C., velvety, with thin, irregular margin, yellow green to dull yellow green near Sprout to Pea Green or Cactus; reverse buff to yellowish brown in age. Conidial heads subglobose then columnar, compact, dull yellow green, 130～400 μ in length, 40～140 μ in diameter. Conidiophores arising from the submerged hyphae, straight or somewhat sinuous, colorless, with walls finely pitted below the vesicle, but smooth toward the base, gradually enlarging toward the vesicle, 120～480×7～11 μ. Vesicles flask-shaped or subglobose, bearing sterigmata on the upper half or over the whole surface, pale brown, 10～35 μ in diameter. Sterigmata in one to two series; in one series 6～14×3～5 μ, in two series with primaries 9～11×3～4 μ, secondaries 8～12×2.5～3.5 μ. Conidia globose to subglobose, smooth or slightly rough, olivaceous green, 3.5～6 μ in diameter. (Figs. 5～6).

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Tamba, Sasayama-cho (Jan. 15, 1958, M. MAEDA). Prov. Kawachi, Tondabayashi-shi (Jan. 27, 1958, W. YAMAMOTO).

5. Aspergillus nidulans (EIDAM) WINTER, in RABENH. Krypt.-Fl. **1**(2) : 62. 1884 - THOM & CHURCH, Asperg. 138. 1926 - PAINE, Mycol. **19** : 255. 1927 - BLOCHWITZ, Ann. Mycol. **31** : 83. 1933 - CHANDHURI & SACHAR, Ann. Mycol. **32** : 93. 1934 - THOM & RAPER, Mycol. **31** : 656. 1939 & Man. Asperg. 156. 1951 - GILMAN, Man. Soil Fung. 220. 1957 - HIRAYAMA & UDAGAWA, Bull. Fac. Agr. Mie Univ. **16** : 15. 1958.

Sterigmatocystis nidulans EIDAM, in SACCARDO, Syll. Fung. **10** : 524. 1892 - THOM & CHURCH, Asperg. 138. 1926.

Colonies on Czapek's solution agar growing rapidly, becoming 6 cm. in diameter in 7 days at 25°C., velvety, deep green to dark green in conidial

areas, with margin thin and irregular; perithecia densely scattered, light cinnamon; reverse purplish red near Cyclamen to Corinthian Purple, becoming dark purple near Wineberry to Indian Purple in age; substratum light purple near Dawn to Ochid. Conidial heads subglobose to shortly columnar, compact, yellowish green near Grass Green to Cactus or Spruce, 50～190 μ in length, 40～60 μ in diameter. Conidiophores arising from the submerged hyphae, sinuous, smooth, rather thin-walled, not septate, cinnamon colored, 90～180 μ in length, 3～4 μ in diameter near the foot, increasing to 5.5～7 μ below the vesicle. Vesicles subglobose, cinnamon colored, bearing sterigmata on the upper half only, 11～15 μ in diameter. Sterigmata in two series; primaries 5～6.5×2～3 μ, secondaries 5.5～8×2～2.5 μ. Conidia globose, rough, olivaceous green, 3～4 μ in diameter. Perithecia subglobose, thin-walled, light cinnamon, 100～250 μ in diameter. Asci subglobose, 8-spored, 8～11 μ in diameter. Ascospores lenticular, smooth-walled, violet, with two equatorial crests, 4～4.5×3.5～4 μ; crests about 1 μ in width. (Fig. 7).

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Tamba, Kasuga-cho (Feb. 4, 1958, N. OYASU).

6. Aspergillus versicolor (VUILLEMIN) TIRABOSCHI, in THOM & CHURCH, Asperg. 142. 1926 - PAINE, Mycol. **19** : 254. 1927 - BLOCHWITZ, Ann. Mycol. **27**: 208. 1929 - CHUNDHURI & SACHDR, Ann. Mycol. **32**: 96. 1934 - THOM & RAPER, Man. Asperg. 190. 1951 - GILMAN, Man. Soil Fung. 224. 1957 - HIRAYAMA & UDAGAWA, Bull. Fac. Agr. Mie Univ. **16** : 18. 1958.

Colonies on Czaperk's solution agar growing slowly, becoming 1.8 cm. in diameter in 7 days at 25°C., velvety, at times more or less floccose, somewhat raised in the central area, dull yellow green to dull green near Cactus to Spruce, becoming olive green in age, with margin compact and white to pale yellow; reverse pale orange to dull red near Salmon Pink to Old Rose; substratum dull red, becoming light yellowish red near Old Coral in age. Conidal heads hemispherical or subglobose, radiate, with periphery variously spilitting, dull yellow green to dull green, 60～130 μ in diameter. Conidiophores straight or somewhat sinuous, smooth, rather thick-walled, colorless, 220～660×4～6 μ. Vesicles flask-shaped, 11～19 μ in diameter. Sterigmata in two series, crowded; primaries 5～8×2～3.5 μ, secondaries 5～8×1.8～2.3 μ. Conidia globose to subglobose, delicately echinulate, olivaceous green, 2.5～3.5 μ in diameter. (Fig. 8).

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Settsu, Yamaghuci-cho (Jan. 29, 1958, M. MAEDA).

7. Aspergillus wentii WEHMER, in Centralbl. Bakt. Paras. 2 Abt. **2** : 150. 1896 - SACCARDO, Syll. Fung. **14** : 1045. 1890 - THOM & CHURCH, Asperg. 183. 1926 - LECLERG, Mycol. **22** : 198. 1930 - THOM & RAPER, Man. Asperg. 246. 1945 - GILMAN, Man. Soil Fung. 230. 1957.

Colonies on Czapek's solution agar growing rather slowly, becoming 3.7 cm. in diameter in 7 days at 25°C., floccose, with entire margin, dull yellow orange to brown near Yellow Ochre to Russet Brown in the conidial area; reverse pale yellow, becoming reddish dirty brown in age. Conidial heads globose, crowded, radiate, yellowish to yellowish brown or brown, 160～420 μ in diameter. Conidiophores arising from the submerged or aerial hyphae, smooth, thin-walled, not septate, colorless, 400～1500×11～12 μ. Vesicles globose, bearing sterigmata over nearly the whole surface, 30～75 μ in diameter. Sterigmata in two series, crowded; primaries 10～18×4～6 μ, secondaries 7～11×3～4 μ. Conidia globose, pyriform or ellipsoid, delicately echinulate, pale brown, 4～7×3.5～5.5 μ. (Fig. 9).

Hab. On bamboos of *Phyllostachys nigra* MUNRO var. *Henonis* MAK. Prov. Tamba, Sasayama-cho (Jan. 10, 1958, W. YAMAMOTO).

On *Phyllostachys reticulata* KOCH. Prov. Settsu, Yamaguchi-cho (Jan. 29, 1958, M. MAEDA).

8. Aspergillus niger v. TIEGHEM, in SACCARDO, Syll. Fung. **4** : 75. 1886 - THOM & CHURCH, 167. 1926 - PAINE, Mycol. **19** : 255. 1927 - CHANDHURI & SACHAR, Ann. Mycol. **32** : 94. 1934 - THOM & RAPER, Man. Asperg. 216. 1951 - GILMAN, Man. Soil Fung. 228. 1957 - HIRAYAMA & UDAGAWA, Bull. Fac. Agr. Mie Univ. **16** : 20. 1958.

Sterigmatocystis nigra v. TIEGHEM, in SACCARDO. Syll. Fung. **4** : 75. 1886 - THOM & CHURCH, Asperg. 167. 1926.

Colonies on Czapek's solution agar growing rapidly, becoming 5.6 cm. in diameter in 7 days at 25°C., velvety, with margin somewhat irregular, brownish black near Sepia; reverse colorless or pale yellow in age. Conidial heads globose to subglobose, radiate, later more or less elongated, with periphery variously spilitting into radiating columns of conidia, brownish black near Sepia, 110～320 μ in diameter. Conidiophores arising from the submerged hyphae, smooth, thick-walled, not septate, colorless or nearly so, 200～900×8～13 μ. Vesicles globose, bearing sterigmata over the whole surface, 20～50 μ in diameter. Sterigmata in two series; primaries long clavate, 20～40×8～11 μ, secondaries 7～10×3～4 μ. Conidia globose, smooth or slightly rough, pale brown, 3～4.5 μ in diameter.

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Tamba, Sasayama-cho (Jan. 15, 1958. M. MAEDA); Kasuga-cho (Feb. 4, 1958, N. OYASU). Prov. Kawachi, Tondabayashi-shi (Jan. 27, 1958, W. YAMAMOTO).

9. Aspergillus quercinus (BAINIER) THOM et CHURCH, in Asperg. 186. 1926 - THOM & RAPER, Man. Asperg, 276. 1951 - HIRAYAMA & UDAGAWA, Bull. Fac. Agr. Mie Univ. **16** : 25. 1958.

Sterigmatocystis quercina BAINIER, in THOM & CHURCH, Asperg. 186. 1926.

Colonies on Czapek's solution agar growing rather slowly, becoming 4 cm. in diameter in 7 days at 25°C., velvety, slightly wrinkled, dull yellow to light reddish yellow near Corn to Apricot Yellow, becoming pale purplish pink in age; reverse cream to dull yellow, becoming pale purplish brown in age. Conidial heads globose, radiate, later columnar, dull yellow to yellow, conidial chains divergent, 120～460 μ in length, 80～140 μ in diameter. Conidiophores arising from the submerged hyphae, somewhat sinuous, rather thick-walled, indistinctly septate, with walls pitted or rough, pale yellowish brown, 900～1600×7～12 μ. Vesicles globose, colorless or pale brown, fragile, bearing sterigmata on the upper half or over the whole surface, 19～35 μ in diameter. Sterigmata in two series; primaries 9～14×3.5～6 μ, secondaries 2.5～3.5×2～2.5 μ. Conidia globose, smooth or slightly rough, pale green, 2.5～3.5 μ in diameter. Sclerotia gregarious, subglobose to irregular, pale pink to pale purplish pink, 300～1450×200～1160 μ. (Fig. 10).

Hab. On bamboos of *Phyllostachys reticulata* KOCH. Prov. Tamba, Sasayama-cho (Jan. 10, 1958, W. YAMAMOTO). Prov. Settsu, Yamagnchi - cho (Jan. 29, 1958, M. MAEDA).

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