

**THE ASPERGILLI FROM JIADING  
SICHUAN CHINA**

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# The Aspergilli from Jiading Sichuan China

Xue-Hui Zhao

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This account is a taxonomic study of the genus *Aspergillus* found around Jiading, Sichuan. More than one thousand pure cultures were isolated to supply materials for this investigation. From these cultures, thirty species and strains were distinguished according to the cultural and microscopic characteristics. The systematic arrangement of the organisms studied is according to the system of Thom and Church.

This work was begun in August 1942 and finished in February 1943 in the laboratory of mycology of the Wuhan University, under the direction of professor X. X. Chung. I am indebted to the authorities of the Wuhan University for the facilities supplied; to professor H. H. Chung for his kind instruction and criticisms through out the work; and finally to Mr. L. Y. Tai from whom I have received a number of cultures of *Aspergillus* and much valuable help.

## Method of Investigation

The *Aspergillus* is commonly encountered on different kinds of organic materials. The cultures employed in this experiment are directly isolated from such materials as cooked rice, baked potato, decaying fruits, oak gall, soy-bean, waste paper, and herbarium specimens etc.. These materials were put in the moist chambers at relatively high temperature under such conditions the *Aspergilli* developed rapidly.

When the pure cultures were isolated, they are transferred to the medium of Czapek's solution agar and incubated at 25 to 32 °C..

## Generic Characterization of *Aspergillus*

The most striking characters of an *Aspergillus* colony usually is its color production. This takes two general forms: (1) color in the aerial part, hyphae, stalks and heads, as universally included in characterization of the species; (2) color included in the substratum, and representing the specific effect of the organism upon particular media. The next important characters of the surface growth which have been described as velvety or floccose; smooth or wrinkled and with or without drops etc., are usually reliable under reasonably uniform condition of culture.

The vegetative mycelium consists of septate branching hyphae, colorless or bright colored, sometimes producing sclerotia, conidial apparatus develops from specialized thick walled hyphal cells, the foot cells, from which arise stalks as branches approximately perpendiculars to long axis

of the foot cells. The stalks may be unseptate or septate, usually enlarging upward and broadening into vesicles, bearing fertile cells or sterigmata either in one series or in two series. Conidia vary greatly in color, size, shape and markings, are successively cut off from the tips of the sterigmata by cross walls, and form unbranched chains, arranged into radiate heads or packed into columnar masses. Perithecia are formed in certain species only, producing asci and ascospores within, in varying period of time.

### Description of Species and Strains

#### 1. *A. clavatus* Desm.

Colonies at first white through bluish green to deep blue green in age, broadly spreading with narrow white margin during the growing period, showing powdery in age, surface slightly wrinkled, with drops colorless, reverse wrinkled and deeply folded, whitish when young, through yellow becoming dark brown when old, agar at first colorless turning to yellowish brown in age; heads clavatus; stalks smooth, colorless, rather thin walled, 500 to 800  $\mu$  by 20 to 30  $\mu$ ; vesicles clavatus, 120 to 200  $\mu$  by 30 to 45  $\mu$ ; sterigmata in one series, closely covering, colorless, 7 to 10  $\mu$  by 2 to 3  $\mu$ ; conidia elliptical, smooth, yellowish green in mass, 4 to 5  $\mu$  by 2.5 to 3.5  $\mu$ .

Habitat: On cooked rice. (culture No. A18)

#### 2. *A. repens* (Corca) Saccardo. Strain 1.

Colonies at first ashy green, then through light yellow, orange, ferrugeneous, for the development of perithecia, becoming greenish black in age, growing very slowly, surface smooth, broadly spreading, conidial heads poorly produced when the temperature over 25 °C or below 20 °C, but the perithecia produced abundantly at 25 to 32 °C, reverse from greenish avellaneous to dark brown in age, agar colorless when young, gradually becoming dark brown when old; heads globose, up to 200  $\mu$  in diameter; stalks smooth, colorless, mostly septate, arising directly from the substratum, gradually enlarged upward, 500 to 800  $\mu$  by 6 to 12  $\mu$ ; occasionally up to 2000  $\mu$  long; vesicles varying from only slight apical dilation's of the stalks to globose 13 to 25  $\mu$  in diameter; sterigmata loosely clustered, fairly large and yellow colored, in one series, 6 to 10  $\mu$  by 3 to 4  $\mu$ , commonly proliferating to become the secondary heads; conidia elliptical or globose, thick walled, delicately roughened or echinulate, green color in mass. 3 to 6  $\mu$  in long axis; perithecia bright yellow colored, globose or subglobose, 50 to 150  $\mu$  in long axis, asci roughly globose, 10 to 12  $\mu$  in diameter, ascospores elliptical, colorless to pale green, thick walled, without frill or ridge, with shallow smooth furrow, 4 to 6  $\mu$  in long axis.

Habitat: On soy bean, and herbarium specimen (culture No. A16b, A24, A38 and A83)

#### 3. *A. repens* (Corda) Saccardo. Strain 2.

This strain differs from strain 1 in that its colonies develop poorly on Czapek's solution agar, but broadly spreading on potato agar, and perithecia bright yellow colored even in old cultures.

Habitat: On soy bean (culture No. A25)

#### 4. *A. glaucus restrictus* Smith.

Colonies growing very poorly on Czapek's solution agar, growing well on potato, ashy green to dark gray; heads globose, up to 100  $\mu$  in diameter; stalks smooth, colorless, up to 800  $\mu$  by 4 to

10  $\mu$  ; vesicles subglobose, colorless, 10 to 20  $\mu$  in diameter; sterigmata in one series, covering the upper half only, 4 to 8  $\mu$  by 2 to 3  $\mu$  ; conidia elliptical or pyriform to globose, thick walled, delicately roughened or echinulate, green color in mass, 3 to 5  $\mu$  in diameter; perithecia not found.

Habitat: on soy bean ( culture No. A16a ).

**5. *A. fumigatus* Fresenius .**

Colonies at first pale green to dark green, becoming almost black in age, surface folded, velvety, conidial densely crowded, reverse and agar colorless when young , becoming light brown when old; heads columnar, with conidial chain up to 200  $\mu$  long; stalks smooth, with more or less greenish color, gradually enlarged upward up to 300  $\mu$  by 4 to 5  $\mu$  ; vesicles subglobose or globose, fertile only on the upper half 10 to 20  $\mu$  in diameter; sterigmata in one series, crowded, with axis roughly parallel to axis of the stalk 6 to 8  $\mu$  by 2 to 3  $\mu$  ; conidia globose or elliptical, 2 to 3  $\mu$  or even up to 6  $\mu$  in long axis.

Habitat: On waste paper. (culture No. A51 ).

**6. *A. versicolor* (vuillemin) Tiraboschi. strain 1.**

colonies at first white then through pale green, yellow green, grape green to dark brown in age, velvety, wrinkled, with some area colored orange or umber and with narrow white margin during the growth period, drops brown to dark brown color, reverse and agar pale yellow to dark brown; heads radiate, incompletely globose; stalks smooth, colorless, 400 to 600  $\mu$  by 4 to 8  $\mu$  ; vesicles subglobose to globose, fertile on the upper two-thirds. 10 to 20  $\mu$  in diameter; sterigmata radiate, colorless, in two series, primary 4 to 6  $\mu$  by 3 to 4  $\mu$  , secondary 5 to 8  $\mu$  by 2  $\mu$  ; conidia globose, delicately roughened, 2.5 to 3  $\mu$  in diameter.

Habitat: on orange, bread and peanut. (culture No. A84).

**7. *A. versicolor* (Vuillemin) Tiraboschi. strain 2.**

This one differ from the strain 1 in its colony characters; colonies with more or less sterile aerial hyphae at the marginal zone, white to buff or orange color, drops yellowish , brown, reverse from pale yellow, orange, to deep coffee brown, agar flesh colored when young, gradually becoming deep brown when old.

Habitat: On herbarium specimen and bread. (culture No. A89).

**8. *A. versicolor* (Vuillemin) Tiraboschi. strain 3.**

This strain differs from the foregoing strains in the color changes of reverse and agar of the colony; reverse and agar at first colorless then through pale yellow, bright red to deep reddish brown in age.

Habitat: On bread. (culture No. A73 ).

**9. *A. versicolor* (Vuillemin) Tiraboschi. strain 4.**

This one differs from the foregoing strains in its colony characters; colonies floccose, with aerial hyphae white to buff or pink color, reverse smooth, from pale yellow, yellowish brown, orange to dark brown, agar from pale brown, pinkies brown to honey brown in age.

Habitat: On soy bean. (culture No. A80).

**10. *A. versicolor* (Vuillemin) Tiraboschi. strain 5.**

This one differs from the foregoing strains in its colony characters; colonies at first white then through pale green, grape green to sage green after one month, surface wrinkled, with more or less sterile hyphae, drops very abundant, yellowish brown; reverse from buff, pink, orange light salmon to red in age, agar flesh colored.

Habitat: On a waste oil bottle in a kitchen. (culture No. A4).

**11. *A. versicolor* (Vuillemin) Tiraboschi. strain 6.**

This strain differs from the foregoing strains in its colony characters; colonies fealty, with more or less sterile hyphae, reverse pale yellow to light brown, agar light yellow when old.

Habitat: On Chinese gall. (culture No. A75).

**12. *A. versicolor* (Vuillemin) Tiraboschi. strain 7.**

This strain differs from the foregoing strains chiefly in colony characters; colonies floccose with abundant aerial hyphae white to buff, pink, or even to purple blue colors, reverse from buff, brown, coffee color to dark when old, agar dark brown.

Habitat: On cooked rice. (culture No. A74).

**13. *A. sydowi* (Bainier and Sartory) Thom and Church.**

Colonies at first white, then greenish blue to deep blue green, becoming dark greenish blue after one month, surface velvety, wrinkled, over growth with more or less trailing hyphae in old culture, and with narrow white margin during the growth period, drops colorless to brown color; reverse pale brown to deep purple red, becoming dark color when old, agar yellowish to purple red; heads nearly globose; stalks arising from submerged hyphae, colorless, smooth, thick walled, up to 500  $\mu$  by 4 to 8  $\mu$ ; vesicle subglobose, 12 to 20  $\mu$  in diameter; sterigmata in two series, primary 4 to 6  $\mu$  by 2 to 3  $\mu$ , secondary 7 to 10  $\mu$  by 2  $\mu$ ; conidia globose, blue green on mass, delicate roughened, 2 to 3  $\mu$  in diameter.

Habitat: On potato. (culture No. A27).

**14. *A. flavipes* (Bainier and Sartory) Thom and Church. strain 1.**

Colonies at first persistent white, then gradually becoming pale pink in age, floccose with abundant woolly aerial hyphae, conidial masses very scantily produced, reverse smooth, white to brown; heads globose; stalk light yellowish, smooth, but occasionally with wart or concretions on the surface of walls, 1 or 2 inconspicuously septate, 300 to 800  $\mu$  by 5 to 10  $\mu$ ; vesicles subglobose, 20 to 30  $\mu$  in diameter; sterigmata radiate, colorless, closely packed, in two series, primary 4 to 6  $\mu$  by 3 to 4  $\mu$ , secondary 6 to 8  $\mu$  by 1.5 to 2.5  $\mu$ ; conidia globose, smooth, 2 to 3  $\mu$  in diameter.

Habitat: On cooked rice. (culture No. A78).

**15. *A. fiacipes* (Bainier and Sartory) Thom and Church. strain 2.**

this one differs from the strain 1 in its colonies at first white through pale yellow becoming flesh color in age, with very abundant white sterile aerial hyphae, and with large drops bright

yellow colored; stalk relatively long, up to 2mm. in length.

Habitat: On bread. (culture No. A70).

**16. *A. candidus* Link.**

Colonies at first white, gradually becoming cream color in age, with more or less aerial hyphae, surface slightly wrinkled, drops colorless reverse and agar colorless to pale yellow when young, becoming dark gray when old; heads roughly globose, radiate, periphery rimose, up to 200  $\mu$  in diameter; stalks smooth, colorless, occasionally with septate, 600  $\mu$  to 1000  $\mu$  by 6 to 10  $\mu$ ; vesicles globose, 25 to 35  $\mu$  in diameter; sterigmata radiate, closely covering, colorless, in two series, primary 8 to 10  $\mu$  by 3 to 4  $\mu$ , secondary 6 to 8  $\mu$  by 2 to 3  $\mu$ , but the primary sterigmata up to 70  $\mu$  by 8 to 12  $\mu$  in its nature habitat; conidia globose, smooth, colorless, 3 to 4  $\mu$  in diameter; sclerotia abundantly produced after a few weeks, purple black, 1 to 2mm. in diameter.

Habitat: On waste paper. (culture No. A26).

**17. *A. niger* Van Tieghem strain 1.**

Colonies at first white, through yellowish black rapidly becoming carbon black, broadly spreading with scanty aerial hyphae, and abundant submerged mycelium, conidial at first more or less scattered but becoming more compact, surface wrinkled, drops abundant, colorless to brownish yellow, reverse first colorless then to bright yellow, becoming dark brown in age, agar colorless when young, yellow colored when old; heads typically globose, more or less rimose at the periphery, up to 300  $\mu$  in diameter; stalks mostly rising directly from the substratum, colored yellowish brown near the vesicle, smooth, with uneven ends when broken, up to 2000  $\mu$  by 10 to 20  $\mu$  and with walls about 2  $\mu$  thick; vesicles globose, brownish colored, 40 to 60  $\mu$  in diameter; sterigmata closely packed, brownish yellow, in two series, primary 20 to 24  $\mu$  by 3 to 4  $\mu$ , secondary 4 to 8  $\mu$  by 2 to 3  $\mu$ , conidia globose, spinulose from coloring substance deposited as tubercles or bars between the outer and inner walls, carbon black in mass, 4 to 6  $\mu$  in diameter.

Habitat: On decaying chestnuts and hog plum. (culture No. A5).

**18. *A. niger* Van Tieghem. strain 2.**

This strain differs from strain 1 in the characters of color changes of reverse and agar; the reverse and agar at first colorless then gradually becoming pale yellow in age; stalks usually up to 4mm. long; sclerotia commonly found, almost globose, white to pink colored after one month, 2 to 4mm. in diameter.

Habitat: On bread and decaying fruits. (culture No. A37).

**19. *A. atropurpureus* Zimmermann.**

Colonies first white, rapidly through yellowish black to sooty black, broadly spreading, surface wrinkled, with drops colorless, then yellowish brown colored, reverse transversely wrinkled, colorless when young, through pale yellow rapidly to dark brown, agar colorless to dark brown; heads globose, radiate, up to 300  $\mu$  in diameter; stalks smooth, yellowish, up to 2mm. by 10 to 20  $\mu$ ; vesicles globose, brownish colored, 60 to 80  $\mu$  in diameter; sterigmata yellowish brown, in two series, closely covering, primary 30 to 50  $\mu$  by 6 to 10  $\mu$ , secondary 6 to 10  $\mu$  by 3 to 4  $\mu$ ; conidia globose, spinulose, brown black in mass, 6 to 8  $\mu$  in diameter.

Habitat: On cooked rice . (culture No. A63 ).

**20. *A. wentii* Wehmer.**

Colonies at first white to deep brown in age, surface floccose, slight wrinkled, with abundant white aerial hyphae, and with drops colorless to light yellow; on potato, producing large masses of aerial mycelium which in tubes may fill the lumen several cm. Above the substratum; reverse at first white then through buff, brown to dark brown when old, agar brownish yellow when mature, heads radiate, globose, with more or less periphery fimbriat, up to 400  $\mu$  in diameter; stalks smooth, colorless, 1 to 2mm. by 10 to 20  $\mu$ , stalk wall 1 to 2  $\mu$  thick; vesicles globose, colorless 20 to 40  $\mu$  in diameter, but up to 120  $\mu$  in potato agar; sterigmata radiate, closely covering, in two series, primary 20 to 30  $\mu$  by 6 to 10  $\mu$ , secondary 10 to 12  $\mu$  by 3 to 4  $\mu$ ; conidia commonly globose roughened, yellowish brown in mass, 4 to 5  $\mu$  in diameter.

Habitat: On dried bamboo shoot . (culture No.A17 ).

**21. *A. ochraceus* Wilhelm. strain 1.**

Colonies at first white then through buff yellow, bright yellowish brown to deep yellow brown in age, surface wrinkled, crowded, with yellow drops, reverse at first colorless, then through buff brown, greenish brown to dark brown when old, agar deep brown when mature; heads radiate, roughly globose; stalks with warts or concretions on the surface of walls, yellowish brown colored, 600 to 1000  $\mu$  by 6 to 12  $\mu$ , thick walled; vesicles globose, yellow, 15 to 25  $\mu$  in diameter; sterigmata radiate, yellow, closely packed, always on two series, primary 10 to 12  $\mu$  by 4 to 5  $\mu$ , secondary 8 to 10  $\mu$  by 2 to 3  $\mu$ ; conidia pyriform to globose, smooth, thin walled, yellow color in mass, 4 to 5  $\mu$  in diameter.

Habitat: On peanut. ( culture No. A59 ).

**22. *A. ochraceus* Wilhelm strain 2.**

This one differs from the foregoing strain in its colonies colored pale yellow throughout the development, conidial production scanty, and with abundant white woolly aerial hyphae, reverse from pale yellow orange to bright brown, agar bright yellow to honey brown; heads mostly globose; stalks finely pitted, up to 2mm.long; conidia globose, 2 to 3  $\mu$  in diameter.

Habitat: On rice. (culture No. A52 ).

**23. *A. ochraceus* Wilhelm. strain 3.**

This one differs from strain 1 in its colonies being floccose, with abundant aerial hyphae, white to buff colored; it differs from strain 2 in its colonies colored bright yellow, not pale yellow; heads columnar; and sclerotia produced abundantly after a few week, white to pink color, 1 to 2mm.in diameter.

Habitat: On peanut. ( culture No, A54 ).

**24. *A. tamaritii* Kita. strain 1.**

Colonies at first white then through cream, buff, honey yellow, olive brown to deep coffee brown in age, broadly spreading, surface transversely wrinkled, drops colorless, reverse and agar colorless when young, gradually through pinkies brown, coffee brown to brownish dark when old; heads radiate, globose to more or less columnar, with periphery fimbriate, up to 300  $\mu$  in diameter;



stalks colorless, roughened and echinulate, up to 1500  $\mu$  by 6 to 15  $\mu$ ; vesicles subglobose to globose, 20 to 40  $\mu$  in diameter; sterigmata one series in small heads, 10 to 12  $\mu$  by 4 to 6  $\mu$ , two series in large heads, primary 10 to 12  $\mu$  by 4 to 6  $\mu$ , secondary 8 to 10  $\mu$  by 3 to 4  $\mu$ ; conidia pyriform to globose, spinulate, 5 to 6  $\mu$ , occasionally up to 8  $\mu$  in diameter; sclerotia not found.

Habitat: On cooked rice. (culture No. A14).

**25. *A. tamarii* Kita. strain 2.**

This strain differs from strain 1 in its far longer stalks up to 5mm.; large conidia 6 to 12  $\mu$  in diameter; and colonies color from cream through buff, golden yellow, light brown to coffee brown in age, surface floccose, with abundant white aerial hyphae, reverse and agar at first yellow, then brownish pink, becoming honey brown in age.

Habitat: On bread (culture No. A62).

**26. *A. oryzae* (Ahlburg) Cohn. strain 1.**

Colonies at first white then through pale yellowish green, yellow green to deep green after one month, gradually to olive brown in age, broadly spreading, surface wrinkled, without drops, reverse yellowish white to brownish yellow, agar pale yellow to light yellow when old; heads globose, radiate or calyptra formed a columnar conidial mass; stalks pitted, uncolored, broadening upward, occasionally septate, 500 to 1000  $\mu$  by 6 to 20  $\mu$ ; vesicles subglobose, 15 to 30  $\mu$  in diameter; sterigmata covering the upper two-thirds of the vesicles, semi-radiate, yellowish green colored mostly in one series 6 to 8  $\mu$  by 2 to 3  $\mu$ ; conidia globose, roughened 4 to 6  $\mu$  occasionally up to 8  $\mu$  in diameter.

Habitat: On cooked rice. (culture No. A3).

**27. *A. oryzae* (Ahlburg) Cohn. strain 2.**

This one differs from strain 1 chiefly in its colony characters; colonies at first white then through pale green to greenish gray on age, surface floccose with abundant white woolly aerial hyphae, and drops colorless, reverse and agar uncolored after one month.

Habitat: On soy bean. (culture No. A1).

**28. *A. oryzae* (Ahlburg) Cohn. strain 3.**

This strain differs from the foregoing strains in its far longer stalks up to 4mm. and colonies floccose, green to ashy green, reverse and agar pale yellow to honey yellow colored.

Habitat: On bread. (culture No. A61.).

**29. *A. flavus* link. Strain 1.**

Colonies at first white then light greenish yellow to yellow green, gradually becoming deep green in age, rapidly and broadly spreading, wrinkled, aerial mycelium scanty growth, and with drops colorless, reverse and agar from pale yellow to honey yellow, and showing coffee brown when old; heads smaller globose and larger columnar, up to 800  $\mu$  in length; stalks finely pitted, uncolored, broadening upward, 600 to 80  $\mu$  even up to 2000  $\mu$ , by 6 to 15  $\mu$ ; vesicles subglobose, yellowish colored, 16 to 40  $\mu$  in diameter; sterigmata colorless, semi-radiate, small heads with simple aeries of a few sterigmata, 7 to 12  $\mu$  by 3 to 5  $\mu$ , large heads partly with simple

sterigmata, partly with double series, primary 8 to 12  $\mu$  by 3 to 4  $\mu$ , secondary 7 to 10  $\mu$  by 2 to 3  $\mu$ ; conidia pyriform or globose, smooth, from colorless, to yellow green, 2 to 4  $\mu$  in diameter; sclerotia commonly developed, white to purple black, 1 to 2mm. in diameter.

Habitat: On potato. ( culture No. A34. ).

**30. *A. flavus* Link. Strain 2.**

This strain differ from strain 1 in its colonies broadly spreading, without aerial hyphae and the submerged hyphae poorly developed also, conidial growth at first scattered and then more compact, reverse and agar colored pale yellow when old, without the coffee brown color.

Habitat: On cooked rice. ( culture No. A91 ).

**Reffrence:**

Shih, Y. K.: 1936. The *Aspergilli* from Wuchang, central China. *Sci. J. of Linnan University*. **15**: 365~378, 607~612.

Thom, C. and Church, M. B.: 1926. The *Aspergilli*. The Williams & Wilkins Co., Baltimore, Md.

**FIGURES**

1. *A. clavatus* Desm.
2. *A. repens* (Corda) Saccardo.
3. *A. versicolor* (Vuillemin) Tiraboschi.
4. *A. fumigatus* Fresenius.
5. *A. conidius* Link.
6. *A. niger* Van Tieghem.
7. *A. tamarii* Kita.
8. *A. ochraceus* Wilhelm.
9. *A. oryzae* (ahlburg) Cohn.
10. *A. flavus* Link.

(Revised in 20, Mar. 1997.)

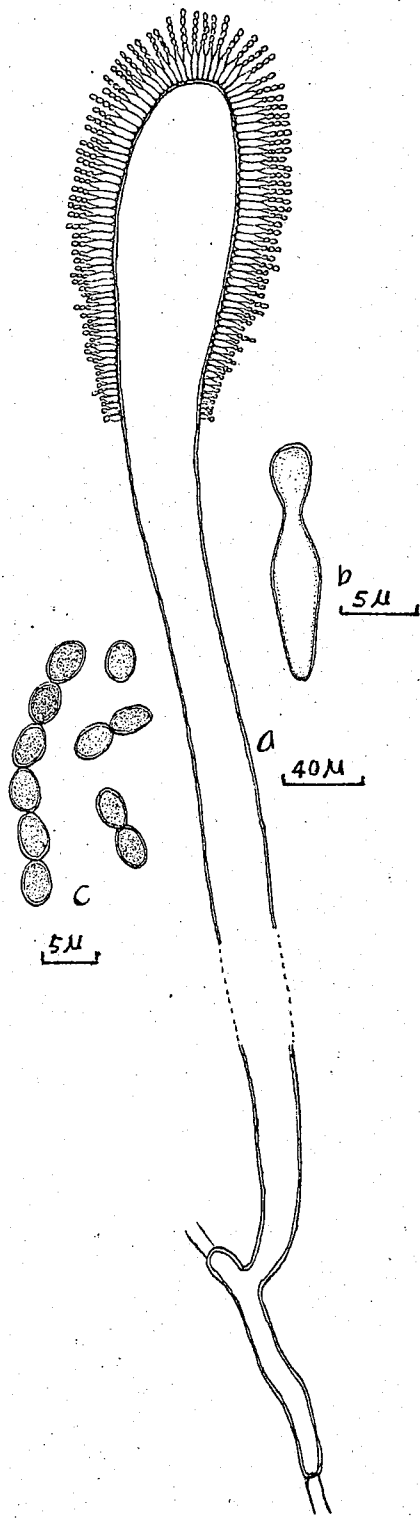


Fig. 1. *A. clavatus* Desm.  
 a, Conidiophore  
 b, Sterigmata  
 c, Conidia

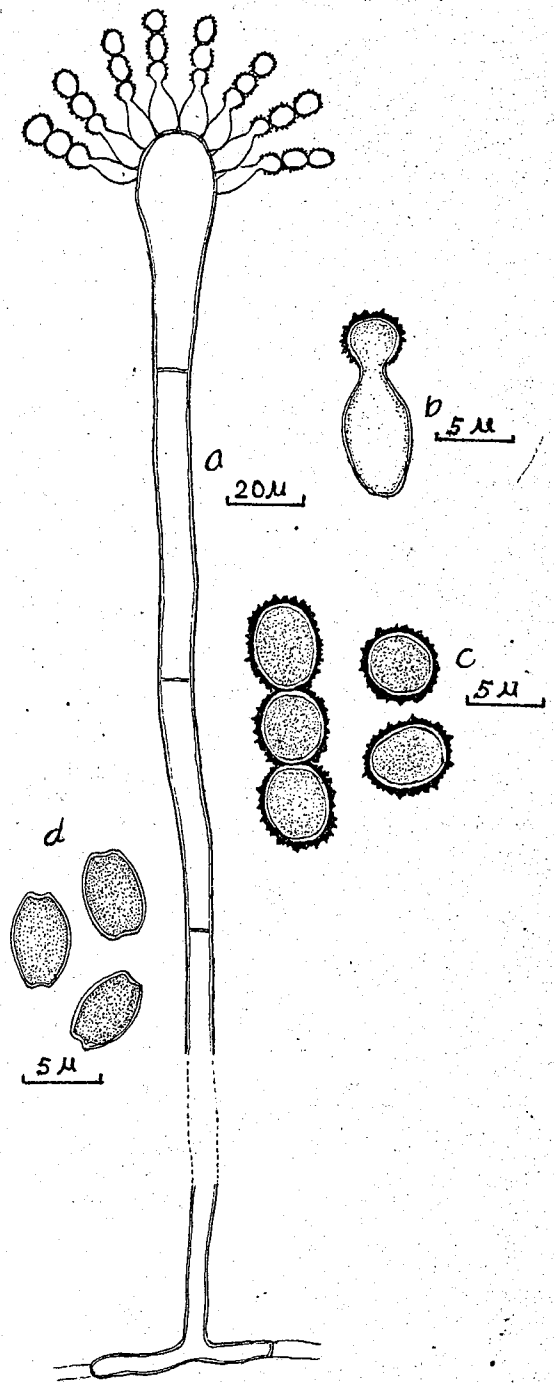


Fig. 2, *A. repens* (Corda) Saccardo.  
 a, Conidiophore  
 b, Sterigmata  
 c, Conidia  
 d, Ascospores

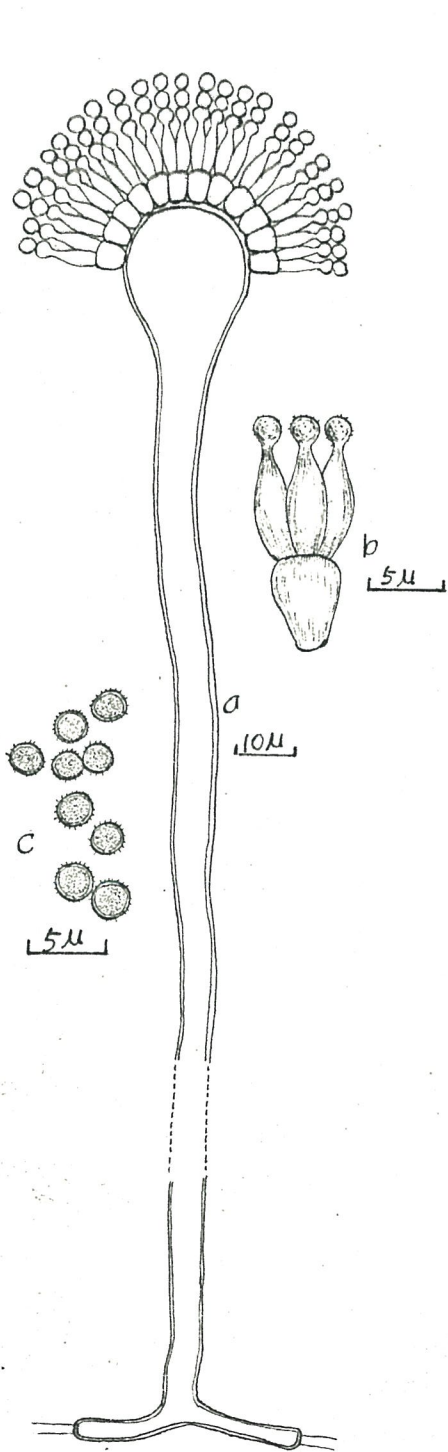


Fig. 3, *A. versicolor* (Vuillemin)  
Tiraboschi.  
a, Conidiophore  
b, Sterigmata  
c, Conidia

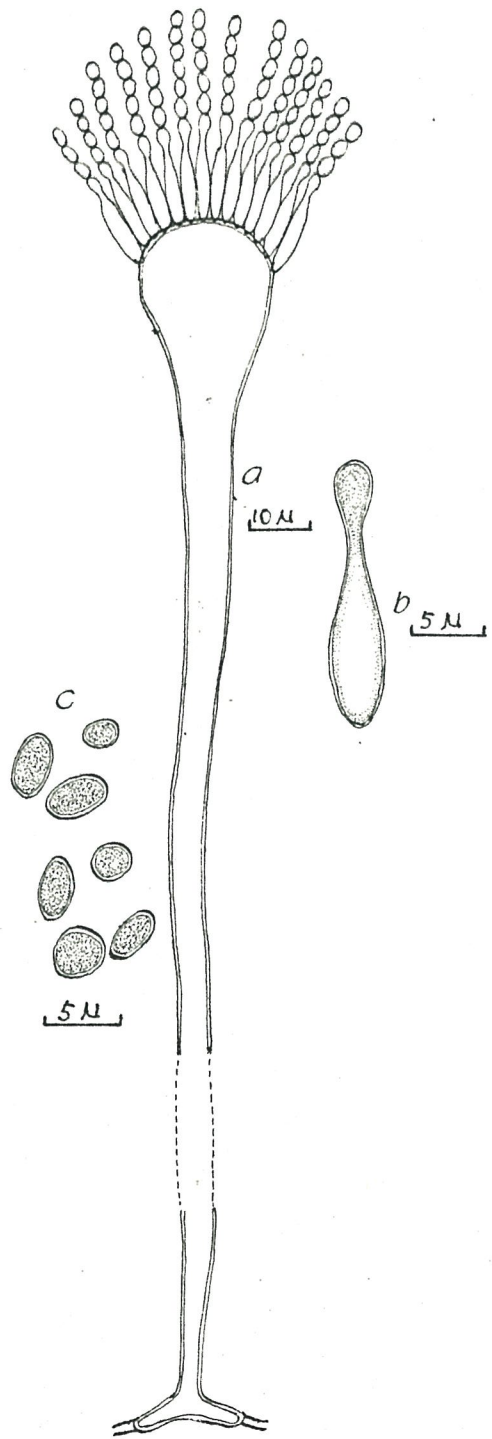


Fig. 4, *A. fumigatus* Fresenius.  
a, Conidiophore  
b, Sterigmata  
c, Conidia

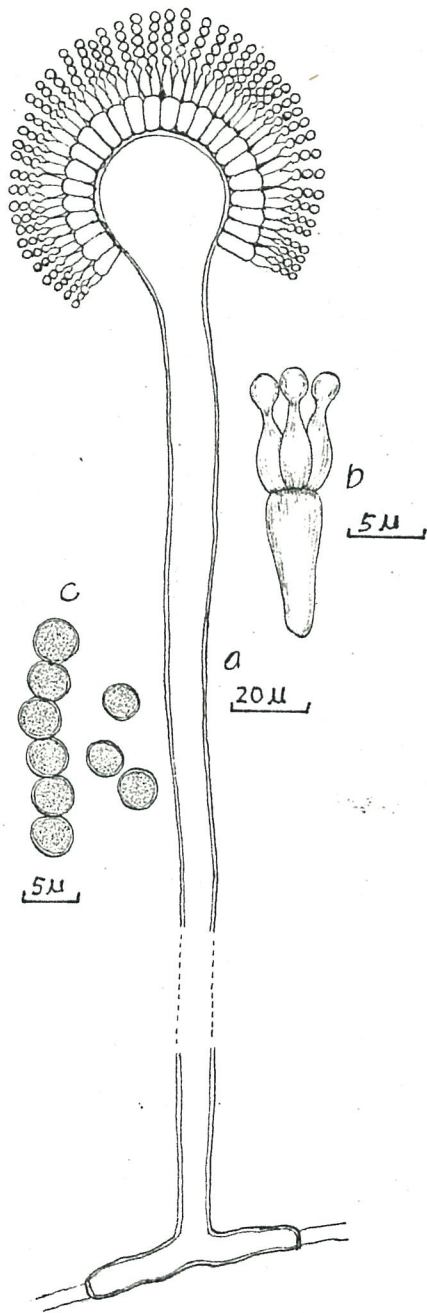


Fig.5, *A. condidus* Link.  
 a, Conidiophore  
 b, Sterigmata  
 c, Conidia

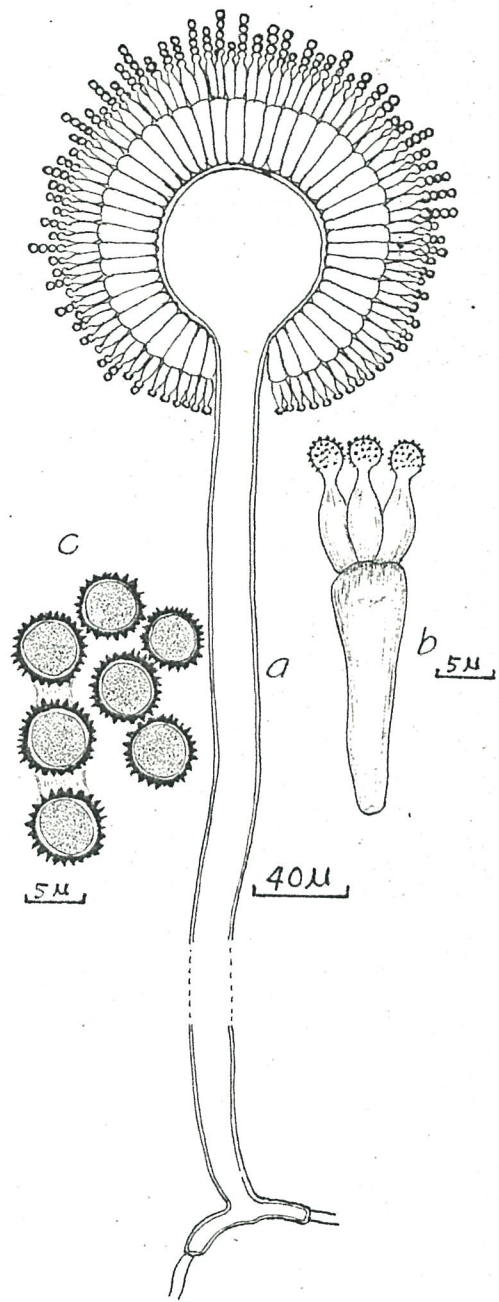


Fig.6, *A. niger* Van Tieghem.  
 a, Conidiophore  
 b, Sterigmata  
 c, Conidia

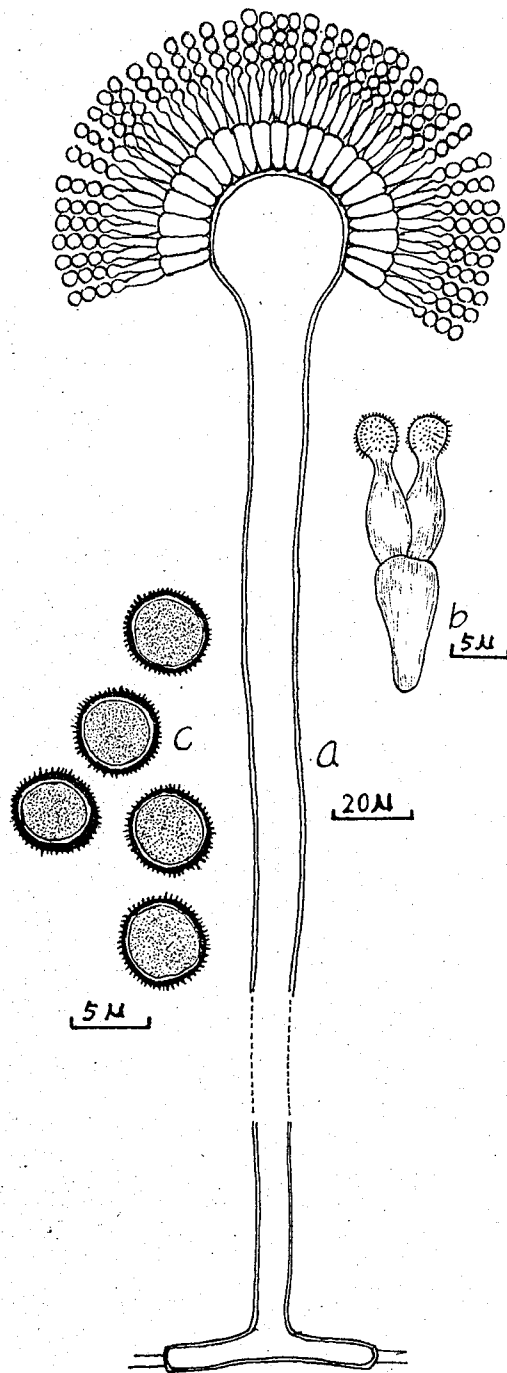


Fig. 7, *A. tamaris* Kita.  
 a, Conidiophore  
 b, Sterigmata  
 c, Conidia

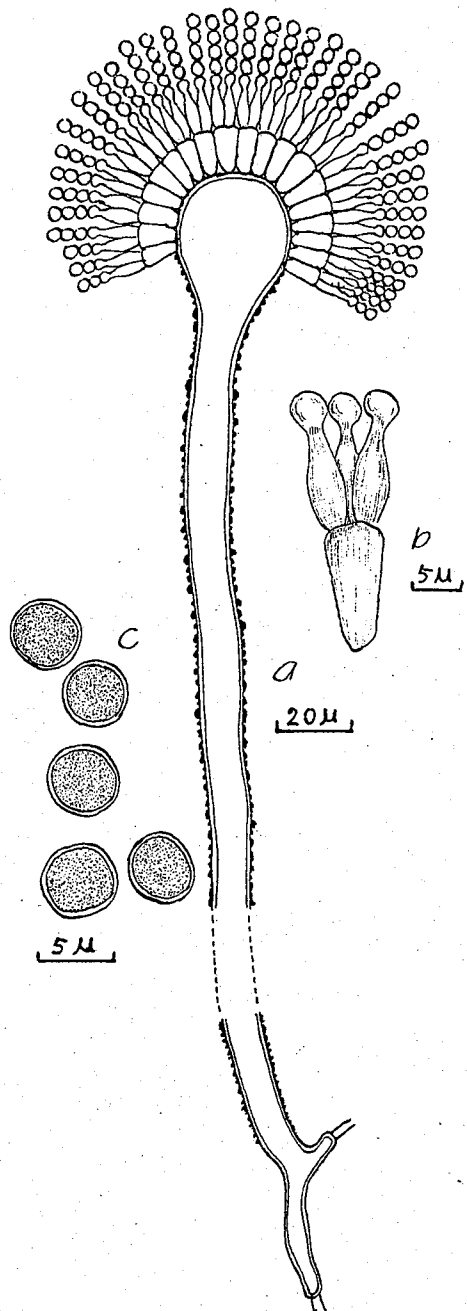


Fig. 8, *A. ochraceus* Wilhelm.  
 a, Conidiophore  
 b, Sterigmata  
 c, Conidia

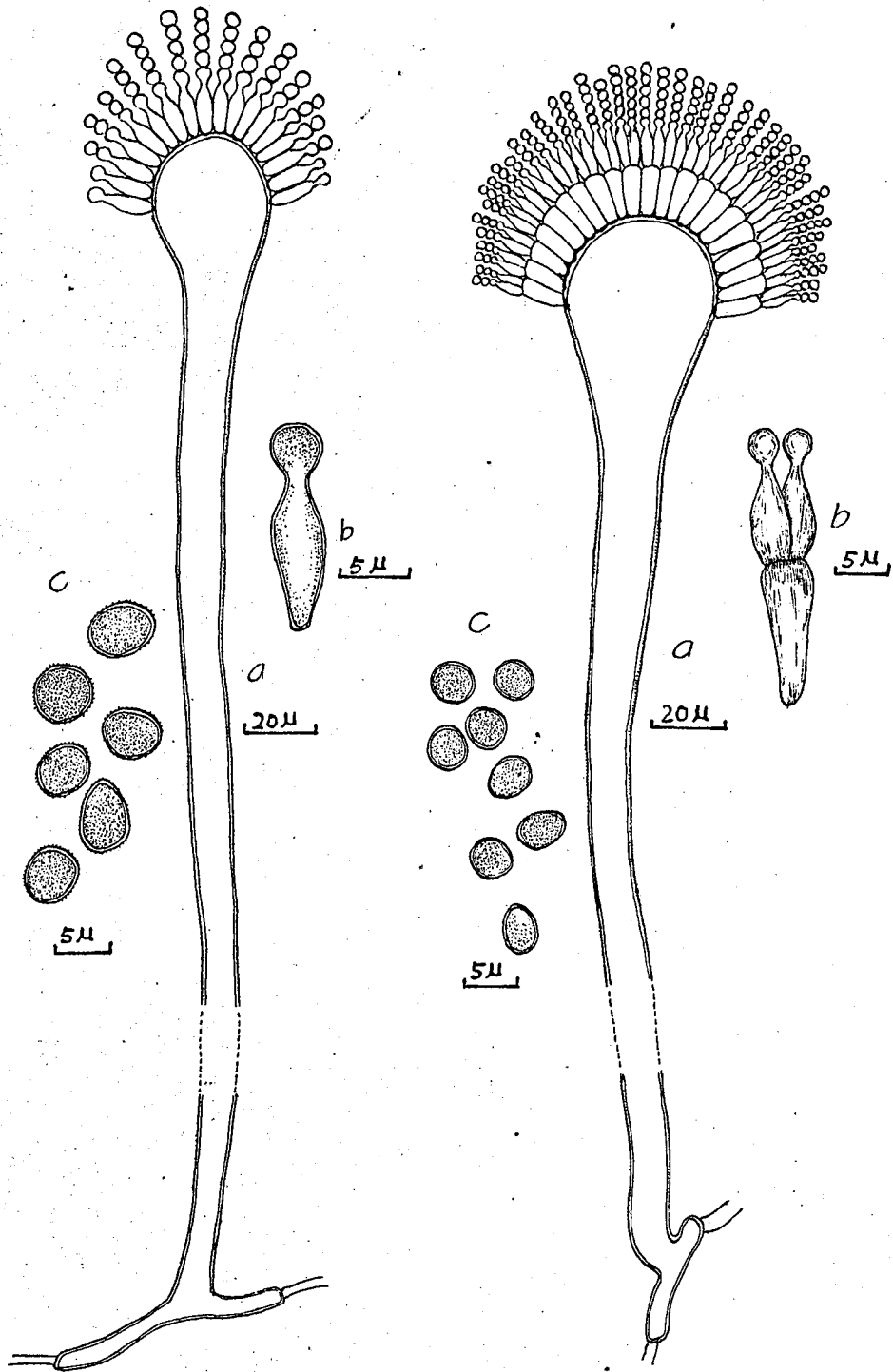


Fig. 9, *A. oryzae* (Ahlburg) Cohn.

- a, Conidiophore
- b, Sterigmata
- c, Conidia

Fig. 10, *A. flavus* Link.

- a, Conidiophore
- b, Sterigmata
- c, Conidia