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The Genus Fusarium - a Pictorial Atlas

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C O N T E N T S

I. PREFACE

This book is conceived as a pictorial atlas, a guide through the phytopathologically very important genus Fusarium, rather than a monograph. The illustrations contained in the book, which represent the whole range of variation of the fungal microstructure, can be compared directly with the pictures seen under the microscope. These photographs and drawings as well as a short description of the macro- and microscopic features shall ensure the identification of the taxa. The main purpose of the work at hand is to serve mycologists and plant pathologists and others interested in Fusarium as a reference book for comparison, identification and diagnoses. It is also intended as a means of pointing out vagueness and gaps in matters concerning nomenclature, systematics and plant pathology. The authors' goal will have been reached if their efforts lead to further studies and research in the field.

With consideration given to current mycological points of view, more than 90 Fusarium species or varieties are here accepted as distinct.

A key has been intentionally omitted, since it would have exhibited the incompletenesses which keys of large genera tend to contain. Nevertheless, we plan to present such a key at a later date. But to do so, further research is needed which will lead to a grouping of Fusarium species different from those of WOLLENWEBER and REINKING (1935) and BOOTH (1971a).

We are most grateful to our former colleagues at our institute, the late Dr. H. RICHTER, Dr. R. SCHNEIDER and Dr. E. SEEMÜLLER as well as to mycologists from all over the world, especially

Dr. C. BOOTH / England, Dr. D. ERSHAD / Iran, Dr. W. GAMS / Netherlands, Dr. G. LAUNDON / New Zealand, Dr. G. LIM / Singapore, Dr. W. MARASAS / South Africa, Dr. E. MÜLLER / Switzerland, Dr. P. NELSON / Pennsylvania, Dr. S. K. SUN / Taiwan, Dr. T. A. TOUSSOUN / Pennsylvania and Dr. A. YLIMÄKI / Finland for critical suggestions, the assistance in making authentic material available and in sending us pure cultures of special Fusarium species.

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II. INTRODUCTION

The concept of WOLLENWEBER and REINKING (1935) was chosen as the basis of arranging and treating each taxon to ensure a direct comparison with their works without the intension of accepting their concept completely. The results of our findings will be critically compared with those of other specialists, especially WOLLENWEBER and REINKING (1935) and BOOTH (1971a).

Each chapter of a taxon is divided into 4 sections: synonyms, description, illustration and discussion.

As a rule only those synonyms are listed that are needed to recognize the differences of our concept compared with the concepts of WOLLENWEBER and REINKING (1935), BOOTH (1971a) and other authors. Therefore we want to point out the comprehensive lists of synonyms in WOLLENWEBER and REINKING (1935), WOLLENWEBER (1931, 1943), BOOTH (1971a) and SUBRAMANIAN (1971).

The description is based almost entirely on our own observations of the fungus in culture under various conditions and consists of notes regarding macroscopic (colony - growth, aerial mycelium, pigmentation, sclerotial bodies, sporulation), microscopic (conidiophores, conidia and chlamydospores) and other features (odour).

Almost each taxonomic unit is illustrated by full-page plates consisting of drawings and photographs. They depict typical microscopic fungal structures (conidiophores, conidia and chlamydospores - if formed by the fungus). To present the whole range of morphological variation, drawings of the original diagnoses or those printed in WOLLENWEBER's "Fusaria autographice delineata" are added. They had to be used solely for those taxa of which no living culture could be obtained.

The discussion of the taxon regarding its taxonomic position and occurrence is more or less extensive depending on its degree of rareness or renown.

The entire material, consisting of notes and partly coloured drawings, left behind by WOLLENWEBER, was screened and filed with the corresponding taxa. The knowledge acquired from these notes and drawings about the origin of cultures (partly ex-holotypes), cultural characteristics and conidial measurements has been incorporated into the description of the individual species or variety. When no pure cultures were available, this material had to suffice. The description and illustration of all other taxa is based upon tens of thousands of single spore isolates which were made during the last 30 years in our institute.

As a rule the strains were cultured on 7 different substrates: wort agar, potato-dextrose agar, carrot-extract agar, oat-meal agar, ear of barley, stem of alfalfa, rice pap under natural day-night-rhythm in the laboratory at approximately 22^{o}C. The conidial samples were taken from the "Hochkultur" stage. In a few exceptional cases some isolates were irradiated with near ultraviolet light (black light) or were grown on a low nutrient medium, SNA (NIRENBERG 1976).

The microphotos were taken from squash mounts made in sterile water without adding any stains and printed at a magnification of 500. Only some pictures of the fungi in the Liseola section were taken on SNA without a coverslip, which were magnified by 200 or 250.

The cultures were received from Europe, North and South America, Asia and Australia either for comparison or identification. Most often, however, they were isolated from diseased plant material mailed to us. Only some few are ex-holotypes of which those from the twenties, thirties and forties are already quite degenerated.

Representative living cultures are preserved in soil (SCHNEIDER 1958) at our institute.

III. THE GENUS FUSARIUM

Fusarium Link - Mag. Ges. naturf. Freunde, Berlin, 3 : 10, 1809 - ex Fries 1821

Fusisporium Link - Mag. Ges. naturf. Freunde, Berlin 3 : 10, 1809 - ex Fries 1821

Selenosporium Corda - Icon. Fung. 1 : 7, 1837

Microcera Desm. - Ann. sci. nat. ser. 3, 10 : 359, 1848

Pionnotes Fries - Summa veg. scand. : 481, 1849

Sporotrichella Karst. - Med. Soc. F. F. Fennica 14 : 96, 1887

Lachnidium Giard - Compt. rend. Acad. Sci. 113 : 813 - 816, 1891

?Discocolla Prill. et Delacr. - Bull. Soc. Mycol. Fr. 10 : 86, 1894

?Rachisia Lindner - Deut. Essigind. 17 : 467, 1913

Discofusarium Petch - Trans. Br. mycol. Soc. 7 : 164, 1921

Pseudomicrocera Petch - Trans. Br. mycol. Soc. 7 : 164, 1921

?Fusidomus Grove - J. Bot., London, 67 : 201, 1929

Pseudofusarium Matsushima - Microfungi of the Solomon Islands and Papua-New Guinea, Osaka : 46, 1971

Type species! Fusarium sambucinum Fuckel - Symb. mycol. 167, 1869
Fusarium roseum Link ex Gray 1821 (nomen ambiguum)

Information about the origin and history of the genus Fusarium as well as its description can be found with WOLLENWEBER and REINKING (1935), GERLACH (1970, 1973, 1981), BOOTH (1971a), SUBRAMANIAN (1971) and DOMSCH et al. (1980).

It is mainly characterized by more or less falcate and pedicellate (macro-) conidia borne from phialides, which arise from the substrate mycelium or aerial mycelium.

Quite recently two new genera were separated from Fusarium:

1. Pseudofusarium - which we do not accept, since the conidiogenous cells which bear macroconidia are phialidic and only the microconidia are borne on polyblastic cells;
2. Gerlachia - which we do accept, since all conidiogenous cells are annellidic.

Section EUPIONNOTES Wollenw. - Phytopathology 3: 206, 1913

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh. - Zentralbl. Bakteriol. 2. Abt. 9: 655, 1891 var. aquaeductuum

Selenosporium aquaeductuum Radlk. & Rabenh. - Hedwigia 2: 73, 1863

Teleomorph: Nectria purtonii (Grev.) Berk. - Outlines Brit. Fung. 394, 1860

Nectria applanata Fuckel - Symb. mycol., Nachtr. 1: 22, 1871

?Nectria episphaeria (Tode ex Sprengel) Fr. var. coronata Wollenw. - Z. Parasitenk. 3: 298, 1931

Descriptions: APPEL & WOLLENWEBER (1910), WOLLENWEBER (1916-1935 no. 75, 78-82, 543, 672, 673, 842, 843), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BOOTH (1959, 1971a), JOFFE (1974), DOMSCH et al. (1980).

C o l o n i e s - slow-growing, reaching 3.0 - 3.2 cm diam. in 10 days at 25°C on PDA.

Aerial mycelium - sparse, white to pinkish, delicately floccose, partly covering the substrate.

Pigmentation - yellowish brown, salmon, red-orange.

Sclerotial bodies - not present.

Sporulation - quickly starting and generally very abundant, orange masses of pionnotal or sporodochial conidia covering the colony surface, when desiccating forming more brick-red to cinnamon coloured crusts.

Odour - if present, musk-like.

C o n i d i o p h o r e s - especially in early stages often formed as unbranched phialides arising laterally from hyphae, later more or less loosely branched.
Phialides - monophialidic, usually almost cylindric, by and large rather long (12-35 µm) and slender (2.0-3.5 µm), elegant, occasionally with a slightly marked collarette.

C o n i d i a - strongly to moderately curved, slender, falcate, with an often hooked apical cell and a barely pedicellate basal cell, predominantly with one indistinct central septum, rarely 0- or 2- to 3-septate, measuring:

0-sept.	13 x 2.4	mostly 9-22 x 1.9-3.0	(6-26 x 1.5-4.0) µm
1-sept.	26 x 2.4	mostly 16-34 x 1.9-3.0	(12-40 x 1.5-4.0) µm
2-3-sept.	35 x 2.5	mostly 33-38 x 2.2-2.5	(29-50 x 2.0-3.5) µm.

C h l a m y d o s p o r e s - never observed.

Explanation of Figure 1:
Drawing and photographs of conidia and conidiophores of strain 63669 on different substrates (x 500).

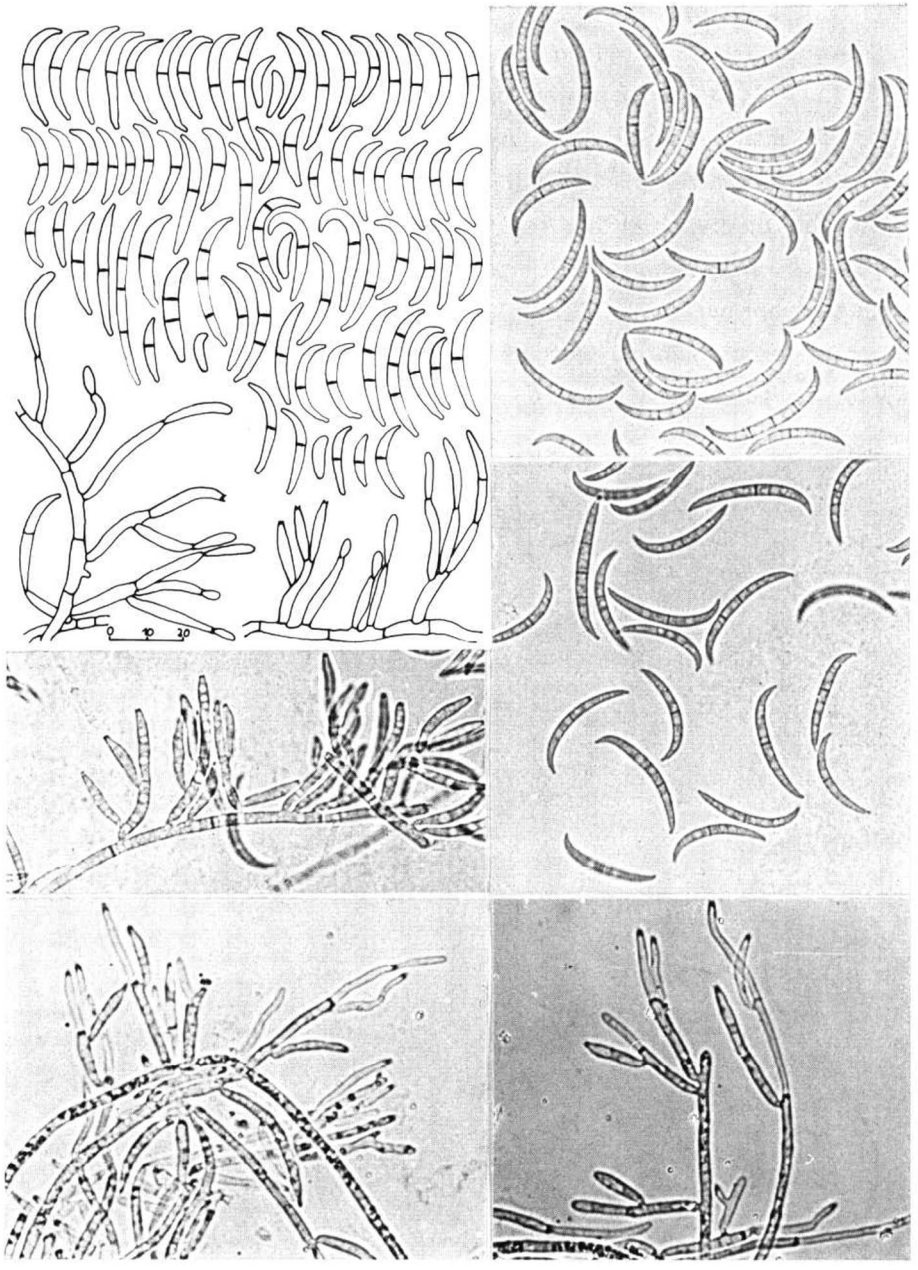

Fig. 1. Fusarium aquaeductuum var. aquaeductuum.

F. aquaeductuum var. aquaeductuum is well-known and generally accepted as distinct. It is a rather common fungus in streaming waters, water pipes, in bleeding sap of trees and on dead twigs. Frequently it is associated with other fungi. However, it seems to occur less frequently than the variety medium and less than literature would lead us to believe. This discrepancy may result from inexact identification. F. aquaeductuum var. aquaeductuum occurs on all continents, but it is perhaps more common in cooler regions. More detailed information is given by DOMSCH et al. (1980). There is no reliable report proving its active role as a plant pathogen.

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh. var. medium Wollenw. - Z. Parasitenk. 3: 298-299, 1931

Fusarium bicellulare Kirschstein - Hedwigia 80: 136, 1941

Fusarium aquaeductuum (Radlk. & Rabenh.) Lagerh. subsp. medium (Wollenw.) Raillo - Fungi of the Genus Fusarium (Moscow): 278, 1950

Teleomorph: Nectria episphaeria (Tode ex Sprengel) Fr. - Summa Veg. Scand. 2: 388, 1849 var. epishaeria

Descriptions: WOLLENWEBER (1916-1935 no. 76, 83, 84, 185, 544, 667-671, 844-847), WOLLENWEBER (1931), WOLLENWEBER & REINKING (1935), BOOTH (1959), GERLACH & ERSHAD (1970), BOOTH (1971a).

C o l o n i e s - slow-growing, reaching 2.5 - 3.5 cm diam. in 10 days at 25°C on PDA.
Aerial mycelium - absent or, if sparse, reduced to hyphal strands especially at the edge of older colonies, whitish to pinkish; colony surface appearing slimy, wrinkled or fibrillose.
Pigmentation - whitish, cream, pinkish to orange.
Sclerotial bodies - not formed.
Sporulation - starting quickly within 2 - 4 days as small, subdeveloped conidia, later macroconidia predominate in pionnotal or sporodochial slimy masses which cover the agar surface.
Odour - not perceptible.

C o n i d i o p h o r e s - arising at first laterally as single phialides from hyphae often aggregated in ropes, later irregularly or sometimes verticillately branching, if produced in sporodochial layers often densely aggregated arising from a stromatic tissue.

Phialides - monophialidic, of various shapes, if formed in the aerial mycelium generally subulate, rather long and slender, mostly 20-35 x 2.0-2.5 µm, if formed in pionnotes or sporodochia often subclavate, shorter, mostly 10-20 x 2.5-4.0 µm.

C o n i d i a - subdeveloped, 0- or 1-septate conidia sometimes rather abundant, ellipsoid to clavate; macroconidia subcylindric, moderately to strongly curved, slightly narrowing toward each end, generally with a somewhat bent apical cell and a more or less distinct pedicellate basal cell, when fully developed, predominantly 3- (to 5-)septate, measuring:

0-sept.	8 x 2.3	mostly 6-12 x 2.0-2.5	(4-25 x 1.5-3.0) µm
1-sept.	27 x 2.5	mostly 18-45 x 2.0-3.2	(13-61 x 1.5-4.0) µm
3-sept.	45 x 2.8	mostly 30-55 x 2.4-3.4	(20-64 x 1.5-4.2) µm
4-5-sept.	51 x 3.0	mostly 45-60 x 2.5-3.5	(35-78 x 2.0-4.2) µm.

C h l a m y d o s p o r e s - not observed; globose to subglobose, inflated cells formed in old conidia or hyphae.

Explanation of Figure 2:

Drawing and photographs of conidia and conidiophores of strains 62153 and 62154 on different substrates (x 500).