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The soil mycoflora of an *Acacia karroo* Community in the Western Transvaal

M. C. PAPENDORF*

ABSTRACT

A survey of the composition and distribution of the soil mycoflora of an *Acacia karroo* Community in the Potchefstroom area was undertaken. A total of 858 sporulating cultures representing 76 genera and 144 species was recovered from this soil. The majority belong in the Fungi Imperfecti and only a limited number of Zygomycetes and Ascomycetes and no Oomycetes or Basidiomycetes were recorded. Members of the genera *Penicillium* and *Aspergillus* were the most abundant. The greatest concentration of individuals and species occurred in the surface layers and a rapid decrease in numbers was noticeable with increasing depth. The nature of this flora suggests a close correlation with the natural plant cover and the existing ecological conditions.

Résumé

*LA MYCOFLORE DU SOL D'UNE COMMUNAUTE D'*ACACIA KARROO *DANS LE TRANSVAAL OCCIDENTAL*

*Une étude de la composition et de la distribution de la mycoflore du sol d'une communauté d'*Acacia karroo *a été entreprise dans la région de Potchefstroom. Un total de* 858 *cultures sporulantes représentant* 76 *genres et* 144 *espèces a été extrait de ce sol. La majorité appartient aux Fungi Imperfecti et un nombre limité seulement de Zygomycètes et d'Ascomycètes ont été observés mais pas d'Oomycètes ni de Basidiomycètes. Les membres des genres* Penicillium *et* Aspergillus *sont les plus abondants. La plus grande concentration d'individus et d'espèces se trouve dans les couches de surface et une rapide diminution en nombre a été observée avec l'accroissement en profondeur. La nature de cette flore suggère une corrélation étroite avec la plante naturelle de couverture et les conditions écologiques existantes.*

During the past decades various aspects of the soil mycoflora have been extensively studied in many parts of the world and a voluminous literature has accumulated (Alexander, 1970; Barron, 1968; Doeksen & Van der Drift, 1963; Parkinson & Waid, 1960; Gilman, 1959; Burges, 1958; Chesters, 1949; Domsch & Gams, 1970, etc.). As a result a fairly clear picture of this flora has emerged and in recent years the suggestion that it is of a uniform and cosmopolitan nature (Waksman, 1916) has been criticized and partly rejected in favour of the view that the soil mycoflora is usually closely correlated with certain ecological factors including the natural plant cover (Eicker, 1974; Morrall & Vanterpool, 1968; Park, 1965; Clark, 1965; Garrett, 1963; Orpurt & Curtis, 1957; Christensen *et al.*, 1952; Tresner *et al.*, 1954).

In South Africa the fungus flora of soils under a natural vegetational cover has so far received little attention and because of the great diversity of climate, soil type and vegetation a vast and interesting field remains to be investigated. Eicker (1969, 1970, 1974) published a comprehensive list of fungi inhabiting two forest soils in Zululand and the soil of the open-savanna of the Transvaal.

This paper is a report on a study which was undertaken to determine the composition and distribution of the soil fungus population of an *Acacia karroo* Community in the Western Transvaal. The *Acacia karroo* Community is typical of the savanna of the more arid western portion of the huge inland plateau of the southern sub-continent commonly referred to as the High Veld. It is dominated by *Acacia karroo* Hayne and in this so-called Thorn Veld the *Acacia* trees appear singly or in groups and are variously scattered leaving large open spaces covered mainly by grass species, herbaceous plants and shrubs of different sizes. The following are the more common species found in the area studied:

TREES: *Ziziphus mucronata* Willd., *Ehretia rigida* (Thunb.) Druce, *Rhus pyroides* Burch., *Maytenus heterophylla* (Eckl. &. Zeyh.) N. Robson.

SHRUBS: *Grewia flava* DC., *Asparagus suaveolens* (Burch.) Miers., *Asparagus cooperi* Bak. and *A. laricinus* Burch.

CLIMBERS: *Clematis brachiata* Thunb., *C. oweniae* Harv., *Galium horridum* Thunb. and *Trochomeria macrocarpa* Hook.f.

HERBS AND GRASSES: *Teucrium capense* Thunb., *Kalanchoe rotundifolia* Harv., *Delosperma herbeum* N.E. Br., *Sida dregei* Burtt Davy, *Lantana salvifolia* Jacq., *Solanum nigrum* Linn., *Lippia scaberrima* Sond., *Conyza podocephala* DC., *Ehrharta panicea* Sm., *Digitaria eriantha* Steud. and *Themeda triandra* Forsk.

The community concerned is situated on the northern boundary of the present campus of the University of Potchefstroom. The annual precipitation in this area is c. 600 mm and occurs mainly in the form of rain of which more than 80% falls during the months October to March. The soil temperature 15 cm below ground level varies and fluctuates between an annual summer maximum of c. 23 °C and a winter minimum of c. 16 °C. The soil is a typical red-brown loam consisting of the weathered products of the underlying diabase.

METHODS

In order to obtain a composite and representative soil sample of the community 10 sampling sites covering the entire area were randomly selected. To expose the profile a trench measuring 90 × 60 cm was excavated at each site and from its sides soil samples were taken at preselected depths of 0–2,5 cm, 15 cm and 30 cm. Samples were collected by means of a tapered and sharpened metal tube which could be driven into the sides of the trench. Two cores were taken from each level of the ten sampling sites. These were placed in separate sterile containers and eventually combined in a large glass container, thoroughly mixed and homogenized and subsequently sieved. From this composite sample 25 g portions were removed for further analysis. Peptone-dextrose agar containing rose bengal and streptomycin (Martin, 1950; Johnson *et al.*, 1959) was used as isolation medium.

* Institute for Botanical Research, Potchefstroom University, Potchefstroom.

The isolation methods employed were all standard procedures used in soil mycological investigations and included the dilution-plate (Waksman & Fred, 1922), soil-plate (Johnson & Manka, 1961; Warcup, 1950) and the soil washing (Gams & Domsch, 1967; Parkinson & Williams, 1961) techniques. Since factors such as the method and media employed in this type of investigation obviously have certain limitations and selective influences it is not claimed that the list compiled from existing data is a complete inventory of this mycoflora.

RESULTS

During this survey a total of 858 sporulating isolates was obtained and preserved in pure culture. An analysis of these isolates gave the following distribution:

	Genera	Species	Total isolates
Zygomycetes	7	8	37
Ascomycetes	8	12	14
Fungi Imperfecti	61	124	807
Total	76	144	858

The individual species are listed in Table 1.

TABLE 1. Fungi recovered from soil of *Acacia karroo* Community

	Number of isolates at		
	0–2,5 cm	15 cm	30 cm
Zygomycetes:			
Absidia cylindrospora Hagem	11	2	—
Circinella sp. (M.C.P. 22)	3	—	—
Cunninghamella echinulata Thaxt.	4	—	—
Gongronella butleri (Lendn.) Peyr. & Dal Vesco	2	2	1
Mortierella alpina Peyr.	1	1	—
Mucor circinelloides Tiegh.	1	—	—
Rhizopus arrhizus Fischer	8	—	—
Rhizopus sp. (M.C.P. 259)	1	—	—
Ascomycetes:			
Auxarthron umbrinum (Boud.) Orr & Plunkett	1	—	—
Chaetomium olivaceum Cooke & Ellis	2	—	—
C. pachypodioides Ames	1	—	—
C. robustum Ames	1	—	—
C. bainieri Munk	1	—	—
Chaetomium sp. (M.C.P. 346)	2	—	—
Herpotrichia striatispora Papendorf & v. Arx	1	—	—
Neocosmospora vasinfecta E. F. Smith	—	—	1
Westerdykella multispora (Saito & Minoura) Cejp & Milko	1	—	—
Thielavia sepedonium Emmons	—	1	—
Microascus cinereus Fuentes & Wolf.	—	1	—
Sordaria fimicola (Rob.) Ces. & De Not	1	—	—
Fungi Imperfecti:			
Moniliales			
Acremonium sp. (M.C.P. 56)	3	—	—
Aphanocladium album (Preuss) W. Gams	2	—	—
Acrospeira levis Wiltshire	—	1	—
Alternaria alternata (Fr.) Keissl.	2	2	—
Aspergillus fumigatus Fres.	—	3	—
A. carneus (v. Tiegh.) Blochwitz	3	—	—
A. flavus Link ex Fr.	—	1	—
A. ochraceus Wilhelm	48	1	1
A. puniceus Kwon & Fennell	6	4	—
A. versicolor (Vuill.) Tirab.	—	1	—
Aspergillus sp. (M.C.P. 44)	1	—	—
Arthrocladium caudatum Papendorf.	—	1	—
Arxiella terrestris Papendorf	2	—	—
Aureobasidium pullulans (De Bary) Arnaud	—	—	1
Beauveria bassiana (Bals.) Vuill.	5	1	—
B. densa (Link) Vuill.	1	—	—
Beltrania rhombica Penz.	12	—	—
Botryoderma lateritium Papend. & Upadh.	1	1	—
Chrysosporium pannorum (Link) Hughes	1	1	—
Cirrhomyces flavovirens Höhnel	1	2	—
Cladosporium cladosporioides (Fres.) De Vries	2	3	—
Drechslera papendorfii (Van der Aa) M. B. Ellis	1	—	—
Dactylium sp. (M.C.P. 153)	1	—	—
Exophiala brunnea Papendorf	3	—	—
Fusarium equiseti (Corda) Sacc.	8	—	—
F. moniliforme Sheldon	2	—	—
F. oxysporum Schlecht. ex Fr.	12	—	—
F. solani (Mart.) App. & Wr.	4	7	—
F. cf. *sporotrichioides* Sherb.	2	—	—
Geotrichum candidum Link	1	—	—
Gliocladium catenulatum Gilman & Abbott	—	2	—
G. penicillioides Corda	2	—	—
G. roseum Bain.	8	4	—
Graphium sp. (M.C.P. 176)	—	—	2
Helminthosporium spiciferum (Bain.) Nicot	—	—	1
H. sativum Pam., King & Bakke	—	2	—
H. dematioideum Bubák & Wroblewski	1	1	—
Humicola fuscoatra Traaen	31	—	1
Humicola sp. (M.C.P. 225)	—	—	2
Leptodiscella africana Papendorf	1	—	—
Myrothecium roridum Tode	4	—	—
M. striatisporum Preston	1	—	—
M. verrucaria (Alb. & Schw.) Ditm. ex Fr.	15	—	—
Nigrospora sp.	1	—	—
Oidiodendron cerealis (Thüm.) Barron	—	2	—
Paecilomyces farinosus (Dicks. ex Fr.) Brown & Smith	1	—	—
P. marquandii (Massee) Hughes	—	—	1
Penicillium adametzi Zaleski	2	40	2
P. citrinum Thom	1	4	—
P. canescens Sopp	2	—	—
P. charlesii Smith	9	—	—
P. frequentans Westling	4	—	—
P. funiculosum Thom	—	1	—
P. javanicum Van Beyma	—	3	—
P. lanosum Westling	1	—	—
P. lilacinum Thom	54	25	5
P. multicolor Grigorieva-Manoilova & Paradielova	1	—	—
P. paraherquei Abe ex G. Smith	89	—	—
P. pedemontanum Mosca & Fontana	2	—	—
P. piscarium Westling	1	—	—
P. restrictum Gilman & Abbott	—	5	—
P. roseo-purpureum Dierckx	3	—	—
P. simplicissimum (Oud.) Thom	1	1	—
P. spinulosum Thom	3	21	—
P. thomii Maire	6	—	—
P. waksmanii Zaleski	5	—	—
P. striatisporum Stolk	1	3	—
Penicillium sp. (M.C.P. 115)	4	—	—
Penicillium sp. (M.C.P. 220)	1	—	—
Penicillium sp. (M.C.P. 164)	3	—	—
Penicillium sp. (M.C.P. 41)	1	—	—
Penicillium sp. (M.C.P. 42)	5	—	—
Periconia igniaria Mason & M. B. Ellis	6	—	—
Scolecobasidium constrictum Abbott	2	—	—
S. humicola Barron & Busch	9	—	—
Scopulariopsis humicola Barron	6	—	—
S. brumptii Salvanet-Duval	1	1	—
Scopulariopsis sp. (M.C.P. 10)	5	1	—
Scopulariopsis sp. (M.C.P. 93)	4	—	—

TABLE 1. Fungi recovered from soil of *Acacia karroo* Community

	Number of isolates at		
	0–2,5 cm	15 cm	30 cm
Staphylotrichum coccosporum Meyer & Nicot	2	1	—
Torulomyces lagena Delitsch	2	—	—
Trichoderma viride Pers. ex Fr.	56	—	—
T. koningii Oud.	2	—	—
Trichurus spiralis Hasselbr.	1	—	—
Ochronis simplex (Papend.) De Hoog & v. Arx	1	—	—
Verticillium chlamydosporium Goddard	1	—	—
V. tenerum (Nees ex Pers.) Link	2	—	1
V. lamellicola (F. E. V. Smith) W. Gams	4	—	—
Verticillium sp. (M.C.P. 335)	3	—	2
Volutella ciliata (A. & S.) Fr.	4	—	—
Melanconiales			
Colletotrichum gloeosporioides Penz.	1	—	—
Cryptosporiopsis sp. (M.C.P. 286)	1	—	—
Pestalotia guepinii Desm.	2	—	—
Pestalotia sp. (M.C.P. 203)	1	—	—
Phialophora hoffmannii (v. Beyma) Schol-Schwarz	4	—	—
P. mutabilis (v. Beyma) Schol-Schwarz	1	—	—
Phialophora sp. (M.C.P. 51,154)	1	—	—
Sphaeropsidales			
Amerosporium atrum (Fuck.) Höhnel.	7	—	—
Amerosporium sp. (M.C.P. 157)	3	—	—
Cicinnobella sp. (M.C.P. 80)	2	—	—
Coniothyrium minitans Campbell	2	—	—
Coniothyrium sp. (M.C.P. 248,300)	1	—	—
Cytospora sp. (M.C.P. 118)	8	—	—
Diplodia sp. (M.C.P. 237)	2	—	—
Discosia artocreas (Tode) Fr.	6	—	—
Dothichiza sp. (M.C.P. 107)	16	—	—
Dothiorella sp. (M.C.P. 112)	3	—	—
Haplosporella bakeriana Sacc.	—	2	—
Hendersonia sp. (M.C.P. 244)	1	—	—
Hyalotia viridis (Torrend) Guba	7	—	—
Hyalotiella transvalensis Papendorf	25	—	—
Melanophoma karroo Papendorf & Du Toit	7	—	—
Microdiplodia palmarum (Corda) Diedicke	1	—	—
Microdiplodia sp. (M.C.P. 251)	2	—	—
Phoma capitulum Pawar & al.	1	—	—
Phoma jolyana Pirozynski & Morgan-Jones	2	—	—
Phoma glumarum Ell. & Tracey	1	—	—
Phoma spp. (M.C.P. 8, 52, 70, 291, 216, 241, 252)	14	2	—
Robillarda sessilis Sacc.	7	—	—
Stagonospora sp. (M.C.P. 273)	1	—	—
Stagonospora sp. (M.C.P. 274)	1	—	—
Pyrenochaeta cf. *decipiens* Marchal	1	—	—
P. cf. *terrestris* (Hansen) Gorenz & al.	3	—	3
Pyrenochaeta sp. (M.C.P. 197)	3	—	—

DISCUSSION

In the final collection (Table 1.) the Zygomycetes, Ascomycetes and Fungi Imperfecti are represented by 7, 8 and 61 genera and 8, 12 and 124 species respectively. No Basidiomycetes or Oomycetes were recovered from this soil.

It is generally accepted that the isolation of Basidiomycetes requires the application of specialized techniques and media (Warcup, 1957; Robbins, 1950) and consequently only very few, if any, Basidiomycetes are recorded in most catalogues listing soil fungi (McLennan & Ducker, 1962; Eicker, 1969, 1974; Miller *et al.*, 1957; Wohlrab & Tuveson, 1965).

The absence of members of the Oomycetes should probably be ascribed to unfavourable environmental conditions including low soil moisture and high summer temperatures often experienced in this area. Eicker (1969, 1974) was also not able to isolate any Oomycetes from two soil types in Zululand and only obtained a single species of *Saprolegnia* from an open-savanna soil.

The Zygomycetes seem to be fairly well established in this habitat and are represented by the following species: *Absidia cylindrospora*, *Circinella* sp., *Cunninghamella echinulata*, *Gongronella butleri*, *Mortierella alpina*, *Mucor circinelloides*, *Rhizopus arrhizus* and *Rhizopus* sp. With the exception of *Rhizopus* the zygomycetous genera recovered are each represented by only one species. The total number of isolates (37) for this group indicates that this soil is relatively sparsely populated by Zygomycetes. The most common genus is *Absidia* (13 isolates) followed by *Rhizopus*, *Gongronella* and *Cunninghamella* with 9, 5 and 4 isolates respectively. *Circinella* is represented by 3, *Mortierella* by 2 and *Mucor* by only a single isolate.

Investigators studying the mycoflora of different soil types from various localities have found that the zygomycetous population can vary considerably. On the whole cool, moist forest soils rich in nutrients and energy sources seem to support a much larger and more varied flora than poor and arid, sandy soils. Many workers who have studied microfungi of soils of more or less arid, sandy areas have indicated a general paucity of mucoraceous forms (Wohlrab & Tuveson, 1965; Kuehn, 1960; Nicot, 1960), Paine (1927) also found that mucors are less prevalent in open pasture land than in forests. Eicker (1969, 1974) and Yung & Stenton (1964) reported fairly large numbers of Zygomycetes from various soils. Gochenauer & Whittingham (1967) and Gochenauer & Backus (1967) investigating the microfungi of certain mesic forest and alluvial soils with coarse-grained texture and low humidity reported that the most important features of the populations of these habitats were the rareness of members of the Mucorales and Moniliales, other than *Penicillium*, in the dry sandy soil as contrasted with the abundance of these types in the mesic soil. This phenomenon is ascribed by them to the high surface temperatures, low moisture content and the limited energy sources available. They consider these habitats to be too rigorous for the survival of the generally hyaline and delicate types as opposed to the dematiaceous forms and many Sphaeropsidales which were recovered more abundantly. The results of this investigation conducted in a more or less semi-arid region, indicate that the zygomycetous flora is not particularly varied and rather poorly represented in number of recordings. This seems to agree with the general pattern for the soils from many arid regions.

Only a relatively small number of Ascomycetes were recorded from this habitat. Warcup (1951b) pointed out that the more generally used techniques, such as the soil dilution method, produce only a few Ascomycetes while methods where the soil is partially sterilized by heat results in the isolation of more and a greater variety of forms. By means of the more conventional methods applied during this survey an aggregate of 14 isolates representing 8 genera were obtained. Only one specimen of each of the following species was recorded: *Auxarthron umbrinum*, *Chaetomium pachypodioides*, *C. robustum*, *C. baineri*, *Herpotrichia striatispora*, *Microascus cinereus*, *Neocosmospora vasinfecta*, *Westerdykella* sp., *Thielavia sepedonium* and *Sordaria fimicola*. *Chaetomium olivaceum* and *Chaetomium* sp. were represented by two isolates each. Of the 14 isolates 11 originated from the upper horizon while 3 were recovered from deeper levels.

In conformity with the general pattern of the soil fungal population in a wide range of localities (Bhatt, 1970; Bagga, 1970; Eicker, 1969, 1974; Wohlrab & Tuveson, 1965; Farrow, 1954) the Fungi Imperfecti was found to be the largest and most varied group. A total of 807 isolates representing 61 genera and 124 species was recovered from this soil. Most of the genera were represented by a relatively small number of isolates suggesting a limited occurrence in this habitat. With only rare exceptions (Lim, 1969) investigators reporting on the Fungi Imperfecti in soil have found that *Penicillium* and *Aspergillus* spp. are usually relatively abundant (Moubasher & Moustafa, 1970; Eicker, 1969, 1974; Gochenauer & Whittingham, 1967; Chen & Griffin, 1966; Christensen *et al.*, 1952.). In the *Acacia karroo* community *Penicillium* was represented by 299 isolates including 25 species and *Aspergillus* by 69 isolates covering 7 species. Eicker (1969, 1974) also found that aspergilli are less plentiful than the penicillia. Most abundant were *P. paraherquei* (89 isolates), *P. lilacinum* (84), *P. adametzi* (44), *P. spinulosum* (24), *Aspergillus ochraceus* (50) and *A. puniceus* (10). Other genera which seem to flourish in this habitat are *Fusarium*, *Humicola*, *Myrothecium*, *Trichoderma*, *Hyalotiella*, *Dothichiza*, *Phoma* and *Beltrania*.

Regarding the vertical distribution of soil inhabiting fungi the available evidence (Eicker, 1970; Yung & Stenton, 1964; Warcup, 1951a; Waksman, 1944; Burges, 1958; etc.) indicates a general decrease in both number of individuals and species with increasing depth. In some reported cases particular fungi are inclined to colonize certain horizons more readily than others. Warcup (1951a) found that forms like *Gymnoascus*, *Cylindrocarpon radicicola* and *Paecilomyces* were more abundant in the lower regions of horizon A and seldom occurred near the soil surface. On the whole the vertical distribution of the fungi in the *Acacia* soil follows this pattern. The surface layer produced 676 isolates against 158 and 24 for the 15 cm and 30 cm layers respectively. Only two species were convincingly more abundant in the deeper horizons, i.e. *Penicillium adametzi* and *P. spinulosum*, while 19 were confined to these sub-surface layers.

From a taxonomic study of the various isolates it was possible to erect 6 new genera and establish 11 new species (Papendorf & Von Arx, 1966; Papendorf, 1967a, 1967b, 1969a, 1969b; Papendorf & Du Toit, 1967; Van der Aa, 1967; Papendorf & Upadhyay, 1969; Stolk, 1969.). The presence of this relatively large number of previously unknown fungi in this particular habitat seems to support the view, referred to earlier, that the soil mycoflora is often closely correlated with certain ecological factors and the natural vegetation.

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UITTREKSEL

'n Ondersoek na die samestelling en verspreiding van die grondmikoflora van 'n Acacia karroo*-gemeenskap in die Potchefstroom-gebied is onderneem. In totaal is* 858 *sporulerende kulture, wat* 76 *genera en* 144 *spesies verteenwoordig, in hierdie grond aangetref. Die meerderheid behoort tot die Fungi Imperfecti en slegs enkeles tot die Zygomycetes en die Ascomycetes terwyl geen Oomycetes of Basidiomycetes aangeteken is nie. Lede van die genera* Penicillium *en* Aspergillus *was in die grootste getalle teenwoordig. Die hoogste konsentrasie van individue het in die oppervlakkige grondlae voorgekom terwyl 'n snelle afname met toenemende diepte merkbaar was. Die aard van hierdie flora dui op 'n noue korrelasie met die natuurlike plantbedekking en die heersende ekologiese toestande.*

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