Bothalia 24,2: 171–185 (1994)

An overview of *Aspergillus* (Hyphomycetes) and associated teleomorphs in southern Africa

A. LOUISE SCHUTTE*

Keywords: *Aspergillus*, *Emericella*, *Eurotium*, fungi, Hyphomycetes, mycotoxins, overview, pathology, southern Africa, taxonomy

ABSTRACT

An overview is given of literature concerning the genus *Aspergillus* Link and its teleomorphs, *Chaetosartorya* Subram., *Emericella* Berk. & Broome, *Eurotium* Link, *Fennellia* B.J. Wiley & E.G. Simmons, *Neosartorya* Malloch & Cain and *Sclerocleista* Subram. encountered in the Republic of South Africa, Botswana, Lesotho, Mozambique, Namibia, Swaziland, Transkei and Zimbabwe up to 1993. The information is grouped under headings that indicate the field of research, namely general mycology, plant pathology, human pathology, animal and insect pathology, industrial relevance and secondary metabolites and mycotoxins. An alphabetical list of recorded *Aspergillus* species is provided and the relevant host or substrate is given together with a literature reference, while the fungal nomenclature has been updated. All the *Aspergillus* species that are regarded as common have been reported from southern Africa. No in-depth research has been done here on this group, except for chemical work on mycotoxins.

UITTREKSEL

'n Oorsig van literatuur aangaande die genus *Aspergillus* Link en sy teleomorwe, *Chaetosartorya* Subram., *Emericella* Berk. & Broome, *Eurotium* Link, *Fennellia* B.J. Wiley & E.G. Simmons, *Neosartorya* Malloch & Cain en *Sclerocleista* Subram., aangetref in die Republiek van Suid-Afrika, Botswana, Lesotho, Mosambiek, Namibië, Swaziland, Transkei en Zimbabwe tot 1993 word gegee. Die informasie word gegroepeer onder opskrifte wat die aard van die navorsing aandui naamlik mikologie, plantpatologie, menslike patologie, dierlike- en insekpatologie, industriële toepassings en sekondêre metaboliete en mikotoksiene. 'n Alfabetiese lys van aangetekende *Aspergillus* spesies word verskaf en die relevante gasheer of substraat word saam met 'n verwysing gegee terwyl die swamnomenklatuur op datum gebring is. Die algemene *Aspergillus* spesies in suidelike Afrika is almal aangeteken. Geen diepgaande navorsing is hier op hierdie groep gedoen nie, behalwe die chemiese werk op mikotoksiene.

INTRODUCTION

'Species of the great group *Aspergillus* form a very considerable percentage of all the mould colonies encountered in the cultural examination of foodstuffs, of soil and of miscellaneous materials' (Thom & Church 1926).

Economically and ecologically *Aspergillus* is a very important group, not only because of its ubiquitous nature, but it also has the ability to grow under a wide range of conditions (Domsch *et al.* 1980). There are probably few substrates that cannot be colonized and degraded. These fungi also synthesize an extraordinary variety of metabolites with biological activity (Raper & Fennell 1973). Profitable and advantageous applications of *Aspergillus* can be found in the production of antibiotics, antifungal substances, vitamins and organic acids, in the preparation of oriental foods, the use of various species in physiological experiments and testing of fungicides as well as in genetic work (Kozakiewicz 1989). Aspergilli also have a deleterious impact: some members of the genus are plant pathogens (Raper & Fennell 1973; Gorter 1977), there are well-known human (Martin & Berson 1973) and animal pathogens (Neitz 1965), many are mycotoxin producers (Frisvad 1989) and they contribute greatly to spoilage (Kozakiewicz 1989).

The genus name *Aspergillus* dates back to Micheli, who used the term because of the similarity between the conidial head and a holy water sprinkler called an aspergill (Raper & Fennell 1973). The development of the taxonomy of *Aspergillus* is described in detail by Raper & Fennell (1973), Christensen & Tuthill (1985) and Kozakiewicz (1989).

The first comprehensive work on the genus *Aspergillus* was by Thom & Church (1926) and the second revision of this work is the monograph currently used for *Aspergillus* identifications (Raper & Fennel 1973). These authors recognised 132 species and separated them into 18 groups. In an update by Samson (1979), he accepted another 34 taxa and nomenclaturally separated the asexual from the sexual states.

A shortcoming of the work of Raper & Fennell (1973) is the fact that both anamorph and teleomorph species are treated under the anamorph genus, *Aspergillus*. The nomenclatural separation of the anamorph from the teleomorph, as incorporated by Benjamin (1955), was not accepted by Raper & Fennell (1973). Benjamin (1955) selected the previously published generic names, *Eurotium* Link, *Emericella* Berk. and *Sartorya* Vuill. for the teleomorphic states. The typification of 190 taxa of *Aspergillus* was investigated by Samson & Gams (1985) and adjustments were made to meet the rules of the International Code of Botanical Nomenclature, giving teleomorphic names priority over anamorphic ones. The taxonomic work of Horie (1980), Gams & Samson (1985) and

* Mycology Unit, Biosystematics Division, Plant Protection Research Institute, Private Bag X134, Pretoria 0001, Republic of South Africa.
MS. received: 1993-10-15.

Kozakiewicz (1989) further contributed to our knowledge of the group.

Various authors have studied specific groups of the genus: Al-Musallam (1980) did a revision of the black Aspergilli, Christensen (1982) revised the *A. ochraceus* group and Kurtzman *et al.* (1986) and Klich & Pitt (1988) differentiated between species in the *A. flavus* group. Horie (1980) and Kozakiewicz (1989) used ascospore and conidial ornamentation as an aid to identification.

More sophisticated methods such as DNA relatedness (Kurtzman *et al.* 1986), mycotoxin production (Klich & Pitt 1988; Frisvad 1989), API-Zym strips (Jain & Lacey 1991) and genetic similarity studies (Peterson 1992) have been used with success in *Aspergillus* identification. Samson & Pitt (1985, 1990) described the use of nucleic acid relatedness, serological methods, exocellular polysaccharides, enzyme electrophoresis, ubiquinone systems and DNA and RNA studies for the same purpose. Their findings confirm the value of a multidisciplinary approach to fungal taxonomy in general, including that of *Aspergillus*.

A major contribution to *Aspergillus* taxonomy has been made by the workshops on *Aspergillus* and *Penicillium* systematics (Samson & Pitt 1985, 1990) as well as the formation of the Subcommission on *Penicillium* and *Aspergillus* Systematics under the International Commission on Taxonomy of Fungi (Samson & Pitt 1990).

This paper is an overview of publications dealing with all aspects of *Aspergillus* in South Africa, Botswana, Lesotho, Mozambique, Namibia, Swaziland, Transkei and Zimbabwe. Literature is grouped under headings indicating the scope of the research and is in chronological order. A list of recorded species is appended in which isolates in the dried collection (PREM) as well as the culture collection (PPRI) of the National Collection of Fungi were included. Culture collections donated to the Mycology Unit as well as catalogues of international culture collections were consulted for additional information. No attempt has been made to verify published data, the identity of *Aspergillus* isolates or any other information. Names of fungi and hosts or substrates are given exactly as in the original text.

OVERVIEW OF LITERATURE

General mycology

The first entry of an *Aspergillus* in the National Collection of Fungi is *A. glaucus* Link (PREM 701—see checklist), collected by J.H.T. De Villiers from *Nicotiana tabacum* in the Cape Colony, on 24 December 1909. *Eurotium herbariorum* Link (PREM 833—see checklist), identified by R.N. Adlam and collected by Medley Wood from *Cephalanthus natalensis* in Transvaal (*Wood 3920*), is the second entry. No author citation or date is given but Medley Wood collected during the previous century and died in 1915 (Doidge 1950). In all probability this specimen represents the first record of an *Aspergillus* in southern Africa.

Aspergillus isolates are often listed in general fungal surveys. Cohen (1950) studied soil fungi and recorded three *Aspergillus* species. Doidge (1950) listed 19 species of *Aspergillus*. Many of these species names are no longer in use. The mycological Herbarium of the Timber Research Laboratory, connected to the Transvaal Chamber of Mines, had a collection of over 1 400 timber-deteriorating fungi, mostly obtained underground. Many of these isolates had been identified overseas by Thom and the CBS (see checklist). Fortunately, Doidge (1950) listed these fungi, including the Aspergilli, as the original information and lists could not be traced.

Ascosporic *Aspergillus* spp. present in the collection of the University of the Witwatersrand were discussed by Swart (1959). Five *Aspergillus* spp., four of which were new records for South Africa, were isolated from forest soil in Zululand (Eicker 1969). The majority of fungi isolated from Zululand soil belonged to the Fungi Imperfecti, with Aspergilli well represented (Eicker 1970a), and distributed evenly in vertical profiles of these soils (Eicker 1970b). In a paper dealing with the occurrence, isolation and identity of thermophylic fungi, Eicker (1972) indicated that *A. fumigatus* Fresen. can grow and sporulate at temperatures ranging from 20°C to 50°C. *A. japonicus* Saito was present in three of the four *Eucalyptus* leaf litter horizons (Eicker 1973). From savanna soil of the Transvaal 16 species of *Aspergillus* were isolated (Eicker 1974), and most of these were deposited in IMI (see checklist). Few isolates of *Aspergillus* were found on litter of *Panicum coloratum* L. (Eicker 1976). In the western Transvaal, seven species of *Aspergillus* were found in the soil of an *Acacia karroo* community (Papendorf 1976). Bezuidenhout (1977) found nine *Aspergillus* spp. among Hyphomycetes associated with the grass, *Cenchrus ciliaris* L. Hyaline amerospores, including those of *Aspergillus*, were found to make up 4.5% of the aerospora above an *Eragrostis curvula* (Schrad.) Nees pasture (Van der Merwe *et al.* 1979).

Gorter (1979) compiled a checklist of fungi recorded in South Africa up to 1977: the original publications are listed here. *A. clavatus* Desm. was found to be present in 45% of industrial malt samples, while *A. flavus* Link comprised about 25% of the fungi found on commercial malt (Rabie & Lübben 1984). Roux (1985) isolated five *Aspergillus* spp. from a Karoo pasture. *A. carbonarius* (Bainier) Thom has been recorded on *Eucalyptus* (Lundquist & Baxter 1985) and *Aspergillus* spp. were found on *Pinus* (Lundquist 1987).

Aspergillus spp. were the dominant fungi isolated from the bare patches on the Giribes plains in Namibia, making up 21% of fungi isolated (Eicker *et al.* 1982), but no explanation could be given for this phenomenon. Allsopp *et al.* (1987) isolated fungi associated with roots of proteaceous seedlings and recorded *A. duricaulis* Raper & Fennell and *A. unilateralis* Thrower from South Africa for the first time. *A. ficuum* (Reichardt) Hennings and *A. ustus* (Bainier) Thom & Church were found to be endophytes in grass (De Villiers 1989). *Aspergillus* spp. were commonly isolated from indigenous stored seed (Isaacs & Benic 1990). Watson *et al.* (1990) found among others, *A. terreus* in the gut of dune dwelling lepismatids, but neither the role nor the effect of these fungi could be determined. Conidiogenesis of *A. niger* Tiegh. was studied by Tiedt (1992).

Plant pathology and seed deterioration

Verwoerd (1929) indicated *A. niger* as the cause of disease of onions and pomegranates in the winter rainfall area. Rosselet (1953) used *A. niger* as test organism in determining available potassium in lowveld soil, and later (Rosselet 1955) to determine levels of potassium, magnesium and phosphorus in citrus orchards as well as in virgin soil. This method is based on the assumption that elements available to micro-organisms will be available to plants. These references possibly have more relevance to plant nutrition than to plant pathology.

Doidge & Van der Plank (1936) indicated *A. niger* and *Aspergillus* spp. as a cause of rot on stored citrus fruit. *A. carbonarius*, *A. niger* and *A. ochraceus* group were listed as plant pathogens by Doidge *et al.* (1953). *A. niger* was found to comprise 6% of fungi in citrus orchard soil whereas in virgin soils *A. fumigatus* was one of the dominant species. The latter species was rarely isolated from citrus soil (Martin 1960). Four species of *Aspergillus* contributed to the decay of litchi fruit, according to Roth (1963) whereas *A. niger* has been isolated from banana hands (Roth & Loest 1965).

Van der Westhuizen & Bredell (1972) found several *Aspergillus* species on high quality maize, *A. flavus*, *A. niger* and *A. sydowi* (Bain. & Sart.) Thom & Church being among the most prevalent ones. Stored lucerne seed was found to yield only a few *Aspergillus* spp. and no increase during storage was reported (Marasas & Bredell 1973). An index of plant pathogens (Gorter 1977) listed *A. flavus* and *A. niger*.

According to Bornman (1978) a large proportion of seeds of *Welwitschia mirabilis* (Hook. f.) are sterile and this situation is aggravated by *A. niger*. This fungus infests the inflorescence, rendering more than 99% of all seeds infertile. This same fungus has also been listed in connection with post-harvest decay of mangoes (Wehner *et al.* 1981). *Aspergillus* contamination of both stored seed and seedlings of maize is high: members of the *A. glaucus* group are often isolated and it is suggested that some *Aspergillus* spp. may be seed-transmitted (McLean & Berjak 1987).

Various *Aspergillus* species were isolated from the roots of *Medicago* spp., but they were not pathogenic (Lamprecht *et al.* 1988). Steinke *et al.* (1990) found that *Aspergillus* spp. deteriorated both *Avicennia* and *Bruguiera* leaves but they made up less than 12% of isolations. This group of fungi occurred in less than 10% of sorghum grain (Bosman *et al.* 1991). *A. niger* commonly occurred in citrus soil but did not have a pronounced antagonistic effect on various fungal pathogens of citrus (Botha & Wehner 1990). Four *Aspergillus* spp. were recorded to be antagonistic to *Rhizoctonia solani* by Weideman *et al.* (1990).

Aspergillus spp. did not pose problems on stored homoiohydrous seeds (Mycock & Berjak 1990). Mycock *et al.* (1990) found that *A. flavus* var. *columnaris* Raper & Fennell can infect maize seedlings and survive in the maturing plant, and Mycock & Berjak (1992) found that hot water treatment of maize seed decreased internal *Aspergillus* counts from 61% to 5%. Healthy chicory roots were inoculated with *Aspergillus* spp. isolated from infected roots, but the fungi had no detrimental effect (Prinsloo *et al.* 1991).

Human pathology

Species of *Aspergillus* are indicated as pathogens worldwide in various aspects in the pathology of humans and of other mammals and insects. In the case of humans information is grouped below according to the effect of the fungus. Thiel (1986) as well as Marasas (1988) considered foodborne mycotoxins such as aflatoxin, produced by *A. flavus* to be of great medical relevance.

Aspergilli as allergens

Members of this genus have allergenic qualities and the first southern African report in this regard is a survey done by Ordman & Etter (1956). They found that *Aspergillus* spp. made up only 0.7% of airborne fungi in Johannesburg and showed no seasonal incidence. A later survey (Ordman 1963) indicated the same tendencies, with similar results obtained for Windhoek (Ordman 1970). Patients with positive precipitins to *Aspergillus* had these to either *A. fumigatus* or *A. niger*; the antigens were prepared locally (Benatar *et al.* 1980). Patients of certain population groups were found to be more allergic to *A. fumigatus* than others (Joubert *et al.* 1988). Ten per cent of allergic children in the Western Cape were sensitive to *Aspergillus* spp. when positive skin tests were done, whereas 12% tested positive to this fungus when IgE responses were used (Potter *et al.* 1991)

Aspergilli and cancer

In an appraisal of liver cirrhosis and hepatoma in the local population, Isaacson (1966) came to the conclusion that liver cell necrosis can be a result of *A. flavus* toxicosis rather than of infective hepatitis. Purchase & Vorster (1968) suggested that aflatoxin M found in milk also had a carcinogenic effect.

Gilman (1972) conducted a comprehensive survey into fungal contamination of food in the Eastern Transvaal and Swaziland and the findings supported an association between mycotoxins in the diet and incidence of liver cancer. Various *Aspergillus* spp. were recorded and aflatoxin was found to be more prevalent in groundnut products than in maize. Peers *et al.* (1976) found a significant correlation between ingested aflatoxin and the incidence of primary liver cancer in Swaziland. *Aspergillus* was present in 3.3% of samples from the low rate area and 6.7% samples from the high rate area of an oesophageal cancer area in Transkei (Marasas *et al.* 1981). The correlation of high risk of exposure to aflatoxin and the hepatitis B virus to hepatocellular carcinoma has been indicated (Bressac *et al.* 1991), but is beyond the scope of this overview. The above-mentioned references are merely representative of this subject; more were traced but they did not refer to a specific fungus.

Aspergillosis, keratitis and otitis

Cases of infection by *Aspergillus* are often associated with degenerative disorders. Jacobs *et al.* (1965) found that pulmonary aspergillosis was extremely rare in all race groups in South Africa and they described a single case. Martin & Berson (1973) gave a comprehensive account of fungal diseases in southern Africa, listing cases of aspergilloses: various *Aspergillus* spp. were considered responsible for 69 cases of diseases of the ear.

Two cases of aspergillosis of the skin were recorded by Findlay *et al.* (1971) and in both cases the organism involved was *A. fumigatus*, while Caro & Dogliotti (1973) described a similar case. Block & Young (1977) indicated the value of early diagnosis of opportunistic fungal infections and again referred to *A. fumigatus*. They also found that the use of membrane filter blood cultures gave better results than serological methods. This same fungus was responsible for four cases of pneumonia described by Kallenbach *et al.* (1977). Bak & Wagenveld (1983) discussed the treatment of otitis where one of the organisms causing problems was *A. niger*. *A. fumigatus* as well as an unidentified *Aspergillus* sp. was found to cause fatal fungal pneumonia in heart transplant patients (Cooper *et al.* 1983). A case report of paranasal sinus aspergillosis was given by Glass *et al.* (1984) but no fungus was indicated. Pulmonary aspergillosis caused by *A. fumigatus* complicated pneumonia and was the cause of death of an otherwise healthy patient (Lewis *et al.* 1985).

Aspergillus spp. were identified in four cases of fungal keratitis that responded well to miconazole treatment (Fitzsimons & Peters 1986). In the area where Mseleni joint disease is found, 41% of homegrown groundnuts were contaminated by *Aspergillus* (Marasas & Van Rensburg 1986). *A. stromatoides* Raper & Fennell was found to cause a fatal sino-orbital infection (Sacho *et al.* 1987), while *A. niger* was isolated from a patient with a fatal brain abscess (Berkowitz *et al.* 1987). Govender *et al.* (1991) reported five cases of *A. fumigatus* infection of the spine and found that the patients responded well to antifungal drugs.

Animal and insect pathology

Prinsloo (1960) found that *A. parasiticus* Speare infected brown locusts both in the laboratory and in the field. Neitz (1965) indicated *A. fumigatus* as an enzootic pathogen in various birds, having obtained some of this information by personal communication. Prozesky *et al.* (1971) gave an account of *A. fumigatus* infection of scaly weavers. An outbreak in a colony of these birds kept at Onderstepoort is described: fortunately, the indicated treatment quickly put an end to the morbidity and deaths. Nesbit (1986) described aspergillosis of a piglet but no causative organism could be isolated.

Industrial relevance

The first record of Aspergilli mentioned in an industrial sense was by Van der Bijl (1920) who studied deterioration of sugar by fungi. Isolates were sent to Thom in America and his full report is included in Van der Bijl's publication. The production of the enzyme invertase by micro-organisms such as *A. niger* and *A. terreus* Thom was influenced by various factors and these were indicated. In the dairy industry *Aspergillus* spp. were reported by Davel & Neethling (1930) to be troublesome. Purchase & Vorster (1968) tested milk samples for the presence of aflatoxin M, as this mycotoxin may be carcinogenic: 21 samples were tested and five gave positive results. A problem with sticky molasses meal was addressed by Roth (1968) who tested many micro-organisms, among others seven species of *Aspergillus*, to render the product more free-flowing.

When fungi found on cheese were tested for toxicity, all isolates of *A. ustus* were found to be toxic to ducklings, but no mycotoxins were detected in the cheese (Lück *et al.* 1976). Likewise, no aflatoxin was detected in cheese or milk powder but 23% of milk samples tested positive (Lück & Wehner 1979).

Aspergillus spp. were found to be more prevalent on grapes infected by *Botrytis* than on healthy ones (Le Roux *et al.* 1973). Using three different techniques, Eicker (1977) isolated thermophylic fungi, including *A. fumigatus*, from mushroom compost. Fungal growth on wet-blue leather is a common occurrence and Russell (1981) tested various fungicides by using fungi including *Aspergillus* spp. isolated from this substrate.

Relative cellulytic activity of 14 species of *Aspergillus* was also determined, when mesophilic fungi on compost was studied (Eicker 1980). Various casing materials for mushroom production were evaluated by Smit (1984) and Aspergilli were encountered during microbiological evaluation. Thermotolerant fungi, namely *A. fumigatus* and an *Aspergillus* sp., were grown on spent sulphite liquor from a pulp mill (Pretorius 1993a, b, c). The potential for single cell protein production, the growth characteristics of these fungi and three reactor configurations were discussed.

Secondary metabolites and mycotoxins

Species of *Aspergillus* and *Penicillium* are potent secondary metabolite and mycotoxin producers (Frisvad 1989). The use of secondary metabolite profiles in the identification of these species is well established and these substances are the subject of ongoing research (Samson & Pitt 1985; Frisvad 1989; Samson & Pitt 1990).

In the early 1960's aflatoxin, a metabolite of *A. flavus* and *A. parasiticus*, was discovered and soon found to be highly carcinogenic (Raper & Fennell 1973). Previously Thom & Church (1926) had already indicated that grain contaminated with *A. flavus* could be poisonous to cattle and swine. As a result of these findings, research in secondary metabolites and mycotoxins became a high priority world-wide. Rabie *et al.* (1964) indicated that *A. amstelodami* (L. Mangin) Thom & Church had a toxic effect on poultry and rabbits. The fungus proved to be lethal to rabbits and reduced the growth of ducks. The work done subsequently by Scott (1965) attracted international attention. He investigated the toxigenicity of fungi obtained from various commercial products: 46 fungal strains belonging to 22 species caused the death of ducklings in only 14 days. Of these, 12 species belonged

to the genus *Aspergillus*. Five of these *Aspergillus* spp. also had a detrimental effect on mice and rats.

Rabie *et al.* (1965) found that *A. wentii* Wehmer was toxic to experimental animals, but the toxin was not identified. Rabie & Terblanche (1967) compared the influence of temperature on two *A. wentii* isolates with variable toxicity. The toxins were characterized and found to be mildly toxic to ducklings (Rabie *et al.* 1986).

Van Warmelo (1967) investigated the correlation between the incidence of toxicity of stock feeds and certain fungal species. Aflatoxin was found in only five of the 39 samples in which *A. flavus* was detected. Van Warmelo *et al.* (1968) found that aflatoxin can accumulate in maize naturally infected with *A. flavus* and that moisture and temperature affect this process.

Holzapfel *et al.* (1966) showed that sterigmatocystin was produced by fungi other than *A. versicolor* (Vuill.) Tiraboschi and found that three out of five strains of *A. nidulans* (Eidam) Wint. caused rapid deaths in ducklings. *A. niger* was the most frequent fungus found on dried fruits and nuts. Wehner & Rabie (1970) indicated that maize on which *A. niger* as well as *A. flavus* was grown had a detrimental effect on ducklings.

The production of ochratoxin by *A. ochraceus* Wilhelm is well documented (Kellerman *et al.* 1988). The structure of the mycotoxin has been determined by Van der Merwe *et al.* (1965a, b), and Purchase & Theron (1968) illustrated the acute toxicity of this fungus to rats.

Rabie *et al.* (1976) grew *A. versicolor* on various media and at various temperatures to determine optimum production of sterigmatocystin: when *Aspergillus* isolates obtained from international culture collections were tested for production of sterigmatocystin, *A. aurantio-brunneus* (Atkins, Hindson & Russel) Raper & Fennell, *A. quadrilineatus* Thom & Raper and *A. ustus* gave positive results (Rabie *et al.* 1977). The latter was a local isolate, producing a low quantity of sterigmatocystin. The effect it had could have been partly due to other toxins such as ausdiol, which were not tested for.

A. clavatus produced a tremorgenic substance which had a lethal effect on cattle and sheep (Kellerman *et al.* 1976). This fatal substance was produced by the fungus when it was grown on malt sprouts as well as on sorghum beer residue (Kellerman *et al.* 1984). In both cases the toxin involved was unknown. The mycotoxins cytochalasin E and K were isolated from an isolate of *A. clavatus* (Steyn *et al.* 1982). The tremorgenic and lethal effect of *A. clavatus* was illustrated with photographs by Coetzer *et al.* (1985) and a similar report was given by Kellerman *et al.* (1988).

Dutton & Westlake (1985) tested agricultural commodities for fungi and their toxins. They found *A. flavus* and *A. parasiticus* in 22% of the samples whereas 27.2% of samples yielded aflatoxin B1 and often also B2, G1 and G2. Westlake & Dutton (1985) reported on the incidence of mycotoxins in the broiler industry and found that aflatoxin may depress growth rates and could play a role in poultry diseases.

Rabie (1986) reviewed contamination of foods by toxigenic fungi and mycotoxins and discussed law-enforcement problems. Rheeder *et al.* (1990) warned that *Aspergillus* on maize grain should be monitored as it poses a mycotoxological threat. Lübben (1992) tested various isolates of fungi obtained from oats and wheat for toxicity and found that several *Aspergillus* isolates tested positive. All isolates that proved to be toxic in the above research are indicated in the appended checklist with an asterisk (*) preceding the reference.

Mutagenic activity of various secondary metabolites of *Aspergillus* spp. has been indicated by Wehner *et al.* (1978), Wehner *et al.* (1979a, b) and Kfir *et al.* (1986). Extracellular enzyme production of *Aspergillus* spp. was studied by McLean *et al.* (1985): *A. flavus* and *A. candidus* Link were found to be prolific enzyme producers. HPLC determinations of aflatoxin B and G in groundnut seed, indicated a 79.1% presence of *A. parasiticus* and 20.9% of *A. flavus* (Labuschagne & Wehner 1990). McLean *et al.* (1990) found that aflatoxin B1 is toxic to callus tissue of maize.

The large number of references concerning work of a chemical nature, is beyond the scope of this overview. However, the following works serve as general references. A symposium on mycotoxins (Anon. 1965) treated various aspects of aflatoxin. Purchase & Theron (1967) gave a comprehensive review of work on mycotoxins in South Africa. Steyn (1980) summarised studies on secondary metabolism, highlighting contributions by South African scientists. The sixth International IUPAC Symposium on Mycotoxins and Phycotoxins (Steyn & Vleggaar 1986) was held in South Africa and two local papers on aflatoxin were included. An update on the mycotoxins produced by *Aspergillus* spp., is included in the work of Frisvad (1989).

DISCUSSION

The 25 commonly encountered species of *Aspergillus* (Domsch *et al.* 1980) have all been recorded from southern Africa, although of the estimated 170–200 described Aspergilli (Christensen & Tuthill 1985), only 72 or about 40% of species with *Aspergillus* anamorphs have been traced and included in the checklist. Forty per cent of all described *Aspergillus* spp. have been recorded from single locations or are restricted in geographic distribution (Christensen & Tuthill 1985); so many probably do not occur here. This may explain why such a relatively low percentage of *Aspergillus* species have been recorded from southern Africa.

It may be concluded that southern Africa, with its varied climatic regions and some of the oldest geological formations in the world, may be a source of *Aspergillus* species differing from those already known. Most records of Aspergilli here have been from foodstuffs, and little information is available concerning the ecological adaptation of members of this genus to the diverse conditions in this country. It is significant that on the arid Giribes Plain of Namibia, the dominant genus isolated from soil in the perplexing bare patches has been *Aspergillus* (Eicker *et al.* 1982). Unfortunately there is no indication how many, if any, of those isolates were difficult to identify and were consequently lumped under the heading '*Asper-*

gillus spp.' The same may be true for other surveys such as those of Eicker (1969, 1970, 1974) and Papendorf (1976), where unidentified Aspergilli were listed. A survey of various ecological niches may prove to be a taxonomically rewarding undertaking and may yield potentially useful but as yet undescribed species.

South African isolates of *Aspergillus* have been mentioned by authorities such as Thom & Church (1926), and Raper & Fennel (1973) who described *A. cristatus* Raper & Fennell on the basis of an isolate 'received in 1954 from the CBS as *H. Swart 168* isolated by H. Swart, S. Africa'. Neither the authors of this fungus name, nor the CBS catalogue (see checklist), indicated a substrate or locality for this isolate. Swart's (1959) writings however, stated that his specimen No. 168 was isolated from mangrove soil, collected on the island of Inhaca off Maputo [Lourenço Marques], Mozambique.

Although no local scientist has made a major contribution to the taxonomy of this group, much attention has been paid to the detection and characterisation of mycotoxins, and South Africans have become world leaders in this field. A large number of references concerning aflatoxin, a metabolite of *A. flavus* and *A. parasiticus*, are available, but these have not been treated here as they do not refer to specific fungal isolates. The same goes for other mycotoxins such as austocystins, ochratoxin and sterigmatocystin. It is of interest that ochratoxin A, B, and C were characterised in South Africa (Van der Merwe *et al.* 1965a, b), and their toxicity determined (Purchase & Theron 1968), but the toxins themselves have never been isolated here (Mantle & McHugh 1993).

Eicker (1975) found that *A. aculeatus* had an antagonistic effect on both *Staphylococcus* and *Candida*. Shortly afterwards a secondary metabolite of this fungus, namely aculeacin A, was found to have strong activity against filamentous fungi, as well as yeasts (Mizuno *et al.* 1977). There may be other members of the group with similar undetected beneficial characteristics.

Species of *Aspergillus* such as *A. ochraceus* K. Wilh., *A. niger* and *A. terreus*, but especially *A. parasiticus*, are known insect pathogens (Domsch *et al.* 1980). Isolates from arthropods have been recorded in southern Africa (Prinsloo 1960), but their potential as agents in biological control has not been investigated. *Aspergillus* spp. are chemically very active and may even be valuable in the control of plant pathogens.

The value of sophisticated chemical methods employed by many *Aspergillus* taxonomists (Samson & Pitt 1985, 1990) as well as that of electron microscopy (Kozakiewicz 1989) has been indicated. They have become indispensable in Hyphomycete taxonomy, but little attention has been given to these methods in South Africa. Morphological and physiological characteristics are almost the only criteria by which *Aspergillus* is identified here. Although this is still the most accessible way of taxonomic determination, the new techniques could become a powerful tool in the hand of South African taxonomists.

It is clear that the field for workers on *Aspergillus* is wide open, be it in industry, ecology, biological control, biochemistry, the various pathology disciplines or by implementing the modern methods available to the taxonomist.

ACKNOWLEDGEMENTS

I thank Ms A. P. Baxter of the Plant Protection Research Institute for kindly reviewing a draft of the manuscript.

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CHECKLIST OF *ASPERGILLUS*, *CHAETOSARTORYA*, *EMERICELLA*, *EUROTIUM*, *FENNELLIA*, *NEOSARTORYA* (= SARTORYA) AND *SCLEROCLEISTA* RECORDED IN SOUTHERN AFRICA

Aspergillus spp. recorded in southern Africa up to 1993 are arranged alphabetically and the host and/or substrate from which each species was recorded is given with the relevant literature reference. Species names as well as substrates are listed as cited in the original publications. To update the nomenclature, cross references to names currently accepted are given and Samson (1979), Horie (1980), Samson & Gams (1985), Samson & Pitt (1985, 1990), Kozakiewicz (1989) as well as Pitt & Samson (1993) were consulted. *Aspergillus* is essentially an anamorphic genus but until recently anamorphic as well as teleomorphic states were grouped under this genus. These two states have now been separated and are therefore listed separately: *Aspergillus* spp. followed by the teleomorphic genera in alphabetical order. In some cases there is more than one reference, or additional culture collection numbers for the same isolate: these are given in square brackets.

The following abbreviations are used in the list:

CBS, South African isolates listed in the 1990 List of Cultures of the Centraalbureau voor Schimmelcultures, 32nd edition, Baarn, The Netherlands.
IMI, cultures listed in the 1992 Catalogue of the Culture Collection, 10th edition, CAB International Mycological Institute, Kew, United Kingdom.
PPRI, isolates in the Culture Collection of the National Collection of Fungi. Isolates identified or verified by Z. Lawrence (neé Kozakiewicz) of the IMI (pers. comm.) are indicated as ver. Z.L. IMI.
PREM, dried material in the National Collection of Fungi. Those specimens that were identified by the CBS are indicated.

The National Collection of Fungi has acquired additional fungal collections over the years. *Aspergillus* isolates in these collections (many no longer viable) are listed under the following abbreviations:
CSIR, isolates listed in a collection received from the Council for Scientific and Industrial Research.
MCP, the collection of Papendorf (1979) received from the University of Pochefstroom for C.H.E. Isolates are listed under the substrate soil, but some could have been from *Acacia karroo* litter.
TRL, a collection of the Transvaal Chamber of Mines, some isolates determined by Thom, as listed by Doidge (1950).
UCT, a collection obtained from the University of Cape Town containing isolates of Allsopp *et al.* (1987).
VdB, records in the Van der Bijl collection which is administered by the National Collection of Fungi; some are mentioned by Van der Bijl (1920).

\# State of the fungus uncertain.
* *Aspergillus* species indicated as toxic.

GENUS ASPERGILLUS

aculeatus (see **A. japonicus**)

allahabadii B.S. Mehrotra & Agnihorti
litter: Eicker (1973)
soil: Eicker (1969, 1970a, b)

alliaceus Thom & Church
aerospora: IMI 087 209
cereals and legume products: Scott (1965)
grass litter: PPRI 3638
Medicago spp.: Lamprecht *et al.* (1988) [PREM 48323, 48324]
soil: PPRI 3185 [PREM 49038]; CSIR 556

alutaceus (see *A. ochraceus*)

ambiguus Sappa
Zea mays: Van der Westhuizen & Bredell (1972)

amstelodami (see **Eurotium amstelodami**)

avenaceus G. Sm.
cereals and legume products: *Scott (1965)
cornmeal: CBS 237.65
soil: CSIR 826

awamori Nakaz.
aeropsora: PPRI 4098
grass hay: Van Warmelo (1967)
groundnut hay: Van Warmelo (1967)
lucerne hay: Van Warmelo (1967)
maize hay: Van Warmelo (1967)
swine meal: Van Warmelo (1967)

caespitosus Raper & Thom
Zea mays: Van der Westhuizen & Bredell (1972)

campestris M. Chr.
mouse nest material: PPRI 4080 [PREM 50885, ver. Z.L. IMI 344 489]

candidus Link
Avena sativa: *Lübben (1992)
cereals and legume products: Scott (1965)
cheese: Doidge (1950)
cotton wool: PPRI 3841
maize meal: Van Warmelo (1967)
man: Martin & Berson (1973)
mouse nest material: PREM 50887
pasture: Roux (1985)
peanut butter/meal/kernels: Gilman (1972)
peat: Smit (1984)
soil: PPRI 4081 [id. Z.L. IMI 344 490], 4518; CSIR 113, 114, 115, 116 [PREM 49364]
sorghum: CSIR 544
sorghum malt: Rabie & Lübben (1984)
swine meal: Van Warmelo (1967)
Zea mays: Gilman (1972); McLean & Berjak (1985); Van der Westhuizen & Bredell (1972); Van Warmelo *et al.* (1968); PPRI 3713 [PREM 49889]

carbonarius (Bainier) Thom
Eucalyptus spp. Lundquist & Baxter (1985) [PPRI 3776, PREM 47143]
undetermined host: IMI 138 280 [CBS 111.80]
Vitis vinifera: Doidge (1950) [Doidge *et al.* (1953); Gorter (1977)]

carneus Blochwitz
cereals and legume products: *Scott (1965)
leather: PPRI 3635
peat: Smit (1984)
soil: Eicker (1974, 1975); Eicker *et al.* (1982); Papendorf (1976) [MCP 131, 133, PPRI 3636]; CSIR 239, 240, 241, 243
undetermined host: CSIR 1208, 1210, 1211 [PPRI 3570, PREM 49363]

cervinus Massee
litter: Eicker (1973)
soil: UCT [PPRI 3284]

chevalieri (see **Eurotium chevalieri**)

chevalieri var. intermedius (see **Eurotium cristatum**)

clavatoflavus Raper & Fennell
man: Martin & Berson (1973)

clavatus Desm.
Avena sativa: Lübben (1992)
cereals and legume products: *Scott (1965)
compost: Eicker (1980)
grass roots: PREM 49066
Hordeum vulgare: PREM 47911
maize sprouts: *Kellerman *et al.* (1984)
peanut butter/meal/kernels: Gilman (1972)
soil: CSIR 133; MCP 1302
sorghum: CSIR: 304, 519, 520
sorghum beer residue: *Coetzer *et al.* (1985); *Kellerman *et al.* (1976); PREM *44972, 45108
sorghum malt : Rabie & Lübben (1984); Steyn *et al.* (1982)
Zea mays: Van der Westhuizen & Bredell (1972); PREM 44702, 44708, 45046, 48598; CSIR 61, 519, 520

cremeus (see **Chaetosartorya cremea**)

cristatus (see **Eurotium cristatum**)

duricaulis Raper & Fennell
Hakea sericea roots: Allsopp *et al.* (1987)
Leucospermum parile roots: Allsopp *et al.* (1987)
soil: Allsop *et al.* (1987) [UCT]

eburneus (see **Fennellia nivea**)

echinulatus (see **Eurotium echinulatum**)

effusus (see **A. oryzae**)

elegans Gasperini
lucerne hay: Van Warmelo (1967)
maize hay: Van Warmelo (1967)

ficuum (see **A. niger** var. **ficuum**)

fischeri (see **Neosartorya fischeri**)

fischeri var. glaber (see **Neosartorya glabra**)

fischeri var. spinosus (see **Neosartorya spinosa**)

flavipes (see **Fennellia flavipes**)

flavus Link
aerospora: Doidge (1950); IMI 089 137
agricultural commodities: Dutton & Westlake (1985)
apricot: Klich & Pitt (1988)
Arachis hypogaea: Anon. (1965); Gorter (1977); Marasas & Van Rensburg (1986)
Avena sativa: *Lübben (1992)
Avicennia seeds: PREM 47526
barley: Klich & Pitt (1988)
beer: Martin & Keen (1978)
biltong: CSIR 1413 [PREM 47906], 1414 [PREM 47908]
Cenchrus ciliaris: Bezuidenhout (1977)
cereals and legume products: *Scott (1965)
chicken feeds and litter: Westlake & Dutton (1985)
coconut matting: ; PREM 33293 [TRL det. CBS]
Cussonia paniculata seed: PPRI 3643
debris: PPRI 3200
face cream: PPRI 3273, 3274, 3275, 3276, 3277, 3278
fenugreek: Klich & Pitt (1988)
flannel bag: Doidge (1950) [TRL det. Thom]
fodder: PREM 43024, 47799
foodstuff: Marasas (1988); Purchase & Vorster (1968)
grapes: Le Roux *et al.* (1973)
grass hay: Van Warmelo (1967)
groundnut seeds/hay: Labuschagne & Wehner (1990); Van Warmelo (1967)
insects (dead Chrysomelidae spp.): PPRI 5062
Litchi chinensis: Roth (1963)
litter: Eicker (1973)
lucerne hay: Van Warmelo (1967)
maize meal/silage: Van Warmelo (1967)
malt: Klich & Pitt (1988)
man: Martin & Berson (1973)
manure: PPRI 3475 [PREM 49335]
material: Doidge (1950)
molasses meal: Roth (1968)
natural gum: Roth (1968)
nuts/dried fruit: *Wehner & Rabie (1970)
Nicotiana tabacum: Doidge (1950)

oats: Klich & Pitt (1988)
paper: PPRI 3644
pasture: Roux (1985)
peanut: Klich & Pitt (1988)
peanut butter/meal/kernels: Gilman (1972)
sclerotia (*Sclerotinia sclerotiorum*): PREM 47228
soil: Allsop *et al.* (1987); Eicker (1969, 1970a, 1974, 1975) [PREM 44262]; Papendorf (1976); Weideman *et al.* (1990); CSIR 203, 204, 205, 209, 211, 212, 213, 215, 216, 217, 222, 223, 224, 225, 229, 231, 237
sorghum: CSIR 299
sorghum malt: Rabie & Lübben (1984)
sugar cane cariopsis: PREM 47532
sunflower hay: Van Warmelo (1967)
sunflower seed: Klich & Pitt (1988)
swine meal: Van Warmelo (1967)
termite comb (*Macrotermes bellicosus*): Doidge (1950) [PREM 1253]
termites (dead *Hodotermes mossambicus*): PPRI 3753
Triticum aestivum: Lübben (1992)
Zea mays: Gilman (1972); Marasas & Van Rensburg (1986); McLean & Berjak (1985, 1987); Mycock *et al.* (1990); Van der Westhuizen & Bredell (1972); Van Warmelo *et al.* (1968); PREM 44927, 44952, 47530, 47552, 47553; CSIR 57, 63, 136, 146, 283, 500, 501, 508, 515, 776, 840, 843, 848, 851, 852, 856, 857
= *flavus* var. *columnaris* Raper & Fennell
compost: Eicker (1980)
cornmeal: CBS 242.65
soil: CSIR 147, 151; MCP 49
sorghum malt: Rabie & Lübben (1984)
Zea mays: Mycock *et al.* (1990); PREM 47529

flavus var. columnaris (see **A. flavus**)

foetidus Thom & Raper
Allium cepa: PPRI 4046 [PREM 49175]
leather: PREM 48031

fumigatus Fresen.
aerospora: Roth (1968)
antigen of: Benatar *et al.* (1980)
Avena sativa: Lübben (1992)
bagasse: PPRI 4975
birds: Doidge (1950)
'blesbok' dung (*Damaliscus dorcas phillipsii*): Eicker (1972)
cereals and legume products: *Scott (1965)
compost: Smit (1984); PPRI 3477 [PREM 49330], 3479 [PREM 42090]
duck (Anatidae spp.): Doidge (1950)
faeces of Cape sparrow (*Passer melanurus*): Eicker (1972)
fowl (*Gallus domesticus*): Neitz (1967)
groundnut seeds: Van Warmelo (1967)
Hakea sericea roots: Allsopp *et al.* (1987)
jackass penguin (*Sphenicus demersus*): Doidge (1950); Neitz (1967)
king penguin (*Aptenodites pathagonica*): Neitz (1967)
Leucospermum parile roots: Allsopp *et al.* (1987)
litter: Eicker (1976)
lucerne hay: Van Warmelo (1967)
maize silage: Van Warmelo (1967)
man: Jacobs *et al.* (1965); Findley *et al.* (1971); Martin & Berson (1973); Caro (1973); Block & Young (1977); Kallenbach *et al.* (1977); Cooper *et al.* (1983); Lewis *et al.* (1985); Joubert *et al.* (1988); Govender *et al.* (1991)
molasses meal: Roth (1968)
mushroom compost: Eicker (1977); PREM 42090
natural gum: Roth (1968)
onion seed: PREM 44770
ostrich (*Struthio camelus*): Doidge (1950); Neitz (1967)
peat: Smit (1984)
scaly weaver (*Sporopipes squamifrons*): Prozesky *et al.* (1971)
sclerotia (*Sclerotinia sclerotiorum*): PREM 47929
soil: Allsopp *et al.* (1987) [UCT]; Cohen (1950); Eicker (1974, 1975); Eicker *et al.* (1982); Martin (1960); Papendorf (1976) [MCP 340]; PPRI 3283; CSIR 85, 86, 87, 88, 89, 94, 97, 98, 99
sorghum: CSIR 305 [PPRI 3290], 306
sorghum malt: Rabie & Lübben (1984)
spent sulphite liquor: Pretorius & Lempert (1993a, b, c)
straw: PPRI 3478 [PREM 49331]
sugar: Van der Bijl (1920) [VdB 906, Doidge 1950, PREM 14258]
swine meal: Van Warmelo (1967)
turkey (*Meleagris gallopavo*): Neitz (1967)
undetermined host: CSIR 1203
Zea mays: Van der Westhuizen & Bredell (1972); CSIR 160, 552, 567
= *fumigatus* var. *ellipticus* Raper & Fennell
fodder: PPRI 4687
grass roots: PREM 49065
soil: PPRI 3210

fumigatus var. ellipticus (see **A. fumigatus**)

giganteus Wehmer
sorghum malt: Rabie & Lübben (1984)

glaucus (see **Eurotium herbariorum**)

heteromorphus Bat. & H. Maia
medical supplies: PPRI 4688

japonicus Saito
grapes: Le Roux *et al.* (1973)
litter: Eicker (1973)
soil: Eicker (1969, 1970a, 1975); PPRI 4070; PREM 44279
= *aculeatus* Iizuka
debris: PPRI 3842 [PREM 50884], 4097
grass roots: PPRI 3326 [PREM 49201, ver. Z.L. IMI 343 117]
soil: Eicker (1974, 1975); PPRI 4227, 4286 [PREM 50884], 4962
Trichilia seeds: PPRI 4854
Zea mays: PPRI 4858

mangini (see **Eurotium herbariorum**)

melleus Yukawa
citrus fruits: Doidge & Van der Plank (1936)
Medicago sativa seed: Marasas & Bredell (1973) [PREM 44411, 44495, 44518]; PPRI 4228 [PREM 50862]
= *quercinus* (Bain.) Thom & Church
Litchi chinensis: Roth (1963)

minutus (see **A. ustus**)

multicolor Sappa
debris: PPRI 3840 [id. Z.L. IMI 343 121]

nidulans (see **Emericella nidulans**)

nidulans var. echinulatus (see **Eurotium echinulata**)

nidulans var. latus (see **Emericella nidulans**)

niger (see **A. niger** var. **niger**)

niger var. **ficuum** (Reichardt) Kozak.
= *ficuum* (Reichardt) Henn.
Allium cepa: PPRI 3389 [PREM 49173], 3390 [PREM 49174], 3391 [PREM 49170], 3424 [PREM 49171], 3425 [PREM 49172]
compost: PPRI 3476 [PREM 49338]
grass endophyte: De Villiers (1989) [PPRI 3455, PREM 49280]
sand/soil: PPRI 3321 [PREM 49203], 3322 [PREM 49200], 3323 [PREM 49204, id. as *A. niger* Z.L. IMI 343 118]

niger Tiegh. var. **niger**
= *niger* Tiegh.
aerospora: Doidge (1950); Roth (1968)
Allium cepa: VdB 95 [Verwoerd (1929), Doidge (1950), Doidge *et al.* (1953); Gorter (1977)]; PPRI 3253 [PREM 49169]; PPRI 5017
Allium sativum: PPRI 3388 [PREM 47499, ver. Z. L. IMI 343 119]
antigen of: Benatar *et al.* (1980)
Arachis hypogaea: Doidge (1950) [Doidge *et al.* (1953), Gorter (1977)]; Marasas & Van Rensburg (1986)
Avena sativa: *Lübben (1992)
Avicennia marina: Steinke (1990)
banana: Roth & Loest (1965)
Bruguiera gymnorrhiza: Steinke (1990)
Cenchrus ciliaris: Bezuidenhout (1977)
cereals and legume products: Scott (1965)
citrus fruits: Doidge & Van der Plank (1936)
Citrus limonia: Doidge (1950)
Citrus sinensis: Doidge (1950) [Doidge *et al.* (1953), Gorter (1977)]
compost: Eicker (1980); Smit (1984)
contaminant on malt agar: PREM 25960
cowpea hay: Van Warmelo (1967)

dairy: Davel & Neethling (1930)
debris: PREM 48974, 48982, 49202
dried sausage: *PREM 45524, *45525
flannel bag: Doidge (1950) (TRL)
fodder: PPRI 3618 [PREM 48029]
fruit (rotting): Doidge (1950); [Doidge *et al.* (1953)]
Gardenia fruits: Doidge (1950) [PREM 23647]
grapes: Le Roux (1973)
grass hay: Van Warmelo (1967)
groundnut hay: Van Warmelo (1967)
insect (dead Chrysomelidae sp.): PPRI 4966
leather (wet-blue): Russell (1981) [PPRI 3255]
Litchi chinensis: Roth (1963)
lucerne hay: Van Warmelo (1967)
Lycopersicum esculentum: Doidge *et al.* (1953)
maize meal/hay/silage: Van Warmelo (1967)
man: Doidge (1950); Martin & Berson (1973); Bak & Wagenfeld (1983); Berkowitz & Jacobs (1987)
Mangifera indica: Doidge (1950)
mango: Wehner *et al.* (1981)
material: Doidge (1950)
Medicago sativa seed: Marasas & Bredell (1973)
Medicago spp.: Lamprecht *et al.* (1988) [PPRI 3739, PREM 48327]
molasses meal: Roth (1968)
nuts/dried fruit: *Wehner & Rabie (1970)
paper: PPRI 3640 [PREM 49877]
paper pulp: Smit (1984)
pasture: Roux (1985)
peanut butter/ meal/ kernels: Gilman (1972)
phylloplane: Eicker (1976)
pomegranate (*Punica granatum*): Verwoerd (1929)
Pyrus malus: Doidge (1950)
soil: Allsopp *et al.* (1987) [UCT]; Botha & Wehner (1990); Cohen (1950); Eicker (1974); Martin (1960); Rosselet (1953, 1955); Weideman *et al.* (1990); PPRI 3328; CSIR 170, 171, 172, 173; MCP 1012
sorghum malt: Rabie & Lübben (1984)
sugar: Van der Bijl (1920) [VdB 905, PREM 14260]
Triticum aestivum: Lübben (1992)
ventilation tubing: Doidge (1950) (TRL det. Thom)
Vitis vinifera: Doidge (1950) [Doidge *et al.* (1953), Gorter (1977)]
Welwitschia mirabilis: Bomman (1978); PREM 36987, 41961, 43736; CBS 139.54
Ximenia americana: PREM 5599
Zea mays: Doidge (1950); Gilman (1972); Marasas & Van Rensburg (1986); McLean & Berjak (1987); Van der Westhuizen & Bredell (1972); Van Warmelo *et al.* (1968); PREM 47914; CSIR 56, 156, 334, 513, 550, 559, 628

= *welwitschiae* (Bres.) Hennings
Welwitschia bainesii: Doidge (1950) [VdB 2499]; Raper & Fennell (1973); PREM 46296

niger var. **tubengensis** (Mosseray) Kozak.
= *tubengensis* Mosseray
compost: Eicker (1980)
debris: PREM 48979, 48981
soil: Eicker (1969, 1970) [PREM 44288]
sugar cane cariopsis: PREM 47531
Zea mays: PREM 47554, 48864

niveus (see **Fennellia nivea**)

nutans McLennan & Ducker
soil: Raper & Fennell (1973) [CBS 122.56]; UCT [PPRI 3227]

ochraceus K. Wilh.
Asclepias stem: PPRI 3764
Andropogon sorghum seed: *CSIR 806 [CBS 263.67]
Avicennia seed: PREM 47524, 47525
cereals and legume products: *Scott (1965)
Citrus limonia: Doidge *et al.* (1953)
contaminant on malt agar: PREM 25961
fodder: PPRI 4687
lucerne hay: Van Warmelo (1967)
Medicago sativa seed: Marasas & Bredell (1973) [PREM 44359]
peanut butter/meal/kernels: Gilman (1972)
soil: Eicker (1974, 1975); Eicker *et al.* (1982); Martin (1960); Papendorf (1976) [MCP 337, 1013]; CSIR 101, 102, 140, 142, 144, 153, 154, 157, 161, 162, 163, 164, 167, 168, 169, 490, 516, 551
sorghum: *Van der Merwe *et al.* (1965b); CSIR 289, 291, 803, 804
Triticum aestivum: Lübben (1992)
unknown host: *Van der Merwe *et al.* (1965a, b); *IMI 132 429
Zea mays: Gilman (1972); McLean & Berjak (1987); Van der Westhuizen & Bredell (1972); Van Warmelo *et al.* (1968); PPRI 3854 [PREM 47920], 3855 [PREM 47534]; CSIR 60; MCP [PPRI 3865]

ornatus (see **Sclerocleista ornata**)

oryzae (Ahlb.) Cohn
cassava: Klich & Pitt (1988)
cattle pellets: PREM 47142
cereal and legume products: Scott (1965)
grass roots: PPRI 3151
manure: PPRI 3474 [PREM 49334]
Zea mays: Mycock & Berjak (1992); PPRI 3629 [PREM 47624]; PREM 47625, 47926

= *effusus* Tirab.
cereals and legume products: Scott (1965)

ostianus Wehmer
sorghum: CSIR 290

parasiticus Speare
aerospora: Doidge (1950)
agricultural commodities: Dutton & Westlake (1985)
Avena sativa: Lübben (1992)
corn: Klich & Pitt (1988)
groundnut seed: Labuschagne & Wehner (1990)
insect (dead Chrysomelidae sp.): PPRI 5063
locust (*Locustana pardalina*): Prinsloo (1960)
man: Martin & Berson (1973)
Medicago spp. Lamprecht *et al.* (1988) [PREM 48325]
oats: Klich & Pitt (1988)
paper: PPRI 3641 [PREM 49873]
soil: Klich & Pitt (1988); CSIR 214
sunflower seed: Klich & Pitt (1988)
termites (dead *Hodotermes mossambicus*): PPRI 3754
Zea mays: Klich & Pitt (1988); CSIR 62

penicilloides Speg.
Arachis hypogaea: CBS 234.65

phoenicis (Corda) Thom
Welwitschia sp. inflorescence: PPRI 4110 (ver. Z.L.), 4111; IMI 056 824

proliferans G. Sm.
= *sartoryi* Syd.
gold mine: Thom & Church (1926), type of *A. sartoryi* [Doidge 1950]

puniceus Kwon-Chung & Fennell
Cenchrus ciliaris: Bezuidenhout (1977)
soil: Papendorf (1976) [MCP 46, 174, 236]

quadrilineatus (see **Emericella quadrilineata**)

quercinus (see **A. melleus**)

repens (see **Eurotium repens**)

restrictus G. Sm.
cereals and legume products: Scott (1965)
soil: CSIR 39, 40, 42
Zea mays: Van der Westhuizen & Bredell (1972); PPRI 4841

ruber (see **Eurotium rubrum**)

rugulosus (see **Emericella rugulosa**)

sartoryi (see **A. proliferans**)

sclerotiorum G.A. Huber
grass litter: PPRI 3678
insects (dead Chrysomelidae spp.): PPRI 5061
paper: PPRI 3304 (PREM 49209)
termites (dead *Hodotermes mossambicus*): PPRI 3305 [PREM 49205]

sparsus Raper & Thom
soil: PPRI 4082 [PREM 50863 ver. Z. L. IMI 344 491]

stromatoides (see **Chaetosartorya stromatoides**)

subsessilis Raper & Fennell
compost: PPRI 4016 (id. Z.L. IMI 343 123)

sulphureus (Fresen.) Wehmer
Nicotiana tabacum: Doidge (1950)

sydowii (Bainier & Sartory) Thom & Church
cereals and legume products: Scott (1965)
compost: Eicker (1980)
grass hay: Van Warmelo (1967)
lucerne hay: Van Warmelo (1967)
maize silage: Van Warmelo (1967)
man: Martin & Berson (1973)
Medicago sativa seed: Marasas & Bredell (1973) [PREM 44470, 44471, 44481]
Melianthus comosus seed: PPRI 3810 [PREM 50888]
oats: Doidge (1950)
silage: CBS 170.63
soil: Eicker (1974); CSIR 122, 123, 124, 125, 126; UCT
sugar: Doidge (1950)
Watsonia marginata seed: PPRI 3839
Zea mays: Gilman (1972); Mycock & Berjak (1992); Van der Westhuizen & Bredell (1972); PREM 47555; CSIR 59

tamarii Kita
cereals and legume products: Scott (1965)
debris: PPRI 4018 [PREM 49064, ver. Z.L.]
dried beans: Klich & Pitt (1988)
peanut butter/meal/kernels: Gilman (1972)
soil: PPRI 4018; CSIR 127, 128, 129, 130, 131
sorghum grain: Bosman *et al.* (1991); CSIR 313
sunflower seed: Klich & Pitt (1988)
Zea mays: Gilman (1972); PREM 47922

terreus Thom
aerospora: Roth (1965)
Avena sativa: *Lübben (1992)
Cenchrus ciliaris: Bezuidenhout (1977)
cereals and legume products: Scott (1965)
debris: PPRI 3182, [PREM 49036]; PREM 48978, 48980
fishmoth gut (*Namibmormisma muricauda*): Watson *et al.* (1990) [PPRI 3614]
grass roots: PPRI 3613 [PREM 48975]; PREM 48976, 48978, 48980
groundnut seeds: Van Warmelo (1967)
leather (wet-blue): Russell (1981)
lucerne hay: Van Warmelo (1967)
maize meal/hay/silage: Van Warmelo (1967)
man: Martin & Berson (1973)
Melianthus comosus seed: PPRI 3615
natural gum: Roth (1968)
pasture: Roux (1985)
sclerotia (*Sclerotinia sclerotiorum*): PREM 47927
soil: Eicker *et al.* (1982); Weideman *et al.* (1990); PPRI 3180 [PREM 49037], 3613; CSIR 174, 175, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191
sorghum: CSIR 307, 309
sorghum malt: Rabie & Lübben (1984)
straw: PPRI 3480 [PREM 49333]
sugar: Van der Bijl (1920) [VdB 904, Doidge (1950), PREM 14261]
Triticum aestivum: Lübben (1992)
Zea mays: Gilman (1972); McLean & Berjak (1987); Van der Westhuizen & Bredell (1972); Van Warmelo *et al.* (1968); PREM 47915, 47916, 47917, 47918, 47919; CSIR 159, 536, 539, 616
= *terreus* var. *boedijni* (Blochwitz) Thom & Raper
soil: CSIR 177, 178
= *terreus* var. *floccosus* Thom & Raper
soil: CSIR 175

terreus var. **aureus** Thom & Raper
compost: Eicker (1980)
millet seed: PPRI 4229 [PREM 50864]

terreus var. boedijni (see **A. terreus**)

terreus var. floccosus (see **A. terreus**)

terricola E.J. Marchal
Watsonia marginata seed: PPRI 3788
Zea mays: PREM 47551

tubengensis (see **A. niger** var. **tubengensis**)

umbrosus (see **Eurotium herbariorum**)

unilateralis Thrower
Hakea sericea roots: Allsopp *et al.* (1987)
Leucospermum parile roots: Allsopp *et al.* (1987)
soil: Allsopp *et al.* (1987)

ustus (Bainier) Thom & Church
aerospora: Roth (1968)
Arachis hypogaea: PPRI 3189 [PREM 49027]
Avena sativa: *Lübben (1992)
canvas ventilation tubing: IMI 089 359
Cenchrus ciliaris: Bezuidenhout (1977)
cereals and legume products: Scott (1965)
cheese: Lück *et al.* (1976); Lück & Wehner (1979)
compost: Eicker (1980)
culture contaminant: Rabie *et al.* (1977)
debris: PPRI 3198 [PREM 49063], 3199, 3639
flannel bag: IMI 089 360
grass endophyte: De Villiers (1989) [PPRI 3456, PREM 49281]
grass roots: PREM 49063
insect (dead Chrysomelidae sp.): PPRI 3191 [PREM 49051], 3192 [PREM 49052], 3193 [PREM 49053]
lucerne hay: Van Warmelo (1967)
maize hay: Van Warmelo (1967)
Medicago sativa seed: PREM 44553
natural gum: Roth (1968)
soil: Eicker (1974, 1975); CSIR 117, 118, 119, 120, 121
sorghum malt: Rabie & Lübben (1984)
Zea mays: Van der Westhuizen & Bredell (1972); CSIR 8
= *minutus* E.V. Abbott
flannel bag: Doidge (1950) (TRL det. Thom)

variecolor (see **Emericella variecolor**)

versicolor (Vuill.) Tirab.
Avena sativa: *Lübben (1992)
canvas: Doidge (1950) (TRL det. Thom)
Cenchrus ciliaris: Bezuidenhout (1977)
cereals and legume products: Scott (1965)
flannel bag: Doidge (1950) (TRL det. Thom)
grapes: Le Roux *et al.* (1972)
Leucospermum parile roots: Allsopp *et al.* (1987)
lucerne hay: Van Warmelo (1967)
man: Doidge (1950); Martin & Berson (1973)
Medicago sativa seed: Marasas & Bredell (1973) [PREM 44486]
Medicago spp.: Lamprecht *et al.* (1988) [PPRI 3502, PREM 48326]
paper: PPRI 3315 [PREM 49208]
peanut butter/meal/kernels: Gilman (1972)
Salvia stenophylla seed: PPRI 3519
soil: Martin (1960); Eicker (1974, 1975); Papendorf (1976) [MCP 339]; CSIR 179, 192, 193, 194, 196, 197, 198, 199, 201, 202; UCT
sorghum malt: Rabie & Lübben (1984)
undetermined host: Rabie *et al.* (1976); CSIR: 1365, 1367, 1370
wooden floor boards: PPRI 3890
Triticum aestivum: Lübben (1992)
Zea mays: Van Warmelo *et al.* (1968); Gilman (1972); McLean & Berjak (1985, 1987); Van der Westhuizen & Bredell (1972); PREM 47626, 47923; CSIR 478

viridinutans Ducker & Thrower
grass debris: PPRI 3327 [PREM 49206]
grass roots: PPRI 3208 [PREM 49067], 3209 [PREM 49068]
soil: PPRI 4976

welwitschiae (see **A. niger** var. **niger**)

wentii Wehmer
Avena sativa: Lübben (1992)
cereals and legume products: Scott (1965) [Rabie & Terblanche (1967)]
compost: Smit (1984)
groundnuts: *Rabie *et al.* (1965)
palm seed (*Arega catechu*): PREM 49026
peanut butter/meal/kernels: Gilman (1972)
soil: Eicker (1974); Weideman *et al.* (1990); CSIR 244, 245, 246, 247, 248, 249, 250, 251, 252, 254
sorghum: CSIR: 294, 295
sorghum malt: Rabie & Lübben (1984); *Rabie *et al.* (1986)
sugar cane cariopsis: PREM 47527
unknown host: Rabie & Terblanche (1967)

Zea mays: Gilman (1972); McLean & Berjak (1987); Van der Westhuizen & Bredell (1972); Van Warmelo *et al.* (1968); PPRI 3905; CSIR 155, 336, 357, 376, 418, 431; IMI 162 039

Aspergillus species undetermined

aerospora: Ordman (1963, 1970); Ordman & Etter (1956); Potter *et al.* (1991); Van der Merwe *et al.* (1979)
agricultural commodities: Dutton & Westlake (1985)
Allium cepa: PREM 46375
Arachis hypogaea : Marasas & Van Rensburg (1986)
Avicennia marina: Mycock & Berjak (1990); Steinke *et al.* (1990)
banana: Roth & Loest (1965)
beer: Martin & Keen (1978)
Bruguiera gymnorrhiza: Steinke *et al.* (1990)
Camellia sinensis: Mycock & Berjak (1990)
Castanospermum australe: Mycock & Berjak (1990)
cereal and legume products: Isaacson (1966)
cheese: Lück & Wehner (1979)
chicken feeds and litter: Westlake & Dutton (1985)
Cichorium intybus: Prinsloo *et al.* (1991)
citrus fruits: Doidge & Van der Plank (1936)
Citrus sinensis: Doidge (1950) [Doidge *et al.* (1953)]
compost: Eicker (1980); Smit (1984)
corn: Marasas *et al.* (1981); Van Warmelo (1967)
cowpea hay: Van Warmelo (1967)
feedstuffs: Dutton & Westlake (1985); Van Warmelo (1967)
Ficus carica: Doidge (1950) [Doidge *et al.* (1953)]
grapes: Le Roux *et al.* (1973)
grass hay: Van Warmelo (1967)
groundnut hay: Van Warmelo (1967)
groundnuts: Marasas & Van Rensburg (1986)
indigenous seed: Isaacs & Benic (1990)
Landolphia kirkii: Mycock & Berjak (1990)
Litchi chinensis: Mycock & Berjak (1990)
lucerne hay: Van Warmelo (1967)
man: Martin & Berson (1973); Cooper *et al.* (1983); Fitzsimons & Peters (1986); Glass *et al.* (1984)
oranges: Doidge & Van der Plank (1936)
Passiflora quadrangularis: Doidge (1950)
pasture: Roux (1985)
piglet: Nesbit (1986)
Pinus sp.: Lundquist (1987)
Podocarpus henkelii: Mycock & Berjak (1990)
Prunus persica: Doidge *et al.* (1953)
Pyrus malus: Doidge *et al.* (1950)
Saccharum officinarum: Doidge (1950) [Doidge *et al.* (1953)]
scale: PREM 26137, 28447
Scadoxus membranaceus: Mycock & Berjak (1990)
soil: Eicker (1974, 1975); Eicker *et al.* (1982); Papendorf (1976)
sorghum grain: Bosman *et al.* (1991)
spent sulphite liquor: Pretorius & Lempert (1993a, b, c)
sunflower hay: Van Warmelo (1967)
swine meal: Van Warmelo (1967)
Zea mays: Gilman (1972); Marasas & Van Rensburg (1986); Rheeder *et al.* (1990); PREM 47913

GENUS CHAETOSARTORYA

cremea (Kwon-Chung & Fennell) Subram.
\# *A. cremeus* Kwon & Fennell
Zea mays: Van der Westhuizen & Bredell (1972)

stromatoides B.J. Wiley & E.G. Simmons
\# *A. stromatoides* Raper & Fennell
man: Sacho *et al.* (1987) [IMI 292 883)]

GENUS EMERICELLA

acristata (Fennell & Raper) Y. Horie
celery seed: PPRI 4961

echinulata (Fennell & Raper) Y. Horie
compost: PPRI 3465
\# *A. nidulans* var. *echinulatus* Fennell & Raper
culture contaminant: PREM 48909

nidulans (Eidam) Vuill.
compost: PPRI 3466, 3467
\# *A. nidulans (Eidam) Wint.*
aerospora: Roth (1968)
Avena sativa: *Lübben (1992)
Cenchrus ciliaris: Bezuidenhout (1977)
cereals and legume products: *Scott (1965)
compost: Eicker (1980)
grass hay: Van Warmelo (1967)
groundnuts: *Holzapfel *et al.* (1966); Van Warmelo (1967)
litter: Eicker (1976)
lucerne hay: Van Warmelo (1967)
lupin seeds: Van Warmelo (1967)
maize hay/silage: Van Warmelo (1967)
Medicago sativa seed: PREM 44520, 44532
molasses meal: Roth (1968)
natural gum: Roth (1968)
pasture: Roux (1985)
soil: Eicker (1974, 1975); Eicker *et al.* (1982); CSIR 103, 104, 105, 106, 107, 108, 109, 110, 111, 997, 998
sorghum malt: Rabie & Lübben (1984)
Triticum aestivum: Lübben (1992)
Zea mays: *Holzapfel *et al.* (1966); Van der Westhuizen & Bredell (1972); Van Warmelo *et al.* (1968); CSIR 835
\# *A. nidulans* var. *latus* Thom & Raper
air-sac of penguin: CSIR 999
compost: Eicker (1980)

quadrilineata (Thom & Raper) C.R. Benj.
Arachis hypogaea: *CBS 235.65
compost: PPRI 3468
\# *A. quadrilineatus* Thom & Raper
Medicago sativa seed: PREM 44514, 44515
Pisum sativum: PREM 44326
soil: CSIR 1000
sorghum: CSIR 295

rugulosa (Thom & Raper) C.R. Benj.
straw: PPRI 3469
\# *A. rugulosus* Thom & Raper
Avena sativa: *Lübben (1992)
compost: Eicker (1980)
Pisum sativum: PREM 44327
soil: Eicker (1974, 1975)

variecolor Berk. & Broome
\# *A. variecolor* (Berk. & Broom) Thom & Raper
Zea mays: Van der Westhuizen & Bredell (1972)

violacea (Fennell & Raper) Malloch & Cain
forest soil: CBS 314.89

GENUS EUROTIUM

amstelodami L. Mangin
aerospora: PPRI 4851
contaminant: PPRI 3429
lupin: PPRI 3720 [PREM 50889]
Melianthus comosus seed: PPRI 3869
Zea mays: PPRI 3836
\# *A. amstelodami* (L. Mangin) Thom & Church
Arachis hypogaea: PREM 48049
cereals and legume products: Scott (1965)
grass hay: Van Warmelo (1967)
groundnut seeds: Van Warmelo (1967)
Litchi chinensis: Roth (1963)
lucerne hay: Van Warmelo (1967)
lupin seeds: Van Warmelo (1967)
mangrove soil: Swart (1959)
Medicago sativa seed: Marasas & Bredell (1973); PREM 44494, 44496
mine timber: Doidge (1950) [TRL det. Thom]
soil: CSIR 19, 20, 25, 28, 29, 31, 32, 36, 38
sugar: Doidge (1950)
swine meal: Van Warmelo (1967)
Triticum aestivum: Lübben (1992)
unknown substrate: *Rabie *et al.* (1964); Swart (1959); PREM 48049
Zea mays: Van der Westhuizen & Bredell (1972); CSIR 137, 841, 863

chevalieri L. Mangin
Zea mays: PPRI 3847 [PREM 49437], 4908
A. chevalieri (Mangin) Thom & Church
cereals and legume products: *Scott (1965)
compost: Eicker (1980)
soil: CSIR 52, 53, 54, 64, 65, 67, 78, 79, 82
Triticum aestivum: Lübben (1992)
unknown substrate: Swart (1959)
Zea mays: Gilman (1972); Mycock & Berjak (1992); Van der Westhuizen & Bredell (1972); PREM 47921, 47924, 47925; CSIR 143

cristatum (Raper & Fennell) Malloch & Cain
horse feed: PPRI 4973
A. chevalieri var. *intermedius* Thom & Raper
soil: CSIR 975, 976
A. cristatus Raper & Fennell
unknown substrate: Raper & Fennell (1973), type of *A. cristatus* [CBS 123.53, IMI 172 278]
Zea mays: PREM 44574, 44575

echinulatum Delacr.
#*A. echinulatus* (Delacr.) Thom & Church
Zea mays: Gilman (1972); Van der Westhuizen & Bredell (1972)

herbariorum Link
Melianthus comosus seed: PPRI 3582
Pisum sativum seed: CBS 127.55
A. glaucus Link
aerospora: Roth (1968)
Abrus precatorius seed: PREM 23617
Avena sativa: Lübben (1992)
Caryopemon cruciger: Doidge (1950) [PREM 23618]
Cenchrus ciliaris: Bezuidenhout (1977)
cheese: Doidge (1950)
contaminant on malt agar: PREM 25959 [id. CBS]
dairy: Davel & Neethling (1930)
Medicago sativa seed: PREM 44364
molasses meal: Roth (1968)
Nicotiana tabacum: Doidge (1950) [PREM 701]
nuts (*Corylus avellana*): PREM 23649
sorghum malt: Rabie & Lübben (1984)
sugar: VdB 902
Triticum aestivum: Lübben (1992)
unknown substrate: Doidge (1950)
Zea mays: McLean & Berjak (1985, 1987); Van Warmelo *et al.* (1968); PREM 47529, 47535
A. mangini Thom & Raper
cereals and legume products: *Scott (1965)
herbarium material: Swart (1959)
mangrove soil: Swart (1959)
soil: CSIR 45
= *Eurotium umbrosum (Bainier & Sartory) Malloch & Cain.*
Arachis hypogaea: CBS 232.65
A. umbrosus Bainier & Sartory
Medicago sativa seed: Marasas & Bredell (1973)
soil: CSIR 43, 44, 46, 47
Zea mays: Van der Westhuizen & Bredell (1972); PREM 44570, 44576

repens De Bary
Cussonia paniculata seed: PPRI 3666
kiwi jam: PREM 47738
Melianthus comosus seed: PPRI 3665 [PREM 49891]
A. repens (De Bary) Fischer
aerospora: Doidge (1950)
cereals and legume products: Scott (1965)
compost: Eicker (1980)
culture contaminant: Swart (1959)
dried sausage: *PREM 47101
peas: Swart (1959)
soil: CSIR 48, 50; MCP 1014
sorghum: CSIR 535, 537, 540
sugar: VdB 901
Triticum aestivum: Lübben (1992)
Zea mays: Gilman (1972); Van der Westhuizen & Bredell (1972)

rubrum J. König *et al.*
contaminant: PPRI 3609
A. ruber (J. König *et al.*) Thom & Church
cereals and legume products: *Scott (1965)
compost: Eicker (1980)
Nicotiana tabacum: IMI 168 779
soil: CSIR 6, 7, 12, 21, 26, 27, 74
Triticum aestivum: Lübben (1992)
Zea mays: Gilman (1972); Van der Westhuizen & Bredell (1972); CSIR 308, PREM 47534

GENUS FENNELLIA

flavipes B.J. Wiley & E.G. Simmons
A. flavipes (Bainier & Sartory) Thom & Church
Cenchrus ciliaris: Bezuidenhout (1977)
cereals and legume products: *Scott (1965)
debris: PREM 48977
insect (dead Chrysomelidae sp.): PPRI 4965
Leucospermum parile roots: Allsopp *et al.* (1987)
soil: Martin (1960); Eicker (1974); PPRI 3181 [PREM 50865], 4226; CSIR 134 [PREM 48046], 135; UCT
sorghum: CSIR 804
Zea mays: Van der Westhuizen & Bredell (1972); CSIR 1085 [PREM 48047]; PREM 48055

nivea (B.J. Wiley & E.G. Simmons) Samson
A. niveus Blochwitz
cereals and legume products: *Scott (1965)
grass hay: Van Warmelo (1967)
soil: CSIR 132; IMI 161 651; UCT
A. eburneus Biourge
timber: Doidge (1950)

GENUS NEOSARTORYA

aurata (Warcup) Malloch & Cain
= *Sartorya aurata* (Warcup) Subram.
soil: CSIR 977, 978 [PPRI 3418, PREM 49322, id. Z. L. IMI 343 120], 979, 980 [PPRI 3419], 981

fischeri (Wehmer) Malloch & Cain
face cream: PPRI 4230 [PREM 50867]
Leucospermum parile roots: Allsopp *et al.* (1987)
A. fischeri Wehmer
litter: Eicker (1973)
peat: Smit (1984)
soil: Cohen (1950); Eicker (1969); CSIR 988, 996, 1050 [PPRI 3195, PREM 49038]; PPRI 4975; IMI 332 643; CBS 317.89; UCT

glabra (Fennell & Raper) Kozak.
soil: UCT [PPRI 3247, PREM 49193]
A. fischeri var. *glaber* Fennell & Raper
soil: CSIR 991, 992 [PPRI 3427, PREM 49319], 993

spinosa (Raper & Fennell) Kozak.
sterilised compost: PREM 47727
A. fischeri var. *spinosus* Raper & Fennell
soil: CSIR 990 [PPRI 3428, PREM 49320]; IMI 332643

stramenia (R. Novak & Raper) Malloch & Cain
= *Sartorya stramenia* (Novak & Raper) Subram.
soil: CSIR 982, 983, 984, 985, 986

GENUS SARTORYA (see genus NEOSARTORYA)

GENUS SCLEROCLEISTA

ornata (Raper *et al.*) Subram.
= *A. ornatus* Raper *et al.*
Zea mays: Gilman (1972)