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THE COPROPHILOUS MYCOFLORA OF HERBIVORES OF THE KRUGER NATIONAL PARK, SOUTH AFRICA

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THE COPROPHILOUS MYCOFLORA OF HERBIVORES OF THE KRUGER NATIONAL PARK, SOUTH AFRICA.

by

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CHAPTER 1. INTRODUCTION AND LITERATURE REVIEW

1.1 General

Coprophilous fungi are an ecological group of fungi adapted to grow mainly on herbivore dung, which is an extremely complex substrate containing the remains of ingested vegetation, digestive tract micro-organisms and numerous other components, such as hairs, soil particles and various waste products.

The nitrogen content of dung as well as the pH value and moisture content are generally higher than most other substrates utilized by fungi (Harrower & Nagy 1979). Thus the coprophilous fungi, in all probability, will exhibit relatively narrow ecological amplitudes with regard to nitrogen requirements, pH tolerance and moisture dependency.

Coprophilous fungi are inhabitants of dung substrates, especially the dung of herbivorous animals. These animals ingest an enormous variety of fungal spores with their food, yet only a relatively small percentage of these fungi, the obligate coprophiles, normally fruit on dung substrates.

When moving through the gut of the animal fungal spores are subjected to various enzymes, relatively high temperatures, in the region of 37 °C, and great fluctuations in the pH values, from 8.1 in the saliva to between 2.1 and 4.1 in the abomasum and back to between 7.6 and 8 in the rumen of ruminants. The coprophilous fungal spores therefore have to be relatively resistant with regard to these factors. Obviously a large number of the fungal spores are destroyed during the passage through the digestive system, others however may survive the harsh conditions in the gut of the animal, yet may not be able to compete effectively with the well adapted coprophilous fungi, or may find the dung substrates unsuitable for fructification (Webster 1970).

1.2 Life cycle of the coprophilous fungi

Many of the coprophilous fungal species rely on a cyclic process involving herbivore ingestion of the spores when feeding; germination of the spores following passage through the digestive system of the herbivores; mycelial growth within, and eventually sporulation on the dung; and dispersal of the spores to the adjacent vegetation following the violent discharge from the sporocarps (Wicklow & Angel 1980).

1.3 Germination

Spores of the coprophilous fungi not only survive passage through the digestive system of the herbivores, the mechanical and chemical digestion processes are beneficial to the germination of the spores on the dung substrates (Harper & Webster 1964). The spores of many of the coprophilous fungi do not germinate readily when plated on to nutrient agar. In view of their ecological niche it is probably advantageous for the spores not to germinate on the wetted vegetation but to rather remain dormant (Webster 1970). Both exogenous as well as constitu-

tional dormancy of spores are represented amongst members of the coprophilous fungi. Exogenous dormancy is a condition where germination is delayed as a result of either unfavourable chemical or physical environmental conditions. Constitutive dormancy is a condition where germination is delayed due to innate properties of the dormant stage. The need for some form of treatment to stimulate germination varies considerably amongst the coprophilous fungi (Webster 1970). Possible causes of dormancy include the following aspects:

1.3.1 Metabolic deficiencies.
1.3.2 Impermeability of the spore walls.
1.3.3 The production of self inhibitors.
1.3.4 Enzymatic reactions within the spores.

1.4 **Limiting factors affecting coprophilous fungi**

For a fungus to establish itself and subsequently to sporulate, it must germinate and its spores and mycelium must withstand stressful situations such as variations in temperature, water availability, pH, nutrient availability, aeration, competition and antagonism (Kuthubutheen & Webster 1986 b).

Coprophilous fungi play an important role in the decomposition and mineralization of dung. The rate of decomposition and mineralization by the coprophilous fungi will however be influenced by a number of abiotic factors in the environment of the dung substrates and within the substrates, as well as by certain biotic interactions in and on the dung substrates.

1.4.1 Abiotic factors

Abiotic factors that may have an influence on the rate of decomposition and mineralization of dung by coprophilous fungi include the following:

1.4.1.1 Temperature

A wide amplitude with regard to temperature as a limiting factor seems to be necessary for any fungus to function successfully in the coprophilous environment. The temperature of the gut of warm-blooded animals is in the region of 37° C, and the spores of many coprophilous fungi must be capable of surviving this temperature for periods varying from a few hours up to about three days (Webster 1970). Once the dung has been voided, relatively high temperatures may still be present inside the substrate, depending on metabolic activities within the substrates and on the environmental conditions prevailing at the time. The upper limit of temperature, with regard to the coprophilous fungi, at which growth is severely impaired seems to be in the region of 30 - 45° C (Fries 1956). At the other extreme coprophilous fungi are known to survive sub-zero temperatures and then to commence normal growth and fructification when incubated at room temperatures (Webster 1970). A decrease in the temperature, from 20° C to 10° C, strongly influenced the ability of some of the coprophilous fungal species to form fruitbodies and the time period necessary for fructification was extended from an average of 10

days to 20 - 30 days (Wicklow & Moore 1974). Some species however, seem to favour colder conditions, this fact is illustrated by extended fructification periods in the case of *Pilaira anomala* and *Piptocephalis cylindrospora*. (Kuthubutheen & Webster 1986 a.)

Temperature, being one of the main factors determining seasonal change, is an important limiting factor to take into consideration during ecological research, even though the coprophilous fungi seem to have a wide amplitude with regard to this ecological factor. The development of locally adapted ecotypes will probably lead to a decrease in the ecological amplitude for the specific species involved.

1.4.1.2 Water availability

Most activities of terrestrial fungi, such as spore germination, mycelial growth and fructification, decrease as the moisture content of the substrates decrease. Several research findings with regard to water availability and fungal development confirm this statement: (Kuthubutheen & Webster 1986 b ; Harrower & Nagy 1979 and Dickinson & Underhay 1977). In this sense water availability is probably the most limiting factor as far as the coprophilous fungi are concerned. The availability of free water or water vapour are essential for spore germination of most fungi (Gottlieb 1978). In general, the latent period for germination increases with declining water potential of the substrates (Kuthubutheen & Webster 1986 b). Harrower & Nagy (1979) showed that with decreasing water availability there was a decrease in both the mycelial growth rate and in the minimum fruiting time of some of the coprophilous fungi. Dickinson & Underhay (1977) reported reduced fruiting when the moisture content of the dung substrate was only slightly lower than that of freshly voided dung. Kuthubutheen & Webster (1986 a) found that the fruiting of most Ascomycetes was dependent on the availability of free water, whilst that of the Deuteromycotina was far less dependent on the availability of water as most of the species continued to fruit at subsaturated atmospheres in the absence of free water. Fungi like *Penicillium* and *Aspergillus* fruited only after prolonged incubation and at low relative humidities (below 81% r.h.)

Mitchell (1970) reported a complete absence of Basidiomycetes and a reduction in the production of fruit bodies by other fungi on dung samples of ostrich and Angora goat collected during the drier month of November compared to those dung samples collected during the much wetter month of September, in South Africa. Wicklow & Yocom (1980) observed a linear relationship between the amount of precipitation and the number of fungal species on rabbit dung substrates in Pennsylvania, U.S.A. They attributed the differences in species diversities and species compositions of the coprophilous fungal communities to micro-climatic factors in the environment.

There is a resumption of fruiting activities when dung substrates that have been incubated at 100 - 81% R.H. for a 60 day period were exposed to free water, the level of recovery was highest on substrates that had been incubated at the lower relative humidities. Thus many coprophilous fungal species can survive prolonged incubation at reduced water availability, and therefore it seems evident that coprophilous fungi are capable of surviving periods of drought (Kuthubutheen & Webster 1986 a).

From all of the above mentioned research findings it is thus clear that the availability of water, either as free water or as water vapour, can be a severely limiting factor with regard to coprophilous fungal activities. However, the capability of fungi to adapt to critical water shortages and local environmental conditions with regard to water availability could possibly play a role in the formation of locally adapted ecotypes.

1.4.1.3 Light

A number of coprophilous fungal species react to light stimuli. Fruit bodies, in the case of some of the zygomycete members such as *Pilobolus*, and asci in the case of some representatives of the Ascomycetes, such as *Ascobolus*, are positively phototropic. These positively phototropic reactions ensure that upon ballistical discharge the spores are directed away from the dung surface towards vegetation, thus ensuring the continuation of the life cycle pattern, as animals tend to avoid vegetation close to faecal matter (Bell 1983).

Morinaga, *et al.* (1980) found, during research on the effect of light on fungal succession on deer dung, that fruit bodies of *Pilobolus crystallinus, Lasiobolus cuniculi,* a *Saccobolus* sp and a *Gyrothrix* sp. appeared to be stimulated by light. Continuous light, as apposed to continuous darkness, enhanced the growth of *Sporormiella minima*.

1.4.1.4 Nutrients

Dung is an extremely complex substratum, containing food residues, the remains of microbes which form an important source of nitrogen and water soluble vitamins that act as growth factors. The nitrogen content of dung is unusually high in comparison with other fungal substrates (Webster 1970).

Harper & Webster (1964) indicated that there is no general correlation between the taxonomic group of a coprophilous fungus and its nutritional carbon source. Harrower & Nagy (1979) found that the majority of the eight coprophilous fungal species tested on different carbon sources, grew on all the media containing simple sugars and about half grew on media containing either starch or carboxymethyl cellulose. However the poor sporulation of species of Mucorales, tested on simple sugars, combined with the inability of Ascomycetes to sporulate on carboxymethyl cellulose substrates, apparently indicate that an explanation of coprophilous succession based upon nutritional factors is invalid. Wicklow *et al.* (1980) reported that the order in which Ascomycetes appear on the surface of cattle dung may however be related to the efficiency with which they are able to utilize cellulose from the digested remains of grasses and herbs. The first colonists with cellulose - degrading ability complete their life cycle rapidly, without exploiting all of the available cellulose. The later appearing, more antagonistic, cellulolytic Ascomycetes then utilize the remaining cellulose. The much later-appearing Basidiomycetes that are capable of preferentially utilizing the lignin component of lignocellulose then sets more cellulosics free that can again be utilized by other fungi, such as members of the Ascomycetes.

The role of growth factors in the growth and development of coprophilous fungi, such as the influence of coprogen on the fructification of *Pilobolus kleinii*, as reported by a number of authors, can not be ignored. However Harper & Webster (1964) could not demonstrate experimentally that these growth factors controlled the level of fruiting of *Pilobolus crystallinus*. They admitted however that growth factor depletion must undoubtedly play some part in the duration of fruiting. The effect of growth factors should thus be taken into consideration, as it could possibly have an influence on the active duration of a fungal species.

From the above mentioned results it is clear that at least some of the coprophilous fungi do have the ability to utilize specific carbon sources in dung substrates. Yet, most of the coprophilous fungi seems to be relatively opportunistic in their utilization of carbon sources. It is therefore possible that the availability of nutrients does play, at least to some extent, a role in the fungal succession on dung. There are, however, a number of other factors that are equally, if not more, important in determining the fungal succession on dung.

1.4.1.5 pH values

Another, somewhat unusual, feature of dung as a fungal substrate is the relatively high pH values registered (Webster 1970). Most fungi grow best in an acidic environment. Coprophilous fungi are exceptions to this rule as they obtain optimal productivity when the pH is close to neutrality (pH 7). This factor may disincline fungi other than coprophilous species from colonizing the dung substrates after it has been voided (Bell 1983).

Singh & Webster (1973) observed that the pH of a 2% liquid malt extract medium influenced the growth of *Stilbella erythrocephala*, a common fungus on rabbit dung, as well as the production of an antibiotic produced by the fungus. The effect of the pH of the medium on the production of the fungal antibiotic was investigated at pH values of 5, 6, 7 & 8 respectively. The results showed that maximum production of the antibiotic was achieved on the second day of fungal growth at each pH. However the highest production level occurred at pH 5 & 6. These results could indicate an enhancement, to a certain degree, of the apparent inability of non-coprophilous fungi to readily utilize dung substrates.

All of the above mentioned observations are only applicable to actively growing fungi. The dormant fungal spores usually encounter severe fluctuations with regard to pH values, as they pass through the digestive system of the animals. It is possible that this fluctuating pH environment, within the animal gut, may play a role in rendering the resistant coprophilous spores capable of germination (Bell 1983).

1.4.2 Biotic factors:

1.4.2.1 Animal characteristics

Herbivorous animals include rodents, lagomorphs, ungulates and ruminants. Large numbers of coprophilous fungi have been reported from the dung of mammals and birds, relatively few have however been reported from the dung of reptiles and amphibia. The warm-blooded condi-

tion of the former group thus appears to be advantageous to the coprophilous habit. Considering the great variation in the food preferences, habitat and digestive systems of the different animals it is somewhat surprising to find how catholic coprophilous fungi are. There seem to be relatively few specialists although certain fungi are undoubtedly more common on some substrates than on others (Webster, 1970).

Wicklow *et al.* (1980) did research on the fungal community expression in lagomorph versus ruminant faeces. The results obtained indicated that the herbivore digestive process was of fundamental importance in determining the species composition and species structure of the coprophilous fungal community under controlled experimental conditions. The authors however suggested that the environmental factors (biotic and abiotic) peculiar to the habitat and time of the year that the dung was deposited will determine how the fungal community expresses itself.

1.4.2.2 Biotic interactions

Biotic interactions can be placed in two distinct categories:

-Interfungal interactions:

These comprise different interactions between the coprophilous fungal species and can be either of a positive or a negative nature. Competition effects and interference phenomena amongst coprophilous fungi can play an important role in limiting the time of appearance, as well as the duration and intensity of fruiting (Harper & Webster 1964). The authors demonstrated a striking antagonistic effect between certain Basidiomycetes and other species of the coprophilous fungi. *Coprinus heptemerus* showed the most severe effect on other fungi, in that it apparently stopped the fruiting of fungi, such as *Pilaira anomala, Pilobolus crystallinus* and *Ascobolus crenulatus* prematurely when compared to the duration of fructification in the absence of *Coprinus heptemerus*. They furthermore illustrated that *C.heptemerus* has the apparent ability to displace *A.crenulatus* in that the latter species exhibited increased apothecial development on the filter paper on which the dung was being incubated, while at the same time there was a decrease in apothecial development on the dung substrate.

The phenomenon of antagonism by *C.heptemerus* was further investigated by Ikediugwu & Webster (1970 a, b). Results indicated that the growth of hyphae of *A.crenulatus* ceased approximately 20 minutes after making contact with the hyphae of *C.heptemerus*, this phenomenon was referred to as hyphal interference. During further research by the same authors it was reported that almost all of the coprophilous fungi tested against *C.heptemerus* exhibited some degree of sensitivity to the presence of *C.heptemerus*, with the exception of *Stilbella erythrocephala*. Furthermore most of the Basidiomycetes tested exhibited hyphal interference against *A.crenulatus*, as well as towards each other. *C.heptemerus* however exhibited the greatest capacity for interference against all other species, with *Bolbitius vitellinus* and *Panaeolus sphinctrinus* next in order of severity.

Singh & Webster (1973) investigated the probable antagonism of *Stilbella erythrocephala* against other coprophilous fungal species. The results obtained clearly indicated that the presence of *S.erythrocephala* suppressed, to varying degrees, the hyphal growth of *Mucor hiemalis, Ascobolus immersus, Sordaria fimicola* and *Mucor oblongisporus*. The duration and abundance of fruiting were also affected in the case of *Pilobolus crystallinus* and the fruiting of *Coprinus heptemerus* was also suppressed. The phenomenon of hyphal interference may be of profound significance as it appears to be a highly effective and precise form of application of interspecies competition (Webster 1970).
Microbial ecologists have supported the notion that an increase in the species diversity of the microflora community, on natural substrates, would, accordingly result in an increase of the rate of decomposition of the substrate. It can, however, be argued that by increasing the number of saprobic species comprising a decomposer community, the potential for competitive interactions are likewise increased (Wicklow & Yocom, 1980). The authors investigated these contrasting ecological views by examining the effects of an increased species diversity on the rate of decomposition of rabbit dung. Results indicate that decomposition losses were greater for single species inoculations of *Sordaria fimicola* and a representative of the genus *Coprinus* than for any other treatment combination. In no instance did any species combination yield higher substrate losses than those recorded when the test fungi occurred singly. In fact, species combinations involving individual species with different decomposition capabilities always resulted in substrate losses equal to that of the least efficient decomposer. The results thus supported the notion that an increase in the fungal species diversity on a substrate may lead to an increase in the level of interspesies competition, which then seems to decrease the rate of decomposition of a substrate.

From an ecological point of view the results obtained can be explained according to the ecological niches occupied by these fungi. An organism's niche is a "n-dimensional" hypervolume, where "n" is the number of environmental factors affecting the organism. The genetic characteristics of the organism determines its fundamental niche, while other environmental factors, such as the resource availability, the influence of abiotic factors and other organisms, determines the actual niche dimensions occupied by the organism in nature. If there is an overlap of the niche hypervolumes of any species populations and if any environmental resource approaches the limits of tolerance of the species populations involved, interspecies competition becomes inevitable (Wicklow & Yocom 1980).

- Intrabiotic interactions:

These can be defined as interactions between fungal communities and other dung inhabiting organisms. The effects of animal populations, such as nematodes, mites, annelids and insects as well as protozoan and bacterial coprophiles as consumers of mycelia, fruit bodies and spores and as substrates for fungal growth has only recently been studied and more research in this complicated ecological field is needed.

The inter-relationships amongst the various coprophiles are undoubtedly complex, however the pressures exerted by these organisms on the coprophilous fungi and vice versa have to be quite significant and important with regard to the fungal activities and niche differentiation (Webster 1970).

Invertebrate colonization of dung substrates apparently affects the coprophilous fungi in two ways; the invertebrates tend to disturb and mix the substrate as a result of their burrowing movements and secondly the invertebrates feed on the fungal structures. The coprophilous fungi are believed to start hyphal growth concurrently with the early insect colonization (Lussenhop *et al.* 1980). The authors studied the insect effects on bacteria and fungi in cattle dung. The dung substrates were subjected to five different treatments: the presence of maggots: the presence of beetles; the presence of both maggots and beetles; the absence of insects and normal colonization as it would take place in nature. Results indicated that the arthropods did not have any effect on the total number of sporulating fungal species or the rate of sporulation per treatment. Hyphal densities were however affected though sporulation was not retarded as a result. On the other hand the presence of the arthropods led to increased bacterial densities on the dung substrates. The bacterial increase can possibly be explained by the following hypothesis:

" In the presence of the insects the competitive advantage of the hyphal growth form is lost to fungi. With arthropod mixing of the substrate, bacteria are continually exposed to fresh substrate, in addition nutrients in arthropod feces and the possibly lowered antibacterial effects of the fungi may contribute to this effect.
With arthropod mixing of the dung, the ability to extend a hyphal network into fresh substrate is less advantageous to fungi because their growth rates are generally lower than those of bacteria " (Lussenhop *et al.* 1980).

Contrary to the findings of the previous authors, Wicklow & Yocom (1982) presented evidence that the grazing larvae of a sciarid fly, *Lycoriella mali*, substantially decreased the number of coexisting coprophilous fungal species fruiting on rabbit dung, and that the grazing collembolans increased bacterial and reduced fungal standing crops. The authors concluded that apart from dung type and the environment in which dung is deposited, the response of individual fungal populations to grazing, and to the other populations of fungi comprising the microfungal community, largely determines the breath of its niche and therefore the success of a particular fungus as measured by sporocarp - spore production.

Insect interference has a definite limiting effect on the coprophilous fungi, it was observed by Wicklow (1979) that larvae of the sciarid fly, *Lycoriella mali*, consume both the mycelium and sporocarps of resident coprophilous fungal populations, however it was observed that *Chaetomium bostrychodes* was nearly the sole survivor on samples colonized by larvae at levels approaching or exceeding the carrying capacity of the substrate. These observations suggested that some form of predator defense mechanism may serve as an arthropod feeding retardant during critical phases of spore production and dispersal. The mechanism for spore dispersal in *Chaetomium* is, in part, dependent on the terminal hairs surrounding the ostiole, as the ascospores are embedded in mucus that then collects amongst the hairs. Any mechanism

protecting the sporocarp and the hairs from arthropod consumption would be to the advantage of the fungus. *Chaetomium bostrychodes* possesses sharply pointed and jagged terminal hairs, these structures, in all probability deter the arthropods from consuming the ascocarps. Furthermore the author suggested that the smooth hooked appendages characteristic of the genus *Kernia* are designed to catch onto the bodies of insects and the fur of animals, in this way the dispersal of the cleistothecia and the mature spores may be facilitated. The role of adult arthropods in the dispersal of coprophilous fungal spores needs to be investigated. The above mentioned results thus indicate that, to at least some extend, the coprophilous fungal / insect interactions are more complex than would be suggested by the mere consumption of the fungal structures by the arthropods.

Another interesting inter - relationship between an invertebrate and a coprophilous fungus was reported on by Doncaster (1981). Here the fungus actually facilitates the dispersal of the juvenile nematodes. The research findings indicate that when faeces from cattle infected with the nematode lungworm *Dictyocaulus viviparus* also contain fungal spores of the genus *Pilobolus*, the fungus produces sporangia at about the same time as the *Dictyocaulus* larvae reach the infective stage. These larvae then climbed up the sporangiophores and invaded the sporangia, shortly before the sporangia were explosively discharged. Free *D.viviparus* larvae are susceptible to desiccation and are harmed by sunlight, by invading the sporangia of *Pilobolus* species the larvae are protected from both these harmful conditions. The *Pilobolus* sporangia and the *D.vivparus* larvae are deposited on vegetation some distance from the dung, after the violent discharge of the sporangia, thus their chances of being ingested by a grazing animal are increased, as animals usually avoid vegetation close to faecal discharges (Doncaster 1981).

Another possible inter - relationship that needs to be researched is that of the role of the predacious fungi such as *Arthrobotrys oligospora*, that feeds on nematodes and has been reported from dung substrates. Watling (1963) reported on the presence of *Athrobotrys oligospora* on hawk pellets, and noted that the fungus developed its characteristic nematode trapping systems. Fructification of the fungus was apparently induced by a depletion in the nematode population. The author concluded that the time of conidiophore production was dependent on the nematode induction period and population number inhabiting the pellet.

In conclusion, it is obvious and essential that the limiting environmental factors with regard to the ecological role of the coprophilous fungi have to be identified and taken into consideration before any possible explanation can be attached to the different ecological phenomena observed. All of the above mentioned environmental abiotic and biotic limiting factors influencing the ecological niche of the coprophilous fungi invariably lead to further deductions and hypotheses; not only is any community subject to various limiting factors, but the different populations comprising the community also have the ability, through the process of factor compensation, to adapt to the local conditions to which they are subjected. Thus ecological phenomena such as seasonality, succession, substrate preferences and ultimately the formation of locally adapted ecotypes could probably be ascribed to the above mentioned factors and processes.

1.5 **Ecological Phenomena**

1.5.1 Seasonality

Iyer *et al.* (1971) studied the coprophilous fungi occurring on the dung of various animals from the Delhi Zoological Park, during the different seasons (i.e. winter, summer and the rainy season). The authors reported the highest species diversity during the winter months, followed by the rainy season. The lowest number of coprophilous species were reported during the summer months.

Nusrath (1976) reported on the seasonal variety in the coprophilous fungal populations on the dung of four animals (i.e. rabbit, sheep, deer and elephant) in India. A marked seasonal variation was observed, with the summer season exhibiting the lowest species diversity. The species diversity increased markedly with the advent of the rainy season to a maximum and remained high till the end of winter, and finally decreased again with the onset of the summer season. The author suggested that the number and variety of the coprophilous fungal spores in the rainy season is unusually high due to the warm and humid conditions at this time of the year.

Bell (1983) reported on the seasonal variety exhibited by the coprophilous fungi in New Zealand, and indicated the autumn and winter months to be the most productive with regard to species diversity and abundances. The results indicated that the two most common fungi on opossum dung substrates were *Ascobolus crenulatus* and *Lasiobolus ciliatus*.The fruit bodies of both species were present each month of the year although they showed a preference for winter, when the rainfall is at its highest (June - August). Fruiting declined to ca 50% occurrence during the warm , drier summer months (December - February).

It therefore seems as if the seasonal differences in the species diversities and abundances of the coprophilous fungi can be ascribed to the annual wet and dry periods. These results and deductions reaffirm the prime importance of water availability as a critical limiting factor with regard to the species diversities and abundance figures for the coprophilous fungi. It also indicates the adaptability of the fungi and poses the distinct possibility of the development of locally adapted ecotypes.

1.5.2 Substrate preferences

There seem to be relatively few coprophilous fungal specialists with regard to the dung substrates, although certain fungi are undoubtedly more common on some substrates than on others (Webster 1970).

Bell (1983) reported on eight genera of the coprophilous fungi and the substrates on which they have been found. The author observed that some genera (e.g. *Delitschia*) tended to be confined to cervid and lagomorph dung substrates, whilst other genera (e.g. *Ascobolus*) occurred on a wide range of dung substrates.

Wicklow *et al.* (1980) studied the fungal community expression in lagomorph versus ruminant feces. The results indicated that the number of species and the frequency of occurrence of Loculoascomycetes and Pyrenomycetes were significantly greater on rabbit (lagomorph) faeces, while Discomycetes were recorded at higher frequencies on sheep (ruminant) feces. These differences were attributed either to the differential survival or germination of fungal spores following passage through the digestive system or to the abilities of individual fungi to compete successfully on dung substrates of differing physical and chemical make-up.

Many coprophilous fungi are specialized to one or a few kinds of dung substrates, although the impression gained from the numerous publications is the opposite (Lundqvist 1972). The author concluded that all investigated species showed a preference for a certain category of matrix, and that some are even more stenoecious, being restricted to dung substrates of a certain age. When the frequency of the species were compared to the number of different substrates inhabited a number of variations without sharp limits was found. The author distinguished three categories in this regard:

- Species with a wide ecological amplitude and a low preference for any substrate.
- Species with a similar tolerance, but with a high preference for a certain kind of substrate.
- Species specialized to one or a few kinds of substrate.

The author accentuated the fact that the frequency of the fungi better illustrated their substrate preference than did the mere number of substrates that they occurred on. Furthermore the observation was made that it seemed natural that a fungus growing on several kinds of dung preferred the dung substrates of related " host " animals, the reason for this phenomenon could be that the substrates have similar chemical and physical properties. As a result the author recognized the following " host " substrate groups:

Cervid dung substrates.
Lagomorph dung substrates.
Bovine dung substrates.
Equid dung substrates.
Rodent dung substrates.
Carnivore dung substrates.
Bird dung substrates.
Reptile dung substrates.

When a comparison is made between the major " host " substrate groups with regard to the number of coprophilous fungi in common, the results indicate that it was possible to recognize an assemblage of fungi that is more limited to the habitat of the "host" animals than to the kind of dung. The author illustrated the existence of such an ecological group that was constituted by the coprophilous fungi associated with the forest-dwelling cervids (elk, reindeer and deer), leporids (rabbits & hares) and tetraonids (grouse).

Bell (1975) studied the fungal succession, seasonality and substrate preferences on the dung of the Brush-tailed opossum in New Zealand. The results obtained indicated a possible forest-canopy fungal flora as the majority of the fungi that regularly occurred on the opossum dung substrate are characterized by having small, hyaline spores. The author suggested that spores with these characteristics may have some selective advantage in reaching the forest-canopy vegetation on which the opossum feeds.

Richardson (1972) studied the coprophilous ascomycetes on different dung types. The author stated that the occurrence or absence of coprophilous fungal species depended greatly on the nature of the dung substrate. Three factors of importance, with regard to the substrates were identified, these are:

- The physical nature of the dung, its consistency, moisture content and moisture holding capacity.
- The chemical nature of the dung.
- The biological nature of the dung, the other organisms which developed on and in it.

The author further stated that with a large number of samples it might be expected that the above mentioned variables would even out, and that any differences with regard to the fungal species composition would indicate substrate preferences. In this sense species common to ruminant dung substrates were identified and include the following:
Cheilymenia spp., Coprobia granulata, Ascobolus immersus, A.furfuraceus, Ascophanus microsporus, Lasiobolus ciliatus and *Podospora curvula.*
Fungi common on lagomorph dung substrates were also identified. When the two substrate types were compared, twenty positive and ten negative associations were found. The positive associations occurred between the members of the ruminant fungi and the negative associations between the ruminant and lagomorph fungi.

Angel & Wicklow (1975) reported on the relationships between the coprophilous fungi and faecal substrates in a Colorado grassland. Dung substrates of pronghorned antelope, cattle, rabbits and small mammals were investigated. Fungal populations on ruminant faeces were found to be most similar in species composition while those on pronghorn and small mammal faeces exhibited the least similarity.

Most authors have listed all substrates occupied by a widely distributed species, but gave no indications of its relative importance on each kind of dung. The lack of such information makes it difficult to determine if these common species have any substrate preferences (Parker 1979). The author described the associations between coprophilous ascomycetes and faecal substrates in Illinois. On the basis of substrate frequency data the coprophilous fungi were separated into three groups:

- Fungi associated with the dung from a certain animal group.
- Fungi associated with animals occupying the same habitat.
- Coprophilous ascomycetes occurring on various substrates.

Positive correlations within the above mentioned groups were indicated. There are also indications of certain coprophilous species being associated only with the dung substrates of either domesticated or wild animals (Lundqvist 1972).

1.5.3 Succession

Mycologists have postulated that the well known sequential appearance of the coprophilous fungi on dung substrates has a nutritional basis. According to this nutritional hypothesis the early colonizers, the Zygomycetes, are considered to be so-called " sugar fungi ", as a result of their apparent inability to utilize cellulose, it was believed that they depended mainly on the soluble carbohydrates such as the sugars. The coprophilous fungi which fruited later, which are to a large extend members of the Ascomycetes, are capable of utilizing cellulose as a carbohydrate source, and therefore it was believed that when the soluble carbohydrates were depleted the Ascomycetes then became dominant on the dung substrates, utilizing the cellulose resources. They in turn were succeeded by the Basidiomycetes, which are capable of utilizing lignin as a energy source. The theory was so self explanatory that it was accepted without the backing of substantiated research. Harper & Webster (1964) first described a quantitative method for following the succession of fungal fruit bodies on dung. The research results indicated that the latent periods for spore germination and the rates of germ tube extension showed no correlation with the observed time of appearance of the fruit bodies, however several of the fungi tested needed a characteristic minimum time to fruit, which corresponded closely to the observed successional sequence. It did not explain the disappearance of the fruit bodies from the dung substrates. Subsequently evidence was obtained that *Coprinus heptemerus* was antagonistic to and limited the fruiting of other fungal species (Harper & Webster 1964; Ikediugwu & Webster 1970 a), that interspecies competition apparently plays a role in limiting the period of fructification of some of the coprophilous fungal species. Ikediugwu & Webster (1970 a, b) illustrated that antagonism between fungi accounted for at least some of the replacements during the observed successional sequence. It was also reported that there was still adequate amounts of cellulose substrate available after the appearance of the Basidiomycetes. Moreover some of the Zygomycetes are capable of utilizing cellulose as a carbohydrate source, and not all late colonizers utilize lignin as a food source. As a result fungal succession on dung can not be explained by only taking the availability of nutrients into consideration.

It would thus appear that the succession of coprophilous fungi on the dung substrates involve a number of complex and dynamic interactions between the abiotic and biotic components of this unique micro-ecosystem (Bell 1983).
Webster (1970) reviewed the successional phenomenon and asked a number of very valid questions with regard to the some what simplistic nutritional hypothesis. This article probably set the whole research effort with regard to fungal succession on dung fully into motion. In this article the author referred to the following aspects that could possibly have an influence on the successional process:

Spore germination - the stimulation of the spores to germinate as they move through the digestive systems of the respective herbivores, could have an influence on the time needed to affect successful germination.

Growth rate - No correlation was found between growth rate and the time of successional appearance.

Mycelial succession versus fruit body succession - There is little evidence that the time necessary for mycelial development and that needed for the development of fruit bodies correlate. All fungi appear to need a specific minimum time to come into fruit.

Taxonomy and nutrition - It is stated that the correlation between carbohydrate nutrition and taxonomic grouping is not exact. Furthermore the differential depletion of other nutritionally important compounds such as nitrogen and growth factors are not taken into consideration.

Other organisms - Organisms sharing the coprophilous life style must affect the fungi present in a number of ways, these factors should be taken into account.

Since the work of Harper & Webster (1964) as well as the above mentioned report by Webster (1970) - a number of other research projects were undertaken to investigate different limiting factors that could possibly play a role in determining the fungal succession on dung: (Bell 1975; Dickinson & Underhay 1977; Ikediugwu & Webster 1970 a, b; Kuthubutheen & Webster 1986 a, b; Mitchell 1970; Morinaga *et al.* 1980; Nagy & Harrower 1979) to name a few.

Mitchell (1970) studied the fungal succession on the dung substrates of ostrich and Angora goat in South Africa, and in general the classic successional pattern was observed. A reduction of fruit bodies were reported on dung collected during the drier periods. The importance of different fungal groups on the respective substrates was reflected in the predominance of Discomycetes on ostrich dung whereas on Angora goat dung the Pyrenomycetes were more important. The author proposed that these differences could possibly be attributed to the different nutritional compositions of the dung substrates.

The succession of fruit bodies of the various species of fungi colonizing brush-tailed opossum pellets was broadly similar to that described for other dung substrates. The species composition of the opossum dung substrate did however differ from dung collected from ground dwelling animals in the same area and thus a distinctive forest-canopy mycoflora is proposed (Bell 1975)

Results on the fungal growth on cattle dung indicated that fungal activity in dung appears to be adversely affected by the water content of the dung and that dung substrates under field conditions, as opposed to dung substrates kept under ideal conditions in the laboratory, were more slowly colonized, exhibited a lower fungal species diversity and shorter fruiting times (Dikinson & Underhay 1977). The authors concluded that further research is needed to demonstrate the way in which fungi colonize dung substrates under field conditions in competition with each other and with the other members of the microflora and fauna.

Coprophilous fungal succession on kangaroo and rabbit dung substrates, in the Southern Hemisphere, were investigated by Nagy & Harrower (1979). The results indicated generally similar successional patterns. Considerable differences were however noted on the duration and profuseness of some of the fruiting fungal species. As a result characteristic species patterns were compiled for each substrate, based on the reproductive output.

Kuthubutheen & Webster (1986 a, b) investigated the influence of the availability of water on the fungal succession (1986 a) as well as the effects thereof on the germination, growth and sporulation of coprophilous fungi (1986 b). Results showed that the largest number of fungal species was recorded on dung pellets provided with free water and that the sequential appearance of fruit bodies conform to the classical pattern. When the dung substrates were incubated at humidities below saturation the Zygomycetes declined in numbers and the Ascomycetes and some representatives of the Basidiomycetes did not form any fruit bodies.
The latent period of germination increased and the growth of the germ tubes were negatively affected. At reduced humidities there was a tendency for the zygomycete and ascomycete phases to overlap, and non-coprophilous fungi were stimulated to fruit, such as species of *Aspergillus* and *Penicillium*. The authors concluded that the coprophilous fungi are capable of surviving protracted periods of drought and as a result of this phenomenon the coprophilous fungal succession should not be seen as a smooth synchronized process, but rather as a pattern consisting of periods of variable duration characterized by sporadic fruiting corresponding to the availability of moisture.

All the coprophilous communities occurring on dung must be regarded as a fully operational micro-ecosystem and as such it is subjected to all the normal "laws" pertaining to ecosystems, such as: the ecological amplitudes expressed by all the communities, including the fungi, with regard to the limits of tolerances, the various possible interaction relationships, homeostatic control, carrying capacities, mortality and production rates, metabolic rates, trophic structures and external biospheric influences. This micro-ecosystem has obviously all the characteristics of any other ecosystem and all possible factors influencing the operation of ecosystems should be taken into account when dealing with the ecological properties of the coprophilous system. The ecologist undertaking research on the coprophilous ecosystem is therefore faced with all the challenges experienced by any other ecologist carrying out research in any of the other terrestrial ecosystems or parts thereof.

1.5.4 Ecotypes

The formation of ecotypes, adapted to the local abiotic and biotic conditions of existence, can obviously have an influence on the distribution patterns of the coprophilous fungi. Lundqvist (1972) stated that a coprophilous species may have different ecological requirements and may be subjected to different conditions of existence in various parts of its distribution area. As a result it may be more stenoecious in some regions, with regard to ecologically limiting factors, and more tolerant in others. A large number of the coprophilous fungal species are considered to be cosmopolitan in their distribution and non-specific with regard to different dung substrates, the ecotype hypothesis can go a long way in possibly explaining these phenomena. If this is the case then the fungi are genetically adapted in either morphological or physiological

aspects, or both, to cope with the complex environmental conditions and biotic pressures they have to deal with in order to be successful on any given substrate at any moment in time, in a specific area.

1.6 **Motivation for the present research**

The coprophilous fungi of the Southern Hemisphere are still relatively unknown in comparison with the research work that has been done in the Northern Hemisphere. Africa and especially the Southern African subregion and its associated coprophilous fungi is virtually unknown, except for the very limited work of Gibbs (1909) in the subregion and the later work of Mitchell (1970) on the fungal succession on ostrich and Angora goat dung substrates, in South Africa. In the past research was mostly done on the coprophilous fungi occurring on the dung of domesticated animals or wild animals kept in captivity, and only to a lesser extent on the dung substrates of wild animals occurring in their natural environment.

Richardson (1972) stated that the dung of exotic animals received attention from earlier mycologists, but these studies were often carried out on dung collected from local zoological gardens, and as a result the food and environment of the animals were artificial.

The coprophilous fungi associated with the dung substrates of the African game animals occurring in their natural environment, where they are free to select their preferred fodder and to utilize the available vegetation in a naturally selective manner have not been studied extensively. This is especially the case in the South African subregion and for the larger herbivores which are indigenous to the area. Comparatively few mycologists have worked in the Southern Hemisphere on coprophilous fungi and consequently much of the mycoflora remains little known and requires investigation (Bell 1975)

Dickinson & Underhay (1977) stated that the need exists for knowledge of the way in which fungi colonize dung under field conditions.

Not only is the taxonomy of the coprophilous fungi occurring in this region poorly known, but the ecology of the coprophilous fungi in conditions close to that experienced in the field needed further research. The present research was thus undertaken to clarify some of these problems and to add to the general knowledge with regard to the coprophilous fungi of the Southern Hemisphere and especially the African continent.

CHAPTER 2. MATERIALS AND METHODS

Dung samples were collected and studied over a period of 36 months, during which time semi-permanent microscope slides were made for later identification.

To ensure a natural collection site, where the animals occur in their natural environment, most dung samples were collected in the Kruger National Park, South Africa. The Park is 19485 square kilometers in size and lies between 22° 30' to 25° 30' south and 31° to 32° east in the north-eastern Transvaal. It is bounded by the Crocodile River in the south, the Mocambique border in the east, a man-made barrier in the west and the Limpopo River 350 Km to the north.

Because the Park is an endemic foot and mouth disease area, collecting freshly voided dung samples resulted in certain restrictions being placed on the sample methods and substrate types, as well as on the researcher.

2.1 **Precautionary Measures**

The removal of any untreated animal parts or animal products (including dung) from a foot and mouth disease area is prohibited by law. There would have been no sense in treating, in this case sterilizing, the dung samples as this would have resulted in destroying the fungal spores. Therefore special permission had to be obtained from the State Veterinary services, for the removal and transportation of all dung samples from the Kruger National Park. After a thorough investigation into the proposed research methods, by the Chief State Veterinary Officer, permission was granted on certain conditions:

- The researcher was placed under a quarantine restriction and in terms thereof was not allowed to visit or work on any farm for the duration of the project.

- A permit had to be issued by the resident State Veterinary surgeon in the Kruger National Park and all dung samples had to be sealed after each and every sample collecting excursion. The seal could only be removed by a State Veterinary surgeon inside the isolation laboratory at the University of Pretoria.

- As a result an isolation laboratory had to be set up and security locks installed. Entrance to the laboratory was restricted to the researcher.

- All containers used for the transportation of the dung samples as well as all used laboratory apparatus had to be placed in a citric acid solution - pH 4 - for a period of seven days to kill any foot and mouth disease causing viruses.

- The old dung samples had to be incinerated after completion of the laboratory investigations.

2.2 **Sample Methods**

The research project involved the collection of freshly voided dung samples, rectal dung samples and samples from different parts of the digestive tracts of the animals in question.

2.2.1 Fresh dung samples

Samples were collected within minutes of being voided, to restrict insect interference. The samples were collected, wrapped in paper towels and placed in sterilized containers, which were then sealed. Samples were collected on a regular basis every two to three months for a period of three years, of the following herbivorous "host" animals:

Loxodonta africana Blumenbach, 1823 (African elephant).

Connochaetes taurinus Burchell, 1823 (blue wildebeest).

Equus burchelli Gray, 1824 (Burchell's zebra).

Giraffa camelopardalis Linnaeus, 1758 (giraffe).

Raphicerus campestris Thunberg, 1811 (steenbok).

Geochelone pardalis Bell, 1828 (leopard tortoise).

The latter two substrates were not collected as frequently as the former substrates.
Fresh elephant dung samples were also collected from the Mabula Game Reserve and National Zoological Gardens in Pretoria every two to three months for a period of two years. The species diversity and species composition on these dung substrates were compared.

2.2.2 Rectal dung samples

Rectal samples were taken from immobilized blue wildebeest and zebra in an effort to avoid aerial and contact contamination by opportunistic fungi. Blue wildebeest were chemical immobilized using 3mg. of the anaesthetic Carphentenol and were revived, after removal of the rectal dung samples, by intravenously injecting 9mg. of the antidote M50:50. Zebra were chemically immobilized using 5mg. of the anaesthetic M99 in combination with 125mg. of the tranquilizer Azaparone. Zebra were revived, after removal of the rectal dung samples, by intravenously injecting 15mg. of the antidote M50:50. During immobilization both species were kept cool by splashing them with water, their eyes were protected from dehydration by coating the eye balls with a soothing eye ointment and the animals were routinely injected with a broad spectrum antibiotic to prevent any infections caused by the wound left by the darts used during the immobilization procedures. Some antibiotic ointment was also applied to the dart wound. Rectal samples were obtained in the following manner:

The anal area of the animal was washed with soap and water and wiped with a disinfectant. Using sterile surgical gloves a dung sample was then removed from the rectum of the animal and placed in a sterile container which was then sealed.

2.2.3 Post mortem dung samples

Post mortem digestive tract dung samples were collected from elephant during the normal culling operations, post mortem giraffe and blue wildebeest digestive tract dung samples were obtained during normal research activities. In the case of the ruminants (blue wildebeest and giraffe) dung samples were taken from the following parts of the digestive tract: the rumen, caecum, colon and rectum. In the case of the elephant, a non - ruminant, it is difficult to differentiate between the different parts of the rather primitive digestive tract and dung samples were taken from the caecum, colon and rectum. All of the post mortem dung samples were obtained by cutting into the gut of the animals and removing the samples, using sterile surgical gloves and placing them into sterile containers which were then sealed.

2.3 **Incubation of the dung substrates**

2.3.1 General procedure

All samples collected were taken to the isolation laboratory at the university of Pretoria and incubated using the following method:
Samples of approximately equal size were placed in sterile Petri dishes on sterile filter paper and covered by sterile glass beakers. Depending on the size of the samples a certain amount of sterile water was added to the substrates. These substrates were then placed in an incubator and kept moist for the duration of the investigation. The temperature and the daylight hours were regulated according to the respective seasons involved.

2.3.2 Ecological parameters

As one of the goals of the research project was to try and establish whether any seasonal variations occurred, as far as the fungal species diversities and species compositions were concerned, it was necessary to replicate as far as possible the seasonal changes that occur in nature. The following ecological parameters were therefore monitored and adjusted when necessary:

2.3.2.1 Temperature

The temperature was regulated in such a way as to represent, as closely as possible , the mean average seasonal temperatures. The following temperature variations were used:

Autumn: an average of 20 °C
Winter: an average of 16 °C
Summer: an average of 28 °C

These averages, between the day and night temperature fluctuations, were calculated using data from the Skukuza weather station obtained from the Weather Bureau, Pretoria. The spring season was ignored as this season is of extremely short duration in the Transvaal Lowveld where the Kruger National Park is located.

2.3.2.2 Photoperiodisity

The photoperiod was regulated to resemble the actual mean average day light hours, per season, as closely as possible. This was achieved by using an ordinary time switch. The following day light time variations were used:

Autumn: 10 hours 55 minutes to 11 hours 30 minutes. Thus an average of 10 hours 29 minutes.

Winter: 10 hours 23 minutes to 10 hours 36 minutes. Thus an average of 10 hours 44 minutes.

Summer: 11 hours 57 minutes to 13 hours 39 minutes. Thus an average of 12 hours 55 minutes.

These daylight hours, between sunrise and sunset, were calculated using data from the Skukuza weather station obtained from the Weather Bureau, Pretoria. The daylight hours were gradually increased or decreased according to the seasons involved.

2.3.2.3 Humidity

This was the one seasonal parameter for which no adjustments were made, it is an assumed fact that most terrestrial fungal activity decreases as the moisture content of the substrate decreases. In this sense water availability is probably the most limiting factor as far as the coprophilous fungi are concerned. Therefore decreasing the water content of the dung substrates according to the seasons involved would have severely impaired the research and thus the dung samples were kept moist at all times. Fructification is reduced when the moisture content of the substrate is only slightly lower than that of freshly voided dung (Dickinson & Underhay 1977).

2.4 **Microscopic examination of dung substrates**

2.4.1 General procedure

Two microscopes were used throughout the investigation, a binocular low magnification type stereo microscope to scan the substrate surfaces and to aid in the removal of the fungal fruitbodies that occurred, as well as a high power compound Nikon microscope with interference contrast for identification purposes. During the stereo-microscope examinations the abundance of each species present was noted. For this purpose the following scale was implemented:

Designation	Symbol	No. of Fruitbodies	Substrate Coverage
Scarce	¼+	1 - 5	2,5 %
Infrequent	½+	6 - 10	5 %
A few	+	11 - 20	10 %
A number	++	21 - 40	20 %
Many	+++	41 - 60	40 %
Numerous	++++	61 - 100	80 %
Covered	+++++	>100	100 %

From an ecological point of view it was important to determine the abundance value of each species over a specific period of time, as this could give an reliable indication of the ecological importance of the species in question. Furthermore the duration of all species on the different substrates were also noted, as were the dates of first appearances and the dates of disappearances or obvious inactivity. The data eventually lead to the calculation of ecological importance values for each species per substrate, season and successional phases. The different importance values thus obtained were used to calculate overall ecological importance values for each species, which is quoted in the species discussions.

2.4.2 Preparation of microscopic slides

Fruitbodies were removed from the substrates and semi-permanent microscopic slides were prepared. As some of the fruitbodies are minute, very thin embroidery needles mounted in Borridale needle holders were used to transfer the fruitbodies to the clean microscope slides. Three mounting media were used - Lactophenol blue, Melzer's reagent and Congo red. A drop of the mounting medium was placed on a clean microscope slide, the fruitbodies were then transferred from the substrate to the mounting medium. A coverslip was placed over the fruitbodies in the mounting medium and a thin seal of nail varnish was applied around the edges of the coverslip in order to prevent the slides from drying out. This rendered semi-permanent slides. With time the mounting media eventually dry out (especially in the case of Congo red and to a lesser degree in the case of Melzer's reagent) It is however possible to replenish the mounting media and to reseal the slides. The sealant "Glyceel" is found to be superior to nail varnish and prevents the slides from drying out (Bell 1983). The material is all deposited at the University of Pretoria.

2.4.3 Formulae for mounting media

2.4.3.1 Lactophenol and cotton blue (Taken from Bell 1983).

Phenol (pure crystals)	20,0 gm
Lactic acid	16,0 ml
Glycerol	31,0 ml
Water	20,0 ml
Cotton blue dye	Sufficient to make a 0,1% solution.

The Cotton blue stains the protoplasm within the cells, but leaves the fungal walls unstained.

2.4.3.2 Melzer's reagent (Taken from Bell 1983).

Potassium iodine	1,5 gm
Iodine	0,5 gm
Distilled water	20,0 ml
Chloral hydrate	20,0 ml

This mounting medium was primarily used to test for any amyloid reaction in the fungal structures. The amyloid reaction is a useful basic characteristic displayed by some fungi, and is used extensively in many of the keys available for identification.

2.4.3.3 Congo red (Taken from Bell 1983).

Congo red	0,2 gm
Alcohol (92%)	6,6 ml
Distilled water	100,0 ml

This is a temporary mounting medium and tends to dry out very quickly, but it renders fungal walls, gelatinous sheaths and spore appendages clearer.
The larger fruitbodies of the Basidiomycetes were sampled and preserved in a mixture of formaldehyde, alcohol and acetic acid (FAA). For examination and identification the samples were removed from the preservant, washed in distilled water and mounted in a 10% Potassium hydroxide (KOH) solution to aid rehydration of the specimens. Although this method proved to be useful, some of the delicate characteristics of especially the genus *Coprinus* became difficult to detect and this in turn hampered identification. It would be advisable rather to dry the specimens (if immediate identification is impossible) and afterwards simply rehydrate by using KOH for stereo-microscopic identification (Bell 1983).

2.5 **Taxonomical Data**

All the specimens were identified using various keys from the available literature. In the case of the coprophilous members of the Pezizales a general key to the genera was compiled (see addendum A). As the microscope slides were prepared directly from the dung substrates, it was inevitable that particles of the substrates were also transferred to the slides. This fact did not hamper identification, but in some cases made successful photography difficult. As a result not all species identified could be successfully photographed. however most of the species present were photographed and are depicted in addendum B.

2.6 **Ecological Data**

The following ecological values were determined from the initial data and are applied and depicted in the resulting tables and graphs.

2.6.1 Ecological Importance values

- For each species per substrate.
- For each species per season.
- For each species per successional phase.
- The overall ecological importance value for each species.

In calculating the above mentioned values, data from all the available samples were used.

2.6.2 Species diversity graphs

- For each substrate.
- For each season.
- For each successional phase.

2.6.3 Similarity and dissimilarity indices

- Between substrates.

In calculating the above mentioned indices, data from all available samples were used.

2.6.4 Species associations

Possible species associations on the different substrates, were investigated and are discussed.

2.6.5 Ecological Formulae used

2.6.5.1 Calculation of peak importance values

$$\text{Peak I.V.} = \frac{2(A+B)+C}{3}$$

$$A = \text{Relative \% Duration} = \frac{\text{no. of peak days / sp.}}{\text{total no. of peak days all spp.}} \times 100$$

$$B = \text{Relative \% Abundance} = \frac{\text{no. of peak "+" / sp.}}{\text{total no. of peak "+" all spp.}} \times 100$$

$$C = \text{Relative \% Occurrence} = \frac{\text{no. of peak occ. / sp.}}{\text{total no. of peak occ. all spp.}} \times 100$$

2.6.5.2 Calculation of the substrate importance values

$$\text{Substrate.I.V.} = \frac{2(A+B)+C}{3}$$

$$A = \text{Relative \% Duration} = \frac{\text{no. of days / species}}{\text{total no. of days all species}} \times 100$$

$$B = \text{Relative \% Abundance} = \frac{\text{no. of "+" / species}}{\text{total no. of "+" all species}} \times 100$$

$$C = \text{Relative \% Occurrence} = \frac{\text{no. of occ. / species}}{\text{total no. of occ. all species}} \times 100$$

2.6.5.3 Calculation of seasonal importance values

$$\text{Seasonal I.V.} = \frac{2(A+B)+C}{3}$$

$$A = \text{Relative \% Duration} = \frac{\text{no. of days / sp. / season}}{\text{total no. of days all spp.\& sea.}} \times 100$$

$$B = \text{Relative \% Abundance} = \frac{\text{no. of "+" / sp. / season}}{\text{total no. of "+" all spp.\& sea.}} \times 100$$

$$C = \text{Relative \% Occurrence} = \frac{\text{no. of occ./ sp./ season}}{\text{total no. of occ. all spp.\& sea.}} \times 100$$

* occ. = occurrences

* sea. = seasons

2.6.5.4 Calculation of successional importance values

$$\text{Successional I.V.} = \frac{2(A+B)+C}{3}$$

$$A = \text{Relative \% Duration} = \frac{\text{no. of days / sp./ phase}}{\text{tot. no. of days all spp.\& phases}} \times 100$$

$$B = \text{Relative \% abundance} = \frac{\text{no. of "+" / sp./ phase}}{\text{tot. no. of "+" all spp.\& phases}} \times 100$$

$$C = \text{Relative \% occurrence} = \frac{\text{no. of occ./ sp./ phase}}{\text{tot. no. of occ. all spp.\& phases}} \times 100$$

* occ. = occurrences * tot = total

More weight is given to the relative percentage friuting durations and the relative percentage fruiting abundances than to the relative percentage occurrences as the duration and abundance of a species are more important than the mere presence or absence of a species (occurrence), because the duration and abundance will determine the rate of metabolic activity of the species and therefore strongly influence its ecological importance value. Which in turn is an excellent indication of the functional role of the species with regard to the mineralization of the dung substrates. Metabolic activity is, however, not restricted to the fungal fruitbodies and the hyphal activities playing a role in dung decomposition should also be taken into consideration. It is normally not possible to identify the fungal hyphae to species level and thus the duration of the fruitbodies is used as ecological indicators.

2.6.5.5 Calculation of overall importance values

$$O.Sub.I.V. = \frac{\text{Sum of the sub.I.V's /sp.}}{6*}$$

$$O.Sea.I.V. = \frac{\text{Sum of the sea.I.V.'s /sp.}}{3*}$$

$$O.Succ.I.V.= \frac{\text{Sum of the succ.I.V.'s /sp.}}{*6*}$$

6* = all possible substrates (in this case = 6)
6 = all possible successional phases (in this case = 6)
3* = all possible seasons (in this case = 3)

$$TOT.O.I.V. = \frac{O.SUB.I.V. + O.SEA.I.V. + O.SUCC.I.V.}{3}$$

O.SUB.I.V. = Overall substrate importance value.
O.SEA.I.V. = Overall seasonal importance value.
O.SUCC.I.V.= Overall successional importance value.
TOT.O.I.V. = Total overall importance value.

2.6.5.6 Calculation of Similarity indices

A number of different community coefficients were tested, amongst others those of Jaccard, Sorensen, Spatz and Ellenberg (Mueller-Dombois & Ellenberg 1974) as well as a new combination of those of Spatz and Ellenberg. Although all of the indices thus obtained were valuable and all indicated similar trends in the community coefficients, it was decided to use the similarity index of Ellenberg (Muller-Dombois & Ellenberg 1974), as this community coefficient best illustrates the similarities and dissimilarities as observed on the different substrates investigated.

Similarity index of Ellenberg (Mueller-Dombois & Ellenberg 1974)

$$IS/e = \frac{Mc/2}{Ma + Mb + Mc/2}$$

Applied to the present data:

$$IS/e = \frac{O.SUB.I.V.c \ / \ 2}{O.SUB.I.V.a + O.SUB.I.V.b + O.SUB.I.V.c \ / \ 2}$$

IS/e = Index of similarity of Ellenberg.

This community coefficient mathematically expresses the similarity between two dung substrates as far as species occurrence, species abundance and species duration are concerned, as expressed in the substrate importance values of each species.

O.SUB.I.V.c/2 = The sum of the overall substrate importance values of the species common to both substrates.

This sum is divided by two as the common species represent two sets of values when their importance values are used, but in terms of presence or absence they represent a single set.

O.SUB.I.V.a = The sum of the overall substrate importance values of the species restricted to substrate A.

O.SUB.I.V.b = The sum of the overall substrate importance values of the species restricted to substrate B.

2.6.5.7 Calculation of dissimilarity indices

The indices of dissimilarity, which is used in the ordination of the appropriate data is calculated using the following formula:

$$DI = 100 - SI$$

DI = Dissimilarity index; SI = Similarity index

Using the respective similarity and the dissimilarity indices it was possible to implement ordination methods with regard to the different substrates.

2.6.5.8 Chi-square tests

To test the validity of the results obtained from the similarity and dissimilarity indices Chi-square tests were carried out. The following formula was used:

$$\text{Chi-square (with Yates' correction)} = \frac{[(ad - bc) - n/2] \times n}{(a+b)(c+d)(a+c)(b+d)}$$

(Mueller-Dombois & Ellenberg, 1974.)

a = Observed no. of spp. common to both substrates.
b = Observed no. of spp. restricted to substrate B.
c = Observed no. of spp. restricted to substrate A.
d = Observed no. of spp. absent on both substrates.
n = Total no. of spp.

All of the methods used were structured to reach the objectives and aims of the overall research project. The results are discussed in detail in the chapters to follow.

CHAPTER 3. TAXONOMICAL RESULTS AND DISCUSSIONS

3.1 Introduction

The taxonomical data obtained are depicted as species descriptions and discussions. Each species identified is dealt with separately. In addition to the normal taxonomical descriptions a number of other parameters with regard to each species is briefly considered, these include the following aspects:

- Distribution and habitat: the data included here do not necessarily represent the global situation with regard to distribution patterns and substrate preferences , but rather reflect that of the literature available to the author.

- Data concerning the seasonality and successional positions as well as the overall importance values are only applicable to the South African results, as the necessary information on reports from elsewhere were mostly not available from the relevant literature.

The discussion following the species descriptions should be read with the above mentioned restrictions in mind.

3.2 Results and discussions

3.2.1 Obligatory coprophilous fungal species

3.2.1.1 Zygomycetes:

Species no. 23

Pilobolus crystallinus (Wigg.), Tode, *Sacc. Syll. Fung.*, VII, 185, 1879.

Description
Sporangiophores 4,5 - 8,5mm [5 - 10mm]; [4 - 4,5mm (Ahmed & Asad 1971)] in length, 60 - 120μm [50 - 150μm] in diameter. *Subsporangial vesicle* club-shaped and inflated, 950 - 1250 x 450 - 750μm [600 - 1200 x 300 - 800μm]. *Sporangia* multispored, hemispherical, black 120 - 360 x 100 - 130μm [100 - 400 x 100 - 150μm]. *Spores* ellipsoid, pale yellow 6,8 - 10,2 x 4,5 - 6,3μm [6 - 12 x 4 - 7μm]; [6 - 9 x 3,5 - 4,5μm (Ahmed & Asad 1971)].

Distribution
Global.

Habitat
Various dung substrates including: deer, horse, rabbit, squirrel, blue wildebeest, elephant, giraffe, zebra, steenbok, tortoise.

Season (RSA): Summer, Autumn and Winter.

Successional position (RSA): Day 3 - 63.
Successional phase (RSA): 1, 2A, 2B, 3 & 4.
Occurrence: Extremely common.
Overall importance value (RSA): 1,19

Discussion

Measurements in square brackets are from Ellis & Ellis (1988), unless otherwise indicated. The South African specimens fall well within the accepted species limits. The species has been recorded on both the dung of wild and domesticated animals, exhibiting no apparent substrate preferences. In South Africa it occurred on tortoise dung during the summer months, on blue wildebeest, elephant and steenbok dung during the autumn months and on blue wildebeest, giraffe and zebra dung during the winter months. The species reached its peak period between days 3 - 30 on all the dung substrates investigated. It generally appeared 3 - 15(-23) days after the onset of incubation and lasted for up to 37(-61) days.

Fungal duration and seasonal occurrences

Zebra Dung	Steenbok Dung	Tortoise Dung
Winter:	Autumn:	Summer:
+++ (day 3-6)	+++ (day 6-9)	+++ (day 5-8)
++ (day 7-10)	++ (day 10-12)	
½+ (day 11-12)		
Tot. days = 10	Tot. days = 7	Tot. days = 4
Peak days = 4	Peak days = 4	

Blue wildebeest Dung	Elephant Dung
Autumn:	Autumn:
+ (day 11-35)	+ (day 8-10)
++ (day 36-39)	
½+ (day 40-44)	+ (day 9-19)
¼+ (day 45-47)	
	Tot. days = 14
+ (day 4-7)	
½+ (day 8-23)	Giraffe Dung
+ (day 4-10)	Winter:
¼+ (day 11-25)	
	¼+ (day 9-14)
Winter:	½+ (day 15-21)
+++ (day 3-4)	Tot. days = 13
++ (day 5-6)	Peak days = 7
+ (day 7-20)	
½+ (day 21-47)	
¼+ (day 48-63)	
+++ (day 6-11)	
Tot. days = 136	
Peak days = 8	

Species no. 24

Pilobolus longipes (van Tieg.), *Sacc. Syll. Fung.*, VII, 185, 1879.

Description
Sporangiophores 22 - 28,8mm [20,5 - 30mm] in length and 150 - 350mm in diameter. *Sub-sporangial vesicle* golden-yellow, ovoid to ellipsoid, inflated, 1,2 - 2,6 x 0,5 - 1mm [1 - 2 mm in length], contents orange in colour. *Sporangia* multispored, hemispherical, black, 420 - 810 x 300 - 650μm. *Spores* ovoid to globose, orange, 11 - 13,6 x 10,5 - 12,8μm [10,5 - 12 x 11,5 - 14μm].

Distribution
Global.

Habitat
Various dung substrates including: cow, horse, donkey, elephant, zebra.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 3 - 42.
Successional phase (RSA): 1, 2A, 2b & 3.
Occurrence: Extremely common.
Overall importance value (RSA): 1,11

Discussion
Measurements in square brackets are from Ahmed & Asad (1971). The South African specimens fall well within the accepted species limits as described and accepted by the authors. The species has been recorded on both the dung of wild and domesticated animals, exhibiting no apparent substrate preferences. In South Africa it occurred on elephant dung during the summer and winter months and on zebra dung throughout the year. The species reached its peak period between days 5 - 7 on zebra dung during the summer months. It generally appeared 3 - 9(-15) days after the onset of incubation and lasted for up to 39 days.

Fungal duration and seasonal occurrences

Elephant Dung	Zebra Dung
Summer:	Summer:
+ (day 4-8)	++ (day 4-17)
	½+ (day 18-37)
Winter:	¼+ (day 38-42)
+ (day 3-5)	++++ (day 5-8)
++ (day 6-10)	
+ (day 11-18)	+++++ (day 5-7)
½+ (day 19-32)	++++ (day 8-11)
¼+ (day 33-39)	
	+ (day 15-23)
+ (day 6-10)	½+ (day 24-25)
Tot. days = 47	Autumn:
Peak days = 5	+++ (day 9-12)
	½+ (day 13-17)
	++ (day 8-13)
	Winter:
	++ (day 3-5)
	++++ (day 6-7)
	+++ (day 6-10)
	Tot. days = 88
	Peak days = 3

Species no. 25

Pilobolus kleinii (van Tieg.), *Sacc. Syll. Fung.*, VII, 185, 1879.

Description

Sporangiophores 2,7 - 3,7mm [2,5 - 5mm]; [2,4mm (Ahmed & Asad 1971)] in length, 80 - 95µm [84 - 110µm (Ahmed & Asad 1971)] in diameter. *Subsporangial vesicle* ventrico-inflated, 620 - 750 x 380 - 550µm [500 - 900 x 400 - 700µm], contents orange-red in colour. *Sporangia* multispored, subglobose, black, 310 - 360 x 200 - 250µm [300 - 350 x 150 - 250µm]. *Spores* ovoid to ellipsoid, smooth, orange, thin-walled, 12,3 - 18,7 x 6,2 - 9,3µm [11 - 20 x 6 - 10µm]; [12 - 13 x 6 - 7,5µm (Ahmed & Asad 1971)].

Distribution
Global.

Habitat
Various dung substrates including: deer, donkey, horse, rabbit, sheep, squirrel, cow, blue wildebeest, elephant, zebra, steenbok.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 4 - 46.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Extremely common.
Overall importance value(RSA): 1,96

Discussion
Measurements in square brackets are from Ellis & Ellis (1988), unless otherwise indicated. The South African specimens fall well within the accepted species limits. The species has been recorded on both the dung of wild and domesticated animals, exhibiting no apparent substrate preferences. In South Africa the species occurred on blue wildebeest and elephant dung during the summer months, on blue wildebeest, elephant, zebra and steenbok dung during the autumn months and on elephant and zebra dung during the winter months. The species reached its peak period between days 5 - 7 during the summer months on blue wildebeest and elephant dung. It generally appeared 4 - 15 days after the onset of incubation and lasted for up to 26(-42) days.

Fungal duration and seasonal occurrences

Zebra Dung	Steenbok Dung
Autumn:	Autumn:
+++ (day 5-8)	½+ (day 7-10)
++ (day 9-12)	
½+ (day 13-17)	Tot. days = 4
+ (day 10-16)	
Winter:	
++ (day 7-10)	
++ (day 6-9)	
+ (day 10-11)	
Tot. days = 30	
Peak days = 4	

Blue wildebeest Dung	Elephant Dung
Summer:	Summer:
+++ (day 4-9)	+++++ (day 5-7)
+++++ (day 5-7)	++++ (day 8-11)
++++ (day 8-17)	+ (day 12-15)
¼+ (day 18-46)	
	+ (day 4-6)
+++++ (day 5-7)	++ (day 7-11)
++++ (day 8-11)	½+ (day 12-20)
	¼+ (day 21-25)
++ (day 15-23)	
½+ (day 24-40)	Autumn:
	+ (day 12-17)
++++ (day 15-18)	½+ (day 18-19)
++ (day 19-25)	
	++++ (day 11-19)
++++ (day 15-25)	½+ (day 20-24)
+ (day 26-32)	¼+ (day 25-27)
Autumn:	Winter:
+ (day 4-8)	+ (day 6-10)
	½+ (day 11-21)
+ (day 4-9)	
Tot. days = 121	Tot. days = 74
Peak days = 6	Peak days = 3

Species no. 29

3.2.1.2 Plectomycetes

Kernia nitida (Sacc.) Nieuwland, Amer. Midl. Nat.4: 379. 1916.

Description beskrywing
Cleistothecia scattered, irregular ellipsoid to triangular, smooth , shiny black 200 - 300 x 140 - 220μm [75 - 400μm] in diameter, with three to four long, septate appendages the apices of which are arcuate and sometimes branched to form hooks, 720 - 1025 x 5 - 6μm [40 - 1500 x 3 - 7μm]. *Peridium* 12 - 20μm [10 - 35μm] in diameter, thickened in the appendaged area. *Asci* broadly pyriform, sessile and evanescent 8 - 12μm [7 - 14μm] in diameter. *Ascospores* unicellular , ellipsoid to ovoid , sub-hyaline with one to two de Bary bubbles present, 4.6 - 5.3 x 3.8 - 4.3 μm [4.5 - 7 x 3.5 - 4.5μm].

Distribution verspreiding
West Pakistan, Canada, Mexico, Spain, Namibia, U.S.A., U.S.S.R., U.K., Kenya, South Africa (RSA).

Habitat habitat
On carnivore, deer, burro, cow, camel, sheep, baboon, jack rabbit, horse, blue wildebeest and elephant dung.

Season (RSA) : Summer and Autumn.
Successional position (RSA): Day 15-47.
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Common.
Overall importance value (RSA): 0,61
Figures: 1 - 3.

Discussion bespreking
Measurements in square brackets are from Malloch & Cain (1970 a).
The South African specimens fit well within the accepted species limits. The species has a wide distribution and occurs on substrates other than dung, it is thus not an obligatory coprophilous species, and exhibits no definite substrate preference. It is for the first time reported from dung in South Africa where it occured on blue wildebeest and elephant dung during the summer months and on blue wildebeest dung during the autumn months. It generally appeared between 15 - 44 days after the onset of incubation and lasted up to 32 days. The species reached its peak period on elephant dung between days 25 - 41 during the autumn months.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung
Summer: + (day 42-44)	Summer:
+++ (day 45-46)	
	+ (day 15-24)
+++ (day 44-46)	+++++ (day 25-41)
Autumn:	+++ (day 42-46)
+ (day 17-19)	
++ (day 20-31)	
+++ (day 32-47)	
Tot. days = 39	Tot. days = 32
Peak days = 21	Peak days = 17

Species no. 28

Kernia sp.1 On giraffe dung collected by Ebersohn in the Kruger National Park, South Africa, 1984.

Description
Cleistothecia superficial, non-ostiolate, globose to subglobose, dark brown to black, opaque, smooth, non-appendaged, 306 - 430μm in diameter. *Peridium* dark, multicellular, cells 3 - 8μm in diameter. *Asci* irregularly disposed, globose to ovoid, non-stipitate, evanescent, eight-spored, 8,4 - 12,7μm in diameter. *Ascospores* ovoid, honey coloured, smooth to very finely punctate, de Bary bubbles absent, 6 - 7 x 4 - 5μm, with a single apical germ pore, 0,3 - 0,6μm in diameter, and a very thin gelatinous sheath, 0,3 - 0,5μm. *Exosporium* well developed and thick, thickened at the spore center, 1,2 - 1,6μm in diameter.

Distribution
Kruger National Park, South Africa (RSA).

Habitat
On giraffe dung.

Season (RSA): Summer.
Successional position (RSA): Day 25 - 44.
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Only known from the collection site.
Overall importance value (RSA): 0,08
Figures: 4 & 5.

Discussion
The specimens exhibit all the attributes characteristic of the genus *Kernia* and resemble in most aspects the known species belonging to the genus. Up to date *Kernia hyalina* and *Kernia pachypleura* (Malloch & Cain 1971) represented the only known non-appendaged species of the genus. The present specimens differ from all other species of the genus in possessing a well developed thick exosporium. It is distinguished from *K. hyalina* by the larger ascocarps and ascospores as well as by the colouration of the ascospores and the absence of de Bary bubbles. The present specimens differ from *K. pachypleura* because of the larger ascocarps and the presence of a single germ pore. The specimens occurred on giraffe dung during the summer months and appeared 32 days after the onset of incubation, lasting for up to 4 days.

Fungal duration and seasonal occurrences

Giraffe Dung
Summer:
+ (day 32-35)
Tot. days = 4

Species no. 30

Kernia sp.2 On tortoise dung collected by Ebersohn, Kruger National Park, South Africa, 1984.

Description
Cleistothecia superficial, non-ostiolate, globose, dark brown to black, opaque, smooth, non-appendaged, 152 - 210μm in diameter. *Peridium* dark, more than one cell layer thick. The peridium cells subhyaline to opaque, subglobose to hexagonal, 9,5 - 19 x 4,6 - 10,4μm. *Asci* irregularly disposed, globose to ovoid, non-stipitate, evanescent, eight-spored, 25 - 33 x 20 - 24μm. *Ascospores* ovoid, pointed at the apex and slightly truncate at the base, honey coloured, smooth, with or without de Bary bubbles, 9 - 11,5 x 6 - 7,3μm, with a slightly raised hyaline apical germ pore, 1,1 - 1,8μm in diameter. Ascospores with a gelatinous sheath, 0,8 - 1,3μm thick.

Distribution
Kruger National Park, South Africa (RSA).

Habitat
On the dung of tortoise.

Season (RSA): Summer.
Successional position (RSA): Day 25 - 44.

Successional phase (RSA): 2B & 3.
Occurrence: Only known from the site locality, South Africa.
Overall importance value (RSA): 0,31
Figures: 6 - 8.

Discussion
The specimens exhibit all the attributes characteristic of the genus *Kernia* and resemble in most aspects the known species belonging to the genus. Up to date *Kernia hyalina* and *Kernia pachypleura* (Malloch & Cain 1971) represented the only known non-appendaged species of the genus. The present specimens differ from the other representatives of the genus by the combination of its much larger asci and ascospores, and the presence of a single apical germ pore. The specimens occurred on tortoise dung during the summer months. It first appeared 25 days after the onset of incubation and lasted for up to 20 days. It reached its peak period between days 25 - 40.

Fungal duration and seasonal occurrences

Tortoise Dung
Summer:
++ (day 25-40)
+ (day 41-44)
Tot. days = 20
Peak days = 16

Species no. 31

Leuconeurospora pulcherrima (Winter) Malloch & Cain, *Can J. Bot.*, 48, 1970.

Description
Cleistothecia scattered, semi-immersed to superficial, globose, dark brown to black, glabrous, 195 - 236μm [150 - 350μm] in diameter. *Peridium* composed of polygonal plates consisting of radiating cells which dehiscence along defined lines at maturity, peridial cells isodiametric at the center of the plates and elongated towards the plate margins. *Asci* irregularly arranged, subglobose to globose, non-stipitate, eight-spored, evanescent, 9,2 - 10,4μm [8 - 11μm] in diameter. *Ascospores* unicellular, hyaline, ellipsoid to elongated, with anastomosing ridges, germ pores absent, 5,9 - 7,2 x 3,8 - 4,7μm [5,5 - 7 x 3,5 - 5μm].

Distribution
Canada, Denmark, Germany, South Africa (RSA).

Habitat
On fox, porcupine, rabbit, rat and blue wildebeest dung.

Season (RSA): Summer.
Successional position (RSA): Day 32 - 46.
Successional phase (RSA): 2B & 3.
Occurrence: Rare.
Overall importance value (RSA): 0,31

Discussion
Measurements in square brackets are from Malloch & Cain (1970b). The South African specimens fall well within the accepted species limits. The species exhibits a limited distribution pattern and is for the first time reported from the Southern Hemisphere and the African continent on a dung substrate. The species has been reported from the dung of both wild and domesticated animals and exhibits no substrate preference. It is for the first time reported from the dung of a large herbivore. In South Africa the species occurred on blue wildebeest dung during the summer months. It appeared 32 days after the onset of incubation and lasted for up to 15 days. The species reached its peak period between days 42 - 46.

Fungal duration and seasonal occurrences

Blue wildebeest Dung
Summer:
++ (day 32-41)
+++ (day 42-46)
Tot. days = 15
Peak days = 5

3.2.1.3 Pyrenomycetes:

Species no. 33

Cercophora californica (Plowr.), Lundqvist, *Symbolae Bot. Upsalienses*, 20(1), 105 - 106, 1972.

Description
Perithecia scattered to aggregated, immersed to semi-immersed, pyriform to subglobose, black, opaque, 650 - 800 x 350 - 500μm, sometimes embedded in a light yellow "stroma-like" layer or when young covered by a white downy layer. *Asci* eight-spored, cylindrical with a prominent smooth spherical subapical globulus and an apical ring. *Ascospores* initially hyaline,

unicellular, vermiform to sigmoid. The hyaline state is usually quite persistent and it is difficult to find pigmented spores, 72 - 83 x 8 - 10μm [67 - 84 x 8 - 10μm]. The ascospores might be able to germinate in the hyaline state (Bell 1983).

Distribution
Europe, New Zealand, U.S.A., South Africa (RSA).

Habitat (RSA)
On the dung of blue wildebeest and giraffe.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 15 - 68.
Successional phase (RSA): 2A, 2B, 3, 4 & 5.
Occurrence: Fairly common.
Overall importance value (RSA): 0,60
Figures: 9 & 10.

Discussion
Measurements in square brackets are from Bell (1983). The South African specimens fall within the accepted species limits as described by the above mentioned author. The species seems to have a wide distribution, but is for the first time reported from Africa. In South Africa the species occurred on blue wildebeest dung during the summer and winter months and on giraffe dung during the summer and autumn months. It generally appeared 15 - 47 days after the onset of incubation and lasted for up to 41 days. The species reached its peak period on blue wildebeest dung during the summer between days 30 - 35.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Giraffe Dung
Summer:	Summer:
++++ (day 30-35)	+ (day 15-25)
++ (day 36-46)	½+ (day 26-31)
	¼+ (day 32-55)
Winter:	Autumn:
+ (day 47-62)	½+ (day 17-19)
++ (day 63-68)	+ (day 20-43)
	½+ (day 44-47)
Tot. days = 39	Tot. days = 72
Peak days = 6	Peak days = 34

Species no. 34

Cercophora coprophila (Fr.), Lundqvist, *Symbolae Bot. Upsalienses*, 20(1), 95 - 100, 1972.

Description
Perithecia aggregated, semi-immersed to superficial, subglobose to ovoid, 802 - 980 x 612 - 730μm [670 - 960 x 480 - 720μm], covered with a greyish-white tomentum which may disappear with age. *Asci* eight-spored, cylindrical to clavate, 240 - 250 x 17 - 20μm [220 - 310 x 15 - 18μm], with a thickened apical ring, subapical globulus absent. *Ascospores* bi-seriately arranged, hyaline stage unicellular, vermiform to slightly sigmoid, oil drops present. Mature ascospores pale brown to brown, 16,7 - 28,4 x 9 - 11μm [17 - 25 x 8,5 - 13μm]; [17 - 30 x 9 - 12μm (Dennis 1978)] and [21 - 29 x 8 - 10μm (Bell 1983)].

Distribution
Sweden, Norway, Finland, Denmark, England, Wales, Scotland, Belgium, France, Germany, Austria, Rumania, Italy, China, Canada, Bermuda, Puerto Rico, Venezuela, Brazil, New Zealand, South Africa (RSA).

Habitat
On cow, horse, sheep, donkey, mule, zebra, bison, buffalo, goat, gazelle, roan antelope, deer, roe deer, elephant, pig, dog, man, hare, rabbit, porcupine and blue wildebeest dung.

Season (RSA): Summer.
Successional position (RSA): Day 15 - 46.
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Very common.
Overall importance value (RSA): 0,35
Figures: 11 & 12.

Discussion
Measurements in square brackets are from Lundqvist (1972) unless otherwise indicated. The South African specimens fall within the accepted species limits, although some of the asci are slightly longer and some of the perithecia are a bit larger. The species is the most common and widely distributed member of the genus. It has been reported commonly from the dung of both domesticated and wild animals, and apparently prefers the cattle dung substrate (93% of all occurrences) to such an extent that Lundqvist (1972) refers to reports from other substrates as unlikely. In South Africa the species was restricted to blue wildebeest dung during the summer months. It appeared 15 - 42 days after the onset of incubation and lasted for up to 28 days. The species reached its peak period between days 32 - 46.

Fungal duration and seasonal occurrences

Blue wildebeest Dung
Summer:
+++ (day 15-24)
++ (day 25-42)
++++ (day 32-46)
+ (day 42-46)
Tot. days = 48
Peak days = 15

Species no. 35

Cercophora mirabilis Fuckel, Jahrb. Nass. ver. Naturk. 23-24: 245, 1869.

Description
Perithecia, scattered to aggregated, semi-immersed to superficial, globose to pyriform, 680 - 790 x 630 - 420µm [570 - 865 x 385 - 500µm], with brown, septate, flexuous hairs. Neck cylindrical, black, opaque, with stout tufts of obtuse septate hairs. *Asci* eight-spored, clavate, 260 - 272 x 15,5 - 17,6µm [250 - 290 x 15 - 18µm], with a thickened apical ring and a spheric subapical globulus. *Ascospores* bi-seriately arranged, hyaline stage unicellular, vermiform. Mature stage bicellular, upper cell brown, ellipsoid, truncate at the base, rounded at the apex, 16,4 - 19,4 x 9,6 - 10,3µm [15 - 21(-25) x 9 - 11µm].

Distribution
Sweden, Norway, Finland, Denmark, Scotland, France, Germany, Poland, Corsica, Italy, Morocco, Canada, Brazil, New Zealand, Morroco, South Africa (RSA).

Habitat
On cow, horse, sheep, roe deer, elephant and giraffe dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 30 - 68.
Successional phase (RSA): 3, 4 & 5.
Occurrence: Common.
Overall importance value (RSA): 0,45
Figures: 13 - 15.

Discussion
Measurements in square brackets are from Lundqvist (1972). The South African specimens fall well within the accepted species limits. The species is rather common with a wide distribution, however it is for the first time reported from Africa. The species has been recorded on the dung of both domesticated and wild animals without exhibiting any apparent substrate preferences. In South Africa it occurred on elephant and giraffe dung throughout the year. It appeared between 30 - 56 days after the onset of incubation and lasted for up to 37 days. The species reached its peak periods during the winter months on elephant dung between days 56 - 68 and during the autumn months on giraffe dung between days 30 - 38.

Fungal duration and seasonal occurrences

Elephant Dung	Giraffe Dung
Winter:	Autumn:
+ (day 32-38)	+ (day 30-37)
++ (day 39-55)	
+++ (day 56-68)	+++ (day 30-38)
Summer:	
++ (day 56-60)	
Tot. days = 42	Tot. days = 17
Peak days = 13	Peak days = 9

Species no. 36

Chaetomium aterrimum Ellis & Everh. ex *Palliser, North Amer. Flora*, (76) 3: 62. 1910.

Description
Perithecia scattered to aggregated, black, densely covered with hairs, globose to subglobose, 208 - 261 x 148 - 237μm [200 - 276 x 150 - 240μm], attached to the substrates by brown rhizoids. *Terminal hairs* dark brown, septate, rough, straight below with 10 - 15 coils above, 5 - 6μm in diameter at the base and 7 - 8μm in diameter at the apex. *Lateral hairs* dark brown, straight to flexed, rough, septate, 4μm in diameter at the base. *Asci* club shaped, pedicellate, eight-spored. *Ascospores* pale to dark brown, lemon-shaped, broadly ovate, 6,5 - 7,8 x 6,1 - 6,9μm [6 - 8 x 6 - 7μm].

Distribution
U.S.A. and South Africa (RSA).

Habitat
On rat, dog, rabbit, blue wildebeest dung and on damaged wheat.

Season (RSA): Summer.
Successional position (RSA): Day 42 - 46.
Successional phase (RSA): 3.
Occurrence: Scarce.
Overall importance value (RSA): 0,16
Figure: 16.

Discussion
Measurements in square brackets are from Seth (1972). The South African specimens fall well within the accepted species limits. The species exhibits a very limited distribution and is for the first time reported from the Southern Hemisphere and outside of the U.S.A. It is not strictly coprophilous in nature as it was first described from damaged wheat. In South Africa it occurred on blue wildebeest dung during the summer months. It appeared 42 days after the onset of incubation and lasted up to 5 days.

Fungal duration and seasonal occurrences

Blue wildebeest Dung
Summer:
¼+ (day 42-46)
Tot. days = 5

Species no. 37

Chaetomium bostrychodes Zopf, *Abh. Bot. Ver. Prov.*, Brandenburg, 19, 173, 1887.

Description
Perithecia aggregated, subglobose to ovoid, dark brown to black, ostiolate, 175 - 310 x 130 - 225µm [184 - 276 x 110 - 230µm]. *Terminal hairs* dark brown, straight below with 7 - 10 spiral coils above, septate, 4 - 5µm at the base, smooth to roughened with blunt subhyaline apices. *Lateral hairs* olive-brown, straight, septate, smooth, 4 - 4,5µm at the base with sharply pointed or collapsed apices. *Asci* clavate, eight-spored. *Ascospores* pale brown, subglobose to ovate, 6,9 - 7,7 x 5,2 - 5,9µm [6 - 7 x 6 - 6,5µm], faintly apiculated at both ends.

Distribution
Belgium, Haiti, Germany, Canada, U.S.A., Japan, Africa, South Africa (RSA).

Habitat
On goat, hog, roe, wood owl, rabbit, dog, fox, giraffe dung and plant matter.

Season (RSA): Autumn.
Successional position (RSA): Day 17 - 39.

Successional phase (RSA): 2A, 2B & 3.
Occurrence: Fairly scarce.
Overall importance value (RSA): 0,11
Figures: 17 - 20.

Discussion
Measurements in square brackets are from Seth (1972). The South African specimens fall well within the accepted species limits. The species is for the first time reported on dung from the Southern Hemisphere and from Africa. The species exhibits a relatively limited distribution in the Northern Hemisphere and has been reported from both dung and other substrates. Therefore the species is not strictly coprophilous in nature. In South Africa the species occurred on giraffe dung during the autumn months. It appeared 17 days after the onset of incubation and lasted for up to 23 days. The species reached its peak period between days 23 - 39.

Fungal duration and seasonal occurrences

Giraffe Dung
Autumn:
½+ (day 17-22)
+ (day 23-39)
Tot. days = 23
Peak days = 17

Species no. 38

Chaetomium homopilatum Ames, *a Monograph of the Chaetomiaceae*, 15 - 16, 1963.

Description
Perithecia ostiolate, pale to dark brown, subglobose to ovoid, 321 - 366 x 242 - 250μm [350 - 410 x 230 - 265μm (Ames 1963)] and [300 - 400 x 200 - 255μm], attached to the substrate by rhizoids. *Terminal hairs* tufted around the ostiole, septate, spine-like, pale yellow-brown with hyaline apices. *Lateral hairs* similar to terminal hairs but shorter. *Asci* eight-spored, club-shaped, pedicellate, evanescent. *Ascospores* dark brown, lemon-shaped, apiculate at both ends, 7,3 - 7,9 x 6,2 - 6,9μm [7 - 8,1 x 6,5 - 7,4μm (Ames 1963)] and [7 - 8 x 6 - 7μm].

Distribution
Greenland and South Africa (RSA).

Habitat
Dead wood, on bird and zebra dung.

Season (RSA): Summer.
Successional position (RSA): Day 105 - 112.
Successional phase (RSA): 5.
Occurrence: Extremely rare.
Overall importance value (RSA): 0,05
Figures: 21 & 22.

Discussion
Measurements in square brackets are from Seth (1972), except when otherwise indicated. The South African specimens fall within the accepted species limits. The species exhibits an extremely limited distribution pattern and has up to now only been reported from Greenland. In South Africa the species appeared 105 days after the onset of incubation and lasted for up to 8 days, if this reflects its general successional position it could possibly explain the rarity of the species, as dung substrates are rarely investigated after 60 - 70 days of incubation. The species was isolated from dead wood and is thus not strictly coprophilous in nature.

Fungal duration and seasonal occurrences

Zebra Dung
Summer:
½+ (day 105-112)
Tot. days = 8

Species no. 39

Chaetomium **cf.** *convolutum* Sörgel ex Seth, Beih.*Nova Hedwigia 37: 52. 1972.*

Description
Perithecia ostiolate, brown to black, densely covered with hairs, pseudoparenchymatous, superficial, globose to subglobose, 180 - 264 x 183 - 280µm [240 - 260 x 180 - 200µm], attached to the substrate by rhizoids. *Terminal hairs* pale to dark brown, slightly roughened, septate, undulate with 1 - 3 coils above, straight below, 4,6 - 5,2µm [4,5 - 5,5 (-6)µm] in diameter. *Lateral hairs* pale brown, septate, undulate, 3,6 - 4µm [3,5 - 4,5µm] in diameter. *Asci* clavate, pedicellate, eight-spored, 23 - 24 x 8µm [24,5 x 8,69µm]. *Ascospores* hyaline to pale brown, ellipsoid, [6 - 7 x 4,3 - 5,3µm], rounded at the apices.

Distribution
Germany and South Africa (RSA).

Habitat Not known for the type specimens, blue wildebeest dung.

Season (RSA): Autumn.
Successional position (RSA): Day 27 - 47.
Successional phase (RSA): 2B & 3.
Occurrence: Extremely scarce.
Overall importance value (RSA): 0,09
Figure: 24.

Discussion
Measurements in square brackets are from Seth (1972). Some difficulty was experienced in identifying this species as mature ascospores were not observed. The perithecia of some of the South African specimens were slightly shorter than that given in the original description. Apart from this the South African specimens fall well within the accepted species limits. In South Africa the specimens occurred on blue wildebeest dung during the autumn months. It appeared 27 days after the onset of incubation and lasted up to 21 days.

Fungal duration and seasonal occurrences

Blue wildebeest Dung
Autumn:
½+ (day 27-47)
Tot.days = 21

Species no. 40

Chaetomium robustum Ames,*a Monograph of the Chaetomiaceae* p.35. 1963.

Description
Perithecia dark brown to black, subglobose to pyriform, parenchymatous, 558 - 764 x 367 - 417μm [500 - 650 x 200 - 265μm], attached to the substrate by rhizoids. *Terminal hairs* septate, with spiral coils, slightly roughened, 6,9 - 9.7μm [7 - 10μm] in diameter at the base. *Asci* clavate to ovoid, pedicellate, eight-spored. *Ascospores* brown, lemon-shaped to ovoid, apiculate at both ends, 6,5 - 7,6 x 5 - 6μm [6 - 8 x 4 - 6μm].

Distribution
Jamaica and South Africa (RSA).

Habitat
Type specimens on vegetable matter and soil litter, South African specimens on blue wildebeest dung.

Season (RSA): Winter.
Successional position (RSA): Day 17 - 22.
Successional phase (RSA): 2A.
Occurrence: Extremely scarce.
Overall importance value (RSA): 0,04
Figures: 23 - 25.

Discussion

Measurements in square brackets are from Seth (1972). The South African specimens fit the species description, but does not overall fall within the accepted species limits. As this is the first time the species has been reported from dung, the possibility of a new variety of the species is not entirely unlikely. To illustrate the situation the following comparative account on the findings of the different authors are given:

Authors	Perithecia	Term. hair	Lat. hair	Ascospores
Ames	575 - 650 x 250 - 265µm	7 - 9,5µm	3,8 - 5µm	6 - 8 x 4,5 - 6,3µm
Seth	500 - 650 x 250 - 265µm	7 - 10µm	3 - 4,5µm	6 - 8 x 4 - 6µm
Present material	558 - 764 x 367 - 417µm	6,9 - 9,7µm	4 - 6,8µm	6,5 - 7,6 x 5 - 6µm

The perithecia of the South African specimens are larger and the lateral hairs much broader. The hairs are slightly roughened as opposed to the smooth hairs as described by Seth (1970). The South African specimens occurred on blue wildebeest dung during the winter months. It appeared 17 days after the onset of incubation and lasted 6 days.

Fungal duration and seasonal occurrences

Blue wildebeest Dung
Autumn:
½+ (day 17-22)
Tot. days = 6

Species no. 41

Chaetomium chrispatum Bainer, *Bull. Soc. Myc.*, France, 25, 214, 1909.

Description
Perithecia scattered, superficial, globose to subglobose, ostiolate, black, densely covered with hairs, 187 - 227 x 98 - 133μm [225 - 320μm in diameter]. *Terminal hairs* dark brown, septate, roughened, undulate below, close spiral coils above, 6 - 7μm [6 - 7μm] in diameter at the base. *Lateral hairs*, pale brown, straight to undulate, septate, 4 - 5μm [4 - 5μm] in diameter at the base. *Asci* cylindrical, eight-spored. *Ascospores* dark brown, broadly ovoid, sub-apiculate at one or both apices, 7,1 - 8 x 5,6 - 6,6μm [6 - 7 x 4 - 5μm].

Distribution
U.S.A., Canada, South Africa (RSA).

Habitat
Parsley seeds, rabbit and elephant dung.

Season (RSA): Summer.
Successional position (RSA): Day 22 - 57.
Successional phase (RSA): 2A, 2B, 3 & 4.
Occurrence: Scarce.
Overall importance value (RSA): 0,16
Figures: 26 & 27.

Discussion
Measurements in square brackets are from Seth (1972). The fruit bodies of the species seems to be very variable in size and exhibits a limited distribution pattern, it is for the first time reported from dung in the Southern Hemisphere. The species has been reported on both dung and vegetable matter and is not strictly coprophilous in nature. The South African specimens fall within the broadly accepted species limits, although the perithecia were consistently smaller. To illustrate the variability in size the following comparative account on the findings of the different authors are given:

Authors	Perithecia	Term. hair	Lat. hair	Ascospores
Chivers	228 - 350 x 228 - 319µm	5,6µm	3,8µm	7,5 - 9 x 6 - 6,8µm
Ames	225 - 320 x 225 - 360µm	5,6µm	3,8µm	7,2 - 9 x 5,5 - 7µm
Skolko & Groves	260µm in diameter.	7µm	3 - 4µm	6,5 - 8 x 5,5 - 6,5 µm
Seth	230 - 276 x in diameter	6 - 7µm	4 - 5µm	6 - 7 x 4 - 6µm
Present material	187 - 277 x 98 - 133µm	6 - 7µm	4,9µm	7,1 - 8 x 5,5 - 6,6µm

In South Africa the species occurred on elephant dung during the summer months. It appeared 22 days after the onset of incubation and lasted for up to 36 days. The species reached its peak period between days 51 - 57.

Fungal duration and seasonal occurrences

Elephant Dung
Summer:
½+ (day 22-50)
++ (day 51-57)
Tot. days = 36
Peak days = 7

Species no. 42

Podospora anserina (Ces. in Rabenh.) Niessl, *Hedwigia*, 22, 156, 1883.

Description:
Perithecia scattered, semi-immersed in the substrate, pyriform to globose, dark brown, 432 - 576 x 321 - 364µm [400 - 600 x 300 - 375µm] Neck short, with black papillae and a few straight brown hairs. *Asci* cylindrical to clavate, rounded at the apices, four-spored, 215 - 261 x 19 - 26µm [200 - 28- x 19 - 29µm]. *Ascospores* uniseriately arranged, ellipsoid, dark brown

to black, opaque 34,5 - 36.1 x 17,3 - 19,8μm [34 - 40 x 18 - 20μm], with a thin exospore and an apical germ pore. Primary appendage cylindrical and secondary appendages lash-like. *Paraphyses* filiform, septate and longer than the asci.

Distribution:
Canada, U.S.A., West Indies, Mexico, Brazil, Argentina, Paraguay, Tahiti, Spain, France, U.K., Belgium, Netherlands, Germany, Italy, U.S.S.R., Czechoslovakia, Sweden, East Africa, Java, New Zealand, South Africa (RSA).

Habitat:
On goose, giraffe, kangaroo, cow, sheep, horse, rabbit, goat, mule, burro, porcupine, chicken, muskrat, dog, wallaby, elephant and zebra dung.

Season (RSA): Summer and Winter.
Successional position (RSA): Day 8 - 63
Successional phase (RSA): 1, 2A, 2B, 3, 4.
Occurrence: Very common.
Overall importance value (RSA): 0,6
Figures: 28 & 29.

Discussion:
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits. It is the first time the species has been reported from South Africa and on elephant dung. The species has a global distribution pattern. It has been reported from both domesticated and wild animal dung substrates without any apparent substrate preference. In South Africa it occurred on elephant dung during the summer and winter months and on zebra dung during the winter months. Perithecia generally appeared 8 - 17 days after the onset of incubation and lasted for up to 47 days. Fruiting reached its peak period between days 40 - 63 on zebra dung.

Fungal duration and seasonal occurrences

Elephant Dung		Zebra Dung
Summer:	Winter:	Winter:
+++ (day 8-24)	++ (day 9-20)	½+ (day 17-19)
++ (day 25-41)	+ (day 21-23)	+++ (day 20-39)
+ (day 42-46)		++++ (day 40-63)
Tot. days = 39	Tot. days = 15	Tot. days = 47
Peak days = 17	Peak days = 12	Peak days = 24

Species no. mz1

Podospora apiculifera (Speg.) Mirza & Cain, *Can. J. Bot.*47: 2006.1969.

Description
Perithecia scattered to aggregated, immersed to semi-immersed, subglobose to pyriform, 483 - 727 x 310 - 460μm [450 - 800 x 300 - 550μm]. Neck black, papilliform with short, straight, septate, brown, hyaline tipped hairs. *Asci* four-spored, cylindrical, 241 - 291 x 32 - 36μm [250 - 320 x (25-) 30 - 40 (-45)μm], rounded at the apices and long stiped. *Paraphyses* filiform, septate, longer than the asci. *Ascospores* uniseriately arranged, ellipsoid, dark brown, opaque, 43,3 - 48,6 x 20 - 26μm [41,5 - 50 x 20,5 - 28 (-35)μm], with an apical germ pore, a small basal primary appendage and two long, lash-like secondary appendages.

Distribution
Argentina, Mexico, U.S.A., South Africa (RSA).

Habitat
On horse, burro and elephant dung.

Season (RSA): Autumn.
Successional position (RSA): Day 11 - 39.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Scarce.
Overall importance value (RSA): 0,3

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits. The species has a limited distribution and is for the first time reported from Africa. Until now it has only been reported from the dung of domesticated animals. In South Africa it occurred on elephant dung during the autumn months. It appeared 11 days after the onset of incubation and lasted for up to 29 days. The peak period was reached between days 22 - 28. The species is very closely related to *P. australis* (Speg.) Niessl., from which it can be separated by its smaller spores (Mirza 1963).

Fungal duration and seasonal occurrences

Elephant Dung
Autumn:
+ (day 11-21)
++++ (day 22-28)
+ (day 29-35)
½+ (day 36-39)
Tot. days = 29
Peak days = 7

Species no. 43

Podospora comata Milovtzova, *Trans. Inst. Bot., Charkov*, 2, 20, 1937.

Description
Perithecia scattered, superficial, black, pyriform to subglobose, 320 - 590 x 192 - 241μm [280 - 640 x 190 - 250μm], with a tuft of straight dark brown setae-like hairs at the base of the neck which is blackened by papillae. *Asci* four-spored, rounded at the apices, cylindrical to clavate, 172 - 193 x 17 - 26μm [160 - 200 x 16 - 27μm]. *Paraphyses* filiform, and longer than the asci. *Ascospores* uniseriately arranged, ellipsoid, 31,5 - 33,4 x 15,5 - 20 (-21,7)μm [26 - 35 x 15 - 19μm], dark brown with a thin exospore and an apical germ pore. Primary appendage cylindrical, secondary appendages lash-like.

Distribution
U.S.S.R., Mexico, Liberia, South Africa (RSA).

Habitat
On horse, burro, goat, cow, giraffe and elephant dung.

Season (RSA): Autumn.
Successional position (RSA): Day 12 - 23.
Successional phase (RSA): 1 & 2A.
Occurrence: Scarce.
Overall importance value (RSA): 0,12
Figures: 30 & 31.

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits, although the ascospores of some specimens were slightly larger. The species exhibits a limited distribution pattern and is for the first time

reported from the Southern Hemisphere. It is also for the first time reported on the dung of wild animals and seems to favour the dung substrates of domesticated animals. In South Africa it occurred on elephant and giraffe dung during the autumn months. It generally appeared 12 - 16 days after the onset of incubation and lasted up to 11 days. The species reached its peak period between days 16 - 23 on elephant dung. This species is closely related to *P. anserina* from which it can be distinguished by its smaller dimensions (Mirza 1963).

Fungal duration and seasonal occurrences

Elephant Dung	Giraffe Dung
Autumn:	Autumn:
+ (day 16-23)	¼+ (day 12-16) ½+ (day 17-22)
Tot. days = 8	Tot. days = 11 Peak days = 6

Species no. 44

Podospora communis (Speg.) Niessl, *Hedwigia* 22: 156. 1883.

Description
Perithecia scattered, semi-immersed, black, pyriform, 605 - 1060 x 305 - 660µm [650 - 1000 x 300 - 500µm], with long flexuous brown septate hairs, Neck long, cylindrical with black papillae. *Peridium* thin and semi-transparent below the neck region. *Asci* eight-spored, clavate, 190 - 212 x 27 - 31µm [180 - 210 x 26 - 32µm], rounded to truncate at the apices with a distinct apical ring. *Paraphyses* filiform and longer than the asci. *Ascospores* bi-seriately arranged, ellipsoid, dark brown, opaque, with an apical germ pore, 32,5 - 40 x 17 - 26,5µm [28 - 36 x 17 - 21µm]. Primary appendage cylindrical with four short secondary appendages at the spore apex and four similar appendages at the distal end of the primary appendage.

Distribution
Canada, U.S.A., Panama, Spain, France, Central Europe, U.K., Bermuda, Mexico, Brazil, Paraquay, Ceylon, Java, New Zealand, Kenya, Tanzania, Uganda, Egypt, Central African Republic, Sweden, Norway, Germany, Poland, Hungary, Bulgaria, Corsica, Italy, Egypt, Indonesia, Argentina, South Africa (RSA).

Habitat
On cow, horse, sheep, rabbit, deer, muskrat, kangaroo, pig, goose, bear, burro, goat, blue wildebeest, elephant, zebra, buffalo, giraffe, donkey, willow grouse, hazel hen, mule, camel, red deer, roe deer, wild hog, hare and guinea pig dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 13 - 50.
Successional phase (RSA): 1, 2A, 2B, 3 & 4.
Occurrence: Very common.
Overall importance value (RSA): 0,36
Figures: 32 - 35.

Discussion

Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits, although the ascospores of some of the specimens are larger than those reported by Mirza (1963), but fall within the species limits as accepted by Bell (1983). To illustrate the variability of the ascospore dimensions the following comparative account on the findings of the different authors are given:

Mirza	Lundqvist	Bell	Present Material
28 - 36 x 17 - 21µm	29 - 40 x 16 - 25µm	37 - 43 x 21 - 23µm	33 - 40 x 17 - 27µm

The species is a common one with a global distribution pattern, however it is for the first time reported from South Africa. It has been reported from the dung of both domesticated and wild animals and exhibits no apparent substrate preferences. In South Africa it occurred on blue wildebeest and zebra dung during the autumn and summer months respectively. The perithecia generally appeared 13 - 32 days after the onset of incubation and lasted for up to 26 days. It reached its peak period between days 46 - 50 on the blue wildebeest dung substrate.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Zebra Dung
Autumn:	Summer:
+ (day 32-38)	½+ (day 13-16)
++ (day 39-45)	+ (day 17-28)
+++ (day 46-50)	++ (day 29-38)
Tot. days = 19	Tot. days = 26
Peak days = 5	Peak days = 10

Species no. 45

Podospora curvuloides Cain, *Can. J. Bot.*, 40, 453 - 454, 1962.

Description
Perithecia scattered, semi-immersed, pyriform, 996 - 820 x 361 - 546μm [550 - 1100 x 350 - 550μm]. *Peridium* thin, semi-transparent, pale brown below and dark brown towards the neck region. Neck small with black papillae and clusters of agglutinated thin-walled hairs and a seta-like terminal hair. *Asci* eight-spored, cylindrical to clavate, 265 - 283 x 26 - 32μm [270 - 310 x 25 - 30μm], broadly rounded at the apices. *Paraphyses* large, swollen, thin-walled, evanescent cells. *Ascospores* uniseriately arranged to bi-seriately arranged at the apices, ellipsoid to elongated, dark brown with an apical germ pore, 31,6 - 38,6 x 17,5 - 23,1μm [31 - 41 x 17 - 20μm], with a slender, cylindrical basal appendage and small lash-like secondary appendages.

Distribution
Brazil, Mexico, Peru, New Zealand, Kenya, South Africa (RSA).

Habitat
On cow, blue wildebeest, elephant, zebra and steenbok dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 7 - 55.
Successional phase (RSA): 1, 2A, 2B, 3 & 4.
Occurrence: Fairly scarce.
Overall importance value (RSA): 0,93
Figures: 36 - 39.

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall within the accepted species limits , although the asci and ascospores of some of the specimens were slightly broader. To illustrate the variability of the asci and ascospore dimensions a comparative account on the findings of the different authors are given:

Authors	Asci	Ascospores
Mirza (1963)	270 - 310 x 25 - 30µm	31 - 41 x 17 - 20µm
Bell (1983)	Unknown	40 - 48 x 21 - 24µm
Krug & Khan (1989)	185 - 250 x 26 - 51µm	29 - 36 (-42) x 17 - 21µm
Present material	265 - 283 x 26 - 32µm	31,6 - 38,6 x 17,5 - 23µm

Krug & Khan (1989) reported slightly shorter asci and ascospores from their African material, the present material correspond with their findings in that the asci are also slightly shorter and broader, and the ascospores slightly broader. The species seems to be relatively scarce with a limited distribution and is for the first time reported from South Africa. Until now it has only been reported from cattle dung, however the species occurred in South Africa on blue wildebeest, elephant, zebra and steenbok dung throughout the year. The species generally appeared 7 - 39 days after the onset of incubation and lasted for up to 49 days. It reached its peak period on zebra dung between days 23 - 55 during the summer months.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung	Zebra Dung
Summer:	Autumn:	Summer:
++ (day 26-35)	+++ (day 31-36)	+ (day 7-11)
+++ (day 36-41)		+++ (day 12-22)
++ (day 42-55)	+ (day 32-40)	++++ (day 23-55)
	+++ (day 41-47)	
Autumn:		Winter:
½+ (day 39-47)		+ (day 9-21)
		++ (day 22-27)
Tot. days = 39	Tot. days = 22	Tot. days = 68
Peak days = 6	Peak days = 13	Peak days = 33

Steenbok Dung
Autumn:
½+ (day 17-23)
Tot. days = 7

Species no. mz2

Podospora globosa (Massee & Salm.) Cain, *Can. J. Bot.* 40, 460, 1962.

Description
Perithecia scattered, semi-immersed to superficial, broadly pyriform, 695 - 743 x 561 - 632µm [720 - 770 x 530 - 670µm], glabrous or with thin hyaline flexuous hairs. Neck cylindrical and broad, [130 - 150 x 170 - 190µm]. *Asci* eight-spored, apical ring absent, 342 - 364 x 36 - 38,7µm [300 - 385 x 35 - 40µm], rounded at the apices, long stiped, [140 - 180µm]. *Ascospores* bi-seriately arranged, ellipsoid, pale brown to dark brown, truncate at the base, 35,7 - 39,5 x 19,4 - 21,3µm [34 - 45 x 19 - 25µm] with an apical germ pore. Single primary appendage tapering below, 24,6 x 36,8 x 5,9 - 6,8µm [25 - 38 x 6 - 7µm]. Ascospore surrounded by a thin gelatinous sheath. Paraphyses apparently absent (Lundqvist 1972).

Distribution
Sweden, England, Canada, New Zealand, South Africa (RSA).

Habitat
On cervid, kangaroo, red-deer, cow and elephant dung.

Season (RSA): Autumn.
Successional position (RSA): Day 11 - 42.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Scarce.
Overall importance value (RSA): 0,27

Discussion
Measurements in square brackets are from Lundqvist (1972). The South African specimens fall within the accepted species limits. The species has a limited distribution and is for the first time reported from Africa. The fungus has been reported from the dung of both domesticated and wild animals and exhibits an apparent preference for the wild animal dung substrates. In South Africa the species occurred on elephant dung during the autumn months. It appeared 11 days after the onset of incubation and lasted for up to 32 days. The species reached its peak period between days 18 - 34.

Taxonomical position
In the opinion of the author the position of the species is uncertain as it shares a number of important characteristics with the genus *Strattonia*. It has been moved to this genus by a former author (Mirza 1963) but Lundqvist (1972) still placed it within the genus *Podospora* . The genus *Strattonia* is presently being revised by Krug (personal communication) and this should resolve the taxonomic position of this species.

Fungal duration and seasonal occurrence

Elephant Dung
Autumn:
½+ (day 11-17)
++ (day 18-34)
+ (day 35-42)
Tot. days = 32
Peak days = 17

Species no. 46

Podospora similis (Hansen) Niessl., *Hedwigia*, 22, 156, 1883.

Description
Perithecia scattered, semi-immersed, pyriform, 572 - 601 x 334 - 391µm [550 - 650 x 300 - 400µm], exposed part with long thin, septate pale brown, flexuous hairs. Neck short, cylindrical with black papillae and a few clusters of short agglutinated brown hairs. *Peridium* thin, membranaceous, pale to dark brown. *Asci* sixteen-spored (sometimes twelve-spored), fusoid to clavate, 243 - 321 x 44 - 58µm [210 - 350 x 40 - 60µm], broadly rounded at the apices. *Paraphyses* filiform and longer than the asci. *Ascospores* bi-seriately arranged, ellipsoid to ovate, 28,1 - 33,4 x 16,1 - 20,7µm [24 - 38 x 15 - 23µm], with an apical germ pore. Primary appendage basal, slender and cylindrical. Secondary appendages lash-like.

Distribution
Canada, Denmark, Belgium, New Zealand, South Africa (RSA).

Habitat
On cow, sheep, rabbit, horse, porcupine, elephant and zebra dung.

Season (RSA): Autumn.
Successional position (RSA): Day 19 - 47.
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Scarce.

Overall importance value (RSA): 0,3
Figures: 40 - 42.

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits, although some of the specimens had twelve instead of the usual sixteen ascospores per ascus. The species exhibits a limited distribution pattern and is for the first time reported from Africa. It has been reported from the dung of both domesticated and wild animals and exhibits no substrate preferences. In South Africa it occurred on elephant and zebra dung during the autumn months. The perithecia generally appeared 19 - 23 days after the onset of incubation and lasted for up to 29 days. It reached its peak period on elephant dung between days 30 - 35 and on zebra dung between days 19 - 47, both peak periods were of the same intensity, but lasted longer on the zebra dung substrate.

Fungal duration and seasonal occurrences

Elephant Dung	Zebra Dung
Autumn:	Autumn:
++ (day 23-29)	+++ (day 19-47)
+++ (day 30-35)	
Tot. days = 13	Tot. days = 29
Peak days = 6	

Species no. 47

Podospora ostlingospora Cain, *Can. J. Bot.*, 40, 456, 1962.

Description
Perithecia scattered to aggregated, immersed to semi-immersed, pyriform to ovate, black, young perithecia with long flexuous hairs, usually smooth when mature, 830 - 920 x 462 - 673µm [750 - 1400 x 450 - 700µm]. Neck smooth, cylindrical with black papillae. *Peridium* thin, membranaceous to slightly coriaceous. *Asci* eight-spored, clavate, rounded at the apices with a small apical ring, evanescent, 292 - 321 x 51 - 68µm [300 - 350 x 50 - 60µm]. *Ascospores* bi-seriately arranged, ellipsoid , dark brown, narrowly rounded at the apices, truncate at the base, 46 - 52 x 25 - 35µm [50 - 55 x 25 - 34µm], with a thick exospore and an apical germ pore. Basal primary appendage clavate to cylindrical with a secondary lash-like appendage at the distal end of the primary appendage and two tufts of secondary appendages at the spore apex.

Distribution
Mexico, West Pakistan, Kenya, Tanzania, South Africa (RSA).

Habitat
On burro, cow, goat, donkey and zebra dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 7 - 44.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Uncommon.
Overall importance value (RSA): 0,27
Figures: 43 & 44.

Discussion
Measurements in square brackets are from Cain (1962). The South African specimens fall within the accepted species limits, although in some specimens the ascospores were slightly shorter and broader and the asci slightly shorter. To illustrate the variability of the species the following comparative account on the findings of the different authors is given:

Author	Asci	Ascospores
Cain (1962)	300 - 350 x 50 - 60µm	50 - 55 x 25 - 34µm
Mirza (1963)	300 - 350 x 50 - 70µm	47 - 58 x 25 - 34µm
Ahmed & Asad (1971)	Unknown	45 - 55 x 25 - 33,5µm
Present material	292 - 321 x 51 - 68µm	46 - 52 x 25 - 35µm

Up to now the species has only been reported from the dung of domesticated animals and therefore zebra dung is reported as a new substrate. The species has a limited distribution and is for the first time reported from South Africa. Here it occurred on zebra dung during the autumn and summer months. The peak periods during the different seasons were of the same intensity, but they lasted longer during the summer months.

Fungal duration and seasonal occurrences

Zebra Dung
Summer:
+ (day 7-11)
+++ (day 12-22)
Autumn:
++ (day 27-40)
+++ (day 41-44)
Tot. days = 34
Peak days = 15

Species no. 48

Podospora pleiospora (Winter) Niessl., *Hedwigia*, 22, 156, 1883.

Description
Perithecia scattered, semi-immersed to superficial, pyriform to globose, black, 550 - 950 x 350 - 495μm [600 - 1000 x 375 - 550μm], upper part with short tubercular hairs and lower part with long flexuous hairs. Neck short, with black papillae. *Peridium* membranaceous, dark brown above and semitransparent below. *Asci* usually 32-spored, sometimes 16-spored, clavate, 280 - 365 x 61 - 68μm [310 - 360 x 60 - 100μm], rounded at the apices and tapering below to a short stipe. *Ascospores* multi-seriately arranged, ellipsoid, dark brown, 25,8 - 32,8 x 18,4 - 20,6μm [25 - 36 x 15 - 24μm], with an apical germ pore. Primary appendages cylindrical, secondary appendages apical in a tuft. A number of small basal secondary appendages are also present.

Distribution
Canada, U.S.A., Mexico, Spain, France, Belgium, Netherlands, Denmark, Germany, Italy, Poland, U.K., Sweden, Czechoslovakia, Hungary, Rumania, New Zealand, Kenya, Tanzania, Algeria, Zimbabwe, South Africa (RSA).

Habitat
On cow, horse, rabbit, sheep, muskrat, goat, cervid, hare, giraffe, burro, moose, elephant, buffalo, zebra, red deer, sambar, hartebeest, sable antelope and brush rabbit dung.

Season (RSA): Autumn.
Successional position (RSA): Day 32 - 46.
Successional phase (RSA): 2B & 3.
Occurrence: Very common.

Overall importance value (RSA): 0,14
Figures: 45 - 48.

Discussion
Measurements in square brackets are from Mirza (1963). The fungus is quite variable with regard to the dimensions of the different fungal structures. These variations tend to correspond with the number of ascospores per ascus (Mirza 1963). The species occupies a position between *P. decipiens* (Wint. ex Fuck.) Niessl, and *P. myriaspora* (Cr. & Cr.) Niessl, in a number of morphological aspects (Lundqvist 1972). The South African specimens tend to reflect the variations within the species limits. To illustrate the variations within the species the following comparative account on the findings of the different authors are given:

Authors	Perithecia	Asci	Ascospores
Mirza (1963)	600 - 1000 x 375 - 550µm	310 - 360 x 60 - 100µm	25 - 36 x 15 - 24µm
Lundqvist (1972)	530 - 1100 x 335 - 550µm	370 - 420 x 50 - 70µm	(25-) 30 - 37 x 18 - 23µm
Bell (1983)	Unknown	Unknown	32 - 40 x 21 - 24µm
Present material	550 - 950 x 350 - 495µm	280 - 365 x 61 - 68µm	25,8 - 32,8 x 18,4 - 20,6µm

The species has a global distribution and has been reported from the dung of both domesticated and wild animals. Lundqvist (1972) reported that the 16 - 32-spored "forms" are largely confined to rabbit and hare dung, whilst the 64-spored "form" shows a preference for cow and horse dung. The species "form" inhabiting the dung of the larger wild herbivores are not known, and until this knowledge is obtained no conclusions can be drawn with regard to substrate preferences. In South Africa the species occurred on zebra dung during the autumn months. It appeared 32 days after the onset of incubation and lasted for up to 14 days. The peak period was reached between days 44 - 46.

Fungal duration and seasonal occurrences

Zebra Dung
Autumn:
+ (day 32-38)
++ (day 39-43)
+++ (day 44-46)
Tot. days = 15
Peak days = 3

Species no. 49

Sordaria brevicollis Olive & Fant., *Am. J. Bot.*, 48 (2), 124 - 128, 1961.

Description
Perithecia scattered to aggregated, superficial, globose to ovoid, black, 416 - 548 x 258 - 375µm [415 - 475 x 300 - 415µm], with thin flexuous hairs. *Peridium* thin and dark brown. *Asci* eight-spored, cylindrical, 148 - 231 x 12,7 - 17,5µm [150 - 245 x 13 - 18µm], rounded at the apices, with an apical ring and a short stipe. *Paraphyses* ventricose and agglutinated. *Ascospores* uniseriately arranged, ellipsoid, dark brown, 16 - 19,2 x 9,3 - 10,5µm [14 - 19,5 x 8 - 12µm], with a thick gelatinous perispore and a basal germ pore.

Distribution:U.S.A., Kenya and South Africa (RSA).

Habitat
On zebra, giraffe and elephant dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 8 - 35.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Very scarce.
Overall importance value (RSA): 0,54
Figures: 49 & 50.

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits, although some of the perithecia were slightly longer. The species has an extremely limited distribution and has only been reported from the dung of wild animals. In South Africa the species occurred on elephant and giraffe dung during the

summer and autumn months respectively. It generally appeared 8 - 11 days after the onset of incubation and lasted for up to 28 days. The species reached its peak period on giraffe dung between days 8 - 15.

Fungal duration and seasonal occurrences

Elephant Dung	Giraffe Dung
Summer:	Autumn:
	++ (day 8-30)
+ (day 11-17)	
++ (day 18-26)	+++++ (day 8-15)
	++++ (day 16-29)
	+++ (day 30-35)
Tot. days = 16	Tot. days = 51
Peak days = 9	Peak days = 8

Species no. 50

Sordaria fimicola (Rob. in Desm.), Ces. & De Not., *Comment. Soc. Crit.*, Ital., 1, 226, 1863.

Description

Perithecia scattered, semi-immersed, pyriform, 320 - 532 x 209 - 311μm [300 - 550 x 200 - 350μm]. Neck short, cylindrical, with black papillae. *Peridium* thin, membranaceous, brown to dark brown. *Asci* eight-spored, cylindrical, 153 - 209 x 14,4 - 16,7μm [140 - 200 x 14 - 16μm], rounded at the apices with an apical ring and a short stipe. *Paraphyses* vesicular and agglutinated. *Ascospores* uniseriately to obliquely uniseriately arranged, ellipsoid, dark brown, 18,5 - 22 x 11 - 12,4μm [18 - 23 x 11 - 13μm], with a gelatinous perispore and a basal germ pore.

Distribution

Canada, U.S.A., Mexico, Puerto Rico, Panama, Brazil, Argentina, Paraquay, Uruquay, Chile, Bermuda, Iceland, Spain, France, Belgium, Austria, Netherlands, Luxembourg, Germany, Switzerland, Italy, Denmark, Sweden, Finland, Czechoslovakia, Bulgaria, East Africa, Liberia, West Pakistan, Java, China, New Zealand, Norway, South Africa (RSA), England, Wales, Scotland, Poland, Hungary, Corsica, Egypt, Lithuania, U.S.S.R.,Yugoslavia, Morocco, Tchad, Tanzania, Japan, Tahiti, Costa Rica, Honduras, Venezuela.

Habitat
On horse, rabbit, cow, moose, porcupine, deer, goat, sheep, donkey, ass, kangaroo, bison, muskrat, elephant, guinea pig, water rat, goose, fox, dog, llama, mouse, hare, elk, roe deer, caterpillar, reindeer, giraffe, camel, fallow deer, sambar deer, capybara, caribou, quagga, hyrax, jaguar, cat, weasel, seal, Kabylian hare, lemming, water vole, snake dung, human faeces and various seeds, other plant matter and from soil.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 5 - 48.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Extremely common.
Overall importance value (RSA): 0,43
Figures: 51 & 52.

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits, although some of the asci are slightly larger. The species is extremely common and has a global distribution. The species has been reported from substrates other than dung and is therefore not strictly coprophilous in nature and exhibits no substrate preferences. In South Africa it occurred on elephant dung throughout the year. The perithecia generally appeared 5 - 17 days after the onset of incubation and lasted for up to 34 days. The species reached its peak period on elephant dung during the winter and summer months, both peaks were of the same intensity, but the summer peak lasted nine days longer than the winter peak.

Fungal duration and seasonal occurrences

Elephant Dung		
Summer:	Autumn:	Winter:
+++ (day 15-35)	+ (day 17-19)	+ (day 5-7)
++ (day 36-42)	++ (day 20-23)	+++ (day 8-19)
+ (day 43-48)		¼+ (day 20-23)
Total days = 60	Peak days = 33	

Species no. 51

Sordaria macrospora Auersw. in Rab., *Hedwigia* 5: 192. 1866.

Description
Perithecia scattered to aggregated, semi-immersed to superficial, pyriform to ovoid, smooth, black, 520 - 744 x 412 - 483μm [500 - 800 x 400 - 550μm]. Neck short, conical to papilliform, covered by black papillae. *Peridium* thin, membranaceous and dark brown. *Asci* eight-spored, cylindrical, 230 - 295 x 18 - 23μm [200 - 320 x 18 - 24μm], broadly rounded to truncate at the apices, with an apical ring and a short stipe. *Paraphyses* vesicular and agglutinated. *Ascospores* uniseriately arranged, ellipsoid, rounded at the apices, dark brown, 24 - 33 x 16 - 19μm [25 - 34 x 15 - 19μm], with a gelatinous perispore and a basal germ pore.

Distribution
Canada, U.S.A., Paraquay, France, Belgium, Netherlands, Luxembourg, Germany, Austria, Italy, Hungary, Poland, Finland, Denmark, New Zealand, Sweden, Norway, Rumania, Bulgaria, England, Scotland, Algeria, India, Kenya, South Africa (RSA).

Habitat
On rabbit, horse, sheep, cow, kangaroo, mouse, hare, goat, dog, elk, donkey, camel, red deer, reindeer, roe deer, sambar, buffalo, bear, hyrax, lemming, water vole, ptarmigan and elephant dung.

Season (RSA): Autumn.
Successional position (RSA): Day 17 - 33.
Successional phase (RSA): 2A & 2B.
Occurrence: Common.
Overall importance value (RSA): 0,09

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits. The species is a common one and has a wide distribution, it is however for the first time reported from South Africa. It has been recorded from the dung of both domesticated and wild animals and exhibits no apparent substrate preferences. In South Africa it occurred on elephant dung during the autumn months. The perithecia appeared 17 days after the onset of incubation and lasted for up to 17 days. It reached its peak period between days 17 - 23.

Fungal duration and seasonal occurrences

Elephant Dung
Autumn:
+ (day 17-23)
½+ (day 24-33)
Tot. days = 17
Peak days = 7

Species no. 52

Strattonia hansenii Mirza, *Class. coproph. ascomycetes: gen. Podospora*, Ph.D thesis, Univ. Toronto, 1963.

Description
Perithecia scattered, immersed, subglobose to pyriform, dark brown, 600 - 742 x 567 - 611µm [900 - 1050 x 625 - 700µm]. Neck short, black, covered by brown flexuous septate hairs. *Peridium* thin, semi-transparent and pale brown. *Asci* eight-spored, cylindrical to clavate, rounded at the apices, 253 - 284 x 23,3 - 34µm [250 - 300 x 23 - 35µm]. *Ascospores* uniseriately to bi-seriately arranged, ellipsoid, dark brown, 31,7 - 35 x 17,8 - 19,4µm [31 - 42,5 x 15,5 - 20µm], rounded at the apex and truncate at the base, with a slender, cylindrical primary appendage, a gelatinous perispore and an apical germ pore.

Distribution
U.S.A. and South Africa (RSA).

Habitat
On cow, blue wildebeest and tortoise dung.

Season (RSA): Summer.
Successional position (RSA): Day 8 - 46.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Extremely scarce.
Overall importance value (RSA): 0,28
Figures: 53 & 54.

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall within the accepted species limits, although the perithecia seems to be somewhat smaller. The species has a very limited distribution and is only known from the type location in Colorado, U.S.A., on cow dung. In South africa the species occurred on blue wildebeest and tortoise

dung during the summer months. This is the first report on the dung of wild herbivores and from the Southern Hemisphere. The perithecia generally appeared 8 - 18 days after the onset of incubation and lasted for up to 39 days. It reached its peak period on blue wildebeest dung between days 18 - 22 and on tortoise dung between days 15 - 32, the peak periods were of the same intensity but lasted longer on the tortoise dung.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Tortoise Dung
Summer:	Summer:
+++ (day 18-22)	+ (day 8-14) +++ (day 15-32) + (day 33-46)
Tot. days = 5	Tot. days = 39 Peak days = 18

Species no. mz3

Strattonia sp. On elephant dung collected from the Mabula Game Lodge and the National Zoological Gardens Pretoria, 1989.

Description

Perithecia scattered, immersed to semi-immersed, globose to subglobose, 588 - 611 x 403 - 465μm, almost bare or covered with subhyaline flexuous, septate hairs up to the base of the neck, which is darkened by black, opaque papillae. *Neck* stout, subcylindrical, 162 - 177 x 130 - 140μm. *Peridium* membranaceous to slightly coriaceous, fairly thick, dark brown to black and opaque. *Asci* eight-spored, cylindrical to clavate, slightly ventricose near the middle, rounded at the apices, 165 - 213 x 21 - 31μm, with an apical ring, gradually narrowing to a fairly long stipe, 41 - 56μm. *Paraphyses* few, slender, filiform and septate. *Ascospores* obliquely bi-seriately arranged, ellipsoid to broadly ellipsoid, young ascospores honey-coloured, globular to granular and semi-septate, mature ascospores dark brown, smooth, with or without de Bary bubbles, 23 - 31 x 17 - 20μm, with a thin gelatinous exosporium and an apical germ pore. Each ascospore has a single, basal, primary appendage, cylindrical to clavate, honey-coloured and two- to four-septate when young, non-septate and stout to collapsed when mature, 17 - 26 x (4,1-) 5 - 8 (-9,6)μm.

Distribution

Mabula Game Lodge, South Africa (RSA).

Habitat

Elephant dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 8 - 33.
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Only known from the two type locations.
Overall importance value (RSA): 0,3
Figures: 55 - 58.

Discussion

The specimens were recorded from and were restricted to the elephant dung substrate. Fruit bodies appeared 8 - 33 days after the onset of incubation and lasted for up to 29 days during the summer and 5 days during the autumn months. It reached its peak period between days 8 - 29 in the summer season.

Fungal duration and seasonal occurrences

Elephant Dung	
Summer:	
	¼+ (day 33-35)
	++ (day 8-29)
	+ (day 30-36)
Autumn:	
	½+ (day 15-19)
Tot. days = 37	
Peak days = 22	

Taxonomical position

Lundqvist (1972) stated that the boundary between the genus *Podospora* and the genus *Strattonia* is well defined, the latter genus is characterized by cylindrical asci with thickened, functioning apical rings, uniseriately arranged, short-pedicellated ascospores without caudae but surrounded by well developed gelatinous sheaths. In contrast the genus *Podospora* is characterized by the prevailing clavate form of the young ascospores, the late formation of the spore septum, the lack of a thickened apical ring the presence of caudae and the absence of gelatinou being partly or totally surrounded by gelatinous sheaths and possessing reduced caudae (*P. excentrica, P. xerampelina* and *P. globosa*). The present material seems to be of a transitional nature and fits in between the genera *Podospora* and *Strattonia*. To illustrate this statement the following comparison of the generic attributes characteristic of the present specimens are given:

Podospora Characteristics	Strattonia Characteristics
Asci sometimes clavate.	Asci sometimes cylindrical.
Ascospores:	Ascospores:
- Obliquely bi-seriately arranged.	- Young spores granular.
- Young spores semi-septate.	
Primary appendage basal.	No caudae present.
	Gelatinous sheath present.
	Apical ring present.

Personal communication with Lundqvist, with regard to the taxonomic position of the present material led to a comparison of the present material with *P. globosa*. However, the present specimens differ considerably from *P. globosa* as far as the general dimensions are concerned, and can not be placed in this species under the present species limits (see table 1). It is the opinion of the author that these specimens form a transitional state between *P. globosa* and members of the genus *Strattonia*. *P. globosa* has previously been transferred to the genus *Strattonia* (Mirza 1963) and the author believes that the combination as proposed by Mirza (1963) is valid. The genus *Strattonia* is at present being revised by Krug and this could place both *P. globosa* and the present material in their correct taxonomical positions.

Table 1.

Fungal Structures	Podospora globosa	Present material
Perithecia	800 - 1400 x 650 - 900µm (Mirza 1963) 720 - 770 x 530 - 670µm (Lundqvist 1972)	588 - 611 x 403 - 465µm
Asci	250 - 320 x 44 - 56µm (Mirza 1963) 300 - 385 x 35 - 40µm (Lundqvist 1972)	165 - 213 x 21 - 31µm
Ascospores	35 - 50 x 20 - 26µm (Mirza 1963) 34 - 45 x 19 - 25µm (Lundqvist 1972) 40 - 47 x 20 - 23µm (Bell 1983)	23 - 31 x 17 - 20µm
Primary appendage	25 - 60 x 5 - 6µm (Mirza 1963) 25 - 38 x 6 - 7µm (Lundqvist 1972) 21 - 33 x 5µm (Bell 1983)	17 - 26 x (4-)5 - 8(-9)µm

Species no. mz4

Zygopleurage zygospora (Speg.) Boedijn, *Persoonia*, 2(3), 316, 1962.

Description

Perithecia scattered, immersed to semi-immersed, pyriform, dark brown to black, 850 - 920 x 480 - 603µm [700 - 1200 x 425 - 650µm], covered with long flexuous hairs below the neck region. Neck cylindrical with dark papillae. *Peridium* thin, membranaceous, brown to black. *Asci* eight-spored, clavate, rounded at the apices, 280 - 350 x 42 - 52µm [250 - 375 x 40 - 60µm]. *Ascospores* bi-seriately arranged, hyaline when young, dark brown when mature, rounded at the apices, truncate at the bases, with an apical germ pore, 33 - 39 x 15 - 17µm [30 - 40 x 14 - 19µm]. Two dark brown terminal spore cells are connected by a filament, secondary appendages attached distally to the terminal spore cells and to the base of the interconnecting filament.

Distribution
Canada, U.S.A., Mexico, Italy, Germany, France, Java, West Pakistan, New Zealand, Sweden, Hungary, Africa, Bulgaria, South Africa (RSA).

Habitat
On cow, horse, goat, pig, rabbit, sheep and elephant dung.

Season (RSA): Summer and Winter.
Successional position (RSA): Day 33 - 45.
Successional phase (RSA): 3.
Occurrence: Fairly common.
Overall importance value (RSA): 0,31
Figures: 59 - 61.

Discussion
Measurements in square brackets are from Mirza (1963). The South African specimens fall well within the accepted species limits. The species is widely distributed, but is for the first time reported from South Africa. The fungus has been reported from the dung substrates of both wild and domesticated animals and exhibits no substrate preferences. In South Africa it occurred on elephant dung during the summer and winter months. The perithecia appeared 33 - 35 days after the onset of incubation and lasted for up to 11 days. The peak period was reached during the summer months between days 36 - 37.

Fungal distribution and seasonal occurrences

Elephant Dung
Summer:
½+ (day 33-35)
++ (day 36-37)
+ (day 38-40)
Winter:
½+ (day 35-38)
+ (day 39-45)
Tot. days = 19
Peak days = 2

3.2.1.4 Discomycetes:

Species no. mz5

Ascobolus albidus Crouan, *Annls. Sci. Nat.. (bot.)*, IV., 10, 193, 1858.

Description
Apothecia scattered to aggregated, sessile, tapering towards the base, 0,75 - 1,5 mm. [0,3 - 1,0(-1,5)mm.], receptacle obconical whitish to pale brown, emarginate, disk flat with protruding asci tips. *Asci* cylindrical to clavate, eight-spored, amyloid, rounded at the apices and tapering downwards, 350 - 408 x 30 - 34μm [(160-)300 - 410 x 26 - 38μm]. *Ascospores* biseriately arranged, ellipsoid, mature spores purple, longitudinally striated, 31 - 34 x 10 - 15μm [(18-)20 - 36(-39) x (9-)11 - 14(-16)μm]. *Paraphyses* branched, septate, cylindrical to clavate, filiform, hyaline, embedded in mucus.

Distribution
Iceland, Sweden, U.K., Netherlands, Belgium, France, Germany, Poland, Czechoslovakia, Italy, Bulgaria, U.S.S.R., Greenland, Canada, U.S.A., New Zealand, South Africa (RSA).

Habitat
On cow, horse, sheep, goat, moose, dog, wolf, rabbit, hare, muskrat and elephant dung.

Season (RSA): Autumn.
Successional position (RSA): Day 35 - 45.
Successional phase (RSA): 3.
Occurrence: Fairly common.
Overall importance value (RSA): 0,05.

Discussion
Measurements in square brackets are from van Brummelen (1967). The South African specimens fall within the accepted species limits. The species has a wide distribution in the temperate Northern Hemisphere and has been reported from New Zealand (Bell 1983). The species is for the first time reported from Africa. It occurs commonly on the dung of both wild and domesticated animals, exhibiting no substrate preferences. In South Africa the species occurred on elephant dung during the autumn months. It had a low intensity occurrence and appeared 35 days after the onset of incubation. The peak period was reached between days 35 - 39.

Fungal duration and seasonal occurrences

Elephant Dung
Autumn:
½+ (day 35-39)
¼+ (day 40-45)
Tot. days = 11
Peak days = 5

Species no. 53

Ascobolus amoenus Oudemans, *Hedwigia*, 21, 165, 1882.

Description:
Apothecia solitary or aggregated, superficial to semi-immersed, sessile. Receptacle subglobose, pale yellow to luteus, smooth and emarginate, mature apothecial disc flat to convex with dark protruding ascus apices. Apothecia 263 - 512μm in diameter [250 - 600μm in diameter]. *Asci* clavate to broadly clavate with a short stipe. Asci 165 - 248 x 32 - 36μm [170 - 300 x 35 - 40μm], eight-spored, ascus wall amyloid. *Ascospores* uniseriately to bi-seriately arranged, ellipsoid to fusiform, mature ascospores brown smooth to minutely punctate, 29 - 34 x 14.1 - 17,8μm [29 - 38 x 14 - 18μm]. *Paraphyses* simple, septate, filiform and hyaline, tips embedded in a greenish-yellow mucus.

Distribution
Netherlands, Canada, U.S.A., Peru, Venezuela, Argentina, Africa and South Africa (RSA).

Habitat
On cow, horse, camel, goat, rabbit, muskrat, giraffe, blue wildebeest and elephant dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 5 - 30
Successional Phase (RSA): 1, 2A & 2B.
Occurrence: Fairly common.
Overall importance value (RSA): 0,35
Figures: 62 - 64.

Discussion:
Measurements in square brackets are from van Brummelen (1967). The South African specimens fall well within the accepted species limits. The species has a wide distribution but is for the first time reported from Africa. It occurs commonly on the dung of both wild and domesticated animals, exhibiting no substrate preferences. In South Africa the species occurred

on the dung of blue wildebeest, elephant, and giraffe, and seems to favour the elephant dung substrate as it reached both peaks on this substrate, it is also the only substrate with both summer and autumn occurrences. This species seems to fruit predominantly during the summer during which time it occurred on all of the above mentioned substrates. However a single high intensity occurrence was reported from elephant dung during the autumn months. It appeared 7 - 12 days earlier in the summer than in the autumn and reached its summer peak 5 - 8 days after incubation. The autumn peak was only reached 17 - 23 days after incubation. Both peaks were of the same intensity, although the autumn peak lasted longer, 7 days in autumn as apposed to 4 days in summer. In general fruit bodies appeared 5 - 22 days after the onset of incubation.

Fungal duration and seasonal occurrences

Blue Wildebeest dung	Elephant dung	Giraffe dung
Summer:	Summer:	Summer:
½+ (day 22-30)	+++ (day 5-8)	++ (day 5-7) + (day 8-15)
Tot. days = 9	Tot. days = 4	Tot. days = 11 Peak days = 3
	Autumn:	
	++ (day 12-16) +++ (day 17-23)	
	Tot. days = 12 Peak days = 5	

Species no. 54

Ascobolus degluptus Brumm., *Suppl. Persoonia*, 1, 78-80, 1967.

Description

Apothecia solitary or aggregated, semi-immersed to superficial, globose, whitish to pale brown, smooth, emarginate, 230 - 340µm [200 - 450µm] in diameter. Disk flat with protruding ascus tips. *Excipulum* 13 - 14.5µm [12 - 15µm] thick. *Asci* clavate, short stiped, rounded at the apices, 391 - 435 x 48,6 - 52,8µm [380 - 500 x 49 - 56µm], eight-spored, amyloid. *Ascospores* bi-seriately to irregularly arranged, ellipsoid, mature ascospores brown to purple, 31,6 - 34,3 x 15,7 - 18,6µm [(27,5) 30 - 33,5 (-35) x 16 - 18µm], covered by warts at the spore caps with the mid-spore region free of pigment. *Paraphyses* simple, septate, filiform, hyaline, embedded in mucus.

Distribution
Great Britain, Netherlands, Poland, South Africa (RSA).

Habitat
On sheep, rabbit, goose and giraffe dung.

Season (RSA): Winter
Successional position (RSA): Day 9 - 21
Successional phase (RSA): 1 & 2A.
Occurrence: Scarce.
Overall importance value (RSA): 0,07
Figures: 65 - 67.

Discussion
Measurements in square brackets are from van Brummelen (1967). The South African specimens fall well within the accepted species limits. The species exhibits an extremely limited distribution and is for the first time reported from the Southern Hemisphere. The fungus exhibits no substrate preference and has been reported from the dung of both wild and domesticated animals. In South Africa it occurred on giraffe dung during the winter months and appeared 9 - 21 days after the onset of incubation.

Fungal duration and seasonal occurrences

Giraffe Dung
Winter:
½+ (day 9-21)
Tot. days = 13

Species no. 55

Ascobolus hawaiiensis Brumm., *Suppl. Persoonia*, 1, 87-88, 1967.

Description
Apothecia solitary or aggregated, superficial, sessile. Receptacle oblong-ellipsoid to subcylindrical, pale brown, smooth, emarginate. Mature apothecial disc slightly convex, whitish with protruding ascus apices. Apothecia 173 - 231µm [150 -250µm] in diameter. *Asci* clavate, tapering towards the stipe, ascus apices rounded, ascus eight spored, ascus walls amyloid. Asci 293 - 312 x 35 - 38µm [280 - 320 x 34 - 38µm] *Ascospores* bi-seriately arranged, ellipsoid, mature ascospores purple to brown, finely warted, with an even thick gelatinous perispore, 19,1 - 21,3 x 9,8 - 11,2µm [18,5 - 21 x 10 - 11,5µm]. *Paraphyses* filiform, septate and

hyaline, without mucus. The species is characterized by very small apothecia and warted ascospores. In *A.immersus* the ascospores are surrounded on all sides by a thick gelatinous layer (van Brummelen, 1967).

Distribution
Hawaii, New zealand, South Africa (RSA).

Habitat
On sheep, cattle, cervid, goat, lagomorph and giraffe dung.

Season (RSA): Summer.
Successional position (RSA): Day 7 - 37
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Scarce.
Overall importance value (RSA): 0,17
Figures: 68 & 69.

Discussion
Measurements in square brackets are from van Brummelen (1967). The South African specimens fall well within the accepted species limits. Apparently the species has a very limited distribution and is for the first time reported from Africa. The fungus exhibits no definite substrate preference. In South Africa it occurred on giraffe dung during the summer months and appeared 7 - 29 days after the onset of incubation. This species fruits predominantly during the summer. It reached its peak period between days 11 - 15.

Fungal duration and seasonal occurrences

Giraffe dung
Summer:
½+ (day 7-10)
+ (day 11-15)
½+ (day 22-28)
+ (day 29-37)
Tot. days = 25
Peak days = 14

Species no. 56

Ascobolus immersus Pers.: Fr., *Syst. Mycol.* 2: 164. 1822.

Description
Apothecia scattered or aggregated, semi-immersed to superficial, sessile, receptacle globose to pyriform opening irregularly, yellowish-brown, smooth, emarginate, mature apothecial disc flat to convex with a few protruding ripe asci. Apothecia 378 - 675μm [500 - 1000μm] in diameter. *Asci* 1 - 40 per apothecium, broadly clavate, 224 - 408 x 83 - 124μm [490 - 720 x 100 - 130μm] short stalked, rounded at the apices, eight-spored (sometimes four- spored) asci walls amyloid. *Ascospores* bi-seriately or irregularly arranged, oblong-ellipsoid, rounded at the spore apices, mature ascospores purple to brown, smooth with a few fine lines or granules, perispore thick gelatinous. Ascospores 44,8 - 58,2 x 27 - 35μm [(35-) 58 - 71 (-81) x (24-) 28 - 36 (-40)μm].

Distribution
Iceland, Finland, U.K., Netherlands, Belgium, Luxembourg, France, Austria, Denmark, Germany, Poland, Czechoslovakia, Switzerland, Italy, U.S.S.R., Pakistan, India, New Guinea, Australia, Hawaii, Canada, U.S.A., Bermuda, Puerto Rico, Brazil, Argentina, New Zealand, Africa and South Africa (RSA).

Habitat
On cow, horse, sheep, goat, nilgai, antelope, dog, hare, rabbit, avian, camel, cervid, chamois, possum, wallaby, elephant, blue wildebeest and zebra dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 3 - 21
Successional phase (RSA): 1 & 2A.
Occurrence: Very common.
Overall importance value (RSA): 1,35
Figures: 70 - 73.

Discussion
Measurements in square brackets are from van Brummelen (1967) The apothecia appears to be quite variable in size. The South African specimens tend to be consistently smaller than the average accepted by van Brummelen (1967) though still falling within the broader species limits. It seems that the smaller apothecia give rise to smaller asci and ascospores. The following comparative account, on the findings of the different authors, is given:

van Brummelen:
Apothecia: 500 - 1000μm in diameter.
Asci: 490 - 720 x 100 - 130μm.
Ascospores: (35-) 58 - 71 x (24-) 28 - 36 (-40)μm.

Ahmed:

Apothecia: up to 2000μm in diameter.
Asci: 500 - 600 x 90 - 100μm.
Ascospores: 50 - 66,5 x 23 - 35μm.

Bell:
Apothecia: not available.
Asci: not available.
Ascospores: 60 - 80 x 34 - 42μm.

Present material:
Apothecia: 378 - 675μm in diameter.
Asci: 224 - 408 x 83 - 124μm.
Ascospores: 44,8 - 58,2 x 27 - 35μm.

The fungus is extremely common and has a global distribution pattern, however it is for the first time reported from Africa. It has been recorded on the dung of both domesticated and wild animals and exhibits no substrate preference. In South Africa it occurred on the dung of elephant, blue wildebeest, and zebra. The species was recorded throughout the year and showed little seasonal fluctuation. It did however reached its peak period between days 10 - 15, on elephant dung during the autumn months. In general fruit bodies appeared 3 - 9 days after the onset of incubation and lasted for up to 19 days .

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung	Zebra Dung
Autumn:	Autumn:	Autumn:
++ (day 8-9)	++++ (day 8-9)	++++ (day 9-12)
+ (day 10-12)	+++++ (day 10-15)	¼+ (day 13-17)
	+ (day 9-11)	++ (day 10-15)
	+++ (day 12-16)	
	+ (day 17-20)	
Winter:	Winter:	Winter:
++ (day 3-5)	+++ (day 6-9)	+++ (day 9-21)
+ (day 6-7)		
½+ (day 8-12)		++ (day 5-9)
		½+ (day 10-13)

Summer:	Summer:	Summer:
++ (day 7-11)	None	+ (day 4-6)
½+ (day 12-13)		+++ (day 7-11)
¼+ (day 14-18)		
		+++ (day 5-7)
		½+ (day 8-10)
Tot. days = 33	Tot. days = 27	Tot. days = 51
Peak days = 9	Peak days = 6	Peak days = 4

Species no. 57

Ascobolus stictoideus Speg., in *Michelia* 1, 474, 1879.

Description
Apothecia scattered or aggregated, immersed to semi-immersed, Globose to pyriform, whitish-yellow, thinly tomentose, emarginate. Mature disk flat, colourless with a few mature protruding asci. *Apothecia* 548 - 570µm [350 - 600µm] in diameter. *Asci* clavate to clavate-saccate, tapering gradually, rounded at the apices, amyloid, eight-spored, 130 -248 x 34 - 47µm [150 - 400 x 39 - 55µm]. *Ascospores* bi-seriately or irregularly arranged, ellipsoid, mature ascospores purple to deep purple, coarsely warted, 26 - 35,6 x 14,5 - 17,5µm [(25,5) 26,5 - 30,5 (-32) x (14,5) 16 - 17,5µm]. *Paraphyses* filiform, simple, septate, hyaline, embedded in pale mucus.

Distribution
Netherlands, Italy, New Zealand, U.K., South Africa (RSA).

Habitat
On cow, horse, sheep, dog, rabbit, muskrat, goose, camel, elephant, giraffe and blue wildebeest dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 5 - 55
Successional phase (RSA): 1, 2A, 2B, 3 & 4.
Occurrence: Common.
Overall importance value (RSA): 1,5
Figures: 74 - 75.

Discussion
Measurements in square brackets are from van Brummelen (1967). The South African specimens fall within the broad species limits, although some of the asci were shorter and some of the ascospores longer. The asci tend to vary in size (van Brummelen 1967). The species is for the first time reported from Africa. It exhibits no apparent substrate preference

and occurred in South Africa on a wide range of dung substrates throughout the year. The peak period occurred during the autumn months between days 10 - 15 on giraffe dung. In general fruit bodies appeared 5 - 18 days after the onset of incubation.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Steenbok Dung
Summer:	Autumn:
+ (day 18-21)	¼+ (day 5-8)
½+ (day 22-26)	+ (day 9-15)
	¼+ (day 16-18)
Tot. days = 9	Tot. days = 14
Peak days = 4	Peak days = 7

Elephant Dung	Giraffe Dung
Autumn:	Autumn:
	+++ (day 8-16)
+ (day 7-10)	
+++ (day 11-16)	++ (day 9-13)
+ (day 17-47)	½+ (day 14-30)
+++ (day 31-35)	++ (day 8-10)
	+++ (day 11-16)
Winter:	
	+++ (day 8-9)
++ (day 5-7)	++++ (day 10-15)
	+++ (day 16-18)
Summer:	
	Winter:
+++ (day 7-11)	
	+ (day 9-21)
½+ (day 22-25)	
	Summer:
Tot. days = 78	
Peak days = 16	¼+ (day 7-36)
	+ (day 37-55)
	Tot. days = 111
	Peak days = 6

Species no. 58

Cheilymenia theleboloides (Alb. & Schw.) Boud., *Hist. Class. discom. d'Eur.* p. 62. 1907.

Description
Apothecia medium to small,[2 - 5 (-10)mm] in diameter, scattered to aggregated, subturbinate to discoid, golden yellow, reddish brown when dry, *excipulum* cells globose to polyhedral 48 - 76μm [25 - 90μm] in diameter. *Apothecial hairs* scattered, yellow-brown to subhyaline, longest ones at the apothecial margin 165 - 763 x 8,4 - 10,2μm [170 - 800 x 8 - 10μm], base bulbous 16 - 23μm [15 - 25μm] in diameter, 1 - 4 septate, straight, unbranched, tapering slightly with blunt apices. *Asci* cylindrical 193 - 206 x 12 - 15,2μm [180 - 220 x 10 - 15μm]. *Ascospores* ellipsoid 16,8 - 19,6 x 8,4 - 9,5μm [(15-)17 - 20(-22) x (7-)8 - 10(-11)μm], smooth, hyaline, eguttulate, with an exosporium that loosens when heated in lactic acid. *Paraphyses* slender, septate, subclavate at the apices [5 - 7μm] in diameter tapering below to [3 - 4μm].

Distribution
U.S.A., Bermuda, Chile, Costa Rica, U.K., Germany, South Africa (RSA).

Habitat
Dung, decaying vegetation, damp soil - not strictly coprophilous.

Season (RSA): Summer and Winter.
Successional position (RSA): Day 32 - 111
Successional phase (RSA): 3, 4 & 5.
Occurrence: Fairly common.
Overall importance value (RSA): 0,38
Figures: 76 - 77.

Discussion
Measurements in square brackets are from Denison (1964). The South African specimens fall well within the accepted species limits. The species has a wide distribution in the Northern Hemisphere and a seemingly restricted distribution in the Southern Hemisphere. In South Africa it occurred on the dung of elephant and giraffe. This species seems to fruit predominantly in summer on the above mentioned substrates. However a single low intensity occurrence was reported from elephant dung during the autumn months. In the summer the fungus appeared 23 days earlier than during the autumn months. Fruiting reached its peak period 40 - 111 days after the onset of incubation on elephant dung during the summer. In South Africa the species seems to favour the elephant dung substrate. In general apothecia appeared 32 - 55 days after the onset of incubation. As the fungus has been reported on substrates other than dung it is not strictly coprophilous in nature.

Fungal duration and seasonal occurrences

Elephant Dung	Giraffe Dung
Summer: ++ (day 40-111)	Summer:
Winter:	¼+ (day 35-43)
+ (day 55-68)	
Tot. days = 86	Tot. days = 9
Peak days = 72	

Species no. 59

Cheilymenia sp. The genus is presently being revised Moravec (1990). The species could not be identified using existing literature.

Description

Apothecia scattered, discoid, pale yellow, 700 - 900µm in diameter. *Excipulum* cells irregularly arranged, subglobose to subcuboidal, thin walled, 7,5 - 11,5 x 5,5 - 6,5µm. *Apothecial hairs* confined to the margin, superficial, light brown to sub-hyaline, slightly bulbous at the base, tapering to sharply pointed apices, thin walled, usually with 7 - 12 distinct septa, 300 - 354 x 17 - 19µm. *Asci* cylindrical, thin walled, operculate, numerous, eight-spored 43 - 53 x 4 - 5µm. *Ascospores* uniseriately to obliquely uniseriately arranged, broadly ellipsoidal, eguttulate, smooth, hyaline with a thin exosporium, ascospores 12 - 15 x 9 - 10µm. *Paraphyses* slender, filiform, slightly inflated at the apices, 1,8 - 2,0µm in diameter tapering below to 1,3 - 1,5µm, usually longer than the asci.

Distribution

Kruger National Park, South Africa (RSA).

Habitat: Elephant dung.

Season (RSA): Winter
Successional position (RSA): Day 32 - 34
Successional phase (RSA): 2B.
Occurrence: Only known from the present material.
Overall importance value (RSA): 0,04
Figures: 78 - 81.

Discussion:

The species occurred on elephant dung during the winter months and appeared 32 days after the onset of incubation. Fruiting lasted for 3 days and exhibited a low fructification intensity.

Fungal duration and seasonal occurrences

Elephant Dung
Winter:
¼+ (day 32-34)
Tot. days = 3

Species no. 60

Coprotus aurora (Cr.and Cr.) Kimbrough *et al.*, *Can. J. Bot.*, 50, 961, 1972.

Description
Apothecia scattered or aggregated, sessile, globose when young, finally discoid, yellow to bright yellow-orange, 230 - 411μm [< 500μm] in diameter. *Excipulum* cells 5,4 - 6,1 x 9,3 - 11,5μm [5 - 6 x 8 - 12μm], with carotenoid pigments. *Asci* eight spored, cylindrical to clavate, 60 - 78 x 10,5 - 14,2μm [65 - 90 x 10 - 15μm], rounded at the apices. *Ascospores* uniseriately to bi-seriately arranged, ellipsoidal, hyaline, smooth, 12,5 - 13,8 x 6,1 - 7,9μm [12 - 14 x 6 - 8μm], with a thin perispore and a single de Bary bubble. *Paraphyses* septate, branched, inflated above with oil guttules.

Distribution
U.S.A., Canada, France, New Zealand, Africa and South Africa (RSA).

Habitat
On cow, horse, moose, porcupine, sheep and elephant dung.

Season (RSA): Summer.
Successional position (RSA): Day 26 - 63
Successional phase (RSA): 2B, 3 & 4.
Occurrence: Fairly common.
Overall importance value (RSA): 0,17
Figures: 82 - 84.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972) The South Africa species fall well within the accepted species limits. This species seems to be fairly common with a wide distribution, however it is the first time this species is reported from Africa. The species has been recorded on dung of both domesticated and wild animals and show no substrate preference. In South Africa it favours the elephant dung substrate and seems to be

predominantly a summer inhabitant of the above mentioned substrate. It reached its peak periods 26 - 35 and 47 - 50 days after the onset of incubation, on elephant dung. In general apothecia appeared 26 - 51 days after the onset of incubation.

Fungal duration and seasonal occurrences

Elephant Dung
Summer: + (day 26-35)
½+ (day 36-40)
+ (day 47-50)
½+ (day 51-63)
Tot. days = 32
Peak days = 14

Species no. 61

Coprotus dextrinoideus Kimbr., *et al.*, *Can. J. Bot.*, 50, 962, 1972.

Description
Apothecia scattered to aggregated, discoid, marginate, white with a pale yellow margin, 0,2 - 0,3mm [0,1 - 0,5mm] in diameter. *Asci* eight-spored, cylindrical, rounded at the apices, tapering below, 102 - 115 x 19,3 - 22μm [80 - 125 x 18 - 24μm]. *Ascospores* uniseriately arranged, broadly ellipsoid, with a de Bary bubble, 12,6 - 13,2 x 8,1 - 9,4μm [11 - 13 x 7,5 - 10μm]. *Paraphyses* hyaline, septate, filiform, branched, with oil guttules.

Distribution
Mexico, Pakistan, Puerto Rico, U.S.A., South Africa (RSA).

Habitat: On cow, deer, antelope, wapiti, burro and zebra dung.

Season (RSA): Summer.
Successional position (RSA): Day 7 - 11.
Successional phase (RSA): 1.
Occurrence: Scarce.
Overall importance value (RSA): 0,04
Figures: 85 - 87.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972). The South African specimens fall well within the accepted species limits. The species exhibits a limited distribution pattern and is for the first time reported from Africa. It has been reported from both the

dung of wild and domesticated animals, exhibiting no substrate preferences. In South Africa the species had a low intensity occurrence on zebra dung during the summer months. Apothecia appeared 7 days after the onset of incubation and lasted for up to 5 days.

Fungal duration and seasonal occurrences

Zebra Dung
Summer:
½+ (day 7-11)
Tot. days = 5

species no. 62

Coprotus disculus Kimbr., *et al.*, *Can J. Bot.*, 50, 962 - 963, 1972.

Description
Apothecia white to pale yellow, discoid to lenticular, 0,6 - 0,7mm [0.5 - 1,0mm] in diameter. *Asci* eight-spored, cylindrical, rounded at the apices, tapering below, 81 - 88 x 11 - 13μm [75 - 90 x 10 - 15μm]. *Ascospores* uniseriately arranged, rarely bi-seriately, narrowly ellipsoid, with a de Bary bubble, 12,5 - 13 x 5,5 - 7,5μm [12 - 13,5 x 5 - 8μm]. *Paraphyses* filiform, septate, hyaline, without oil guttules, apices inflated, 3 - 4μm [3 - 4μm].

Distribution
Canada, U.S.A., Italy, New Zealand, South Africa (RSA).

Habitat
On deer, horse, cow, rodent, bison, camel and zebra dung.

Season (RSA): Winter.
Successional position (RSA): Day 21 - 55.
Successional phase (RSA): 2A, 2B, 3 & 4.
Occurrence: Uncommon.
Overall importance value (RSA): 0,22
Figures: 88 & 89.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972). The South African specimens fall well within the accepted species limits. The species exhibits a limited distribution pattern and is for the first time reported from Africa. It has been reported from the dung of both wild and domesticated animals, exhibiting no substrate preferences. In South Africa it

occurred on zebra dung during the winter months. The species appeared 21 - 26 days after the onset of incubation and lasted for up to 30 days. It reached its peak period between days 21 - 26.

Fungal duration and seasonal occurrences

Zebra Dung	
Winter:	
	½+ (day 26-31)
	+ (day 32-55)
	+++ (day 21-26)
Tot. days = 36	
Peak days = 6	

Species no. 63

Coprotus glaucellus (Rehm.) Kimbrough, *Am. J. Bot.*, 54, 22, 1967.

Description
Apothecia scattered or aggregated, smooth, semitransparent to white, becoming pale yellow, discoid to lenticular, 600 - 850μm [100 - 1200μm] in diameter. *Excipulum* cells hyaline to faintly yellow, thin walled, 5,3 - 6,4 x 6,2 - 7,3μm [5 - 6 x 6 - 8μm]. *Asci* eight spored, cylindrical, rounded at the apices, shortly stipitate, 42 - 51 x 8,3 - 11,7μm [40 - 55 x 8 - 12μm]. *Ascospores* uniseriately to bi-seriately arranged, ellipsoidal, 7,8 - 10,4 x 4,3 - 5,5μm [7,5 - 9 x 4,5 - 5,5μm], each with a single de Bary bubble. *Paraphyses* hyaline, filiform, septate, uncinate at the apices, slightly inflated above without oil guttules.

Distribution
Bavaria, Canada, Europe, Mexico, U.S.A., New Zealand, South Africa (RSA).

Habitat
On deer, goat, moose, porcupine, rabbit, cervid, giraffe and elephant dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 8 - 32
Successional phase (RSA): 1, 2A & 2B.
Occurrence: Very common.
Overall importance value (RSA): 0,29
Figures: 90 - 92.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972) The South African specimens fall well with in the accepted species limits. This species is one of the most common coprophilous Discomycetes and exhibits a wide cosmopolitan distribution, it is however for the first time reported from Africa. It has been reported on the dung of both domesticated and wild animals, but seems to have a preference for wild animal dung substrates. In South Africa it occurred on the dung of elephant and giraffe and the species seems to be predominantly a summer inhabitant on giraffe dung and an autumn inhabitant on elephant dung. It reached its summer peak period between days 15 - 25 and its autumn peak period between days 16 - 24. The summer peak was of a higher intensity and lasted 2 days longer than that of the autumn peak. In general the apothecia appear 8 - 26 days after the onset of incubation.

Fungal duration and seasonal occurrence

Elephant Dung	Giraffe Dung
Autumn:	Summer:
++ (day 16-24)	++ (day 8-14)
+ (day 25-31)	+++ (day 15-25)
	++ (day 26-32)
Tot. days = 16	Tot. days = 25
Peak days = 10	Peak days = 11

species no. 64

Coprotus lacteus (Ck. & Phill.) Kimbrough et.al., *Can. J. Bot.*, 50, 965, 1972.

Description
Apothecia whitish - yellow, smooth, discoid to cupulate, sessile but with a small basal attachment, 231 - 409μm [200 - 500μm] in diameter. *Excipulum* cells thin walled, 7,2 - 9,1 x 3,8 - 5,2μm [8 - 10 x 4 - 5μm]. *Asci* eight spored, cylindrical to clavate, 61 - 78 x 14,8 - 18,2μm [65 - 85 x 15 - 20μm], rounded at the apices. *Ascospores* uniseriately to bi-seriately arranged, smooth, hyaline, ellipsoidal, 9,1 - 10.2 x 5,1 - 6,4μm [8 - 10 x 5 - 6,5μm], each with a single de Bary bubble. *Paraphyses*, septate, simple to sparsely branched, hyaline, slightly inflated and uncinate at the apices.

Distribution
England, Canada, Mexico, Puerto Rico, U.S.A., New Zealand, Venezuela, Africa and South Africa (RSA).

Habitat
On cow, deer, porcupine, horse, rabbit, burro, goat, sheep, giraffe, elephant and opossum dung.
Season (RSA): Summer and autumn.
Successional position (RSA): Day 35 - 80
Successional phase (RSA): 3, 4 & 5.
Occurrence: Quite common.
Overall importance value (RSA): 0,34
Figures: 93 & 94.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972). The South African specimens fall well with in the accepted species limitation. The species is a common one that exhibits a wide distribution, nevertheless it is for the first time reported from Africa. It has been recorded from the dung of both domesticated and wild animals and exhibits no substrate preferences. In South Africa it occurred on the dung of elephant and giraffe. The species seems to be predominantly a summer inhabitant, although it did have a single low autumn occurrence on giraffe dung. In South Africa the species seems to favour the elephant dung substrate. It reached its summer peak period between days 35 - 38 and its autumn peak period between days 40 - 48. The summer peak was of a higher intensity than the autumn peak. In general apothecia appeared 35 - 46 days after the onset of incubation.

Fungal duration and seasonal occurrences

Elephant Dung	Giraffe Dung
Summer:	Autumn:
++++ (day 35-38)	++ (day 40-48)
+++ (day 39-45)	
++ (day 46-80)	
Tot. days = 46	Tot. days = 9
Peak days = 4	

species no. 65

Coprotus leucopocillium Kimbrough *et al.*, *Can. J. Bot.*, 50, 965 - 966, 1972.

Description
Apothecia scattered or aggregated, white to pale yellow, smooth, cupulate to lenticular, 320 - 480μm [300 - 500μm] in diameter. *Excipulum* cells 5 - 9 x 13 - 15,5μm [5 - 8 x 12 - 15μm] sometimes almost isodiametric. *Asci* eight-spored, broadly cylindrical, 84 - 97 x 14,5 - 18,8μm [80 - 110 x 15 - 22μm] rounded at the apices, shortly stipitate. *Ascospores* ellipsoid to

ovoid, bi-seriately arranged, hyaline to pale yellow, smooth 14,8 - 15,6 x 8,4 - 9,9μm [14 - 18 x 7,5 - 11,5μm] each with a single de Bary bubble. *Paraphyses* hyaline, septate, simple, inflated at the apices and slightly uncinate, without oil guttules.

Distribution
Bermuda, Canada, France, Pakistan, U.S.A., New Zealand, Venezuela, South Africa (RSA).

Habitat
On cow, porcupine, goat, moose, deer, cervid, giraffe, blue wildebeest and tortoise dung.

Season (RSA): Summer and Autumn.
Successional position (RSA.): Day 15 - 42
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Uncommon.
Overall importance value (RSA): 0,36
Figures: 95 - 97.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972) The South African specimens fall well within the accepted species limits. This is a common coprophilous species which exhibits a wide distribution. It has been reported from the dung of both domesticated and wild animals and seems to have a possible preference for cow dung, as it is most often reported on this substrate. In South Africa the apothecia occurred on blue wildebeest, giraffe and tortoise dung and seem to predominantly appear in summer on blue wildebeest and tortoise dung, although it did have a single high intensity occurrence during the autumn months on giraffe dung. It reached its peak period between days 26 - 32 on tortoise dung. The species appeared 17 days earlier in the summer than in the autumn. In general apothecia appeared 15 - 32 days after the onset of incubation.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Giraffe Dung	Tortoise Dung
Summer: + (day 15-20) Tot. days = 6	Autumn: +++ (day 32-39) Tot. days = 8	Summer: ++ (day 15-18) +++ (day 19-25) ++++ (day 26-32) + (day 33-42) Tot. days = 28 Peak days = 7

species no. 66

√ *Coprotus luteus* Kimbrough *et al.*, *Can. J. Bot.*, 50, 966-967, 1972.

Description
Apothecia scattered, yellow to orange, discoid to cupulate, pigment concentrated in the margins, 170 - 880 μm [200 - 800 μm] in diameter. *Excipulum* slightly thick-walled, excipulum cells 4,3 - 5,2 x 8,6 x 12 2 μm [4 - 5 x 8 - 12 μm]. *Asci* eight-spored, cylindrical, rounded at the apices, shortly stipitate, 63 - 78 x 9,8 - 13,3 μm [60 - 85 x 10 - 15 μm]. *Ascospores* uniseriately arranged, hyaline, thin walled, ellipsoid,8,6 - 10,4 x 5,1 - 7,2 μm [8 - 10,5 x 5 - 6,5 μm], each with a single de Bary bubble. *Paraphyses* filiform, septate, simple, inflated and slightly uncinate at the apices, with numerous oil guttules.

Distribution
Canada, Mexico, U.S.A., New Zealand, Venezuela, South Africa (RSA).

Habitat
On cow, moose, deer, goat, horse, opossum, giraffe, blue wildebeest and elephant dung.

Season (RSA): Autumn and Winter.
Successional position (RSA): Day 44 - 60
Successional phase (RSA): 3 & 4.
Occurrence: Uncommon.
Overall importance value (RSA): 0,27
Figures: 98 - 100.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972) The South African specimens fall within the accepted species limits although some of the apothecia are slightly larger and some of the ascospores are slightly broader. The species is a common one with a wide distribution, however it is for the first time reported from Africa. It has been reported

from the dung of both wild and domesticated animals, and exhibits no substrate preference. In South Africa it occurred on the dung of blue wildebeest, giraffe and elephant. This species seems to fruit predominantly in autumn. It did however have a single low intensity occurrence on giraffe dung during the summer months. Fruiting reached its autumn peak period between days 44 - 47 and its summer peak period between days 55 - 60. The summer peak was of a much higher intensity, although two days shorter than the autumn peak, and appeared 11 days earlier than the autumn peak. In general apothecia appeared 44 - 55 days after the onset of incubation.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung	Giraffe Dung
Autumn:	Autumn:	Autumn:
½+ (day 47-51)	+++ (day 44-47)	+ (day 51-55)
		++ (day 56-58)
		Summer:
		+ (day 55-60)
Tot. days = 5	Tot. days = 4	Tot. days = 14
		Peak days = 3

Species no. 67

Coprotus marginatus Kimbrough *et al.*, *Can. J. Bot.*, 50, 967, 1972.

Description
Apothecia scattered, white to yellowish, smooth, discoid to lenticular, margins slightly rolled, 930 - 1200 µm [1000 - 1600 µm] in diameter. *Excipulum* cells inflated at the apices and difficult to distinguish from the paraphyses, 121 - 130 x 11,5 - 14 5 µm [>100 x 12 - 15 µm]. *Asci* eight - spored, cylindrical, rounded at the apices, shortly stipitate, 77 - 93 x 9,1 - 12,2 µm [80 - 100 x 8 - 12 µm]. *Ascospores* uniseriately arranged, hyaline, ellipsoid to fusoid, 8,3 - 9,4 x 4,3 - 5,2 µm [8,5 - 10 x 4 - 5 µm], each with a single de Bary bubble. *Paraphyses* filiform, septate, inflated at the apices, without oil guttules.

Distribution
Costa Rica, Panama, U.S.A., South Africa (RSA).

Habitat
On cow, horse, rabbit and giraffe dung.

Season (RSA.): Summer.
Successional position (RSA.): Day 7 - 55
Successional phase (RSA): 1, 2A, 2B, 3, 4 & 5.
Occurrence: Fairly rare.
Overall importance value (RSA): 0,19
Figures: 101 & 102.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972) The South African specimens fall well within the accepted species limits. The species is not a common one and has a limited distribution. It is for the first time reported from the Southern Hemisphere. Apothecia have been reported from the dung of mainly domesticated animals and exhibit no apparent substrate preference. In South Africa it occurred on giraffe dung during the summer months. Fruiting reached its peak period between days 37 - 55. Apothecia appeared 7 days after the onset of incubation and lasted for up to 49 days.

Fungal duration and seasonal occurrences

Giraffe Dung
Summer:
¼+ (day 7-36)
+ (day 37-55)
Tot. days = 49
Peak days = 19

Species no. 68

Coprotus winteri (Marchal.) Kimbrough, *Am. J. Bot.*, 54, 22, 1967

Description
Apothecia scattered to aggregated, semitransparent to white, globose to cupulate, smooth with protruding ripe asci, apothecia 447 - 538 µm [400 - 500 µm] in diameter. *Excipulum* cells thin-walled, 10,3 - 12,1 x 4,2 - 4,8 µm [10 - 12 x 4 - 5 µm]. *Asci* approximately 256 - spored, broadly cylindrical to clavate, rounded at the apices, 149 - 185 x 44 - 50 µm [160 - 210 x 45 - 55 µm]. *Ascospores* irregularly arranged, ellipsoid, smooth, 10,3 - 12,1 x 4,2 - 4,8 µm [10 - 12 x 4 - 5 µm], each with a single de Bary bubble. *Paraphyses* hyaline, filiform, septate, branched above, slightly inflated at the apices and uncinate.

Distribution
Belgium, U.S.A., South Africa (RSA).

Habitat
On "damarum", horse and elephant dung.

Season (RSA): Autumn.
Successional position (RSA): Day 46 - 50
Successional phase: 3 & 4.
Occurrence: Very scarce.
Overall importance value (RSA): 0,06
Figures: 103 & 104.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1972) The South African specimens fall within the accepted species limits although the apothecia are slightly larger and the ascospores slightly broader. The species is extremely scarce with a limited distribution. This is the first time it has been reported from Africa. In South Africa it occurred on elephant dung during the autumn months. In general apothecia appeared 46 days after the onset of incubation and lasted for up to 5 days.

Fungal duration and seasonal occurrences

Elephant Dung
Autumn:
+ (day 46-50)
Tot.days = 5

Species no. 69

Fimaria hepatica (Batsch) Brumm., *Persoonia* 2: 322. 1962.

Description
Apothecia aggregated, superficial to semi-immersed, 2,5 - 3,1mm [1 - 3(-4)mm] in diameter, receptacle closed to discoid, purple brown to reddish, smooth, marginate. Disk concave to flat, with protruding ascus tips. *Asci* broadly cylindrical, rounded at the apices and short stiped, eight-spored, non-amyloid, 167 - 189 x 18,3 - 23,4μm [170 - 200 x 19 - 25μm]. *Ascospores* uniseriately arranged, ellipsoid, hyaline to pale brown, smooth, 23,4 - 33,4 x 9,8 - 12,2μm [22 - 35(-38,5) x 10 - 13μm]. *Paraphyses* septate, cylindrical, hyaline, simple to branched, inflated at the apices.

Distribution
U.K., Belgium, France, Germany, Poland, U.S.A., Czechoslovakia, South Africa (RSA).

Habitat
On mouse, rabbit, sheep and elephant dung.

Season (RSA): Autumn.
Successional position (RSA): Day 40 - 43.
Successional phase (RSA): 3.
Occurrence: Fairly common in the northern hemisphere.
Overall importance value (RSA): 0,06

Discussion
Measurements in square brackets are from van Brummelen (1962). The South African specimens fall within the accepted species limits. The species has a relatively wide distribution throughout Europe but is for the first time recorded in the Southern Hemisphere. It seems to inhabit a limited variety of mostly wild animal dung substrates. In South Africa it occurred on elephant dung during the autumn months. Apothecia appeared 40 days after the onset of incubation and lasted for only 4 days.

Fungal duration and seasonal occurrences

Elephant Dung
Autumn:
++ (day 40 - 43)
Tot. days = 4

Species no. 70

Iodophanus carneus (Pers.) Korf apud Kimbr. & Korf.*Amer. J. Bot.* 54: 18. 1967.

Description
Apothecia scattered to aggregated, globose when young, finally lenticular to discoid with protruding asci, pale yellow-orange, 920 - 1130 µm [1000 - 2000 µm] in diameter. *Excipulum* cells subglobose to elongate 10,7 - 12,2 x 19,1 - 20,3 µm [10 - 12 x 18 - 20 µm]. *Asci* cylindrical to clavate, rounded at the apices, shortly stipitate, amyloid, eight-spored, 148 - 235 x 26 - 41 µm [150 - 250 x 25 - 40 µm]. *Ascospores* bi-seriately arranged, hyaline, ellipsoid, tapering slightly towards the apices, thick walled when young, finally thin walled with a punctate episporium, 15,8 - 18,4 x 8,5 - 11 4 µm [15 - 20 x 7,5 - 10,5 µm] *Paraphyses* stout, septate, inflated above, guttulate.

Distribution
U.S.A., Austria, Mexico, New Zealand, U.K., Argentina, Venezuela, Africa and South Africa (RSA).

Habitat
On cow, deer, sheep, rabbit, muskrat, horse, bear, chicken and blue wildebeest dung.

Season (RSA): Winter.
Successional position (RSA): Day 21 - 24
Successional phase (RSA): 2A.
Occurrence: Common.
Overall importance value (RSA): 0,06
Figures: 105.

Discussion
Measurements in square brackets are from Kimbrough *et al.* (1969) The South African specimens fall well within the accepted species limits, although the asci and ascospores are slightly broader. This species is a common one with a wide distribution, however it is for the first time reported from Africa. It has been reported from the dung of both domesticated and wild animals. Most of the reports have been made from cow dung and therefore it seems as if the species has a preference for this substrate. In South Africa it occurred on blue wildebeest dung during the winter months. It reached its peak period between days 21 - 24. Apothecia appeared 21 days after the onset of incubation and lasted for 4 days.

Fungal duration and seasonal occurrences

Blue wildebeest Dung
Winter:
++ (Day 21-24)
Tot.days = 4

Species no. 71

Lasiobolus intermedius Bezerra & Kimbrough, *Can. J. Bot.* 53, 1218 - 1220, 1975.

Description
Apothecia aggregated, sessile, emarginate, setose, obconical to turbinate, light yellow to yellow, 300 - 465 µm [210 - 465 µm] in diameter. *Setae* arising from the lower and median apothecial regions, non-septate, rigid, smooth, pointed at the apices and slightly ventricose at the bases, 203 - 245 x 13 - 27 µm [200 - 522 x 12 - 30 µm]. *Excipulum* cells elongate, 9 - 21 x 3 - 6 µm [4 - 26 x 2,5 - 7 µm]. *Asci* cylindrical to clavate, rounded at the apices, stipitate, attenuate below, eight-spored, 132 - 171 x 13,6 - 18 µm [(90) 120 - 160 x 14 - 20 µm]. *Ascospores* uniseriately arranged, hyaline, ellipsoid, rounded at the apices, often collapsed at one

side, smooth, 14,4 - 15,8 x 9 - 11 μm [13 - 18 x 7,5 - 11,5 μm], each with a single de Bary bubble. *Paraphyses* hyaline, filiform, septate, simple to branched, slightly inflated at the apices.

Distribution
U.S.A., Canada, Switzerland, New Zealand, South Africa (RSA).

Habitat
On moose, horse, deer, elk, opossum, sheep, musk ox, porcupine and giraffe dung.

Season (RSA): Winter.
Successional position (RSA): Day 6 - 21
Successional phase (RSA): 1 & 2A.
Occurrence: Fairly common.
Overall importance value (RSA): 0,13
Figures: 106 - 108.

Discussion
Measurements in square brackets are from Bezerra & Kimbrough (1975). The South African specimens fall well within the accepted species limits. The species is a fairly common one with a wide distribution, however it is for the first time reported from Africa. It has been reported from the dung of both domesticated and wild animals and exhibits no substrate preference. In South Africa it occurred on giraffe dung during the winter months. It reached its peak period between days 9 - 15. In general apothecia appeared 6 days after the onset of incubation and lasted for up to 16 days.

Fungal duration and seasonal occurrences

Giraffe Dung
Winter:
½+ (day 6-8)
+++ (day 9-15)
+ (day 16-21)
Tot. days = 16
Peak days = 8

Species no. 72

Lasiobolus lasioboloides March., *Mem. Soc. Bot. Belgique,* 24, 68 - 69, 1885.

Description
Apothecia scattered to aggregated, sessile, emarginate, subglobose to pulvinate, whitish to yellow , setose, 225 - 355 μm [210 - 750 μm]. *Setae* arising from the lower and median apothecial regions, non-septate rigid,sharply pointed at the apices, non-ventricose at the base, smooth, 108 - 152 x 8,5 - 13,4 μm [(25-) 65 - 192 x 5 - 9 μm]. *Excipulum* cells elongated, 6 - 12 x 4,2 - 5,8 μm [4 - 14 x 4 - 6 μm]. *Asci* cylindrical to clavate, rounded at the apices, attenuate below, shortly stipitate, eight-spored, 81,5 - 89 x 18 - 30 μm [75 - 115 x 18 - 30 μm]. *Ascospores* bi-seriately arranged, hyaline, broadly ellipsoid to near subglobose, rounded at the apices, smooth, 14 - 15.8 x 8,8 - 10,9 μm [13 - 18 x 9 - 13,5 μm]. *Paraphyses* hyaline, filiform, septate, simple to somewhat branched, slightly inflated at the apices.

Distribution
U.S.A., Canada, Belgium, South Africa (RSA).

Habitat
On moose, deer, rat, elk, sheep, wapiti, goat and giraffe dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 5 - 28
Successional phase (RSA): 1, 2A & 2B.
Occurrence: Fairly scarce.
Overall importance value (RSA): 0,32
Figures: 109 - 110.

Discussion
Measurements in square brackets are from Bezerra & Kimbrough (1975). The South African specimens fall well within the accepted species limits although the setae are slightly broader. This species seems to be fairly rare and has a limited distribution. Until now it was reported only from the Northern Hemisphere. It has been reported on the dung of both domesticated and wild animals and exhibits no substrate preference. In South Africa it occurred on giraffe dung during the summer, autumn and winter months. Apothecia appeared 5 - 23 days after the onset of incubation and lasted for up to 15 days. This species seems to be predominantly a summer and autumn inhabitant on giraffe dung, however a single low intensity occurrence during the winter months was recorded. It appeared up to 18 days earlier in the summer than in the autumn. The summer peak period was reached 8 - 15 days and the autumn peak period 17 - 23 days after the onset of incubation. Both peaks were of the same intensity although the summer peak lasted longer.

Fungal duration and seasonal occurrences

Giraffe Dung		
Summer:	Autumn:	Winter:
½+ (day 15-18) + (day 5-7) ++ (day 8-15)	½+ (day 19-22) ++ (day 8-16)	½+ (day 9-21
Tot. days = 15 Peak days = 8	Tot. days = 10 Peak days = 9	Tot. days = 13

Species no. 74

Saccobolus beckii Hiemerl, *Jber.K.K.*, Ober-Realschule Bezirke Sechshaus Wien, 15, 18, 1889.

Description
Apothecia scattered to aggregated, superficial, sessile, subglobose to pulvinate, almost colourless, emarginate, with protruding asci, apothecia 310 - 450 µm [100 - 700 µm] in diameter. *Excipulum* composed of thin cylindrical hyphae, 2,4 - 3,4 µm [2 - 3,5 µm] in diameter. *Asci* broadly clavate, tapering to a thick base, truncate at the apices, eight-spored, amyloid, 127 - 161 x 41 - 46 µm [130 - 180 x 40 - 47 µm]. Compact elongate *spore clusters* 44,6 - 53,1 x 19,2 - 24,2 µm [42 - 60 x 18 - 24 µm] *Ascospores* ellipsoid-fusiform, black, slightly ventricose, 20,1 - 22,6 x 11,8 - 13,3 µm [17,5 - 23 x 8,5 - 10(-12) µm] with coarse rather thick warts 1.1 - 2,8 µm [1 - 3 µm] in diameter. *Paraphyses* hyaline, simple to branched, septate, cylindrical.

Distribution
Austria, Germany, U.K., Bermuda, Brazil, South Africa (RSA).

Habitat
On cow, deer, elephant and zebra dung.

Season (RSA): Summer.
Successional position (RSA): Day 7 - 36
Successional phase (RSA): 1, 2A, 2B & 3.
Occurrence: Uncommon.
Overall importance value (RSA): 0,25
Figures: 111 - 113.

Discussion
Measurements in square brackets are from van Brummelen (1967). This species is not a common one and exhibits a rather limited distribution pattern. The South African specimens fall well within the accepted species limits. The species is recorded for the first time in Africa. It occurred on elephant and zebra dung during the summer months and appeared on elephant dung 32 days and on zebra dung 7 days after the onset of incubation and lasted for up to 27 days. It reached its peak period on zebra dung between days 12 - 20.

Fungal duration and seasonal occurrences

Elephant Dung	Zebra Dung
Summer:	Summer:
¼+ (day 32-36)	++ (day 7-11)
	+++ (day 12-20)
	++ (day 21-33)
	Tot. days = 27
Tot. days = 5	Peak days = 9

Species no. 75

Saccobolus glaber (pers. per Pers.) Lamb., *Fl. Mycol. Belg. Suppl.*, 1, 284, 1887.

Description
Apothecia scattered to aggregated, superficial, sessile, globose to pulvinate, golden-yellow to amber-coloured, smooth, emarginate, 160 - 710 µm [200 - 1000 µm] with protruding asci. *Excipulum* cells subglobose, 9.5 - 21 x 9,5 - 14 µm [10 - 22 x 9 - 15 µm]. *Asci* cylindric-clavate, curved, shortly stipitate, flattened at the apices, with a large operculum, eight-spored, amyloid, 148 - 231 x 27 - 46 µm [150 - 275 x 25 - 48 µm]. Compact elongated *spore-clusters*, 49 - 66 x 16 - 23 µm [50 - 68 x 16 - 25 µm] with a gelatinous sheath.
Ascospores fusiform-ellipsoid, with blunt apices, mature spores purplish-brown, smooth, with a few cracks, 19,3 - 24,4 x 9,7 - 14,1 µm [(19-) 22 - 29 x 8,5 - 14,5 µm] *Paraphyses* simple to branched, septate, irregularly cylindrical, inflated at the apices.

Distribution
Sweden, U.K., Netherlands, Belgium, France, Germany, Denmark, Poland, Czechoslovakia, Austria, Italy, Romania, Pakistan, India, Cuba, Indonesia, Tahiti, Canada, U.S.A., Bermuda, Jamaica, Republica Dominicana, Puerto Rico, Guatemala, Venezuela, Trinidad, Brazil, New Zealand, South Africa (RSA).

Habitat
On cow, horse, zebu, sheep, gnu (blue wildebeest), deer, bear, elephant and tortoise dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 15 - 55
Successional phase (RSA): 2A, 2B, 3 & 4.
Occurrence: Very common.
Overall importance value (RSA): 0,75
Figures: 114 - 116.

Discussion

Measurements in square brackets are from van Brummelen (1967). This species is truly a cosmopolitan one that exhibits an extremely wide distribution. The South African specimens fall well within the accepted species limits. The species has been reported from the dung of both domesticated and wild animals and exhibits no substrate preference. In South Africa the species occurred on blue wildebeest, elephant and tortoise dung throughout the year. It is recorded for the first time in South Africa on dung. The species seems to be a year round inhabitant, commonly occurring on blue wildebeest dung and rarely on elephant and tortoise dung. It reached its highest peak on blue wildebeest dung, during the winter months from day 33 - 55.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung	Tortoise Dung
Summer: + (day 15-24) ½+ (day 25-39) Autumn: ++ (day 24-25) + (day 26-29) Winter: ½+ (day 17-20) + (day 21-26) ++ (day 27-32) +++ (day 33-55) Tot. days = 66 Peak days = 23	Autumn: + (day 44-47) Tot. days = 4	Summer: +++ (day 15-25) ++ (day 26-32) ½+ (day 33-44) Tot. days = 30 Peak days = 11

Species no. 76

Saccobolus minimus Vel., *Monogr. Discom. Boh.*, 1, 370, 1934.

Description
Apothecia scattered to aggregated, superficial, sessile, globose to pulvinate, transparent to dark yellow, smooth, emarginate, 96 - 163 µm [100 - 200 µm] with protruding asci. *Excipulum* cells subglobose, 4,8 - 11,8 µm [5 - 12 µm]. *Asci* cylindric-clavate, gradually tapering to a stipe, truncate at the apices, eight-spored, amyloid, 47 - 54 x 13,9 - 15,6 µm [50 - 60 x 14 - 16 µm]. *Spore clusters* compact ellipsoid, 29,1 - 32,6 x 11,9 - 13,9 µm [29 - 33 x 12 - 15 µm] with a gelatinous sheath. *Ascospores* ellipsoid to fusiform, purplish-brown when mature, finely punctate to smooth, 11,3 - 13,2 x 5,4 - 6,3 µm [(10-) 11,5 - 13,5 x 5,5 - 6,5 (-7,5) µm]. *Paraphyses* simple, septate, filiform, not inflated at the apices.

Distribution
France, Germany, Czechoslovakia, Austria, Poland, Thailand, Hawaii, Canada, U.S.A., Ecuador, New Zealand, South Africa (RSA).

Habitat
On cow, goat, sheep, deer, burro, muskrat, cervid, horse, giraffe and zebra dung.

Season (RSA): Autumn.
Successional position (RSA): Day 40 - 52
Successional phase (RSA): 3 & 4.
Occurrence: Fairly common.
Overall importance value (RSA): 0,24
Figures: 117 - 119.

Discussion
Measurements in square brackets are from van Brummelen (1967). This species is a fairly common one, although it has not been extensively collected, probably due to the small size of the species, according to van Brummelen (1967). It exhibits a wide distribution and is possibly cosmopolitan in nature. The South African specimens fall well within the accepted species limits, although some of the apothecia and asci are slightly smaller. The species has been reported on the dung of both domesticated and wild animals and exhibits no substrate preference. In South Africa apothecia were found on giraffe and zebra dung during the autumn months and appeared 40 days after the onset of incubation. It reached its peak period between days 44 - 48. The species is reported for the first time from Africa.

Fungal duration and seasonal occurrences

Giraffe Dung	Zebra Dung
Autumn:	Autumn:
++ (day 40-43)	+ (day 40-43)
+++ (day 44-48)	+++ (day 44-46)
	+ (day 47-52)
Tot. days = 9	Tot. days = 13
Peak days = 5	Peak days = 3

Species no. 77

Saccobolus portoricensis Seaver, *North Am. Cup-Fungi*, 94, 1928.

Description
Apothecia scattered to aggregated, sessile, superficial, globose to discoid, emarginate, smooth, pale yellow-brown, 135,8 - 195μm [up to 1mm] in diameter, disc flat to convex, blackened by the protruding ascus tips. *Asci* eight-spored, clavate, tapering to a long stipe, apices truncate, 180 - 195 x 37 - 38μm [170 - 200 x 35 - 40μm]. *Spore clusters* oblong to subglobose, compact, opaque, 30 - 42 x 20 - 29μm [34 - 44 x 22 - 30μm]. *Ascospores* purple to brown, reticulated, with granulated pigment, 14,4 - 19,1 x 10,4 - 11,4μm [young spores 19 - 21 x 9 - 10μm; mature spores 15 - 17,5 x 10 - 12,5μm]. *Paraphyses* simple , septate, thin, yellow to orange in colour.

Distribution
Puerto Rico, South Africa (RSA).

Habitat
Unknown dung type in Puerto Rico, giraffe dung in South Africa.

Season (RSA): Summer.
Successional position (RSA): Day 5 - 15.
Successional phase (RSA): 1 & 2A.
Occurrence: Extremely rare.
Overall importance value (RSA): 0,1
Figures: 120 & 121.

Discussion
Measurements in square brackets are from van Brummelen (1967). The South African specimens seem to fit into the accepted species limits, although both the spore clusters and the ascospores are slightly smaller. The dung substrate of the type species is unknown, in South Africa apothecia occurred on giraffe dung during the summer months. It appeared 5 days after the onset of incubation and reached its peak period between days 8 -15.

Fungal duration and seasonal occurrences

Giraffe Dung
Summer:
+ (day 5-7)
++ (day 8-15)
Tot. days = 11
Peak days = 8

Species no. 78

Saccobolus verrucisporus Brumm., *Suppl. Persoonia*, 1, 198 - 199, 1967.

Description
Apothecia scattered to aggregated, superficial, sessile, receptacle subglobose to cylindrical, whitish to very pale purple, covered by hyphae, emarginate, disc flat to discoid, with protruding ascus tips, 171 - 215μm [130 - 200μm] in diameter. *Asci* broadly clavate, eight-spored, apices truncate, amyloid, 102 - 109 x 27 - 28μm [90 - 110 x 26 - 29μm]. *Spore clusters* elongated and compact, 35 - 37 x 15,5 - 16,4μm [33 - 39 x 14 - 16μm]. *Ascospores* dark purple, with coarse isolated warts, 15 - 19,5 x 9,9 - 11,3μm [14 - 16 x 8 - 9μm]; [15 - 18 x 7 - 10μm, (Bell 1983)]. *Paraphyses* thin, branched, translucent to pale violet.

Distribution
New Guinea, New Zealand, South Africa (RSA).

Habitat
On roe deer, cervid, goat, lagomorph, sheep and giraffe dung.

Season (RSA): Summer.
Successional position (RSA): Day 40 - 44.
Successional phase (RSA): 3.
Occurrence: Very rare.
Overall importance value (RSA): 0,06
Figures: 122 - 124.

Discussion
Measurements in square brackets are from van Brummelen (1967), except when otherwise indicated. The South African specimens seem to fit into the species limits as described by both van Brummelen (1967) and Bell (1983). The apothecia and the ascospores are larger than those reported on by van Brummelen (1967), but fit the rest of the species description. The ascospore dimensions correspond closely to those described by Bell (1983). Apothecia occur on both the dung of wild and domesticated animals, exhibiting no substrate preferences. It has a very limited distribution and is reported for the first time from Africa. In South Africa the fungus occurred on giraffe dung during the summer months, it appeared 40 days after the onset of incubation and lasted for up to 5 days.

Fungal duration and seasonal occurrences

Giraffe Dung
Summer:
++ (day 40-44)
Tot. days = 5

Species no. 79

Thelebolus crustaceus (Fuck.) imbr. in Kobayasi et al., *Ann. Report Inst. Fermentation, Osaka* 3: 49. 1967.

Description
Apothecia scattered to aggregated, superficial, sessile, 600 - 740µm [0,1 - 0,5mm] in diameter. Receptacle closed, opening slightly at maturity, subglobose to cupulate, non-setose, yellow-brown. *Asci* 10 - 14 [7 - 17, mostly 9 - 12] per ascocarp, broadly clavate and short stiped, multispored, non-amyloid with a distinct apical ring, 48 - 65 x 18,3 - 23,8µm [45 - 50 x 18 - 22µm]. *Ascospores* uniseriately arranged, ellipsoid, smooth, hyaline, 5,8 - 8,2 x 3,8 - 4,3µm [5 - 7 x 3,5 - 4,5µm]. *Paraphyses* filiform, septate and simple.

Distribution
Japan, New Zealand, Alaska, Germany, Africa and South Africa (RSA).

Habitat
On rabbit, dog, opossum, blue wildebeest, zebra, giraffe dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 7 - 55.
Successional phase (RSA): 1, 2A, 2B, 3 & 4.
Occurrence: Scarce.

Overall importance value (RSA): 0,54

Discussion

Measurements in square brackets are from Otani & Kanzawa (1970). The South African specimens fit well into the accepted species limits although some of the asci are slightly larger and some of the ascospores slightly longer. Bell (1983) also reported longer ascospores from New Zealand. The species has a limited distribution and is reported for the first time from Africa. It exhibited no substrate preferences in South Africa and occurred on blue wildebeest dung during the autumn, giraffe dung during the winter and on zebra dung during the summer months. The fungus reached its peak period during the summer months, between days 43 - 47 on zebra dung. It generally appeared 7 - 37 days after the onset of incubation and lasted for up to 35 days.

Fungal duration and seasonal occurrences

Blue wildebeest	Giraffe dung	Zebra dung
Autumn:	Winter:	Summer:
½+ (day 30-39)	+ (day 9-14)	½+ (day 7-11)
	++ (day 15-20)	++ (day 12-13)
	+ (day 21-24)	+++ (day 14-26)
		++ (day 27-33)
		½+ (day 34-42)
		++ (day 37-42)
		++++ (day 43-47)
		++ (day 48-55)
Tot. days = 10	Tot. days = 16	Tot. days = 55
	Peak days = 6	Peak days = 5

Species no. 80

Trichobolus sphaerosporus Kimbr., *Amer. J. Bot.*, 54(1), 21, 1967.

Description

Apothecia white, sessile, setose, closed when young, opens slightly when mature, 310 - 326µm [300 - 375µm] in diameter. *Setae* 20 - 25 in number, 121 - 158µm [110 - 160µm] long, pointed, 8,2 - 10,4µm [7 - 10µm] in diameter at the base, 3 - 4 septate. *Asci* ovate, non-amyloid, one multispored ascus per ascocarp, 130 - 148 x 152 - 181µm [125 - 150 x 150 - 200µm]. *Ascospores* > 2500 per ascus, globose to subglobose, 7 - 11 x 8,7 - 9,5µm [9 - 9,6 x 8,4 - 9µm]. *Paraphyses* filiform, branched, longer than the asci and embedded in mucus.

Distribution
U.S.A., New Zealand, Africa and South Africa (RSA).

Habitat
On deer, opossum and elephant dung.

Season (RSA): Winter.
Successional position (RSA): Day 18 - 19.
Successional phase (RSA): 2A.
Occurrence: Very rare.
Overall importance value (RSA): 0,03

Discussion
Measurements in square brackets are from Kimbrough & Korf (1967). The South African specimens fall with in the accepted species limits, although the ascospores tend to be slightly larger. Bell (1983) reported larger ascospores from New Zealand. The species has a limited distribution and is reported for the first time from Africa. It seems to be restricted to the dung of wild animals and in South Africa occurred on elephant dung during the winter months. It appeared 18 days after the onset of incubation and lasted for only 2 days.

Fungal duration and seasonal occurrences

Elephant Dung
Winter:
¼+ (day 18-19)
Tot. days = 2

3.2.1.5 Loculoascomycetes:

Species no. 82

Sporormiella australis (Speg.) Ahmed & Cain, *Can. J. Bot.*, 50, 434-435, 1972.

Description
Pseudothecia scattered, immersed to superficial, subglobose to pyriform, smooth, bare, black, 266 - 304 x 193 - 259µm [220 - 300 x 160 - 200µm]. Neck short, smooth , conical and black. *Peridium* thin and membranaceous. *Asci* eight-spored, subcylindrical, 124 - 147 x 17,5 - 19,8µm [120 - 150 x 17 - 21µm], rounded at the apices, broadest below the middle, abruptly contracted to form a short stipe. *Ascospores* obliquely bi- or tri-seriately arranged, four-celled,

dark brown when mature, 38,8 - 42,1 x 7,2 - 7,8μm [38 - 46 x 7 - 8μm], transversely septate, constrictions at the septa broad and shallow, easily separable into segments. Terminal cells slightly narrowing at the ends. Germ slit oblique. Perispore hyaline and gelatinous.

Distribution
Argentina, Canada, Europe, U.S.A., Mexico, New Zealand, Africa and South Africa (RSA).

Habitat
On burro, cow, deer, goat, horse, moose, rabbit, porcupine, sheep, giraffe and elephant dung.

Season (RSA): Summer and Winter.
Successional position (RSA): Day 36 - 60.
Successional phase (RSA): 3 & 4.
Occurrence : Fairly common.
Overall importance value (RSA): 0,17
Figures: 125 - 127.

Discussion
Measurements in square brackets are from Ahmed & Cain (1972). The South African specimens fall within the accepted species limits, although the pseudothecia of some specimens are slightly larger. The species has a wide distribution and is fairly common, however it is reported for the first time from Africa. It has been reported from the dung of both domesticated and wild animals and exhibits no substrate preferences. In South Africa fruit bodies occurred on the dung of elephant during the summer months and on giraffe dung during the winter months. The species appeared 36 - 54 days after the onset of incubation and lasted for up to 22 days. The peak period was reached between days 54 - 60 on giraffe dung. This species is related to *S. minima* and *S. intermedia* and possesses asci and ascospores which are intermediate in size between these two species (Ahmed & Cain 1972).

Fungal durations and seasonal occurrences

Elephant Dung	Giraffe Dung
Summer: + (day 36-49)	Winter: ++ (day 54-60)
½+ (day 50-57)	
Tot. days = 22	Tot. days = 7
Peak days = 14	

Species no. 83

Sporormiella isomera Ahmed & Cain, *Can. J. Bot.* 50: 445. 1972.

Description
Pseudothecia scattered, immersed to semi-immersed, subglobose to pyriform, smooth, black, 210 - 238 x 207 - 224μm [200 - 250μm] in diameter. Neck small, cylindrical to papilliform, smooth and black. *Peridium* thin and membranaceous. *Asci* eight-spored, subcylindrical, 124 - 151 x 13,2 - 14,8μm [120 - 160 x 13 - 15μm], rounded at the apices, broadest above the middle, narrowing to a short stipe. *Paraphyses* filiform, septate, longer than the asci. *Ascospores* obliquely bi-seriately arranged to uniseriate below, four-celled, cylindrical, dark brown when mature, 31,8 - 38,4 x 5,8 - 6,8μm [32 - 40 x 5,5 - 8μm], transversely septate, septa constrictions broad and deep, separating into segments, terminal cells narrower towards the ends. Germ slit near parallel with a kink near the middle, perispore gelatinous.

Distribution
Canada, Africa and South Africa (RSA).

Habitat
On moose, partridge, porcupine, rabbit, giraffe and blue wildebeest dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 16 - 41.
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Rare.
Overall importance value (RSA): 0,35
Figures: 128 - 130.

Discussion
Measurements in square brackets are from Ahmed & Cain (1972). The South African specimens seem to fit the description of this species best as it fits well into the accepted species limits, however the form of the pseudothecia differs slightly. The species has a very limited distribution as up to now it was only known from Canada. The fungus seems to be restricted to the dung of wild herbivores. In South Africa fruit bodies occurred on blue wildebeest dung during the summer and winter months and on giraffe dung during the autumn months. It reached its peak period between days 16 - 22 on giraffe dung and generally appeared 13 - 17 days after the onset of incubation, lasting for up to 25 days. The species can be distinguished from the closely related *S. minima* by the larger pseudothecia, larger asci, the gradual narrowing towards the lower end of the asci and the length of the ascospores (Ahmed & Cain 1972).

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Giraffe Dung
Summer: + (day 13-21)	Autumn:
++ (day 22-25)	+++ (day 16-22)
+ (day 26-31)	
Winter:	
++ (day 17-19)	
+ (day 20-25)	
½+ (day 26-41)	
Tot. days = 44	Tot. days = 7
Peak days = 7	

Species no. 84

Sporormiella minima (Auersw.) Ahmed & Cain, *Can. J. Bot.*, 50, 449 - 450, 1972.

Description
Pseudothecia scattered, immersed to semi-immersed, subglobose to subpyriform, smooth, dark brown, 115 - 223 x 85 - 125µm [100 - 200 x 90 - 120µm]. Neck smooth, black and papilliform. *Peridium* thin and membranaceous. *Asci* eight-spored, cylindrical to subcylindrical, 78 - 124 x 14 - 17,8µm [80 - 100 x 13 - 18µm], rounded at the apices, broadest part below the middle, contracted below to a short stipe. *Paraphyses* filiform, septate, as long as the asci. *Ascospores* obliquely bi or tri-seriately arranged, four-celled, cylindrical, dark brown when mature, 27,7 - 34,9 x 5,5 - 6,2µm [28 - 34 x 5 - 6µm], transversely septate, septa constrictions broad and deep, separate easily at the central septa, not as easily at the other septa. Terminal spore cells slightly narrower towards the ends. Germ slit near parallel with a kink near the middle, with a gelatinous perispore.

Distribution
Canada, Quebec, Mexico, U.S.A., U.K., New Zealand, Europe, Africa and South Africa (RSA).

Habitat
On bear, cow, deer, fox, goat, horse, moose, rabbit, sheep, giraffe, blue wildebeest, elephant, zebra, steenbok and tortoise dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 5 - 60.
Successional phase (RSA): 1, 2A, 2B, 3, & 4.
Occurrence: Fairly common.
Overall importance value (RSA): 3,21
Figures: 131 - 133.

Discussion

Measurements in square brackets are from Ahmed & Cain (1972). The South African specimens generally fit in with the accepted species limits, although a few of the specimens were slightly larger in most aspects. The species has a fairly wide distribution. It has been previously reported from the Southern Hemisphere (Bell 1983) but it is reported for the first time from Africa. It exhibits no substrate preferences and occurs on the dung of both wild and domesticated animals. In South Africa it occurred on the dung substrates of all the animals investigated throughout the year. It generally appeared between 5 - 37 days after the onset of incubation and lasted for up to 54 days. It reached its peak period on zebra dung between days 26 - 46.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Steenbok Dung	Tortoise Dung
Autumn: ++ (day 37-43) +++ (day 44-47) Winter: ++ (day 7-26) Tot. days = 21 Peak days = 4	Autumn: ++ (day 7-13) Tot. days = 7	Summer: +++ (day 5-32) Tot. days = 28

Elephant Dung	Giraffe Dung	Zebra Dung
Summer: ++ (day 36-57) ½+ (day 7-10) + (day 11-21) ½+ (day 22-36) Winter: +++ (day 18-38) + (day 39-44) Tot. days = 79 Peak days = 21	Summer: ++ (day 7-17) +++ (day 18-25) ++++ (day 26-54) +++ (day 55-60) ++ (day 5-8) +++ (day 9-24) ++++ (day 25-32) +++ (day 33-46) Autumn: +++ (day 9-12) ++++ (day 13-22) +++ (day 23-32) ++ (day 33-49) +++ (day 24-32) ++ (day 33-46) +++ (day 24-32) ++ (day 33-46) Winter: +++ (day 21-26) Tot. days = 189 Peak days = 47	Summer: +++ (day 15-32) ++ (day 33-42) +++ (day 43-46) Autumn: +++ (day 11-16) ++++ (day 17-44) +++++ (day 26-46) Winter: + (day 5-7) ++ (day 8-16) +++ (day 17-26) ++ (day 27-56) Tot. days = 139 Peak days = 21

Species no. 85

Sporormiella minimoides Ahmed & Cain, *Can. J. Bot.* 50: 450. 1972.

Description
Pseudothecia scattered, semi-immersed to nearly superficial, subglobose, smooth, dark brown, 178 - 250 x 132 - 158μm [180 - 240 x 100 - 150μm]. Neck small, papilliform, black. *Peridium* thin and membranaceous. *Asci* eight-spored, cylindrical, 103 - 113 x 16,6 - 19,9μm [90 - 110 x 16 - 20μm], rounded at the apices, broadest part at the middle, abruptly contracted to a short stipe. *Paraphyses* filiform, septate and longer than the asci. *Ascospores* obliquely bi or tri-seriately arranged, four-celled, cylindrical, dark brown when mature, 32,1 - 33,5 x 6 - 7,8μm [28 - 36 x 6 - 7μm], transversely septate, septa constrictions narrow and deep, segments separating easily. Terminal spore cells slightly narrower towards the ends. Germ slit oblique to diagonal, ascospores with a gelatinous perispore.

Distribution
Canada, Mexico, Africa and South Africa (RSA).

Habitat
On carnivore, fox, rabbit, wolf, elephant, blue wildebeest and zebra dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 4 - 50.
Successional phase (RSA): 1, 2A, 2B, 3 & 4.
Occurrence: Rare.
Overall importance value (RSA): 0,60
Figures: 134 - 136.

Discussion
Measurements in square brackets are from Ahmed & Cain (1972). The South African specimens fall well within the accepted species limits, although a few of the pseudothecia were slightly larger. It has a very limited distribution and is for the first time reported from the Southern Hemisphere. It seems to be restricted to the dung of wild animals. In South Africa it occurred on the dung of blue wildebeest, elephant and zebra throughout the year. It generally appeared 4 - 32 days after the onset of incubation and lasted up to 33 days. The species reached its peak period on blue wildebeest and zebra dung between days 32 - 46, during the autumn and summer months respectively.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung	Zebra Dung
Autumn:	Summer:	Summer:
+++ (day 32-46)	½+ (day 7-11)	++ (day 18-36)
	++ (day 12-21)	+++ (day 37-41)
	½+ (day 22-26)	+ (day 42-46)
	¼+ (day 4-10)	½+ (day 47-50)
	+ (day 11-17)	
	½+ (day 18-20)	
	Winter:	
	++ (day 15-20)	
Tot. days = 15	Tot. days = 43	Tot. days = 33
	Peak days = 16	Peak days = 5

Species no. 86

Sporormiella subtilis Ahmed & Cain, *Can. J. Bot.* 50: 459. 1972.

Description
Pseudothecia scattered, immersed to semi-immersed, subglobose, smooth, dark brown to black, 248 - 321 x 223 - 307µm [200 - 350µm in diameter]. Neck cylindrical, smooth and black. *Peridium* thin and membranaceous. *Asci* eight-spored, cylindrical to clavate, 142 - 151 x 12,3 - 14,2µm [120 - 160 x 12 - 14µm], rounded at the apices, broadest near the apex, gradually narrowing into a long stipe. *Paraphyses* filiform, septate, longer than the asci. *Ascospores* bi- or tri-seriately arranged above, uni- or bi-seriately arranged below, four-celled, cylindrical, dark brown when mature, 22,8 - 28,3 x 5,4 - 6,1µm [23 - 29 x 5,5 - 6,5µm], transversely septate, septa constrictions broad and deep, spore cells equal in width, terminal cells slightly longer than mid-cells and tapering towards the ends. Germ slit oblique to diagonal and ascospores with a gelatinous perispore.

Distribution
Canada, Mexico, Africa and South Africa (RSA).

Habitat
On burro, partridge, porcupine, rabbit and blue wildebeest dung.

Season (RSA): Summer.
Successional position (RSA): Day 33 - 55.
Successional phase (RSA): 2B, 3 & 4.
Occurrence: Rare.

Overall importance value (RSA): 0,19
Figures: 137 & 138.

Discussion
Measurements in square brackets are from Ahmed & Cain (1972). The South African specimens fall well within the accepted species limits. The species has a very limited distribution and is for the first time reported from the Southern Hemisphere. It seems to be restricted to the dung of wild animals. In South Africa the species occurred on blue wildebeest dung during the summer months. Fruit bodies appeared 33 days after the onset of incubation and lasted for up to 23 days. Fruiting reached its peak period between days 48 - 55.

Fungal duration and seasonal occurrences

Blue wildebeest Dung
Summer:
++ (day 33-47)
++++ (day 48-55)
Tot. days = 23
Peak days = 8

Species no. 87

Trichodelitschia microspora Ebersohn & Eicker, sp. nov.,*South Afr. J. Bot.* (in press) 1992.

Description
Pseudothecia scattered, immersed to semi-immersed, at times superficial, subglobose to pyriform, semi-transparent and membranaceous below the substrate, to black, opaque and coriaceous above the substrate, 98 - 158 x 58 - 150μm, with straight dark brown spiny appendages, restricted to the neck region, 50 - 60 x 5,4 - 9,5μm. *Peridium* cells, thin-walled, irregular to angular, dark brown, opaque, 8,8 - 12,7μm in diameter. *Asci* eight-spored, cylindrical, 108 - 162 x 11 - 15μm, rounded at the apices, narrowing below to form a long stipe. *Paraphyses* filiform, hyaline, septate, as long as the asci and 1,5μm in diameter. *Ascospores* obliquely uniseriately arranged, ellipsoid to oblong, dark brown when mature, 13 - 18 x 5 - 8μm, transversely uniseptate, constricted and separable at the septa. Spore cell apices with hyaline raised apophyses and germ pores, 3μm in diameter. Young ascospores with a thick gelatinous sheath, absent or very thin when mature. Mature ascospores with a dark exosporium, 1,5μm thick.

Distribution
Kruger National Park, South Africa (RSA).

Habitat
Giraffe dung.

Season (RSA): Summer.
Successional position (RSA): Day 32 - 46.
Successional phase (RSA): 2B & 3.
Occurrence: Known only from the type locality, South Africa.
Overall importance value (RSA): 0,1
Figures: 139 - 142.

Discussion
Measurements are from Ebersohn & Eicker (1991). This is a new species of the genus *Trichodelitschia* and is only known from the type locality. It occurred on giraffe dung during the summer months and appeared 32 days after the onset of incubation, lasting up to 15 days.

Fungal duration and seasonal occurrences

Giraffe Dung
Summer:
++ (day 32-46)
Tot. days = 15

Basidiomycetes:

Species no. 88

Coprinus cinereus (Schaeffer ex Fries) Gray, *A Natural Arrangement of British Plants*, 1, 634, 1821.

Description
Cap when young with fibrils and scales, conical to cylindrical, [10 - 50 x 6 - 30mm], expanding to 35 - 45mm [20 - 50mm] broad and smooth, whitish to smoky grey. *Gills* when young white in colour turning black at maturity. *Stem* 87 - 103 x 5mm [40 - 120 x 3 - 6mm], base thickened, narrowing towards cap, white. *Spores* brown, ellipsoid, central germ pore, 9,8 - 11, 6 x 5,7 - 6,6µm [9 - 12 x 6 - 7µm]. *Basidia* four-spored. *Marginal cystidia* globose to pyriform, [20 - 70 x 16 - 38µm]. *Facial cystidia* ellipsoid to cylindrical, [60 - 98 x 18 - 45µm]. *Veil* hyaline, filamentous hyphae.

Distribution
U.K., South Africa (RSA). (from the available literature).

Habitat
(RSA): Blue wildebeest, elephant, giraffe, zebra and tortoise dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 5 - 66.
Successional phase (RSA): 1 - 5.
Occurrence: Common.
Overall importance value (RSA): 2,13

Discussion
Measurements in square brackets are from Henderson; Orton & Watling (1979). The South African specimens fall well within the accepted species limits. In South Africa basidiocarps occurred on blue wildebeest, elephant, giraffe, zebra and tortoise dung throughout the year. They appeared 5 - 32 days after the onset of incubation and lasted for up to 49 days on the substrates. Fruiting reached its peak periods between days 23 - 35 on giraffe dung and between days 43 - 47 on tortoise dung.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Giraffe Dung	Zebra Dung
Summer:	Autumn:	Summer:
+ (day 7-12)	+ (day 10-15)	½+ (day 7-10)
+++ (day 13-18)	++ (day 16-22)	+ (day 11-13)
++ (day 19-55)	+++ (day 23-29)	½+ (day 14-18)
	++++ (day 30-35)	
Winter:		+ (day 15-20)
	+++ (day 16-22)	
+ (day 5-25)	++++ (day 23-28)	Autumn:
++ (day 26-53)		
+++ (day 54-66)	+ (day 10-15)	¼+ (day 16-20)
	+++ (day 20-23)	Winter:
	++++ (day 24-26)	
	++ (day 27-39)	++ (day 32-42)
		+ (day 43-46)
	Winter:	
	++ (day 6-8)	
	+++ (day 9-14)	
	++ (day 15-21)	
Tot. days = 111	Tot. days = 85	Tot. days = 38
Peak days = 19	Peak days = 14	Peak days = 11

Elephant Dung	Tortoise Dung
Summer:	Summer:
++ (day 22-31)	+++ (day 15-32)
+ (day 32-50)	++ (day 33-42)
	++++ (day 43-47)
Tot. days = 29	Tot. days = 33
Peak days = 10	Peak days = 5

Species no. 89

Coprinus curtus Kalchbrenner, *Grevillea*, 9: 138. 1881.

Description
Cap when young covered by a rust coloured veil, pubescent, ovoid, when mature expanding to 2,5 - 7mm [3-9mm] broad, white to clay coloured with scattered granules concentrated at the centre. *Gills* when young pale grey turning black at maturity. *Stem* 27 - 36 x 0,5 - 0,7mm [10 - 40 x 0,35 - 0,8mm], hyaline to white, pubescent to smooth. *Spores* dark brown, with small germ pores, ellipsoid, 9,8 - 10,2 x 4,9 - 5,8μm [10 - 11 x 5,5 - 6,2μm]. *Basidia* four-spored. *Marginal cystidia* collapsing. *Facial cystidia* absent. *Setules* present on cap, with swollen base. *Veil* clusters of subglobose yellow-brown cells.

Distribution
U.K., South Africa (RSA). (from the available literature).

Habitat(RSA): Giraffe dung.

Season (RSA): Autumn.
Successional position (RSA): Day 50 - 60.
Successional phase (RSA): 4.
Occurrence: Scarce.
Overall importance value (RSA): 0,06

Discussion
Measurements in square brackets are from Henderson; Orton & Watling (1979). The South African specimens fall well within the accepted species limits, although the spores tend to be slightly smaller in some specimens. In South Africa basidiocarps occurred on giraffe dung during the autumn months. They appeared 50 days after the onset of incubation and lasted for up to 11 days.

Fungal duration and seasonal occurrences

Giraffe Dung
Autumn:
+ (day 50-60)
Tot. days = 11

Species no. 90

Coprinus heptemerus Lange & Smith, *Mycologia*, 45: 751. 1953.

Description
Cap when young ovoid to subcylindrical and granular, convex with torn margin and striated when mature, 4 - 7 x 2 - 4mm [1 - 10 x 0,5 - 5mm], white to grey with pale buff to cinnamon-buff centre. *Gills* white-grey to black. *Stem* 20 - 43 x 0,5 - 1,3mm [5 - 50 x 0.1 - 1mm]. *Spores* pale brown, ellipsoid to elongated, 10,8 - 13,2 x 5,7 - 7,1μm [(11-)11,5 - 14,5 x (5-)6 - 7μm] with large eccentric germ pores. *Basidia* four-spored. *Marginal cystidia* subglobose to ellipsoid, [25 - 50μm] in diameter. *Facial cystidia* absent. *Setules* present on cap. *Veil* globose brown sphaerocysts.

Distribution
Widely distributed including U.K., New Zealand, South Africa (RSA).

Habitat
On rabbit, deer, sheep, cow, blue wildebeest, elephant, giraffe, zebra and steenbok dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 5 - 60.
Successional phase (RSA): 1 - 4.
Occurrence: very common.
Overall importance value (RSA): 2,01

Discussion
Measurements in square brackets are from Henderson; Orton & Watling (1979). The South African specimens fall within the accepted species limits. In South Africa basidiocarps occurred on blue wildebeest, elephant, giraffe, zebra and steenbok dung throughout the year. They appeared 5 - 52 days after the onset of incubation and lasted for up to 40 days. Fruiting reached its peak period during the summer months between days 25 - 46 on zebra dung.

Fungal duration and seasonal occurrences

Elephant Dung	Giraffe Dung	Zebra Dung
Summer:	Summer:	Summer:
+ (day 7-10)	¼+ (day 37-54)	+++ (day 32-42)
+++ (day 11-36)	+ (day 55-57)	++++ (day 43-46)
++ (day 37-43)		
	+++ (day 5-24)	++++ (day 25-41)
Autumn:	++ (day 25-32)	++ (day 42-46)
½+ (day 44-47)	Winter:	Autumn:
Winter:	¼+ (day 9-16)	++ (day 23-37)
	+ (day 17-22)	½+ (day 38-39)
½+ (day 7-31)	++ (day 23-38)	
++ (day 32-38)	½+ (day 39-47)	+ (day 52-60)
½+ (day 39-44)		
		Winter:
		+ (day 20-55)
Tot. days = 79	Tot. days = 88	Tot. days = 99
Peak days = 26	Peak days = 20	Peak days = 21

Blue wildebeest Dung	Steenbok Dung
Summer:	Autumn:
½+ (day 22-25)	½+ (day 9-19)
+ (day 26-35)	++ (day 20-32)
++ (day 36-41)	+ (day 33-48)
+++ (day 42-47)	
½+ (day 44-48)	
Tot. days = 31	Tot. days = 40
Peak days = 6	Peak days = 13

Species no. 91

Coprinus miser Karsten, *Bidrag till Kannendom af Finlands Natur och Folk*, 37: 236. 1882.

Description
Cap when young ellipsoid, rusty tawny in colour, [2 - 5 x 1 - 3mm], expanding to 3 - 6mm [2 - 8mm] broad, becoming greyish-buff and striated when mature. *Gills* pale grey to black. *Stem* smooth, white to pale grey, 15 - 30 x 0,5mm [5 - 40 x 0,1 - 0,5mm]. *Spores* honey-coloured, ellipsoid to slightly triangular in face view, with central germ pore, 7,4 - 8,1 x 5,2 - 5,5 x 5,9 - 8,2μm [7 - 9(-9,5) x 5 - 6 x 6 - 8μm]. *Basidia* four-spored. *Marginal cystidia* vesiculose to pyriform, [12 - 24μm]. *Facial cystidia* absent. *Cap cuticle* cells globose to ellipsoid, [12 - 24μm]. *Veil* absent.

Distribution
U.K., New Zealand, Finland, South Africa (RSA). (from available literature).

Habitat
On cow, horse, lagomorph, elephant, giraffe and zebra dung.

Season (RSA): Summer, Autumn and Winter.
Successional position (RSA): Day 4 - 66.
Successional phase (RSA): 1 - 5.
Occurrence: Fairly common.
Overall importance value (RSA): 0,53

Discussion
Measurements in square brackets are from Henderson; Orton & Watling (1979). The South African specimens fall within the accepted species limits. In South Africa basidiocarps occurred on elephant , giraffe and zebra dung throughout the year. They appeared 4 - 37 days after the onset of incubation and lasted for up to 44 days. Fruiting reached its peak period between days 37 - 47 during the summer months on giraffe dung.

Fungal duration and seasonal occurrences

Elephant Dung	Giraffe Dung	Zebra Dung
Winter:	Summer:	Winter:
¼+ (day 32-50)	+++ (day 4-36)	½+ (day 9-21)
½+ (day 51-53)	++++ (day 37-47)	
++ (day 54-59)		
½+ (day 60-66)	Autumn:	
	½+ (day 37-42)	
Tot. days = 35	Tot. days = 50	Tot. days = 8
Peak days = 6	Peak days = 11	

Species no. 92

Coprinus poliomalus Romagnesi, *Revue de Mycologie*, 10: 81. 1954.

Description
Cap when young ovoid to cylindrical, covered with floccose pubescence, expanding to 4,5 - 5,3mm [4 - 5mm] broad, becoming smooth and striated from the margin inwards. *Gills* whitish-grey to black. *Stem* 18 - 33 x 0,5mm [20 - 40 x 0,2 - 0,5mm], slightly attenuated towards cap, white to pale grey, slightly pubescent to striated. *Spores* sepia, ellipsoid to cylindrical ellipsoid, central germ pore, 7,2 - 8,6 x 3,4 - 4,2μm [7 - 9 x 3,7 - 4,5μm]. *Basidia* four-spored. *Marginal cystidia* cells ellipsoid. *Facial cystidia* absent. *Cap cuticle* cellular. *Veil* thick-walled globose to fusiform encrusted cells, [25 - 45 x 13 - 16μm].

Distribution
U.K., New Zealand, South Africa (RSA). (from available literature).

Habitat
On cow, cervid, blue wildebeest, elephant and zebra dung.

Season (RSA): Autumn and Winter.
Successional position (RSA): Day 17 - 38.
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Fairly common.
Overall importance value (RSA): 0,38

Discussion
Measurements in square brackets are from Henderson; Orton & Watling (1979). The South African specimens fall within the accepted species limits. In South Africa basidiocarps occurred on blue wildebeest and elephant dung during the autumn months and on zebra dung during the winter months. They generally appeared 17 days after the onset of incubation and lasted for up to 22 days. Fruiting reached its peak period during the autumn months between days 24 - 32 on elephant dung.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung	Zebra Dung
Autumn:	Autumn:	Winter:
½+ (day 17-19)	+++ (day 17-23)	+ (day 17-24)
+ (day 20-32)	++++ (day 24-32)	
	+++ (day 33-38)	
Tot. days = 16	Tot. days = 22	Tot. days = 8
Peak days = 13	Peak days = 9	

Species no. 93

Coprinus stellatus Buller apud Bisby, Buller & Dearness, *Fungi of Manitoba*, p. 119. 1929.

Description
Cap when young conical to cylindrical, expanding conically with a recurved margin, splitting stellately, yellowish white with a pale brown center. *Gills* white to dark grey. *Stem* attenuated towards the cap, pale brown to white, 35 - 59 x 1,5mm [40 - 70 x 1 - 2mm]. *Spores* ellipsoid, 8,3 - 10,2 x 4,5 - 5,1μm [8 - 10 x 4 - 5μm]. *Basidia* dimorphic. *Marginal cystidia* cylindrical [130 - 170 x 20 - 26μm]. *Facial cystidia* cylindrical [130 - 170 x 20 - 26μm]. *Setules* on cap pointed, [40 - 50μm] long.

Distribution
U.K., South Africa (RSA), North America, Europe. (from available literature).

Habitat
On cow, horse, blue wildebeest and elephant dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 24 - 68.
Successional phase (RSA): 2B - 6.
Occurrence: Fairly common.
Overall importance value (RSA): 0,53

Discussion
Measurements in square brackets are from Henderson; Orton & Watling (1979). The South African specimens fall within the accepted species limits. In South Africa basidiocarps occurred on blue wildebeest and elephant dung during the autumn months and on elephant dung during the summer months. They generally appeared 24 - 26 days after the onset of incubation and lasted for up to 43 days. Fruiting reached its peak period during the autumn months on blue wildebeest dung between days 32 - 38, and on elephant dung between days 24 - 38 and days 46 - 57.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Elephant Dung
Autumn:	Autumn:
½+ (day 26-31)	++ (day 24-38)
++ (day 32-38)	+ (day 39-45)
+ (day 39-68)	++ (day 46-57)
	+ (day 58-68)
	Summer:
	½+ (day 25-31)
	+ (day 32-37)
Tot. days = 43	Tot. days = 58
Peak days = 7	Peak days = 27

Species no. 94

Coprinus niveus (Persoon ex Fries) Fries, *Epicrisis Systematis Mycologici*, p. 246. 1838.

Description
Cap when young ellipsoid to ovoid, thickly white flocculose, [15 - 30 x 9 - 17mm], becoming campanulate, expanding to 18 - 45mm [20 - 40mm] broad with a split margin, grey and striated when mature. *Gills* pale grey to black. *Stem* slightly attenuated towards the cap, 55 - 87 x 3,5mm [30 - 90 x 3 - 6mm], white, more or less tomentose. *Spores* dark brown to black, ellipsoid to ovoid and slightly angular in face view, with a central germ pore, 16,8 - 18,4 x 8,5 - 12,5µm [15 - 19 x 8,5 - 10,5 x 11 - 13µm]. *Basidia* four-spored. *Marginal cystidia* globose. *Facial cystidia* vesiculose. *Veil* cells subglobose to ellipsoid, smooth.

Distribution
U.K., South Africa (RSA), New Zealand. (from available literature).

Habitat
On cow, horse, blue wildebeest and giraffe dung.

Season (RSA): Summer and Autumn.
Successional position (RSA): Day 20 - 46.
Successional phase (RSA): 2A, 2B & 3.
Occurrence: Common.
Overall importance value (RSA): 0,34

Discussion

Measurements in square brackets are from Henderson; Orton & Watling (1979). The South African specimens fall within the accepted species limits. In South Africa basidiocarps occurred on blue wildebeest dung during the summer months and on giraffe dung during the autumn months. They appeared generally 20 - 32 days after the onset of incubation and lasted for up to 27 days. Fruiting reached its peak period during the autumn months between days 26 - 31 on giraffe dung.

Fungal duration and seasonal occurrences

Blue wildebeest Dung	Giraffe Dung
Summer:	Autumn:
++ (day 32-42)	+++ (day 20-25)
+ (day 43-46)	++++ (day 26-31)
	++ (day 32-38)
	+ (day 39-46)
Tot. days = 15	Tot. days = 27
Peak days = 11	Peak days = 6

3.3 **Other fungal species**

3.3.1 Introduction

Apart from the already described species, the following species were also recorded on the different dung substrates (Table 2), but were not described as they are either not considered to be regular inhabitants of dung substrates or they could not be identified to species level. Included in this list are all the representatives of the Deuteromycotina. This does not imply that the ecological role, of this group is neglible, to the contrary - some of the representatives of the Deuteromycotina exhibited high overall importance values on the different dung substrates and may represent the conidial states of some of the coprophilous Ascomycetes and Basidiomycetes. However, the coprophilous nature of these fungi have not yet been truly established, and they are therefore treated as facultative coprophiles and are not included in the species descriptions. All of these species are represented in the following table:

Table 2. Other fungal species on dung substrates

Species	Substrates	O.I.V.	Phase
Deuteromycotina:			
Acremonium sp	Elephant, Zebra, Tortoise.	1,75	1 - 5
Aspergillus niger	Elephant.	0,51	1 - 4
Aspergillus glaucus gr.	Elephant, Steenbok.	0,3	1 - 2B
Aspergillus flavus gr.	Elephant.	0,31	1 - 3
Arthrobotrys oligospora	Giraffe.	0,36	2A - 4
Bahupaathra samala	Elephant, Giraffe, Zebra.	0,52	1 - 3
Chalara sp	Giraffe, Steenbok, Zebra.	0,91	1 - 3
Epicoccum purpuracens	Blue wildebeest.	0,04	4
Fusarium sp	Giraffe.	0,17	2A - 2B
Geotrichum candidum	Blue wildebeest, Zebra, Tortoise.	0,66	1 - 4
Gliomastix sp	Elephant.	0,15	5
Graphium calcioides	Blue wildebeest.	0,37	2B - 3
Penicillium sp (monoverticillata gr.)	Elephant.	0,05	1
Penicillium sp (biverticillata gr.)	Elephant	0,49	1 - 4
Phialophora sp	Blue wildebeest, Zebra, Steenbok.	1,09	1 - 3

Sporotrichum sp	Blue wildebeest, Giraffe.	0,39	1 - 4
Stachybotrys chartarum	Blue wildebeest, Elephant, Giraffe, Zebra.	0,92	1 - 3
Trichurus spiralis	Elephant.	0,22	2A - 4
Coelomycetes:			
Myrothecium verrucaria	Elephant.	0,22	3 - 5
Phoma sp	Elephant.	0,46	1 - 5
Zygomycotina:			
Actinomucor elegans	Elephant.	0,04	1 - 2B
Coemansia sp	Elephant.	0,1	2A - 3
Mucor sp	Blue wildebeest, Elephant, Giraffe.	0,27	1 - 2B
Rhizopus stolonifer	Elephant, Zebra.	0,38	1 - 3
Rhopalomyces sp	Elephant, Giraffe.	0,18	1 - 2A
Ascomycotina:			
Plectomycetes:			
Pseudeurotium sp	Elephant.	0,04	4
Loculoascomycetes:			
Botryosphaeria sp	Blue wildebeest.	0,05	3
Discomycetes:			
Peziza sp	Blue wildebeest, Zebra.	0,47	1 - 5

Basidiomycotina:			
Panaeolus sp	Giraffe.	0,05	4

3.3.2 Percentage occurrences

When the tabulated data were broken down into percentage occurrences, on the different dung substrates, the following results were obtained:

Elephant dung = 39%
Giraffe dung = 17,4%
Blue wildebeest dung = 17,4%
Zebra dung = 15,2%
Steenbok dung = 7%
Tortoise dung = 4%

The elephant dung substrate has a very high incidence of facultative coprophilous species compared to the other dung substrates. This can possibly be explained when the nature of elephant dung and the primitive nature of the digestive tract of the animal is taken into consideration. Elephant dung is extremely coarse, whole fruits, sticks and pieces of bark are easily discernible, thus rendering a dung type closer to compost than to faeces and a potentially nutrient rich and diverse substrate, resulting in an increase of the colonization possibilities of the substrate. The relatively primitive digestive system of the elephant allows for the rapid passage of the ingested foodstuffs. This is reflected in the high food intake and dung production (the average animal food intake is 250 kg fodder per day, resulting in the production of 100 kg dung (Smithers (1983). As a result of the rapid movement of the ingested fodder through the digestive system it is possible that a higher percentage of non-coprophilous fungal spores actually survives the passage through the animal gut, as the time spent in the digestive system, exposed to high temperatures and fluctuating pH values, is greatly reduced.
The relatively low percentage occurrences on steenbok and tortoise dung can be ascribed to the fact that these dung substrates were not collected as frequently as the other dung substrates investigated.

3.3.3 Ecological notes on the facultative coprophilous species.

3.3.3.1 Class Hyphomycetes

Species no. 1

Acremonium sp.

The representative of this genus was rather common on the elephant dung and was also recorded from fresh zebra and tortoise dung. The highest importance value was recorded on the elephant dung. It occurred during both the summer and winter months but reached its highest seasonal importance value during the summer. It occurred during all the successional phases. The species reached its highest importance value during phases 2B and 3, followed by a subpeak during phase 5. As it was impossible to identify the species involved it is not possible to come to any conclusions with regard to the coprophilous status of this species. The species exhibited the highest total overall importance value of all Hyphomycetes recorded on the different dung substrates. The following overall importance values were calculated:

Overall seasonal importance value	=	2,22
Overall substrate importance value	=	1,11
Overall successional importance value	=	1,92
Total overall importance value	=	1,75

Species no. 2

Aspergillus niger van Tieghem

This species was fairly rare and was only recorded from the elephant caecum and colon dung substrates. The species reached its highest importance value on the elephant colon dung substrate. It was present during both the summer and autumn months, but reached its highest importance value during the autumn season. It occurred during all the successional phases with the exception of phase 5, and reached its highest importance value during phase 1 with a subpeak during phase 3. As the species has been widely recorded on substrates other than dung and as it was not recorded on any of the fresh dung substrates investigated it can not be considered strictly coprophilous. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,64
Overall substrate importance value	=	0,32
Overall successional importance value	=	0,57
Total overall importance value	=	0,51

Species no. 3

Aspergillus sp. (glaucus group)

This species group was fairly rare and was recorded from the elephant caecum and colon dung substrates as well as a single recording from the steenbok fresh dung substrate. The representative was present during both the summer and autumn months, but reached its highest importance value during the autumn season. It occurred during successional phases 1 to 3 and reached its highest importance value during phase 1. As this group has been widely recorded on substrates other than dung, it can not be considered strictly coprophilous. The following overall importance values were calculated for the representative of this group:

Overall seasonal importance value	=	0,40
Overall substrate importance value	=	0,21
Overall successional importance value	=	0,30
Total overall importance value	=	0,30

The occurrence of the fungus on the fresh dung substrate of steenbok could be attributed to aerial contamination of the substrate, as all other representatives of the genus *Aspergillus* recorded were restricted to the digestive tract dung substrates and the spores of these species do not seem to be able to survive passage through the digestive tract.

Species no. 4

Aspergillus sp. (flavus group)

This species was fairly rare and was only recorded from the elephant caecum and colon dung substrates. It reached its highest importance value on the elephant caecum dung substrate. It was present during both the summer and autumn months, but reached its highest importance value during the autumn season. It occurred during successional phases 1 to 3 and reached its highest importance value during phase 1. As this group has been widely recorded on substrates other than dung and as it was not recorded on any of the fresh dung substrates investigated, it can not be considered as strictly coprophilous. The following overall importance values were calculated for the representative of this group:

Overall seasonal importance value	=	0,39
Overall substrate importance value	=	0,20
Overall successional importance value	=	0,35
Total overall importance value	=	0,31

The three representatives of the genus *Aspergillus* exhibit the following common characteristic concurrences:-
The representatives of the genus were restricted to the digestive tract dung substrates with the exception of a single occurrence on the steenbok fresh dung substrate of a representative of the *Aspergillus* glaucus group. Peak seasonal importance values were recorded during the autumn months and peak successional importance values were recorded during phase 1.

Species no. 5

Arthrobotrys oligospora Fresen.

This species occurred on the fresh dung substrate of giraffe. It was present during both the summer and autumn months, but reached its highest importance value during the autumn season. It occurred during successional phase 2A and 4 and reached its highest successional importance value during phase 3. As this species has been reported from substrates other than dung it can not be considered strictly coprophilous. The species is a predator of nematodes and forms fruitbodies concurent with the decline in the nematode population (Watling 1963). The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,48
Overall substrate importance value	=	0,23
Overall successional importance value	=	0,36
Total overall importance value	=	0,36

Species no. 6

Bahupaathra samala Subramanian & Lodha

This species is not all that common, but when present it tends to form dense colonies on parts of the substrate. *B. samala* was previously recorded from dung in India and probably is a true coprophilous fungus. It occurred on the fresh dung substrates of elephant and giraffe where it reached its highest importance value on the fresh dung substrate of giraffe. However, it also occurred on elephant colon and rectum dung substrates as well as on zebra rectum dung substrates. If all the above-mentioned substrates are taken into consideration, it reached its highest importance value on the elephant dung substrates. It fruited during all seasons, but reached its highest importance value during the summer months. This species occurred during successional phase 1 to 3 and reached it highest importance value during phase 2A. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,71
Overall substrate importance value	=	0,36
Overall successional importance value	=	0,48
Total overall importance value	=	0,52

Species no. 7

Chalara sp.

This was a fairly common species on both the rectal and fresh dung samples of giraffe and blue wildebeest. It also occurred on the steenbok dung substrate. The highest importance values were recorded on the fresh dung substrates of giraffe and blue wildebeest. The species was present during all seasons, but reached its highest importance value during the autumn

months. It occurred during phases 1 to 3 and reached its highest importance value during phase 2A. As this species could not be positively identified it is impossible to come to any conclusions regarding its coprophilous status. It was, however, quite common on the aforementioned substrates and occurred in both cases on both the rectal and fresh dung substrates, which could indicate a possible coprophilous nature. The following overall importance values were calculated:

Overall seasonal importance value	=	1,27
Overall substrate importance value	=	0,63
Overall successional importance value	=	0,84
Total overall importance value	=	0,91

Species no. 8

Epicoccum purpurascens Ehrenb.
This species is commonly found as a saprophyte, more rarely as a parasite, on grass and cereal seeds and plant material. It is a very common species but it is not usually recorded on dung substrates. The fact that the species did not occur on any of the fresh dung substrates, indicates that it is unlikely to be coprophilous. It occurred on the blue wildebeest rectum dung substrate during the autumn months in successional phase 4. The following overall importance values were calculated for this species:

Overall seasonal importance value	=	0,07
Overall substrate importance value	=	0,03
Overall successional importance value	=	0,03
Total overall importance value	=	0,04

Species no. 9

Fusarium sp.

This genus is well known from substrates other than dung and can thus not be considered as strictly coprophilous. The representative occurred on giraffe rectum and fresh dung substrates and reached its highest importance value on the latter. The species fruited during both the autumn and winter months, but reached its highest importance value during the winter season. It occurred during successional phases 2A and 2B and reached its highest importance value during phase 2A. As it was not possible to identify this representative to species level the precise coprophilous status can not be determined. The following overall importance values were calculated:

Overall seasonal importance value	=	0,23
Overall substrate importance value	=	0,12
Overall successional importance value	=	0,15
Total overall importance value	=	0,17

Species no. 10

Geotrichum candidum Link.

This is a relatively rare species that occurred on the fresh dung substrates of blue wildebeest, zebra and tortoise. It reached its highest importance value on the blue wildebeest dung substrate. It was present during both the summer and winter months, but reached its highest importance value during the winter season. The species occurred during all successional phases, except phase 5 and reached its highest importance value during phase 1. The perfect stage of this fungus is *Endomyces geotrichum* which belongs to the Hemiascomycetes. Only the non-ascosporic state (the conidial state) was reported in this case. The species is common in soil, dairy products, sewage and is thus not strictly coprophilous in nature. The following overall importance values were calculated:

Overall seasonal importance value	=	0,84
Overall substrate importance value	=	0,42
Overall successional importance value	=	0,73
Total overall importance value	=	0,66

Species no. 11

Gliomastix sp.

This species seems to be extremely rare on dung and was confined to the elephant colon dung substrate during the summer season and occurring only in phase 5 of the successional sequence. The following overall importance values were calculated:

Overall seasonal importance value	=	0,23
Overall substrate importance value	=	0,11
Overall successional importance value	=	0,11
Total overall importance value	=	0,15

Species no. 12

Graphium calcioides (Fr.) Cooke & Massee

The species seems to be restricted to the blue wildebeest dung substrates, and occurred on the above-mentioned rumen, rectum and fresh dung samples. It reached its highest importance value on the blue wildebeest rumen dung substrate. The species was present during both the summer and autumn months, but reached its highest importance value during the summer season. It occurred during successional phases 2B and 3 and reached its highest importance value during the 3rd phase. The following overall importance values were calculated:

Overall seasonal importance value	=	0,52
Overall substrate importance value	=	0,27

Overall successional importance value	=	0,32
Total overall importance value	=	0,37

Species no. 13

Penicillium sp. (group monoverticillata)

This *Penicillium* sp. seems to be extremely rare on dung substrates although it was not possible to identify the representative to species level, it seems to be restricted to the elephant digestive dung substrates. It was present on the elephant caecum dung substrate during the autumn season and was restricted to the 1st successional phase. This group was not recorded on any of the fresh dung substrates investigated, it is normally widely recorded on substrates other than dung and is consequently not strictly coprophilous in nature. The following overall importance values were calculated:

Overall seasonal importance value	=	0,07
Overall substrate importance value	=	0,04
Overall successional importance value	=	0,04
Total overall importance value	=	0,05

Species no. 14

Penicillium sp. (biverticillata group)

This *Penicillium* sp. seems to be extremely rare on dung and was restricted to the elephant digestive tract dung substrates. It was not possible to identify the representative to species level. It occurred on the elephant caecum and colon dung substrates and reached its highest importance value on the former substrate. It was only recorded during the autumn months. The species was present during successional phase 1 to 4 but reached its highest importance value during phase 1. The following overall importance values were calculated:

Overall seasonal importance value	=	0,60
Overall substrate importance value	=	0,29
Overall successional importance value	=	0,57
Total overall importance value	=	0,49

Representatives of both the mono- and biverticillata groups of the genus *Penicillium* exhibit the following concurrences:
The highest importance values were recorded on the elephant caecum dung substrate during the first successional phase and they were restricted to the autumn season.

Species no. 15

Phialophora sp.

The species could not be identified to species level, but was the second most common hyphomycete representative on the different dung substrates. It occurred on the blue wildebeest colon, rectum and fresh dung substrates as well as on the fresh dung substrates of zebra and steenbok. It reached its highest importance value on the fresh dung substrate of blue wildebeest and was present during both the summer and autumn months but reached its highest importance value during the summer season. It occurred during successional phases 1 to 3 and reached its highest importance value during phase 2A. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	1,42
Overall substrate importance value	=	0,71
Overall successional importance value	=	1,15
Total overall ecological importance value	=	1,09

Species no. 16

Sporotrichum sp.

The species occurred on the fresh dung substrates of blue wildebeest and giraffe, it reached its highest importance value on the former substrate. It was present during both the summer and winter months but reached its highest importance value during the summer season. The species occurred during successional phases 1 to 4 and reached its highest importance value during phase 2A, a recurrent sub-peak was also recorded during phase 3. It was not possible to identify this representative up to species level and consequently it is not possible to evaluate its coprophilous nature. Other species of the same genus have however been recorded on substrates other than dung. The following overall importance values were calculated:

Overall seasonal importance value	=	0,49
Overall substrate importance value	=	0,25
Overall successional importance value	=	0,43
Total overall ecological importance value	=	0,39

Species no. 17

Stachybotrys chartarum (Ehrenb.) Hughes

The species exhibited the third highest total overall ecological importance value within the Hyphomycetes and seems to be quite common. It occurred on the fresh elephant dung substrate, the rectum and fresh dung substrates of blue wildebeest, the fresh dung substrate of giraffe as well as the rectum and fresh dung substrates of zebra. The highest importance value was recorded on the fresh dung substrate of zebra. It was present during all the seasons but the

highest importance value was recorded during the winter season. It occurred during successional phases 1 to 3 and reached its highest importance value during phase 2A. The following overall importance values were calculated:

Overall seasonal importance value	=	1,22
Overall substrate importance value	=	0,61
Overall successional importance value	=	0,94
Total overall ecological importance value	=	0,92

Species no. 18

Trichurus spiralis Hasselbring

The species seems to be extremely rare on dung substrates and was only recorded on the elephant colon dung substrate during the summer season. It was present during successional phases 2A to 4 and reached its highest importance value during phase 3. The species was not once recorded on any of the fresh dung substrates investigated and it is known from substrates other than dung, consequently it can not be considered strictly coprophilous in nature. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,29
Overall substrate importance value	=	0,15
Overall successional importance value	=	0,23
Total overall ecological importance value	=	0,22

3.3.3.2 Class Coelomycetes

Species no. 19

Myrothecium verrucaria (Alb. & Schw. : Fr.) Ditmar

The species was extremely rare and exhibited a very limited distribution. It was recorded only once on the elephant colon dung substrate during the summer months. It is considered to be an opportunistic facultative coprophilous species as it was never recorded on any of the fresh dung substrates investigated. It occurred during successional phases 3, 4 & 5 but reached its peak period during phase 5. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,31
Overall substrate importance value	=	0,61
Overall successional importance value	=	0,20
Total overall importance value	=	0,22

Species no. 20

Phoma sp.

The representative of this genus was not a very common one and was restricted to the elephant dung substrate where it was recorded from the colon, rectum and fresh dung samples. It reached its highest substrate importance value on the elephant rectum dung substrate. The species was present during both summer and winter months, but reached its highest seasonal importance value during the summer season. It was not restricted to any specific successional phases and was recorded during all the phases. However, it reached its highest successional importance value during phase 5. This genus has been recorded from substrates other than dung and consequently the unidentified species can not be considered strictly coprophilous. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,62
Overall substrate importance value	=	0,33
Overall successional importance value	=	0,43
Total overall importance value	=	0,46

3.3.3.3 Class Zygomycetes

With the exception of the *Rhopalomyces sp.* all other representatives exhibited peak successional importance values during phase 1 (*Rhopalomyces sp.* peaked during phase 2A) and thus tend to follow the classical succession hypothesis of the so-called "sugar fungi" being the first to fruit on dung substrates.

Species no. mz6

Actinomucor elegans (Eidam.) C.R. Benjamin & Hesseltine

This fairly rare species occurred on the elephant colon dung substrate, the blue wildebeest fresh dung substrate and the giraffe rectum dung substrate, it reached its highest importance value on the latter dung substrate. It was present during all the seasons but reached its highest importance value during the autumn season. It occurred during successional phases 1 to 2B and reached its highest importance value during phase 2A. As this species has previously also been recorded from substrates other than dung it can not be considered strictly coprophilous in nature. The following importance values were calculated:

Overall seasonal importance value	=	0,39
Overall substrate importance value	=	0,20
Overall successional importance value	=	0,23
Total overall ecological importance value	=	0,27

Species no. 21

Coemansia sp.

This was an extremely rare species which occurred only on the elephant colon dung substrate, during the summer season. It occurred during successional phases 2A to 3 and reached its highest importance value during phase 2B. The species could not be positively identified and it is consequently not possible to discuss its coprophilous status. However, the fact that it was never recorded on any of the fresh dung substrates investigated, suggests that this representative does not normally occur on dung or only very rarely. The following overall importance values were calculated:

Overall seasonal importance value	=	0,13
Overall substrate importance value	=	0,07
Overall successional importance value	=	0,11
Total overall importance value	=	0,10

Species no. 26

Rhizopus stolonifer (Ehrenb. : Fr.) Vuill.

This species, relatively rare on dung substrates, occurred on the elephant caecum and colon dung substrates and on the zebra fresh dung substrate. The species was present during all the seasons, but its highest seasonal importance value was recorded during the summer season on the zebra fresh dung substrate. It occurred during successional phases 1 to 3 and reached its highest successional importance value during phase 1. As the species is very common on substrates other than dung it can not be considered to be strictly coprophilous in nature. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,52
Overall substrate importance value	=	0,26
Overall successional importance value	=	0,37
Total overall ecological importance value	=	0,38

Species no. 27

Rhopalomyces sp.

The species occurred on the elephant rectum dung substrate as well as the giraffe fresh dung substrate. It reached its highest substrate importance value on the elephant rectum dung substrate. The species was present during the summer and winter months, and its highest seasonal importance value was recorded during the summer season. It occurred during successional phases 1 and 2A and reached its highest successional importance value during phase 2A. As

representatives of the genus have been recorded on substrates other than dung it can not be considered to be strictly coprophilous in nature. The following overall importance values were calculated for the species:

Overall seasonal importance value	=	0,25
Overall substrate importance value	=	0,13
Overall successional importance value	=	0,16
Total overall ecological importance value	=	0,18

3.3.3.4 Class Plectomycetes

Species no. 32

Pseudeurotium sp.

This fungus could not be identified to species level and consequently no specific conclusions can be drawn as to its coprophilous nature. It occurred on the giraffe fresh dung substrate during the summer months and it was only present during successional phase 4. The following overall importance values were calculated:

Overall seasonal importance value	=	0,07
Overall substrate importance value	=	0,03
Overall successional importance value	=	0,03
Total overall ecological importance value	=	0,04

3.4 **Taxonomical conclusion:** Records

The taxonomical records were compiled using the available literature, it is however possible that some previous records are not known to the author. Representatives of the coprophilous Basidiomycetes were not taken into consideration as the available literature on the distribution of this fungal group is incomplete. Research on the coprophilous fungi in the Southern Hemisphere and Africa consists of only a few reports (Bell 1975 & 1983; Jeng & Krug 1977; Khan & Cain 1977; Krug & Khan 1989; Minoura 1969), as a result it is inevitable that every research report, at this stage, will add a number of species to the existing coprophilous species of Africa. The present research is only the second such project in South Africa. Previously Mitchell (1970) reported the following species on ostrich and Angora goat dung:

Ascobolus furfuraceus, Ascobolus immersus, Ascobolus stictoideus, Ascodesmis sphaerospora, Ascophanus granulatus, Arthrobotrys dactyloides, Cladosporium herbarum, Cephalosporium sp, Chaetomium sp, Coprinus stercorarius, Iodophanus carneus, Lasiobolus equinus, Mucor mucedo, Penicillium cyclopium, Pilobolus crystallinus, Podospora anserina, Podospora pleiospora, Saccobolus depauperatus, Sordaria humana, Sporormiella minima.

The following species were recorded for the first time in either the Southern Hemisphere, the African continent or South Africa as designated in Tables 3, 4 and 5.

3.4.1 Table 3. Records for the Southern Hemisphere (15 species).

Species	Dung Substrates
Plectomycetes	
Leuconeurospora pulcherrima	Blue wildebeest.
Pyrenomycetes	
Chaetomium aterrimum	Blue wildebeest.
Chaetomium homopilatum	Zebra.
Chaetomium convolutum cf.	Blue wildebeest.
Chaetomium robustum	Blue wildebeest.
Chaetomium chrispatum	Elephant.
Strattonia hansenii	Blue wildebeest.
Loculoascomycetes	
Trichodelitschia microspora	Giraffe.
Discomycetes	
Ascobolus degluptus	Giraffe.
Coprotus dextrinoideus	Zebra.
Coprotus marginatus	Giraffe.
Coprotus winteri	Elephant.
Fimaria hepatica	Elephant.
Lasiobolus lasioboloides	Giraffe.
Saccobolus portoricensis	Giraffe.

3.4.2 Table 4. Records for the African Continent (18 species).

Species	Dung Substrates
Pyrenomycetes	
Cercophora californica	Blue wildebeest & Giraffe.
Cercophora coprophila	Blue wildebeest.
Podospora apiculifera	Elephant.
Podospora globosa	Elephant.
Podospora similis	Elephant & Zebra.
Zygopleurage zygospora	Elephant.
Discomycetes	
Ascobolus albidus	Elephant.
Ascobolus hawaiiensis	Giraffe.
Cheilymenia theleboloides	Elephant & Giraffe.
Coprotus disculus	Zebra.
Coprotus glaucellus	Elephant & Giraffe.
Coprotus leucopocillium	Blue wildebeest & Giraffe.
Coprotus luteus	Blue wildebeest, Elephant & Giraffe.
Lasiobolus intermedius	Giraffe.
Saccobolus beckii	Elephant.
Saccobolus glaber	Elephant.
Saccobolus minimus	Giraffe.
Saccobolus verrucisporus	Giraffe.

3.4.3. Table 5. Records for South Africa (21 species).

Species	Dung Substrates
Plectomycetes	
Kernia nitida	Blue wildebeest & Elephant.
Pyrenomycetes	
Cercophora mirabilis	Elephant & Giraffe
Chaetomium bostrychodes	Giraffe
Podospora comata	Elephant, Giraffe & Zebra.
Podospora communis	Blue wildebeest & Zebra.
Podospora curvuloides	Blue wildebeest & Elephant.
Podospora ostlingospora	Zebra.
Sordaria brevicollis	Giraffe & Elephant
Sordaria fimicola	Elephant.
Sordaria macrospora	Elephant.
Loculoascomycetes	
Sporormiella australis	Elephant & Giraffe
Sporormiella isomera	Giraffe & Blue wildebeest
Sporormiella minimoides	Blue wildebeest, Elephant, Zebra
Sporormiella subtilis	Blue wildebeest
Discomycetes	
Ascobolus amoenus	Blue wildebeest, Elephant & Giraffe
Coprotus aurora	Elephant
Coprotus lacteus	Elephant & Giraffe
Thelebolus crustaceus	Blue wildebeest, Giraffe, Zebra
Trichobolus sphaerosporus	Elephant
Zygomycetes	
Pilobolus kleinii	Blue wildebeest, Elephant, Zebra & Steenbok.
Pilobolus longipes	Elephant & Zebra.

When the data on the new records are broken down into percentage occurrences on the different dung substrates, that had been collected with the same frequency, the following results were obtained:

Substrates	% Occurrence
Elephant dung	34,6%
Giraffe dung	28,4%
Blue wildebeest dung	22,2%
Zebra dung	13,6%

These results correspond exactly with the results on the species diversity hierarchy on the different dung substrates. The coprophilous fungi inhabiting the dung substrates of African game animals have not been fully investigated and further research in this area will undoubtedly lead to new records for the continent and the recording of either ecotypes or species new to science.

CHAPTER 4. ECOLOGICAL RESULTS AND DISCUSSIONS

4.1 General Introduction

Sir Napier Shaw once made the following statement: "Every theory on the course of events in nature is necessarily based on some process of simplification and is to some extent, therefore a fairy tale." Bearing this reality in mind, unravelling and understanding the ecology of the coprophilous fungi becomes both a daunting and a challenging task. Studying the ecology of any of the other groups of organisms in nature is to a certain extent "easier" as their representatives are to a large degree always visibly present and identifiable. The fungi however, "hide" for much of their life cycles inside the substrates they occupy, as largely unidentifiable mycelia. The ecologist endeavouring to study the fungi has to depend to a large extent on the presence of the fungal fruit bodies, present only for a relatively short time of the life cycles of the organisms, for identification purposes - this fact constitutes the exact type of simplification process as referred to by Sir Napier Shaw.
Bearing these restrictions in mind is essential when carrying out ecological research on the coprophilous fungi and especially so when drawing conclusions from the research data obtained. Understanding the processes that prompt the formation of fungal fruit bodies are essential. Therefore research with regard to the effects of environmental factors both favouring and limiting the production of fruit bodies on dung substrates are essential.

A number of research reports have been made in this regard as were discussed in the literature review. Environmentally limiting factors such as the influences of light, temperature, water availability, competition and pH values were addressed.
The coprophilous fungi as an independent, recognizable community exhibit certain ecological characteristics such as species diversities on the different dung substrates, substrate preferences, seasonality, fungal succession on the different dung substrates, the formation of species associations and general adaptations to the coprophilous life style that are reflected in their ecological amplitudes with regard to the limiting factors in their environment. These ecological aspects will be dealt with in detail in the text to follow.

4.2 Fungal species composition and species diversity on the different dung substrates

4.2.1 Introduction

The possibility that the food preferences, feeding habits and the type of digestive system of the different herbivorous animals, *Connochaetes taurinus* (Blue wildebeest), *Equus burchelli* (Burchell's zebra), *Loxodonta africana* (African elephant) and *Giraffa camelopardalis* (Giraffe) could have had on the coprophilous fungal species composition and species diversity on the different dung substrates, were investigated. Under normal environmental conditions, a high species diversity indicates homeostatic stability in the community, while a low species diversity may indicate stress or unstable situations, which may rapidly change to further successional stages. Consequently the species diversity of any community at any time may be indicative of ecological stress related syndromes on the one hand, or of a healthy stabilized ecological environment on the other hand, depending on the form of the species diversity curve at the time. When the number of species of a community is plotted against the importance values of the species, the general relationship takes the form of a concave curve. Stress often tends to flatten the curve as the number of rare species is reduced and dominance of a few common species, that are tolerant of, or adapted to, the stress factors increases (Odum 1971). This statement also holds true for coprophilous fungal communities.

The question therefore arises whether the feeding habits, food preferences and digestive systems of different herbivorous animals have any influence on the fungal species compositions and the fungal species diversities of the dung substrates of these animals.

Animals occurring in their natural environment

Connochaetes taurinus Burchell 1823 (Blue wildebeest).
Equus burchelli Gray 1824 (Burchell's zebra).
Loxodonta africana Blumenbach 1797 (African elephant).
Giraffa camelopardalis Linnaeus 1758 (Giraffe).

Animals in captivity

Loxodonta africana Blumenbach 1797 (African elephant).

These particular herbivorous animals were selected for the following reasons:

Connochaetes taurinus (Blue wildebeest)

Food	Feeding habit	Digestive system	Dung
96% grass 4% bark & browse (Attwell 1977) Partial to new growth on burnt areas. (Smithers 1983)	Non-selective short grass feeder. utilize a wide variety of grass spp up to 15 cm in height. (Smithers 1983)	Ruminant - highly effective digestor	Compact with a fine texture.

Equus burchelli (Burchell's zebra)

Food	Feeding habit	Digestive system	Dung
74% grass 13% Browse 12% Herbs 1% Sedges (Smuts 1972) Partial to new growth on burnt areas. (Smithers 1983)	Partly selective Select the plant parts to be utilized. (Smithers 1983) Tall grass feeder Graze from 15 cm upwards. (Smuts 1972)	Non - ruminant with a monogastric hind gut fermentation type digestive system.	Less compact and coarser than Blue wilde-beest.

Loxodonta africana (African elephant)

Food	Feeding habit	Digestive system	Dung
53% Browse 25% Grass 22% Herbs Williamson 1975 Fruit, bark, and roots are also utilized. Ratio varies according to the season & availability. (Smithers 1983)	Intermediate bulk feeder. Utilize a wide variety of plant Spp from grass root to tree top level. 170 - 300 Kg. green fodder per day. 100 kg dung 40% of intake is effectively digested. (Smithers 1983)	Non - ruminant with a monogastric hind gut fermentation type digestive system.	Extremely coarse, slightly compact. Composition: Differs from all other dung types.

Giraffa camelopardalis (Giraffe)

Food	Feeding habit	Digestive system	Dung
Varies with the seasons. Hot wet months: Deciduous browse Spp Hot dry months: Semi-deciduous & evergreen Spp Cool dry months: Evergreen Spp & mineralised soil supplements	Selective browser. Feeding between 2 to 5 meters above ground level. (Smithers 1983) (Hall-Martin 1974 and Langman 1978)	Ruminant - highly effective digestor	Very fine and compact.

4.2.2 Results

The species diversity and species composition of the different coprophilous fungal communities were determined according to the different dung substrates investigated. (Graph Figs. 1.1, 1.2, 2.1, 2.2 & Tables 6 & 8). As can be seen in Graph Figs. 1.1 and 1.2 all of the species diversity curves exhibit typical concave curvatures, when the number of species present are plotted against the substrate importance values. This indicates that on all four substrates there are a few common species with high substrate importance values and many rare species with low substrate importance values. This is a common community structure characteristic shared by all natural communities in homeostatic stable ecosystems, although the quantitative species abundance relationships can vary widely (Odum 1971). Therefore the species diversity curves, as exhibited by the four substrates in Graph Figs. 1.1 and 1.2 indicate that no meaningful, in these cases proposed, nutritional stress factors exist in the environment of the animals from which the dung substrates were collected. This is to be expected as the animals occur in their natural environment in the Kruger National Park, and are free to select the food they prefer and need.

On the other hand in Graph Figs 2.1 and 2.2 the flattened species diversity curve as exhibited by substrates, obtained from the National Zoological Gardens, indicates a possible, nutritional stress related situation in the environment of these specific animals. The species diversity curve exhibited by the other substrates, collected from the Mabula Game Reserve, in Graph Figs. 2.1 and 2.2 prove to be similar to those exhibited in Graph Figs. 1.1 and 1.2 and thus indicates that no meaningful nutritional stress factors exists in the environment of the animals.
The elephant dung substrates exhibiting the flattened curve were collected from animals in captivity (in the National Zoological Gardens, Pretoria). These animals are fed artificial and non-natural food substances, such as commercially produced fodder (lucerne), fruit and vegetables, as well as a limited variety of natural foods. The animals are not free to select their own food sources and the food they utilize have been grown commercially and were subjected to various forms of herbicides and insecticides. Furthermore, there was a total lack of any species belonging to the class Discomycetes on all the dung substrates investigated over a period of three years (see Table 6.). This fact tends to underline the above given explanation of the marked drop in the fungal species diversity of these dung substrates. At the same time the other elephant dung substrates depicted in Graph Figs. 2.1 and 2.2 exhibit a typical concave species diversity curves, these substrates were collected from free roaming animals, occurring in their natural habitat, in the Mabula Game Reserve. Furthermore, a relatively large number of species belonging to the class Discomycetes were recorded from these substrates. On the latter substrates there were consequently no indication of similar nutritional related stress factors.
The fact that the fungal inocculum on the dung substrates obtained from the captive animals could have been lower as a result of the circumstances under which the fodder was produced can not be ignored.

Table 6. Fungi occurring on elephant dung collected at Mabula Game Reserve and the National Zoological Gardens, Pretoria.

Fungal Class	Species Mabula Substrate	Species Zoo Substrate
Hyphomycetes	Graphium calcioides	Graphium calcioides
		Stachybotrys chartarum
Coelomycetes	None	Phoma sp
Zygomycetes	Pilobolus crystallinus	Pilobolus longipes
		Actinomucor elegans
Plectomycetes	Kernia nitida	Kernia nitida
Pyrenomycetes	Podospora anserina	Podospora anserina
	Podospora apiculifera	Podospora communis
	Podospora comata	Sordaria fimicola
	Podospora globosa	
	Sordaria fimicola	
	Zygopleurage zygospora	
Loculo - ascomycetes	Sporormiella minima	Strattonia sp.1
	Strattonia sp.1	
	Strattonia sp.2	

Discomycetes	Ascobolus albidus	None
	Ascobolus immersus	
	Ascobolus stictoideus	
	Coprotus disculus	
	Coprotus leucopocillium	
	Coprotus winteri	
	Iodophanus carneus	
	Lasiobolus lasioboloides	

4.2.3 Observations on the species diversity of the substrates

It thus seems possible to use the species diversity curves, Graph Figs. 1.1, 1.2, 2.1 & 2.2, or species diversity indices of the coprophilous fungal communities as early indicators of nutritionally related or other stress syndromes in animals kept in captivity or stressed environments. Further investigations are however needed.

Other observations can be made from the data as illustrated in Graph Fig.1.1 & 1.2. The species diversity curves of the different dung substrates are not at equal levels as the substrates were collected from different animal species. It is thus possible to classify the different animal dung substrates according to the individual species diversities as illustrated in the graphs.

4.2.3.1 Elephant dung

This substrate exhibited the highest species diversity. This phenomenon can be explained if the feeding habit and the food preferences of the animal are taken into consideration. The feeding habit of the animal ensures that it obtains its food from virtually all possible feeding levels (from grass roots to tree tops). The animal utilizes an extremely wide variety of plant species and is to a large degree a non-selective bulk feeder. Consequently the ingestion of the largest possible variety and mass of fungal spores is inevitable, resulting in an extremely high fungal species diversity on the dung substrate.

4.2.3.2 Giraffe dung

This substrate exhibited the second highest species diversity. This can be attributed to a number of reasons, the giraffe is highly selective with regard to preferred browse during the different seasons. As a result a large variety of plant species at different feeding levels are util-

ized. The animal's feeding habit is such that it feeds at different feeding levels, from approximately 2 - 5 meters in height, this invariably brings it into contact with a wide, but nevertheless relative specific, variety of fungal spores. The giraffe dung substrate has the highest percentage of rare coprophilous fungal species, in relation to the other substrates investigated. Some species seems to be restricted to this substrate (species of the genus *Lasiobolus*) and a number of extremely common species (species of the genus *Pilobolus*) is very poorly represented on the giraffe dung. This can be attributed to the fact that the relatively large wet spore types probably do not travel the distance required to place it within reach of the normal feeding levels of the animal. It seems as if the smaller, dry or dried out, aerial dispersed spores of some of the coprophilous fungal species are more readily available for ingestion, as they are easily dispersed to the required feeding levels. All of the results on this dung substrate, exhibiting the second largest species diversity of all substrates investigated and at the same time having a unique species composition, seem to correlate with the findings of Bell (1975) on the existence of a recognizable forest canopy fungus flora.

4.2.3.3 Blue wildebeest dung

This substrate exhibits the third highest species diversity. The animal is strictly a non-selective short grass feeder, feeding up to approximately 15 cm. in height from ground level. This feeding habit brings the animal in contact with relatively specialized coprophilous fungal spore types, the heavier wet spores. Its non-selective feeding habit, on the other hand, ensures that it utilizes a wide variety of grass species, and this causes it to come into contact with a large number of fungal spores. As a result the blue wildebeest dung substrate has a higher species diversity and, to a certain extent, a different species composition than that of the zebra dung substrate.

4.2.3.4 Zebra dung

This substrate has the lowest species diversity of all the substrates investigated. This animal is predominantly a partly selective tall grass feeder, not feeding lower than approximately 15 cm from ground level. This feeding habit will restrict the number of fungal spores ingested, as some of the coprophilous fungi do not discharge their spores up to the animals feeding level. This was proven in the case of the genus *Pilobolus*, where the species with shorter sporangiophores, *P.crystallinus* and *P.kleinii* were present at lower substrate importance values than that of the larger *P.longipes*. The reverse situation was observed on the substrates obtained from the short grass feeder, blue wildebeest. Furthermore, it feeds more selectively than the blue wildebeest, selecting and cutting the grass instead of cropping it. Therefore the possibility of ingesting fungal spores is reduced, in comparison with the blue wildebeest.
Similarity (SI.) and dissimilarity (DI.) indices were calculated for the different dung substrates using the similarity index of Ellenberg (Mueller-Dombois & Ellenberg 1974). The results are illustrated in Table 7 where the DI.values are depicted in the top right hand part of the matrix and the SI. values are depicted in the bottom left hand part of the matrix.

Table 7. Similarity and Dissimilarity indices

SI. / DI.	Elephant	Giraffe	B. wilde-beest	Zebra
Elephant	----	71%	71%	62%
Giraffe	29%	----	75%	74%
B. wildebeest	29%	25%	----	57%
Zebra	38%	26%	43%	----

As can be seen from the matrix the greatest similarity was recorded between zebra and blue wildebeest dung. This was to be expected as both these animals are grazers and they obtain their food in a relatively narrow range, from ground level to approximately 1 meter in height. The degree of dissimilarity can be attributed to the fact that their respective feeding levels only overlap marginally and their feeding habits differ markedly.

The greatest dissimilarity was recorded between the blue wildebeest and giraffe dung substrates. This was to be expected as the feeding levels, the feeding habits and the preferred food substances of these animals differ greatly. The degree of similarity can be attributed to the presence of the more common fungal species and the fact that giraffes do ingest mineralised soil substances during the winter months as part of their diet.

The elephant dung substrate occupies an intermediate position since the same degree of dissimilarity with the giraffe and blue wildebeest dung substrates was recorded. This can be attributed to the fact that the elephant dung substrate differs markedly in composition from that of all the other dung substrates as a result of the feeding habit, type of digestive system and food ingested by elephants. The degree of similarity can be attributed to the the fact that the elephant feeding level overlaps to a very large degree with that of all the other animal species investigated.

The results obtained from calculating the similarity and dissimilarity values were tested for validity using Chi square (X^2) tests. The following correlations were obtained:

Elephant dung in comparison to all other dung:

X^2 values	Giraffe	B. wildebeest	Zebra
Elephant	$X^2 = 2,07$	$X^2 = 2,68$	$X^2 = 0,17$

$X^2 = 1,32$ at $P = 0,25$ and $X^2 = 2,71$ at $P = 0,1$; thus the probability that the differences between the elephant and giraffe / blue wildebeest dung substrates can not be attributed to a random fungal species distribution is 10 - 25%.

$X^2 = 0,102$ at $P = 0,75$ and $X^2 = 0,455$ at $P = 0,5$; thus the probability that the difference between the elephant and zebra dung substrates can not be attributed to a random fungal species distribution is 50 - 75%.

Giraffe dung in comparison to all other dung:

X^2 values	Elephant	B. wildebeest	Zebra
Giraffe	$X^2 = 2,07$	$X^2 = 0,94$	$X^2 = 2,36$

$X^2 = 1,32$ at $P = 0,25$ and $X^2 = 2,71$ at $P = 0,1$; thus the probability that the differences between the giraffe and elephant / zebra dung substrates can not be attributed to a random fungal species distribution is 10 - 25%.

$X^2 = 0,016$ at $P = 0,9$ and $X^2 = 0,102$ at $P = 0,75$; thus the probability that the difference between the giraffe and blue wildebeest dung substrates can not be attributed to a random fungal species distribution is 75 - 90%.

Blue wildebeest dung in comparison to all other dung:

X^2 values	Elephant	Giraffe	Zebra
B. wildebeest	$X^2 = 2,68$	$X^2 = 0,94$	$X^2 = 1,27$

$X^2 = 1,32$ at $P = 0,25$ and $X^2 = 2,71$ at $P = 0,1$; thus the probability that the difference between the blue wildebeest and elephant dung substrates can not be attributed to a random fungal species distribution is 10 - 25%.

X^2 = 0,016 at P = 0,9 and X^2 = 0,102 at P = 0,75; thus the probability that the difference between the blue wildebeest and giraffe dung substrates can not be attributed to a random fungal species distribution is 75 - 90%.

X^2 = 0,455 at P = 0,5 and X^2 = 1,32 at P = 0,25; thus the probability that the difference between the blue wildebeest and zebra dung substrates can not be attributed to a random fungal species distribution is 25 - 50%.

Zebra dung in comparison to all other dung:

X^2 values	Elephant	Giraffe	B. wildebeest
Zebra	X^2 = 0,17	X^2 = 2,36	X^2 = 1,27

X^2 = 0,102 at P = 0,75 and X^2 = 0,455 at P = 0,5; thus the probability that the difference between the zebra and elephant dung substrates can not be attributed to a random fungal species distribution is 50 - 75%.

X^2 = 1,32 at P = 0,25 and X^2 = 2,71 at P = 0,1; thus the probability that the difference between the zebra and giraffe dung substrates can not be attributed to a random fungal species distribution is 10 - 25%.

X^2 = 0,445 at P = 0,5 and X^2 = 1,23 at P = 0,25; thus the probability that the difference between the zebra and blue wildebeest dung substrates can not be attributed to a random fungal species distribution is 25 - 50%.

The results of the Chi square tests underscores, to a certain degree, the deductions made from the calculations of the similarity and dissimilarity indices and the results obtained from the species diversity curves.

4.2.4 Observations on the species composition of the substrates

The species composition of any substrate is regarded as being very specific and the result of any number of ecological, physiological and genetical forces working together to bring about the specific species composition. A coprophilous species may have different ecological requirements in various parts of its distribution area, some coprophiles have undoubtedly evolved ecotypes. Furthermore, the frequency of the fungi better illustrates their substrate preference than does the number of substrates (Lundqvist 1972).

4.2.5 Observations on substrate fidelity:

With regard to substrate fidelity the following five classes were distinguished for each substrate, using the data as set out in Table 8.

Exclusive species: These species are limited to the specific substrate.

Combined species: These species are shared between two different substrates and have a positive correlation as far as the animal feeding habits or the types of digestive systems are concerned.

Selective species: These species have a definite preference for one substrate but at the same time have a low presence on another substrate.

Preferential species: These species occur on different substrates but reach an optimum importance value on a specific substrate.

Indifferent species: All other species that occur on a substrate are regarded as either common species or accidental species.

If a species was placed in the combined species category and also qualified for any of the other categories it was given preference as a Combined species and was thus not noted in any of the other categories. Only the "obligatory coprophilous" species were taken into account and species previously recorded from substrates other than dung were ignored. Only the present research data was taken into account in distinguishing the appropriate fidelity classes, and previous recordings on other dung substrates were not implemented in these categories. These fidelity classes determine to a large extent the species composition of any specific substrate.

4.2.5.1 Fidelity classes of the elephant dung substrate:

Exclusive species:
Sordaria macrospora, Coprotus aurora, Coprotus winteri, Fimaria hepatica, Trichobolus sphaerosporus.

Combined species (on accord of the type of digestive system):
Pilobolus longipes, Podospora anserina, Podospora similis, Saccobolus beckii.

Combined species (on accord of the feeding habit):
Podospora comata, Sordaria brevicollis, Sporormiella australis, Cheilymenia theleboloides, Coprotus glaucellus, Coprotus lacteus.

Selective species:
Cercophora mirabilis, Coprinus stellatus.

Preferential species:
Ascobolus amoenus, Coprinus poliomalus.

Indifferent species: See Table 8.

4.2.5.2 Fidelity classes of the giraffe dung substrate:

Exclusive species:
Ascobolus degluptus, Ascobolus hawaiiensis, Coprotus marginatus, Lasiobolus intermedius, Lasiobolus lasioboloides, Saccobolus portoricensis, Saccobolus verrucisporus, Coprinus curtus, Paneolus sp.

Combined species (on accord of the type of digestive system):
Cercophora californica, Sporormiella isomera, Coprotus leucopocillium.

Combined species (on accord of the feeding habit):
Podospora comata, Sordaria brevicollis, Sporormiella australis, Cheilymenia theleboloides, Coprotus glaucellus, Coprotus lacteus.

Selective species: None

Preferential species:
Sporormiella minima, Ascobolus stictoideus, Coprotus luteus, Coprinus cinereus, Coprinus miser.

Indifferent species: See Table 8.

4.2.5.3 Fidelity classes on the blue wildebeest dung substrate:

Exclusive species:
Cercophora coprophila, Strattonia hansenii, Sporormiella subtilis, Iodophanus carneus.

Combined species (on accord of the type of digestive system):
Cercophora californica, Sporormiella isomera, Coprotus leucopocillium.

Combined species (on accord of the feeding habit):
Podospora communis, Peziza sp

Selective species:
Kernia nitida, Saccobolus glaber.

Preferential species:
Pilobolus kleinii.

Indifferent species: See Table 8.

4.2.5.4 Fidelity classes on the zebra dung substrate:

Exclusive species:
Podospora ostlingospora, Podospora pleiospora, Coprotus dextrinoideus, Coprotus disculus.

Combined species (on account of the type of digestive system):
Pilobolus longipes, Podospora anserina, Podospora similis, Saccobolus beckii.

Combined species (on account of the feeding habits):
Podospora communis, Peziza sp.

Selective species:
Saccobolus minimus.

Preferential species:
Podospora curvuloides, Ascobolus immersus, Thelebolus crustaceus, Coprinus heptemerus.

Indifferent species: See Table 8.

Table 8: Substrate importance values.

Fungal species	Substrate importance values.			
	Elephant Dung	Giraffe Dung	Blue wilde beest Dung	Zebra Dung
Deuteromycotina:				
Acremonium sp.	4.89	----	----	0.89
Aspergillus niger	1.93	----	----	----
Aspergillus (glaucus gr.)	1.07	----	----	----
Aspergillus (flavus gr.)	1.17	----	----	----
Arthrobotrys oligospora	----	1.36	----	----
Bahupaathra samala	1.24	0.67	----	0.24
Chalara sp.	----	2.11	----	1.23

Epicoccum purpurascens	----	----	0.20	----
Fusarium sp.	----	0.69	----	----
Geotrichum candidum	----	----	1.51	0.75
Gliomastix sp.	0.68	----	----	----
Graphium calcioides	----	----	1.59	----
Myrothecium verrucaria	0.94	----	----	----
Penicillium sp. (monoverticillata gr.)	0.21	----	----	----
Penicillium sp. (biverticillata gr.)	1.74	----	----	----
Phialophora sp.	----	----	3.54	0.48
Phoma sp.	2.00	----	----	----
Sporotrichum sp.	----	0.40	1.07	----
Stachybotrys chartarum	0.18	0.37	1.42	1.69
Trichurus spiralis	0.88	----	----	----
Zygomycotina:				
Coemansia sp.	0.39	----	----	----
Mucor sp.	0.44	0.47	0.26	----
Pilobolus crystallinus	0.47	0.29	2.93	0.40
Pilobolus longipes	1.20	----	----	3.56
Pilobolus kleinii	2.53	----	4.21	1.38
Rhizopus stolonifer	0.88	----	----	0.68
Rhopalomyces sp.	0.45	0.30	----	----

Ascomycotina:				
Class: Plectomycetes				
Kernia nitida	0.96	----	1.47	----
Kernia sp 1.	----	0.20	----	----
Leuconeurospora pulcherrima	----	----	0.55	----
Pseudeurotium sp.	0.20	----	----	----
Class: Pyrenomycetes				
Cercophora californica	----	1.21	1.14	----
Cercophora coprophila	----	----	1.40	----
Cercophora mirabilis	1.12	0.61	----	----
Chaetomium aterrimum	----	----	0.17	----
Chaetomium bostrychodes	----	0.44	----	----
Chaetomium homopilatum	----	----	----	0.22
Chaetomium concinnum	----	----	0.36	----
Chaetomium robustum	----	----	0.20	----
Chaetomium chrispatum	0.64	----	----	----
Podospora anserina	1.19	----	----	1.04
Podospora comata	0.24	0.26	----	----
Podospora communis	----	----	0.65	0.81
Podospora curvuloides	0.84	----	1.06	1.57
Podospora similis	0.53	----	----	0.59

Podospora ostlingospora	----	----	----	1.08
Podospora pleiospora	----	----	----	0.60
Sordaria brevicollis	0.45	1.55	----	----
Sordaria fimicola	1.71	----	----	----
Sordaria macrospora	0.38	----	----	----
Strattonia hansenii	----	----	0.32	----
Class: Loculoascomycetes				
Botryosphaeria sp	----	----	0.22	----
Sporormiella australis	0.44	0.30	----	----
Sporormiella isomera	----	0.35	1.11	----
Sporormiella minima	1.63	5.27	0.82	3.52
Sporormiella minimoides	1.16	----	0.44	0.83
Sporormiella subtilis	----	----	0.69	----
Trichodelitschia sp.nov.	----	0.38	----	----
Class: Discomycetes				
Ascobolus amoenus	0.83	0.39	0.23	----
Ascobolus degluptus	----	0.28	----	----
Ascobolus hawaiiensis	----	0.65	----	----
Ascobolus immersus	1.61	----	1.61	2.25
Ascobolus stictoideus	2.23	3.22	0.29	----
Cheilymenia theleboloides	1.32	0.22	----	----

Cheilymenia sp.	0.15	----	----	----
Coprotus aurora	0.72	----	----	----
Coprotus dextrinoideus	----	----	----	0.18
Coprotus disculus	----	----	----	0.86
Coprotus glaucellus	0.45	0.77	----	----
Coprotus lacteus	1.12	0.32	----	----
Coprotus leucopocillium	----	0.36	0.22	----
Coprotus luteus	0.32	0.68	0.18	----
Coprotus marginatus	----	0.72	----	----
Coprotus winteri	0.21	----	----	----
Fimaria hepatica	0.26	----	----	----
Iodophanus carneus	----	----	0.26	----
Lasiobolus intermedius	----	0.54	----	----
Lasiobolus lasioboloides	----	1.29	----	----
Peziza sp.	----	----	0.16	1.61
Saccobolus beckii	0.17	----	----	0.79
Saccobolus glaber	0.20	----	2.10	----
Saccobolus minimus	----	0.48	----	0.53
Saccobolus portoricensis	----	0.39	----	----
Saccobolus verrucisporus	----	0.27	----	----
Thelebolus crustaceus	----	0.50	0.24	1.71
Trichobolus sphaerosporus	0.14	----	----	----

Basidiomycotina:				
Coprinus cinereus	0.59	3.46	2.10	1.18
Coprinus curtus	----	0.28	----	----
Coprinus heptemerus	1.71	1.86	0.94	2.58
Coprinus miser	0.67	1.18	----	0.22
Coprinus poliomalus	0.91	----	0.37	0.24
Coprinus stellatus	1.16	----	0.78	----
Coprinus niveus	----	0,96	0.44	----
Paneolus sp.	----	0.24	----	----

4.2.6 Conclusion

In conclusion the following statements and general deductions can be made:

-The larger the scope of the feeding levels, the higher the coprophilous fungal species diversity and species composition on the dung substrate.

-The less selective the feeding habit, the larger the coprophilous fungal species diversity on the dung substrate.

-No positive correlation could be made between the coprophilous fungal species diversity with regard to the type of digestive system of the animals as both the highest as well as the lowest coprophilous fungal species diversities were recorded on the dung of animals with a monogastric hind gut fermentation type of digestive system. However, a limited positive correlation was found with regard to the species composition of the different dung substrates, as was indicated in the combined species fidelity classes discussed.

It is thus clear that both the fungal species compositions as well as the species diversities on the different dung substrates are to a large extent influenced by the feeding habits and food preferences of the animals, and to a lesser extent by the type of digestive system.

4.3 A comparison of the fungal species composition and diversity on freshly voided dung and digestive tract dung substrates

4.3.1 Introduction

When feeding the herbivorous animals ingest a large variety of fungal spores, not all of these spores survive the passage through the animal digestive system, thus a number of the fungal spores are destroyed probably as a result of the chemical and mechanical digestive processes. The coprophilous fungal spores however not only survive the relative high temperatures and fluctuating pH values, but fungal spore germination is possibly stimulated by the exposure to the digestive processes during passage through the animal gut. Dung collected from different parts of the digestive systems of blue wildebeest, elephant and giraffe were investigated to determine the fungal species composition and species diversity in the different parts of the digestive systems. Ecological importance values were calculated for each species present on the specific dung substrates. The following species compositions were recorded on the different dung substrates:

4.3.2 Elephant dung substrates

Hyphomycetes:				
Species	Caecum	Colon	Rectum	Fresh
Acremonium sp	----	1,77	1,64	1.19
Aspergillus niger	0,79	0,96	----	----
Aspergillus glaucus gr.	0,50	0,57	----	----
Aspergillus flavus gr.	0,78	0,39	----	----
Bahupaathra samala	----	0,21	0,42	0,61
Gliomastix sp	----	0,68	----	----
Penicillium sp monoverticillata gr.	0,21	----	----	----
Penicillium sp biverticillata gr.	0,96	0,79	----	----
Stachybotrys chartarum	----	----	----	0,18
Trichurus spiralis	----	0,87	----	----
% Occurrence	27,8%	44,4%	11,1%	16,7%
Total importance value	3,24	6,24	2,06	1,98

Both the highest hyphomycete species diversity, as percentage occurrence, and rate of ecological activity, as indicated by the total importance value, were obtained on the colon dung substrates. On average the total importance values were higher on the digestive tract dung substrates than on the fresh dung substrates. This can possibly be attributed to the fact that a num-

ber of the representatives of the Hyphomycetes do in all probability not survive passage through the digestive system of the animal and are thus not truly coprophilous in nature. For example representatives of the genera *Aspergillus* and *Penicillium* were restricted to the elephant digestive tract dung substrates. The relatively high percentage of Hyphomycetes on elephant dung compared to the other dung substrates could possibly be ascribed to the composition of the dung as a result of the feeding habit of the animal. The dung substrate is extremely coarse and bits of bark, twigs and fruit are easily discernible rendering a substrate closer to compost than to faeces and is therefore, in all probability, a more favourable substrate with regard to some of the opportunistic representatives of the Hyphomycetes than any other dung substrate.

Coelomycetes:

Species	Caecum	Colon	Rectum	Fresh
Myrothecium verrucaria	----	0,88	----	----
Phoma sp	----	0,48	1,51	0,18
% Occurrence	----	50%	25%	25%
Total importance value	----	1,36	1,51	0,18

The highest species diversity, as percentage occurrence, was obtained on the colon dung substrates whilst the highest rate of ecological activity, as indicated by the total importance value, was obtained on the rectum dung substrates. The total importance value decreased markedly on the fresh dung substrates thus reducing the ecological role of the representatives of the Coelomycetes as decomposers of elephant dung. No representatives of this class were reported from the dung substrates of the other animals investigated.

Zygomycetes:

Species	Caecum	Colon	Rectum	Fresh
Coemansia sp	----	0,39	----	----
Mucor sp	----	0,44	----	----
Pilobolus crystallinus	----	----	0,28	0,19
Pilobolus longipes	----	----	0,21	0,99
Pilobolus kleinii	----	0,28	0,56	1,70
Rhizopus stolonifer	0,16	0,72	----	----
Rhopalomyces sp	----	----	0,46	----
% Occurrence	8,3%	33,3%	33,3%	25%
Total importance value	0,16	1,83	1,51	2,88

The highest species diversity, as percentage occurrence, was reached on both the colon and rectum dung substrates, the highest rate of ecological activity, as indicated by the total importance value, was however, reached on the fresh dung substrates. The decreased species diversity on the fresh dung substrates can be attributed to the fact that only representatives of *Pilobolus*, an obligatory coprophilous genus, were present. The other representatives of the Zygomycetes in all probability do not survive passage through the digestive system of the animal. The low occurrence of *Mucor* species and the absence of the genus *Pilaira* differ from the research findings of other authors. The absence of *Pilaira* can probably be attributed to the colonizing nature of the fungus, requiring a humid and colder climate (Webster et al. 1986). The low occurrence of *Mucor* can be attributed to the fact that the dung was collected directly after voidance, as such the opportunistic coprophiles are restricted.

Plectomycetes:

Species	Caecum	Colon	Rectum	Fresh
Kernia nitida	----	----	----	0,96
% Occurrence	----	----	----	100%
Total importance value	----	----	----	0,96

Only one representative of this class occurred on the freshly voided dung substrates and none was reported on the digestive tract dung substrates.

Pyrenomycetes:				
Species	Caecum	Colon	Rectum	Fresh
Cercophora mirabilis	----	----	0,27	0,85
Chaetomium chrispatum	----	0,64	----	----
Podospora anserina	----	----	----	1,19
Podospora comata	----	----	----	0,24
Podospora communis	----	----	0,44	----
Podospora curvuloides	----	0,57	0,50	----
Podospora similis	----	----	----	0,53
Sordaria brevicollis	----	----	0,45	----
Sordaria fimicola	----	0,82	0,36	0,55
Sordaria macrospora	----	----	----	0,38
% Occurrence	----	21,4%	35,7%	42,9%
Total importance value	----	2,03	2,02	3,74

The highest species diversity, as percentage occurrence, as well as the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates, whilst no fungal species were reported from the caecum dung substrates. The only non-coprophilous species present, *Chaetomium chrispatum*, occurred on the colon dung substrates but was absent from the fresh dung substrates. This can be attributed to the fact that the spores probably do not survive passage through the digestive system of the animal.
However, a number of other representatives of the genus did occur on the freshly voided blue wildebeest dung substrates and one species occurred on the freshly voided giraffe dung substrates. This phenomenon could possibly be attributed to the differences in the feeding habits and digestive systems of the different animals, both blue wildebeest and giraffe being ruminants and elephant being a non-ruminant. Furthermore, only once was a representative of this genus reported from zebra dung, another non-ruminant. It would therefore seem probable that the ruminant digestive processes play a role in rendering the spores of the genus *Chaetomium* viable for germination. This hypothesis needs further investigation before any definite conclusions can be drawn.

Discomycetes:				
Species	Caecum	Colon	Rectum	Fresh
Ascobolus amoenus	0,52	----	----	0,32
Ascobolus immersus	----	----	0,52	1,10
Ascobolus stictoideus	0,32	----	0,71	1,29
Cheilymenia theleboloides	----	----	1,02	0,42
Cheilymenia sp	----	----	----	0,15
Coprotus aurora	----	----	0,71	----
Coprotus glaucellus	----	----	0,45	----
Coprotus lacteus	----	----	1,12	----
Coprotus luteus	----	----	----	0,32
Coprotus winteri	----	----	----	0,21
Fimaria hepatica	0,26	----	----	----
Saccobolus beckii	----	----	0,17	----
Saccobolus glaber	----	----	----	0,32
Trichobolus sphaerosporus	----	----	----	0,14
% Occurrences	15,8%	----	36,8%	47,4%
Total importance value	1,10	----	4,70	4,27

The highest species diversity, as percentage occurrence, was recorded on the fresh dung substrates, the highest rate of ecological activity, as indicated by the total importance value, was recorded on the rectum dung substrates.
This can be attributed to the relatively high importance values of *Cheilymenia theleboloides*, which exhibited decreased ecological activity on the fresh dung substrates and *Coprotus lacteus* which was absent from the fresh dung substrates. No fungal species were reported from the colon dung substrates. All of the species reported from the different dung substrates are considered to be obligatory coprophiles.

Loculoascomycetes:

Species	Caecum	Colon	Rectum	Fresh
Sporormiella australis	----	0,42	----	----
Sporormiella minima	----	0,46	0,55	0,58
Sporormiella minimoides	----	0,49	0,39	0,28
% Occurrences	----	42,8%	28,6%	28,6%
Total importance value	----	1,37	0,94	0,86

Both the highest species diversity, as percentage occurrence, and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the colon dung substrates. All the representatives are members of the genus *Sporormiella* and were absent from the caecum dung substrates. Representatives of this genus did however reached its highest species diversity and importance values on the freshly voided dung substrates of blue wildebeest and giraffe. Thus it would seem as if representatives of this genus have a wide ecological amplitude with regard to the limiting factors present in the digestive systems and on the dung substrates of the animals.

Basidiomycetes:

Species	Caecum	Colon	Rectum	Fresh
Coprinus cinereus	----	0,59	----	----
Coprinus heptemerus	----	----	0,85	0,86
Coprinus miser	----	----	----	0,67
Coprinus poliomalus	----	----	----	0,91
Coprinus stellatus	----	----	----	1,27
% Occurrences	----	16,7%	16,7%	66,6%
Total importance value	----	0,59	0,85	3,71

The highest species diversity, as percentage occurrence, as well as the highest rate of ecological activity, as indicated by the total importance value, were recorded on the freshly voided dung substrates. This was also the case on the blue wildebeest and giraffe dung substrates. It would therefore seem that the spores of the genus *Coprinus* benefit from the passage through

the digestive system and are only fully capable of germination on fresh dung substrates. Lower importance values were however recorded for some of the *Coprinus* species on the digestive tract dung substrates of all the animals investigated.

4.3.3 Blue wildebeest dung substrates

Hyphomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Epicoccum purpuracens	----	----	----	0,20	----
Geotrichum candidum	----	----	----	----	1,51
Graphium calcioides	1,19	----	----	0,24	0,36
Phialophora sp.	----	----	0,66	1,12	1,75
Sporotrichum sp.	----	----	----	----	1,07
Stachybotrys chartarum	----	----	----	0,59	0,82
% Occurrences	9,1%	----	9,1%	36,4%	45,4%
Total importance value	1,19	----	0,66	2,15	5,51

Both the highest species diversity, as percentage occurrence, and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to both the presence and relatively high importance values of *Geotrichum candidum* and a *Sporotrichum* species, as well as an increase in the importance of *Stachybotrys chartarum* and a *Phialophora* species. No fungal species were reported from the caecum dung substrates.

Zygomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Mucor sp.	----	----	----	----	0,26
Pilobolus crystallinus	----	----	----	0,71	2,10
Pilobolus kleinii	1,14	0,53	----	1,12	1,42
% Occurrences	14,3%	14,3%	----	28,6%	42,8%
Total importance value	1,14	0,53	----	1,83	3,78

Both the highest species diversity, as percentage occurrence, and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to an increase in the importance of representatives of the genus *Pilobolus* and the presence of a representative of the genus *Mucor*. No fungal species were reported from the colon dung substrates.

Plectomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Kernia nitida	0,30	----	----	0,38	0,78
Leuconeurospora pulcherrima	0,55	----	0,44	----	----
% Occurrences	40%	----	20%	20%	20%
Total importance value	0,85	----	0,44	0,38	0,78

Both the highest species diversity, as percentage occurrence, and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the rumen dung substrates. This can be attributed to the combined presence of the two recorded representatives of the class as well as to the relatively high importance value of *Leuconeurospora pulcherrima* on this dung substrate. However, *Kernia nitida*, did exhibit an increase in importance on the rectum and fresh dung substrates, reaching its highest importance value on the latter substrate. No fungal species have been recorded on the caecum dung substrates.

Pyrenomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Cercophora californica	----	----	----	0,62	0,52
Cercophora coprophila	0,49	----	----	0,21	0,70
Chaetomium aterrimum	----	----	----	0,17	----
Chaetomium convolutum	----	----	----	----	0,36
Chaetomium robustum	----	----	----	----	0,20
Podospora communis	----	----	----	0,65	----
Podospora curvuloides	----	----	----	----	1,06
Strattonia hansenii	----	----	----	----	0,32
% Occurrences	9,1%	----	----	36,4%	54,5%
Total importance value	0,49	----	----	1,65	3,16

Both the highest species diversity, as percentage occurrence, and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the presence of two species of the genus *Chaetomium* and *Strattonia hansenii* as well as both the presence and the relatively high importance value of *Podospora curvuloides*. No fungal species have been reported from the caecum and colon dung substrates.

Discomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Ascobolus amoenus	----	----	----	----	0,23
Ascobolus immersus	----	----	----	0,67	0,83
Ascobolus stictoideus	----	----	----	----	0,29
Coprotus leucopocillium	----	----	----	----	0,22
Coprotus luteus	----	----	----	----	0,18
Iodophanus carneus	----	----	----	----	0,26
Peziza sp	----	----	----	----	0,16
Saccobolus glaber	0,22	----	----	0,34	1,50
Thelebolus crustaceus	----	----	----	0,24	----
% Occurrences	8,3%	----	----	25%	66,7%
Total importance value	0,22	----	----	1,25	3,67

Both the highest species diversity, as percentage occurrence, and the highest rate of ecological activity, as indicated by the the total importance value, were recorded on the fresh dung substrates. This can be attributed to the presence of a number of fungal species as well as to the increase in importance of *Ascobolus immersus* and *Saccobolus glaber*. No fungal species were recorded on the caecum and colon dung substrates.

Loculoascomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Botryosphaeria sp	----	----	----	0,22	----
Sporormiella isomera	----	----	----	----	1,11
Sporormiella minima	----	----	----	----	0,82
Sporormiella minimoides	----	----	----	0,44	----
Sporormiella subtilis	----	----	----	----	0,69
% Occurrences	----	----	----	40%	60%
Total importance value	----	----	----	0,66	2,62

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the presence and relatively high importance values of representatives of the genus *Sporormiella*. No fungal species were recorded on the rumen, caecum and colon dung substrates.

Basidiomycetes:					
Species	Rumen	Caecum	Colon	Rectum	Fresh
Coprinus cinereus	----	----	----	----	2,27
Coprinus heptemerus	----	----	----	0,18	0,75
Coprinus poliomalus	----	----	----	----	0,37
Coprinus stellatus	----	----	----	0,78	----
Coprinus niveus	----	----	0,44	----	----
% Occurrences	----	----	16,7%	33,3%	50%
Total importance value	----	----	0,44	0,96	3,39

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the presence and relatively high importance value of *Coprinus cinereus* and the increased importance of *Coprinus heptemerus*. No fungal species were recorded on the rumen and caecum dung substrates.

4.3.4 Giraffe dung substrates

Hyphomycetes:					
Species	Rumen	Caecum	Colon	Rectum	Fresh
Arthrobotrys oligospora	----	----	----	----	1,36
Bahupaathra samala	----	----	----	----	0,67
Chalara sp.	----	----	----	0,78	1,33
Fusarium sp.	----	----	----	0,30	0,39
Sporotrichum sp.	----	----	----	----	1,07
Stachybotrys chartarum	----	----	----	0,59	0,82
% Occurrence	----	----	----	33,3%	66,7%
Total importance value	----	----	----	1,67	5,64

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the presence of a number of fungal species and the relatively high importance values of *Arthrobotrys oligospora* and a *Sporotrichum* species. No fungal species were recorded on the rumen, caecum and colon dung substrates.

Zygomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Mucor sp.	----	----	----	0,47	----
Pilobolus crystallinus	----	----	----	----	0,29
Rhopalomyces sp.	----	----	----	----	0,30
% Occurrence	----	----	----	33,3%	66,7%
Total importance value	----	----	----	0,47	0,59

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the the presence of two representatives of this class. No fungal species were recorded on the rumen, caecum and colon dung substrates.

Plectomycetes:

Species	Rumen	Caecum	Colon	Rectum	Fresh
Kernia sp.	----	----	----	----	0,20
Pseudeurotium sp.	----	----	----	----	0,20
% Occurrences	----	----	----	----	100%
Total importance value	----	----	----	----	0,40

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates, as fungal species were only recorded on the fresh dung substrates.

Pyrenomycetes:					
Species	Rumen	Caecum	Colon	Rectum	Fresh
Cercophora californica	----	----	----	----	1,21
Cercophora mirabilis	----	----	0,37	0,24	----
Chaetomium bostrychodes	----	----	----	----	0,44
Podospora comata	----	----	----	----	0,26
Sordaria brevicollis	1,08	----	----	----	0,47
% Occurrences	14,3%	----	14,3%	14,3%	57,1%
Total importance value	1,08	----	0,37	0,24	2,38

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value were recorded on fresh dung substrates. This can be attributed to the presence of a number of fungal species and a relatively importance value of *Cercophora californica*. No fungal species were recorded on the rumen, caecum, colon and rectum dung substrates.

Discomycetes:					
Species	Rumen	Caecum	Colon	Rectum	Fresh
Ascobolus amoenus	----	----	----	----	0,88
Ascobolus degluptus	----	----	----	----	0,28
Ascobolus hawaiiensis	----	----	----	----	0,65
Ascobolus stictoideus	----	0,37	0,78	0,48	1,49
Cheilymenia theleboloides	----	----	----	----	0,22
Coprotus glaucellus	----	----	----	----	0,77
Coprotus lacteus	----	----	----	----	0,32
Coprotus leucopocillium	----	----	0,36	----	----
Coprotus luteus	----	----	0,25	0,21	0,22
Coprotus marginatus	----	----	----	----	0,72
Lasiobolus intermedius	----	----	----	----	0,54
Lasiobolus lasioboloides	0,55	----	----	----	0,91
Saccobolus minimus	----	----	----	----	0,48
Saccobolus portoricensis	----	----	----	----	0,39
Saccobolus verrucisporus	----	----	----	----	0,27
Thelebolus crustaceus	----	----	----	----	0,50
% Occurrences	4,5%	4,5%	13,6%	9,1%	68,3%
Total importance value	0,55	0,37	1,39	0,96	8,64

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the presence of a relatively large number of fungal species on the fresh dung substrates.

Loculoascomycetes:					
Species	Rumen	Caecum	Colon	Rectum	Fresh
Sporormiella australis	----	----	----	----	0,33
Sporormiella isomera	----	----	----	0,35	----
Sporormiella minima	----	0,64	0,64	----	4,17
Trichodelitschia sp.	----	----	----	----	0,38
% Occurrences	----	16,7%	16,7%	16,7%	50%
Total importance value	----	0,64	0,64	0,35	4,88

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the number of fungal species on the fresh dung substrates as well as to the increase in the importance value of *Sporormiella minima*. No fungal species were recorded on the rumen dung substrates.

Basidiomycetes:					
Species	Rumen	Caecum	Colon	Rectum	Fresh
Coprinus cinereus	0,64	0,95	0,38	0,82	0,67
Coprinus curtus	----	----	----	----	0,28
Coprinus heptemerus	----	----	----	----	1,86
Coprinus miser	----	----	----	----	1,18
Coprinus niveus	----	----	----	----	0,96
Panaeolus sp.	----	----	----	----	0,24
% Occurrences	10	10%	10%	10%	60%
Total importance value	0,64	0,95	0,38	0,82	5,19

Both the highest species diversity, as percentage occurrence and the highest rate of ecological activity, as indicated by the total importance value, were recorded on the fresh dung substrates. This can be attributed to the high number of fungal species present on the fresh dung substrates.

4.3.5 Conclusion:

All of the deductions discussed should be interpreted taking into consideration that the digestive tract dung substrates from the different animals were not collected as frequently as the freshly voided dung substrates. The results as discussed should only be seen as indicative of possible trends, with regard to the species diversities and the ecological activities on the dung substrates obtained from the different parts of the digestive systems of the animals.

More comprehensive research in this regard is needed before definite conclusions can be drawn with regard to the coprophilous nature of the fungal species occurring on dung substrates. However, it is possible to conclude that in general both the highest species diversities and importance values were reached on the freshly voided dung substrates, thus lending credibility to the fact that the spores of many of the coprophilous fungal species need to pass through the entire animal digestive system to facilitate germination. On the other hand it also seems as if spores of many fungal species do not survive passage through the digestive system of the animals or are present on the freshly voided dung substrates as a result of aerial and contact contamination, as opportunistic fungi.

4.4 Correlations between fungal spore sizes, spore dispersal mechanisms, species composition of the dung substrates, feeding levels and feeding habits of the animals investigated

4.4.1 Introduction:

The possibility that the fungal spore sizes as well as the spore distribution mechanisms could have had an influence on the species diversity of the different dung substrates were investigated. Bell (1975) reported on the existence of a forest-canopy fungal flora on the dung of the brush-tailed opossum in New Zealand, as the majority of the fungi that regularly occurred on the opossum dung substrate were characterized by having small hyaline spores. The present research indicated a markedly different species composition on the giraffe dung substrate in comparison to the other dung substrates investigated. The fungal flora on the giraffe dung substrate included the highest number of rare species recorded. In order to investigate and possibly clarify this phenomenon all fungal species recorded were classified according to their respective spore sizes and dispersal mechanisms.
The percentage representation of each spore size class was calculated for the different dung substrates investigated. Only the obligatory coprophilous species were included in these calculations. Some of the species are represented in two or more different spore size classes as the spore sizes, spore clusters or part-spores belonged to or overlapped the different spore size classes that were deliminated. Whenever this situation occurred the specific species was counted as if it represented two or more different species, consequently the actual percentages could be calculated. In determining the spore size classes only the accepted spore length limits were taken into consideration as the spore widths in virtually all cases exhibited a fixed relation to the spore lengths. As a result the spore sizes, whether on the small or large side, within the accepted species limits remain relatively constant with regard to the relationship between the spore lengths and spore widths. The spore lengths of all the recorded fungal species fit within the range of 5-85 μm.

4.4.2 Spore size classes

The following spore size classes were deliminated:

Legend:
A = active dispersal
P = passive dispersal
w = wet adhesive spores
d = dry non-adhesive spores
* = represented in more than one spore size class
Ps = part-spore
Sc = spore cluster

Class 1: 5 - 10 μm in length.

Species	Spore size (length)	Aw/Pd
Chaetomium aterrimum	6 - 8 μm	Pd
Chaetomium bostrychodes	6 - 7 μm	Pd
Chaetomium homopilatum	7 - 8 μm	Pd
Chaetomium convolutum	6 - 7 μm	Pd
Chaetomium robustum	6 - 8 μm	Pd
Chaetomium chrispatum	6 - 8 μm	Pd
Coprinus cinereus *	9 - 12 μm	Pd
Coprinus miser	7 - 10 μm	Pd
Coprinus poliomalus	7 - 9 μm	Pd
Coprinus stellatus	8 - 10 μm	Pd
Coprotus glaucellus	7 - 10 μm	Aw
Coprotus lacteus	8 - 10 μm	Aw
Coprotus luteus	8 - 10 μm	Aw
Coprotus marginatus	9 - 10 μm	Aw
Kernia sp 1 *	6 - 7 μm	Pd
Kernia sp 2 *	9 - 12 μm	Pd
Kernia nitida *	7 - 14 μm	Pd
Leuconeurospora pulcherrima	5 - 7 μm	Pd
Pilobolus crystallinus	6 - 10 μm	Aw
Sporormiella australis (Ps)	9 - 10 μm	Aw
Sporormiella isomera (Ps)	8 - 10 μm	Aw
Sporormiella minima (Ps)	7 - 9 μm	Aw
Sporormiella minimoides (Ps)	7 - 9 μm	Aw
Sporormiella subtilis (Ps)	6 - 7 μm	Aw
Thelebolus crustaceus	5 - 8 μm	Aw
Trichobolus sphaerosporus	9 - 10 μm	Aw

Class 2: 11 - 18 μm in length.

Species	Spore size (length)	Aw/Pd
Cheilymenia sp.	12 - 15 μm	Aw
Coprinus cinereus	9 - 12 μm	Pd
Coprinus curtus	11 - 12 μm	Pd
Coprinus heptemerus	11 - 15 μm	Pd
Coprinus niveus	15 - 19 μm	Pd
Coprotus aurora	12 - 14 μm	Aw
Coprotus dextrinoideus	11 - 13 μm	Aw
Coprotus disculus	12 - 14 μm	Aw
Coprotus leucopocillium	14 - 18 μm	Aw
Coprotus winteri	11 - 12 μm	Aw
Iodophanus carneus	15 - 18 μm	Aw
Kernia sp.2 *	9 - 12 μm	Pd
Kernia nitida *	7 - 14 μm	Pd
Lasiobolus lasioboloides	13 - 18 μm	Aw
Lasiobolus intermedius	13 - 18 μm	Aw
Pilobolus kleinii	12 - 18 μm	Aw
Pilobolus longipes	11 - 13 μm	Aw
Saccobolus minimus *	12 - 14 μm	Aw
Saccobolus portoricensis *	14 - 19 μm	Aw
Saccobolus verrucisporus *	15 - 18 μm	Aw
Trichodelitschia microspora	13 - 18 μm	Aw

Class 3: 19 - 30 μm in length.

Species	Spore size (length)	Aw/Pd
Ascobolus amoenus *	29 - 38 μm	Aw
Ascobolus degluptus *	27 - 33 μm	Aw
Ascobolus hawaiiensis	19 - 21 μm	Aw
Ascobolus stictoideus *	26 - 35 μm	Aw
Cercophora coprophila	19 - 30 μm	Aw
Cercophora mirabilis	19 - 21 μm	Aw
Cheilymenia theleboloides	19 - 22 μm	Aw
Fimaria hepatica *	22 - 35 μm	Aw
Podospora pleiospora *	25 - 36 μm	Aw
Podospora similis *	24 - 38 μm	Aw
Saccobolus beckii *	20 - 23 μm	Aw
Saccobolus glaber *	21 - 25 μm	Aw
Saccobolus minimus * (Sc)	29 - 33 μm	Aw
Sordaria fimicola	19 - 23 μm	Aw
Sordaria macrospora *	25 - 34 μm	Aw
Sporormiella minima *	28 - 34 μm	Aw
Sporormiella minimoides *	28 - 36 μm	Aw
Sporormiella subtilis	23 - 29 μm	Aw

Class 4: 31 - 40 μm in length.

Species	Spore size (length)	Aw/Pd
Ascobolus albidus	31 - 34 μm	Aw
Ascobolus amoenus *	29 - 38 μm	Aw
Ascobolus degluptus *	27 - 33 μm	Aw
Ascobolus stictoideus *	26 - 35 μm	Aw
Fimaria hepatica *	22 - 35 μm	Aw
Podospora anserina	34 - 40 μm	Aw
Podospora comata	31 - 35 μm	Aw
Podospora communis	32 - 40 μm	Aw
Podospora curvuloides	31 - 40 μm	Aw
Podospora globosa *	34 - 45 μm	Aw
Podospora pleiospora *	25 - 36 μm	Aw
Podospora similis *	24 - 38 μm	Aw
Saccobolus minimus * (Sc)	29 - 33 μm	Aw
Saccobolus portoricensis * (Sc)	34 - 44 μm	Aw
Saccobolus verrucisporus (Sc)	33 - 39 μm	Aw
Sordaria macrospora *	25 - 34 μm	Aw
Sporormiella australis *	38 - 46 μm	Aw
Sporormiella isomera	32 - 40 μm	Aw
Sporormiella minima *	28 - 34 μm	Aw
Sporormiella minimoides *	28 - 36 μm	Aw
Strattonia hansenii	31 - 35 μm	Aw
Zygopleurage zygospora	33 - 40 μm	Aw

Class 5: 41 - 85 μm in length.

Species	Spore size (length)	Aw/Pd
Ascobolus immersus	44 - 58 μm	Aw
Cercophora californica	67 - 84 μm	Aw
Podospora apiculifera	41 - 50 μm	Aw
Podospora globosa *	34 - 45 μm	Aw
Podospora ostlingospora	50 - 55 μm	Aw
Saccobolus beckii (Sc)	42 - 60 μm	Aw
Saccobolus glaber (Sc)	50 - 68 μm	Aw
Saccobolus portoricensis * (Sc)	34 - 44 μm	Aw
Sporormiella australis *	38 - 46 μm	Aw

The following results, depicted in table 9, were obtained when the relative percentage occurrence within the different spore size classes on each dung substrate were calculated:

Table 9.

Substrate	Class 1	Class 2	Class 3	Class 4	Class 5
Giraffe Dung	26,7%	24,4%	20%	20%	8,9%
Elephant Dung	25,5%	16,4%	21,8%	25,5%	10,8%
Zebra Dung	25%	21,9%	18,8%	25%	9,3%
Blue wildebeest Dung	40,5%	16,2%	16,2%	19%	8,1%

From these results the spore size classes can be arranged according to the relative percentage importance on the different dung substrates.

Spore size class sequences on the different dung substrates

Substrates	Spore size classes
Giraffe dung	class numbers 1; 2; 3 & 4; 5.
Elephant dung	class numbers 1 & 4; 3; 2; 5.
Zebra dung	class numbers 1 & 4; 2; 3; 5.
Blue wildebeest dung	class numbers 1; 4; 2 & 3; 5.

4.4.3 Conclusion

The following general conclusions and deductions can be made:

- A definite forest-canopy fungal flora, as exhibited on the giraffe dung substrate can be identified. The spore size class sequence on this substrate differs markedly from that of all the other substrates investigated, in that spore size class no 1 & 2 was dominant on the giraffe dung substrate whilst spore size classes no 3 and or no 4 occupied the concurrent position on the other dung substrates investigated. As a result the coprophilous fungal community on the giraffe dung substrate is dominated by fungal species possessing relatively small and, to a large extent, dry spores. This is expected as only spores possessing these qualities can easily be dispersed to the animal's feeding level. Spore size class no 4 occupied a much lower position on Giraffe dung than on all of the other dung substrates investigated.

- A definite grassland fungal flora, as exhibited on the blue wildebeest and zebra dung substrates, can be identified. The spore size class sequences on these dung substrates are identical but differ from the spore size class sequences on the other dung substrates in that spore size class no 2 on the giraffe dung substrate and spore size class no 3 on the elephant dung substrate occupy higher positions. The coprophilous fungal community on blue wildebeest and zebra dung is dominated by fungal species possessing relatively large and, in most cases, wet spores. The spore dispersal range of species exhibiting these spore characteristics are limited and are consequently only dispersed up to the feeding levels of grazing animals.

- The spore size class sequence exhibited by the elephant dung substrate occupies an intermediate position between that of the giraffe dung substrate, representing the forest-canopy fungal flora, on the one hand and the blue wildebeest and zebra dung substrates, representing the grassland fungal flora on the other hand. This is to be expected as the elephant is an intermediate feeder, utilizing both browse and graze species at a variety of feeding levels.

- On average the percentage actively dispersed spore types are much higher than that of the passively dispersed spore types on the different dung substrates. This can be seen as an adaptation to the coprophilous life style, by means whereof the possibility of spore ingestion by herbivorous animals is increased.

_ These results underline the importance of the food preferences and feeding habits of the animals in the determination of the species composition of the coprophilous fungal flora on the different dung substrates.

4.5 Fungal species composition and species diversity during the different seasons

4.5.1 Introduction

The influence of the following seasons were investigated: summer (warm wet period) autumn (transitional period) and winter (cool dry period). The spring season was excluded as it is of extreme short duration in the study area, the Transvaal Lowveld. The phenomenon of seasonal distribution of organisms is usually ascribed to the local climate, which is predominantly determined by the average daily temperature, temperature fluctuations, the average daily photoperiodicities and the amount, form and periodicities of precipitation.

4.5.2 Results

As can be seen in Graph Figs. 3.1 and 3.2 all of the species diversity curves exhibit typical concave curvatures when the number of species present is plotted against the seasonal importance values. The normal concave curvatures as exhibited by all three seasons indicate that all the species present are well adapted to the local seasonal fluctuations and no severe seasonal stress factors are present, or on the other hand, none of the species are severely limited by the seasonal stress factors present. Fruiting of some species was however restricted to certain seasons or had lower seasonal importance values during certain months. As a result the seasonal species diversity curves are not at equal levels.

4.5.2.1 The Autumn season

The autumn season species diversities are relatively high with regard to the very rare species but the curve then flattens rapidly, causing this season to exhibit only the second highest species diversity of all seasons investigated. This phenomenon could possibly be ascribed to the transitional nature of the season.

4.5.2.2 The Summer season

The summer season exhibits the highest species diversity overall. This is expected as the summer season in the Kruger National Park, where the dung substrates were collected, is generally regarded as the most productive season on account of it being the annual warm wet period, resulting in an increase in the vegetation productivity.

4.5.2.3 The Winter season

The winter season exhibits the lowest species diversity and this can be attributed to the relative low temperatures and the fact that this season represents the annual dry period, resulting in a decrease in the vegetation productivity.

4.5.3 Discussion

These results differ markedly from those of other authors, however the peak season in South Africa also coincided with the warm and humid period as was the case in India (Nusrath 1976) and with the the peak rainy season as was the case in New Zealand (Bell 1975). It thus is possible that the seasonal differences in the species diversities and abundances of the coprophilous fungi can be attributed to the annual wet and dry periods. These results and deductions reaffirm the prime importance of water availability as a critically limiting factor with regard to the fruiting, species diversity and abundance figures for the coprophilous fungi. It also indicates the adaptability of the fungi and poses the distinct possibility of the development of locally adapted ecotypes.

4.5.4 Conclusion

In conclusion the following statements and general deductions can be made:

- The highest species diversity occurred during the summer season as a result of it being the annual warm wet, highly productive period. This is in contrast with the findings of Bell (1983), who found the autumn and winter months to be the peak periods with regard to species variety and quantity in New Zealand.

- The autumn season had the largest number of rare species as a result of it being a transitional period.

- The lowest species diversity occurred during the winter season as a result of it being the annual cool dry period, characterized by a decrease in productivity.

4.6 **Fungal class and species ordinations**

4.6.1 Fungal class ordination.

One-dimensional ordination of the coprophilous fungal classes was carried out according to the Total Overall Ecological Importance Values (TOEIV*) that were calculated for each species.

4.6.1.1 **Hyphomycetes**

Position	Species.	TOEIV.*
1.	Acremonium sp.	1,75
2.	Phialophora sp.	1,09
3.	Stachybotrys chartarum.	0,92
4.	Chalara sp.	0,91
5.	Geotrichum candidum.	0,66
6.	Bahupaathra samala.	0,52
7.	Aspergillus niger.*	0,51
8.	Penicillium sp. biverticillata group.*	0,49
9.	Sporotrichum sp.	0,39
10.	Graphium calicioides.	0,37
11.	Arthrobotrys oligospora.	0,36
12.	Aspergillus sp. flavus group.*	0,31
13.	Aspergillus sp. glaucus group.	0,30
14.	Trichurus spiralis.*	0,22
15.	Fusarium sp.	0,17
16.	Gliomastix sp.*	0,15
17.	Penicillium sp. monoverticillata group.*	0,05
18.	Epicoccum purpurascens.*	0,04

* These species were restricted to the different digestive tract dung substrates and were not once recorded on the fresh dung substrates investigated. Whether the spores of these species can actually survive the passage through the digestive tract is questionable. The fact that representatives of these species were never recorded on the fresh and rectal dung substrates seem to indicate that the spores of the species in question are either mechanically and or chemically damaged as they pass through the digestive tract of the animal. The absence of these species can also be contributed to the possibility that they can not compete and fruit successfully when growing with other, more fully adapted coprophilous organisms. Thus these species can not be considered as obligate coprophilous representatives.

The majority of the hyphomycete representatives can not be considered strictly coprophilous as most of them have in fact been widely recorded from substrates other than dung. Nevertheless the importance of this fungus group in the mineralization of the dung substrates should not be underestimated as is clearly indicated by the relatively high total overall ecological importance values calculated for the representatives of the Hyphomycetes.

It is possible that the ecological role of the Hyphomycetes as decomposers of dung substrates has been, to a large extent, overlooked in the past and more research with regard to the Hyphomycetes as coprophilous decomposers is essential before any definite conclusions, as to the extent of their ecologigal role, can be drawn.

4.6.1.2 **Coelomycetes**

Position	Species	TOEIV. *
1.	Phoma sp*	0,46
2.	Myrothecium verrucaria.*	0,22

* Both genera present have been recorded from substrates other than dung, therefore neither of these species can be considered as being strictly coprophilous in nature. The fact that only two species of this fungal class has been recorded indicates that representatives of this class do not, in any large extent, contribute to the decomposition of the dung substrates.

4.6.1.3 **Zygomycetes**

Position	Species	TOEIV. *
1.	Pilobolus kleinii.	1,96
2.	Pilobolus crystallinus.	1,19
3.	Pilobolus longipes.	1,11
4.	Rhizopus stolonifer.*	0,38
5.	Mucor sp*	0,27
6.	Rhopalomyces sp*	0,18
7.	Coemansia sp*	0,10

* These species have been reported on substrates other than dung and are therefore not strictly coprophilous in nature. The only true coprophilous genus represented in the Zygomycetes, *Pilobolus*, exhibited the highest total overall ecological importance values on the different substrates, as can be expected.If the general feeding levels and habits of the animals in question are taken into consideration, together with the spore discharge heights of the three different species of *Pilobolus*, the differences of the three *Pilobolus* species can be explained as follow:
As *P.crystallinus* has the smallest sporangia of the three *Pilobolus* species, its sporangium discharge height is accordingly the lowest - therefore its sporangia tend to cling to the lower vegetation stratum, it becomes accessible to animals that feed at that lower level. The fact that the highest substrate importance value for this species was recorded on the blue wildebeest dung substrate conforms to this hypothesis. On the other hand *P.longipes*, the species with the largest sporangia of the three *Pilobolus* species has accordingly the largest sporangium discharge height and its sporangia tend to cling to a higher vegetation level, where it becomes more accessible to animals feeding on that higher level, again the fact that the highest substrate importance value for *P.longipes* was recorded on the zebra dung substrate attest to this hypothesis. *P.kleinii* the intermediate species of the three *Pilobolus* species has accordingly an

intermediate sporangium discharge height and its sporangia attach to vegetation intermediate between the two vegetation strata as mentioned above. As a result its sporangia are probably accessible to the widest number of grazing animals used in this investigation. Likewise it exhibits the highest substrate importance value of all three of the *Pilobolus* species present. Furthermore if all the dung substrates on which this species occurred are taken into consideration the highest substrate importance value was recorded on blue wildebeest dung, if however only the fresh dung substrates are taken into consideration, the highest substrate importance value was recorded on zebra dung. This conforms to the above mentioned hypothesis as this fact would place the species in question intermediate between the other two species of the genus *Pilobolus*.

4.6.1.4 **Plectomycetes**

Position	Species	TOEIV.*
1.	Kernia nitida.	0,61
2.	Kernia sp.1	0,31
3.	Leuconeurospora pulcherrima.*	0,31
4.	Kernia sp.2	0,08
5.	Pseudeurotium sp*	0,04

* These species have been reported on substrates other than dung and are thus not strictly coprophilous in nature. The only true coprophilous genus represented in the Plectomycetes, *Kernia*, exhibited the highest total overall ecological importance values on the different substrates, as can be expected. All the representatives of this genus were restricted to successional phases 2A & 3. The highest successional importance values were recorded during phase 3. The representatives exhibited peak seasonal importance values during the summer months.

4.6.1.5 **Pyrenomycetes**

Position	Species	TOEIV.*
1.	Podospora curvuloides.	0,93
2.	Cercophora californica.	0,60
3.	Podospora anserina.	0,60
4.	Sordaria brevicollis.	0,54
5.	Cercophora mirabilis.	0,45
6.	Sordaria fimicola.	0,43
7.	Podospora communis.	0,36
8.	Cercophora coprophila.	0,35
9.	Podospora similis.	0,30
10.	Strattonia hansenii.	0,28
11.	Podospora ostlingospora.	0,27
12.	Chaetomium aterrimum.*	0,16
13.	Chaetomium chrispatum.*	0,16
14.	Podospora pleiospora.	0,14
15.	Podospora comata.	0,12
16.	Chaetomium bostrychodes.*	0,11
17.	Chaetomium convolutum.*	0,09
18.	Sordaria macrospora.	0,09
19.	Chaetomium homopilatum.*	0,05
20.	Chaetomium robustum.*	0,04

* These species have been reported on substrates other than dung and are thus not strictly coprophilous in nature. Representatives of the genus *Chaetomium* are also known to inhabit other substrates but nevertheless seem to occupy a transitional position with regard to substrate

preference as members of this genus do occur on dung quite frequently. The other species listed of this class all seem to be strictly coprophilous in nature, with the genus *Podospora* being dominant followed by the genera *Cercophora, Sordaria* and *Strattonia* respectively.

4.6.1.6 **Discomycetes**

Position	Species	TOEIV.*
1.	Ascobolus stictoideus.	1,50
2.	Ascobolus immersus.	1,35
3.	Saccobolus glaber.	0,75
4.	Thelebolus crustaceus.	0,54
5.	Peziza sp.	0,47
6.	Cheilymenia theleboloides.	0,38
7.	Coprotus leucopocillium.	0,36
8.	Ascobolus amoenus.	0,35
9.	Coprotus lacteus.	0,34
10.	Lasiobolus lasioboloides.	0,32
11.	Coprotus glaucellus.	0,29
12.	Coprotus luteus.	0,27
13.	Saccobolus beckii.	0,25
14.	Saccobolus minimus.	0,24
15.	Coprotus disculus.	0,22
16.	Coprotus marginatus.	0,19
17.	Coprotus aurora.	0,17
18.	Ascobolus hawaiiensis.	0,17
19.	Lasiobolus intermedius.	0,13
20.	Saccobolus portoricensis.	0,10
21.	Ascobolus degluptus.	0,07
22.	Coprotus winteri.	0,06
23.	Fimaria hepatica.	0,06
24.	Iodophanus carneus.	0,06
25.	Saccobolus verrucisporus.	0,06
26.	Cheilymenia sp.	0,04
27.	Coprotus dextrinoideus.	0,04
28.	Trichobolus sphaerosporus.	0,03

All of the recorded species belonging to the class Discomycetes are obligatory coprophiles. The genus *Ascobolus* exhibited the highest total overall importance value, followed by the genus *Coprotus* and the genus *Saccobolus* respectively. All of the other genera present exhibited markedly lower importance values and as such contribute to the generic diversity rather than to the generic dominance pattern.

4.6.1.7 **Loculoascomycetes**

Position	Species	TOEIV.*
1.	Sporormiella minima	3,21
2.	Sporormiella minimoides	0,60
3.	Sporormiella isomera	0,35
4.	Sporormiella subtilis	0,19
5.	Sporormiella australis	0,17
6.	Trichodelitschia microspora	0,10

All of the above mentioned species belonging to the class Loculoascomycetes are obligatory coprophiles. The genus *Sporormiella* were well represented and as such exhibited the highest total overall importance value. The single representative of the uncommon genus *Trichodelitschia* is a newly described species.

4.6.1.8 **Basidiomycetes**

Position	Species	TOEIV.*
1.	Coprinus cinereus	2,13
2.	Coprinus heptemerus	2,01
3.	Coprinus miser	0,53
4.	Coprinus stellatus	0,53
5.	Coprinus poliomalus	0,38
6.	Coprinus niveus	0,34
7.	Coprinus curtus	0,06
8.	Panaeolus sp.	0,05

All the recorded species belonging to the class Basidiomycetes are obligatory coprophiles. Species of the genus *Coprinus* were extremely well represented and as such exhibited the highest total overall ecological importance value. The single representative of the genus *Panaeolus* could not be identified to species level.

4.6.2 Fungal species ordination

One-dimensional ordination of the coprophilous fungal species was carried out according to the Total Overall Ecological Importance Values (TOEIV*) that were calculated for each species.

Position.	Sp No	Species	TOEIV.*
1.	84.	Sporormiella minima.	3.21
2.	88.	Coprinus cineratus.	2.13
3.	90.	Coprinus heptemerus.	2.01
4.	25.	Pilobolus kleinii.	1.96
5.	1.	Acremonium sp.	1.75
6.	57.	Ascobolus stictoideus.	1.50
7.	56.	Ascobolus immersus.	1.35
8.	23.	Pilobolus crystallinus.	1.19
9.	24.	Pilobolus longipes.	1.11
10.	15.	Phialophora sp.	1.09
11.	45.	Podospora curvuloides.	0.93
12.	17.	Stachybotrys chartarum.	0.92
13.	7.	Chalara sp.	0.91
14.	75.	Saccobolus glaber.	0.75
15.	10.	Geotrichum candidum.	0.66
16.	29.	Kernia nitida.	0.61
17.	33.	Cercophora californica.	0.60
18.	42.	Podospora anserina.	0.60
19.	85.	Sporormiella minimoides.	0.60
20.	49.	Sordaria brevicollis.	0.54
21.	79.	Thelebolus crustaceus.	0.54
22.	91.	Coprinus miser.	0.53
23.	93.	Coprinus stellatus.	0.53
24.	6.	Bahupaathra samala.	0.52
25.	2.	Aspergillus niger.	0.51
26.	14.	Penicillium sp. biverticillata gr.	0.49
27.	73.	Peziza sp.	0.47
28.	20.	Phoma sp.	0.46
29.	35.	Cercophora mirabilis.	0.45
30.	50.	Sordaria fimicola.	0.43
31.	16.	Sporotrichum sp.	0.39
32.	58.	Cheilymenia theleboloides.	0.38
33.	92.	Coprinus poliomalus.	0.38
34.	26.	Rhizopus stolonifer.	0.38
35.	12.	Graphium calicioides.	0.37
36.	5.	Arthrobotrys oligospora.	0.36
37.	65.	Coprotus leucopocillium.	0.36
38.	44.	Podospora communis.	0.36

39.	53.	Ascobolus amoenus.	0.35
40.	34.	Cercophora coprophila.	0.35
41.	83.	Sporormiella isomera.	0.35
42.	94.	Coprinus niveus.	0.34
43.	64.	Coprotus lacteus.	0.34
44.	72.	Lasiobolus lasioboloides.	0.32
45.	4.	Aspergillus sp. flavus group.	0.31
46.	28.	Kernia sp.	0.31
47.	31.	Leuconeurospora pulcherrima.	0.31
48.	3.	Aspergillus sp. glaucus group.	0.30
49.	46.	Podospora similis.	0.30
50.	63.	Coprotus glaucellus.	0.29
51.	52.	Strattonia hansenii.	0.28
52.	22.	Mucor sp.	0.27
53.	66.	Coprotus luteus.	0.27
54.	47.	Podospora ostlingospora.	0.27
55.	74.	Saccobolus beckii.	0.25
56.	76.	Saccobolus minimus.	0.24
57.	62.	Coprotus disculus.	0.22
58.	18.	Trichurus spiralis.	0.22
59.	19.	Myrothecium verrucaria.	0.22
60.	67.	Coprotus marginatus.	0.19
61.	86.	Sporormiella subtilis.	0.19
62.	27.	Rhopalomyces sp.	0.18
63.	55.	Ascobolus hawaiiensis.	0.17
64.	60.	Coprotus aurora.	0.17
65.	9.	Fusarium sp.	0.17
66.	82.	Sporormiella australis.	0.17
67.	36.	Chaetomium aterrimum.	0.16
68.	41.	Chaetomium chrispatum.	0.16
69.	11.	Gliomastix sp.	0.15
70.	48.	Podospora pleiospora.	0.14
71.	71.	Lasiobolus intermedius.	0.13
72.	43.	Podospora comata.	0.12
73.	37.	Chaetomium bostrychodes.	0.11
74.	21.	Coemansia sp.	0.10
75.	77.	Saccobolus portoricensis.	0.10
76.	87.	Trichodelitschia microspora.	0.10
77.	39.	Chaetomium cf. convolutum.	0.09
78.	51.	Sordaria macrospora.	0.09
79.	30.	Kernia sp.	0.08
80.	54.	Ascobolus degluptus.	0.07
81.	89.	Coprinus curtus.	0.06
82.	68.	Coprotus winteri.	0.06
83.	69.	Fimaria hepatica.	0.06

84.	70.	Iodophanus carneus.	0.06
85.	78.	Saccobolus verrucisporus.	0.06
86.	81.	Bothryosphaeria sp.	0.05
87.	38.	Chaetomium homopilatum.	0.05
88.	95.	Panaeolus sp.	0.05
89.	13.	Penicillium sp. monoverticillata gr.	0.05
90.	40.	Chaetomium robustum.	0.04
91.	59.	Cheilymenia sp.	0.04
92.	61.	Coprotus dextrinoideus.	0.04
93.	8.	Epicoccum purpurascens.	0.04
94.	32.	Pseudeurotium sp.	0.04
95.	80.	Trichobolus sphaerosporus.	0.03

The one-dimensional ordinations recorded are obviously determined by the type of dung substrates investigated and consequently only represent the present research data. However, it can be considered indicative of the degree of species dominance and of the ecological importance of the species on the dung substrates investigated.

4.7 **Fungal species associations**

4.7.1 Introduction

Nineteen different species association classes were recognized as delimited by the computer cluster analyses program - Decorana, according to the peak ecological importance values of the individual species, taking into account all possible substrates and seasons involved.

These species association classes can, in general, be explained on account of the overlapping of, or the joint absences of species during the peak ecological periods, or as a result of interrelated species combinations with regard to the presence/absence patterns exhibited by these species combinations within the specific association classes during the peak fruiting periods.

Two of the original associations delimited by the Decorana program were discounted and moved to another species association class. In both cases the original "associations" consisted of a single species that could easily be accommodated in another existing association class as both share the essential delimiting characteristic of species association class no. 15.

One of the original association classes (no. 9) can be subdivided into three subclasses (no. 9A, no. 9B & no. 9C) on accord of distinct subclass characteristics. As a result of the formation of these three subclasses species 31, which originally belonged to species association class no. 10 is moved to species association subclass no. 9A as it now clearly belongs to the subclass in question, sharing the same distinct characteristic exhibited by this subclass.

4.7.2 Species association classes

The following species association classes were delimited as all exhibit specific species correlations with regard to the time and duration of their respective peak fruiting periods:

Legend:
(Toeiv.* = Total overall ecological importance value.)

4.7.2.1 Species association class no. 1:

This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
4.	Aspergillus sp. flavus gr.	0,31	1
40.	Chaetomium robustum.	0,04	2A
43.	Podospora comata.	0,12	2A
51.	Sordaria macrospora.	0,09	2A
74.	Saccobolus beckii.	0,25	2A
80.	Trichobolus sphaerosporus.	0,03	2A

All species involved reached a common peak fruiting period during day 18 and were closely associated during days 17 - 20.

4.7.2.2 Species association class no. 2:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
2.	Aspergillus niger.	0,51	1
3.	Aspergillus sp. glaucus gr.	0,3	1
14.	Penicillium sp. monovert. gr.	0,05	1
23.	Pilobolus crystallinus.	1,19	1
24.	Pilobolus longipes.	1,11	1
25.	Pilobolus kleinii.	1,96	1
26.	Rhizopus stolonifer.	0,38	1
27.	Rhopalomyces sp.	0,18	2A
53.	Ascobolus amoenus.	0,35	1
56.	Ascobolus immersus.	1,35	1
57.	Ascobolus stictoideus.	1,5	1
61.	Coprotus dextrinoideus.	0,04	1
71.	Lasiobolus intermedius.	0,13	1 & 2A
72.	Lasiobolus lasioboloides.	0,32	2A
77.	Saccobolus portoricensis.	0,1	1

All species involved exhibited peak fruiting periods within 14 days after the onset of incubation.

4.7.2.3 Species association class no. 3:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
49.	Sordaria brevicollis.	0,54	2A
54.	Ascobolus degluptus.	0,07	2A
73.	Peziza sp.	0,47	2A

All species involved exhibited common peak fruiting periods during days 9 -14 and 18 - 20 and were jointly absent during day 17.

4.7.2.4 Species association class no. 4:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
6.	Bahupaathra samala.	0,52	2A
22.	Mucor sp.	0,27	2A
63.	Coprotus glaucellus.	0,29	2A
83.	Sporormiella isomera.	0,35	2A

All species involved reached a common peak fruiting period during days 16 - 17.

4.7.2.5 Species association class no. 5:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
7.	Chalara sp.	0,91	2A
18.	Stachybotrys chartarum	0,92	2A
50.	Sordaria fimicola.	0,43	2A

All species involved reached a common peak fruiting period during days 8 - 34.

4.7.2.6 Species association class no. 6:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
10.	Fusarium sp.	0,17	2A
16.	Phialophora sp.	1,09	2A
52.	Strattonia hansenii.	0,28	2A
55.	Ascobolus hawaiiensis.	0,17	2A

All species involved reached common peak fruiting periods during days 15 - 19 and 23 - 29.

4.7.2.7 Species association class no. 7:
This species association class contains the following species:

Sp No	Species	Toeiv.*	Peak Phase
15.	Penicillium sp. bivert. gr.	0,49	1
17.	Sporotrichum sp.	0,39	2A
70.	Iodophanus carneus.	0,06	2A
92.	Coprinus poliomalus.	0,38	2A

An interrelated species combination exists between species 15 and 17 as they commonly reached peak fruiting periods during days 15 - 20 and 43 - 45. Species 15, 70 and 92 were closely associated and reached a common peak ecological period during days 21 - 24.

4.7.2.8 Species association class no. 8:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
75.	Saccobolus glaber.	0,75	2B
79.	Thelebolus crustaceus.	0,54	3
84.	Sporormiella minima.	3,21	2B
85.	Sporormiella minimoides.	0,6	2A

All species involved reached common peak fruiting periods during days 17 - 20 ; 33 - 38 and 43 - 45.

4.7.2.9 Species association class no. 9:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
9.	Epicoccum purpurascens.	0,04	4
13.	Graphium calcioides.	0,37	3
21.	Phoma sp.	0,46	5
31.	Leuconeurospora pulcherrima.	0,31	3
41.	Chaetomium chrispatum.	0,16	4
48.	Podospora pleiospora.	0,14	3
67.	Coprotus marginatus.	0,19	3
68.	Coprotus winteri.	0,06	3
76.	Saccobolus minimus.	0,24	3
86.	Sporormiella subtilis.	0,19	3
93.	Coprinus stellatus.	0,53	3

In this species association class the following three subclasses can be distinguished on account of common presences and joint absences during the peak fruiting periods.

- Species association subclass no. 9A:

Sp no.	Species	Toeiv.*	Peak Phase
13.	Graphium calcioides.	0,37	3
31.	Leuconeurospora pulcherrima.	0,31	3
48.	Podospora pleiospora.	0,14	3
68.	Coprotus winteri.	0,06	3
76.	Saccobolus minimus.	0,24	3

All species involved reached a common peak fruiting period during day 46.

- Species association subclass no. 9B:

Sp no.	Species	Toeiv.*	Peak Phase
9.	Epicoccum purpurascens.	0,04	4
21.	Phoma sp	0,46	5
41.	Chaetomium chrispatum.	0,16	4

All species involved reached a common peak fruiting period during days 52 - 55.

- Species association subclass no. 9C:

Sp no.	Species	Toeiv.*	Peak Phase
67.	Coprotus marginatus.	0,19	3
86.	Sporormiella subtilis.	0,19	3
93.	Coprinus stellatus.	0,53	3

All the species involved reached a common peak fruiting period during days 48 - 55 and thus partly overlaps with association subclass 9B. Species 67 and 93 also partly overlap with association subclass 9A. This association subclass therefore forms a transitional group between the other two subclasses involved.

4.7.2.10 Species association class no. 10:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
44.	Podospora communis.	0,36	3
45.	Podospora curvuloides.	0,93	3
64.	Coprotus lacteus.	0,34	3

All species involved reached a common peak fruiting period during days 46 - 48. Because of the overlapping of day 46 this species association is closely related to association subclass 9A.

4.7.2.11 Species association class no. 11:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
19.	Trichurus spiralis.	0,22	3
34.	Cercophora coprophila.	0,35	3
69.	Fimaria hepatica.	0,06	3
78.	Saccobolus verrucisporus.	0,06	3
81.	Botryosphaeria sp	0,05	3
87.	Trichodelitschia sp	0,1	3

All species involved reached a common peak fruiting period during day 40.

4.7.2.12 Species association class no. 12:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
5.	Arthrobotrys oligospora.	0,36	3
29.	Kernia nitida.	0,61	3
39.	Chaetomium convolutum.	0,09	3
46.	Podospora similis.	0,3	2B
60.	Coprotus aurora.	0,17	4
90.	Coprinus heptemerus.	2,01	3
94.	Coprinus niveus.	0,34	3

All species involved reached a common peak fruiting period during days 27 - 42. The competitive interference of *C. heptemerus* is well documented (Ikediugwu & Webster 1970a,b), it would therefore be interesting to test the ability of the other species, belonging to this association, to withstand the competition of *C. heptemerus*.

4.7.2.13 Species association class no. 13:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
8.	Coemansia sp	0,1	2B
28.	Kernia sp 1.	0,31	3
30.	Kernia sp 2.	0,08	2B
37.	Chaetomium bostrychodes.	0,11	2A
59.	Cheilymenia sp	0,04	2B
65.	Coprotus leucopocillium.	0,36	2B

All species involved reached a common peak fruiting period during days 33 and 34.

4.7.2.14 Species association class no. 14:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
36.	Chaetomium atterimum.	0,16	3
62.	Coprotus disculus.	0,22	2B

Both species involved reached a common peak fruiting period during days 17 - 26.

4.7.2.15 Species association class no. 15:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
11.	Geotrichum candidum.	0,66	1
33.	Cercophora californica.	0,6	3
35.	Cercophora mirabilis.	0,45	3
47.	Podospora ostlingospora.	0,27	3
82.	Sporormiella australis.	0,17	4
91.	Coprinus miser.	0,53	3

Two distinctly separable peak fruiting periods are exhibited by all the species involved. An early peak period starting as early as day 5 and lasting up to day 49, depending on the particular species involved. As well as a late peak period starting as late as day 41 and lasting up to day 68, again depending on the particular species involved. The distinct association characteristic being the two separable peak periods exhibited by all species involved.

4.7.2.16 Species association class no. 16:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
42.	Podospora anserina.	0,6	2A
95.	Paneolus sp.	0,05	4

Both species involved reached a common peak fruiting period during days 52 - 58.

4.7.2.17 Species association class no. 17:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
32.	Pseudeurotium sp.	0,04	4
66.	Coprotus luteus.	0,27	4
88.	Coprinus cinereus	2,13	2A
89.	Coprinus curtus.	0,06	4

All species involved reached a common peak fruiting period during days 55 - 60.

4.7.2.18 Species association class no. 18:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
12.	Gliomastix sp	0,15	5
20.	Myrothecium verrucaria.	0,22	5
58.	Cheilymenia theleboloides.	0,38	5

All species involved reached a common peak fruiting period during days 76 - 98.

4.7.2.19 Species association no. 19:
This species association class contains the following species:

Sp no.	Species	Toeiv.*	Peak Phase
1.	Acremonium sp	1,75	2B & 3
38.	Chaetomium homopilatum.	0,05	5

Both species involved reached a common peak fruiting period on day 112.

4.7.3 Conclusion

In conclusion the following general statements and deductions can be made:

-These species association classes could have specific ecological indicator values, as they are characterized by relatively strong species correlations within the respective association classes. Consequently the presence of at least a significant number of the species within the association class could indicate the possible presence of other species correlated with those observed.

-Furthermore, the different species association classes correlate extremely well with the peak fruiting periods of the different successional phases recognized, again lending credibility to the hypothesis of partly generic or species specific based succession rather than environmentally dominated succession. The possibility of a combination of both the species specific and the environmentally dominated succession processes can not be ruled out and remains a strong and logical possibility as far as an explanation of the fungal fruit body succession on dung is concerned.

-The species association classes indicate a certain degree of tolerance amongst the species constituting the specific association class and thus possibly a decrease in interference type competition. The possibility that the species comprising each species association could probably enhance the fruiting of each other in a synergistic manner should also be taken into consideration. However, the delimited association classes should only be seen as preliminary trends as

more research of this nature is needed before definite conclusions can be drawn, especially with regard to the tolerance within and the competition amongst the different association classes.

-The total overall ecological importance values (Toeiv.*) illustrate the ecological dominance hierarchy within each association class.

4.8 **Fungal species composition and species diversity during the different successional fruiting phases**

4.8.1 Fungal species composition:

4.8.1.1 Introduction

Succession involves a change in the species composition and species abundance values over a period of time. The fruit body succession phenomenon in nature can be ascribed to the influence of any of a number of factors or, in most cases, to the combined influences of a number of factors. The importance of any one factor, in bringing about succession, can change as a result of the influences of the other factors present. These factors can be of a ecological, physiological or of a genetical nature and in the case of the coprophilous fungi the following factors could possibly play a role in determining the species composition of a substrate at any moment in time:

- Ecological factors:

The food preferences, feeding habits and type of digestive system of the animals as well as environmental factors such as temperature fluctuations, photoperiodicities, water potential of the substrates, the availability of nutrients in the substrates, the role of other dung inhabiting organisms and interspecific fungal species competition, will definitely influence the species composition of any substrate at any moment in time.

- Physiological and genetical factors :

Periodicities with regard to spore germination, maturation and fructification also play a role in determining the specific species composition at any given moment.
Because of the varied nature and influences of all the factors mentioned it is not in the scope of the present research to pinpoint the possible cause / effect results. The present research indicated a gradual change of fruit body frequency and importance values of the fungi on the dung substrates over time. As a result the presence of the different fungal species and even fungal classes tend to overlap. It is therefore not possible to easily distinguish clear cut successional phases by merely observing the presence and absence patterns of the fungi on the dung substrates.

4.8.1.2 Results

All of the fungi present on the different dung substrates exhibited periods of peak activity. These peak periods were determined by the abundance values and density of fruiting. As a result it was possible to calculate a peak importance value for each species present. These values were then used to determine the successional position of each species. This lead to a subjective determination of the following successional phases:

Phase 1: Day 1 - 4
Phase 2: Day 5 - 14
Phase 3: Day 15 - 32
Phase 4: Day 33 - 48
Phase 5: Day 49 - 67
Phase 6: Day 68 - 104
Phase 7: Day 105 - 112

These findings were then tested using the objective Twinspan computer cluster analyses program which resulted in the construction of a dendrogram (Graph Fig.5). The following results were thus obtained:

Phase 1: Day 1 - 4
Phase 2: Day 5 - 14
Phase 3: Day 15 - 34
Phase 4: Day 35 - 49
Phase 5: Day 50 - 65
Phase 6: Day 66 - 104
Phase 7: Day 105 - 112

After analyses of the dendrogram the following final successional phases and respective class sequinces were identified:

Phase 1: Day 1 - 14
Zygomycetes.

Phase 2A: Day 15 - 25
Hyphomycetes, Pyrenomycetes, Discomycetes gr.1

Phase 2B: Day 26 - 34
Plectomycetes, Basidiomycetes.

Phase 3: Day 35 - 49
Coelomycetes, Loculoascomycetes,
Discomycetes gr.2, Basidiomycetes.

Phase 4: Day 50 - 65
Coelomycetes.

Phase 5: Day 66 - 112
No dominant fungal class was discernible and only 2,11% of all the species exhibited any peak fruiting activity during this period.

Phase 2 was divided into phases 2A and 2B as these divisions occurred on a lower level in the dendrogram (Graph Fig. 5) than all the other phases, yet clearly constituted separate identifiable phases. The fact that water as a limiting factor was excluded, as a result of the dung substrates being kept moist for the duration of the investigations, and the fact that other environmentally limiting factors such as temperature and photoperiodicity were regulated according to the seasonal changes, to a large extent cancelled the environmental impact that these factors might have had on the fungal composition of the substrates at any given moment in time. Other environmental factors such as inter- and intra- species competition and synergism were not monitored, however the fact that competition can play a part in determining fungal succession on dung substrates cannot be discounted. Therefore the resulting fungal composition of the different successional phases can to a large extent be attributed to generic succession. The phenomenon of generic succession can possibly be ascribed to inherited physiological and genetical characteristics rather than merely to environmentally limiting factors.

4.8.1.3 Discussion

In total, representatives of 23 genera were observed during the investigation period, of these 14 genera were represented by more than one species all of which to some degree exhibited similar species successional phase correlations. The minimum association factor in all cases being a 33% species successional phase correlation and the maximum association factor in 50% of the cases being a 100% species successional phase correlation .

Percentage of common genera with a 100% species successional phase correlation = 50%

Percentage of common genera with > 57% species successional phase correlation = 71%

Percentage of common genera with > 40% species successional phase correlation = 86%

Percentage of common genera with > 33% species successional phase correlation = 100%

Thus 61% of all species present on all dung substrates and during all seasons and successional phases exhibited some degree of positive species association within the specific genus involved. The other 39% of the species present were the only representatives of the particular genus and as such contributed to the generic diversity rather than to the generic dominance pattern.

4.8.1.4 Conclusion

Fungal fruit body succession on dung substrates cannot merely be ascribed to a single environmental or generic factor or even a simple combination of factors. However, it seems possible that at the very least 60% of the successional occurrences in the common genera, as observed during the laboratory investigations, can be attributed to some degree (50%) to inherited physiological characteristics. Consequently it is highly probable that a combination of both environmental and genetical factors could determine the phenomenon of fungal succession on dung substrates and can account for the majority of the successional phase positions occupied by the more common coprophilous genera and their respective representatives.

The degree to which any specific factor or combination of factors influences the succession of fungi on dung substrates will probably vary within the distribution range of the specific fungus and with the prevalent conditions of existence at any moment in time, as the coprophilous fungi have in all probability developed locally adapted ecotypes as is the case in most ecological groups. If this is the case then the coprophilous fungi are genetically adapted in either morphological and / or physiological aspects to cope with the complex environmental conditions and biotic pressures they have to deal with in order to be successful on any given substrate at any moment in time, in a specific area of their distribution. This phenomenon could thus give a possible explanation for the morphological differences, within a species, as reported by some authors from different countries and regions within the distribution area of the fungus.

4.8.2 Fungal species diversity:

4.8.2.1 Results and discussion

As can be seen in Graph Figs. 4.1 and 4.2 the species diversity curves exhibit typical concave curvatures, when the number of species present is plotted against the successional importance values. The species diversity curve of phase 5 exhibits a degree of deviation (flattening) when compared to the species diversity curves of the other successional phases. Phase 5 lasted from day 66 - 112 after the onset of incubation. The relatively low species diversity of phase 5 can be attributed to the fact that virtually no new species appeared after day 60 and a very low number of species (2,11 %) exhibited any peak ecological activity during this period. Arrangement of the different successional phases are possible according to the relevant species diversity curves. The highest species diversity was observed during phase 2A, closely followed by phases 3 and 2B. The next highest species diversity was exhibited by phase 1 followed by phase 4 and 5 respectively.

The classification of the successional phases according to their respective species diversities are summarized in the following table:

Position.	Phase.	Duration.
1	2A	Day 15 - 25
2	3	Day 35 - 49
3	2B	Day 26 - 34
4	1	Day 01 - 14
5	4	Day 50 - 65
6	5	Day 66 - 112

4.8.2.2 Conclusion

In conclusion the following statements and general deductions can be made:

-When investigating incubated substrates it can be expected to observe the highest species diversity on all substrates between days 15 - 25 after the onset of incubation.

-Investigation can be terminated approximately 65 - 70 days after the onset of incubation.

-Fungal fruit body succession on dung can be attributed to the concurrent influences of a number of environmental factors, biotic pressures and inherited genetical characteristics.

SUMMARY

The coprophilous mycoflora of the larger herbivores of the Kruger National Park, South Africa.

by

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As a result of the taxonomical research a number of new records was established and a new species of the genus *Trichodelitschia* was described. In all 15 new records for the Southern Hemisphere; 18 new records for the African continent and 21 new records for South Africa were noted. Thus up to 70% of all the species recorded are new records for the Republic of South Africa. A number of extremely rare species were encountered, some of which were previously only known from the type locality. A relatively small number of the fungi recorded could not be identified to species level, these mostly belonged to fungal groups that are not normally reported from dung substrates. The largest number of fungal species belonged to either the Pyrenomycetes or the Discomycetes. The order Pezizales was well represented and a key to the coprophilous genera of this order was compiled (see addendum A).

As a result of the ecological research it was possible to conclude that the feeding habits, food preferences and to a lesser degree the type of digestive systems had a definite influence on the fungal species composition and species diversity on the different dung substrates investigated.

The existence of a forest-canopy coprophilous fungal flora and a grassland coprophilous fungal flora were established. These phenomena were attributed to the difference in fungal propagule sizes and the spore dispersal mechanisms as exhibited by the species on the different dung substrates.

A comparison between the fungal species diversity on freshly voided dung substrates and substrates from different parts of the digestive tracts of the animals confirmed that the spores of the coprophilous species survive passage through the digestive system and are probably stimulated to germinate by the digestive processes.

A comparison between the fungal species composition and the species diversity on freshly voided elephant dung substrates obtained from free roaming animals and animals kept in captivity were carried out. The results indicated a markedly lower fungal species diversity on the latter dung substrates. The possibility that these results could be indicative of a nutritionally related stress syndrome in the environment of the animals were implied, however the results could also be indicative of a lower fungal inoculum present on the food sources of the captive animals.

With regard to the seasonality of fruiting of the coprophilous fungi the present research results differed from the observations of other authors in that the summer months proved to be the most productive period. However, the summer season in the study area represent the annual warm wet period and as such the results do concur with those of other authors.

The fungal fruit body succession on the different dung substrates was investigated and the successional phases determined by means of a computer cluster analysis program. The conclusion was reached that the successional patterns exhibited could in all probability be attributed to a number of environmentally limiting factors and biotic pressures as well as the existence of inherited physiological characteristics exhibited by the fungi.

Certain species associations were delimited by means of a computer cluster analysis program, these associations were found to be indicative of the peak ecological periods as exhibited by the members of each association.

One-dimensional ordinations, with regard to the total overall ecological importance values, were constructed. These results lead to the arrangement of the coprophilous fungal species in order of ecological importance.

OPSOMMING

Die koprofiele mikoflora van die groter herbivore van die Kruger Nasionale Park, Suid Afrika.

deur

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Die taksonomiese navorsing het 'n aantal nuwe aanwinste opgelewer en 'n nuwe spesie van die genus *Trichodelitschia* is beskryf. In totaal is 15 nuwe rekords vir die Suidelike Halfrond, 18 nuwe rekords vir Afrika en 21 nuwe rekords vir Suid Afrika genoteer. Gevolglik is tot 70% van al die spesies waargeneem nuwe rekords vir die Republiek van Suid Afrika. Verskeie besonder skaars spesies het voorgekom, waarvan sommige voorheen nog net in hul tipe lokaliteit aangetref is. 'n Relatiewe klein getal spesies kon nie tot op spesie-vlak geïdentifiseer word nie. Hulle behoort egter grootliks tot genusse wat nie normaalweg as koprofiele beskou word nie. Die oorgrote meerderheid spesies het tot die Pyrenomycetes of die Discomycetes behoort. Die orde Pezizales was goed verteenwoordig en 'n sleutel tot die koprofiele genusse van hierdie orde is saamgestel (kyk addendum A).

As gevolg van die ekologiese navorsing was dit moontlik om tot die gevolgtrekking te kom dat die voedingsgewoontes, voedselvoorkeure en tot 'n mindere mate die tipe spysverteringstelsels van die diere, 'n definitiewe invloed op die fungus spesie samestelling en spesie diversiteit van die verskillende mis-substrate gehad het.

Die bestaan van 'n woud-gewelf (blaredak) koprofiele mikoflora en 'n grasveld koprofiele mikoflora is bewys op grond van die verskille in die spoorgroottes en verspreidingsmeganismes van die verskillende spesies teenwoordig.

'n Vergelyking tussen die spesie samestelling en die spesie diversiteit van vars olifantmis-substrate, wat verkry is van diere wat vrylik in die natuur voorkom en diere in aanhouding is uitgevoer. Die resultate dui op 'n merkbare verlaging van die spesie diversiteit op laasgenoemde substrate. Die moontlikheid dat hierdie resultate veroorsaak word deur 'n voedingsverwante spanningsindroom in die omgewing van die diere word geïmpliseer, die moontlikheid dat die voedsel van die diere in aanhouding egter oor 'n laer fungus inokulum beskik word nie buite rekening gelaat nie.

Met betrekking tot die seisoenaliteit van die koprofiele fungusse het die huidige navorsingsresultate verskil van die waarnemings van ander outeurs, aangesien die somermaande die hoogste produktiewiteit opgelewer het. Die somerseisoen in die studiegebied verteenwoordig egter die jaarlikse warm vogtige periode en as sulks stem die resultate ooreen met die van dié ander outeurs.

Die fungus vrugliggaam-suksessie op die verskillende mis-substrate is ondersoek en die suksessionele fases is aan die hand van 'n groepsanalise rekenaarprogram bepaal. Daar is tot die gevolgtrekking gekom dat die suksessionele patrone in alle waarskynlikheid toegeskryf kan word aan 'n aantal beperkende omgewingsfaktore en die invloed van biotiese interaksies, asook aan die moontlike bestaan van generiese erflikheidsfaktore.

Sekere spesie assosiasies is onderskei deur middel van die groepsanalise rekenaarprogram. Hierdie assosiasies is 'n aanduiding van die periodes van hoogste ekologiese aktiwiteite soos uitgebeeld deur die vrugliggame van die onderskeie verteenwoordigers van elke assosiasie.

Een-dimensionele ordenings met betrekking tot die totale algehele ekologiese belangrikheidswaardes is uitgevoer. Hierdie resultate het gelei tot die rangskikking van die koprofiele fungusspesies in volgorde van ekologiese belangrikheid.

ADDENDUM A: COPROPHILOUS GENERA OF THE ORDER PEZIZALES

6.1 Introduction

During the present research, some difficulty in using existing keys for identification purposes was experienced. This was especially true in the case of the coprophilous Discomycetes. Changes in the taxonomy of this fungal group, outdated literature and the general confusion caused by the various synonyms that exist (see Table 1.), prompted the author to compile a relative simple, yet reliable dichotomous key, geared towards the identification of the coprophilous genera of the order Pezizales. Three genera of the order Helotiales are also treated at the end of the key.

Two excellent keys treating all the genera of the order Pezizales do exist, as well as a general key to the genera of the coprophilous fungi, all of which were referred to in compiling the present key:
1. Ainsworth, G.C. et.al. 1973. The fungi, an advanced treatise.
2. Korf, R.P. 1972. Synoptic key to the genera of the Pezizales.
3. Ellis, M.B. & Ellis, J.P. 1988. Fungi on Dung.

However when using the first two keys, the student is still faced with numerous options that have to be worked through in order to identify the coprophilous genera and a few genera were not included in the latter key. This can be both confusing and time consuming, especially for the inexperienced student. Thus a key was constructed to exclusively include those families, subfamilies, tribes and genera of the Pezizales and three genera of the Helotiales to which the coprophilous fungi are restricted. The author fully realizes that the list of coprophilous genera included in the key may not be complete, and will probably change as the knowledge of this fungal group is broadened by research. However, the key can be used to identify all of the major and some of the not so common coprophilous genera of the Pezizales, as well as three genera of the order Helotiales.

Seeing that all but one genus, and a doubtful one at that, belong to the suborder Pezizineae, the key will commence with the families belonging to the Pezizineae. A brief description of the order Pezizales and the suborders are given.

Order Pezizales:
Ascocarps are usually epigean. Apothecia of various shapes that range from minute to quite large in size. The apothecial tissues are usually fleshy but sometimes leathery or brittle and rarely of a gelatinous nature. The asci occur in a definite hymenium with paraphyses present. Sometimes the ascocarp resembles a cleistothecium with only a few asci or a single ascus, as represented by some members of the Theleboleae. In the case of the genus *Ascodesmis* the ascocarp is reduced to a mycelial tuft with no excipulum present. The asci are cylindrical to clavate and open by means of an operculum, or at times by means of a vertical apical slit, as is the case in some members of the Theleboleae. The ascospores are actively discharged and the number of ascospores per ascus range from the usual eight spores (sometimes two to four) to

numerous (up to 7000) in some representatives of the Theleboleae. Ascospores are hyaline to brown and in some instances different shades of purple. The ascospores are always unicellular, smooth, variously sculptured or plicated.

Suborder Sarcoscyphineae
Nannfeldtiella is the only genus belonging to this suborder reported on dung. The only species of this genus, *Nannfeldtiella aggregata*, was probably wrongly described and it may be closer related to the genus *Discina* (Helvellaceae) according to Korf (1972).

Suborder Pezizineae
By far the largest number of representatives of the coprophilous Discomycetes belong to this suborder. Apothecia are usually fleshy, in some cases dry and brittle, and are not embedded in a gelatinous matrix. Ascospores are hyaline, brown or purple, guttulate or eguttulate, uni- or multi-nucleate. Paraphyses are not anastomosed. The asci are clavate to cylindrical, thin walled and opening by means of an opperculum or asci are clavate to ovoid, thick-walled and opening by means of an irregular tear. Ascus apex amyloid or non-amyloid.

6.2 Keys to the coprophilous genera of the order Pezizales

6.2.1 Key to the coprophilous families of the suborder Pezizineae

Key characteristics are printed in **bold.**
Three of the five families of this suborder have coprophilous representatives.

A. **Ascospores thick-walled when young**, ascospores eguttulate and hyaline, asci amyloid.

OR

Ascospores thick-walled when young, ascospores eguttulate and purple to brown as a result of epiplasmic pigments, ascus apex amyloid or non-amyloid. ----------> **Ascobolaceae**

AA. **Ascospores thin-walled when young**, ascospores guttulate or eguttulate, **mature ascospores usually hyaline**, if brown then not as a result of epiplasmic pigments but in the form of cyanophilic spore markings. Ascus apex amyloid or non-amyloid ----------> **B**

B. Asci apices **intensely blue** or asci walls diffusely blue in iodine, apothecia usually large ----------> **Pezizaceae**

BB. Asci non-amyloid (not blue in iodine), apothecia relatively small ----------> **Pyrenomataceae**

6.2.2 **Key to the coprophilous tribes and genera of the family Ascobolaceae**

Key characteristics are printed in **bold.**

A. Mature ascospores purple to brown. Asci amyloid or non-amyloid.----------->**Tribe: Ascoboleae** ----------> **B**

AA. Mature ascospores remain hyaline, or if with brown markings then not as a result of epiplasmic pigments. Asci diffusely amyloid.----------->**Tribe:Iodophaneae** ----------> **C**

B. 1. Ascospores united into a cluster and discharged as such, sometimes loosely united and then freed on discharge, ascospores smooth to granulated.----------> *Saccobolus*

2. Ascospores free never arranged in a cluster, ascospores verrucose or cracking into striae, warts or reticulae. ----------> *Ascobolus*

C. 1. Apothecia lenticular to convex in shape **with carotenoid pigments** giving a yellowish colour, ascospores ovoid, eguttulate, **with a thin epispore**, with or without a thin mucilaginous perispore. Ascospores weakly to strongly warted, asci operculate, eight-spored, **with a short stipe.** ----------> *Iodophanus*

C. 2. Apothecia subconical, cylindric to turbinate, rarely discoid. **No carotenoid pigments**, apothecia white to different shades of purple. Ascospores ovoid, eguttulate, **with a swollen epispore** and a thick, irregular, **mucilaginous perispore.** Ascospores smooth to finely warted. Asci operculate, 8-32 spored, **with a long stipe.** ----------> *Thecotheus*

6.2.3 Key to the coprophilous subfamilies, tribes and genera of the family Pyrenomataceae

Key characteristics are printed in **bold**.

A. **Mature ascospores brown** or with browning walls, if hyaline purple pigments are present in the apothecia.
----------> **subfamily: Ascodesmidioideae** ----------**>C**

AA. **Mature ascospores hyaline**, apothecia lacking purple pigments.----------**> B**

B. 1. **Ascospores eguttulate**, frequently with de Bary bubbles. Apothecia **without carotenoids.**
----------> **subfamily: Ascophanoideae** ----------**> D**

B. 2. Ascospores guttulate or eguttulate, apothecia **with carotenoids.**---**> subfamily: Scutellinioideae** ----------**> E**

C. **Only one genus of a coprophilous nature.** Apothecia minute, in the form of a fascicle of asci and paraphyses, **without an excipulum.** Mature ascospores brown, spherical to ovoid, reticulatedly marked with ridges and or spines. Ascospores biseriate to irregularly arranged. Asci obliquely operculate, non-amyloid, eight-spored, ascospores crowded in the upper part of the ascus prior to discharge. Paraphyses stout, numerous, septate, unbranched and inflated at the apices.----------> *Ascodesmis*

D. **1.** Apothecia discoid, with **coarse brown hyphoid hairs.** Ascospores yellowish, resinous and somewhat refractive.
----------**> Tribe: Pseudombrophileae** --------**> F**

D. **2.** Apothecia discoid to turbinate or subglobose. Apothecial margins fringed with delicate **hyaline hyphae or stiff hyaline setae.**--------**> Tribe: Theleboleae** ----------**> G**

E. **1.** Either with **rooting brown pointed setae** or a combination of the following: **Ascospores eguttulate, with a loose perispore and globose excipulum cells.**
----------**> Tribe: Scutellinieae** ----------**> H**

E. **2. No rooting hairs** present, not combining the three characters above. Apothecia minute to large, not discolouring when bruised, marginate.---**> Tribe: Aleurieae**----------**> I**

F. **1.** Apothecial hairs blunt at the apices and more or less flexuous. Apothecia brown to yellow-brown with a sterile, elevated, toothed marginal rim. Asci non-amyloid. Ascospores elliptical, eguttulate, smooth and yellowish in colour. **Paraphyses embedded in a brownish matter at the apices.** ----------> *Fimaria*

F. **2.** **Ascospores flattened at one surface to lunate.** (ascospores asymmetrical) **Paraphyses anastomosing.** Only one genus. ----------> *Selenospora*

G. **1.** Asci opening by means of an **operculum.** ----------> **J**

G. **2.** Asci opening by means of a **vertical slit** or an **irregular tear.** ----------> **K**

H. **1.** **Apothecial hairs absent**, excipulum cells globose. Asci non-amyloid, eight-spored. Ascospores uniseriately to irregular biseriately arranged, eguttulate, hyaline, smooth, ellipsoid, usually with double de Bary bubbles and a **loose wrinkled perispore. Paraphyses nearly as broad as the asci** with swollen tips. ----------> *Coprobia*

H. **2.** Apothecial hairs (setae) present, setae superficial or rooted or both, setae-base lobed, branched or forked. Paraphyses slender to gracile. ----------> **L**

I. **1.** Apothecial hairs absent or at most downy. Apothecia orange to red with a prominent sterile dented margin. **Margin composed of long-clavate cells.** Ascospores smooth or variously sculptured (usually finely warted), ellipsoid to fusoid, guttulate. Paraphyses slender, straight, sometimes curved at the apices. ----------> *Octospora*

I. **2.** Apothecia smooth, subglobose to pyriform, **seated on a web of hyphae.** Apothecial **margin composed of angular or subglobose cells.** Ascospores **smooth**, ellipsoid to fusoid, with two or more guttules. Asci eight-spored. ------> *Byssonectria*

J. **1. Apothecia non-setose, > 0,2mm in diameter**, lenticular to discoid, pallid, white to yellow. Asci operculate, non-amyloid, cylindric to broadly clavate, 8 to 256 spored, **usually eight-spored.** Ascospores smooth, eguttulate, hyaline to faintly yellow, **thin-walled**, with conspicuous de Bary bubbles.----------> *Coprotus*

J. **2. Apothecia non-setose, < 0,2mm in diameter**, discoid to flattened. Several asci per apothecium. Asci **multisporous (32 to 250)**, non-amyloid, **thin-walled.** Ascospores ellipsoid to ovoid, hyaline, smooth, small **never more than 6-7 x 3-4µ.** Paraphyses slender, septate. ----------> *Ryparobius*

J. **3. Apothecia setose, setae non-septate and superficial**, brightly coloured. Asci non-amyloid, cylindric, **usually indented at the operculum**, 8 to 128 spored. Ascospores smooth, eguttulate, hyaline to yellowish-brown, uniseriately to irregular biseriately arranged, **more than 20µ long** with prominent de Bary bubbles. ----------> *Lasiobolus*

K. **1.** Apothecia setose, setae septate, superficial,setae-base enlarged to bulbous or non-bulbous, **base never lobed, forked or branched.** Asci inoperculate.----------> **M**

K. **2.** Apothecia non-setose. Asci inoperculate. ----------> **N**

L. **1.** Apothecia in shades of yellow or red, with a fringe of setae along the margin , setae septate with **pointed apices** and **lobed to branched bases, yellow to brown in colour.** Setae superficial, in some species accompanied by rooting hairs. Ascospores **eguttulate**, ovoid, **smooth,** with a **loose perispore.**----------> *Cheilymenia*

L. **2.** Apothecia brown to red, setose, setae septate, **thick-walled,** forked at the bases, rooted. Ascospores ornamented, **spherical to elliptical, usually with** many guttules. ----------> *Scutellinia*

M. **1.** Apothecia setose, setae septate, **hyaline and blunt above and yellow below**, base enlarged. Apothecia **bright yellow.** Asci opening by means of an irregular tear, eight-spored. Ascospores smooth, eguttulate, hyaline, biseriately arranged, shorter than 10μ and thick-walled.---> *Lasiothelebolus*

M. **2.** Apothecia setose, setae septate, never yellow at the base. Ascospores smooth or ornamented. ----------> **O**

N. **1.** Apothecia non-setose, asci inoperculate with an apical plug, 15 to 25 asci per apothecium, **asci 1000 to 1500 spored**, non-amyloid. Ascospores smooth, eguttulate, **less than 6μ long.** Only one species. ------> *Caccobius minisculus*

N. **2.** Apothecia non-setose. Asci inoperculate without an apical plug, with or without an apical ring. Asci apices stain in congo red. ----------> **P**

O. **1.** Apothecia setose, **setae 1 to 10 septate**, non-bulbous at the base, situated in the upper part of the apothecia. Asci non-amyloid, inoperculate, ovate to cylindric, 1 to 40 asci per apothecium, 8 to multispored. **Ascospores smooth**, eguttulate, **less than 12μ long**, de Bary bubble sometimes present. ----------> *Trichobolus*

O. **2.** Apothecia setose. Setae septate, non-bulbous at the base, **with cyanophilic markings**, thick-walled. Asci non-amyloid, inoperculate with no apical differentiation, **thin and evanescent. Ascospores ornamented** with ridges to form reticulae, eguttulate, **less than 9μ long**, with or without de Bary bubbles. ----------> *Mycoarctium*

P. **1.** Apothecia non-setose. Asci inoperculate, **without an apical plug or an apical ring.** Asci 256 (rarely 64) spored, non-amyloid, 50 to 70 asci per apothecium. **Ascospores more than 14μ long**, smooth, eguttulate, hyaline with de Bary bubbles. ----------> *Coprobolus*

P. **2.** Apothecia non-setose. Asci inoperculate, with an apical ring but without an apical plug. Ascospores 12μ or shorter. **Ascus apices hyaline in congo red.** ----------> **Q**

Q. **1.** Apothecia non-setose, discoid. Asci inoperculate **with an apical ring but without an apical plug**, opening by means of a **vertical apical slit**, 32 to 128 spored. **Ascospores 12μ or shorter**, elliptical to naviculate, smooth, eguttulate, **thick spore wall** (± 1,4μ). ----------> *Ascozonus*

Q. **2.** Apothecia some shade of brown, non-setose. Asci inoperculate, with an apical ring but without an apical plug. **Apothecia resemble cleistothecia.** Asci opening by an **irregular tear**, 8 to 2500 spored. Ascospores 12μ or shorter, smooth, eguttulate, subspherical to ellipsoid. **A single ascus per apothecium.** Paraphyses inflated at the apices. ----------> *Thelebolus*

6.2.4 **The coprophilous genera of the family Pezizaceae**

Key characteristics are printed in **bold.**

The genus *Peziza* is the only genus of this family with coprophilous representatives.

Apothecia discoid to cupulate. Asci with a distinct **amyloid apical ring** or asci apices **strongly blue** in iodine. -------> *Peziza*

6.2.5 **The coprophilous representatives of the order Helotiales**

Three genera are included, as the only known genera of this order occurring on dung substrates (Ellis & Ellis 1988).

Family: Sclerotiniaceae and Helotiales

A. Apothecia stalked. ----------> **1**

AA. Apothecia sessile. ----------> **2**

1.1 Apothecia long-stalked, arising from small black sclerotia.
----------> *Martininia*

1.2 Apothecia short-stalked, arising from black stromata.
----------> *Lanzia*

2. Apothecia sessile, without a stroma or a sclerotium.
----------> *Pezizella*

Table 1. A list of the genera included in the keys, with possible synonyms, wrong identifications and references where applicable.

Genera	Synonyms & wrong ID.	References
1. Ascobolus	Dasyobolus Fimaria Peziza Saccobolus Spaeridiobolus Thelebolus	Ref.3; 6
2. Ascodesmis	None	Ref.28
3. Ascozonus	Coprotus Streptotheca	Ref.3; 16
4. Byssonectria	Humaria, Octospora Peckiella Peziza	Ref.11; 24
5. Caccobius	None.	Ref.20; 30
6. Cheilymenia	Ascobolus Ciliaria Lachnea Patella Peziza Scutellinia	Ref.3; 4; 10; 15; 27; 30; 1
7. Coprobia	Ascophanus	Ref.4; 30; 27
8. Coprobolus	None	Ref.7
9. Coprotus	Ascophanus Ascozonus Ryparobius	Ref.3; 18; 20; 22; 1
10. Fimaria	Ascobolus Ascophanus Humarina	Ref.3; 5; 1

11. Iodophanus	Ascophanus Humarina	Ref.19; 21
12. Lanzia	Coprotinia Helotium	Ref.3
13. Lasiobolus	Dasyobolus	Ref.3; 20; 1
14. Lasiothelebolus	None	Ref.23
15. Martininia	Martinia	Ref.3
16. Mycoarctium	None	Ref.14
17. Nannfeldtiella	Discina	Ref.12
18. Octospora	Byssonectria Humaria Humarina Kotlabaea Neottiella	Ref.3; 12; 30
19. Peziza	Aleurina Ascobolus Byssonectria Cheilymenia Daleomyces Dermatea Galactina Geopyxis Humarina Hymenoscyphus Lamprospora Neottiella Plicaria	Ref.1; 3; 11; 30

20. Pezizella	Allophylaria Calycellina Crociocreas Cyathicula Discohainesia Eubelonis Helotium Hyalinia Hyaloscypha Hymenoscyphus Micropodia Mollisiella Ombrophila Urceolella	Ref.3; 1
21. Ryparobius	Coprotus Thelebolus	Ref.3; 16
22. Saccobolus	Ascobolus	Ref.3; 6
23. Scutellinia	Ciliaria Cheilymenia Lamprospora Melastiza Patella Sphaerospora Sphaerosporella	Ref.3; 9; 11; 1
24. Selenaspora	None	Ref.11
25. Thecotheus	Ascophanus Ascophanella Zukalina	Ref.3; 16; 17
26. Thelebolus	Ascophanus Ryparobius Streptotheca	Ref.8; 15; 20; 30; 1
27. Trichobolus	None	Ref.20; 26

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ADDENDUM B: FIGURES

Plectomycetes:

Figs. 1-3: *Kernia nitida*.

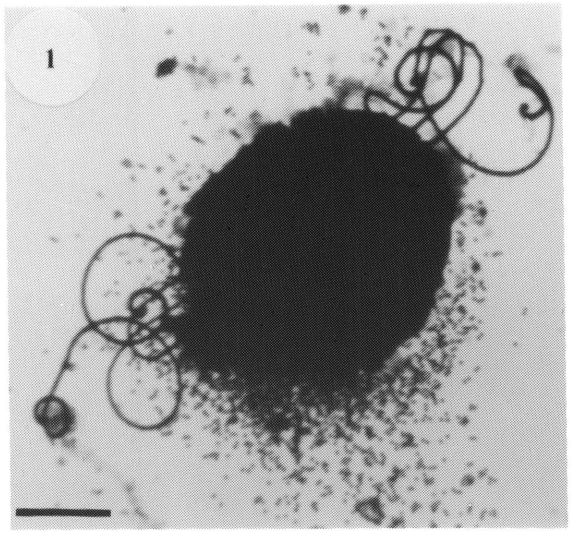
1. Cleistothecium (x5)
2. Appendages (x40)
3. Ascospores (x100)

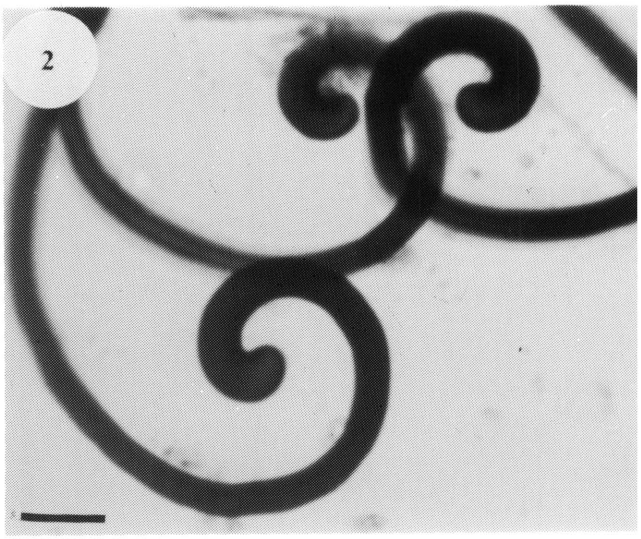
Figs. 4-5: *Kernia* sp.1.

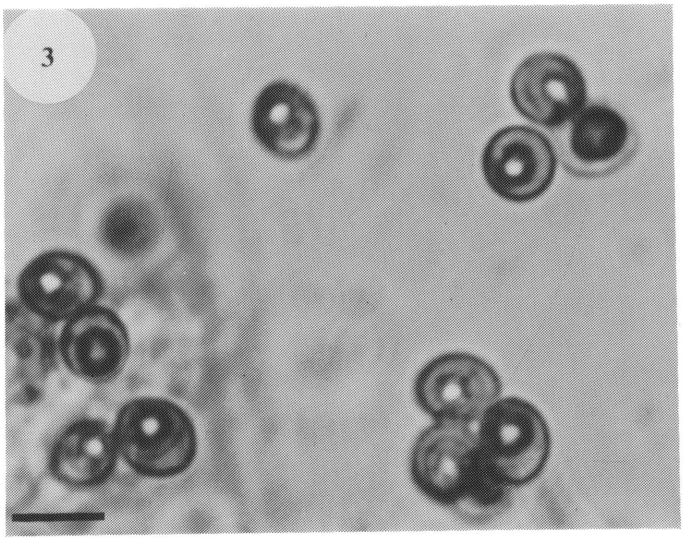
4. Cleistothecium (x10)
5. Ascospores (x40)

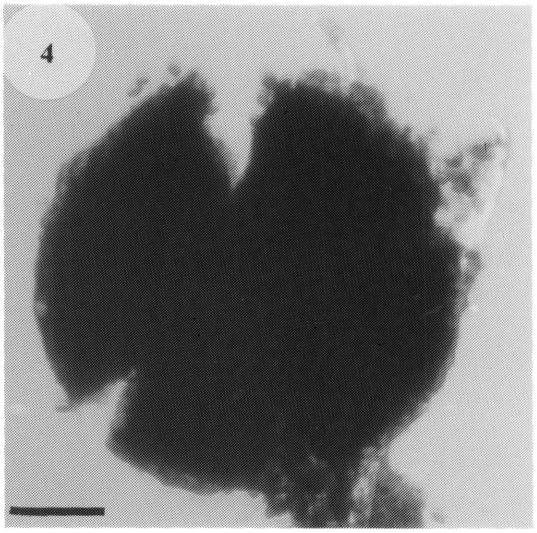
Figs. 6-8: *Kernia* sp.2.

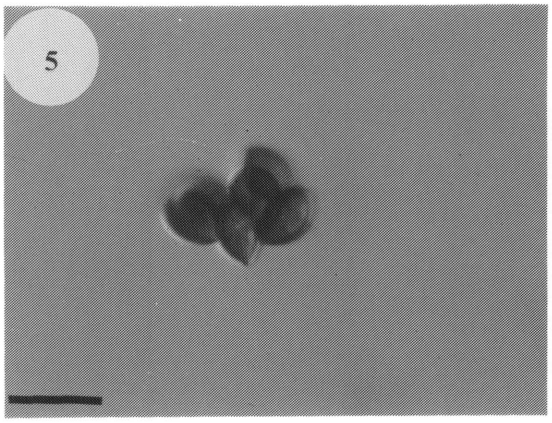
6. Cleistothecium (x10)
7. an Ascus (x100)
8. Ascospore (x100)

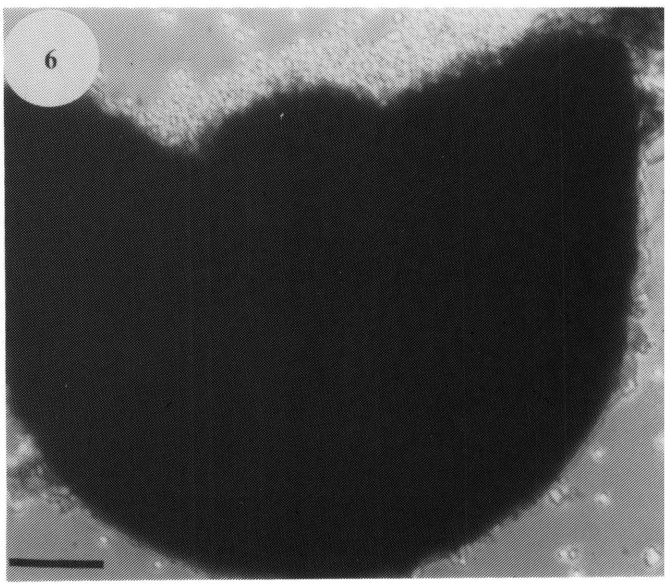


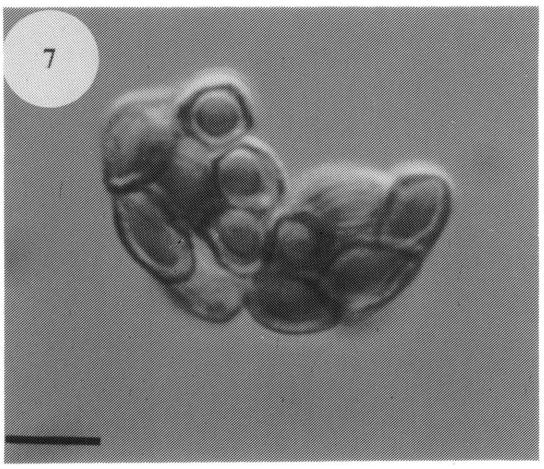


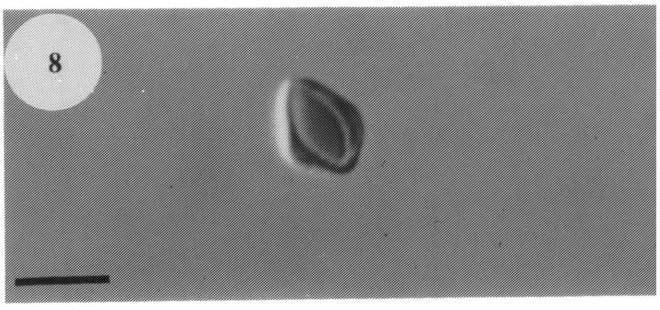












Pyrenomycetes:

Figs. 9-10: *Cercophora californica.*

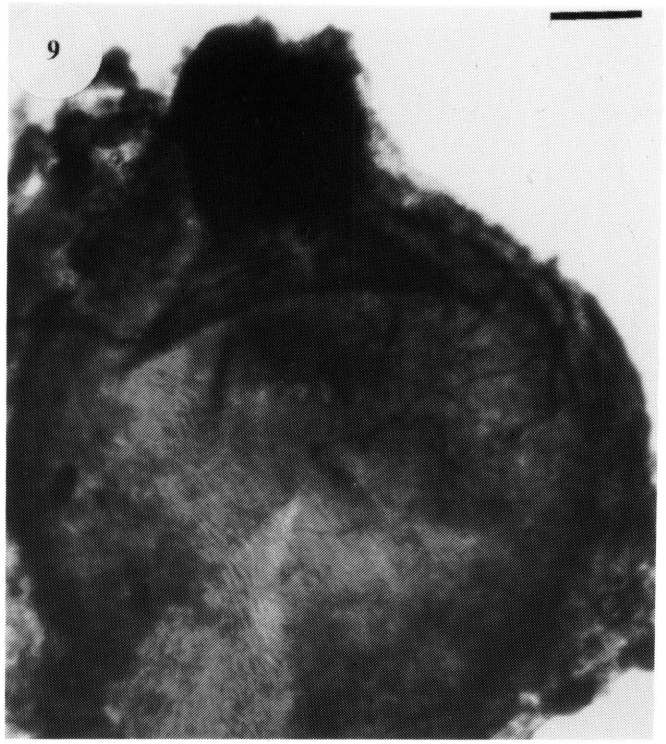
9. Perithecium (x5)
10. Tip of an ascus showing the subapical globulus (x40)

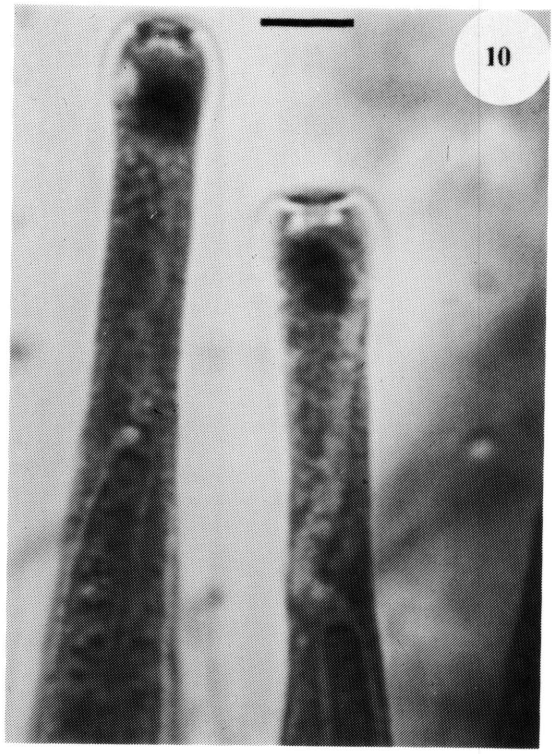
Figs. 11-12: *Cercophora coprophila.*

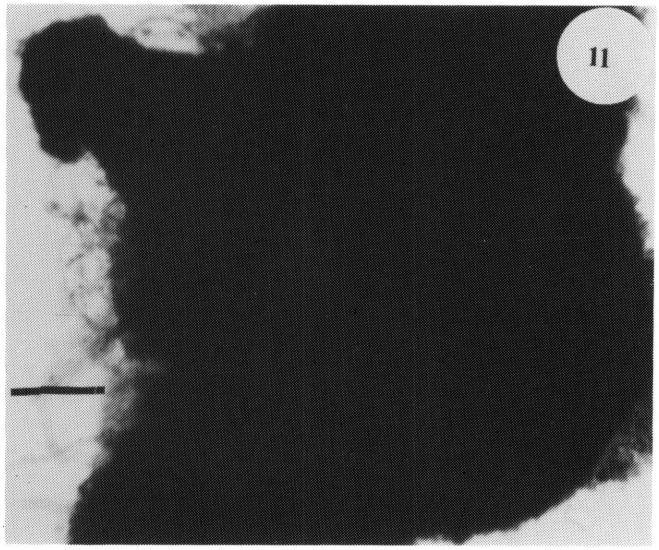
11. Perithecium (x5)
12. Neck of perithecium (x10)

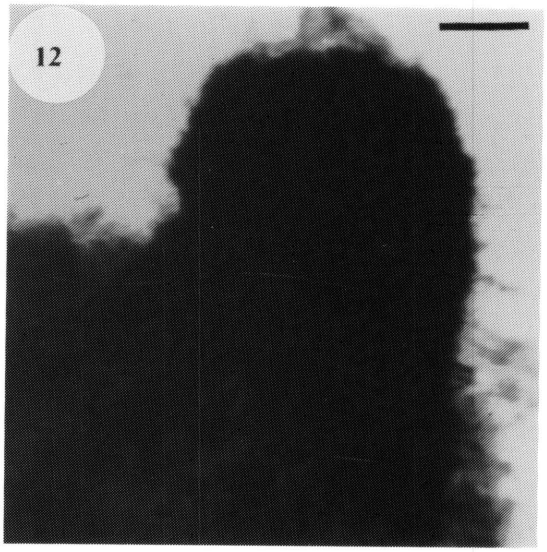
Figs. 13-15: *Cercophora mirabilis.*

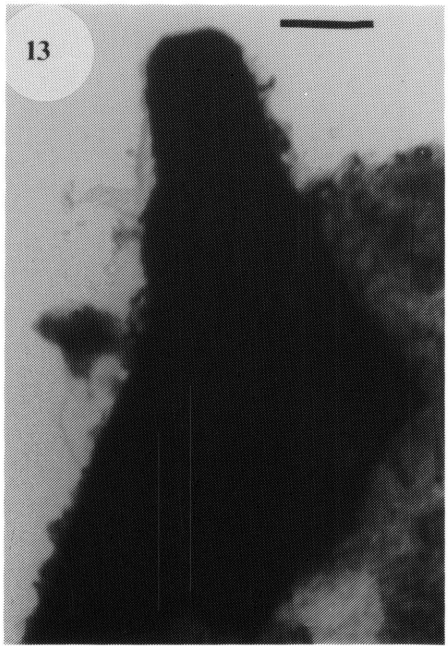
13. Neck of perithecium (x5)
14. Tip of an ascus showing the subapical globulus (x100)
15. an Ascospore (x100)

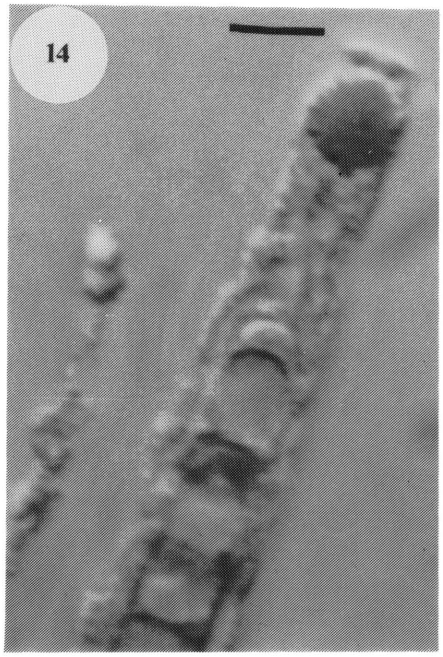












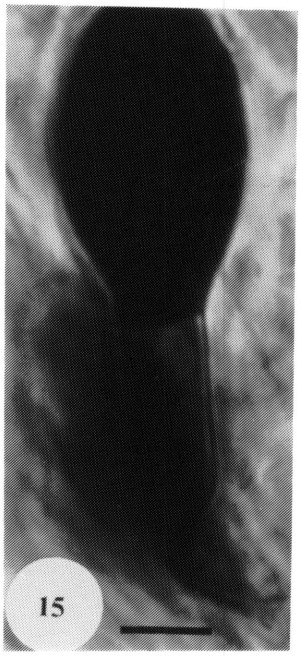


Fig. 16: *Chaetomium aterrimum*.

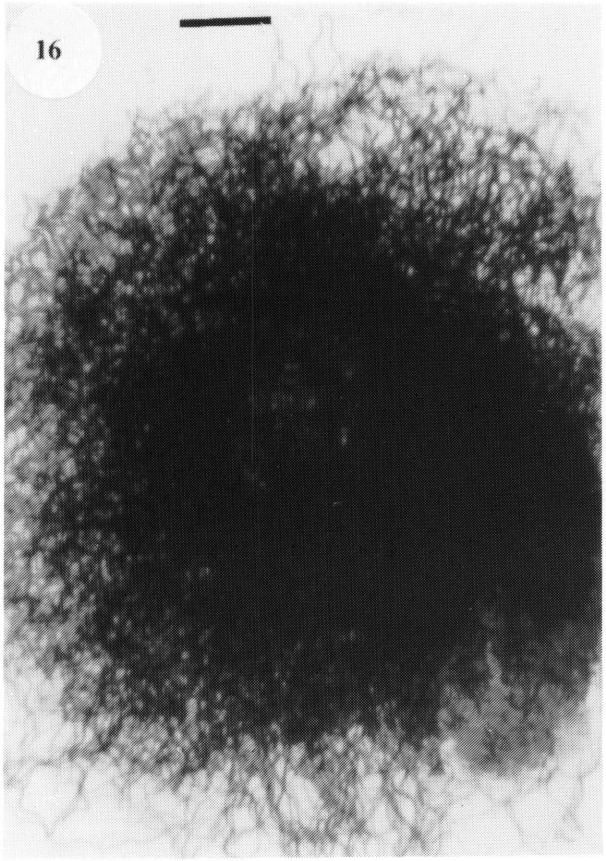
16. Perithecium (x5)

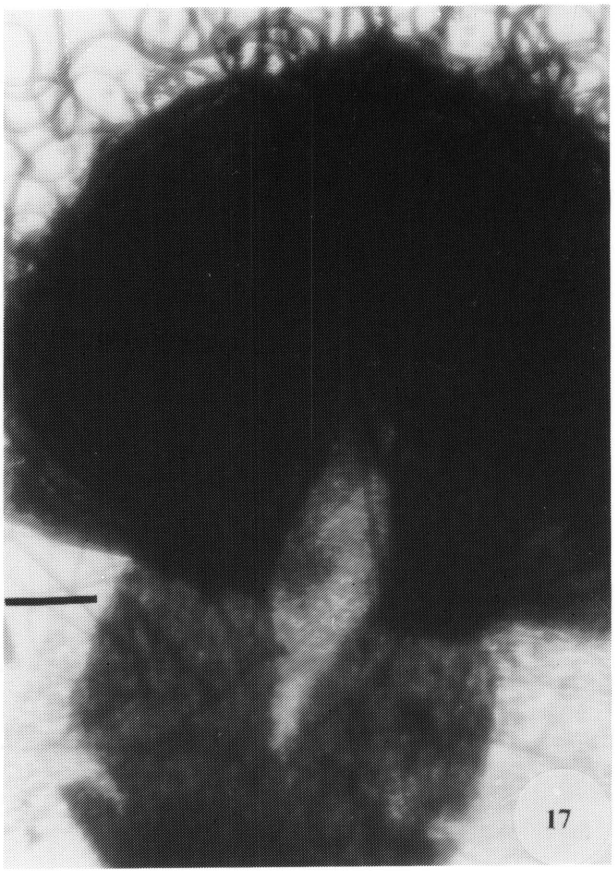
Figs. 17-20: *Chaetomium bostrychodes*.

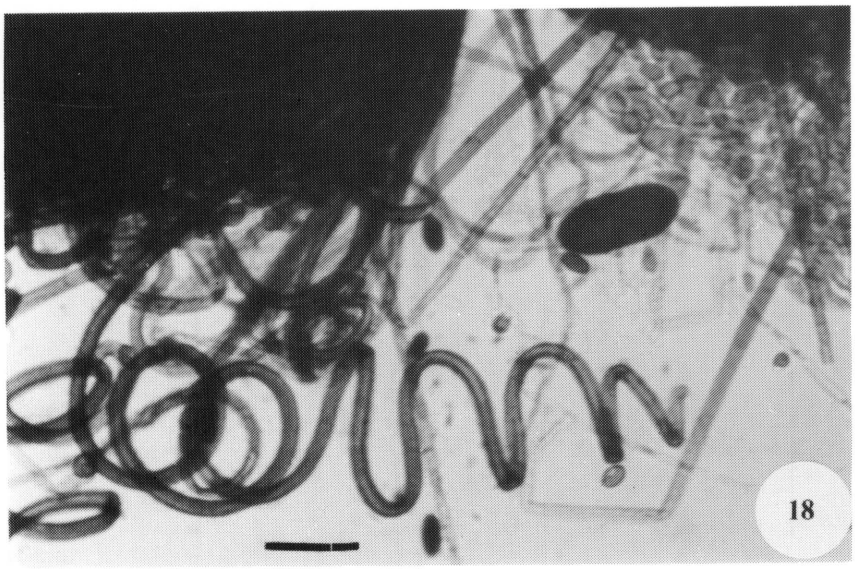
17. Perithecium (x10)
18. Terminal and lateral hairs (x20)
19. an Ascus (x100)
20. Ascospores (x100)

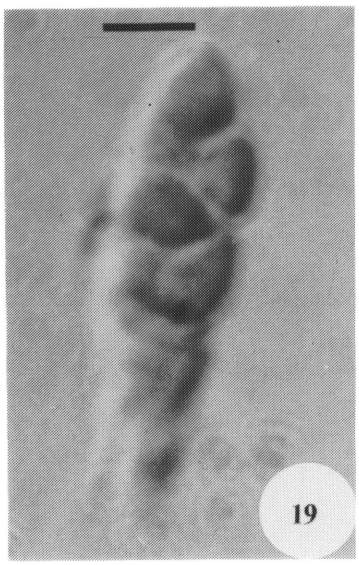
Figs. 21-22: *Chaetomium brevipilium*.

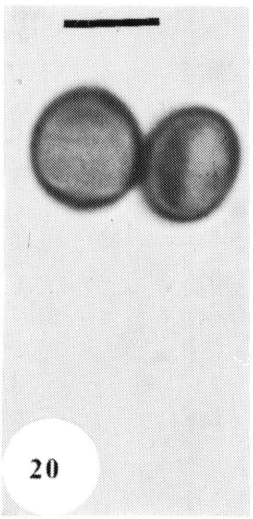
21. Perithecium (x5)
22. an Ascus (x100)

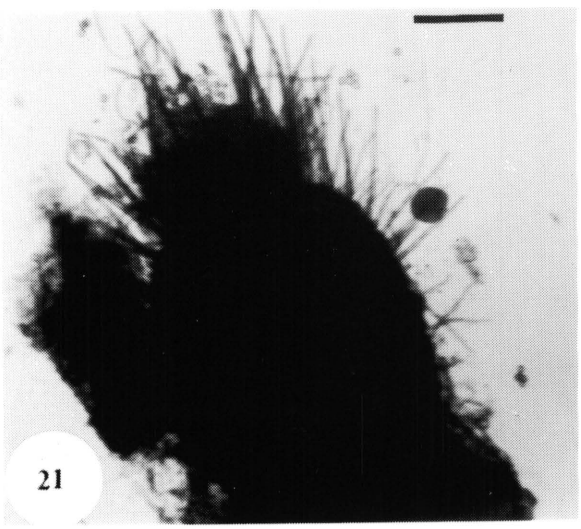


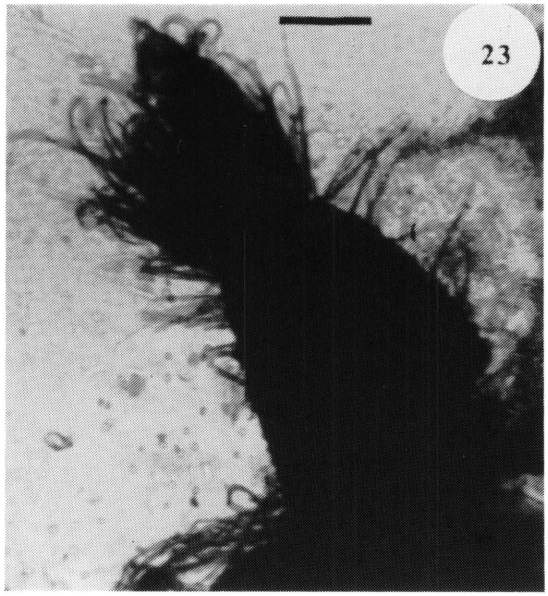


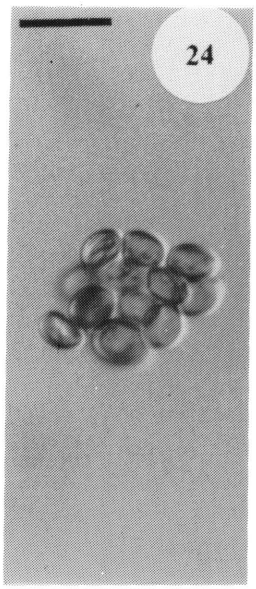


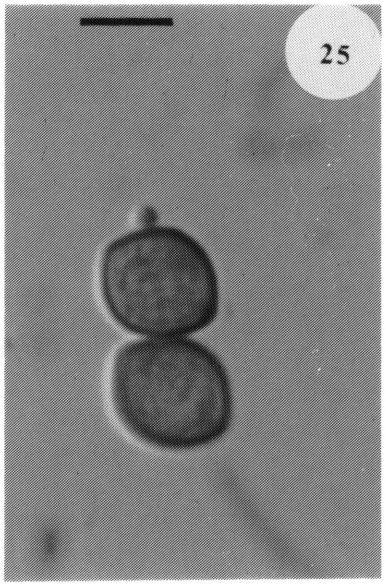


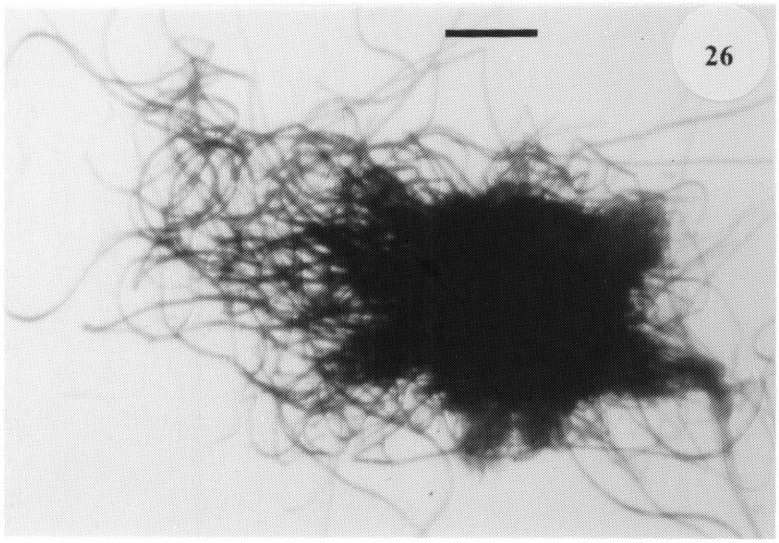


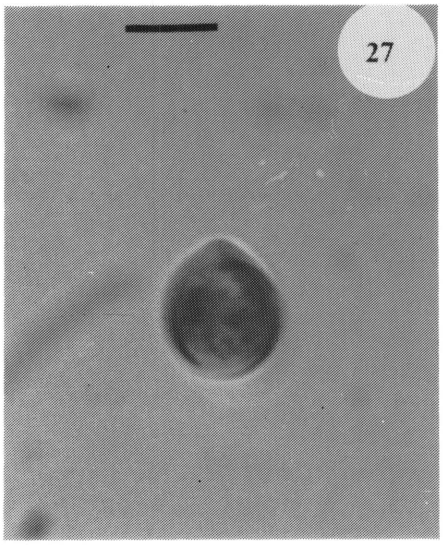


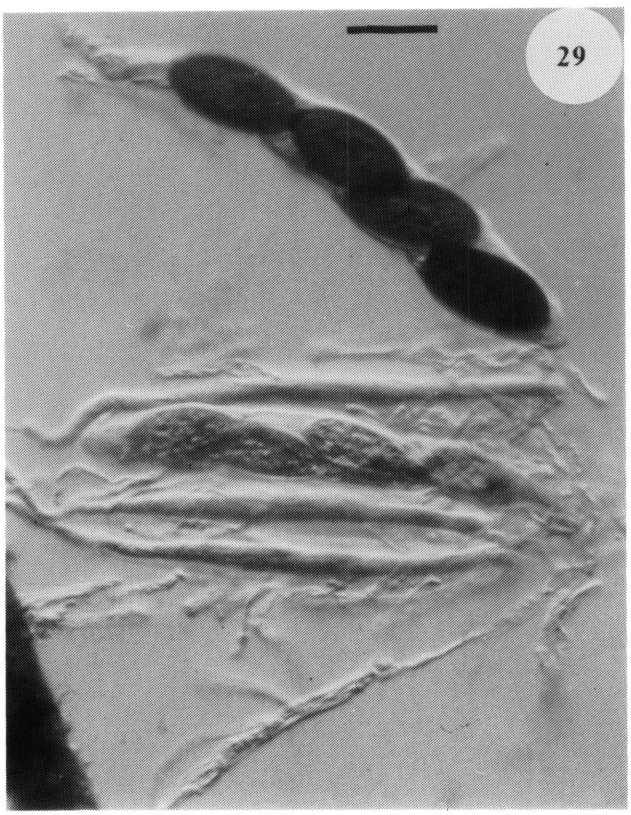










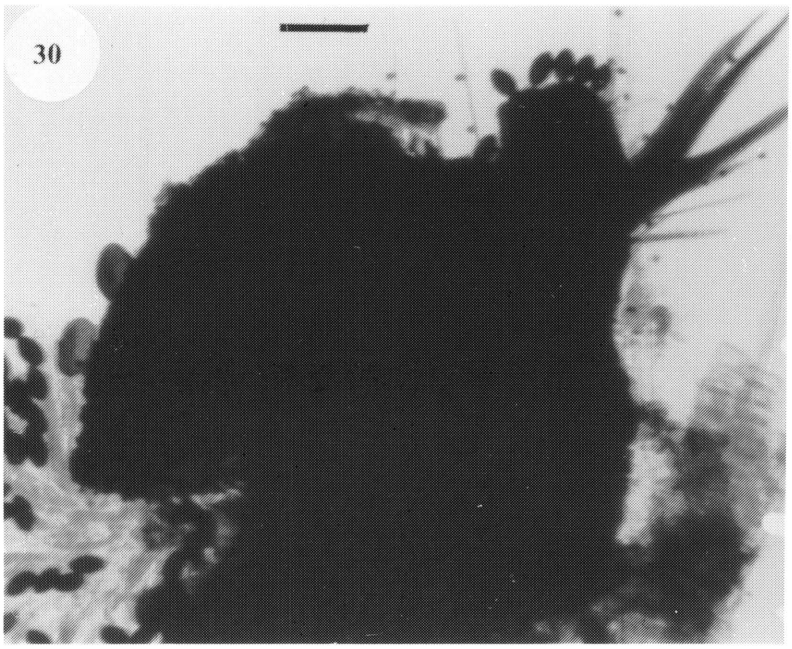


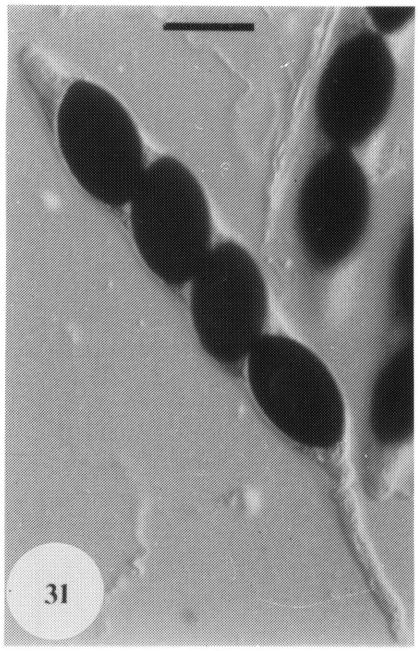
Figs. 30-31: *Podospora comata*.

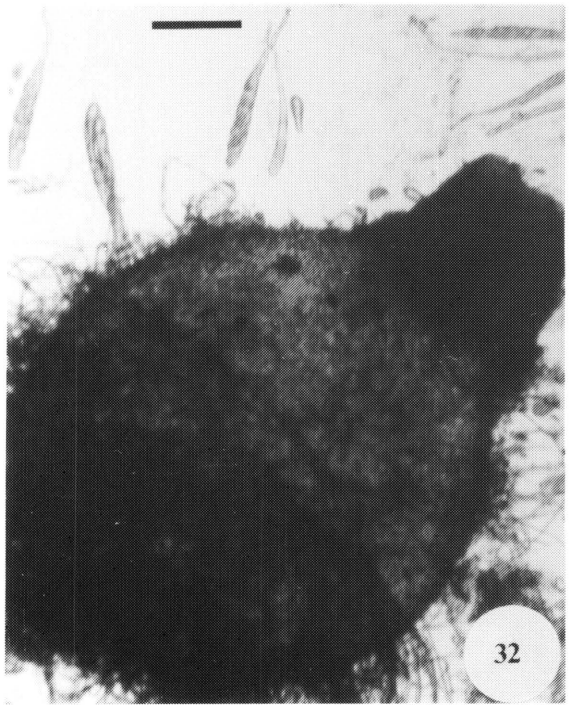
30. Perithecium (x5)
31. an Ascus with ascospores (x20)

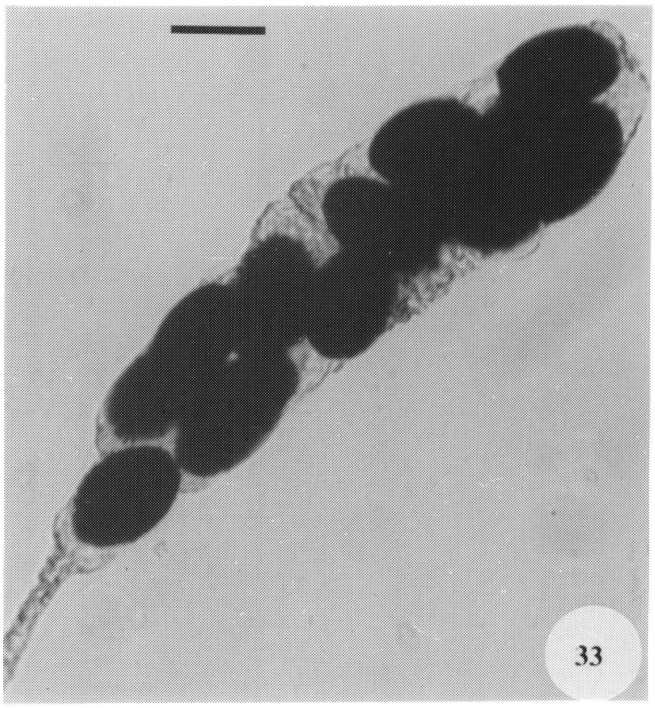
Figs. 32-35: *Podospora communis*.

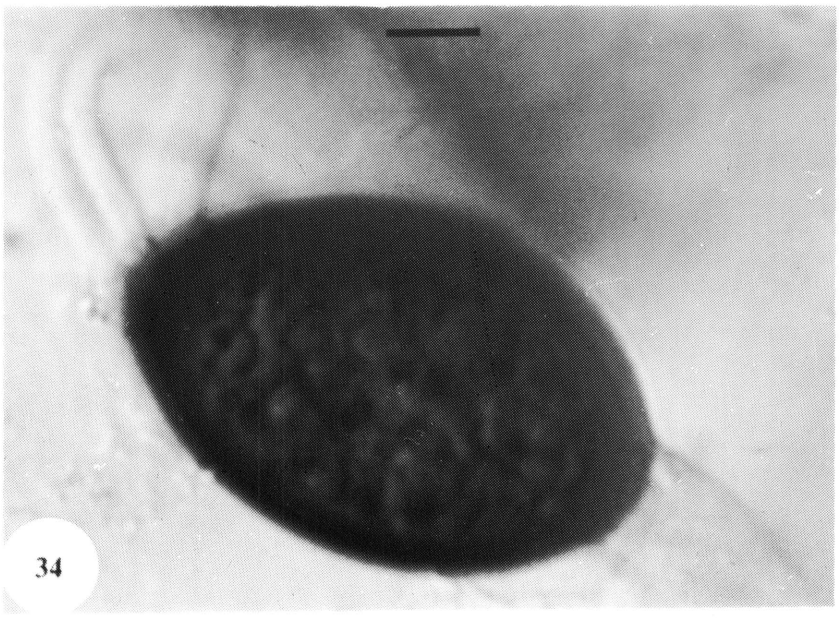
32. Perithecium (x5)
33. an Ascus with ascospores (x20)
34. Ascospore (x100)
35. Immature ascus (x20)

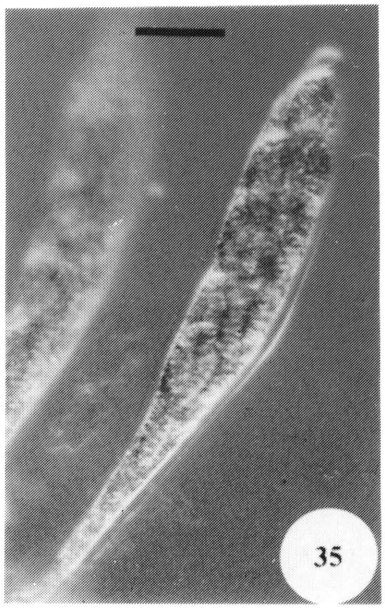










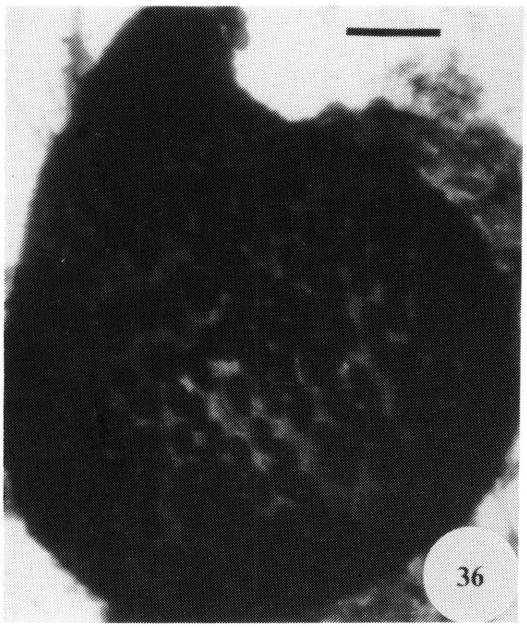


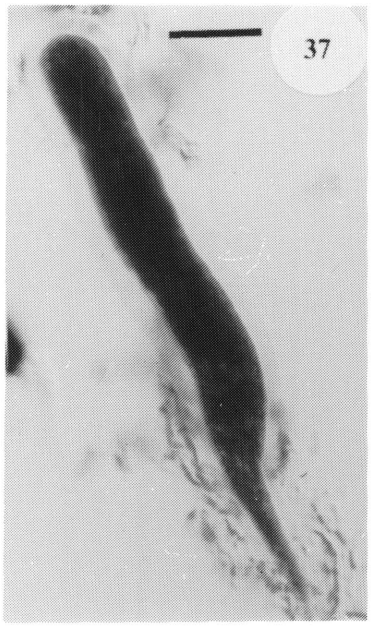
Figs. 36-39: *Podospora curvuloides*.

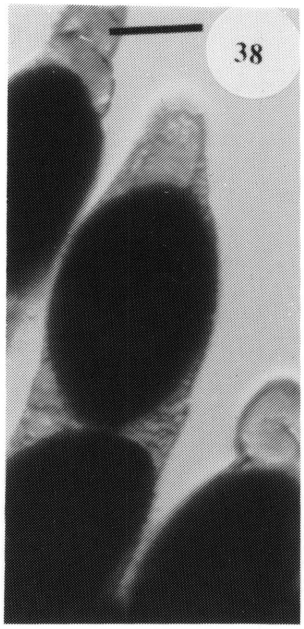
36. Perithecium (x5)
37. an Young ascus (x20)
38. Mature ascus (x40)
39. Ascospores (x40)

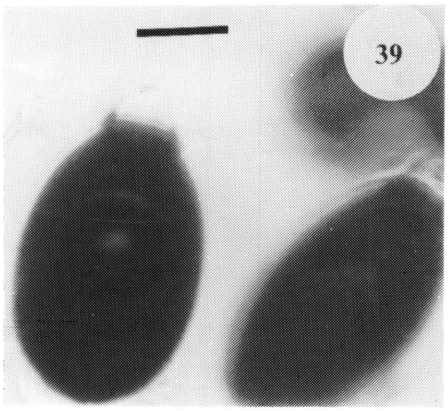
Figs. 40-42: *Podospora similis*.

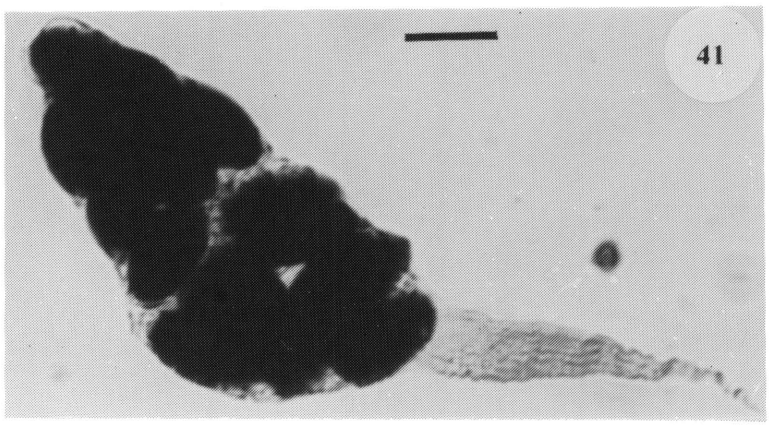
40. Part of a perithecium with asci (x5).
41. Mature ascus with ascospores (x20)
42. an Young ascus (x20)

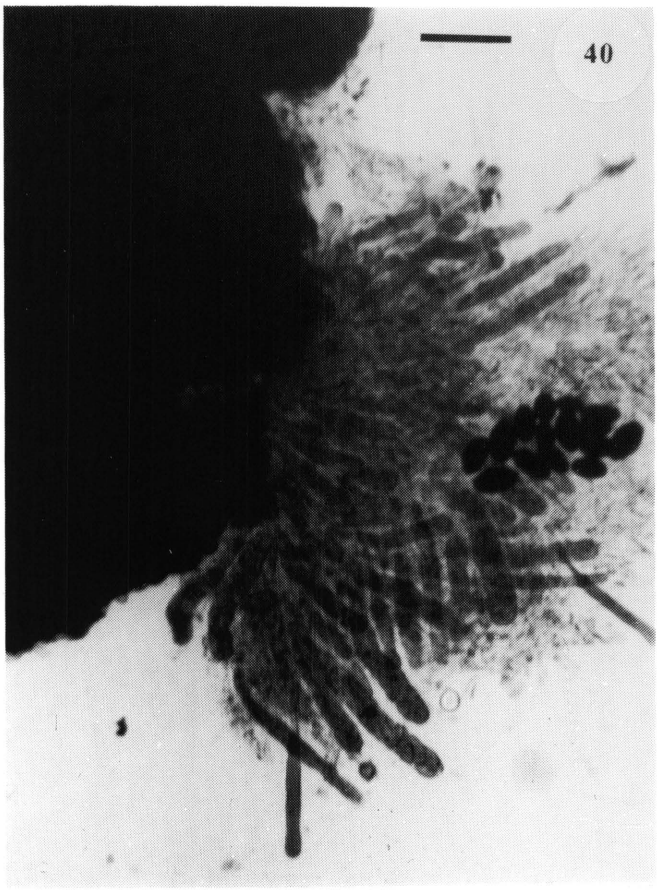


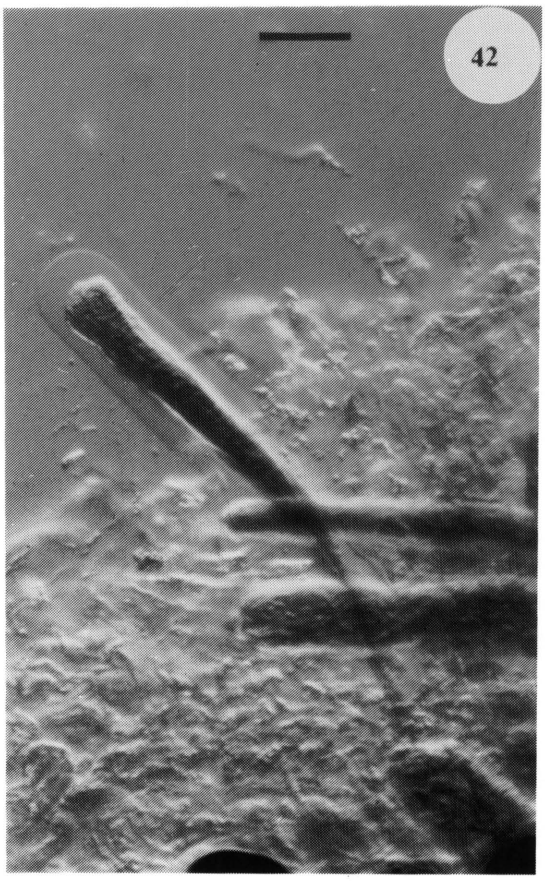










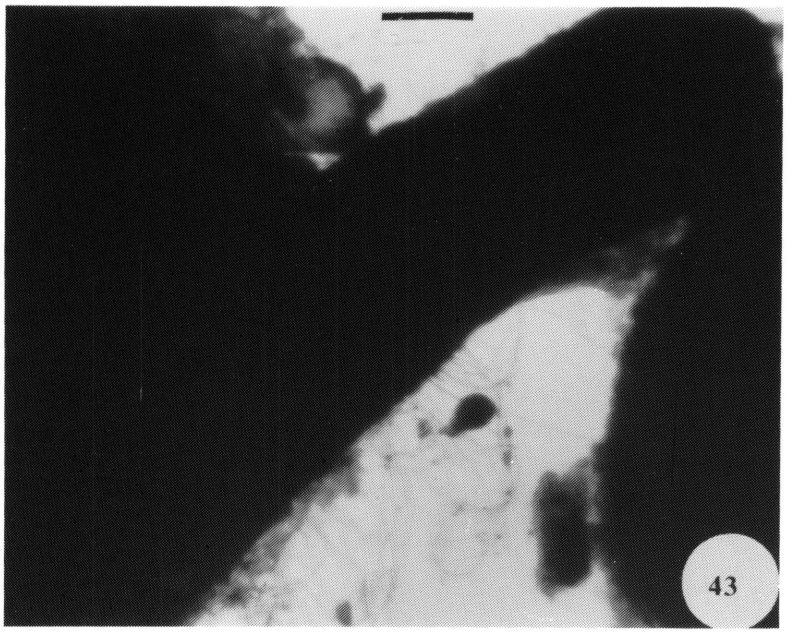


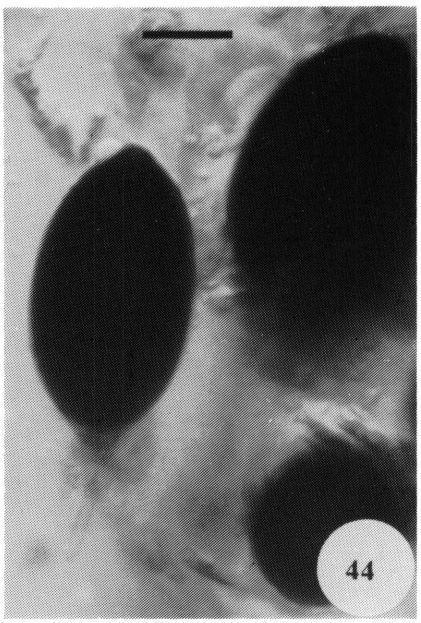
Figs. 43-44: *Podospora ostlingospora.*

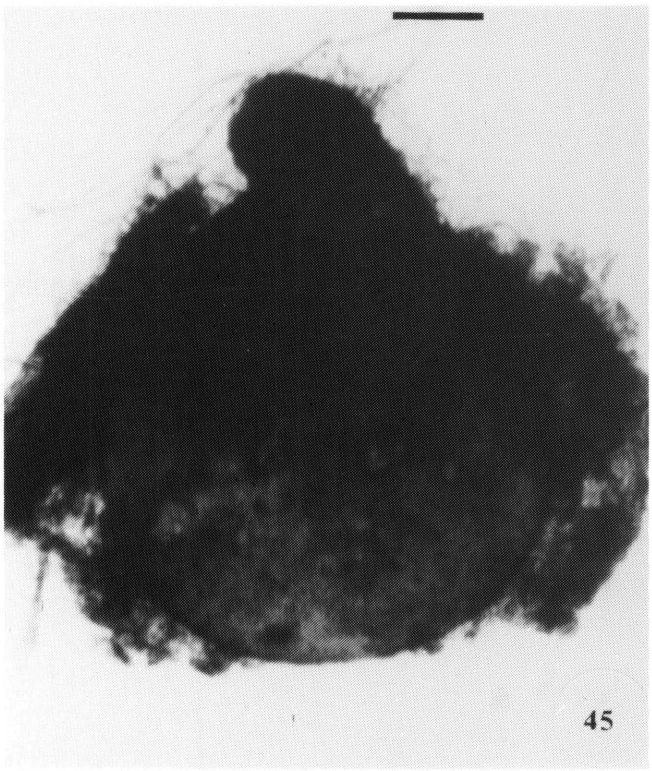
43.Neck of perithecium (x5)
44. Ascospores (x40)

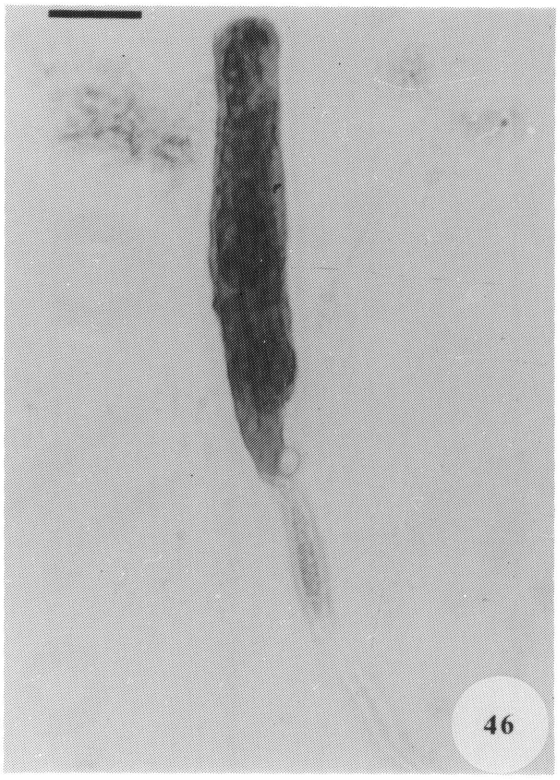
Figs. 45-48: *Podospora pleiospora.*

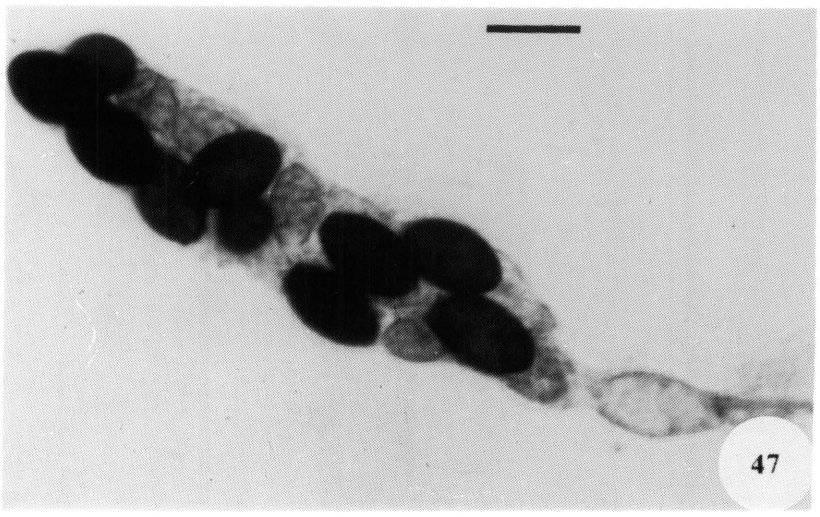
45. Perithecium (x5)
46. an Young ascus (x20)
47. Mature ascus with ascospores (x20)
48. Ascospores (x40)

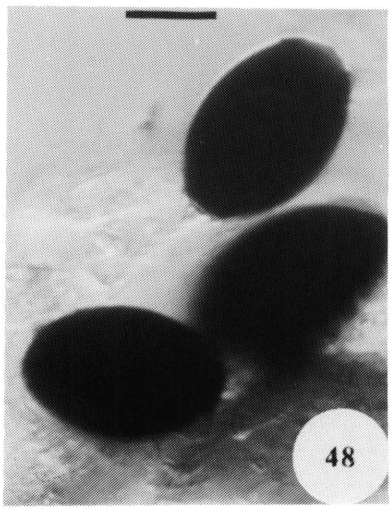










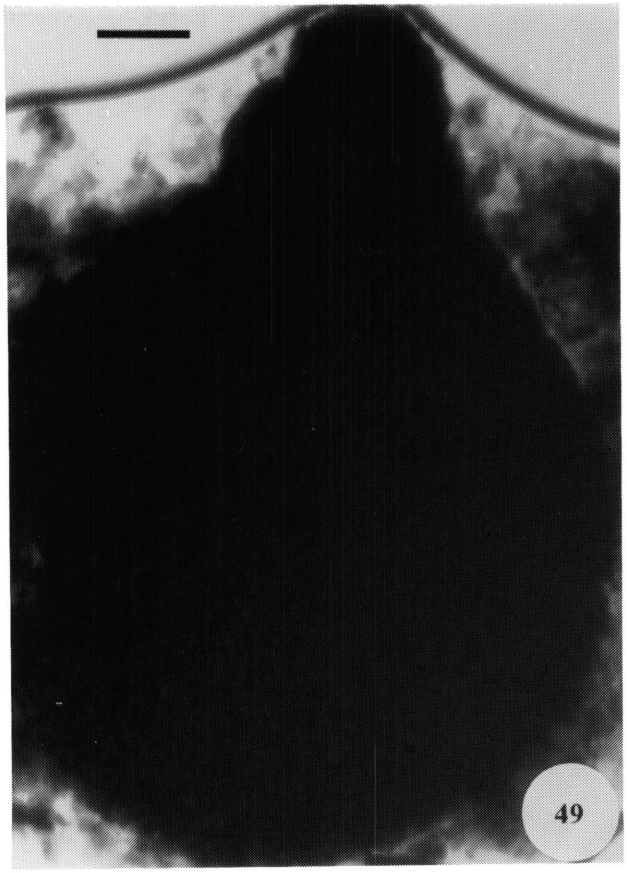


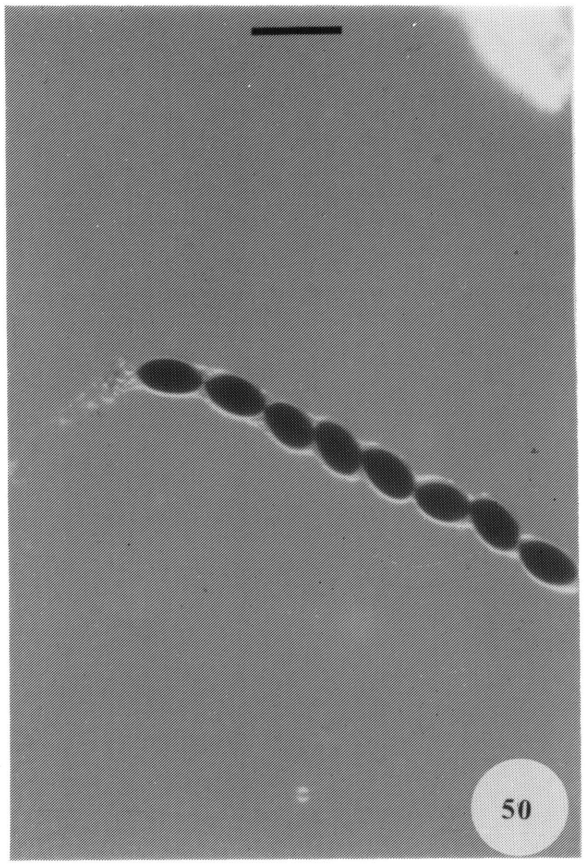
Figs. 49-50: *Sordaria brevicollis*.

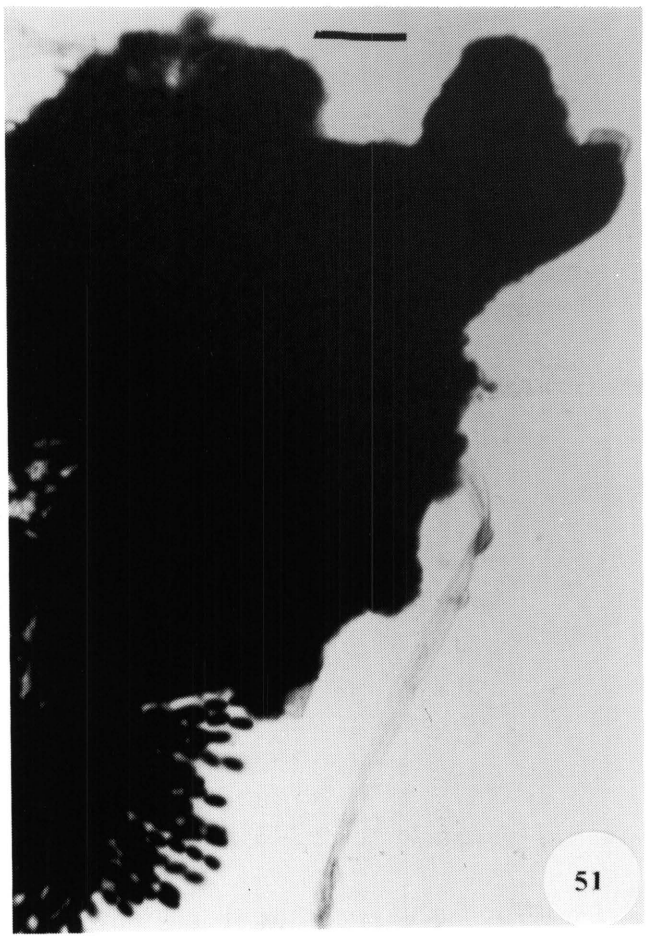
49. Perithecium (x10)
50. Mature ascus with ascospores (x20)

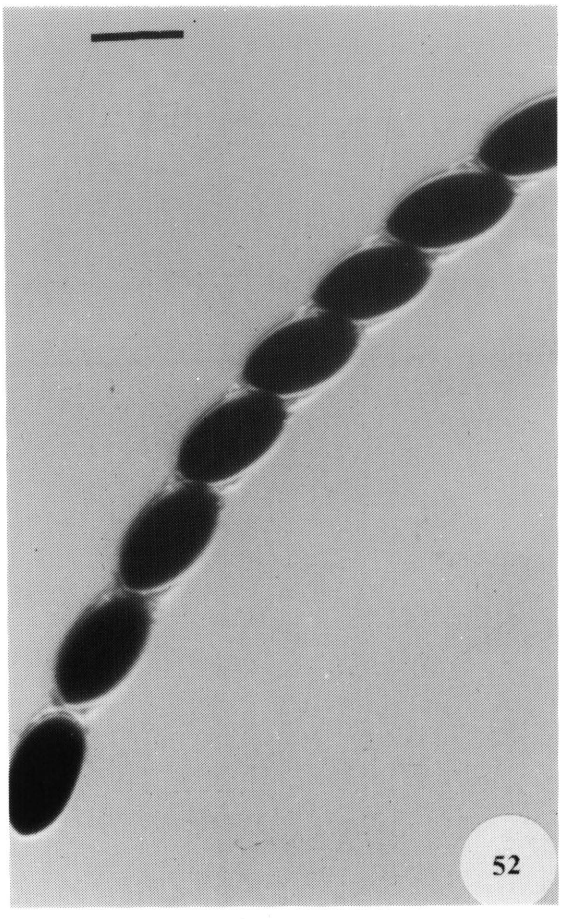
Figs. 51-52: *Sordaria fimicola*.

51. Perithecium (x5)
52. Mature ascus with ascospores (x40)







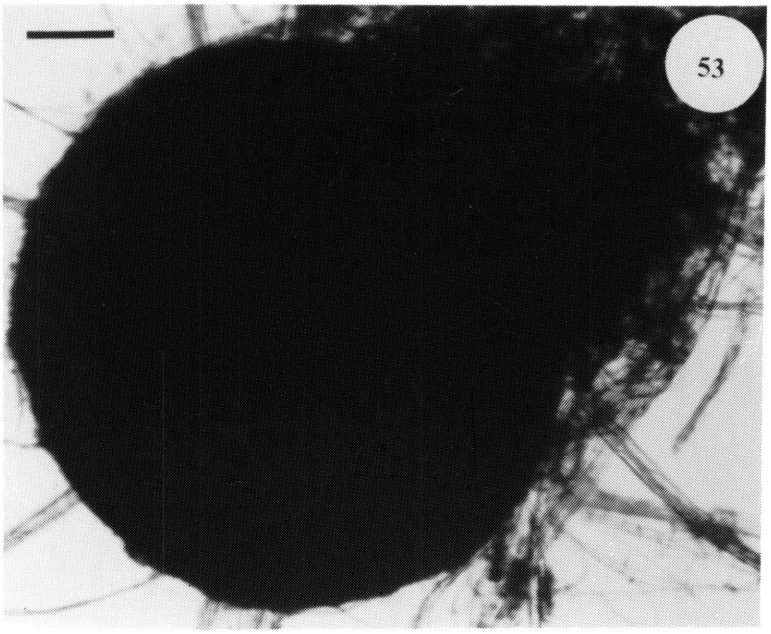


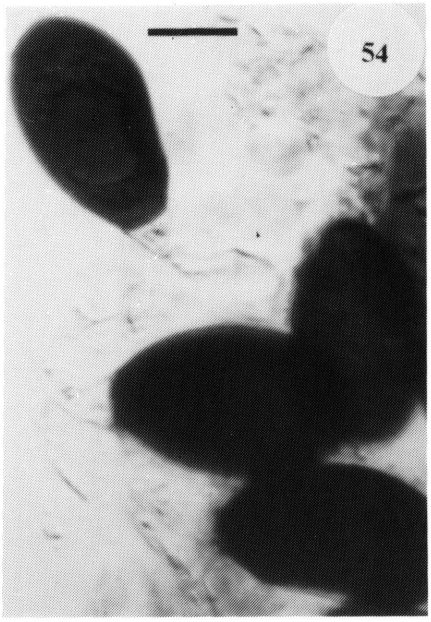
Figs. 53-54: *Stratonia hansenii*.

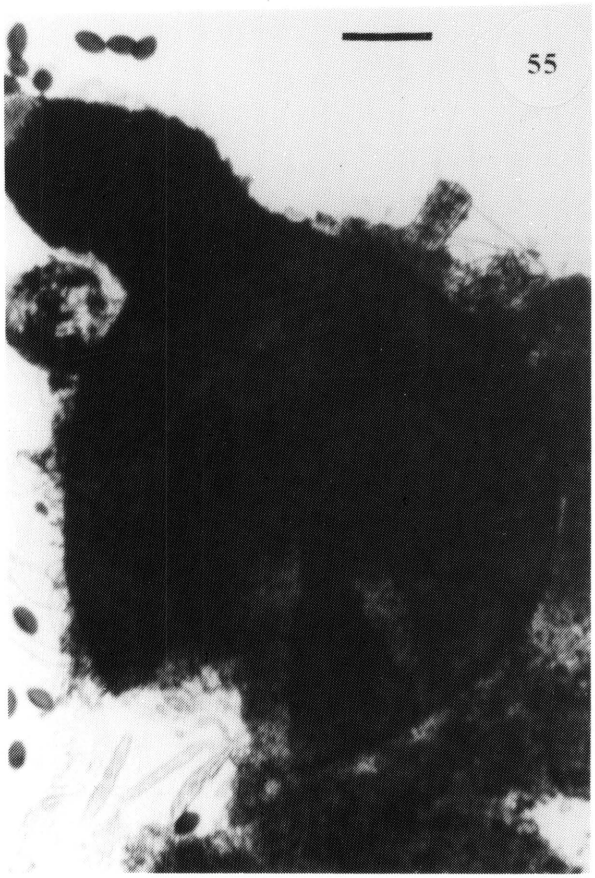
53. Perithecium (x5)
54. Ascospore (primary appendage faintly visible) (x40)

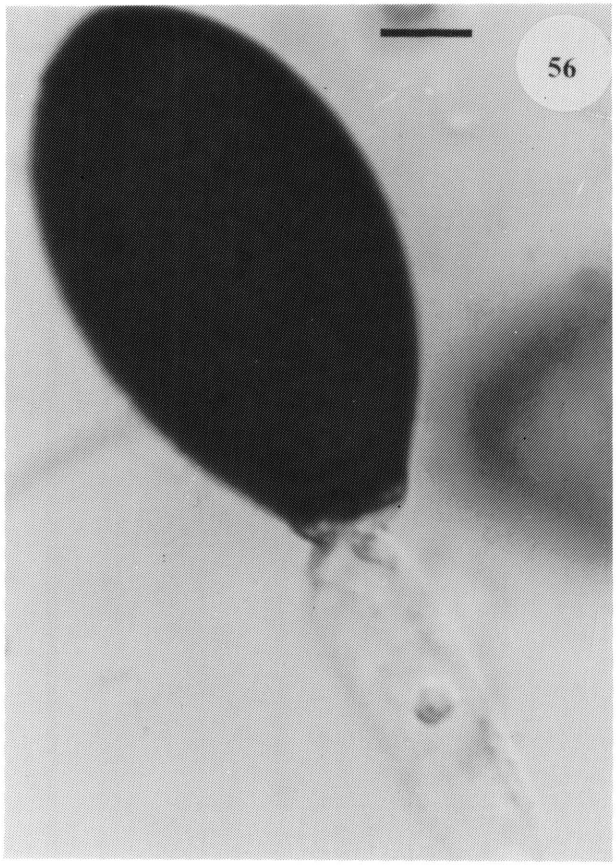
Figs.55-58: *Strattonia globosa* var. *africana*.

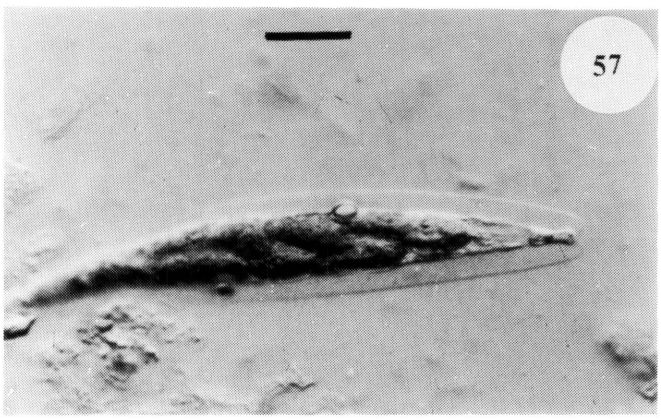
55. Perithecium (x5)
56. an Ascospore (x100)
57. an Immature ascus (x20)
58. an Immature ascospore (x40)

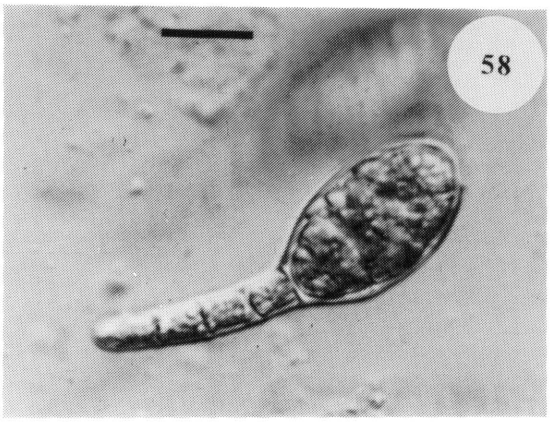












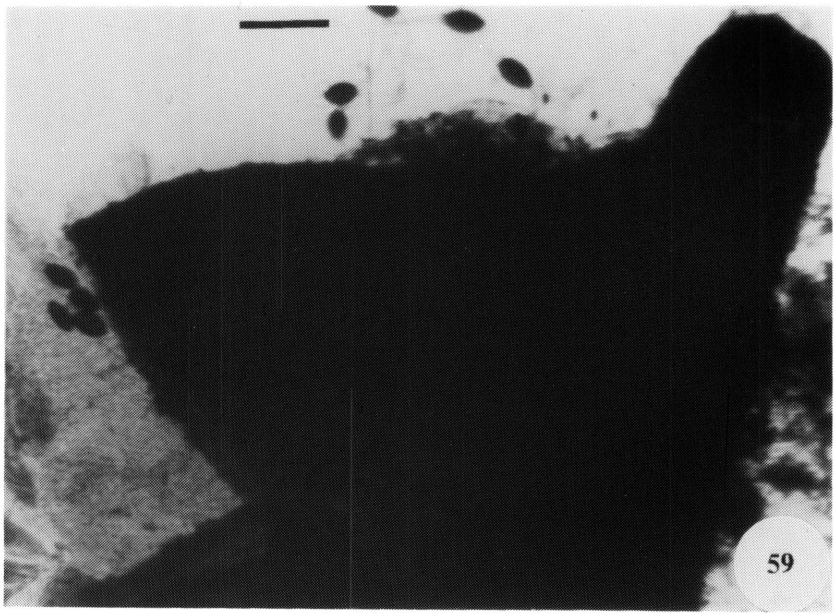
Figs. 59-61: *Zygopleurage zygospora.*

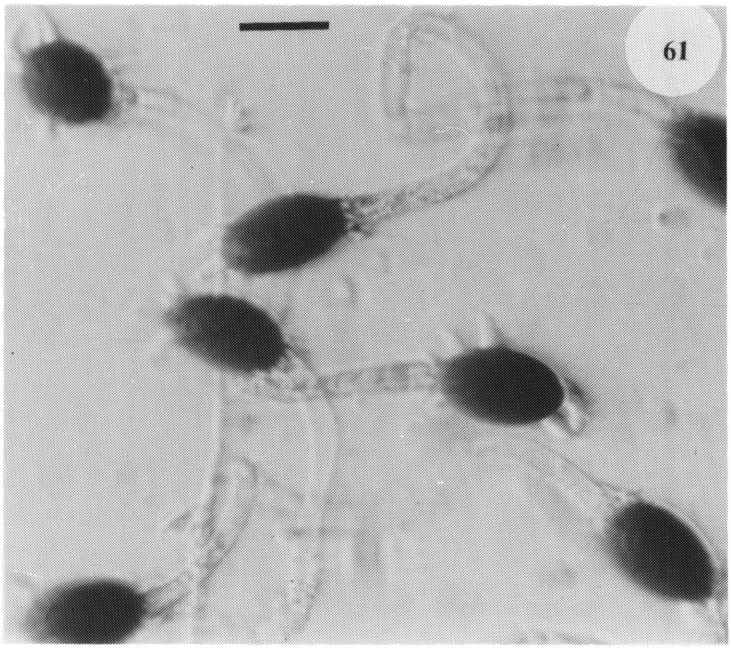
59. Perithecium	(x5)
60. an Young ascus	(x20)
61. Ascospores	(x20)

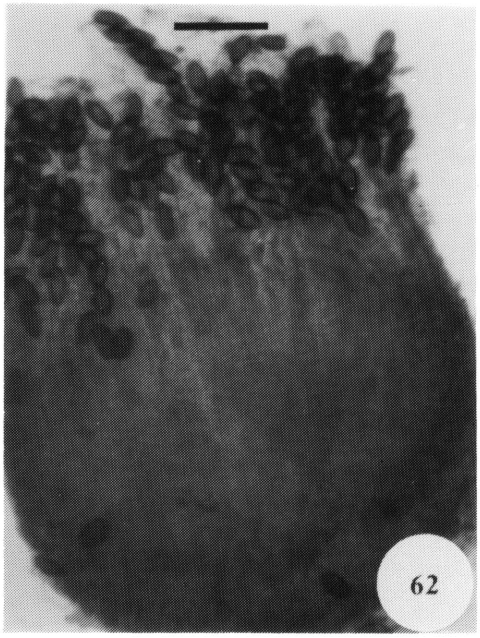
Discomycetes:

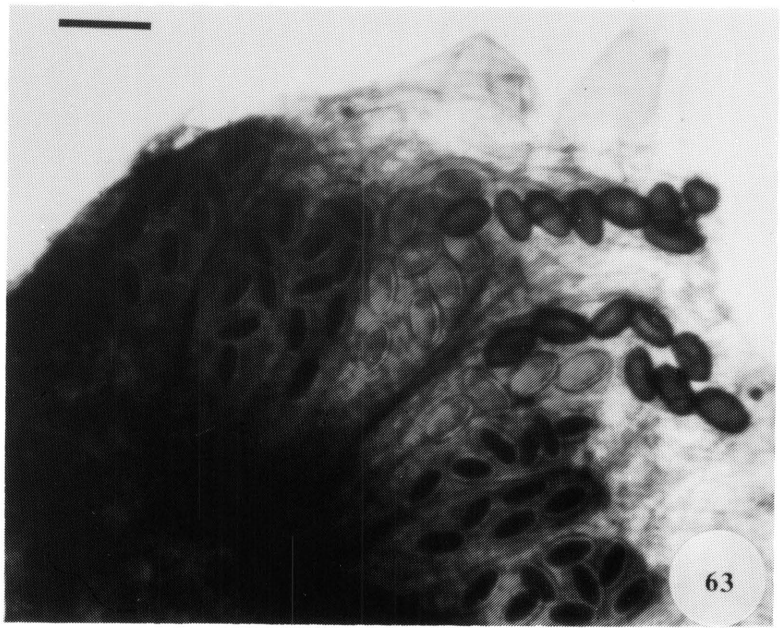
Figs. 62-64: *Ascobolus amoenus.*

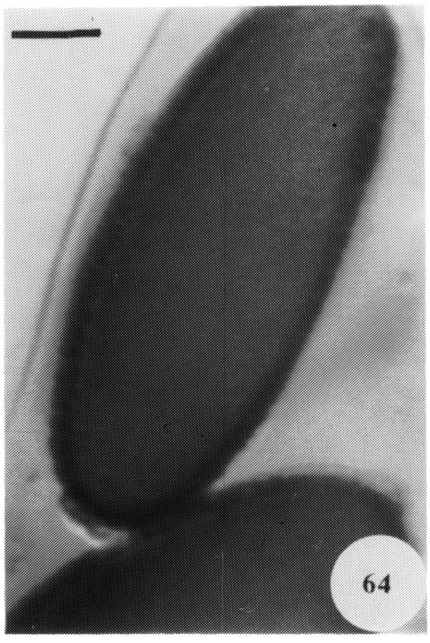
62. Apothecium	(x5)
63. Asci	(x10)
64. Ascospores	(x100)









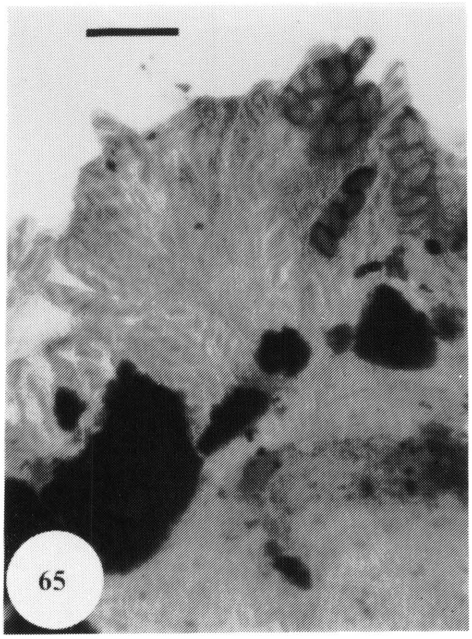


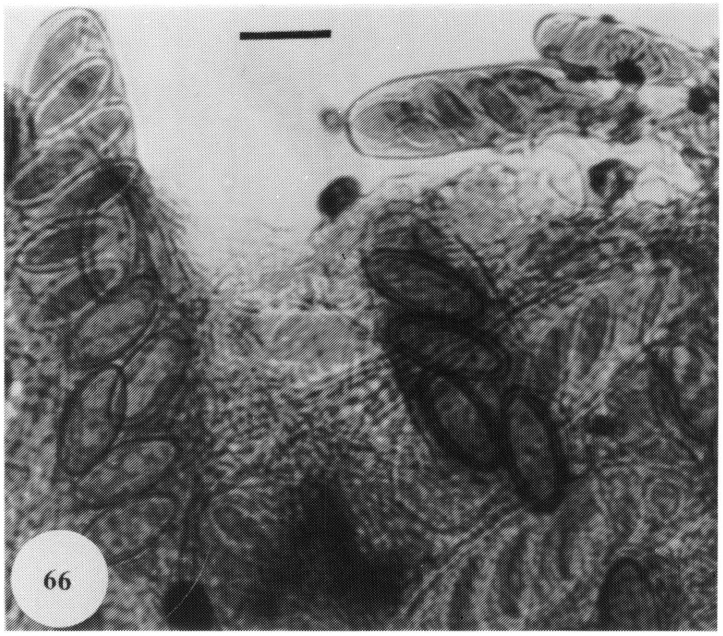
Figs. 65-67: *Ascobolus degluptus*.

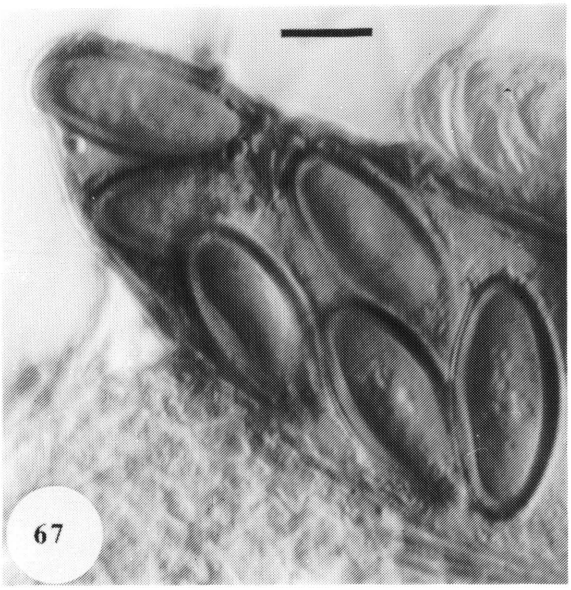
65. Apothecium (x5)
66. Asci (x20)
67. Ascospores (x40)

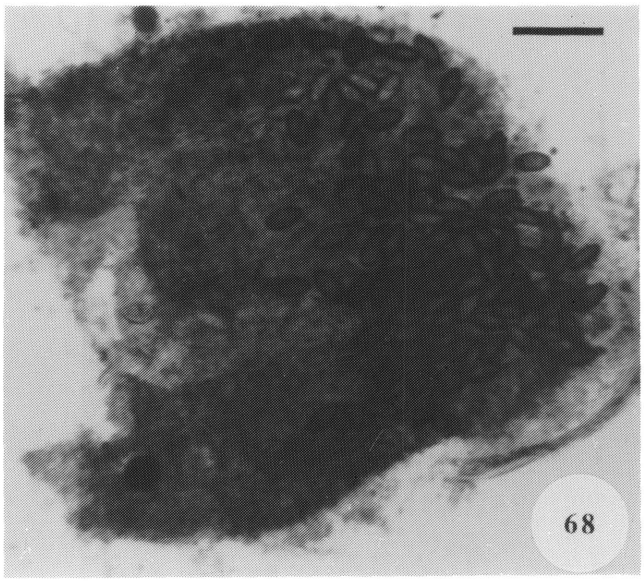
Figs. 68-69: *Ascobolus hawaiiensis*.

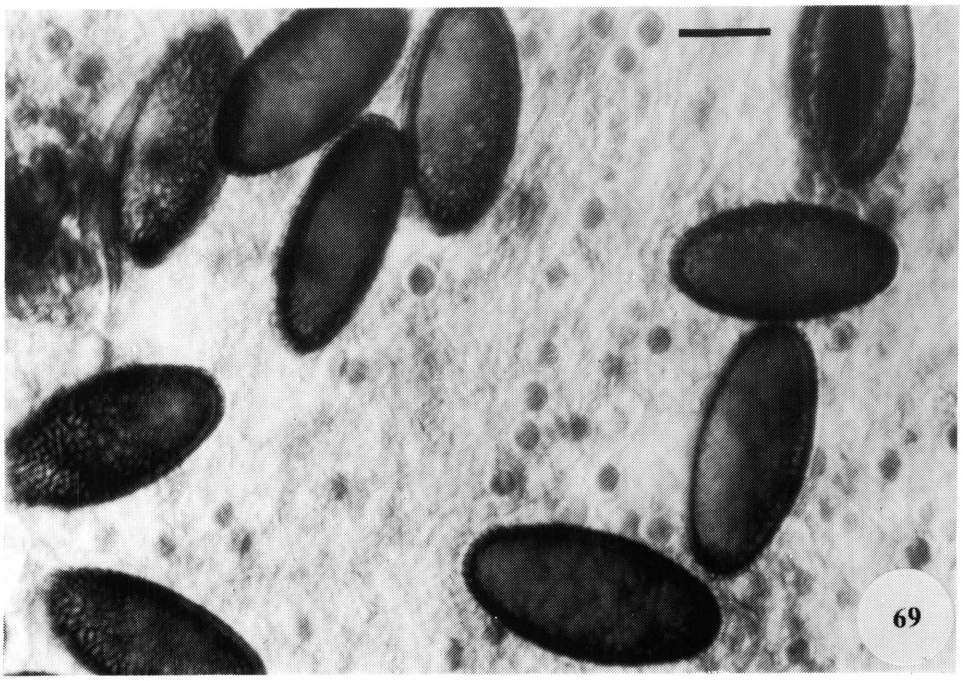
68. Apothecium (x5)
69. Ascospores (x40)









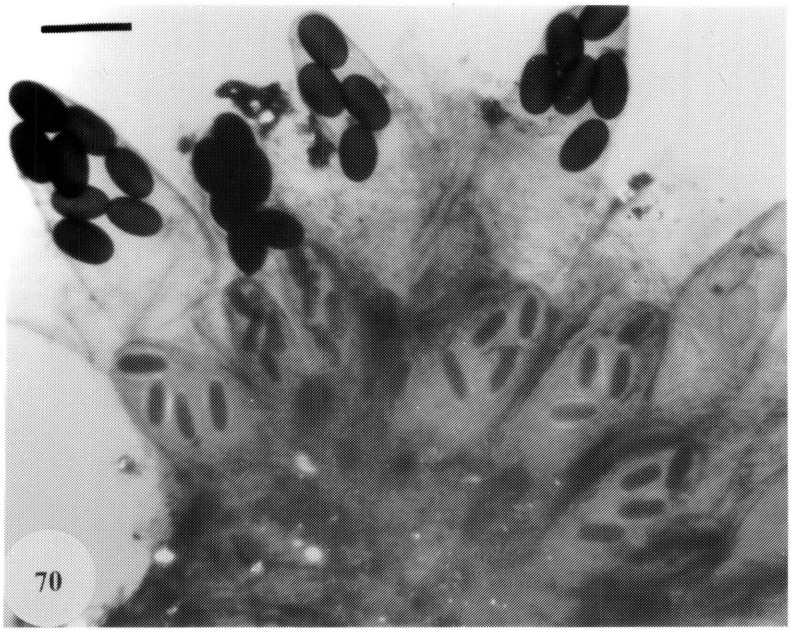


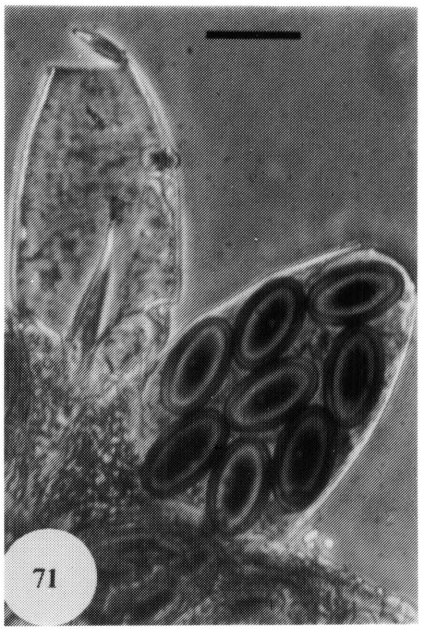
Figs. 70-73: *Ascobolus immersus*.

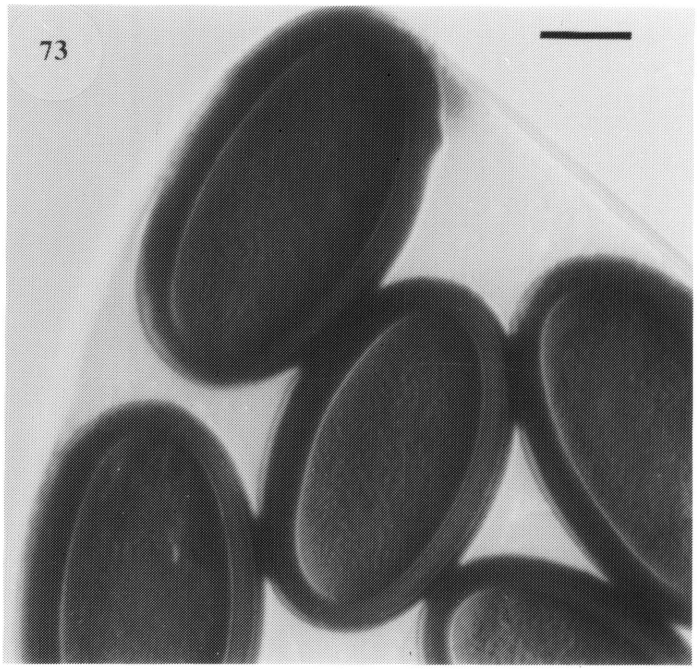
70. Apothecium (x5)
71. Mature ascus with ascospores (x10)
72. Ascus with ascospores (x20)
73. Ascospores (x40)

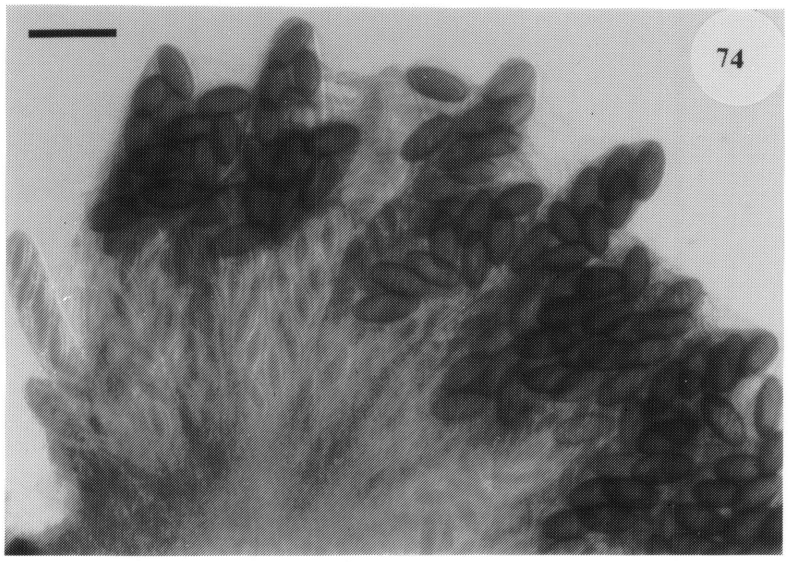
Figs. 74-75: *Ascobolus stictoideus*.

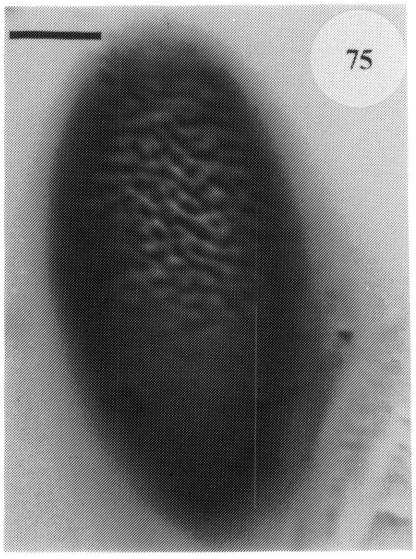
74. Apothecium (x10)
75. Ascospore showing the spore ornamentation (x100)









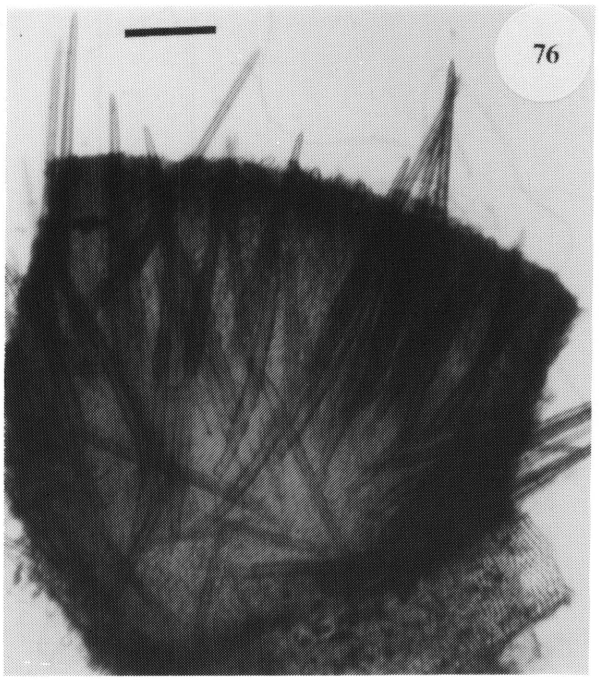


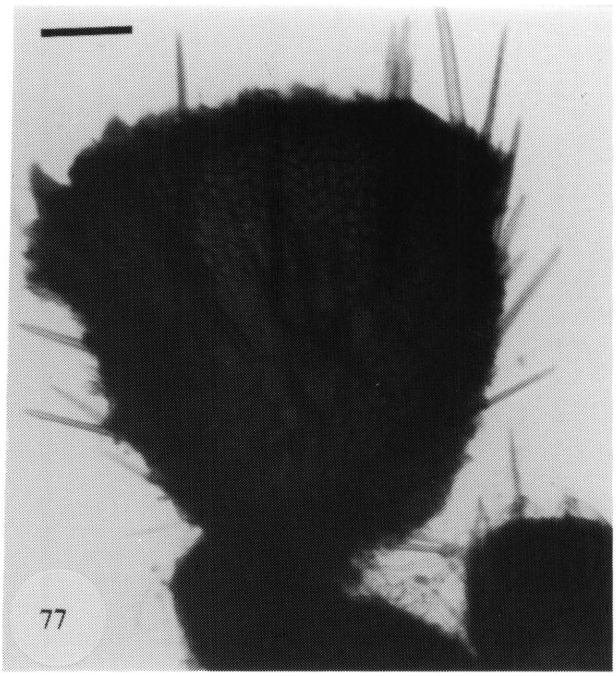
Figs. 76-77: *Cheilymenia theleboloides*.

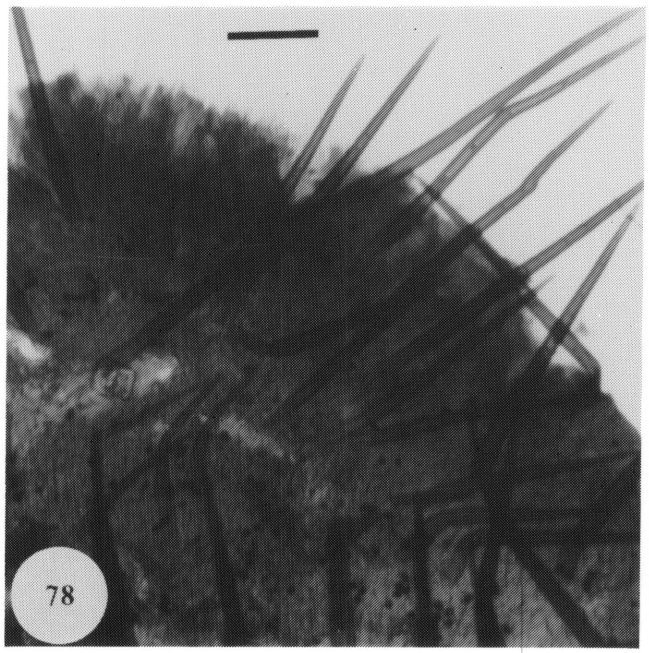
76. Apothecium (x5)
77. Apothecium on neck of perithecium (x5)

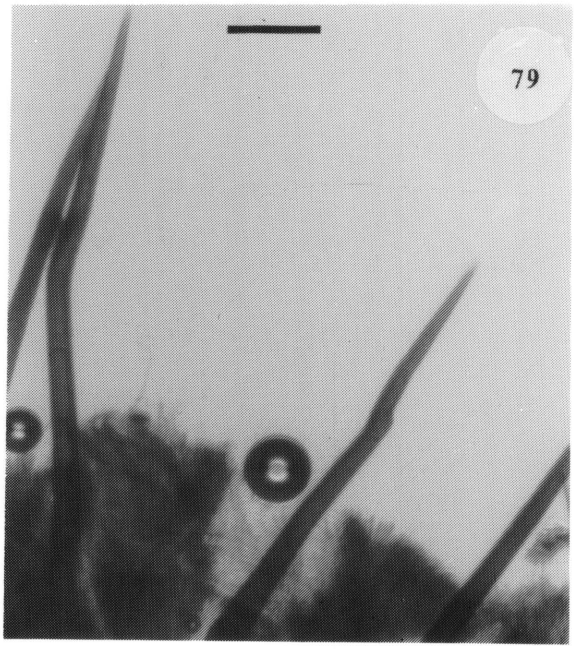
Figs. 78-81: *Cheilymenia* sp.

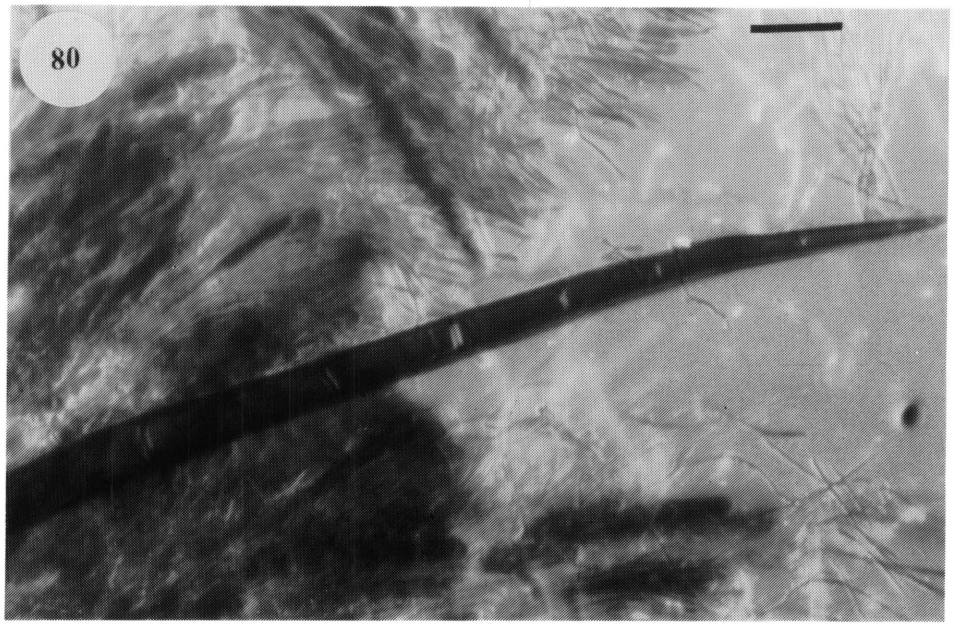
78. Apothecium (x5)
79. Setae (x5)
80. a Seta showing the septa (x10)
81. Mature ascus (x40)

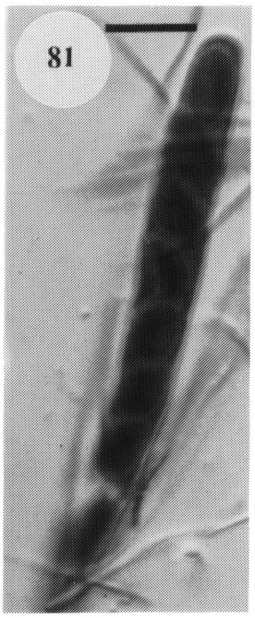












Figs. 82-84: *Coprotus aurora*.

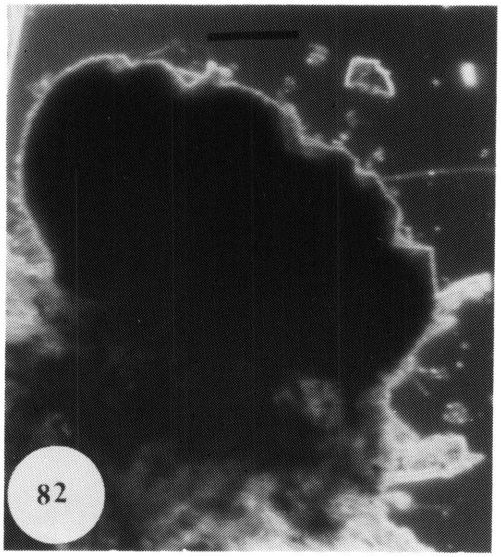
82. Apothecium (x5)
83. Asci (x40)
84. Ascospores (x100)

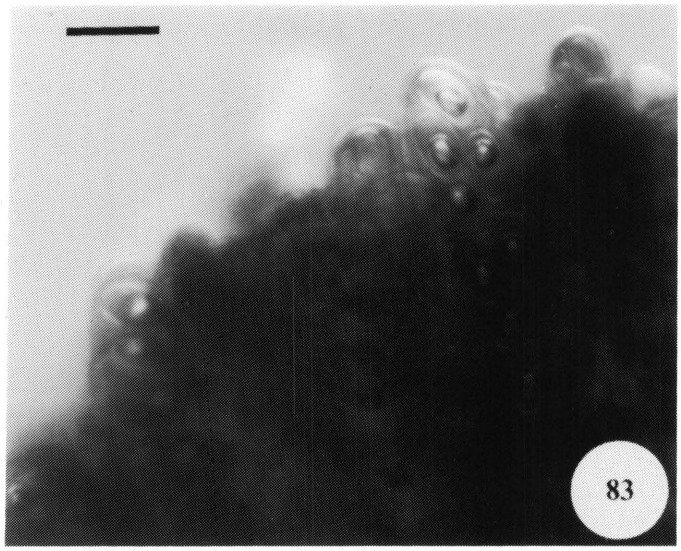
Figs. 85-87: *Coprotus dextrinoideus*.

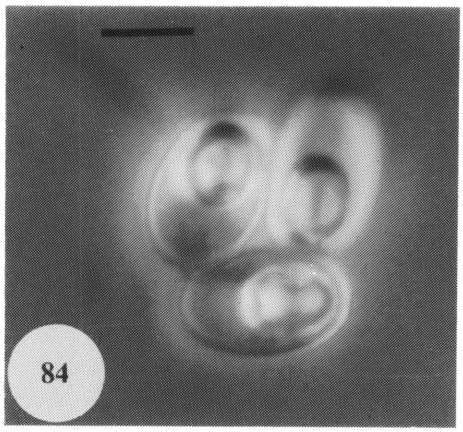
85. Apothecium (x10)
86. Asci (x40)
87. Ascospores (x100)

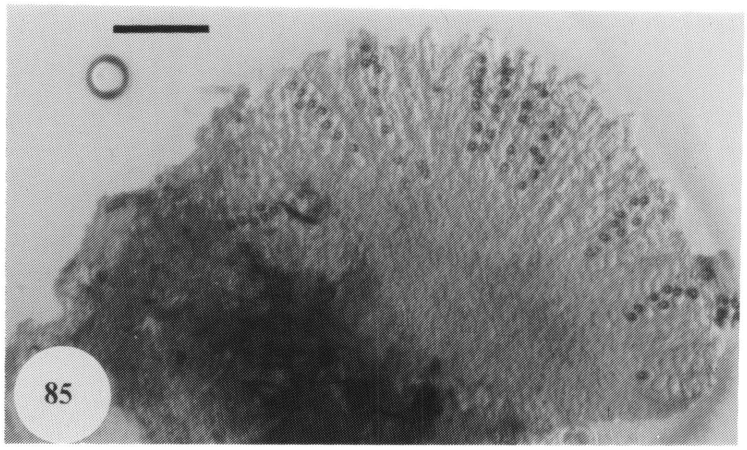
Figs. 88-89: *Coprotus disculus*.

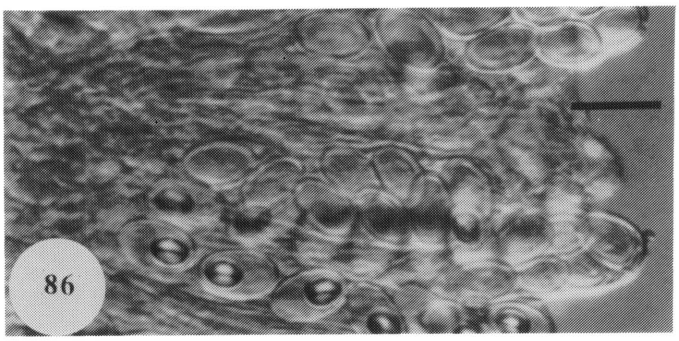
88. Apothecium (x20)
89. Ascospores (x100)

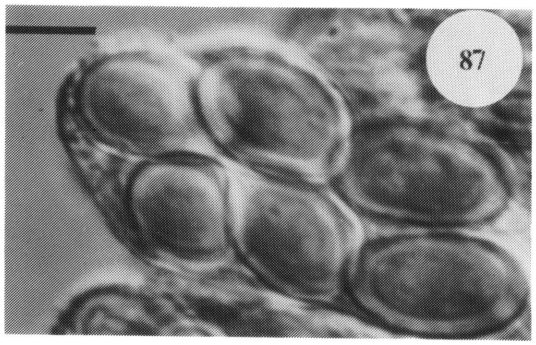


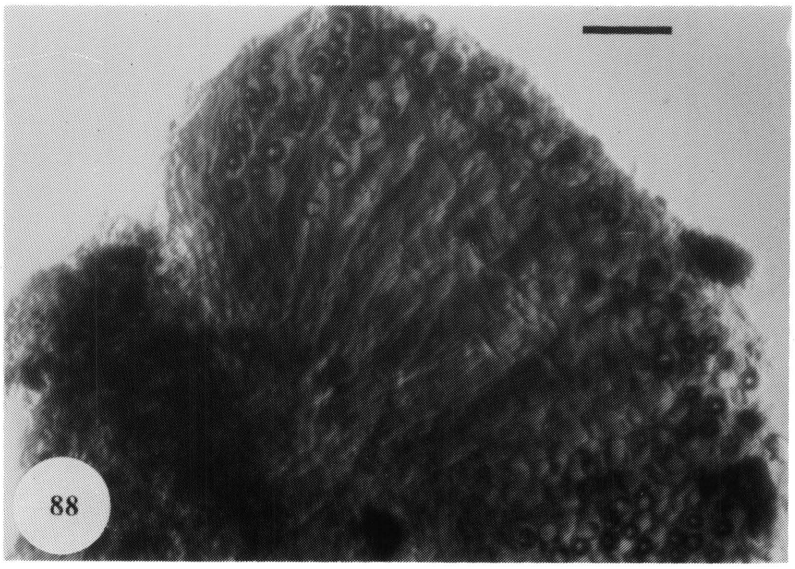


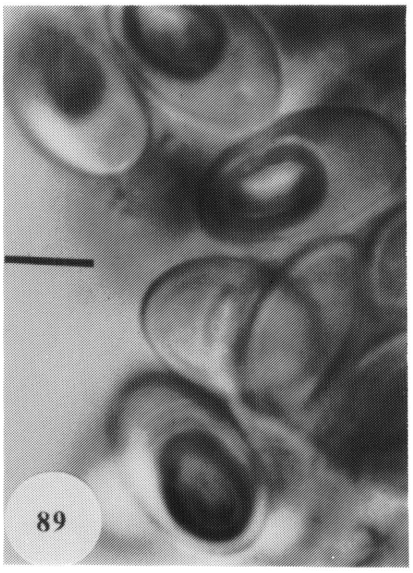












Figs. 90-92: *Coprotus glaucellus*.

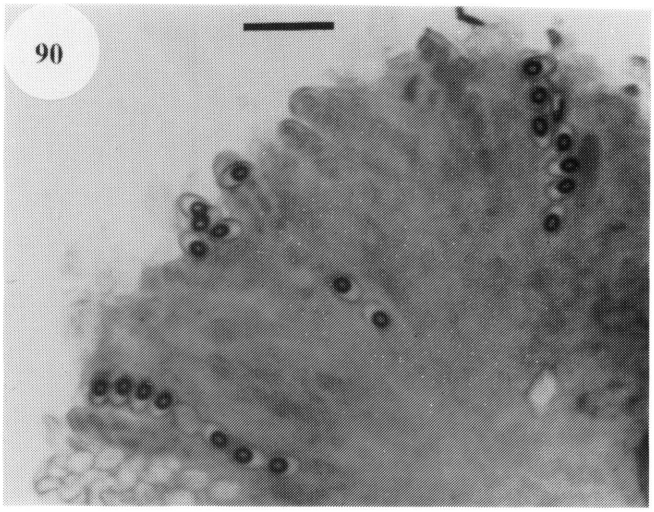
90. Apothecium (x20)
91. Asci with ascospores (x40)
92. Ascospores (x100)

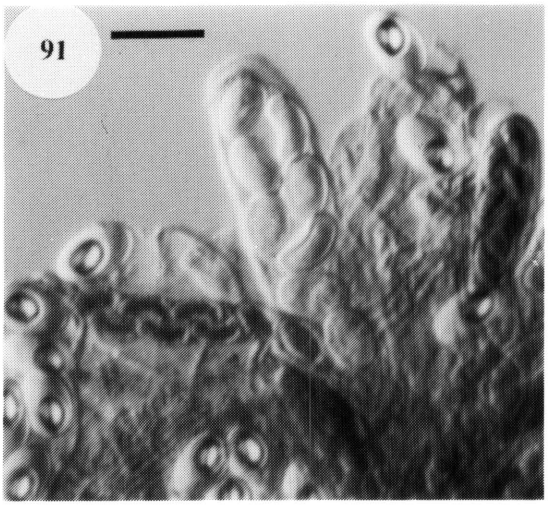
Figs. 93-94: *Coprotus lacteus*.

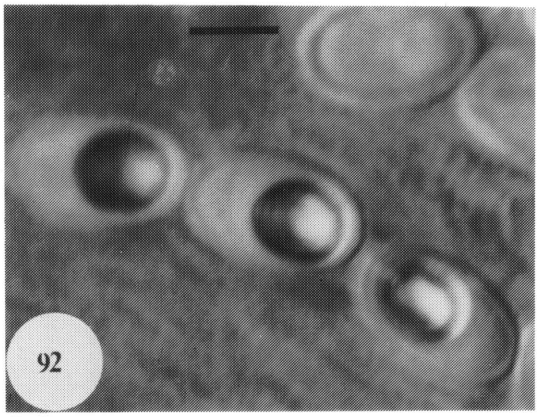
93. Apothecium (x5)
94. Mature ascus with ascospores (x40)

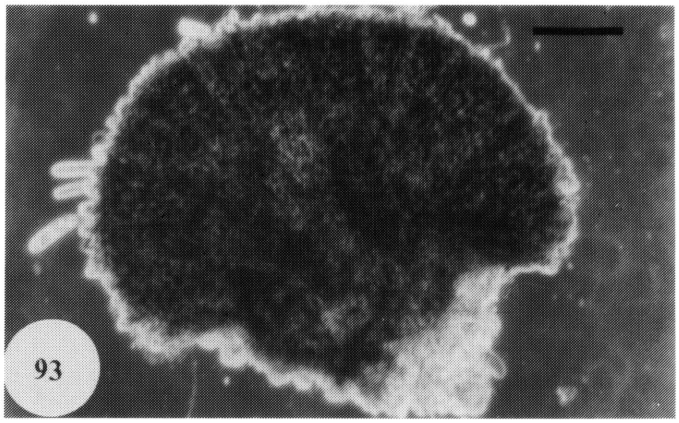
Figs. 95-97: *Coprotus leucopocillium*.

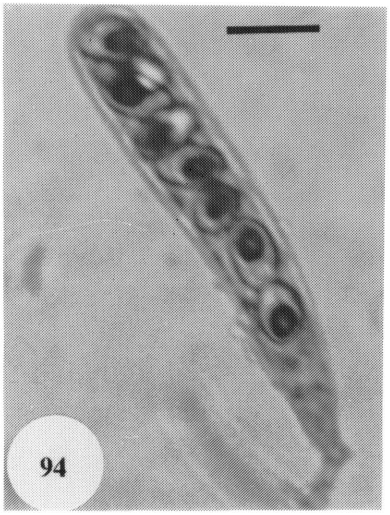
95. Apothecia (x10)
96. Mature ascus with ascospores (x40)
97. Ascospores (x100)

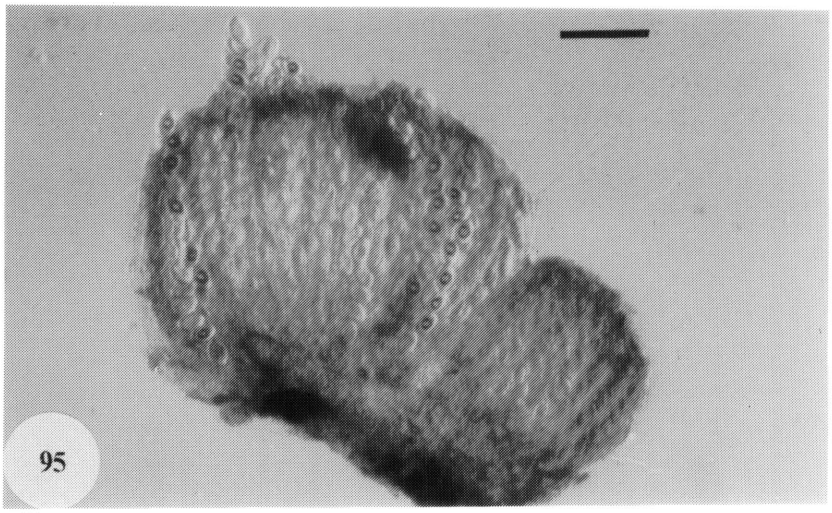


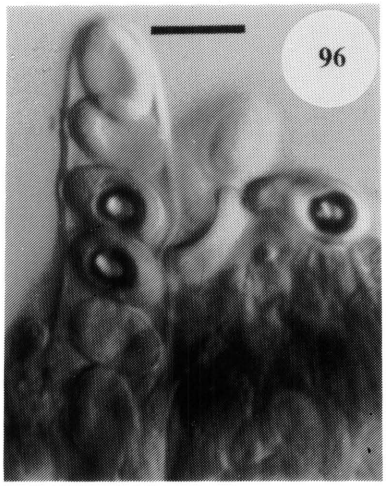


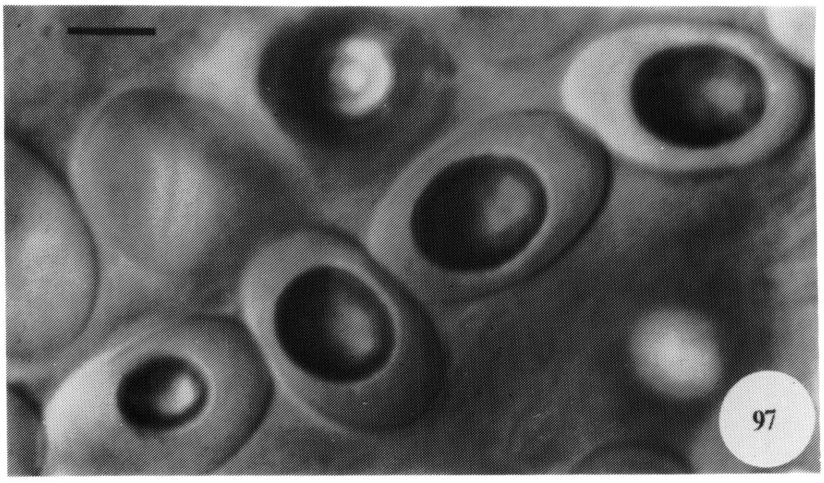












Figs. 98-100: *Coprotus luteus*.

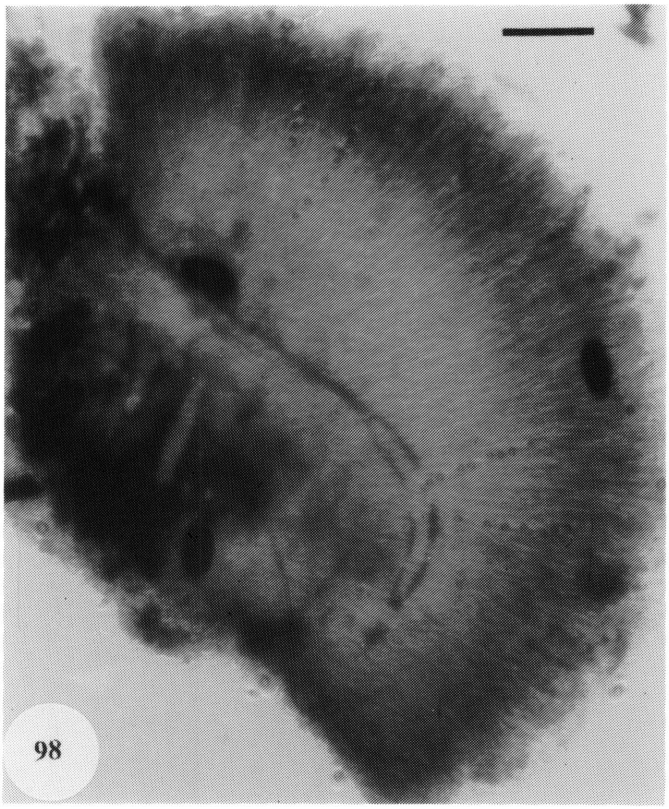
98. Apothecium (x10)
99. Mature ascus with ascospores and paraphyses (x40)
100. Ascospores (x100)

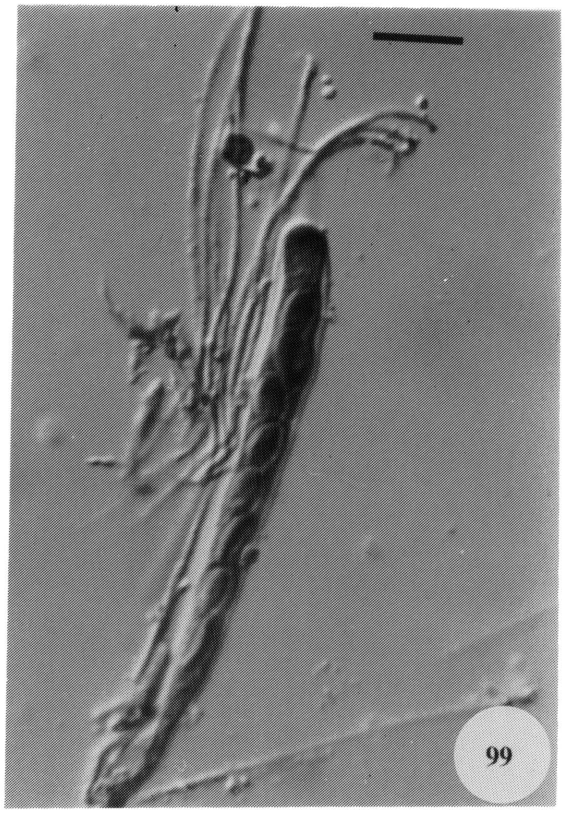
Figs. 101-102: *Coprotus marginatus*.

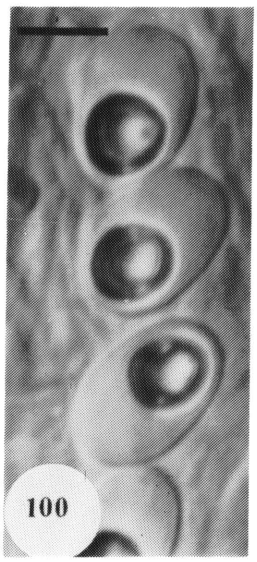
101. Apothecium (x5)
102. Mature ascus with ascospores (x40)

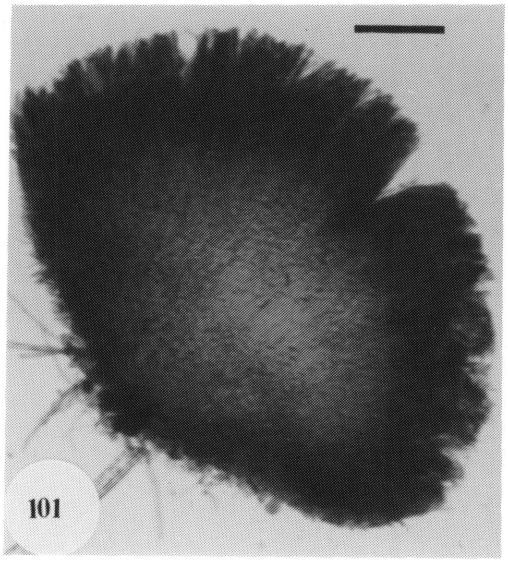
Figs. 103-104: *Coprotus winterii*.

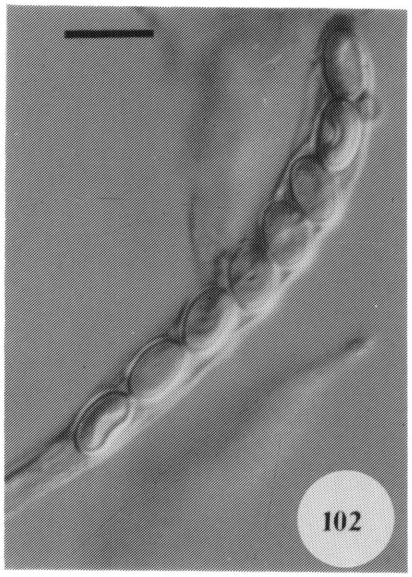
103. Apothecium (x5)
104. Mature ascus with ascospores (x20)

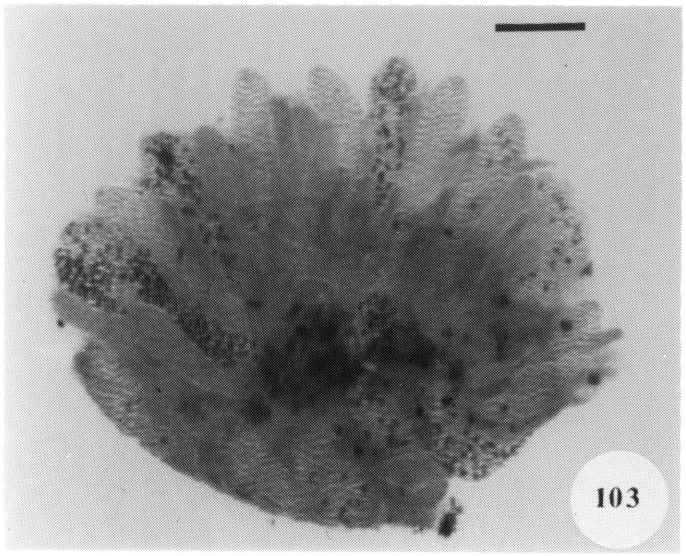












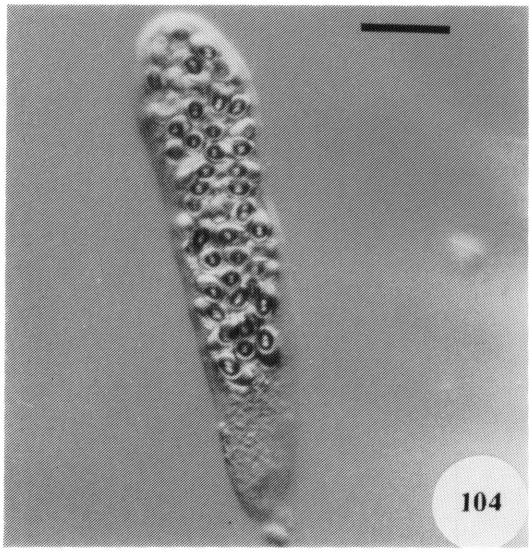


Fig. 105: *Iodophanus carneus*.

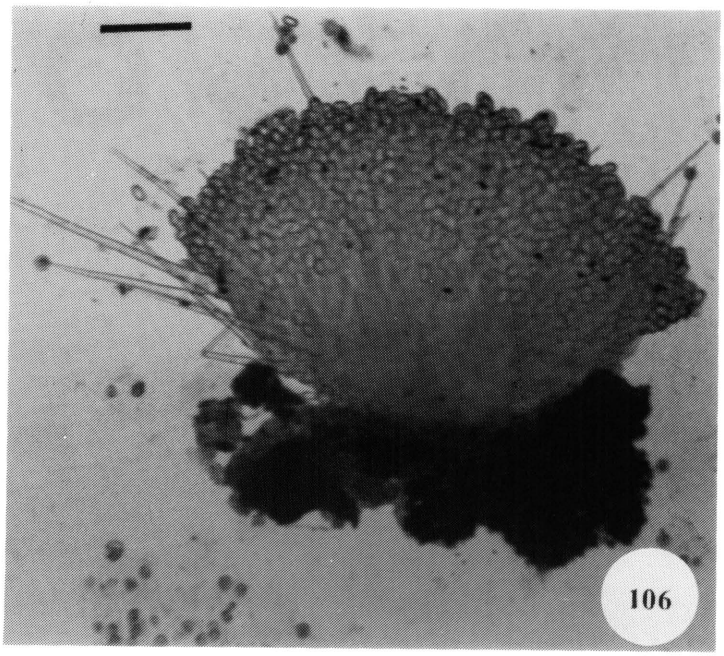
105. Mature ascus with ascospores and an empty ascus showing the operculum.

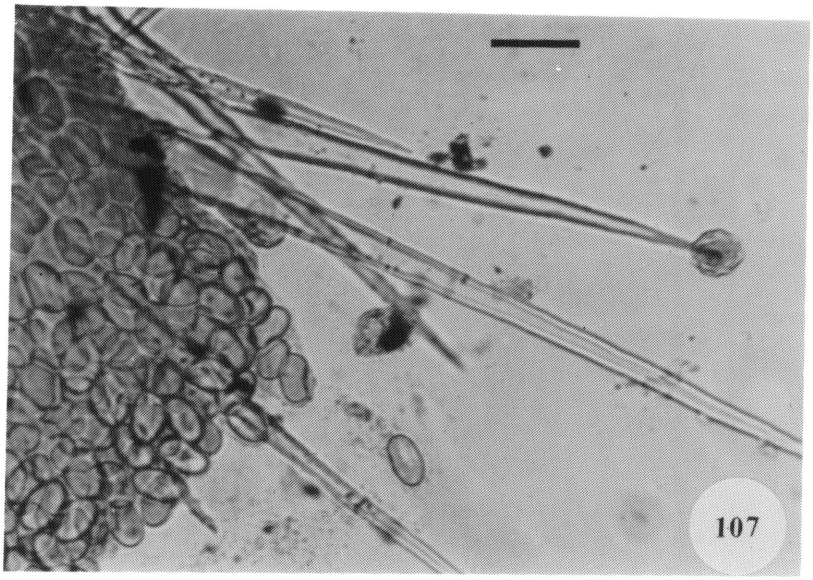
Figs. 106-108: *Lasiobolus intermedius*.

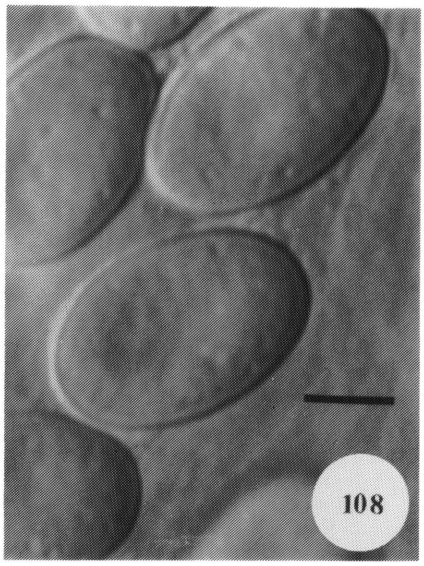
106. Apothecium (x5)
107. Setae (x20)
108. Ascospores (x100)

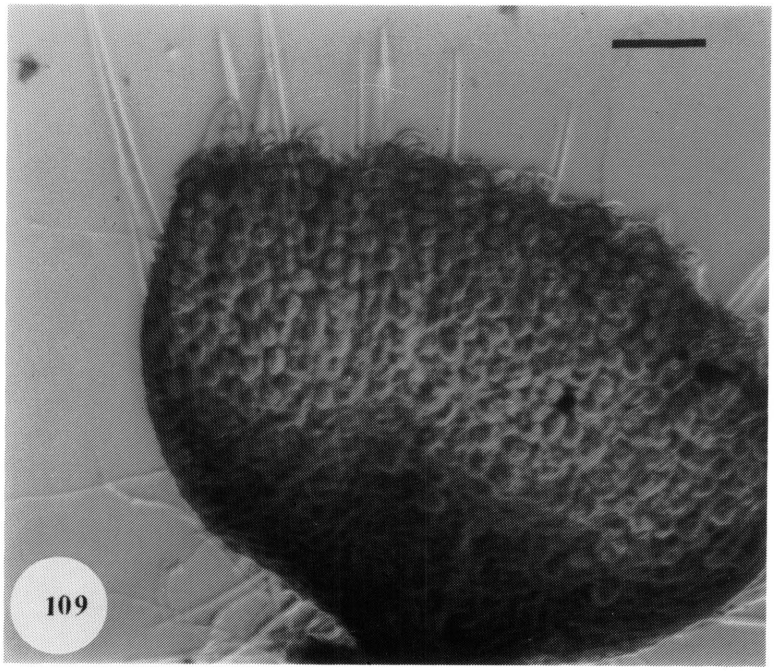
Figs. 109-110: *Lasiobolus lasioboloides*.

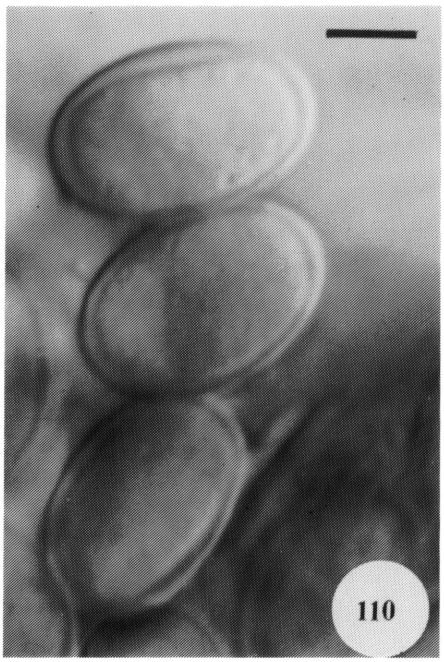
109. Apothecium (x10)
110. Ascospores (x100)









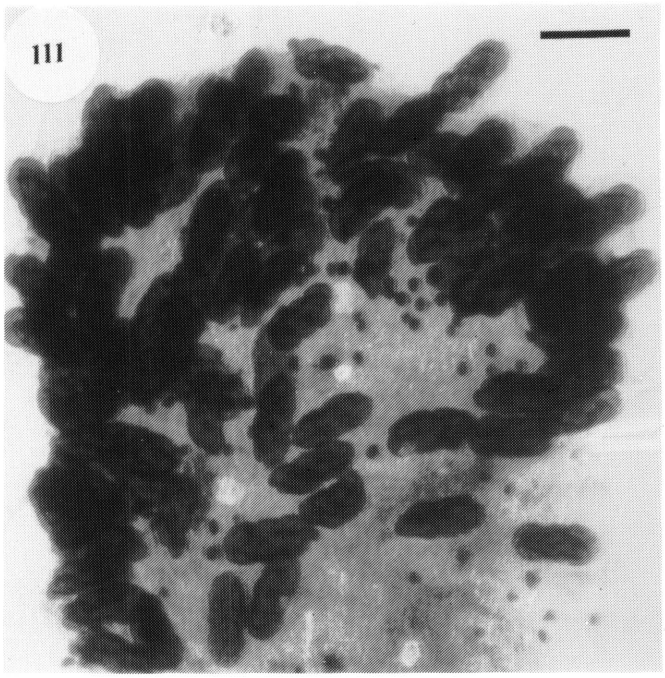


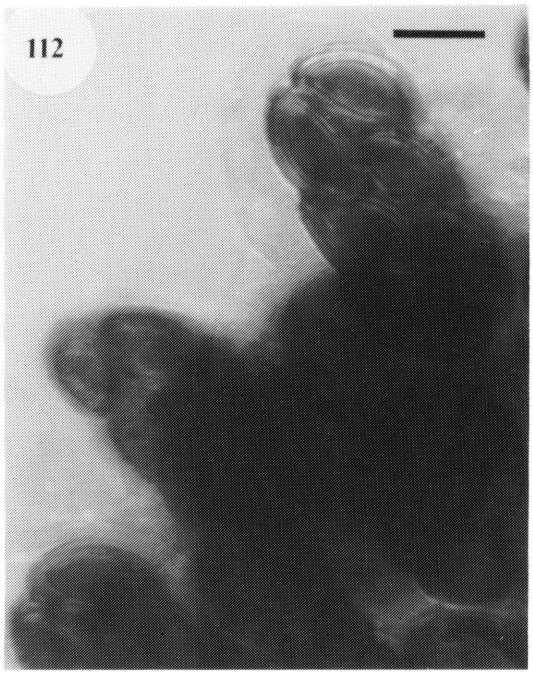
Figs. 111-113: *Saccobolus beckii*.

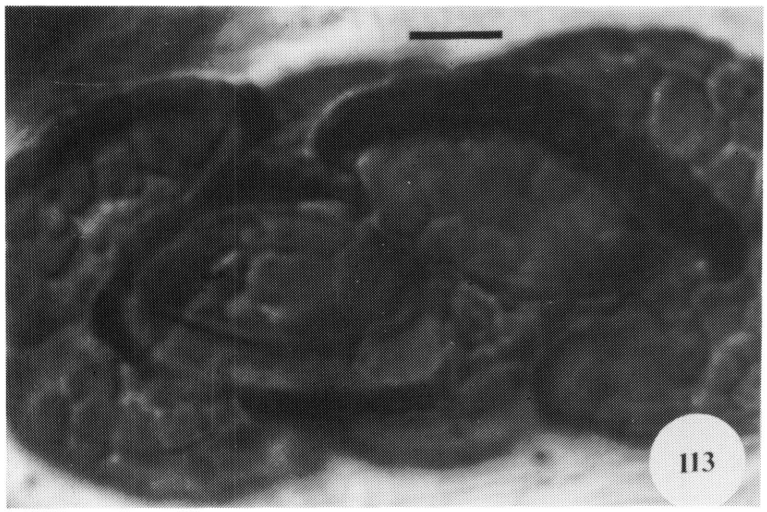
111. Apothecium (x10)
112. Mature ascus with spore cluster (x40)
113. Ascospores (x100)

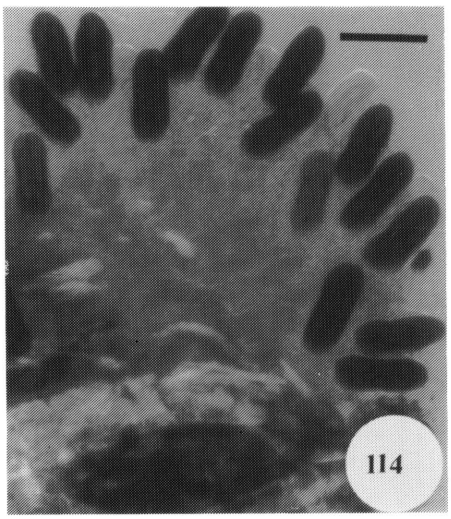
Figs. 114-116: *Saccobolus glaber*.

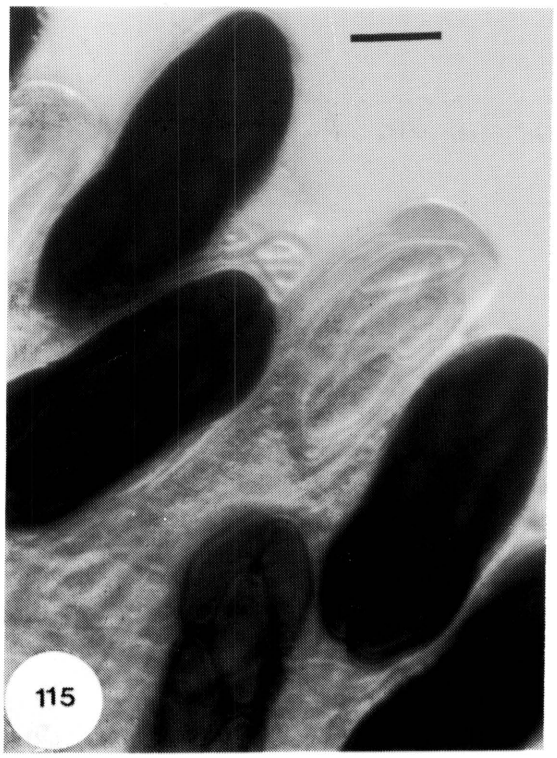
114. Apothecium (x10)
115. Mature and young asci with spore clusters (x40)
116. Ascospores (x100)

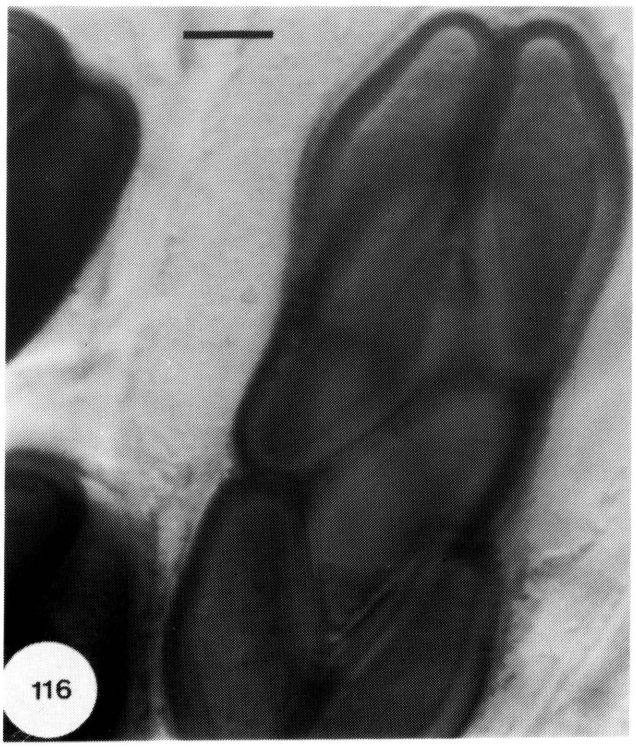












Figs. 117-119: *Saccobolus minimus*.

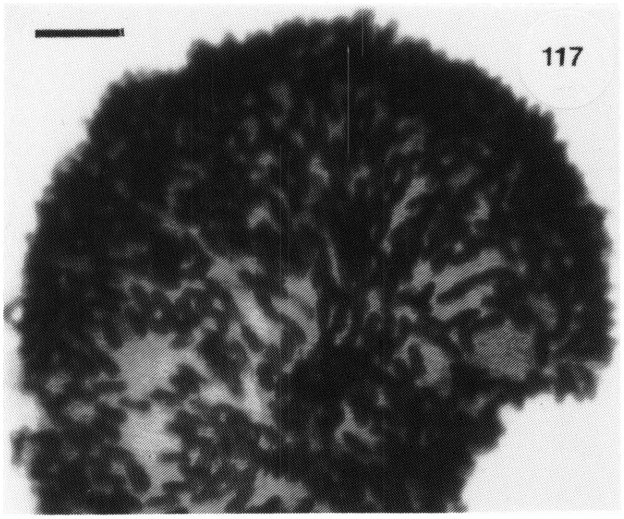
117. Apothecium (x5)
118. Ascospores (x100)
119. Mature asci with spore clusters (x40)

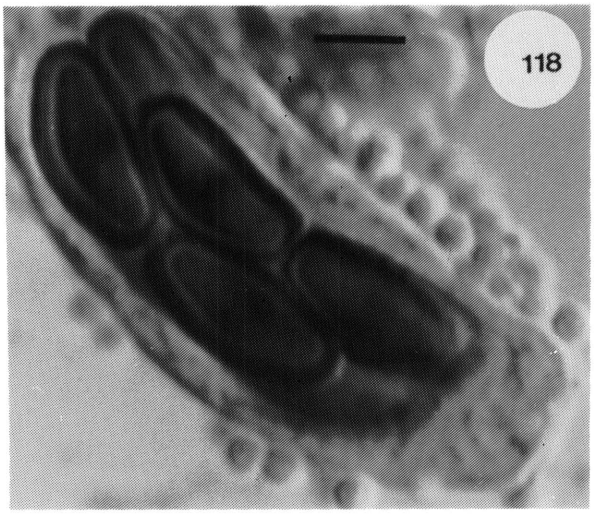
Figs. 120-121: *Saccobolus portoricensis*.

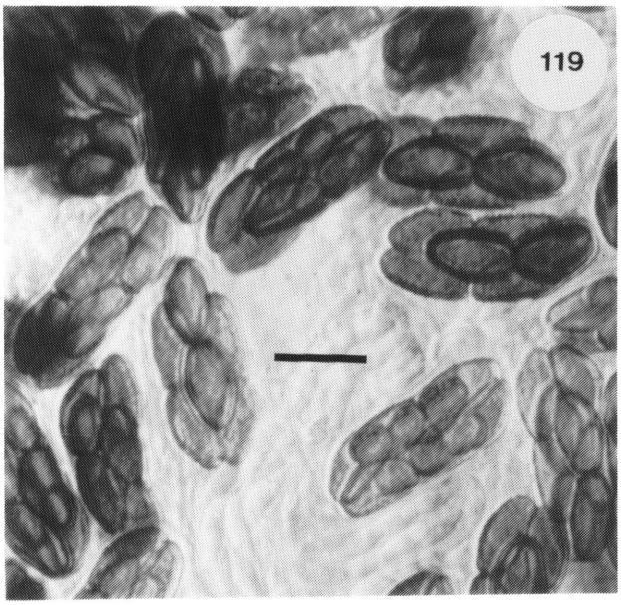
120. Apothecium with mature asci and spore clusters (x20)
121. Ascospores (x100)

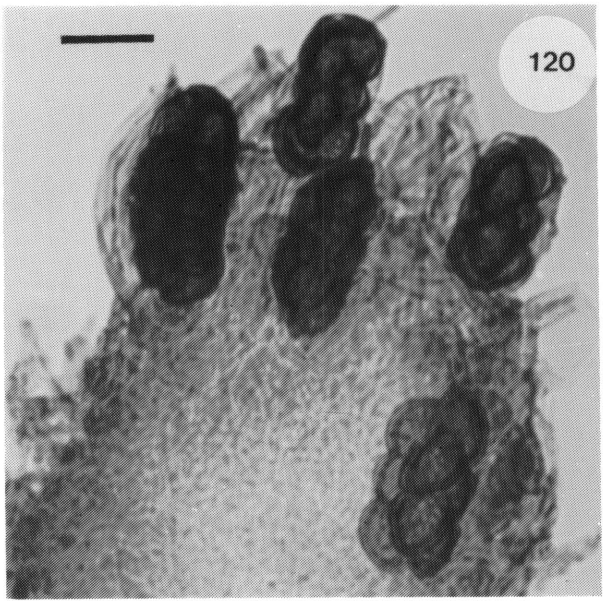
Figs. 122-124: *Saccobolus verrucisporus*.

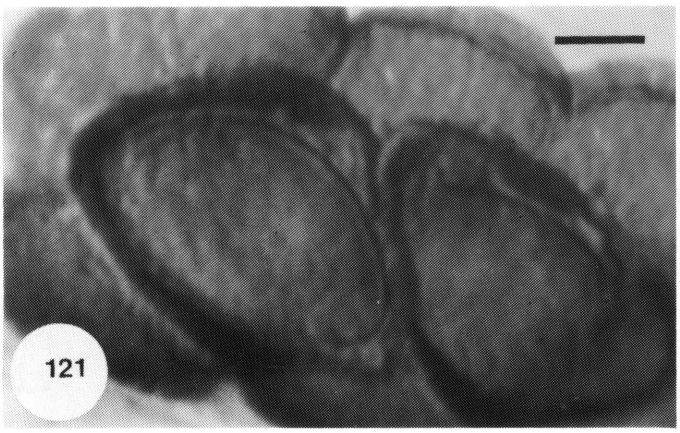
122. Apothecium (x10)
123. Spore clusters (x40)
124. Ascospores (x100)

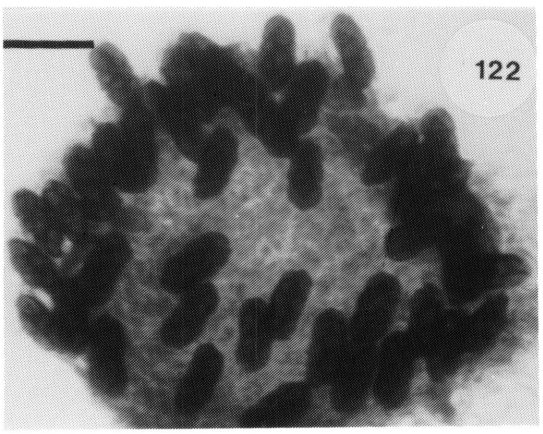


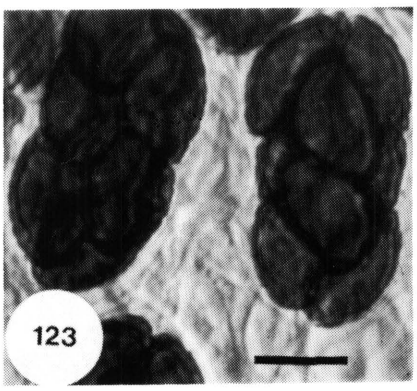


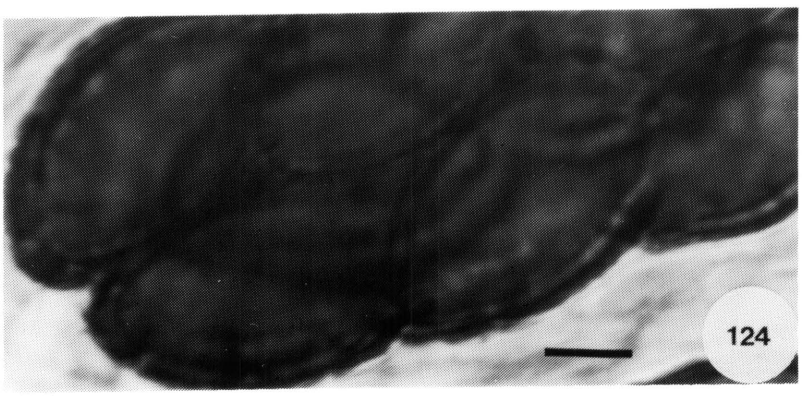












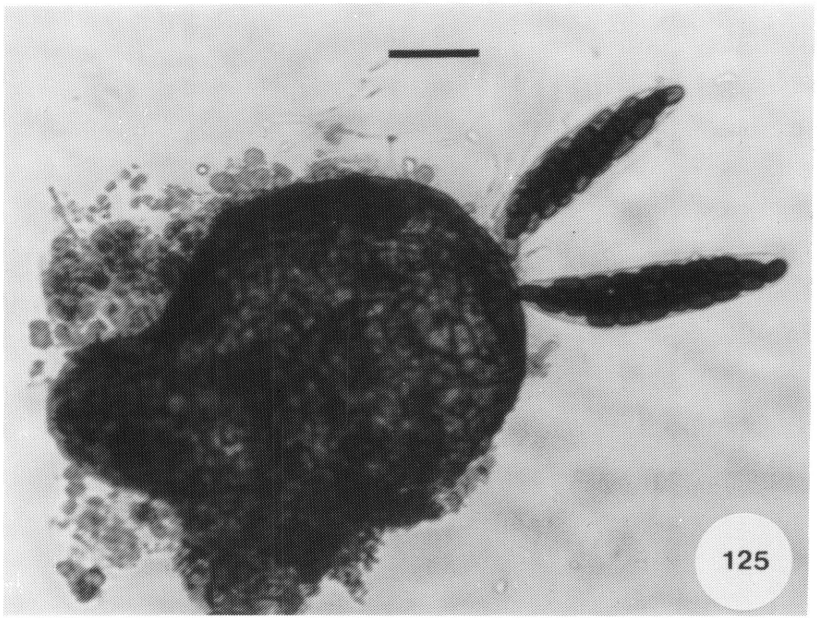
Loculoascomycetes:

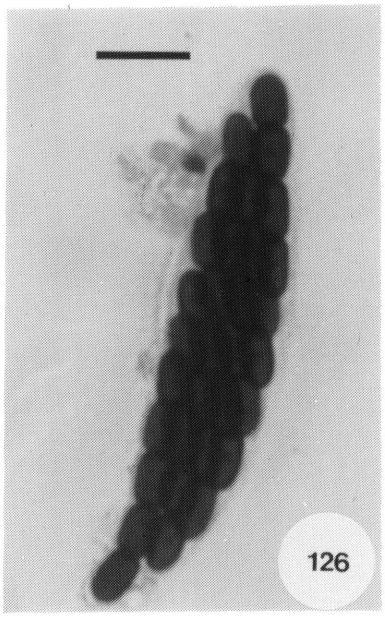
Figs. 125-127: *Sporormiella australis*.

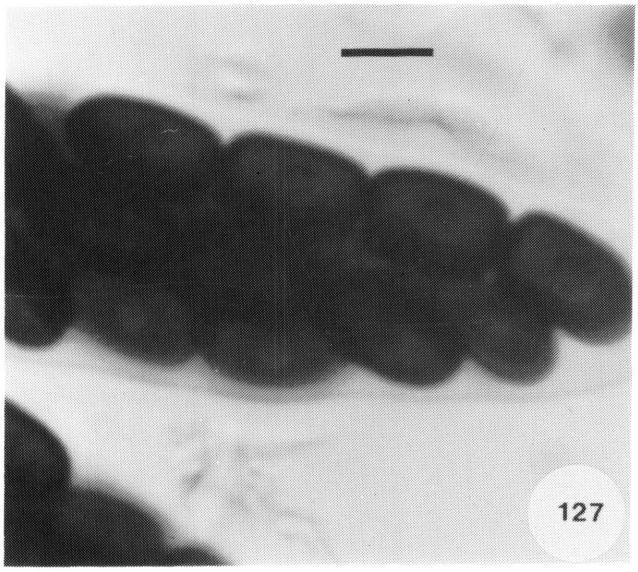
125. Pseudothecium (x20)
126. Mature ascus with ascospores (x40)
127. Ascospores (x100)

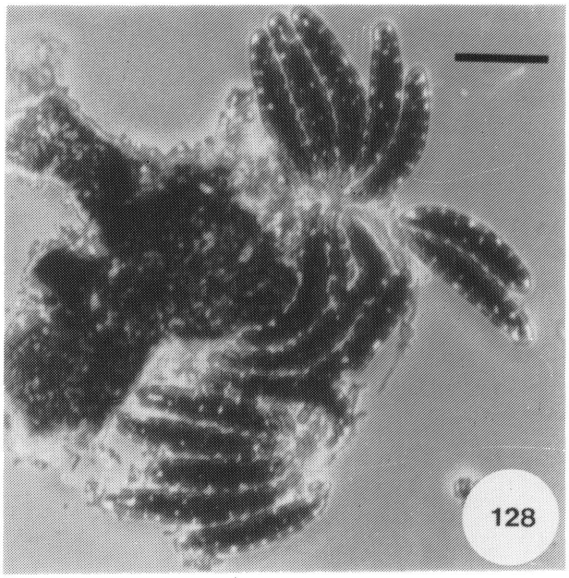
Figs. 128-130: *Sporormiella isomera*.

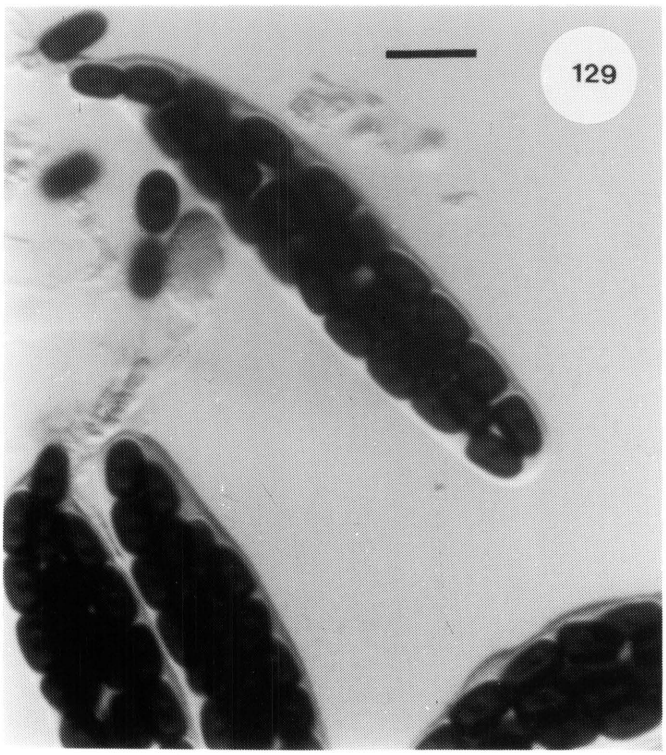
128. Pseudothecium with mature asci (x10)
129. Mature ascus with ascospores (x40)
130. Ascospores (x100)

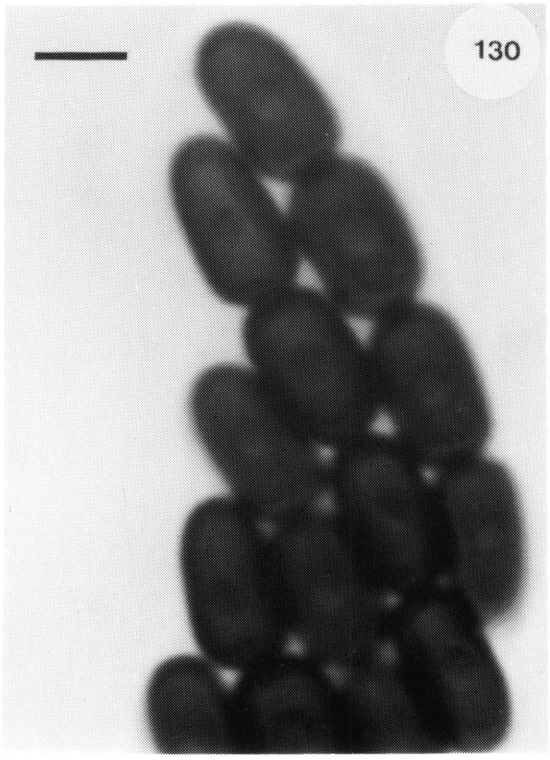










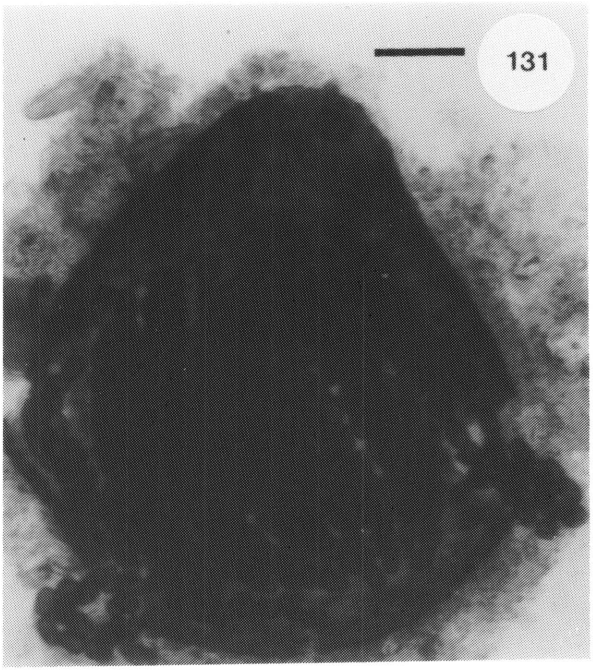


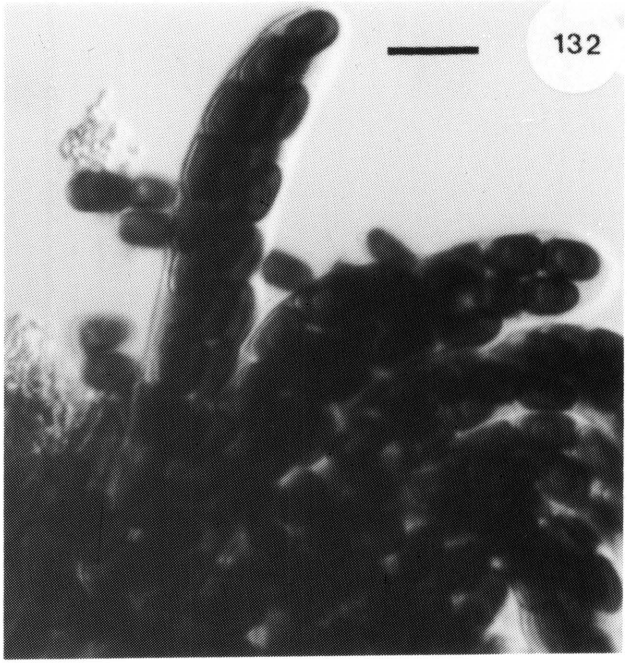
Figs. 131-133: *Sporormiella minima*.

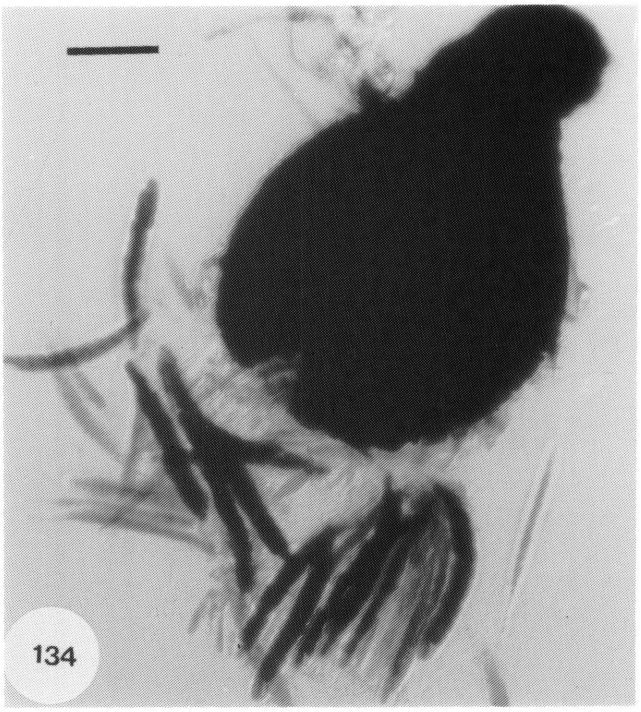
131. Pseudothecium with mature asci (x20)
132. Mature asci with ascospores (x40)
133. Ascospores (x100)

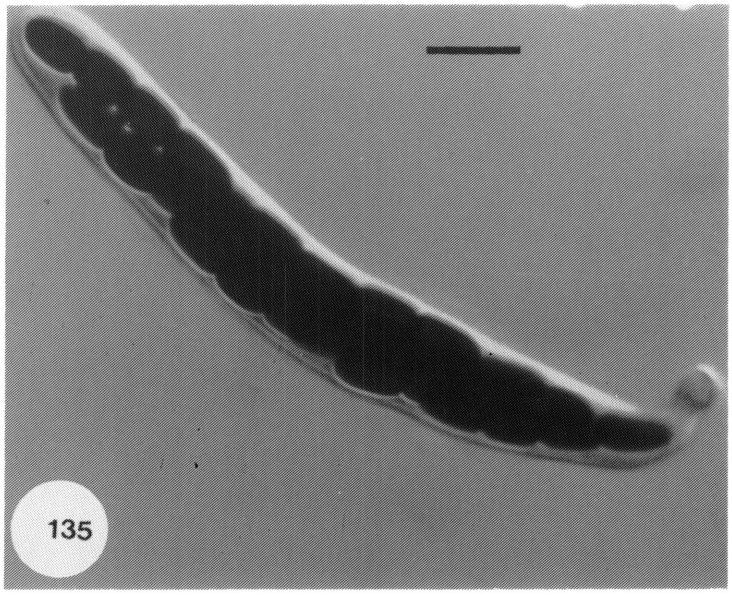
Figs. 134-136: *Sporormiella minimoides*.

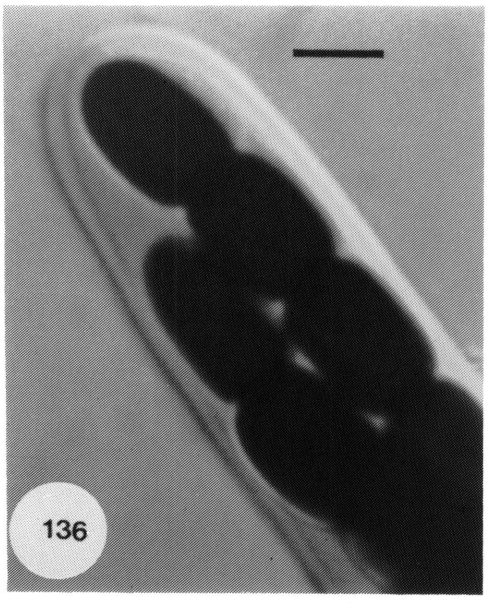
134. Pseudothecium (x5)
135. Mature ascus with ascospores (x40)
136. Ascospores (x100)









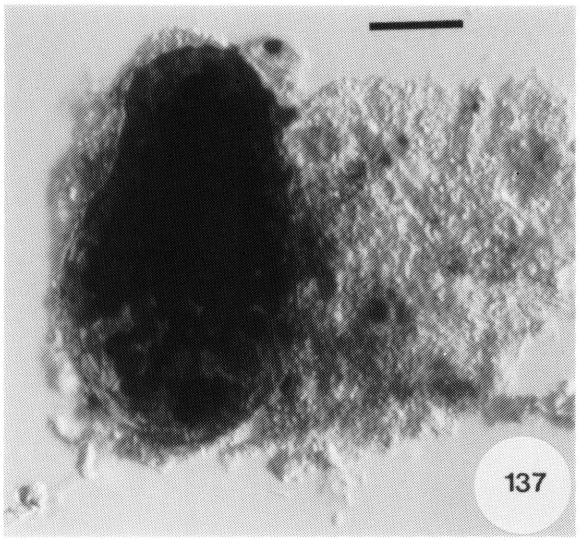


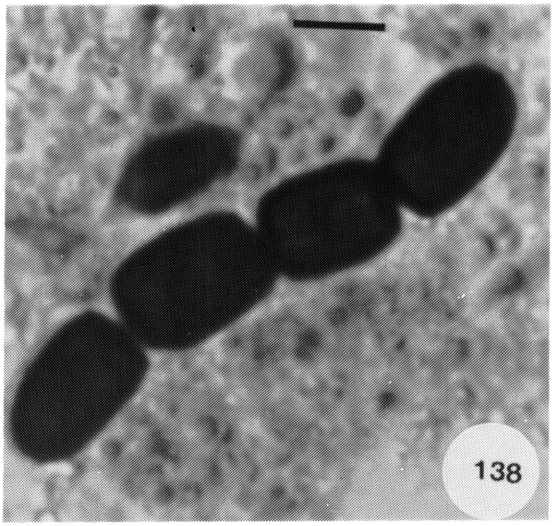
Figs. 137-138: *Sporormiella subtilis*.

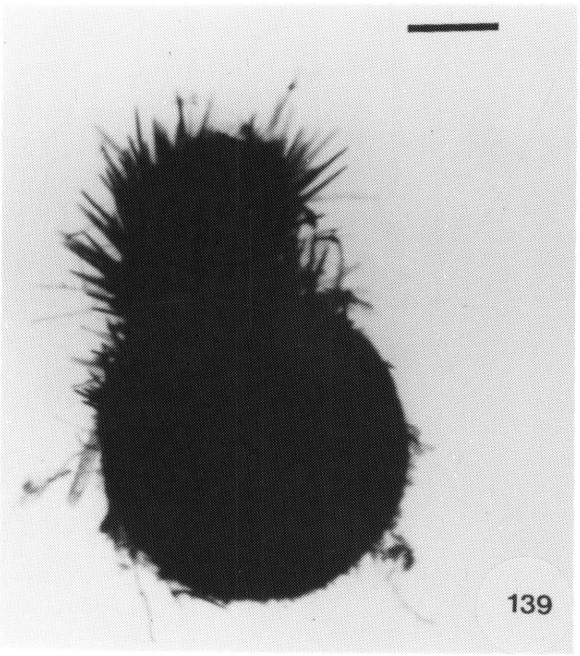
137. Pseudothecium (x20)
138. Ascospore (x100)

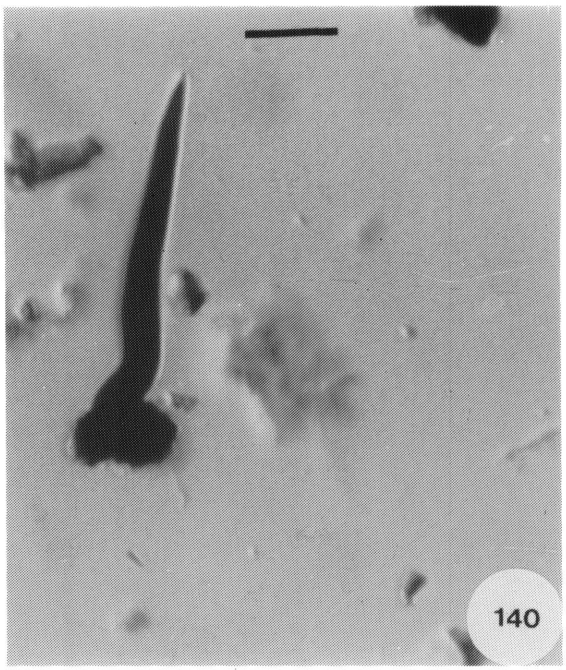
Figs. 139-142: *Trichodelitschia sweniensis*.

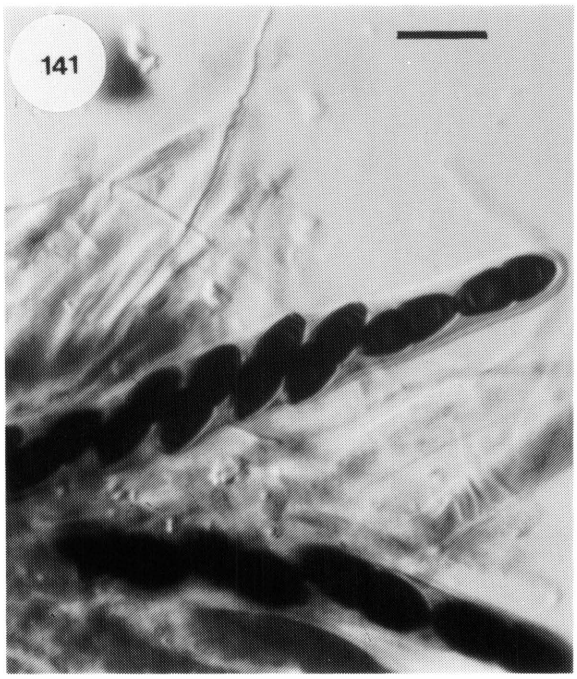
139. Pseudothecium (x5)
140. Seta (x40)
141. Mature ascus with ascospores (x40)
142. Ascospores (x100)

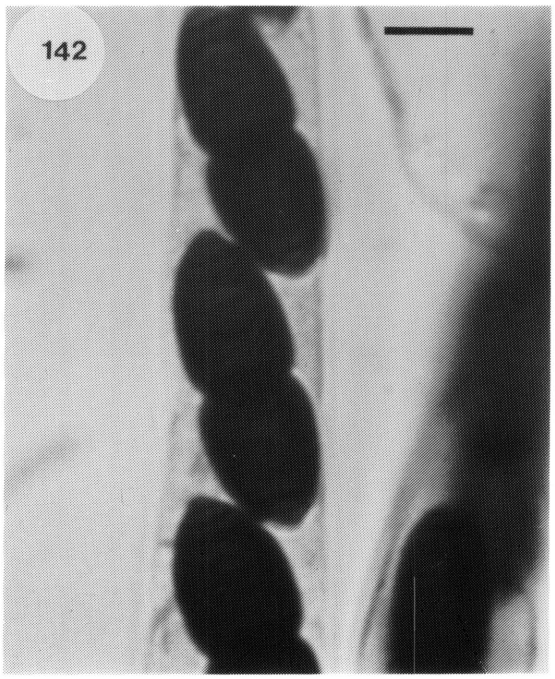




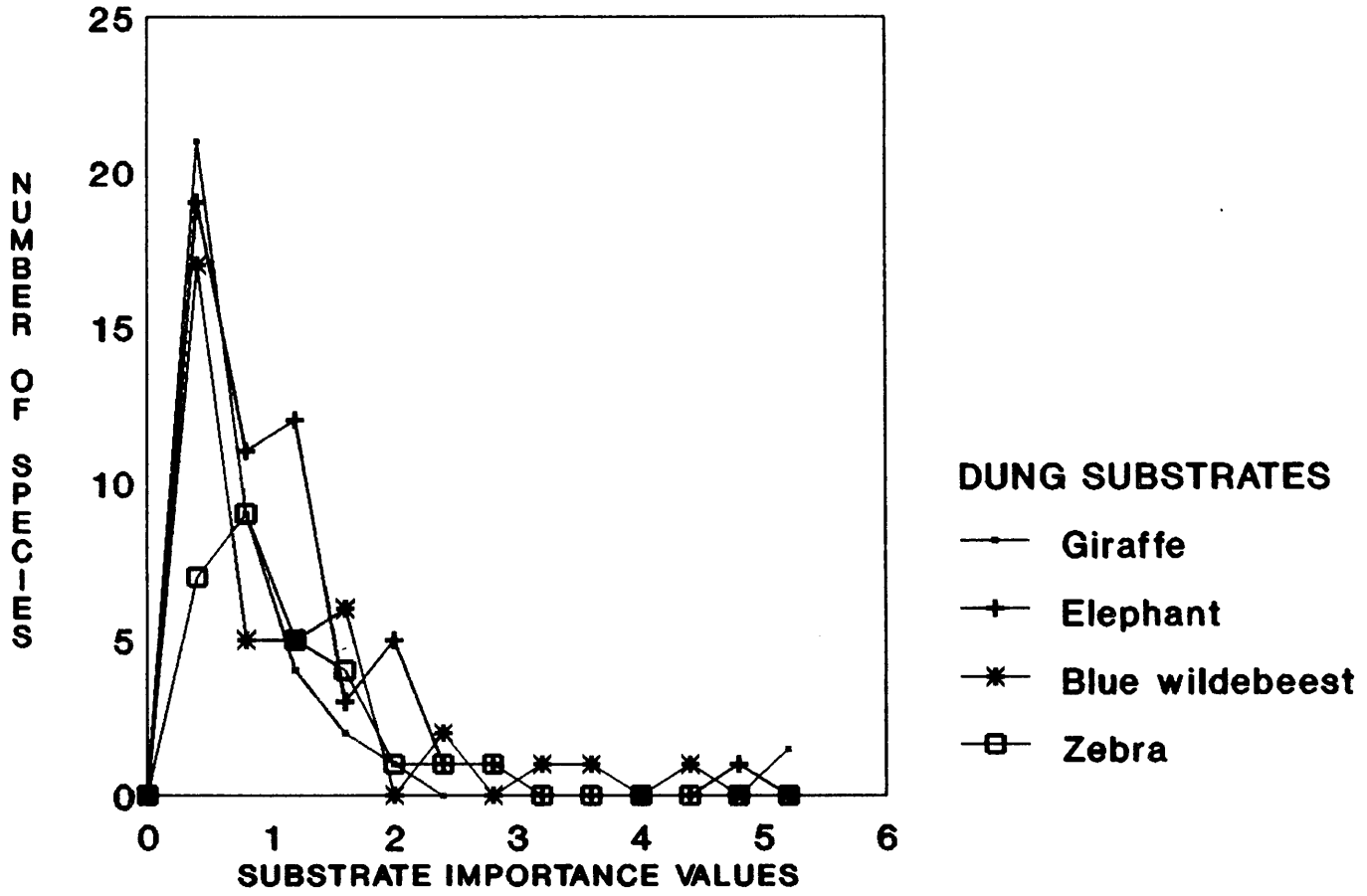




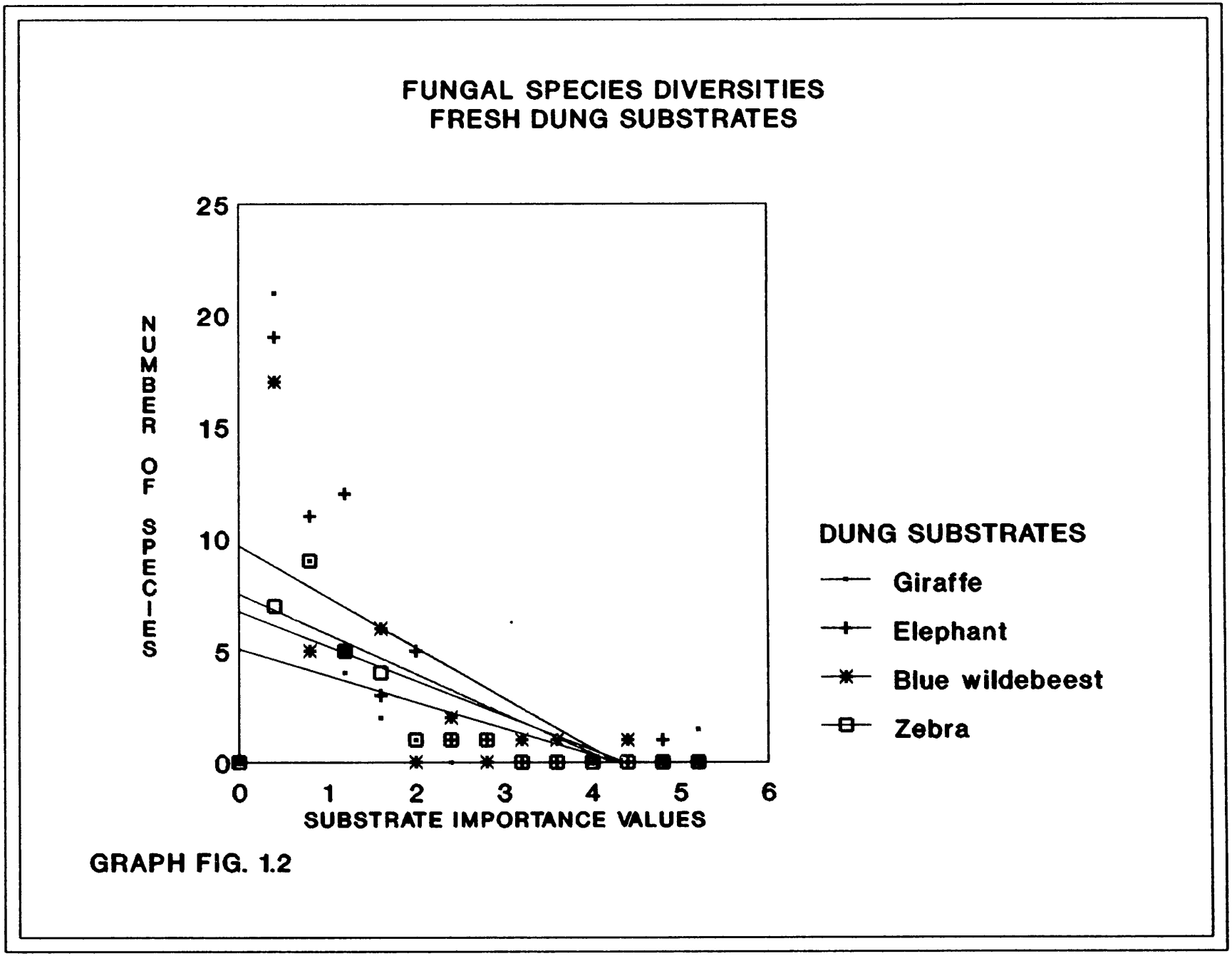




FUNGAL SPECIES DIVERSITIES FRESH DUNG SUBSTRATES.

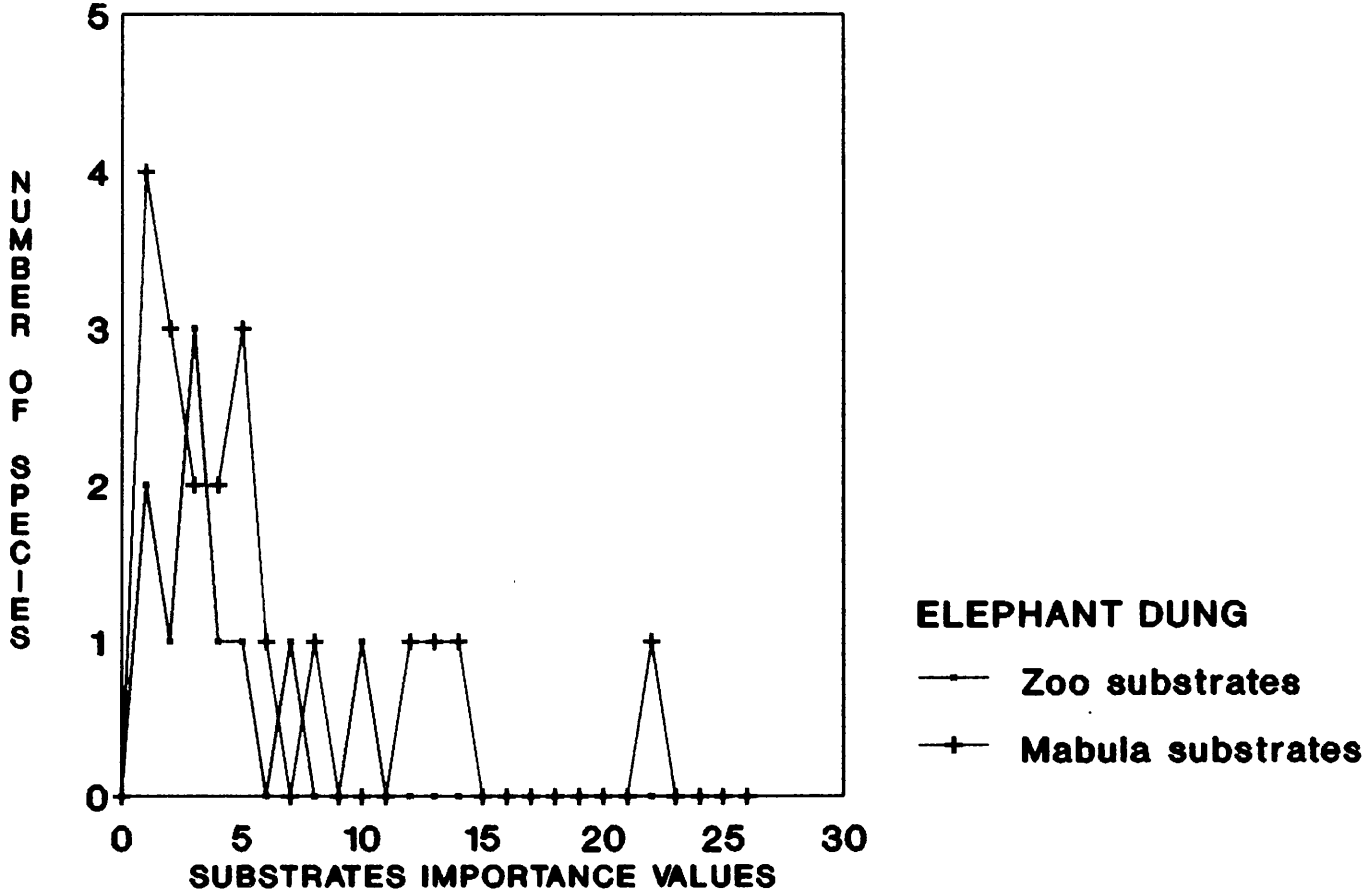


GRAPH FIG. 1.1



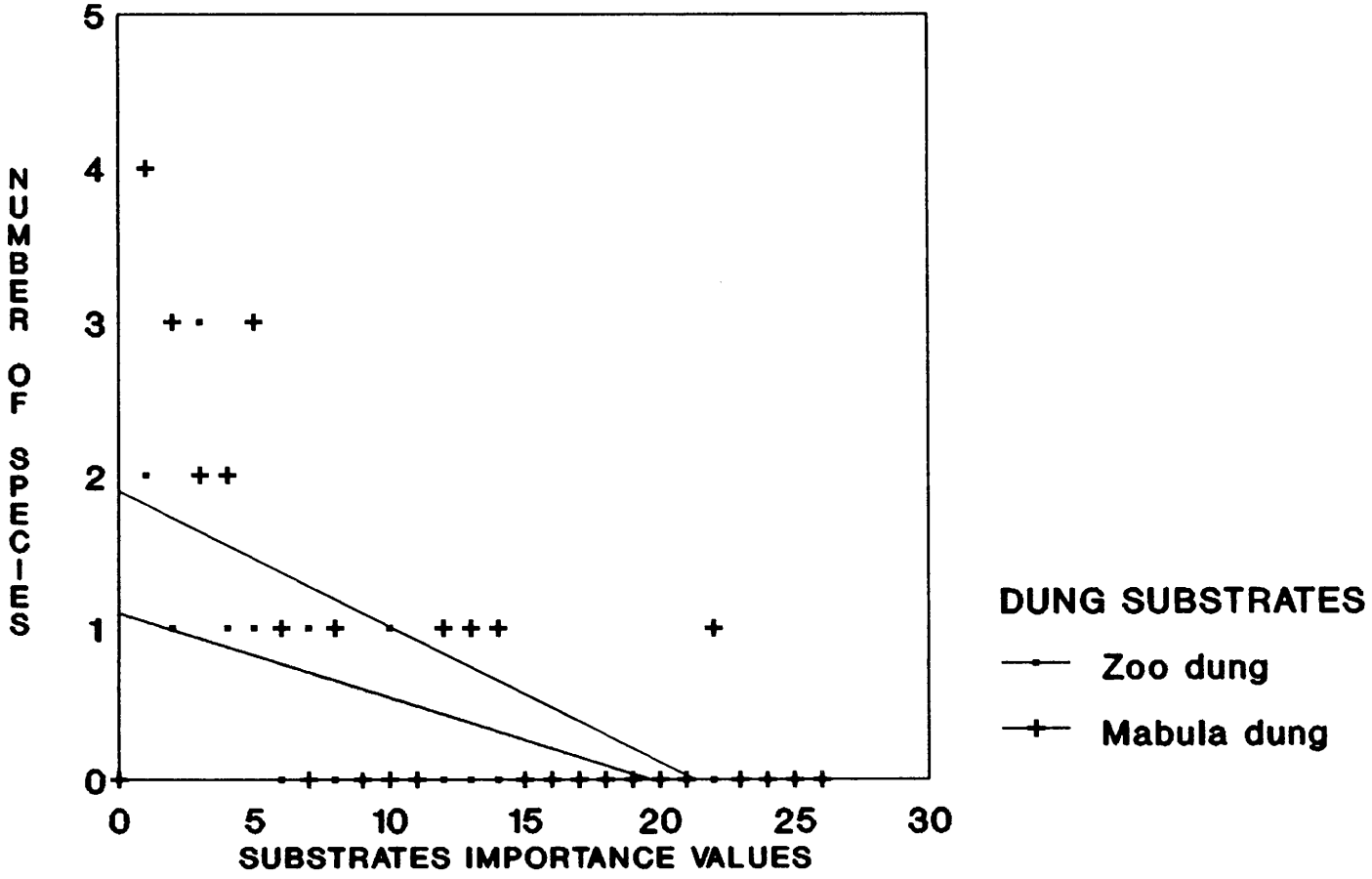
GRAPH FIG. 1.2

FUNGAL SPECIES DIVERSITIES.
MABULA & ZOO FRESH DUNG SUBSTRATES.

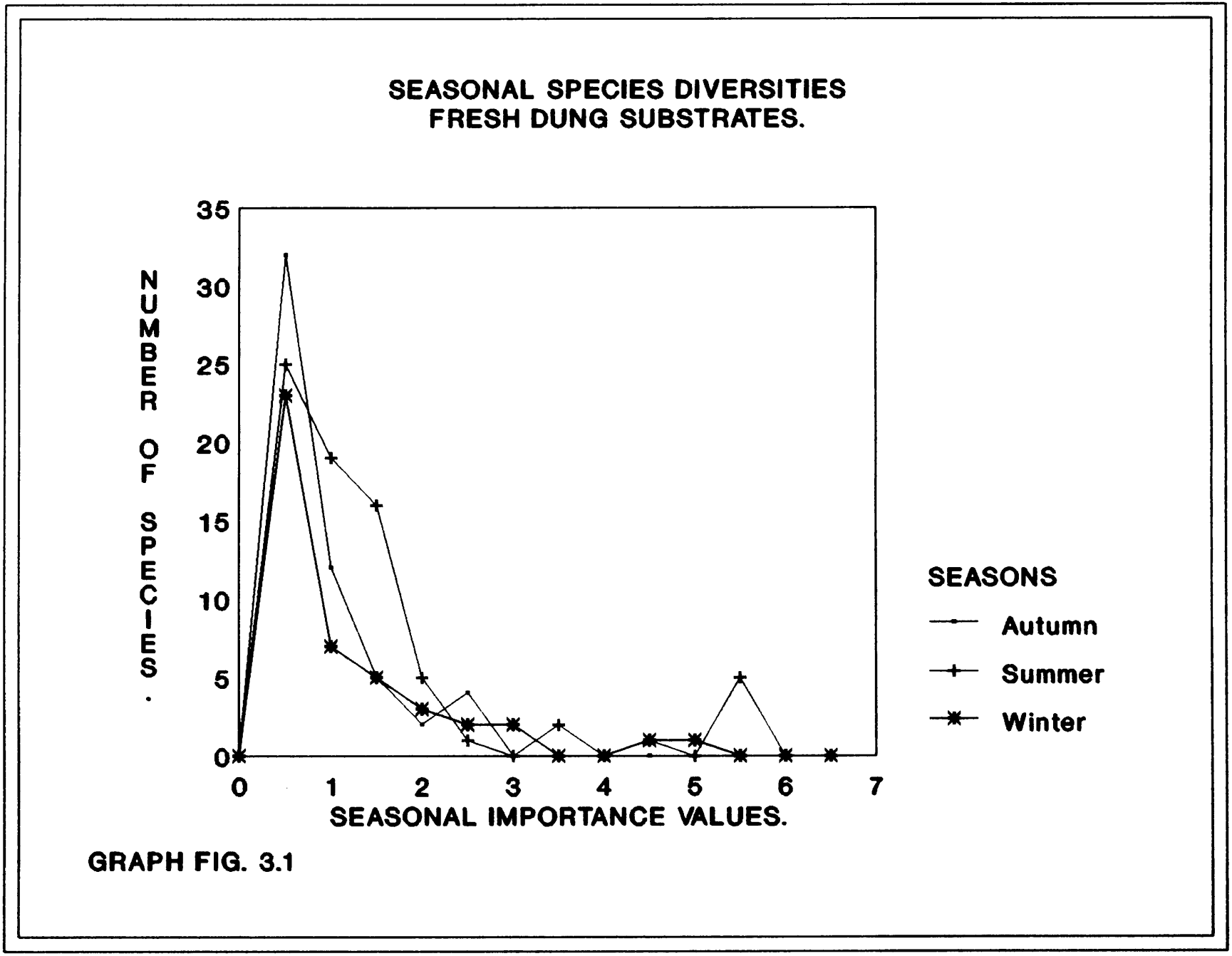


GRAPH FIG. 2.1

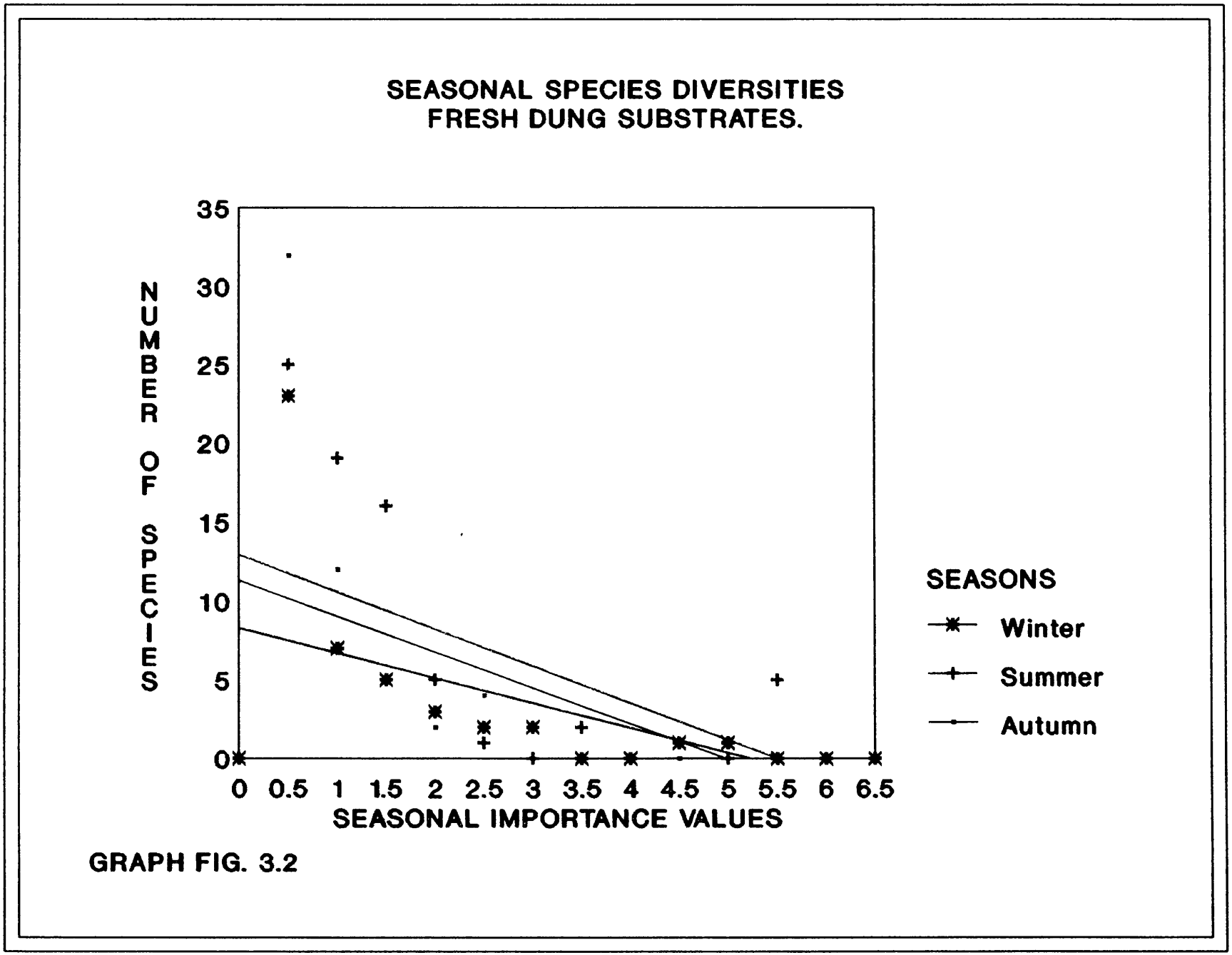
FUNGAL SPECIES DIVERSITIES.
MABULA & ZOO FRESH DUNG SUBSTRATES.



GRAPH FIG. 2.2

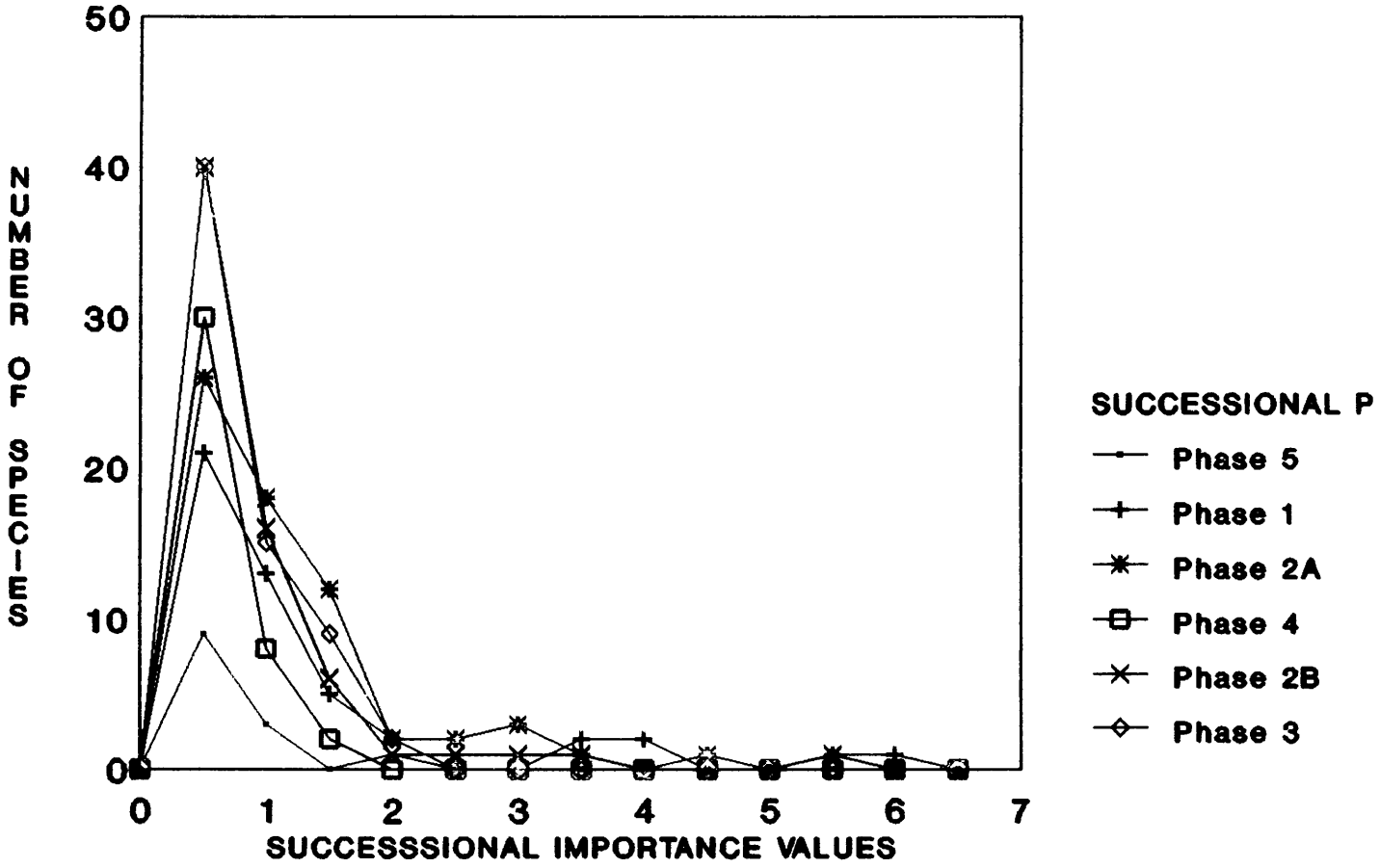


GRAPH FIG. 3.1



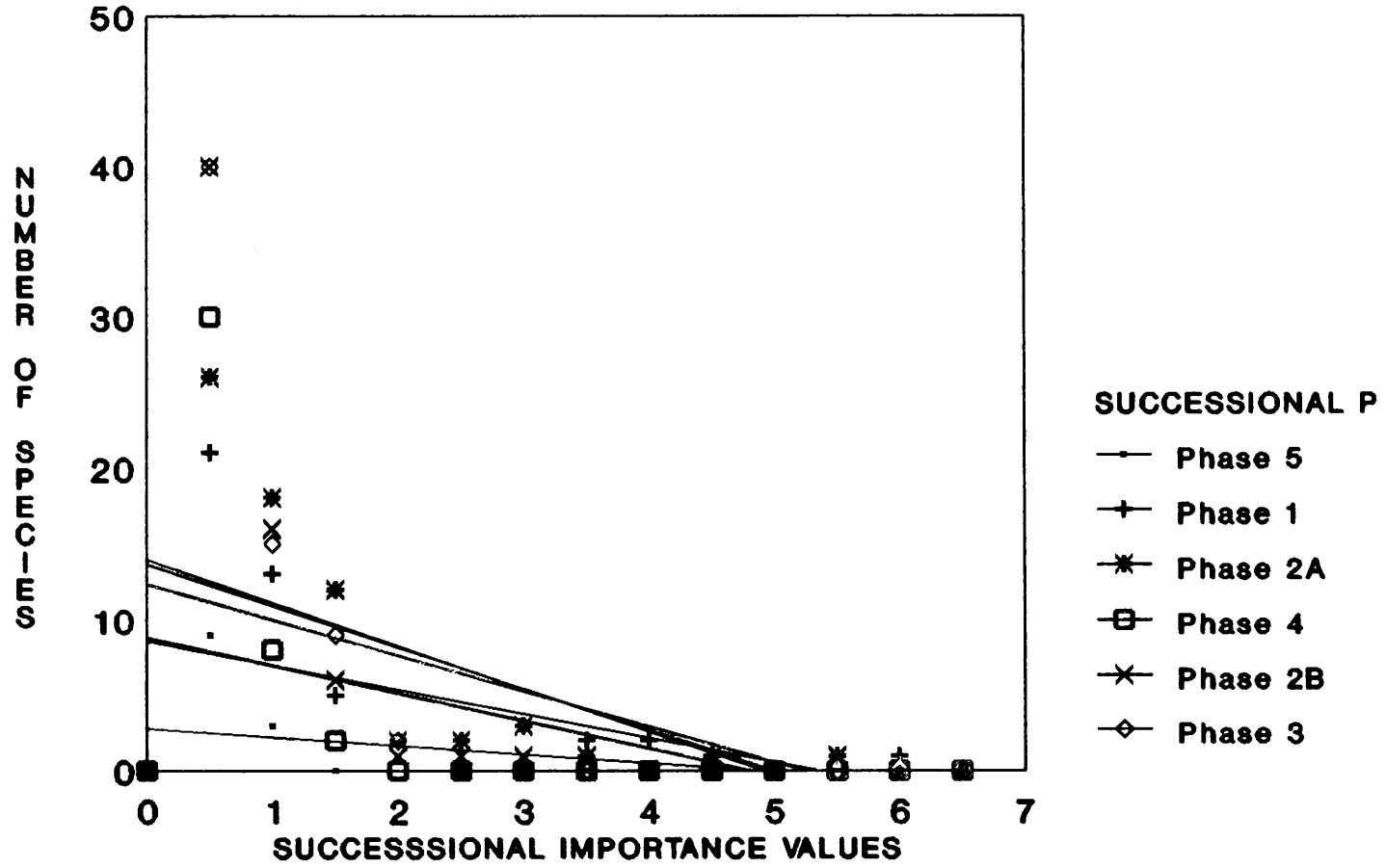
GRAPH FIG. 3.2

SUCCESSIONAL SPECIES DIVERSITIES FRESH DUNG SUBSTRATES.



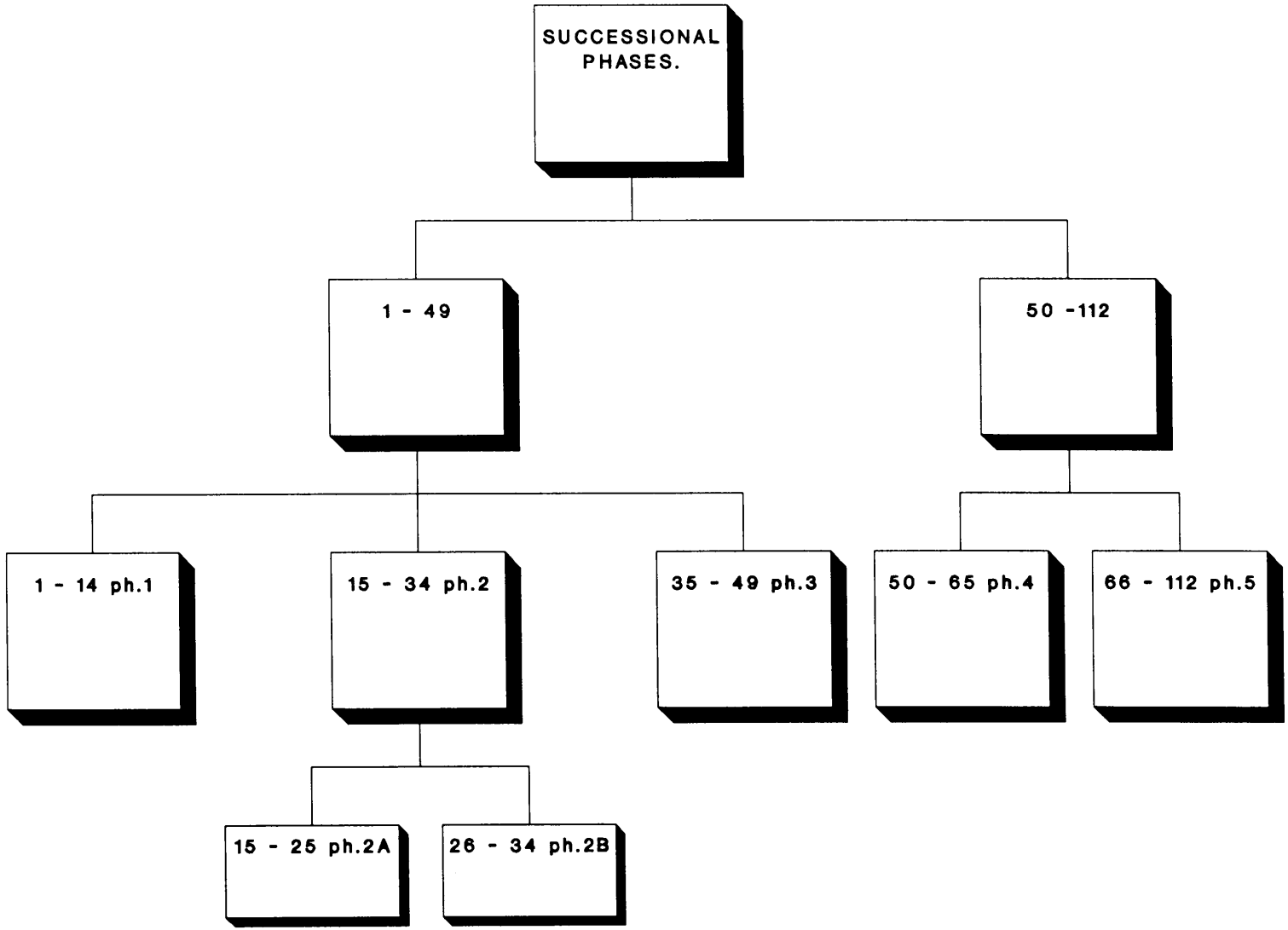
GRAPH FIG. 4.1

SUCCESSIONAL SPECIES DIVERSITIES FRESH DUNG SUBSTRATES.



GRAPH FIG. 4.2

DENDROGRAM.
SUCCESSIONAL PHASES



GRAPH FIG. 5

ACKNOWLEDGMENTS

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I am grateful to our Creator, Who must have been in a " playful and abundant " mood the day He created the coprophilous fungi - I was astounded by the enormous diversity and intricate beauty of the fungal flora. This again brought home the fact that the creation of such abundance and specialization could under no circumstances have been the work of chance, let alone man.

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