Bot. Bull. Academia Sinica (1992) **33:** 85-95

# Coprophilous fungal species composition and species diversity on various dung substrates of African game animals

Colleen Ebersohn* and Albert Eicker
*Department of Botany, University of Pretoria, Pretoria, 0002, South Africa*

(*Received September 9, 1991; Accepted November 18, 1991*)

**Abstract.** 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 an effect on the coprophilous fungal species composition and species diversities on the different dung substrates, were investigated. The results are discussed and illustrated. Certain positive associations are indicated.

**Key words:** *Connochaetes taurinus*; Coprophilous fungi; Dung substrates; *Equus burchelli*; *Giraffa camelopardalis*; *Loxodonta africana*.

## Introduction

Coprophilous fungi play an important role in the mineralization of dung, especially of herbivores. Most coprophilous fungi exhibit the following general life cycle pattern: The fungal spores are distributed to nearby vegetation by means of various dispersal mechanisms. These spores are then ingested by herbivores feeding on the plants. The spores not only survive passage through the digestive system of the animals, but in most cases the mechanical and chemical digestion processes benefit germination of the spores on the dung substrates (Bell, 1983).

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. Therefore 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.

## Materials and Methods

### *Sample Methods*

Fresh dung samples were collected within minutes of being voided, to restrict insect interference and to limit aerial and contact contamination by fungus spores other than that of the coprophilous species. The

*Present Address: Technikon Pretoria, Private bag X680, Pretoria, 0001, South Africa.

samples were collected, wrapped in paper towels and placed in sterile containers, which were then sealed. Samples were collected on a regular basis every two to three months for a period of three years.

To determine the influence of the feeding habits, food preferences and digestive systems of the herbivorous animals with regard to the fungal species compositions and fungal species diversities of the different dung substrates, freshly voided dung of the following animal species were investigated:

*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* (African elephant).

The selection of the particular herbivorous animals is explained in Table 1.

*Incubation of the Dung Substrates*

All samples collected were taken to the laboratory and incubated using the following method:

Samples 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 substrate. The substrates were then placed in an incubator and kept moist for the duration of the investigation. The temperature and day light hours were regulated according to the respective seasons involved.

Humidity 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 and Underhay, 1977)

*Microscopic Examination of the Dung Substrates*

Two microscopes were used throughout the investigation, a binocular low magnification stereo type microscope to scan the substrate surfaces and to aid in the removal of the fungal fruit bodies that occurred, as well as a high power compound microscope with phase contrast for identification purposes. During the stereo microscope examinations the relative abundance of each species was noted, using a scale based on the number of fruit bodies observed on the substrate: ¼ + for 1-5, ½ + for 6-10, + for 11-20, ++ for 21-40, +++ for 41-60, ++++ for 61-100 and +++++ for over 100 fruitbodies.

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 a reliable indication of the ecological importance of the species. 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 resulting data eventually lead to the calculation of ecological importance values for each species per substrate. The different importance values thus obtained were used to calculate an overall ecological importance value for each species. The substrate importance values of the coprophilous species were calculated using the following formula:

$$\text{Substrate importance value (IV)} = \frac{2(A+B)+C}{3}$$

A = Relative % duration

$$= \frac{\text{No of days/Sp./substrate}}{\text{No of days all Spp. and substrates}} \times 100/1$$

B = Relative % abundance

$$= \frac{\text{No of "plus"'s/Sp./substrate}}{\text{No of "plus"'s all Spp. and substrates}} \times 100/1$$

C = Relative % occurrence

$$= \frac{\text{No of occ./Sp./substrate}}{\text{No of occ. all Spp. and substrates}} \times 100/1$$

More weight is given to the relative % duration and the relative % abundance than to the relative % occurrence as the duration and abundance of a species are considered more important than the mere presence or absence of a species (occurrence), as the duration and abundance of a species will determine the rate and extent of metabolic activity and thus strongly influence

**Table 1.** *The food, feeding habit, digestive system and nature of the dung of four herbivorous animals used in this investigation*

| Food | Feeding habit | Digestive system | Dung |
| --- | --- | --- | --- |
| 1. **Connochaetes taurinus** (Blue wildebeest): | | | |
| 96% Grass; 4% Bark & Browse (Attwell, 1977) | Non-selective short grass feeder. | Ruminant-highly effective digestor | Compact with a fine texture. |
| Partial to new growth on burnt areas. (Smithers, 1983) | Utilize a wide variety of grass spp up to 15 cm in height. (Smithers, 1983) | | |
| 2. **Equus burchelli** (Burchell's zebra): | | | |
| 74% Grass; 13% Browse; 12% Herbs; 1% Sedges (Smuts, 1972) | Partly selective<br>Select the plant parts to be utilized. (Smithers, 1983) | Non-ruminant with a monogastric hind gut fermentation type digestive system. | Less compact and courser than Blue wilde-beest. |
| Partial to new growth on burnt areas. (Smithers, 1983) | Tall grass feeder<br>Graze from 15 cm upwards. (Smuts, 1972) | | |
| 3. **Loxodonta africana** (African elephant): | | | |
| 53% Browse; 25% Grass; 22% Herbs. (Williamson, 1975) | Intermediate bulk feeder. | Non-ruminant with a monogastric hind gut fermentation type digestive system. | Extremely course, slightly compact. |
| | Utilize a wide variety of plant spp from grass root to tree top level. | | Composition: differ from all other dung types. |
| Fruit, bark and roots are also utilized. Ration varies according to the season & availability. (Smithers, 1983) | 170-400 KG. Green fodder per days.<br>40% of intake is effectively digested. (Smithers, 1983) | | |
| 4. **Giraffa camelopardalis** (Giraffe): | | | |
| Varies with the seasons. | Selective browsers feeding between 2 to 5 meters above ground level. (Smithers, 1983) | Rurminant-highly effective digestor | Very fine and compact. |
| Hot wet months: deciduous browse spp.<br>Hot dry months: semi-deciduous & evergreen spp.<br>Cool dry months: evergreen spp. & mineralised soil supplements.<br>(Hall-Martin, 1974 & Langman, 1978) | | | |

its ecological importance value.

## Results and Discussion

The species diversities and species compositions of the different coprophilous fungal communities were determined according to the different dung substrates investigated (Figs. 1 and 2; Tables 2 and 3). As can be seen in Fig. 1 all 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

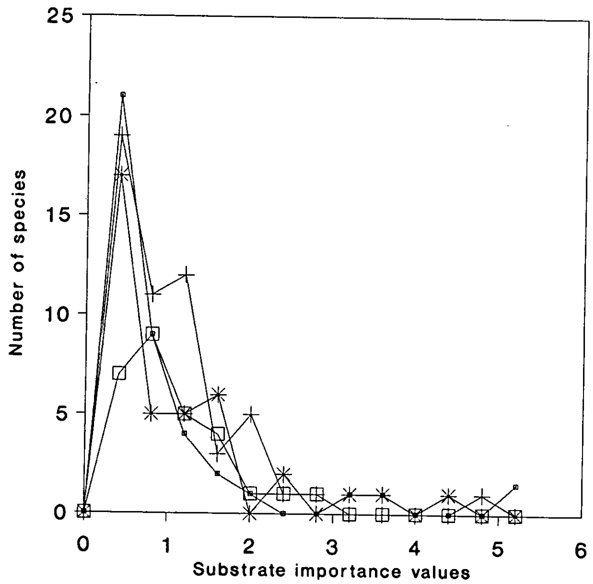


Fig. 1. Fungal species diversities of different dung substrates. -⊞-, Giraffe; +, Elephant; ✳, Blue wildebeest; -⊟-, Zebra.

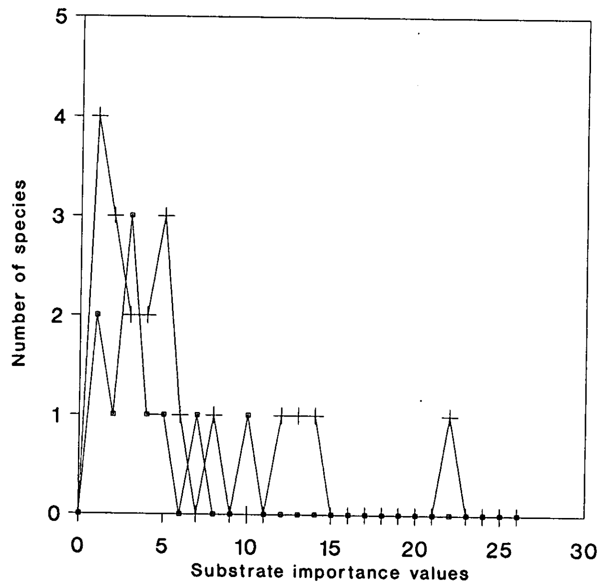


Fig. 2. Fungal species diversities of dung substrates from zoo elephants and Mabula Game Lodge elephants. -⊞-, Zoo elephant; +, Mabula elephant.

**Table 2.** *The coprophilous mycoflora of elephant dung collected from elephants in captivity and those roaming free in a game park*

| Fungal class | Species on mabula substrate | Species on zoo substrate |
|---|---|---|
| Hyphomycetes | *Graphium calcicoides* | *Graphium calcicoides; Stachybotrys chartarum* |
| Coelommycetes | None | *Phoma* sp. |
| Zygomycetes | *Pilobolus crystallinus* | *Pilobolus longipes; Actinomucor elegans* |
| Plectomycetes | *Kernia nitida* | *Kernia nitida* |
| Pyrenomycetes | *Podospora anserina; Podospora apiculifera; Podospora comata; Podospora globosa; Sordaria fimicola; Zygopleurage zygospora* | *Podospora anserina; Podospora communis; Sordaria fimicola* |
| Loculo-ascomycetes | *Sporormiella minima*<br>*Strattonia* sp. 1<br>*Strattonia* sp. 2 | *Strattonia* sp. 1 |
| Discomycetes | *Ascobolus albidus; Ascobolus immersus; Ascobolus stictoideus; Coprotus disculus; Coprotus leucopocillium; Coprotus winteri; Iodophanus carneus; Lasiobolus lasioboloides* | None |

**Table 3.** *Substrate importance values*

| Fungal species | Substrate importance values | | | |
|---|---|---|---|---|
| | Elephant | Giraffe | Blue wildebeest | Zebra |
| **Deuteromycotina:** | | | | |
| *Acremonium* sp. | 4.89 | – | – | 0.89 |
| *Aspergillus niger* | 1.93 | – | – | – |
| *Aspergillus glaucus* gr. | 1.07 | – | – | – |
| *Aspergillus flavus* gr. | 1.17 | – | – | – |
| *Atrobotrys oligospora* | – | 1.36 | – | – |
| *Bahupaathra samala* | 1.24 | 0.67 | – | 0.24 |
| *Chalara* sp. | – | 2.11 | – | 1.23 |
| *Epicoccum purpuracens* | – | – | 0.20 | – |
| *Fusarium* sp. | – | 0.69 | – | – |
| *Geotrichum candidum* | – | – | 1.51 | 0.75 |
| *Gliomastix* state of *Wallrothiella* | 0.68 | – | – | – |
| *Graphium calcicoides* | – | – | 1.59 | – |
| *Myrothecium verrucaria* | 0.94 | – | – | – |
| *Penicillium monoverticillata* gr. | 0.21 | – | – | – |
| *Penicillium 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 |
| *Rhophalomyces* sp. | 0.45 | 0.30 | – | – |
| **Ascomycotina:** | | | | |
| **Class: Plectomycetes** | | | | |
| *Kernia nitida* | 0.96 | – | 1.47 | – |
| *Kernia* sp. | – | 0.20 | – | – |
| *Leuconeurospora pulcherrima* | – | – | 0.55 | – |
| *Pseudoeurotium* 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 brevipilium* | – | – | – | 0.22 |
| *Chaetomium concinnum* | – | – | 0.36 | – |
| *Chaetomium robustum* | – | – | 0.20 | – |
| *Chaetomium tortile* | 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 |

**Table 3.** *Continued*

| Fungal species | Substrate importance values | | | |
|---|---|---|---|---|
| | Elephant | Giraffe | Blue wildebeest | Zebra |
| *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. | – | 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 niveus* | – | 0.96 | 0.44 | – |
| *Coprinus poliomalus* | 0.91 | – | 0.37 | 0.24 |
| *Coprinus stellatus* | 1.16 | – | 0.78 | – |
| *Paneolus* sp. | – | 0.24 | – | – |

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 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 Fig. 1 indicate that no meaningful, in these cases proposed nutritional, stress factors exist in the environment of the animals from which these dung substrates were collected. This is to be expected as the animals occur in their natural environment in the Kruger National Park, and are thus free to select the food they prefer and need.

On the other hand, in Fig. 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 substrate, collected from the Mabula Game Reserve, Fig. 2, proves to be similar to those exhibited in Fig. 1 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 (lucern), fruit and vegetables, as well as a limited variety of natural foods. The animals are therefore not free to select their own food sources and the food they utilize have been grown commercially and were subject to various forms of herbicides and insecticides. Furthermore, there were a total lack of any species belonging to the class Discomycetes on all these dung substrates investigated over a period of three years (See Table 2). 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 Fig. 2 exhibit a typical concave species diversity curve, these substrates were collected from free roaming animals, occurring in their natural habitat, in the Mabula Game Reserve. A relatively large number of species belonging to the class Discomycetes were recorded from these substrates. On the latter substrates there are thus no indication of similar nutritional related stress factors.

*Observations on the Species Diversities of the Substrates*

It thus seems possible to use the species diversity curves (Fig. 2), 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 in this regard.

Other observations can be made from the data depicted in Fig. 1: 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 graph.

*(a) The elephant dung substrate*

This substrate exhibits the highest species diversity. This can be explained if the feeding habit and the food preferences of the animal is 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). Therefore the ingestion of the largest possible variety of fungal spores are inevitable, resulting in an extremely high fungal species diversity on the dung substrate.

*(b) The giraffe dung substrate*

This substrate exhibits 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 utilized. 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, 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 the results obtained from 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.

*(c) The blue wildebeest dung substrate*

This substrate exhibits the third highest species diversity. This 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 a relatively restricted number of coprophilous fungal spore types, although its non-selective feeding habit ensures that it utilizes a wide variety of grass species, and thus causing it to come into contact with a larger 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.

*(d) The zebra dung substrate*

This substrate has the lowest species diversity of all the substrates investigated. The 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 small - spored species, *P. crystallinus* and *P. kleinii* have lower substrate importance values than that of the large-spored *P. longipes*. The reverse situation was observed on the substrates obtained from the short grass feeder, blue wildebeest. Furthermore, zebra feeds more selectively than blue wildebeest, selecting and cutting the grass instead of cropping it. Therefore, the possibility of ingesting fungal spores is reduced, in comparison with blue wildebeest.

*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).

In the case of the coprophilous fungi, the following forces could possibly play a role in determining the species composition of a substrate:

*(a) Ecological forces*

The food preferences, feeding habits and type of digestive system of the animals as well as other environmental factors such as temperature fluctuations, photoperiodisities, water potential of the substrates, the availability of nutrients in the substrates, the role of other dung inhabiting organisms and interspecific fungal species competition.

*(b) Genetical factors*

Periodicities with regard to spore germination, maturation and fructification also play a role in determining the specific species composition at any moment in time. Because of the varied nature and influences of all the factors mentioned, it is not in the scope of the present research to pin-point the possible cause/effect results and therefore the fidelity classes distinguished for each substrate should only be taken as possible trends. These results overall indicate that further research in this regard is needed before definite correlations can be drawn.

*Substrate Fidelity*

With regard to substrate fidelity the following five classes were distinguished for each substrate, using the data as set out in Table 3:

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 reaches 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 substrates 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.

*(a) Fidelity classes of the elephant dung substrates*

Exclusive species: *Sordaria fimicola, Sordaria macrospora, Coprotus aurora, Coprotus winterii, Fimaria hepatica, Trichobolus sphaerosporus.*

Combined species (On accord of the 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 coprophila, Coprinus stellatus.*

Preferential species: *Ascobolus amoenus, Coprinus poliomalus.*

Indifferent species: See Table 3

*(b) Fidelity classes of the giraffe dung*

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 coprophila, 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 3.

*(c) Fidelity classes of the blue wildebeest dung substrates*

Exclusive species: *Cercophora coprophila, Stratonia hansenii, Sporormiella subtillis, 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 3.

*(d) Fidelity classes of the zebra dung substrates*

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 3.

## Conclusions

1. The larger the scope of the feeding levels, the higher the coprophilous fungal species diversity and species composition on the dung substrate.
2. The less selective the feeding habit, the larger the coprophilous fungal species diversity on the dung substrate.
3. 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.

4. 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. It is therefore possible to state that the feeding habits and food preferences of the animals have a very definite influence on the coprophilous fungal species diversities and the fungal species composition of dung substrates of african game animals, at any specific time.

**Acknowledgements.** Financial support by the South African Foundation for Research Development and the University of Pretoria is gratefully acknowledged. Prof. G.J. Bredenkamp, Dept. of Botany, University of Pretoria, is thanked for editing the manuscript. The personnel of the National Parks Board, the National Zoological Gardens Pretoria and Mabula Game Lodge are thanked for their kind assistance.

## Literature Cited

Atwell, C. A. M. 1982. Population ecology of the blue wildebeest *Connochaetes taurinus* in Zululand, South Africa. African J. Ecol. **20**: 147-168.

Bell, A. 1975. Fungal succession on dung of the Brushtailed Opossum in New Zealand. New Zealand J. Bot. **13**: 437-462.

Bell, A. 1983. Dung Fungi, an illustrated guide to coprophilous fungi in New Zealand. Victoria University Press, Private Bag Wellington, New Zealand.

Dickinson, C. H. and V. H. S. Underhay. 1977. Growth of fungi in cattle dung. Trans. Brit. Mycol. Soc. **82**: 174-177.

Hall-Martin, A. J. 1974. Food selection by Transvaal lowveld giraffe as determined by analysis of stomach contents. J. S. African Wildl. Managem. Ass. **4**: 191-202.

Langman, V. A. 1978. Giraffe pica behavior and pathology as indicators of nutritional stress. J. Wildl. Managem. **42**: 141-147.

Lundqvist, N. 1972. *Nordic Sordariaceae s. lat., In* Symbolae Botanicae Upsalienses, Vol. 20 (1), published by the University of Uppsala, Sweden 374 pp (+plates).
Saunders company, Philadelphia. London. Toronto.

Smithers, R. H. N. 1983. The Mammals of the Southern African Subregion. University of Pretoria, Pretoria. Republic of South Africa.

Smuts, G. L. 1972. Seasonal movements, migration and age determination of Burchell's zebra (*Equus burchelli antiquorum*, H. Smith, 1841) in the Kruger National Park (30/11/72 to 4/12/72). M. Sc. Thesis, University of Pretoria.

Williamson, B. R. 1975. The condition and nutrition of elephant in Wankie National Park. Arnoldia. Rhod. **7**: 1-20.

# 非洲動物糞便中眞菌相及其歧異度

Colleen Ebersohn and Albert Eicker

Department of Botany, University of Pretoria, Pretoria, 0002, South Africa

草食性動物，包括非洲大羚羊、斑馬、非洲象與長頸鹿等，由於對食物嗜好，取食習性，以及消化系統之差異，可能影響到其糞便內眞菌相及其歧異度。本文對此問題加以研究與討論。