Chapter 7

DUNG PREFERENCES OF DUNG BEETLES IN FOUR DIFFERENT HABITATS

7.1. INTRODUCTION

Different animals are adapted to feed on a large variety of food plants. The vegetation upon which they graze affects the chemical composition of the dung they produce (Al-Houty & Al-Musalam, 1997). Consequently dung types which vary in texture, consistency, moisture content, microbial content, odour and quantity are produced. Rainio (1966) found that beetles usually feed on vertebrate dung, mostly on that of ungulates, such as domestic animals. The suitability of dung as an insect food is influenced by the species of animal that produces it (Edwards, 1991). Due to fencing and farming of previously open areas in southern Africa over the last century, the distribution of most mammals was dramatically affected (Du Plessis, 1969). Today large game concentrations occur only in game reserves and this has an effect on the distribution of dung beetles (Tribe, 1976). Fincher, Stewart & Davis (1970) also found that the alteration in the habitat affects the dung beetle community through changes in numbers and species of food-producing vertebrate animals. The original food source of dung beetles was gradually replaced by dung of domestic animals. The shift from wild herbivore dung to the dung of domesticated animals was, however, easily achieved by most dung beetles. In this regard Gordon (1983) and Tyndale-Biscoe (1988) state that the nature of the dung on which both adults and larvae of dung beetles feed may determine their distribution in different habitats. On the other hand, Landin (1961) and Nealis (1977) maintained that the distribution of dung beetles in different habitats does not depend on the kind of dung. The size of the dung pat is more significant to dung beetles than quality and kind of dung (Cambefort, 1991). The presence of large mammals will therefore have the greatest influence on dung beetles.

Most dung beetle species are coprophagous, but there are records of species utilising other types of food such as carrion and rotting plant material (Doube, *et al.* 1991; Gill 1991; Hanski & Cambefort 1991a). The two main types of food resource used by dung beetles are large herbivore dung and omnivore dung (Hanski & Cambefort, 1991a). Relatively few dung beetles are attracted to carnivore dung (Hanski 1987a; Rainio 1966). Davis (1977) suggested that a viable population of endocoprids can only be maintained where there is a sufficient density of large, intact, dung masses of larger herbivores. Stewart (1967) found that *Phanaeus* species showed a preference for pig dung, while opossum dung was second choice and even in an environment dominated by cattle, the preference was for pig or opossum dung.

Some dung beetle species are stenophagous, feeding only on a certain type of dung. The majority, however, are euryphagous, feeding indiscriminately or with a low degree of preference, on the various types of dung available (Halffter & Matthews, 1966). Rainio (1966) reported that in Helsinki (S. Finland) none of the dung beetle species he investigated are entirely specialised to a particular kind of dung.

The question is whether different resources have a significant influence on the distribution of dung beetles in different habitats. The dung preferences of dung beetles in four different habitats were determined in an attempt to answer this question.

7.2. MATERIAL AND METHODS

Sampling methods

Sampling for this study was done during January 1997 with four different dung types as bait in four different habitats. The four different habitats used for sampling were a natural bushveld habitat in Sandveld Nature Reserve, a disturbed bushveld habitat on the farm Josina, a natural grassveld habitat in Sandveld Nature Reserve and a disturbed grassveld habitat on the farm Rietvlei. 11 Plastic pitfall traps were baited with four different dung types, i.e. 200g of fresh cattle, buffalo, white rhinoceros and horse dung. Fresh cattle dung was collected on the dairy farm Bospré, near Bloemfontein (26°00'S; 29°00'E). Fresh horse dung was collected at stables in Bainsvlei (29°07'S,25°12'E) near Bloemfontein and fresh buffalo and white rhinoceros dung was collected at the Bloemfontein Zoo. The dung was transported in plastic buckets, covered tightly with lids to avoid desiccation and oxidation of the dung. In each habitat there were four sampling sites spaced 1 km apart and each site contained three plots, spaced 50 metres apart, each containing four traps. The traps were spaced 2m apart and each of the four traps in a plot was randomly baited with a different dung type. The traps were buried up to the rim and the bottom filled with salt water. A container with 200g of fresh dung was put inside the trap to attract the dung beetles. Both flying and walking dung beetles could be caught in these traps. Dung beetles attracted by the dung fell into the traps and could be collected later. The traps were left for 24 hours before the dung beetles were collected. They were preserved in 70% alcohol and kept for later identification.

Analysis of different dung types

The mean pH ± SD of five fresh dung samples of each dung type was measured with a pH meter. The mean percentage moisture ± SD of five fresh dung samples was determined by weighing fresh dung, oven-drying it for a period of 48 hours and weighing the dried dung. The percentage moisture could then be determined from the difference between the wet and dry weight of the sample. In another trail dung was dried in sunlight for about a month and then ground into a fine powder. Mean fibre ± SD and mean nitrogen ± SD content of the different dung types were then determined according to analytical procedures described by AOAC (1984).

7.3. RESULTS AND DISCUSSION

Differences in species richness, diversity, number of individuals, and total biomass of dung beetle assemblages attracted to four different dung types in four habitats

The same order of preference in terms of number of species colonising the dung types was observed in all four habitats. Cattle dung was preferred by most species, while buffalo dung was second in preference followed by horse and white rhinoceros dung (Table 7.1). There was a large difference in the number of individuals, the maximum number of individuals, as well as the biomass of dung beetles colonising the different dung types. In all the habitats the number of individuals, maximum number of individuals and biomass of dung beetles attracted to cattle dung were more than double that of dung beetles attracted to the other dung types (Table 7.1). In the grassveld habitats buffalo dung was second in preference followed by horse and finally white rhinoceros dung, while in the bushveld habitats white rhinoceros dung was second in preference, followed by horse and buffalo dung (Table 7.1). This difference in dung preference between the bushveld and grassveld habitats might be explained by the shade cover in the bushveld habitat, which results in slower drying out of the drier dung types than in the open habitats.

There were slight differences in the Berger-Parker indices for dung beetle assemblages attracted to the different dung types in the different habitats, but these differences were not significant. This indicates that although there is a drastic difference in species richness, individuals and biomass of dung beetles attracted to different dung types, the dominance of dung beetle assemblages attracted to different dung types does not necessarily differ (Table 7.1).

Table 7.1: Differences in species richness (S), number of individuals (N), maximum number of individuals (Nmax), Berger Parker dominance index (1/d) and biomass (g) of dung beetles attracted to four different dung types in four different habitats.

Habitat	Dung type	S	N	N max	1/d	Biomass (g)
Sandveld grassveld (natural grassveld)	Cattle	13	632	197	3.21	172.48
	Horse	7	37	12	3.08	18.19
	White rhinoceros	5	25	15	1.66	22.44
	Buffalo	12	211	104	2.02	23.64
Rietvlei (disturbed grassveld)	Cattle	15	407	106	3.84	62.30
	Horse	7	79	30	2.63	15.02
	White rhinoceros	7	57	20	2.85	14.05
	Buffalo	10	344	201	1.7	26.53
Sandveld Bushveld (natural bushveld)	Cattle	20	590	212	2.78	50.43
	Horse	10	170	78	2.18	2.60
	White rhinoceros	10	178	99	1.8	5.80
	Buffalo	15	132	39	3.38	4.20
Josina (disturbed bushveld)	Cattle	16	290	103	2.82	30.12
	Horse	10	97	35	2.77	0.905
	White rhinoceros	8	106	39	2.72	0.977
	Buffalo	11	49	13	3.77	2.118
		F=41.08 P<0.05	F=11.01 P<0.05	F=8.94 P<0.05	F=2.81 P>0.05	F=5.71 P<0.05

For herbivores, interspecific variability in dung characteristics arises from the major dichotomies in herbivore feeding and digestion, namely grazing vs browsing, and rumination vs non-rumination (Edwards, 1991). These sources of variation result in dung that differs in characteristics such as texture and size and water, nitrogen and fibre content. Cattle dung, because of its richness in organic material and its microclimatic conditions, is an ideal medium for the establishment of a specific, rich and varied community (Galante *et al.* 1993). Cattle dung also has high water content and the outer crust prevents evaporation of water. Results in the present study indicate that a greater variety of species and also more individuals are attracted to cattle dung than to the other dung types tested, irrespective of the habitat. Cattle dung had the highest moisture content and buffalo dung the second highest, while white rhinoceros and horse dung had lower moisture content than cattle and buffalo dung with horse dung having the lowest (Table 7.2.). The pH did not differ much between the different dung types, but cattle dung had a slightly lower pH (Table 7.2.). The fibre content of cattle and buffalo dung was lower and nitrogen higher than that of horse and white rhinoceros dung (Table 7.2). These characteristics might explain the preferences of dung beetles for certain dung types. Edwards (1991) considers the moisture content of dung the most important attribute for coprophagous insects. Since adult dung beetles feed on the fluid component of dung (Halffter & Matthews, 1966), cattle dung will be most favourable as this dung type has the highest percentage moisture. Al-Houty & Al-Musalam (1997) found that dung of low moisture content is unsuitable for telecoprid dung beetles because it is difficult for these beetles to form and roll dung balls when the dung is too dry, while Edwards (1991) found that dung of low moisture content is unsuitable for dung beetles since the adults cannot extract the dung fluid from the dung. The fibre content might also have an influence in the present study with cattle and buffalo dung, with a lower fibre content, easier for the formation of balls than horse and white rhinoceros dung. Dung beetles of the other functional groups might also be influenced by the desiccation rate of the dung. Horse and white rhinoceros dung is more fibrous and has a looser structure than cattle and buffalo dung and will consequently dry out more rapidly than cattle dung. Species that stay in the dung for longer periods will therefore choose a dung type that will be more consistent and dry out slower.

Table 7.2: pH and mean percentages of moisture, fibre and nitrogen in the four different dung types used as bait.

n=5	% Moisture ± SD	PH ± SD	% Fibre ± SD	Nitrogen (N) ± SD
Cattle	82.15±0.94	6.88±0.74	34.75±0.56	10.27±0.65
Buffalo	78.24±0.77	7.42±0.91	35.72±0.76	9.38±0.98
White Rhinoceros	76.06±0.52	7.83±0.45	42.15±0.91	7.27±0.93
Horse	74.45±0.52	7.12±0.63	41.23±0.43	6.99±0.68

Dung beetles attracted to cattle dung were most abundant in terms of species richness, individuals and biomass in all the habitats. Dung beetle abundance and biomass were highest in the natural grassveld habitat and second highest in the natural bushveld habitat with the abundance in numbers and biomass much lower in the disturbed habitats (Table 7.1). Even though there are no cattle present in the natural habitats dung beetles in these habitats still showed a stronger preference for cattle dung than white rhinoceros and buffalo dung, which occur naturally in these areas. The association with particular habitats is therefore not a reflection of the distribution of a certain type of food. Although dung beetles show a preference for a certain dung type they are very adaptable and are able to survive successfully on any dung type available. Dung beetles have thus adapted successfully to a change in dung type on the farms but are, however, less successful in these habitats than in the natural habitats. There are other factors in the habitats, which influence this success of dung beetles, and the dung type is not necessarily an important one. This is in agreement with Nealis (1977) who concluded that food is not an important determinant in local distributions for most species. This is supported by Lumaret *et al.* (1992) who found that numbers and biomass of dung beetles rather depended on the quantity of the trophic resources.

Functional group structure of dung beetle assemblages attracted to different dung types in different habitats

In the natural grassveld habitat dung beetles belonging to all functional groups were most strongly attracted to cattle dung (Fig. 7.1 a). Of all the functional groups dung beetles belonging to F.G. II showed the strongest preference for cattle dung with almost no dung beetles in this group attracted to other dung types (Fig. 7.1 a). This was also the case in the other habitats (Fig. 7.1 b-d). In the natural bushveld habitat and both the disturbed habitats the different functional groups showed a stronger preference for the horse, white rhinoceros and buffalo dung than in the natural grassveld habitat (Fig. 7.1). It also seems that F.G. I and II, containing the larger, better competitors, preferred cattle dung exclusively with almost no attraction to the other dung types. F.G. IV, V, VI and VII, containing the smaller less effective competitors, were more attracted to other dung types than F.G. I and II (Fig. 7.1). Cattle dung is dropped in large pats and has a high moisture content and a smooth texture. Horse is dropped in more scattered pats and is also drier and more fibrous than cattle dung. Although white rhinoceros dung occurs in large heaps, it is more fibrous and drier than cattle dung. Smaller species of F.G. IV, V, VI and VII are more generalist in their preferences and able to utilise many different food sources. Dung beetles of these functional groups also do not roll dung balls, but feed at the dung pat, making it easier to utilise more fibrous dung. These smaller species are less abundant in the natural grassveld habitat than the other habitats explaining the lower attraction to other dung types in this habitat. Larger dung beetles need larger amounts of dung for feeding and breeding and because cattle dung pats provide a large amount of dung with the right texture and moisture content it is ideal for these dung beetles. Dung beetles in F.G. I and II roll balls and cattle dung is also easier to form into a dung ball. Lumaret *et al.* (1992) found that in southern Europe larger species, owing to their preference for large pats, were favoured by a change in resource from sheep to cattle dung.

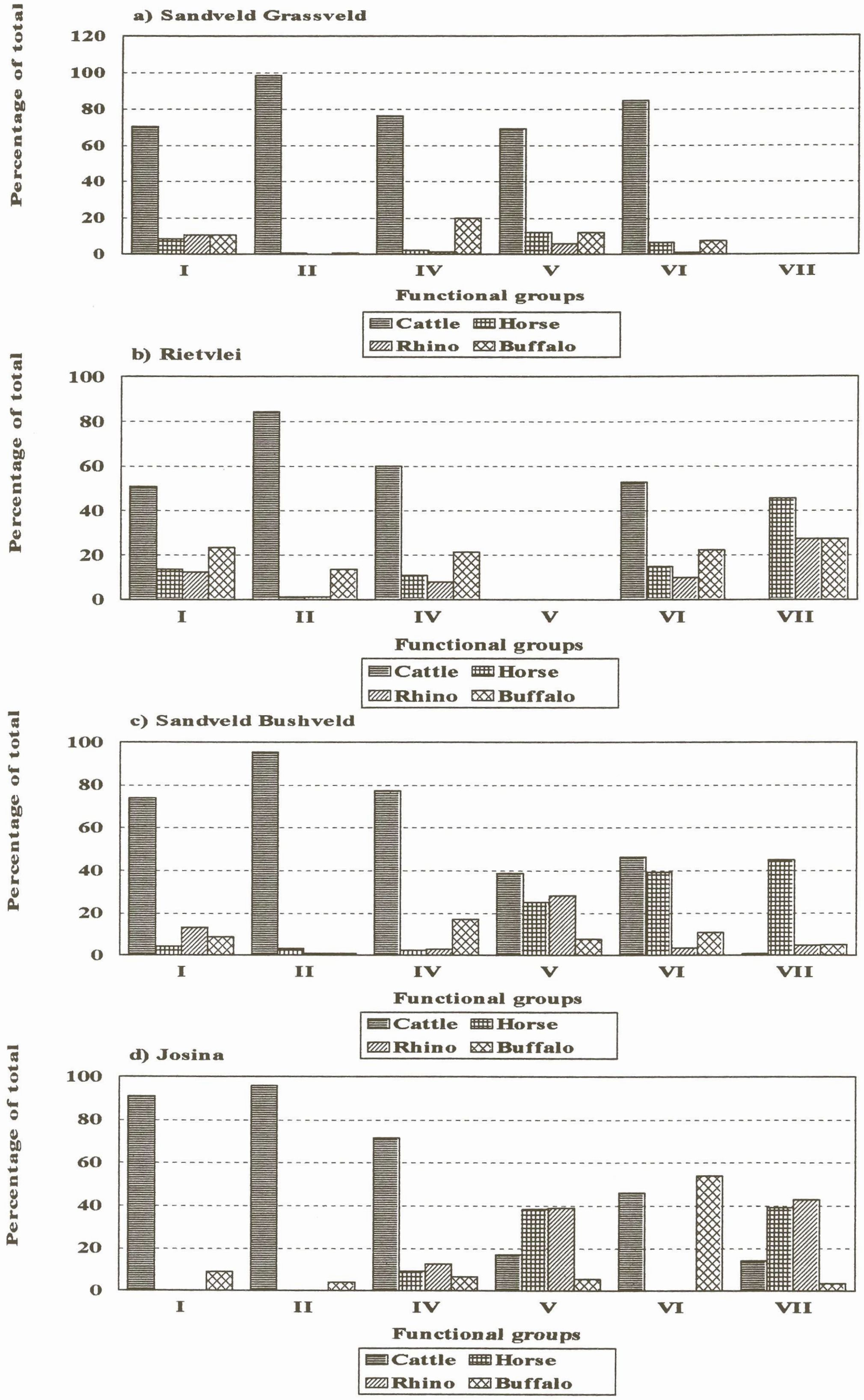

Fig. 7.1: Functional group structure of dung beetles attracted to different dung types in four different habitats.

Abundance of different dung beetle species attracted to different dung types in four different habitats

Abundance of different species differed in the different habitats, but the respective species all preferred cattle dung in all these habitats (Table 7.3). *Pachylomerus femoralis* was also attracted to the other dung types in the grassveld habitats, while there was very little attraction to other dung types in the bushveld habitats (Table 7.3). *Scarabaeus flavicornis* and *Scarabaeus ambiguus* seemed to be exclusively attracted to cattle dung, with little or no attraction to other dung types in all the habitats (Table 7.3). *Neosisyphus ruber,* which only occurred in the disturbed grassveld habitat, preferred cattle dung, but was also attracted to buffalo dung (Table 7.3). *Onthophagus quadraliceps* was attracted to all the dung types in the natural grassveld habitat, to cattle and buffalo dung in the disturbed grassveld habitat and only to cattle dung in both the bushveld habitats (Table 7.3). In the grassveld habitats *O. obtusicornis* was only attracted to cattle dung, while in the bushveld habitats they were attracted to different dung types (Table 7.3). *O. pilosus* occurred most abundantly in the disturbed grassveld habitat where they were attracted to all the dung types (Table 7.3). *O. xanthopterus,* which occurred most dominantly in the natural grassveld habitat, preferred cattle dung with only very slight attraction to buffalo dung (Table 7.3). *Liatongus militarus,* which occurred only in the bushveld habitats, was the only species which preferred buffalo dung over cattle dung. No individuals of this species were attracted to cattle dung (Table 7.3). Both *O. variegatus* and *O. sugillatus* occurred most abundantly in the bushveld habitats, where they were attracted to all the dung types (Table 7.3). These species were attracted to cattle dung in the natural grassveld habitat, but in much lower numbers. They were also attracted in much lower numbers to other dung types than in the bushveld habitats (Table 7.3). *Caccobius seminulum* was most abundant in the disturbed grassveld habitat and was also more attracted to dung types other than cattle dung in this habitat than in the other habitats (Table 7.3).

The degree of dung preference differed between species and between different habitats. It seems that the more abundant a species in a habitat the wider the dung preference becomes. This is in agreement with Hanski & Krikken (1991) who found that the most abundant species in the local community have more diverse food habits than the less abundant ones. This might be explained by intraspecific competition when the species is abundant in a habitat. In such a scenario the preference might be for cattle dung, but because of strong competition for this dung type, individuals of this species might be forced to feed on other dung types. It is this adaptability of dung beetle species to utilise different food sources under extreme conditions that determines their success in an environment. Howden & Nealis (1975) found that most dung beetle species in Colombia, they studied seemed capable of utilising several dung types, with only slight preferences and Rainio (1966) found that none of the dung beetle species in S. Finland was wholly specialised to any particular kind of dung.

7.4. CONCLUSION

Differences in the characteristics of cattle, horse, white rhinoceros and buffalo dung reflects differences in the feeding ecology and digestion of these animals. These differences influenced the preferences of dung beetles for a particular dung type. Although dung beetles showed preferences for certain dung types, this did not reflect association with a particular habitat. Dung beetles seem to be very adaptable and will colonise the most favourable dung type when it is available. The dung type will, however, not limit the dung beetles to a particular habitat because they are able to adapt to feeding on many different dung types. According to Lumaret *et al.* (1992) dung beetles, which have evolved over a long time to cope with ungulate dung, are quickly and easily able to react to sudden changes in the type of dung. The degree of dung preference also differed between species and between different habitats with the more abundant species in a habitat showing a wider dung preference. This might be a result of strong intraspecific competition within a habitat. Because of the adaptability of dung beetle species to utilise different dung types dung beetles of the same species can successfully co-occur in similar macrohabitats.

Table 7.3: Abundance of different dung beetle species in different dung types (cattle, horse, white rhinoceros and buffalo) in four different habitats: S.G. – Sandveld grassveld, natural grassveld; Rietvlei – disturbed grassveld; S.B. – Sandveld bushveld, natural bushveld; Josina – disturbed bushveld.

Species	S.G.				Rietvlei				S.B.				Josina			
	Cattle	Horse	Rhino	Buffalo	Cattle	Horse	Rhino	Buffalo	Cattle	Horse	Rhino	Buffalo	Cattle	Horse	Rhino	Buffalo
FGI																
pf	100	12	15	15	32	10	9	17	17	1	3	2	10	0	0	1
FGII																
sfl	113	1	0	1	28	0	0	0	108	4	1	0	42	0	0	0
sa	2	0	0	0	10	0	0	2	7				24	0	0	1
nr	0	0	0	0	40	1	1	11	0	0	0	0	0	1	0	1
FGIV																
m1	20	0	0	1	18	1	2	1	12	0	0	2	2	2	1	0
m2	2	0	0	1	8	2	0	0	3	1	0	1				
oae	0	0	0	0	0	0	0	0	4	0	0	1	27	0	0	4
of	0	0	0	0	7	0	0	0	17	0	2	1	0	0	0	0
oq	197	7	5	63	31	0	0	16	11	0	0	0	2	0	0	0
oob	21	0	0	0	11	0	0	0	212	4	5	39	103	15	28	2
opi	2	2	0	6	106	30	20	45	8	0	1	5	5	0	0	0
ox	41	0	0	3	2	0	2	3	15	0	0	3	32			
lm	0	0	0	0	0	0	0	0	0	4	3	10	0	4	0	10
FGV																
ova	18	4	1	1	1	0	0	0	52	22	14	6	10	28	25	2
osu	27	4	3	7	0	0	0	0	103	78	99	25	18	35	39	7
FGVI																
cs	88	7	1	8	106	30	20	45	13	11	1	3	6	0	0	7
FGVII																
al	0	0	0	0	0	5	3	0	0	0	0	0	0	2	3	0
at	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
apl	0	0	0	0	0	0	0	0	0	5	0	5	1	0	0	0
adu	0	0	0	0	0	0	0	0	1	40	49	0	0	0	0	0
an	0	0	0	1	0	0	0	0	0	0	0	0	3	3	1	1
ats	0	0	0	0	0	0	0	0	0	0	0	0	0	6	8	0

***For codes of species names see Chapter 2 - Table 2.4**