Morphological criteria to identify faecal pellets of sympatric ungulates in West African savanna and estimates of associated error

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Abstract

Indirect surveys may prove to be useful tools in complementing classical direct counts when monitoring ungulate populations and may also promote better understanding of the precise structure and functioning of the rich ungulate communities of African savannas. However, the identification of faecal pellets can be difficult where several sympatric species occur. This study develops simple field criteria for distinguishing between pellets among ten sympatric West African ungulates. A discriminant analysis was performed, using the mean of measurements of pellet groups from different species to pinpoint and characterize the most useful morphological criteria for separation between them. The mean diameter of pellets within each pellet group proved to be the most valuable variable for species segregation, whilst the second axis separated species by mean indent depth. The pellet groups of six of the ten designated species could be identified with a minimum misclassification error. However, no simple morphological variables emerged to permit discrimination between hartebeest and topi, or between bushbuck and Bohor reedbuck pellets. Once pellet groups have been identified, their density and spatial distribution may provide useful information on the use of space and habitat of sympatric species, over given periods.

Key words: faecal pellet, identification, indirect surveys, savanna, ungulate, West Africa

Résumé

Les études indirectes peuvent compléter de façon intéressante les comptages directs classiquement utilisés pour le suivi des populations d'ongulés et pour mieux appréhender la structure et le fonctionnement des riches communautés d'ongulés des savanes africaines. Toutefois, dans les cas où plusieurs espèces coexistent, l'identification de leurs crottes peut s'avérer difficile. Cette étude propose des critères simples pour distinguer sur le terrain les crottes de dix espèces d'ongulés d'Afrique de l'Ouest. Les moyennes de différentes mesures sur les tas de crottes ont été analysées à l'aide d'une analyse discriminante afin d'identifier les meilleurs critères de distinction entre les espèces. Le diamètre moyen ainsi que la profondeur moyenne de la cupule des crottes d'un même tas, respectivement associés au premier et au second axe discriminants, se sont révélées les meilleures variables pour séparer les espèces. Les tas de crottes de six espèces parmi les dix étudiées ont pu être identifiées avec une faible erreur de classification. Néanmoins, aucun critère morphologique simple n'a pu être identifié pour distinguer les crottes du bubale de celles du damalisque, et les crottes du guib harnaché de celles du rédunca. Une fois que les tas de crottes sont identifiés, leur densité et leur distribution spatiale peuvent fournir une information intéressante sur l'utilisation de l'espace et des habitats par des espèces sympatriques pour des périodes données.

Introduction

Monitoring large mammal populations in Africa is classically based on aerial surveys or ground counts (Caughley,

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1977; Bothma *et al.*, 1990; Barnes, 2001; Bouché, 2001). However, many animals are difficult to observe because of their rarity, small size, elusive behaviour or nocturnal habits, or because of dense vegetation cover (Stuart & Stuart, 2000). Hence, methods based on indirect observation such as pellet-group counts are being developed for monitoring African ungulate populations, not only in deep forest (Barnes, 1993, 2001) but also in savanna ecosystems (Jachmann & Bell, 1979; Plumptre & Harris, 1995; Plumptre, 2000; Barnes, 2002; Mubalawa & Sikubwabo, 2002; Ellis & Bernard, 2005; Young *et al.*, 2005). In addition to censuses, faecal studies are useful for estimating ungulate habitat use (Ne, 1968) or population trends (Putin & Albaret, 1999), or even capture–mark–recapture designs for small populations by genotyping (Kohn *et al.*, 1999). Diet, nutrition and health status can also be investigated (Putman, 1984; Chapeau *et al.*, 1993), as well as seed dispersal or digestive transit-induced germination (Feer, 1995; Dryden, 2003).

The West African savanna ungulate communities have been not extensively studied by comparing southern and East African communities. Determinants of community structure and the role of this structure in the functioning of savanna ecosystems have recently aroused interest (Macnaughton, 1992; Fritz & Duncan, 1994; Belovsky, 1997; Olff *et al.*, 2002), although specifically West African communities are yet to be examined, despite recent advances (Fritz, 1997). Critically, West African ungulates are generally considered more threatened by growing human populations and resulting habitat loss than those of other sub-Saharan regions (Sayer, 1979; Brashares *et al.*, 2001). In the context of conservation, indirect monitoring techniques may prove useful in complementing classical direct counts.

In African savanna ecosystems, a huge number of ungulate species of the same guild generally occur together (Prins & Ol, 1998). In less diverse ungulate communities in America, Ne (1968) reported several situations where more than one pellet-forming ruminant was present, with attendant difficulties in distinguishing species pellets. According to Seton (1925), form and content of faeces are excellent diagnostic guides for mammalian orders, and sometimes species as they reflect their specific anatomy (Chame *et al.*, 1991; Chame, 2003). One can assume that the risk of confusion in pellet determination in the field increases with an increasing number of similar and sympatric species. Variation in pellet shape and size in tropical ungulates also depends on seasonal variation in diet (Stuart & Stuart, 2000; Chame, 2003). Precise descriptors of pellets are therefore essential in preventing confusion among sympatric species at the given seasons and locations.

However, there are few published references dealing with the criteria for pellet identification in local communities of ungulates in West Africa (Lamarque, 2004). Most field guides focus on southern African ungulates. The pellets of only a few species found in West Africa have been described, but then only in the southern African ecosystem context (Walker, 1996; Stuart & Stuart, 2000; Chame, 2003).

We sought simple field criteria for accurate pellet identification of some sympatric West African ungulates, without the need for laboratory techniques such as genotyping. More specifically, we analysed pellet morphology of ten of the fifteen ungulates of the Niger W Regional Park, whose community is representative of the large mammal communities of Sahelo–Sudanian savannas of Western Africa (Hibert *et al.*, 2004). Prior to this study, we had presented different pellet groups of known species to a sample of local hunters and game scouts so that they could try to identify them. Identification criteria varied according to persons and identification errors were substantial for most of the species (>30% of pellet groups were wrongly identified). Nevertheless, we tested some of their qualitative criteria as complements to metric measurements.

In this paper, we describe the research to determine the optimal criteria for discriminating between species pellet groups, and we identify potential sources of error in our classification model.

Material and methods

Study area

The Niger W Regional Park (WRP) (N 11°30′, E 1°30′), so named because of the local configuration of the Niger River, comprises three contiguous National Parks, crossing the borders between Benin (550,000 ha), Burkina Faso (250,000 ha) and Niger (220,000 ha). The area exhibits the Sahelo–Sudanian climatic conditions typically found in a wide strip bordering the southern Sahara. The annual rainfall, although averaging between 600 mm in the North and 1000 mm in the South, is very erratic and restricted to the well-marked rainy season (May/June to September/October). The predominant vegetation type is

Sudanese wooded savanna (Arbonnier, 2002; Dulieu, 2004).

Field data collection

Faeces are less regular and less recognizable during the rainy season (Chame, 2003). Thus, the dry season is the best for conducting pellet counts and analyses to minimize confusion. For this reason, most faeces collection was performed in February and March.

In the WRP, we mainly collected pellets of animals actually observed defecating; these included Defassa waterbuck (*Kobus ellipsiprymnus defassa* Ogilby, 1833), roan antelope (*Hippotragus equinus* Desmarest, 1804), kob (*Kobus kob* Erxleben, 1777), bushbuck (*Tragelaphus scriptus* Pallas, 1766), Bohor reedbuck (*Redunca redunca* Pallas, 1767), red-fronted gazelle (*Gazella rufifrons* Gray, 1846) and oribi (*Ourebia ourebi* Zimmermann, 1783). Some other pellet groups were reliably identified by the presence of unambiguous accompanying spoors, such as for gazelles or roan antelopes. Most Defassa waterbuck pellets, unlike those of other species, were clumped. We chose pellet groups for which pellets were not aggregated and that might have been confused with those of roan antelope at first glance. Bushbuck droppings were collected in dense galleries in a zone close to rivers where animals could be regularly observed and where Bohor reedbuck, whose pellets appear quite similar, are very infrequent. We collected Bohor reedbuck droppings in grasslands of drainage lines where the species occurs in greatest densities.

We were able to observe only a single grey duiker (*Sylvicapra grimmia* Linnaeus, 1758) actually defecating. For this species, we referred to hunting guides and scouts and to pellet samples collected in the Comoe Park in Ivory Coast by Poilecot (unpubl. data). Pellets attributed to grey duiker were collected far from water points, and were unlikely to have originated from red-flanked duiker, which are known to be restricted to the vicinity of permanent water points (Delvingt & Lobão Tello, 2005). However, we cannot be categorical concerning the duiker species attributed to 'grey duiker' pellets in the rest of this paper as some risk of confusion might persist, although fairly low. We could not find enough reliably identified pellets for red-flanked duiker (*Cephalophus rufilatus* Gray, 1846), topi (*Damaliscus lunatus korrigum* Burchell, 1824) and hartebeest (*Alcelaphus buselaphus major* Pallas, 1766), all of which have become quite rare in the Park. In our analysis, we used reliably identified pellets from observed individuals of topi (subspecies *tiang*) and hartebeest (subspecies *lelwel)* from the Zakouma National Park in Chad (N 10°34′–11°03′, E 19°21′–20°00′). Topi and hartebeest are still very common in this other Sahelo–Sudanian ecosystem, which has habitats similar to those in the WRP. We assumed that the two species produce similar faeces in both ecosystems although belonging to different subspecies in each case.

The other species such as elephant (*Loxodonta africana* Blumenbach, 1797), hippopotamus (*Hippopotamus amphibius* Linnaeus, 1758), buffalo (*Syncerus caffer* Sparrman, 1779) and warthog (*Phacochoerus africanus* Gmelin, 1788) produce easily identifiable faeces.

The newly collected pellets were dried in sunlight for a few days, until they became very hard. Then they were stored in dry and dark conditions. For each species, ten pellet groups were collected.

Measurements

Using callipers, the length (maximal distance between each extremity) and the diameter at the half length of the pellet were measured and recorded for each pellet. We also recorded easily observable characteristics such as the presence and sizes of tips and indents, and the uniformity and symmetry of pellet shapes within the group, further named 'regularity' in this paper. This more qualitative parameter was suggested by local hunters and game scouts. An indent is formed on one side of the pellet by the imprint of another pellet in the digestive tract. To record the sizes of tips and indents, we distinguished four classes as described in Fig. 1. For regularity, we simply recorded whether or not the pellet was regularly shaped.

Data analysis

All analyses were performed using the R statistical package in its 2.2.1 version (R Development Core Team, 2004). Significance levels for statistical tests were fixed at 5%. We used a linear discriminant analysis with the *discrimin* function of the *ade4* package of R to identify the best morphological variables to segregate species. The analysis provided successive orthogonal axes such that the total variance carried by these axes was equal to one for each axis, and that the between species variance was maximal. We investigated whether those criteria were sufficient to reclassify all species using the *lda* function of the *MASS*

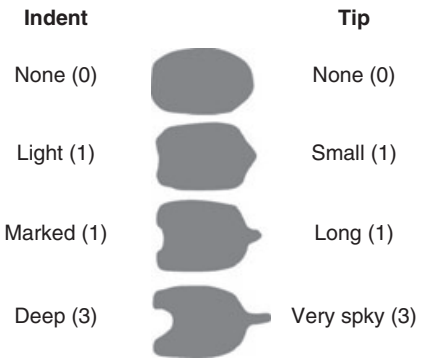

Fig 1 Classes of tip and indent size

package of R, which gives the same discrimant functions as *discrimin*.

To estimate the sampling effort in measuring pellets, we applied a bootstrap procedure (1000 repetitions for each pellet number) on a single pellet group from each species. These whole pellet groups contained 63 pellets in hartebeest, 99 in topi, 177 in red-fronted gazelle, 113 in roan antelope, 61 in Defassa waterbuck, 69 in Bohor reedbuck, 104 in Buffon's kob, 200 in oribi, 288 in grey duiker and 116 in bushbuck. We evaluated the minimum number of pellets to approach the overall within-group variance in pellet length and diameter. Hence, we measured twenty pellets taken at random in each pellet group for red-fronted gazelle, grey duiker and bushbuck, 25 for hartebeest, topi, oribi, Defassa waterbuck and Bohor reedbuck, and 30 pellets each for Buffon's kob and roan antelope. We then calculated the mean value of each variable for each pellet group as we considered the pellet group as a whole as the sampling unit. For semi-quantitative variables, mean values were calculated on code values.

Diameter and indent were log transformed in new variables Diam1 and Indent1 by log(Diameter + 1) and log(Indent + 1) to equalize dispersions around species means. We did not find a significant correlation between means and variances for the transformed variable Diam1.

The discriminating power of the variables was tested with a one-way ANOVA to check whether variation of each variable was well explained by the species seen as a factor, i.e. whether the inter-species variation contributed strongly towards overall variation.

The variable regularity was discarded as almost all pellets in each pellet group for each species were regular in shape. We also discarded length as it was strongly correlated with diameter (Spearman correlation test, $\rho = 0.87$, $P < 0.005$) and it presented a lower discriminating power between species than diameter (Table 1).

A non-parametric version of the test of Pillai was used to test whether the sum of eigenvalues was high enough to conclude that overall variability obtained with the model was mainly because of the between-species variability. We identified which species differed significantly in their means calculated for each main original variable using Tukey's 'Honest significant difference' method.

Results

Faeces general shape

From each of ten pellet groups, we selected and photographed one pellet that seemed representative of the shape of most of the pellets in the group (Fig. 2). Size of pellets allowed visual discrimination between small antelope pellets and larger antelope pellets but discrimination was less easy within small, medium-sized and large antelope pellets. Among smaller antelopes, we noted that the drop shape of most red-fronted gazelle pellets did not occur in oribi. The latter tended to be more bulging than grey duiker pellets, which had a more irregular surface. Among Bohor reedbuck droppings, we found some hartebeest-like pellets, which were not the case among bushbuck droppings. Nevertheless, most pellets of bushbuck and Bohor reedbuck were quite similar in shape. We were unable to find any reliable shape criterion for distinguishing between topi and hartebeest pellets, both of which exhibited wide variability in shape.

Morphological variables and species discrimination

The discriminant analysis produced three successive and orthogonal axes. The interspecies variation of projected

Table 1 Discriminating power of variables. Results of one-way ANOVA with values of different morphological variables as the dependent variable and the ungulate species as the independent variable. The R^2 measures the proportion of the observed variance in the dependent variable, which is explained by the independent variable, here the factor species

Variable	Multiple R^2	*F*-statistic	df	*P*-value
Length	0.833	50.5	9 and 91	$<2.10^{-16}$
Diam1	0.971	335.1	9 and 91	$<2.10^{-16}$
Tip	0.478	9.2	9 and 91	7.10^{-10}
Trough1	0.633	17.4	9 and 91	$<2.10^{-16}$

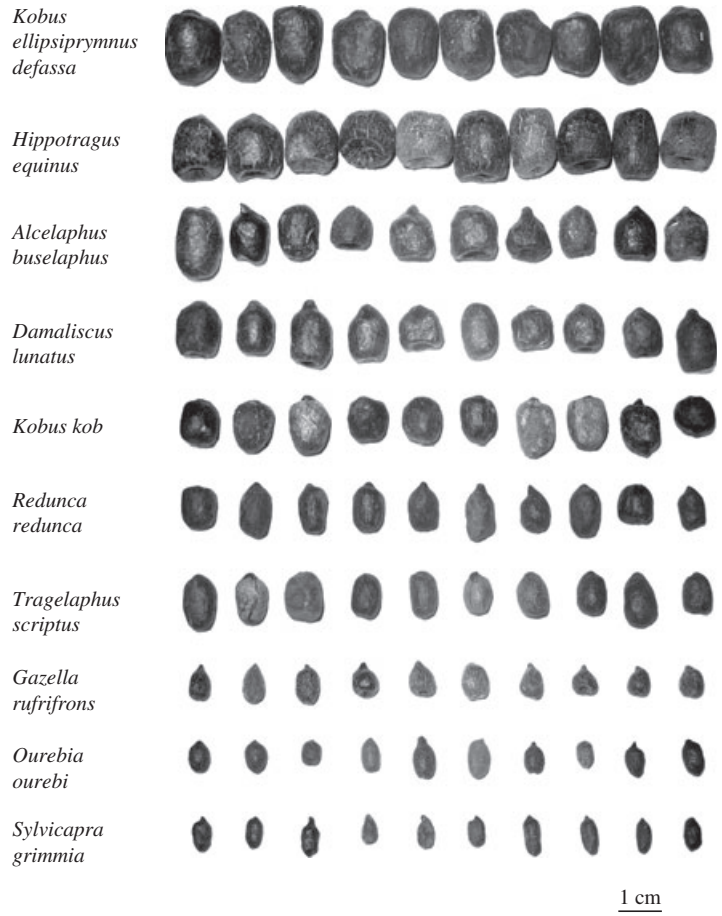

Fig 2 Photographs of one representative pellet from each of ten pellet groups

data scores accounted for 97.2% of the total variance on the first axis, 62.3% on the second axis and 20.9% on the third axis, respectively. We kept the two first discriminant axes to investigate the separation between species. The nonparametric version of the Pillai's test of the sum of the discriminant analysis eigenvalues (1000 repetitions, test: 0.602, $P = 0.001$) showed that the model built on chosen variables split up the pellet group values in such a way that mean overall variability was well explained by variability between species.

The first function corresponded almost exactly with the variable Diam1 (Table 2) suggesting that the mean diameter of pellets within the pellet group was the most important variable for species segregation, whereas the second axis separated species along the indent depth.

Kob, hartebeest and topi, Bohor reedbuck and bushbuck, and waterbuck and roan could not be well discriminated by the first axis but the second axis allowed clear separation between kob and hartebeest, between kob and topi, and between roan and waterbuck (Fig. 3). Looking at the original variables, we found that the pellet mean diameter calculated for the pellet group allowed us to distinguish clearly between small species such as grey duiker and oribi (Tukey-HSD test, $P < 0.05$), but less well between medium

Table 2 Standardized canonical weight of former variables in the discriminant functions and correlations between former variables and canonical variables

Selected variable	Standardized canonical weight		Correlation	
	Function 1	Function 2	Function 1	Function 2
Diam1	−1.003	0.128	−0.997	−0.075
Tip	0.025	−0.124	0.519	−0.388
Trough1	0.067	−0.985	−0.195	−0.976

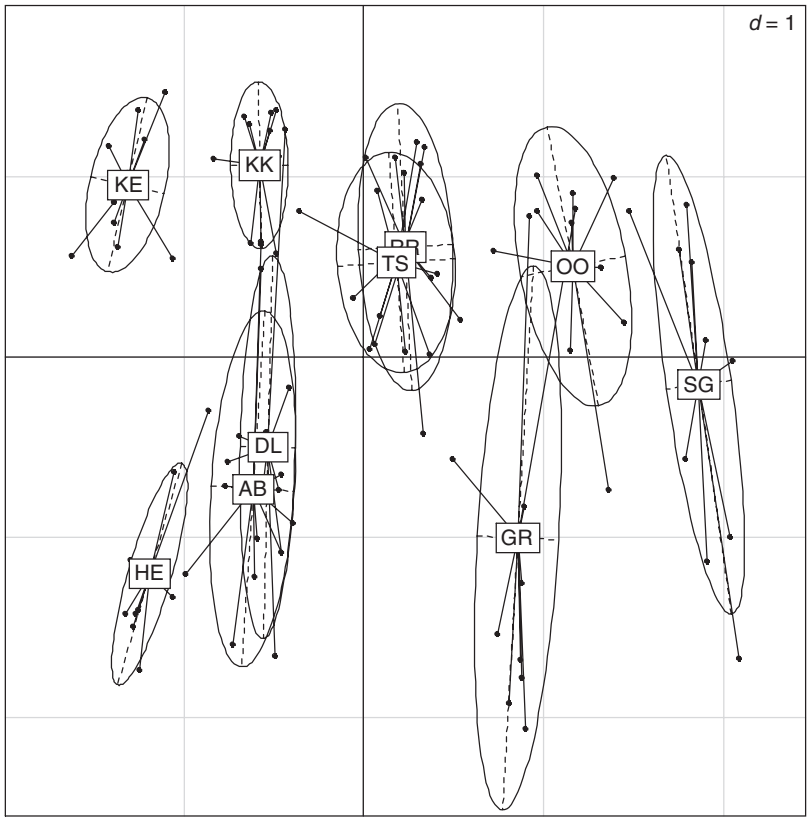

Fig 3 Results of discriminant analysis showing pellet group means separation. Graduations account for 1. Code for species names: KE (Defassa waterbuck), HE (roan antelope), AB (hartebeest), DL (topi), KK (Buffon's kob), RR (Bohor reedbuck), TS (bushbuck), GR (red-fronted gazelle), OO (oribi), SG (grey duiker)

size species such as Bohor reedbuck and bushbuck or bigger species such as kob, hartebeest and topi, or roan and waterbuck ($P > 0.05$). A synthesis of measurements of sampled pellets is given in Table 3. Mean indent depth then became of interest because it allowed significant segregation of waterbuck pellets, whose indent is weakly defined, from the roan pellets, whose indent is generally present and deeply cut. The indent depth also allowed significant separation of kob and oribi pellets, neither of which had clear indents, from hartebeest, topi and red-fronted gazelle, all of which

Table 3 Synthesis of measurements of sampled pellets in collected pellets

	Length (mm)		Diameter (mm)		Tip (% of pellets)				Indent (% of pellets)			
Species	Mean	SD	Mean	SD	None	Small	Long	Very spiky	None	Light	Marked	Deep
Waterbuck	17.8	2.2	13.4	0.9	54	40	6	0	84	16	0	0
Roan	15.9	2.2	13.3	0.9	64	30	6	0	9	34	54	3
Hartebeest	14.1	2	10.8	0.8	29	31	31	9	27	48	26	0
Topi	13.6	1.9	10.3	0.6	30	43	26	1	34	50	16	0
Kob	12.8	1.7	10.1	0.7	69	26	5	0	87	13	0	0
Bushbuck	11.9	1.5	7.9	0.9	50	39	10	0	85	13	1	0
Reedbuck	12	1.5	7.7	0.7	31	40	29	0	79	17	3	1
Red-fronted gazelle	9.1	1.3	6.4	0.5	3	13	80	3	25	34	39	1
Oribi	8.8	1.3	5.4	0.5	32	47	21	0	82	17	0	0
Grey duiker	9.2	1.2	4.1	0.3	11	47	37	5	87	7	5	0

usually possessed clear indents. Red-fronted gazelle pellets were wider, with more marked indents, than oribi pellets. None of the morphological variables permitted discrimination between hartebeest and topi, or between bushbuck and Bohor reedbuck pellets.

Misclassification error of the model for identifying pellets

The reclassification procedure alerted us to misclassification error in the discriminant model. Waterbuck, Buffon's kob, oribi, red-fronted gazelle, grey duiker and roan antelope pellet groups were all satisfactorily reclassified in the right species classes (Table 4). However, we were able to isolate two categories of pellet groups, each from two species, between which the model did not distinguish clearly. Bohor reedbuck pellet groups were confused with bushbuck, and bushbuck pellet groups with Bohor reedbuck. Hartebeest and topi pellet groups comprised the second category, responsible for the highest tally of incorrect reclassifications. A few hartebeest pellet groups (< 18%) did not possess well-marked indents and these were reclassified as kob.

A few atypical pellet groups (<20% in all species) were also wrongly reclassified. They consisted of a few particularly short and large pellets, which conferred a large mean diameter and a small mean length (one pellet group in red-fronted gazelle, one in grey-duiker) or, conversely, were composed of particularly narrow and long pellets (one pellet group in red-fronted gazelle, one in roan antelope). This suggested that pellets of these groups were exceptionally compressed or stretched inside the digestive tract.

Using other models based on only half the data, randomly selected, with the same variables, we tested the reclassification of the other half of the data (Fig. 4). Hartebeest, topi, Bohor reedbuck and bushbuck pellet groups still appeared to be least well reclassified, with fewer than 50% attributed to the correct species.

Table 4 Results of reclassification of pellet groups with the discriminant model

	Number of pellet groups in redeployment categories										Wrongly reclassified
Species	AB	DL	GR	HE	KE	KK	OO	RR	SG	TS	(%)
AB	5	3	0	1	0	2	0	0	0	0	55
DL	4	5	0	0	0	1	0	0	0	0	50
GR	0	0	8	0	0	0	1	0	0	1	20
HE	1	0	0	9	0	0	0	0	0	0	10
KE	0	0	0	0	10	0	0	0	0	0	0
KK	0	0	0	0	0	10	0	0	0	0	0
OO	0	0	0	0	0	0	10	0	0	0	0
RR	0	0	0	0	0	0	0	7	0	3	30
SG	0	0	0	0	0	0	1	0	9	0	10
TS	0	0	0	0	0	1	0	2	0	7	30

Code for species names: KE (Defassa waterbuck), HE (roan antelope), AB (hartebeest), DL (topi), KK (Buffon's kob), RR (Bohor reedbuck), TS (bushbuck), GR (red-fronted gazelle), OO (oribi), SG (grey duiker).

Discussion

Identifying ungulate pellet groups is not always easy when many species occur together. As noted by Chame (2003), animal size and pellet size seem to be linked by an allometric relationship, resulting from differences in diameter of the digestive tract. However, diameter of pellets of adult individuals was inadequate for separating all species, and we discovered great diversity in pellet size and shape, both between and within species.

Our discriminant analysis of identified pellet groups pinpointed and characterized the most useful morphological criteria for separating the species. We conclude that a simple measure of the diameter of some pellets, if

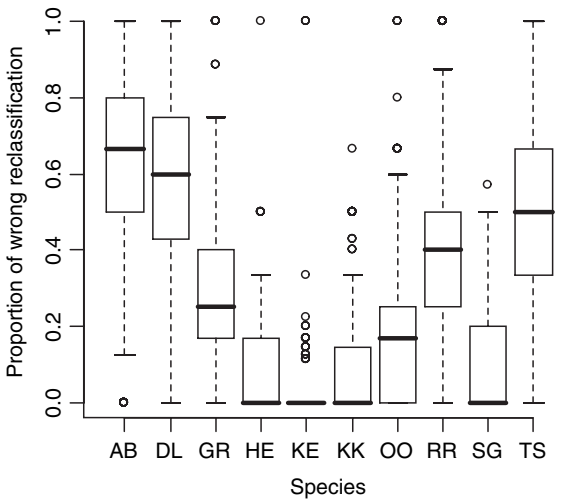

Fig 4 Boxplot showing reclassification quality obtained from running 1000 discriminant models built on 50% of the data taken at random and run for the remaining data. Code for species names: KE (Defassa waterbuck), HE (roan antelope), AB (hartebeest), DL (topi), KK (Buffon's kob), RR (Bohor reedbuck), TS (bushbuck), GR (red-fronted gazelle), OO (oribi), SG (grey duiker)

necessary, coupled with checking for the presence of an indent on the majority of the pellets within the pellet group, would allow satisfactory identification of pellet groups of six of the ten studied species in WRP (Fig. 5).

Nevertheless, neither indent depths nor pellet diameters were sufficient, on their own, to distinguish hartebeest from topi, and bushbuck from Bohor reedbuck pellet groups. Shape criteria also did not permit separation between these species. To identify Bohor reedbuck, bushbuck, hartebeest and topi pellet groups in the field, without considering habitats, we recommend the use of other indices such as spoor associated with the droppings, when present (see Lamarque, 2004; Stuart & Stuart, 2000). It is of particular importance to identify indices related to rare and endangered species, such as topi, in West Africa (Sayer, 1982) to study the distribution and habits of surviving groups. We were unable to collect any pellets of the rare and elusive red-flanked duiker, although some individuals were occasionally observed. Lamarque (2004) distinguished red-flanked duiker from grey duiker pellets because of the remarkable absence of tips and the roundedness of one extremity, compared with the flatness of the other extremity, in red-flanked duiker. For the study of less rare species, indirect indices remain a promising tool in situations where the animal's behaviour, especially in heavily poached areas, or where the vegetation structure restricts visibility. Ellis & Bernard (2005) stated that indirect surveys are particularly suitable for the study of thicket dwelling species such as bushbuck. Some other species, such as Bohor reedbuck, oribi or grey duiker are also difficult to count precisely, because they can sink to the ground and hide or remain supine when they sense danger (pers. obs.; Estes, 1997).

We must emphasize that our criteria are only relevant to the dry season and to pellets of adult individuals. Unfortunately, we were able to observe young or juvenile individuals defecating only for a few species in the field. Further study should integrate juvenile pellet groups to assess the risk of confusion between pellets of young individuals of one species with pellets of adults of other species. Obviously, seasonal changes cause changes in vegetation. At the beginning of the rainy season, mixed-feeding species, such as roan in the WRP, alter their diet, consuming less browse and more fresh grass. In June, soon after the first heavy rains brought on the flush, roan faeces were very wet and were no longer produced as identifiable pellets, illustrating how diet determines pellet size and shape. We observed that pellets dried very quickly during the dry season and became very hard in <2 days. Then, their shape and dimensions did not change during the rest of the dry season unless they were attacked by insects or hydrated by rains. Thus, morphometric discrimination should remain feasible whatever the pellet age during dry season.

In our study, facing the problem of finding reliable criteria for identifying pellets of rare species, we considered collecting pellet samples from captive animals. Gazelle pellets were collected at the Niamey Zoo in Niger but animals there, which were fed dry hay forage, produced very big, round pellets, which did not correspond at all to those found in the wild. We drew the same conclusion for a grey duiker fed with hibiscus leaves and salad in a hunting camp near the WRP. Its pellets were quite large and did not correspond to any pellets found in the park. Thus, pellets of captive animals appear to be neither representative nor relevant for the purpose of studying wild populations, unless they are fed a natural diet.

A comparison with indications and dimensions of samples given by Walker (1996) [see synthesis on dimensions calculated from Walker's pictures by Chame (2003)] calls also into question the reliability of the southern African field guides for identifying pellets of ungulates in West

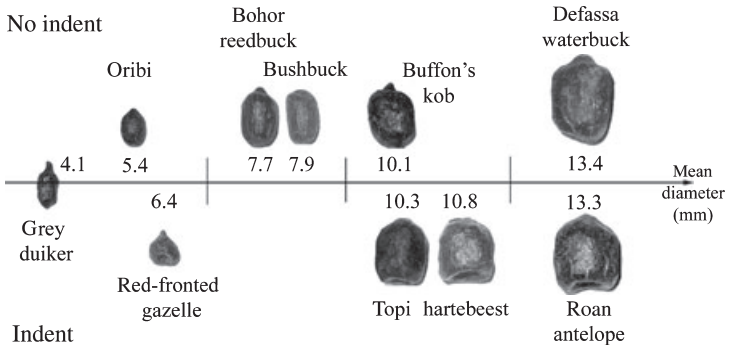

Fig 5 Summary diagram of main criteria for the discrimination of pellets of six ungulates in the WRP

Africa. For example, we found larger and less round pellets in oribi pellet groups (Chame: 7.5 × 5 mm, this study: 8.8 × 5.4 mm), much narrower and not round pellets in grey duiker (Chame: 6 × 6 mm, this study: 9.2 × 4.1 mm). Our topi pellets were much smaller (Chame: 22 × 18 mm, this study: 13.6 × 10.3 mm). Topi and hartebeest pellets used in this analysis were collected in the Zakouma National Park in Chad. This calls the need of checking in further study that topi and hartebeest produce similar pellets in WRP. In bushbuck, we did not observe any clumped pellets and pellets were wider (Chame: 14 × 6 mm, this study: 11.9 × 7.9 mm). These differences might be explained by different resource selection in West African savanna animal diets, rather than by morphological differences in southern and western Africa populations of the same species. We also distinguished the scattered roan-like pellets from the clumped pellets in Defassa waterbuck. Scattered pellets seemed more commonly found in the Defassa subspecies in WRP than in waterbuck in southern Africa ecosystems.

It appears then that our West African study provides original criteria that complement the knowledge developed in southern Africa and the local expertise of scouts, for the identification of ungulate faecal pellets during the dry season. If it is possible to identify the pellet groups of certain species, it becomes feasible to use pellet groups as indices for monitoring the abundance of ungulate populations in savanna ecosystems. Further characteristics such as defecation rates, decay lengths or criteria for aging pellets should be studied to conduct appropriate pellet-group counts.

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