

PIETERSEN L M

QUALITY OF FOOD AND VOLUNTARY INTAKE OF MALE
IMPALA (AEPYCEROS MELAMPUS) IN THE TIMBAVATI
AREA

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QUALITY OF FOOD AND VOLUNTARY INTAKE OF MALE IMPALA

***(Aepyceros melampus)* IN THE TIMBAVATI AREA**

by

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ABSTRACT

The study was conducted on free-roaming male impala in the Timbavati Private Nature Reserve. The aim was to obtain information on quality of diet selected during different seasons, to determine intake and to convert this data into estimates of energy requirements which can be used when calculating carrying capacity for impala. These figures were compared to published estimates by Meissner *et al* (1983).

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CHAPTER 1

1.1 INTRODUCTION

There has been a general increase in game farming during the past few years (Bothma, 1989) with a subsequent urgent need for proper grazing strategies. According to all available information, there are not many given standards whereby the carrying capacities for game species can be determined. Despite the wealth of scientific publications, little attention has been paid to the stocking rate of wild animals and how it should be calculated (Mentis, 1977). There is no reliable scientific data available as yet to calculate carrying capacity of wild, free-roaming animals. A critical factor that determines carrying capacity is intake, and no direct measurement of the intake of free-roaming antelope seems to have been made as no published data was found. If the actual food intake of wild animals was determined, these figures could possibly be used to estimate carrying capacity, which could be of special importance in smaller nature reserves.

Impala, together with elephants, constitute the greatest biomass of wild animals in the Klaserie/Timbavati Private Nature Reserves (Zambatis, 1980). In sheer numbers impala are the most abundant antelope species in the Transvaal and especially in the Lowveld, and therefore may cause the biggest grazing problems and have the greatest impact on the veld. Workers in the field believe this to be true, but to date this has not been conclusively proved.

During the past few years in certain areas of the Lowveld deterioration of the veld and changing habitats have been monitored by, amongst others, the Transvaal Directorate of Nature Conservation. Habitats have changed and grazing has deteriorated to such an extent that certain antelope species which were abundant in the Lowveld do not occur in the area anymore e.g. roan and sable antelope (Porter, 1970; Hoheisen, pers. comm.). It is generally believed that veld deterioration and a change of habitat in the Klaserie and Timbavati Private Nature Reserves are largely due to an increase in

impala as well as elephant and warthog numbers (Transvaal Directorate of Nature Conservation, 1989 census figures). The balance between species as well as the biomass of animals have a very sensitive effect on habitat composition and maintenance (Collison & Goodman, 1982).

The management of veld stocked with game is extremely complex. Generally, the smaller the area being used for wildlife, the more intensively it must be managed (Bothma, 1989). The most important factors to consider in formulating a veld management program are the assessment of veld condition, the setting of realistic stocking rates of wildlife, grazing and browsing management, water provision, veld burning and monitoring veld condition (Trollope, 1990). The stocking rate of the different game species will primarily be a function of the grazing and browsing capacity of the veld (Trollope, 1990), thus illustrating the importance of intake.

The current methods used for estimating carrying capacity of the veld on game ranches are the estimate method, the energy method and the LSU method (Bothma, 1989). An assessment of these methods shows that estimation of the carrying capacity of the veld for game populations is partly an art and partly a science (Bothma, 1989) and that generally the current methods are unsatisfactory. This is a matter of opinion and the present study was concerned with testing the viability of using the LSU figures.

Recommendations for stocking rates presently made to farmers and nature reserves by the Transvaal Directorate of Nature Conservation are based on the Large Stock Unit (LSU), i.e. a LSU is the equivalent of a steer with a mass of 450 kg which has a growth rate of 500 g/day on pasture with a digestible energy content of 55%. Using this method, 6,3 impala rams are equivalent to one steer. It may be inaccurate to assume that figures based on the same principles used to calculate intake of domestic animals apply to wild ungulates, unless accurate intake figures are known. In practice though, these LSU equivalents seem to have limited use (Bothma, 1989) but are important depending on the way they are used (Meissner, pers. comm.). Food and habitat preferences of game species differ largely and composition and condition of

veld varies from area to area so that these generalised conversions can serve only as broad guidelines. These conversion tables used in conjunction with energy conversion, food requirements and food preferences of game as well as the composition and condition of the veld would then be practical to use.

The carrying capacity for wild ungulates in Southern Africa used to be expressed in terms of biomass. This was incorrect as energy consumption is a function of metabolic mass, $W_{\text{kg}}^{0,75}$ (Mentis, 1977). According to Meissner (1982), this subject has received wide documentation by various authors. Mentis & Duke (1976) and Mentis (1977) preferred to compare the metabolic mass of wild ungulates to well-studied domestic animals as a means to estimate their energy requirements. This calculation assumes that differences between animals are only proportional to a specific exponent, i.e. 0,75 of body mass (Meissner, 1982). This means that food intake per metabolic mass will be the same for all animals at the same physiological stage. Available data seems to indicate that food intake of wild ungulates is less than that of domestic animals of comparable size (Meissner & Hofmeyr, 1972; Meissner, 1976; Kay, Engelhard & White, 1979).

It was also suggested in earlier ecological studies that wild herbivores could be stocked on natural veld at higher rates than those for domestic herbivores (Talbot, Payne, Ledger, Verdicourt & Talbot, 1965). Mentis & Duke (1976) and Mentis (1977) found that carrying capacities for wild ungulates were at least half of the agriculturist's figures and that carrying capacities for small wild ruminants is likely to be even lower because of their need to feed selectively. Mentis (1978) supports this and so do Rowe-Rowe & Scotcher (1986) who found that the stocking density of antelope in the Drakensberg over many years has naturally been kept at one LSU/55 ha, a figure 1/10 of the lowest estimated carrying capacity for cattle in the same region. This statement may not be altogether true, as the comparison between a duiker and a steer may be unjustified since they have different habitats and the stocking rate may be due *inter alia* to a lack of shelter and not a lack of food (Meissner, pers. comm.).

Meissner (1982) proposed another approach based on the growth data of wild animals. A specific growth rate is caused by a specific increment of food of a certain quality. He then calculated the food intake from the rate of growth and this energy consumption figure was then compared to the LSU used by agriculturists. Meissner's study was based mainly on a theoretical approach assuming various conversion factors and he stated that research is necessary to determine the legitimacy of his figures and to determine methods to estimate intake of free-roaming ungulates. With this statement in mind, the objectives of the present study were formulated.

Herbage intake and veld condition are limiting factors with regard to the number of animals which can be kept in an area, as grazing only has a certain production potential. Overstocking would therefore cause drastic overgrazing and deterioration of the veld (Trollope, 1990).

By measuring food intake which, together with grazing condition, water availability and shelter, are limiting factors with regard to carrying capacity for animals, we would determine the nutritional needs of impala and this could then be used to estimate carrying capacity.

1.2 OBJECTIVES

The three main objectives of the project therefore were:

- a. To determine a suitable method whereby the intake of free-roaming wild ungulates could be estimated.
- b. To determine the seasonal nutritional needs in terms of quality and quantity of impala.
- c. To test the viability of the game carrying capacity figures that are presently used by the Department of Agricultural Development and are based mainly on a theoretical approach (Meissner, Hofmeyr, van Rensburg & Pienaar, 1983).

1.3 REVIEW OF TECHNIQUES TO DETERMINE INTAKE ON FORAGE

To calculate intake as accurately as possible, it was necessary to have the animals graze under natural conditions. This would allow them to select freely, which was important.

Impala are classified by Hofmann (1968) as intermediate feeders meaning that they both graze and browse. Bothma (1989) states that the composition of their diet consists of 35% grass and 65% trees and/or shrubs. Engelbrecht (1986) in his study in the Kruger National Park found that grass constituted 63% with trees and/or shrubs 37%, while Owen-Smith & Cooper (1985) also found that grass constituted the maximum part of the diet at 75% and trees/shrubs 25%. Observations in the present study confirm that grass forms the bulk of the impala diet.

As the impala were to be studied in free-grazing conditions, a method had to be found to determine as accurately as possible the intake of impala. There are various methods available to determine food intake of domestic animals, but under free-grazing conditions the direct measurement of pasture intake is impossible. An indirect approach therefore had to be adopted. There are basically four animal-based techniques in use today which measure the intake of herbage indirectly (Streeter, 1969).

One method involves water turnover (Benjamin, Degen, Brieghet & Tahhan, 1975), but is inaccurate. The other three techniques require the quantification of faeces excretion in grazing ruminants whereafter herbage intake is calculated in various ways. The knowledge of faeces excretion per unit time is imperative for determining the quantitative food intake of free-grazing animals (Arnold, 1960, cited by De Waal, 1980). The total daily faeces excretion can be measured using one of the following methods:

- i) indirectly, using internal or external indicators or
- ii) directly, using faeces bags harnessed to the animals.

The first problem, therefore, is to find a technique which measures faeces excretion accurately.

The use of natural or internal markers (markers which occur naturally in the diet e.g. lignin, nitrogen and acid insoluble ash) and external markers (markers which are added to the diet) are common to determine faeces excretion. The most popular external marker is chromic oxide (Cr_2O_3) (Hodgson & Rodriguez, 1970), but Morgan, Pienaar & Clark (1976) had better recoveries with Cr-EDTA though neither of these were 100% accurate.

Another method to measure faeces excretion is the use of faeces collection bags harnessed to the animals. Morgan *et al* (1976) suggest that a well designed bag limits the possibility of faeces being lost when animals lie down. They state further that the technique is accurate and simple, gives rapid results and markers do not have to be analyzed afterwards. Some researchers do claim that the use of faeces bags are laborious and could become heavy and limit intake (Hodgson & Rodriguez, 1970; van Keulen & Young, 1977), but Arnold (1960) cited by De Waal (1986) states that this method is the most accurate if bags are designed to keep faeces loss to a minimum. Experience gained from the present study is in agreement with the latter suggestion.

Once faeces excretion has been quantified, there are basically three techniques with many variations which allow digestibility and thus intake to be estimated (Morgan *et al*, 1976):

i) Marker-ratio technique

Digestibility is calculated from the relative contents of a naturally occurring indigestible marker in samples of herbage grazed and in samples of faeces (Kotb & Luckey, 1972). This method may only be used if a representative sample of the herbage consumed and of the faeces produced can be obtained and if the indicator is completely indigestible.

With an indigestible natural marker, intake is calculated as:

$$\text{Intake of organic matter (OM)(g/day)} = \frac{\text{Quantity of indicator excreted/day}}{\text{Quantity of indicator/g of ingested herbage OM}}$$

Van Schalkwyk, Lombard & Vorster (1967) and van Keulen & Young (1977) suggest that HCl insoluble residue (acid insoluble ash) could be such a marker as it gave the best recovery and excretion was not affected by season. Engels, van Schalkwyk & Malan (1975) found it to be inaccurate because of ingested soil incorporated in the residue. Lignin could also be used as a natural marker.

ii) Faecal index technique

This technique involves the prediction of digestibility from the composition of the faeces.

Intake is calculated as:

$$\text{Intake of OM (g/day)} = \frac{\text{Faeces OM (g/day)}}{100 - \% \text{ digestibility of OM}} \times 100$$

Here faecal nitrogen (N) could be used as an index of OM digestibility. A regression equation is obtained for % digestibility of OM versus % N in faeces of caged and fed animals. Thus from % N in faeces of animals in the field, the % OM digestibility can be calculated and herbage intake estimated. McManus (1961), Langlands (1966) and Little (1972) concluded that N content of ingested food could be reliably estimated from the measurement of bolus N concentration. Unfortunately the % N in faeces for a given digestibility for a given herbage and for different parts of the same herbage need not be constant (Engels, Baard & Malan, 1974) because the N excreted in the faeces originates from ingested food as well as from bacterial digestion and depends on the quantity of OM fermented in the large intestine (Morgan, 1975; cited by Morgan *et al*, 1976). Morgan *et al* (1976) therefore conclude that such a regression equation cannot confidently be used unless it can be shown that there is no selection in the field or that the equation applies to the selected herbage. New equations need to be determined for each new herbage.

iii) Digestibility technique

Here digestibility of herbage is measured directly by the *in vitro* technique (Tilley & Terry, 1963) which involves incubation of the herbage sample with rumen fluid and pepsin, and intake is calculated with the aid of the equation in Method (ii). The general criticism of the *in vitro* fermentation technique is that many errors are possible which may yield varying results. This can be checked by using a standard reference feed. Engels *et al* (1974) found a high correlation of 0,945 between *in vivo* digestibility at *ad lib* intake and *in vitro* digestibility. Engels, van Schalkwyk, Niemann & Swart (1970) and Engels & Van der Merwe (1967) found a high degree of repeatability of *in vitro* digestibility of the same forages on successive days between different sheep and even after the lapse of a year.

Considering the close relationship between *in vivo* and *in vitro* digestibility in studies undertaken by Raymond (1969) and Engels *et al* (1974), the *in vitro* fermentation technique is suitable for the prediction of digestibility of pastures ranging between 40 and 70%, when representative dietary samples consumed by the grazing animals are available. These forage samples can be obtained from oesophageally fistulated animals, but it must be borne in mind that the *in vitro* technique is unreliable when tannins are present in the fermentation tube (Barry & Blaney, 1987; Acheampong-Boateng, 1991).

Samples taken from oesophageally fistulated animals represent the best available estimate of the qualitative intake of grazing animals (Van Dyne & Torrel, 1964; Langlands, 1969; Morgan *et al*, 1976; Meissner, H.H., pers. comm.). These researchers all used domestic animals, though others have inserted oesophageal fistulae into wild animals, e.g. white-tailed deer (Veteto, Davis, Hart & Robinson, 1972), reindeer (Dieterich, 1975), eland (Nge'the & Box, 1976) and topi and wildebeest (Usenik, Kreulen & Duncan, 1977).

For the purposes of this study impala rams were oesophageally fistulated so as to obtain samples of forage grazed. The digestibility of these samples was determined using the *in vitro* technique (Tilley & Terry, 1963). Faeces samples were collected

using faeces bags harnessed to the animals. Food intake was then calculated indirectly using the appropriate formula once the *in vitro* figures had been converted to *in vivo* figures:

$$\text{Intake of OM (g/day)} = \frac{\text{Faeces OM (g/day)}}{100 - \% \text{ digestibility of OM}} \times 100$$

The above method has been recognised by many researchers as the most reliable to calculate intake (Morgan *et al*, 1976; Meijs, 1981; Galyean, Krysl & Estell, 1986).

CHAPTER 2

2.1 INTRODUCTION

The oesophageal fistulation/faeces collection bag method used in the study meant that the animals had to be handled considerably. It was therefore necessary to have relatively tame impala. As we were trying to simulate as natural a situation as possible, the animals had to be free-roaming so as to select freely, be exposed to all the natural elements as well as to the presence of predators.

A number of control tests were carried out to determine if the catching and taming of impala, the use of tranquillizers in the process and the attachment of faeces bags would have any effect on intake.

2.2 FREE CHOICE STUDY

2.2.1 Introduction

The general project is concerned with determining the food intake of impala under natural conditions. To do this it was necessary to capture impala lambs and hand-raise them in order to tame them so as to be manageable.

As part of the raising, the animals were fed woody plants as soon as possible. Locally occurring woody plants known to be favoured by impala (Engelbrecht, 1986) as well as from local field observations were made available. It was feared that by feeding the animals certain species constantly, a preference would develop for these species (Arnold & Maller, 1977 cited by Malechek & Balph, 1987), thus the feeding behaviour of the test animals could be biased. It was also envisaged that by capturing the animals at less than a month old, the selection of food species by the impala would

not be the same as that of lambs which had spent more time with the herd (Lobato, Pearce & Beilharz; 1980).

Tame ungulates have been used for feeding studies in different parts of the world for many years. McMahon (1964), Healey (1968) and Currie, Reichert, Malechek & Wallmo (1977) worked with tame deer while Le Resche & Davis (1973) studied tame moose. The diets of various African ungulate species were studied amongst others, by Field (1968, 1970), Leuthold (1971), Duncan (1975), Nge'the & Box (1976), Frost (1981) and Monroe (1982).

Most of these authors seem to agree that the feeding habits of tame individuals are similar to those of their wild counterparts, but Leuthold (1971) and Frost (1981) suggest otherwise. They conclude that feeding habits in young antelope are formed on the basis of both innate behaviour and learning ability and that lambs probably learn from older members in the herd. In addition, it must be borne in mind that changes in food quality and quantity may force impala to try new plants previously ignored, while palatability, environmental, social and individual differences may also determine the type of food selected (Stewart, 1971; McAllister & Bornman, 1972; Rodgers, 1976; McNaughton, 1987; Malechek & Balph, 1987; Cooper, Owen-Smith & Bryant, 1988; Owen-Smith & Cooper, 1988).

2.2.2 Aim

The aim of the exercise was threefold.

- a) To determine whether feeding preferences of impala lambs kept in captivity for a longer period of time differed from lambs who had spent a longer time with the herd.
- b) To determine the possible differences in food preferences between age groups.

- c) To draw up a preference list for woody plants utilized by impala lambs in the area.

2.2.3 Procedure

Ten impala lambs were caught over a period of a month in an area that had the same basic vegetation. The lambs varied in age at the time of capture and were divided into three groups:

- A: The oldest group that had spent the longest time with the herd and were captured at 7 - 8 weeks of age. (3 lambs).
- B: The group that had been in captivity the longest, were 3-4 weeks old when captured but were the same age as A when the test commenced. (4 lambs).
- C: The youngest group, captured at the same time as group A but were younger ie. 3-4 weeks of age. (3 lambs).

Age was determined by observation of time of birth of the first impala in the area and monitoring the time lapse thereafter.

Groups A and C were captured at the same time, the only difference being that the older animals (A) had spent a longer time with the herd and could possibly have learnt to select according to the impala herd's preferences. The younger group at that age were at the start of their learning phase and were only beginning to nibble at foliage, therefore may not have had time to learn preferences. Group B had been in captivity for 3 to 4 weeks and were fed certain woody plants during that period.

The animals were housed in 2,3 x 4,7 m brick enclosures with an outside courtyard of the same size. After capture, the lambs were bottle fed as they had not yet been weaned. Each animal was weighed and fed an amount equal to 10% of its body weight (Young, 1975). This is equivalent to what they would drink naturally. 'Numel' milk powder was used, supplemented with 50ml cream (fresh, tinned or long life) per litre of milk due to the low fat content of the powdered milk in comparison to the

composition of impala milk (Bothma, 1989). Three weeks were allowed for adaptation to the milk before any monitoring occurred. Groups A and B were then 10 - 11 weeks old and drank about 700 ml milk per day while group C lambs were 6 - 7 weeks old and drank about 500 ml milk per day. This is the amount that they would most likely have had from their mothers. Judging from the amount of browse eaten during the experiment we were confident that the milk did not adversely affect browse intake.

During this period a wide variety of 45 different species of freshly cut woody plants were offered to the animals of which 25 species were eaten to a greater or lesser extent. Of the plants offered, 20 species were rejected outright. From the literature cited (Engelbrecht, 1986; McAllister, 1971; Jarmen, 1973) as well as from local field observations, 15 of the 25 species were then selected as being most accepted by the lambs. Though impala are primarily grazers as seen in the aforementioned literature and confirmed by the present results, it was decided to use woody plants for the test due to practical implications. Cutting sufficient quantities of preferred grass species was not feasible. The grass would have to be chopped into bite size pieces due to the eating habits of impala, which could then have influenced selection. Browse contributes about 30% to an impala's diet and sometimes more depending on the area so the same objectives will be achieved when using woody plants.

The 15 selected plant species were divided into 3 groups of 5 plants according to expected palatability. These 5 plants were offered to all 3 groups of impala simultaneously once a day and in sufficient quantity that all the animals could feed ad-lib for the entire duration of the test (Rollison & Harker, 1955; Spinage, 1968; Jarman & Jarman, 1973). The plant species were separated to make observations easier and care was taken to ensure that all the animals in the group had equal access to all the test plants. The test continued for as long as the animals ate or until one of the species became so depleted that all the animals no longer had equal access to that plant. Plant species were not weighed beforehand but feeding frequency was determined by observation at 4 minute intervals as described by Taylor, Rollison & Harker (1955), Spinage (1968) and Jarman & Jarman (1973).

Once the first group of plants had been tested in this way, the second and third groups were tested in the same way. A relegation test was then conducted between the less palatable plants of the first group and the most palatable plants of the second group to determine whether species should move up or down the list. The same procedure was followed between group 2 and 3 plants. Only the feeding frequencies of the final tests are used to indicate preferences. The entire duration of the test was 6 weeks.

2.2.4 Results and Discussion

The observed feeding frequencies of individual lambs for the 12 most preferred species of woody plants are presented in Table 1.

Data was then analysed using the Chi-squared continuous table test (Clark, 1987) and the one way analysis of variance of the GLM (General Linear Models) procedure (S.A.S. 1985), followed by an F-test using the three groups (A vs B vs C) as variables. Only the 12 most preferred species of woody plants were used for the analysis and only results of the GLM procedure are presented in Table 2, since the Chi² test gave the same results.

All three groups of impala differ in their relative preferences (Table 2). Group A (the oldest group which spent the longest time with the herd) differed significantly 50% of the time from group B (the longest in captivity), which seems to suggest that group B had been influenced by their captivity and therefore selected differently. Then again, the preferential selection of group C was similar to that of group A or B and differed in only one instance. The third group had been captured at 3 - 4 weeks of age and were only beginning to nibble at foliage which is normal for impala at that age (Young, 1975; Bengis, pers. comm.) This infers that the influence of adults on their selection would have been minimal at the time of capture so that their selective preferences were probably purely instinctive which leads to the conclusion that certain intrinsic factors within the animal itself do play a role in selection. Preliminary results by

Breytenbach (unpublished) support this theory. He used hand-reared blesbok (*Damaliscus dorcas phillipsi*) and fed them good quality lucerne, teff (*Eragrostis teff*) and low quality winter veld grass from blesbok habitat. They preferred the low quality grass.

Although there were significant differences in feeding frequency between the groups, it is suggested that these differences are due to the palatability of plants (Owen-Smith & Cooper, 1988) or to preferences of individual animals, or the group, for a specific plant and that no significant differences occurred between the groups as a whole. As an example in Table 2 group A apparently had a high preference for *Dichrostachys cinerea*. Referring to Table 1, it is noted that animal 1 had a notably higher selection for *D. cinerea* than the rest of the group. Likewise in group B it is seen that there is a nil feeding frequency for *Dalbergia melanoxylon* and a positive frequency for *Grewia bicolor* (Table 2). While referring to Table 1, it is seen that none of group B ate *D. melanoxylon*, yet they had a high selection for *G. bicolor* in comparison to the other 2 groups.

If this suggestion is accepted, one can assume on the basis of the above tests, that there is no significant difference between feeding preferences, based on frequency, between animals that have been kept in captivity from shortly after birth and animals that were allowed to spend a greater length of time with the herd. Likewise there are also no significant differences in food preferences between the different age groups tested.

The results of these tests tend to support the theory that food selection is instinctive according to authors mentioned in 2.2.1 and not affected by feeding young animals specific plants (Arnold & Maller, 1977 cited by Malechek & Balph, 1987).

On the other hand, the young experimental animals as well as those captured at 6 months of age would not eat lucerne when at first offered to them, as it was not a natural part of their diet. They were eventually taught to eat it, which shows that they do have a learning ability as long as the plants offered are palatable.

Table 1. Observed feeding frequency of individual lambs for 12 species of woody plants.

Group A			Group B				Group C			TOTAL	Species
1	2	3	4	5	6	7	8	9	10		
17	20	12	14	16	16	4	17	14	15	145	<i>Securinega virosa</i>
5	3	3	11	9	9	22	10	13	14	99	<i>Grewia flavescence</i>
7	8	13	4	3	5	4	9	10	6	69	<i>Acacia nigrescence</i>
9	3	4	9	9	8	7	5	9	5	68	<i>Grewia monticola</i>
3	2	3	4	5	3	3	12	12	13	60	<i>Acacia exuvialis</i>
5	10	8	0	0	0	0	9	7	7	46	<i>Dalbergia melanoxylon</i>
1	4	5	5	7	4	5	3	1	3	38	<i>Ziziphus mucronata</i>
10	5	6	4	6	0	0	1	1	0	33	<i>Dichrostachys cinerea</i>
1	1	1	7	9	9	3	0	0	0	31	<i>Grewia bicolor</i>
3	6	3	5	3	0	0	4	3	2	29	<i>Acacia gerrardi</i>
1	0	0	5	1	4	0	2	2	0	15	<i>Albizia harveyii</i>
0	0	1	2	0	0	0	2	4	6	15	<i>Dombeya rotundifolia</i>
62	62	59	70	68	58	48	74	76	71	648	TOTAL

Table 2. Observations of feeding frequencies of three groups of impala lambs for 12 species of woody plants in February 1989.

Plant species	Impala groups			Level of significance
	A	B	C	
<i>Securinega virosa</i>	0.267 ^b	0.199 ^a	0.208 ^{ab}	*
<i>Grewia flavescence</i>	0.060 ^a	0.226 ^b	0.168 ^b	**
<i>Acacia nigrescence</i>	0.154 ^a	0.068 ^b	0.114 ^{ab}	*
<i>Grewia monticola</i>	0.087	0.136	0.085	NS
<i>Acacia exuvialis</i>	0.044	0.062	0.168 ^b	**
<i>Dalbergia melanoxylon</i>	0.126	0.000 ^a	0.104 ^b	**
<i>Ziziphus mucronata</i>	0.055	0.087	0.032	NS
<i>Dicrostachys cinerea</i>	0.115 ^b	0.036 ^a	0.009 ^a	**
<i>Grewia bicolor</i>	0.016 ^a	0.113 ^b	0.000 ^a	**
<i>Acacia gerrardi</i>	0.065	0.029	0.040	NS
<i>Albizia harveyii</i>	0.005	0.039	0.018	NS
<i>Dombeya rotundifolia</i>	0.006	0.007	0.055	NS

The values in the table are expressed as a proportion of total observations.

^{ab} - Means with different superscripts are significantly different

*

- Significant

**

- Highly significant

NS

- Not significant

Published data on impala diet depict wide differences in browse content in different areas as well as seasonal and individual differences (Talbot & Talbot, 1962; Lamprey, 1963; McAllister, 1967; Azavedo & Agnew, 1968; Stewart, 1971; Rodgers, 1976; Frost, 1981; Monroe, 1982; Engelbrecht, 1986).

In the present study only browse species were tested, but impala are known to be primarily grass eaters, though able to utilize a wide variety of other plants, as seen from the above-mentioned publications. The observed differences in selection need not necessarily mean that hand-reared impala select differently from wild impala and it is concluded as do Leuthold (1971) and Frost (1981) that specific feeding habits are formed on the basis of both an innate selecting mechanism as seen in the free choice study (2.2) and a learning process, as seen from the fact that they were taught to eat lucerne.

As a matter of interest, a list was drawn up of the most preferred locally occurring woody plants to be used as a reference for future hand-rearing of impala lambs in the area (Tables 1 & 2).

2.2.5 Conclusion

Based on the fact that the preferences of group C were not different from groups A or B we were confident that results would not be biased by the use of hand-reared lambs. The experimental animals used for the food intake study ie. main study were a combination of hand-reared animals and impala captured at six months of age. It was later determined that there was no significant difference in intake or quality of intake between individual impala (see 3.5), therefore time of capture made no difference to their selective abilities in this case.

One important aspect, though, is that hand-rearing impala is an arduous, time-consuming and expensive task. Using impala captured at 6-8 months of age and even older is possible and even preferable for a similar study. As can be seen

from the results there was no significant difference between impala regarding their diet selection, regardless of time of capture.

2.3 TRANQUILLIZER STUDY

2.3.1 Aim

As mentioned previously it was difficult and time-consuming to hand-rear impala lambs. The capture of older lambs was far easier but they had to be tamed. Two long-acting tranquillizers which are routinely used by the National Zoological Gardens, Pretoria (Dr H Ebedes and Dr R Burroughs) and Veterinary Services of the Kruger National Park (Dr R Bengis) were tested on the impala. The tranquillizers used were Piportil depot (Pipothiazine - palmitate) (Maybaker) and Trilafon (Perphenazine - enanthate) (Schering Labs). The above-mentioned veterinarians had all successfully used the two drugs to calm animals for a certain length of time for transporting them, keeping them captive or for handling purposes (Gandini, Ebedes & Burroughs, 1989). The effect of both drugs presumably lasted 7 to 16 days. Monthly data could be collected during that period so if the drugs could successfully keep the animals calm and docile during that time without affecting intake, it would have been an advantage.

The aim of this study was to determine whether it was possible to rely on these drugs to help tame the impala and if so, whether they could be used to calm the animals during collection periods without affecting intake.

2.3.2 Procedure

Firstly a number of five-month old impala lambs were caught at night using spotlights to momentarily blind them. They were then physically caught by hand.



Fig. 1 Capturing impala at night using spotlights.

The animals were housed together at first and then separately in a 2,3 m x 4,7 m brick enclosure with an outside courtyard of the same size. Each impala was injected with 75-100 mg Trilafon per animal and then released into the enclosure. They were fed lucerne and browse material. This method proved to be unsuccessful as the animals were placed under too much stress at once. Though the impala tamed down well, they were not given a transition period to adapt to eating lucerne and had been taken straight from natural grazing, tranquillized and housed in unnatural conditions. An extremely cold spell at the time proved fatal. Dr Bengis, State Veterinarian in the Kruger National Park, confirmed that the long-acting tranquillizers do affect temperature control in animals.

The following procedure proved far more successful. A 50 m x 50 m x 4 m high enclosure of game capture sheeting was erected in an area containing natural grazing. Eight to twelve-month old impala lambs were caught and immediately released into the boma. A number of the impala were caught at night using lights and the rest were darted during the day using the following drugs. Each impala

was darted with 20 mg fentanyl with 5 mg rompun or alternatively with 0,75 mg etorphine (M99) with 5 mg rompun. Before being released into the boma, an antidote of 2 mg diprenorphine (M5050) plus 15-20 mg azaperone, a short-term tranquillizer, were injected. The dart wounds were treated with intramammary antibiotics (Bengis, pers. comm.).

Fresh lucerne was made available to the impala and as the natural grazing became depleted, so they slowly adapted to eating lucerne. This took about one to two months, but proved to be an effective method of adaptation. Water was available at all times and was treated with amprol (amprolium) for coccidiosis.

As much time as possible was spent with the animals in the enclosure to calm them. When adaptation was complete they were caught after being herded into a dark room especially erected for the purpose. Each animal was injected with 100-150 mg of either of the two long-acting tranquillizers and then released singly into the brick enclosures. After two days the impala were relatively calm, but not manageable. After a few weeks they were used to human presence and the experiment to test the effect of the tranquillizers on food intake commenced.

The impala were now 12 - 16 months old and 5 of them were used. They were allotted a number and treatment at random in a change-over design with three periods as shown below. According to the allotted number, they were injected with 150 mg/animal of either Trilafon, Piportil or no injection (Control) (Gandini *et al*, 1989).

Periods	Treatment		
	Control	Trilafon	Piportil
1	AB	C	DE
2	EC	AD	B
3	D	BE	AC

Numbers A to E are the impala

About 2,5 kg of lucerne was weighed and fed to each animal every morning, the residue being weighed after 24 hours. Samples of lucerne before feeding and of the orts were taken, weighed and dried to ensure that all results were on a dry matter (DM) basis.

Trial periods were 15 days each during which intake was measured. The animals were allowed a rest period between trials of at least 14 days for the effects of the drugs to wear off, before commencement of the next period.

2.3.3 Results

Results were analysed using the GLM procedure (S.A.S. 1985) for change-over designs followed by Tukey's t-test or the Bonferroni (Dunn) t-test in the case of unbalanced data. Dry matter intake of impala as affected by treatment is shown in Tables 3 and 4.

Due to the fact that one trial period was concluded after 11 days and not 15, data was analysed twice, using the balanced period of 11 days as well as the unbalanced period of 15 days to see if the number of days made a difference.

As can be seen from both Tables 3 and 4, there was a highly significant difference in intake between animals treated with Trilafon or Piportil and the control animals. This means that both tranquillizers had a significantly depressing effect on intake for at least 15 days after treatment. The difference between tranquillizers was not significant.

Table 3. The effect of tranquillizers on DM intake of impala over an 11-day period.

Treatment PR > F 0,0001 **	Intake g/day
Control	1009 ^b
Trilafon	854 ^a
Piportil	794 ^a
M S E	28,3

^{ab} - Means with different letters are significantly different ($P \leq 0,05$).
(Tukey's t-test)

** - Highly significant

M S E - Mean standard error

Table 4. The effect of tranquillizers on DM intake of impala over a 15-day period.

Treatment PR > F 0,0001 **	Intake g/day
Control	996 ^b
Trilafon	890 ^a
Piportil	832 ^a
M S E	24,5

^{ab} - Means with different letters are significantly different ($P \leq 0,05$).
(Bonferroni t-test.)

** - Highly significant

2.3.4 Conclusion

The use of either of the two long-acting tranquillizers, Piportil or Trilafon depressed DM intake very significantly. This means that for any food intake experiment it is apparently not possible to tranquillize the animals with these drugs. It may be advisable, though, to use the tranquillizers during the taming process as they have a significantly calming effect and then to withdraw medication before food intake trials proceed.

2.4 FAECES BAG STUDY

2.4.1 Aim

The experimental impala were to be fitted with bags for faeces collection. Faeces bags and harnesses may stress the animals or burden them because of the extra weight (Hodgson *et al*, 1970). Therefore it is important to establish whether food intake is normal with the extra burden. This was the aim of this particular study.

2.4.2 Procedure

Five 18-month old lucerne-fed impala rams were used for the experiment. They were allocated at random to two treatments, with and without faeces bags in a change-over design.

The impala had to be accustomed to the faeces bags and harnesses beforehand. The faeces bags could not be fitted immediately as the animals were heavily stressed. To adapt them to the strange attachments, small rags were first used and then progressively bigger ones as the animals became accustomed to them.

After two weeks the faeces bags were attached successfully. Faeces bags were initially emptied twice a day, but this proved too stressful for the animals and thereafter were emptied only once a day in the morning. It was apparent that the weight of the bags did not physically affect the impala, as can be seen from the results (2.4.3).

The animals were fed liberal amounts of lucerne daily (weighed beforehand) and at the same time a sample of the feed and feed remains from the previous day were taken for DM determination. The samples were dried at 100° C in a convection oven. All calculations were then done on a DM basis. Intake was measured for a period of five days in general and four days in one case, after adaptation to lucerne for at least three weeks. The experiment was repeated eight months later with three of the impala. The animals were given two days to adapt to the faeces bags and harnesses before intake measurements commenced.

2.4.3 Results and Conclusion

Results were analysed using the GLM procedure for change-over designs followed by Tukey's t-test (balanced data) or the Bonferroni (Dunn) t-test (imbalanced data).

The DM intake of impala with and without faeces bags is shown in Tables 5 and 6.

Table 5. DM intake of impala with or without faeces bags (g/day) - 1st trial.

Treatment PR > F 0,1349 NS	Intake g/day
With	963
Without	1031
M S E	47,9

Bonferroni test - imbalanced data ($P \leq 0,05$).

NS - not significant.

M S E - mean standard error

Table 6. DM intake of impala with or without faeces bags (g/day) - 2nd trial.

Treatment PR > F0,8377 NS	Intake g/day
With	1291
Without	1282
M S E	32,9

Tukey's t-test - balanced data ($p \leq 0,05$).

NS - Not significant.

The increased intake by the impala as portrayed in Table 6 was due to the fact that the animals were older and weighed more.

Both studies showed no significant difference in DM intake by impala, whether fitted with faeces bags or not. This implies that the burden of a faeces bag did not affect intake negatively contrary to data of Hodgson and Rodriguez (1970).

Knowing that the attachment of faeces bags had no effect on intake, it was possible to proceed with this method of total faeces collection.

CHAPTER 3

3.1 INTRODUCTION

Once preliminary control tests (Chapter 2) were complete, the main study could commence. This was conducted on natural grazing during monthly periods spanning a year to study voluntary intake and quality of selection by male impala. Pasture samples were collected using oesophageally fistulated impala so as to be able to determine digestibility of the selected forage. Faeces were collected using faeces bags harnessed to the impala. Intake was calculated by the ratio of faeces voided to the indigestible portion of the forage.

3.2 AIM

The aims were to obtain information about the seasonal needs, quantity and quality of diet selected by impala to estimate energy requirements and also to use these figures to test the viability of the game carrying capacity figures presently used by the Department of Agricultural Development (Meissner *et al*, 1983).

3.3 METHODS

3.3.1 Study Area

The study was conducted in the area around the Hans Hoheisen Wildlife Research Station of the Directorate of Nature Conservation. It is situated in the Timbavati Private Nature Reserve bordering the Kruger National Park. This part of the Eastern Transvaal Lowveld has an altitude of 400 m, with an annual rainfall of 300-650 mm largely confined to the summer months of October to April. Summers are hot to very hot and winters are mild, i.e. a subtropical climate.

During the study period in 1989 the rainfall averaged 476 mm, with two winter months, May and June, recording 27,5 and 30,5 mm respectively. (This is not uncommon.) The maximum temperature recorded was 39°C and the minimum 9°C. The highest humidity recorded was 99% and the lowest 45%.

3.3.2 Vegetation

The study area consists mainly of open *Acacia nigrescens* woodland with scattered *Grewia* species and *Securinega virosa* shrubs. The grass stratum is dominated by *Panicum maximum* followed by *Themeda triandra*. Other grasses that occur are *Urochloa mosambicensis*, *Schmidtia pappophoroides*, *Heteropogon contortus*, *Digitaria eriantha*, *Brachiaria serrata*, *Aristida* spp., *Cenchrus ciliaris* and various forbs.

3.3.3 Animals studied

3.3.3.1 Fistulation

Four 18-30 month old partially tamed impala males weighing between 40 and 55 kg were equipped with oesophageal fistulae using the method described by Visser, Pietersen, Spreeth & Meissner (1990). The standard removable sheep cannula with slightly altered dimensions on the plug and base were used, as illustrated in Figure 2.

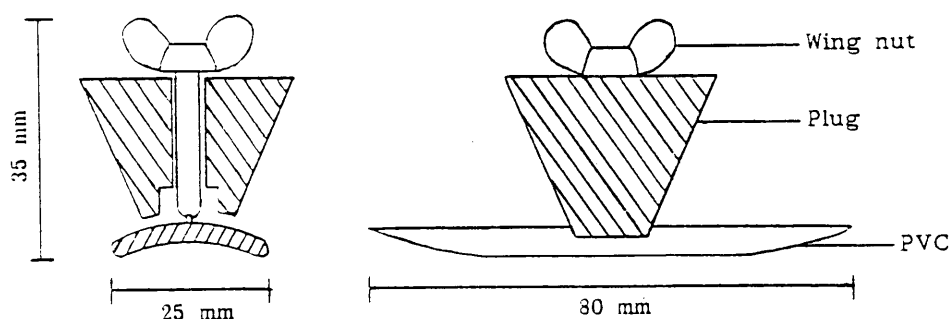


Fig. 2 Removable cannula

The cannula is inserted ventral to the *m. cleidomastoideus* and dorsal to the *m. sternomandibularis*, approximately in the middle of the neck lateral to the *linea mediana ventralis* where the oesophagus is closest to the skin. This reduces the incidence of pressure necrosis and facilitates neck movement. The procedure resembles the methods of Veteto *et al* (1972), except that the cannula is fitted halfway up the neck and lateral to the ventral mid-line. This facilitates a secure and mostly leakage-free fitting of the collection bags.

In the long term problems such as blockage of the cannula, oesophageal obstruction by ingesta and fistula enlargement or shrinkage occurred as experienced by various authors (Veteto *et al*, 1972; Usenik *et al*, 1977), and were dealt with accordingly. Clearing of blockages during the first fortnight was done with a stomach tube to prevent injury to the fistula orifice. Thereafter the cannulae were removed and blockages cleared manually. If the fistula orifice became

enlarged, the size of the plug was enlarged accordingly, and if shrinkage occurred, the orifice was surgically snipped using local anaesthetic.



Fig. 3. Fistulated impala with and without collection bag.

3.3.3.2 Management of the impala

All animals in the trial were kept free of internal parasites using injections of Ivomec and after capture were preventatively treated for coccidiosis. No problems were encountered with external parasites. Fresh water was always available. During the preliminary taming period, the animals were kept in brick enclosures with an attached courtyard as mentioned previously (2.2.3). While in the enclosures, they were fed good-quality lucerne.

During the main experimental period, the impala were kept on natural grazing in a succession of camps enclosed by plastic game capture sheeting (Fig. 4). Each enclosure was roughly 50 x 50 m in size and 3 m high. The animals were rotated

every two to three days. This was done to prevent grazing becoming limited by opening a curtain between two successive enclosures and then re-erecting the first enclosure adjoining the second. This leap-frog system allowed them to select freely within a relatively large area. These enclosures were erected within a 10 ha camp in an area known to be favoured by impala. The outside perimeters were electrified against predators. The animals should preferably have been able to graze freely within the 10 ha camp, but were not tame enough to be herded in such a big area.

During extremely windy periods, the sheeting could not withstand high winds for any length of time and the animals would then escape and have to be herded back again. This was a limiting factor as far as management of the animals was concerned.

The impala were caught by being herded into a specially designed funnel-shaped corner of the grazing enclosure. As the animals were herded towards the corner, a curtain of plastic game capture sheeting was closed behind them. Once confined to the smaller area, they were easily caught by the horns (the tips of which had been sawn off) by a single person, while two more held the legs.



Fig. 4. Enclosure erected on natural grazing.

3.3.3.3 Pasture sampling and preparation

Samples were collected monthly during a three week period:

- i) First week - two oesophageal fistula samples collected from each animal
- ii) Second week - faeces collection for a minimum period of five days
- iii) Third week - two oesophageal fistula samples collected.

Pasture samples from the oesophageal fistula were collected between 14h00 and 15h00 on the respective days.

The impala were starved for 6-7 hours prior to collection to prevent rumination and thus contamination of the fistula samples as fasting had no effect on extrusa samples (Langlands, 1967). Water was freely available during this period. The animals were caught in the camp, carried to the brick enclosures and kept individually prior to sampling. It was not possible to confine them to any small space within the camp itself as they fought once in close proximity. After the starvation period, the cannulae were removed and the animals equipped with canvas bags around their necks in which pasture samples were accumulated (Figs. 5 & 6). They were then caught and carried back to the grazing camp where sampling commenced for a period of 50-60 minutes. During this time they were left undisturbed to prevent nervousness and a cessation of grazing.

After sample collection, the impala were again caught and the cannulae re-inserted. The oesophageally collected samples were individually strained through a double layer of cheesecloth to remove most of the saliva before being dried at 50° C for 48-50 hours in a convection oven to constant mass (Engels, de Waal, Biel & Malan, 1981). Any samples contaminated with rumen contents were abandoned. This seldom occurred. After drying, the samples were ground in a Tecator mill with a 1 mm sieve and stored separately in airtight containers for later laboratory analysis.

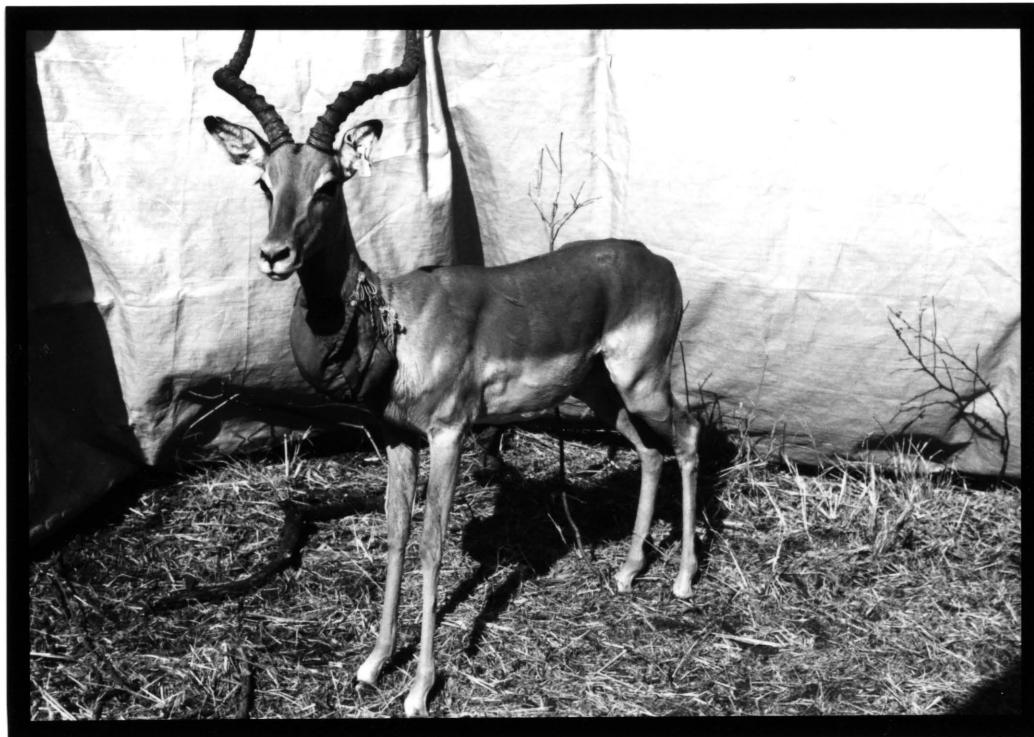


Fig. 5 Impala equipped with extrusa collection bag.



Fig. 6 Sample collection bags with extrusa.

3.3.3.4 Faeces collection

All animals were equipped with harnesses and nylon canvas bags (Arnold, 1960 cited by De Waal, 1986) to collect faeces daily for five days during the second week of the three week sampling period (see Fig. 7). Animals were given two to three days to adapt to the burden of a faeces bag before sampling commenced.

Faeces were collected each morning at 08h00, the procedure being that the animals were driven into the corner of the camp and a curtain closed behind them. They were then caught and the bags emptied. Care was taken to ensure that the bags were securely sealed (using small bolts and nuts) as the animals were easily excited, resulting in a loss of material. If this occurred, samples for that day were abandoned and the sampling period extended.

The faeces samples collected during a 24-hour period were weighed and a representative sample of 10% of the daily excretion of each animal kept frozen in a plastic bag. Daily samples were added to the 10% aliquots of previous days. Samples from individual impala were pooled separately. At the end of the weekly collection period, a part of the pooled sample was dried at 100°C for DM determination of excretion. Another part was dried at 60°C, ground in a Tecator mill to pass through a 1 mm sieve then stored in a container for future analyses in the laboratory.



Fig. 7 Impala fitted with faeces collection bags.

3.3.4 Parameters

The samples collected from the oesophageally fistulated impala were analysed to determine chemical composition as well as digestibility of the selected herbage. Faeces samples were also analysed for chemical composition. All samples were analysed in duplicate for each parameter.

The following variables were under investigation:

in vitro digestibility of organic matter (OM) of herbage

in vivo digestibility of OM (calculated)

Dry matter (DM) intake

OM content

Crude protein (CP)

Neutral detergent fibre (NDF)

Acid detergent fibre (ADF)

Hemicellulose (calculated)
Cellulose (calculated)
Acid detergent lignin (ADL)
Digestibility (calculated) of NDF
Digestibility (calculated) of ADF
Digestibility (calculated) of hemicellulose
Digestibility (calculated) of cellulose

3.3.5 Analytical methods

3.3.5.1 Dry matter (DM) determination

The DM content of all samples were analysed so that results could be portrayed on a DM basis. This procedure is described in the publication of the Association of Analytical Chemists (AOAC, 1984). An accurately weighed sample was dried and weighed and the DM percentage determined.

3.3.5.2 Ash determination (AOAC, 1984)

Subsequent to the above DM analysis, the dried samples underwent complete combustion at 600°C in a muffle furnace for four hours after which ash percentage was calculated.

3.3.5.3 Organic matter content (OM) (AOAC, 1984)

Utilizing the DM and the ash content of the samples, the OM content was calculated by subtraction.

3.3.5.4 Digestibility of OM - *in vitro*

The *in vitro* digestibility of oesophageal fistula collected samples was determined using the two-stage technique of Tilley & Terry (1963) as modified by Engels & van der

Merwe (1967) regarding nitrogen (N) supplementation. The rumen liquor was obtained by means of a suction pump from sheep and goats fitted with permanent rumen fistulae, which were consistently fed good quality lucerne hay. The liquor was kept at 39°C and then strained through four layers of cheese cloth before being added to the test tubes to promote the first stage of digestion.

3.3.5.5 Digestibility of OM - *in vivo*

Once the *in vitro* digestibilities are calculated, the *in vivo* digestibility of the pasture can be estimated using regression equations which describe the relationship between *in vitro* and *in vivo* digestibilities. The standard error (SE) of prediction of $\pm 2,996$ (Engels *et al*, 1974) and $\pm 3,04$ (Engels & van der Merwe, 1967) compared favourably to the $\pm 2,31$ of Tilley & Terry (1963). Engels *et al* (1974) stated that differences between *in vitro* and *in vivo* digestibilities of OM were lowest at digestibilities of around 60%. Differences were more pronounced at higher ($\pm 75\%$) as well as lower ($\pm 40\%$) digestibilities. Current observations fell within this range. The *in vivo* OM digestibility was therefore calculated using the regression equation of Engels *et al* (1981) to adjust the *in vitro* digestibility:

$$\text{In vivo DOM\%} = 0,7892 (\text{in vitro DOM\%}) + 16,42$$

3.3.5.6 OM Intake

Organic matter intake was calculated using the calculated *in vivo* DOM percentage of the forage and the total faeces OM excreted

$$\text{Intake of OM (g/day)} = \frac{\text{Faeces OM (g/day)}}{100 - \% \text{ in vivo DOM}} \times 100$$

By adding the forage ash content, DM intake could be calculated.

3.3.5.7 Crude protein content

The N content of pasture and faeces samples were determined using the macro-kjeldahl method (AOAC, 1984). Once this was determined, crude protein (CP) was calculated as:

$$\text{CP} = \% \text{ N} \times 6,25$$

To compensate for N loss when the liquid fraction is removed from total extrusa and the solid fraction is then dried at 50° C, instead of freeze-drying the following equation was used to adjust N values as proposed by Engels *et al* (1981):

$$\text{N\% (freeze-dry)} = 0,017 + 1,1307 \text{ N\% (oven dry)}$$

3.3.5.8 Cell wall constituents - cellulose, hemicellulose and lignin

The cell wall constituents of food and faeces samples were determined using the methods described by van Soest & Wine (1967). Cell solubles are extracted by neutral detergent solution, the residue being neutral detergent fibre (NDF) which approximates the cell wall.

An acid detergent solution is used to extract the more soluble cell wall or hemicellulose. The residue called acid detergent fibre (ADF) consists mainly of cellulose, cutin and lignin. After exposure to 72% H₂SO₄ the residue is acid detergent lignin (ADL) after which lignin is determined by ashing in a muffle furnace at 550° C.

$$\% \text{ Hemicellulose} = \% \text{ NDF} - \% \text{ ADF}$$

$$\% \text{ Cellulose} = \% \text{ ADF} - \% \text{ ADL}$$

$$\% \text{ Lignin} = \% \text{ ADL} - \% \text{ Ash}$$

Different subsamples were used for each of the above determinations.

3.3.5.9 Digestibility (D) of cell wall constituents

From knowledge of the percentage of cell wall constituents in the food and faeces, the amounts of cell wall constituents consumed and excreted could be calculated indirectly which enabled calculation of the approximate digestibilities of these constituents.

3.4 STATISTICAL ANALYSIS

All results were analysed by one-way analysis of variance procedure using the GLM programme (S.A.S. 1985) with animals and months or seasons as variables. This was followed by the Bonferroni (Dunn) t-test in the case of empty cells or otherwise the Duncan t-test. Means and standard errors for all chemical parameters, digestibilities and DM intakes were determined. If values within the same analysis fell below 20% or exceeded 80% and if observations were limited (ie. < 30), values were transformed to square roots before the GLM procedure (Steel & Torrie, 1960). All analyses of hemicellulose and the digestibilities of ADF, NDF, hemicellulose and cellulose as well as faeces analyses were transformed to square roots.

Dry matter intake was regressed on *in vitro* digestibility of OM (IVDOM) as well as on lignin and CP and the results plotted. IVDOM was also regressed on lignin and CP.

3.5 RESULTS

Results of the averages of individual impala are presented in Tables 7 and 8. As can be seen from these tables, variation between impala regarding the quality of selection as well as DM intake was extremely small and there were no significant differences between individuals - 2,6% for CP, 4,2% for *in vitro* digestibility of OM, 0,7% for NDF and 7,8% for lignin. This fact has significant implications as it indicates that the number of animals used in sampling under these conditions can be reduced and that oesophageal samples can be pooled to cut costs, labour and time. Furthermore, different animals can be used to collect oesophageal extrusa and faeces samples.

There were no impala/month interactions, consequently all observations were processed irrespective of individual impala. Monthly differences in intake and quality of food selected were then determined. These results are depicted in Tables 9 and 10.

In Table 9 and Figure 8, the monthly fluctuations of DM intake, OM digestibility, lignin and CP are depicted for comparison as well as rainfall in fig. 8. Intake dropped significantly during the very dry month of May (sampling occurred before the light rains fell) when digestibility was also at its lowest, mostly due to the fact that lignin content of food was high. Intake was not that low during June and July because of showers in late May and June enabling consumption of higher digestible material and CP was supplemented by the intake of significant amounts of browse. Dry matter intake decreased again in August and October when precipitation was zero but once the rainy season commenced at the end of October, *in vitro* digestibility and DM intake increased considerably, while lignin percentage decreased.

In vitro digestibility of OM averaged 57,2% and varied between 40 and 70% and DM intake averaged 1413 g varying between 900 and 1900 g/day in the dry and wet seasons respectively. Faeces DM output averaged 575 g/day. Both digestibility of OM (Table 9) as well as cell wall constituents (Table 10), were significantly lower during the dry months than during the wet months, due to the higher lignin content. The more soluble hemicellulose is less affected by lignin complex formation and therefore its digestibility was not reduced to the same extent as other cell wall constituents.

Total cell wall as described by NDF averaged 66,6% and the less available lignified tissue described by ADF averaged 41,3%. Hemicellulose averaged 25,2% and fluctuated between 20 and 30,9%, while cellulose averaged 28,6% and fluctuated between 23,2 and 32,4%. The primarily grass diet of the impala contained 5-15% lignin, depending on the season and increased considerably during the drier month of May, when very dry grass as well as a certain amount of browse was eaten.

Crude protein selected averaged 9,7% and fluctuated between 6,1 and 12,9%. The CP content was significantly higher during the wet season than during August to October, but lower than during June to July when the impala apparently selected significant amounts of browse and tender grass shoots which emerged after rains fell during the latter part of May as well as in June. October registered the lowest CP% being toward the end of the dry season with little browse available.

When quality parameters are grouped according to season (Table 11 & Figures 9 & 10) a clearer picture emerges. November to March are effectively the summer months (hot/wet), April and May are autumn (hot/dry), June and July are the winter months (cold/dry) and August to October is spring (hot/dry).

There is a definite seasonal effect on intake, quality and digestibility of food and its constituents. The lowest intake recorded was during Autumn when the quality of grazing was at its lowest with lignin percentage at its highest. It is interesting to note that May is the peak of the rutting season for impala in that area. From observations it was clear that the experimental animals were certainly rutting although they were not in contact with ewes. Much time was spent fighting, which obviously could have had a very definite effect on intake and this, together with the low quality grazing, led to a pronounced drop in intake during that month. The highest intake figures were measured during summer (November / December) when rainfall and therefore grazing quality were at their peak. Digestibility followed the same pattern as DM intake. A seasonal cycle in voluntary food intake seems to be a normal occurrence in many deer (Kay *et al*, 1979).

The increased effect that browse has on the crude protein of the diet is seen especially during autumn and winter when significant amounts of browse were taken in. A flush of green grass after good rains in June/July, combined with a high intake of browse, resulted in a high CP content. Spring registered the lowest CP percentage, being toward the end of the dry season when no browse was available. Dry season browse contains a high CP level (Rees, 1974) while wet season forages are of a higher quality than dry season forages (McNaughton, 1987).

TABLE 7. Differences in DM intake and quality of food as selected by individual impala.

PR > F Impala No.	0,5179 NS DM intake g/day	0,2425 NS IVDOM %	0,8847 NS CP %	0,9287 NS NDF %	0,4398 NS ADF %	0,8249 NS Hemi- cellulose %	0,9386 NS Cellulose %	0,4175 NS Lignin %
1	1419	58,7	9,9	66,2	40,6	25,0	28,4	8,6
8	1407	57,6	9,9	67,2	41,4	25,6	29,0	8,2
10	1421	57,4	9,6	66,1	41,1	25,0	28,3	8,0
11	1384	51,6	9,2	67,0	43,1	25,0	29,0	10,1
M S E	62,6	1,19	0,29	0,88	0,54	0,64	0,68	0,35

NS - not significant

M S E - Mean standard error.

TABLE 8. Differences in digestibility of cell wall constituents as selected by individual impala (%)

PR > F Impala No.	0,9598 NS D. NDF	0,9160 NS D. ADF	0,1767 NS D. Hemicellulose	0,7739 NS D. Cellulose
1	63,2	52,3	80,7	63,5
8	63,6	52,4	81,6	65,5
10	63,1	51,6	82,0	64,5
11	64,0	51,3	85,7	65,2
M S E	1,12	1,34	1,20	1,75

NS - not significant

M S E - Mean standard error

D - Digestibility

The above values were calculated as described in 3.3.5.9

Table 9. Monthly differences in DM intake and quality of material selected by impala.

PR > F	0,0001 **	0,0001 **	0,0001 **	0,0001 **	0,0001 **	0,0001 **	0,0001 **	0,0001 **
Month 1989	DM Intake g/day	IVDOM %	CP %	NDF %	ADF %	Hemicellu- lose %	Cellulose %	Lignin %
February	1711 ^{cd}	64,5 ^{bde}	8,9 ^{abc}	69,5 ^{bc}	42,3 ^c	27,2 ^{bcd}	31,7 ^a	5,6 ^{cde}
March	1242 ^{abc}	62,2 ^{defg}	10,3 ^b	68,9 ^{bc}	41,4 ^{bc}	28,2 ^{cd}	30,1 ^a	7,4 ^{cde}
April	1290 ^{abc}	53,2 ^c	8,2 ^{ab}	69,5 ^c	45,1 ^{cd}	24,4 ^{abc}	31,5 ^a	9,2 ^{bd}
May	921 ^a	40,4 ^a	9,3 ^{abc}	63,1 ^{ab}	42,6 ^c	20,5 ^a	24,8 ^{bc}	15,3 ^a
June	1373 ^{bcd}	51,7 ^c	12,9 ^d	57,8 ^a	36,4 ^a	21,2 ^{ab}	23,2 ^b	10,8 ^b
July	1594 ^{bcd}	58,6 ^{ce}	11,8 ^c	63,0 ^{abc}	38,1 ^{ab}	24,9 ^{bc}	26,8 ^{ab}	7,7 ^{be}
August	1315 ^{bc}	49,3 ^{acf}	9,0 ^{abcd}	63,6 ^{abc}	39,5 ^{abc}	24,1 ^{abc}	26,9 ^{ab}	8,3 ^{bde}
October	1265 ^{ac}	55,4 ^{cd}	6,1 ^a	68,4 ^{bc}	44,9 ^d	22,7 ^{ab}	32,4 ^a	7,4 ^{be}
November	1559 ^{bcd}	66,9 ^{be}	10,0 ^b	68,3 ^{bc}	40,8 ^{bc}	27,5 ^{bcd}	28,5 ^{ab}	6,0 ^{cde}
December	1858 ^d	69,1 ^{bg}	9,3 ^{abc}	72,2 ^c	41,3 ^{bc}	30,9 ^d	30,1 ^{ac}	5,5 ^{ce}
Mean	1413	57,2	9,7	66,6	41,3	25,2	28,6	8,5
M S E	66,7	1,71	0,57	1,56	1,02	0,96	1,03	0,60

- ** - highly significant (Bonferroni test)
 abcdefg - means with different superscripts are significantly different
 M S E - mean standard error

Table 10. Monthly differences in digestibility of cell wall constituents selected by impala.

PR > F	0,0001 **	0,0001 **	0,0001 **	0,0001 **
Month (1989)	D. NDF %	D. ADF %	D.Hemicellulose %	D. Cellulose %
February	73,0 ^{cd}	64,3 ^d	86,6 ^{cd}	74,7 ^{cd}
March	65,7 ^{bc}	54,9 ^{cd}	82,0 ^b	66,9 ^c
April	62,2 ^b	52,8 ^{bc}	79,6 ^b	64,3 ^c
May	47,1 ^a	36,7 ^a	68,6 ^a	44,7 ^a
June	51,0 ^a	36,8 ^a	74,3 ^{ab}	49,0 ^{ab}
July	63,0 ^b	51,0 ^{bc}	81,1 ^b	65,3 ^c
August	57,2 ^{ab}	45,0 ^{ab}	77,1 ^{bc}	60,3 ^{bc}
October	64,0 ^{bc}	56,1 ^{cd}	79,3 ^{bc}	66,3 ^c
November	73,6 ^{cd}	60,4 ^{cd}	93,1 ^{de}	72,3 ^c
December	76,8 ^d	62,8 ^d	95,6 ^e	82,2 ^d
M S E	1,09	1,31	1,5	1,8

** - highly significant (Bonferroni test)

abcd - means with different superscripts are significantly different.

D - Digestibility

M S E - mean standard error

The above values were calculated as described in 3.3.5.9

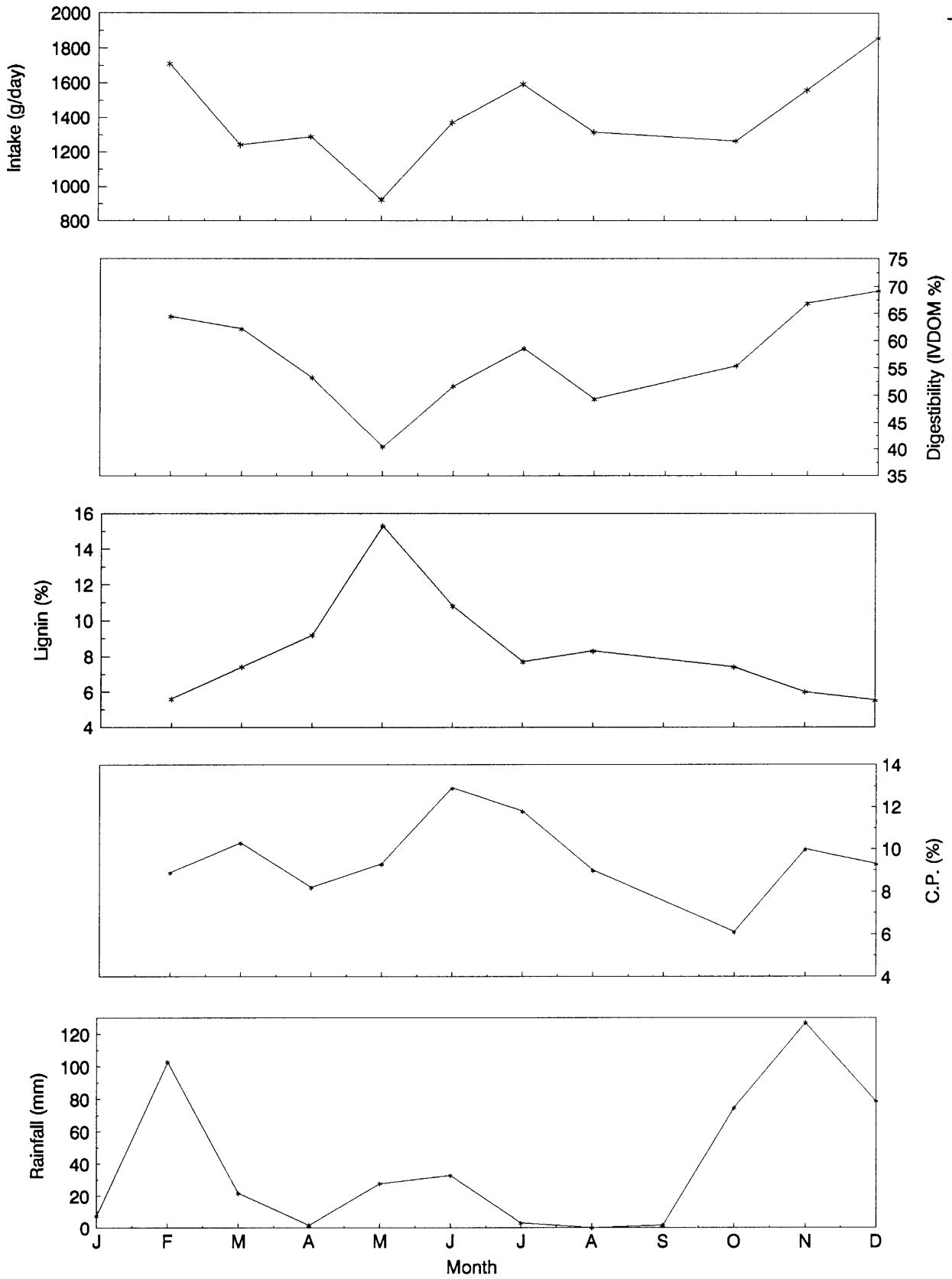


Figure 1. Rainfall data and monthly differences in DM intake and quality of food eaten by impala.

Table 11. Quality parameters in food, digestibility of food constituents and DM intake of male impala, as affected by seasons.

	Seasons				MSE	Level of Significance
	Summer (Nov-March)	Autumn (April-May)	Winter (June-July)	Spring (Aug-Oct)		
<u>Quality parameters (% of DM)</u>						
Crude protein	9,7 ^b	8,8 ^{ab}	12,4 ^c	6,9 ^a	0,22	**
NDF	69,6 ^b	66,2 ^b	60,3 ^a	67,1 ^b	0,65	**
ADF	41,4 ^b	43,8 ^b	37,1 ^a	43,1 ^b	0,41	**
Hemicellulose	28,3 ^b	22,6 ^a	23,2 ^a	23,6 ^a	0,40	**
Cellulose	30,1 ^b	28,3 ^{ab}	24,8 ^a	30,8 ^b	0,46	**
Lignin	6,3 ^a	12,1 ^c	9,4 ^b	7,7 ^{ab}	0,30	**
<u>Digestibility (% of DM except IVDOM)</u>						
IVDOM	65,1 ^c	46,8 ^a	54,8 ^b	53,7 ^{ab}	0,74	**
NDF	71,7 ^b	54,7 ^a	57,0 ^a	60,6 ^a	1,12	**
ADF	59,8 ^b	44,7 ^a	43,9 ^a	50,6 ^{ab}	1,24	**
Hemicellulose	88,9 ^b	74,1 ^a	77,7 ^a	78,3 ^a	1,01	**
Cellulose	73,5 ^b	54,5 ^a	57,2 ^a	63,3 ^{ab}	1,53	**
<u>DM intake (kg/day)</u>	1,55 ^b	1,11 ^a	1,48 ^b	1,29 ^{ab}	0,41	**

** - highly significant

abc - means with different superscripts are significantly different. ($P \leq 0,05$)

MSE - Mean Standard Error

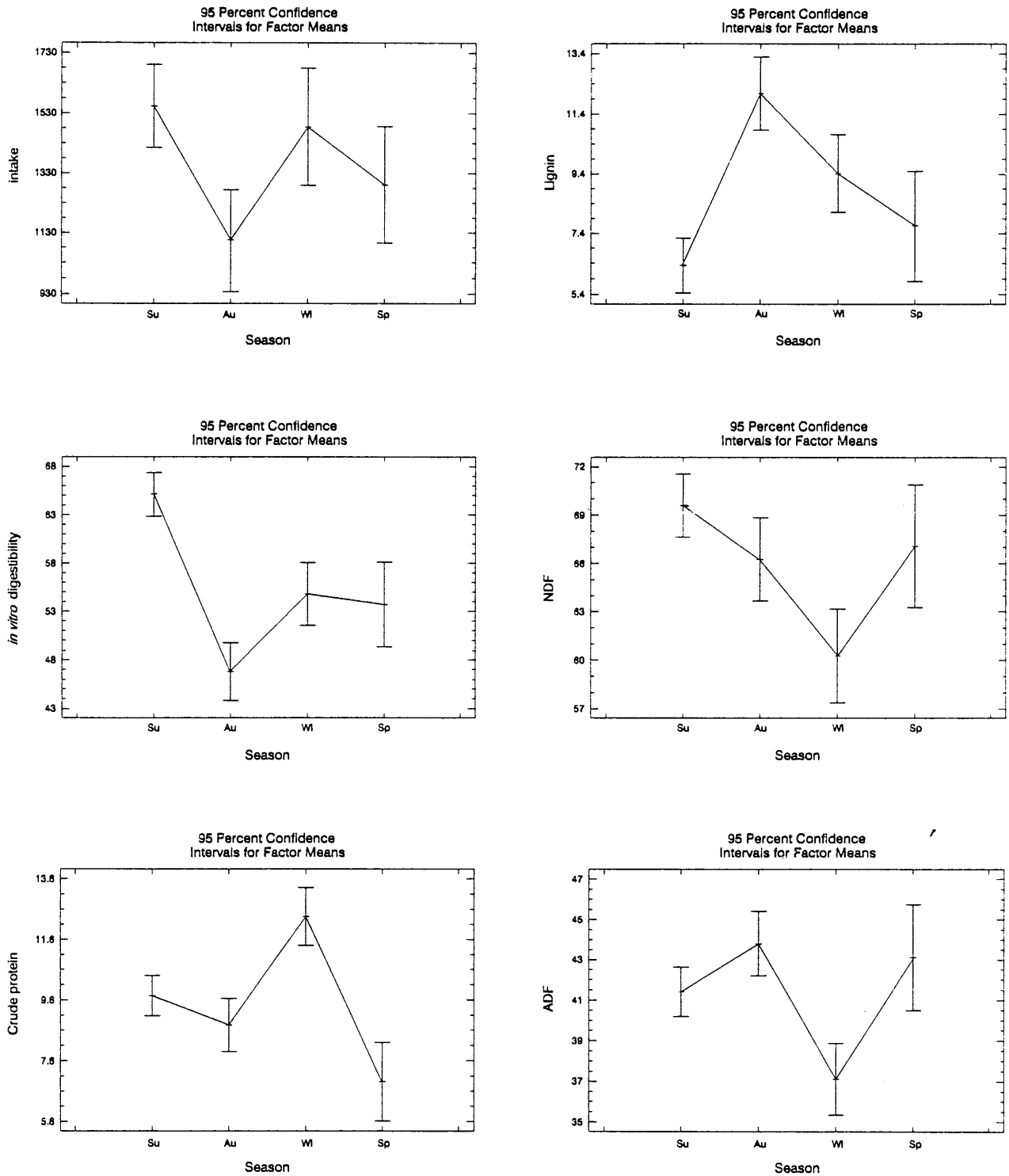


Figure 9. Seasonal effect on intake, digestibility and quality parameters of impala.

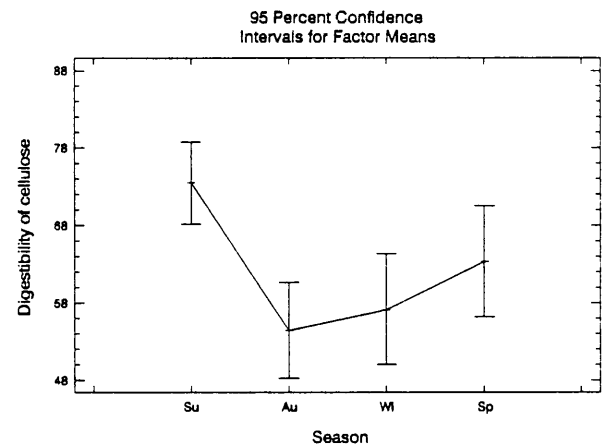
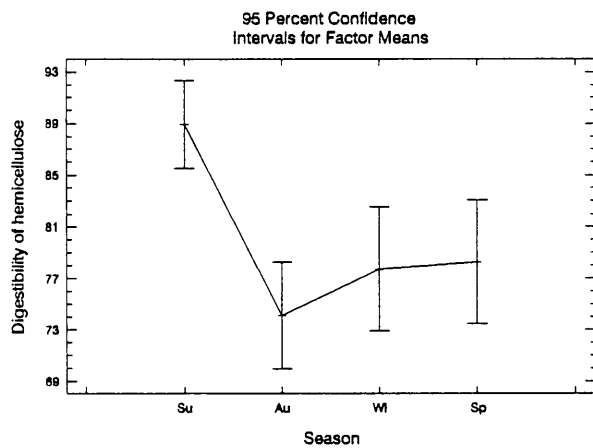
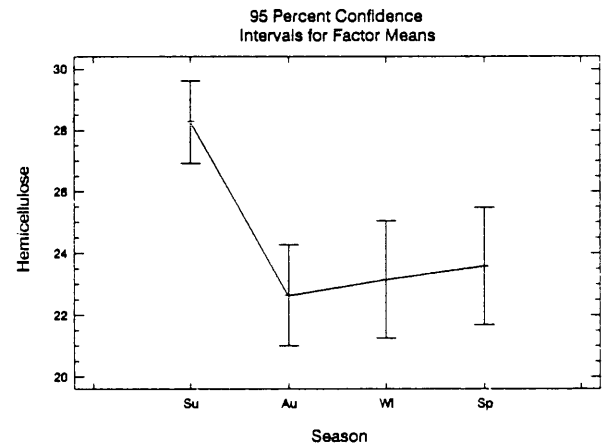
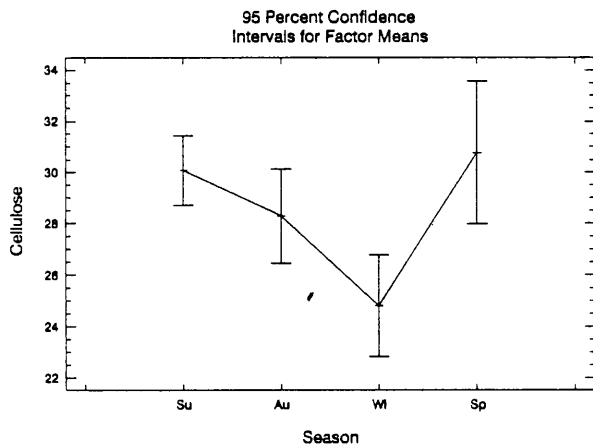
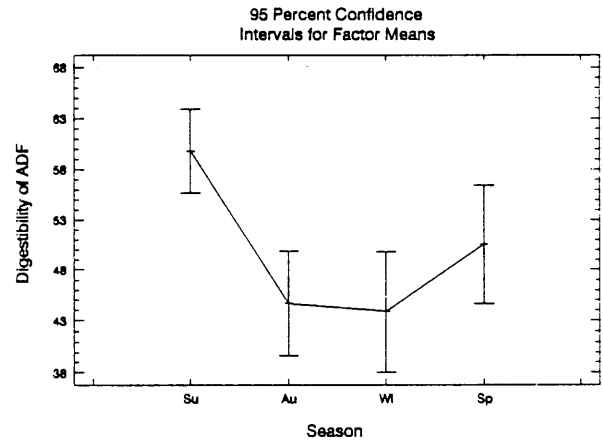
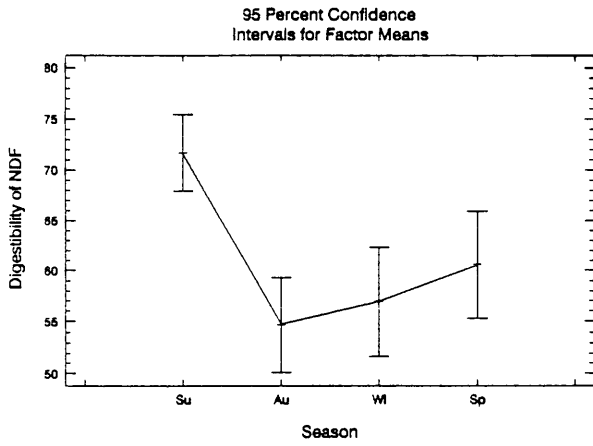


Figure 10. Seasonal effect on quality parameters of impala.

The increased lignin content of grazing during the dry months (Figure 9) resulted in a low digestibility of OM, but cell wall constituents still realised a relatively high digestibility, especially hemicellulose, which is more soluble than cellulose (60% digestible) (Figure 10).

Seasonal differences with regard to all parameters were highly significant.

Lignin content seems to be the main determinant of *in vitro* digestibility and DM intake, with some additional variation being accounted for by variation in CP content. Although it was possible to predict DM intake with a linear regression equation using lignin percentage:

$$\begin{aligned} \text{DM intake (g/day)} &= 2035 - 75 (\% \text{ lignin}) \\ r &= -0,81 \end{aligned}$$

A stronger relationship was found to exist between the reciprocal of DM intake and % lignin:

$$\begin{aligned} \frac{1}{\text{DM intake(g/day)}} &= 0,000352 + 0,0000459 (\% \text{ lignin}) \\ r &= +0,88 \end{aligned}$$

This is depicted in Figure 11. The inner broken lines represent 95% confidence intervals of the observed values while the outer lines are the intervals for any future predicted values.

The linear equation can be improved by the addition of CP as another independent variable in a multiple linear regression equation:

$$\begin{aligned} \text{DM intake (g/day)} &= 1640 - 79,8 (\% \text{ lignin}) + 45.5 (\% \text{ CP}) \\ r &= -0,87 \end{aligned}$$

A strong positive linear relationship between intake and IVDOM was also observed:

$$\begin{aligned}\text{DM intake (g/day)} &= -59,9 + 25,8 (\% \text{ IVDOM}) \\ r &= 0,85\end{aligned}$$

As depicted in Fig. 12, the intake of impala in the present study increased significantly when the quality and digestibility of forage increased during summer (wet period).

The negative correlation between IVDOM and a combination of lignin and CP in a multiple linear regression gives a very high correlation coefficient of 0,9. Lignin content seems to be the main determinant of *in vitro* digestibility which is in agreement with results obtained by Engels, *et al* (1971) with sheep:

$$\begin{aligned}\text{IVDOM (\%)} &= 66,7 - 2,6 (\% \text{ lignin}) + 1,3 (\% \text{ CP}) \\ r &= -0,90\end{aligned}$$

The relationship between IVDOM and ADF was tested but a poor correlation coefficient existed ($r = 0,26$). This may be due to the relatively small variation in ADF content of selected forage. Acid detergent fibre therefore cannot be used for predicting digestibility of forage grazed by impala.

From the results of the present study it is evident that lignin content of grazing seems to be a limiting factor in the digestibility and DM intake of available plant material.

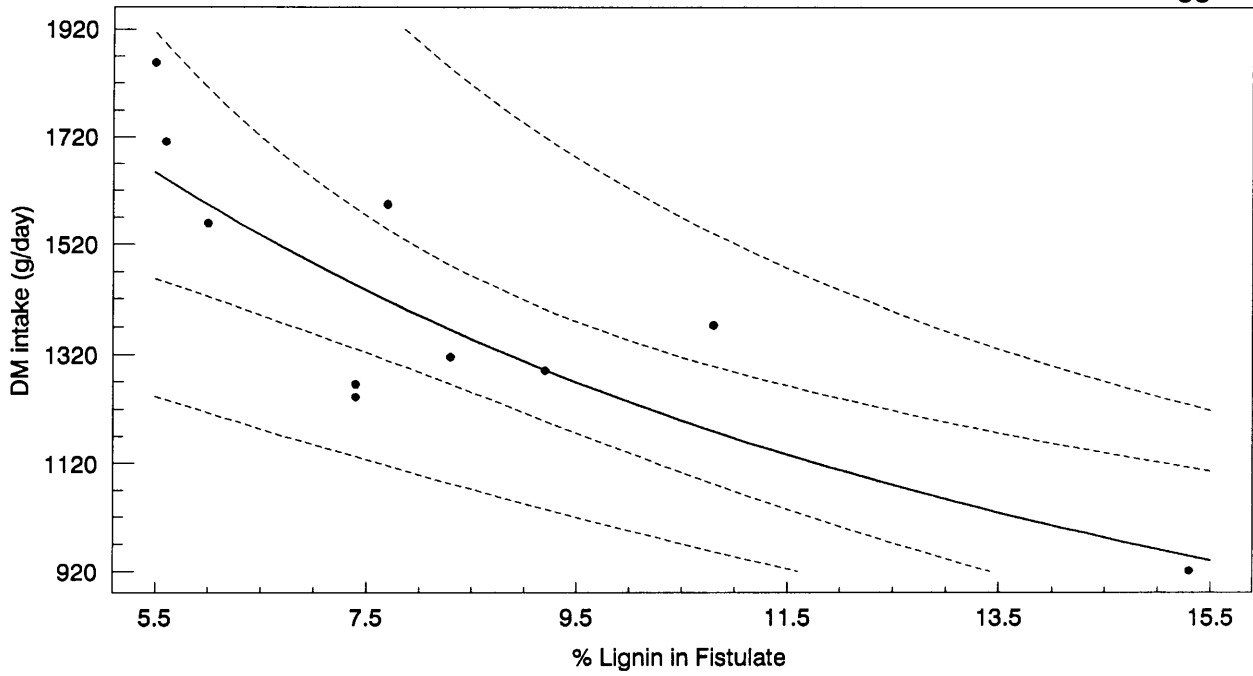


Figure 11. DM intake of impala as affected by lignin content.

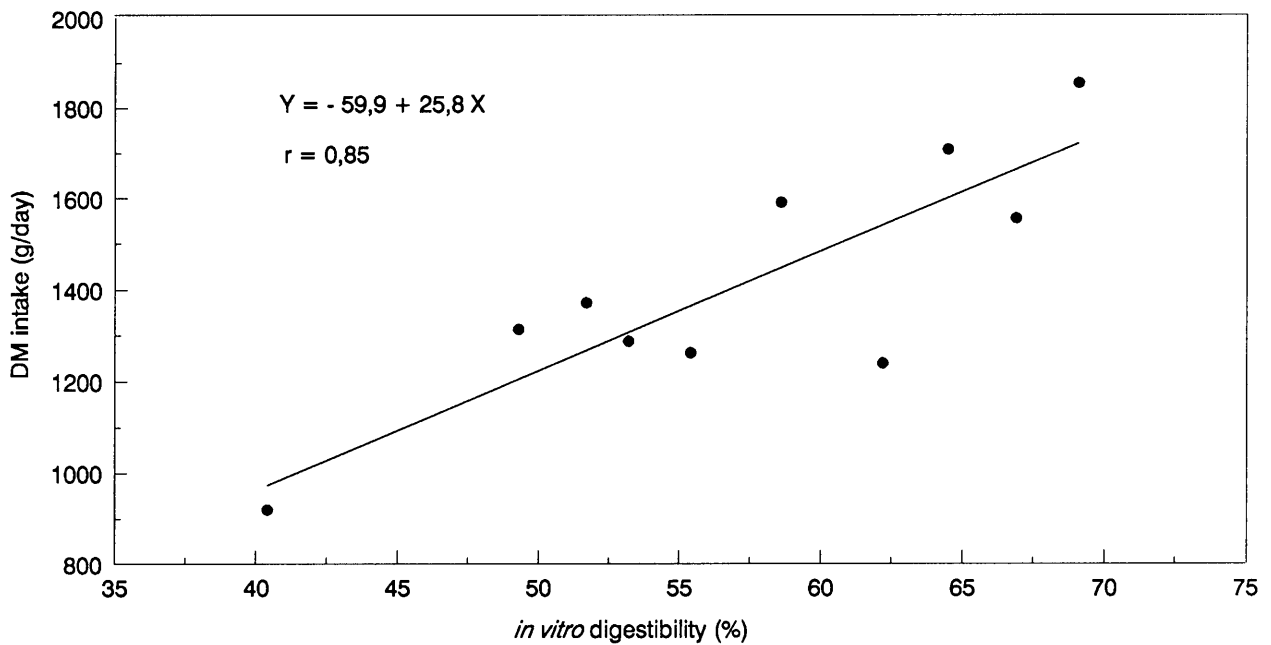


Figure 12. DM intake of impala as affected by *in vitro* digestibility.

3.6 DISCUSSION

3.6.1 Efficacy of methodology

One of the objectives raised was to find a suitable method whereby intake of free-roaming wild ungulates could be estimated. Judging from the success rate, the digestibility technique where samples are taken from oesophageally fistulated impala, while faeces excretion is measured using faeces bags, is apparently very suitable and a recommended method to use. Generally, the animals adapted well to fistulation and the attachment of faeces bags and the latter had no significant effect on intake (2.4). It is important to have relatively tame animals available for this type of study as this makes handling easier and decreases their stress level which otherwise may affect intake. The impala were able to graze and select freely, but were still confined to a smaller area than the ideal situation, i.e. being able to roam freely within their home range. This was one of the limitations of the study. Another was that the animals only had access to a certain veld type, i.e. open *Acacia nigrescens* woodland with scattered *Grewia* species and a grass stratum consisting mainly of *Panicum maximum* and *Themeda triandra* (See 3.3.2). This particular area is known to be favoured by impala and the results are an indication of the quantity as well as the quality of food eaten on this particular veld type. It would be preferable to sample other habitats in future studies.

The influence of different rumen inoculums on botanical composition of *in vitro* digested residues was not evaluated. Based on data from Blankenship, Varner & Lynch (1983), it is doubtful that the source of inoculum has a significant influence on results. Their study showed that donor animal species and diet have a small effect on the extent of *in vitro* digestion. Using inoculum from goats / sheep fed good quality lucerne hay would probably not affect results. This assumption nevertheless should be tested in further studies, particularly as Boomker (1987), working with kudu (*Tragelaphus strepsiceros*) emphasizes the importance of using inoculum from the particular animal species to be studied. However this will depend on the food consumed. Kudu are browsers and consume browse from trees, shrubs and forbs

which may contain tannins which could have an effect on *in vitro* digestion (Barry & Blaney, 1987; Acheampong-Boateng, 1991). Because 80% of all shrubs and 15% of forbs contain tannins (Rhodes, 1979; cited by Hobbs, 1987) and impala ingest a reasonable amount at certain times of the year, only rough estimates of dietary quality may be possible according to Arman, Hopcraft & McDonald (1975). The impala in the present study ingested some browse in May to July which could have affected results, but by and large, grass formed the bulk of the diet (sometimes 90% and more). A further assumption is that the *in vitro* technique was suitable to predict *in vivo* digestibility of impala. The equation proposed by Engels *et al* (1981) was developed for subtropical grasses ranging in digestibility from 40 to 70%. Since this range was similar to the present study (Table 9) we are satisfied that our approach was acceptable.

One criticism could be that the sample size was too small and that the results obtained from 4 impala may not be sufficiently accurate to extrapolate to other impala. From analysis of results it is obvious that variation between individuals was small and that the results obtained from these animals could be a true reflection of the quantitative and qualitative intake of other impala. Speculatively this seems to be an evolutionary adaptation of impala where the survival of the fittest has led to this remarkably small variation between individuals. In follow-up studies by Serfontein (unpublished) the small variation was once again noted.

The statement that a hand-reared animal may select differently to his wild counterpart, may not hold true. In this case two hand-reared animals, 18 months old by now, plus two which had been captured in the wild at six months of age and at 30 months were a year older than the former two, selected similar diets. This means that neither age difference (1 year), age at capture or hand-rearing had any negative effect on selection and intake.

3.6.2 Comparison of results with relevant literature

The study of Skinner, Monroe & Zimmermann (1984) on Nylsvley Nature Reserve presents some basis of comparison (Table 12), although the methodology differs considerably. Data obtained by these authors was from one single tame male impala using simulated hand-picked diets or from the rumen contents of shot impala. Composition of the diet and total daily intake was calculated after measuring biting rates and estimating bite sizes. Data may be biased and inconclusive and may not offer a reliable comparison (Theurer, Lesperance & Wallace, 1976; cited by Howery & Pfister, 1990), due to the apparent ability of wild ungulates to select the most nutritious forage available (Swift, 1948). Faeces production was measured monthly during a three day period of confinement of the tame impala. The impala was studied for one 24-hour period each month for a year which also may not offer reliable results. Unwashed rumen content may be affected by rumen microbiota as well as recycled urea as stated by the authors themselves.

Table 12. A comparison of some aspects of the feeding behaviour of impala at Nylsvley and Timbavati Nature Reserves (Av. of 50 kg animal)

	Nylsvley	Timbavati
OM intake (g/day)	850 - 1100	835 - 1650
% of body weight	2,1 - 2,6	1,7 - 3,3
OM excreted (g/day)	290 - 420	350 - 580
OM digestibility (%)	57 - 69	40 - 69
CP in food (%)	16 - 29	6 - 13
CP in faeces (%)	17 - 20	6 - 10

As can be seen in Table 12 the results of Skinner *et al* (1984) underestimated the upper limit of intake, in comparison to our results, while faeces excretion was also less. Organic matter digestibility at its lowest level in Nylsvley was also far higher than our lowest level.

The biggest difference is the CP content of the food and faeces. Results of the present study were determined using oesophageal samples, while those at Nylsvley were determined from unwashed rumen contents of shot impala as well as from a handpicked simulated diet. Obviously the rumen microbiota as well as recycled urea in the rumen influenced the results, while, as mentioned, the handpicked sample may not be an accurate assessment of intake. According to Skinner *et al* (1984), dicotyledons made up an average of 33% of wild impalas' diet and increased to 70% during the dry season. This is in contrast to Engelbrecht (1986), where the highest browse content was 33% and Owen-Smith *et al* (1985), where browse contributed 25% on average. This contradiction could be due to different habitats. The high browse content of the diet of the Nylsvley impala could contribute to the high CP intake as Rees (1974) states that there is a high level of protein in dry season browse. Our results agree (Table 10). Firebreaks were also readily used during early summer due to the availability of young green nutritional grass which would increase CP content. Rainfall could also have been a contributing factor as a higher rainfall would increase the nutritional value of grazing.

Contrasting results are partly due to the two different sampling methods. Using an oesophageal sample would be more accurate than a hand-picked sample as the latter could be inaccurate (Theurer *et al*, 1976; cited by Howery & Pfister, 1990). Data from Skinner *et al* (1984) was also very limited. Another consideration is that the two different habitats and therefore vegetation composition as well as rainfall would play a role. This habitat difference can be seen in a comparison of results offered by Klein and Fairall (1986). They compared protein, neutral detergent fibre (NDF) and acid detergent lignin (ADL) in impala faeces in three different areas in the Transvaal. These results are presented in Table 13. It is interesting that values of CP in the Kruger

National Park are much higher than those in the Timbavati in spite of similar habitats. Rainfall could be a determining factor as this would increase forage quality.

The NDF content of all samples fell within the same limits. Acid detergent lignin content was uniform throughout though the percentage was slightly higher in the Timbavati.

In another study by Fairall & Klein (1984) impala were seen to have very high faecal CP values of $\pm 17\%$ in comparison to Blesbok while Skinner *et al* (1984) found a CP content of 22% in unwashed rumen samples. In the present study, faecal CP values varied between 6,1 and 12,9%. The CP content of 17% seems exceptionally high but this could be due to rainfall, habitat differences and the high intake of forbs and shrubs. As reflected in a study by Erasmus, Penzhorn & Fairall (1978) there was a positive correlation ($r = 0,73$, $P < 0,05$) between protein content of the feed and that of faeces on a pelleted ration. However, this correlation is food specific and should not be used in the determination of an unknown diet as selected by an animal (Erasmus *et al*, 1978; Church, 1969).

Fairall & Klein (1984) and Klein & Fairall (1986) collected faeces samples in the field immediately after being dropped.

Table 13. Percentages of protein, NDF and ADF in impala faeces

	Derdepoort Aug/Oct	SA Lombard Reserve Oct	Kruger Nat. Park Sept	Timbavati Aug/Oct	Timba- vati Year Average
CP	14,71	11,21	12,81	6,27	7,8
NDF	58,32	60,03	57,5	55,7	56,6
ADL	17,69	17,21	17,44	20,6	23,5

A study by Boutton, Tieszen and Imbamba (1988) on the grassland vegetation of the Nairobi National Park and Masai Mara Game reserve concluded that crude protein levels of the live grass compartment fall below maintenance levels required for ruminants, ie. 5% CP (A.R.C. 1965). This implies that herbivores in East African grasslands experience seasonal shortages of nutritionally adequate food during dry seasons. Sinclair (1975) confirmed that this happens at Serengeti National Park. It has been suggested that a dietary level of 0,9 - 1% N ($\pm 7\%$ CP depending on protein degradability) is the minimum necessary to prevent impairment of rumen function (Dietz, 1965 cited by Howery & Pfister, 1990).

It is evident from present data that CP intake decreases to below maintenance levels especially during the critically dry period of October when browse is virtually non-existent and before the beginning of seasonal rains. The average CP % was 6,1%. This implies that impala in the Timbavati also experience seasonal deficiencies of nutritionally adequate food especially if one takes into consideration that wild herbivores and therefore impala select the most nutritious plant species and plant parts available in the habitat (Sinclair, 1974; Owen-Smith, 1982; McNaughton, 1985) and the N content of their food is usually greater than the average concentration available in the habitat. The effect that browse has on CP values is seen during May when individual CP levels of intake fell below 6% during the sampling period. The moment adequate amounts of browse were made available CP levels increased considerably. Rodgers (1976) states that dicotyledons (browse) have a higher nutritional content especially in the dry season (Rees, 1974).

In comparison to sheep (merino wethers) grazing on natural pasture at Glen in the Orange Free State (Engels *et al*, 1975), impala generally eat more (1400 g/day compared to 1300 g/day) especially during the wet summer months (1800 g to 1300 g). A comparison of chemical composition and *in vitro* digestibilities showed that average CP values of sheep were higher (11,94%) than impala (9,7%) while IVDOM values of impala varied between 40 and 69% and those of sheep between 49 and 67% (Engels, van Schalkwyk, Malan & Baard, 1971). ADF and cellulose values were similar while lignin content of the sheep diet was much higher with an average of 12% (8 -

18%) compared to the 9% of impala (5 - 15%). The average weight of 45 kg of the merino wethers was similar to the average weight of the impala.

3.6.3 Energy requirements

Meissner (1982) calculated energy requirements of game animals, including impala, to facilitate estimates of carrying capacity. Due to a shortage of data a theoretical approach had to be adopted in many cases, which led to a few assumptions because no actual intake figures were available as mentioned before. Data from the present study may be used as a comparison to see to what extent the published estimates fall within the range of the needs of impala. Estimates are depicted in Table 14. For digestible energy (DE) intake, an energy with combustion value of 18,4 MJ/kg DM was assumed and metabolizable energy (ME) was taken as 82% of DE (A.R.C. 1965).

The calculations suggest that DM intake of adult male impala can vary between 2 and 3% of body mass depending on quality of diet.

As shown in Table 14, energy intake in the present study varied between 0,4 and 0,83 MJME/kg $W^{0,75}$ /day depending on the season and quality of food available. The average DM intake and *in vitro* DOM obtained in the study was 1,4 kg/day and 57,2% respectively (Table 9). This converts to an energy intake of 0,64 MJME/kg $W^{0,75}$ /day which corresponds to the estimate of 0,63 MJME/kg $W^{0,75}$ /day of Meissner (1982) for 2 year old males.

The low intake in the dry season was primarily due to poor quality of available forage (*in vitro* DOM 40 to 50%) rather than lack of quantity, because sufficient forage was available to allow free selection. Under natural conditions the quantity of available forage also becomes limited in the dry season, suggesting even lower energy intakes. Drastic weight losses and deaths would occur, which implies that the carrying capacity of impala should be calculated on the basis of dry season forage, energy and nutrient supply, rather than on a yearly average.

In the study of Meissner, Spreeth, de Villiers, Pietersen, Hugo & Terblanche (1990) on male elephant, the correspondence with Meissner's (1982) estimate was fairly similar (0,62 vs 0,65 MJME/kg $W^{0.75}$ /day). Tentatively it is concluded that in view of the fact that the estimates correspond for two species that differ widely in mass and feeding habits, the Meissner (1982) figures are probably sufficiently accurate to be used as guidelines for most other species. Furthermore, the correspondence in estimates between elephant and impala implies that metabolic mass can be used as common denominator to predict requirements of less well-studied game species (Mentis, 1977).

Table 14. Estimates of intake and energy requirements of 2-year old male impala weighing 50 kg at different DM digestibilities.

	<i>In vitro</i> DOM (%)			
	45	55	65	57*
DM intake, kg/day	1,10	1,35	1,60	1,40
DM intake, % of body mass	2,20	2,70	3,20	2,80
ME intake, MJ/day	7,45	11,2	15,7	12,0
ME intake, MJ/kg $W^{0.75}$ /day	0,40	0,60	0,83	0,64

Comparison with Meissner (1982):

2-year old male,	MJ/kg $W^{0.75}$ /day	0,63
adult male,	MJ/kg $W^{0.75}$ /day	0,57
adult non-lactating female,	MJ/kg $W^{0.75}$ /day	0,59
adult, lactating female,	MJ/kg $W^{0.75}$ /day	0,80

* Average of study

CHAPTER 4

4.1 CONCLUSIONS AND RECOMMENDATIONS

Judging from the success rate, the digestibility technique using oesophageally fistulated impala to obtain representative dietary samples consumed by the animals is apparently very suitable and a recommended method to use.

Generally the animals adapted well to fistulation as well as to the attachment of faeces bags for faeces collection and the latter had no significant negative effect on intake.

The influence of different rumen inoculums on *in vitro* digestion of impala needs to be considered in future studies as well as the effect that tannin content of browse may have on the results.

Once the *in vitro* digestibilities were calculated, the *in vivo* digestibility of pasture was estimated using regression equations which described the relationship between *in vitro* and *in vivo* as determined by using domestic animals. It is important for future studies to calculate regression equations for wild ungulates and specifically impala.

The animals were studied in free-grazing conditions but only had access to a certain veld type. Future studies need to concentrate on different habitats.

Variation between impala regarding intake and quality of selection was extremely small. There were no significant differences between individuals and no impala/month interaction. This would seem to be an evolutionary adaptation for survival by impala and suggests that fewer animals can be fistulated for this type of study. It also means that neither the age difference of a year (animals were between 18 and 30 months old), the age at capture or hand-rearing animals had any negative effect on qualitative or quantitative selection.

Intake and digestibility of grazing were at their lowest during Autumn, mostly due to the high lignin content of grazing. May is the peak of the rutting season in this area and it was obvious that the impala were certainly rutting though not in contact with ewes. This possibly could have had a negative effect on DM intake and values decreased to 900 g/day. During the summer months (rainy season) intake realised values of 1900 g/day during December. Dry matter intake averaged 1400 g/day and faeces output 580 g/day. Total rainfall during the wet and dry periods was 411 mm and 65 mm respectively.

The digestibility of OM as well as cell wall constituents (ADF, NDF, cellulose, hemicellulose) was significantly lower during the dry period than during the wet period. The increased lignin content during the dry months resulted in low digestibility of OM but cell wall constituents still realised a relatively high digestibility, especially the more soluble hemicellulose.

Crude protein intake was significantly higher during the wet season than during spring, but lower than during winter when the impala apparently selected significant amounts of browse. October registered the lowest CP values being toward the end of the dry season with little good quality food available. Results seem to suggest that impala experience seasonal shortages of nutritionally adequate food during dry seasons, especially toward the end of the season before the commencement of spring rains.

Lignin content seems to be the main determinant of *in vitro* digestibility and DM intake, with some additional variation being accounted for by variation in CP content.

It is possible to predict DM intake with a linear regression equation using lignin % but a better relationship exists between the reciprocal of DM intake and lignin % ($r = +0,88$). A multiple linear regression equation using lignin and CP % offers another good predictor of intake ($r = -0,87$).

A strong positive linear relationship ($r = 0,85$) exists between DM intake and IVDOM suggesting that impala in the present study increased their intake significantly when the quality and digestibility of forage improved during the summer months.

Using a multiple linear regression with lignin and CP % as variables, it is possible to predict the digestibility of forage fairly accurately ($r = -0,9$).

The relationship between IVDOM and ADF was very poor and this cannot be used as a predictor of digestibility.

Data from the present study was used in comparison to published estimates by Meissner, Hofmeyr, van Rensburg & Pienaar (1983) to test the accuracy of these figures. The mean DM intake of 1,4 kg/day calculated in the present study converts to a ME requirement of 650 - 700 KJ/day for a 45 - 55 kg male impala. This closely resembles Meissner's (1982) estimates of 630 KJ/day. Therefore these published estimates may be considered sufficiently accurate to be used as a guideline for impala. DM intake of male impala varied between 2 to 3% of body mass, depending on diet quality.

4.2 SUMMARY

1. Despite the wealth of scientific publications little attention has been paid to stocking rate of wild animals and how it should be calculated (Mentis, 1977). In sheer numbers, impala are the most abundant antelope species in the Transvaal and may have the greatest impact on grazing. A critical factor that determines carrying capacity is intake and no direct measurement of the intake of free-roaming antelope seems to have been made. By measuring food intake, which together with grazing condition, water availability and shelter, are limiting factors regarding carrying capacity, the nutritional needs of impala were determined. These figures could serve as guidelines for estimating carrying capacity.
2. Four 18 - 30 month old partially tamed impala males weighing between 40 and 55 kg were oesophageally fistulated (Visser *et al*, 1990) to obtain samples of forage eaten. The digestibility of these samples was determined using the *in vitro* technique (Tilley & Terry, 1963) as modified by Engels & van der Merwe (1967) regarding N supplementation. The *in vivo* digestibilities of the pasture samples were then estimated using the regression equation $Y = 16,4205 + 0,7892 X$ (Engels *et al*, 1981).
3. Faeces samples were collected using nylon canvas bags harnessed to the animals (Arnold, 1960, cited by de Waal, 1980).
4. From knowledge of quantitative faeces excretion as well as *in vivo* digestibilities, food intake of impala was calculated:

$$\text{Intake OM (g/day)} = \frac{\text{Faeces OM (g/day)}}{100 - \% \text{ digestibility OM}} \times 100$$

5. Other parameters studied were:

N content of food and faecal samples using Kjeldahl and converting to CP by multiplying by 6,25. To compensate for N loss when squeezing through cheese cloth, the following equation was used: $Y = 0,017 + 1,1307 X$ (Engels *et al*, 1981).

Cell wall constituents (NDF, ADF, hemicellulose, cellulose and lignin) were determined or calculated using the methods described by van Soest and Wine (1967).

The approximate digestibilities of cell wall constituents were calculated from knowledge of the percentages present in the food and faeces.

6. All results were analyzed by one-way analysis of variance procedure using the General Linear Models programme (S.A.S. 1985) followed by the Bonferroni or Duncan t-test or f-test. Means and standard deviations of all parameters were determined.

7. A number of preliminary tests were conducted:

- i) the viability of using hand-reared animals was tested as it was feared that these impala may select differently to their wild counterparts. Results concluded that there was no significant difference with regard to food selection.
- ii) the effect that long-acting tranquillizers (piportil and trilaфон) may have on food intake by impala, was assessed. The conclusion was that it is not possible to use these tranquillizers as they had a significantly depressing effect on intake ($p < 0,05$). It is feasible to use the tranquillizers in the taming process of the impala, but not during food intake trials.

iii) it was feared that the attachment of faeces bags may negatively affect DM intake, but trials proved to the contrary and this method of faeces collection was used.

8. The study was conducted in the area around the Hans Hoheisen Research Station within the Timbavati Private Nature Reserve. Habitat composition consisted mainly of *Acacia nigrescens* woodland, *Grewia* species and *Securinega virosa* shrubs. The grass stratum was dominated by *Panicum maximum* followed by *Themeda triandra*.
9. Variation between impala regarding quality of selection as well as DM intake was extremely small - 2,6% for CP, 4,2% for IVDOM, 0,7% for NDF and 7,8% for lignin. There were no significant differences between individuals suggesting that fewer animals may be fistulated for this type of study.

Crude Protein selected varied between 6 and 13% on a DM basis, was significantly higher in the wet season than during August to October, but lower than during May to July when the impala selected significant amounts of browse. October realised the lowest CP values being toward the end of the dry season. Results seem to suggest that impala experience seasonal shortages of nutritionally adequate food during dry seasons as suggested by Sinclair (1975) and Boutton *et al* (1988).

Digestibility of OM and cell wall constituents were significantly lower in dry months than during wet months. *In vitro* digestibility of OM varied between 40 and 70 % and DM intake between 900 and 1900 g/day in the dry and wet seasons respectively. There was a pronounced decrease in intake in May, digestibility and DM intake increased considerably and lignin % decreased. May is the peak of the rutting season for impala in this area. It was clear that the animals were rutting and this obviously could have had a negative effect on intake.

Total cell wall (NDF) averaged 66,6% (58 - 72%) and less available lignified tissue (ADF) averaged 41,3% (36 - 45%). Hemicellulose averaged 25,2% (20 - 31%) and cellulose 28,6% (23 - 32%). The primarily grass diet of impala contained 5 - 15% lignin, depending on the season, and increased considerably during the dry month of May. The increased lignin content during the dry months resulted in low digestibility of OM but cell wall constituents still realised a relatively high digestibility, especially that of hemicellulose. Seasonal differences with regard to all parameters were highly significant.

10. Most of the variation in intake and digestibility was explained by variation in the lignin content of oesophageal extrusa, with some additional variation being accounted for by variation in CP content. The following prediction equation was calculated:

$$\begin{aligned} \text{DM intake (g/day)} &= 2035 - 75\% \text{ lignin} \\ r &= -0,81 \end{aligned}$$

but a stronger relationship ($r = 0,88$) than this linear line existed between the reciprocal of DM intake and % lignin. The linear equation can be improved by the addition of CP as another independent variable in a multiple linear regression equation:

$$\begin{aligned} \text{DM intake (g/day)} &= 1640 - 79,8 (\% \text{ lignin}) + 45,5 (\% \text{ CP}) \\ r &= -0,87 \end{aligned}$$

The negative correlation between IVDOM and a combination of lignin and CP realised a high correlation coefficient:

$$\begin{aligned} \text{IVDOM (\%)} &= 66,7 - 2,6 (\% \text{ lignin}) + 1,3 (\% \text{ CP}) \\ r &= -0,9 \end{aligned}$$

The correlation between IVDOM and ADF was poor and ADF cannot be used as a predictor of digestibility.

The intake of impala in the present study increased significantly during the wet period when the quality of grazing increased, It was evident that the lignin content of grazing seems to be a limiting factor in the DM intake and digestibility of forage.

11. Dry matter intake figures were calculated for impala and compared to published estimates in use (Meissner *et al*, 1983).

The mean DM intake of 1,4kg/day converts to a ME requirement of 650 - 700 KJ/day for a 45 - 55 kg male impala. This closely resembles published estimates of 630 KJ/day and may therefore be considered sufficiently accurate to be used as guidelines for impala. DM intake of male impala varied between 2 and 3% of body mass depending on diet quality.

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