Final Technical Report

R6166: Effect of feed quality and time of access to feed on feeding behaviour and nutrient intake of tropical cattle and donkeys.

Executive Summary

Purpose Improved seasonal availability and utilisation of local feed resources for livestock production in crop-livestock systems and promotion of appropriate feed management strategies.

Research activities: Techniques for the estimation of dry matter intake (DMI) and the measurement of foraging behaviour were developed for application in tropical countries

An experiment with penned-animals using cattle, 4 donkeys and ponies was carried out in Scotland. These animal were given eight hour access to either alfalfa, haylage or straw, between 09:00 and 17:00 h. In cattle, restricted feed access only resulted in reduced dry matter intake (DMI) when straw was fed. However, in ponies and donkeys, restricted feed access (8-hours) reduced DMI of three diets fed. Cattle, ponies and donkeys all spent significantly (P<0.00 less time eating when fed alfalfa than when fed haylage or straw. The effect of restricting access to feed was more severe for equids than for cattle because the rates of intake by the former were slower and, because the equids had to complete comminution before they could swallow

In Alemaya, Ethiopia, rangeland study of cattle was conducted during both the wet and dry seasons using *in vitro* dry matter digestibility (DMD) and an external marker to estimate DMI. Three groups of 4 cattle were provided with either 7-hour pasture access, 7-hour pasture access and hay supplement during kraaling, or -hour pasture access. Cattle with 7-hour access to pasture alone achieved the same DMI as cattle with -hour access with 7-hour access and hay supplement. There was no apparent advantage to extending grazing period or to providing hay supplement.

At Matopos, Zimbabwe, rangeland study with 1 cattle and donkeys was conducted during both the wet and dry seasons. Each species group (cattle and donkeys was divided into three sub-groups of four; each sub-group was given was given either 8-, 1- 23-hour pasture access. Cattle with -hour pasture access achieved DMI similar to those of cattle with 24-hour access. The DMI of cattle with 8-hour access to pasture **was** only significantly (P< 0 1 less than the -hour access group during the wet season. Restricting time of access to pasture had significant

depressive effect (P< 0.00 the DMI of donkeys with both 1-hour and 7-hour access during both seasons. Increasing the time available for eating from 8 to hours had no significant effect on the DMI of donkeys. Cattle compensated for restricted feeding time (RFT), firstly, by increasing bite rate and then, by increasing eating time per hour (ETPH). Increased bite rate was achieved at the expense of diet quality in cattle with 8-hour access to pasture during the dry season. The donkeys with free access to pasture spent significantly (P<0.001 longer grazing (16 hours per day) than cattle (0 hours). Treatment groups with 8- and 1-hours of available eating time spent 95 % of this time, grazing. Donkeys only increased bite rate to compensate for restricted eating time when pasture access was restricted to 8-hours.

Outputs: This project has produced recommendations that will contribute to the development of separate management strategies for donkeys and cattle, particularly for working animals

- Restricting donkeys' pasture access results in greater live weight losses during the dry season and smaller live weight gains during the wet season, as consequence of both reduced DMI and diet quality
- Management strategies that increase donkeys pasture access will result in better work output from these animals, at little or no extra cost to farmers.
- Grazing management strategies for donkeys need to be devised locally take account of feed resource priorities and to avoid possible conflicts with crop farmers.

Contribution to DFID's development goals: Application of improved donkey management strategies will result in better performance of this class of livestock, particularly in crop-livestock systems.

Background

One of the main constraints to improved crop production under tropical conditions is lack of sufficient feed resources to sustain required levels of work from donkeys used for draught. This problem is often exaggerated where access to feed is restricted, for example where part of the day is taken up by work. Access to feed may also be limited in areas where land is intensively cropped and animals are tethered to prevent them causing damage. Under-nutrition may result in decreased

production in terms of growth, milk production of nursing animals, reproductive activity and work output, with the consequent effects crop yields and area cultivated This project is aimed at the following needs

). the need to maintain adequate feed intakes where there restricted access to grazing feeds,

.) the need to animal and feed resources efficient sustainable way minimising the impact the ironment.

Studies at CTVM with buffalo and cattle showed that food intake remained the same whether animals were allowed 20 24 hours access to diets based barley straw. Working the same animals for four hours during the restricted food access period also had significant effect food intake (Pearson and Smith, 994) When time available for eating reduced to only hours per day, dry matter intake of buffalo and cattle lower than when they given 24 hour to food Furthermore, when the animals were worked for hours per day and had the total feed access time limited to hours, dry matter intakes were lower than either the 24 hour food access treatment the hours food access treatment access and Smith, 994 These results indicated that, poor quality diets, working buffalo and cattle couldn maintain food intake where loss of feeding time exceeds four hours

Studies by Bayer 990 and Smith 96 have shown that cattle are able to compensate for limited access to grazing by ETPH Bayer 990 found that Fulani cattle not any more productive when given hours access to grazing than when given hours Smith 96 unable to show any difference productivity between cattle with 24-hour access to grazing and those with hours access in Zambia However, both cases the ability to compensate depended the quality and density of the pasture forage Cattle unable to compensate for severely restricted grazing time where pasture forage sparse and of low quality because of insufficient time to selectively harvest adequate diet.

Work in Ta under the FMC project X0 86 has shown that dry female goats grazing tether for 4 hours have similar intakes to goats tether-grazing for hours (Romney *et al.*, 996) Goats were able to compensate for the shorter time available for grazing by eating for larger proportion of the time and by increasing intake rates.

Ruminants are able to maintain food intake when feed access time is limited by compensating with either faster eating rates or spending a greater proportion of their time eating when feed is available. However, the ability of the animals to compensate is limited by the quality of the food on offer and the degree to which the access to food is restricted. Tropical feed resources could be used more efficiently if methods were devised to enable animals to maximise their ability to compensate for the loss of eating time imposed by traditional grazing practises, tethering or work.

The demand for this project was identified through stakeholder meetings carried out in Ethiopia (British Council funded project) and Zimbabwe (Project R5926). In Zimbabwe, the issue of pasture access time is of particular relevance because it is one of the features that distinguishes communal livestock management from more productive commercial livestock management. Furthermore, in sub-Saharan Africa the role of donkeys as draught animals was identified as being increasingly important and little was known about sustainable management techniques to improve their productivity.

Project Purpose

Improved seasonal availability and utilisation of local feed resources for livestock production in crop-livestock systems and promotion of appropriate feed management strategies. Restricted nutrient intake is probably the largest single factor which limits the productivity of grazing animals (Hodgson, 1982) and night-kraaling may further limit nutrient intake by restricting foraging time. Furthermore, although the quality of the available forage is not affected by night-kraaling, there is limited evidence to suggest that animals which were closer to satiety selected a better quality diet than those that were more hungry (Hatfield *et al.*, 1990). Improving the knowledge about how traditional African grazing systems affect nutrient intake of cattle and donkeys will contribute to the development of sustainable strategies for improving the performance of livestock.

Research Activities

Method development

Estimation of dry matter intake at pasture using the ratio technique

Although not ideal, the ratio technique was considered most suitable for application under rangeland conditions. Several research objectives were established with the aim of improving the reliability of the ratio technique under these conditions. These objectives were

to develop techniques for the rapid and efficient dosing of external markers to both donkeys and cattle;

2) to test the suitability of various internal markers for the estimation of DMD in both donkeys and cattle;

3) to develop in vitro techniques for the estimation of DMD that could be applied to donkeys;

4) to develop sampling procedures that would provide representative samples of ingesta on a quantitative basis;

5) to test the suitability of the alkane-pair method of estimating DMI under tropical rangeland conditions;

6) to improve confidence in DMI estimates using several simultaneous techniques.

A rapid method for simultaneously dosing even-chain alkane and Cr_2O_3 markers that could be readily applied to both equids and cattle was developed. This system involved twice daily dosing, which resulted in a more even distribution of marker throughout the gut, thereby reducing circadian variation in faecal marker concentrations.

Several internal markers, used to estimate DMD in vivo, were tested; acid-detergent lignin (ADL) was the most reliable. However, the recovery rates of this marker must be established using penned animals, in order that the measured values of ADL in the faeces could be adjusted for incomplete recovery

An *in vitro* DMD technique, based on Tilley and Terry (1963), was developed that provided more reliable estimates of *in vivo* DMD than the unmodified techniques used in equine species. The modified method was used successfully to estimate the DMD of forage consumed by donkeys in Zimbabwe.

Obtaining representative sample of ingesta remains major problem if ratio methods to be used to estimate DMI at pasture. Extrusa collected from oesophageal-fistulated animals remains the method of choice for most pasture research scientists. The reliability of this method for collecting ingesta samples from free-ranging herbivores is questionable, therefore the method of obtaining representative dietary samples was by rigorous hand-plucking.

During the Zimbabwe study, several methods of estimating DMI attempted simultaneously. Two external markers were fed (C_{36} and Cr_2O_3) and the double marker ADL and C_{36}), alkane pair (C_{35}/C_{36}) and external marker (C_{36}) / in vitro DMD techniques were used to estimate DMI at pasture. When recovery values for external and internal markers, obtained from parallel-penned trials applied, there was significant difference between DMI estimates obtained using the three techniques (although the alkane pair method showed the greatest amount of variation [C.V. 54% for the reason described above. The close agreement between the three techniques increases confidence in the accuracy of the estimated values because each technique had different sources of error. Whilst this does not necessarily indicate that estimated DMI was close to the quantity of dry matter consumed, theoretical comparison between estimated DMI and predicted DMI using energetic models also showed close agreement. The use of simultaneous techniques required extra fieldwork, although laboratory analysis was increased, and thus, these techniques can be applied as readily as single method under rangeland conditions.

The techniques used to estimate DMI at pasture are still not perfect, but this project has contributed to both the testing and development of novel measurements of nutrient intake in free-range animals. More work is still required for the development of appropriate techniques, particularly in respect to the collection of quantitatively representative samples of consumed forage. The unreliability of current methods of collecting consumed forage represents the single, greatest limiting factor to the reliability of measurements of DMI by animals at pasture.

Automation of behavioural data collection and processing

The foraging behaviour of herbivores rangeland is valuable indicator of the response of animals to both the abundance and quality of the available food resource.

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devices for the complete automation of behavioural data collection were useful, they could not totally replace manual observations.

The effect of restricted grazing time on dry matter intake and foraging behaviour

The objectives of this research were: 1) to investigate the interacting effects of restricted feeding time, diet quality and forage availability on the dry matter intake of cattle and donkeys; 2) compare the foraging strategies of cattle and donkeys; 3) to examine any behavioural compensation strategies of cattle and donkeys managed under traditional African grazing systems (TAGS); 4) investigate the management implications of TAGS and explore sustainable alternatives for improving animal productivity.

An experiment with penned-animals using 4 cattle, 4 donkeys and 4 ponies was carried out in Scotland. These animal were given eight hour access to either alfalfa, haylage or straw, between 09:00 and 17:00 h. The DMI, DMD, mean retention time (MRT) and faecal output of the animals were measured over a seven-day period. Behavioural measurements were made over the subsequent seven-days. Time budgets and circadian behaviour patterns were calculated from 72 hours of observations. In cattle, restricted feed access only resulted in reduced DMI when straw was fed. However, in ponies and donkeys, restricted feed access (8-hours) reduced DMI when all three diets were fed. Cattle, ponies and donkeys all spent significantly ($P<0.001$) less time eating when fed alfalfa than when fed haylage or straw. A significant relationships ($r^2 = 0.76$, $P< 0.001$) between bite size and bite rate was measured. Bite size and the number of chews per unit mass ingested, appeared to be closely related to the physical nature and fibre content of the feed fed for both cattle and equids. The effect of restricting access to feed was more severe for equids than for cattle because the rates of intake by the former were slower and, because the equids had to complete comminution before they could swallow

In Alemaya, Ethiopia, a rangeland study of cattle was conducted during both the wet and dry seasons using *in vitro* DMD and an external marker to estimate DMI. Three groups of 4 cattle were provided with either 7-hour pasture access, 7-hour pasture access and a hay supplement during kraaling, or 11-hour pasture access. Cattle with 7-hour access to pasture alone achieved the same DMI as cattle with 11-hour access or

with 7-hour access and a hay supplement. There was no apparent advantage to extending grazing period or to providing a hay supplement. Cattle given 11-hour access utilised the additional time to graze, spending significantly ($P< 0.05$) longer grazing than those with either 7-hour access or 7-hour access and a hay supplement. Cattle with 11- hour access to pasture spent longer eating, but decreased their rate of intake by taking fewer bites per minute. Under the conditions at Alemaya, increasing the amount of time available for grazing or providing supplementary feed did not result in increased DMI.

At Matopos, Zimbabwe, a rangeland study with 12 cattle and 12 donkeys was conducted during both the wet and dry seasons. Each species group (cattle and donkeys) was divided into three sub-groups of four; each sub-group was given was given either 8-, 11- or 23-hour pasture access. Cattle with 11-hour pasture access achieved DMI similar to those of cattle with 24-hour access. The DMI of cattle with 8-hour access to pasture was only significantly ($P< 0.01$) less than the 11-hour access group during the wet season. Restricting time of access to pasture had a significant depressive effect ($P< 0.001$) on the DMI of donkeys with both 11-hour and 7-hour access during both seasons. Increasing the time available for eating from 8 to 11 hours had no significant effect on the DMI of donkeys. Cattle compensated for restricted feeding time, firstly, by increasing bite rate and then, by increasing eating time per hour. Increased bite rate was achieved at the expense of diet quality in cattle with 8-hour access to pasture during the dry season. The donkeys with free access to pasture spent significantly ($P<0.001$) longer grazing (16 hours per day) than cattle (10 hours). Treatment groups with 8- and 11-hours of available eating time spent 95 % of this time, grazing. Donkeys only increased bite rate to compensate for restricted eating time when pasture access was restricted to 8-hours.

Outputs

The penned-animal trial showed that time spent eating was related to food quality/ease of eating and that donkeys, ponies and cattle all strive to maximise rate of intake. However, under rangeland conditions, the effect of diet quality on time spent eating was confounded by forage availability. During the dry season cattle in Zimbabwe took

smaller bites and more steps per day than during the wet season, as a consequence they expended more effort to achieve a lower DMI. Donkeys had similar DMI during both the dry and wet seasons but they took more steps per day and had smaller bite sizes during the wet season than during the dry. Consequently, less effort was expended foraging when forage quality was low than when it was moderate. Cattle in Ethiopia spent similar amounts of time grazing during both the wet and dry seasons, and achieved similar levels of DMI; dry herbage mass during the wet season was almost 5x greater (131 g/m^2) than during the dry season (37 g/m^2). The influence of forage availability and quality on DMI has not been fully resolved by this project. Further research is required to investigate the effect of forage availability, forage quality and sward structure on the DMI of cattle and donkeys grazing tropical rangelands during all seasons.

In both Ethiopia and Zimbabwe, RFT had no significant effect on the DMI of cattle except in the Zimbabwe 8-h grazing group, during the wet season when DMI was reduced (Figures 1 and 2). The groups with reduced access increased the amount of time spent per hour grazing (where possible) and increased bite rate to compensate for RFT. Donkeys in Zimbabwe ate less as the time available for eating was decreased from 23 to 11-h. This effect was more pronounced during the wet season than during the dry.

The penned-animal trial showed a clear inverse relationship between bite size and bite rate; as bite size increased the rate fell (Figure 3). This relationship has important ramification on possible BCS for RFT, because bite rate was constrained by bite size and therefore, an animal's ability to increase bite rate to compensate for RFT was limited. When herbivores are foraging upon rangeland, intervals between bites are likely to be prolonged by selection/search activities. In this situation, increasing bite rate to compensate for RFT was less constrained by bite size than it is in pen-fed animals.

The rangeland studies highlighted several behavioural compensation strategies that cattle adopted to compensate for loss of eating time. They were to increase bite rate, increase ETPH and an increase the number of bites per step. Compensation strategies by donkeys have not been clearly identified and further studies are required to investigate the response of these animals to restricted grazing time under different

pasture conditions. The following discusses the foraging strategy of the species studied and goes on to explore the implications for grazing management.

Fenced night paddocks, or effective barriers around crops would allow donkeys to graze unsupervised at night, but the cost of fencing is prohibitive. Providing a limited amount of poor quality, supplementary fodder in the kraal at night would provide a sustainable method of compensating for the loss of feeding time. In cattle hay supplementation would generally depress the intake of the communal, pastoral feed resource. Donkeys that are closer to satiety select a better quality diet than when hungry, and would therefore make more efficient use of any communal feed resources. The amount of supplementary fodder offered to each animal should be limited, to ensure that they are still motivated to feed at pasture and that the majority of the dietary DM would still be obtained there

Providing small amounts of concentrate feed (0.3–0.5 kg per animal) would probably have a more beneficial effect than supplementary fodder, as the effect of level of intake on MRT would be less pronounced; consequently, fodder consumed at pasture would be digested more efficiently. Whether this is a viable option for poor farmers in developing countries is questionable. Small-scale, crop processing by-products and kitchen waste could possibly fulfil this role, although donkeys would have to compete with meat-producing livestock for this resource.

The nutritional cost/benefit of providing fodder or concentrate supplements to donkeys with restricted access to pasture is clearer than it is for cattle. Donkeys with less than 12-hour grazing time have lower DMI than those with free access to pasture, regardless of pasture availability or quality. Donkeys are seldom used for anything other than to provide power and the benefit of sustained work may not outweigh the costs both in terms of effort and lost productivity by other classes of livestock.

Contribution of Outputs

The effect time of access to pasture on DMI in two classes of livestock, cattle and donkeys, under most pasture conditions has been established. In cattle, time of access to pasture greater than 8 hours is not likely to restrict intake of unselected indigenous animals, however in donkeys restricting access time to less than 11 hours per day reduced DMI; donkeys with free access to pasture spent between 13.5 – 17 h per day foraging. During the dry season donkeys with more time in the day to feed selected a diet that was of significantly (P 0.01) better quality than donkeys with 8 hour access to pasture.

Moreover, donkeys with free-access to pasture maintained live weight during the dry season and gained more weight in the wet season than donkeys with restricted pasture access.

Donkeys compete for feed resources with other, more multipurpose, classes of livestock such as cattle, sheep and goats, supplemental feed resources, if available, are therefore unlikely to be directed toward donkeys. However, the maintenance liveweight and body condition is known to increase the longevity of draught animals and to improve their work output (Fall *et al*, 1997). The results from this project show that the nutrition of donkeys can be improved by maximising pasture access time, leading to optimal DMI and enhanced diet quality. Improved nutrition of working donkeys would lead to more timely cropping activities, leading to improved livelihoods of resource poor people of Africa, either through increased productivity from their land or as a result of improved food security.

Promotional pathways and the technological interventions required to bring about increased pasture access times for donkeys have still to be identified. Further research is required in order to develop methods which do not cause excessive increases in labour demands or conflicts with crop farmers. These methods should be devised and validated at a local level with the full involvement of community stakeholders

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Figure 1: Dry matter intake (g per kg $M^{0.75}$) by cattle in Ethiopia with pasture access time restricted to either 11 hours, 7 hours or 7 hours plus hay supplement during the dry and wet season

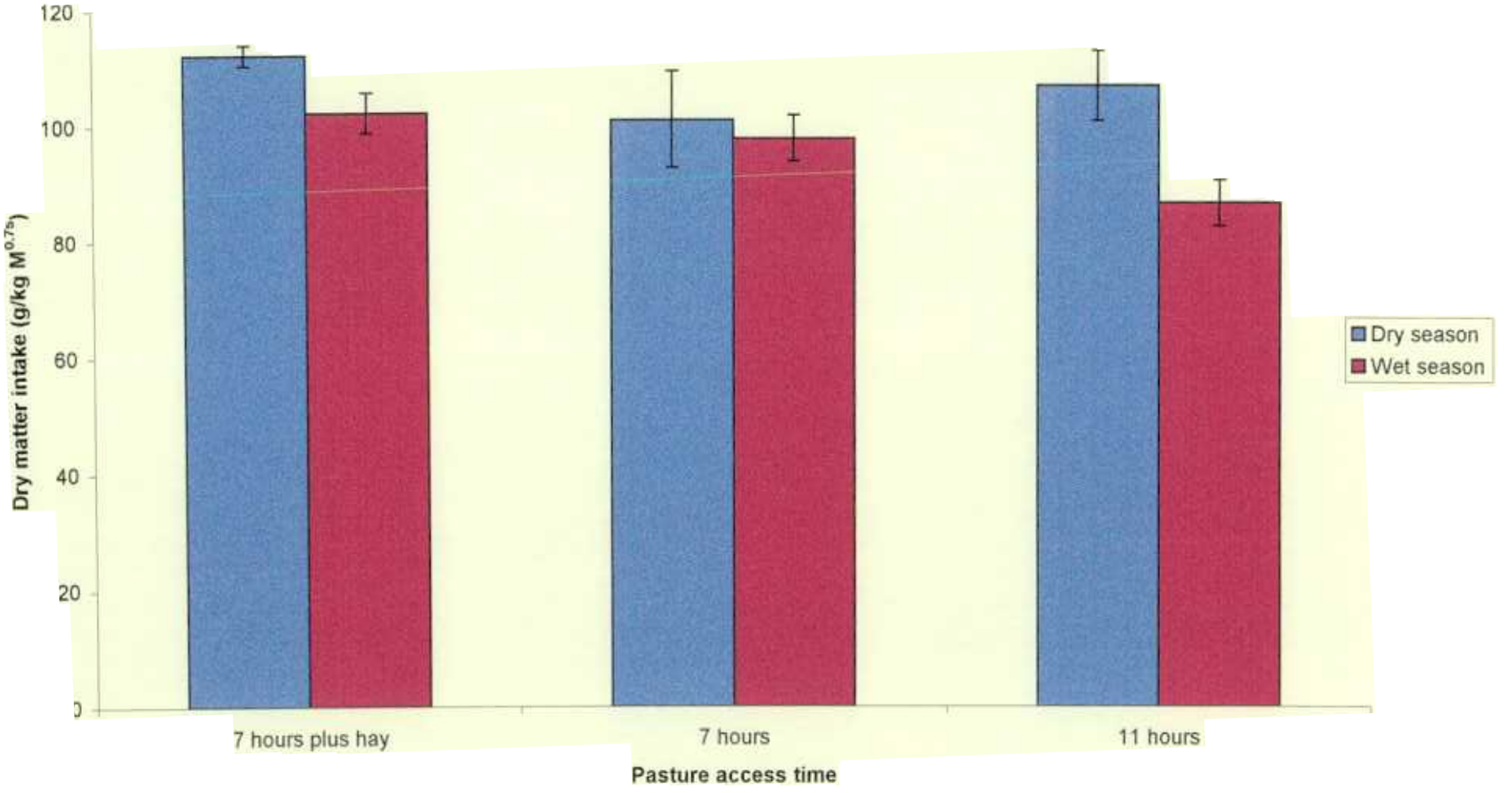

Figure 2: Dry matter intake (g per kg $M^{0.75}$) by cattle and donkeys in Zimbabwe with pasture access times of either 23, 11 or 7 hours during the dry and wet season

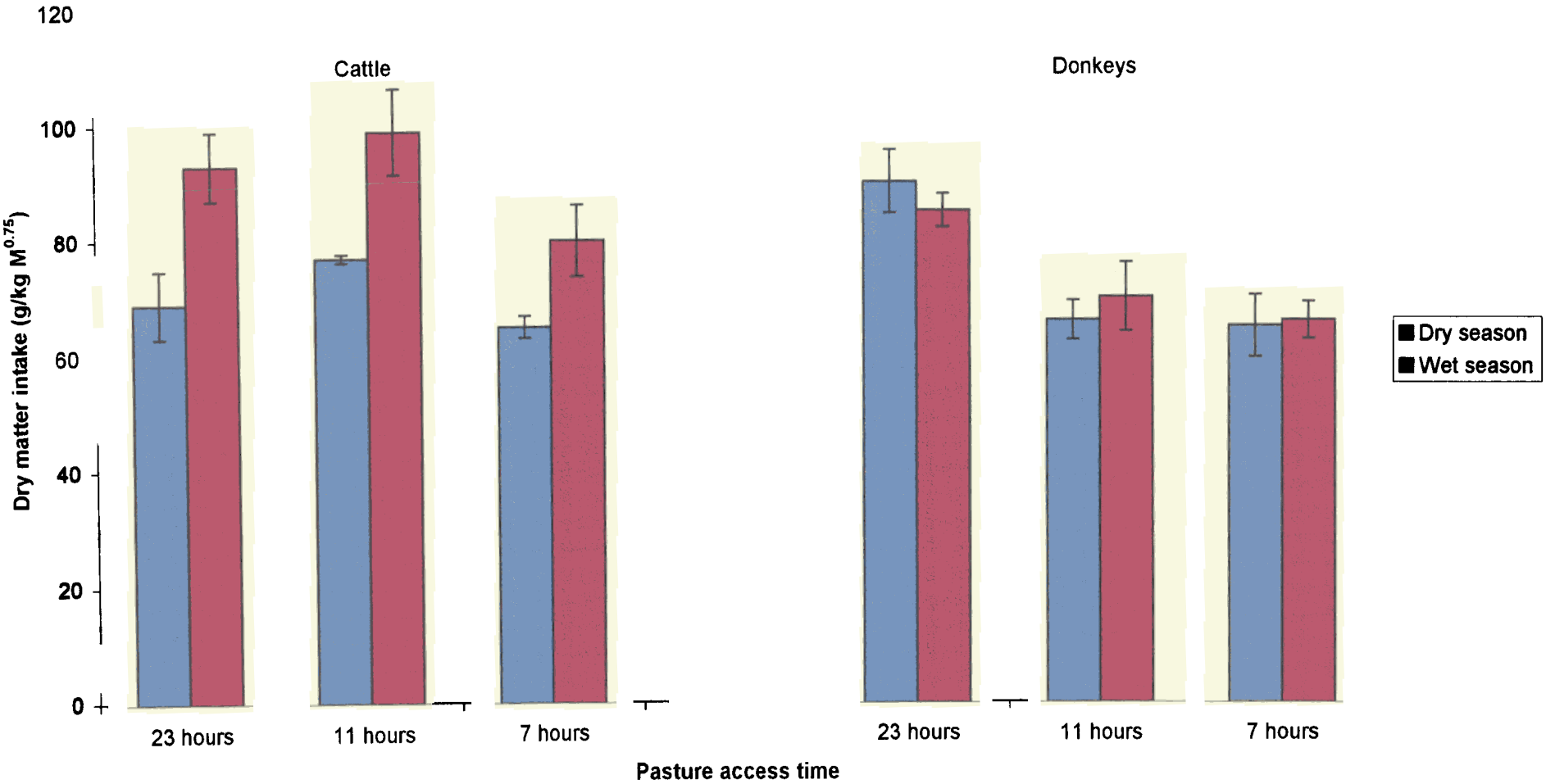

Figure 3: The relationship between bite rate (bites per minute) and bite size (mg/bite/$M^{0.75}$) measured in cattle, donkeys and ponies fed alfalfa, haylage or straw .