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The donkey as a draught power resource in smallholder farming in semi-arid western Zimbabwe 1. Live weight and food and water requirements

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Abstract

Three experiments were undertaken to assess the Zimbabwean donkey. In the first study, 191 male and 144 female working donkeys from Matopos, Nkayi and Matobo districts were weighed. Age, sex and coat colour were recorded and heart girth, umbilical girth, body length and height were measured. There were no differences ($P > 0·05$) *in live weight, 142 and 141 kg, heart girth 115 and 115 cm, body length 89 and 90 cm and height 105 and 105 cm between males and females. This suggests that draught potential might be similar between the sexes. Heart girth was the best single predictor of live weight: live weight (kg) = heart girth* $(cm)^{2·83}/4786$ ($R^2 = 0·86$). *Donkeys were similar in size to others in Africa. In the second study, the voluntary dry-matter intake (DMI) of a poor quality hay was measured for 35 days in nine male (mean live weight 150 kg) and nine female donkeys (142 kg) allocated to one of three treatment groups: water available* ad libitum, *or given every 48 h, or every 72 h. There were significant differences in daily water* ($P < 0·001$) *and DMIs* ($P < 0·05$)*: 8·5, 4·9 and 5·1 l and 3·1, 2·8 and 2·7 kg for the three treatment groups, respectively. However even with restricted access to water, donkeys maintained a relatively high DMI. In the third experiment a 3 × 3 Latin square was designed with three teams of four male donkeys each, either working (5 h/day)/no access to food (5 h/day); not working/no access to food (5 h/day) or not working/access to food 24 h/day, for 63 days. For working and non-working donkeys, there were no significant differences* ($P > 0·05$) *in DMI, DM apparent digestibility and mean retention time (MRT) of hay. Time of access to food did not influence DMI. The apparent lack of response was attributed primarily to the poor quality of the hay.*

Keywords: *donkeys, digestibility, food intake, live weight, water intake, work.*

Introduction

Cattle are the traditional source of draught animal power (DAP) in Zimbabwe. However, recurrent droughts in the last two decades have resulted in heavy cattle losses and consequently severe shortages of DAP. Smallholder farmers, the primary users of cattle DAP, have resorted to other sources of DAP, particularly donkeys (*Equus asinus*) (Ellis-Jones *et al.*, 1994). Zimbabwe has an estimated donkey population of 492 000 (Central Statistics Office, 1997) and these are increasingly being used for DAP, particularly in the semi-arid areas. It is not clear where donkeys in Zimbabwe originate from, although there have been suggestions that they came either from north Africa (Jones, 1991) or from the Horn of Africa (L. R. Ndlovu, personal communication). Therefore donkeys in Zimbabwe and southern Africa may be morphologically and genetically similar to those in north and east Africa. Despite the increase in use, there is little information on either the morphology or genetics of the Zimbabwean donkey. This information would be useful to help determine the DAP resource available to smallholder farmers.

Frame-size is a useful morphological attribute that can be determined through body measurements. Other morphological attributes such as coat colour could also contribute to genetic characterization.

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Work output is a function of live weight (Bartholomew *et al.*, 1993). Knowledge of live weight is also important when dosing or vaccinating donkeys (Eley and French, 1993) and in the assessment of nutritional requirements. Simple and practical methods of estimating live weight of donkeys have been developed elsewhere for field use (Eley and French, 1993; Pearson and Ouassat, 1996).

Wilson (1981) reported that the donkey's water conservation mechanism was second only to that of the camel. Donkeys are reportedly capable of tolerating a water loss of up to 30% from the body (Schmidt-Nielsen, 1964), levels which would be fatal in cattle. In Zimbabwe, a mortality rate of 10% was reported in donkeys, compared with 75% in cattle during the 1991-92 drought in the semi-arid areas (Ellis-Jones *et al.*, 1994).

Typically, donkeys in Zimbabwe are worked for 6 h or more per day (Ellis-Jones *et al.*, 1994). The demand for DAP is particularly high in the ploughing season when farmers prepare the seedbed for the main planting season. If an animal is working, the time available for feeding is reduced. Donkeys are also penned at night, so time of access to grazing can be severely limited on working days. Working donkeys would be expected to lose weight due to the limited feeding time and increased energy expenditure of work. The poor quality of the grazing in the tropics and the effects of the reduced feeding time and work are likely to result in a lower dry-matter (DM) intake (DMI) and weight loss in donkeys during work periods. Effects of work on voluntary food intake of horses and donkeys have been studied in temperate areas (Orton *et al.*, 1985; Pearson and Merritt, 1991) but not in tropical areas with tropical food.

Three studies were carried out in south-west Zimbabwe, on-station and on-farm: (1) to establish the morphological characteristics of working donkeys in Zimbabwe, (2) to determine the effect of water availability on voluntary food intake of penned donkeys, and (3) to assess the effect that work and time of access to food have on voluntary food intake and food digestibility by donkeys.

Material and methods

Experiment 1

Animals. Three hundred and thirty-five working donkeys from Matopos Research Station, Bulawayo, Nkayi and Matobo districts of western Zimbabwe were used in the study. These comprised 191 males and 144 females.

Measurements. Measurements were taken while donkeys were standing squarely on level ground or a wooden platform with the head up in a steady position to ensure accurate measurements. The following measurements were taken: (1) heart girth — the circumference of the chest on the caudal edge of the withers and behind the elbow (cm) which is sometimes referred to as chest girth; (2) umbilical girth — the circumference measured approximately over the umbilicus, at the widest part of the abdomen (cm); (3) body length — measured from the olecranon (point of the elbow) to the tuber ischii, i.e. diagonally (cm) according to Pearson and Ouassat (1996); (4) height at the withers — measured from level ground to the highest point on the withers (cm). Live weight, sex, age and coat colour were also recorded. Age was estimated by dentition, as described by Tutt (1987), or from the farmers' own records. The donkeys were weighed using a portable electronic system, Ruddweigh KM-2 (Ruddweigh Australasia Pty. Ltd, NSW, Australia).

Statistical analyses. Data on the body measurements for the 191 male and 144 female donkeys were initially tested separately for normality using the Anderson-Darling Normality Test (MINITAB Inc., 1994). Where the measured values for individual variables were not normally distributed or had dissimilar variances, the data were subjected to non-parametric tests (Mann-Whitney) to test for the differences between male and female donkeys. For variables which fulfilled the conditions for parametric tests, the data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure (MINITAB Inc., 1994) with sex as a source of variation. Thereafter, pooled data for the 335 donkeys were subjected to similar tests to compute, where appropriate, the medians or means of the body measurements for the group. Heart and umbilical girths, body length and height at withers were used in regression analyses to predict live weight.

Experiment 2

Animals and treatments. Nine male donkeys, mean live weight 150 (s.e. 3·6) kg and nine female donkeys, 142 (s.e. 8·7) kg, were used in this experiment. The male donkeys were 8 (s.e. 0·8) years old and the females were 6 (s.e. 1·2) years old. Three groups, of similar mean initial live weight, each comprising three male and three female donkeys, were formed and allocated to three treatments: 1 = water offered *ad libitum*; 2 = water offered every 48 h; 3 = water offered every 72 h. Mean live weights at the start of the experiment for treatments 1, 2 and 3 were, 147 (s.e. 10·7) kg, 145 (s.e. 9·8) kg and 146 (s.e. 3·6) kg, respectively. Donkeys were weighed at the start and at the end of the experiment. The experiment lasted for 35 days during the dry winter months (June and July).

Housing, watering and feeding. The donkeys were individually penned in partially roofed stalls with earthen floors. They were acclimatized to penning and individual feeding and watering for 3 weeks prior to the start of the experiment. Donkeys in each treatment group were in adjacent pens. A pen was left vacant between different treatment groups. Donkeys in treatments 1 and 3 were furthest apart. Donkeys in treatment 1 were offered water every morning at 08:00 h after recording and removal of refusals from the previous day. Thereafter, known amounts of water were added according to individual rates of consumption. On the appropriate watering days, donkeys in treatments 2 and 3 were offered water *ad libitum* for 1 h after which it was withdrawn and intake recorded. In treatments 2 and 3 the behaviour of the donkeys was recorded, for example, attitude towards the presence of water; when they started drinking; and for how long they drank in the 1 h. Donkeys were offered a poor-quality hay (crude protein (CP) 60 g/kg DM, neutral-detergent fibre (NDF) 780 g/kg DM, acid-detergent fibre (ADF) 460 g/kg DM, ash 40 g/kg DM; Spring Farm, Hay Distributors Ltd, Zimbabwe) *ad libitum*. The hay was offered unchopped twice a day, at 08:00 h and 14:00 h, in portions of up to 2 kg per donkey.

Measurements. Daily water intake and DMI, faecal DM content and live weight were measured. Samples of the hay were taken at the start, middle and end of the experiment for chemical analysis of CP, NDF, ADF and ash. Milled samples (1-mm screen) were analysed after bulking and sub-sampling. DM content was determined after oven-drying at 60°C for 24 h. Grab samples of faeces were taken in the morning before water was offered. This was done at the start, middle and end of the experiment and samples were oven-dried at 60°C for 48 h for analysis of DM content. The mean faecal DM content for each animal over the 35 days of the experiment, was calculated. CP was analysed by the Kjeldahl method recommended by the Association of Official Analytical Chemists (1990). NDF and ADF were analysed according to Goering and Van Soest (1970).

Statistical analyses. Data were analysed using the MINITAB version 10.5 statistical software package (MINITAB Inc., 1994). Analyses of variance were performed on the data using the general linear model (GLM) procedure with sex, treatments and random error as the sources of variation.

Experiment 3

Animals, treatments and experimental design. Twelve male donkeys were used in this experiment. Three groups of four donkeys each were formed and allocated to the following treatments: 1 = working (5 h/day), no access to food during this time; 2 = not working, no access to food for 5 h/day; 3 = not working, access to food (24 h/day).

The mean live weights for treatments 1, 2 and 3 were 154 (s.e. 6·9) kg, 154 (s.e. 7·0) kg and 155 (s.e. 2·4) kg, respectively. Each team was subjected to each treatment for a period of 21 days, producing a 3 × 3 Latin-square change-over design (3 treatments, 3 periods and 3 teams).

Housing and feeding. The donkeys were individually penned on concrete floors that had a two per cent slant towards a drainage canal. The food given (hay) and feeding procedures were the same as in experiment 2, except that food troughs were removed from the pens of donkeys in treatment 2 when donkeys in treatment 1 were working. The food troughs were only returned after the working donkeys had returned to their respective pens. Therefore, donkeys in treatments 1 and 2 had no access to food for approximately 5 h/day (see above). Water was available *ad libitum*.

Working regime. The work consisted of the four donkeys pulling a two-wheeled cart, with a differential and pneumatic tyres (Biddak Engineering Pvt Ltd, Zimbabwe), along a circular generally flat route of 11·3 km with no steep hills, twice daily for 5 days/week. The route consisted of 4·8 km of dirt road and 6·5 km of tarmac. The weight of cart plus load was 630 kg. Work commenced at 08:00 h and the teams had 1 h rest between each circuit. They covered a total of 22·6 km per working day. The average speed of carting for each working team was calculated. The working donkeys were spanned two abreast. Breastband harnesses, trace chains and eveners were used to hitch the donkeys to the cart.

Measurements. Daily DMI, food composition, speed of working, apparent digestibility of DM (as in experiment 2) and mean retention time of solid phase of digesta were determined.

Marker dosing and sample collection procedures. Food was removed from the troughs at least 12 h before dosing. Each donkey was dosed at 06:00 h on the 1st day of each collection period, with 50 g chromium-mordanted hay (hereafter referred to as Cr hay), containing Cr_2O_3 as the inert marker (Udén *et al.*, 1980). The Cr hay was dosed to estimate the transit time of the solid phase of the digesta through the gastro-intestinal tract. The Cr hay was mixed with sugar-cane molasses (Triangle Animal Feeds Ltd., Zimbabwe) to improve palatability and this mixture was offered in open pans. When necessary, the

Table 1 *Medians of age, heart girth, body length and height at withers and means (± s.e.) of live weight and umbilical girths of 335 working donkeys (191 males and 144 females) in semi-arid western Zimbabwe*

	No.	Age (years)	Live weight (kg)	Umbilical girth (cm)	Heart girth (cm)	Body length (cm)	Height at withers (cm)
Males	191	9	142 ± 1·8	138 ± 0·8	115	89	105
Females	144	7	141 ± 2·2	142 ± 1·0	115	90	105
Significance of difference		**		**			
Range	335	1-25	78-222	112-179	93-140	67-103	91-120

donkeys were hand-fed until all the Cr hay had been consumed. Faecal samples were collected at: 8, 10, 12, 14, 16, 18, 20, 26, 28, 30, 32, 34, 39, 50, 54, 56, 61, 72, 76, 80, 85, 96, 100, 104, 109, 120, 128, 144, 152 and 168 h after dosing.

Chemical and statistical analyses. Faecal samples were ground to pass through a 1-mm screen, sub-sampled and 0·4 g taken for analysis of Cr_2O_3 according to Mathers *et al.* (1989). DM content of the bulk faecal samples was determined after drying at 60°C for 48 h. Apparent digestibility of hay DM (DMD) was calculated from DMI and faecal DM output during each collection period. The mean retention time (MRT) was determined using the following equation:

$$\text{MRT (h)} = \Sigma\, m_1\, t_1 / \Sigma\, m_1$$

where m_1 is the amount of Cr_2O_3 excreted in faeces at time t_1 after dosing with the marker (Blaxter *et al.*, 1956). The data were subjected to ANOVA to determine the effects of the different treatments. Sources of variation included treatment, period, team and random error.

Results

Experiment 1

Morphological characteristics. Pooled data for live weight and umbilical girth of the 191 males and 144 female donkeys satisfied the requirements for parametric tests and ANOVA was performed on the measured values (Table 1). The results for age and the other body measurements were pooled and data analysed using the Mann-Whitney non-parametric test (Table 1). The males were significantly older ($P < 0·01$) than the females, 9 years compared with 7 years. Approximately 10% (25 males and seven females) of the 335 donkeys were older than 14 years. There were no significant differences ($P > 0·05$) in heart girth, body length or height at withers between male and female donkeys. Grey was the most predominant coat colour. Donkeys tended to have paler shades on the bellies compared with the upper body and most had shoulder crosses.

Relationship between live weight and body measurements. When single variables were used to predict live weight, heart girth was the best predictor, with 84% of the residuals within ± 10 kg of the actual live weight and over 96% within ± 20 kg: live weight (kg) = heart girth (cm)$^{2·83}$/4786 ($R^2 = 0·86$) ($P < 0·001$) for adult donkeys (no. = 280); live weight (kg) = heart girth (cm)$^{2·8}$/4266 ($R^2 = 0·88$) ($P < 0·001$) for growing donkeys less than 3 years old and weighing between 78 kg and 146 kg (no. = 55).

The other body measurements were less accurate; umbilical girth ($R^2 = 0·75$), body length ($R^2 = 0·62$) and height at withers ($R^2 = 0·55$).

Various combinations of any two body measurements were also regressed against live weight resulting in a small but unimportant improvement in the adjusted R^2 value, for example, heart and umbilical girths (adjusted $R^2 = 0·90$)

Experiment 2

Ambient temperatures during the experiment ranged from a minimum of –5°C to a maximum of 26°C. In treatments 2 and 3 the donkeys generally started drinking as soon as water was offered and consumed at least 14 l within the first 10 to 15 min.

Donkeys in treatment 1 had the highest ($P < 0·001$) daily water intake over the experiment of 8·5 (s.e. 0·61) l/day, compared with 4·9 (s.e. 0·30) l/day and 5·1 (s.e. 0·29) l/day, for donkeys in treatments 2 and 3, respectively (daily intakes for each week are in Table 2). This represented a reduction in water intake of proportionately 0·42 and 0·40, for donkeys watered every 48 h and 72 h, respectively, compared with those with *ad libitum* access. When water intake was calculated as a proportion of live weight (LW), donkeys with *ad libitum* access consumed water

Table 2 *Mean daily water intake (l) and dry matter (DM) intake (kg) of donkeys given hay* ad libitum *and offered water either* ad libitum, *every 48 h or 72 h for 35 days†*

Treatment	Week 1		Week 2		Week 3		Week 4		Week 5	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e
Water intake										
Ad libitum	$8\cdot3^{a}$	0·77	$9\cdot2^{a}$	0·63	$8\cdot8^{a}$	0·66	10^{a}	0·38	$6\cdot3^{a}$	0·75
48 h	$3\cdot9^{b}$	0·53	$5\cdot3^{b}$	0·33	$7\cdot2^{b}$	0·44	$4\cdot2^{b}$	0·31	$4\cdot2^{b}$	0·44
72 h	$4\cdot1^{b}$	0·34	$4\cdot9^{b}$	0·64	$5\cdot7^{c}$	0·47	$8\cdot5^{c}$	0·42	$2\cdot6^{c}$	0·35
Significance										
DM intake										
Ad libitum	$3\cdot2^{a}$	0·11	$3\cdot7^{a}$	0·24	3·5	0·16	2·9	0·10	2·4	0·15
48 h	$2\cdot6^{b}$	0·20	$3\cdot0^{b}$	0·13	3·3	0·07	2·9	0·07	2·4	0·07
72 h	$2\cdot4^{b}$	0·10	$2\cdot9^{b}$	0·17	3·2	0·12	3·0	0·11	2·2	0·08
Significance	**									

† Results are means of six animals; means in the same column and same part of the table with different superscripts differ at $P < 0\cdot05$.

equivalent to proportionately 0·059 of LW, significantly higher ($P < 0\cdot05$) than consumption for donkeys watered every 48 h and 72 h, 0·034 and 0·036 of LW, respectively. In week 5, when maximum ambient temperatures were lower than the preceding weeks (below 20°C), all donkeys generally consumed less water. Calculated per kg metabolic live weight ($LW^{0\cdot75}$), daily water intake was highest ($P < 0\cdot001$) for donkeys with *ad libitum* access, 204 ml/kg $LW^{0\cdot75}$ compared with 119 ml/kg $LW^{0\cdot75}$ and 124 ml/kg $LW^{0\cdot75}$, for donkeys with access every 48 h and 72 h, respectively over the experiment.

Donkeys in treatment 1 had a significantly higher ($P < 0\cdot05$) daily DMI than those in treatments 2 and 3 in weeks 1 and 2 (Table 2). There were no significant differences ($P > 0\cdot05$) in DMI of donkeys in treatments 2 and 3 during the same period. In weeks 3, 4 and 5, no significant differences ($P > 0\cdot05$) in DMI were observed between treatments. Overall, daily DMIs were higher ($P < 0\cdot05$) for donkeys in treatment 1 (3·1 (s.e. 0·14) kg) than for donkeys in treatment 2 (2·8 (s.e. 0·07) kg) and 3 (2·7 (s.e. 0·09) kg). The reductions in daily DMI on treatments 2 and 3, were proportionately 0·097 and 0·129, when compared with treatment 1. Calculated per kg $LW^{0\cdot75}$, over the 5 weeks, donkeys in treatment 1 had the highest daily intake ($P < 0\cdot05$) of 75 (s.e. 1·72) g/kg $LW^{0\cdot75}$, compared with 69 (s.e. 2·7) g/kg $LW^{0\cdot75}$ and 66 (s.e. 1·6) g/kg $LW^{0\cdot75}$, for treatments 2 and 3. The ratio of water to DMI was highest ($P < 0\cdot001$) for treatment 1, 2·7 (s.e. 0·12) l/kg DM, compared with 1·7 (s.e. 0·08) l/kg DM and 1·9 (s.e. 0·080) l/kg DM, for treatments 2 and 3. The ratio was similar ($P > 0\cdot05$) for treatments 2 and 3.

Faecal DM was highest ($P < 0\cdot01$) for donkeys in treatment 3, 371 (s.e. 6·6) g/kg and higher in treatment 2 ($P < 0\cdot05$), 358 (s.e. 6·7) g/kg than in treatment 1, 338 (s.e. 4·9) g/kg. Faecal DM for donkeys in treatments 2 and 3 was similar ($P > 0\cdot05$). All donkeys lost weight during the experiment, the highest loss of 5 kg for donkeys in treatment 3, compared with 3 kg and 1 kg losses for donkeys in treatments 1 and 2. However, the differences were not significant ($P > 0\cdot05$).

Experiment 3

Daily DMI, DM apparent digestibility and MRT of hay were not significantly different for the treatments imposed (Table 3). The mean recovery rates of the Cr hay in the collection and recording period was 90% for all three treatments. The total time the donkeys in treatments 1 and 2 had no access to food for periods 1, 2 and 3, inclusive of the 1-h break between carting sessions, was 5·5, 5·1 and 5·7 h/day, respectively. However, time of access to food for donkeys in treatments 1 and 2 had no

Table 3 *Dry matter intake (DMI) per day (kg), dry matter apparent digestibility (DMD) (%) and mean retention time (MRT) of hay (h) of donkeys when (1) working (5 h)/no access to food for 5 h; (2) not working/no access to food for 5 h; (3) not working/access to food for 24 h†*

Treatment	DMI		DMD		MRT	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
(1) Working/ not feeding	3·3	0·50	48	0·3	70·4	11·4
(2) Not working/ not feeding	3·5	0·52	49	0·2	77·6	14·7
(3) Not working/ feeding	3·3	0·41	41	0·3	74·0	14·3

† Means of 12 animals

significant effect on DMI ($P > 0{\cdot}05$) when compared with donkeys on treatment 3. The carting speeds for teams 1, 2 and 3, in periods 1, 2 and 3, were similar ($P > 0{\cdot}05$), 1·4 (s.e. 0·05) m/s, 1·6 (s.e. 0·12) m/s and 1·3 (s.e. 0·03) m/s, respectively.

Discussion

This work was carried out in western Zimbabwe where the donkey is an important source of draught power. Over 72% of Zimbabwe's total donkey population is found in this area, therefore the donkeys in this area should be representative of most of those in Zimbabwe. Notwithstanding other physiological conditions such as pregnancy and lactation, the similarity in morphological attributes and live weight of male and female donkeys suggests that in theory, their draught potential could be similar. The mean live weight of donkeys in the present study was similar to that reported in other parts of Zimbabwe and in other countries in Africa: Bwakura (1994) recorded a mean live weight of 152 kg for 125 mature male and female donkeys in southern and northern Zimbabwe. The major significant difference between the male and female donkeys was umbilical girth, which was larger ($P < 0{\cdot}01$) in female than in male donkeys, probably because some of the females were in the later stages of pregnancy. In Sudan, a mean height at the withers of 105 cm was reported (Wilson, 1981) while in Morocco, the mean live weight, height at the withers and body length recorded for 516 working donkeys were 135 kg, 105 cm and 84 cm, respectively (Pearson and Ouassat, 1996). The similarities in donkey types suggest that performance, management and food requirements will be similar. If this is true, then research results and management strategies could be applied across the respective countries.

The age distribution in this study showed that only 10% of the donkey population was over 14 years old (median 8 years, Table 1). Pearson and Ouassat (1996) found that working donkeys in Morocco rarely exceeded 12 years of age. In the UK, donkeys often live in excess of 37 years (Bliss, 1989). This longevity may reflect the generally better management and lower (or zero!) work demands made on donkeys in temperate areas compared with those in the tropics and sub-tropics.

Knowledge of the average size of the Zimbabwean donkey is essential in the assessment of their draught potential, particularly for ploughing. Reh (1982) suggested that because of the small frame size of donkeys in Africa (height range 70 to 100 cm; weight 80 to 100 kg), ploughing would be too heavy a task for them. However, the results here show that the average Zimbabwean donkey is bigger and heavier than that defined by Reh (1982) and so the potential for ploughing might warrant investigation.

Grey was the most predominant coat colour, as reported by Mason and Maule (1960). The well defined 'cross' on the shoulder, absence of leg stripes and size suggest that the Zimbabwean donkey is likely to be more closely related to the Nubian wild ass (*Equus asinus africanus*), which has a prominent shoulder 'cross' than the Somali wild ass (*Equus asinus somaliensis*), which has prominent leg stripes (Camac, 1989).

Although the use of more than one variable in a regression analysis generally results in a higher R^2 value, the interpretation becomes more complex. The ultimate objective of computing the predictive equations is to produce simple management tools for smallholder farmers, such as weighbands (using one predictor) and nomograms (using at most two predictors) to estimate live weight of donkeys in the absence of weighing scales.

The predictive equations derived in the present study confirmed observations elsewhere (Eley and French, 1993; Pearson and Ouassat, 1996) that heart girth is one of the best single predictors of the live weight of adult donkeys. Although umbilical girth was the second best predictor, its use could be compromised by pregnancy, leading to a tendency to overestimate live weight in females. Generally donkeys in the tropics are given high roughage diets which result in distended 'hay bellies', which could also contribute to the overestimation of live weight. Predictive equations work 'best' when used to describe the data from which they were derived. Bearing this in mind, the body measurements were used to estimate live weight using two prediction equations commonly used for donkeys. The predictive equation of Eley and French (1993) derived from 243 donkeys in the UK: live weight (kg) = height at withers$^{0{\cdot}24}$ × heart girth$^{2{\cdot}58}$ × 0·000252 (adjusted $R^2 = 0{\cdot}92$) and the predictive equation for donkey live weight of Pearson and Ouassat (1996), derived from data from 516 working donkeys in Morocco: live weight (kg) = heart girth (cm)$^{2{\cdot}65}$/2188 (adjusted $R^2 = 0{\cdot}81$).

The equation of Eley and French (1993) which was derived from non-working donkeys in the UK over-estimated live weight of the Zimbabwean donkeys considerably, that of Pearson and Ouassat (1996), provided a better match, although it did marginally over-estimate weight of the Zimbabwean donkeys. Excess body fat in a donkey is found on the neck and haunches and to a limited extent around the heart girth. It is thus likely that prediction equations developed from inactive donkeys on good feeding in temperate areas will tend to give over-estimates of live weights of working donkeys in the more arid areas of the world, which tend to have smaller body fat deposits.

The donkeys' capacity to rehydrate quickly following periods of up to 72 h without water (experiment 2) was consistent with results elsewhere. For example Jones *et al.* (1989) reported that donkeys with no access to water for 19 h, compensated for the deficit within 1 h of water becoming available. In the present study, in 1 h, donkeys consumed up to proportionately 0·60 of the water deficit, when compared with the intake of those with *ad libitum* access. Donkeys have been reported to drink as much as 20·5 l in 2·5 min or 24 to 30 l in 3 to 5 min, without apparent harmful effects (Schmidt-Nielsen, 1964; Maloiy, 1970). The water intake of donkeys as a proportion of LW, was lower in experiment 2, 0·059 and 0·035 of LW, for donkeys with *ad libitum* access and those with restricted access, respectively, compared with intakes reported by Mueller and Houpt (1991) which were 0·076 of LW for donkeys with access every 4 h and 0·070 of LW, for those without access for 36 h. The generally lower ambient temperatures in the present experiment (mean of about 11°C) compared with 18 to 24°C in the study of Mueller and Houpt (1991), could account for the differences.

That donkeys are able to continue feeding during periods of water deprivation, is due, in part, to their capacity to continue saliva secretion (Dill *et al.*, 1980). This ability contributes to their overall capacity to withstand drought, when water is the most limiting factor affecting livestock survival. Although the donkeys with restricted access to water in the present experiment had a significantly ($P < 0·05$) lower food intake, proportionately 0·13 less when compared with those with *ad libitum* access, the reduction was proportionally less than the corresponding reduction in water intake of 0·42 ($P < 0·001$).

Another survival mechanism during periods of water scarcity would be the reduction of water losses from the body, for example, through sweating, expired gases, faeces and urine. Faecal water losses can be high, for example, Somali donkeys exposed to ambient temperatures of 22°C, lost half of the total water from the body through the faeces (Maloiy, 1970). In the present experiment, donkeys with access to water every 72 h, produced proportionately about 0·10 less faecal water ($P < 0·01$) than those with *ad libitum* water access. This could be due to an increased water resorption capacity in the hind-gut of donkeys when water supply is limited. Donkeys can endure body water loss of up to 0·3 of LW during dehydration (Maloiy, 1970), while in cattle a 0·10 loss is considered severe dehydration (Houpt, 1993). Therefore, donkeys are better suited than cattle to dry conditions.

Work results in increases in nutrient requirements, specifically energy. The digestible energy (DE) requirements for donkeys for maintenance and light work are between 190 and 193 kJ/kg live weight (Mueller, 1996). Some workers, e.g. Orton *et al.* (1985) with horses, have reported increases in food intake of animals in response to work, while others have not. The results here showed that food intake of tropical donkeys did not increase when they were working. This confirms the observations of Pearson and Merritt (1991), who found no increase in roughage intake above resting levels when donkeys walked 14-km per day at 1·0 m/s for 5 days/week in a temperate area. The lack of effects of work on food intake in the present experiment, may be due to the poor quality of the hay given (DE content = 7·1 MJ/kg DM). Given this quality of hay, a DMI of at least 4 kg DM per day would be required to meet the donkeys' DE requirements for maintenance and work. This level of intake was not reached even when food and water were available *ad libitum* over the day (Table 3). Experiment 2 has shown that infrequent watering can further reduce daily DMI. If access to food is only prevented for 5 h/day, DMI is not affected (experiment 3). However on a typical smallholder farm in Zimbabwe, access to food is likely to be restricted for longer periods. Donkeys can be penned for up to 12 h overnight and working time can exceed 6 h. In these situations it is likely that DMI may be reduced on work days, unless frequency and rate of eating increase.

It has been suggested that work or light exercise could increase the digestibility of roughages by donkeys (Pearson and Merritt, 1991), although the mechanisms for this are not clear. Clapperton (1964) suggested that increases in body temperature caused by exercise or work, could increase fermentation rates, thereby enhancing digestibility in sheep. In experiment 3, although the change was not significant, working donkeys tended ($P > 0·05$) to digest the roughage better and maintained a faster throughput of digesta, than resting donkeys, possibly due to enhanced fermentation in the hind-gut. The short-term increased energy demands for work, might also have encouraged greater enzymic secretion in donkeys to enhance DMD.

The study has shown that any improvements in DMI and DMD associated with work in donkeys are small and would not be sufficient to meet extra nutrient requirements for work when donkeys are on low quality diets (DE content 7·1 MJ/kg DM), even if the food and water are available *ad libitum*. Donkeys on smallholder farms in Zimbabwe will need better quality foods when working regularly if they are not to lose weight.

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