

# A COMPARISON OF THE ENERGY REQUIREMENTS FOR WORK IN DONKEYS, PONIES AND CATTLE

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## 1. INTRODUCTION

In draught animals in the semi-arid tropics, the energy costs of locomotion and work have a considerable influence on daily energy requirements. Meeting energy requirements from food available can be most difficult during the dry season, due to food scarcity. In addition as animals travel longer distances in search of food, more energy is needed for walking during the dry season, than in the wet season when food is more plentiful. Extra energy needs for work during the dry season can place an additional burden on the animal's ability to meet its energy requirements from the food supply.

This paper presents work carried-out at the Centre for Tropical Veterinary Medicine during the summer of 1993, which investigated the energy needs of small equids pulling loads of up to 15 kg df/100 kg lwt. of body weight. The results of this study and other recent investigations have shown that the equine species use considerably less energy for locomotion than the bovine species. This may result in common tropical equids such as donkeys and ponies having a lower overall energy demand than their cattle equivalents, resulting in them placing less demand on scarce feed resources.

## 2. MATERIALS AND METHODS

The experiment was carried using 5 adult male shetland ponies (two stallions and three geldings) with live weights between 152 and 227 kg. The animals were kept on pasture and received no supplementary feeding. The ponies were trained, for a period of one month before the start of the experiment, to walk on a treadmill at an approximate speed of 1 m.s<sup>-1</sup>, to pull a load whilst walking, and to wear a face mask. The animals were worked whilst on the tread-mill using a loading device described by Mawrence and Stibbards (1990). The three treatments carried-out were:

- 1. walking at 1m.s<sup>-1</sup> pulling 5 kg df/100 kg live weight;
- 2. walking at 1 m.s<sup>-1</sup> pulling 10 kg df/100 kg live weight;
- 3. walking at 1 m.s<sup>-1</sup> pulling 15 kg df/100 kg live weight.

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During each of these treatments the animals were fitted with a breast-plate harness which, during the pulling phase of each treatment, was attached to the loading device by means of rope traces. Each of the treatments was replicated five times for each pony during the course of the experiment. To eliminate the effect of improving fitness, energy expenditure each of the ponies underwent all three treatments in each replicate in sequence before proceeding to the replicate. Two treatment sessions were carried-out each day, each pony undergoing one treatment every three or four days.

Each experimental session was preceded by a 1-2 hour stabilization period after the gas analysis machinery was switched on. This was followed by a 20 minute base-line reading, where atmospheric air was drawn through the face mask and the concentration of oxygen and carbon dioxide was measured and recorded. After this period the pony was brought on to the treadmill, the breast plate harness and mask were fitted to it and the animal stood for 20 minutes. The animal was then walked at a speed of 1 ms<sup>-1</sup> on the treadmill for 20 minutes. At the end of the walking period the rope traces were attached to the loading device and the appropriate draught force applied whilst the animal was still walking. The animal pulled this load for 20 minutes. After 20 minutes the load was steadily removed whilst the animal was still walking. The animal was then walked for a further 20 minutes period unloaded, followed by a 20 minute rest period. At the end of the rest period the face mask and breastplate harness were removed from the pony and the animal was led away from the treadmill. This was followed by a further 20 minute period of baseline measurements. During each of these 20 minute measurements air was drawn through the face mask at a constant rate (700 l/minute). This flow was sufficient to prevent the escape of exhaled air from the sides of the mask and to ensure that all this air was collected. Carbon dioxide and the difference in oxygen content of this air and dried atmospheric air was measured (Richards and Lawrence, 1984). Energy expenditure was calculated from the rate of carbon dioxide production and oxygen consumption as described by Lawrence and Stibbards (1990). This data was recorded by means of a modified personal computer.

### 3. RESULTS

The energy costs of standing, walking and pulling are shown in Table 1. The mean energy cost of standing for all the treatments was 1.94 (s.e.  $\pm$  0.08). There were significant differences ( $P < 0.05$ ) between all animals with the exception of the two heavier ponies. The mean cost of walking during the 5 kg df / 100 kg lwt. pulling treatment was significantly higher ( $P < 0.05$ ) than during the other two treatments. A comparison of the energy expenditure of walking before and after pulling using a paired t-test, showed a significant difference ( $P < 0.05$ ) during the 15 kg df / 100 kg lwt. treatment, but no significant difference during the 5 and 10 kg lwt. treatments.

The mean energy expenditure of pulling 5 kg df / 100 kg lwt of body weight was significantly ( $P < 0.05$ ) higher than either the 10 or 15 kg df / 100 kg lwt. treatments. There were no significant differences between ponies. The overall mean energy cost of pulling for all three treatments was 31.20 (s.e.  $\pm 0.77$ ) J/m.kg pulled.

The efficiency of pulling was significantly higher ( $P < 0.05$ ) during the 10 kg df / 100 kg lwt. treatment than during the 5 and 15 kg df / 100 kg lwt. treatments. The overall mean efficiency of the animals during pulling was 0.32 (s.e.  $\pm 0.005$ ).

**Table 1. The energy cost of standing, walking, pulling and the efficiency of work in shetland ponies walked at  $1\text{m}\cdot\text{s}^{-1}$**

activity	Pulling 5 kg df by 100 kg lwt (s.e.)	Pulling 10 kg df by 100 kg lwt (s.e.)	Pulling 10 kg df by 100 kg lwt (s.e.)
Standing (W/kg lwt)	1,97 ( $\pm 0,02$ )	1,83 ( $\pm 0,02$ )	2,05 ( $\pm 0,02$ )
Walking (J/m.kg lwt)	1,30 ( $\pm 0,05$ )	1,07 ( $\pm 0,03$ )	1,10 ( $\pm 0,05$ )
Pulling (J/m.kg pulled)	33,12 ( $\pm 0,70$ )	29,11 ( $\pm 0,85$ )	31,36 ( $\pm 0,75$ )
Efficiency of work	0,33 ( $\pm 0,01$ )	0,34 ( $\pm 0,01$ )	0,30 ( $\pm 0,05$ )

#### 4. DISCUSSION

The energy costs standing and walking (1.97 W/kg lwt. and 1.09 J/m.kg lwt. respectively) obtained in this experiment are similar to results published by other researchers. Booth, Pearson and Cuddeford (1993) report similar standing and walking values for shetland ponies of 1.37 W/kg and 1.02 J/m.kg live weight respectively. Dijkman (1992) found that in temperate regions the energy cost of walking in donkeys was 0.97 J/m.kg live weight, whilst in the tropics P. Mueller and A. Fall (personal communication) found that the energy cost of standing and walking in the same species was 1.4 W/kg live weight and 1.43 J/m.kg respectively. The results for the energy cost of standing in this experiment tend to be higher than those found by other workers. This discrepancy may have been due to the short adaptation time that the ponies in this experiment had, leading to a restlessness during the standing period of the experimental treatment. The energy costs of pulling in this experiment (32.2 J/m.kg pulled) are similar to those reported by Dijkman (1992) for donkeys (26.5 J/m.kg pulled), with donkeys showing a higher efficiency of pulling (0.37) than shetland ponies (0.32).

The energy cost for a cow of 450 kg fed on poor quality diet is approximately 1.12 W/kg lwt (Matthewman and Dijkman 1993). The energy cost of walking

in cattle is reported widely as approximately 2 J/m/kg live weight (Lawrence and Stibbards 1990, Brody 1945). This indicates that whilst bovines have a low energy requirement for standing, their energy requirement for walking is approximately twice that of small equines. Similarly, when the efficiency of pulling is considered cattle appear less efficient (0.30) (Lawrence and Sibbards 1990) than ponies (0.32).

Table 2 shows the relative energy costs of standing, walking and pulling in cattle, donkeys and ponies, these figures are expressed as W/kg lwt, to allow a comparison between activities to be made. The energy cost of standing in cattle is considerably lower than that of donkeys or ponies. However, the energy cost of walking in donkeys and ponies is 54% and 50% respectively less than that of cattle, whilst the energy cost of pulling in donkeys and ponies is 27% and 22% less than that of cattle.

**Table 2. Comparison of the energy cost of work in cattle, ponies and donkeys at a walking speed of  $1\text{ m}\cdot\text{s}^{-1}$  on a level hard surface (W/kg live weight)**

Species	Standing	Walking	Pulling	Source
Donkey (130 kg)	1.40*	0.97	2.65	Dijkman 1992
Pony (200 kg)	1.93	1.06	2.91	Present study
Cow (450kg)	1.12**	2.1	3.27	Lawrence and Stibbards (1990)

\*Mueller and Fall (personal communication)

\*\*Matthewman and Dijkman (1993)

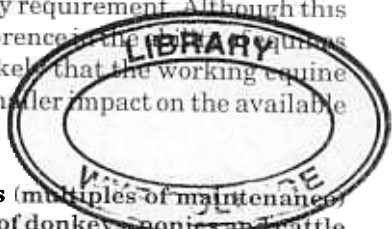
There are several explanations for the differences in the energy cost of walking for cattle, ponies and donkeys. One possible reason lies in the different anatomical arrangement of muscle and skeletal tissue of the two types of animal allowing equines to achieve forward movement with a smaller energy cost than ruminants (Djikman) 1992).

Another explanation may lie in the differences in the gut capacity relative to the body size of ruminants and equines. When full, the gut of the ruminant represents a greater proportion of the total weight of the animal than the full gut of the equine. The weight ration of full gut to muscle is therefore greater in ruminants (frape 1984). As a consequence of this, ruminant musculature must work proportionately harder to achieve the same amount of forward movement as equine musculature.

Although the smaller energy cost of work in equines means that they are working more efficiently than cattle the consequences of this on their daily energy requirement and hence their demand for feed cannot be evaluated

unless the full energy budget of the animal is examined. A realistic comparison of donkeys, ponies and cattle is difficult as the species differ greatly in terms of live weight. Table 3 shows two comparisons of cattle, donkeys and ponies. A comparison of the three species doing the same amount of walk relative to their body size shows that in donkeys and ponies the extra energy demands resulting from pulling 10 kg df/100 kg lwt. of body weight for a distance of 10 km are considerably smaller than those of cattle. On the other hand, when species are compared on the basis of doing the same actual amount of amount of work (pulling 20 kg df), cattle, due to their larger body size use less energy in terms of multiples of maintenance. However, in both cases, the daily energy requirements of a 130 kg donkey and a 200 kg pony are less than that of a 450 kg cow. Although it may seem unreasonable to compare animals of such a range in body size these live weights do reflect the situation in the field ( Pearson & Ouassat, personal communication; Matthewman & Dijkman 1994). It would be a gross distortion of reality to compare these species at equal live weight.

The comparison presented here of cattle, donkeys and ponies shows that when average sized working animals for each species are compared it is the equine species that have a smaller daily energy requirement. Although this comparison does not take into account the difference in the ability of horses and bovines to digest low quality feeds it is likely that the working equine has a smaller feed requirement and hence a smaller impact on the available feed resources.



**Table 3. The additional energy requirements (multiples of maintenance) and daily energy requirements (MJ) of donkeys, ponies and cattle when walked for 10km on a flat hard surface, pulling either 10 kg df/100 kg lwt. of body weight or 20 kg df**

Species	....Pulling 10 kg df /100 kg lwt.lwt....		.....Pulling 20 kg df.....	
	Extra energy cost (multiple of maintenance	Daily energy requirement (MJ)	Extra energy cost (multiple of maintenance	Daily energy requirement (MJ)
Donkey (130 kg)	0.30	18.20	0.42	19.88
Pony (200 kg)	0.33	31.48	0.35	31.95
Cow (450 kg)	0.55	67.48	0.36	59.21

Adapted from Lawrence and Sitbbards (1990), Dijkman (1992), Matthewman & Dijkman (1994), Booth *et al.*, (1993), Mueller & Fall (personal communication)

A comparison of the energy cost of work in ponies, donkeys and cattle shows that whilst cattle have a smaller energy cost of maintenance relative to body size, donkeys and ponies have a lower energy cost of walking and work. A

true comparison between species is difficult because of the great difference in body size but if average sized animals are compared doing either the same amount of work relative to body size, or the same actual amount of work, it is the equines that are likely to have smaller daily energy requirements, and hence feed requirements. Consequently, donkeys and ponies can be seen as a more sustainable alternative to draught cattle, provided that farmers have a choice and other constraints such as disease do not prohibit their selection.

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