Improving draft animal nutrition management through strategic supplementation in Zimbabwe

by

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Abstract

Four pairs of Mashona oxen (3.5 years old, average weight 328 kg (SD=35)) were used in a cross-over design to determine the effect of time of supplementary feeding on work output and concentrations of plasma lactate, pyruvate and free fatty acids in draft animals. Work consisted of pulling a mouldboard plow from 0600 to 1000 hours for four successive days. Plows were set to penetrate 13–16 cm deep into red clay soils. When not working, animals were allowed access to maize stover on arable lands. They were also fed crushed maize grain (500 g/head per day) as supplementary feed either immediately before or 12–14 hours before working. Lactate, pyruvate and free fatty acid levels in plasma, and body weight, of all oxen were monitored. Draft force, distance covered and work output of each span were recorded daily.

Ten minutes after work lactate, pyruvate and free fatty acid concentrations were, respectively, 50–350, 20–130 and 120–580% higher than pre-work levels. Accumulation of lactate during work caused fatigue, particularly in the smallest team with a mean animal weight of 290 kg. Signs of overstress (increased drooling of saliva, heavy panting, sluggish walking, reluctance to work and laying down) became evident after 2–2.5 hours of work in this team. (Such stress reactions would represent a serious problem if plowing was urgently required for timely planting.) All teams worked erratically in the last hour of work. Strategically timing the feeding of crushed maize grain failed to stop the mobilisation of free fatty acids from fat depots to fuel work. Smaller oxen lost a greater proportion of their weight than heavier ones.

Body weight of oxen strongly influenced work performance. Heavier spans outperformed lighter ones in terms of mean distance covered and work output. Daily draft forces varied slightly.

Introduction

Of all the uses of Mashona cattle in Zimbabwe's small-scale agricultural sector, manure and draft power constitute critical crop production inputs. Farmers generally consider that four oxen are needed to provide adequate draft power, and 30–40% of the 650 000–850 000 communal area households own four or more oxen (Shumba, 1984). For tillage operations, such as plowing, two or more animals are harnessed together to pull mouldboard plows. Excessively high stocking rates on communally-grazed pasture and crop residues result in low availability of feed biomass, particularly during the long dry season. Huge weight losses are therefore inevitable. The animals are made to work soon after the first rains, even though they are least fit to do so at that time.

It would be expected that supplementing these cattle with crushed maize grain would increase glucose availability during work by supplying bypass starch. This would improve the rumen ecosystem leading to increased microbial growth, and promote propionate production relative to other volatile fatty acids. Because feeding crushed maize grain is associated with low methane and heat production, the efficiency of utilisation of energy for work would be increased (Preston and Leng, 1987).

However, even with the best feeding management, heavy workloads, for example during plowing, may result in lack of coordination of the cardiovascular, pulmonary and thermoregulatory systems. Consequent onset of fatigue limits the realisation of an animal's genetic potential for work (Martin and Teleni, 1988). Thus an understanding of the physiology of working Mashona oxen will allow the formulation of improvements to existing small farmers' draft animal power systems. Selected physiological parameters were studied and are reported here.

Materials and methods

Eight fairly well-trained Mashona oxen aged three to five years, in good condition and with a mean liveweight of 328 kg (SD=35), were teamed in pairs according to weight and compatibility. They were harnessed using double withers yokes and pulled mouldboard plows set to penetrate 13–16 cm into dry red clay soils. The normal communal area practice of winter plowing for four hours a day (0600–1000 hours) in June was followed. In a cross-over design, each team worked for four successive days, then rested for 14 days before

working again. A plowman worked with the same team while another individual led the animals.

Basal diet consisted chiefly of crop residues which were grazed freely by the animals when not working or penned at night. Each ox was fed 500 g of crushed maize grain (CMG) per day irrespective of its weight, immediately (Treatment 1) or 12–14 hours (Treatment 2) before work. Water was provided *ad libitum* except when the animals were working.

Blood was sampled by jugular venipuncture on the fourth day of work, 5–10 minutes before and after work. Plasma lactate, pyruvate and free fatty acids were determined as outlined in the modified methods of Noll (1974), Czok and Lamprecht (1974) and Hron and Menahan (1981), respectively.

Animals were weighed to the nearest 5 kg at 1000 hours (after work) on the first and fourth days. Distance covered and working time were recorded during work using a tape measure and stopwatch. A hydraulic dynamometer was used to monitor the force transmitted in the draft chain as the oxen worked. As the dynamometer readings varied continuously, a subjective assessment of the mean reading was made every 10 minutes and averaged each half hour.

Draft forces were then obtained using the formula of Matthews (1987):

$$Actual\ draft\ force\ (kN) = \frac{RF \times \sqrt{L^2 - (H-h)^2}}{L}$$

where

RF = Recorded draft force (kN)
H = Height of attachment to the yoke (m)
h = Load working height (m)
L = Length between the load and yoke (m)

These records were later used to calculate work done. The magnitudes of changes in lactate, pyruvate and free fatty acids were calculated for individual oxen before making comparisons between animals. Comparisons were also made between the two feeding treatments for individual teams of oxen, before comparing ox teams with each other. In this way, each ox or team acted as its own control for all parameters monitored. In-depth statistical analysis has yet to be carried out on these data. Preliminary findings only are reported in this paper.

Results

Ten minutes after completion of work, raised levels were recorded for plasma lactate (up 50–350%), pyruvate (up 20–130%) and free fatty acids (up 120–580%), as shown in Figures 1, 2 and 3. Lactate and free fatty acid concentrations were slightly higher when crushed maize grain was fed 12–14 hours before work than when it was fed immediately before work. No consistent pattern of change in pyruvate concentration was apparent under these two treatments.

Lighter oxen lost a greater proportion of their initial weights during work than heavier ones (Figure 4), but weight losses under the two feeding treatments were almost the same. All oxen regained weight during the 14-day rest period.

Draft forces varied little throughout the study. For all spans, mean daily work output was highest on the first and least on the fourth working days. Mean hourly draft performance fell from the first to the last hours of work (Figure 5). Heavier spans outperformed lighter ones.

Discussion

Pyruvate and lactate levels rose with work, showing that anaerobic pathways of energy supply operated. Singh, Nangia and Dwaraknath (1980) reported that changes in blood lactate were proportional to work done. Accumulation of lactate leads to fatigue in draft cattle (Martin and Teleni, 1988) and shows severity of workloads (Pearson and Archibald, 1989). Drooling of saliva, continuous panting, increased reluctance to work, and laying down were most marked in the lightest team (span 2, with mean animal weight of 290 kg) after 2–2.5 hours of work. Unexpected work stoppages became more frequent thereafter, which indicated that the intensity of work stress was highest in this team. It was, however, more difficult to control all work teams in the last hours of work when performance, especially by lighter members of these spans, became erratic.

The increases in plasma free fatty acid concentrations observed in this study are consistent with their increased role in energy supply to skeletal muscles during heavy exercise (Pethick, 1984).

The fact that all oxen lost weight when they worked, but managed to regain it during the 14-day rest period, implies that the oxen could not meet their high energy requirements by raising voluntary feed intake. This agrees with Soller, Reed and Butterworth (1986). It also suggests that 500 g per head of crushed maize grain, strategically fed before work, fails to provide the extra energy required for work. Lighter animals lost more weight than heavier ones, probably due to a more intense work stress which resulted in heavier mobilisation of stored body energy sources.

Mobilising reserves of glycogen or glucose to provide ready energy for work cannot be sustained

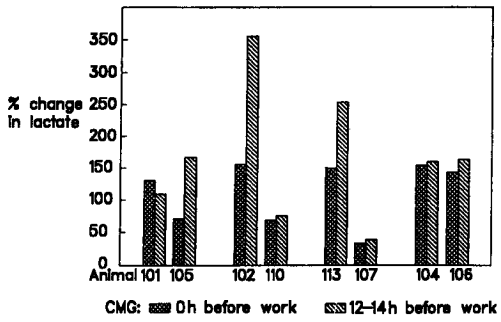

Figure 1: Percentage changes in blood lactate levels in oxen fed maize 0 or 12–14 hours before work

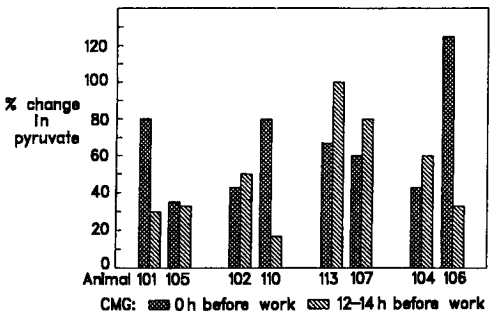

Figure 2: Percentage changes in blood pyruvate levels in oxen fed maize 0 or 12–14 hours before work

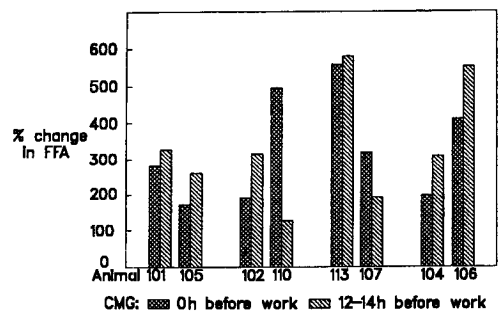

Figure 3: Percentage changes in free fatty acid levels in oxen fed maize 0 or 12–14 hours before work

for long since they are soon depleted and work performance drops (McMiken, 1983). Maybe this is why mean hourly work performance per day declined gradually in this study. Pearson (1989) also reported a decline in speed and other work performance indices due to onset of fatigue as work progressed. The results reported here show that Mashona oxen used in this study were overworked,

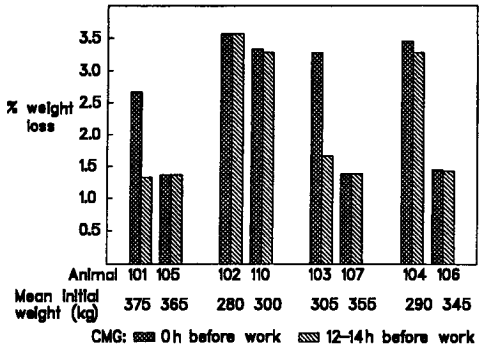

Figure 4: Percentage changes in body weight of oxen fed maize 0 or 12–14 hours before work

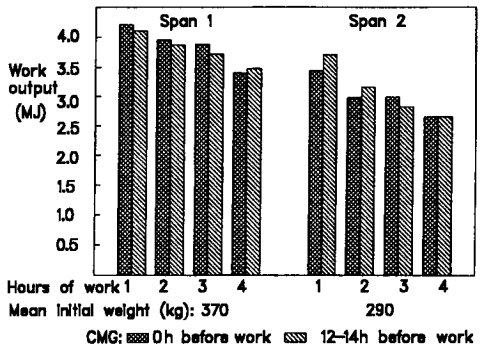

Figure 5: Mean hourly work done during four-hour period of oxen fed maize 0 or 12–14 hours before work

culminating in fatigue. Overstressing the oxen on successive days may also explain the observed continuous fall in draft output from the first to the fourth day.

Conclusion

This study has demonstrated that work animals should be rested when signs of overstress become evident. If this is not done, the rate of draft work may suffer. Strategic timing of feeding crushed maize grain to supply energy for work could not stop the animals from mobilising body fat depots. Communal area farmers should aim to have their animals in good condition before using them for plowing for protracted periods.

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