Effect of diet restriction on work performance and weight loss of local Zebu and Friesian × Boran crossbred oxen

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Summary

EAST AFRICAN *Shorthorned Zebu cattle are the main source of draught power in Ethiopia. Recently, crossbred Friesian x Ethiopian Boran oxen have become available as a result of a programme to provide crossbred dairy cattle to small-scale milk producers. Crossbred oxen are heavier than local cattle and produce more force but also require more feed.*

In 1983 a 23-week experiment was conducted by ILCA to determine the effect of diet restriction on the work performance and body weight loss of crossbred (X) and local zebu (L) oxen worked as singles with a modified maresha *in farmers' fields. Digestibility trials were carried out at the end of the experiment.*

Control animals (LC and XC) were fed 100% of the metabolisable energy requirements for maintenance plus 5 hours of work per day; restricted animals (LR and XR) were fed 75% of the control ration for the first 5 weeks of the experiment and 50% thereafter. All oxen lost weight during the experiment but LC lost significantly more than XC. LR and XR lost weight at the same rate. Breed had a significant effect on force but not on power. Force exerted by both XC and XR was significantly higher than that exerted by LC and LR.

The digestibility of rations by LC oxen was significantly higher, and that of LR significantly lower, than for the rest of the animals. Feed restriction had no measurable effects on work performance in this experiment.

Introduction

Oxen are important suppliers of draught power for land development, tillage, threshing and transport in many developing countries. Draught performance may depend on the breed of the animal and on the quantity and quality of available feed. The cropping pattern in relationship to soil type, rainfall and feed resources may also affect the condition of oxen and their work performance (Goe and McDowell, 1980).

East African Shorthorned Zebu oxen are the major source of draught power in Ethiopia. A typical farmer uses a pair of oxen for 450 hours per year for cultivation and threshing (Gryseels, 1983). The main feed resources available are cereal crop residues and natural pastures. The amount and quality of forage available from natural pastures depend on season and stocking rates. In the cereal cropping zone around Debre Zeit, central Ethiopian highlands, local oxen weighing on average 280 kg at the beginning of the cropping season lost 9 to 18% of body weight by the end of the season (Mukasa-Mugerwa, 1983).

Friesian x Boran dairy cattle have recently been introduced into this area to increase the income of smallholder farmers from the sale of milk. The crossbred oxen produced on these enterprises

are heavier (450 to 500 kg) than the local oxen (c. 280 kg) and need more feed. In trials conducted by ILCA at Debre Berhan, Ethiopia, crossbred oxen were found to require more energy per unit of body weight for maintenance and work output than local oxen (Abiye Astatke, 1983). Although the work was not definitive, the difference in energy requirements could be important in a system where feed is in short supply.

The aim of the experiment described here was to determine the effect of diet restriction on work performance and body weight loss in crossbred and local oxen worked as singles in farmers' fields around Debre Zeit during the normal cultivation season. Its results are discussed in the light of the implications for the management of draught animals, as well as from the point of view of the practical limitations in the performance of this type of research.

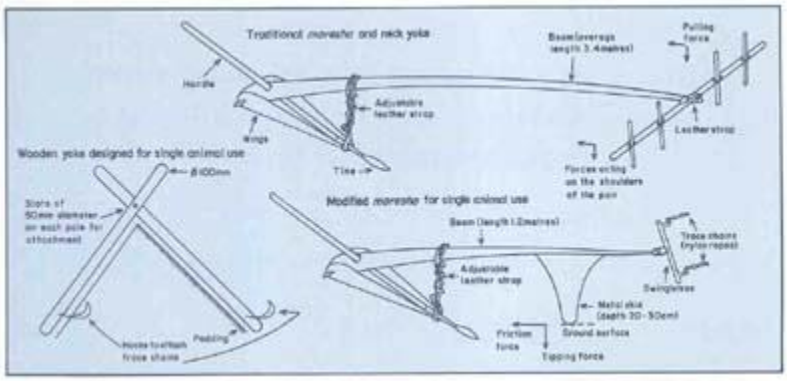
Methods

Animals and treatments

Ten local Zebu and four Friesian x Boran oxen—more crossbred animals within the required weight range were not available at the start (April 1983) of the experiment—were trained as singles for ploughing with a modified *maresha*[1]. Compared with the traditional *maresha,* which is pulled by a pair of oxen, the improved implement has a shorter draught pole (1.5 m), a 0.4 m metal skid attached under the shortened beam, and a swingle-tree to balance the trace ropes of a simple, inverted 'V'-type yoke designed for single-ox use (Figure 1).

1. A pointed, steel-tipped tine attached to a draught pole at an adjustable shallow angle.

Figure 1. *Traditional and modified yokes and* maresha*.*



Both the local (L) and crossbred (X) oxen were divided into control (LC and XC) and restricted (LR and XR) groups. The control animals were fed 100% of the estimated metabolisable energy (ME) requirements for both maintenance and 5 hours of work per day. The restricted animals received 75% of the control ration during the first 5 weeks of the trial and 50% during the rest of the trial period.

Estimates of ME requirements for maintenance and work were obtained from equations derived from feeding trials in Debre Berhan. For local animals the estimated ME (MJ) requirements for maintenance and work were 19.24 + 0.06W (where W = liveweight in kg) and 3.85 MJ/ hr,

respectively; the ME requirements for crossbreds were 29.82 + 0.059W for maintenance and 6.7 MJ/hr for work (Abiye Astatke, 1983).

Breed and treatment combinations were: local oxen on control ration (LC); local oxen on restricted ration (LR); crossbred oxen on control ration (XC); and crossbred oxen on restricted ration (XR). Average body weights at the beginning of the trial were 309 ± 49 kg (LC), 302 ± 36 kg (LR), 372 ± 32 kg (XC) and 465 ± 85 kg (XR). The oxen were walked to farmers' fields and worked for about 5 hours per day; no work was done on weekends and religious holidays. On non-working days, LC and XC were fed a maintenance ration only and LR and XR received either 75% (first 5 weeks) or 50% of their maintenance requirements. All oxen were weighed weekly on the same day prior to watering.

Diets consisted of 20% concentrate and 80% hay; their chemical compositions are given in Table 1. The concentrate mix consisted of 35% wheat bran, 32% wheat middlings, 30% *noug (Guizotia abyssinica)* cake, 2% bone and meat meal, and 2% salt.

Table 1. *Composition of the concentrate and hay used during the trial, Debre Zeit, 1983.*

	Estimated ME (MJ/kg)	N content (% DM)	Fibre (NDF)[1](% DM)	Lignin (% DM)
Concentrate	9.2	3.0	46.9	5.4
Hay	7.8	0.9	70.9	5.7

[1]Neutral detergent fibre.

Measurement of force and power

Force exerted by each ox was measured with a battery-powered dynamometer[2] consisting of a load cell secured between the drawbar of the *maresha* and the swingle-tree, and an indicator connected to the load cell by a cable. The average minimum and maximum force (kN) over a 20-m distance was recorded, as well as the time taken to travel the 20 m. A damper was used to minimise variations in force readings.

2. Novatech Measurements Ltd, Beddington, Croydon, UK.

The working height of both the yoke and the implement hitch and the length of the draught chain were measured, and the force parallel to the ground, which is the force actually used for cultivation, was calculated using a trigonometric relationship. Power was calculated by multiplying actual force (kN) by speed (m/sec). Force was measured for each ox on one day a week, at hourly intervals during the working period, resulting in 4 to 5 recordings per ox per week. The total time worked and the area cultivated were measured for each ox on every working day.

Digestibility trial

At the end of the experiment a digestibility trial was conducted. All four crossbred oxen were fed a maintenance ration because they were in poor condition and it was undesirable to prolong the

period of undernutrition, while the LC animals were fed at maintenance and the LR group received 50% of the control ration.

Statistical analysis

Analysis of variance was used to test the effects of breed and diet restriction on parameters of work performance and weight loss. The parameters of work performance were force, power output, cultivation rate, turn-around time and depth of ploughing.

Weight loss over the working period was linear for all groups. The rate of weight loss for each ox was calculated using linear regression. The effects of breed and diet restriction were tested using analysis of variance.

The T-test was used to test the significance of differences in digestibility between the XC, LC and LR groups.

Results

Weight loss

The rate of weight loss is shown in Table 2. Both restricted groups lost weight at the same rate over the 23-week trial period. The LC group lost weight at twice the rate of the XC group. Breed did not have a significant effect on weight loss whereas diet had a significant effect ($P < 0.001$). There was a significant interaction between diet and breed: local animals lost weight at a significantly higher rate than crossbreds on the control diet. Restricted animals had a higher rate of weight loss than control animals. Weight loss as a percentage of body weight was greater for the restricted groups across breeds, and greater for local oxen across diets (Table 2). The fact that even the control animals lost weight indicates that the estimated ME requirements must have been too low, reflecting those of oxen working in pairs rather than as singles.

Table 2. *Rate of weight loss and weight loss as percentage of body weight for local control, local restricted, crossbred control and crossbred restricted oxen.*

Treatment group	Rate of weight loss (kg/week)		Weight loss (% of body weight)	
	Mean	SD	Mean	SD
LC	1.8	±0.3	10.0	±3.9
LR	3.1	±0.3	16.7	±4.3
XC	0.9	±0.5	4.0	±0.4
XR	3.1	±0.5	13.7	±0.7

Work performance

Breed had a significant effect on depth of ploughing, area ploughed and cultivation rate (Table 3), but diet did not have a significant effect on these parameters of work performance. Operation (first, second or third cultivation pass) and soil moisture had significant effects on depth of

ploughing, area ploughed and cultivation rate (Tables 4 and 5). Average cultivation rates for all passes were 220 m^2/hr and 242 m^2/hr for local and crossbred oxen, respectively.

Table 3. *The effects of breed on depth of ploughing, area cultivated and cultivation rate.*

Breed	No. of observations	Mean depth (cm)	SE	Area (m^2/day)	Cultivation rate (m^2 /min)
Crossbred	256	14.6	±0.3	998	4.04
Local	613	13.9	±0.2	920	3.67
F-ratio		7.4***		4.4*	6.3**

* P<0.1; ** P<0.01; *** P< 0.001.

Table 4. *The effects of soil moisture on depth of ploughing, area cultivated and cultivation rate.*

Moisture level	No. of observations	Mean depth (cm)	SE	Area (m^2/day)	Cultivation rate (m^2/min)
Dry	386	13.5	±0.2	1009	4.0
Moist	242	13.1	±0.3	764	3.2
Wet	241	16.2	±0.4	1103	4.4
F-ratio		45.9***		28.0***	17.9**

Table 5. *The effect of operations on depth of ploughing, area cultivated and cultivation rate.*

Pass	No. of observations	Mean depth (cm)	SE	Area (m^2/day)	Cultivation rate (m^2/min)
1	73	12.7	±0.4	1001	4.3
2	158	13.8	±0.3	935	3.7
3	143	14.2	±0.3	930	3.8
4	90	15.4	±0.4	1181	4.8
5	33	14.6	±0.6	1041	4.0
6	8	16.7	±1.1	1037	3.8
7	364	12.6	±0.2	585	2.8

Breed had a significant effect on force but not on power, while diet did not have a significant effect on either force or power (Table 6). The LC and LR groups developed the same average force over the working period. XR animals developed a higher average force than XC animals, probably because the XR group weighed more than the XC group and force developed is dependent on ox weight.

Table 6. *Average force, power developed and the F-ratio for breed and diet of local control, local restricted, crossbred control and crossbred restricted oxen*.

	Force (kN)	Power (kW)
LC	0.59	0.30
LR	0.60	0.31
XC	0.66	0.33
XR	0.71	0.36
F-ratio for breed	23.22***	2.86
F-ratio for diet	2.33	0.91

***P<0.001.

Digestibility

The LC group had the highest dry-matter digestibility (DMD), and this was significantly higher than that for the LR group (P<0.025) (Table 7). The average DMD for the LR group was 17 and 12 units lower than those for the LC and crossbreds, respectively. The lower digestibility for the LR group indicates an overall nutrient deficiency in animals on the restricted diet.

Table 7. *Mean digestibility of the diet on offer for crossbred, local control and local restricted oxen*.

	Digestibility (% DM)	
	Mean	S.D.
Crossbred	52.4a[1]	2.7
LC	57.5b	2.7
LR	40.2c	6.8

[1]Means followed by different letters are significantly different.

Discussion

Power developed is a function of force and rate of work. Since the daily cultivation rate and force exerted by crossbreds were higher than those for local animals, a significant effect of breed on power would be expected. Although restricted oxen of both breeds lost more weight than control oxen, feed restriction had no measurable effect on work performance.

Work demand may have been similar for both the local and crossbred animals, as it is determined by the type of cultivation and the keenness of the ox handler. Therefore, relative to body weight it would be greater for local oxen, and this may explain why these animals lost a greater percentage of body weight than crossbreds on both diets. Alternatively, the feed requirements of local oxen for work and maintenance may have been underestimated.

Weight losses, even on the restricted diets, were within the range observed for oxen worked as pairs by farmers in the Debre Zeit area (Mukasa-Mugerwa, 1983). Dicko and Sangare (1984) found that improved nutrition prior to the working period had a significant effect (although only at the 10% level) on the efficiency with which work was performed. They concluded that supplementation before the cultivation season was desirable for oxen with a body weight less than that required to generate the power necessary for cultivation. The results given above indicate that the oxen did not lose sufficient weight during the experiment to reach this threshold.

Breed, soil moisture and operation had a significant effect on the depth, area and rate of cultivation, as shown in Tables 3, 4 and 5. The crossbred animals had a greater depth of ploughing, ploughed larger areas, and had a higher cultivation rate than local oxen. Operation type is related to soil moisture: the first pass or operation is made just after the first rains when the soil is friable enough to be ploughed. The furrows made in this pass are wider-spaced than those made in the consecutive passes when the soil is wetter. Passes made on very wet soils for teff cultivation resulted in shallower ploughing and a slower rate of cultivation.

Conclusions

The lack of any significant effect of diet restriction on work performance suggests that oxen in good condition at the beginning of the cultivation season are able to perform adequately as singles for at least 23 weeks even when they are poorly fed. Both restricted and control oxen lost weight during the working period, which indicates that they used body reserves for work.

A possible strategy would be to let oxen lose weight during working periods and regain condition over the non-working periods. Using this strategy, work performance would probably not be affected over a working period of about 4 months provided the oxen were in good condition at the beginning of that period. Since it appears that cereal crop residues and grazing on natural pastures cannot meet the energy requirements of oxen during short intensive cultivation periods, farmers are probably already using this strategy.

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