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Nutrition of draught oxen in semi-arid west Africa
3. Effect of body condition prior to work and weight losses during work on food intake and work output

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Abstract

Eighteen oxen were allotted to three treatment groups according to their body condition: poor, medium and good. Work output, speed, live weight and body condition were measured during 7 weeks when animals worked 4 days/week, 4 h/day, pulling loads equivalent to 12·5 kgf/100 kg live weight. The animals were given millet stover ad libitum *during hours they did not work plus 10 g/kg M of a concentrate mix. Work did not influence intake of millet stover. However, food intake improved as work progressed and animals in bad condition ate more millet stover than animals in good body condition. Work performance was affected by live weight but not body condition. Live-weight losses did not have a detrimental effect on work performance. Power output improved during the course of the experiment while animals were losing weight Animals in all treatment groups lost body weight during the 7 weeks of work but weight losses were more pronounced in oxen in good than in poor body condition. At the end of the working period, animals were put on natural pastures without supplementation. It took 4 weeks for animals in poor and medium body condition and 6 weeks for animals in good body condition to reach their pre-work live weight.*

Keywords: *body condition, draught animals, food intake, live weight, millet stover, work.*

Introduction

Draught oxen in good condition and of suitable live weight are required to ensure timeliness in soil preparation and in planting, crucial for successful cropping in semi-arid areas of west Africa. This is because work output is a function of body size and working animals preferably use long-chain fatty acids from fat reserves to fuel muscular activity during sustained exercise (Preston and Leng, 1987; Pethick, 1993). Unfortunately, draught oxen often lose weight during the dry season (Wilson, 1987). Therefore they have minimum live weight and body reserves at the start of the cultivation period when farm power demand is highest. This is also a time when food resources are scarce and do not match the nutrient requirements of draught oxen for maintenance, let alone work. While body condition and weight losses during work may not constrain performance when animals are only used for short periods (3 weeks), they take on greater significance where animals are used for longer periods (more than 4 weeks). Although the cropping season is short in semi-arid areas, many oxen are hired out or loaned to other farmers and used for transport. Hence those oxen that are available may be used over extended periods.

Supplementary food is often recommended as a means of producing draught oxen in good condition and live weight to optimize power available. However, food supplementation is expensive. Furthermore, investigations of the effect of dry season supplementation on draught oxen have generally failed to show any significant benefit of committing scarce food resources to work output and consequently to better crop production (Dicko and Sangaré, 1984; Astatke *et al.*, 1986; Khibe and Bartholomew, 1993). Feeding strategies for draught oxen can be better planned if the minimum working weight for cultivation is known and if the losses in weight and body condition that animals can tolerate before work output is affected are known. Hence in this study the relationship between body weight, body condition, weight loss during work and work output of draught oxen were investigated.

Material and methods

Animals and feeding

This experiment was conducted from July to September 1994 at the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) Sahelian Centre in Niger. Eighteen oxen, aged 4 to 7 years, with an average live weight of 326 kg, were used. They were given chopped millet stover *ad libitum*, supplemented daily with 10 g dry matter (DM) per kg $M^{0.75}$ of a concentrate mix made up (g/kg) of wheat bran (500), groundnut cake (350), rock phosphate (50), crushed bone (50) and common salt (50). Animals at rest were allowed to eat when other ox teams were working.

Treatments and experimental design

Treatments consisted of three levels of body condition before work (IBC). The oxen were given enough food during the 3 months before the experiment in order to reach contrasting body condition scores as defined by Nicholson and Butterworth (1986) on a scale from 1 (emaciated) to 9 (obese). Three pairs of oxen were assigned to each of the three treatment groups with average body condition scores of 2·33, 3·67 and 5·67 for groups 1, 2 and 3, respectively. Average M of teams in groups 1, 2 and 3 were 615, 650 and 692 kg, respectively.

The experiment lasted 7 weeks. Teams worked for 4 days each week. Work consisted of pulling a loaded sledge around a flat circuit. Each day, the teams worked for 4 h to complete 10 laps of the circuit. Work stopped when the set distance or the set time was complete or when oxen were unwilling to continue or when it was judged that the oxen were too tired to continue working. During the preparation phase an ergometer (Lawrence and Pearson, 1985) was used to measure work performed, distance travelled and elapsed working time for different known loads. A regression analysis of force on sledge load was performed and used to determine the load required for each team so that the draught force exerted was equivalent to 12·5 kgf per 100 kg M. The following equation was used to determine work loads: load (kg) = 0·201 × force (N) – 7·44.

Animals were allowed to stop for 3 to 4 min after each lap. Respiration rate and rectal temperature were then recorded. Respiration rate was assessed by counting the number of flank movements for 30 s. Rectal temperature was measured with a clinical thermometer. Live weight was measured for 3 days consecutively at the beginning of each week.

Body condition was assessed each week as defined by Nicholson and Butterworth (1986). Each day, individual food allowances and refusals were weighed and a food sample taken, dried and ground for laboratory analysis (Fall *et al.*, 1997b).

At the end of the 7 weeks of work, 10 animals were monitored for 2 months to investigate the rate of weight gain after work. The animals grazed rainy season natural pastures from 08.30 to 17.00 h without supplementation. They were kept in stables after grazing and had access to water *ad libitum*. M was measured for a 2-month period every 2nd day in the morning before grazing.

Data analysis

During the course of the experiment two oxen, one in team 3 ('poor' IBC) and one in team 6 ('medium' IBC), were impaired by joint disorders. They were consequently allowed to rest from the 5th week of the experiment. Sound oxen in these pairs were teamed up so that they could continue work for the rest of the experiment. Therefore, different sets of data were used to analyse parameters of interest in this study. The data set used to analyse daily intake of millet stover and daily weight changes included all weeks and all oxen except ox 17 and 25. Teams 3 and 6 were excluded from the analysis of speed, power and work output.

Statistical models used to analyse food intake, weight change, body condition, speed, power and work output using Statistical Analysis Systems Institute (1985) are given below:

(1) intake of millet stover (g DM per day per kg M and g DM per day per kg $M^{0.75}$)

$$Y_{ijkl} = \mu + C_i + T_{(i)j} + A_k + W_l + C \times A_{ik} + C \times W_{il} + W \times T_{(i)jl} + e_{ijkl}$$

(2) change in live weight (g/day) and body condition (points per week)

$$Y_{ijl} = \mu + C_i + T_{(i)j} + W_l + C \times W_{il} + W \times T_{(i)jl} + e_{ijl}$$

(3) speed (m/s) and power (W and W/100 kg M)

$$Y_{ijkm} = \mu + C_i + T_{(i)j} + W_k + R_m + C \times W_{ik} + C \times R_{im} + W \times T_{(i)jk} + e_{ijkm}$$

where: Y = one observation of daily food intake daily weight change, weekly body condition score force, distance, speed, power or work; μ = mean; C_i = ith IBC score, i = 1, 2 and 3 (1 = 'poor', 2 = 'medium'

3 = 'good' IBC); $T_{(i)j}$ = jth oxen team nested within the ith IBC group, j = 1, 2 and 3; A_k = kth activity, k = 0: rest, k = 1: work; W_l = lth experimental week, l = 1, 2. . .7; $C \times A_{ik}$ = interaction between the ith IBC and the kth activity; $C \times W_{il}$ = interaction between the ith IBC and lth week; $W \times T_{(i)jl}$ = interaction between the ith week and the jth team in the ith IBC group; R_m = mth lap of the circuit travelled; $C \times R_{im}$ = interaction between the ith initial body condition and the mth lap travelled; e = random error.

The effect of IBC on daily intake, weight change, speed, power and work was tested using team within condition ($T_{(i)j}$) as the error term. The interaction between week and team within condition ($W \times T_{(i)jl}$) served as the error term to test the effects of week and the interaction between week and other factors included in the model. Orthogonal polynomial regressions were fitted for variables such as week, lap, and their interaction with IBC to investigate the trend in food intake, weight change, speed, power and work over time.

Results

Linear effect of IBC ($P < 0{\cdot}05$) and the linear and quadratic effect of week ($P < 0{\cdot}05$) on daily intake of millet stover (g/day per kg M; g/day per kg $M^{0.75}$) were seen (Table 1). The poorer the IBC the higher was the intake of millet stover. Intake of millet stover increased steadily over time and reached a plateau by the 4th week. Food intakes on working and non-working days were similar.

Differences ($P < 0{\cdot}01$) in daily weight gain due to IBC were observed. All oxen lost weight during the experiment but weight losses were highest in oxen in 'good' IBC. Daily weight losses were 456 (s.e. 103·3), 308 (s.e. 103·3) and 719 (s.e 89·5) g/day for oxen in 'poor', 'medium' and 'good' IBC, respectively. Weight losses averaged 21·9 kg for oxen in the 'poor' IBC group, 14·8 kg for oxen in the 'medium' IBC group and 34·5 kg for oxen in the 'good' IBC group over 7 weeks. These weight losses were equivalent to proportionately 0·074, 0·047 and 0·099 of the initial M for oxen in 'poor', 'medium' and 'good' IBC, respectively.

Weight losses estimated from polynomial regressions are illustrated in Table 1. The pattern of live-weight changes was the same irrespective of IBC. Daily weight losses were highest during the 1st week of the experiment and decreased from week 1 to week 4. There was a steady increase in weight losses from week 5 to week 7. The regression of daily weight losses on intake of millet stover showed no association between these two measurements.

Body condition scores of all oxen declined over time. The regression of body condition on time showed that the better the IBC the more severe was its deterioration Body condition score declined at a rate of 0·006, 0·107 and 0·235 points per week, for oxen in 'poor', 'medium' and 'good' IBC, respectively.

In the 10 oxen monitored on good quality natural pastures after work, rapid weight gains were

Table 1 *Daily intake (g/kg M and g/kg $M^{0.75}$) of millet stover and daily live-weight losses over 7 weeks by oxen in 'poor', 'medium' and 'good' IBC on working and non-working days*

	Daily food intake g/kg M		Daily food intake g/kg $M^{0.75}$			Daily weight losses (g/day) estimated by polynomial regression IBC		
Sources of variation	Mean	s.e.	Mean	s.e.	Significance	'Poor'	'Medium'	'Good'
Initial body condition								
'Poor'	18·1	0·26	75·1	1·08				
'Medium'	17·2	0·26	72·9	1·07				
'Good'	15·2	0·22	64·8	0·93				
Activity								
Rest	17·2	0·20	72·2	0·86				
Work	16·6	0·19	69·7	0·79				
Week					Linear***			
1	13·8	0·22	58·1	0·94	Quad.***	206	409	1193
2	15·4	0·24	64·8	1·00		477	306	650
3	16·3	0·23	68·4	0·95		421	211	449
4	17·4	0·23	72·9	0·95		272	185	478
5	17·0	0·22	71·2	0·93		263	288	628
6	17·7	0·22	73·6	0·94		625	583	788
7	17·2·	0·24	71·6	1·03		1592	1129	847

observed as illustrated by the following regression equations of M (kg) on time (60 days [D] after work): M = 257 (s.e. 12) + 0·825 (s.e. 0·054) × D for oxen in 'poor' IBC (at the start of the experiment), M = 302 (s.e. 12) + 0·967 (s.e. 0·041) × D for oxen in 'medium' IBC (at the start of the experiment), M = 303 (s.e. 11) + 0·870 (s.e. 0·037) × D for oxen in 'good' IBC (at the start of the experiment).

The overall rate of change of M was similar irrespective of the IBC score. However oxen in 'poor' and 'medium' IBC had higher M gains (3·20 g/day per kg M) than oxen in 'good' IBC (2·87 g/day per kg M). Oxen in 'poor' and 'medium' IBC were able to reach their initial live weight 4 weeks, on average, after work stopped. It took 6 weeks after the cessation of work for oxen in 'good' IBC to reach their pre-work M.

IBC did not affect speed of work of teams. Power (W) developed by teams in 'poor' and 'medium' IBC was similar but significantly lower than power output (W) of oxen in 'good' IBC ($P < 0·01$). However, when power was expressed relative to live weight (W per 100 kg M), the effect of IBC was no longer significant. Three oxen teams with approximately similar M and in different body condition (team 1: 'poor' IBC, 719 kg, team 2: 'medium' IBC, 721 kg; team 3: 'good' IBC, 739 kg) developed similar power output (team 1: 775 W; team 2: 697 W; team 3: 741 W).

Differences in speed and power output due to week of work were significant ($P < 0·01$, Table 2). Speed and power output increased steadily over weeks for all teams irrespective of their IBC. Even though oxen lost body weight throughout the experiment, there was a significant weekly increase of 0·035 m/s and 25·1 W in speed and power, respectively.

Lap number had a significant effect ($P < 0·01$) on speed and power output. Two contrasting phases were observed in the pattern of power output each day. During the first three laps of work (1st h) there was an increase of 0·01 m/s and 9 W in speed and power each lap. In the second phase starting from the fourth lap a steady decline in speed and work output of 0·014 m/s and 10·3 W were observed for each lap completed.

Discussion

As in previous studies (Fall *et al*., 1997) work did not affect intake of millet stover. These results are consistent with most other studies that indicated no differences in intake in working animals as compared with animals at-rest (reviewed by Pearson and Dijkman, 1994). Poor body condition before work was conducive to higher intake of millet stover than good body condition before work over 7 weeks.

Table 2 *Speed (m/s) and power (W and W per 100 kg M) for oxen in different initial body condition (IBC) over 7 weeks and during each lap around the circuit*

Source of variation	Speed (m/s)	Power (W)	Power (W per 100 kg M)
Initial body condition			
'Poor'	0·94	637	117
'Medium'	0·86	637	107
'Good'	0·96	780	118
s.e.	0·005	4	0·6
Lap			
1	0·95	706	117
2	0·97	722	120
3	0·97	724	120
4	0·95	706	117
5	0·92	690	115
6	0·92	685	114
	0·89	666	111
8	0·88	654	109
9	0·87	651	108
10	0·87	646	107
s.e.	0·08	6	
Week			
1	0·78	590	95
2	0·84	631	103
3	0·88	653	107
4	0·98	725	120
5	1·00	744	124
6	0·96	713	120
7	0·99	739	126
s.e.	0·07	5	1

Early in lactation increases in DM intake were seen in cows with a low body condition as compared with those in a better body condition (Jones and Garnsworthy, 1989). As suggested by Faverdin *et al.* (1995), undernutrition induces an increase in food intake when food unavailability is no longer a limiting factor.

The steady increase in food intake and power output over 7 weeks observed in this study suggests that oxen underwent an adaptation to work during the first days of work. They became more adapted as work went on and they were therefore able to increase their intake. Bartholomew *et al.* (1994) also attributed increases in speed of working teams over time to adaptation to work. Therefore, working during the dry season would have the advantage that oxen are fit when cultivation starts and do not have to undergo this adaptation period in the cropping season.

During the preparation phase of the experiment oxen were given food to reach the targeted body condition and live weight. This was however difficult to achieve because live-weight changes were associated with changes in body condition. At the start of the experiment heavier animals tended to have better body condition than lighter animals. In order to minimize the confounding effect of M and IBC on the rate of work (W) in different treatment groups, power output was expressed relative to M (W per 100 kg M). The use of power relative to M to investigate the effect of IBC on work performance was based on the assumption that oxen in 'good' IBC had a higher fat content per kg M than oxen in 'poor' or 'medium' IBC.

Power output is a function of speed and draught force. The latter was set in this experiment to be proportional to M. Therefore any advantage of oxen in good condition over those in poor condition would have been expressed as a higher average walking speed. As compared with oxen in poor condition, oxen in good condition would perform work at a higher rate or for a longer period of time because they would have more body reserves to draw on to fuel muscle activity. However walking speed was not significantly affected by body condition in this experiment. Furthermore, the effect of IBC on power output was no longer significant when power output was expressed in relation to M. The similarity of power output relative to M for all oxen suggested that animals with same body mass, irrespective of fat content, generated the same power output This suggests that power output is more dependent on body mass than body condition. Oxen in good condition did not out-perform oxen with equal M but in poor body condition. These results are consistent with those reported by Bartholomew *et al.* (1994). These authors evaluated the relative importance of body weight and body condition on work performance by applying the same load of 367 N to groups of oxen weighing 310 and 360 kg and in good and poor condition. Light oxen in good condition could not sustain the work level applied. They concluded that live weight rather than body condition is the single most important determinant of work output. Therefore, it seems that farmers should be encouraged to select large-framed animals for draught purposes. This may be constrained by the fact that more young animals are being used for draught purposes with a rapid on-farm turn-over rate of these animals, apparently driven by an attractive meat market. There is therefore a genuine need to investigate feeding and management practices that will optimize power and meat output in these farming systems.

Good IBC may allow work for longer periods of time in the cropping season. In the present study, oxen in 'poor' IBC sustained average draught forces of 682 N. These animals might not be able to perform ploughing or ridging for extended periods because these two activities require draught forces of about 820 N (Khibe and Bartholomew, 1993). They could however pull heavily loaded carts without undue stress.

It was expected that weight losses would adversely affect work output. In this experiment power output improved over weeks while oxen were undergoing weight losses. The same trends in live-weight change and power output were reported by Bartholomew *et al.* (1993). Therefore the weight losses oxen can tolerate before work output is affected are difficult to estimate. Continuous and severe weight losses can compromise the health of the animal, or even its life. However in this experiment, oxen were able to regain live weight at a rapid rate when they had access to good quality pasture during the rainy season. It took them 4 to 6 weeks to reach their pre-work live weight.

At the start of the cropping season, various body conditions are found in oxen because of differences in food resources, management practices and the disease situation in farming systems in the semi-arid zone. Observations from this study suggest that a body condition score of between 2 and 3 as defined by Nicholson and Butterworth (1986) would be a low critical score below which work may irreversibly damage the oxen's health. The ideal body condition score would range between 4 and 6. These animals are not too fat nor too lean and can perform well if they are in good health. Oxen with a body condition score of over 6 may be too fat to move comfortably and are more susceptible to heat stress than leaner oxen. Moreover, the feeding level required to reach a body condition score over 6 is unlikely to be profitable as far as feeding for work performance is concerned.

Oxen should be supplemented during the cropping season when work is performed for more than 6 weeks. If the working period is short, weight losses could be tolerated as animals will regain their live weight rapidly. Supplementary feeding is however worthwhile for animals scheduled to be sold for meat after work, even for short working periods, so that work does not adversely affect their market value. In semi-arid west Africa food supplementation under these circumstances may be based on whole cotton seed, groundnut, sesame or cotton cakes if available. These foods are rich in protein and energy and provide substrates (long-chain fatty acids, glycogenic compounds) that can be directly used for work.

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