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The effects of work on food intake and ingestive behaviour of draught cattle and buffalo given barley straw

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Abstract

In the first experiment the animals were worked for 5 h/day and/or given 17 h access to food. In the second experiment they were worked for 4 h/day and/or given 20 h access to food. When animals were prevented from feeding on barley straw for 7 h/day their dry-matter intake (DMI) was significantly less than when they were given 24 h access to food. When feeding was prevented for only 4 h/day food intake was not significantly different from that with 24-h access.

A study of feeding behaviour (experiment 2) suggested that when most animals were deprived of food for 4 h they maintained similar intakes to those on ad libitum *feeding by increasing their rate of eating, rather than by increasing the time they spent eating. Preventing food intake for 4 h/day was associated with little change in time spent ruminating during the day. On all treatments, the buffalo spent significantly less time eating and more time ruminating than the cattle.*

Work, during the periods when food was withheld, had little effect on the DMI of either the buffalo or cattle compared with restricted feeding. No rumination occurred during the time that the animals were at work. However on working days, time spent ruminating was similar to that seen on restricted feeding days, but the animals spent more time ruminating later in the day than when they were able to ruminate during the middle of the day.

Keywords: *buffaloes, cattle, feeding behaviour, food intake, work.*

Introduction

Cereal crop residues, hays and field and roadside grasses, commonly form the staple diets of draught ruminants. The diets are characteristically high in fibre, low in nitrogen, and are poorly digested, with a metabolizability rarely above 0·4. Animals have enough difficulty eating sufficient quantities of these diets to meet their maintenance requirements without meeting any extra requirements for work. On these diets work is often associated with a reduction in food intake and/or weight loss in ruminants (Wanapat and Wachirapakorn, 1987; 1988; Pearson, 1990; Pearson 1992).

working during a day, which can be up represents time unavailable for eating. If kraaled at night without access to then there is little opportunity for them to up the time lost in eating over non-working This is a problem when food

Draught animals can therefore be considerably disadvantaged on working days. Not only are their energy requirements increased due to work but the time available to eat in order to meet those requirements is considerably reduced. This is not a problem to a farmer if he can afford to feed his animals a high density, concentrate food supplement on working days and most farmers recognize the need to supplement the diets of their draught animals on working days. However on many subsistence farms where draught ruminants are used, concentrate food is too costly for farmers to use, or the money needed to purchase it is not available. In these areas, during the working season draught ruminants are expected to lose weight. This can be tolerated if they are in a reasonable condition at the start of work, and if the working season is short. However if this is not the case, then working and feeding practices may need to be modified to reduce detrimental effects of work on food intake and give the draught ruminant more opportunity to consume roughage to replace at least some of the energy used for work.

It is unclear whether reductions in food intake on working days are due only to a reduction in time available for eating, or whether the work itself has a detrimental effect on the animal's desire to eat the fibrous diets. The draught ruminant's ability to compensate for decreases in time available for eating on fibrous diets by changing its ingestive behaviour has not been investigated. This paper describes two preliminary experiments which have been undertaken to study these two issues in draught ruminants. In the first experiment the dry-matter (DM) intake (DMI) of two cattle and two buffalo given 24 h access to food (*ad libitum* treatment) were compared with the DMI of the same animals when given 17 h access to food (restricted treatment) and when worked for 5 h/day and given 17 h access to food (work treatment). In the second experiment, in order to provide sufficient opportunity for the animals to increase DMI to compensate for the increased energy demands of work, the amount of time available for eating in the restricted and work treatments was increased to 20 h and the work period reduced to 4 h.

Material and methods

Experiment 1

Animals and management. The experiment was carried out at the Centre for Tropical Veterinary Medicine (CTVM) in Edinburgh, over the summer of 1991. Two 18-month-old Jersey heifers (live weights at the start of experiment 264 and 266 kg) and two 2-year-old swamp buffalo steers (live weights at the start of the experiment 387 and 452 kg) were used. The animals were housed in a large open-fronted pen with railings down the centre. A buffalo and one of the cattle were tethered on each side of the railings, with pairs of animals opposite each other. Partitions prevented food mixing from one side of the railings to the other. The animals were spaced sufficiently far apart to prevent one animal feeding or drinking from another's trough. However, tethering was sufficiently free to allow the animals to exhibit normal behaviour. Each animal was, to some degree, able to solicit or accept social contact from one or more of its neighbours. Clean water was available whenever the animals were present in the building.

Feeding and diets. The animals were fed on barley straw *ad libitum* (except where stated in the treatments). This was supplemented with a pelleted concentrate food for cattle, supplied by Seafield Mill, Roslin, Midlothian. Each animal received 1 kg (cattle) or 2 kg (buffalo) concentrate per day. The straw and concentrate diet was sufficient to provide for the maintenance requirements of the animals and allow for some growth. The compositions of the foods are given in Table 1. The animals had been given a hay/straw diet previously and were given 2 weeks to adapt to the experimental diet, before recording of the DMI of the animals started.

Table 1 *Mean chemical composition (g/kg dry matter (DM)) of foodstuffs based on weekly samples*

	Barley straw		Concentrate	
	Mean	s.e.	Mean	s.e.
Experiment 1 (no. =9)				
DM (g/kg)	931	0·2	932	1·2
Gross energy (MJ/kg DM)	16·9	0·12	17·0	0·15
Organic matter	940	1·0	839	1·0
Neutral-detergent fibre	853	3·0	331	2·9
Acid-detergent fibre	582	2·0	123	1·0
Crude protein	24·5	4·03	202·2	2·1
Experiment 2 (no.=9)				
DM (g/kg)	875	13·4	888	3·8
Gross energy (MJ/kg DM)	18·2	0·16	18·9	0·24
Organic matter	940	1·1	913	1·0
Neutral-detergent fibre	859	4·2	318	3·8
Acid-detergent fibre	602	7·0	150	0·3
Crude protein	31·1	0·48	180	0·2

Concentrates were given to the animals at 16.30 h each day on all treatments. Fresh barley straw was placed in front of the animals at 15.30 h in the two restricted treatment periods, and at 12.00 h and 14.00 h in the *ad libitum* period. All troughs were topped up at 18.00 h and 21.00 h.

Experimental design. The experiment involved three treatments, each run as a separate block. Treatment 1 was carried out in the first 12-day period, treatment 2 in the second 12-day period and treatment 3 in the last 12-day period. Each treatment period was followed by a 7-day rest period.

In treatment 1 (work) there was 5 h work per day with 17 h access to food. Animals were worked for 5 h/day with a break of 1 h after 2·5 h work. Work consisted of pulling a light cart around undulating roads and tracks. The work began at 09.30 h and was completed at about 15.30 h. During work the animals had no access to food or water. Water, but not food was available during the 1 h rest period between the two work sessions. Work output was measured using an ergometer (Lawrence and Pearson, 1985) and energy expenditure during work was estimated according to Lawrence (1985).

The animals' access to food was restricted to 17 h/day. Food troughs were removed from the front of the animals at 08.30 h and fresh food was placed in front of them at 15.30 h immediately after work.

In treatment 2 (restricted intake) there was no exercise with 17 h access to food. The animals' access to food was restricted to 17 h/day. Food troughs were removed at 08.30 h and then replaced at 15.30 h so that the period of food restriction exactly matched that of the previous treatment. The animals remained in the pens for the duration of the experiment, only being removed for weighing.

In treatment 3, (*ad libitum* intake) there was no exercise with 24 h access to food. The animals had 24 h access to food and remained in the pens for the duration of the treatment apart from during weighing. During the final 10 days of the experiment total faecal collections were taken from individual animals to enable food apparent digestibilities to be obtained.

Experiment 2

Animals and management. The experiment was carried out at the CTVM, over the summer of 1992. Two 3 year-old swamp buffalo steers (live weights 519 and 469 kg), one 2-year-old (Jersey × Limousin) × Sahiwal steer (live weight 340 kg), and one 2-year-old Jersey heifer (live weight 322 kg) were used.

Management of the animals was the same as in experiment 1 except that one set of barn lights was kept on constantly to enable the animals' behaviour to be observed during the night.

Feeding and diets. The animals were given a diet of barley straw and pelleted cattle food as in experiment 1. Animals had *ad libitum* access to straw, except where stated in the treatments. The food bins were filled and topped up with barley straw as in experiment 1, and the animals were given concentrates once daily at 12.30 h. On each day the buffalo received 2 kg, and the two cattle received 1.5 kg of the concentrate food.

Experimental design. The experimental design was essentially the same as in experiment 1.

Treatments. In treatment 1 (work) there was 4 h walking per day with 20 h access to food. The animals were walked between 11.30 h and 15.30 h daily for a period of 12 days. During this exercise period the animals had no access to bulk food or water. The animals were exercised on a horse walker. The machine was set to walk the animals at an appoximate speed of 1m/s. The distance covered by the animals each day was recorded with a mechanical odometer and energy expenditure during walking was estimated according to Lawrence (1985).

In treatment 2 (restricted intake) there was no exercise with 20 h access to food. Food was removed from in front of the animals between 11.30 h and 15.30 h, thereby preventing their access to food for 4 h/day. The period of food restriction exactly matched the period of work in the previous treatment both in length of time and time of day. The animals were not worked during this treatment, and remained in the pens except when being weighed. To be weighed they walked a short distance (approx. 140 m) to the weigh-bridge, twice a week.

In treatment 3 (*ad libitum* intake) there was no exercise, 24 h access to food. The animals remained in the pens and were only exercised to and from the weighing machine twice a week.

Measurements in experiments 1 and 2

Climatic monitoring and live weight. The minimum and maximum ambient temperatures and the relative humidity of the barn were recorded at 11.30 h each day.

The animals were weighed at the start, twice during and at the end of each treatment. On each occasion weighing was carried out at the same time of the day.

Dry-matter intake and food digestibility. The weight of food offered to the animals was recorded each day. Samples of the straw and concentrates offered to the animals were taken daily and pooled over each 7-day period.

When the food troughs were removed from the animals the amount of uneaten food remaining in them was collected and weighed. Any food that had fallen to the floor around the trough was collected and weighed separately. Samples of the floor- and trough-refusals were taken each day and dried to determine DM content. The daily DMI of the animals was determined by subtracting the dry weight of the trough- and floor-refusals from the total dry weight of the food offered.

Total faeces collections from each animal were carried out in period three of experiment 1 (*ad libitum* intake). Individual collections of faeces, collected at regular intervals during each day, were weighed and thoroughly mixed. A 20 g/kg sample from each collection was taken and pooled over the 10-day collection period for each animal for analysis.

Observation methods in experiment 2. During the experiment the animals were observed using the scan observation technique. The behaviour of all four animals was observed every 5 min over a 3 h observation period (Smith and Hodgson, 1984; Altman, 1974). The time of the observation periods was staggered over 4 days so that over a 96-h period the animals had been observed for 24 h. Two or three observation sessions occurred each day. This sequence was repeated twice more over the next 8 days so that by the end of the 12-day treatment period, three 24-h composite behaviour patterns of all the animals had been produced. The sequence of observation sessions was exactly the same in each of the three treatment periods.

Measurements of feeding behaviour in experiment 2. The amount of time the animals spent eating and ruminating was calculated from the observation sheets, by multiplying the number of times the behaviour was observed by the interval between observations (5 min). Due mainly to the deep feeding bins and physical arrangement of the experiment it was impossible to count and therefore measure chewing rates accurately during eating. The rate at which the animals chewed and swallowed regurgitated boluses during rumination was determined by counting the number of jaw movements and the number of swallows which occurred in a 2-min period. The number of chews per bolus was calculated from the number of chews per min divided by the number of boluses per min. A single meal or rumination bout was defined as a period of continuous eating or ruminating not interrupted by any other oral activity for more than 5 min. These measurements were taken directly from the behaviour record sheet.

Analysis of food and faecal samples. Samples of food and faeces were dried in a forced air-oven to constant weight at 60°C and ground through a 1-mm sieve before being analysed. The following determinations were made on the weekly pooled samples of food: acid-detergent fibre (ADF), neutral-detergent fibre (NDF), nitrogen (N), organic matter (OM) and gross energy (GE), according to the Association of Official Analytical Chemists (1990).

Statistical analysis. Parametric parameters such as food intake, chew rates, swallow rates, time spent eating, lying down and ruminating, were analysed using paired Student's '*t*' tests or analysis of variance using the Minitab statistical computer package.

Results

All the animals apart from one buffalo which became lame during experiment 2, remained fit and well during the course of both experiments. The lameness of this animal resulted in both buffalo being rested for 6 days during the first treatment period of the second experiment. The buffalo carried out the missing days of exercise treatment 2 weeks later during the second treatment period.

Climatic monitoring and live weight

The average minimum and maximum temperatures during experiment 1 were 13·1 (s.e. 0·4) °C and 19·7 (s.e. 0·3) °C respectively, with an average relative humidity of 0·47 (s.e. 0·017). During experiment 2, the average minimum and maximum temperature were 13·0°C (s.e. 0·5) and 19·8°C (s.e. 0·5) respectively, with an average relative humidity of 0·40 (s.e. 0·016). At these temperatures the animals showed minimal signs of heat stress during work: increased respiration rate, but not rapid panting or marked drooling.

During experiment 1, there was a small increase (3 (s.e. 0·1) kg). in the live weight of the buffalo and a larger increase (16 (s.e. 0·7) kg) in live weight of the cattle. In the second experiment the live weight of the buffalo and cattle increased by an average of 19·0 (s.e. 1·2) kg and 20 (s.e. 4·2) kg, respectively.

Energy expenditure during work

In experiment 1, the average estimated energy expenditure for work was calculated from work done, distance travelled, live weight and energy costs of walking and pulling (Lawrence and Stibbards, 1990). This was 6·5 (s.e. 0·3) MJ/day equivalent to about 0·2 × maintenance, for the buffalo and 6·6 (s.e. 0·2) MJ/day, equivalent to about 0·3 × maintenance, for the cattle. In experiment 2, the estimated energy expenditure for walking was calculated from the distance walked, live weight, and the energy cost of walking on a flat hard surface of 2 J/kg live weight per m walked (Lawrence and Stibbards, 1990). During this experiment the energy expenditure of walking was 8·0 (s.e. 0·2) MJ/day, about 0·2 × maintenance, for the buffalo and 6·7 (s.e. 0·3) MJ/day, about 0·2 × maintenance for the cattle.

Dry-matter intake

The DMI of animals in both experiments is shown in Figure 1. In the first experiment cattle and buffalo with access to food for 24 h/day (*ad libitum* treatment) ate significantly more than when their access to food was reduced by 7 to 17 h/day ($P < 0·001$). Work for 5 h/day, during the 7-h period without food (work treatment), was associated with a greater reduction in food intake compared with that seen when the animals access to food was restricted, but they did not work (restricted treatment). In this first experiment, when DMI was expressed on a metabolic-weight basis, cattle ate significantly more than the buffalo ($P < 0·001$), but in the second experiment there were no significant differences between species in DMI expressed per unit metabolic weight.

In experiment 2, when access to food was only reduced by 4 h to 20 h/day, there was no significant effect on daily DMI. Both cattle and buffalo showed

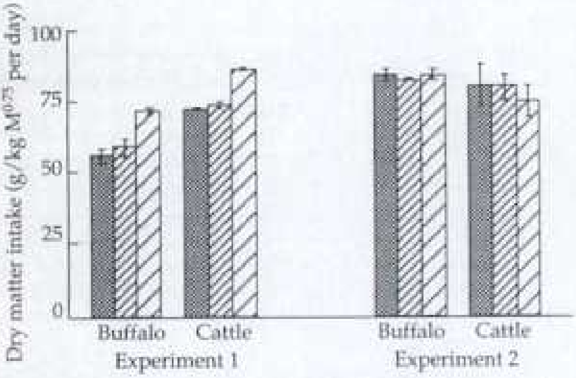

Figure 1 Mean (s.e.) dry-matter intake of barley straw by cattle and buffalo during three 12-day treatment periods in experiment 1 and experiment 2. Work plus feeding time restricted, ▓. No work with feeding times restricted, ▨. No work with *ad libitum* access to food, ▧. In experiment 1, the animals were worked for 5 h, and had feeding time restricted by 7 h. In experiment 2, the animals were worked for 4 h, and had feeding time restricted by 4 h.

similar intakes to those seen when food was available for 24 h/day.

The apparent digestibility coefficients of the diet

In the buffalo the apparent digestibility coefficients of DM, OM, NDF, ADF and crude protein (CP) of the straw/concentrate diet were 0·56 (s.e. 0·0013), 0·57 (s.e. 0·013), 0·62 (s.e. 0·013), 0·58 (s.e. 0·007) and 0·26 (s.e. 0·06). In the cattle for the same diet the apparent digestibility coefficients of DM, OM, NDF, ADF, and CP were 0·57 (s.e. 0·008), 0·59 (s.e. 0·01), 0·63 (s.e. 0·008), 0·61 (s.e. 0·007) and 0·43 (s.e. 0·06) respectively.

Behavioural observations

The results of some of the behavioural activities associated with feeding are given in Table 2 and Figure 2.

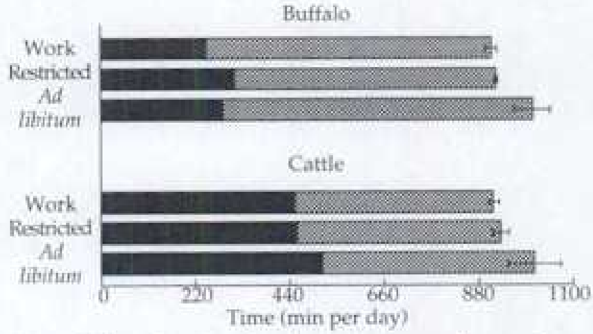

Figure 2 Mean (s.e.) total oral activity time and proportion spent in eating ▇ and ruminating ▒ by buffalo and cattle when walked for 4 h/day (work), when food restricted for 4 h/day (restricted) and when fed *ad libitum* (*ad libitum*).

Table 2 *Mean time spent eating and ruminating, number of meals per day, meal length, number of rumination bouts per day and rumination bout length in cattle and buffalo when walked for 4 h/day (work), when time available for eating was restricted for 4 h/day (restricted) and when fed* ad libitum (ad libitum)

		Buffalo		Cattle		All animals	
Activity	Treatment	Mean	s.e.	Mean	s.e.	Mean	s.e.
Eating (min/day)	Work	238	22·5	450	18·0	344	62·5
	Restricted	309	6·5	453	49·5	381	46·3
	Ad libitum	281	22·5	511	51·0	396	70·3
	Mean	276	15·5	471	22·7		
Ruminating (min/day)	Work	670	10·0	465	5·0	56	59·4
	Restricted	612	3·5	478	29·5	545	40·5
	Ad libitum	723	19·5	500	10·0	612	64·9
	Mean	668	21·1	481	10·3		
Meal length (min)	Work	21·2	2·0	37·5	4·3	29·4	5·1
	Restricted	31·6	3·4	40·6	0·3	36·1	2·9
	Ad libitum	23·4	1·9	49·1	1·2	36·3	7·5
	Mean	25·4	3·1	42·4	3·5		
Rumination bouts per day	Work	14·0	1·2	15·2	0·8	14·6	0·7
	Restricted	15·8	1·5	18·2	0·3	17·0	0·9
	Ad libitum	16·8	0·8	17·2	1·2	17·0	0·6
	Mean	15·5	0·8	16·9	0·9		
Rumination bout length (min)	Work	48·2	3·5	30·7	1·3	39·5	5·3
	Restricted	39·0	3·5	26·3	1·4	32·7	4·0
	Ad libitum	43·2	3·3	29·3	2·7	36·3	4·4
	Mean	43·5	2·6	28·8	1·3		

Time spent eating and ruminating per day
The amount of time spent eating and ruminating showed considerable variation between individuals. Despite this some significant patterns were apparent. Taken together, the animals spent significantly less time eating during the work treatment than during the *ad libitum* treatment ($P < 0{\cdot}05$). On the restricted treatment, without work, the cattle spent a similar time eating during the day as on the work treatment. The buffalo however, spent more time in eating during the restricted treatment than they did on either the *ad libitum* treatment or the work treatment. In both species the least amount of time was spent eating during the work treatment. A comparison between species showed that the buffalo spent significantly less time (proportionately about 0·50; $P < 0{\cdot}001$) than cattle in the activities of eating.

Although the buffalo spent less time eating than cattle, they spent significantly more time in ruminating than the cattle on all treatments ($P < 0{\cdot}001$). All animals spent less time per day ruminating during the work and restricted treatment periods than during the *ad libitum* treatment period ($P = 0{\cdot}056$). On working days, the animals spent more time ruminating later in the day than when they were able to ruminate during the middle of the day on the restricted and *ad libitum* treatments.

The time spent in the two activities of eating and ruminating were combined to give total oral activity time. There was less variation in the total oral activity time between species and individuals than in either the eating or ruminating times. There were significant differences in the time spent in total oral activity between the *ad libitum* treatment and the two treatments in which food was restricted ($P < 0{\cdot}05$), that is both the work and restricted treatment periods. The differences in the time spent in total oral activity by the animals in the restricted treatment period compared with the period in which they were also working, were not significant ($P > 0{\cdot}05$).

Between species there were no significant differences in total oral activity, the differences in time spent eating between the species were compensated for by reciprocal differences in time spent ruminating.

Number of meals per day, meal length, number of rumination bouts and rumination bout length
The number of meals per day showed no significant change from one treatment to another. There was little variation in number of meals between treatments, species or individual animals. The length of meals did not change significantly with treatment, however there were significant differences between species ($P < 0{\cdot}001$). The cattle spent longer over meals than the buffalo, proportionately about 0·4 more time per meal. The number of rumination bouts per day was affected by treatment. None of the animals ruminated when working. All animals had significantly fewer rumination bouts per day during the work treatment than when on the restricted or *ad libitum* treatments ($P < 0{\cdot}05$ and $P < 0{\cdot}01$, respectively), in which rumination was not suppressed. Differences between species were not significant.

When rumination bout length was studied it appeared that the reduction in the number of rumination bouts was at least partly compensated for by an increase in rumination bout length. When worked, animals tended to ruminate for a longer time per bout than on the other two treatments. The effect was more noticeable in the buffalo than in the cattle, where differences between the worked and *ad libitum* treatments were small.

Chews per min, number of swallows per min and number of bites per bolus during rumination
There was remarkably little variation in the number of chews per min during rumination. The cattle tended to chew more quickly than the buffalo (61·7 (s.e. 1·1) bites per min and 55·1 (s.e. 0·9) bites per min respectively). There was little effect of the treatments on chew rates. Variation in chew rates was greater between animals than between treatments or species. The same was true for swallows per min (overall mean 1·1 (s.e. 0·04)) and chews per bolus (overall mean 55·7 (s.e. 1·7)). There was a slight tendency for the buffalo to swallow less frequently and chew each bolus more times than the cattle.

Discussion

The small number of animals and the different species involved in this experiment mean that the results must be interpreted with some care. However, a number of inferences of the effects of work on feeding behaviour of draught cattle and buffalo and their food intake can be drawn.

Work was associated with a small decrease in intake in the first experiment and little change in intake in the second. During both these experiments the animals did not ruminate during the work periods and as a consequence had to compensate for both lost eating and rumination time when they returned from work. This suggests that any stimulatory effect there may have been of work on appetite was counteracted by the reduction in time available for cominution (eating and rumination). The observations are consistent with other observations in working oxen and buffalo given high roughage diets. Oxen in Costa Rica consuming poor quality hay, oxen in Nepal consuming rice straw (Pearson present study were not unduly stressed by the work. Under more stressful conditions, that is at higher rates of energy expenditure and in hotter environmental conditions, effects of work on ingestive behaviour may be greater than observed in this study in the United Kingdom.

The results from this experiment have not shown an increase in DMI in response to increased energy requirements for work. This may have been due to the poor quality of the diet which limited the animals' ability to increase food intake. Further experimental work is required to investigate the interaction between work done and the quality of the diet.

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