A COMPARISON OF JERSEY CROSSBRED AND LOCAL OXEN AS DRAUGHT ANIMALS IN THE EASTERN HILLS OF NEPAL

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Summary

Four pairs of draught oxen (two local and two Jersey crossbred) were studied when they ploughed dry land on local farms.

Work done, distance travelled and body temperature of each ox were measured continuously over a 5 h working day. A different team worked each day, completing at least six days work each.

Individual food intakes and digestibility of feed were measured when the animals were given rice straw and tree fodder, and housed and fed according to local husbandry practices.

The Jersey crossbreds, particularly the longer legged type, had a higher rate of work than the local oxen in this study. They did significantly more work and covered a greater distance during the day.

The absence of a hump in the crossbred oxen had no effect on the position of the yoke or the way the oxen pulled when ploughing.

The longer legged type of Jersey crossbred tended to work more erratically than any of the other teams. A fast rate of work made the oxen more liable to heat stress. When fed according to local practices and given the same amount of feed as local oxen, Jersey crossbreds tended to do less well. During the ploughing months, the local oxen gained weight, while the crossbreds remained at the same or lost some weight.

Although there were some disadvantages to keeping Jersey crossbreds for work, their favourable work output suggests that the introduction of the Jersey crossbred in the hills of Nepal is unlikely to be detrimental to the performance of the work oxen population.

(**Key Words:** Draught Oxen, Work Output, Nutrition, Food Intake, Body Temperature)

Introduction

In the Eastern hills, the majority of male cattle are castrated, and kept on farms only for work purposes. Apart from hand labour, these are the only means the farmer has of cultivating his land. They also provide manure which is valued as a fertilizer. For religious reasons, female animals may not be worked and cattle may not be killed and eaten. In a survey of animal numbers in thirty-five panchayats (a group of villages making up a village council) of the Koshi hills, Gurung et al. (1989) found that eighty-five percent of farmers own draught oxen. Most farmers keep two oxen for work and some keep younger homebred animals for sale. Working oxen are usually purchased when required, as any home-bred replacements are unlikely to be ready when needed.

Under development schemes run by the Nepalese Government and foreign aid agencies, Jersey bulls have been imported during the last twenty years to cross with local hill cows. The resulting crossbred cows produce more milk than the local cows, but their milk yield is still below that of local and crossbred buffaloes (Shrestha et al., 1988). The performance of the Jersey crossbred as a draught animal has not been studied, or compared to that of the local oxen, although work is the main role of oxen in the hills.

Surveys have shown that the number of Jersey crossbreds is low in the Eastern hills (Gurung et al., 1989; Gatenby et al., 1990). However, to establish if the policy of continuing to introduce Jersey stock into the hills will have any effect on the performance of the work oxen population, a comparison of Jersey crossbred and

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local oxen was carried out at Pakhribas Agricultural Centre from December 1989 to March 1990. As the farmer has to consider feeding requirements as well as work output, food intake and digestibility of feed were compared in addition to work performance.

Materials and Methods

Animals

Four pairs of draught oxen were purchased locally. A small pair and a sturdy larger pair of local oxen were chosen to represent the range of local animals that are used in the hills. Similarly the Jersey crossbred oxen were selected to represent the types available: one pair was taller than most local animals, with longer legs and typical 'Jersey' features. The other pair was shorter and sturdier than the first pair without obvious 'Jersey' characteristics. Both pairs of crossbred animals lacked the pronounced hump of the local animals.

Work Output Study

Feeding and management

When not working the oxen were kept in individual stalls in a shed or field shelter. Each animal was fed on locally available roughage (rice straw and cut grass or tree fodder) and received a concentrate ration of maize flour (630 g/kg), rice bran (300 g/kg), mustard cake (40 g/kg) and salt (30 g/kg), given at a level of 1 kg on work days and 0.5 kg on rest days. The ration was fed in the early morning (about 06:00 h) before work. Animals had free access to water, except when working.

Work

The four teams of oxen were compared when they ploughed 'bari' (dry) land terraces on the hillsides at between 1400 m and 1800 m above sea level in December and January. A traditional plough (ard) and yoke were used. A different team worked each day begining at about 08:00 h and finishing after five hours ploughing at about 13:00 h. Rest periods of at least three days were given between each working day. Each team completed a total of six days work each during the experiment. Three men took it in turn to plough during the day. The cattle worked in a similar manner for each man.

Measurements

Body weight was estimated at the start and end of the study from girth measurements using the formula: Weight (kg) = $-141.6 + 2.38$ Heart girth (cm) (Yazman, 1987). This formula was calculated from data obtained from oxen visiting Pakhribas Agricultural Centre and included both Jersey crossbred animals and other local types of oxen. Condition scores were assessed on a scale from 1 to 9 ($1-3$ = lean; $4-6$ = medium; $7-9$ = fat), according to Nicholson and Butterworth (1985). To compare the conformation of each animal some anatomical measurements were also made:

1. Height at withers. 2. Depth of ribcage over heart. 3. Length of foreleg from elbow to ground. 4. Circumference of foreleg cannon bone. 5. Length of body from point of shoulder to tuber ischii. 6. Height at tuber coxae. 7. Length of hindleg from stifle to ground.

Body temperature (℃) of each animal, work output (kJ), distance travelled (m) and time spent working (elapsed work time, EWT) were recorded every minute during the five hours the oxen worked using sensors and data logging instruments described by Pearson et al. (1989).

Ambient temperature and relative humidity, measured using a whirling hygrometer, (Zeal Ltd, Merton, London S.W. 19, U.K.) were monitered in the field every 15 minutes when the oxen were ploughing.

Estimates of the energy requirements for maintenance were calculated according to the Agricultural Research Council (ARC, 1980). Estimates of the energy expended by the oxen during work were calculated from the figures for total work done during the day, body weight and distance travelled, according to Lawrence (1985) using the formula

$$E = AFM + W/B$$

where E = extra energy used for work (kJ); F = distance travelled (km); M = body weight (kg); W = work done whilst pulling loads (kJ); A = 2 = energy used (J) to move 1 kg of body weight 1 m horizontally (ARC, 1980; Lawrence, 1985); B = 0.298 = ratio of work done pulling: energy used (Lawrence, 1985).

Statistical differences between means were estimated using Student's t tests (Mead and

Curnow, 1983).

Nutritional Study

Feeding and management

The eight oxen were kept in individual stalls in the covered shed. Prior to the study the oxen had been eating rice straw and cut grass or tree fodder and some concentrate. Each day they were fed rice straw ad libitum, 4 kg fresh weight of tree fodder and 1 kg of the concentrate ration. The tree fodder was either Nebharo (Ficus auriculata) or Gogan (Saurauia napaulensis), given as two meals, in the morning and afternoon. Trees were lopped on the day of feeding in the early morning and only branches of less than 30 mm in diameter were fed. The concentrate ration was also divided into two meals, given morning and afternoon. The quantity of rice straw offered depended on appetite but was always offered in excess of voluntary food intake. Clean water was always available when the oxen were inside the shed. In mid-morning the animals were tethered outside in the sun, according to local practice, for three hours. During this time they did not receive any feed or water.

Measurements

Measurements were taken over a period of five weeks. The maximium and minimum ambient temperature and relative humidity was measured inside and outside the covered shed daily at 09:00 h. Body weights of each animal were estimated at the start and end of the study according to Yazman (1987).

Voluntary food intake was recorded daily from the start of the experiment. Total faecal collections were made from each animal over a six day period in the last week of the experiment to enable digestibility measurements to be made.

Results

Body Condition and Conformation of Oxen

The estimated body weight and condition score of each animal at the start and end of the study are given in table 1. All of the animals had little fat cover, but they varied in muscle development and conformation. Measurements of conformation are given in table 2. The Jersey crossbred animals did not show any marked change in weight. However, the local oxen all gained weight during the six weeks that they were ploughing.

The first team of Jersey crossbreds had proportionally longer legs than the other oxen. When viewed from behind both animals were 'cow hocked' with poor muscle development in the hindquarters. These oxen were thin and the vertebral spines, pin bones (tuber coxae and tuber ischii), tail head and ribs were prominent. The muscle mass between the tuber coxae and tuber ischii was concave. The second team of Jersey crossbreds were both more compact, shorter legged animals, carrying more condition than the first pair. When viewed from behind the legs were straight and muscle development in the hindquarters was better. The ribs on both animals were visible but the spinous processes were not easily seen. The muscle mass between the tuber coxae and the tuber ischii was level/convex in both animals. The right animal in particular was smooth and well covered and in the best condition of all the oxen.

The local animals also varied in size and condition. The first, and smaller, team contained an animal in poor condition similar to that described for the first team of Jersey crossbreds. This animal had poor muscle development, particularly in the hindlimbs. It was teamed with a small but compact animal in reasonable condition, with straight hindlimbs and good hind muscle development. The muscle mass between the tuber coxae and tuber ischii was not concave on this animal, ribs and spinous processes were just visible. The second team of local animals contained the largest and longest animal. This animal was teamed with a slightly smaller, but sturdy ox (see table 2). Both animals were in reasonable condition, but with little fat cover. Spinous processes were barely visible, and when viewed from behind leg muscles and hindquarters were well developed.

Working Conditions When Ploughing

Most of the ploughing was done in sunshine, however on four days (one with each team) cooler misty conditions were experienced for most of the day. Minimum and maximium dry bulb temperatures were 8.7 (s.d. 1.89)℃ and 14.5 (s.d. 1.80)℃, respectively ($n = 24$) during the 5 h work. The mornings started cool and temperatures generally reached their highest levels in the fourth

TABLE 1. ESTIMATED BODY WEIGHT AND CONDITION SCORE OF TWO TEAMS OF JERSEY CROSSBRED AND TWO TEAMS OF LOCAL OXEN

Oxen	Initial		Final	
	Body weight (kg)	Condition score	Body weight (kg)	Condition score
Jersey crossbred oxen				
1 Left	205	4	210	4
1 Right	192	3	203	3
Total weight of team (kg)	397			
2 Left	204	5	210	5
2 Right	220	6	213	6
Total weight of team (kg)	424			
Local oxen				
1 Left	173	3	186	3
1 Right	185	5	205	5
Total weight of team (kg)	358			
2 Left	233	5	258	5
2 Right	209	6	220	6
Total weight of team (kg)	442			

TABLE 2. MEASUREMENTS OF ANATOMICAL CHARACTERISTICS OF TWO TEAMS OF JERSEY CROSSBRED AND TWO TEAMS OF LOCAL OXEN

Oxen	Anatomical measurements (cm)*						
	1	2	3	4	5	6	7
	Height withers	Heart depth	Length foreleg	Circum. foreleg	Length body	Hip height	Length hindleg
Jersey crossbred oxen							
1 Left	110	55	66	15	119	112	76
1 Right	111	54	65	13	118	111	75
2 Left	107	53	56	15	108	109	70
2 Right	105	51	56	15	119	107	69
Local oxen							
1 Left	106	49	56	13	116	98	68
1 Right	100	52	59	14	110	101	63
2 Left	115	53	59	15	124	109	72
2 Right	106	48	55	15	109	106	72

* See text for details

and fifth hour. Mean relative humidity averaged daily over the 5 h work was 69 (s.d. 7.68) percent (n = 24).

All ploughing was done in the dry season and no measurable rainfall occurred during the course of the experiment. During the six days of ploughing each team experienced the range of conditions prevailing, hot sunny days and cool misty ones, both first and second ploughing of land and the different soil types, as far as possible in equal amounts. As ground conditions have a marked effect on work output on terraces. a scale from 1 to 4 was devised to account for the difficulty experienced in ploughing the land due to soil condition. The condition of the ground which was ploughed varied from light sandy loam to land which was fairly hard and compacted, but was not unploughable:

1 light sandy soil.
2 tending towards light soil.
3 tending towards hard soil.
4 hard dry soil.

These scores were added up over the six days for each team. The Jersey crossbreds had a score of 15 (team one) and 13 (team two). The local oxen had a score of 15 (team one) and 16 (team two). Therefore each team ploughed under similar conditions with the exception of the second Jersey crossbred team which possible had easier working conditions.

The terraces were generally ploughed parallel to the hillside, beginning at the front edge of the terrace and working to the back. Small areas were often ploughed to finish off a terrace. Oxen then spent a good deal of their time turning round. No appreciable differences in draught force were observed on the small areas or on smaller terraces, although EWT was usually lower than on larger areas or terraces.

The cattle worked in a similar manner for each man. There was no significant difference between ploughman in the way these animals worked.

EWT was between 46 to 55 minutes in each hour. The teams were stopped for three minutes each hour for measurements from instruments to be taken. However on no occasion did any of the teams work for the whole of the remaining 57 minutes. They tended to pause when turning at the end of terraces. Other stoppages were made to adjust the plough when the handle or beam became loose after turning or hitting an obstruction (usually a root or rock) and on one occasion (see later) to allow oxen to rest (EWT = 40 minutes per hour).

Work Output of the Teams of Oxen

The daily work done, distance travelled, average draught force (ADF, calculated from distance and work measurements), speed (calculated from EWT and distance) and power (calculated from work and EWT measurements) for each team are given in table 3.

The Jersey crossbreds did significantly ($p < 0.01$) more work and covered a greater distance during the day than the local animals. The larger local team (team two) had a significantly ($p < 0.05$) higher work output and covered a greater distance than the smaller local team (team one).

The crossbred oxen had a significantly ($p <$

TABLE 3. TOTAL WORK DONE, DISTANCE TRAVELLED, AVERAGE DRAUGHT FORCE (ADF), SPEED AND POWER WHEN JERSEY CROSSBRED AND LOCAL TEAMS OF OXEN PLOUGHED FOR 5 H PER DAY (N = 6)

	Jersey crossbred oxen				Local oxen			
	Team 1		Team 2		Team 1		Team 2	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Work done (kJ/team)	3906	256[a]	3369	126[a]	2228	60[c]	2641	146[b]
Distance travelled (km)	6.07	0.41[a]	5.40	0.28[a]	3.90	0.23[c]	4.01	0.26[b]
ADF (N)	646.1	27.8[a]	628.9	23.9[a]	581.1	29.8[a]	662.7	24.7[a]
Speed (m/s)	0.40	0.02[a]	0.35	0.02[a]	0.26	0.02[b]	0.25	0.01[b]
Power (w)	257.7	13.3[a]	218.2	7.0[b]	149.1	4.6[d]	166.7	7.6[c]

[a,b,c] For each variable values with the same superscripts are not significantly different from each other ($p < 0.05$).

0.01) faster speed of working than the local oxen.

ADF was variable and depended largely on the ground conditions rather than any differences between teams of oxen.

One crossbred team (team one) showed a significantly ($p < 0.05$) greater power output over the day than the other crossbred pair, but both teams had a significantly ($p < 0.01$) higher average power output than the local oxen.

The 0.5 h averages for work performance (figure 1) show the pattern of work during the day. The first crossbred team had a more erratic way of working and showed a greater variation in each of the 0.5 h periods than any of the other teams. The second team of crossbreds, however, showed a similar pattern of working to the local teams. The local oxen tended to work slowly and steadily throughout the day, showing little change from hour to hour. The exception was the second local team which started off at a good rate, comparable to the second team of crossbreds, only to slow down after the first 0.5 h.

The higher work output and distance travelled by the crossbred oxen during the five hours of ploughing compared with the local animals was associated with a higher estimated energy expenditure during the working period. Differences were significant ($p < 0.01$) when expressed per kg body weight $M^{0.75}$ and as a proportion of the daily maintenance requirement of individual oxen (table 4).

Changes in Body Temperature During Work

All animals showed an increase in rectal temperature after they started work. In some cases after the initial increase to 39-40℃, body temperature remained fairly stable at the higher level until work finished. In other cases body temperature continued to rise steadily throughout the 5 h period. In these instances animals usually showed signs of heat stress begining at about 40.5℃, particularly in the last 1-2 h of work. They began panting and drooling in varying degrees. Differences in the rate and extent of change in body temperature during work were seen between animals in the same team on the same day (e.g. figure 2). The smaller animals tended to get hotter than the larger animals when working, presumably as they expended more energy for work in proportion to body weight than their larger team mates. Similarly the smaller local team (team 1) tended to get hotter than the larger local team doing similar work. Differences in resting body temperature between animals did not seem to be associated with differences in body condition. Thin animals did not

TABLE 4. CALCULATED ADDITIONAL ENERGY USED ABOVE MAINTENANCE WHEN JERSEY CROSSBRED AND LOCAL TEAMS OF OXEN PLOUGHED FOR 5 H PER DAY (N = 6)

Oxen	Energy expenditure				
	$kJ/kgM^{0.75}$			Multiple of maintenance	
	Mean	S.E.	Range	Mean	S.E.
Jersey crossbred oxen					
1 Left	167.7	10.6^{cd}	132-210	0.40	0.03^{b}
1 Right	172.3	10.9^{d}	136-216	0.41	0.03^{b}
2 Left	145.6	5.5^{cd}	123-163	0.35	0.01^{b}
2 Right	140.6	5.3^{c}	119-158	0.34	0.01^{b}
Local oxen					
1 Left	106.7	3.5^{b}	95-122	0.25	0.01^{a}
1 Right	91.9	3.4^{a}	91-119	0.24	0.01^{a}
2 Left	105.6	5.9^{b}	92-132	0.25	0.01^{a}
2 Right	111.1	6.2^{b}	96-139	0.26	0.01^{a}

[a,b,c,d] For each variable values with the same superscripts are not significantly different from each other ($p < 0.05$).

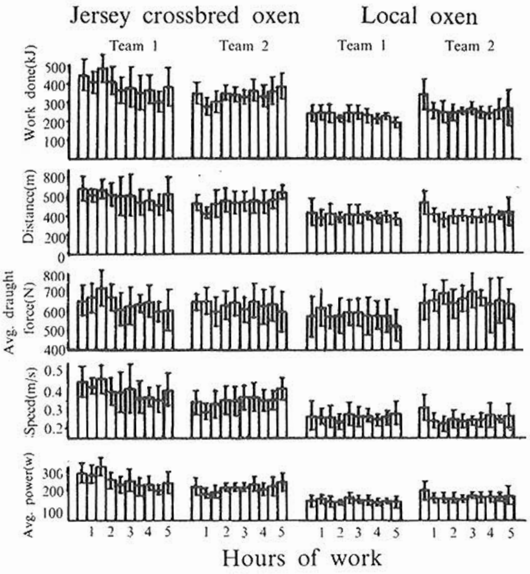

Figure 1. Mean ± s.d. half hourly work done (kJ), distance covered (m), speed when working (m/s), average draught force (N) and power (W) of two teams of Jersey crossbred and two teams of local oxen ploughing continously for 5 h per day (n = 6).

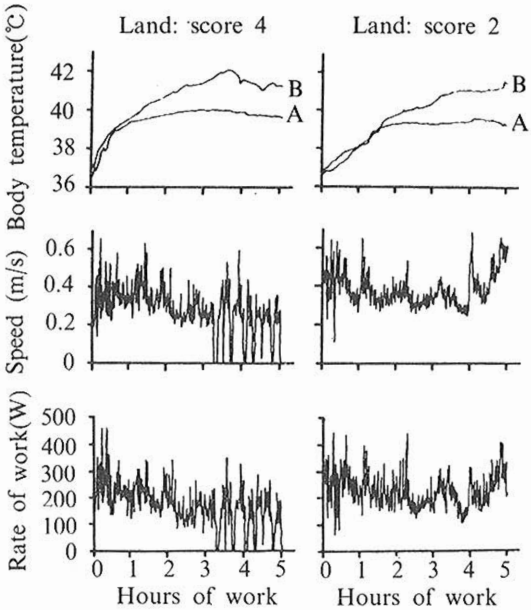

Figure 2. Body temperature (℃) of left (A) and right (B) oxen, speed (m/s) and rate of working (W) of the first team of Jersey crossbred oxen on one day ploughing hard land (score 4) and one day ploughing easier land (score 2).

start at lower body temperatures in the morning than those in better condition.

Heat stress and a continous increase in body temperature were seen under a range of different circumstances, but were mainly associated with the difficulty found in ploughing the land and the speed of working of the oxen, rather than any differences in environmental conditions experienced when ploughing. For example, the first local team showed a greater increase in body temperature on a cold misty day (ambient temperature 5-13℃) when ploughing hard land (score 4) than on a warm sunny day (ambient temperature 9-16℃) when ploughing sandy land (score 1, figure 3).

In the first team of Jersey crossbreds, the right ox always appeared heat stressed after 2-3 h of work and on one occasion it became so stressed, reaching a body temperature above 41℃, that it was necessary to rest it in the shade for 10-15 minutes in each hour to allow it to cool down (e.g. figure 2). On this day the land being ploughed was hard (score 4) and although the average speed at which the animals were working was lower than on other days when land conditions were easier (score 2, figure 2), the animal showed a greater increase in body temperature. The other ox in this pair never showed signs of heat stress, other than an increase in respiration rate, regardless of the type of land being ploughed.

The second team of local animals also became more heat stressed when ploughing hard land (score 4), despite working at a slower speed and achieving a lower work output than on the easier land. This was not the case with the second Jersey crossbred team. On easier land (score 1) they worked faster and showed a greater increase in body temperature than on hard land (score 4) when conditions dictated that they went slower.

Temperament of Oxen

All the oxen in the study were experienced draught animals and usually responded well to the voice to turn, stop and start. The first team of Jersey crossbreds, while easy to handle and yoke, did tend to work erratically, although

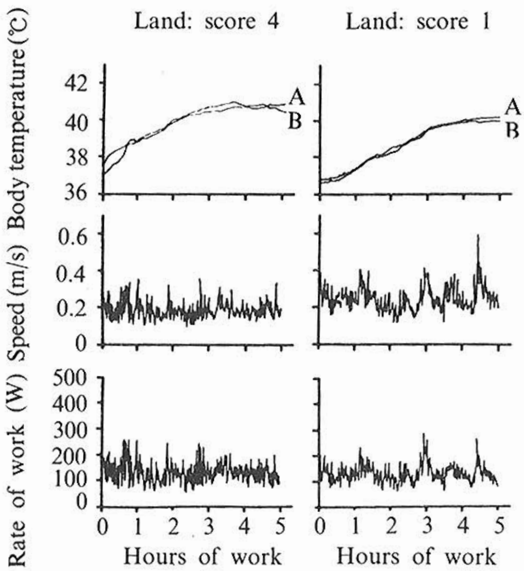

Figure 3. Body temperature (℃) of left (A) and right (B) oxen, speed (m/s) and rate of working (W) of the first team of local oxen on one day ploughing hard land (score 4) and one day ploughing easier land (score 1).

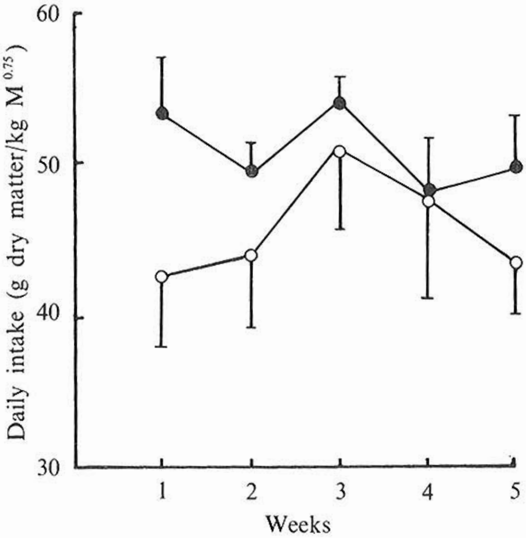

Figure 4. Mean ± s.d. voluntary intake of rice straw (g dry matter / kg $M^{0.75}$) by Jersey crossbred (o) and local (o) oxen during a five week period (n = 4).

keeping in a straight line along the furrow. The right ox sometimes sat down towards the end of the 5 h period. The other crossbred team and the smaller local team (team one) worked steadily, although the small left ox of the local team often tried to duck out from under the yoke when higher draught forces were required on the harder land. This ducking tended to occur more often towards the end of the 5 h period, presumably as the animal began to tire. On the light land it occurred less frequently. In the second team of local oxen the left animal was very lazy and needed constant encouragement to go forward. The right animal worked well, with little encouragement, consequently this animal was often ahead of the other and the yoke was rarely at a right angle to the furrow when the animals were ploughing.

Harnessing of Oxen

In the hills of Nepal the yoke is a solid rectangular piece of wood, with the narrowest part at the base, resting on the necks of the animals, and the broader surface resting against the shoulders. When a force is exerted on the yoke as the animals pull, the broader part comes into contact with the shoulders. The yoke was mainly in contact with the shoulders when ploughing and there was no difference in its position on the two types of oxen. The presence or absence of a hump seems to have no effect on the position of the yoke or the way the oxen pull. Other than the small local ox (team one, left) the oxen had no problems in supporting the yoke or working in this harnessing system.

Voluntary Food Intake and Digestibility of Feed

During the five weeks that nutritional measurements were made minimum dry bulb temperatures were 9.2 (s.d. 1.2)℃ and 6.9 (s.d. 1.1)℃ inside and outside the shed, respectively (n = 35). Maximum dry bulb temperatures were 12.8 (s.d. 1.2)℃ and 16.8 (s.d. 2.8)℃ inside and outside the shed, respectively (n = 35). Mean relative humidity at 09:00 h was 75 (s.d. 6.0) percent inside and 75 (s.d. 6.8) percent outside the shed (n = 35).

Daily voluntary intakes of rice straw by the Jersey crossbreds and the local oxen are given in figure 4. The Jersey cossbreds consumed more during the day than the local oxen, but apart from the first week ($p < 0.05$) the differences were not statistically significant.

Differences in the digestibility coefficients of dry matter (0.57, s.d. 0.04, 0.59, s.d. 0.02), neutral detergent fibre (0.68, s.d. 0.03, 0.06, s.d. 0.01) and acid detergent fibre (0.60, s.d. 0.03, 0.58, s.d. 0.02) from the Jersey crossbreds and the local oxen respectively were not statistically significant.

Discussion

Under the conditions prevailing during this experiment the Jersey crossbred oxen did more work than the local oxen. The higher work output resulted from a faster rate of working by the Jersey crossbreds compared with the local oxen, rather than from any difference in draught forces found between the teams when ploughing (see table 3). Farmers in West Nepal, where the Jersey crossbreds are more numerous than in the Koshi hills, have also found that Jersey crossbreds tend to work at a faster speed than local oxen (Joshi, 1990).

The Jersey crossbreds with the longest legs in proportion to their body size of all the oxen (see table 2) had the highest speed when working of all the teams. This should be borne in mind when farmers wish to select oxen for speed.

The absence of a hump in the crossbred oxen had no effect on the position of the yoke or the way the oxen pulled when ploughing. The broadest surface of the yoke is mainly in contact with the shoulders when ploughing using a local yoke. A well muscled animal with a good neck to support the yoke seems to be a more important requirement than an animal with a hump.

At first sight Jersey crossbreds would seem to be the oxen of choice in the hills. However a number of other factors have to be considered:

The results are based on only four teams of oxen, although every effort was made to ensure that the oxen were representative of the types available. The animals ploughed in relatively cool conditions, on dry land only. While the crossbred oxen and small local oxen seemed to have been typical of type, the larger local oxen selected were not well matched. The team contained a very lazy animal which probably resulted in a poorer performance than would have been seen by a well matched local pair. Comparison of the work done by local oxen over 5 h in this study and a previous one (Pearson et al., 1989) showed that work done (22.2-24.6 kJ/M$^{0.75}$) and estimated energy expended by the local teams (0.24-0.26 x maintenance) was lower than in the previous study (23.6-28.4 kJ/M$^{0.75}$ and 0.03-0.38 x maintenance, respectively), while that of the crossbreds was slightly higher (29.5-37.8 kJ/M$^{0.75}$ and 0.34-0.4 1 x maintenance, respectively). It would have been useful to have looked at more teams, but time and finances restricted the number to four.

Although the longer legged types of Jersey crossbred had a higher speed of working than the other oxen, they tended to work more erratically than any of the other teams (figure 1). This made them difficult to manoeuvre on small terraces. Hence crossbreds may not be appropriate on small or hilly terraces where the steadier pattern of working of the local animals (see figure 1) may be seen as an advantage. The shorter stockier Jersey crossbreds did not show the same erratic way of working, nor did they have the same average speed of working over the day as the longer legged animals. These observations suggest that conformation and temperament may play a greater part in determining suitability for work than breed or type. Animals with longer legs are capable of working faster than shorter stockier animals and lazy animals are more difficult to work than animals of a more forward disposition.

A fast rate of work made the oxen more liable to heat stress, particularly after 2-3 hours of ploughing. The crossbred oxen required more rest periods when ploughing than the local oxen. Heat stress (panting and drooling) was most frequently seen in the team of crossbreds which had the highest rate of work. It is likely that in warmer conditions later in the year or at lower altitudes this may be a more significant constraint to the amount of work done in a day, the faster speed of working being counteracted by the necessity to rest more often than required for local animals with a slower speed of working. Similarly farmers may find the Jersey crossbreds less suitable for ploughing their 'khet' (irrigated) land, which in the Koshi hills is often at a lower altitude, and therefore warmer climatically than their 'bari' (dry) land.

Heat stress was associated with a continous rise in body temperature during work. Body temperature in unstressed oxen increased initially then remained stable at the higher level during the rest of the working period.

Body temperature also provided a useful means of assessing how well pairs of oxen were matched when ploughing. When animals were not well matched either by size or way of working then one animal found work harder than the other and showed a greater rise in body temperature (e.g. figure 2). When oxen were well matched they often showed similar changes in body temperature during the working period (e.g. figure 3).

When fed according to local practices and given the same amount of feed as local oxen, Jersey crossbreds tended to do less well. During the ploughing months, the local oxen gained weight, while the crossbreds remained at the same or lost some weight. Preliminary results suggest that maintaining oxen in good condition for work may be more of a problem in crossbred animals than local oxen when feed is limited.

The results show that even the Jersey crossbred oxen with the appearance of poor muscle development could match or exceed the work output of sturdier local oxen. However farmers often do not like the typical 'Jersey' appearance of some Jersey crossbreds, with cow hocks and prominent pin bones. As a result these animals can fetch a lower price at sale than sturdier local oxen. The tall Jersey crossbreds can be difficult to pair up for work with other oxen as many of the local oxen available are shorter.

Although there are some disadvantages to keeping Jersey crossbreds for work, particularly those with typical 'Jersey' features, their favourable work output suggests that the introduction of the Jersey crossbred in the hills is unlikely to be detremental to the performance of the work oxen population. In some cases, for example in cool conditions where speed is required on large terraces, then Jersey crossbreds are likely to perform better than local oxen.

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