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Effect of Cattle Genotype and Variable Feed Supply on Forage Intake and Digestibility

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ABSTRACT : An experiment was carried out to investigate whether a local breed of cattle is better adapted than European breed crosses to low quality feeds and to variations in their supply. Four Red Chittagong (RC) and four Holstein cross Sahiwal (Hx) cattle were used to compare the intake and digestibility of German grass (*Echinocloa crusgalli*) and rice straw with four regimes of feed supply. These were; a choice of German grass and rice straw each offered *ad libitum* on the same day (A); German grass and rice straw offered *ad libitum* on alternate days (B); rice straw offered *ad libitum* for 5 days followed by German grass *ad libitum* for 5 days (C); and German grass offered *ad libitum* for 5 days followed by rice straw *ad libitum* for 5 days (D). Each breed was offered the treatments in a 4×4 Latin Square design. The German grass intake and total dry matter intake per kg metabolic live weight were significantly higher for the Hx than for RC, but there were no significant effects of genotype on digestibility of nutrients or live weight. Treatment A had the highest proportion of German grass relative to rice straw in the total DM intake, and had the highest total DM intake and apparent digestibility of nutrients compared with treatments B, C and D. It was concluded that there was no significant evidence that the RG cattle were better adapted to a variable supply of low quality feed than Hx cattle, and that the variable feed supply reduced the ability of cattle to select a preferred diet and consequently nutrient intake was depressed. (**Key Words :** Cattle, Genotype, Forage Intake, Digestibility, Feed Supply)

INTRODUCTION

Livestock development in tropical countries has to a large extent based genetic improvement on the crossbreeding of native cattle with European (*Bos taurus*) cattle to produce ‘exotic crossbreds’. Native ruminants tend to be non-descriptive and their genetic potential has generally not been assessed. *In situ* conservation of native animal germplasm is however increasingly seen as a priority for future livestock development and essential to underpin the increasing demand for milk and meat produced in a wide range of environments. The government of Bangladesh is trying to increase the production of milk and meat through the use of crossbreds from native cows and Holstein or Holstein cross bulls.

The Red Chittagong (RC) is the only recognized native cattle breed in Bangladesh, although the cattle are considered by some to be a variety not a pure breed (Mason and Buvanendran, 1982). The cattle are found in the Chittagong district and possess the distinct characteristics necessary to be considered a breed. The cattle have a red coat colour and smooth hair, and their eye-lids, eyebrow, muzzle, nostril, switch and hoof are also red. The history of the development of this breed is not clear and it has been speculated that it has evolved through interbreeding of local breeds and through selection (Ali, 1965). The performance of the RC breed has been examined in different production systems (Khan et al., 2000), but there is little information available on the digestive performance and weight gain of the breed compared with the exotic (European) crossbred.

A research programme has commenced to evaluate RC cattle as a genetic resource, and more specifically to examine the nutritional efficiency of the breed and how it compares with the *Bos taurus* type. This RC breed may be better adapted to the variable supply of both quantity and quality of feed which occurs throughout the year in tropical countries and which is a major constraint to ruminant production. This study therefore compared the intake and digestibility of nutrients by RC and Holstein cross (Hx)

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cattle when there was a variation in the daily supply of either German grass (*Echinochloa crusgalli*) grown for cattle feeding or of rice straw, an important crop by product used for cattle feeding.

MATERIALS AND METHODS

The experiment lasted for 60 days and was carried out at the Department of Animal Nutrition Field Laboratory of Bangladesh Agricultural University, Mymensingh, Bangladesh.

Source of forages

The rice straw (RS) was collected from the local market and the German grass *Echinochloa crusgalli* (GG) was cultivated in field plots at the Field Laboratory of the University. A total of 0.4 ha of land was used and this was divided into eight plots of 0.05 ha. The GG was planted at one- week intervals in an attempt to maintain a grass supply at a similar stage of maturity during the feeding experiment.

Animal housing and management

Eight steers of about two years of age were used in this experiment. These included four Red Chittagong (RC) and four Holstein cross Sahiwal (Hx) cattle with an average live weight of 139 kg.

Before starting the experiment, the faeces of each animal were examined by a veterinarian and animals were de-wormed using an anthelmintic drug (Tetranid). The animals were kept individually in a well-ventilated 'face-out' stanchion barn and the animals had their own stall, manger and water. Good sanitary conditions were maintained throughout the whole experimental period, with close observation of the physical condition of each animal.

Experimental diets

The four treatments were: (A) Choice of GG and RS each offered *ad libitum* on the same day; (B) GG and RS offered *ad libitum* on alternate days; (C) RS offered *ad libitum* for 5 days followed by GG *ad libitum* for 5 days; and (D) GG offered *ad libitum* for 5 days followed by RS *ad libitum* offered for 5 days. Treatments C and D were both included to test over a 10 day period whether there were any carry-over effects on intake and digestibility from the previous diet.

Digestibility trial

Each period of the digestibility trial lasted for 15 days, the last 10 days of which was a measurement period used for intake and faecal collection. In the 5 day preliminary period prior to the measurement period, Treaments C and D received GG and RS respectively. The body weight of each individual animal was recorded at the start of each treatment period and at the end of the experiment.

The daily dry matter intake of each animal was measured from the weighed amount of fresh feed offered and refused and their dry matter contents. Daily samples of offered and refused feed were oven dried (days 6-15) to estimate the daily amount of dry matter offered and refused, and for proximate analysis.

Faeces were collected over 10 days for each individual animal immediately after being voided. The total faeces voided per day by the animal were weighed and mixed, and from this 10% was kept on an aluminium plate and dried in the sun. A representative sample of fresh faeces was also kept in a freezer for analysis of dry matter. The dried faeces of individual animals for each collection period were thoroughly mixed and kept for proximate analysis.

Chemical analysis

The dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen-free-extract (NFE) and total ash of feeds, refusals and faeces were determined by proximate analysis following the methods of AOAC (1990). All the samples were analysed in duplicate and the mean values were recorded on a dry matter basis. The apparent digestibility of each nutrient was calculated from the formula:

$$\text{Coefficient of digestibility} = \frac{\text{Intake of nutrient - faecal output of nutrient}}{\text{Intake of nutrient}}$$

(Givens et al., 2000).

Statistical analysis

The experiment was conducted with two 4×4 Latin Squares (2 breeds, 4 animals of each breed, 4 feeding treatments and 4 experimental periods). Data in the experiment were analysed by general analysis of variance (ANOVA) procedures of Genstat Lawes Agricultural Trust (Genstat, 1987), with breeds (1 df), feeding treatments (3 df) and their interaction (3 df) as main effects, and periods (3 df) as blocks, with 21 df for error.

RESULTS

There were no significant interactions between genotype and feeding treatment for any of the measurements and therefore only the main effects are presented in the tables.

Chemical composition of feeds

The chemical analyses of the feeds are presented in Table 1. GG had a lower dry matter, higher crude protein and crude fibre, and lower ash content than RS. Although GG was planted at intervals in order to maintain the maturity level throughout the experiment, there was some

Table 1. Chemical composition (g/kg DM except where stated) of German grass, rice straw and refusals (mean±standard error of the mean estimated across treatments and periods)

Forage	Dry matter (g DM/kg)	Crude protein	Crude fibre	Ether extract	NFE	Ash
German grass	204	61	433	13	424	69
(SEM)	±13.1	±9.8	±10.2	±2.3	±27.9	±0.94
Refusals	261	24	437	15	482	41
(SEM)	±9.0	±1.1	±7.6	±1.0	±7.3	±2.2
Rice straw	831	48	382	14	440	116
(SEM)	±8.5	±3.1	±6.6	±1.1	±13.2	±6.7
Refusals	828	45	397	16	404	138
(SEM)	±3.9	±1.4	±2.2	±0.4	±2.0	±1.1

decline in quality during the experiment as indicated by a reduction in crude protein (CP) content. RS remained relatively constant in quality throughout the experiment. The refusals of GG were higher in DM and lower in CP than the feed offered. For RS there were much smaller differences in CP between offered and refused, and there was no clear effect on DM content. For both feeds there was only a slight increase in CF for the refusals compared with that offered.

Dry matter intake and live weight

The results for DM intake and live weight are shown in Table 2. The intakes of GG ($p<0.05$) and of total DM intake per kg metabolic live weight ($LW^{0.75}$) ($p<0.01$) were significantly greater for the Hx cattle compared with RC. Differences between breeds in the DM intake of RS and in total DM were not significant.

The feeding treatment had significant effects on GG and RS DM intake ($p<0.001$), total DM intake ($p<0.01$), and total DM intake per kg metabolic live weight ($p<0.001$). This resulted mainly from the intake of GG being significantly greater and the intake of RS being significantly less ($p<0.001$) for treatment A than for the other three treatments.

There was no significant effect of breed on the proportion of GG: RS selected in the total diet. A consequence of the high intake of GG by treatment A was that the proportion of GG in the total diet (0.748) was significantly greater ($p<0.001$) than for the other three treatments (mean 0.533), and conversely the proportion of RS in the total diet was less for treatment A (0.252 and 0.467).

The CP content of the feeds offered relative to that in the refusals enabled a differential of CP content of feed selected relative to offered to be calculated. There was no significant effect of breed on the selection differential for CP in either GG or RS forages. For GG, the treatment groups all selected a higher proportion of CP than that on offer, presumably by selecting more leaf and less stem. Treatment A selected a higher proportion of CP ($p<0.05$) than the remaining three treatments (1.33 times that on offer for A, and 1.15 times for B, C and D). For RS there was no apparent selection differential for CP, and no significant effect of breed or treatment (mean 1.04 times the CP in the offered forage). The average amount offered relative to the amount eaten was 1.34 for GG and 1.75 for RS.

The short period length of 15 days was too short to detect differences in live weight due to the feeding

Table 2. Effect of genotype and feeding regime on DM intake (DMI kg/day), DM intake per kg metabolic live weight (kg TDMI/kg $LW^{0.75}$), proportion of German grass selected relative to rice straw, CP content of forage selected relative to CP of forage offered, and live weight (kg)

	Breed		Treatment				Breed	Treatment
	RC	Hx	A	B	C	D	SED sig	SED sig.
GG DMI	1.84	1.99	2.70	1.68	1.62	1.67	0.071*	0.101***
RS DMI	1.29	1.35	0.92	1.50	1.40	1.47	0.084NS	0.119***
Total DMI	3.13	3.35	3.62	3.18	3.02	3.14	0.112NS	0.159**
TDMI $LW^{0.75}$	75.8	82.5	88.2	77.9	73.8	76.7	1.90**	2.69***
Proportion GG	0.584	0.590	0.748	0.530	0.535	0.535	0.0164NS	0.0232***
Proportion RS	0.416	0.410	0.252	0.470	0.465	0.465	0.0164NS	0.0232***
CP selected								
GG	1.22	1.18	1.33	1.13	1.19	1.13	0.031NS	0.044***
RS	1.03	1.04	106	1.02	1.02	1.04	0.031NS	0.044NS
Live weight	143	140	141	141	141	142	6.1NS	8.6NS

RC = Red Chittagong; Hx = Holstein cross; GG = German grass; RS = Rice straw.

A = GG and RS offered on the same day; B = GG and RS offered on alternate days; C = RS offered for 5 days followed by GG for 5 days; D = GG offered for 5 days followed by RS for 5 days.

CP = Crude protein; NS = Not significant; * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

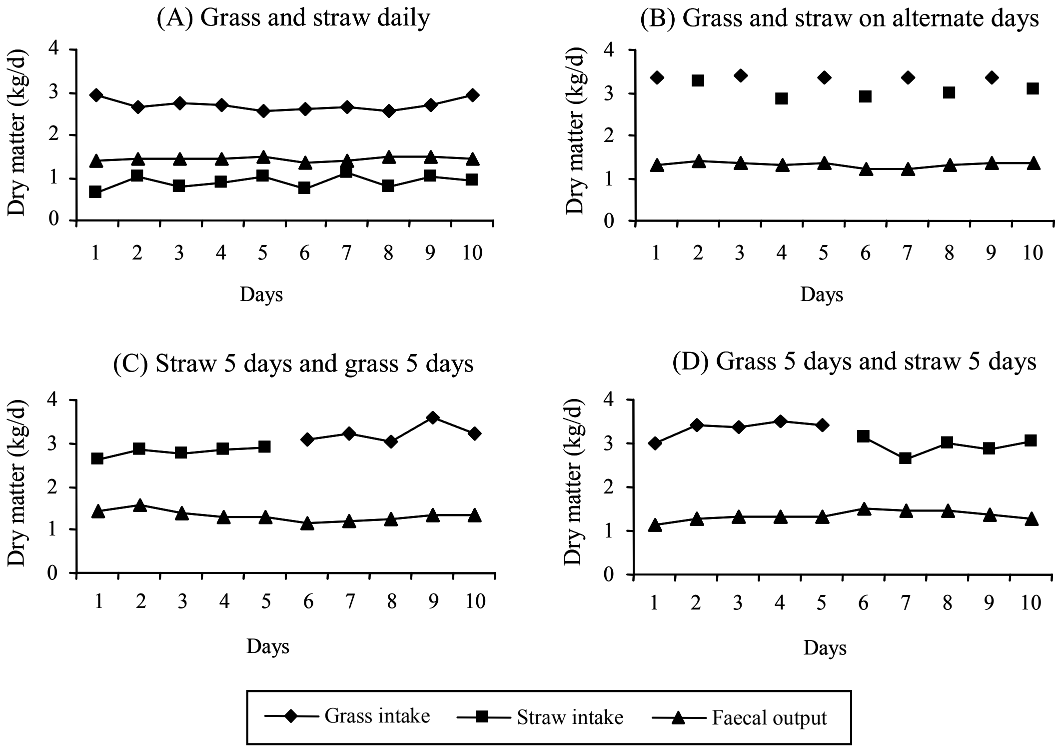

Figure 1. Mean daily intake of German grass (-●-); and rice straw (-■-); and mean daily faecal output (-▲-) over the 10 day collection period.

treatments, and although the RC cattle were 3 kg heavier on average than the Hx cattle, the difference was not significant.

Daily variation in feed intake and faecal output

The mean within period, individual day results across genotypes are shown in Figure 1. For treatment A the selection of GG relative to RS remained relatively constant throughout the 10 day collection period. The amounts eaten on alternate days by treatment B remained similar for GG but the amount of RS eaten gradually increased from day 4 indicating some adaptation to the RS diet over time. Treatments C and D showed as for B the higher intake of GG than RS.

The faecal output remained similar throughout the 10 days for all treatments. There was no indication that RS followed by GG (treatment C) gave any different pattern of intake and faecal output than GG followed by RS (treatment D).

Whole tract digestibility of feeds

The whole tract (apparent) digestibility results are shown in Table 3. There were no differences between RC and Hx genotypes in the digestibility of individual nutrients. The higher proportion of GG in the diet of treatment A led to significantly higher digestibility coefficients for dry matter ($p<0.01$), organic matter ($p<0.01$), crude protein ($p<0.05$), crude fibre ($p<0.01$) than for treatments B, C, and D, indicating that GG had a higher digestibility than RS.

DISCUSSION

Effect of genotype on intake and digestibility of feeds

The RC cattle did not show any improvement over the Hx cattle in this study in DM intake or in whole tract

Table 3. Effect of genotype and feeding regime on the apparent digestibility of nutrients (g/kg)

	Breed		Treatment				Breed	Treatment
	RC	Hx	A	B	C	D	SED sig.	SED sig.
Dry matter	583	578	603	588	559	573	8.2NS	11.6**
Organic matter	617	606	634	610	598	605	5.6NS	8.1**
Crude protein	604	566	660	588	546	545	26.3NS	37.2*
Crude fibre	690	691	712	692	674	685	6.9NS	9.7**

RC = Red Chittagong; Hx = Holstein cross; GG = German grass; RS = Rice straw.

A = GG and RS offered on the same day; B = GG and RS offered on alternate days; C = RS offered for 5 days followed by GG for 5 days; D = GG offered for 5 days followed by RS for 5 days.

CP = Crude protein; NS = Not significant; * p<0.05; ** p<0.01; *** p<0.001.

digestibility of nutrients. The dry matter intake of GG and total DM intake per kg metabolic live weight were significantly higher for the Hx cattle. There were no significant interactions between genotype and feeding regime, which indicates there were no advantages shown by the RC cattle over the Hx cattle in any of the variable feed supply treatments.

The RC are *Bos indicus* cattle and the Hx cattle in this experiment were *Bos indicus* crossed with *Bos taurus*. Comparisons of cattle using 100% *Bos taurus* and *Bos indicus* cattle have shown some differences in digestive capacity, digesta flow and fermentation rate (Hungate et al., 1960; Hunter and Siebert, 1985). However, whilst a number of studies have indicated that *Bos indicus* cattle might have a higher digestive efficiency of low quality forages than *Bos taurus* cattle (French, 1940; Duckworth, 1946; Phillips et al., 1960), the differences have tended to be small and non-significant. The results of this experiment tend to confirm these conclusions.

Effect of variation in feed supply on intake and digestibility of feeds

Offering a choice of forages in treatment A led to a significantly higher total DM intake than for treatments B, C and D where there was no choice available. This indicates a potential benefit to animal performance in offering a choice of forages. Both genotypes of cattle ate a significantly higher proportion of GG relative to RS on treatment A (0.748:0.252) when both feeds were offered *ad libitum* each day, compared with treatments B, C and D (mean 0.534:0.466) where only one feed was on offer *ad libitum* on a particular day. Treatments B, C and D had similar proportionate intakes of the two feeds.

The cattle on treatment A, whilst showing a clear preference for the GG forage, also ate a considerable amount of RS. Cooper and Kyriazakis (1995) found that sheep offered a free choice of feeds, which differ in digestibility, do not completely avoid the less digestible feed, instead they choose to eat a mixture of both feeds. Rose and Fuller (1995) suggested that a non-random average choice as in treatment A is largely the result of animals having an absolute preference for one of the foods. Here the steers showed a preference for GG possibly due to its higher digestibility than rice straw. Habib et al. (2006) have previously shown that digestibility is a major factor influencing choice when two forages are offered simultaneously. A further difference between the two feeds was in DM content and preference for GG may therefore have been due to its lower DM content. Such an effect could represent a palatability benefit over RS, as palatability is known to influence the selection of feeds in many species (Peter et al., 1991).

Unlike treatment A the two forages were not offered to treatments B, C and D on the same day and therefore any preference for GG or RS would be influenced by the drive to eat the forage available on that particular day. This resulted in no significant differences between the treatments B, C and D in intake or digestibility. Sanda (1999) compared Napier grass and barley straw alternated daily, alternated every five days, or alternated every ten days and found no significant differences in intake and digestibility between feeding treatments, although a significantly lower live weight gain was found when the feeds were changed every five days.

Changing from one feed to another feed with different digestibility and crude protein content can lead to effects on nutrient supply at rumen level, which in turn may influence the microbial population. It might be expected that changing the feed every five days would be more disruptive to the microbial population than changing every day, but this was not apparent from the intakes and digestibilities in this experiment. The faecal outputs (Figure 1) for treatments C and D were similar throughout the ten day collection periods, and also indicates that the pattern of feed supply was not particularly disruptive to rumen function. However the two forages were not too dissimilar in protein and fibre contents, and more extreme changes in diet every five days might cause greater disruption to the microbial population with a consequential impact on digestibility and intake.

IMPLICATIONS

There was no evidence that RC cattle digested low quality forages more efficiently that Hx cattle, with no significant differences between the two genotypes RC and Hx in the apparent digestibility of GG and RS feeds. There was some indication that the Hx cattle had a greater intake capacity as they exhibited higher intakes per kg metabolic weight than for RC. There were no significant interactions between genotype and feeding treatment indicating no difference between genotypes in adaptation to the individual variable feed supply treatments. The Hx cattle used were however only half *Bos taurus* and a comparison of RC cattle with full *Bos taurus* cattle may have shown different outcomes. The variable feed supply of changing the GG and RS forages on alternate days (B) or every five days (C and D), removed the opportunity for animals to select between forages compared with when both forages were offered on the same day (A). This resulted in the variable feed supply treatments (B, C and D) eating a lower proportion of GG relative to RS (compared with treatment A), and having significantly lower intakes and digestibilities of total feed. It can be concluded that there can be a significant penalty to total digestible nutrient intake associated with variations in feed supply. However, if a feed such as GG is more expensive or more variable in supply it may be preferable to control its intake through offering restricted access as in treatments B, C or D.

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