Final Technical Report (FTR)

Project Title:	Reproductive Performance of Crossbred Cattle Developed for Milk Production in the Semi-Arid Tropics and the Effect of Feed Supplementation
DFID Project Reference No:	R6955
Programme:	Livestock Production Programme
Programme Manager (Institution):	Dr J I Richards (NRIL)
Lead Institute	Dr PJH Ball/Prof C Thomas, SAC
Collaborating Organisations	University of Zimbabwe and R&SS, Zimbabwe
Production System:	Semi arid
Programme Purpose:	Improved performance of livestock (particularly milk production) in semi-arid crop/livestock and livestock production systems
Commodity Base:	Milk and associated products
Beneficiaries:	Small scale farmers and the rural communities they serve
Target Institutions:	Zimbabwe: Matopos Research Station; University of Zimbabwe; Dairy Development programme; Gulathi Dairy Co-operative; Irisvale Dairy Co-operative
Geographic Focus:	Semi-arid area of Zimbabwe (applicable in other semi-arid regions)

Executive Summary

The project was designed to study the underlying causes of poor reproductive performance in indigenous cattle in the semi-arid tropics and to evaluate the contribution of exotic genetics through crossbreeding and of feed supplementation towards improvements in milk production and reproductive performance. Four on-station experiments, two on-farm trials and a survey contributed to the conclusion that lack of ovarian activity was a major cause of poor reproductive performance. Both exotic genes (50% Jersey blood in an F1 cross) and low levels of feed supplementation improved performance. However, 75% Jersey backcrosses performed worse than F1s and overfeeding may have compromised pregnancy in indigenous cows.

The self-coating radioimmunoassay was established at the University of Zimbabwe and should prove invaluable in future research and advisory work.

The project demonstrated the value of conserving forages for dry season supplementation and the short-term benefits of crossbreeding with appropriate exotic breeds. It also demonstrated the need for further investigation of the relative merits of crossbreeding and of selection within indigenous breeds and for further studies on the best time to feed conserved forages if there is insufficient material to feed throughout the dry period. Implementation of the findings should improve livestock productivity, reducing the need to maintain unproductive stock and producing surpluses, which should be available to improve the nutritional status of the communities concerned.

Background

Reproductive performance of cattle in semi-arid conditions is very poor and constitutes a severe

restraint to productivity. Normally, cattle will only produce milk after they have calved, so that cattle that calve less than once every year in semi-arid environments spend a high proportion of their lives non-productively. Such cattle tend not to be observed in oestrus and in many cases it is not known whether they have been mated or, if so, whether the bull is fertile. One of the primary aims of the project was to determine the underlying causes of this poor reproductive performance.

Milk production of indigenous cattle in this environment is also very low. To some extent this is known to be due to the genetic make-up of the cows, which tend to store surplus energy as body tissue, rather than use it for milk production.

Two possible approaches to the improvement of performance (particularly milk production and reproduction) in such conditions are supplementary feeding, especially during the dry season, and the use of exotic breeds as crosses. A further aim of the project was to compare the relative merits of the two approaches and of interactions between them.

Milk progesterone measurement is one of the basic tools that can be invaluable in managing reproduction and also in the scientific investigation of factors affecting it. There was a need for an independent facility to measure milk progesterones in Zimbabwe, significantly assisting future interventions in dairy cattle management and research.

Project Purpose

The project was designed to develop and promote strategies to optimise livestock production in the crop-livestock system through improved allocation and management of on-farm resources. In particular, it aimed to develop breeding, reproductive and other management strategies to optimise use of available resources. The specific objective of these series of studies was to assess the effect of feed supplementation and breed on reproductive performance and milk yield in cows bred for use in the smallholder dairy sector.

With the co-operation of the United Nations International Atomic Energy Agency, a secondary purpose of the project was to establish the agency's self coating assay at the University of Zimbabwe.

Research Activities

Four on-station experiments, one survey and two on-farm studies were undertaken in Matebeleland South Province, Zimbabwe. In the course of the experiments and studies, ovarian activity was monitored using milk progesterone profiles (thrice weekly sampling) so that dates of ovulation, conception and apparent embryo/fetal loss could be ascertained. Milk yields, body condition scores and oestrous activity were recorded.

On-station experiments:

1. This was conducted at Matopos Research Station. freshly calved Tuli x Jersey and Nkone x Jersey (crossbred) and Tuli and Nkone (indigenous) cows were offered two diets starting at five days post-calving. The diets were; grazing of natural pasture at a stocking rate of 1 LU:15 ha alone or supplemented with 2 kg/cow/d of a maize/soyabean-based commercial dairy meal. Cows were milked away from their calves, which were allowed to suckle them after milking, but were separated from them overnight.

2. This experiment was essentially a repeat of the first, according to the original proposal, but cows were milked in the presence of their calves, which were allowed to suckle them briefly to stimulate milk let down.

3. In this experiment, cows were supplemented pre-partum using forage sorghum (*Sorghum bicolor*) and lablab (*Lablab purpureus*) mixed silage. The cows were offered a control diet consisting of grazing natural pasture at a stocking rate of 1 LU: 15 ha and three supplementary diets supplying 0.16 (3 kg DM), 0.32 (6 kg DM) and 2 times (ad lib.) maintenance energy requirements.

4. The fourth on-station experiment was also conducted at Matopos Research Station from September 2000 to June 2001. The collection of data went beyond the 31 March 2001 completion date of the project. The first objective of this on-station experiment was to evaluate the effect of postpartum supplementary feeding with lablab/bana grass (*Pennisetum spps*) on milk yield and reproductive performance. The second objective was to compare milk yield and reproductive performance of crosses of Jersey and Nkone/Tuli (F1) (50% Jersey + 50% Nkone/Tuli) with Jersey backcrosses (F2) (75% Jersey + 25% Nkone/Tuli).

Survey:

A survey to assess the reproductive performance and milk yield of cows in smallholder farming areas was conducted in Gulathi communal area and Irisvale resettlement area

On farm studies:

1. Based on the survey findings, a study was conducted in Gulathi to measure reproductive performance and milk yield. Milk yield, body weight and condition scores were measured from calving. Milk progesterone was used to assess reproductive performance

2. A second on-farm study was carried out at Irisvale to determine the effect of feed supplementation on reproductive performance and milk yield. Cows on the control diet were allowed to graze on natural pasture at a stocking rate of 1 LU: 20 ha. In addition to grazing of natural pastures, supplemented cows were offered 2 kg/cow/d of a maize/soyabean-based dairy meal starting from calving until conception.

Outputs

<u>On-station experiments</u>:

1. Table one summarises the results of the first on-station experiment

Table 1 Oestrus detection rates, assumed pregnancy rate, pregnancy loss, mean milk yield, bodyweight and body condition score for indigenous and crossbred cows in the control and supplemented treatment groups (1997/1998).

	Indigenous		Crossbreds	
Diet	Control	Supplemented	Control	Supplemented
Number of cows	19	19	22	23
Number of cows that ovulated By 200 d postpartum	12	17	17	22
Mean interval from calving to first ovulation (days)	113[a] ± 36	103 [b] ± 39	116 [a] ± 40	98 [b] ± 39
Oestrus detection rates (%)	20[a]	43 [b]	59 [c]	59 [c]
Assumed pregnancy rate (%)	52.6 [a]	73.7 [b]	72.7 [b]	70 [b]
Actual pregnancy rate (%)	47 [a]	30 [a]	44 [a]	70 [b]
Assumed pregnancy loss (%)	10 [a]	57 [b]	38 [b]	0 [a]
Calving rate (%)	47 [a]	30 [a]	44 [a]	70 [b]
Mean milk yield (kg/d ± SD)	0.61 [a] ± 0.19	0.71 [a] ± 0.31	2.37 [b] ±	2.47 [b] ± 1.24
Bodyweight (kg)	332 [a]	339 [b]	323 [c]	329 [a]
Body condition score	2.6 [a]	3.4 [b]	2.5 [a]	2.7 [a]

[a,b] Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Supplementary feeding reduced ($P < 0.05$) the mean intervals from calving to ovulation in indigenous and crossbred cows. The estimated cumulative probability of ovulation occurring by 200 d postpartum for supplemented cows was 0.9 and higher ($P < 0.05$) than the probability of 0.63 obtained for unsupplemented cows (see Fig.1).

There was an interaction ($P < 0.05$) between breed and diet on the oestrus detection rates. Indigenous supplemented cows had the highest increase in oestrus detection rate. The pregnancy and calving rates were higher ($P < 0.05$) in crossbred cows than in indigenous cows. The interaction between breed and diet on pregnancy and calving rates was significant ($P < 0.05$). Supplemented indigenous cows had the highest assumed pregnancy rate (i.e. they were diagnosed pregnant at 25 days by milk progesterone profile) and supplemented crossbred cows had the highest actual pregnancy rate and calving rate. In indigenous cows, the pregnancy loss rate (apparent embryo/fetal death) was increased ($P < 0.05$) by supplementary feeding. However, supplementary feeding

reduced pregnancy loss rate ($P < 0.05$) in crossbred cows. All the supplemented indigenous cows that lost pregnancies were in their first parity and all crossbreds that lost pregnancies were multiparous and were not supplemented.

1. Similar trends were observed during the 1998/99 season in Experiment 2 (Table 2).

Table 2 Oestrus detection rates, assumed pregnancy rate, pregnancy loss, mean milk yield, bodyweight and body condition score for indigenous and crossbred cows in the control and supplemented treatment groups (1998/1999).

	Indigenous		Crossbreds	
Diet	Control	Supplemented	Control	Supplemented
Number of cows	20	20	20	20
Number of cows that ovulated by 200 days postpartum	12	10	17	17
Mean interval from calving to first ovulation (days)	109 [a] ± 39	103 [a] ± 40	80 [b] ± 44	73 [b] ± 39
Oestrus detection rates (%)	45.5[a]	65 [b]	44.4[a]	45.5 [a]
Assumed pregnancy rate (%)	38.5 [a]	41.2 [a]	68.2 [b]	62.5[b]
Actual pregnancy rate (%)	34.6 [a]	35.3 [a]	59.1 [b]	56.3 [b]
Assumed pregnancy loss (%)	10 [a]	14 [a]	13.3 [a]	10 [a]
Calving rate (%)	34.6 [a]	35.3 [a]	59.1 [b]	56.3 [b]
Mean milk yield (kg/d ± SD)	0.55 [a] ±	0.61 [a] ± 0.3	1.69 [b] ± 1.02	1.88 [b] ± 1.02
Bodyweight (kg)	375 [a]	382 [a]	319 [b]	340 [c]
Body condition score	2.5 [a]	2.6 [a]	2.0 [b]	2.1 [b]

[a,b] Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Crossbred cows were superior to indigenous cows in terms of reproductive performance and milk yield ($P < 0.05$). The interval from calving to first ovulation was 76 ± 41 d for crossbred and 106 ± 38 d for indigenous cows. Supplementary feeding reduced ($P < 0.05$) the interval from calving to first ovulation in both breeds. There was an interaction ($P < 0.05$) between breed and diet on the oestrus detection rates. Supplemented indigenous cows had the highest increase in oestrus detection rate. Indigenous cows had higher ($P < 0.05$) body weights and body condition scores than crossbred cows irrespective of diet. In contrast to the findings of experiment 1, supplementary feeding did not increase the pregnancy loss rate in indigenous cows. Presumably, this is because prevailing conditions in that season resulted in a smaller increase in body condition.

There was an interaction ($P < 0.05$) between breed and diet on body weight. Supplemented crossbred cows had the highest increase in body weight.

1. Supplementation with forages at the level of 0.32 M and 2 M improved body condition at calving ($P < 0.05$; Table 3).

Table 3 Effect of breed and prepartum silage supplementation level on mean body condition scores at calving

Silage supplementation level (multiples of maintenance energy requirements)	Crossbreds	Indigenous
Control (NS)	$1.6^{ac} \pm 0.005$	$1.9^{bc} \pm 0.0003$
0.16 M (1.11 kg DM)	$1.6^{ac} \pm 0.005$	$2.0^{bc} \pm 0.006$
0.32 M (2.22 kg DM)	$2.0^{ad} \pm 0.001$	$2.6^{bd} \pm 0.001$
2 M (8.88 kg DM)	$2.7^{ae} \pm 0.007$	$3.0^{be} \pm 0.002$

$^{a-b}$ Within a row, means with different superscript letters differ ($P < 0.05$).

$^{c-e}$ Within a column, means with different superscript letters differ ($P < 0.05$).

The time from calving to ovulation was reduced by prepartum silage supplementation at all levels in crossbreds and at levels of .32M and above in indigenous cows. Interaction between breed and supplementation level on the interval from calving to ovulation was significant ($P < 0.05$; Table 4).

Table 4 Effect of breed and prepartum silage supplementary feeding level on interval from calving to ovulation (days)

Silage supplementation level (multiples of maintenance energy requirements)	Crossbreds	Indigenous
Control (NS)	$116^{ac} \pm 66$	$104^{be} \pm 24$
0.16 M (1.11 kg DM)	$53^{ad} \pm 15$	$97^{be} \pm 35$
0.32 M (2.22 kg DM)	$49^{ad} \pm 66$	$81^{bf} \pm 11$
2 M (8.88 kg DM)	$53^{ad} \pm 32$	$74^{bf} \pm 26$

$^{a-b}$ Within a row, means with different superscript letters differ ($P < 0.05$).

[c-f] Within a column, means with different superscript letters differ ($P < 0.05$).

Crossbred cows had higher pregnancy rates than indigenous cows across all supplementary feeding levels (P<0.05; Table 5).

Table 5 Effects of breed and prepartum silage supplementation on postpartum pregnancy rates (%)

Silage supplementation level (multiples of maintenance energy requirements)	Crossbreds	Indigenous
Control (NS)	80[ac]	60[bc]
0.16 M (1.11 kg DM)	80[ac]	60[bc]
0.32 M (2.22 kg DM)	80[ac]	60[bc]
2 M (8.88 kg DM)	80[ac]	60[bc]

[a-b] Within a row, means lacking a common superscript letter differ ($P < 0.05$).

[c] Within a column, means lacking a common superscript letter differ ($P < 0.05$).

The crossbred cows produced higher (P < 0.001) mean daily milk yields than indigenous cows, but there was no significant response to supplementation (Table 6).

Table 6 The effect of breed and prepartum supplementation on subsequent lactation milk yield (kg/d)

Silage supplementation level (multiples of maintenance energy requirements)	Crossbreds	Indigenous
Control (NS)	2.9[ac] ± 0.7	1.4[bc] ± 0.4
0.16 M (1.11 kg DM)	3.0[ac] ± 0.6	1.3[bc] ± 0.6[c]
0.32 M (2.22 kg DM)	3.1[ac] ± 0.6	1.4[bc] ± 0.4
2 M (8.88 kg DM)	3.6[ac] ± 0.3	1.3[bc] ± 0.7

[a-b] Within a row, means lacking a common superscript letter differ ($P < 0.001$).

[c] Within a column, means lacking a common superscript letter differ ($P < 0.001$).

Table 7 shows the milk yields of the indigenous and crossbred cows over three seasons: 1997/98 (Experiment 1); 1998/99 (Experiment 2); 1999/2000 (Experiment 3). Overall, mean daily milk yields were significantly higher in crossbred than in indigenous cows ($P < 0.05$).

Table 7 Milk yield for crossbred and indigenous cows over three seasons

Season	Crossbreds	Indigenous
1997/98	2.4±1.2 (n=45)	0.6±0.28 (n=38)
1998/99	1.8±1.1 (n=38)	0.6±0.23 (n=43)
199/00	3.1±0.6 (n=20)	1.9±0.49 (n=20)

1. The Supplemented F1 cows had a mean daily milk yield of 4.2 l compared to 3.8 l for the non-supplemented F1 cows. The supplemented F2 cows gave 3.6 l mean daily milk yield compared to 2.8 l for the non-supplemented F2 cows. These results suggest that milk yield of Jersey backcrosses is lower than that of F1 crosses.

   The conception rate was 71% for both the supplemented and non-supplemented cows. However, grazing was very good due to very good rains, so that early lactation supplementation would have been less effective and rat damage limited the amount of supplementary forage available. The number of F2 back-crosses was very low (4 per treatment) so that comparison would be inconclusive results, but they generally seemed to have low conception rates. This could be due to the fact that they have a higher level of Jersey inheritance, and therefore might require a higher plane of supplementation compared with the F1 crosses and indigenous cows, and may thus be less suitable for communal farming environment

Survey:

Farmers reported calving intervals of two to three years and milk yields of 1.5 kg/cow/d. They provided no information on calving to ovulation intervals, calving rates and lactation lengths.

On farm studies:

1. Gulathi

The study showed that out of 36 cows monitored only three crossbred cows had ovulated by 200 days postpartum. A mean interval from calving to ovulation of 63 ± 29 d and a calving rate of 3% were obtained. Average daily milk yield was 1.2 ± 0.9 kg and lactation length was 174 ± 47 d. (See Table 8).

Table 8 The effect of breed and prepartum supplementation on subsequent lactation milk yield (kg/d)

Silage supplementation level (multiples of maintenance energy requirements)	Crossbreds	Indigenous
Control (NS)	2.9[ac] ± 0.7	1.4[bc] ± 0.4
0.16 M (1.11 kg DM)	3.0[ac] ± 0.6	1.3[bc] ± 0.6[c]
0.32 M (2.22 kg DM)	3.1[ac] ± 0.6	1.4[bc] ± 0.4
2 M (8.88 kg DM)	3.6[ac] ± 0.3	1.3[bc] ± 0.7

[a-b] Within a row, means lacking a common superscript letter differ ($P < 0.001$).

[c] Within a column, means lacking a common superscript letter differ ($P < 0.001$).

1. Irisvale

Supplementary feeding reduced ($P < 0.05$) the interval from calving to and increased the oestrus detection rate ($P < 0.05$). Supplementation increased conception rate from 35% to 80% and calving rate from 18% to 65% over two seasons.

Supplementary feeding also increased daily milk yield from 1.3 ± 0.5 kg to 3.3 ± 1.3 kg. (See Table 9).

Table 9 Reproductive performance data for Irisvale cows

	Control	Supplemented
Number of cows	52	60
Number of cows that had ovulated by 300 days postpartum	32	47
Mean interval from calving to ovulation (d)	132[a] ± 63	108[b] ± 56
Oestrus detection rate (%)	10[a]	38[b]
Conception rate (%) for 1999/00	35[a]	47[b]
Conception rate (%) for 2000/01	50[a]	80[b]
Calving rate (%) for 1999/00	18[a]	33[b]

	Control	Supplemented
Calving rate (%) for 2000/01	38[a]	65[b]
Mean body condition score	2.8[a] ± 0.21	3.1[b] ± 0.2
Mean bodyweight (kg)	391[a] ± 64	423[b] ± 56
Mean daily milk yield (kg)	1.26[a] ± 0.5	3.1[b] ± 1.1
Mean total lactation milk yield (kg)	252[a] ± 1.0	698[b] ± 1.5
Mean lactation length (days)	200[a] ± 25	225[b] ± 45

[a,b] Within a row, means lacking a common superscript letter differ ($P < 0.05$).

There was a net economic benefit from increased milk production and extra calves in the supplemented cows compared to the unsupplemented.

The on farm studies in particular revealed that the root cause of failure to conceive was a failure to ovulate. In other words, poor reproductive performance was basically caused by ovarian inactivity. Overall, the studies demonstrated that low levels of feed supplementation were beneficial in improving reproductive performance of cows bred for or in the smallholder farming sector of Zimbabwe. This was achieved by stimulating earlier ovulation and also by improving oestrus detection and pregnancy rates. There was, however, an indication that indigenous cows were more likely to lose embryos if they were supplemented. This type of cow is more inclined to store extra energy as fat, and this could be detrimental to pregnancy. Supplementation also increased milk yield. In addition, F1 crossbred cows were superior to indigenous cows in terms of their reproductive performance and milk yield. Some of this improvement may well have been due to hybrid vigour, and it is thus not surprising that 75% Jersey back crosses gave less milk than their F1 counterparts.

<u>The setting up of the progesterone "Self Coating" assay in Zimbabwe.</u>

This has been achieved at UZ in the course of the project and is running successfully. Its use obviates the need for importing expensive assay kits. There is still a need to import radioactive progesterone and it is to be hoped that eventually this could be produced in the region.

Severe drought prevented the production of sufficient forage for the planned first stage of the on-station forage supplementation experiment. A six-month extension to the project enabled the completion of all the anticipated outputs.

Contribution of Outputs

The project has identified management strategies that should form the basis of future promotional activities:

1. Low levels of feed supplementation in both indigenous and crossbred cows enhance milk production and reproductive performance. Supplementary dry season feeding is economically viable and is best achieved by forage conservation during the wet season.

2. Indigenous cows are inclined to store excess energy as fat, and there was an indication that this could impair embryo survival. Farmers need to understand the concept and methodology of body condition scoring to avoid wasteful, and possibly harmful, overfeeding.

3. F1 Indigenous/Jersey crossbreds are potentially superior to indigenous breeds in terms of milk production and reproductive performance. However, they may need better feed management in order to take advantage of this superiority.

4. Back-cross cows (75% Jersey) perform less well than F1s, possibly in part due to hybrid vigour in the latter. In practice it would be difficult to maintain the right proportion of exotic blood in the crossbreds.

The project has also helped to identify future research and development strategies that DFID should pursue:

5. Further research is needed on the relative merits of pre-partum and post-partum dry season forage feeding. Both methods have proved effective, but if there is only enough forage for one or the other, the farmer needs to know which is best.

6. In the long term, genetic improvement through genetic selection of indigenous breeds is more likely to be stable and sustainable. A project along these lines could compare the merits of such selection with that of a controlled crossbreeding programme aimed at creating a new, stable, breed with, say, 50% exotic blood.

Results have already been disseminated by means of :

7. Workshop reports:

   MUNYORO, E.C. and BALL, P.J.H. (1999) Reproductive Performance of Crossbred Cows Developed for Milk Production in Semi-Arid Regions and The Effect of Feed Supplementation: An Interim report on early post partum activity in indigenous and crossbred cows. Second DR&SS/NRILPP workshop.

   MUNYORO, E.C. and HAMUDIKUWANDA, H.H. (1999) Performance of Crossbred Cows Developed for Milk Production in Semi-Arid Regions and The Effect of Feed Supplementation. DANIDA workshop.

   GARWE, E.C, BALL, P.J.H., HAMUDIKUWANDA, H. AND MUTISI,C. (2000) Reproductive Performance of Crossbred Cows Developed for Milk Production in Semi-Arid Regions and The Effect of Feed Supplementation: Third DR&SS/NRILPP workshop.

8. Scientific papers. Two have been submitted (one of which has been accepted) , and five more are in preparation

   Garwe E. C., Ball P. J. H., Hamudikuwanda H. H., Mutisi C. Nevison, I. and Ntaisi M. Postpartum Ovarian Activity in Indigenous and Crossbred Cows Developed for Milk Production in Semi-arid Regions and the Effect of Postpartum Feed Supplementation. Submitted to British Journal of Animal Science.

Garwe E. C., Ball P. J. H., Hamudikuwanda H. H., Mutisi C. Nevison, I. and Ntaisi M. (in press). The Effect of Feed Supplementation on Conception Rates and Embryo and Foetal loss in Indigenous Sanga and Crossbred Cows Developed for Milk Production in Semi-arid Regions of Zimbabwe. Vet. Rec.

9. Internal Reports:

   Quarterly and annual reports for each quarter from December 1997 to December 2000

10. Other Dissemination of Results:

    Field days at Gulathi and Irisvale.

    Visits by farmers to view on farm trials

    Preparation of farmer oriented result sheet.

Figure 1: Cumulative probability of ovulation by diet