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Embryo transfer for improved feed conversion efficiency in cattle

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ABSTRACT

Over 3 years at Whatawhata Research Centre, 515 Jersey and Hereford x Friesian (HxF) cows were calved, having been previously mated predominantly by embryo transfer. Beef sire x Friesian calves on recipient Jersey cows consistently grew at 90 to 100% of the growth rates of similar calves on HxF cows ($P<0.01$ first year, NS years 2 and 3). There were no significant differences between recipient breeds in apparent calf milk consumption. Liveweights of the Jersey and HxF cows at weaning were on average, 371 and 524kg ($P<0.001$). Efficiency ratios favoured the Jersey recipient. In each of the 3 years, the ratio of calf weaning weight per kg cow liveweight was 0.53, 0.45, and 0.45 for the HxF and 0.66, 0.61, and 0.58 for the Jersey cows respectively (within years: $P<0.001$). The Jersey cow was on average 33% more efficient. Feed conversion efficiency, expressed as the ratio of calf daily liveweight gain/kg DM intake favoured the Jersey by 0, 24 and 22% in each of years 1, 2 and 3 respectively. The results indicate that the use of ET on small cows, rearing high growth rate beef type calves can potentially yield significant efficiency gains. However, these gains can be reversed if the small cow-large calf unit suffers disproportionately high losses.

Keywords: embryo transfer; feed conversion efficieny; small cow; weaning weight.

INTRODUCTION

Beef cow systems are perceived by many to be less profitable than other stock classes (Webby & Thomson, 1994) even when their indirect benefits of pasture management and control (McCall, 1994; Nicol & Nicoll, 1987; Pleasants *et al*., 1994) are included. This is in spite of recent advances such as selective breeding, yearling mating and crossbreeding (McMillan, 1989; McMillan & McCall, 1991). Gains in both productivity and profitability are highly desirable Progress is being made through breeding programmes but is hampered by the positive correlation between calf birth and mature liveweights. Selection for high growth weight and slaughter weight usually results in higher calf birth weights and higher cow live weights (Anon, 2000). Combining this with the fact of the near-linear relationship between intake and beef cow live weight (Smeaton *et al.,* 1999), efficiency barely alters in most breeding programmes. One example where the above has not occurred has been in the Landcorp Angus breeding programme (Enns and Nicoll, 1997). Over a 17-year period to 1993, slaughter weight breeding value increased by 1.45kg per year whereas mature weight breeding value *declined* by 0.73kg per year. If this result is reliable, it implies that cow liveweight would decline by 7kg per 10 years with a 15kg increase in slaughter weight. Based on these results, feed conversion efficiency gains probably occurred.

New reproductive technologies described by Thompson *et al.*(1998) have the potential to quickly achieve large gains in feed conversion efficiency because of their ability to allow separation of the genetic link between dam and offspring via embryo transfer (ET), control of both progeny sex and genetics and ultimately by cloning, to further minimise genetic variation. In addition, due to the way the technologies are applied, there are small benefits from calving to either single or repeat synchronised mating cycles (Pleasants *et al.*, 1999).

Smeaton (2001) modelled the use of small cows conceiving by ET to high growth rate embryo breeds and predicted that a 20% gain in productivity was possible although it would not be a long-term genetic gain. Nevertheless, it could be achieved in 1 year compared to the 17 years quoted by Enns and Nicoll (1997) for a considerably smaller gain. The present paper documents a field study carried out to test these assertions and to observe any practical issues that might affect the outcome.

MATERIALS AND METHODS

A farm systems approach was taken, with the project run on a suitably subdivided area at Whatawhata Research Centre. Many of the cows were ET mated off site in other beef cattle herds or on dairy farms. The objective was to run ET mated cows in balanced farmlets so that various mating or breed treatments could be compared. In all 3 years of the project, the cows were fed at similar grazing pressures (as assessed by pre- and post-graze herbage mass) so that differences in feed conversion efficiency could be determined. The feed efficiency comparisons were made over the calving to weaning period. Other comparisons such as calving difficulty, cow and calf survival were also made but the animals were not in separate farmlets over the calving period.

In each of 3 years, approximately 450 mixed age cows were mated to a single cycle of synchronised ET using the protocol described by Smeaton *et al.*(2003)

who reported on the pregnancy rates of the same animals. Jersey cows from dairy farms were compared to suckled Hereford x Friesian (HxF) beef cows as the recipient breeds. Cull Jersey cows (chosen at mating time and excluding any animals with a previous history of calving problems) were used as the small cow model because they were deemed to be readily available from the dairy industry and the breed has a history of good milk performance. Jersey cows are also reputed to be easy calvers (Baker *et al*., 1990). In years 2 and 3 of the project, some of the Jersey cows, which had been ET mated the previous year re-entered the programme. The HxF cows were obtained from beef herds owned by AgResearch on their North Island research farms. First calving heifers from both breed types were excluded from the project.

Embryos for the ET matings were produced at the Ruakura Reproduction Laboratory and were the same as those described by Smeaton *et al*., (2003). In the first year of the project, a low birth weight EBV (-1.0) Simmental bull was used to sire the IVP embryos as predicated by the modelling of Smeaton (2001). Also in year 1, a small group (40) of HxF cows were naturally mated to a Simmental bull with similar EBV to the IVP embryo bull to provide cohorts for comparison with the ET cows. Due to subsequent calving problems in year 1 (see Results), management conditions were imposed in years 2 and 3 by the Ruakura Animal Ethics Committee. These included the replacement of the Simmental bull used for ET by a Hereford bull of low birth weight EBV (+0.6) and high 400-day weight EBV (+40). This same bull was also used to provide a contemporaneous group of AI mated cows for year 2. Also, all Jersey cows in years 2 and 3 were subjected to the managed calving programme described by Lambert *et al*. (1998) to reduce gestation length by about 10 days and calf birth weight. In year 3, approximately 70 Wagyu embryos were available and were transferred to a balanced group of the HxF and Jersey cows.

In year 1 after calving (September 2000), the cows were divided into duplicate farmlet mobs each of 20 to 24 cows and they were farmed in these groups through to weaning approximately 7 months later. The cows and calves were farmed on a 20 to 30 day rotation depending on pasture growth rate with surplus feed removed by non-experimental stock when necessary. In this regard, all farmlets were treated similarly with the primary management objective being to graze the cows at similar grazing pressure across replicates and treatments. In years 2 and 3, the experiment was run in a similar manner except that in year 3 there were insufficient animals to run replicate mobs for the Jersey recipient cows.

In all years, pasture mass was visually assessed before and after paddocks were grazed using pasture cuts for calibration as described by Smeaton *et al.* (1983). Pasture quality was assessed as green DM (dry matter) % by pasture dissection of sub-samples taken prior to grazing. All animals were weighed approximately monthly at the end of a grazing break and an estimate of milk production was made by a variation of the Plunket method, as described by Boom *et al.* (2003), on a similar number of occasions. All deaths were recorded.

Productivity results were expressed as kg calf weaning weight/kg cow liveweight at weaning and kg calf weaning weight/kg DM eaten by the cow and calf per day. The animal data were analysed by analysis of variance (Genstat Committee, 2002). All data presented are fitted estimates. First-order interactions were tested for all factors in all years but were never significant and so were omitted from the final models. Smeaton *et al.* (2003) reported pregnancy rates and embryo and calf survival so these results are not described here. Pasture data and feed conversion efficiency data are presented as means of mob replicates over the period calving to weaning with standard error mean (sem) assessments. The pasture and feed conversion efficiency data relate only to those cow and calf units surviving to weaning and do not include the effects of deaths or losses prior to and during calving

RESULTS

Pasture data

Table 1 shows there was no practical difference in pre and post-grazing pasture masses between recipient breed groups reflecting that similar grazing pressures were applied to each group. In each of the 3 years, the HxF cows plus their calves, consumed between 9 and 28% more than the Jersey cows over the lactation period.

TABLE 1: Pasture data: pre and post-grazing pasture mass and estimated daily intake of the cow and calf combined. Pasture mass sem values ranged from 50 to 100 kgDM/ha and intake sem values ranged from 0.25 to 0.60.

Lactation year	**2000/01**		**2001/02**		**2002/03**	
Project year	1		2		3	
Cow breed	HxF	Jersey	HxF	Jersey	HxF	Jersey
Pre-grazing mass (kgDM/ha))	3040	3096	3262	3213	3312	3272
Post-grazing mass (kgDM/ha))	2078	2149	2295	2313	2269	2210
Estimated intake (kg DM/head/day)	12.5	11.5	17.6	13.8	18.3	15.2

TABLE 2: Cow and calf liveweight and some calving data for all 3 years, within recipient breed, across all calf breeds, adjusted for calf sex and calving date. Results shown are fitted values, followed by sed and significance levels. Note: † = P<0.1.

Lactation year	**2000/01**			**2001/02**			**2002/03**		
Project year	**1**			**2**			**3**		
Cow breed	**HxF**	**Jersey**	**prob., sed**	**HxF**	**Jersey**	**prob., sed**	**HxF**	**Jersey**	**prob., sed**
Cow weaning weight (kg)	511	364	*** 6.3	526	369	*** 6.2	530	380	*** 0.14
Calf weaning weight (kg)	266	239	** 7.5	240	231	* 6.5	227	218	NS 7.5
Avg daily liveweight gain (kg/calf/day)	1.13	1.02	** 0.03	1.09	1.06	NS 0.03	0.99	1.01	NS 0.04
Calf birth weight (kg)	45.5	40.7	** 1.3	36.6	33.8	*** 1.0	34.2	32.1	† 1.0
Gestation length (days)	286	285	NS 0.7	276	275	NS 0.9	281	278	NS 1.9
Calving date	6 Sep	29 Aug	*** 1.8	25 Aug	31 Aug	** 2.5	28 Aug	4 Sep	*** 1.2

TABLE 3: Efficiency calculations for all 3 years, within recipient breed. Calf weaning weight was adjusted for sex and calving date. In rows 3 and 4 of the table, sem values were approximately 0.9 and 0.006 respectively.

Lactation year	2000/01		2001/02		2002/03	
Project year	**1**		**2**		**3**	
Cow breed	**HxF**	**Jersey**	**HxF**	**Jersey**	**HxF**	**Jersey**
Calf weaning weight/kg cow weaning weight	0.53 ***	0.66 sed .020	0.46 ***	0.65 sed .019	0.43 ***	0.58 sed .027
Calf weaning weight/kg daily DM intake	21.3	20.8	13.6	17.3	12.3	14.3
Calf daily liveweight gain/kg daily DM intake	0.090	0.089	0.062	0.077	0.054	0.066

TABLE 4: Calving results (raw means) for each year: deaths relate to the period 7 days before and after calving. Note S = Simmental, H = Hereford, F = Friesian, W = Wagyu, NM = naturally mated.

Year 1: spring 2000			
Cow mating group	**HxF ET**	**Jersey ET**	**HxF NM**
Cows present at calving (n)	81	75	50
Cow deaths (%)	4	15	2
Caesareans (%)	2	17	0
Calf deaths (%)	7	17	6
Calf breed	SxF	SxF	Sx(HxF)
Year 2: spring 2001			
Cow mating group	**ET HxF**	**ET Jersey**	**AI Jersey**
Calving treatment	**Managed**	**Managed**	**Natural**
Present at calving (n)	87	49	41
Cow deaths (%)	1	10	2
Caesareans (%)	0	6	0
Calf deaths (%)	5	10	2
Calf breed	HxF	HxF	HxJersey
Year 3: spring 2002			
Cow mating group	**ET HxF**	**ET Jersey**	**ET HxF**
Calving treatment	**Managed**	**Managed**	**Managed**
Present at calving (n)	41	36	42
Cow deaths (%)	0	3	0
Caesareans (%)	0	8	0
Calf deaths (%)	29	28	5
Calf breed	HxF, W	HxF, W	SxF

Cow liveweight, calf growth, and milk consumption

Calves from all dam breeds achieved growth rates of more than 1 kg/calf/day (Table 2) confirming that the smaller Jersey cows could grow calves at rates almost equivalent to that of the much heavier HxF cows. The HxF cows were 40% heavier than the Jersey, cows, across all years (Table 2). Estimated milk production (not shown) was similar across recipient breeds in all years although the within group variation was large. The calves from the Jersey recipients were 2 to 5kg lighter at birth than those from the HxF cows; gestation lengths were similar. The difference in calving dates was a direct reflection of differences in ET mating dates.

Efficiency measures

Based on the ratio of calf weaning weight (kg)/kg cow liveweight at weaning, the Jersey cow was about 30% more efficient than the HxF cow across all years (Table 3). On a feed conversion efficiency basis, the Jersey cow was between 0 and 27% more efficient than the HxF depending on whether the ratio was expressed per kg calf weaning weight or per kg daily liveweight gain (Table 3). The latter figure intrinsically included an adjustment for calving date.

Calving difficulty, cow and calf survival (raw means)

In year 1, the Jersey ET cows had considerably more calving problems and lower survival rates of both cows and calves than the HxF ET cows which in turn fared slightly worse than naturally mated HxF contemporaries (Table 4). Once calving was finished, cow and calf survival exceeded 95% for all groups. In year 2 under the imposed managed calving programme (Table 4), a better calving result was obtained. All calving "severity" indicators were lower and calf birth weights were much lower than in the previous year (Table 2). However, the Jersey ET cows still appeared to have more trouble than the other two groups including the group of AI mated Jersey contemporaries (Table 4). Some of the Jersey ET cow losses occurred due to seemingly rare events. Two Jersey cows died, or were destroyed from torsion of the uterus, one died from causes unknown four days post calving, one died due to an infection from retained membranes four days after calving; and one died due to complications from a caesarean operation five days previously. In year 3 (Table 4) cow losses were very low. Calf deaths were high (Table 5) but this was due to very high losses in the Wagyu calves.

TABLE 5: Calving results year 3 (October 2002) by embryo breed. Birth weight sed values were approximately 1.0.

Embryo breed	**SxF**	**HxF**	**Waygu**
No. born	39	48	42
Calf deaths (%)	5	8	33
Caesarean births (%)	0	0	7
Birth weight (kg)	37.7	35.3	32.3

DISCUSSION

The calf liveweight gain, cow liveweight, milk intake and pasture DM intake and efficiency results were in close agreement with the expectations generated by the model of Smeaton (2001). That model forecasted an increase in feed conversion efficiency (compared to HxF cows) of 20% from using a small, high milk-producing cow ET mated to a high growth-rate breed of embryo. The present project achieved gains of 0% in year 1 and 16 to 27% in years 2 and 3.. The nil response in year 1 was surprising because half way through lactation in that year, there had been a 22% gain in feed conversion efficiency in favour of the Jerseys (data not shown). The only explanation for the subsequent loss in efficiency is either pasture assessment errors (Smeaton and Winn, 1981) or that the Jerseys ate relatively more in the second half of lactation. This "problem" did not re-occur in years 2 and 3. Our fieldwork only covered the lactation period due to difficulties in getting all the cows together in the previous mating to calving period. However, the model of Smeaton (2001) and feed requirement data cited by Geenty and Rattray (1987) predicted that a 525kg HxF cow would eat 30% more than a 370kg Jersey cow over the 5 month period (weaning to calving) that was not assessed in this project. The contention therefore remains that small cows, such as Jerseys, could be expected to be 15 to 20% more efficient than larger cows such as HxF on an annual basis in terms of calf liveweight gain/kg of DM consumed.

Our results have illustrated the *potential* benefits from using a small cow like the Jersey, pregnant by ET to, and rearing, high growth rate calves and confirmed the modelling work of Smeaton (2001). Quite clearly these benefits can be readily destroyed if cows and calves fail to survive prior to and during calving. In fact, the Jerseys in this project would have been considerably less efficient if all deaths of cows and calves were included. This is a very real risk in ET programmes using high growth rate embryo breeds in small cows. Our Jersey cows were unable to reliably deliver high birth weight/liveweight-gain calves without severe losses despite anecdotal and other evidence (Baker et al., 1990) that it should be possible. In previous work involving twin ET with HxF embryos and HxF recipient cows (Smeaton 2000), those cows which were twin ET mated but which subsequently calved singles appeared to have little trouble calving although exact figures were not available. Singleton ET HxF calf birth weights in these earlier years were about 3 kg lighter than for the singleton HxF ET calves described in the present work.

The managed calving programme was used to shorten gestation by 7 to 10 days and coincidentally reduce calf birth weight (Lambert et al., 1998). In years 2 and 3 when it was applied, it did control calf birth weight but may have compromised the immune systems of the cows given the incidence of unusual deaths although we have no data to prove this. However, this would not be an inconsistent outcome as the corticosteroids used to shorten gestation are "stress" hormones (Macmillan, 1998).

The AI mated Jersey cows (Year 2) were not put through the managed calving programme. They calved unassisted and did not have a single death (apart from 1 due to misadventure). Their calves were HxJersey breed compared to the HxF embryos used in their ET mated contemporaries so that some birth weight reduction would have been expected due to the calf breed differences (Baker et al., 1990). Despite this, our ET calves were heavier at birth than expected. Reasons for the poorer survival of the Wagyu calves could not be provided.

CONCLUSIONS

Use of ET, small cows with high milking ability and high growth rate embryos can potentially yield a large gain in FCE. However, these benefits can be destroyed by calving difficulties and subsequent cow and calf losses. Use of managed calving to control these losses was not, in our opinion, an effective panacea. Selection of low birth weight, high growth rate ('curve bender') sires for use in IVP programmes would be of benefit. The above problems and requirements should be manageable and if the cost requirements described by Smeaton and Vivanco (2002) can be met, the productivity gain described above should be financially viable provided risk can be kept at an acceptable level.

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