CONTRACT REVIEW

BEEF CATTLE TWINNING

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INTRODUCTION

Beef twinning offers the prospect of a large increase in the efficiency of the breeding herd. It has been the subject of a co-ordinated Meat Research Corporation sponsored project to apply advanced reproductive technology to the temperate pasture zones of south eastern Australia. Our aim has been to develop an inhibin based twinning vaccine, to demonstrate the production benefits and practical problems associated with twinning and to develop a bioeconomic model suitable for evaluating twin and single calving herds under a wide range of conditions.

We have already presented a progress report to this Society (Cummins 1992) and further results are given in this contract. We indicated that twinning could be achieved through several pathways. At present none of these is commercially viable in Australia although several alternatives offer good prospects if current research is successful.

INHIBIN VACCINES FOR INCREASED OVULATION RATE AND FECUNDITY IN CATTLE

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Cummins *et al.* (1986), Price *et al.* (1987) and Bindon *et al.* (1988) all reported multiple ovulations in cattle immunised against ovarian follicular fluid inhibin of varying degrees of purity.

In developing a prototype vaccine for use in cattle, 15 different inhibin formulations (using synthetic inhibin-alpha fragments, recombinant inhibin fusion proteins or native ovine inhibin in Montanide:Marcol adjuvant) were evaluated for effects on ovulation rate (determined by laparoscopic examination), oestrous activity and specific inhibin binding in beef heifers (Bindon *et al.* 1994; O'Shea *et al.* 1994). These tests identified a recombinant inhibin alpha-chain immunogen *(Rec. ovine inhibin-α.3)* which increased ovulation rate in 87% of treated heifers. A dose-response experiment using *Rec. ovine inhibin-cr.3* showed that similar ovulation increases occurred in heifers following immunisation with 1000, 500, 250 and 125 μg.

Initial field studies of the effects of the prototype vaccine with 500 μg/immunisation used parous beef cows. The treatment protocol involved a primary vaccination given to randomly cycling cows, followed by a booster 28 days later on days 2, 9 or 16 of a synchronised cycle. The cows were mated at the following oestrus. In these field evaluations, ovulation rates, foetal numbers and development were monitored by real-time ultrasound imaging. Two experiments at Hamilton, in 1991/92 and 1992/93, showed that day of the cycle on which cows received the booster vaccination significantly influenced both the ovulatory responses and fertility. Forty one percent of cows treated early in the cycle (days 2 and 9) were in the ovulation class targeted for twinning (ie., 2 to 3 ovulations) but 30% had higher ovulation rates. The response for day 16 was unacceptable. Only 9% of cows treated on day 16 had multiple foetuses, compared to 47% of those treated on days 2 and 9 which had multiple foetuses at 40 to 60 days post-mating. An experiment at Grafton in 1991 also indicated that boosting on day 2 gave a superior ovulatory response than on day 16 of the cycle.

In 2 field tests in 1992, booster vaccination on day 2 of the oestrous cycle was followed by either 2 mating cycles (Grafton) or synchronised artificial insemination 20 to 21 days after booster and return mating(s) for 70 days (Armidale). Similar mean ovulation rates were observed (Grafton, 3.0 ± 0.3; Armidale, 3.2 ± 0.4), though the proportion of cows with ovulation rates in the range of 2 to 4 varied (Grafton, 52%; Armidale, 28%). Both sites had a high proportion of cows (-20%) with ovulation rates > 4. Conception rates for inhibin-immune cows (77%) were lower than for control cows (100%) at Grafton, while at Armidale 95% of treated and all control cows conceived. At both sites -40% of inhibin-vaccinated cows that conceived had multiple foetuses. Significant foetal wastage occurred in treated cows (Wilkins *et al.* this contract). At 1 week post-partum the numbers of calves/cow joined showed a benefit to vaccination of 22% at Armidale, but a deficit of 21% at Grafton.

As a result of over-stimulation observed in 20-30% of cows studied in the initial field trials, a series of dose-response experiments evaluated vaccines with lower doses of *Rec. ovine inhibin-α.3*. The booster was given on day 2 of the cycle. The first (at Hamilton) examined ovulation rates and fertility of groups (n -26) of cows vaccinated with immunogen dosages of 500, 250, 125, 62.5 and 0 μg/immunisation. All 4 treated groups responded similarly with no evidence of a dose-response relationship for inhibin antibody binding, ovulation rate or foetal numbers in early pregnancy. Although first cycle conception rates were depressed by inhibin treatment, the proportion of cows conceiving during the 84-day mating period was equal to control cows (81%). At 85 to 100 days gestation, 42% of pregnant cows in the treated groups were carrying multiple foetuses, of which 9% were triplets. Two experiments at Grafton involving a total of 204 cows have confirmed the potency of the immunogen. Dosages as low as 7.8 μg induced multiple ovulation in mature cows and similar ovulatory responses were seen in animals treated with 31.2 μg through to 500 μg of antigen.

The inconsistent field results are due to an unacceptably high proportion of cows with excessive ovarian stimulation, which has led to either poor conception rates in the first mating, cycle and/or significant foetal mortality during pregnancy. Further studies are required before any commercial release of this technique can be considered.

GENETICS OF TWINNING IN CATTLE

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Breeds differ in their twinning rates, and this provides the first suggestion that variation can be in part genetic, with high rates found, for example, in Charolais, Maine Anjou and Simmental. We have observed consistently high rates in a few pedigree dairy herds (the highest being 9.4% twins from 936 calvings over 11 years). A common factor appears to be a relatively closed herd and high inbreeding, with possibly accidental concentration of genes for twinning. Maijala and Syvajarvi (1977) reported negative heterosis for twinning, which is consistent with the above.

Twinning has a low repeatability of 0.06 to 0.12 (Maijala and Syvajarvi 1977; Gregory *et al.* 1990), and a low heritability of 0.02 to 0.06 (Gregory *et al.* 1990). The realised heritability estimate of 0.06 was equivalent to a value of 0.42 on the continuous and normally distributed liability scale (ie., after adjustment to make it similar to a trait distributed like yearling weight). Genetic progress has, however, been made by identifying and collecting together elite cows from industry and multiplying their genes in a nucleus herd. Examples have been reported in Australia, France, Germany, New Zealand and the USA (Morris and Day 1990). The greatest success and largest herd is in the USA (Gregory *et al.* 1990) where the present twinning rate is about 30%.

Analyses have been carried out unsuccessfully to demonstrate segregation of a major gene in France, Israel, New Zealand, Norway and the USA (Morris and Foulley 1991). Most groups searched for a dominant gene, whilst we are now collecting more data in New Zealand on the possibility of a recessive gene. Given the time and resources spent on the Booroola gene in sheep, it is not surprising that identifying such a cattle gene is still elusive.

Major efforts have been made, particularly in New Zealand and the USA to monitor double ovulation data from heifers and cows in the nucleus herd (eg., Echternkamp *et al.* 1990). At Clay Center, Nebraska, the repeatability and heritability in heifers were both 0.07 for a single record. This gave a heritability of 0.31 for 6 records, and has permitted effective indirect selection for twinning rate. Embryonic survival as a genetically controlled trait has not yet received much attention. By monitoring New Zealand Dairy Board data on triplet and higher order births over 5 years, we have shown that a few bulls feature more prominently as sires of triplet calving cows than would be expected from a random sample of dairy cows. This sire effect could include a component for embryo survival.

In conclusion, genetic progress can be made for twinning, but it requires a large herd and/or a large data base from which to screen animals.

EMBRYO LOSS IN MULTIPLE BEARING COWS

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We have monitored early pregnancy, embryo and foetal viability and final calving results in single and twin bearing cows following embryo transfer (ET) or multiple ovulation in this project.

Results are presented in Table 1 from 4 years' matings using Angus x Hereford cows at Grafton. Matings in 1989-1991 used artificial insemination (AI) and supplemental ET (Cummins *et al.* 1992), whilst matings in 1992 (both AI and bulls) followed an anti-inhibin vaccine which promoted multiple ovulation (Hillard *et al.* this contract). These latter matings should be considered separately from those using ET since it is not yet established if the vaccine has any effect on embryo survival. Pregnancy and litter size were monitored by realtime ultrasound imaging. The first observation to diagnose pregnancy was at 30 days after AI or observed mating, followed by litter size diagnoses at 45, 75 and 100 days gestation and frequent paddock observations at birth. Cows diagnosed as having 3 or more embryos are not included in Table 1 and are discussed separately.

Table 1. Embryo wastage during different stages of gestation in single and twin bearing cows over 4 years mating at Grafton.

Year mated (method)[A]	Cows[B] losing pregnancy (%) 30-45 days		Embryos[C] lost (%) 45-75	75-100	100-term	
		(n)		*Singles*		(n)
1989 (ET)	8.5	(94)	5.0	1.7	3.3	(60)
1990 (ET)	3.3	(153)	4.8	0	3.2	(62)
1991 (ET)	8.7	(196)	4.6	6.2	1.5	(65)
1992 (inhib)	6.2	(145)	0	1.9	2.8	(108)
				Twins		
1989 (ET)			2.1	5.7	6.4	(140)
1990 (ET)			2.3	2.3	9.3	(172)
1991 (ET)			0.9	1.8	5.7	(228)
1992 (inhib)			16.1	3.6	7.1	(56)

[A]Twinning by embryo transfer (ET) or following anti-inhibin vaccination (inhib)
[B]As % of all cows pregnant at 30 days (litter size unknown)
[C]As % of embryos identified at 45 days

The mean overall rates of loss in single and twin pregnancies in the ET groups were not significantly different for proportions of embryos lost after day 45 (10.2 vs 11.7%; from Table 1) or proportions of cows losing embryos (10.2 vs 12.2%); similar to the results of Echternkamp *et al.* (1990) with cattle selected for increased ovulation rate. Most of the embryos lost in twin pregnancies (95%) shown in Table 1 involved both embryos. Losses among singles were greater in the first trimester in contrast to losses in twins which were greater in the second and third trimesters.

In the anti-inhibin vaccinated cows neither single or twin groups conformed to the patterns for the ET groups. There was significantly ($P < 0.005$) greater loss overall among twins in anti-inhibin treated cows (26.8%) compared to those twinning by ET (11.7%), but this comparison is confounded by year since there was no ET group in 1992. Data from 2 other groups of cows (not included in Table 1) mated in 1992 at Armidale and Grafton following anti-inhibin treatment indicated a loss of 27% of multiple conceptions from 30-45 days and 21% from 45-100 days, but many of these involved ovulations of >4.

Cows were given anti-inhibin vaccination in 2 experiments at Hamilton. In 1991/92, those with single ovulations and single pregnancies at day 45 (n = 13) suffered no loss to term, compared with the birth of 3 singles and 3 twins from 6 cows scanned with 2 ovulations and 2 embryos. In 1992/93, of 30 cows with twins identified at 40-60 days of gestation, 17 delivered twins, 9 singles and 4 failed to calve; an embryo loss of 28% (similar to the vaccinated cows in Grafton, Table 1).

In the Grafton matings there were 9/37 multiple conceptions in the anti-inhibin groups with 3 embryos at 45 days, and 5/275 in the ET groups. From these 14 animals, only 1 set of triplets was born alive and survived. Following anti-inhibin vaccination at Hamilton in 1991/92, 9 cows with 3 or more ovulations had multiple embryos at day 35, but produced only 1 set of twins and 2 singles at term. In 1992/93, 5 cows actually had triplets at term, but only 2 sets were born alive.

The embryo wastage shown here is additional to the loss from mating to 30 days. For groups in Table 1 given ET, conception rates varied from 6781% over 3 years, with a mean of 75%. Thus there was failure in 25% of cows to 30 days (fertilisation failure plus early embryo loss), followed by failure in 16% of cows from 30 days to term.

Echternkamp *et al.* (1990) proposed that ovulation rate rather than embryo survival was the prime constraint to increasing litter size in cattle. Our ET results support that conclusion, showing little difference in rates of loss in single and twin conceptions.- However, it is possible that wastage may be greater following anti-inhibin induced multiple ovulations.

CALVING MANAGEMENT FOR A TWINNING HERD

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This paper aims to provide some guidelines for the management of twin calving cows. Our experience indicates the importance of this to the success of a twinning herd. McLeod *et al.* (1992) presented our preliminary data. The potential problems with twin bearing cows begin 2 months prior to calving and may extend to some time after, but are clearly concentrated during the birth process and the first few days after salving.

There have been several instances of pregnancy toxaemia resulting in cow deaths in our work. At Hamilton these have involved either cows bearing litters of more than 2 calves and/or a combination of nutritional and other stressors (eg. handling). The risk of this is very low when normal standards of cow nutrition are applied. In the last 4 years, 178 twinning cows have calved in autumn, under the poor feed conditions typical of this time of year, with only 2 cases being observed following yarding in late pregnancy. K. Martin (pers comm) reported twinning cows had elevated blood β-hydroxybuterate levels 6-8 weeks prior to calving (twins 0.7 ± 0.3 (SD), singles 0.5 ± 0.2, empties 0.4 ± 0.2mmol/L). Blood ketones in late pregnancy may turn out to be a useful management tool (see also Graham *et al. 1990). No* cases of pregnancy toxaemia were observed in 256 twin bearing cows at Grafton over 4 calvings but 2 cases were diagnosed from higher litter sizes. However, there has been a low incidence of grass tetany/milk fever in twin rearing cows at peak lactation, grazing irrigated pasture. This highlights the importance of levels and balance of nutrients, both pre and post calving.

The level of calving assistance has varied between years (Table 2), and management strategies must be flexible enough to cope with the worst years. Twinning cows usually require more assistance than those bearing singles. Assistance has usually been required for malpresentation, including breech and simultaneous presentation of both calves. In most cases these can be corrected and delivered with relative ease. We suggest that close observation of the calving herd and checking of cows considered to be in trouble in early labour is appropriate. This leads to earlier intervention than is usually required for single calving herds. When a cow is expected to be having twins, failure to produce a second calf within a short

Table 2. Calving performance of cows bearing singles or twins

	Hamilton				Grafton			
	1990	1991	1992	1993	1990	1991	1992	1993
No. of calves born								
Single	17	113	120	43	66	52	59	104
Twin	38	142	140	36	118	146	208	40
Calf survival (%)								
Single	100	94	97	100	97	100	92	98
Twin	87	90	86	89	93	87	80	80
Assisted births (%)								
Single	0	0	2	5	6	4	12	3
Twin	5	2	4	17	3	4	22	20
Assisted mothering (%)								
Single	0	0	1	2	5	0	0	9
Twin	8	17	17	30	8	14	13	25
Retained placentae (%)								
Single	1	1	3	0	0	0	0	1
Twin	12	19	20	16	25	17	23	25

time should be investigated.

The failure of the cow to mother up with both calves has been the most time consuming aspect of calving management. It is very important to recognise this problem early and this will require calf tagging and a good paddock recording system. Identification of calves soon after birth must be approached with judgement since some cows are easily disturbed from the early stages of bonding to their calves. In most cases, chaining the deserted calf to its mate with dog collars and a short chain for 3-4 days is all that is required. Occasionally, the cow and calves need to be penned up and assisted to suckle by bailing up or hobbling the cow. Once the cow has accepted both calves there seem to be no further mothering problems. In larger herds some form of drift calving is likely to be appropriate.

The increased incidence of retained placentae can be treated conservatively. This involves observation and not treating unless the cow appears sick. Under these circumstances in most years only a few cows are actually treated and to date there appears to have been minimal effects on subsequent fertility. High quality supplements in late pregnancy may improve calving outcomes and reduce the incidence of retained placentae (Gordon 1983).

In 1991 many herds in Hamilton were affected by “white scours”. The treatment rate in the twinning groups (9%) was higher than in singles (3.5%). Scouring has not occurred to any significant extent at Grafton over the 4 years.

In 1993 we attempted to quantify the extra time required to supervise calving in a group of twinning cows at Hamilton. Thirty five cows diagnosed pregnant with multiples following inhibin vaccination (using real time ultrasound imaging) were compared with 34 cows with single foetuses. On average twin calving cows required 45 minutes supervision/cow, while singles only required 5 minutes/cow. These observations were made in a year where the proportion of animals requiring assistance was higher than normal (Table 2). This suggests that given good facilities, adequate preparation and a normal calving spread, a good cattle manager should be able to handle a herd of 300-400 cows with a twinning rate of 50% or more. It is likely however, that this person would be fully occupied for the peak month of calving. It would be advisable to gain experience with a smaller twinning herd before moving to this scale of operation.

At both locations we are still learning about the most appropriate way to manage a twinning herd. Ultimately our suggestions will be modified by practical farmer experience.

THE EFFECT OF TWINNING AND STOCKING RATE ON CALF GROWTH AT HAMILTON

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In 1991 and 1992 pluriparous cows with single or twin calves grazed moderately fertilised, improved pastures at fixed stocking rates. The experiment had Hereford x Friesian cows grazing at 0.8, 1.2 and 1.2/ha with supplements, and Angus x Hereford cows at 1.2/ha. There were 2 replicates with 5 cows/plot each year. They grazed for a whole year from late pregnancy until after weaning. Twinning had been induced by embryo transfer (Cummins *et al. 1992)* and any cows which failed to rear the appropriate number of calves were replaced. The supplementary feeding treatment consisted of 2 kg of lupin grain/cow.day in late pregnancy and early lactation (February until July and required 400 kg/cow in 1991 and 340 kg/cow in 1992). Weaning occurred at approximately 10 months of age in January. All cows were joined by natural service for 9 weeks each winter. Acceptable pregnancy rates (≥ 80%) were achieved in all groups except the Hereford x Friesian cows with twins stocked at 1.2/ha without supplements.

Table 3. Treatment and birth type effects on growth to weaning at Hamilton

	1991				1992			
	BW (kg)	WW (kg)	WG (kg/day)	SG (kg/day)	BW (kg)	WW (kg)	WG (kg/day)	SG (kg/day)
Treatment								
Friesian x, 0.8/ha	35	307[a]	0.91[a]	1.16	36	316	0.96[a]	1.02
Friesian x, 1.2/ha	35	283[bc]	0.73[bc]	1.18	33	286	0.78[b]	1.11
Friesian x, 1.2/ha + sup	35	292[ab]	0.82[ab]	1.10	36	292	0.82[b]	1.06
Angus x, 1.2/ha	34	273[c]	0.66[c]	1.16	34	285	0.76[b]	1.09
LSD	3	19	0.14	0.10	3	39	0.11	0.12
Birth type								
Single	38.6[a]	325[a]	0.95[a]	1.22[a]	39.7[a]	331[a]	1.02[a]	1.15[a]
Twin	30.8[b]	253[b]	0.60[b]	1.08[b]	29.9[b]	258[b]	0.64[b]	1.15[a]
LSD	2.2	14	0.10	0.07	2.0	28	0.08	0.09

For each year BW = birth weight, WW = weight at weaning, WG = winter growth from birth to August, and SG = spring growth from August until weaning.
Different superscripts within column and either treatment or birth type indicate significant differences ($P < 0.05$).

Calf growth was analysed by considering 4 phases; birth weight (BW), weaning weight (WW), winter growth (birth until August, WG) and spring growth (August until weaning, SG). A split plot analysis of variance was carried out with treatment (stocking rate and cow type) and birth type (single or twin) and their interaction at the whole unit level, and sire, sex and other interactions at the sub unit level. In each year, treatment had significant effects on some aspects of calf growth while birth type had significant ($P < 0.05$) effects on all aspects (Table 3). There was only 1 significant interaction between treatment and birth type, involving SG in 1991 when the difference between single and twin born calves in the Angus cross cow treatment was greater than in the other 3 treatments.

Sex of calf'also followed expectations, with males heavier than females. Within twin pairs a preliminary analysis of the data did not suggest significant effects of the sex of the other calf. The sire of the calf had a small effect in 1991 with Murray Grey sires (transferred embryo) producing slightly heavier weaners than Hereford sires (naturally conceived embryos); all other terms and interactions were not significant. .

The difference in liveweight between twins and singles was 22% at both birth and weaning. This difference became larger during the relatively poor feed conditions during winter. However, during spring the twins increased their growth rate by 80% whereas the singles only increased by 20%. This allowed the twins to regain their relative position by weaning time. Twin rearing, autumn calving cows, weaned at 10 months of age, produced 156% of the weight weaned by comparable single rearing cows.

FORAGE INTAKE AND EFFICIENCY OF BEEF COWS REARING SINGLE OR TWIN CALVES AND GRAZING IRRIGATED PASTURES

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The beef cows used in this study were Angus x Hereford which were 7-9 years of age, and twinning was induced by embryo transfer as described by Cummins *et al.* (1992).

Cows grazed irrigated ryegrass between May and November which was oversown into summer-growing grasses in March of 1991 and 1992. During 1991/92, the stocking rates (cows/ha) for twin-rearing cows were 1.9 (low), 2.5 (medium) and 3.2 (high), with a single-rearing group at the high rate. Rates for twin-rearing cows in 1992/93 were 2.6, 3.2 and 3.8 cows/ha for low, medium and high stocking rates, respectively, with single-rearing cows at the medium and high rates. A further treatment involved weaning 1 calf from a high stocking rate group at approximately 70 days after birth. Calving occurred from July to September and estimates were made of calf growth until the calves were weaned in April of 1992 and 1993. Forage intake of cows was calculated during early (October), mid (December) and late (February) lactation from estimates of the digestibility of "plucked" pasture and the output of faeces determined using Cr_2O_3 dilution from a controlled release device in the rumen.

Table 4. Efficiency of calf output from single and twin-rearing systems at Grafton

	Stocking rate (cows/ha)	Calf wean weight (kg)	Calf growth rate (g/day)	Weaned calf output (kg/ha)	Mean cow forage intake (kg/ha.day)	Efficiency (output/intake) (%)
1991/92						
Single	3.2	261	974	835	35.3	8.8
Twin	1.9	225	856	854	24.1	13.5
	2.5	208	801	1040	25.3	15.8
	3.2	194	709	1244	36.5	12.4
s.e.		17.2	71.5	-	3.0	-
1992/93						
Single	3.2	274	984	877	39.6	7.9
	3.8	265	948	1007	50.9	7.1
Twin	2.6	232	824	1206	32.9	13.0
	3.2	210	729	1344	41.4	11.2
	3.8	222	766	1687	47.5	12.2
	3.8,EW[A]	252	897	1223	50.8	8.2
s.e		15.7	51.1	-	3.3	-

[A]One calf from each pair weaned early, 70 days after birth.

Comparisons between systems were made, based on a measure of efficiency, which was calculated by comparing the daily growth rate of calves per unit of pasture area to the mean forage intake of cows over the 3 estimates. During 1991/92 the efficiency with which cows rearing a single calf converted pasture organic matter (OM) intake to calf output was 8.8% (ie. 8.8 kg calf/100 kg OM) whereas, at the same stocking rate, the twin-rearers' efficiency was 12.4% (Table 4), a 40% increase in daily output.

The highest efficiency for twin-rearers during 1991/92 was recorded at the medium stocking rate (2.5

cows/ha). This efficiency was due to a large (25%) increase in daily calf growth and only a small (5%) increase in cow forage intake as stocking rate increased from 1.9 to 2.5 cows/ha. These increases were 39% (calf growth rate) and 51% (cow forage intake) when stocking rate increased from 1.9 to 3.2 cows/ha, resulting in the reduced efficiency at the higher stocking rate.

Efficiency was maximised in 1992/93 at 13.0% at 2.6 cows/ha (Table 4), ie. at a similar stocking rate as in 1991/92. However, during 1992/93 there was little difference between stocking rates in the efficiency with which twin-rearing cattle reared calves, since stocking rate had minimal effect on individual cow forage intake. Lactating twin-rearing cows had mean intakes similar to single rearing cows and this differs from the 45% higher intake reported earlier (Hennessy *et al.* 1992). Early weaning of 1 of the calves was less efficient than allowing cows to suckle both calves to a 230-day weaning. During 1992/93, calf output was almost doubled by rearing twins rather than a single calf at 3.8 cows/ha with the production efficiency increasing by 50%. The twins that were weaned were *c.*80% of the liveweight of single-reared calves.

POST WEANING GROWTH OF TWIN BORN CATTLE AT HAMILTON AND GRAFTON

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Single and twin born calves were weaned at approximately 10 months of age at Hamilton in January 1992. These calves were born on the experimental plots described by Cummins *et al.* (this contract). Between January and April these cattle grazed on a drained peat swamp at the Pastoral and Veterinary Institute. In April, the single and twin born steers and the freemartin heifers were equally allocated to be grazed on 2 producers' properties (A and B) in the Hamilton district. Final liveweights were taken in December 1992 and all the cattle from property A were slaughtered and carcase measurements obtained. The results are shown in Table 5.

Table 5. Growth and carcase measurements of cattle grown in the Hamilton district in 1992

	Growth (kg/day)[A]			Carcase[B]		
	PVI 14/1-9/4	A 9/4-3/12	B 9/4-11/12	Wt(kg)	Dressing %	P8 fat (mm)
Freemartins	0.31	0.46	0.57	207	53.6	10.4
Single Steers	0.40	0.57	0.56	269	53.7	11.2
Twin Steers	0.42	0.63	0.63	249	53.9	9.5

[A]Initially at the Pastoral and Veterinary Institute (PVI) then at properties A and B.
[B]Only measurements for cattle on property A were obtained.

Single and twin born calves were weaned in March 1992 at Grafton. These calves were between 203-278 days old and had been produced from the experimental plots described by Hennessy *et al.* (this contract). At weaning they were treated with an anthelmintic and grazed pastures of summer growing grasses until July when they were transferred to a pasture of mixed summer and winter grasses (digestibility 56-75%). They remained on these pastures until they were sold at approximately 19 months of age. The effect of sex and birth type is shown in Table 6. Weaning weights have been adjusted to a common age of 230 days and the final weights to 565 days.

At both sites the twin born calves showed evidence of compensatory gains after weaning. At Hamilton, twin born steer calves grew 9.7% faster then singles over the whole period. This figure is comparable to that recorded previously under similar grazing conditions (Clark *et al.* 1992). At Grafton, twin steer calves had a 16% higher post weaning gain than singles, fertile heifers a 10% advantage and freemartins a 2% advantage.

Table 6. Final liveweight and growth of single and twin-born calves at Grafton in 1992/93

	Steers		Heifers		
	Single	Twin	Single	Twin	Freemartin
Weaning weight (kg)	286	219	246	208	204
Final weight (kg)	411	364	386	362	347
Growth rates-weaning to 19 months (g/day)	370	430	415	455	425

DEVELOPMENT OF A COMPUTER SIMULATION MODEL TO EVALUATE TWINNING IN BEEF CATTLE

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A bio-economic simulation model of a self-replacing, grazing beef herd (Spath *et al.* 1984), has been extensively revised and modified to allow simulation of cows bearing and rearing twins. The model, named IACOAT, uses climate data (temperature, rainfall and evaporation), and inputs describing the potential pasture growth, the breed and age structure of the herd, the timing of events in the herd (mating, calving, weaning and sales) and financial information (sale prices, production costs), to simulate the pasture and animal production of a beef herd, on a weekly basis, and the financial performance of the enterprise each year.

The modifications made to allow for simulation of twin bearing and rearing cows included reducing the expected calf birth weight of twins to 0.75 that of a single born calf, which also affected the energy requirement of pregnancy in the cow, and the conceptus weight gain; increasing the peak lactation milk yield for cows suckling twins to 1.3 times that of a cow suckling a single calf, which increased the energy requirement for lactation and the appetite of the lactating cow; shortening the gestation length by one week in cows bearing twins; and increasing the incidence of calf mortality in twins to 1.2 times that of single born calves. These factors were derived from values reported in the literature on twinning in cattle.

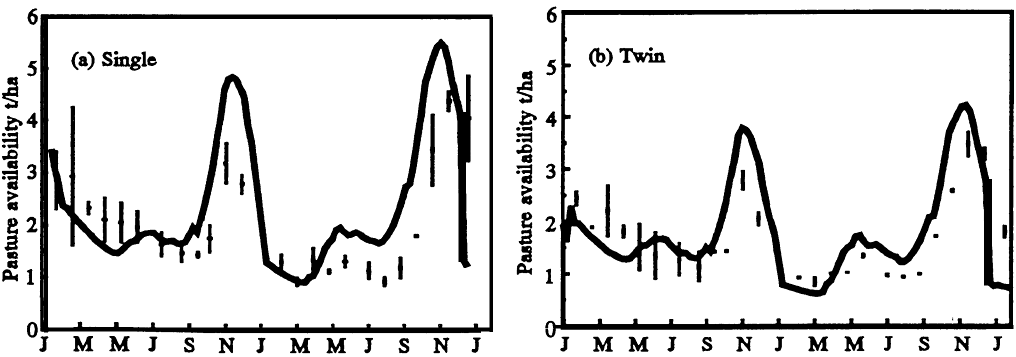

Figure 1. Observed (error bars) and predicted (lines) availability of total pasture for Angus x Hereford cows rearing (a) single or (b) twin calves at 1.2 cows/ha at Hamilton, Victoria.

Assessment of IACOAT, and fine tuning of the model, is being carried out using data from the twinning studies at Hamilton and Grafton during 1991-92. Figure 1 shows reasonable agreement between the model's predictions of total pasture availability and actual observations from paddocks grazed by either single rearing or twin rearing Angus x Hereford cows at Hamilton. The predictions and observations of green pastures gave similar agreement. Further development of the model is being undertaken to improve its predictions of animal intake and liveweight change. When the assessment and modification of the model is complete, IACOAT will be used to examine the profitability of alternative management strategies for twinning in beef herds.

REFERENCES

BINDON, B.M., ANDERSON, S.T., CUMMINS, L.J., FINDLAY, J.K., HILLARD, M.A., PAULL, J.M., TSONIS, C.G. and WILKINS, J.F. (1994). *Aust. J. Agric. Res. 45:* (in press).

BINDON, B.M., O'SHEA, T., MIYAMOTO, K., HILLARD, M.A., PIPER, L.R., NETHERY, R.D. and UPHILL, G. (1988). *Proc. Aust. Soc. Reprod. Biol. 20: 28.*

CLARK, A.J., **GRAHAM,** J.F., CUMMINS, L.J. and McLEOD, I.K. (1992). *Proc. Aust. Soc. Anim. Prod.* **19:** 442-3.

CUMMINS, L.J. (1992) *Proc. Aust. Soc. Anim. Prod.* **19:** 438-47.

CUMMINS, L.J., CLARK, A.J., McLEOD, I.K., WILKINS, J.F., WILLIAMSON, P.J., HENNESSY, D.W., HILLARD, M.A., PASHEN, R.L. and DARROW, M.D. (1992). *Proc. Aust. Soc. Anim. Prod.* **19:** 440-1.

CUMMINS, L.J., O'SHEA, T and BINDON, B.M. (1986). *Proc. Aust. Soc. Reprod. Biol.* **18: 39.**

ECHTERNKAMP, SE., GREGORY, K.E., DICKERSON, G.E., CUNDIFF, L.V., KOCH, R.M. and VAN VLECK, L.D. (1990). *J. Anim. Sci. 68:* 1877-88.

GORDON, I. (1983). "Controlled Breeding in Farm Animals", pp. 123-45 (Pergamon Press Ltd: Oxford).

GRAHAM, J.F., CUMMINS, L.J., CLARK, A.J. and LANG'AT, K.A. (1990). *Proc. Aust. Soc. Anim. Prod.* **18: 216-9.**

GREGORY, K.E., ECHTERNKAMP, SE., DICKERSON, G.E., CUNDIFF, L.V., KOCH, R.M. and VAN VLECK, L.D. (1990). *J. Anim. Sci. 68:* 1867-76.

HENNESSY, D.W., WILKINS, J.F., WILLIAMSON, P.J., ANDREWS, C.M. and MAKINGS, B.J. (1992). *Proc. Aust. Soc. Anim. Prod.* **19: 444-5.**

MAIJALA, K. and SYVAJARVI. J. (1977). *Z. Tierzuchtg. Zuchtgshiol. 94:* 136-50.

McLEOD, I.K., CLARK, A.J., CUMMINS, L.J., WILKINS, J.F., HENNESSY, D.W., ANDREWS, CM. and WILLIAMSON, P.J. (1992). *Proc. Aust. Soc. Anim. Prod.* **19: 441-2.**

MORRIS, C.A. and DAY, A.M. (1990). *J. Anim. Breed. Genet.* **107: 2-6.**

MORRIS, C.A. and FOULLEY, J.L. (1991). *Genetique, Selection, Evolution 23:* 345-50.

O'SHEA, T., HILLARD, M.A., ANDERSON, S.T., BINDON, B.M., FINDLAY, J.K., TSONIS, C.G. and WILKINS, J.F. (1994). *Theriogenology* **41: 3-17.**

PRICE, C.A., MORRIS, B.A., O'SHEA, T. and WEBB, R. (1987). *J. Reprod. Fert.* **81:** 161-8.

SPATH, E.J.A., MORLEY, F.H.W. and WHITE, D.H. (1984). *Proc. Aust. Soc. Anim. Prod.* **15: 597-600.**