Changes in the beef cattle industry through application of scientific knowledge

J.N. Wiltbank

Department of Animal Science, Brigham Young University, Provo, Utah

Significant changes have occurred in the beef cattle industry in the past few decades. Many of these changes have occurred because cattlemen have applied information provided by animal scientists. Some of these changes are crossbreeding, selection, meeting nutrient requirements of cattle in various stages of production, use of feed additives, use of implants, use of non-protein nitrogen, artificial insemination, oestrus synchronization, and management systems for improving reproduction in heifers and cows. Although these changes have been substantial, many practices have been adopted only partially or by a limited number of ranchers. Therefore, a wide gap exists between available knowledge and the application of that knowledge. To help the cattleman make decisions, animal scientists need to develop models able to predict the economic value of adopting various techniques. The cattleman can then decide when and if the technique should be used in his operation. However, the problem of how to use the technique in different situations still remains and must be the concern of thoughtful animal scientists.

S. Afr. J. Anim. Sci. 1986, 16: 105 – 112

Betekenisvolle veranderinge het oor die afgelope paar dekades in die vleisbeesbedryf plaasgevind. Baie van hierdie veranderinge het plaasgevind omdat beesboere die inligting wat deur veekundiges verskaf is, toegepas het. Van hierdie veranderinge is kruisteling, seleksie, voldoening aan voedingsvereistes van beeste in verskillende stadia van produksie, gebruik van voerbymiddels, implanterings, gebruik van nie-proteïenstikstof, kunsmatige inseminasie, sinkronisasie van estrus en bestuurspraktyke vir verbetering van reproduksie by verse en koeie. Alhoewel daar reeds wesentlike veranderinge plaasgevind het, is daar baie praktyke wat net gedeeltelik, of net deur 'n beperkte aantal boere toegepas word. Daar bestaan dus 'n groot gaping tussen beskikbare kennis en die toepassing van daardie kennis. Veekundiges moet modelle ontwikkel om die ekonomiese waarde van die toepassing van verskeie tegnieke te voorspel en so die boere te help om besluite te neem. Die beesboer kan dan besluit of 'n sekere tegniek bruikbaar is in sy opset en ook wanneer om dit te gebruik. Die probleem van die toepassing van die tegnieke in verskillende situasies moet egter steeds die besorgdheid van toegewyde veekundiges geniet.

S.-Afr. Tydskr. Veek. 1986, 16: 105 – 112

Presented at the Symposium on 'The scientist serving animal production' at the 25th Annual Congress of the South African Society of Animal Production, Transkei, 15 – 17 April, 1986

J.N. Wiltbank

Department of Animal Science, Brigham Young University, Provo, Utah 84322

Introduction

Changes occur slowly in most industries. Nevertheless, significant changes have occurred in the beef cattle industry in the last few decades. Many changes have been the result of applying scientific information developed by animal scientists. Most of these changes have had and will have an economic impact on the beef cattle industry. The purpose of this article is to point out some of these changes and review briefly some research that demonstrates the value of the principles. Even though the principles are generally accepted, a wide gap exists between knowledge and adoption. Some causes for lack of adoption will be pointed out.

Animal breeding

Crossbreeding is one of the significant changes that has occurred in the beef cattle industry in the past few years. Estimates indicate that 70% of the cattle entering commercial feedlots in the United States are crossbreds. Numerous studies have shown that crossing of breeds will cause significant improvement in beef production by heterosis and addition of desired traits.

Koger (1973) summarized much of the crossbreeding research and concluded that the most significant contribution of crossbreeding was in improvement of maternal traits. This was true when *Bos taurus* and *Bos indicus* breeds were crossed or when *Bos taurus* breeds were crossed. Production per cow was increased by 54 kg in the *Bos taurus – Bos indicus* F1 female, whereas a 17 kg increase was noted in the F1 *Bos taurus* cross female (Table 1). The improvement was the result of an increase in weaning rate and weaning mass in the F1 crossbred cow. The increase in weaning rate occurred because calving rate and survival rate were both higher in the F1 cow than in straightbreds. The increase in weaning mass was 40 kg in *Bos taurus – Bos indicus* F1 crosses and 11 kg in *Bos taurus* F1 breed crosses.

Production per cow was improved when a crossbred calf was nursing a straightbred dam but was substantially less than from a F1 female. Production was also less in rotational crossing systems than that noted in F1 cows but was substantially higher than in straightbred cattle.

Although most of the data summarized by Koger (1973) were generated several years ago, changes in commercial cow herds have occurred slowly. Lack of implementation appears to be the inability of the rancher to know how to use crossbreeding on his ranch. Many ranchers who use crossbreeding have no planned system. Therefore, many of the benefits from heterosis are not realized.

Crossbreeding has been used extensively to add traits such

Table 1 Advantages of crossbreeding (adapted from Koger, 1973)

	Bos taurus – Bos indicus cross Progeny rotational				*Bos taurus* – breed crosses Progeny rotational			
	SB	F_1 Progeny	F_1 Dams	Cross-breeding	SB[a]	F_1 Progeny	F_1 Dams	Cross-breeding
Calving rate (%)	81[a]	−7[b]	12	4	87	2	4	–
Survival rate (%)	83	6	5	4	90	3	1	–
Weaning rate (%)	67	3	13	6	78	1	3	3
Weaning mass (kg)	175	19	40	44	177	6	11	15
Production per cow (kg)	117	14	54	36	138	2	17	23
ADG Feedlot (kg)	0,92	0,12	0,02	0,00	0,98	0,04	0,02	0,06

[a]Mean of two breeds; [b]Figures are changes expected to occur

as growth or milk to a breed. Many times the addition of one trait has had a negative effect on other traits. For example, in Gelbvieh sires bred to Hereford or Angus cows weaning mass increased with 14 kg (Gregory, Cundiff, Smith, Laster & Fitzhugh, 1978). However, there was a 4,6 kg increase in birth mass which was associated with a 4,1% increase in calving difficulty and a 4,5% increase in perinatal mortality (Table 2). Consequently, calf crop weaned was 8% less in cows bred to Gelbvieh bulls. As a result of problems such as these, many cattlemen have abandoned crossbreeding.

Limited observations indicate that crossbred cows perform at higher levels in marginal environments. An experiment showing a genetic environmental interaction on age at puberty is used as evidence for such a phenomenon (Wiltbank, Kasson & Ingalls, 1969). Two levels of nutrition were fed to heifers starting at weaning time, and time of puberty was determined. Only small differences were noted in age of puberty between crossbred and straightbred heifers fed the high level of nutrition (Table 3). Puberty occurred later in all heifers fed the low level of nutrition. However, puberty occurred only 43 days later in crossbred heifers fed a low level of nutrition whereas puberty occurred 273 days and 109 days later in Hereford and Angus heifers fed low levels of nutrition. Large differences in age at puberty between crossbred and straightbred heifers receiving low levels of feed were, therefore, apparent. The value of the crossbred cow in marginal environments needs to be elucidated further.

The results from numerous studies indicated that substantial improvements should be realized from crossbreeding. Although many ranchers crossbreed, few use planned programs. Many ranchers will have bulls of several breeds in the same pasture. It is doubtful whether many ranchers understand how best to implement crossbreeding systems. A casual look gives the impression of widespread use of crossbreeding. Close inspection, however, indicates implementation is far from the level which would be the most profitable.

Selection as a tool to cause changes in commercial cow herds is an ancient practice. The Bible records that Jacob used selection to acquire many of his father-in-law's cattle. However, using genetic information to cause effective changes in commercial beef cattle is still in an early stage of development. This, in spite of the fact that performance records have been available for several decades and in the last few years many breeds have made progeny test data available for use. There is still a lack of information needed to make intelligent decisions, but a more important problem is that records are not used. Most commercial bulls, at least in our part of the world, are still bought by pedigree and 'eye ball'. This occurs even though the effectiveness of using 365-day mass as a selection tool has been shown repeatedly. However, information may have been presented in such a way that the cattleman did not understand the benefits. Recently, a demonstration was conducted which clearly showed the benefits (Spitzer, personal communication). Two Santa Gertrudis bulls were selected on the basis of an index of 114 and 86 for adjusted 365-day mass. The two bulls were mated to produce approximately 40 calves. Offspring of the two bulls differed in average weaning mass by 15 kg and by more than 30 kg in average yearling mass (Table 4). These data show the benefits of using an index. More of this type of information needs to be used for educating producers.

Several breed associations supply their breeders with progeny data on bulls in their breed. An example of data on four bulls from the 1986 Simmental sire selector is presented to show how information can be used to make intelligent decisions (Table 5). Expected progeny differences, effective

Table 2 Changing traits by crossbreeding in Hereford or Angus cows (adapted from Gregory, Cundiff, Smith, Laster & Fitzhugh, 1978)

Trait	Sire: A or H[a]	Sire: Gelbvieh	Difference
Calving difficulty (%)	2,9	7,0	4,1
Perinatal mortality (%)	2,7	7,2	4,5
Calf crop weaned (%)	96	88	−8
Birth mass (kg)	36,8	41,4	4,6
200-day mass (kg)	188	202	14

[a]Angus or Hereford

Table 3 Crossbreeding and puberty in heifers receiving two levels of feed (Wiltbank, *et al.*, 1969)

	Breed			Difference	
	H	A	H×A	H−X	A−X
Age at Puberty (days)					
Low[a]	660	483	424	236	59
High[b]	387	374	381	6	−7
Difference	273	109	43	–	–
Mass at Puberty (kg)					
Low[a]	279	257	254	25	3
High[b]	294	305	330	−36	−25
Difference	15	48	76	–	–

[a]Full fed grass hay + 0,2 kg protein supplement; [b]Full fed concentrates + 1,3 – 1,8 kg grass hay

Table 4 Selection for growth using two Santa Gertrudis bulls (Spitzer, personal communication)

	High performance bull	Low performance bull	Difference
Own Performance			
205-day mass (kg)	255(103)*	227(95)	28
365-day mass (kg)	553(114)	414(86)	139
Offspring's performance[b]			
Weaning mass (kg)	243 ± 3,3	228 ± 4,0	15[a]
Yearling mass (kg)			
Steers	405 ± 6,2	370 ± 8,5	35[a]
Heifers	323 ± 7,8	290 ± 7,6	33[a]

*Ratio in parenthesis; [a]$P < 0,01$; [b]Progeny approximately 40 per bull

progeny number, and accuracy of that information are available to help in making decisions. As an example, bull 1 could be used to increase growth rate without increasing dystocia. Bull 2 might increase growth rate but you have no idea what will happen to dystocia. Bull 3 will increase growth and also increase birth mass and dystocia. Bull 4 is close to the breed average in most traits but will increase maternal milk and the performance of his offspring is highly predictable in all traits. Although some ranchers do make use of these data, the practice is not widespread. Unfortunately, most cattlemen in our country do not use and probably do not know how to use this type of information.

Synthetic breeds are now being developed in many countries. In Canada, a group of cattlemen have developed and marketed several maternal lines and sire lines. Other lines are being developed at research stations and by breeders. It would appear that many synthetic breeds will be used or misused commercially in the next few years.

Nutrition

Advances in nutrition have been phenomenal over the last few decades. Many subtle changes have occurred which received little or no publicity outside the scientific arena. The basic knowledge of nutrition that the producer uses daily is usually taken for granted. However, this knowledge was gained through many years of painstaking effort by many animal scientists. Two important areas of information resulting from research are the nutrient requirements of animals at various stages of production and the nutrient composition of feedstuffs. These facts are well documented and will not be attempted here. However, knowledge in these areas is constantly changing and becoming more reliable and more useful.

The work on minerals and vitamins makes livestock production economically feasible and is used world-wide. A summary of many accomplishments was made by Ammerman & Goodrich (1983). A great deal of work has been published and is used daily on nitrogen metabolism (Owens & Bergen, 1983). In discussing energy requirements, the work of Lofgreen & Garrett (1968) must be mentioned. They partitioned net energy into that used for maintenance and that used for growth. This concept is used by most commercial feedlots today in computer systems to predict gain and profitability. Close examination of close out sheets from commercial feedlots indicate that gains can be predicted reliably under many circumstances. However, weather is still an important consideration making prediction difficult or nearly impossible.

Table 5 Example from Simmental sire selector (unpublished data, 1986)

Measurement	Bull number 1	2	3	4
Calving ease, first calf (1,74 bulls – 1,37 heifers)				
EPD[a]	102,9	96,6	87,2	99,1
EPN[b]	168	0	162	1273
ACC[c]	0,63	0,18	0,71	0,91
Birth mass (40,82 kg bulls – 36,28 kg heifers)				
EPD	– 2,6	0,1	4,0	0,1
EPN	1232	62	1682	6294
ACC	0,87	0,51	0,89	0,95
Weaning mass (263,49 kg bulls – 228,57 kg heifers)				
EPD	15,9	15,4	18,0	2,0
EPN	1751	56	1896	8142
ACC	0,87	0,46	0,88	0,95
Yearling mass (455,78 kg bulls – 348,3 kg heifers)				
EPD	40,6	23,6	38,0	9,5
EPN	470	16	357	1900
ACC	0,87	0,44	0,86	0,95
Maternal calving ease (1,72 bulls – 1,36 heifers)				
EPD	107,6	100,9	98,4	98,6
EPN	207	0	80	923
ACC	0,67	0,13	0,68	0,91
Maternal weaning mass (268,93 kg bulls – 239,91 kg heifers)				
EPD	4,2	6,2	– 3,6	8,6
EPN	705	0	137	6333
ACC	0,81	0,20	0,74	0,94
Maternal milk				
EPD	– 3,7	0,6	– 12,6	7,7
EPN	705	0	137	6233
ACC	0,79	0,14	0,71	0,93

[a]Expected progeny difference from breed mean;
[b]Effective progeny number;
[c]Accuracy;
[d]Breed average for trait in parenthesis

Although information is available and has been available for some time, it should be remembered that production is often limited in cow/calf operations and stocker operations by low levels of nutrition.

Recently advances have been made in the areas of growth promotants, feed additives and use of non-protein nitrogen. Much of this knowledge is now being used in beef cattle production. An example is the use of implants for promotion of growth. Implants are used at most levels of production in the beef cattle industry. One study is shown here as an example of the type of information available. Three types of implants were compared with a control group in a feedlot study (Basson, Dinusson, Embry, Feller, Gorham, Gruetter, Hinman, Mcaskill, Parrott, Riley, Stanton, Young & Wagner, 1985). Average daily gain and average daily feed consumption was increased in cattle receiving implants (Table 6). The feed consumed to gain ratio was decreased. However, it should be noted that gain was reduced and feed to gain ratio increased in steers receiving a single implant. Although these kinds of

Table 6 Effect of implants on feedlot performance over 164 days (Basson, *et al.*, 1985)

Treatment	No steers	ADG[c] (kg)	ADF[d] (kg)	F/G[e]
Control	192	1,2[f]	8,3[f]	6,9[f]
Single implant[a]	202	1,3[g]	8,7[g]	6,7[f]
Re-implant[a]	202	1,4[h]	8,9[g]	6,4[c]
ESRT[b]	193	1,4[h]	8,7[g]	6,4[c]

[a]Synovex or Ralgro; [b]Estradiol sustained release; [c]Average daily gain; [d]Average daily feed; [e]Feed to gain ratio; [f,g,h]means in same column with different superscripts differ

data are well documented in this study and other studies, many producers fail to use implants or misuse them. It has been estimated that hormonal growth promotants increase performance with 10 – 15%. Use of antibiotics improves performance by about the same amount in feedlot cattle whilst improvements of up to 25% have been estimated in calves (Rumsey, 1983). Many other feed additives such as ionophores and sodium bicarbonate are being used routinely in feedlots and many others are being tested. Undoubtedly many changes will be seen in the next few years. However, although feed additives are useful, some cattlemen have wrongly used them to replace basic nutritional needs.

Large amounts of non-protein nitrogen are routinely used in the beef cattle industry. Use occurs at all levels of production. Some misuse of the product appears to occur, particularly in supplements for beef cows.

Commercial feedlots acquire and use nutritional knowledge rapidly. However, acquisition and use of nutritional information by cow/calf producers has been relatively slow.

Reproduction

Many 'eye catching' and spectacular scientific advances have been made in reproduction recently. Close examination reveals, however, that use of these techniques has, as yet, had little or no impact in the commercial beef cattle industry. Some techniques have been used routinely by a limited number of cattlemen with great success. Artificial insemination (AI) is an example of such a technique. Information such as length of oestrus, time of ovulation, breeding time and methods of oestrus detection were made available through research. Some cattlemen have used this information and have conducted successful AI programmes for several years. There are commercial cattlemen who have used no bulls in their operations for 10 – 12 years. Still, AI is used by less than 4% of the commercial producers in the United States. The main reason for the low level of use is inability of the rancher to see a financial advantage. Many cattlemen have attempted AI in poorly managed herds and have failed. The cost of failure has been ascribed to AI. Others have improved their feeding programmes and charged the AI programme for the improved management. AI can be successful only in well-managed herds. Predictions of costs in well-managed herds show AI to be less expensive than natural mating on many ranches. Even so, use of AI continues at relatively low levels because too many ranchers fail to see the financial incentive for implementation.

A technique which has potential to increase the number of cows bred with AI is synchronization of oestrus. The main systems being used in the United States are prostaglandins and Synchromate B (SMB). Methods for use have been documented but the techniques are not widely used. Many cattlemen have tried to synchronize oestrus and experienced failure. The main reason for this failure was poor management. Some cattlemen have attempted to use the technique as a 'cure all', whereas synchronization techniques can only be successful in well-managed herds. Using information available in the literature, the results expected from using synchronization of oestrus can be predicted. An example will be used later in this paper to illustrate this principle.

A technique which has received a great deal of publicity and attention recently is embryo transfer (ET). To date, the impact of ET in beef cattle populations has been relatively small. Two areas where ET might have an impact are twinning and production of bulls for AI. ET has been used for twinning on an experimental basis. However, techniques have not been applied to commercial cow herds. ET is being used in the dairy industry to produce bulls with a high genetic potential. Some of these bulls are then used widely in AI studs. However, use of ET to produce bulls for use in AI in beef cattle is still in its infancy. Because AI is used in only a small number of beef cows, little impact would be expected.

Reproductive techniques which are not as spectacular as those previously mentioned are now being used by progressive cattlemen to improve reproduction in heifers and cows. The following practices have been shown to be useful in heifers: (1) feeding to attain earlier puberty; (2) calving heifers in a short concentrated period prior to the cow herd; (3) decreasing calving difficulty by feeding or by measuring pelvic opening; and (4) use of nutrition and sorting to increase the number of heifers which will breed for their second calf. Many progressive cattlemen routinely use either some or all of these practices in their heifer programmes.

The value of feeding heifers to attain puberty will be shown using results of two studies. A group of Hereford heifers of unknown ages were weighed prior to being exposed to the bull for 60 days. Heifers were checked for pregnancy 40 days after the end of the breeding season. The heifers were calved in a large pasture. The second year, the cows were bred for 120 days. The calves were counted at weaning time and cows were checked for pregnancy. Pregnancy rate in the first year varied from 65% in heifers weighing less than 250 kg at the start of breeding to 90% in heifers weighing over 272 kg (Table 7). There was a marked difference in losses between pregnancy diagnosis and weaning in light and heavy heifers. Also, fewer wet cows became pregnant for the second calf in the light heifers. Proper heifer development increased pregnancy rate the first year, decreased calf losses and increased pregnancy rate the second year in this study. The second study confirmed the results noted in the preceding demonstration and provided additional details on time of puberty, conception rate, and growth of the pelvis.

A group of 1/4 to 1/2 Brahman heifers was divided into two equal groups and fed for 200 days (Wiltbank, Roberts,

Table 7 Reproductive performance in Hereford heifers of varying mass

	Mass at start of breeding (kg)		
	< 250	250 – 272	> 272
Number of Heifers	40	166	45
Pregnant in 60 days (%)	65	77	90
Calves weaned (%)	40	71	86
Losses pregnancy diagnosis to weaning (%)	25	6	4
Wet cows pregnant (%)	18	57	69

Nix & Rowden, 1984). One group was fed to weigh 272 kg (TW1) at the start of the breeding season whilst the second group was fed to weigh 318 kg (TW2). Heifers were checked for oestrus and were bred using AI for 90 days. Heifers were calved, bred the second season, and a weaning mass was obtained. All cows were handled similarly from start of first breeding season onward. Weaning rate was 17 and 16% lower and calves were born 17 and 12 days later in TW1 than TW2 heifers for first and second calf, respectively (Table 8). The first calf born to TW2 heifers weighed 14 kg more at weaning than calves born to TW1 heifers and a 7 kg difference was estimated for the second calf. In the first 2 years of production, therefore, TW2 heifers weaned 76 kg more calf per female exposed than TW1 heifers. Correctly developing heifers increased pounds of calf weaned for first and second calves by increasing number of heifers showing oestrus early in the breeding season and by increasing conception rate at first service. In addition, the pelvic area was 12 cm^2 larger at the start of breeding and 9 cm^2 larger shortly before first calving in TW2 than TW1 heifers. All heifers were bred to a bull known to sire small calves, consequently, little or no calving difficulty was encountered. Data such as these are available but not used widely or used only partially. Most ranchers fail to weigh heifers or feed to reach target mass.

Table 8 Performance of Heifers fed to two target masses (Wiltbank, *et al.*, 1984)

Measurement	Target mass (kg) 272	318	Difference
Number of heifers	110	111	
Daily Ration (kg)			
Corn	1,7	2,8	1,1
Hay	4,5	4,0	0,5
Cost (US $)[a]	100	120	20
Mass (kg)			
Start of breeding	280	324	44
End of breeding	330	353	23
First breeding season			
Mass weaned per heifer exposed (kg)	102	141	39
Calves weaned (%)	63	80	17
Weaning mass (kg)	162	176	14
Average day of birth	58	41	17
Bred 1st 20 days (%)	33	63	30
Bred 1st 40 days (%)	56	80	24
Pregnant first service (%)	46	63	17
Size of pelvic opening (cm^2)			
Start of breeding	197	209	12
Before calving	249	250	9
Second Breeding Season			
No. of cows exposed	65	88	–
Mass weaned per cow exposed (kg)	122	159	37
Calves weaned[b] (%)	67	83	16
Weaning mass (kg)[c]	185	192	7
Average day of birth	42	30	12
Bred 1st 20 days (%)	12	24	12
Bred 1st 20 days (%)	48	70	22
Pregnant first service (%)	69	81	12

[a]Cost of feed for 200 days;
[b]Estimated from cows pregnant;
[c]Estimated from time of conception

Measurements of pelvic area have been used by cattlemen to cull heifers with small pelvic openings. Problems have been encountered. One of these can be illustrated by looking at the results of a survey made on ranches in Nebraska. Most of the heifers in the survey were Hereford heifers, calving for the first time at 2 years of age. The pelvic area was measured at a pregnancy check approximately 4 months prior to the start of calving. A relationship between pelvic area and calving difficulty was apparent (Table 9). However, to decrease calving difficulty to acceptable levels, most of the heifers would have to be culled. As an example, if heifers having a pelvic opening from 150 to 189 cm^2 were culled, 46% of the heifers would be culled and 45% of the remaining heifers would experience calving difficulty. Either the heifers need to be bred to bulls that sire smaller calves or the number of heifers with larger pelvic areas must be increased.

Table 9 Pelvic opening and calving difficulty

Pelvic area (cm^2)	Number calving	%	Calving difficulty (%)	Very difficult (%)
150–169	29	7	76 (22)[a]	14 (4)
170–189	157	39	63 (99)	4 (6)
190–209	148	37	49 (72)	3 (4)
210–229	57	14	40 (23)	2 (1)
> 229	15	4	27 (4)	0
Overall	406		54 (220)	4 (15)

[a]Figures in parenthesis are number

In a previous study, growth of the pelvic area was shown to be influenced by feeding level prior to breeding. Other data indicate nutrition has a marked effect on growth of the pelvis during pregnancy (Wiltbank & Remmenga, 1982; Bellows & Short, 1978). Many ranchers attempt to decrease calving difficulty by feeding heifers on low levels of feed during the last 1/3 of gestation. Birth mass is decreased in pregnant heifers on low levels of feed but the pelvis grows at a slower rate and consequently, calving difficulty is not decreased (Wiltbank & Remenga, 1980; Bellows & Short, 1978). Pelvic growth occurs at a predictable rate in heifers receiving proper nutrition. However, if the diet changes, then growth patterns change and predictability is more difficult. Even with these difficulties, there are ranchers who consistently measure pelvic area and report little or no calving problems. However, most ranchers measuring pelvic opening also develop heifers properly, feed proper levels of nutrition in late pregnancy, and breed heifers to bulls known to sire calves with low birth masses.

Many progressive ranchers breed heifers earlier than the cow herd. Cattlemen using this practice can give more attention to heifers during the calving season, calves born earlier in the calving season weigh more at weaning, and more heifers become pregnant for their second calf. These principles were shown in a study with Angus heifers (Wiltbank & Spitzer, 1978). Heifers were divided into two groups. In the new management system, the breeding season started 20 days earlier in heifers than in the regular cow herd, synchronization of oestrus was used, heifers were selected for early pregnancy, and both heifers and cows were bred in a 45-day breeding season (Table 10). In contrast, cows and heifers in the conventional system were bred for 90 days, the breeding of heifers started the same day as the breeding of the regular cow herd, and no selection for early calving was practiced. All open cows

Table 10 Comparison of reproductive performance and productivity in new management and conventional management systems[a] (Wiltbank & Spitzer, 1978)

	New system	Conventional system
Length of breeding season (days)	45	90
Number of heifers exposed	137	86
Per cent of heifers pregnant after breeding for		
25 days[b]	59	44
45 days[b]	74	59
90 days	–	83
Number of cows exposed	195	199
Per cent of cows pregnant after breeding for		
25 days[b]	74	60
45 days	87	78
90 days	–	92
Average weaning mass, adjusted to bull basis (kg)[b]	203	188

[a]Five-year study; [b]Significant difference ($P < 0,05$)

and heifers in both groups were culled at the end of their respective breeding seasons, except in the first breeding season. Cows in the new and in the conventional management groups were on the same pastures and were fed for maximum reproductive performance. The new management system caused the heifers to calve early, and cows and heifers to calve in a short period of time. On the other hand, heifers and cows in the conventional system had a long calving season. Fifty-nine per cent of the heifers in the new management group became pregnant in the first 25 days of the breeding season, as compared with 44% ($P < 0,05$) in the conventional management group (Table 10). Similar differences were apparent after 45 days of breeding.

Pregnancy rates in the cows differed by 14% ($P < 0,05$) after 25 days of breeding, 9% after 45 days ($P > 0,05$), and 5% ($P > 0,05$) at the end of the breeding season. The length of the breeding season was 45 days in the new management group and 90 days in the conventionally managed group.

Whilst the pregnancy rate for the entire breeding season over 5 years did not differ, more of the new management heifers and cows calved early in a shorter period of time. Seventy-five per cent of the heifers in the new management group had calved by the 10th day of the calving season, whereas it was the 50th day of the calving season before an equal percentage of conventionally managed heifers had calved. The earlier calving in the heifers and cows caused an increase in weaning mass of 15 kg in calves in the new management group. Data from this study indicate that management systems that employ techniques for shortening the breeding and calving seasons can improve reproductive performance and calf weaning mass.

Many cattlemen feed heifers but most do not weigh heifers but 'eye ball' them to determine size, and rations are not formulated correctly but occur because of happenstance.

Techniques used by ranchers to improve reproduction in cows are: (1) a short calving season; (2) having cows in moderate body condition; (3) short-term calf removal; (4) feeding cows to gain mass near breeding; and (5) breeding cows to fertile bulls. Many times, ranchers use a single technique and experience little or no success in improving reproduction. Recently, these five techniques have been incorporated into a system called the O'Connor Management System (Anderson, Fillmore & Wiltbank, 1986). An experiment was conducted to determine the economic value of the O'Connor System. A group of Hereford cows was allotted into two groups. One group of cows (controls) calved over a 120-day period, they received no special nutrition program during pregnancy or during the breeding season, and the cows were bred by a random group of bulls. Conversely, cows in the O'Connor System were selected to calve in a 60-day period, were fed to have a moderate body condition at calving time and to gain mass near breeding. Calves were removed from the cows for 48 h at the start of the breeding season and cows were bred to bulls which had passed a test for potential fertility. There was a marked difference in reproductive performance in cows in the O'Connor group and cows in the control group. Approximately 30% more O'Connor cows were bred early in the breeding season and pregnancy rate at first service was 30% higher (Table 11). Consequently, 52% more O'Connor cows had calved after 20 days of calving and 27% after 60 days of calving. Calf losses from birth to weaning were 7% higher in the control cows. The O'Connor cows weaned 14% more calves and each calf weighed 13 kg more at weaning. Therefore, 41 kg more calf was weaned per cow bred and the gross return was increased by US $59. The cost per cow bred was increased by US $16 in the O'Connor group and thus return was increased by US $43 per cow bred.

Elements of this system are being applied. However, most people are disappointed in the results. They apply one technique but fail in another and so results expected are not attained. They do not realize that failure in one area leads to poor reproductive performance.

One of the reasons why changes occur at slow rates in the beef cattle industry is that the economic value of the change has not been shown. A practice which is biologically correct may not be economically feasible. Economics change; consequently, ranchers need alternatives. There is a need, therefore, to use available scientific information to predict outcomes. Models are now available to determine what should be done. Most models make certain assumptions and the

Table 11 O'Connor system and reproductive performance (Anderson, *et al.*, 1986)

	Management system		
Measurement	O'Connor	Control	Difference
Number of cows	89	86	
Cows bred (%)			
After 25 days	95	59	36
After 46 days	98	72	26
Pregnancy rate first service (%)	80	50	30
Calving (%)			
After 20 days	80	28	52
After 40 days	91	52	39
After 60 days	99	72	27
After 90 days	99	93	6
Calf losses birth to weaning (%)	6	13	−7
Calves weaned (%)	92	78	14
Weaning mass (kg)	222	209	13
Per cow bred			
Calf weaned (kg)	204	163	41
Return[a] (US $)	292	233	59
Additional cost	16	0	16
Return — additional cost	276	233	43

[a]At US $1,43 per kg

Table 12 Prediction of performance in two cow herds (Fillmore, 1984)

Measurement	Regular management (86 Cows)			O'Connor management (89 Cows)		
	Actual	Predicted	Difference	Actual	Predicted	Difference
Showing oestrus						
After 25 days[a]	51	41	10	85	79	6
After 46 days[a]	62	50	12	87	89	2
Pregnant						
After 20 days[a]	24	20	4	71	63	15
After 60 days[a]	62	42	20	88	84	4
After 120 days[a]	80	74	6	88	89	1
Calves weaned[a]	71	70	1	85	86	1
Weaning mass (kg)	209	201	8	221	220	1
Kg calf weaned	14 828	14 056	771	18 816	18 792	24
Gross return (US $)	20 606	19 599	1 007	26 016	26 007	9
Cash position (US $)	1 018	41	977	2 985	2 976	9

[a]Figures are number of cows

Table 13 Response expected in cows following use of Synchronate B (SMB) and calf removal

Body condition	Days post partum	Expected cycling[a]	Expected in heat		Expected pregnant	
			1 day	25 days	1 day	25 days
Moderate	80	100	95	100	57	83
Moderate	60	88	85	100	51	80
Moderate	40	61	57	100	34	74
Thin	80	72	70	80	42	65
Thin	60	55	52	72	31	56

[a]Cycling at time of implant removal

conclusions are only valid when these assumptions are used. Prediction is difficult if not impossible unless we can control some of the variables. An example of the value of predicting in two cow herds was shown by Fillmore (1984). In one herd, only limited control was exercised whilst the other herd was managed under the O'Connor system. Performance was predicted in both herds quite accurately. Cash position in the herd with regular management (86 cows) was within US $977 of the realized position (Table 12). Predicted value and actual value differed by only US $9 in 87 cows managed under the O'Connor System. Even so, certain kinds of performance such as pregnancy in first 60 days of breeding in the cows managed in a regular system and pregnancy rate after 20 days of breeding in the O'Connor cows were not predicted accurately.

Predictions should be used to estimate response expected where techniques such as synchronization of oestrus is contemplated. The response expected from use of SMB was predicted (Table 13). Careful examination of the table would allow a producer to decide when or if he should use SMB. Expected pregnancy rates vary from 31% to 57% after a single service and from 56 to 83% after 25 days of breeding. Using these data, the economic value of using SMB could be ascertained.

Conclusions

Many changes have occurred in the beef cattle industry as a result of application of scientific principles by producers. However, application of many principles is far from optimum. Whilst we, as animal scientists, would like to place much of the blame for lack of application on the cattleman and hide under the umbrella of 'the cattleman is not progressive', we must accept much of the burden for lack of application. We have developed biological facts but in many cases have not shown their economic consequences. We have developed principles but have not shown how or under what conditions they are useful to the cattleman. In many cases, we do not understand and are not interested in his problems. We live in a world of laboratories and classrooms isolated from the cattleman's world. Changes must occur in the beef cattle industry to meet the needs of changing populations, changing land resources, and changing economic conditions. Closer cooperation between cattlemen and researchers must be achieved if the beef cattle industry changes to meet the challenges successfully. Models predicting outcomes from application of scientific information and the economic consequences must be developed and used. Animal scientists cannot rest on past performance but must provide the ways and means for even more significant changes to occur.

References

AMMERMAN, C.B. & GOODRICH, R.D., 1983. Advances in mineral nutrition in ruminants. *J. Anim. Sci.* 57, Suppl. 2, 519.

ANDERSON, R.S., FILLMORE, H.L. & WILTBANK, J.N., 1986. Improving reproductive efficiency in range cattle: an application of the O'Connor management system. *Therio.* 26.

BASSON, R.P., DINUSSON, W.E., EMBRY, L., FELLER, D.L., GORHAM, P.E., GRUETER, H.P., HINMAN, D.D., MCASKILL, J., PARROTT, C., RILEY, J., STANTON, J.L., YOUNG, D.C. & WAGNER, J., 1985. Comparison of the performance of estradiol silicone rubber implant-treated steers to that of zearalanol or estradiol + progesterone. *J. Anim. Sci.* 61, 1023.

BELLOWS, R.A. & SHORT, R.E., 1978. Effects of precalving feed level on birth weight, calving difficulty and subsequent fertility. *J. Anim. Sci.* 46, 1522.

FILLMORE, H., 1984. A model for predicting performance in a cow-calf enterprise. M.S. Thesis, Brigham Young University.

GREGORY, K.E., CUNDIFF, L.V., SMITH, G.M., LASTER, D.B. & FITZHUGH, JR., H.A., 1978. Characterization of biological types of cattle — cycle II: 1. birth and weaning traits. *J. Anim. Sci.* 47, 1022.

KOGER, M., 1973. Summary — crossbreeding beef cattle. Univ. of Florida Press, p. 434.

LOFGREEN, G.P. & GARRETT, W.N., 1968. A system for expressing net energy requirements and feed values for growing and finishing beef cattle. *J. Anim. Sci.* 27, 793.

OWENS, F.N. & BERGEN, W.G., 1983. Nitrogen metabolism of ruminant animals: historical perspective, current understanding and future implications — 1983. *J. Anim. Sci.* 57, Suppl. 2, 498.

RUMSEY, T.S., 1983. Experimental approaches to studying metabolic fate of xenobiotics in food animals. *J. Anim. Sci.* 56, 222.

WILTBANK, J.N., KASSON, C.W. & INGALLS, J.E., 1969. Puberty in crossbred and straightbred beef heifers on two levels of feed. *J. Anim. Sci.* 29, 602.

WILTBANK, J.N. & REMMENGA, E.E., 1982. Calving difficulty and calf survival in beef cows fed two energy levels. *Therio.* 17, 587.

WILTBANK, J.N., ROBERTS, S., NIX, J. & ROWDEN, L., 1984. Reproductive performance and profitability of heifers fed to weigh 272 or 318 kg at the start of the first breeding season. *J. Anim. Sci.* 60, 25.

WILTBANK, J.N. & SPITZER, J.C., 1978. Recent research on controlled reproduction in beef cattle. *World Anim. Rev.* 27, 30.