THE APPLICATION OF ARTIFICIAL BREEDING AS A REPRODUCTIVE TECHNIQUE IN CATTLE*

K. L. MACMILLAN
Awahuri Artificial Breeding Centre, Palmerston North

SUMMARY

Survey data show that 100 cows reported in calf to artificial breeding (AB) at the conclusion of one mating season will produce 29 AB replacement heifers in milk in the herd three seasons later. Consequently, 72% of the herd must be reported in calf to AB to maintain an average replacement rate of 21%. Submission rate (percentage of herd mated within 4 weeks) may be more important than conception rate (percentage of cows conceiving to first insemination) in achieving the 72% figure within a 7-week AB period. It is easier to predict submission rate than conception rate and management practices should be orientated accordingly. Virtually all cows seen in oestrus during a 7-week mating period must be artificially inseminated if all replacement stock are to be AB progeny.

A study of the way in which AB is being used shows marked locality differences. These differences may be due to extension techniques but highlight the misinformed attitude that mating is a genetical rather than a management exercise. This attitude may have arisen because advisory officers accepted a scientist's viewpoint but did not use their field experience to subsequently raise relevant questions with the scientist.

Any development in reproductive techniques in cattle will only be implemented if it means that a herd owner is better able to achieve his management objectives. The primary objective of the New Zealand dairy-herd owner is to have a concentrated calving so that maximum per-cow production coincides with adequate supplies of pasture. In most herds the secondary objective is to produce potential replacement heifers from within the herd and thereby at least maintain herd numbers. Ideally, these replacement heifers should be the progeny of genetically superior sires so that production can be increased through planned breeding. Artificial breeding is the rational method to produce these heifers and is the oldest example of the application of a reproductive technique in cattle. But the greatest return from the extra production obtained through using AB will only be obtained if a concentrated calving can

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be maintained, management costs are minimized, and a high proportion of replacement heifers are AB progeny.

It is probable that one reason why AB is not more widely used in New Zealand is because the use of this reproductive technique has been primarily advocated in terms of genetical advantages without giving due consideration to its implementation relative to the overall objectives of the herd owner. This situation may have arisen because farm advisors did not associate its implementation with other apparently more important aspects of farm management such as calving date, pasture supply and milking technique. These same problems will arise with other techniques such as induced calving, oestrus synchronization and ovum transplantation. Such techniques must allow a herd owner to at least maintain, if not improve the chances of achieving a concentrated calving without increasing the herd wastage rate. If it is accepted that a dairy herd owner's primary objective is to achieve a concentrated calving, the factors which influence its attainment naturally assume prime importance. The two most obvious factors are the rate at which a herd is mated following the commencement of mating (submission rate) and the rate at which they conceive (conception rate).

SUBMISSION RATE

This term can be defined as the percentage of a herd which is mated or inseminated at least once during the first 4 weeks of mating. This 4-week submission rate (SR) is an important reproductive parameter for herds in which a concentrated calving is a major objective.

Results were obtained from 97 herds in the Wellington-Hawke's Bay Herd Improvement Association in which over 90% of the cows were inseminated and which used AB exclusively for at least 7 weeks (Table 1). These herds were first divided into three SR categories and then re-classified within each category into three conception rate (CR) groups. They show that within each SR category, the CR has little effect on the proportion of the herd inseminated at least once by the end of the fourth week. However, by the end of the seventh week of mating, the 4-week differences between the three SR categories were greatly reduced. In a larger Taranaki study the average SR was 85% (Fielden and Macmillan, 1973). This is a reasonable objective, but a group of herds in Table 1 were able to better 90%. If this higher SR was reflected by a higher in-calf rate, then management techniques used by the herd owners with these SRs deserve closer study.

TABLE 1: PERCENTAGE OF COWS INSEMINATED AFTER 4 AND 7 WEEKS OF MATING IN HERDS WITH VARIED SUBMISSION AND CONCEPTION RATES

SR[1]	*CR*[2]	*% Cows Inseminated after* 4 *wk*	7 *wk*
Low	Low	73	90
	Average	74	89
	High	74	93
Average	Low	85	94
	Average	85	95
	High	85	93
High	Low	93	99
	Average	93	98
	High	92	97

[1] Low SR: Herds with less than 80% of cows inseminated during first 4 weeks; Average SR: At least 80% but less than 90% inseminated; High SR: At least 90% inseminated.

[2] Low CR: Herds with a 49-day non-return rate for all first inseminations of less than 57%; Average CR: Non-return rates of at least 57% but less than 63%; High CR: Non-return rates of at least 63%.

CONCEPTION RATE

It is pointless achieving a high SR if many of the cows submitted for insemination are not in oestrus. However, this will be reflected by lower CRs. The results in Table 2 show that even though herds were classified into SR and CR groups, there were a similar number of herds in each CR group within an SR category and that the CR trends were similar. The CR was computed on all first inseminations and should not be confused with the in-calf rate.

HERD IN-CALF RATE

The most important effects of SR and CR will involve the herd in-calf rate (HIR). This is the percentage of the herd reported in-calf to a first or subsequent insemination at specified intervals after the commencement of mating. It is based on results recorded by the herd owners and will be slightly higher than the true pregnancy rate. Within each SR category, both the 4-week and 7-week HIRs increase with increasing CR (Table 3). The differences produced by SR are greater than those produced by CR particularly in the 4-week HIR. The 4-week HIR for the low SR-high CR group in which the CR was 68.5% (Table 2), was 53% (Table 3) whereas the compar-

TABLE 2: NUMBER OF HERDS AND AVERAGE CONCEPTION RATES IN 97 HERDS WITH VARIED SUBMISSION AND CONCEPTION RATE CLASSIFICATIONS.

SR[1]	*CR*[1]	*No. Herds*	*Actual CR (± SD)*
	Low	8	50.8 (3.7)
Low	Average	9	59.5 (1.7)
	High	11	68.5 (5.2)
	Low	17	51.0 (5.7)
Average	Average	14	59.6 (2.2)
	High	15	65.4 (2.0)
	Low	7	51.1 (2.4)
High	Average	7	60.2 (1.5)
	High	9	65.6 (1.6)
	Total = 97	Mean = 59.3	

[1] Refer Table 1.

able figure in the high SR-low CR group was 56% (Table 3) even though their CR was only 51.1% (Table 2).

The results in Table 3 show that if a herd owner achieves a high SR he will have a high 7-week HIR provided his CR is at least 50%. If management techniques are adopted which allow the herd owner to achieve a high SR, the unpredictable aspects of CR become less important because cows which return to a first insemination made during the first 4 weeks

TABLE 3: PERCENTAGE OF HERDS RECORDED IN-CALF AFTER 4 OR 7 WEEKS IN HERDS WITH VARIED SUBMISSION AND CONCEPTION RATES

SR[1]	*CR*[1]	*HIR*[2]	
		4 wk	*7 wk*
	Low	45	66
Low	Average	47	67
	High	53	78
	Low	50	69
Average	Average	54	73
	High	59	75
	Low	56	74
High	Average	59	76
	High	65	79

[1] Refer Table 1.
[2] % of herd recorded in-calf.

of mating can be re-inseminated before the end of the seventh week. The value of keeping pre-mating heat records is to allow the owner's veterinarian to examine unobserved cows before the commencement of mating so that appropriate remedial measures can be implemented to produce a high SR.

HERD REPLACEMENTS

The second objective in most herds which have a concentrated calving is to produce replacement heifers from within the herd. Ideally, the heifer calves should be born reasonably close together for convenient bucket rearing, and they should be progeny from cows with production records or cows in-calf to proven sires. The genesis of these replacements must be studied from their conception to their coming into milk at 2 years of age. Survey results show that breed differences in calving rate (percentage of cows reported in-calf to AB which calve to AB) are compensated for by breed differences in the calf retainment rate (percentage heifer calves suitable for rearing) (Table 4). A commonly ignored source of loss is between weaning at 2 months and calving at 2 years of age. This heifer retainment rate has declined from 87% for heifers conceived in 1962 to 79% for heifers conceived in 1968 (Macmillan, 1973).

The overall effect of these different sources of loss is that every 100 cows reported in calf to AB at the conclusion of the mating season could produce 29 heifer replacements in milk in the herd three seasons later (Table 4). To maintain a re-

TABLE 4: SOURCES OF WASTAGE INFLUENCING LOSS OF REPLACEMENT HEIFERS FROM THEIR CONCEPTION TO CALVING

Source of Wastage	*Breed of Sire*		
	Ayrshire	*Friesian*	*Jersey*
Calving Rate[1]	83	82	84
Sex Ratio[2]	47.6	47.6	47.6
Calf Retainment Rate[3]	92	93	91
Heifer Retainment Rate[4]	80	80	80
Heifer Replacements[5]	29.1	29.0	29.1

[1] % cows reported in-calf to AB which calve to AB.
[2] % heifer calves.
[3] % heifer calves suitable for rearing.
[4] % identified heifer calves.
[5] Number of heifer replacements in milk per 100 cows reported pregnant to AB.

placement rate of 21% (New Zealand Dairy Board, 1972), 72% of the herd (21/29 = 72.4%) must be recorded in-calf to AB sires or to other selected sires.

Reference to Table 3 shows that three of the nine groups did not achieve this 72% HIR within a 7-week AB mating period. Two of the groups were in the low SR category (low SR-average CR and low SR-low CR) and the third was in the average SR category (average SR-low CR) (Table 3). The respective mating intervals in those groups which achieved the 72% HIR varied from 5.2 weeks in the high SR-high CR to 6.8 weeks in the average SR-average CR group (Macmillan and Watson, 1973). However, CR is a parameter which can only be approximated even 3 weeks after an insemination, and therefore the herd owner does not know which cows will return within a defined mating period. All groups which recorded at least a 72% 7-week HIR inseminated over 90% of their herd during this period, and all three CR groups within the high SR category mated at least 97% of their herd (Table 1). Only two of the 97 herds achieved the 72% HIR by the end of the fourth week of mating.

A RECOMMENDED BREEDING PROGRAMME

These results suggest that where a herd owner wishes to achieve a concentrated calving, as well as breeding all his own replacements from proven AB sires, he should:

(1) Adopt management techniques which will allow him to mate at least 90% of his herd within 4 weeks from the commencement of mating.

(2) Mate all cows seen in oestrus following the commencement of mating irrespective of their post-calving interval and irrespective of their level of production unless they are to be culled.

(3) Use AB for all cows mated during an AB mating period of at least 7 weeks.

(4) Use only semen from breeds of sires other than that used to breed replacement heifers after the first 7 weeks of mating.

HOW EFFECTIVELY IS AB USED?

Having established some objectives and the necessary recommendations to achieve these objectives, the way in which AB is currently used can be examined to determine whether these objectives are being achieved in practice. Artificial breeding data for seasonal herds which primarily used unfrozen semen in services provided by the Wellington-Hawke's Bay

TABLE 5: NUMBER OF HERDS IN VARIED SIZE CATEGORIES IN AREAS SERVICED BY THE TARANAKI AND WELLINGTON-HAWKE'S BAY HERD IMPROVEMENT ASSOCIATIONS AND THE PERCENTAGE OF HERDS WHICH USED AB

Herd-size Category (cows)	*Total No. Herds*		*% using AB*	
	Tar.	*W'gton.-H.B.*	*Tar.*	*W'gton.-H.B.*
10–39	128	192	11	23
40–59	247	224	20	32
60–79	523	370	37	46
80–99	703	389	44	59
100–149	1142	514	62	62
150–199	363	151	66	72
200 or more	103	77	88	100
Total	3209	1917	50	53

and Taranaki Herd Improvement Associations in 1971 were used in such a study (Macmillan *et al.*, 1973). The results showed that a similar proportion of herds in both Associations used the unfrozen semen service in 1971 (Table 5). In all but one herd-size category there was proportionately greater AB usage in Wellington-Hawke's Bay. A reported advantage of AB is that smaller herds can increase cow numbers by not having to carry a bull. These results show that it is the larger herds which prefer to use AB, possibly because it is more convenient to draft off cows for insemination rather than hand mate (Table 5).

The way in which AB was used in these herds varied markedly between the two Associations. Whereas in Taranaki 68% of the cows in the herds which used unfrozen semen

TABLE 6: PROPORTION OF HERD INSEMINATED AND PERIOD OF USAGE IN HERDS USING AB IN TARANAKI AND WELLINGTON-HAWKE'S BAY HERD IMPROVEMENT ASSOCIATIONS

Herd-size Category (cows)	*% of Herd Inseminated*		*Period of Usage (days)*	
	Tar.	*W'gton.-H.B.*	*Tar.*	*W'gton.-H.B.*
10–39	73	88	38	46
40–59	70	83	38	52
60–79	67	78	37	50
80–99	68	81	38	51
100–149	69	74	36	51
150–199	68	77	36	50
200 or more	69	80	34	51
Average	68	78	36	51

were inseminated, 78% of the cows were inseminated in Wellington-Hawke's Bay (Table 6). Taranaki herd owners used the service for an average of 36 days compared with 51 days for the Wellington-Hawke's Bay owners (Table 6). The minimal effect of herd size on these usage patterns suggests that two distinct populations have been generated. The reasons for these differences are subject to speculation but probably involve either the nature of the services offered by the two Herd Improvement Associations, or the influence of advisory personnel within the two Associations.

TABLE 7: CONCEPTION RATES AND % OF HERDS RECORDED IN-CALF TO AB IN HERDS USING AB IN TARANAKI AND WELLINGTON-HAWKE'S BAY HERD IMPROVEMENT ASSOCIATIONS

Herd-size Category (cows)	*Conception Rates*		*% of Herd In-calf to AB*	
	Tar.	*W'gton.-H.B.*	*Tar.*	*W'gton.-H.B.*
10–39	67	63	63	69
40–59	71	66	56	69
60–79	69	65	53	64
80–99	69	63	52	62
100–149	68	62	52	60
150–199	67	59	52	61
200 or more	68	58	53	65
Average	68	62	52	63

In light of these different usage patterns, the higher percentages of cows in herds in Wellington-Hawke's Bay reported in-calf to AB was expected (Table 7). The lower CRs in the Wellington-Hawke's Bay (Table 7) partly arose because of the negative correlations between CR and the percentage of the herd inseminated, and between CR and period of AB usage (Macmillan *et al.*, 1973). In both Associations the percentage of the herd reported in-calf to AB was less than the 72% HIR necessary to produce sufficient AB replacement heifers to maintain a 21% replacement rate. A recent survey showed that 85% of the cows in Taranaki herds were seen in oestrus during the first 4 weeks of mating (Fielden and Macmillan, 1973). Unless some of these cows were being intentionally withheld from mating, many Taranaki herd owners were hand mating concurrently with the use of AB.

CONCLUSIONS

The data suggest that AB is not being used as effectively as had been expected in New Zealand dairy cattle. This situation

is applicable to herds which at least used AB and does not consider the potential losses which are probably occurring in over 40% of the country's herds which make no use of this service. The effective use of any reproductive technique must be considered, first, relative to its effect of allowing a herd owner to maintain a concentrated calving; secondly, in terms of producing live heifer calves which will get in-calf at 15 months of age; and, thirdly, in promoting increased production through breeding genetically superior replacements.

It is probable that farm advisory officers accepted the third objective as the reason for using AB and even tolerated a loss in calving concentration because their client's mating management was inadequate. While this approach may have been the consequence of necessity, it highlights the tendency for advisers to adapt information produced by the scientist to suit their clients, and may not produce information obtained by these clients to influence the scientist. On-farm priorities must be identified and the implementation of new reproductive techniques examined in terms of how they affect the achievement of these priorities. This same philosophy should be applicable to all new techniques.

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