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Nucleus Bull-breeding Herds

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ABSTRACT

A nucleus bull-breeding herd is an elite herd of cattle that is maintained on a commercial property specifically to breed sires for the commercial herd. Successful nucleus bull-breeding requires a clear vision of the desired traits in cattle selected for the nucleus. Bulls from well managed nucleus bull-breeding herds can have at least three major advantages over purchased bulls:

- they are selected from animals bred and raised in the environment in which they are expected to work;
- they do not need to adapt to a new environment as purchased bulls might; and,
- they provide substantial long term savings through a reduction in the average cost of breeding bulls.

INTRODUCTION

The establishment of a nucleus bull-breeding herd is a long-term management decision that requires careful planning. The infrastructure needed for such a herd and potential cost savings must be carefully considered. Successful nucleus bull-breeding requires more input into cattle management such as more facilities and maintaining more records, than when purchasing bulls from a commercial herd. The infrastructure to ensure adequate bull control may require a capital outlay.

The costs of establishing and maintaining a nucleus bull-breeding herd vary greatly depending on how the nucleus is established and managed. Nucleus bull-breeding herds are influenced by economies of scale. Usually, the larger the nucleus herd, the lower is the average cost per bull.

This Technote discusses available options for establishing successful nucleus bull-breeding herds and issues associated with their management. After discussing these issues a simple cost comparison between purchasing bulls and nucleus bull-breeding is given.

ESTABLISHING AN ELITE HERD

To establish a nucleus bull-breeding herd several decisions need to be made. The most important include:

- the source(s) of foundation stock;
- whether or not to close the nucleus;
- whether or not to use artificial breeding technology;
- what size nucleus is required to meet the needs of the commercial herd;
- what is the desired age structure of the nucleus;
- which performance and pedigree records are necessary;
- what selection criteria will be used;
- how to guarantee accurate selection decisions; and
- what new infrastructure will be required and how much will it cost.

FOUNDATION STOCK FOR NUCLEUS HERDS

There are three options for foundation stock for a nucleus herd:

- purchase and introduce cattle specifically for the nucleus herd;
- select cattle from within an existing commercial herd; or
- use a combination of these two methods.

The most common management option for nucleus herds founded on introduced cattle is to select replacement heifers for the nucleus from within the nucleus, and to purchase replacement sires. Nucleus herds can be gradually expanded to meet the bull requirements of the commercial herd. If it is a practical option, artificial insemination can be used to maximise genetic progress. Continuing to purchase some replacement females for the nucleus is also an option.

Nucleus bull-breeding herds that make genetic improvement can be established using breeders selected from within a commercial herd. Genetic improvement can be made using the very best bulls bred in the nucleus as nucleus sires. However, sourcing nucleus cattle from a wider gene pool increases the rate of genetic improvement.

OPEN AND CLOSED NUCLEUS HERDS

Open nucleus herds allow heifers to be promoted from the commercial herd into the nucleus and allow females purchased from outside the herd into the nucleus. Open nucleus herds have two major advantages over closed nucleus herds:

1. They enable higher rates of genetic gain in desirable traits than closed nucleus herds. The increased genetic gain is brought about because of the introduction of outside genes and/or heifers from the commercial herd. Depending on circumstances, the best heifers bred in the commercial herd will often be genetically superior to the worst heifers bred in the nucleus.

2. They reduce the rate of inbreeding. This reduces the likely depression in performance due to inbreeding. If nucleus replacement bulls come from the nucleus and half the replacement heifers for the nucleus come from the commercial herd, then the rate of inbreeding is approximately halved.

A closed nucleus never, or very rarely, allows entry of outside breeding stock to the nucleus. Closed nucleus herds are only an option if the nucleus herd is elite compared to all or most other cattle in the same breed.

NUCLEUS SIZE

The most important decision in establishing a nucleus breeding operation is deciding on its size. There are several tradeoffs. With increasing nucleus size, greater selection pressure can be applied to potential breeding stock resulting in more rapid genetic gains. However, increasing the nucleus size also increases the cost of maintaining it. If replacement females for the nucleus are selected from the nucleus and the commercial herd, larger nucleus herds are less elite when compared to the commercial herd.

Many nucleus herds are too small to allow adequate selection pressure to ensure genetic improvement. Even with nucleus herds founded on introduced bulls and cows it is easy to fall into the trap of having a nucleus that is too small. The end result is that the producer is not able to use any or enough selection pressure to ensure genetic improvement in the commercial herd as a result of using nucleus bred bulls.

If all nucleus replacement cattle are selected from the nucleus and commercial herd, optimum open nucleus size for genetic gain is 10% of the commercial breeder herd. Genetic gains are not markedly lower if such nucleus herds are 5% of the size of the commercial herd. However, genetic gains fall rapidly if nucleus herds managed this way are smaller than 5% of the commercial herd. This happens because not enough selection pressure can be applied. There are too few offspring to choose from to make much progress because all or a very high proportion of the bulls bred must be used. With an open nucleus herd size of 5 to 10% of the commercial herd, approximately half of the nucleus replacement heifers should come from the commercial herd each year.

The required size for a nucleus bull-breeding herd can be calculated, based on the size and management of the commercial breeder herd plus assumptions on the factors affecting the number of bulls produced from a nucleus herd. The calculations for a stable herd size are as follows:

Total commercial bull no. = Bull mating % x Total commercial breeder no.

$$\textbf{Replacement bulls required per year (RB)} = \frac{\textbf{Total bull no.}}{\textbf{Average working bull lifetime}}$$

For example, a 3000 cow breeder herd, mated at 4% bulls would have 120 bulls. If the average working lifetime of bulls in the commercial herd is 5 years, 24 replacement bulls are required annually.

Assuming that half the weaner calves are bulls, the absolute minimum nucleus herd size can be calculated using the following equation:

$$\textbf{RB} = \frac{\textbf{Min no. nucleus cows (Min NC) x Expected nucleus weaning (Ex. NW)\%}}{\textbf{2}}$$

This equation can be rearranged to:

$$\textbf{Min. NC} = \frac{\textbf{RB x 2}}{\textbf{Ex. NW \%}}$$

If 24 replacement bulls are required annually and the expected nucleus weaning is 80%, then 60 nucleus breeders is the absolute minimum required (24 x 2/0.8 = 60).

In practice allowances must be made for four additional factors:

- deaths and/or injuries in young bulls rendering them unavailable for mating;
- the possibility of bull calves weaned being less than 50% in some years;
- years when the nucleus weaning percentage is lower; and,
- the opportunity for selection pressure to be applied.

To account for the worst case scenario of young bulls being unavailable for breeding or unfit, the possibility of less than 50% of weaners being bulls and a reduced nucleus weaning percentage, a modified version of the previous equation can be used to calculate the number of nucleus breeders required:

$$\textbf{NC} = \frac{\textbf{RB}}{\textbf{Min. \% young bulls fit to work x Min. bull weaners \% x Min. NW \%}}$$

In the worst case scenario of:

- losses and/or injuries claiming 10% of young bulls;
- the proportion of bull calves weaned being 40%; and,
- weaning percentage falling to 60%;
- the number of nucleus breeders required would rise to 112 = 24/(0.9 x 0.4 x 0.6) = 111.1.

In the worst case scenario this nucleus size does not allow for any selection pressure. If the producer decides that a maximum of 75% of young bulls are to be kept in the worst case scenario then 150 nucleus breeders are required (112/0.75 = 150). This equates to 5% of the commercial breeder herd and 6.25 times the number of replacement bulls required. Making such an allowance ensures that significant selection pressure can always be applied to young bulls to ensure continual genetic improvement.

Under the original assumptions (50% weaners being bulls, no deaths or injuries and 80% weaning rate) 150 nucleus breeders would produce 60 young bulls to select from. Selecting 24 young bulls for the commercial herd would result in a selection rate of 40%.

If the nucleus is unable to supply enough young bulls that meet the required standards for desired traits (selection criteria) the shortfall can be made up in the short term by purchasing bulls. In the medium and long terms the nucleus may need to be expanded or improved (or both) to ensure enough young bulls meet the selection criteria.

NUCLEUS AGE STRUCTURE

The age structure of both the nucleus and commercial herds is also important for genetic gain. Reducing the number of sire and dam age groups increases the rate of genetic gain in the traits being selected for. This can be achieved by moving both bulls and cows from the nucleus into the commercial herd at an early age e.g. bulls at two to three years and cows at three to five years, well before they would be culled for age. Thereafter they are treated as commercial cattle.

SELECTION ACCURACY

Selection accuracy is very important in nucleus breeding. Unless selection is based on traits desired in both the nucleus and commercial herds, and this selection is done accurately, genetic progress will be hindered. Selection accuracy is far more important for bulls than for heifers because fewer sires are needed, and they have far more progeny.

Selecting breeding cattle in stages can have management and cost savings advantages. Young bulls and heifers that have no chance of meeting final selection criteria can be removed at younger ages. A trade-off can be that selection accuracy can be reduced if these decisions are made without sufficient information.

The most important point is to make sure the best bulls are selected from those available. This means running all young bulls together because preferential treatment to some will result in inaccurate selection. Heifers born in the commercial herd with minimal performance records can be selected without halting genetic progress. A better option is to run nucleus weaner heifers and some or all of the commercial weaner heifers together from weaning until selection. This creates the opportunity to more accurately select heifers by comparing them for performance and other desired traits.

PEDIGREE AND PERFORMANCE RECORDING

Nucleus bull-breeding herds can be managed without complex recording systems. A simple system is to have individual identification and performance records for important traits. Pedigree recording gives good information but may not be cost-effective for multiple sire mating situations because sires must be found by DNA testing. Mothering-up to find dams can also be expensive because it is time consuming.

Using individual records is good enough for selection on traits that are moderately to highly heritable. Growth rate from weaning to 18 months or two years is a moderately heritable trait of direct economic importance. Selection based on scrotal circumference at 12 to 18 months, which is correlated with both male and female fertility and also correlated with growth rate, can also be achieved with individual records.

Nucleus herds can be enrolled in BREEDPLAN provided pedigree and performance records are collected. Enrolling in BREEDPLAN costs more than using simple recording systems, but the big advantage is that the estimated breeding values (EBVs) of cattle bred in the nucleus can be compared with the breed average and with other cattle in the breed. This information can be used to select the best bulls, semen or cows to use in the nucleus. This particularly applies to traits that are difficult and costly to measure such as carcase traits.

BULL PURCHASES VERSUS NUCLEUS BREEDING: A SIMPLE COST COMPARISON

Establishing a nucleus bull-breeding herd can be considered a new enterprise that replaces part of the existing cattle enterprise. To compare nucleus breeding with bull purchases requires a partial budget. Partial budgets only consider those costs and returns that change. The partial budget in this case is divided into five sections:

- increased income from the new enterprise;
- increased costs of the new enterprise;
- decreased income from the existing enterprise;
- decreased costs of the existing enterprise; and,
- capital costs associated with the new enterprise.

There are many variables associated with establishing and managing nucleus bull-breeding herds. Possible costs associated with purchasing bulls or nucleus bull-breeding for three different sized commercial breeder herds over a 10 year period are compared in Table 1. Economic variables such as inflation and interest costs have been deliberately excluded for simplicity. The following assumptions have also been made:

- there is no increase in income from the nucleus or decrease in income from the commercial herd;
- bull costs for both options remain constant over 10 years;
- all nucleus females are purchased in year one;
- nucleus females are self replacing after initial purchase;
- the nucleus relies on natural mating;
- the nucleus bull mating percentage is 3%;
- nucleus sires get replaced by purchased sires every third year;
- the number of cows required for the nucleus is five times the number of commercial bulls annually required from the nucleus;
- replacement commercial bulls are purchased for the first three years because it takes three years before the nucleus produces working age bulls; and,
- all infrastructure costs are incurred in year one.

There are too many variables to cover the economics of different nucleus bull breeding scenarios in this Technote. The best option will differ for different producers. Producers can use the concepts presented in Table 1 and account for other costs that apply to their situation to assist with developing partial budgets and making their own decisions on whether establishing a nucleus bull-breeding herd is worthwhile.

Purchasing all the foundation stock for the nucleus in the first year (as assumed in this example) is the most expensive option. The options of selecting some or all of the nucleus females from the existing commercial herd and/or gradually building up the size of the nucleus over a few years would reduce the initial outlay. Where practical, these options should be considered.

Table 1. Example cost comparison between purchasing bulls and nucleus bull-breeding for three different sized commercial herds

COSTS	**Purchase**	**Nucleus**	**Purchase**	**Nucleus**	**Purchase**	**Nucleus**
Bulls						
No. herd bulls required/year	60		20		6	
No. nucleus sires purchased yr 1	-	9	-	3	-	1
Ann. no. nucleus sires purchased	-	3	-	1	-	0.33
Herd bull landed on property	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500
Nucleus bull landed on property	-	$7,500	-	$7,500	-	$7,500
Cows						
No. nucleus cows purchased yr 1	-	300	-	100	-	30
Cow landed on property	-	$1,000	-	$1,000	-	$1,000
Infrastructure and management						
New infrastructure cost yr 1	-	$25,000	-	$15,000	-	$7,500
Additional management cost/yr	-	$15,000	-	$10,000	-	$4,000
Total costs						
Year 1 COST	$150,000	$557,500	$50,000	$197,500	$15,000	$64,000
Years 2 and 3 COST/YEAR	"	$165,000	"	$60,000	"	$19,000
Years 4 – 10 COST/YEAR	"	$37,500	"	$17,500	"	$6,475
TOTAL COST OVER 10 YEARS	$1.5M	$1.15M	$500,000	$440,000	$150,000	$147,325
10 YEAR AV. COST PER BULL	$2,500	$1,920	$2,500	$2,200	$2,500	$2,455

Economies of scale, with increasing nucleus size, are apparent from Table 1 because the average cost per bull falls with increasing nucleus size. This example shows that the smallest nucleus only marginally decreases average bull cost compared to purchasing bulls. However, potential lower cost options of gradually expanding the nucleus, selecting some of the nucleus breeders from the commercial herd and artificial breeding were not considered.

Nucleus bull-breeding herds relying on natural mating with one sire can reduce costs without sacrificing genetic improvement, depending on how the nucleus is established and managed. When single sire mating, it is critical that all bulls are reproductively and structurally sound and have high enough libido to mate with the cows allotted to them. If artificial breeding is cost-effective, there is no minimum nucleus size required for a nucleus herd to make savings. The minimum commercial herd size to make running a nucleus bull-breeding herd worthwhile will vary depending on the different factors described in this Technote. It is therefore imperative to consider all of the factors that apply to your particular situation when comparing nucleus bull-breeding options with purchasing bulls.

SUMMARY

Many factors need to be considered when establishing a bull-breeding nucleus. The most important factor is to make the nucleus large enough. This ensures enough progeny are born to enable sufficient selection pressure to improve production traits without neglecting other important traits such as temperament.

Sourcing cattle from a wide gene pool for an open nucleus is the most appropriate management strategy to increase the rate of genetic improvement in most nucleus herds. Where practical, artificial breeding can be used. Nucleus age structure is important. Continually replacing nucleus cattle with younger breeding stock hastens genetic progress. To achieve genetic progress in desired traits, selection decisions must be accurate. Selection efforts should concentrate on bulls. To accurately select the best young bulls they must all be run together and sound performance records for important production traits should be maintained and used when making selection decisions.

An open nucleus herd 5% of the size of the commercial herd, with accurate individual performance records for the heritable traits - growth rate from weaning to two years and scrotal size at 12 to 18 months - is a simple way of breeding and selecting bulls from a nucleus herd. Smaller nucleus herds can be very successful if they are genetically superior cattle to the commercial herd and produce enough young bulls to allow reasonable selection pressure to be applied.

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