

BREEDING VALUES FOR FERTILITY

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Fertility is extremely important in a beef cattle herd, **but there are difficulties** when estimating breeding values for fertility traits.

Fertility can only be defined by indicator traits, e.g.

- age at first calving,
- inter-calving period and
- scrotum circumference and is also measured relatively late in life.

Genetically, fertility traits have **heritabilities** in the **low range**, implying that environmental effects have a large influence (Cammack, et al., 2009). Some aspects of estimation of breeding values for the fertility traits Age at First Calving (AFC) and Inter-calving Period (ICP) will be discussed here.

AGE AT FIRST CALVING (AFC)

Age at First Calving (AFC) is regarded as a measure of heifer fertility. However, in

South Africa, AFC has a large environmental component caused by the management procedure of the breeder. In some herds heifers are mated so that they calve at two years, thereby placing a strong selection pressure on fertility. As this is simply not possible in many regions and herds in South Africa, or due to the breeder's choice, more Nguni heifers are mated to calve around three years (Figure 1). The heifer calving at 36 months may be **just as fertile** as the heifer calving at 24 months of age, but **the age at which she calves for the first time is determined purely by the management practise of the herd in which she calved, and not her genetics.**

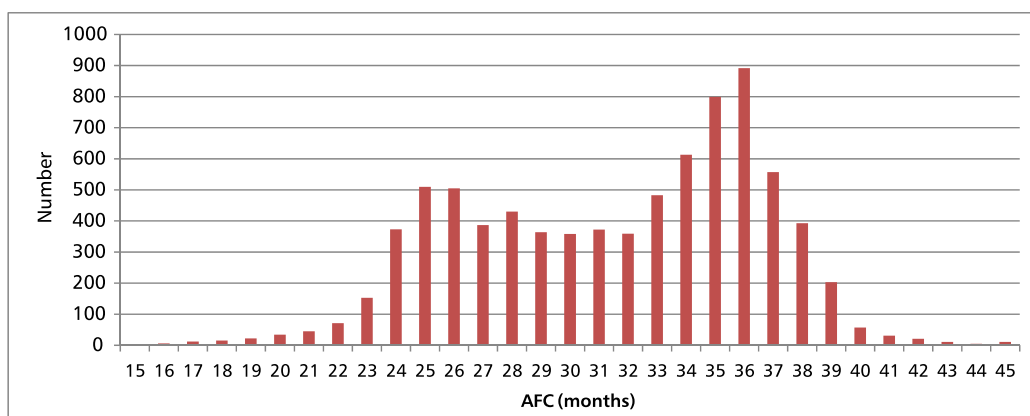


***Figure 1:** Age at First Calving (AFC) of active Nguni heifers indicates that more heifers calve at 3 years of age for the first time, than at 2 years of age. This is purely a management decision.*

The question is therefore: How can breeding values be accurately estimated?

The answer is **simple**: just as **weaning weight breeding values are estimated regardless of the favourable or poor environment in which the calf was weaned, fertility breeding values are estimated regardless of the management practice of the breeder.** The key is the contemporary group: if all animals within the same contemporary group are treated the same, the ones calving first within the contemporary group, are the most fertile, and the ones calving later or not at all, are less fertile or infertile. Contemporary group definition for AFC therefore accommodates the large management differences between herds.

In the absence of mating list information, the contemporary group for AFC is set up as follows: All heifers that were born together in a specific year-season on a specific farm and then calved for the first time on the same farm are in the

same contemporary group. Take for example in a group of heifers that were born together and calved on average at 30 months of age. The ones calving at for example 28 months will have above average genetic potential, while the ones calving for example only at 32 months, will in this particular group, be below average. However, the one calving at 32 months in another group with average 36 months, will by genetically superior, if she was one of the first ones to calve within her contemporary group.

Because of different management practices between farms, the farm effect is included to make sure that only heifers that were born together and calve together, are placed in the same contemporary group. Heifers being sold are therefore not included in the same contemporary group as the heifers they were born with, unless they are sold as a group. They are also not included with the heifers on the new farm. Heifers that were born together and calve together on the same farm should be in the same group. The effect of management practice (e.g. 2 or 3 year calving) then becomes an environmental effect. As can be seen from Figure 2, herds that calve on average at 2 years do not have the highest breeding values for AFC, or herds calving on average at a later age, do not have poorer breeding value indices.

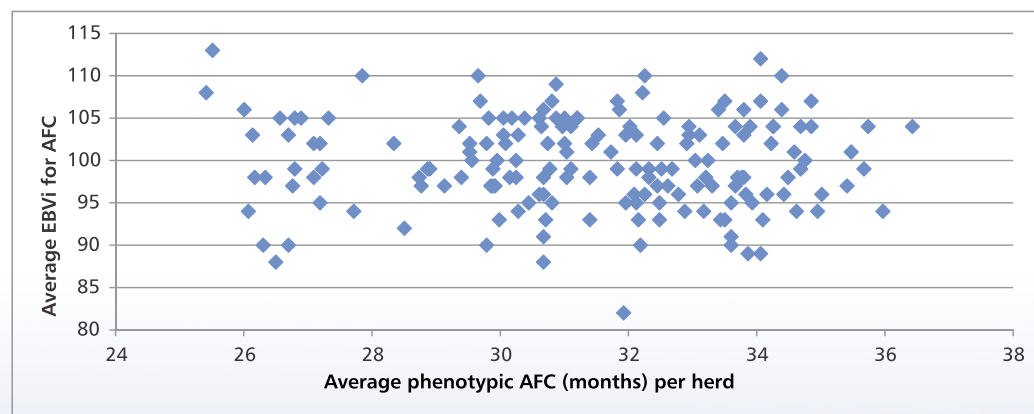
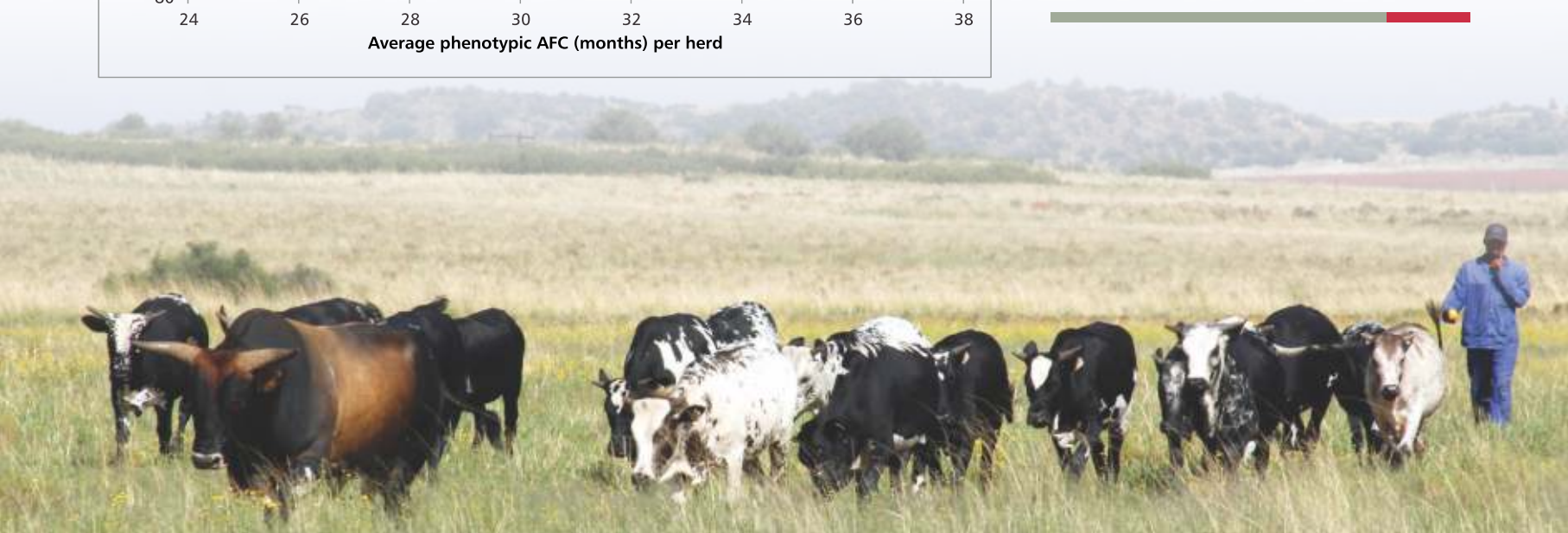


Figure 2: When phenotypic herd averages for Age at First Calving (AFC) are plotted against the herd average for the breeding value index for AFC, it can clearly be seen that earlier calving herds do not have the higher EBVs, showing that the herd management effect of calving age have effectively been removed from the breeding values.



When estimating breeding values, it is also **important to include less fertile and infertile heifers**, i.e. those who skipped a calving, or never calved, so as to include the full range. **Estimating breeding values on only animals that have calved, will not give an accurate picture.** It is also important to include the data of infertile daughters in the estimation of breeding values for sires.

Infertile daughters are included in the **genetic evaluation** by awarding them an AFC which is a form of penalization. Heifers should calf for the first time between 15 months to 4.5 years. Heifers that calve after 4.5 years are allocated 4.5 years. In accordance with international practices, animals that are still alive in the herd at a late stage, without having calved, is penalized by allocating her an extreme age at first calving value. **It is accepted that a heifer is infertile if a breeder cancelled her at 3 years of age or older without a calving being recorded.** An Age of First Calving of more than 4.5 years is then allocated to her, which makes it possible to compare her with heifers that did calve.

	Weaning weight	AFC	ICP1	ICP2	ICP3
Weaning Weight	0.24	0.13	0.01	0.28	0.10
AFC		0.22	0.17	0.13	0.28
ICP1			0.13	0.11	0.58
ICP2				0.09	0.52
ICP3					0.03

Cows have three chances for a measurement, so if a cow for example has 3 short ICPs, she will be very fertile, as opposed to for example cows with only one or two short ICPs. The genetic correlations between traits are also used to strengthen the information when estimating the breeding value. The breeding value for ICP is therefore a weighted measure of three ICP breeding values, namely ICP1 (between first and second calf), ICP2 (between second and third calf) and ICP3 (third and fourth calf). These 3 ICPs are weighted equally and then combined into one ICP breeding value.

Should **contemporary groups be split**, for example should a breeder decide to mate some of his heifers to calf at 30 months and some at 36 months, it would result in the heifers calving at 30 months to have the better breeding values, as the heifers that calved at 30 and 36 months are placed in the same contemporary group because they were born together. **It would thus be more correct to use a mating list rather than the birth contemporary group as the fertility contemporary group. Mating lists is the only sure way to know that the cow was mated**, especially for the cows that are penalized. However, mating lists cannot be used as they are not currently available.

COW FERTILITY: INTER-CALVING PERIOD (ICP)

Cow fertility is best measured with inter-calving period, or ICP. ICP is a trait that can be measured more than once in a cow's life, and if more than one measurement is included in the breeding value, it will be more accurate. However, when ICPs 1 to 12 are

included as a repeatable trait in the evaluation model, the heritability was found to be only 7%, which is low. As only 16% of Nguni calves are born from cows 5 years or older (fourth ICP or later), ICP1, ICP2 and ICP3 are included in a multitrait model together with weaning weight.

The heritabilities from South African data show that AFC has a heritability of 24%, while ICP1, ICP2 and ICP3 have heritabilities of between 3% and 13% (Table 1), which is higher for ICP1 and ICP2 than with the repeatability model and in agreement with results elsewhere in the world (Cammack, 2009). Weaning weight is always included as an anchor trait, as it is the trait with the most measurements, but its genetic correlation with the fertility traits are low to zero. AFC shows a low genetic correlation with ICP.

Table 1: Heritabilities on the diagonal and genetic correlations between the fertility traits Age at First Calving (AFC), ICP1, ICP2 and ICP3 (Inter Calving Periods between first and second, second and third and third and fourth calves respectively) used in the South African genetic evaluation. Weaning weight is included as an anchor trait.

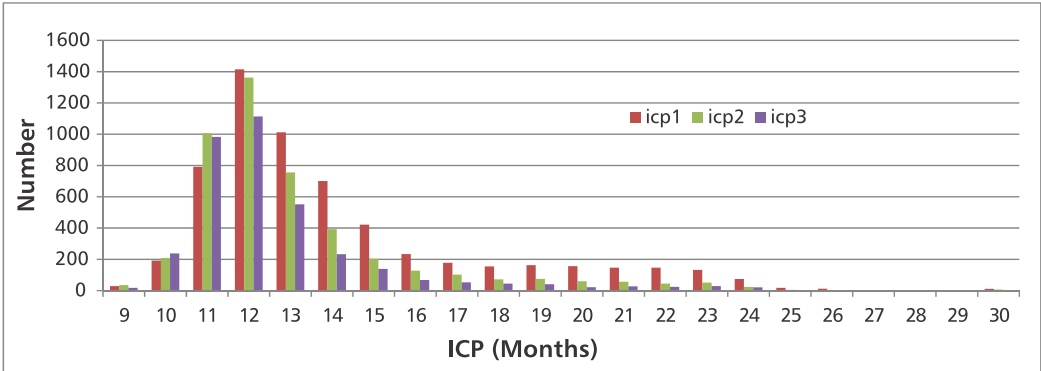


Figure 3: Phenotypic Intercalving Periods for active Nguni cows. ICP peaks around 11-13 months.

The contemporary group for ICP is similar to that of AFC, namely the group of cows that have calved together on the same farm and in the same year-season and calving the next calf again together on the same farm. Cows can be in the same group even if some skipped a calving, as long as all cows calved on the same farm, and the previous calf was born in the previous year.

The limits for ICP are between 270 and 900 days (roughly 8 to 30 months) for cows that have calved. ICP of between 200 and 270 days is set as 270, and more than 900 is set as 900. Cows that have been cancelled at a late stage and didn't calve are penalised with an ICP of 902 days. An ICP1 of 902 days is also allocated to cows cancelled at 4 years

and only calved once. In the same way cows are penalised for ICP2 if she was cancelled at 5 years and only calved twice and for ICP3 if she was cancelled at 6 years or later but only has 3 calves.

EMBRYO CALVES AND SMALL GROUPS?

Measurements of animals of which embryo calves were born, as well as data of any following calvings are excluded. **Data of cows calving in contemporary groups of 3 or less animals are removed from the data set, as for all other traits. Animals of which measurements are not included during breeding value estimation receive breeding values based on pedigree information.**

RESULTS FROM THE SOUTH AFRICAN ANALYSIS

The genetic trends for AFC and the combined ICP are shown in Figure 4. AFC has genetically improved by 2.2 days and ICP by 1.5 days in the past 17 years. It shows that there has been genetic improvement for all fertility traits in the last years.

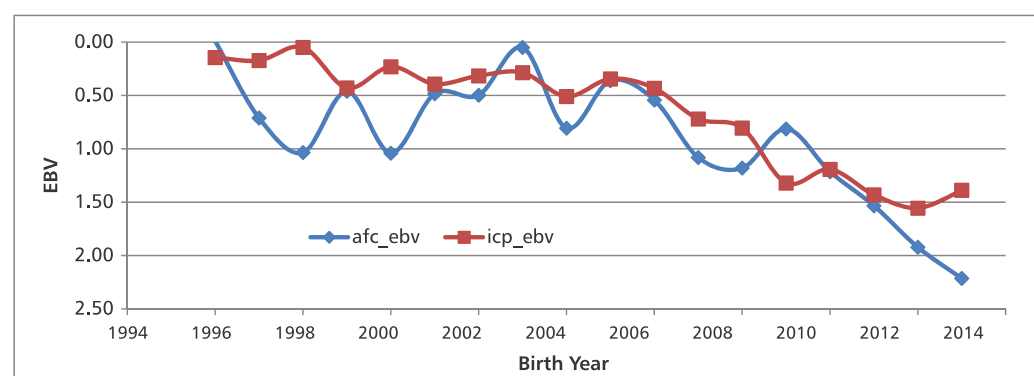


Figure 4: Genetic trends for fertility traits show that Nguni cattle have decreased AFC genetically with just over 2 days and ICP with 1.5 days.

THE GENOMIC LINK

Genomic selection will enable more accurate selection of animals for 'difficult' traits at a younger age than current methods. These traits include traits measured late in life, like milk production and longevity, or traits that have large environmental influences and therefore relatively low heritabilities, like fertility traits. In order to fully take advantage of genomic selection, it is key to make the necessary connections between breeding values on the one hand and the SNPs on the DNA on the other hand (Ibañez-Escriche and Gonzalez-Recio, 2010).

Breeding values for fertility traits is a step forward in reaping the full benefit of genomic selection. ■

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