Breeding objectives in different environments

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The most important equation in animal breeding relates to the two main influences on differences in performance among animals, namely the environment and the genetic merit of each individual animal. The challenge is therefore to separate these two components so that the true genetic merit of each animal for each trait of economic importance can be known.

The rate of selection progress depends on an interwoven set of factors, namely the variance in genetic differences among the animals available for selection, the ability to accurately determine the transferrable genetic merit of each animal (the breeding value) and the proportion of the animals kept as parents for the next generation.

Measuring selection

Successful selection can be measured in terms of the rate of replacing a generation with one that will ensure more profit within the constraints of the practiced production system. The first notion will therefore be to select animals in exactly the same environmental influences that the progeny have to perform.

Although this might be a noble idea, it is not practical as environmental changes over time (on the same farm or locality) cannot be catered for (except in environmentally controlled environments like in-house chicken units or similar systems). So, in essence no extensive livestock recording system (or for that matter any other livestock system) can claim selection within the environment of where breeding stock is kept to be identical, or even similar to the environment where the progeny have to perform.

This is sometimes even more complicated where some scientific studies indicate relative low or no correlation between performance at low input systems versus high energy diets (like in feedlots). The question is: "Is it possible to select effectively where it is known that the progeny has to perform well in a different environment to where the breeding animals are kept?"

Numerous studies and genetic progress in many countries and diverse environments show that this is in fact possible, given that the diversity in environments is within reasonable bounds. Recording and selection strategies can also be applied to make sure all aspects are covered. Breeders and other producers should also make use of other aids, and sometimes common sense in selecting the desirable breeding animals.

"Real" genotype vs perceived interactions

Sometimes preconceived ideas or old habits dictate that a genotype by environmental interaction will lead to a so-called meaningful re-ranking among animals. Classic work indicates not one, but four different types of interactions. In two of these types positive selection in one environment will lead to positive genetic responses in the other.

Figure 1: Two different environments but no difference in the average and variance in performance of the progeny of four bulls (**absence of any genotype x environment interaction**)

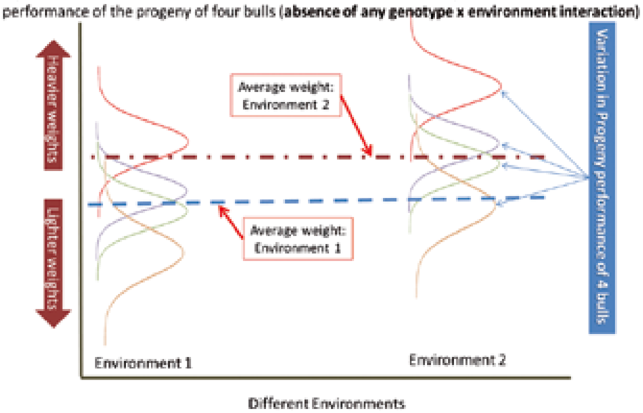

Figure 2: Different environments with a difference in the average, variance and possible re-ranking in performance of the progeny of four bulls

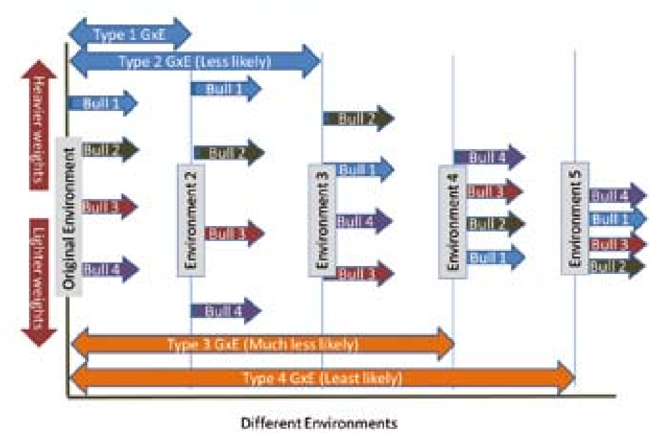

Figure 2 depicts the different possible types of genotype crossed with environment interactions. *Figure 1* illustrates a situation where progeny from different bulls have to perform in different environments where there is no interaction.

Figure 1 shows a practical situation where four bulls in a breed produced progeny on two different farms (or even on the same farm, but born in two different years). The second environment is more favourable, resulting in higher body weights. As would be expected, the progeny of each bull will vary in weights, but there

The result of such a search can be seen in *Table 1*.

Table 1: Example of ten bulls with EBVs in the 25th percentile for Birth Weight (direct), Weaning Weight (direct and maternal) and Average Daily Gain

Name of animal	Birth weight direct	Weaning weight direct	Weaning weight maternal	Mature weight	Average daily gain
ONE	-.19	29.4	8.5	25	318
TWO	.18	25.8	6.3	43	318
THREE	.51	17.5	6.8	12	299
FOUR	-.57	21	7.4	-7	288
FIVE	.28	19.9	8.2	43	283
SIX	-.88	21.4	8.6	13	282
SEVEN	.36	14.1	10.8	16	281
EIGHT	.18	25.9	7.5	10	275
NINE	.26	19.5	6.8	22	272
TEN	.52	23	8.7	42	270

will be differences in the average weights of each bull's progeny group.

These differences contribute towards the predicted breeding value of the bulls. Breeding value predictions based on the relative performances in one environment are therefore very good indicators of the performance differences in the other environment.

Figure 2 depicts the possible different types of genotype by environmental interactions. Type 1 genotype by environmental interaction is the typical situation where average weights of the progeny groups of the four bulls show much more variation in the second environment. The differences among their progeny become more pronounced. This usually happens where the second environment is much more favourable for growth than the first, but the reverse is sometimes also true. What is, however, noted is that the ranking remains exactly the same.

Type 2 interaction depicts the first possible situation where a genotype by environmental interaction could cause some problems in predicting the genetic merit of animals over more than one set of environmental conditions. In this type of interaction (Type 2), some re-rankings take place among the progeny groups of the different bulls, causing selection in the first environment to be less effective to predict production differences in the second.

It is, however, very important to note that the top animals' progeny will still outperform the poor animals' progeny. Therefore, although some re-ranking takes place among individual bulls' progeny, there is no effective re-ranking in the population as a whole. To overcome the effects on the efficiency of selection, the use of groups of bulls (selected as a whole breeding group) will ensure top performance of progeny in a different environment.

Types 3 and 4 interactions are extremely rare and occur where there is a complete reverse re-ranking (Type 3 interactions) or absolutely no pattern in the re-ranking of progeny averages (Type 4 interactions). Both these type of cases are more of a theoretical value as it possibly will have no bearing on modern day breeding of livestock.

Top animals and "undesirable" correlations

Undesirable genetic correlations sometimes make it more challenging to identify animals to be used as breeding material. The advent of best linear unbiased prediction (BLUP) breeding values have enabled breeders and other livestock producers to pool the whole population (breed) in comparing the genetic merit of animals, irrespective of locality, age or status. This leads to new possibilities for rapid genetic progress for a number of desirable traits.

BLUP estimated breeding values (EBVs) also give an added assurance that, due to the genetic linkages among animals, because of pedigree information, related animals are evaluated under different environmental conditions (other farms and in other years and seasons). This caters very eloquently for any possibility of a genotype by environment interaction that might be responsible for some degree of re-ranking in the progeny performance of these animals.

Breeding plans always start with objectives, followed by criteria (or minimum standards). Modern systems also enable breeders and other livestock producers to trace animals that will fit nicely into these objectives. One such system, for example, is Logix Beef, the recording system of SA Stud Book. Users can set their own search criteria to look for the "ideal" bull (or cow), making use of the Logix web.

In this search the breeder has set criteria on birth weight, weaning weight (direct and maternal) and average daily gain. In all cases only animals with predicted breeding values in the upper 25 percentile are considered. What should be noted is that birth and weaning weights are recorded on normal, usually extensive, farming conditions while average daily gain is recorded under typical feedlot conditions. Finding the "ideal animal" will therefore by some be deemed as impossible.

A closer scrutiny of the animals conforming to these criteria makes interesting reading. Only two bulls, numbers four and nine, will be used as examples. Both will breed extraordinary daughters with extremely good figures for milk (wean maternal) and calves with growth, but not extraordinary heavy at birth. Bull four's daughters will be much lighter at maturity than those of bull nine, while both will breed progeny growing extremely well in feedlots.

Perspective

It is always a matter of perspective. Making use of all the possible tools is what modern breeding is about. The effects of genotype by environmental interactions are not really causing problems if proper recording and breeding practices are followed. These include:

- Well defined contemporary groups to allow for fair comparison among animals affected equally by non-genetic factors.
- Accurate, objective, non-selective recording.
- Avoiding preferential treatment.
- Establishing and maintaining good genetic ties (exchanging, selling or buying in bulls and/or using artificial insemination).
- Taking part in joint growth tests of young bulls. SB