Components and auxiliary traits of dairy cow fertility: The genetic view

Hermann H. Swalve

Institute of Agricultural and Nutritional Sciences
Group Animal Breeding
Martin-Luther University Halle-Wittenberg
Adam-Kuckhoff-Str. 35. 06118 Halle (Saale), Germany

Types of fertility

In dairy farming and breeding, fertility besides milk production is a trait of utmost importance. When talking about fertility, male and female fertility have to be differentiated. Male fertility, also called paternal fertility, is the ability of a bull to get the cow in calf. For this, as most matings are done via artificial insemination, the quality of semen has to be such that enough active sperm cells are contained in each insemination dose. This will be ensured through technical standards on the A.I. stud. However, the ability for fertilization may not entirely be covered by these standards. Male fertility also includes other traits like libido strength which either for natural service or at the A.I. stud are important criteria.

Since from the perspective of the cattle holder most problems with respect to male fertility are taken care of by the A.I. stud, female fertility, also called maternal fertility or cow fertility, usually is the trait in focus. This is also justified since a cow is expected to stay on farm for several calvings and thus should exhibit a repeatable fertility performance which also partly will be passed on to her progeny. In contrast, a different A.I. bull can be picked for each insemination and can be chosen from a worl-wide offer of bulls. Hence, female fertility is much more relevant when trying to improve sustainable fertility on farm.

Female fertility quite naturally has to be separated into the fertility performance of virgin heifers and the fertility of lactating cows. This differentiation is necessary since a lactating cow has a metabolic condition which is fundamentally different from the status of a virgin heifer. Obviously, the fertility performance of virgin heifers is expected to be higher than the one of lactating cows. Furthermore, oestrus synchronization programmes are easier carried out in virgin heifers than in lactating cows.

Elements of female fertility

Female fertility, even when differentiated into fertility of virgin heifers and lactating cows, still is a highly complex trait. Three main elements can be differentiated: The ability to start cycling again (for lactating cows only), the act of fertilisation itself, and early embryonic losses. The first element, the ability of a cow to exhibit luteal activity after having calved, is difficult to measure.

Ideally, this can be done by checking hormone (progesterone) profiles. It has been shown that the trait derived under this approach, commencement of luteal activity (CLA), is very valuable from a genetic point of view as it has a comparatively high heritability. If no progesterone profiles are available, an accurate recording of heat can be used to describe the recycling activity. The use of the trait "days to first service" (DFS) also points into this direction although quite clearly management decisions on when a cow should be inseminated will influence the trait. This will not impose problems for genetic evaluations as long as the management policy is identical for all cows within herd but will create biases if this is not the case.
The act of fertilisation itself can only be measured by the success of an insemination. This will require highly accurate insemination records. A big problem is the fact that for a cow that subsequently will have a calf, very accurate figures can be calculated from insemination records and calving dates. Cows that leave herd, however, will only contribute data of lesser accuracy.

Early embryonic losses are estimated to be far more frequent than anticipated by most farmers. Again, accurate figures will depend on highly accurate insemination data, so that deviant cycles can be detected.

Apart from the three main elements of female fertility, other aspects contribute to reproductive success. One aspect clearly is the behaviour of cows when showing heat as pronounced heat signs are a prerequisite for successful inseminations. Disorders (Cysts of the ovary, retained placenta, etc.) are other topics relevant to female fertility. Genetic approaches to improve heat signs and decrease the incidence of disorders so far have been very limited.

The relationship between milk production and female fertility

A highly debated topic in dairy cattle breeding is the relationship between dairy production and female fertility. It has widely been accepted that this relationship is negative, i.e. antagonistic. Breeding for high yield will have detrimental effects on fertility. However, it is still unclear if the genetic mechanism behind this truly is a negative genetic correlation arising from pleiotropic effects of individual genes. Rather than pleiotropic effects of individual genes, metabolic stress of high producing cows may be the reason behind the antagonism. This hypothesis is backed by observations in many countries which show that phenotypic records of fertility improve in high producing herds as compared to medium herds. New models may be needed to give further insight into the genetic relationship between production and fertility.

Approaches for genetic evaluations

Two main sorts of genetic evaluations for female fertility can be differentiated. The first one is based on milk recording data only and hence the trait 'calving interval' is the central if not the only trait in focus. The second approach uses insemination records in addition to milk recording data. This approach hence requires that insemination records will be made available be A. I. studs. So called 'biological' records that truly reflect the inseminations performed per cow and service period may be needed to be separated from 'financial' records that state which inseminations were charged for. Insemination records have the intrinsic problem that inseminations done by other people than technicians who are employees of the A.I. stud, may be less accurately recorded. On all kinds of farms, furthermore the part-use of natural service bulls may create further weaknesses in data quality. In any case, before used in genetic evaluations, insemination records will have to be subject to rigorous data editing.

Both approaches of genetic evaluations, may insemination records be included, or not, so far have the drawback that they define traits of low heritability. Hence, chances for genetic improvement are limited but not nil.

Auxiliary traits

A fundamental principle of genetic evaluations is that any trait genetically correlated with the target trait can aid in genetic evaluations of the target trait. In recent years, body condition score has shown that it will function as such a trait. The physiological relationship is quite clear: Cows with a very poor body condition (emaciated, thin) will have poorer reproductive performance. The reasons for this have a metabolic background but also hormonal aspects can contribute to this.

Many more traits genetically correlated to fertility can be found: One obviously is milk yield but conformation traits, longevity, and cell scores have been proposed as well. In summary, besides body condition score, no trait with a very strong relationship with fertility seems to be available. This may point to the conclusion that the ideal auxiliary trait is still looked for.

The work ahead

As is true for many functional aspects of the dairy cow, future trait definitions for fertility have to be more precise, more directly connected with physiology, and more accurately recorded. Quite clearly, progesterone profiles are an example for this but their collection up to now is costly and the profiles cover only parts of female fertility. As aids for management purposes, many more parameters are already collected on some farms. These include milk conductivity data, pedometer data, and milk ingredients other than conventionally used in milk recording schemes. Since most of this data is created repeatedly per cow and day, masses of data would be needed to be transferred to evaluation centres per day. This big effort may be ineffective but more research is needed in this field.

More research is also needed to address the field of early embryonic loss and on the question how to distinguish between metabolic stress and genetic relationships based on pleiotropy.

Finally, high hopes exist for the use of genomic selection as an aid in genetic improvement for fertility. So far, SNP effects found will mostly be based on associations with the traits recorded conventionally. In the long run, SNP associations with new traits will be needed.