Embryonic developmental programming – The future of better cows

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Creating a dairy cow that produces a lot of milk, has good fertility, and stays healthy is a major challenge. In recent years, more and more attention has been paid to the rearing of young cattle. However, the key to progress may lie in a concept that begins long before the calf takes its first breath. It has long been known that genetics and selection play an important role. More recently, research has increasingly focused on the environment in the uterus, and thus on embryonic developmental programming. This topic is rapidly gaining interest.

What is embryonic developmental programming?

Embryonic developmental programming, also known as fetal programming, is a new concept based on the idea that various conditions in the womb influence the development of the embryo, and that these effects remain visible throughout the animal's life. These effects appear to be caused by epigenetic (non-genetic) influences on gene expression in the embryo, leading to further changes in fetal development. For example, it is known that smoking during pregnancy has a negative impact on fetal development in humans. Babies of smoking mothers are smaller and are more likely to develop diseases later in life. Cows do not smoke, of course, but dairy cows are unique pregnant animals. Most animals stop lactating before they become pregnant again. In dairy cows, however, it is desirable for them to become pregnant again while they are still at the peak of lactation.

In the first weeks of gestation, the calf develops its circulatory system (around 25 days), followed by the placenta and organs. In male calves, testicle development begins around day 45. In female fetuses, ovary development begins around day 50. During this period, the placenta also develops, which determines how nutrients are transferred to the embryo.

Cows are true athletes, but during this period there is competition for nutrients between the uterus and the udder. In addition to milk production, factors such as nutrition, the cow's age, the number of calvings she has already had, and environmental conditions—especially heat stress—play an important role in embryonic programming.

The nutritional status of the cow during pregnancy is also an important factor. Usually, the emphasis is placed on malnutrition, which is associated with growth restrictions in the fetus. Cows can be malnourished in early lactation due to high milk production, overcrowding in barns or pastures, heat stress, or if they are still young, growing heifers. Nutritional deficiencies during pregnancy lead to higher calf mortality, intestinal and respiratory problems, metabolic diseases, reduced growth rate after birth, and lower meat quality. On the other hand, there is the “fat cow syndrome,” in which overweight pregnant cows pass on an increased risk of metabolic disorders to their daughters.

In beef breeds, it is known that malnutrition of the mother early in pregnancy leads to reduced ovarian capacity in her daughters. Heifers whose mothers were underfed in the middle of

pregnancy have more fertility problems, and bulls show reduced fertility. Finally, if beef cows are malnourished at the end of gestation, we see lower weaning weights, smaller carcass weights, and poorer marbling of the meat.

In recent years, a lot of research has been done on heat stress and its effect on pregnancy. Cows exposed to heat late in pregnancy give birth to calves with a significantly lower birth weight. Heat stress causes cows to eat less, which limits the nutrition of the fetus. In addition, heat disrupts the development of the placenta. Such cows calve on average 2–4 days earlier than cows in cooler conditions. The earlier calving leads to lower birth weight and negative effects on the calf's heart, liver, kidneys, and immune system.

The effects of developmental programming manifest themselves in differences in growth, immunity, metabolism, and fertility in offspring. These factors lead to physiological adaptations that can influence the health and productivity of the animal throughout its life.

Birth weight as a predictor of future health

One of the most visible effects of developmental programming is birth weight. Interestingly, top athletes in humans are often born with an average or above-average birth weight. In addition to good genetics, this also points to an ideal uterine environment.

We also look for top performers in cattle. Holstein-Friesian calves, for example, have a wide birth weight range between 24 and 55 kg. Studies show that both low and high birth weights carry risks.

Calves with a low birth weight sometimes appear healthy and can even catch up in the first months of life. Ultimately, they reach the same weight as their peers. However, rapid growth can lead to metabolic problems, such as insulin resistance and obesity later in life. Calves with a low birth weight are more likely to have growth problems, a weaker immune system, and a higher risk of disease. If they are closely monitored, their later milk production appears to be lower and they are removed from the herd more quickly. By keeping track of birth weight and growth rate, farmers can improve the selection of replacement heifers. Too low a birth weight is a serious risk factor!

Assisted reproductive technologies

Techniques such as superovulation, embryo transfer, and in vitro fertilization (IVF) often result in calves with excessively high birth weights compared to artificial insemination. This is due to manipulation of the embryo and epigenetic changes that influence gene expression and disrupt proper development. These calves can range from slightly heavier to dangerously heavy, which can lead to birth complications.

Fertility and reproductive performance

Development programming also affects fertility. Research shows that IVF calves take an average of 3.06 to 4.44 days longer to become pregnant as adult cows compared to cows conceived through AI.

Heifers represent the latest genetics in the herd. To maximize female offspring, farmers often use sexed semen. However, the uterine environment of a heifer (which does not produce milk) is very different from that of a lactating cow. Whether heifers born from heifers are more fertile than those born from cows is still a matter of debate. Studies show varying results.

Heat stress has been extensively researched in relation to prenatal effects on fertility and milk production. Research shows that the season of conception influences fertility. Cows conceived in winter are more fertile than those conceived in summer. Animals conceived in the summer take longer to become pregnant or have lower fertility. This has a direct impact on productivity.

Finally, endocrine disruptors during pregnancy can also affect the future fertility of the embryo. This has not yet been extensively researched in cattle. Recent research shows that newborn calves can contain traces of isoflavones. Cows absorb this substance through feedstuffs such as soy, rapeseed, linseed, red clover, or alfalfa. Isoflavones are phytoestrogens that can influence hormonal systems, although their direct effects are not yet well understood.

Milk production

As mentioned earlier, the uterine environment influences future milk production. Heifers from high-yielding or heat-stressed mothers often have lower milk production during their first lactation than their mothers. For optimal udder development, it is important that pregnant cows are not undernourished, but also not too fat. This explains the phenomenon that so-called top-performing cows in the barn often fail to produce heifers that excel in milk production. Despite passing on exceptional genetics, these cows sometimes prioritize milk production so much that it comes at the expense of the uterine environment of the future "top calf."

In summary: three key recommendations

Embryonic developmental programming is a new concept that examines how the uterine environment shapes the future of the cow. By understanding and applying the principles of this programming, Belgian dairy or beef farmers can improve the health, productivity, and longevity of their herds and contribute to a more profitable and sustainable business. Therefore, here are three important recommendations:

1. Heat stress has long-term effects – Make sure you have cooling systems in place during hot months. The effects are noticeable, both in the mother and in the heifers that are still in the womb at that time.

2. Monitor and record the birth weight and growth rate of calves – This helps improve the selection of replacement heifers. A birth weight that is too low constitutes a risk group!

3. Nutrition of the cow during pregnancy is crucial! – Avoid both underfeeding and overfeeding.