

Reproduction and Genetic Selection

Chapter 11: Reproduction and Nutrition

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INTRODUCTION

Water, energy, protein, minerals and vitamins are required for normal reproduction. These nutrients are the same as those required for other body processes: maintenance, growth and milk production. The impact of cows' nutritional status on their reproductive performance may affect their ability to:

- Conceive (initiate a new pregnancy);
- Provide the proper amount and balance of nutrients to support the growth of a normal fetus;
- Deliver a calf without complications (retained placenta, milk fever, etc.).

HEIFER GROWTH AND NUTRITION

The heifer's weight, rather than her age, determines when puberty occurs and the heat cycle begins. The first signs of heat usually appear when heifers have reached about 40% of their mature body weight. In well-fed heifers, sexual maturity usually occurs at about 11 months of age. However, heat stress and underfeeding of calves and young heifers delays sexual maturity and prevents initiation of heat cycles. In tropical regions, sexual maturity of heifers may not occur before 14 to 15 months of age.

Heifers should weigh about 60% of their mature body weight at the time of insemination (14 to 15 months of age). Thus if cows average about 600 kg, heifers should weigh about 360 kg (600 x 60/100) at the time of insemination (Table 1).

Table 1. Body weight of dairy heifers at various ages assuming different body weights at birth and daily growth rates.

Months of Age	Breed Size ¹ Daily Gain (kg/day)			
	Large (0.725)	Medium (0.650)	Small (0.500)	Local (0.300)
0 (birth)	42	32	25	20
1	64	52	40	29
3	107	91	70	47
6	173	149	115	74
9	238	208	160	101
12	303	266	205	128
15 ²	368	325	250	155
18	434	383	295	182
21	499	442	340	209
24 ³	564	500	385	236
	Mature Body Weight (kg) ⁴			
	620	550	424	260

¹ Example of the different breeds could include: Large = Holstein and Brown Swiss; Medium = Ayrshire and Guernsey; Small = Jersey; Local = small unselected local breeds.

² Age at first breeding.

³ Age at first calving.

⁴ Cows should continue to grow throughout the first and second lactation. Mature body weight should be reached by the beginning of the third lactation.

COW NUTRITION

Nutrition and pregnancy

Malnutrition during pregnancy may lead to:

Premature birth, malformations and weak calves that result from maternal deficiencies in energy, protein, vitamins and minerals;

Abortion, which is rarely due to poor nutrition, except in severe cases of deficiency, the ingestion of moldy feed, or when feed contains high levels of estrogen (a hormone).

Nutrition and post-calving complications

Many complications at calving are related, at least in part, to nutritional imbalances:

- **Fat cow syndrome** is a condition resulting from excess energy during late lactation or during the dry period leading to obesity, loss of appetite and excess body mobilization in early lactation.
- **Milk fever** is due to the drain of calcium from the blood to the milk the first days after calving. This condition is caused, in part, by excess calcium or an imbalance between calcium and phosphorus in the diet. Paralysis and death may occur if not treated immediately.
- **Displaced abomasum** is a condition in which the abomasum is twisted to the left or right of its normal position. The primary cause of this problem may be an excess of concentrate (lack of fiber) in the diet in association with the increased space in the abdominal cavity after calving.
- **Ketosis** is a metabolic disorder occurring in cows with insufficient or excess body reserve at calving--cows lose their appetites, and milk production and fertility decrease.

Cows suffering from milk fever and fat cow syndrome also have a much greater chance of suffering from retained placenta, metritis, dystocia and reduced conception.

Lactation versus conception

In early lactation, milk production has the highest priority for the available nutrients. In addition to the nutrients found in the diet, cows tend to mobilize their body reserve (primarily energy) to support milk production. Cows cannot eat sufficient amounts during early lactation; thus they are in a state of energy deficiency, they lose weight and their ability to conceive is drastically reduced. It is only at a later stage of lactation, when the energy ingested is in balance with the energy required for milk production, that the ability to initiate a new pregnancy increases.

Energy balance and fertility

One of the most common causes of low fertility in dairy cows is the deficiency of energy relative to the animal's need, or negative energy balance. Depending on milk production in early lactation, negative energy balance may last for the first two to 10 weeks of lactation (two and a half months). The effect of body weight change during the month of conception (two to three months after calving) is illustrated in Table 2.

Table 2: Effect of cow's energy status in early lactation on conception rate.

Change in cow's weight	Services	Number of pregnancies	Services per conception	Conception rate
Gaining	1368	911	1.5	67
Losing	544	234	2.32	44

Conception rates are lower for cows inseminated during negative energy balance (cows losing weight) compared to cows inseminated during positive energy balance (cows gaining weight). There is no evidence that higher producing cows have inherently lower reproductive ability. However, it is clear that cows with a negative energy balance have low fertility regardless of milk producing ability.

Protein and fertility

The effect of dietary protein on reproduction is complex. In general, inadequate amounts of protein in the diet reduce milk yield and reproductive performance. Excess protein may also have a negative effect on reproduction. Sometimes, however, higher amounts of protein in the diet are associated with higher fertility. Some of the following effects have been demonstrated to explain the poor reproduction sometimes observed with excessive levels of protein in the diet:

- High levels of blood urea may occur, which has a toxic effect on the sperm, the ova, and the developing embryo;
- The balance of hormones may be altered--progesterone levels are low when the blood contains high levels of urea.
- In the early lactating cow, high levels of protein may exacerbate the negative energy balance and delay the return of normal ovarian function.

Feeding protein and urea, such that early lactating cows have a diet containing 16% protein and late lactating cows have a diet containing 12% protein, should optimize the fertility of the cows.

Minerals, vitamins and fertility

Minerals and vitamins play an important role in reproduction. The effects of severe deficiencies are usually well understood. However, it is difficult to establish possible effects of long term marginal deficiencies or excesses. In addition, there are many interactions between minerals, especially the microminerals. In general, almost all required vitamins and minerals (except iron) have either a direct or indirect effect on the cow's fertility (Table 3) and the cow's ability to give birth to a healthy calf (Table 4).

Table 3: Effect of micromineral deficiencies on reproductive disorders.

Reproductive Disorder	Micromineral ¹						
	Cu/Mo ²	Co	I	Mn	Se	Zn	Fe
Variable length of estrous cycle	4		4				
Anestrus or silent heat	4		4	4			
increase services per conception	4	4	4	4			
Abortion			4	4	4	4	
Retained Placenta			4		4		

¹ Cu = copper; Mo = molybdenum; Co = cobalt; I = iodine; Mn = manganese; Se = selenium; Zn = zinc; Fe = iron.

² Excessive levels of molybdenum, with adequate levels of sulfur, will develop a copper deficiency.

Phosphorus deficiency may greatly delay sexual maturity in heifers and decrease the fertility of dairy cows. A deficiency of either calcium or phosphorus in the diet may lead to milk fever at calving. A calcium-to-phosphorus ratio of from 1.5:1 to 2.5:1 is desirable. However, a ration should always be balanced for the amount of calcium and phosphorus that is required rather than the calcium-to-phosphorus ratio.

Table 4: Effect of nutrient deficiency during pregnancy on the health of newborn calves¹.

Nutrient	Deficiency symptoms in calves
Energy	Low calf weight at birth; unthrifty, slow-growing calves
Protein	Low calf weight at birth; slow-growing calves, under severe deficiency, decreased immunity (resistance to infectious agents) due to lowered immune globulins in colostrum.
Calcium and Phosphorus	Rarely a problem because large amounts of calcium and phosphorus may be mobilized from bone for fetal growth
Iodine	Goiter in newborn calves
Copper	Weak calves, showing symptoms of rickets
Selenium	Unthrifty calves, muscle degeneration (white muscle disease), paralysis and heart failure
Vitamin A	Shortened gestation periods and in severe cases abortion; birth of weak, blind or uncoordinated calves; severe (white) diarrhea in calves
Vitamin D	Birth of calves with rickets (rare).
Vitamin E	Related to selenium deficiencies; weak limbs, difficulty standing and inability to suckle.

¹ Linn, J.G.; D.E. Otterby; J.K. Reneau. 1990. Dairy management manual; Factsheet 617.00.

Genetic selection and reproduction

Among breeds of dairy cows, the intense selection for higher milk production during the last 20 to 30 years has accentuated the problem of negative energy balance in early lactation. Consequently, as milk production has increased, reproductive efficiency has decreased. Although a conception rate of 50% is considered to be a poor level of reproductive performance today, it is probably above average in the U. S. dairy industry. Some believe that the decrease in reproductive efficiency is due to genetic selection for milk production. However, research indicates that the conception rate of heifers has remained unchanged for the last 25 years, suggesting that genetic selection for higher milk production is not the cause of lower fertility.

The heritability of reproductive traits, such as days open, is very low. Thus improving reproduction through selection would be very inefficient. It is likely that cows selected for higher milk yield were also selected (indirect selection) for their ability to mobilize body reserve and to ingest more feed. Cows with higher intake in early lactation are likely to have fewer reproductive problems than cows that mobilize large amounts of body reserves. Thus it is probable that selection of cows with higher intake capacity in early lactation may allow for higher milk production with minimal negative effects on reproduction.