INFLUENCE OF NUTRITION ON REPRODUCTIVE PERFORMANCE
OF THE MILKING/GESTATING COW IN THE TROPICS

by

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Good milk production and numbers of calves per unit time are only obtained by achieving early conception in heifers and a short inter-calving interval in adult cows. Factors affecting fertility in dairy cows are numerous (Table 1).

Table 1. Possible factors affecting fertility in dairy cattle.

* A. GENETICS 20 per cent
* B. ENVIRONMENT 80 per cent
* 1. CLIMATE - temperature, humidity
* 2. INFECTIONS
* 3. PARASITES
* 4. MANAGEMENT = FARMER
*   a. hygiene
*   b. HEAT DETECTION
*   c. suckling effect
*   d. FEEDING - NUTRITION (deficiency - excess)
  * Rearing calves - HEIFERS - adult cows
  * Nutrients - contents of feed plants and concentrates
  * ENERGY - Protein
  * minerals, trace elements
  * vitamins
  * substances in food with negative influences
  * on fertility (nitrate, goitrogens, oestrogenics-antioestrogenics, mycotoxins)
* e. Food production
* Fertilisation, quality of soil
* Cultivation and preparing of feed plants and pasture
* C. MALE FERTILITY

It is estimated that about 80 per cent of the variance in fertility is due to environmental factors, of which more than 50 per cent is explained by nutrition, when severe infections and male fertility are excluded. Even predisposition to infectious diseases can be caused or increased by nutritional failures. Therefore balanced feeding is fundamental to milk production as well as health and fertility.
The present paper is mostly based on data which were obtained in dairy cows kept under temperate climate conditions, because of a lack of knowledge about relationships under tropical conditions. Except for some cases, the results should be seen as an indication of possible relationships.

In feeding dairy cows, three basic points must be considered in order to get good reproductive performance:
1. Balanced feeding is necessary throughout the year (lactation, gestation, dry period).
2. Reproduction can be affected by both an excess as well as a nutritional deficiency.
3. Interactions exist between the factors affecting fertility so that the combined effects are additive.

The last point mainly applies to energy deficiency. Energy is an important nutrient for dairy cows both before and after calving and there is no substitute for energy in the diet of ruminants. A balance of energy and protein is required, even before calving and in the dry period (Table 2).

Table 2. Reproductive performance and frequency of metabolic diseases in dairy cows fed different levels of energy and protein in the dry period.

<table>
<thead>
<tr>
<th>Feeding level:</th>
<th>Group 1</th>
<th>Group 2</th>
<th>signif.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maintenance + 16 kg FCM</td>
<td>Maintenance + 2 kg FCM</td>
<td></td>
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<tr>
<td></td>
<td>HIGH 53.6</td>
<td>LOW 17.2</td>
<td>**</td>
</tr>
<tr>
<td>delayed uterine involution</td>
<td>70.8</td>
<td>26.9</td>
<td>**</td>
</tr>
<tr>
<td>puerperal endometritis</td>
<td>44.8</td>
<td>18.7</td>
<td>*</td>
</tr>
<tr>
<td>follicular cysts</td>
<td>46.4</td>
<td>74.1</td>
<td>*</td>
</tr>
<tr>
<td>conception rate with one or two inseminations</td>
<td>26.2</td>
<td>6.3</td>
<td>*</td>
</tr>
<tr>
<td>subclinical acetonaemia</td>
<td>65.5</td>
<td>45.5</td>
<td>*</td>
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</table>

Lotthammer and Faries (1975)
As table 2 shows, all parameters of reproductive performances in Group 1 (overfed during the dry period) pointed to lower fertility compared to Group 2 with restrictive feeding (for maintenance and 2 kg milk). Furthermore the incidences of sub-clinical ketosis and parturient paresis were higher. Milk production after calving however was not increased (difference 0.5 kg/day), but the milk fat content was significantly elevated by 0.9% in the overfed group due to lipolysis. This effect, moreover, results in fatty liver. The metabolic stress is caused by a decreased intake after calving. Similar results were also obtained by Boisclair et al. (1988) and Flipot et al. (1988). There is a consensus among the authors that overfeeding should be avoided in the last stages of lactation to prevent fattening. About two weeks before the expected calving date, the cow's rumen should be prepared by a gradual increase in concentrates (0.5 kg per day more).

On the other hand, an energy deficiency before calving (below maintenance) should be avoided as well because this leads already at this stage to metabolic stress with subclinical ketosis and liver damage, followed by a higher incidence of retained placenta, endometritis and low conception rates in the following lactation.

The negative effect of an insufficient energy provision before calving will be enhanced by an energy deficiency after the following parturition. Probably due to the liver damage which occurs in this case, there is also an impact on fertility (Lotthammer, 1975; Reid et al., 1979). One also finds more severe infections of the udder, mainly from E.Coli. Furthermore we found that, in herds with a high incidence of liver damage, the response to vaccination against IBR/IPV (BHV-1) was significantly depressed. These results suggest an immunosuppression due to liver damage.

The importance of energy after parturition is well known. Already in the first two to three weeks of lactation, energy from any source is important for the onset of ovarian activity (Butler et al., 1981; Terqui et al., 1982; Villa-Godoy et al., 1988) and, related to this, for uterine involution. Energy deficiency leads to acyclia, silent heat, delayed ovulations and follicular cysts. Significant correlations exist between fertility and weight loss or body condition, as indicators of negative energy balance in the first weeks after calving (Oxenreider and Wagner, 1971; Godfrey et al., 1982; Rutter and Randel, 1984). Weigelt et al. (1988) also report embryonic mortality in cows with energy deficiency. The effects of energy intake on reproduction follow the pathway summarized in Figure 1. That even the result of therapeutic treatments of reproductive disturbances such as endometritis depends on the nutritional status is demonstrated in Table 3.

Under tropical conditions in the dry period, energy provision is insufficient and related to fertility problems. This is suggested by
the field investigations of Betancourt et al. (1985) carried out in Columbia with the dual purpose Zebu (Figure 2). More exactly, we could demonstrate the correlations between energy and reproduction in relation to the seasonal conditions in Pakistan in milk buffaloes (Figure 3).

Figure 1. Effects of energy imbalance and acidosis ante- and post-partum on health and reproductive performance in dairy cows (Lotthammer 1987).
Figure 2. Monthly amount of rainfall in Cordoba (Colombia) and percentages of static ovaries in dual purpose Zebus in the dry (Jan to May) and rainy season (June to Dec) (Betancourt et al., 1985).

Table 3. Results in pregnancy, number of treatments and inseminations per pregnancy after treatment of puerperal and postpuerperal endometritis and losses in cows with different nutritional status and health.

<table>
<thead>
<tr>
<th>nutritional status/health</th>
<th>normal</th>
<th>energy deficiency</th>
<th>energy excess of protein</th>
<th>energy liver damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>energy deficiency</td>
<td>excess of protein</td>
<td>energy liver damage</td>
<td></td>
</tr>
<tr>
<td>% of pregnancies</td>
<td>94.4</td>
<td>81.0</td>
<td>54.5</td>
<td></td>
</tr>
<tr>
<td>treatments per cow</td>
<td>1.22</td>
<td>1.46</td>
<td>1.66</td>
<td></td>
</tr>
<tr>
<td>inseminations/pregnancy</td>
<td>1.39</td>
<td>2.19</td>
<td>2.59</td>
<td></td>
</tr>
<tr>
<td>interval treatment - conception (days)</td>
<td>48.50</td>
<td>66.90</td>
<td>68.30</td>
<td></td>
</tr>
<tr>
<td>costs of treatment/ conception ($)</td>
<td>17.-</td>
<td>24.-</td>
<td>40.-</td>
<td></td>
</tr>
<tr>
<td>differences to &quot;normal&quot; group by costs of treatment and losses per cow ($)</td>
<td>+ 78.-</td>
<td>+ 100.-</td>
<td></td>
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(Escherich and Lotthamer, 1987)
As Figure 3 demonstrates, the glucose levels in the (dry) summer are at a minimum and they increase with the beginning of rainfall in the autumn. At the same time, the percentage of conceptions increases too. This suggests that, with better feeding conditions following rainfall, the energy supply is also improved which results in a higher conception rate. The high urea levels in the dry period indicate imbalanced energy/protein supply too, due to an energy deficiency.

Figure 4 illustrates the problem of providing energy and protein in regions with a dry and rainy season. The nutritional conditions are changing between high intake and deficiency with consequences for metabolism. This mainly influences reproduction in the dry season. To get better results, efforts should be made to balance these conditions. That means transferring part of the surplus from the rainy season to the dry season by the following activities:

1. Ensilage of well grown feed plants (king grass, corn, etc.)
2. Introduction of new feed plants (corn or other) (Lotthammer, 1982)
3. Irrigation of grassland to shorten the dry period and to extend the period of vegetation
4. Good grassland management.
The importance of protein sometimes seems to be overestimated, if it is appreciated that ruminants are producing about 70% of their "own protein" by means of microbes in rumen. These need mainly energy in the form of carbohydrate. This means that, with normal rumen conditions for the microbes, ruminants are already supplied with protein and energy via gluconeogenesis. This could be demonstrated by Kaufmann (1976) and is indicated by the positive correlation between energy intake and protein content in milk.

We found a curvilinear correlation between conception rate and protein supply. Protein deficiency as well as an excessive protein supply causes acyclia and low conception rates.

The negative effect of a relatively excessive intake of protein is enhanced by energy deficiency at the same time. Under these conditions, a large amount of ammonia is flowing through the liver and causes liver damage. In these cases we find static ovaries, silent heat, anaphrodisia, purulent endometritis and embryonic mortality. This can be caused by alterations of uterine secretions (Jordan et al., 1981; Ferguson and Chalupa, 1989). Uterine treatments with antibiotics or other preparations in these cases are not very successful until nutrition is balanced (see Table 4) and therefore they are not economic.
Table 4. Incidence of diseases in health and fertility post-partum after grazing on pastures with different concentrations of nitrate in grass dry matter.

<table>
<thead>
<tr>
<th>Disease</th>
<th>NO$_3^-$ concentration in dry matter (%)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>&lt; 0.30</td>
</tr>
<tr>
<td>Paresis</td>
<td>0</td>
</tr>
<tr>
<td>Puerperal endometritis</td>
<td>25.0</td>
</tr>
<tr>
<td>Retained placenta</td>
<td>0</td>
</tr>
<tr>
<td>Abortions/stillbirths</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Minerals

For many years, phosphorus deficiency was given as a main cause of infertility. Legel (1970) demonstrated in a definitive experiment that phosphorus deficiency decreased total intake which caused a lower energy supply and lower weight gain in heifers. A negative effect on reproduction was not found. In the case of stress, the negative effect of P deficiency is enhanced. The Ca:P ratio also seems to be important. The results of our experiments show that the frequency of non-infectious endometritis is increased when Ca:P ratios decrease. Furthermore a lower content of manganese is found in uterine tissue.

This also demonstrates the importance of calcium, which has functions for the uterine performance, especially after calving for involution of the uterus. The advice is to keep Ca:P ratio in total intake over 2:1 with marginal P supply which should be higher under stress conditions. Depending on soil quality and fertilizer use, a deficiency of sodium and a correlated excess of potassium can reduce fertility by irregular oestrus cycles, endometritis and follicular cysts (Lotthammer and Ahlswede, 1973). The Na:K ratio should be kept under 10:1. Sodium supplementation by salt is very cheap and should be given ad libitum.

Of the trace minerals, manganese and selenium may influence reproduction. Manganese supply is correlated with pH value of the soil because high pH values inhibit uptake from the soil. A deficiency of manganese produces anaphrodisia, endometritis and abortions (Anke et al. 1987). Daily supply per cow should be 1000 mg. Recently selenium deficiency has been discussed, in combination with vitamin E, producing retained placenta, endometritis and cystic ovaries (Harrison et al., 1986). The authors state that only a combined treatment with selenium and vitamin E improves fertility.
**Vitamins**

Of the vitamins, vitamin A is seen nearly exclusively as the factor affecting fertility. In several experiments with heifers and milking cows, we could demonstrate a negative effect of β-carotene deficiency on fertility, unrelated to vitamin A (Lotthammer, 1979). The failures are silent heat, delayed ovulations, follicular and luteal cysts, early embryonic mortality and diarrhoea in calves. These problems occurred in spite of sufficient vitamin A. The daily supply needed is 125 mg for dry cows and heifers and about 300 mg for milking cows. The carotene status is easily observed by the colour of the serum.

The effect of vitamin E deficiency cannot be separated from selenium deficiency (see above). Both must be considered to prevent fertility problems. The requirement will be supplied by green feed or silage.

**Other factors**

Under certain conditions, some substances in plants can affect health and fertility. As pointed out above (Table 4), fertility problems increased with higher concentrations of nitrate in grass. The content of nitrate in plants is positively correlated with dry conditions and fertilization with nitrogen. Energy deficiency enhances the negative effect. Also some plants (e.g. Cruciferae) have high concentrations of nitrate.

Other substances in plants are oestrogenic. These substances can be produced by plants themselves (Trifolium) or by fungi on plants and fungi cause problems in tropical areas. The oestrogenic substances influence fertility directly via the ovaries in a very severe way (Kallela, 1968; Lotthammer et al., 1970). Avoiding the growth of fungi is the best way to prevent disturbances.

**Conclusion**

More research is needed to increase our knowledge of the effects of nutritional factors affecting fertility and health. Furthermore, more work is needed to determine the contents of all nutrients in local feeds, in relation to season and soil conditions.
REFERENCES


