PJN
ISSN 1680-5194

# PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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Pakistan Journal of Nutrition 4 (2): 117-122, 2005
ISSN 1680-5194


# Effects of Poor Nutrition on Reproduction of Dairy Stock on Smallholder Farms in the Tropics

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**Abstract:** The relationship between nutrition and reproduction is a topic of increasing importance. Many research reports have clearly demonstrated that energy, protein and minerals intake are the most important nutritional factors affecting reproduction and therefore milk production in dairy farms. This is particularly evident on smallholder farms in the tropics where feed is often inadequate. On these farms, voluntary feed intake in relation to the feed required for maintenance is the most important factor determining the animal's body condition. Many of the dairy animals on smallholder farms cannot build sufficient body reserves (particularly energy and protein) due to lack of adequate feed. As a direct consequence of feed inadequacy, dairy stock on most smallholder resource-poor farms are often in poor body condition (emaciated). Conception rate and calving intervals have been shown to be highly correlated, to by weight and body condition. The study revealed that animals with low body weights showed low conception rate and long calving interval. Energy and protein have shown to maintain essential levels of blood cholesterol and improve pregnancy from 42 to 72% respectively. Correlation of reproductive hormone cycle, calf and lamb birth rates, weaning rates, lactation length and yield with plane of nutrition, have been adequately illustrated. This is evidenced by the current high incidences of dairy cow infertility on smallholder farms in Kenya. Based on the literature reviewed, the current study concluded that poor nutrition is a major contributor to the current poor reproductive performance of dairy cows on smallholder farms. Poor nutrition is also largely incriminated for predisposing animals to diseases leading to high mortality and morbidity rates on these farms. It is therefore perceived that improvement of ruminant livestock diets on smallholder farms will greatly improve reproductive performance and therefore herd productivity on smallholder farms. In the long run, this will also impact positively on the economic status of the household.

**Key words:** Dairy cows, fertility; lactation length, conception rate, energy, protein, minerals

## Introduction

The relationship between nutrition and reproduction is a topic of increasing importance among dairy producers, veterinarians, feed dealers and animal nutrition experts. This is due to the recognition of the fact that high reproductive efficiency in dairy herds is dependent upon good nutrition and management. Infertility is one of the most important economic losses in high producing dairy cows. Though these losses are largely attributed to health related factors such as retain placenta, metritis, anestrous, silent estrous, cystic follicles, repeat breeding and abortions/still birth, poor feeding and management have often reportedly predisposed the cows to infertility causing factors. Today, many people are implicating deficiencies of various trace minerals, inadequate vitamin intake, energy-protein imbalances as major contributors to infertility and poor reproductive performance. Availability of these nutrients depends on their voluntary intake. For this reason therefore, feed intake is one of the most important factors determining both productivity and reproductive performance in all dairy systems. By the act of eating, dairy animals prevent the energy and protein stores in their body from being oxidized to fuel the processes necessary for maintenance of life, production (i.e milk) and reproduction. By ingesting sufficient of quality feed, the animals will be able to deposit sufficient nutrients in their bodies to support vital body maintenance processes, growth (including that of foetus), milk production and reproduction.

In modernized European and North American dairy production systems, animals are fed according to their production potential and that all ingredients of the animal's diet are fed in controlled amounts. In such systems, if the energy (net) concentration of a certain feed is too low to meet the requirements of the cow at assumed potential intake part or all of that feed is replaced by other products. The situation in the tropics,

particularly on smallholder resource-poor farm level, is very different. Majority of dairy cows on these farms entirely depend on voluntary intake of essential nutrients (energy, protein and minerals) from feeds offered or those they obtain through "scavenge" grazing. Most of these feeds are deficient of the required nutrients (Minson, 1982) and it is these deficiencies that are limiting dairy production in the tropics (Blaxter, 1978). The situation is worse during the dry season whence animals heavily rely on crop residues. Because of economic reasons, smallholder resource-poor farmers can often not afford to provide nutrient supplements. The prices of commercially compounded concentrates are often beyond the purchasing abilities of these farmers. Land resources for fodder production have also further declined over the last two decades in the densely populated farming areas in the tropics. In Kenya, average land size per household has declined from about 25 acres in the 1970s to between 1.0 and 5.0 acres 1990s. Cases of 0.5-acre holdings are common. The term smallholder does not seem to fit in well to the present situation. "Micro-farm-holders" seems to be the most appropriate term to use under the current scenario. The current chronic lack of adequate feeds is primarily attributed to lack of sufficient land for fodder production. As a direct consequence, most dairy cows on smallholder vis a vis "micro farmholders" are chronically in poor body conditions. During the dry season, these animals are often too emaciated and are therefore hardly in a good physiological state to exhibit reproductive cycle. This paper reviewed some of the available research information relating nutrition to reproduction in dairy cows. It further attempted to relate this information to the current situation on smallholder (or micro-farmholders) dairying in the tropics. The objective was to provide an explanation to the current high incidences of impaired dairy cow fertility on these farms. It also seeks to provide a basis from which to evaluate and intervene to counteract potential nutritional factors that are attributed to reproduction on resource-poor farms.

## Materials and Methods

The study was conducted over a period of 3 months at agricultural college of Yangzhou University, Jiangsu Province, P.R. China. During the study, old and recent publications, books and technical reports dealing on nutrition-reproduction interrelationships were reviewed. Consultations with subject experts were also conducted. The qualitative information obtained was concretized and presented as summation of the current review findings.

## Results and Discussion

Dairy production in the tropics is often limited by deficiencies of protein, energy and minerals (Blaxter, 1978). These deficiencies have been reported to cause serious health and reproduction problems (McDonald *et al.*, 1988; Georgievskii *et al.*, 1982). This consequently leads to poor herd productivity (Mukasa-Mugerwa *et al.*, 1992). During the current study, scientific findings on the effects of deficiencies or sometimes excesses of these nutrients were reviewed. The study revealed that of all nutrients considered to be limiting dairy production and reproduction in the tropics, energy and protein are the most critical (Sauvant *et al.*, 1987; Sauvant and Morand-Fehr, 1991; Sanz Sampelayo *et al.*, 1991).

Production and reproduction performance of an animal depends largely on its body condition. Energy and protein intake (which is a function of metabolic weight) is considered to be the most important nutritional factors affecting body condition of dairy cows on most dairying farms (Sauvant and Morand-Fehr, 1991). Inadequate amount of energy delays sexual maturity in heifers (Graves and McLean, 2003). It is also reported (McDolnal *et al.*, 1988) that, if energy deficient rations are fed to heifers that have begun to have normal estrous cycles, they may stop cycling. On smallholder farms many growing dairy heifers are usually not offered energy or protein supplements. This has been shown to lead to retarded growth. Since energy ingested by the animals during their growth period is an important factor of their growth capacity, retarded growth shown by heifers on smallholder farms can therefore be attribute to energy deficiency. This has also been shown to lead to failure to show signs of estrous. This is particularly evident during the dry season when they have to rely on poor diets comprising of crop residues or tropical grasses' standing hay. Lactating cows and calves are reported to suffer the most under such circumstances (Ward, 1968). It is widely known that many high producing cows are often in negative energy balance during early lactation. This is largely attributed to the fact that, high yielding cows are at high nutrient mobilization state. As such they cannot consume adequate feed to meet the nutrient requirements for high levels of milk production. The energy stores in the body tissues are more often mobilized leading to weight losses. Factors associated with the negative energy balance have been suggested as causes of reproductive failures. A Cornell study examined the effect of negative energy balance in high producing cows. The results of this study indicated that, the functioning of normal estrous cycle activity after calving depends on the energy balance during the first 3 weeks of lactation. The same study concluded that, the greater the negative-energy balance the longer the interval of first ovulation. Where diets are deficient of essential nutrients and/or insufficient to provide the minimum gut fill proportion required to supply these nutrients, the resultant outcome could be detrimental in terms of subsequent productivity and reproduction of the cow. On smallholder farms in Kenya, the normal

Table 1: The effects of energy intake during the last six weeks of pregnancy on the live weight (LW) gains of ewes and on the birth weights (BW) of their twin lambs

| Group | Energy (MJ ME/d | LW change of ewes (kg) | BW of lambs (kg) |
|---|---|---|---|
| 1 | 9.4 | - 14.5 | 4.3 |
| 2 | 12.4 | - 12.7 | 4.8 |
| 3 | 12.9 | - 11.4 | 5.0 |
| 4 | 18.6 | - 5.4 | 5.2 |

Table 2: Comparative performance of dairy cattle under large scale and well managed smallholder farms in Tanzania

| Reproductive parameter | Large scale farms | Small holder farms |
|---|---|---|
| Age at first calving (months) | 32.5 ± 2.2 | 34.48 ± 2.9 |
| Calving interval (days) | 417.2 ± 37.6 | 466.8 ± 34.4 |
| Lactation milk yield (kg) | 2317 ± 509 | 2060 ± 575.2 |
| Lactation length (days) | 304.5 ± 37.5 | 335.5 ± 47 |
| Dry period (days) | 117.4 ± 28.7 | 142.4 ± 41.3 |

Adapted from Kishindi, 1999

physiological negative-energy balance following parturition is aggravated by chronic nutrient deficiencies. The current high incidences of dairy cow infertility; low milk yield (Staal *et al.*, 1998; Muriuki, 2003) and the evident poor body condition of cows are an attestation of chronic malnutrition on these farms. Severe energy deficiencies leads to loss in body weight and therefore body condition. Table 1 illustrates the effects of energy intake on both dam weight and that of offspring at birth. It has been reported (Graves and McLean, 2003; Voh and Otchere, 1989) that lower conception rates and longer calving intervals are associated with severe weights loss. One of the recently developed management approaches aimed at enabling farmers track the herd progress towards meeting the desired target, is the use of body condition scoring (BCS; Whitman, 1975; Sprott, 1985) and Near infra red (NIR) in conjunction with animal nutrition balance system software (NUTBAL PRO). In this approach body condition is essentially the degree of body fat required to meet a given reproductive goal of a dairy or beef herd. Monitoring fatness is important in that, reproductive success of dairy cows depends on providing sufficient luteinizing hormone to support formation and stability of the egg for maximum exposure to viable sperm cells. An important precursor to this important reproductive hormone is cholesterol, which is highly influenced by the level of stored body fat, the amount of circulating fat in the blood stream, mineral balance and the level of energy in the diet above maintenance requirement. To build fat reserves, a dairy cow requires energy in the diet above maintenance requirements. NIR/NUTBAL PRO allows farmers in developed countries to monitor diet quality in terms of protein, energy and phosphorus considered important in ensuring optimum herd performance. BCS and NIR/NUTBAL PRO have been used to clearly illustrate the relationships between body fatness as an indicator of body condition and further as an indicator of nutrition quality and reproduction (Fig. 1 and 2). Fig. 1 provides a generalized relationship between pregnancy rates of cows when scored at weaning, breeding and calving.

Results of 6 trials presented in Table 4 clearly illustrate the effect of body condition at calving on subsequent reproductive performance of cows. In trial 1 the percent of cows that had been in heat within 80 days after calving was lower for cows with a body condition of less than 5 than for cows scoring more than 5. Low body condition can lead to low pregnancy rates as evidenced in the other 5 trials.

Despite the novelty of these new advances, they are of no value to smallholder farming situations in the tropics where a myriad of factors militate against their application. In the tropics, attempts were made to relate the body weight and reproduction in beef and dairy herds. Past research studies reported that cattle not only grow slowly, but also have a poor reproductive performance. Ideally, all adult females should calf once every year. In Kenya, smallholder dairy herds (2 to 3 cows), one finds many cows which are neither in lactation nor pregnant. Very long calving intervals implies very low reproductive performance (Table 2). Table 2 compares performance of dairy stock on large scale (resource endowed) and some well-managed smallholder (resource-poor) farms in Tanzania (Kishindi, 1999).

Significant differences were observed between large commercial and smallholder dairy farms. While not overruling genetically spurred differences, a nutrition factor is equally likely to be the cause for the observed variability. Low fertility is most likely to be due to a long term reproductive cycle caused by inadequate feed, which affects body weight among others (Ward, 1968, Entwistle, 1983). Many studies have shown that live weight is the major factor determining onset of puberty and hence, fertility in heifers. Conception rate has been shown to increase with increasing live weight at mating in *Bos indicus* cross heifers (Goddard *et al.*, 1980; Rudder *et al.*, 1985; Couchman, 1983; Reynolds *et al.*, 1971). Ward (1968) reported that mean weight of cows pregnant at the end of the breeding season was about 300 kg and approximately to 250 kg for those not pregnant. He further reported that protein supplemented cows (Groundnut cake 908 $gcow^{-1}d^{-1}$) in the dry season maintained their weight, while those without supplementation lost heavily (Table 3). This is in agreement with Sparke and Lamond (1968) research work.

Supplementation with groundnut cake increased the pregnancy rate from 42 to 76%. The natural tendency of cows under low plane of nutrition is to exhibit long silent

Table 3: Effect of groundnut cake (GNC) and Phosporus (P) supplementation on various production parameters

| Reproductive parameters | Mean Values | | | P + GNC | Probability of effects | |
|---|---|---|---|---|---|---|
| | - | P | GNC | | P | GNC |
| Calving Rate (%) | 56.7 | 61.7 | 72.2 | 76.7 | ns | *** |
| Weaning rate (%) | 56.7 | 61.7 | 68.5 | 76.7 | * | *** |
| Birth weight (kg) | 20.6 | 21.0 | 22.7 | 23.6 | ns | *** |
| Birth to weaning gain (kg) | 104 | 117 | 113 | 123 | ** | ns |
| Weaning weight (kg) | 125 | 138 | 135 | 146 | ** | ** |
| TWC* weaned/cow/6yrs (kg) | 425 | 511 | 556 | 673 | ** | ** |
| % Improvement as compared to the control: | | | | | | |
| Weaning rate (%) | - | 8.9 | 20.8 | 35.3 | | |
| Weight at weaning (%) | - | 10.5 | 8.2 | 17.0 | | |
| Weight at weaning/cow | - | 20.2 | 30.8 | 58.4 | | |

Adapted from Ward, 1968. TWC* - Total weight of calves weaned/cow/6yrs (kg). ns - Not significant (P>0.05). * - Significant (P<0.05). ** - Significant (P<0.01). *** -Significant (P<0.001).

Table 4: Effect of body condition at calving on subsequent reproductive performance of beef cows

| Trials | | Body condition at calving | | |
|---|---|---|---|---|
| | | 4 or Less | 5 | 5 or More |
| 1 | Number of Cows (N) | 272 | 364 | 50 |
| | % In heat within 80 days after calving | 62 | 88 | 98 |
| 2 | Number of Cows (N) | 78 | 10 | 0 |
| | % Pregnant after 60 days | 69 | 80 | - |
| 3 | Number of Cows (N) | 25 | 139 | 23 |
| | % Pregnant after 60 days | 24 | 60 | 87 |
| 4 | Number of Cows (N) | 32 | 60 | 87 |
| | % Pregnant after 180 days | 12 | 50 | 90 |
| 5 | Number of Cows (N) | 168 | 274 | 197 |
| | % Pregnant after 60 days | 70 | 90 | 92 |
| 6 | Number of Cows (N) | 122 | 300 | 619 |
| | % Pregnant after 150 days | 58 | 85 | 95 |

Adapted from Whitman, 1975; Sprott, 1985

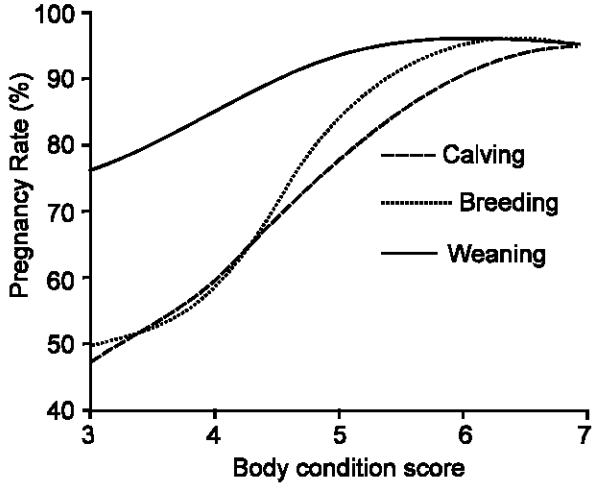


Fig. 1: Relationship between pregnancy rates of cows and body condition scoring at weaning, breeding and calving (adapted from (Whitman, 1975; Sprott, 1985)

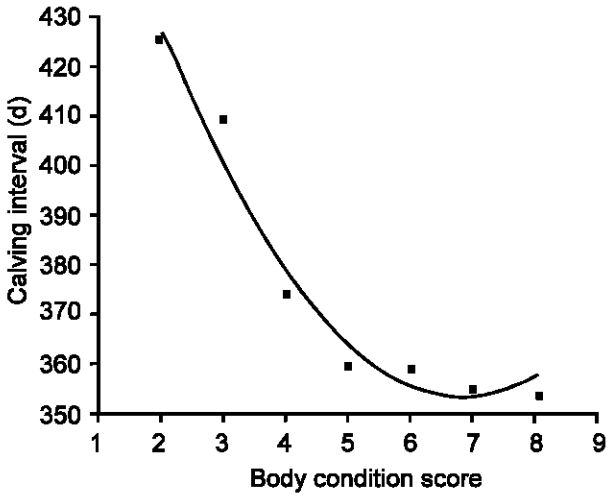


Fig. 2: The Relationship between calving interval and body condition scoring (Whitman, 1975; Sprott, 1985)

estrous, hence long calving intervals. This is in agreement with the current situation on smallholder farms in Kenya. On smallholder daily farms in Kenya, calving intervals are long, with official national estimate of 450 days (Muriuki, 2003) and some studies have reported an average of 590 days on some dairying areas (Staal *et al.*, 1999).

In addition to energy and protein deficiencies, mineral deficiency has also been strongly associated with decreased reproductive performance in daily cows. Inactive ovaries (anaestious), delayed sexual maturity and low conception rates have been reported when phosphorus intakes are low. Calcium has been associated with milk fever in lactating cows. Selenium deficiency in dry cows has been reported to cause retained placenta and therefore subsequent reproductive system problems. Reproduction is also influenced through iodine's action on the thyroid glands. Inadequate thyroid function reduces conception rate and ovarian activity. Thus, iodine deficiency impairs reproduction. Excessive iodine intakes have also been associated with various health problems including abortion and decreased resistance to infection and diseases. On potassium research indicates that, feeding high levels may delay the onset of puberty, delay ovulation, impair corpus luteum (yellow body) development and increase the incidence of anaestrous in heifers. Other minerals such as copper, manganese and cobalt deficiencies have been associated with impaired ovarian function, silent aestrous and abortions. Vitamins A, D and E are also essential for normal functioning of the physiological systems. Vitamin A deficiency has been associated with delayed sexual maturity, abortion, birth of dead or weak calves, retained placenta and metritis. Vitamin D is required for normal calcium and phosphorus metabolism. It is the combination of all these factors that is being incriminated for the current productivity and reproduction problems facing smallholder farmers.

**Conclusion:** Many past research studies have more often attributed low reproductive performance to disturbances caused by diseases or other abnormalities. These studies have erroneously overlooked the critical role nutrition plays in reproduction. Others have regarded dairy cow infertility as an entirely veterinary problem. It is the opinion of the authors of this paper that more attention be given to nutrition particularly on smallholder farm level. Thus, if our aim is to provide lasting solutions to the low productivity of smallholder dairy herds, then it is imperative to begin by tackling the problem of poor nutrition. Nutrition is the building block upon which all others depend. With improved nutrition dairy cows will be able to express their genetic potential and wad-off many diseases. It suffice here to recon that without adequate nutrition, efforts to improve reproduction performance, herd productivity, genetic merit and health will be futile. Deliberate efforts should be made to ensure that, as much as it is practical, rations balanced for energy, protein and minerals are provided to the dairy stock on these farms. This is particularly critical during the dry season when majority of feed resources available are of low quality. This will help maintain cows in satisfactory condition conducive for optimum performance at calving and breeding. The present lack of sufficient land for fodder production requires special strategic choices by dairy farmers concerning which feed to use, when and how to use it. This therefore calls for enhancement of farmers capacity to make appropriate choices at appropriate time. Building farmers' capacity through training/field demonstration to judiciously utilize the available feeds in appropriate ways should therefore be made part and parcel of dairy development process. At research level, animal nutrition researchers must seek to strengthen research-farmer linkage, develop cost effective ways of maximizing on the available feeds and deliberately and innovatively broaden feed resource base through identification, evaluation and domestication of the many potential wild forages for use at farm level. This is in recognition of the fact there is little we can do further on the fodder crops we already know. Ideally, those legume fodder crops that can integrate well with cereals and have positive impact on soil fertility will have high chance of being accepted by farmers. *Vicia sativa* is one such fodder that requires popularization of smallholder farms in the tropics. In tropical eco-systems, large variety of potential feed resources remains un-exploited. *Commelinaceae*, which is one, of the largest and most successful tropical plant families need to be evaluated as ruminant feed on smallholder farms.

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