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REDUCING THE AGE AT FIRST CALVING THROUGH NUTRITIONAL MANIPULATIONS IN DAIRY BUFFALOES AND COWS: A REVIEW

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ABSTRACT

Raising heifers is the most expensive component of the dairy farm operations. Poor growth rate resulting in delayed age at maturity in our local dairy animals further aggravates the situation. However, cost of heifer production can be reduced through better management, balanced feeding, use of performance modifiers and better health care. Selection for higher milk yield is likely to have a favorable impact on age at first calving. Yet, the current age at maturity in buffalo and Sahiwal cow can be reduced to 2 and 1.5 years, respectively, with better feeding and management. Protein and energy are the most critical nutrients affecting the weight and consequently age at puberty in heifers. Higher protein levels than current recommendations of NRC for dairy cattle can reverse the adverse effects of high plane of nutrition on udder development. Accelerated growth rate through performance modifiers to reduce the age at maturity is also helpful provided they do not adversely affect development of secretory tissue of udder for future milk production. Judicious use of balanced feed and performance modifiers has led to reduced age at puberty in exotic dairy heifers. These data can be used to device optimum heifer production systems in the country. However, for offering solid recommendations on optimum heifer production requires well planned research to see the effects of proteins, energy, minerals and other performance modifiers for economical heifer production in our country.

Key words: Nili-Ravi buffaloes, Sahiwal cows, age at first calving, nutrition.

INTRODUCTION

Heifers are future herd of a dairy farm. They must be produced to replace the older and uneconomical females of the farm through voluntary culling. When genetic trends are positive, such replacements help harvest the benefits of genetic gain. Heifer production is most expensive part of the dairy farm operation (Heinrichs, *et al*., 1993). It requires more inputs for a longer period of time with no visible returns than any other farm operation. Growth rates of replacement heifers affect economic returns on dairy farms (Cady and Smith, 1996). Balanced feeding, improved management and minimum disease prevalence can be helpful in reducing the age at first calving (Heinrichd *et al*, 2005). Proteins and energy are most critical nutrients influencing the growth of calves to become heifers. However, minerals and vitamins are also important. Other than essential nutrients, there are performance modifiers that can accelerate the growth rate of claves and help attain early puberty in heifers.

The first major issue is the lower growth rate of calves during early months of their age and just after weaning. Lower growth rate in the early life of the calves is either due to underfeeding or imbalanced feeding. Genetics does play its role as well. This lower growth rate results in higher age at puberty and thus higher age at first calving in heifers. Average age of puberty in buffalo and cow heifers is 37 and 34 months, respectively (Bashir, 2006; Rehman, 2006). This age at puberty is higher than exotic or crossbred cattle (18 months). Age at calving in Nili-Ravi buffaloes, Sahiwal and Holstein cows is 55, 46 and 29 months, respectively (Moore, *et al*., 1990; Bashir, 2006; Rehman, 2006). Age at puberty and calving is related with weight (Moore *et al*., 1990). Heifers can be bred when they have attained 60% of their adult body weight. Assuming an average adult weight of a buffalo as 550 kg, buffalo heifers can be bred when they have attained a weight of about 330 kg. Nutrition plays a major role in attaining the proper weight at proper time (Chaudhry *et al*., 1988; Marston *et al*., 1995). Age at puberty is negatively correlated with plane of nutrition (Patterson *et al*., 1992; Schillo *et al*., 1992). If buffalo heifers can grow at an average rate of 500 g per day from the date of birth, they can attain the critical weight (330 kg) required for breeding at the age of 22 months and can calve at the age of 32 months which is 23 months earlier than the current calving age of 55 months in buffaloes. Similarly, Sahiwal heifers can attain puberty at the age of 18 months (against 34 months) at a weight of 225 kg (60% of 375 kg) with an

average growth rate of 380 g per day and calve at the age of 28 months against current calving age of 46 month.

The objective of this review is to set a future direction for reducing the age at first calving in our local dairy breeds in the light of available information on this aspect.

NUTRITIONAL MANIPULATION

Effect of suckling and hand feeding on calf health

Direct suckled calves are healthier than weaned calves. In a review, Ryle and Orskov (1990) have concluded that advice given to farmers in developing countries to wean calves early in order to increase the amount of saleable milk is inappropriate. They have summarized the results of various studies on calf rearing. Studies showing more economic returns to wean calves at the youngest age possible are also there but that does not apply to the farmers in resource-poor developing countries. This is because of the unhygienic conditions prevailing during artificially feeding the calves. Furthermore, maintenance of desired temperature of milk fed to calves especially in winter is difficult. In a study at Animal Sciences Institute, National Agriculture Research Centre, Islamabad, Pakistan, Khan and Preston (1992) have reported that calves reared by restricted suckling of their dams had better growth rate (552 vs 370 g/d) on less milk consumed (2.7 vs 3 kg/d) than those given milk through nipple pale. Sanh *et al*. (1997), in a study with Holstein crossbreds in Vietnam, have also reported similar results. They found that weight gain of direct suckling calves was higher (445 vs 422 g/d) than that of artificially reared calves. The milk consumed per kg of weight gain was less in suckling calves than on artificially reared calves (4.2 vs 4.7 kg respectively). Similar results were obtained by Gaya *et al*. (1977), where restricted suckled calves had better growth rate (500 vs 350 g/d) than bucket fed. In the light of these studies, the farmers in developing countries should be encouraged to follow the indigenous practices that can enhance daily growth rate to get a healthier calf crop. Indigenous research studies are also needed to test the hypothesis whether weaning should or should not be practiced in Sahiwal cattle or Nili-Ravi buffalo that have a very strong mother instinct to milk let down in the presence of calf which if weaned results into either abandoning of the lactation or milk let down through oxytocin.

Effect of protein and energy in calf starter ration

In our country, calves are usually raised on fodders with limited amounts of concentrates low in protein and energy before and after weaning. This is one of the reasons for lower growth rate and delayed age at puberty in heifers. This issue has been taken up by research workers in our country. In buffalo calves given calf starter ration containing CP% and TDN%, 17, 78 and 16, 72, respectively, a higher daily growth rate (471 vs 336 gm) has been observed on higher protein and energy ration (Ahmad and Jabbar, 2000). In Holstein calves, during 28 to 56 days of their age, given ration in varying amount of CP% at 3.5 Kcal of ME, maximum weight gain (860 g/d) has been observed when the calves were given 20% CP (Akayezu *et al*., 1994). Beyond the level of 20% CP, no additional response was observed on the daily growth rate of calves. In our country, where there is no check on quality of concentrates for ruminants, offering a quality concentrate supplement with higher protein and energy may accelerate growth rate in the replacement calves with positive effects on reducing the age at puberty.

Effect of concentrate feeding on puberty

In a study in Nili-Ravi buffalo heifers, Chaudhry *et al*. (1988) fed green fodder only and fodder plus concentrate at rate of 1% of body weight in two groups of buffalo heifers. They found that age at puberty was reduced by 8 months in heifers fed fodder plus concentrate than those fed fodder only (Table 1). The concentrate ration had 15.4% CP and 65% TDN. In another study, Chaudhry *et al*. (1991) reported that age at puberty could be reduced by one month through additional concentrate feeding for a few months before the onset of puberty in Nili-Ravi buffalo heifers. However, mineral supplementation in this study did not reduce the age at puberty in buffalo heifers. In the aforementioned studies, the initial age at which the experiments were started was about 520 and 350 days, respectively. In a later study, Rafiq and Chaudhry (2002) confirmed the findings of previous studies indicating that supplementation of concentrate with green fodder particularly in summer season reduced the age at puberty in buffalo heifers. In spring born Hereford x Angus cattle, Ciccioli *et al*. (2005) have shown that feeding high starch diet (73% corn; 53% starch) 60 days before breeding may increase the incidence of puberty during breeding of heifers that have inadequate yearling weight.

Table 1: Average age and live weight of buffalo heifers at puberty and first calving as influenced by plane of nutrition

Traits	Fodder + concentrate		Fodder only	
	Number	Average	Number	Average
Daily weight gain (kg)	20	000.78	20	000.49
Age at puberty (months)	20	024.60	19	032.60
Weight at puberty (kg)	20	393.00	19	362.00
Age at first conception (months)	17	034.20	14	039.50
Weight at first conception (kg)	17	487.00	14	426.00
Services per conception	17	003.80	14	003.10
Age at first calving (months)	17	044.40	14	049.60
Weight at first calving (kg)	17	556.00	14	539.00

Source: Chaudhry *et al*. (1988).

In our country mostly it is forage based system, where animals are mainly raised on fodder and poor quality roughages. Concentrates are supplemented with fodder to reduce the age at maturity as is clear from the aforementioned studies. These studies have been conducted when the heifers were already ≥ one year of age. Furthermore, the CP and energy concentration of the concentrate supplement are still less than the recommended levels for a total mixed ration for temperate breeds. This information provides further room for reducing the age at puberty by providing a supplement with higher CP and energy concentration or a total mixed ration. In the absence of comprehensive studies on response of protein, energy and minerals on pubertal age in heifers starting from birth to puberty, future studies are needed to concentrate on heifer nutrition starting form birth to first estrous or conception on a higher plane of nutrition.

Effect of bST on age at puberty

Somatotropin is a hormone produced by the anterior pituitary, a small gland located at the base of the brain, and is transported by the blood to various body organs where it has its biological effects. It has been extensively used in ruminants for promoting growth and production (Bauman, 1992). Radcliff *et al*. (1997) reported that injection of bST (25 µg/kg of body weight) in Holstein heifers increased daily body weight gain and weight at puberty by 10%, and 25 kg, respectively and reduced the age at puberty by up to 24 days. In another study, Radcliff *et al*. (2000) found that in heifers with initial body weight of 135 kg, injection of bST at a rate of 25 µg/kg of body weight at a high plane of nutrition (CP: 19.7% and energy 2.8 Mcal/kg) reduced the age at puberty in Holstein heifers by 90 days (Table 2). The age at puberty in these heifers was 336 days. Hall *et al*. (1994) reported that bST altered the intermediary metabolism in a manner that increased lean tissue and decreased fat deposition, however, it had no effect on age and weight at maturity. In the light of any inconclusive role of bST on age at puberty on temperate breeds, research in local dairy breeds is required to establish a role of bST in reducing the age at puberty and its cost effectiveness in our setup.

Effect of ionophores on puberty

Ionophores are antibiotics produced by a variety of actinomycetes. Feeding ionphores typically increases the efficiency of feed utilization in ruminant animals. Meinert *et al*. (1992) reported that feeding monensin significantly decreased the age at breeding by 15 and 24 d and age at calving by 36 and 61 days for heavy and light Holstein heifers, respectively. In an earlier study, Mosley *et al*. (1977) reported that 92% of the heifers fed monensin reached puberty compared with only 58% of heifers in control group, with no effect on weight gain. In another study (Mosely *et al*., 1982), cows fed 200 mg of monensin per day had lower age at puberty compared with control, regardless of weight. Lalman *et al*. (1993) have also reported that monensin feeding tended to decrease the age at puberty in beef heifers without affecting the weight (Table 3). Bagley (1993),

Table 2: Effect of bovine somatotropin (bST) on age and weight at puberty and first calving in Holstein heifers

Traits	Standard diet	High energy diet	High energy diet + bST	SEM
Initial age (days)	120	121	117	4
Initial body weight	138	134	133	2
Weight gain (kg)	0.77	1.12	1.18	0
Age at 1st insemination	425	333	336	6
Age at 1st calving	719	631	622	9

Source: Radcliff *et al*. (2000).

Table 3: Age and weight at puberty in beef heifers as influenced by ruminally undegradable protein (RUP), propionic acid or monensin

Traits	Control	RUP	Propionic acid	Monensin	SE
Age (days)	376	386	376	369	4.0
Weight (kg)	384	396	385	375	5.7

Source: Lalman *et al*. (1993).

in his review on nutritional management of replacement beef heifers, has summarized the results of various studies, indicating that ionophores increase growth rate and decrease age at puberty in grazing heifers. Purvis and Whittier (1996) have also indicted that animals fed ionophores alone or in combination with anthelmintic attained puberty at a younger age in spring-born beef heifers. This is another area of research where possibility of reducing the age at puberty can be explored with its cost effectiveness in our setup.

Effect of breeding season on puberty

Buffalo is partially seasonal breeder. Bashir (2006) has reported that buffaloes calving in summer (June to August) had a shorter calving interval than those calving in other seasons (Fig. 1). The longest calving interval was observed in buffaloes calving in winter (December-January). This means that the buffaloes that had calved just before the onset of their breeding season (October-November) had more chances of getting bred than those calving after passing their breeding season. This implies that the buffalo heifers attaining their proper weight just before their breeding season are more likely to get bred than those passing this period and thus may have lower age at puberty and consequently at calving than those attaining proper weight after this season. Based on this hypothesis, while raising the replacement buffalo heifers, efforts should be made to keep an eye on both critical weight of buffaloes for attaining the age at puberty and also the season in which this weight is attained. In this regard, adjustments in feeding regime may be required to get the critical weight of buffalo heifers just before their breeding season. Because once this breeding season is over then feeding for accelerated growth may not reduce the age at their puberty and then one has to wait for their next breeding season to see the puberty in the heifers. Similar research is required to see the effect of seasonality on age at puberty and calving in heifers.

In the same study, Bashir (2006) has also reported that age at first calving in Nili-Ravi buffalo is 24% heritable. This indicates that there is room for reducing the age at calving in buffaloes through individual selection too.

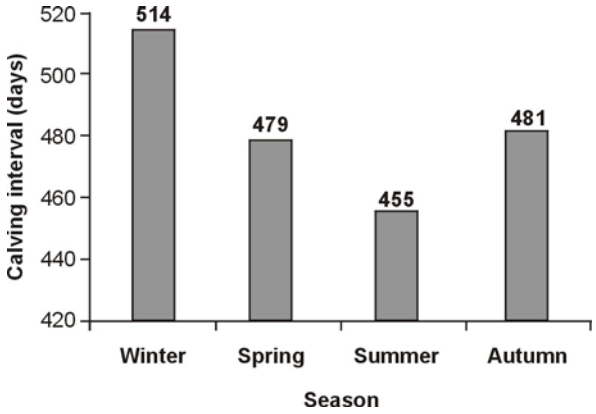

Fig. 1: Effect of calving season on calving interval in Nili-Ravi buffaloes (Source: Bashir, 2006).

Effect of diet on mammary gland development

Accelerated pre-pubertal heifer growth rates have been shown to decrease subsequent milk production in some studies (Foldager and Sejrsen, 1991; Lammers *et al*., 1999), while no effect in other studies (Waldo *et al*., 1997; Van Amburgh *et al*., 1998). Rapid growth rates during the pre-pubertal period decrease mammary secretory tissue development, which can lead to a decrease in subsequent milk production. According to Sejrsen and Purp (1997), when the average daily gain of pre-pubertal Holstein heifers exceeds 700 g/day, the mammary secretory tissue development can be impaired and subsequent milk production can be reduced. On the contrary, Kertz *et al*. (1987) found that daily gain of Holstein heifers 3 to 12 months of age could be accelerated upto 1000 g per day without excessive fattening. Daccarett *et al*. (1993) also observed similar results and reported that Holstein heifers could be fed at 115% of NRC (1989) recommendations. As the growth rate increases, the crude protein requirements increase at a faster rate than energy requirements (Preston, 1966). Therefore, increased protein to energy ratio for rapidly growing heifers can reverse the adverse effects of high energy diets on their mammary gland development. Pirlo *et al*. (1997) have shown that Italian Friesian heifers can tolerate an average daily gain of approximately 600 g from 100 to 300 kg of body weight without any detrimental effects on future milk production. A recent study of Lammers and Heinrichs (2000) endorses these

findings, in which it has been found that feeding ratios of protein to energy above NRC recommendations improved feed efficiency and increased average daily gain and mammary development. Thus, increased protein concentration in the ration of dairy heifers with high energy can reduce the age at puberty without adversely affecting the mammary gland development and its subsequent effects on milk production. Carstens *et al*. (1997) have suggested that rapid growth rate of heifers can be maintained during allometric growth period of mammary gland development without having detrimental effects on mammogenesis through the use of bST.

Conclusions

Different approaches to raise the heifers on economical basis and reduce their age of puberty have been summarized. In any particular situation, one has to keep in view the cost of inputs involved and returns thereof. Any system that is more feasible in a given set of environment should be applied judiciously. In our system, forage should be the main feed supplemented with concentrates and other performance modifiers to gain a faster growth rate for early puberty on cost effective basis.

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