LACTATION-REPRODUCTION INTERACTION IN DAIRY BUFFALOES

A dissertation submitted to the N.W.F.P Agricultural University, Peshawar in partial fulfillment of the requirement for the Degree of

DOCTOR OF PHILOSOPHY IN LIVESTOCK MANAGEMENT

BY

SARZAMIN KHAN

DEPARTMENT OF LIVESTOCK MANAGEMENT
FACULTY OF ANIMAL HUSBANDRY AND VETERINARY SCIENCES
N.W.F.P AGRICULTURAL UNIVERSITY
PESHAWAR, PAKISTAN
JULY, 2007
In The Name Of Allah, The Most Beneficent, The Most Merciful
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Approved by:

1. Prof. Dr. Nazir Ahmad
   (Dept. of livestock Management)

   Chairman
   Supervisory Committee

2. Prof. Dr. M. Subhan Qureshi
   (Dept. of livestock Management)

   Member

3. Prof. Dr. M. Anjad
   Chairman
   (Dept. of Animal Nutrition)

4. Prof. Dr. M. Younas
   (Dept. of livestock Management)
   (U.A.Faisalabad)

5. Prof. Dr. M. Subhan Qureshi
   (Dept. of livestock Management)

6. Prof. Dr. Fazli Raziq Durrani

7. Prof. Dr. Farhatullah

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BY

SARZAMIN KHAN

THESIS APPROVED BY:

EXTERNAL EXAMINER: Kazim R. CHOHAN
Director of Andrology,
Division of Clinical Pathology,
Upstate Medical University,
Syraeuse, USA.
LACTATION- REPRODUCTION INTERACTION IN DAIRY BUFFALOES

BY

SARZAMIN KHAN

THESIS APPROVED BY:

EXTERNAL EXAMINER: 
(Yoshihisa NAKANO, PhD)
Professor, College of Life & Environmental Science, Center for Research and Development Bioresources Organization, Osaka Prefecture University, Japan
Lactation-Reproduction Interaction in Dairy Buffaloes

Sarzamin Khan and Nazir Ahmad
Department of Livestock Management
NWFP Agricultural University Peshawar, Pakistan

ABSTRACT

Dairy buffalo is the major source of milk production kept under peri-urban, low input production system. There is no practice of feeding animals according to production requirements; exposing them to nutritional deficiency with the onset of pregnancy. The onset of pregnancy leads to a decline in milk yield, which compels the farmers to keep the animals un-bred. The present work was completed under four studies to investigate the post-conception decline in milk yield in relation to feeding regime and milk progesterone levels. The overall economic losses due to delayed breeding were also investigated.

Study-I, A total of 30912 weekly milk yield records of lactations pertaining to 465 pregnant and 179 non-pregnant buffaloes from three different locations were recorded for 48 weeks. Post conception reduction in milk yield was effected by location, conception season, lactation week, gestation month and parity. Gestation month contributed to the reduction in milk yield by 1.4%. Parity 3 showed the least reduction followed by parity 2, 4, 1, 5, and 6, indicating it as the best phase for milk production in dairy buffaloes. Under the Study-II reduction in milk yield due to pregnancy was worked out as the difference between milk yield of 23 pregnant and 17 non-pregnant buffaloes, through various models. The buffaloes were provided with three treatments: i) pregnant-ration-traditional (PRT); ii) pregnant-ration-supplemented (PRS) and; iii) non-pregnant-ration-traditional (NPRT). The animals were categorized into HMY, MMY, LMY, producing 66-75, 56-65, and 46-55 liters per week, respectively. Milk production was recorded up to 23rd week and the difference in means was worked out. The reduction in milk yield was apparent after 5th week of conception and was significant in 7th week. The line JP8 model (two straight lines with joining point at week 8) gave good fit ($R^2 = 0.9527$) and the predicted values were much closer to the actual. The treatment effect was significant after 6th week post conception. In MMY the supplementation support to milk yield was smaller than the HMY. In LMY buffaloes the decline was drastic in PRT than the other two treatments.

In Study-III, Forty adult lactating dairy buffaloes were investigated from 1st to 23rd weeks post-conception at a peri-urban dairy farm in Pakistan. The animals were assigned to three treatments: PRT (pregnant-ration traditional), PRS (pregnant-ration supplemented), NPRT (non-pregnant-ration traditional) and.three milk yielding (MY) groups (HMY, high, 66 to 75 liter/wk, n=12; MMY, moderate, 56 to 65 liter/wk, n=16; LMY, low, 46 to 55 liter/wk, n=12). Milk samples were collected on alternate weeks. Milk composition was determined through ultrasonic milk analyzer. EIA (enzyme immunoassay) was used for MPL. Groups means were compared and correlation analysis was conducted. The trends of milk yield as affected by progesterone concentration were analyzed using a regression model based on joining point of the two phases.
Differences in MPL became significant among the production groups after 8 weeks of conception. Treatment had a significant effect on MPL. Interaction of production groups was significant with treatments during the 2-8 weeks and with weeks post conception during 10-23 weeks. Treatment x week interaction was significant only during 2-8 weeks. MPL increased in a similar pattern with the advancing weeks post-conception in all the three production groups; however the progesterone levels were slightly but constantly higher in LMY followed by MMY and HMY buffaloes. The HMY and LMY buffaloes showed greater MPL in the supplemented than the animals on traditional ration (P<0.001). MPL correlated positively with fat (%) while negatively with milk yield, protein (%) and lactose contents (%). Decrease in milk yield was mild with the increasing progesterone levels up to 6.44 ng/ml but further increase in the MPL decreased the yield drastically. The PRT animals showed a sharp decline in milk yield with increasing progesterone levels. However, in the PRS animals increasing MPL from 2.0 to 5.84 ng/ml did not affect the milk yield while further increase in MPL resulted in a decrease in milk yield.

In Study-IV, Complete milk yield records of 3,304 buffaloes were collected from a group of state farms. Economic traits including lactation yield, lactation length, calving interval (CI), dry period and milk yield per day of calving interval (MYPDCl) were derived from the data. The animals were grouped according to parity number (1-3), service period (G1 to G4, conceiving during <150, 150-200, 200-300 and >300 days), respectively and milk yield levels as HMY>2,500; MMY 2,001-2,500; and LMY 1,500-2,000 liters/lactation. The effect of pregnancy on milk composition was investigated in a medium size private dairy farm, using forty lactating buffaloes of three yield levels and four service period groups as described, already. Milk was sampled on the alternate weeks and analyzed for fat and protein contents (%). For quantifying the value of milk produced during a lactation period; the value corrected milk (VCM) was determined and converted to lactation milk value (LMV). Group means were compared for various parameters. Highest milk yield (2,836.50±15.68 liters/lactation) was recorded in the HMY animals of G4 group while lowest milk yield of 1,657.04±18.34 liters/lactation was found in LMY of G1. Lactation length was significantly increased with the increasing service period. The shortest dry period was recorded in HMY, parity 1, G1 animals and the longest in parity 2, MMY, G4. The CI was shortest in HMY, parity 1, and G1 animals and longest in LMY, parity 3, G4 buffaloes. The HMY, parity 2, G1 buffaloes showed the highest MYPDCl and the lowest value (6.53±0.17 vs 2.76±0.04 liter/day) was recorded for LMY, parity 1, G4 buffaloes. The VCM decreased with the delayed conception. This decreasing trend was higher in respect to the total yield but the decrease in the VCM was smaller due to the increasing levels of fat and protein contents in the milk. The gap among various production classes was reduced while looking at the VCM as compared to the milk yield per day of CI. The LMV showed a consistent decline with the extending service period in all the three production groups.

In conclusion, the onset of pregnancy in dairy buffaloes results a drastic decline in milk yield at an early stage and the high milk producers are more sensitive to this decline. Buffalo does not loose her body condition rather decrease her milk yield rapidly than cattle, after the onset of pregnancy. A pregnant animal, if supplemented at the rate of 1 kg ration for every 2 liters of milk will retain milk yield level for a longer duration post-conception. In high milk producers the cost of this supplementation was ten times less
than the loss due to milk yield decline after the onset of pregnancy. Increase in MPL with an almost constant linear trend in dairy buffaloes was reported. Concentrates supplementation raised progesterone levels probably through reducing production stress. The critical level of 6.4 ng/ml of MPL caused drastic decline in milk yield while the two parameters also showed a constant inverse relationship in buffaloes. An animal conceiving at later stages of lactation showed a decline in financial returns by 24-27% than those conceiving earlier.
Dedication
This humble effort is
Dedicated to
My loving parents
Family and children
Who always
Pray for my success.
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<td>Bovine Somatotrophin</td>
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<td>CI</td>
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<td>DO</td>
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<td>4.</td>
<td>ELISA</td>
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<td>Farm Animal Welfare Council</td>
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<td>HMY</td>
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<td>VCM</td>
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<td>Voluntary Waiting Period</td>
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1. INTRODUCTION

Buffalo is the major source of milk production contributing 12.1% in World, 38.0% in Asia, 55.0% in India, 66.6% in Pakistan, 16.4% in China, and 65.2% in Nepal’s total milk production. In addition to the milk, the buffalo contributes 1.3, 2.8, 24.4, 26.9, 0.6, and 51.8% of the total meat in these countries, respectively, which is a by-product of buffalo farming, in the aforementioned regions. In Egypt 50.8% of the total milk and 21.2% of the total beef is contributed by the buffalo (FAOSTAT, 2007). The Indo-Pak subcontinent possesses the best dairy buffalo breeds, named as Nili-Ravi of Pakistan and Murrah of India.

Zicarelli (2006) reported that in countries with temperate climate the cattle are able to express their genetic potential and buffalo can not compete for milk and meat production. However, the buffalo milk possesses greater quantity of proteins and for each protein percent point, more than 5 cheese yield points are obtained in buffalo than 3 points in cows. Buffaloes are mainly used for milk and meat production in Asia, especially in the densely populated countries of Indian subcontinent and China (Ranjhan and Qureshi, 2006). In Pakistan, buffalo are kept under peri-urban and rural farming systems with the primary aim to produce milk (Qureshi, 1995). Dairy farming in Pakistan is based on low input, depending upon opportunity cost and assets inherited from forefathers. Same Scale feeding is practiced irrespective to nutrient requirements of the animal. There is a little trend of new investment for establishing farming facilities on scientific lines. It has been recently supported by the state through establishment of Livestock and Dairy Development Board.

Under the traditional farming system in Pakistan buffaloes are not bred early postpartum with the fear that the milk production will decline. Thus buffalo remain non pregnant for longer period, which affects future replacement of animals in the herd. The code of belief amongst farmers and extension people is that the post-conception metabolic adaptation in buffaloes is affecting their milk production more than the body conditions. The extent to which pregnancy in buffaloes is affecting the production with traditional feeding is not known.
The most important economic trait in dairy cow is the milk yield potential. Losses in milk yield have been reported in dairy cows from the 5th month towards the end of lactation (Olori et al., 1997; Brotherstone et al., 2004). An earlier decline was also observed by Bormann et al. (2002). Lee et al. (1997) showed a significant relationship between days open (i.e., pregnancy status) and 305-d milk yield, and their report showed that even a slight change in days open (<10 days) had significant effects on milk production. They also pointed out that days open alone is probably not an accurate means to assess the effect of pregnancy on milk yield. There is a high probability that high-yielding cows will have greater days open, thereby biasing the result by up to 70%. By removing the effect of early lactation milk yield (first 100 days), Lee et al. (1997) still found that pregnant cows produced 265 kg less milk, 9.8 kg less fat, and 9.2 kg less protein than non-pregnant cows over 305 days of lactation period.

Eley et al. (1978) and Prior and Laster (1979) reported an exponential growth of fetal tissues, with a rapid growth after 90 days of gestation (approximately 25th week of lactation in seasonal herds). This growth of fetal tissue corresponds to the increased body weight (5.2 kg) of the pregnant twin cows after 25 week of lactation. From Dairy Health Association data, Bormann et al. (2002) reported a negative effect of pregnancy on milk volume after approximately 90 days of gestation. However, the statistical significance of this difference or the point at which the difference became significant was not reported.

Karmarkar (1964) reported a daily milk yield of 8.0 and 9.1 kg and Fat contents of milk were about 8% in Bombay and Pargaon districts. Compared to the fund of recorded experience and experiments to the Western breeds of dairy cows, the knowledge of nutrition and reproductive physiology of buffaloes and their potential as milk producer is much less comprehensive and of comparatively recent dates (Kay, 1974). Production of average fat corrected milk has been reported to be 15.31 and 13.55 kg/day in the normal and low breeding seasons in Nili-Ravi buffaloes. The greater milk production was associated with better body condition score and high milk progesterone levels. (Qureshi et al., 1999 b)

Pregnancy has been reported to drain a lot of nutrients from main pool of the body, sparing little for other functions. The growing fetus on one hand, procures more
nutrients for development (Bell et al., 1995) and on the other, its presence in the body of a lactating animal puts further stress in the form of hormonal changes and expanding space requirements (Bachman et al., 1988; Aker, 20002). In addition, the fetus acts as a foreign body, have antigenic activity, which interact with the maternal immune system (Hunter and Einer-Jensen, 2003). In turn adversely affects the lactation synthesis and physiology of reproduction. These two parameters carry significant economic importance and lead to a depression of the associated economic traits in dairy animals.

In dairy cows, relationship of milk progesterone levels with milk yield has been reported to be negative during both the first and third luteal phases postpartum in second parity cows (Reksen et al., 2002). Negative energy balance has been associated with reduced values for milk progesterone during the third luteal phase in second parity cows. An association was demonstrated between the likelihood of conception and the energy coverage in Norwegian cattle; possibly mediated through progesterone deficiency. Decline in milk yield after the peak has been associated primarily with decline in mammary cell numbers due to apoptosis (Knight and Wilde, 1993), decline in milk yield during pregnancy has been associated primarily with decline in milk synthesis and the rate of secretion accompanying an increase in progesterone (Forsyth, 1999).

Serum progesterone concentration (SPC) was depressed in cows fed with high nitrate ration. This effect was prominent in open, luteal phase cows, less prominent but still apparent in early pregnant cows, and absent in mid-pregnant cows. The early reproductive problems of chronic nitrate toxicosis may be due to depression in SPC. The possible mechanism for the depression in luteal phase progesterone synthesis might be due to inhibition of cytochrome P-450 (Paque et al., 1990).

Other important traits affected by the pregnancy include various reproductive parameters i.e service period, conception rate, dry period and calving interval. Pregnant heifers produce $66.35$ valu less milk than open heifers, and $26.41$ less compared to aborted heifers (Jim et al., 1991). Pregnant heifers in the feedyard can have increased health costs (dystocias, cesarean-sections, death losses, abortion and Veterinarian fees) as well as losses due to a decreased slaughter prices for the pregnant and recently calved heifers. Healthy pregnant heifers can have decreased dressing percentages (Clayton and
Lloyd, 1984). Problems associated with pregnant heifers also can have a negative effect on morale among feedyard employees. Bahman et al. (2003) concluded that ignoring heifer pregnancy would not be economically advantageous unless purchased groups were essentially guaranteed not to contain pregnant animals. Net returns declined rapidly if pregnant animals were retained in a lot. The drop was steeper for rail pricing than live pricing, due to trim and carcass penalties.

In above studies the effects of pregnancy on milk production have been investigated on the basis of data from dairy cows. This information can not be applied exactly to dairy buffaloes due to the difference in species, climate and socio-economic conditions of the farmers. In addition, other economic traits indicating the productivity of dairy animals, as affected by pregnancy, need to be documented in buffaloes. Present study was therefore conducted with the following objectives:

**Objectives:**

1. To study decline pattern in milk yield of buffalo after conception and the role of feed supplementation for its prevention.

2. To investigate the post partum progesterone profile and its role in declining milk yield.

3. To study the effect of pregnancy on economic traits and lactation milk value of dairy buffaloes.
II. REVIEW OF LITERATURE

Pregnancy in lactating animals is associated with a rapid decline in milk yield as compared with non pregnant animals. This decline is considered to be mediated through an increase in nutrient requirements of pregnant animal as well as hormonal changes associated with pregnancy. An early or delayed breeding is also associated with variations in economic traits of dairy animals leading to an interaction between lactation and reproduction. Literature regarding this lactation-reproduction interaction was reviewed in this chapter under the following subtitles.

2.1 Decline in Milk Yield with Lactation Stage

Wood (1969) analyzed 44 weeks lactation of dairy cows. He reported peak yield on week 5. The values for constants a, b and c were 19.1, 0.20 and .04, respectively. Kumar and Bhat (1979 b) worked on lactation curve of Indian buffaloes. They reported the peak yield on week 7.5. The values of a b and c constant were 43.58, .300 and .04, respectively. Gondal (1985) analyzed 39 week lactation of Pakistani buffaloes. He reported peak yield on 8.1 week. The values for a, b and c were 37.45, 300 and .037, respectively. Samak et al. (1988) described lactation curve of milk yield of Egyptian buffaloes using the linear form of the incomplete gamma function and reported values of the initial milk yield (a) ranging between 17.43 and 27.43 kg in the first and fourth parities, respectively. Ibrahim (1995) estimated lactation curve parameters for milk yield of Egyptian buffaloes using the nonlinear form of the incomplete gamma function. The initial milk yield (a) in his study ranged between 37.20 and 52.90 kg and the estimates of b and c were between 0.31 and 0.37 kg and between 0.06 and 0.08 kg, respectively. Sadek et al. (1998) reported similar results to those obtained by Ibrahim (1995), ranging between 35.5 and 52.3 kg for the initial milk yield (a), between 0.27 and 0.36 kg for the rate of increase to peak production (b) and between 0.05 and 0.07 kg for the rate of decline after peak (c) Aziz et al. (2006) reported values of the initial milk yield (a) for the first six lactations, ranging between 30.30 and 44.38 kg. The rate of increase to peak production (b) in their study ranged between 0.17 and 0.27 kg and those of the rate of decrease after peak (c) were between 0.02 and 0.03 kg.
2.2 Declines in Milk Yield with Pregnancy

Knight and Wilde (1988) reported that pregnancy had no effect on milk yield during the first 8 weeks of pregnancy in Saanen goats, but milk yield decreased rapidly thereafter and was 57% of the value of non pregnant goats in the last week of pregnancy. Salama et al. (2005) observed that pregnancy reduced milk yield from week 10 after conceiving onwards in goats. Borman et al. (2002) reported a decline in milk yield, from approximately 90 days in pregnant cows, compared to non pregnant cows. The difference in production was particularly noticeable during the third trimester of gestation. The report of Borman et al. (2002) suggests that there is a milk production cost of pregnancy well in advance of 190 days. However, the significance for the difference between milk yields of pregnant and non pregnant cows was not reported. The greater effect of pregnancy on late lactation may be due to the decreasing power of galactopoietic hormones as lactation advances. Sorensen and Knight (2002) reported that blood concentration of growth hormone (GH) decreased whereas insulin concentration increased as lactation is advances in dairy cows. Pregnancy also caused a significant decline in milk yield of dairy cows in late lactation from 5th month of gestation onward (Olori et al., 1997; Brotherstone et al., 2004) or as early as month 3rd of pregnancy (Bormann et al., 2002). Placental lactogen peaks during the last third of pregnancy and may influence mammogenesis and lactogenesis, and alter the maternal metabolism to accommodate the growth and development of the fetus (Akers, 2002).

In addition to the hormonal effect, milk yield losses might be due to the nutritive requirements of the gravid uterus. Energy requirements for pregnancy not only include the energy deposited in the conceptus, but also the energy used for the conceptus metabolism and the energy used by maternal tissues to support the conceptus. Bell et al. (1995) defined the energy requirements of the pregnant dairy cow after 190 days of gestation and developed a quadratic equation to describe the daily change in energy content of the gravid uterus. Energy requirements directly attributable to pregnancy are presumed to be close to zero (NRC, 2001), when the day of gestation is 190 days. In most seasonal calving situations, a lactation length of 305 days is targeted, thereby allowing two months dry period. Therefore, the energy requirements of the gravid uterus would not be expected to have a significant effect on milk production. However, Eley et al. (1978)
and Prior and Laster (1979) reported an exponential growth of fetal tissues, and energy demand, increased after 90 days of pregnancy. Glucose is the main source of energy for the gravid uterus, and an increase in the net hepatic plasma glucose release in pregnant ewes has been reported from day 40 of pregnancy towards the end of gestation (Freetly and Ferrell, 1998). Despite this hepatic release of glucose, pregnant goats had lower concentrations of blood glucose than did the non-pregnant goats after 84 day of pregnancy (Kham and Lurdi, 2002). This suggests that there may be competition for glucose between the mammary gland (for lactose synthesis) and the gravid uterus which would result in milk yield losses during pregnancy.

Coulon et al. (1995) worked on modeling the effect of the stage of pregnancy on milk yield in dairy cows. The lactation yield of pregnant (601 lactations) and non-pregnant (169 lactations) cows of similar parity (primiparous or multifarious) and production potential (rank for primiparous cows and 3 for multifarious cows) were compared. The daily milk yield of pregnant cows was lower than that of corresponding non-pregnant cows by week 20 of pregnancy, regardless of lactation group. The effect of pregnancy on milk yield was lower in primiparous than in multiparous cows. In Primiparous cows, the daily milk yield of pregnant cows was 1 kg lower than non-pregnant cows by week 27 of pregnancy, and 1.7 kg lower by week 29 of pregnancy. In multiparous cows, the daily milk yield of pregnant cows was >1.5 kg lower than non-pregnant cows by week 26 of pregnancy. From week 26 onward the decrease in milk yield was greater in high-producing than medium or low producing multiparous cows; by week 29 of pregnancy the daily milk yield was 3.6 and 2.4 kg lower for high- and medium/low-producing cows respectively. A non-linear model was fit to each lactation group and the milk yield losses due to pregnancy were calculated. For primiparous, low and medium-producing multiparous, and high producing multiparous cows total milk yield losses over a complete lactation were 89, 137 and 203 kg, respectively. Lee et al. (1997) showed a significant relationship between days open (i.e., pregnancy status) and 305-day milk yield. They reported that even a slight change in days open (<10 d) had a significant effects on milk production. However, they also pointed out that days open alone is probably not an accurate means of assessing the effect of pregnancy on milk yield, as there is a high probability that the high-yielding cows have greater days open,
thereby biasing the result by 70%. By removing the effect of early lactation milk yield (first 100 days), Lee et al. (1997) still found that pregnant cows produced 265 kg less milk, 9.8 kg less fat, and 9.2 kg less protein than non pregnant cows over 305 days. Rodriguez et al., (1985) studied the effect of relative humidity, temperature, pregnancy and stage of lactation on milk composition and milk yield. They reported that the stage of lactation and pregnancy affects account for about 50 percent of the variability in yield and 3 to 23 percent of milk content percentages.

Olori et al. (1997) studied the effect of gestation stage on daily milk yield and milk composition using first lactation weekly test day records of 325 Holstein-Friesian cows in one herd. Gestation stage had a significant effect (p<0.05) on all traits, accounting for 1.38 to 1.69 % reduction in total sum of squares for milk yield traits and <0.4% reduction in total sum of squares for content traits. The decline in daily milk yield due to pregnancy began from the first month of gestation and increased non-linearly to about 3.0, 0.08, 0.12 and 0.14 kg/day, respectively for milk, fat, protein and lactose yield in the 8th month of gestation, corresponding to 7-12% of the mean daily yield. A significant interaction between gestation stage and lactation stage was observed, indicating that the adverse effect of pregnancy was higher in mid-lactation than in late-lactation. Roche (2003) reported a decline in milk yield from 126 days of pregnancy in twins that were pregnant, but the decline was small and non-significant, until 147 day of gestation (at 33 week of lactation), after which pregnant cows produced less milk (0.8 kg/cow per day). He concluded that the decline may be associated to low feed intake due to pregnancy. In his support Grummer and Carroll (1990) observed that reproductive hormones, estrogen and progesterone, play a role in the regulation of appetite. They reported that intravenous infusion of 17-estradiol decreased both dry matter intake (DMI) and milk yield in dairy cattle. Progesterone has not been shown to have a direct effect on intake, but has been reported to block the effects of estrogen in dairy cattle (Muir et al., 1972). Grummer (1995) suggested that estrogen or estrogen to progesterone ratio might influence prepartum DMI depression. Adipose tissue mobilization during late pregnancy causes a rise in circulating levels of non esterified fatty acids (NEFA) and ketones. A negative relationship between plasma NEFA and DMI during the prepartum period was described. Subcutaneous injections of β-hydroxybutyrate have been shown to cause
intake depression in rats. The reduction in feed intake may also be attributed to the elevated level of leptin hormone during pregnancy. Ehrhardt et al. (2001) reported that plasma leptin increases during early pregnancy in ewes and during the third part of pregnancy in cows. The level of leptin decreases just before parturition and remains low during lactation in ewes and cows. The Leptin is produced and secreted by the adipose tissue, and functions as the afferent signal in a feedback loop regulating adipose tissue mass by decreasing appetite and increasing energy expenditure. In ewe and cow, like in monogastric species, circulating leptin concentrations were positively related to the energy ingested daily in the short term, and the degree of adiposity and the plane of nutrition in the long term. (Ehrhardt et al., 2001; Holtenious et al., 2003; Liefers et al., 2003 and Chilliard et al., 2003)

2.3 Body Condition Score and Milk Yield

Body condition scores (BCS) are subjective, visual or tactile evaluations of the amount of subcutaneous fat on a cow (Edmonson et al., 1989 and Wildman et al., 1982). Two BCS systems for dairy cattle in the US have been reported in the literature (Edmonson, 1989 and Wildman, 1982). Scores range from 1 (thin) to 5 (obese); scoring increments may be a tenth, quarter, or half points (Braun et al., 1986). Ferguson and Otto, (1994) expanded the usefulness of both BCS systems. Garnsworthy, (1988) suggested that the relationship between BCS at parturition (PBCS) and milk yield was variable and that cows with higher BCS at calving generally lost more body condition during lactation, which could negatively influence milk yield. Cows that are fat or over conditioned at calving may be at risk for lower yield and increased reproductive and health problems (Boisclair et al., 1986, Fronk et al., 1980, Gearhart et al., 1990). However, they reported that under conditioned cows may represent extremes in BCS that are not typically seen in high yielding dairy herds. Two studies (Braunet al., 1986) found no difference in health or reproductive problems based on BCS. Daily milk yeilds or cumulative milk yields between cows calving above or below a BCS of 3.5 on a five-point scale did not differ in a study involving 66 cows (Ruegg, 1992); mean daily milk yield was not influence by the amount of BCS loss. The amount of BCS loss was related to BCS at calving.
Ferguson et al. (1992) reported a non significant influence of PBCS on milk yield of 1300 cows. Results from Italy (Pedron et al., 1993) indicated that BCS at calving was not important to total milk yield, but a change in BCS influenced peak yield and the shape of the lactation curve. In contrast, Waltner et al. (1993) suggested that PBCS and a change in BCS during lactation were related to total yield of 3.5% FCM at 90 days of lactation. Ruegg (1992) reported no difference in 305-days FCM milk yields or peak milk yield among 429 cows in 13 Canadian herds based on PBCS. Body condition score at calving appears to have little influence on milk yield. However, changes in BCS, which are related to BCS at calving, have influenced milk yield. The effect of BCS at dry-off (DBCS) or changes in BCS during the prepartum period were not included in previous studies and could influence milk yield. The rate of increase in milk yield in early lactation is important to total yield and may more accurately reflect the dynamic biological changes experienced by the cow. The rate of increase in milk yield may be associated with BCS or with changes in BCS.

2.4 Fertility and milk yield

Breeding programs world wide have been based almost entirely on increased milk production per animal until recently. Little or no emphasis was placed on ancillary traits relating to health and reproduction efficiency. It has now been recognized that selection in dairy animals solely for high milk production is generally accompanied by reduced fertility (Hoekstra et al., 1994; Grosshans et al., 1997; Roxstrom et al., 2001; Royal et al., 2002). Therefore, most countries have begun to include traits, other than those associated with milk production, in their selection indexes (Philipsson et al., 1994; Visscher et al., 1994; Heringstad et al., 2000; Veerkamp et al., 2002). Though progress towards increased milk production may be reduced, but these selection indexes suggest that better overall economic efficiency will be obtained when functional non production traits are included in the selection criteria. Hansen et al., (1983) reported that genetic correlations of heifer fertility and first-parity yield usually were negative and opposite in sign from genetic correlations of first-parity fertility, and yield. Most estimates of genetic correlation between heifer and first-parity fertility were not significantly different from zero. The authors concluded that increasing milk yield may improve genetic potential for fertility, but stress of increased milk yield may overcome genetic potential for improved fertility.
Nebal and McGilliard (1993) reported that correlations between reproductive traits and measures of milk yield are associated phenotypically and genetically with reduced reproductive performance in lactating cows. The others concluded that reproductive performance is compromised, primarily through delayed ovarian activity and reduced conception rates, by the demands of high milk yield. However, daily managerial decisions to obtain efficient reproductive performance have considerable impact. Management can offset depression in fertility, because high yielding herds often achieve the fewest days open. Selection for milk yield has increased blood concentrations of Somatotropin and Prolactin, stimulators of lactation, and decreased insulin, a hormone that is antagonistic to lactation and may be important for normal follicular development. These changes in hormone concentrations promote higher milk yield but may be potentially detrimental to other physiological functions, such as reproduction, if the management is not adequate to meet the metabolic demands of lactation. Timing and magnitude of negative energy balance apparently interact to determine the extent to which negative energy balance alters hypothalamic secretion of GnRH and its effect on gonadotropin secretion and, therefore, ovarian secretion of progesterone, which affects expression of estrus and support of the uterus during early pregnancy.

Mayne et al. (2002) established a comprehensive database on the milk production and reproductive performance of dairy cows in 19 selected herds in Northern Ireland, varying in size, management system and genetic merit. Data were obtained for 2471 cows, 1775 of which calved in a second year, and 693 were culled from the herd for the specific reasons. The estimated mean rate of heat detection (assessed by the interheat interval during the main breeding season) in all the herds was 71 %, with a range from 53 to 92 %. The average conception rate to first insemination was 37.1 % (range 21 to 66 %). The average calving interval for the retained cows was 407.2 days (range 359 to 448 days). A 28 % of the cows that calved were culled, due to infertility being the largest single reason (26.8 % of the cows culled). There were major differences in reproductive performance between the herds, but heat detection rate, conception rate and calving interval did not appear to be affected by a herd's genetic merit. The herds with shorter calving intervals were characterized by better heat detection efficiency (83 vs 61 %, p<0.01), a shorter interval from calving to first insemination (74 vs 97 days; p<0.05), a
higher conception rate to first insemination (45 vs 34 %, p>0.10) and a lower removal rate (23 vs 37 %, p<0.01). Further more, the cows in these herds had lower body condition scores (BCS) in the dry period (3.0 vs 3.3 BCS units; p<0.05) and lost less body condition during early lactation (0.3 vs 0.6 BCS units, p<0.05). These results show that dairy herd fertility in Northern Ireland is generally low and similar to that previously reported for England and the USA, in some herds changes in herd management practices improved the fertility.

Windig et al. (2005) reported that high level milk production affects health and fertility traits. They explored relationships among milk yield, health, and fertility traits both across and within herd environments on a national scale. A total of 4,56,574 lactations from 3904 herds recorded between 1995 to 1999 in the Netherlands were analyzed. Herd environment was defined by 41 variables derived from production records and the annual national agricultural survey. Principal components analysis reduced this set to 4 components; intensity, defined as the average production per cow, average fertility, farm size, and relative performance indicating whether the herds had good or poor health and fertility despite a high or low production. Both fertility and health were better for some traits in high-intensity herds and for other traits in low-intensity herds. In high-intensity herds, the somatic cell count (SCC) levels were lower, drops in milk production occurred more often and first service took place earlier but with lower success. High fertility occurred more often in herds located on sandy soils and in those that had lower SCC levels, had fewer drops in milk production and higher cow survival. On large farms, drops in milk production were less frequent and fertility was better. The within-herd analysis showed that the relationship of milk yield with health and fertility was stronger in herds with high production, fertility, or both. In herds with poor relative performance, there was no difference in production levels between animals with good health or fertility and those with poor health or fertility.

2.5 Feed Supplementation and Milk Yield

Buffaloes are more efficient than cattle in digesting and utilizing fibrous feeds. The results of controlled studies on the comparative nutritional efficiency of cattle and buffaloes possessing greater ability to digest fibrous feeds (Mudgal and Ray, 1962,
Inchhiponani et al., 1969 and Gilani, 1980), whereas the findings of other workers (Naga and El-Shazly, 1969 and Chalmers, 1974) did not sustain this view. From the present state of knowledge of the comparative nutritional physiology of buffaloes and cattle, it is not possible to draw any definite conclusions as to whether one species differs from the other or is superior in relation to digestion and utilization of nutrients in commonly used feed and fodders. The optimal nutritional requirements of the buffalo, therefore still remain unknown. The feeding standards as recommended by the National Research Council of the United States or the Agricultural Research Council of the United Kingdom for cattle have been therefore principally adopted for buffaloes.

The effect of level and method of feeding on milk yield in buffaloes was studied by Kumar and Tripathi (1978). Marrah buffaloes in four groups were studied from 30 days before until 90 days after calving. The buffaloes were fed according to weight, pregnancy, milk yield and milk fat content on a mixed green feed and a concentrate mixture. Group 1, were given their calculated requirements individually, Group 2, had that amount as a group, Group 3 and Group 4 had 120% of requirements individually or as a group. Mean milk yield and fat content were 7.32 kg and 6.14 %, 7.27 kg and 6.35%, 7.69 kg and 5.92% and 8.35 kg and 6.2%. The differences were not significant.

Taparia and Sharma (1980) conducted three experiments, each with 6 lactating Mehsana and Surti buffaloes to investigate the effect of supplementary feeding of concentrates. The treatments were as follows: In experiment 1: Berseem hay ad libitum (H), berseem hay ad libitum and concentrates at 15% of the hay DMI (HC1); berseem hay ad libitum and concentrates at 30% of the hay DMI (HC2). In experiment 2: maize silage ad libitum (S); maize silage ad libitum and concentrates at 15% of silage DMI (SC1); maize silage ad libitum and concentrates at 30% of silage DMI (SC2). In experiment 3: wheat straw ad libitum and concentrates at 30% of straw DMI (WC1); wheat straw ad libitum and concentrates at 50% of straw DMI (WC2); wheat straw ad libitum and concentrates at 70% of straw DMI (WC3). The daily milk production was 5.0-6.8, 4.1-4.6 and 5.0-8.5 kg in experiments 1 to 3 respectively at the time buffaloes were assigned to the experiments. They found that in experiments 1, feeding of supplements resulted in small increases of 0.67 and 0.73 kg in milk yield, on treatment HC1 and HC2, respectively over that of H. In experiment 2, the milk yield of buffaloes increased significantly.
(p<0.01) as a result of supplementary feeding. This increase was 1.1 and 1.7 kg on treatment SC₁ and SC₂, respectively over the yield of treatment S. In experiment 3, supplementary feeding on rations WC₂ and WC₃ resulted in an improvement in milk yield over that of WC₁ (p<0.05). The increase in milk yield being 0.67 and 0.87 kg for WC₂ and WC₃, respectively. The regression coefficient (0.55± 0.16) of FCM on TDN intake, from the pooled data of experiments 1 to 3 was significant (p<0.05). Yadav and Gupta (1983) used 12 lactating buffaloes, giving them diets with roughages: concentrate rations of 80:20 and 60:40. Buffaloes given the diet with a 60:40 roughage-concentrate ratio consumed significantly more DM and TDN and produced significantly more milk than did the animals given the other diet. Singh and Gupta (1983) studied the effect of replacing concentrates by Sorghum-Cowpea silage. For 7 weeks, 12 buffaloes in three groups were given concentrate and wheat straw to the requirements or Sorghum/Cowpea (2:1) silage for maintenance or maintenance plus 2 kg per liter of milk and concentrates for the rest of their requirements. Differences in daily milk, milk fat and SNF contents did not differ significantly between diets. Chauhan and Chopra (1984) replaced the concentrate mix by berseem hay in silage-based rations. The berseem hay (4th and 5th cut material) was incorporated at 33% (T₁) or 66% (T₂) in the concentrate mix of lactating buffaloes on the basis of in vitro digestible organic matter. The basal ration contained maize silage and oat each for 35 days. The milk yield and composition were similar for all the groups. Tsankova et al. (1984) studied the effect of the amount of protein in the diet on milk production in buffalo and dairy cows. In two experiments, two groups of seven Murrah and Murrah X Bulgarian buffalo cows were given diets providing 100% of their energy requirements and protein providing either 100% (controls), or 80% (Experiment 1) or 120% (Experiment 2) of requirements for 63 and 77 days. A 20% decrease in dietary protein did not significantly affect milk yield or fat content. With the higher level of dietary protein, milk yield was 674.5 kg and fat 9.31% compared with 643.4 and 8.48% in controls. The authors did not state whether this difference was statistically significant. The results of these studies indicate that with supplementary concentrate feeding, the DM and TDN intakes were increased which resulted in an increase in milk yields. India and Pakistan have more than half of the total buffalo population of the world. Most of them are maintained in rural areas and owned by
farmers. The standard of nutrition of these buffaloes in most of the rural and urban areas throughout India is very poor. Most milk producing buffaloes are fed on straws and chopped sorghum. The results of a survey made in selected dairies in four cities in the Punjab province of India showed that buffaloes, whether in milk or dry, were not correctly fed (Ahlawat et al., 1960). In Pakistan, farmers normally give a small concentrate allowance during lactation for a month before calving, but the animals subsist mainly on green fodder (Khan, 1974). In the milk colonies near the principal cities, particularly Karachi, the buffaloes are fed principally on concentrates and dry fodder; green fodder is expensive and is given in limited quantities or not at all. Dry fodders consist of hay, wheat straw, chaffed dry maize or sorghum (Wahid, 1973). On state farms particularly in the home districts of the Nili-Ravi breed in the Punjab province of Pakistan, where green fodder is plentiful throughout the year, sorghum, maize, clover, alfalfa, turnips and green oats are usually fed chopped, at a rate of around 50-60 kg/day together with around 5 kg of dry fodder in the form of hay or chopped wheat straw. The maintenance ration of concentrates is usually 1.8-2.7 kg. The production ration is 1 kg for each 3 kg of milk. A ration of 0.5-1 kg is given daily during the last three months of pregnancy. A typical feed concentrate mix should contain two parts of cottonseed cake and one part each of wheat bran, crushed barley or maize and gram (Khan, 1974). In most of the buffalo rearing countries where the effect of season on availability of fodder is pronounced, the total milk yield of buffaloes calving in different seasons show wide variations much of which is likely to be explained by variations in nutrition. As most of the information regarding milk production in dairy buffaloes comes from the state farms or commercial herds where the animals are maintained under standard husbandry conditions; a significantly high milk production during a particular part of the year, coinciding with availability of abundant green fodder and concentrates suggests that nutrition of these buffaloes affects their lactation yield.

2.6 Pregnancy and Milk Composition

Barlow (1934) noted increases in the constituent percentages between the 4th and 5th month of gestation that accompanied the characteristic decline in milk yield. Bailey (1952), Mather et al. (1969) and Wilcox et al. (1959) detected pregnancy effects on fat,
protein, and SNF percentages after 4th month of pregnancy for mature cows and slightly later for the first and second calf heifers. Loganathan and Thompson (1967) reported significant effects of stage of pregnancy on fat yield and SNF percentages, but pregnancy accounted for less than 0.5% of the total variance in each. Mathur et al. (1969) found ratios of SNF:fat and protein:fat declined in late pregnancy. Sharma et al., (1989) reported that in general, yields declined and percentages increased after about 3 months of lactation. Chloride percentage showed an initial decline and then a rise after 2 months. Stage of pregnancy accounted for small but significant variation in most traits; variation was 0.2 to 0.4 % and <0.1 to 3.0 % in yields and percentages for Holsteins, and <0.1 to .2% and .1 to 1.1% for Jerseys. Interactions between stage of lactation and pregnancy were investigated by the response surface methodology and found to be very small, than non pregnant cows over 305 days. Lee et al., (1997) found that pregnant cows produced 265 kg less milk, 9.8 kg less fat, and 9.2 kg less protein than non pregnant cows. Olori et al., (1997) studied the effect of gestation stage on daily milk yield and composition using first lactation weekly test day records of 325 Holstein-Friesian cows in one herd. Gestation stage had a significant effect (p<0.05) on all traits, accounting for 1.38 to 1.69% reduction in total sum of squares for yield traits and <0.4% reduction in total sum of squares for content traits. Decline in daily yield due to pregnancy began from the first month of gestation and increased non-linearly to about 3.0, 0.08, 0.12 and 0.14 kg/day, respectively for milk, fat, protein and lactose yield in the 8th month of gestation, corresponding to 7-12% of the mean daily yield. There was little change in protein and lactose content but fat content increased significantly from the 6th month of gestation. A significant interaction between gestation stage and lactation stage was observed, indicating that the adverse effect of pregnancy was higher in mid-lactation than in late-lactation. Lactation milk fat, protein and lactose yield was estimated to decrease by 21, 1.5, 0.9 and 1.4 kg, respectively, for cows that were pregnant for 3 months during lactation. If pregnant for 8 months, corresponding losses were 207, 8.1, 8.7 and 10.7 kg, respectively due to the effect of pregnancy. Borman et al., (2002) reported a decline in the yield of milk, milk fat, and milk protein, from approximately 90 days in pregnant cows, compared with non-pregnant cows. The difference in production was particularly noticeable during the third trimester of gestation.
Roche (2003) reported a decline in milk yield from 126 days of pregnancy in twins that were pregnant, but the decline was small and insignificant until 147 days of gestation (at 33 weeks of lactation), after which pregnant cows produced less milk (0.8 kg/cow per day). Protein and fat concentration increased in pregnant cows from 77 and 133 days of gestation, respectively. The milk fat yield and protein was not affected by pregnancy until 168 days of gestation, after which pregnant cows produced less milk fat (0.06 kg/cow per day) and milk protein (0.04 kg/cow per day) compared with their non pregnant twins. Leaking of tight junctions (TJ) during advanced pregnancy may account for milk composition differences between pregnant non pregnant animals. Elevated levels of progesterone induce TJ leakiness, and the injection of a progesterone antagonist in mice in late pregnancy resulted in a rapid closure of TJ (Nguyen et al., 2001). The highest level of circulating progesterone was reported to be between 8th week (when placenta is functional) and 17th week of pregnancy in goats (Kornalijnslijper et al., 1997), and was proportional to the number of fetuses. Thus, elevated progesterone concentrations during advanced pregnancy may favor TJ leaking.

2.7 Post Ponception Progesterone Pattern

Singh and Puthiyandy (1980) reported that progesterone concentration in the milk of pregnant buffaloes (24.83 ± 3.85 ng/ml) was significantly higher than those in non-pregnant animals (2.89 ± ng/ml) on day 20 after insemination and the difference between the two values increased with time. Christine and Tomas (1985) reported that the average and baseline concentrations as well as the magnitude and amplitude of ovarian branch of the ovarian vein (OBOV) progesterone on days 70-100 were higher than on days 120-150 of pregnancy in the beef cow. The number of pulses per window and the relative increase of pulses were not different between the two periods. This indicated that from period 1 (days 70-100) to period 2 (days 120-150) during gestation, there was a decrease in the release of progesterone by the ovary, but that the pattern of secretion remained the same. That is, the number of pulses per window and the relative increase of pulses above the baseline remained constant. From period 2 (days 120-150) to period 3 (days 180-210) secretion changed such that there was increase in the concentration of progesterone secreted with each pulse while the number of pulses per window remained unchanged.
This data agree with the report of Erb et al., (1968) that progesterone concentration increased from day 90 to 120 in abattoir samples collected at slaughter or at ovariectomy from pregnant cows. In their study there was a decline in OBOV progesterone after day 120, with the lowest values detected during the period of days 199-237. In study of Christine, and Thomas (1985), however, progesterone concentration increased after Day 180. Alila and Hansel (1984) reported that there is a decrease in the number of small luteal cells as pregnancy progresses in the cow, and that the large, granulosa-cell derived cells disappeared after day 100 of gestation. This may partially explain the decrease in OBOV progesterone concentration from period 1 to period 2 since, under LH stimulation, the small luteal cells are believed to be the major progesterone producers in the corpus luteum of a cow (Ursely and Leymarie, 1979; Koos and Hansel, 1981) and ewe (Fitz et al., 1982). However, this does not explain the fact that there seems to be an increase in ovarian progesterone secretion during period 3. The apparent decrease in progesterone production by the ovary found during period 2 (days 120-150), without a corresponding decrease in the jugular vein (JV) progesterone. Increase in progesterone concentration could be explained by the increasing capacity of the placenta to produce progesterone on days 90-150 (Shemesh et al., 1984), which would compensate for the reduced ovarian progesterone release. The fact that the changes in OBOV progesterone concentrations are not reflected in the JV could also be due in part to a change in the metabolic clearance rate of progesterone in the periphery. In pregnant women, transcortin levels increase as gestation progresses (Cheeseman, 1982). This would allow a longer clearance rate for progesterone in the periphery as well as an increase in the peripheral levels of progesterone.

Sousa et al., (1999) investigated blood progesterone levels in pregnant goats, and reported that it differed significantly between the first and third week of gestation. Later changes within the two week intervals were not that distinct. However, during the whole pregnancy the authors did not observe progesterone levels exceeding 10 ng/ml.

2.8 Progesterone and Milk Yield

Decline in milk yield after the peak is associated primarily with a decline in cell number of mammary gland due to apoptosis (Knight and Wilde, 1993), while decline in
milk yield during pregnancy is associated primarily with a decline in milk synthesis and the rate of secretion accompanying the increase in progesterone (Forsyth, 1999). The distinct decrease in milk yield occurs at about 5th or 6th month of gestation (Schmidt, 1971; Coulon et al., 1995). In cows during early pregnancy, the progesterone concentration curve appears to be diphasic over time: increasing during 3 to 12 days after mating, leveling off until about 30 day, and increasing further to 39 day (Henricks et al., 1972). However, late in pregnancy, progesterone levels tend to level off after about 50 day of gestation and start to decline around 250 day to undetectable levels at parturition (Gomes and Erb, 1965; Erb et al., 1968). The effect of progesterone during pregnancy on decrease in milk yield can be seen around 150 day of gestation (Schmidt, 1971; Coulon et al., 1995). This finding is consistent with findings in cows whose concentration of progesterone in blood reached relatively high levels by about 130 day after pregnancy (Gomes and Erb, 1965). Grossman and Koop (2003) concluded that milk yield increases rapidly to a peak as the secretion rate increases, maintains a level for a period of time, and then decreases until the end of lactation as mammary gland cell number decreases due to apoptosis.

Reksa et al. (2002) reported relationships among milk progesterone, concentrate allocation, energy balance (EB), milk yield and conception rate in 146 lactations in 94 moderate yielding cows. The conception rate increased linearly by rising milk progesterone for values of cumulative progesterone in the lowest third of the range, whereas the likelihood of conception did not differ between milk progesterone concentrations within the upper two-thirds. This implies that the progesterone values were below a threshold value for optimal reproductive success in one-third of the services performed in this study. Milk progesterone concentrations during the third luteal phase postpartum were low when the high-energy diet was fed. Negative EB was associated with reduced values for milk progesterone during the third luteal phase in second parity cows. Likewise, milk yield was inversely related to progesterone levels during both the first and third luteal phases postpartum in second parity cows. Energy balance was higher and milk yield lower during peak lactation among second parity cows that conceived compared to cows that remained open after the first artificial insemination. The present study has demonstrated an association between likelihood of conception and the energy
coverage in Norwegian cattle. This relationship is possibly mediated through progesterone deficiency.

2.9 Supplementation and Progesterone

Under nutrition or negative energy balance may compromise pregnancy through its effects on the corpus luteum. High milk producing dairy cows have lower blood concentrations of progesterone and the lower blood progesterone concentration may lead to infertility (Lucy, 2001). There is a positive association between blood progesterone concentrations and pregnancy (Lamming and Darwash, 1998). Cattle that are underfed have smaller corpora lutea and lower blood progesterone concentrations (Gombe and Hansel, 1973). Cyclic cattle that are underfed have progressively smaller and less estrogenic dominant follicles before they succumb to anestrus (Bossis et al., 1999). The smaller dominant follicles give rise to smaller corpora lutea. Steroidogenic capacity of the luteal cells is also dependent on hormones such as somatotropin, insulin and IGF-I that are controlled by the nutrition of the cow (Lucy, 2000).

Paque et al.(1990) worked on forty clinically normal lactating Holstein cattle from a herd involved in a natural outbreak of chronic nitrate toxicosis dividing into 2 equal groups according to production, stage of lactation, age, and apparent pregnancy state (pregnant or non pregnant). One group was fed a low-nitrate ration (average of 356 parts per million (ppm) on dry matter basis in concentrate; less than 400 ppm in free-choice hay for first 5 wks of study). The 2nd group was fed a high-nitrate (HN) ration (average of 1,600 ppm in protein concentrate-amended corn silage; 4,000 ppm in free-choice hay for the 8-week study). At the end of the study, the 2 groups were classified according to their starting reproductive status: non pregnant (open); early pregnant (less than 60 day); mid pregnant (average of 105 days). Milk production, milk fat, and milk nitrate concentrations were similar for cows fed both rations. Serum progesterone concentration (SPC) was depressed (P less than 0.05) in cows fed the HN ration. This effect was prominent in open, luteal phase cows, less prominent but still apparent in early pregnant cows, and absent in mid pregnant cows. The early reproductive problems of chronic nitrate toxicosis may be due to depression of SPC. A possible mechanism of inhibition of luteal progesterone synthesis by inhibition of cytochrome P-450 is presented.
Lucy (2001) reported that increased milk yield and good reproductive performance do occur in many dairies and suggest that insufficient management is playing a major role in reduced reproductive performance. For example, even within well managed herds, the highest producing cows do not necessarily have the poorest reproductive performance. Plots of accumulated energy balance during the first 28 days postpartum against days to first increase in plasma progesterone with healthy herd mates identified as low, medium, or high producers or identified as pregnant or non pregnant by 100 days in milk typically indicate no discernable pattern. Some high producing cows have large energy deficits in early lactation, yet begin cycling soon after calving and conceive at their first insemination after the voluntary wait period. The difference between these cows and apparently healthy herd mates that produce less, have moderate energy deficits, fail to cycle, and fail to conceive.

Poor nutrition and body weight loss decrease circulating progesterone concentrations and as mentioned previously, selection for increased milk yield has reduced plasma progesterone concentration (Lucy and Crooker, 2001). It has been hypothesized that growth and development of follicles during periods of negative energy balance lead to impaired development of the CL and a reduction in progesterone secretion (Butler, 2000). Cows that produce more milk have smaller CL at the peak of lactation (Lucy, 2000) and CL size has been correlated positively with circulating progesterone concentration (Sartori et al., 2002). However, circulating progesterone concentration is determined by rates of secretion and clearance. Clearance rates of progesterone increase with feed intake due, in part, to an increase in hepatic metabolism (Sangsritavong et al., 2002). Therefore, at least two factors (CL size and feed intake) appear to be responsible for the reduction in circulating progesterone in cows that produce more milk.

The addition of fat to the rations of dairy cows resulted in an increase in the levels of progesterone in blood (Lucy et al., 1993). Progesterone is synthesised by the corpus luteum and is responsible for good implantation of the embryo in the uterus and helps to maintain gestation, providing the embryo with food. There are two possible reasons for explaining the increase in progesterone in blood. It could be related to an increase in blood cholesterol or due to large size of the follicles when the diet is supplemented with
fat. It should be remembered that one of the precursors of progesterone is cholesterol. This is necessary for the formation of chylomicrons and, as a result, it increases naturally when the levels of fat in the ration are increased. The work of Grummer and Carrol (1990) and Lucy (1993) showed this relationship between the higher level of fat in the diet and the increase in plasma progesterone. But the level of cholesterol is not the only factor that could explain the increase in plasma progesterone. Lucy (1993) observed a direct relationship between the addition of fat and the size of the follicles and, as a result of the corpus luteum. The larger the size of the corpus luteum the greater the synthesis of progesterone. Singh and Puthiyandy (1980) estimated progesterone in buffalo milk. Fats and milk samples were collected on day 20, 24, 28 and 40 after insemination. The percentage of fat and their progesterone concentration in the milk were correlated (p<0.01)

2.10 Service Period, Lactation Yield and Length

Considerable variation in the service period, or the period between calving and conception of buffaloes, in different countries has been observed. In Indian buffaloes it ranges between 129 to 202 days, in Pakistani buffaloes it varies from 190 to 221 days whilst in Egyptian buffaloes it is between 135 to 283 days (Gondal 1985).

A significant positive correlation between service period and lactation milk yield has been reported by Ragab et al., (1956) in Egyptian buffaloes. The others observed that the correlation between service period and milk yield in Egyptian buffaloes was only significant for first lactation animals (0.28). Basu and Ghai (1978) also reported a significant positive correlation between service period and lactation milk yield. A very highly significant effect of service period on first lactation milk yield with a correlation coefficient of 0.30 was reported in Indian buffaloes (Kanaujia and Balaine 1975). Polikhrhonov (1965) reported that generally in Bulgarian buffaloes both lactation length and milk yield were greater when the service period was longer. Increase in both milk yield and lactation length following an increase in service period in Indian buffaloes was also reported by Venkayya and Anantakirshnan (1957).

In dairy cattle possibility of extending lactations has received attention as an alternate to maximizing the peak yield and minimizing the calving interval (Knight, 1997;
Extended lactations can be accomplished by planned increase in calving interval (Bertilsson et al., 1997) for example, and by use of bovine somatotropin to increase daily yield (Van Amburgh et al., 1997). Expected benefits of extended lactations, defined as calving every 18 months or more, might include reduction in the number of excess progeny, insemination costs, number of days dry within cow's lifetime (FAWC, 1997). For the animal well being, there could be benefits in reduced metabolic stress, in exposure to fewer periods of high risk, and in increased longevity (FAWC, 1997; Knight, 1998). Extending the lactation, however, has its problems for high-yielding dairy cows. It is sometimes difficult to get cows pregnant at the desired time (i.e., 9 months after calving), because some cows become too fat and perform unsatisfactorily in late lactation. Nevertheless, one approach to extend the lactation is to alter the shape of the lactation curve to produce flatter, more persistent, prolonged lactations (FAWC, 1997). In case of dairy buffalo the delay in post partum breeding is mainly associated to inestrus, poor heat detection, and poor quality of semen, or deplete for more milk in current lactation (Sayed et al., 2003).

According to Schmidt (1971), pregnancy has an inhibitory effect on the milk yield of dairy cows, particularly during the latter part of the lactation. The way in which pregnancy inhibits milk secretion has not been fully understood. Hafez (1972) stated that the conditions associated with advanced stage of pregnancy particularly after the first twenty weeks following fertile service are inhibitory to production; because increased blood supply to the fetus may limit or inhibit the supply to the mammary gland and thereby reduce the milk secretion. Another possibility is that pregnancy inhibits the milk secretion by changing the levels of hormones in the body e.g. a combination of oestrogen and progesterone has an inhibitory effect on milk secretion in most animals (Schmidt, 1971). It is possible that in late pregnancy estrogen and progesterone increase to a level that inhibits milk secretion. The increased lactation yields associated with longer service period may therefore be due to shifting of the effect of advanced pregnancy from the latter part of lactation.

From the above data it is evident that the lactation milk yield is affected by the pregnancy, the effect depending upon the length of the service period. It can be assumed
that the lactation length would also increase with increase in the service period which could result in higher lactation yields. However, the gain thus made would be offset by the corresponding increase in the calving interval, which in turn would reduce both annual milk yield and the calf crop. The longer service period would therefore not be an economic proposition for obtaining better lifetime production from dairy buffaloes.

2.1.1 Service Period, Dry period and Calving Interval

Tiwana et al., (1994) and Usmani et al., (1997) reported that variation in service period significantly affected dry period. Exceptionally long or short dry periods will adversely affect the profitability of individual cows. A short dry period will not provide adequate rest and time for mammary afford regeneration, while long dry periods will result in higher feed costs with no income from milk production. Long dry periods can also result in fat cows that are more prone to problems with health and reproductive performance. Each day dry period over 60 days costs $3. However, each day dry period under 40 days costs $2. (Smith, and Becker, 1994)

Length of calving interval is one of the major traits affecting the economic efficiency of the herd. Deliberate or natural delay in breeding of dairy animals directly affect calving interval and in turn the net profit from an animal (Syed et al. 2003). Tiwana et al., (1994), Nasir et al., (1994), Usmani et al., (1997) and Sujit et al., (2000) reported that first calving interval was significantly affected by service period in dairy buffalo. Shivi et al., (2001) reported that the affect of service period on first calving interval was less significant in Murrah buffalo. Preliminary data from a Danish study with two small herds (Bertilsson et al., 1997) did not show any significant differences in reproductive efficiency in herds managed for a 12, 15 or 18 month calving interval. However, the longer voluntary waiting period (VWP, 140 days) in herd 1 numerically showed a better reproductive efficiency.

Cornell University compared the reproductive performance of cows with a voluntary waiting period of 60 or 150 days that were treated with BST (Van Amburgh et al., 1997). The estrus detection, conception and pregnancy rates were not different between both groups. Although the cows with the extended voluntary waiting period spent more time later in the lactation but average daily milk yield during the entire
lactation was similar (79 vs. 69 lbs). The economic comparison of calving intervals of 13.2 vs 18 months, including use of BST, showed that the extended calving interval was $274 / cow / year more profitable. The majority of this profitability was explained due to increased milk income over feed cost during a cow's productive life. The authors concluded that extending the calving interval to 16.5 months might be economically warranted, especially in high producing herds. This would push the voluntary waiting period to 150 days. Especially first parity cows could benefit from an extended calving interval. An other large study (Mc-Grath et al., 2003) evaluated voluntary waiting periods of 60 and 165 days, with and without the BST in 26 herds. Delayed breeding resulted in more days dry, longer calving intervals, and similar percentages of cows pregnant. The authors concluded that delayed breeding increased net income over feed cost and BST cost per cow per year in first parity cows but not in older cows (Lormore, 2003). In Israel, the voluntary waiting period was delayed in first parity cows from 90 to 150 days and in older cows from 60 to 120 days (Arbel et al., 2001). Conception rates for both voluntary waiting periods were similar in each parity group, but first parity cows had greater conception rates. Milk yields per day, measured as energy corrected milk, were 1.7 lbs higher in first parity cows but similar in older cows. During the first year in which the voluntary waiting period was delayed, profit per day was increased by $0.19 in first parity cows and $0.12 in older cows. Results in the second year were also in favor of the delayed voluntary waiting period group. These authors also concluded that first parity as well as older cows with extended lactation were more profitable. Again the advantage for the first parity cows was greater because of their more persistent lactation curves.

A Danish study concluded, that extending the voluntary waiting period by an additional 70 days was not profitable (Sorensen and Østergaard, 2003). Herd profitability was reduced by 1 to 4% and the reduction was greatest in herds with poor reproductive efficiency. These authors concluded that their economic analysis was sounder than in the study by Arbel and others in Israel. The Israeli study did not properly accounted cow culling and replacement costs. If herd replacement is included, then the effect of lactation persistency and the number of days dry per year will be less important then when only consecutive lactations for single cows are considered. Economic analyses with computer programs that optimize breeding and culling decisions also revealed that high producing
and persistent cows could have extended voluntary waiting periods and should be rebred longer before being culled (Dekker et al., 1998; Rajala-Schultz et al., 2000). Such programs have also shown that seasonality in performance and prices has a significant effect on optimal breeding decisions.

2.12 Service Period and Yield per Day of Calving Interval

Yield per day of calving interval is the most important trait from economic point of view. It is the function of milk produced by a buffalo in lactation between two successive calvings. Arbel et al., (2001) conducted a field trial to examine the effect of extended CI on production and profitability of high yielding cows (n = 937). First insemination was performed at 154 and 93 days post partum (pp), for treatment and control primiparous cows, respectively, and at 124 and 71 days pp for treatment and control multiparous cows, respectively. The authors reported that primiparous and multiparous cows with extended lactations were more profitable. During the first experimental lactation there were advantages of $0.19 and $0.12 per days of CI in the net returns for primiparous cows and multiparous cows with longer CI, respectively. When the economic analysis included the first experimental lactation plus the first 150 days of the subsequent one, the net return per day of CI was higher for cows with an extended VWP: $0.21/days and $0.16/days for primiparous and multiparous cows, respectively. A delay of 60 days, with respect to the usual VWP in the beginning of inseminations of high-yielding cows, has economic advantages and allows the farmer an option for decisions regarding individual cows. Weller and Folman (1990) stated that late conception reduced profitability and showed early breeding to be advantageous, especially if the value of a calf is high.

Other studies have demonstrated an advantage for a longer days open (DO) period: Bar-Anan and Soller (1990) reported that in high-yielding herds the highest productivity in the current and subsequent lactations was achieved by primiparous cows that were inseminated not earlier than 70 days pp and by multiparous cows at 41 to 90 DO. Heimann (1984) advocated prolonged calving intervals, particularly for high-yielding cows with good persistency, whereas Weller et al., (1985) reported that conception before 60 post partem had an adverse effect on the annual cumulative milk
yield of the current and following lactations, and found that 110 to 130 days DO to be optimal for primiparous cows.

Farmers deliberately delaying breeding of their animals receive a high lactation yield but face a significantly heavy loss due to significant reduction in milk yield per day of calving interval. Sayd et al., (2003) reported that yield per day of calving interval was positively correlated with lactation yield ($r = 0.85; p = 0.001$) and negatively correlated with calving interval ($r = 0.46; p = .001$).
III. MODELING AND MANAGEMENT OF POST-CONCEPTION DECLINE IN MILK YIELD OF DAIRY BUFFALOES

Sarzamin Khan, Nazir Ahmad, Muhammad Subhan Qureshi, Muhammad Amjed and Muhammad Younas*
Faculty of Animal Husbandry and Veterinary Sciences, NWFP Agricultural University, Peshawar-25120, Pakistan
* Department of Livestock Management, University of Agriculture Faisalabad, Pakistan.

3.1 ABSTRACT

Dairy buffalo is the major source of milk production kept under peri-urban, low input production system. There is no practice of feeding animals according to production requirements; exposing them to nutritional deficiency with the onset of pregnancy. It leads to a decline in milk yield, which compels the farmers to keep the animals un-bred. The present work was completed under two studies to document, model and manage the post-conception decline in milk yield. The first study comprised analysis of 30912 weekly milk yield records for 48 weeks of lactation pertaining to 465 pregnant and 179 non-pregnant buffaloes from three locations. Under the second study reduction in milk yield due to pregnancy was worked out as the difference between milk yield of 23 pregnant and 17 non-pregnant buffaloes, through various models. The buffaloes were provided with three treatments: i) pregnant-ration-traditional (PRT); ii) pregnant-ration-supplemented (PRS) and; iii) non-pregnant-ration-traditional (NPRT). The animals were categorized into HMY, MMY, LMY, producing 66-75, 56-65, 46-55 Litre/week, respectively. Milk production was recorded up to 23rd weeks and the difference in means was worked out. Reduction in milk yield was effected by location, conception season, lactation week, gestation month and parity. Gestation month contributed to the reduction in milk yield by 1.4%. Parity 3 showed the least reduction followed by parity 2, 4, 1, 5, and 6, indicating it as the best phase for milk production in dairy buffaloes. The reduction was apparent after 5th week of conception and was significant in the 7th week. The line JP8 model (two straight lines with joining point at week 8) gave good fit ($R^2 = 0.9527$) and the predicted values were much closer to the actual. In the high yielders, the
predicted reduction was highest (-4.48 Litres/week) than moderate and low yielders (-2.37 and -0.94 Litres/week, respectively) during 6\textsuperscript{th} week post-conception. The treatment effect was significant after 6\textsuperscript{th} week. The group x treatment interaction affected milk yield decline on 4\textsuperscript{th}, 6-9\textsuperscript{th}, and 14-15\textsuperscript{th} and beyond 18\textsuperscript{th} week post-conception. In HMY buffaloes, the average weekly yield was 50.0, 45.8, 50.9 L in PRS, PRT and NPRT treatments, respectively. The respective values were 38.7, 36.0 and 40.6 Litres/week for MMY buffaloes and 29.5, 23.0 and 29.9 Litres/week for LMY. In HMY, the decline in PRS was moderate while in PRT it was the greatest and in NPRT was the smallest. In the MMY the supplementation support to milk yield was smaller than the HMY. In LMY buffaloes the decline was drastic in PRT than the other two treatments. It may be concluded that the onset of pregnancy in dairy buffaloes results in drastic decline in milk yield at an early stage and the high yielders are more sensitive. Buffalo does not loose body condition rather decrease milk yield rapidly than the cattle, after the onset of pregnancy. An animal becoming pregnant, if supplemented at the rate of 1 kg per 2 liters of milk will retain yield level for a longer duration post-conception. In the high milk yielders the cost of this supplementation was ten times less than the loss due to milk yield decline.

**Keywords:** Milk yield, pregnancy, nutrition, dairy buffalo

### 3.2 MATERIALS AND METHODS

The present investigations were completed under two studies at buffalo farms in the central valley of North-West Frontier province of Pakistan situated at 31-37\degree N and 65-74\degree E. Climate of this region is of continental type. The first study was made at a large sized state farms in which the decline pattern of milk yield with the onset of pregnancy was recorded, as effected by various factors. In the second study a controlled experiment was conducted on a medium-sized private farm to model the predicted decline in various yield groups and lactation stages. The third study comprised preventing decline in milk yield through feed supplementation of the pregnant group at a medium-sized private farm to compare it with non-supplemented pregnant and non-pregnant animals.
3.2.1 Study I: Decline pattern in milk yield

Selection of animals: The experimental units were three large sized state farms (number of animals varying from 150 to 300). These farms possess sufficient land, manpower and financial resources. Standardized procedures are in practice at these farms under a central command.

The period of this study was from the year 1995 to 2005. Complete milk yield records for 48 weeks of lactation were obtained for 465 pregnant and 179 non-pregnant buffaloes from three locations and thus a total of 30912 weekly milk yield records of pregnant and non-pregnant buffaloes were available for analysis of the effect of pregnancy on milk yield. Information on season of conception (as defined by Qureshi et al., 2002), conception week (10\textsuperscript{th} to 35\textsuperscript{th} week of lactation), and parity (1 to 6) was available for pregnant animals. For non-pregnant buffaloes information on parity was also available.

Statistical analysis: The models adopted by Olori et al., (1997) were modified as follows. Model-1, involved gestation stage in months was fitted using all the 30912 records. Then a reduced model-2 was fitted excluding gestation stage. The reduction in milk yield due to pregnancy was worked out relative to their non-pregnant counterparts. Only the data for lactation weeks after conception were analyzed to find out the milk reduction. Model 3 was used to analyze the factors affecting milk yield reduction due to pregnancy:

\[ Y = L + P + L \times P + LW + GM + E \]  \hspace{1cm} (1)

\[ Y = L + P + L \times P + LW + E \]  \hspace{1cm} (2)

\[ RY = L + CS + P + LW + GM + E \]  \hspace{1cm} (3)

Where \( Y \) is milk yield, \( RY \) is the reduction in milk yield; \( L \) is location, \( P \) is parity, \( LW \) is lactation week, \( GM \) is gestation month, \( CS \) is conception season \( E \) is the residual term associated with the model. The milk records were divided in three subsets: lactation weeks 11-28 (early lactation); 29-36 (mid lactation); and 37-48 (late lactation) and analysed separately to estimate the effect of pregnancy at different lactation stages.
3.2.2 Study II: Modeling and managing decline in milk yield

Selection of animals: The period of this study was July 2005 to December 2005, conducted at a medium-sized private buffalo farm. All experimental animals were stall-fed and provided green fodder ad lib. Water shower was provided to all animals during hot season twice a day at the farm. Drinking water was provided three times daily. Animal sheds were washed twice daily at morning and evening. Twice a day milking was practiced at 4 am and 4 pm. Vaccines against hemorrhagic septicemia and Foot and Mouth disease were administered to all experimental animals, as per prevailing practice. Anthelmintic drench of Levamisole hydrochloride plus Oxychloasanid was provided according to manufacturer instructions at the start of experiment.

The feeding regime was adopted as follows:

Basal ration: It comprised green fodder ad lib during June through October including maize, sadabahar (sorghum x sudan grass) and sorghum. During November to May, Egyptian clovers, oats, brassica and wheat straw were offered.

Traditional ration: In addition to the green fodder, animals were provided a commercial concentrate; having 18% crude protein and 72% total digestible nutrients at the rate of 1.5 kg per animal irrespective of its lactation stage, milk yield level and pregnancy stage, as per the routine practice under the conventional farming system in the region. This constituted ration for all the non-pregnant and one group of pregnant experimental animals.

Supplemented ration: In addition to the basal ration, the same commercial concentrate was provided at the rate of 1 kg per 2 liters of milk as recommended by Ranih (1994) for lactating buffaloes under tropical conditions. This ration was provided to one group of pregnant animals.

Experimental design: Forty adult buffaloes were selected for this study. Milk production was recorded daily in litres and pooled to weekly intervals starting from the date of conception, through 25th weeks post-conception. The animals were selected, after conception was confirmed through milk progesterone profiles 21 days post-breeding as reported (Qureshi et al., 2000 b).
conception was confirmed through milk progesterone profiles 21 days post-breeding as reported (Qureshi et al., 2000 b).

Treatments:

\[ PRT \quad \text{(Pregnant-Ration-Traditional, n=12 x 23 weeks)} \]

\[ PRS \quad \text{(Pregnant-Ration-Supplemented, n=11 x 23 weeks)} \]

\[ NPRT \quad \text{(Non Pregnant-Ration-Traditional, n=17 x 23 weeks)} \]

Production groups

\[ HMY: \quad \text{High milk yielders, 66 to 75 L/wk (n=12 x 23 weeks)} \]

\[ MMY: \quad \text{Moderate milk yielder, 56 to 65 L/wk (n=16 x 23 weeks)} \]

\[ LMY: \quad \text{Low milk yielders, 46 to 55 L/wk (n=12 x 23 weeks)} \]

Statistical Analysis: Reduction in milk yield due to pregnancy was calculated as the difference between milk yield of 23 pregnant and 17 non-pregnant buffaloes. The data for milk yield reduction per week for week 1 to 23 of pregnancy were used to investigate milk yield reduction due to pregnancy. Eight different models were applied. MS Excel workbook was programmed to fit different models. Two straight lines model (Draper and Smith, 1981, Neter et al., 1985) with a joining point at 8 weeks had good fit and \( R^2 \) of 0.9629, while the quadratic model also gave a good fit with an \( R^2 \) of 0.9863. Empirically, the quadratic model seems to be better because of its higher \( R^2 \), but logically we prefer the model with two straight lines as the first line reflects a little decline while the second line gives a drastic decline at certain stage of gestation.

For dairy cows, Coulon et al., (1995) modeled the effect of pregnancy stage on milk yield. In present study the correction term was modified to \( Pw - 5 \), because the effect of pregnancy was noted after 5th week post-conception. The modified model was applied as follows:

\[
Y = -e^{0.9602 \{PW-5\}} \cdot e^{-0.15 \cdot PW}
\]  

(4)

Where \( Y \) is the decline in milk yield, \( PW \) is the postpartum week and \( e \) is the base of natural logarithm. In this study two straight lines gave better fit (\( R^2 = 0.9629 \)) for the reduction of milk due to pregnancy than Coulon et al. (1995) model (\( R^2 = 0.9445 \)).

Weekly yield decline: Milk yield data for each week were statistically analyzed using the following linear model:
\[ Y_{ijk} = \mu + \rho_i + \alpha_j + (\rho \alpha)_{ij} + \epsilon_{ijk} \] (5)

Where, \( Y_{ijk} \) is the \( k \)th observation of the \( i \)th group and \( j \)th treatment; \( \mu \) is over all mean; \( \rho_i \) is \( i \)th group effect; \( \alpha_j \) is \( j \)th treatment effect; \( (\rho \alpha)_{ij} \) is interaction between \( i \)th group and \( j \)th treatment; and \( \epsilon_{ijk} \) is Random effect associated with \( k \)th animal of the \( i \)th group and \( j \)th treatment.

*Interactions among groups, treatments, and weeks:* The milk yield data were also analyzed as combined over weeks to find out interactions among groups, treatments, and weeks. The following model was used for the combined analysis:

\[ Y_{ijkl} = \mu + \rho_i + \alpha_j + \beta_k + (\rho \alpha \beta)_{ij} + (\rho \beta)_{ik} + \rho \alpha \beta_{ijk} + \epsilon_{ijkl} \] (6)

Where, \( Y_{ijkl} \) is the \( l \)th observation of the \( i \)th group, \( j \)th treatment, and \( k \)th week; \( \mu \) is over all mean; \( \rho_i \) is \( i \)th group effect; \( \alpha_j \) is \( j \)th treatment effect; \( \beta_k \) is the \( k \)th week effect; \( (\rho \alpha)_{ij} \) is interaction between \( i \)th group and \( j \)th treatment; \( (\rho \beta)_{ik} \) is the interaction between the \( i \)th group and \( k \)th week; \( (\rho \alpha \beta)_{ijk} \) is the interaction between the \( i \)th group, \( j \)th treatment, and \( k \)th week; and \( \epsilon_{ijkl} \) is random effect associated with \( k \)th animal of the \( i \)th group and \( j \)th treatment.

*Yield decline in two phases:* Combined analysis was made for the first eight weeks, for the last 15 weeks, and for all the 23 weeks of the milk yield data, because the decline seemed to be affected by pregnancy and ration in weeks- 9 to week-23.

### 3.3 RESULTS

#### 3.3.1 Study 1: Decline pattern in milk yield

Analysis of variance for effects of location, parity, lactation week, gestation month, and location-parity interaction, on milk yield in Model 1 showed a significant affect of location while in model 2, excluding the pregnancy, the effect was non-significant. The other factors affected milk yield significantly in both the models. The GM (gestation month) effect was calculated as described by Olori et al., (1997).

\[
\text{GM effect} = \frac{\text{Residual SS model 2} - \text{residual SS model 1}}{\text{Total SS}} \times 100 = 1.44 \%
\]
Analysis of variance for reduction in milk yield showed a significant effect of location, conception season, parity, and lactation week and gestation month on milk yield reduction after conception. Parity 3 showed the least reduction followed by parity 2, 4, 1, 5, and 6, indicating it as the best phase for milk production in dairy buffaloes.

The data in Table 3.1 indicates that post-conception reduction in milk yield was earlier in the buffaloes that conceived during 11-28 weeks of lactation, followed by those conceived during 29-36 and 37-48 weeks of lactation, respectively. Noticeable reduction in milk yield was found during 3rd, 5th and 6th month of pregnancy in the animals conceiving at early, mid or later stages of lactation.

The Figure 3.1 shows the changes in milk yield with the advancement of pregnancy as compared with non-pregnant animals. It is evident that initially the milk yield in pregnant animals increases up to 2 months post-conception and then decreases at an almost constant rate.

3.3.2 Study II: Modeling and managing decline in milk yield

The linear model did not give good fit which is clear from the predicted values of the model ($R^2 = 0.9237$) Table 3.2. The quadratic model though gave good fit ($R^2 = 0.9863$) yet predicted values seem to be slightly different from the actual values. The line JP8 (joining point at week 8) model also gave good fit ($R^2 = 0.9527$) and the predicted values were much closer to the actual values. The decline in milk yield with the advancement of pregnancy was slight up to a point which we declared as joining point; thereafter the decline was much greater.

The actual and predicted reduction in milk yield due to pregnancy is given in Table 3.3. The reduction in milk yield started after 5th week of conception and became significant on 7th week as evident from the Table 3.4 and Figure 3.2.

The Figure 3.3 shows post-conception reduction in milk yield in the high, moderate and low milk yielding buffaloes. The reduction in high yielding buffaloes was slight up to 16th week but later on it became drastic. In the moderate milk yielding buffaloes the reduction was the least while in the low milk producing buffaloes the reduction was slightly greater. In the high yielders, the predicted reduction was the highest (-4.48 L/wk) followed by the moderate and low yielders (-2.37 and -0.94 liters/wk), respectively.
during 6th week post-conception. It shows the sensitivity of the high yielding buffaloes to the onset of pregnancy. Total predicted reduction in milk yield due to pregnancy in various production groups (6-23 weeks post conception) was 173.97, 100.81 and 129.14 liters, respectively.

**Managing decline in milk yield**

The differences in weekly milk yield of buffaloes recorded from 1 to 23 week, as affected by various treatments in the three production groups, are shown in Table 3.4. The difference among the high, moderate and low yielders was significant throughout the lactation. The effect of supplementation on decline after 5th week was apparent but became significant in 7th week. The group x treatment interaction had significant effect on milk yield decline during 4th, 6-9th, 14-15th and beyond 18th week post-conception.

Average milk yields of the high, moderate and low production group of buffaloes over 23 weeks period, affected by ration and pregnancy are presented in Figure 3.4. The average weekly milk yield of the high yielding animals was 50.0, 45.8, 50.9 litres/week in the pregnant-ration-supplemented (PRS), pregnant-ration-traditional (PRT) and non-pregnant-ration-traditional (NPRT) buffaloes, respectively. For the moderate yielding buffaloes the values were 38.7, 36.0 and 40.6 litres/week, respectively, showing a decline in milk yield in animals, both on supplemented and traditional rations. The low yielders showed a decline pattern (29.5, 23.0, 29.9 litres/week for PRS, PRT and NPRT buffaloes) almost similar to the high yielders.

A treatment x week interaction is shown in Figure 3.5 A – 3.5 C. In the high production group (Figure 3.5-A), the decline in PRS was moderate while the decline in PRT was the highest and in NPRT was the lowest. These results showed that supplementation of the pregnant animals with concentrate feed maintained milk production levels post-conception while a drastic decline in milk yield was seen in pregnant buffaloes on traditional ration. In the moderate production group (Figure 3.5-B) the supplementation support to milk yield was smaller than the high yielding group. However, beyond the 15th week post-conception, the decline in yield in the pregnant buffaloes on traditional ration was greater. It shows a little beneficial affect of feed supplementation to the moderate yielding buffaloes. In the low production group (Figure
3.5-C), the pregnant buffaloes on supplemented ration maintained the milk yield almost similar to the non-pregnant buffaloes on the traditional ration.

**Combined analysis of 23 weeks milk yield:** The data for milk yield during a period of 23 weeks was analyzed using combined analysis of variance. (Table 3.5). The difference in milk yield among the production groups (high, moderate and low yielders) and treatments (pregnant with supplemented ration, pregnant with traditional ration and non-pregnant with traditional ration), was significant (p<0.01). Effect of post-conception weeks was also significant (p<0.01). Interaction between production groups x treatments, and treatments x post-conception weeks was significant (p<0.01). Interaction among the production groups x weeks x treatments was also significant (p<0.01). Interaction between production groups x post-conception weeks was non-significant.

### 3.4 DISCUSSIONS

**3.4.1 Decline in milk yield**

A noticeable reduction in milk yield was observed during 3rd, 5th and 6th month of pregnancy in buffaloes conceiving at the earlier, mid or late stages of lactation. It shows that onset of early pregnancy results in a drastic decline in milk yield at an early stage compared to those conceiving at later stages. Similarly, Olori et al., (1997) reported that the adverse effects of pregnancy were higher in mid-lactation than in late lactation dairy cows.

The decline in milk yield with the advancement of lactation is a natural phenomenon, while pregnancy further accelerates its rate. Lactation curve of buffaloes has been studied previously. Gondal (1985) provided a lactation curve for Pakistani dairy buffaloes with constants a, b and c. The three constants correlated with the milk yield (p<0.001). A rapid and then a gradual postpartum increase was found up to 8th week (a=37.453 ± 10.003, b=0.300±0.162) followed by a gradual decrease up to the end of lactation at 40th week (c=0.0373±0.0173). In Egyptian buffaloes, the greatest value of the initial milk yield (a) was in parity 10, while the lowest value was in the first parity. In contrast, the highest rate of increase to peak production (b) was in the first parity and the lowest was in parity 10.
The rate of decline after peak (c) was fairly constant and ranged between 0.02 and 0.03 kg. Values of $r^2$ ranged between 0.90 and 0.98 (Aziz et al., 2006).

These studies show that peak yield is attained in dairy buffaloes before 3rd month of lactation. This is a physiological phenomenon in dairy animals. Tucker, (2000) suggested that hormone concentrations, hormone receptors, growth factors, and binding proteins in blood; hormonal regulation of nutrient partitioning; and hormonally induced mechanisms of action within mammary cells possesses a due role in maintaining milk yield, control of mammary growth and lactation however, the greatest physiological stimulus for milk yield is pregnancy, not some cocktail of exogenous factors. Svennersten-Sjauanja and Olsson (2005) agreed with the concept and reviewed previous studies reporting that the mammary blood flow suddenly increased tremendously at parturition, full development of the capillary network and metabolic activity, as judged by the occurrence of carbonic anhydrase activity in the capillary endothelium, was not reached until several days after the onset of lactation in goat (Cvek et al., 1994). The blood flow to the mammary gland is thereafter correlated to the milk yield of the animal and decreases after peak lactation when the lactation curve declines (Linzell, 1974).

In this study the pregnancy occurred after the period when the physiological decline in milk yield was already in progress. It is suggested that the onset of pregnancy share the nutritional partitioning and the buffaloes prioritize activities as follows: i) maintain the body condition; ii) meet the development requirements up the fetus; iii) and milk synthesis. Thus, the natural increase in milk yield was prevented by the early onset of pregnancy.

3.4.2 The period of notable decline

At medium sized private dairy farms the reduction in milk yield started after 5th week post-conception. This reduction is noticed at much earlier stage in buffaloes than the 20th week of pregnancy in dairy cows as reported by Coulon et al. (1995). Erb et al. (1952) reported that the decline in milk yield post conception neither depended on the stage of lactation at the time of conception nor on the cow's characteristics, in particular this is
affected by the milk yield level. An early decline in milk yield has been reported in dairy cows, up to one month post-conception (Bar-Anan and Genizi, 1981). The effect of pregnancy became apparent (> 1kg/day) after the 25th week of pregnancy in dairy cows. (Coulon et al., 1995; Bachman et al., 1988 and Genizi et al., 1992). In our study the equivalent decline level (about 4 kg/week) was observed on 12th week post-conception.

The present study shows a higher sensitivity of the high yielding buffaloes to milk decline with the onset of pregnancy. This may be due to higher energy loss and poor nutritional status. In a previous study Khan and Lurdi, (2002) reported that pregnant goats had lower blood glucose than non-pregnant after day 84 of pregnancy. They suggested that there may be competition for glucose between the mammary gland and the gravid uterus which would result in milk yield losses due to pregnancy in high yielder. Olori et al. (1997) found that during first lactation the cows were more sensitive to the stress of pregnancy in mid lactation when milk production was greater than the later stage of lactation. It was suggested that mammary gland is generally less responsive to the onset of conception.

The resource constrained-poor-unaware farmers under the conventional buffalo farming in this region are unable to provide sufficient feeding and management support. On the other hand they are reluctant for rebreeding of their high yielding buffaloes for fear of a drastic decline in milk yield. The findings of the present study have demonstrated this post-conception decline in milk yield under the traditional same-scale-feeding regime.

3.4.3 Buffalo does not produce at its own cost

The present study indicated an early decline in milk yield post-conception than cows (after 5th week buffaloes versus 18 weeks for cows reported by Coulon et al., 1995). It shows a special character of buffalo to retain body condition and manifest a decline in milk yield rather than to produce high quantities of milk, in contrary to cattle. Dairy cows produce milk at the expense of loss of body condition while dairy buffalo does not seem
to loss body conduction. Therefore, pregnancy in buffalo leads to an early decline in milk yield before it looses its condition.

The specific behavior of buffalo to retain body condition during milk production appears to be linked with the adverse climatic and management conditions in the region having buffalo dairy farming. In these regions a continental climate is prevailing where extreme cold and hot season shows a variation in atmospheric temperatures from -10° C to +50° C. This is coupled with poor housing and feeding conditions where the requirements of the animals are ignored (Qureshi et al., 2002). In addition the ration contain more roughages which lead to production of acetates and butyrate which are lipogenic, tending to enhance body condition. In contrary under the temperate conductions the high energy diets results in the production of propionates in cows, which are glycogenic in nature. Propionates tend to increase the milk yield instead of supporting the body conduction.

From genetic point of view, we can see that dairy cows have been selected for better traits over a long period of time, whereas buffaloes are raised without any scientific or commercial support. A little improvement has been made so far, to use buffalo as a dairy animal under intensive farming conditions. The findings of the present study shows that the drastic decline in milk yield with the onset of pregnancy in buffalo may be due to dramatic shifts in nutrient partitioning which spare little nutrients for milk synthesis and utilize more nutrients for maintaining body conduction.

3.4.4 Fertility – lactation relationship

In the present study milk yield increased initially with the advancement of pregnancy as compared with the non-pregnant animals and then decreased at an almost constant rate (Figure 3.1). The initial increase may be due to an association of the milk yield efficiency with the reproductive efficiency as the animals that conceived also produced more milk. Our finding supports the early reports in dairy cows where a positive correlation between milk production and reproductive performance was found in dairy cows (Lopez-Gatius et al., 2006). Based on the odds ratio, high-producing cows increased the probability of high fertility by a factor of 6.8. Furthermore, each 1 kg decrease in milk yield at 50 days
postpartum was associated with an increase of 1.8 days in the parturition to conception interval. In fact, higher producing herds generally have better reproductive performance (Windig et al., 2005; Mayne et al., 2002; Laben et al., 1982; Hansen et al., 1983; Nebel and McGilliard, 1993). The present study concluded that buffaloes conceiving at an early stage of lactation were also good milk producer in comparison to their non-pregnant counterparts.

3.4.5 Preventing post-conception decline in milk yield

The present results show that a pregnant animal will maintain high levels of milk production, if supplemented with extra feed during pregnancy. Ration supplementation beyond 6th week post-conception, significantly increased milk yield than the non-supplemented buffaloes. Average weekly yield of the high yielding animals was almost similar in the pregnant-ration-supplemented (PRS) and non-pregnant-ration-traditional (NPRT) while the pregnant-ration-traditional (PRT) buffaloes showed a drastic decline in yield.

There was little beneficial affect of feed supplementation to the moderate yielding buffaloes. In the low production group the pregnant buffaloes with supplemented ration and non-pregnant buffaloes with traditional ration had similar trend of decline in milk production. This decline trend was not very high. However, the decline in pregnant buffaloes on traditional ration was drastic.

The present study shows that concentrate supplementation of high yielding pregnant animals maintained high milk production levels post-conception because the concentrates supplementation fulfilled the nutrient requirement of the growing feus and energy reiriments for milk synthesis. In the moderate yielders the feed requirements were less and so the feed supplementation effect was also smaller. In the low yielders the reduction in feed intake was not parallel with the decline in milk yield, leading to adverse effects of excess intake of feed. It may be explained in light of findings (Qureshi et al., 2002) where excess intake of protein associated with high levels of urea, was found as cause of reduction in milk yield in dairy buffaloes. This effect of pregnancy was lacking in the
moderate yielders as the nutrient intake was probably utilized for milk synthesis and there was no excess intake of protein which could exert adverse effect on milk yield.

As mentioned in previous in study (Qureshi, 1995), the farmers under field conditions practice same scale feeding irrespective of milk yield or pregnancy status. The present study has confirmed that under such conditions the pregnant non-supplemented animals are unable to maintain high milk yields post-conception. Resultantly this decline in milk yield post-conception discourages farmers for early post partum breeding. The delayed breeding becomes uneconomical because maintaining dry buffaloes will not support their production cost. In the high yielding buffaloes the average weekly decline was about 5 liters costing Rs.250 (Rs.60=1USS), while the cost of feed supplementation to maintain this production level, was about Rs.25, which is ten times less than the loss due to milk decline. Based on these findings it may be recommended that feed supplementation of producing buffaloes will be economical under field conditions.
3.5 CONCLUSIONS

Based on present findings it is concluded that the onset of pregnancy in dairy buffalo results in a drastic decline in milk yield at an early stage as compared to those conceived at later stages of lactation. The natural increase in milk yield is prevented by an early pregnancy onset. A noticeable decline (about 4 litres/week) has been observed on 12th week post-conception. The high yielding buffaloes are more sensitive to decline in milk yield with the onset of pregnancy. The farmers are unable to provide sufficient feed and proper management to those animals due to the lack of resources and knowledge. The dairy buffaloes maintain body condition and manifest an early decline in milk yield with the onset of pregnancy, than the cows. The buffaloes conceiving at an early stage of lactation were good milk producer in comparison to their non-pregnant counterparts. A buffalo becoming pregnant, if supplemented with extra feed for milk production, will maintain its milk yield even after getting pregnant. In the high yielding buffaloes the cost of feed supplementation to maintain this production level, was ten times less than the loss due to milk yield decline.

3.6 ACKNOWLEDGEMENTS

Financial sponsorship of the Higher Education Commission, Islamabad, Pakistan made this investigation possible which is highly acknowledged. Prof.Dr.Pegham Shah assisted in management and analysis of the data. Mr.Kamran Safder provided experimental animals at his commercial buffalo dairy farm, which is highly acknowledged. Mr.Muhammad Navaz assisted us in traveling to the experimental stations.
Table 3.1  Reduction in milk yield at different months after conception for the three subsets of data (Mean ± SE)

<table>
<thead>
<tr>
<th>Month Conception</th>
<th>Lactation stage when the animal conceived</th>
<th>Weeks 11-28</th>
<th>Weeks 29-36</th>
<th>Weeks 37-48</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.944±0.4370</td>
<td>5.289±1.0178</td>
<td>8.624±3.8918</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-0.757±0.7174</td>
<td>3.341±0.7953</td>
<td>4.940±1.5700</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-3.113±1.0819</td>
<td>0.504±0.7281</td>
<td>4.198±0.8703</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-3.738±1.5861</td>
<td>-1.953±0.8003</td>
<td>1.920±0.5659</td>
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<tr>
<td>5</td>
<td>-4.359±3.0647</td>
<td>-3.917±0.9753</td>
<td>-1.053±0.4092</td>
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</tr>
<tr>
<td>6</td>
<td>--</td>
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</tr>
<tr>
<td>7</td>
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<td>--</td>
<td>-4.987±0.5725</td>
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</tr>
<tr>
<td>8</td>
<td>--</td>
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</tr>
<tr>
<td>9</td>
<td>--</td>
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<td>-6.697±1.1318</td>
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<tr>
<td>10</td>
<td>--</td>
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<td>-7.210±2.2491</td>
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Table 3.2  Fitting different models for reduction in milk yield (overall average)

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<tr>
<th>Milk reduction due to pregnancy</th>
<th>JPW*</th>
<th>R square</th>
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<tbody>
<tr>
<td>Straight line regression</td>
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<tr>
<td>Quadratic equation</td>
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<td>0.9863</td>
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<td>Two straight lines with joining point at</td>
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<td>0.9629</td>
</tr>
<tr>
<td>A plateau and quadratic curve with a joining point at</td>
<td>5.0</td>
<td>0.9838</td>
</tr>
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<td>A plateau and a straight line with a joining point b/w 5.0, 6.0</td>
<td>5.7</td>
<td>0.7026</td>
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<tr>
<td>Two straight lines with joining point at</td>
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<td>0.8826</td>
</tr>
<tr>
<td>A plateau and a straight line with a joining point at</td>
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<td>0.9527</td>
</tr>
<tr>
<td>Coulon model exponential function</td>
<td>5.0</td>
<td>0.9445</td>
</tr>
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</table>

JPW* Joining point week
<table>
<thead>
<tr>
<th>Week Pregnant</th>
<th>Actual Reduction</th>
<th>Predicted reduction</th>
<th>Line JP8</th>
<th>Plateau &amp; quadratic</th>
<th>Plateau &amp; line</th>
<th>Coulon Model</th>
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<tr>
<td>W6-23</td>
<td>-127.627</td>
<td></td>
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</table>
Table 3.4  Changes in milk yield of buffaloes as affected by production groups and treatments

| SOV\(^1\) | DF | Week post-conception (1-12) |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| \(G\)\(^2\) | 2 | *** | *** | *** | * | *** | *** | *** | *** | *** | *** | *** |
| \(T\)\(^3\) | 2 | NS\(^4\) | NS | NS | NS | NS | *** | *** | * | * | * | *** |
| \(G \times T\) | 4 | NS | NS | NS | NS | * | *** | *** | * | NS | NS | NS |

---

```
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<th></th>
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<tr>
<td>(G)</td>
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<td>***</td>
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<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
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<tr>
<td>(T)</td>
<td>2</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
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<td>***</td>
<td></td>
</tr>
<tr>
<td>(G \times T)</td>
<td>4</td>
<td>NS</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
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<td></td>
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</tbody>
</table>
```

\(^1\) SOV = Source of variation;  
\(^2\) G = Groups (HMY, MMY and LMY)  
\(^3\) T = Treatments (PRT, PRS and NPRT);  
\(^4\) NS = Non-significant  
\(*\) = Significant (p < 0.05),  
\(**\) = Significant (p < 0.01)

---

Table 3.5  Combined ANOVA for milk yield of buffaloes during 23 weeks

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>DF</th>
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<th>Prob.</th>
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<tr>
<td>Production Groups (G)</td>
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<td>31417.64</td>
<td>0.0000</td>
</tr>
<tr>
<td>Treatments (T)</td>
<td>2</td>
<td>2319.13</td>
<td>0.0000</td>
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<tr>
<td>G x T</td>
<td>4</td>
<td>77.04</td>
<td>0.0000</td>
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<td>Weeks</td>
<td>22</td>
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<tr>
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<td>7.41</td>
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<tr>
<td>T x weeks</td>
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<tr>
<td>G x T x W</td>
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<tr>
<td>Error</td>
<td>713</td>
<td>7.18</td>
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</tr>
<tr>
<td>Total</td>
<td>919</td>
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<td>--</td>
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</tbody>
</table>
Figure 3.1  Changes in milk yield with the advancement of pregnancy in dairy buffaloes at large-sized state farms

Figure 3.2  Changes in milk yield with the advancement of pregnancy in dairy buffaloes at small-sized private farms \( Y = -0.9602 \times (PW - 5) \times e^{-0.15 \times PW}; \ R^2 = 0.9445 \)
Figure 3.3  Change in milk yield with the onset of pregnancy in dairy buffaloes in high (HMY □), moderate (MMY ●) and low (LMY ▲) yielding groups

Figure 3.4  Average milk yields of the high (HMY □), moderate (MMY □) and low yielding groups (LMY □) buffaloes over 23 weeks period in Pregnant-Ration-Supplemented (PRS), Pregnant-Ration-Traditional (PRT) and Non-Pregnant-Ration-Traditional (NPRT)
Figure 3.5-A  Treatments x week's interaction in high production group {pregnant-ration-traditional (■); pregnant-ration-supplemented (●); non-pregnant-ration traditional (▲)
Figure 3.5-B Treatments x week's interaction in moderate production group (pregnant-ration-traditional (■); pregnant-ration-supplemented (●); non-pregnant-ration traditional (▲)).
Figure 3. Treatments x week's interaction in low production group (pregnant-ration-traditional(●); pregnant-ration-supplemented(●); non-pregnant-ration traditional (▲)
IV. FEED SUPPLEMENTATION PREVENTS DECLINE IN MILK PROGESTERON LEVELS ASSOCIATED WITH POST-CONCEPTION PRODUCTION STRESS IN DAIRY BUFFALOES

Sarzamin Khan, Muhammad Subhan Qureshi, Nazir Ahmad, Muhammad Amjad, Muhammad Younas* and Altafur Rahman

Faculty of Animal Husbandry and Veterinary Sciences, NWFP Agricultural University, Peshawar-25120, Pakistan

* Department of Livestock Management, University of Agriculture Faisalabad, Pakistan.

4.1 ABSTRACT

The onset of pregnancy is associated with an upsurge in milk progesterone levels (MPL) and there is also a drastic decline in milk yield during this period in dairy buffaloes. To investigate this phenomenon, forty adult lactating dairy buffaloes were selected from 1st to 23rd weeks post-conception at a peri-urban dairy farm in Pakistan. The animals were assigned to three treatments: PRT (pregnant-ration traditional), PRS (pregnant-ration supplemented), NPRT (non-pregnant- ration traditional) and three milk yielding (MY) groups (HMY, high, 66 to 75 liter/wk, n=12; MMY, moderate, 56 to 65 liter/wk, n=16; LMY, low, 46 to 55 liter/wk, n=12). Milk samples were collected on alternate weeks. Milk composition was determined through ultrasonic milk analyzer. EIA (enzyme immunoassay) was used for MPL. Groups means were compared and correlation analysis was conducted. The trends of milk yield as affected by progesterone concentration were analyzed using a regression model based on joining point of the two phases.

Difference in MPL became significant among the production groups after 8 weeks of conception. Treatment had a significant effect on MPL. Interaction of production groups was significant with treatments during the 2-8 weeks and with weeks during 10-23 weeks post-conception. Treatment x week interaction was significant only during 2-8 weeks. MPL increased in a similar pattern with the advancing weeks post-conception in all the three production groups; however the progesterone levels were slightly but constantly
higher in LMY followed by MMY and HMY buffaloes. The HMY and LMY buffaloes showed greater MPL in the supplemented than the animals on traditional ration (P<0.001). MPL correlated positively with fat (%) while negatively with milk yield, protein (%) and lactose (%). Decrease in milk yield was mild with the increasing progesterone levels up to 6.44 ng/ml but further increase in the MPL decreased the yield, drastically. The PRT animals exhibited a sharper decline in milk yield with the increasing progesterone levels. However, in the PRS animals the increasing MPL from 2.0 to 5.84 ng/ml did not decrease the milk yield while further increase in MPL resulted in a decreased milk yield.

The present study indicated a post-conception increase in MPL with an almost constant linear trend in dairy buffaloes. Concentrates supplementation raised progesterone levels probably through reducing production stress. The critical level of 6.4 ng/ml of MPL caused drastic decline in milk yield while the two parameters also showed a constant inverse relationship in buffaloes.

Key words: Progesterone, Pregnancy, Milk yield, Concentrates supplementation, Dairy buffaloes.

4.2 MATERIALS AND METHODS

4.2.1 Animal Selection and Management

This study was conducted at a medium-sized private buffalo farm, during the July 2005 to December 2005. The animals were selected for the experiment within 60 to 90 days after parturition. All experimental animals were stall-fed and provided green fodder ad lib. Water shower was provided to all animals during hot season twice a day at the farm. Drinking water was provided three times daily. Animal sheds were washed twice daily at morning and evening. Twice a day milking was practiced at about 4 am and 4 pm. Vaccines against hemorrhagic septicemia and Foot and Mouth Disease were administered to all experimental animals, as per prevailing practice. Anthelmintic drench of Levamisole Hydrochloride plus Oxychlozanide according to manufacturer instructions was provided at the start of the experiment.
4.2.2 Feeding Regime and Milk Sampling

*Basal ration:* It comprised green fodder *ad lib* during June through October including maize, sadabahar (sorghum x sudan grass) and sorghum. During November to May, Egyptian clovers, oats, brassica and wheat straw were offered.

i) *Ration Traditional (RT):* In addition to the green fodder, all animals were provided a commercial concentrate; having 18% crude protein (CP) and 72% total digestible nutrients (TDN) at the rate of 1.5 kg per animal irrespective of its lactation stage, milk yield level and pregnancy stage, as per routine practice under the conventional farming system in the region. This constituted ration for all the non-pregnant and one group of pregnant experimental animals. Pregnancy diagnosis of the experimental animals was made on 21 days post-breeding through milk progesterone EIA.

ii) *Ration supplemented (RS):* In addition to the basal ration, the same commercial concentrate was provided at the rate of 1 kg per 2 liter of milk as recommended by Ranjhan (1994) for lactating buffaloes under tropical conditions. Supplemented ration was provided to one group of pregnant animals.

iii) *Milk sampling:* Milk samples, 20 ml each were collected from evening milk of all experimental animals on alternate weeks just after insemination, till the cessation of lactation.

iv) *Milk composition:* Milk samples (10 ml each) collected from the experimental animals was utilized for composition determination. Milk contents were determined through ultrasonic milk analyzer (model Ekomilk Total Ultrasonic Milk Analyser, Bultech 2000, Stara Zaqora, Bulgharia), using manufacturer’s instruction.

v) *Milk progesterone assay:* Milk samples (10 ml each) collected from experimental buffaloes was utilized for milk progesterone assay. Sodium azide 200 micro liters in 0.1 percent concentration was added to each milk sample as preservative. Samples with preservative were stored at -20 °C till its use for progesterone assay. Milk progesterone was determined through ELISA as described by Qureshi et al. (1992). The intra- and inter-assay coefficients of
variation were 3.54% and 9.21%, respectively. The sensitivity (detection limit) of the assay was 0.09 ng/ml.

4.2.3 Experimental design

The experimental animals were subjected to various treatments as follows:

*Treatment groups:*

- **PRT**  (Pregnant-Ration traditional, \( n=12 \times 23 \) weeks)
- **PRS**  (Pregnant-Ration supplemented, \( n=11 \times 23 \) weeks)
- **NPRT** (Non Pregnant-Ration traditional, \( n=17 \times 23 \) weeks)

Experimental animals were divided into three production groups on the basis of Milk production.

*Production groups*

- **HMY:** High yielders, 66 to 75 L/wk (\( n=12 \times 23 \) weeks)
- **MMY:** Moderate yielders, 56 to 65 L/wk (\( n=16 \times 23 \) weeks)
- **LMY:** Low yielders, 46 to 55 L/wk (\( n=12 \times 23 \) weeks)

4.2.4 Statistical Analysis

*Post conception milk progesterone pattern:* MPL at various weeks postpartum as affected by groups, treatments, post-conception weeks, and their interactions was worked out. Due to the biphasic rising pattern of progesterone with the advancement of pregnancy in dairy cows (Henricks et al., 1972) and buffaloes (Qureshi et al., 2000), the data were split in two sets for combined analysis, set one consisted data from weeks 2 to 8 and set two comprised data from weeks 10 to 22. Some sum of squares (SS) for interaction in the combine ANOVA for even weeks were negative, so regression approach was used to calculate SS for the sources of variation. Full model and reduced models were fitted to the data for MPL during weeks 2 to 8 and weeks 10 to 22, separately to calculate SS for the different sources of variation in ANOVA using the following model.

\[
Y = \mu + G + T + GT + W + GW + TW + GTW
\]

(1)

Where \( Y \) is MPL; \( \mu \) is overall mean, \( G \) is milk production class, \( T \) is treatment, \( W \) is post-conception week and GT, GW and GTW are the respective interactions.
**Relationship of MPL with various parameters:** Correlation analysis was conducted for determination of correlation coefficient of MPL with milk yield fat\%, SNF\%, protein\%, lactose\% and ash\% using the following model:

\[
\rho_{x,y} = \frac{\text{cov}(X, Y)}{\sigma_x \sigma_y}
\]  

(2)

Where \( \rho_{x,y} \) is the correlation coefficient, \( X \) and \( Y \) are the parameters, \( \sigma_x \) and \( \sigma_y \) are variance of the respective parameter.

**Progesterone interacts with milk yield:** The decline in milk yield also showed a critical point beyond which it became comparatively rapid. So the trends of milk yield as affected by progesterone concentration were analyzed using the following regression model based on joining point of the two phases:

\[
Y = a + bP + cP'
\]  

(3)

Where \( Y \) is decline in milk yield; \( a, b \) and \( c \) are constant; \( P \) is progesterone; \( P' \) is 1 for \( P \leq JP \) and \( P-JP \) for \( P > JP \). \( JP \) is joining point.

### 4.3 RESULTS

#### 4.3.1 Post Conception Milk Progesterone Pattern

MPL did not vary among the production groups during the initial 8 weeks but later on the difference became significant (Table 4.1). It was probably due to the overall lower quantity of MPL initially which later on increased, making the dilution factor and the difference in MPL larger. Treatment had a significant effect on MPL during both the initial and later phases. During the initial phase the non-pregnant animals showed lower progesterone levels than the pregnant ones while during the later phase the concentrates supplementation supported MPL through better metabolic support. Post-conception week showed a significant variation in MPL due to advancement in embryonic development and implantation supported by increasing size of luteal tissues and other sources.
Interaction of production groups was significant with treatments during the 2-8 weeks and with weeks during 10-23 weeks post-conception. Treatment x week interaction was significant only during 2-8 weeks. Interaction among production groups and weeks was significant and with the advancement of pregnancy the MPL increased in all groups. Treatment interaction with the production groups and post-conception week was significant during the initial phase. However, later on the treatment confounded the effect of production groups, post-conception week and both of them jointly, providing support to MPL in different ways.

The Figure 4.2 shows that MPL increases in a similar pattern with the advancing weeks post-conception in all the three production groups; however the progesterone levels were slightly but constantly higher in LMY followed by MMY and HMY. It may be due to the decreasing concentration of progesterone with the increasing volume of milk.

4.3.2 Post-conception MPL

The Figure 4.1 shows that the MPL rises slowly during the initial phase from week 2 to week 8 post-conception. Later on the rate of enhancement increases rapidly which may be due to enhanced production of progesterone to support the developing and implanting embryo from corpus luteum as well as placenta.

4.3.3 Effects of Feeding Status

The Figures 4.3 A – 4.3 C report the changes in MPL in the three treatments PRS, PRT and NPRT animals belonging to three production groups: The non-pregnant animals showed a lower MPL which was sampled only up to 8 week post-conception. Pregnant buffaloes offered with PRS in HMY and LMY groups showed greater MPL than the animals provided with traditional ration (P<0.001). These findings suggest that concentrates supplementation raises progesterone levels in high and low yielders.

4.3.4 Progesterone interacts with Milk yield and Composition

Correlation of MPL with various milk parameters are given in Table 4.2 MPL correlated positively with fat (%) and negatively with milk yield, protein (%) and lactose
(%) constants. An advancing MPL means an advancing gestation where the conceptus development regulates nutritional partitioning among the fetus and the dam. So more fat while little protein and lactose are secreted with the rising MPL. The negative correlation of MPL with milk yield is probably due to the dilution effect of progesterone with the increasing milk volume.

The Figure 4.4 reports the change in milk yield with the increasing progesterone levels. There was a mild decrease rate with the increasing progesterone levels up to 6.44 ng/ml (joining point of the two phases) but further increase in the MPL decreased the milk yield drastically.

The Figure 4.5 shows that the animals with traditional ration exhibited a sharp decline in milk yield with the increasing progesterone levels, in an un-interrupted trend. However, the concentrate supplemented animals showed the decline in two phases. With the increasing MPL from 2.0 to 5.84 ng/ml the decrease in milk yield was zero. Further increase in MPL resulted in a decreasing milk yield with a comparatively slower rate than the buffaloes on traditional ration.

The Figure 4.6 show that all the high, moderate and low milk yielding buffaloes exhibit a decline in milk yield with the increasing progesterone levels beyond 6 ng/ml. However, this decline was faster in higher yielders followed by moderate and low yielders.

4.4 DISCUSSION

4.4.1 Post Conception Milk Progesterone Pattern

The present study indicated a post-conception increase in MPL is constant in dairy buffaloes. In dairy cows early in pregnancy, the progesterone concentration curve appears to be biphasic over time: increasing during 3 to 12 days after mating, leveling off until about 30 days, and increasing further to 39 days (Henricks et al., 1972). In cows later in pregnancy, however, progesterone levels tend to level off after about 50 days of
gestation and decline after about 250 days to undetectable levels at parturition (Gomes and Erb, 1965; Erb et al., 1968). There is a positive association between blood progesterone concentrations and pregnancy (Lamming and Darwash, 1998). Sousa et al. (1999) investigated blood progesterone levels in pregnant goats and found that it differed significantly between the 1st and 3rd week of gestation. Later changes within the two-week intervals were not that distinct, although in goats of the Canadian breed the blood progesterone level was also increasing between the 7th and 11th week of gestation.

In agreement to the present study, our previous investigations (Qureshi and Ahmad, 2007) found a slight increase in MPL during the first month postpartum followed by a rapid increase during the second month; a plateau up to 4th month and than again a rapid increase onwards. In dairy buffaloes Singh and Puthiyandy (1980) reported that progesterone concentration in the milk of pregnant animals (24.83 ± 3.85 ng/ml) was significantly higher than that of non-pregnant animals (2.89 ±1.21 ng/ml) on Day 20 and the difference between the two increased with time after insemination. Progesterone concentration was found to be positively correlated with corpus luteum size (Qureshi et al., 1992) and the corpus luteum was not efficiently working to produce sufficient progesterone for reproductive cyclicity during summer (Qureshi et al., 2002).

4.4.2. Feed Supplementation Reduces Production Stress

The present results indicate that concentrates supplementation raises progesterone levels in high and low yielders. In the HMY animals there may be production stress which may lower the MPL and this lowering trend is prevented by the concentration supplementation. In LMY buffaloes there seemed to be the stress of overfeeding of degradable protein (Qureshi et al., 2002) as they were fed at the same scale under conventional feeding regime, at par with the high and moderate yielders; and they could not utilize the excess intake of protein. In the supplemented buffaloes the animals were fed according to the feed requirements, there was no question of overfeeding which resulted in enhanced MPL.

In line with our findings, Gombe and Hansel (1973) reported that underfed cattle had smaller corpora lutea and lower blood progesterone concentrations. In a later study,
cyclic underfed cattle had progressively smaller and less estrogenic dominant follicles before they succumb to anestrous (Bossis et al., 1999). The smaller dominant follicles gave rise to smaller corpora lutea. Steroidogenic capacity of luteal cells is also dependent on hormones such as somatotropin, insulin and IGF-I that are controlled by the nutrition of the cow (Lucy, 2000). Association of progesterone levels with milk yield acting via nutritional status has been suggested (Lucy, 2001). Under nutrition or negative energy balance may compromise pregnancy through its effects on the corpus luteum. High-producing dairy cows had lower blood concentrations of progesterone and the lower blood progesterone concentration were attributed to infertility.

Mechanism of action of nutritional stress associated with body weight loss and lower circulating progesterone concentrations has been attributed to selection for increased milk yield (Lucy and Crooker, 2001). It has been hypothesized that growth and development of follicles during periods of negative energy balance lead to impaired development of the CL and a reduction in progesterone secretion (Butler, 2000). Cows that produce more milk have smaller CL at the peak of lactation (Lucy, 2000) and CL size has been correlated positively with circulating progesterone concentration (Sartori et al 2002). However, circulating progesterone concentration is determined by rates of secretion and clearance. Clearance rates of progesterone increase with feed intake due, in part, to an increase in hepatic metabolism (Sangsritavong et al, 2002). Therefore, at least two factors (CL size and feed intake) appear to be responsible for the reduction in circulating progesterone in cows that produce more milk. The addition of fat to the rations of dairy cows resulted in an increase in the levels of progesterone in blood (Lucy et al, 1993).

Stress due to high nitrate feeding has been reported (Paque et al., 1990) to depress serum progesterone concentration in cows. This effect was prominent in open, luteal phase cows, less prominent but still apparent in early pregnant cows, and absent in mid pregnant cows. A possible mechanism of inhibition of luteal progesterone synthesis by inhibition of cytochrome P-450 was presented.
Similarly, summer stress has been shown to lower MPL (Qureshi et al., 2000) in dairy buffaloes. MPL was found highest in spring (3.00 ± 0.12 ng/ml) followed by winter (1.77 ± 0.32), autumn (0.84 ± 0.72 ng/ml), summer (0.25 ± 0.04) (P<0.01). Summer contributed to the low breeding season (LBS) when the MPL did not reach the optimum levels until day 84 postpartum, indicating that the corpus luteum did not function efficiently to maintain high progesterone levels required for reproductive cyclicity. Interestingly, the incidence of silent ovulation in the buffaloes was higher in LBS than in NBS (70.6 vs 29.4%, respectively). Qureshi et al. (1999) found that MPL showed a pattern opposite to atmospheric temperature. Similarly, in a study on 17 complete postpartum periods in Murrah buffaloes in Sri Lanka, plasma progesterone concentrations remained basal (< 0.25 ng/ml) for a period ranging from 92-210 days (Perera et al., 1984). In Swamp buffaloes (Perera, 1982), it was found that postpartum anestrus was due to a failure in the resumption of ovarian cyclicity in the suckled buffaloes. Kaur and Arora (1984) concluded that malnutrition coupled with high environmental temperature stress was responsible for long anestrous periods in buffaloes.

4.4.3 Progesterone interacts with milk yield and composition

Our study defined the critical level of 6.4 ng/ml of MPL causing drastic decline in milk yield while the two parameters also showed a constant inverse relationship in buffaloes. Previous studies on cows have reports of the effect of progesterone during pregnancy on decrease in milk yield, by about 150 days of gestation (Schmidt, 1971; Coulon et al., 1995). Milk yield decreased in cows when concentration of progesterone in blood reached relatively high levels by about 130 days after pregnancy (Gomes and Erb, 1965). Grossman and Koops (2003) concluded that yield rises rapidly to a peak as secretion rate increases, maintains a level for a period of time, and then decreases until the end of lactation as cell number decreases due to apoptosis and as secretion rate decreases due to pregnancy. Decline in milk yield after the peak is associated primarily with decline in cell numbers due to apoptosis (Knight and Wilde, 1993), decline in milk yield during pregnancy is associated primarily with decline in milk synthesis and rate of secretion accompanying the increase in progesterone (Forsyth, 1999).
Milk composition begins to change around parturition, the timing depending on the species, and gradually approaches the composition of true milk. Much of this change in composition can be attributed to closure of TJ (tight junctions) Fleet et al., 1975, Neville, 1995). The mammary epithelium is highly permeable during pregnancy. Linzell and Peaker (1974) reported that most of the leaky TJ are in the alveolar epithelium. At the same time Pitelka et al. (1973) demonstrated that the disorganized pattern of the TJ strands in the mammary gland of pregnancy becomes highly organized in lactation. This observation provided a structural basis for the observed physiologic changes in epithelial permeability. Together findings from tracer, milk composition and cell biological experiments indicate that the mammary TJ, particularly in the alveoli, are leaky during pregnancy and close around parturition to form a tight barrier that prevents paracellular movement of molecules across the mammary epithelium. The hormonal regulation of tight junction closure per se has not been studied. However, lactogenesis itself is thought to be triggered by progesterone withdrawal and depend on the presence of glucocorticoids and prolactin (Neville et al., 2001).

4.5 CONCLUSION
The present study indicated a post-conception increase in MPL in two phases in dairy buffaloes; an early sluggish increasing phase of 8 weeks followed by a rapid increasing phase. Concentrates supplementation raised progesterone levels probably through reducing production stress. The critical level of 6.4 ng/ml of MPL caused drastic decline in milk yield while the two parameters also showed a constant inverse relationship in buffaloes.

4.6 ACKNOWLEDGEMENTS
Financial sponsorship of the Higher Education Commission, Islamabad Pakistan made conduction of this investigation possible which is highly acknowledged. Prof. Dr. Pegham Shah assisted in management and analysis of the data. Mr. Kamran Safdar provided experimental animals at his commercial buffalo dairy farm, which is highly acknowledged. Mr. Muhammad Nawaz assisted us in traveling to the experimental stations.
Table 4.1  Combined ANOVA for milk progesterone levels (ng/ml) during various weeks post-conception

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<td>DF</td>
</tr>
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<tr>
<td>Treatments (T)</td>
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</tr>
<tr>
<td>G x T</td>
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</tr>
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<td>1.951</td>
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<td>Error-II</td>
<td>93</td>
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Table 4.2  Relationship (correlation coefficients “r”) of milk progesterone levels (MPI) with various Parameters in dairy buffaloes

<table>
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<tr>
<th>Parameters</th>
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<th>SNF%</th>
<th>Protein%</th>
<th>lactose%</th>
<th>Ash%</th>
<th>MPL</th>
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<td>0.0211</td>
<td>0.3184***</td>
<td>0.1683**</td>
<td>0.0418</td>
<td>-0.6083***</td>
</tr>
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<td>-0.0688</td>
<td>-0.4744***</td>
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<td>SNF%</td>
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<td>0.0759</td>
<td>-0.0031</td>
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<tr>
<td>Protein%</td>
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<td>-0.1383*</td>
<td>0.0161</td>
<td>-0.4995***</td>
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<tr>
<td>Lactose%</td>
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<td>--</td>
<td>-0.0218</td>
<td>-0.3611***</td>
</tr>
<tr>
<td>Ash%</td>
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<td>--</td>
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<td>--</td>
<td>-0.0623</td>
</tr>
</tbody>
</table>

* Significant (P<0.05)  ** Significant (P<0.01)  *** Significant (P<0.001)
Figure 4.1 Milk progesterone levels (MPL) during post-conception period in dairy buffaloes
Figure 4.2  Milk progesterone levels (MPL) in high (●), moderate (■) and low (▲) yielding buffaloes
Figure 4.3-A to 4.3-C  Milk progesterone levels (MPL) in PRS (♦), PRT (■) and NPRT (▲) high (A), moderate (B) and low (C) yielding buffaloes
Figure 4.4 Changes in milk yield with the increasing milk progesterone levels in dairy buffaloes. \( Y = 47.41937 - 0.88148 \ P - 1.59907 \ P' \); For MPL < 6.44: \( P' = 0 \); \( R_1^2 = 0.761 \), \( Y = -0.8237X + 46.763 \); and for MPL > 6.44: \( P' = P - 6.44 \); \( R_2 = 0.9875 \); \( Y = -3.3822 \ X + 43.328 \); Joining point of the two lines is 6.44, the critical point defining the drastic decline in milk yield.)
Figure 4.5 Milk progesterone levels (MPL) change with milk yield in PRS (■) and PRT(♦) buffaloes ( ■ \( Y_1 = 57.1677 - 2.0099P' \); R-square = 0.9901; 
\( Y_2 = 51.4432 - 1.5946P - 1.2549P'' \); R-square = 0.9910)
Figure 4.6  Milk progesterone levels (MPL) change with milk yield in high (怏), moderate (■) and low (▲) yielding buffaloes. (怏 Y1 = 61.8977 - 1.0976P - 2.3694 P²; R1² = 0.9826, ■ Y2 = 48.5818 - 1.0665P - 0.9689 P²; R2² = 0.9911; ▲ Y3 = 36.6094 - 0.9923 P - 1.7256P²; R3² = 0.9949)
V. EFFECT OF PREGNANCY ON LACTATION MILK VALUE IN DAIRY BUFFALOES

Sarzamin Khan, Muhammad Subhan Qureshi, Nazir Ahmad, Muhammad Amjed and Muhammad Younas*

Faculty of Animal Husbandry and Veterinary Sciences, NWFP Agricultural University, Peshawar-25120, Pakistan

*Department of Livestock Management, University of Agriculture Faisalabad, Pakistan.

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5.1 ABSTRACT

Buffalo is a major source of milk production, contributing 12.1% in the World and 38.0% in Asia. The buffaloes are kept under peri-urban farming systems to produce milk for the urban populations. Breeding is delayed in these herds to get more economic benefit because the farmers believe that pregnancy decrease milk production of their herds. The lactation milk value has been studied in this paper as an economic indicator. Complete milk yield records of 3304 buffaloes were collected from a group of state farms. Economic traits including lactation yield, lactation length, calving interval (CI), dry period and milk yield per day of the calving interval (MYPDCI) were derived from the data. The animals were grouped according to parity number (1-3), service period (G1 to G4, conceiving in <150, 150-200, 200-300 and >300 days postcalving) and yield levels (HMY >2500; MMY 2001-2500; and LMY 1500-2000 liters/lactation). To study the effect of pregnancy on milk composition a research trail was conducted at a medium sized private dairy farm, using forty lactating buffaloes of three yield levels and four service period groups. Milk was sampled on alternate weeks and analyzed for fat and protein contents (%). For quantifying the value of milk produced during a lactation period, the value corrected milk (VCM) was determined and converted to lactation milk value (LMV). Group means were compared for various parameters. Highest milk yield (2836.50 ±15.68 liters/lactation) was recorded in the HMY animals of G4 group while lowest milk yield of 1657.04±18.34 liters/lactation was found in LMY of G1. Lactation
was significantly increased with the increasing service period. The shortest dry period was recorded in HMY, parity 1, G1 animals and the longest in parity 2, MMY, G4. CI was shortest in HMY, parity 1, and G1 animals and longest in LMY, parity 3, G4 buffaloes. The HMY, parity 2, G1 buffaloes showed the highest MYPDCI and the lowest value was recorded (6.53 ± 0.17 vs. 2.76 ± 0.04 liter/day) for LMY, parity 1, G4 buffaloes. The VCM decreased with the delayed conception. This decreasing trend was higher in respect of the total yield but decrease in the VCM was smaller due to the increasing levels of fat and protein contents in the milk of buffaloes conceiving later (G3 and G4). The gap between the various production classes was reduced while looking at the VCM as compared with the yield per day of CI. LMV showed a consistent decline with the extending service period in all three production groups. The study suggests that CI increased with delayed conception, showing a consistent trend, in the low, moderate and high yielding buffaloes. There was a coherent declining pattern of milk yield with the delaying conception, associated with prolonged CI. An animal conceiving at a later stage of lactation showed a decline in financial returns by 24 to 27% than those conceiving earlier.

*Keywords:* Pregnancy; Lactation Milk Value; Dairy buffaloes; Reproduction

### 5.2 MATERIALS AND METHODS

#### 5.2.1 Date collection

Present study was conducted in two parts. First part comprised data on milk yield by using the records of 3304 buffaloes maintained at a large state farm during the years 1995-2005. The management system for health, nutrition and reproduction was similar at all farms. Complete milk yield records of 3304 buffaloes was collected. Economic traits derived from the data were lactation yield, lactation length, calving interval, dry period and yield per day of calving interval.

The animals were grouped according to parity number (1-3), conceiving during various stages of lactation (G1 = service period of <150; G2, 150-200; G3, 200-300; and
G4 = >300 days). The data were further grouped on the basis of yield levels (LMY 1500 to 2000; MMY 2001-2500; HMY, >2500 liters/lactation) as shown in (Table 5.1).

5.2.2 Milk sampling, analysis and corrected values

The second part of this study was regarding the determination of milk composition with the advancement of lactation and pregnancy during different stages of conception. For this purpose, an experiment was conducted during the year 2005, at a medium-sized private buffalo farm, located in peri-urban areas of Peshawar, Pakistan. Total number of forty lactating buffaloes divided into three production classes: HMY, >2500; MMY 2001-2500; LMY, 1500 to 2600 liters/lactation and four conception groups (G1 = service period of <150; G2, 150-200; G3, 200-300; and G4 = >300 days) were used in this investigation. Twice a day milking was practiced at 4 am and 4 pm. Milk yield was recorded on alternate weeks and sampled for determination of milk composition through ultrasonic milk analyzer (model Ekomilk Total Ultrasonic Milk Analyser, Bulltah 2000, Stara Zaqora, Bulgharia), using manufacturer's instruction. Mean milk fat and protein (%) were used for tabulating the output, reporting distribution of the data among various yield groups and service periods.

In order to quantify the value of milk produced during a lactation period by the buffaloes conceived during various stages of lactation, the MYPDCI was converted to VCM using the following formula as reported by Arbel et al. (2001):

\[
\text{VCM (kg)} = -0.05 \times \text{milk (kg)} + 8.66 \times \text{fat (kg)} + 25.98 \times \text{protein (kg)}
\]

(1)

For calculation of lactation milk value, the VCM was treated as follows:

\[
\text{LMV (US$)} = \text{VCM} \times 400 \times 20 \div 60
\]

(2)

Where LMV is the lactation milk value, VCM is value corrected milk, 400 is the length of ideal calving interval in buffaloes (days), 20 is the current wholesale price of milk in Pakistani rupees and 60 is the conversion factor (US$ 1 = Pak-Rs.60).
5.2.3 Statistical analysis

Lactation records from 3304 buffaloes belonging to three parities, three yield classes and four service periods, were analyzed using the procedures described by Steel and Torrie, (1987). Means, variances, standard errors of all the combinations of parities, production classes and groups were calculated. Group means within parities-production-classes combinations were compared using t-test. As heterogeneity of variances was suspected and the number of records varied for the different combinations of groups, classes and parities; F-test was used to find out if variances are equal or not. When the variances were equal, pooled variance \((S_p^2)\) was used to calculate \(t\) using the following formula:

\[
t = \frac{\bar{Y}_1 - \bar{Y}_2}{\sqrt{\text{Sp}^2 \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}
\]

(3)

When variances were not equal, variances from the two groups were used to calculate \(t\) using the following formula:

\[
t = \frac{\bar{Y}_1 - \bar{Y}_2}{\sqrt{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)}}
\]

(4)

5.3 RESULTS

5.3.1 Lactation yield and length

Mean lactation yield was categorized into various parities, yield classes and service groups as given in Table 5.2. In overall parities, the highest milk yield of \(2836.50 \pm 15.68\) liters per lactation was recorded in the HMY of G4 group while lowest milk yield of \(1657.04 \pm 18.34\) liters/lactation was reported in the LMY buffaloes of G1 group. In MMY and LMY buffaloes and in the data pooled for overall parities a decreasing milk yield was observed in G1 through G4 animals with a consistent trend. However, HMY animals in parity 1 showed a decreasing milk yield pattern in G3 followed by G2, G4 and G1. These
results indicate that lactation yield increased with increasing service period in a linear pattern.

Results regarding lactation length in buffaloes conceived during various stages of lactation for the three parities and production classes are given in Table 5.3. Lactation was significantly longer in G4 buffaloes followed by G3, G2 and G1, respectively. This pattern was observed in all the production classes suggesting an increase in lactation length with the increasing service period.

5.3.2 Dry period and calving interval

Parity-wise mean dry period of high, moderate and low yielding buffaloes conceived during different stages of lactation is given in Figure 5.1 (A). The shortest dry period (111.18 ± 6.40 days) was recorded in HMY, parity 1, G1 animals and the longest period (320.41 ± 3.54 days) was recorded during parity 2 in MMY, G4 animals. Buffaloes in G4 group had a significantly longer dry period as compared with the other three groups.

Parity-wise mean CI of high moderate and low yielding buffaloes conceived during different stages of lactation is given in Figure 5.1 (B). CI ranged from 402.77 ± 5.25 days in HMY, parity 1, G1 animals and the longest CI was found in the LMY, parity 3, and G4 buffaloes (652.46 ± 5.67 days). The calving interval increased with delayed conception, showing a consistent trend, in the low, moderate and high yielding buffaloes.

5.3.3 Milk yield per day of calving interval

Parity wise mean milk yield per day of calving interval (MYPDCI) of high moderate and low yielding buffaloes conceived during different stages of lactation is given in Table 5.4. The HMY, parity 2, G1 buffaloes showed the highest yield per day of calving interval and the lowest value was recorded (6.53 ± 0.17 vs. 2.76 ± 0.04 liters per day) for LMY, parity 1, G4 buffaloes. Across all the parities and yield classes, the mean MYPDCI was significantly higher in buffaloes conceived in G1 buffaloes followed by G2, G3 and G4 buffaloes. It showed a consistent declining pattern of MYPDCI with the delaying conception, associated with prolonged calving interval (Figure 2).
5.3.4 Milk Fats and Protein contents

Table 5.5 reports values of milk fat and protein contents in three production classes for the four service period groups of buffaloes. Milk fat and protein contents decreased across all production classes from group 4 to group 1. Fat and protein values for group 4 and 3 animals were highest and statistically similar followed by G2 and G1 buffaloes.

5.3.5 Milk corrected values

Table 5.6 reports the mean value corrected milk production (VCM, kg/day) across various production levels and service periods. VCM decreased with the increasing service period, i.e. the delayed conception. This decreasing trend was higher in respect to the total milk yield but decrease in the VCM was smaller due to the increasing levels of fat and protein contents in the milk. The gap between various production classes was reduced while looking at the VCM as compared with the yield per day of calving interval (Table 5.5) which indicates that the low producers showed a higher decrease in milk yield quantity but quality enhanced as evident from increase in fat and protein contents (Table 2). LMV milk values are given in Table 7, showing a consistent decline in LMV with the extending service period from < 150th day of lactation up to > 300th day. This trend was seen in all three production groups. The decrease in LMV was 27.6, 24.7 and 23.3% respectively, in the high, moderate and low yielding buffaloes.

These results indicate that an animal conceiving at an earlier stage of lactation returns better in monetary terms than those conceiving later

5.4 DISCUSSION

5.4.1 Lactation yield and length

The present study showed a consistent and significant increase in lactation yield in animals conceiving in early lactation, than those conceiving at the end of lactation in all production classes and parities. The low yield in early bred animals may be due to the effect of pregnancy on lactation. Pregnancy has been reported to have a negative effect on milk yield of dairy cows due to hormonal changes, causing regression of the
mammary gland (Akers, 2002), and the nutrient requirements of the fetus reduce the available nutrients for milk production (Bell et al., 1995). The effect of pregnancy is small at the beginning of gestation and becomes greater at later stages of gestation when growth and nutrient requirements of the conceptus are increased. Significant effect of pregnancy on milk yield is usually observed from the 5th month of gestation onwards (Bormann et al., 2002; Haile-Mariam et al., 2003; Olori et al., 1997; Roche, 2003).

The present results showed that the impact of pregnancy on milk yield varies with conception at various stages of lactation. The effect was higher in early lactation followed by mid late and after lactation. Olori et al., (1997) reported that the effect was higher in mid lactation than in late lactation in cattle. Cows with higher milk yield during early lactation had longer days open which increases subsequent yield (Lee et al., 1997). Longer days open in the previous lactation positively affects test-day milk and component yields. Cows with longer previous days open have higher milk yields in the subsequent lactations because they had more time to renew body fat that is used in the next lactation. (Sadek and Freeman, 1992). Funk et al. (1987) reported that the effect of previous and present days open on milk yield is similar across parities. The effect of previous days open on test-day milk yield is greater in later stages of lactation than in earlier stages (Bormann et al., 2002). The length of days open is also associated with the shape of lactation curve. Cows that conceive shortly after calving had lower persistency of lactation (Brotherstone et al., 2004). The Buffaloes conceived after lactation had significantly higher yield and longer lactation length. Lactation in these animals was not under the influence of pregnancy and therefore performed at maximum of their potentials due to prolonged lactation.

The present study shows a significant increase in lactation length with delayed conception. In dairy cattle possibility of extending lactations has received attention as an alternative to maximizing peak yield and minimizing calving interval (Knight, 1997, 1998). Extending lactations can be accomplished by planned increase in calving interval (Bertilsson et al., 1997), for example, and by use of bovine somatotropin to increase daily yield (van Amburgh et al., 1997). Expected benefits of extended lactations, defined as
calving every 18 months or more, might include reduction in number of excess progeny, insemination costs, and in number of days dry within the cow's lifetime (FAWC, 1997). For animal well-being, in addition, there could be benefits in reduced metabolic stress, exposure to fewer periods of high risk, and in increased longevity (FAWC, 1997; Knight, 1998). Extending the lactation, however, has its problems for high-yielding dairy cows. It is sometimes difficult to get cows pregnant at the desired time (i.e., 9 months after calving), for example, and some cows become too fat and perform unsatisfactorily in later lactations.

Nevertheless, one approach to extending the lactation is to alter the shape of the lactation curve to produce flatter, more persistent, prolonged lactations (FAWC, 1997). In case of dairy buffalo the delay in postpartum breeding is mainly associated to anoestrus, poor heat detection, and poor quality of semen or mediated for more milk in current lactation (Syed et al., 2003).

The present study suggests that delayed breeding favors higher milk production during a prolonged lactation. It gives an economic edge to the late conceiving buffaloes under the peri-urban dairying where the land and operational inputs are expensive, discouraging keeping of less productive animals. Under such a system the rearing of pregnant and low yielding animals is not feasible, and these need to be shifted to remote areas with less expensive operational inputs.

5.4.2 Dry period and calving interval

The present study concluded that delayed conception prolonged dry period and vice versa. The shorter service period favored birth of another calf followed by lactation. While the traditional farming system with the taboo of intentional delayed breeding for the fear of milk decline with the onset of pregnancy, leads to a prolonged service period and dry period. The peri-urban dairy farmers can not sustain by keeping animals in dry period and the lack of any organized system for breeding of these buffaloes, leads them to the slaughter house.
Present findings were supported by the results of Tiwana et al., (1994), Usmani et al., (1997) and Sujit et al., (2000). Exceptionally long or short dry periods will adversely affect the profitability of individual cows. A short dry period will not provide adequate rest and time for mammary regeneration, while long dry periods will result in greater feed costs with no income from milk production. Long dry periods can also result in fat cows that are more prone to problems with health and reproductive performance. Each day dry over 60 days costs $3. However, each day dry under 40 days costs $2 (Smith and Becker, 1994).

Same is the status of calving interval which increased with delayed conception, showing a similar trend, in the low, moderate and high yielding buffaloes. Calving interval is one of the major traits affecting the economic efficiency of the herd. Deliberate or natural delay in breeding of dairy animals directly affect calving interval and in turn the net profit from an animal (Syed et al., 2003). Tiwana et al., (1994), Nasir et al., (1994), Usmani et al., (1997) and Sujit et al., (2000) reported that first calving interval was significantly affected by the service period in dairy buffalo. Shiv et al., (2001) reported that the effect of service period on first calving interval was less significant in Murrah buffalo.

Preliminary data from a Danish study with two small herds (Bertilsson et al., 1997) did not show any significant differences in reproductive efficiency in herds managed for a 12, 15, or 18 month calving interval. However, the longer voluntary waiting period (VWP, 140 days) in herd 1 numerically showed a better reproductive efficiency. Cornell University compared the reproductive performance of cows with a voluntary waiting period of 60 or 150 days that were treated with BST (Van Amburgh et al., 1997). Their economic comparison of calving intervals showed that the extended calving interval was $274 / cow / year more profitable. Another large study evaluated VWP of 60 and 165 days, with and without the BST in 26 herds (Mc-Grath et al., 2003). Delayed breeding resulted in more days dry, longer calving intervals, and similar percentages of cows pregnant. The authors later concluded that delayed breeding increased net income over
feed cost and BST cost per cow per year in first parity cows but not in older cows (Lormore, 2003).

In Israel, the VWP was delayed in first parity cows from 90 to 150 days and in older cows from 60 to 120 days (Arbel et al., 2001) and it was concluded that first parity and older cows with extended lactation were more profitable. Again the advantage for the first parity cows was greater because of their more persistent lactation curves. A Danish study concluded, that extending the voluntary waiting period by an additional 70 days was not profitable (Sorensen and Ostergaard, 2003). Economic analyses with computer programs that optimize breeding and culling decisions also revealed that high producing and persistent cows could have extended VWP and should be rebred longer before being culled (Dekker et al., 1998; Rajala-Schultz et al., 2000). Such programs have also shown that seasonality in performance and prices has a significant effect on optimal breeding decisions.

5.4.3 Milk yield per day of calving interval

The present study showed a stable declining pattern of MYPDCI with the delayed conception, associated with prolonged CI. It indicates that delayed breeding reduces the economic weightage of buffalo in terms of milk productivity because the total yield is distributed evenly throughout a prolonged calving interval in a delayed breeder. Buffalo farmers deliberately delaying postpartum breeding of their animals receive a high lactation yield but face a significantly heavy loss due to significant reduction in MYPDCI. This economic loss was greater in HMY followed by MMY and LMY, respectively.

The optimal calving interval for dairy buffaloes in Pakistan was found to be 12–13 months (Shah et al., 1991). Losses caused by suboptimal calving intervals were Pakistani Rs. 9–14 per extra day per calving interval. Losses for forced replacement was Rs. 133 per buffalo and the lactation persistency curve has a stronger influence on the losses
caused by longer calving intervals than change in milk prices. Syed et al. (2003) reported that yield per day of calving interval was positively correlated with lactation yield and negatively correlated with CI. In dairy cows, Arbel et al. (2001) examined the effect of extended CI on production and profitability of high-yielding cows (n = 937) and reported that primiparous and multiparous cows with extended lactations were more profitable. A delay of 60 days, with respect to the usual VWP has economic advantages and allows the farmer an option for decisions regarding individual cows.

Weller and Folman (1990) stated that late conception reduced profitability and showed early breeding to be advantageous, especially if the value of a calf is high. Bar-Anan and Soller (1990) reported that in high-yielding herds the highest productivity in the current and subsequent lactations was achieved by primiparous cows that were inseminated not earlier than 70 days post partum and by multifarious cows at 41 to 90 days open. Heimann (1984) advocated prolonged CI, particularly for high-yielding cows with good persistency, whereas Weller et al., (1985) reported that conception before 60 days in milk (DIM) had an adverse effect on the annualised cumulative milk yield of current and following lactations, and found 110 to 130 days open to be optimal for primiparous cows.

Vries (2006) estimated the value of pregnancy to be US$ 278. The value of a new pregnancy increased with days in milk early in lactation but typically decreased later in lactation. The cost of pregnancy loss typically increased with the length of gestation. Increased persistency of lactation, increased probability of pregnancy, and decreased replacement heifer cost greatly decreased the average value of pregnancy. An improved understanding of the value of pregnancy for individual cows may assist in decision making in reproductive management.

5.4.4 Milk corrected values

This study indicated that an animal conceiving at an earlier stage of lactation returns better in monetary terms than those conceiving later, which contradicts the prevailing opinion among the conventional farmers, who desire to delay breeding for the loss of milk with the onset of pregnancy. Although in shorter term there is an immediate saving
in milk but prolonged lactation and calving interval reduce the financial returns are reduced in late conceivers.

5.5 CONCLUSIONS

The calving interval increased with delayed conception, showing a consistent trend, in the low, moderate and high yielding buffaloes. There was a consistent decline pattern in milk yield per day of calving interval with delayed conception, associated with prolonged calving interval. An animal conceiving at a later stage of lactation showed a decline in financial returns by 24 to 27% than those conceiving early.
Table 5.1 Distribution of animals according to parity, yield class and service period

<table>
<thead>
<tr>
<th>Parity and production class</th>
<th>Service Period (days)</th>
<th>&lt;150</th>
<th>150-200</th>
<th>200-300</th>
<th>&gt;300</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>Parity 1</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>HMY</td>
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<td>76</td>
<td>91</td>
<td>91</td>
<td>304</td>
<td></td>
</tr>
<tr>
<td>MMY</td>
<td>81</td>
<td>93</td>
<td>100</td>
<td>100</td>
<td>374</td>
<td></td>
</tr>
<tr>
<td>LMY</td>
<td>65</td>
<td>63</td>
<td>94</td>
<td>433</td>
<td>355</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>192</td>
<td>232</td>
<td>285</td>
<td>324</td>
<td>1033</td>
<td></td>
</tr>
<tr>
<td>Parity 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMY</td>
<td>53</td>
<td>76</td>
<td>91</td>
<td>89</td>
<td>309</td>
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<td>MMY</td>
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<td>102</td>
<td>112</td>
<td>110</td>
<td>419</td>
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<tr>
<td>LMY</td>
<td>63</td>
<td>61</td>
<td>237</td>
<td>148</td>
<td>509</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>211</td>
<td>238</td>
<td>440</td>
<td>347</td>
<td>1236</td>
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</tr>
<tr>
<td>Parity 3</td>
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<td></td>
</tr>
<tr>
<td>HMY</td>
<td>51</td>
<td>73</td>
<td>89</td>
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<td>MMY</td>
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<td>112</td>
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<td>LMY</td>
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<td>76</td>
<td>317</td>
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<td>Total</td>
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<td>234</td>
<td>314</td>
<td>277</td>
<td>1035</td>
<td></td>
</tr>
<tr>
<td>G. Total</td>
<td>613</td>
<td>704</td>
<td>1039</td>
<td>948</td>
<td>3304</td>
<td></td>
</tr>
</tbody>
</table>

* HMY = >2500, MMY = 2001-2500, LMY = 1500-2000 Liters per lactation.

Table 5.2 Mean Lactation yield of dairy buffalo having various service periods

<table>
<thead>
<tr>
<th>Parity</th>
<th>Prod Class</th>
<th>Service Period (days)</th>
<th>&lt;150</th>
<th>151-200</th>
<th>201-300</th>
<th>&gt; 301</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HMY</td>
<td>2576.98±28.23</td>
<td>2618.23±21.43</td>
<td>2692.64±26.47</td>
<td>2616.52±33.23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>2182.64±26.06</td>
<td>2233.67±29.03</td>
<td>2301.80±30.93</td>
<td>2332.87±42.42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>1588.02±18.88</td>
<td>1641.94±27.75</td>
<td>1699.16±32.26</td>
<td>1797.05±42.42</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HMY</td>
<td>2634.67±54.73</td>
<td>2695.08±26.77</td>
<td>2772.45±27.65</td>
<td>2851.70±21.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>2196.10±29.85</td>
<td>2260.25±29.66</td>
<td>2322.79±30.75</td>
<td>2409.63±11.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>1675.38±34.38</td>
<td>1736.00±37.34</td>
<td>1797.34±29.12</td>
<td>1857.54±17.12</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>HMY</td>
<td>2668.73±59.03</td>
<td>2732.15±29.78</td>
<td>2811.69±25.21</td>
<td>2896.74±18.18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>2239.63±33.15</td>
<td>2301.63±29.01</td>
<td>2374.8±24.41</td>
<td>2453.96±9.91</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>1709.14±33.74</td>
<td>1771.65±37.10</td>
<td>1842.17±29.60</td>
<td>1921.55±14.12</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>HMY</td>
<td>2630.07±19.10</td>
<td>2682.42±16.15</td>
<td>2760.11±16.09</td>
<td>2836.50±15.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>2210.79±16.26</td>
<td>2266.45±17.02</td>
<td>2340.77±16.22</td>
<td>2417.08±8.81</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>1657.94±18.34</td>
<td>1716.43±21.00</td>
<td>1789.28±18.25</td>
<td>1848.68±11.41</td>
<td></td>
</tr>
</tbody>
</table>

* Means followed by different letters in same row are significantly different from one another (P<0.05)

** HMY = >2500, MMY 2001-2500, LMY = 1500 to 2000 Liters per lactation.
### Table 5.3  Mean lactation length of dairy buffalo conceived at various stages of lactation

<table>
<thead>
<tr>
<th>Parity</th>
<th>Prod Class**</th>
<th>Service Period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;150</td>
</tr>
<tr>
<td>1</td>
<td>HMY</td>
<td>291.59±2.76</td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>288.96±2.40</td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>293.08±2.22</td>
</tr>
<tr>
<td>2</td>
<td>HMY</td>
<td>291.53±2.70</td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>287.35±1.84</td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>288.32±2.38</td>
</tr>
<tr>
<td>3</td>
<td>HMY</td>
<td>292.59±2.64</td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>292.40±1.91</td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>294.29±2.08</td>
</tr>
<tr>
<td>Overall</td>
<td>HMY</td>
<td>291.94±1.53</td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>289.60±1.13</td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>291.92±1.31</td>
</tr>
</tbody>
</table>

* Means followed by different letters in same row are significantly different from one another (P<.05)

** HMY = >2500, MMY = 2001-2500, LMY = 1500-2000 liters per lactation.

### Table 5.4  Mean yield per day of calving interval in dairy buffalo conceived at various stages of lactation

<table>
<thead>
<tr>
<th>Parity</th>
<th>Prod Class**</th>
<th>Service period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt; 150</td>
</tr>
<tr>
<td>1</td>
<td>HMY</td>
<td>6.41±0.10</td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>5.36±0.08</td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>3.85±0.06</td>
</tr>
<tr>
<td>2</td>
<td>HMY</td>
<td>6.53±0.17</td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>5.41±0.09</td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>4.12±0.09</td>
</tr>
<tr>
<td>3</td>
<td>HMY</td>
<td>6.53±0.17</td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>5.45±0.09</td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>4.15±0.08</td>
</tr>
</tbody>
</table>

* Means with different letters in same row are different from one are other (P<.05)

** HMY = >2500, MMY = 2001-2500, LMY = 1500-2000 litres per lactation.
Table 5.5  Mean values for milk fat and protein contents (%) of buffalo conceived during various stages of lactation

<table>
<thead>
<tr>
<th>Milk contents</th>
<th>Production Levels**</th>
<th>Service period (days)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;150</td>
<td>150-200</td>
<td>200-300</td>
<td>&gt;300</td>
<td></td>
</tr>
<tr>
<td>Fats</td>
<td>HMY</td>
<td>6.22±.21</td>
<td>6.51±.06</td>
<td>6.87±.25</td>
<td>6.90±.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>6.34±.27</td>
<td>6.63±.03</td>
<td>6.90±.33</td>
<td>7.10±.39</td>
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</tr>
<tr>
<td></td>
<td>LMY</td>
<td>6.36±.36</td>
<td>6.66±.07</td>
<td>6.93±.18</td>
<td>7.10±.33</td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>HMY</td>
<td>3.41±.02</td>
<td>3.52±.03</td>
<td>3.60±.02</td>
<td>3.60±.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MMY</td>
<td>3.40±.03</td>
<td>3.53±.02</td>
<td>3.61±.02</td>
<td>3.64±.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LMY</td>
<td>3.40±.02</td>
<td>3.55±.03</td>
<td>3.62±.03</td>
<td>3.65±.02</td>
<td></td>
</tr>
</tbody>
</table>

* Means with different letters in same row are different from one are other (P<.05)

** HMY: = >2500, MMY = 2001-2500, LMY = 1500-2000 liters per lactation

Table 5.6  Mean value corrected milk (kg/day) in dairy buffalo conceived at various stages of lactation

<table>
<thead>
<tr>
<th>Prod Classes*</th>
<th>Service period (days)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;150</td>
<td>150-200</td>
<td>200-300</td>
<td>&gt;300</td>
<td></td>
</tr>
<tr>
<td>HMY</td>
<td>8.92</td>
<td>8.18</td>
<td>7.54</td>
<td>6.46</td>
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<tr>
<td>MMY</td>
<td>7.48</td>
<td>6.93</td>
<td>6.42</td>
<td>5.63</td>
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</tr>
<tr>
<td>LMY</td>
<td>5.59</td>
<td>5.38</td>
<td>4.97</td>
<td>4.29</td>
<td></td>
</tr>
</tbody>
</table>

* HMY = >2500, MMY = 2001-2500, LMY = 1500-2000 liters per lactation.

Table 5.7  Lactation milk value (Rs) of buffaloes conceived during various stages of lactation

<table>
<thead>
<tr>
<th>Production classes*</th>
<th>Service period (days)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;150</td>
<td>150-200</td>
<td>200-300</td>
<td>&gt;300</td>
<td></td>
</tr>
<tr>
<td>HMY</td>
<td>71360</td>
<td>65440</td>
<td>60320</td>
<td>51680</td>
<td></td>
</tr>
<tr>
<td>MMY</td>
<td>59840</td>
<td>55440</td>
<td>51360</td>
<td>45040</td>
<td></td>
</tr>
<tr>
<td>LMY</td>
<td>44720</td>
<td>43040</td>
<td>39760</td>
<td>34320</td>
<td></td>
</tr>
</tbody>
</table>

** HMY = >2500, MMY = 2001-2500, LMY = 1500-2000 liters per lactation.
Figure 5.1  Dry period (A) and calving interval (B) for animals conceiving at various stages of lactation (G1= conceiving during 90-150 days postpartum, G2= conceiving during 151-200 days postpartum; G3= conceiving during 201-300 days postpartum; G4 = conceiving after 300 days postpartum; in three yield classes {high: light horizontal;, moderate: light vertical low yielders: zig zag}). Means for all the three yield classes were different (P<0.05) at various stages of conception, with the ranking order of D, C, B and A.
Figure 5.2 Overall milk yield per day of calving interval (MY/DCI) for animals conceiving at various stages of lactation (G1 = conceiving during 90-150 days postpartum, G2 = conceiving during 151-200 days postpartum; G3 = conceiving during 201-300 days postpartum; G4 = conceiving after 300 days postpartum; in three yield classes {high: light horizontal; moderate: light vertical low yielders: zig zag}). Means for all the three yield classes were different (P<0.05) at various stages of conception, with the ranking order of D, C, B and A.
VI. SUMMARY

Dairy buffalo is a major source of milk production Pakistan kept under peri-urban, low input production system. There is no practice of feeding animals according to production requirements; exposing them to nutritional deficiency with the onset of pregnancy. It leads to a decline in milk yield, which compels the farmers to keep the animals un-bred. The present work was completed under four studies to investigate the post-conception decline in yield and relate it to feeding regime, milk progesterone levels and overall economic losses due to the delayed breeding.

The first study was conducted to document the general post conception decline pattern in dairy buffaloes. Three large sized state farms (number of animals varying from 150 to 300) were selected. These farms possess sufficient land, manpower and financial resources. Standardized procedures are in practice at these farms under a central command. The data comprised 30912 weekly milk yield records for 48 weeks of lactation pertaining to 465 pregnant and 179 non-pregnant buffaloes. Reduction in milk yield was effected by location, conception season, lactation week, gestation month and parity. Gestation month contributed to the reduction in milk yield by 1.4%. Parity 3 showed the least reduction followed by parity 2, 4, 1, 5, and 6, indicating parity 3 the best phase for milk production in dairy buffaloes. It was being concluded that the onset of pregnancy in dairy buffaloes results in a drastic decline in milk yield at an early stage and the high yielders are more prove to milk decline. The buffaloes conceiving at an early stage of lactation were also good milk producer in comparison to their non-pregnant counterparts.

The second study was conducted for modeling and managing post conception milk yield decline. The study continued from July 2005 to December 2005, at a medium-sized private buffalo farm. Reduction in milk yield due to pregnancy was worked out as the difference between milk yield of 23 pregnant and 17 non-pregnant buffaloes, through various models. The buffaloes were provided with three treatments: i) pregnant-ration-traditional (PRT); ii) pregnant-ration-supplemented (PRS) and; iii) non-pregnant-ration-traditional (NPRT). The animals were categorized into HMY, MMY, LMY, producing 66-75, 56-65, 46-55 Litre/week, respectively. Milk production was recorded up to 23rd week and the difference in means was worked out. The reduction was

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after 5th week of conception and was significant in 7th week. The line JP8 model (two straight lines with joining point at week 8) gave good fit ($R^2 = 0.9527$) and the predicted values were much closer to the actual. In the high yielders, the predicted reduction was highest (-4.48 Litre/week) than moderate and low yielders (-2.37 and -0.94 Litre/week, respectively) during 6th week post-conception. The treatment effect was significant after 6th week. The group x treatment interaction effected milk yield decline on 4th, 6-9th and 14-15th and beyond 18th week post-conception. In HMY buffaloes, the average weekly yield was 50.0, 45.8, 50.9 liters in PRS, PRT and NPRT treatments, respectively. The respective values were 38.7, 36.0 and 40.6 liters/week for MMY buffaloes and 29.5, 23.0 and 29.9 Litre/week for LMY. In HMY, the decline in PRS was moderate while in PRT it was the greatest and in NPRT was the smallest. In the MMY the supplementation support to milk yield was smaller than the HMY. In LMY buffaloes the decline was drastic in PRT than the other two treatments. Compared to cow, the buffalo does not loose her body condition rather decreases her milk yield rapidly after the onset of pregnancy. A pregnant animal if supplemented at the rate of 1 kg ration for every two liters of milk will retain her milk yield level for longer duration post-conception. In the high yielders the cost of this supplementation was ten times less than the loss due to milk yield decline.

The third study aimed at investigating the role of milk progesterone levels (MPL) with the post conception decline in milk yield. For this purpose forty adult lactating dairy buffaloes were selected from 1st to 23rd weeks post-conception at a peri-urban dairy farm in Pakistan. The animals were assigned to three treatments: PRT (pregnant-ration traditional), PRS (pregnant-ration supplemented), NPRT (non-pregnant- ration traditional) and three milk yielding (MY) groups (HMY, high, 66 to 75 liter/wk, n=12; MMY, moderate, 56 to 65 liter/wk, n=16; LMY, low, 46 to 55 liter/wk, n=12). Milk samples were collected on alternate weeks. Milk composition was determined through ultrasonic milk analyzer. EIA (enzyme immunoassay) was used for MPL. Groups means were compared and correlation analysis was conducted. The trends of milk yield as affected by progesterone concentration were analyzed using a regression model based on joining point of the two phases.
Difference in MPL became significant among the production groups after 8 weeks of conception. Treatment had a significant effect on MPL. Interaction of production groups was significant with treatments during the 2-8 weeks and with weeks during 10-23 weeks post-conception. Treatment x week interaction was significant only during 2-8 weeks. MPL increased in a similar pattern with the advancing week’s post-conception in all the three production groups; however the progesterone levels were slightly but constantly higher in LMY followed by MMY and HMY buffaloes. The HMY and LMY buffaloes showed greater MPL in the supplemented than the animals on traditional ration ($P<0.001$). MPL correlated positively with fat (%) while negatively with milk yield, protein (%) and lactose (%). Decrease in milk yield was mild with the increasing progesterone levels up to 6.44 ng/ml but further increase in the MPL decreased the yield, drastically. The PRT animals exhibited a sharp decline in milk yield with the increasing progesterone levels. However, in the PRS animals the increasing MPL from 2.0 to 5.84 ng/ml did not decrease the milk yield while further increase in MPL resulted in a decreased milk yield.

The present study indicated a post-conception increase in MPL with an almost constant linear trend in dairy buffaloes. Concentrates supplementation raised progesterone levels probably through reducing production stress. The critical level of 6.4 ng/ml of MPL caused drastic decline in milk yield while the two parameters also showed a constant inverse relationship in buffaloes.

The fourth study was conducted to investigate the extent of loss in milk yield of buffaloes conceiving during various post partum phases. For this purpose omplete milk yield records of 3,304 buffaloes was collected from a group of state farms. Economic traits including lactation yield, lactation length, calving interval (CI), dry period and milk yield per day of calving interval (MYPDCI) were derived from the data. The animals were grouped according to parity number (1-3), service period (G1 to G4, conceiving during $<150$, 150-200, 200-300 and $>300$ days) and yield levels (HMY $>2,500$; MMY 2,001-2,500; and LMY 1,500-2,000 liters/lactation). To study the effect of pregnancy on milk composition a research trail was conducted in a medium sized private dairy farm, using forty lactating buffaloes of three yield levels and four service period groups as described, already. Milk was sampled on alternate weeks and analyzed for fat and protein.
(%). For quantifying the value of milk produced during a lactation period, the value
corrected milk (VCM) was determined and converted to lactation milk value (LMV).
Group means were compared for various parameters. Highest milk yield (2,836.50±15.68
liters/lactation) was recorded in the HMY animals of G4 group while lowest milk yield of
1,657.04±18.34 liters/lactation was found in LMY of G1. Lactation was significantly
increased with the increasing service period. The shortest dry period was recorded in
HMY, parity 1, G1 animals and the longest in parity 2, MMY, G4. CI was shortest in
HMY, parity 1, and G1 animals and longest in LMY, parity 3, G4 buffaloes. The HMY,
parity 2, G1 buffaloes showed the highest MYPDCl and the lowest value was recorded
(6.53±0.17 vs. 2.76±0.04 liter/day) for LMY, parity 1, G4 buffaloes. The VCM decreased
with the delayed conception. This decreasing trend was higher in respect of the total yield
but decrease in the VCM was smaller due to the increasing levels of fat and protein
contents in the milk. The gap between the various production classes was reduced while
looking at the VCM as compared to the yield per day of CI. The LMV showed a
consistent decline with the extending service period in all the three production groups.
The study suggests that CI increased with delayed conception, showing a consistent
trend, in the low, moderate and high yielding buffaloes. There was a coherent declining
pattern of yield with the delaying conception, associated with prolonged CI. An animal
conceiving at a later stage of lactation showed a decline in financial returns by 24 to 27%
than those conceiving earlier.
VII. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

1. Pregnancy in dairy buffaloes results in a decline in milk yield at an early stage as compared to those conceived at later stages of lactation.

2. A noticeable decline in milk yield (about 4 kg/week) was observed on 12th week post-conception.

3. The high milk producing buffaloes are more sensitive to a decline in milk production with the onset of pregnancy.

4. The dairy buffaloes do not produce milk on the cost of losing their body condition therefore manifest an early decline in milk yield with the onset of pregnancy than the cows.

5. The buffaloes conceiving at an early stage of lactation were also good milk producer in comparison to their non-pregnant counterparts.

6. An animal if supplemented with extra feed for milk production, would maintain the higher yield level even after getting pregnant.

7. In high yielding buffaloes the cost on feed supplementation of pregnant buffaloes for maintaining milk yield level almost similar to their non pregnant counterpart was ten times less than the loss due to milk yield decline.

8. The present study indicated a post-conception increase in MPL in two phases in dairy buffaloes; an earlier sluggish increasing phase of 8 weeks followed by a rapid increasing phase.

9. Concentrate supplementation raised milk progesterone levels probably through reducing production stress.
10. The critical level of 6.4 ng/ml of MPL caused drastic decline in milk yield while the two parameters also showed a constant inverse relationship in buffaloes.

11. The calving interval increased with delayed conception, showing a consistent trend, in the low, moderate and high yielding buffaloes.

12. Delay in post partum breeding resulted a consistent decline in milk yield per day of calving interval, associated with prolonged calving interval.

13. A buffalo conceiving at a later stage of lactation showed a decline in financial returns by 24 to 27% than those conceiving earlier post partum.

6.2 RECOMMENDATIONS

1. It is a fact that buffaloes exhibit a decline in milk yield after getting pregnant; however, this decline may be prevented through feed supplementation instead of same scale feeding as practiced under traditional system.

2. Early post partum breeding along with feed supplementation is recommended to prevent losses in milk yield per lactation as it will result an increase in milk yield per day of calving interval, in addition to production of another calf and lactation.

3. The present peri-urban system of buffalo farming is based on milk supply to the urban areas. This system cannot afford to keep animals with advanced pregnancy. Therefore these animals should be shefted to remote areas for commercial farming.
LITRATURE CITED


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