REVIEW OF LITERATURE
Estimates of productive and reproductive performance of crossbred dairy cow population indicate the success rate of breeding policy adopted as well as feeding and management inputs rendered to the animals by the farmers. It also helps in policy formulation in dairy sector for the economic upliftment of the farmers.

Milk yield and reproductive efficiency play major roles in determining the profitability of a dairy herd (Britt, 1985; Arbel et al., 2001). Inadequate reproductive performance is one of the most costly problems facing dairy producers. For example, Esslemont and Kossaibati (1997) found that poor fertility remained the single most important reason for involuntary culling, whatever the age of the animal, based on investigations of 50 dairy herds in England. In addition, Pelissier (1982) estimated the total losses for dairy farmers and consumers associated with sub-optimal reproductive performance in the US dairy industry, accounting all major sources of inefficiency to be $1.2 billion or approximately $116 per cow. Moreover, Strandberg and Oltenacu (1989) demonstrated that the effect on net return per year of delaying pregnancy by one day ranged from SEK 0.3 to 11.6 depending on calving month, stage of lactation, parity, and production level and suggested that for all combinations of characteristics early conception was the most profitable.
2.1 NUTRITIONAL STATUS

Monitoring the nutritional status of beef cattle is critical to enhance cow reproductive efficiency, limit the emission of excess nutrients into the environment, and optimize overall cow performance. An animal is said to be in good nutrients status if it is having a good balance between the requirements of the body nutrients with their availability. More nutrients may be available for numerous reasons: an increase in feed intake, change in ration density and feed availability, milk production, and changes in the body’s response to growth hormone. The changes in late lactation result in stabilization and in potential increases in body condition score (BCS). The nutritional status is generally assessed in terms of a balance among Dry Matter (DM), Crude Protein (CP) and Total Digestible Nutrients (TDN).

2.1.1 Body Condition Score (BCS)

The simplest and most economical way to assess the nutritional status of cows is to body condition score (BCS) (Eversole et. al, 2000). Body condition scoring is a management tool used extensively by beef, dairy, and sheep producers. Using this management tool, body condition scores are derived and assigned by physically handling and/or visually appraising animals for evidence of fat. Areas of utmost importance when analyzing cattle for deposition of fat are the brisket, spine, ribs, hooks, pins, and tail head (Evans, 1978; Hady et. al, 1994; Gallo et al., 1996; Eversole et al., 2000).

Body condition scores are subjective measurements (Evans, 1978; Hady et al., 1994; Gallo et al., 1996). By scoring animals instead of measuring animals for actual amounts of fat,
there tends to be a high degree of subjectivity which results in assessor bias. Some assessors may have a tendency to consistently score animals high or low. Therefore, research suggests that 2 to 3 individuals BCS independently, which will help remove the possibility of assessor bias (Evans, 1978). However, trained evaluators should not disagree by more than one score (Herd and Sprott, 1986).

Body condition scoring systems vary among species and at times can even differ within species. For beef cattle, scores generally range from 1-9, with 1 being an extremely thin, emaciated appearing animal and 9 being a very obese individual (Herd and Sprott, 1986; Taylor and Field, 1998; Eversole et al., 2000; Minick et al., 2001).

Houghton et al. (1990) described a 1-5 cattle BCS system where -, C, and + were used to improve accuracy. This BCS system developed by Purdue University personnel was relatively similar to the 1-9 system described previously. Cow weight has been studied to determine its relationship to BCS. Actual cow bodyweight alone was determined as a fairly inaccurate predictor of BCS since cows can differ significantly in their type and size (Klosterman et al., 1968). Based on percentage of cow bodyweight and using the coefficient of 1.00 for the cow at BCS 5, Herd and Sprott (1986) developed coefficients of .74 and 1.36 to be multiplied by the bodyweight at a BCS 5 in order to determine the bodyweight of cows at a BCS 1 and 9, respectively.

Values between 0.74 and 1.36 were used to determine cow bodyweight at other BCS. Yet, once cow bodyweight at BCS 5 is determined with relative accuracy, percentages of that animal’s...
BCS 5 bodyweight can be used to determine amount of bodyweight change is needed to change a cow one BCS. The lower the actual BCS the less bodyweight gain is required for a one BCS increase (Herd and Sprott, 1986; NRC, 1996). Herd and Sprott (1986) reported that a cow must gain 5.8, 8.0, and 10.2% of their bodyweight at a BCS 5 to go from a BCS 1 to a BCS 2, BCS 5 to a BCS 6, and BCS 8 to a BCS 9, respectively. Due to the inaccuracy of using bodyweight solely as a predictor of cow BCS, weight to height ratio (WHR) has been evaluated as a possible way to determine cow BCS (Klosterman et al., 1968; Herd and Sprott, 1986; Houghton et al., 1990). Using cow WHR at a BCS 1, 5, and 9, the cow should weigh 18.08, 25.54, and 33.30 kg/cm (Herd and Sprott, 1986). Klosterman et al. (1968) reported accurate and similar WHR for Charolais and Hereford cattle that were different in height at their hooks. Although using WHR to determine BCS is less subjective compared to visually predicting cow BCS, it is not as widely used practice since it requires facilities to physically restrain the animals. This method is neither as time, labor, or cost efficient (Houghton et al., 1990).

The amount of body fat cattle have is directly related to their body condition score. Comparisons were made among thin (BCS 3), average (BCS 5), and fat (BCS 7) cows that were considered a BCS 5 at 498.95 kg (Herd and Sprott, 1986). Body fat represented 30.39, 71.21, and 124.74 kg of the empty bodyweight for the BCS 3, 5, and 7 cows, respectively. As BCS increases, the percentage of fat composing the cow's body steadily increased from 8, 16, to 24% of the cow's empty bodyweight composition. Percentages of protein and water of the cow's empty bodyweight decrease as the cow gains body condition. Percentages of protein and water for BCS 3, 5, and 7...
cows were 20, 18, and 17% protein and 67, 61, and 55% water. From a BCS 3 to a BCS 5 and a BCS 5 to a BCS 7 there was a difference of 40.82 and 53.52 kg, respectively. However, the differences in the amount of protein and water of the cow's empty bodyweight were identical as 4.54 kg of protein and 15.42 kg of water were calculated as the difference between BCS 3 and 5 and BCS 5 and 7 cows (Herd and Sprott, 1986). On the average BCS 1, 5, and 9 cows are approximately 3.77, 18.89, and 33.91% body fat (NRC, 1996). As animals fatten their caloric intake increases. Herd and Sprott (1986) reported that as beef cows increase in BCS, their caloric value per kilogram of bodyweight gain increases. For beef cows to go from a BCS 1 to a BCS 2, BCS 5 to a BCS 6, and BCS 8 to BCS 9 values of 1.22, 1.46, and 1.65 Mcal/kg of bodyweight gain, respectively, were reported. In order for animals to gain body condition, they must have a higher caloric intake which may be achieved through increasing feed intake or by consuming a more energy dense diet (Herd and Sprott, 1986).

Cows at either end of the BCS spectrum are undesirable as they are more apt to experience metabolic problems and diseases, decreased milk yield, low conception rates, and calving difficulty (Ferguson and Otto, 1989). Excessively conditioned cows are more susceptible to calving problems and having lower dry matter intake during early lactation. Also, cows in poor body condition may not have adequate reserves to maximize milk production and typically will not breed back as readily (Roche et al., 1992; Wright et al., 1992). Crossbred cows that were fed to maintain BCS had heavier calves at weaning than cows that were fed to lose bodyweight during lactation (Richards et al., 1986).
Cattle producers strive to maintain a 12-month calving interval, which means cows must be rebred within 83 d of calving (NRC, 1996). Cows in low body condition (BCS 1 to 3) commonly do not get rebred during this window resulting in low pregnancy rates in beef females. Other factors contributing to when ovulation occurs include response to calf suckling and energy balance control (Roche et al., 1992; Wright et al., 1992). Herd and Sprott (1986) studied the percentage of cows pregnant 60 and 180 d after calving and found cows that calved at a BCS 5 or more had higher pregnancy rates. Over three production years, crossbred cows that calved at a BCS 5 or greater had less days to estrus (P < .01) and pregnancy (P < .05) compared to BCS 4 or lower cows (Richards et al., 1986). Also, Wright et al. (1992) found conception rates to be maximized using BCS 5 cows, which are deemed exactly average in their condition.

2.1.2 Availability of different nutrients

Digestible energy and total digestible nutrients (TDN) are very similar estimates of energy content in different feedstuffs. The major downfall to using DE and TDN energy value estimates with ruminants is they both tend to over predict energy values of high-fiber feedstuffs such as straw and hay in comparison to more highly digestible feeds that are lower in fiber like corn and wheat (Pond et al., 1995).

Sohal et al. (1982) reported that nutritional requirements of livestock in rural areas around Karnal were hardly met. They also reported low availability of DCP and TDN in case of high producing animals as compared to low producing animals.

Sinha (1982) observed that farmers feed concentrate to
the animals depending upon their economic status and not on the needs of the animals. Green fodders were fed by large and medium farmers, whereas landless, marginal and small farmers were not at all feeding any green fodder.

Kologi and Anand (1985) reported that in certain part of Karnataka, high cost of feed and mineral mixture is a limiting factor for adoption of improved feeding practices.

Thole et al. (1988) reported that animals reared by landless categories of farmers had lower milk yield than other categories of the animals. They also showed that dry matter intake of animals did not show large seasonal variations but tend to increase during rainy season.

Randhe et al. (1993) observed poor nutritional status of animals in landless category of farmers led to poor milk yield in this group.

Loknath (1995) reported that animals in rural areas of Faizabad district were under fed in terms of DCP, however, they were fed excess amount or nearly at par of DM and TDN as compared to their requirements.

Maurya et al. (2004) reported that the cross-bred cattles of Gorakhpur district are deficient in terms of DCP, TDN and phosphorus. This deficiency led to poor milk yield and long anoestrus periods in these cattles.

Thus the nutritional status of dairy animals are most important criteria for their management practices; as poor nutrition and body weight affect lactation as well as reproductive performance (Roche et al., 2007).
In case of dairy animals maternal nutrition is of more importance because of the milk production by the females. Moreover, in a recent study it has also been concluded that maternal diet, in the form of increased amounts of rumen protected PUFA fed around conception, rather than maternal body condition, can skew the sex ratio towards males (Green et al., 2008). These observations may have implications to the livestock industry and animal management policies when offspring of one sex may be preferred over the other.

### 2.2 LACTATION PERFORMANCE

At the onset of lactation a cow's body undergoes many dramatic changes. Most of the cow's energy intake is utilized for milk production. In over 80% of all dairy cattle milk production causes the cow to go into a negative energy balance (NEB) shortly after parturition.

The lactation performance of dairy cattle is usually measured by determining the total milk yield per lactation or per year, average daily milk yield, lactation length, lactation persistency, and milk composition. Generally, the reproductive performance and lactation performance of dairy cattle are closely associated with each other. Breeding failure has a clear negative influence on milk production and farm income and determines the future sustainability of a dairy farming operation.

#### 2.2.1 Daily Average Milk Yield

Srivastava et al., (1980) conducted a survey on different categories of households in Patna (Bihar) and found no
difference in the daily herd average of milk yield.

Thole et al. (1988) reported that animals reared by landless categories of farmers had lower milk yield than other categories of the animals.

Bordoloi et al. (2006) conducted a study on the lactation performance of cross bred dairy cattle in different household categories of Guwahati; where they did not find any significant difference between different households for daily herd average milk yield and daily wet average milk yield.

In a study, Lobago (2007) estimated the overall daily mean milk yield for the first 43 lactation weeks was 11.7 L/day. The daily milk yield increased gradually and peaked at 13.8 L/day approximately 11 weeks postpartum, after which it declined gradually and steadily. Suckling status, season of calving and parity number significantly influenced the estimated average daily milk yield. The estimated daily milk yield was lower for those cows suckled their calves and those cows having a parity number greater than three, while the effect of calving season was variable in the two lactation length categories considered.

In case of Uttar Pradesh, Singh et al. (2008) reported that the average daily milk yield in urban and peri urban categories was differing significantly from rural categories of farmers.

2.2.2 Total Lactation Milk Yield

Milk production level and lactation persistency are crucial factors determining the appropriate calving interval (Arbel et al., 2001). On the other hand, the costs of fertility depend on the stage of lactation and the shape of the lactation curve. Cows
normally have a lactation curve that loses 8 to 10% per month after the peak, but those rare animals whose production declines by only 4% or so may make a longer calving interval justified (Esslemont, 2003).

Bordoloi et al. (2006) conducted a research on the performance of cross bred dairy cattle in different household categories at Guwahati and found that the lactation milk yield of cows in landless households was found to be slightly higher than marginal and small farmer households. This trend of higher milk yield in landless labourer households was due to slightly longer lactation length of the cows.

Kabirizi et al. (2006) incorporated leguminous forages in the diet of cattle at Uganda. Their results showed that daily mean milk yield could be improved with a change in the diet of cattle.

Rajendran (2007) carried out a survey on the lactation performance of Umblachery breed of cattle in Tamilnadu. Milk recording was carried out at monthly intervals in 13 randomly selected villages in Thiruvarur and Nagapattinam districts of Tamilnadu, India. A total of 1591 milk recordings were made at monthly intervals from 435 cows. The cows were milked twice a day in the morning and evening. He found that average daily partial milk yield in those cattle ranged from 0.4 liter to 4.75 liters. He reported the total milk yield for a lactation to be 494 Kg.

In a recent research conducted on the management, productive and reproductive performance of dairy herds in Bangladesh; Sutradhar et al. (2008) reported that milk...
production is also correlated with the reproductive performance. She found that comparatively more milk production was present in cows that required less number of services per conception; whereas the cows requiring more number of services per conception are poor in milk production.

The 305 day lactation yield is also dependent on the breed types and agro ecological zone (Vargas, 2008).

2.2.3 Lactation Length

In most modern dairy farms, a lactation length of 305 days is commonly accepted as a standard. However, such a standard lactation length might not work for smallholder dairy cows in which the lactation length is extended considerably in most cases (Teodoro and Madalena, 2003; Masama et al., 2003; Msangi et al., 2005). Furthermore, such an extended lactation period has practical significance for the smallholder dairy farmer as it provides compensation for the usually extended calving interval (Tanner et al., 1998). The profitability of short or extended lactation length depends on various factors, including the lactation length persistency. Numerous studies have documented that additional days in which cows are not pregnant beyond the optimal time post calving are costly (Groenendaal et al., 2004; Meadows et al., 2005). However, Borman et al. (2004) demonstrated that extended lactations are suitable for some dairy enterprises and that the suitability depends particularly on cow milk potential, the ability to grow pasture or feed supplements economically, management expertise, environmental constraints, herd size and labour availability. Moreover, by combining a longer calving interval
with increased milking frequency, daily milk production from one calving to another could be increased, making an increased calving interval an interesting option for dairy farmers. In addition, an economic advantage in extending lactations (by 60 days) was found even in the case of high-yielding cows. This advantage was greater for primiparous cows, because of the high persistency of their milk production and the increase in the fat and protein contents of their milk as lactation progresses (Arbel et al., 2001). Thus, it is of interest to properly evaluate the economic benefits and subsequently optimize both the lactation length and calving interval under the given production level and prevailing management conditions.

Bordoloi et al. (2006) conducted a study on the lactation performance of cross bred dairy cattle in different household categories of Guwahati; where they found that the average lactation length of cows in landless labourer households was observed to be higher than marginal and small farmer households. The difference in lactation length between landless labourer and marginal farmer households was statistically significant.

Lobago (2007) investigated the lactation performance of dairy cattle in Ethiopia; and reported that the mean lactation length was 54.4 weeks.

2.2.4 Dry Period

The mammary gland of the dairy cow requires a nonlactating (dry) period prior to an impending parturition to optimize milk production in the subsequent lactation. This period is called the dry period, and it includes the time between...
halting of milk removal (milk stasis) and the subsequent calving.

The optimal dry period length between lactations in dairy cows has been debated since the early 1800s. During this time, some English farmers believed that a two-month dry period was optimal, while others believed that a two-week dry period was adequate. More than a century later during World War II, the 60-d dry period was adopted as the optimal dry period length for maximal milk yield and genetic progress during this time of food shortage (Knight, 1998). Since its adoption, the 60-d dry period has been maintained as the dry period length that best maintains the balance between lost milk income during the dry period and production levels achieved in the subsequent lactation. Currently, a majority of U.S. dairies manage for a 60-d or longer dry period (USDA, 2002). However, there have been many changes since adoption of the 60-d dry period that include a 5000 kg increase in milk yield per lactation, a larger emphasis on profit, accelerated genetic progress through artificial insemination and embryo transfer, adoption of the total mixed ration, increased milking frequency (IMF), altered photoperiod management, and commercialization and adoption of bovine somatotropin (bST) (Annem et al., 2004a). Such changes warrant a reevaluation of the optimal dry period length in today's high-producing dairy cow.

Milk yield responses to planned and retrospective studies on modified dry periods have been recently reviewed by Bachman and Schairer (2003), Annen et al. (2004a), and Grummer and Rastani (2004). These studies evaluated the effects of short or omitted dry periods using records from herds that were managed for a 60-d or longer dry period. Reasons for

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short or no dry periods in these herds are unknown but are likely the result of multiple births, mismanagement, and aborted pregnancies, all factors that would negatively bias subsequent milk yield.

Production responses to shortened dry periods ranged from 0 to 10% reductions in subsequent milk yield (Coppock et al., 1974; Lotan and Alder, 1976; Sorensen and Enevoldsen, 1991). Production responses to omitted dry periods or continuous milking range from 17 to 38% reductions in subsequent milk yield (Swanson, 1965; Smith et al., 1967; Remond et al., 1992).

Recent research, some of which incorporates bST supplementation, IMF, and other mammogenic treatments, has demonstrated potential for reducing dry period length in high-producing cows. The 30-d dry period has been shown to be equal to a 60-d dry period with or without bST supplementation during late gestation and early lactation (Bachman, 2002; Gulay et al., 2003; Rastani et al., 2003; Annen et al., 2004b).

2.2.5 Milk Constituents

The minimum standards for market milks are fixed for fat and SNF contents to ensure quality milk supply to the consumers and to prevent adulteration of milk. Various grades of market milk are supplied to the consumer after standardization to the prescribed levels of fat and SNF content of milk. Indigenous cattle are being bred with exotic germplasm to increase the milk yield. As the exotic blood level increases there is an increase in the milk yield of the crossbred animals if the animals are in high plane of nutrition. In the underfed animals the milk yield and SNF in milk are low and farmers suffer since...
low SNF milk is either not accepted or very low price is paid. The temperature prevailing in most part of the year is unfavorable for high milk essential to take steps to improve the milk yield with required SNF content.

Rajendran (2007) carried out a research on the lactation performance and milk constituents of Umblachery breed of cattle in Tamilnadu. Milk recording was carried out at monthly intervals in 13 randomly selected villages in Thiruvarur and Nagapattinam districts of Tamilnadu, India. A total of 1591 milk recordings were made at monthly intervals from 435 cows. The cows were milked twice a day in the morning and evening. The average of milk fat percentage was 4.94 ± 0.06. The mean fat percentage at first month was 4.46 ± 0.14 and by eighth month of lactation was 5.65 ± 0.50. There was no specific trend in the monthly averages for the fat and SNF content. But, when fat content of the milk considered as early, mid and late lactation the same was found to increase as the lactation advanced. The average solids-not-fat percentage was 7.80 ± 0.03 and ranged from 7.73 to 8.17. The SNF is less than the standard of 8.5% prescribed for cow milk under PFA rules 1955.

Kumaresan et al. (2008) conducted a research on various milk constituents of Jersey and Holstein Friesian crossbred cattle in Tamilnadu. The fat percentage of the crossbred Jersey cow milk ranged from 3.00 to 6.30 per cent. The mean high (4.61 ± 0.08 per cent) fat content of Jersey crossbred cow milk was observed during the month of January 2006 and mean low fat (4.05 ± 0.08 per cent) content of milk was observed during the month of April 2006. The fat content of the Holstein Friesian crossbred cow milk ranged from 3.10 to 5.20 per cent. The high
mean fat content (3.96 ± 0.10) was observed during the month of January 2006 and low mean (3.60 ± 0.07) fat content was noticed during the month of May 2006. The high mean SNF content (8.30± 0.04) for milk of Jersey crossbreds was observed during the month of December 2005 and low mean SNF content (7.97 ± 0.03) was observed during the month of May 2006. Similarly the high mean SNF content (8.19 ±0.02) was observed for the milk of Holstein Friesian crossbred during the month of December 2005 and low mean SNF content (7.91 ± 0.03) was observed during May 2006 with the values ranging between 7.70 to 8.70 per cent.

For production of milk fat, highly significant (p<0.01) differences were found between agro ecological zones, but no significant differences were detected between breed types (Vargas et al., 2008).

2.3 BLOOD BIOCHEMICAL PROFILE

Minerals have a beneficial role in endocrine system and tissue integrity. They are essential for basal metabolism, growth, pregnancy, lactation, wool production, reserve deposition and reproductive cycling. Hence mineral imbalance may affect the productive and reproductive efficiency in animals.

Use of profiles of blood metabolites to identify problem herds and dietary causes of low production or disease has been recommended. Payne and coworkers in 1970 were the first to propose specific "normal" or "baseline" ranges for diagnosis.

Multiple regressions on blood variables may be useful in predicting energy and nutrient intakes, and regression analysis...
may help in selection of blood measurements for inclusion in profiles. Best serum predictors of ration variables include cholesterol, phosphorus and globulin (Kronfeld et al., 1982).

The use of certain blood parameters as indicators of the physiological, nutritional, metabolic and clinical status of farm animals is gaining a wider application. In addition, methodology and reagents are becoming more standardized with the use of commercially available diagnostic kits. It is well known that variables such as breed, stage of growth, age, reproductive status and stage of lactation have an influence on many blood parameters. The reference values of blood parameters of livestock at different age and stages of lactation have been reported (Doornenbal et al., 1988).

Since small holding livestock system is mainly dependent on grazing and crop residues, mineral imbalance is quite common in India (Prasad et al., 1995).

Jorritsma et al. (2003) discussed about various metabolic changes that may affect lactation and reproductive performance in cattle and found that factors that play a role in the link between declined reproductive performance and the metabolic situation of the cow during the early lactating period include insulin, insulin-like growth factors, leptin, neuropeptide Y, nonesterified fatty acids, thyroid hormones, urea, and ammonia.

Singh et al. (2008) estimated various parameters in blood profiles of cattle and buffaloes in different categories of livestock owners and found no significant difference in various parameters except that the serum urea concentration was higher and cholesterol concentration was lower in buffaloes than in cattle.
2.3.1 Blood Glucose

In all species glucose is used by various tissues and organs for free energy (i.e. ATP) production. In addition, glucose may be converted either into glycogen or triacylglycerols which are subsequently stored within tissues (liver, adipose tissues, and muscles) or into lactose which is subsequently incorporated into milk in the case of lactating females. The destination of glucose is regulated by various hormones such as insulin, cortisol, glucagon, somatotropin and adrenalin, and consequently blood glucose levels depend on the nutritive values of the diets, on social or environmental stress conditions as well as on physiological phases.

A number of authors have studied the effect of calving distance on metabolic profile (Campanile et al., 1997). Several researches on dairy animals during the dry milk period and lactation indicated that, among energetic metabolism indicators, serum glucose levels were very constant (Bertoni and Piccioli, 1994; Satriani et al., 2001). Several authors (Setia et al., 1992; Campanile et al., 1997; Montemurro et al., 1997), subsequently, reported increased evidence that nutritional status plays a major role in determining variations of the circulating glucose concentration levels. Low serum glucose levels have been found in buffaloes in taking less than 1020 Kcals/l of milk of NE/l (net energy/lactation), inversely correlated with the quantity of milk produced, but positively correlated with the distance from calving (Zicarelli et al., 1982; Elthohamy et al., 1994). Other studies have shown an increase of glucose following a rise of T3 and T4 values in cold climates (Campanile et al., 1994).
It is well known that early lactation is characterized by a negative energetic balance, which is less intense in buffalo than in bovines: plasma glucose concentrations are lower during the catabolic phase of lactation, and are higher during the anabolic phase of lactation when energy intake is equal or superior to the energy release (De Rosa et al., 2001). Terzano et al. (1997), studying the effect of feeding systems and puberty onset on blood metabolites in buffalo heifers, found that blood glucose levels remained within physiological ranges with a mean value (4.08 mmol/l) similar to that reported by Campanile et al. (1991) and Bertoni and Piccioli. (1994) in lactating buffalo cows or by Borghese (1994) in buffalo heifers, while Montemurro et al. (1995) reported lower glucose values in heifers bred in two different farms (2.80-3.44 mmol/l). In the same study the feeding system significantly affected the glucose level as found by other authors (Montemurro et al., 1995; Zicarelli et al., 1982), according to the energy level of diet: heifers bred in a feedlot and fed maize silage ad libitum (DM 33 percent, crude protein 8 percent, crude fiber 21 percent, 0.85 MFU/kg DM) plus hay (about 20 percent on fed maize silage) and protein-mineral-vitamin supplement, showed higher daily gains and higher glucose concentration than heifers fed natural pasture (50 percent graminaceae, 40 percent leguminosae and 10 percent other species; DM 20-70 percent, crude protein 10-21 percent, crude fiber 18-35 percent, 0.50-0.85 MFU/kg DM). The same authors reported that glucose levels were significantly affected by the onset of puberty since this probably involves a more intensive energy metabolism. Zia-Ur-Rahman et al. (1997), studying the changes in hormones and haematochemical parameters in buffaloes undergoing transport (150-320 km)
handling and slaughter stress, found a strong positive correlation between glucose concentration and struggling time and, specifically, glucose levels rose from a basal value of 3.20 mmol/l to 3.80 mmol/l (after transport), to 3.40 mmol/l (after handling) and to 3.80 mmol/l (after slaughter), due to an increase in cortisol levels.

In a recent study, Balusamy et al. (2008) found that the blood glucose levels in Indian buffaloes were higher during the late stage of lactation.

### 2.3.2 Serum Total Protein, Albumin & Globulins

Unlike lipid metabolism, protein metabolism is not markedly influenced by the energy-protein content in diets or by different environmental conditions. When the protein level of the diets is high, animals enhance gluconeogenesis by amino acids from protein degradation; on the contrary, when the protein level of the diets is low, animals reduce production (meat and milk) and afterwards enhance hepatic protein synthesis and the production of microbial protein which may represent a significant part of total amino acid entering the small intestine of host animals. Thus, microbial protein contributes to satisfying the protein requirement of the animal for tissue maintenance and growth and for milk and wool production.

In a previous study Bertoni et al. (1994), studying the serum protein levels of lactating buffaloes reported no significant variations during lactation. Campanile et al. (1991), setting the metabolic conditions of healthy and affected buffaloes in farms with a high incidence of endometritis, found that the endometritis affected animals tended to have a significant
increase of γ-globulins; the latter, therefore, can represent a useful indicator of this pathological phenomena. Montemurro et al. (1997) reported low serum total protein and globulin levels in buffaloes before calving and after 45 days of lactation. The same authors reported high serum albumin levels at the end of pregnancy, while the serum total protein levels have been found to show very little variation during lactation, as reported by Campanile et al. (1997). Montemurro et al. (1995) showed that, in heifers, different seasons and feeding did not markedly affect the serum total protein, albumin and globulin levels. On the contrary, Setia et al. (1992) and Campanile et al. (1994) found a significant effect of feeding systems on serum total protein levels. In the study of Terzano et al. (1997), feeding systems affected serum total protein levels as heifers fed natural pasture benefited from more protein than the heifers bred in the feedlot and fed maize silage ad libitum (69.4 g/l vs. 73.2 g/l, respectively). The same authors reported serum total protein levels to be significantly affected by puberty, showing an increasing trend with significant differences after puberty (69.0 g/l vs. 73.6 g/l). Zia-Ur-Rahman et al. (1997), in a study on hormonal and haematological profiles in buffaloes after transport, handling and slaughter stress, found higher serum total protein and albumin levels after transport, higher serum total protein after handling, higher serum albumin levels and lower serum globulin levels after slaughter.

Balusamy et al. (2008) correlated the serum protein levels in different stages of lactation in buffaloes and found that the total protein was lower in early stages of lactation.

In a recent study Cardoso et al. (2008) showed that the
levels of serum total protein and albumin decreased in cattle suffering from left displacement of abomasum.

2.3.3 Serum Cholesterol

The values of serum cholesterol are usually considered as an indicator of good hepatic lipoproteins production used as carriers of triglycerides, synthesized from NEFA (Non Esterified Fatty Acid). Total cholesterol and HDL (High Density Lipo Protein)-fractions indirectly reflect the degree of exogenous energy availability and the hepatic functionality: its levels rise owing to a moderate negative energetic balance: lactation, low temperatures and high thermal ranges (Campanile et al., 1994).

In a study Grasso et al. (2004), observed a marked effect of calving distance on this parameter (ranging between 2.05 and 3.01 mmol/l); in the same study the authors showed that housing systems (intensive vs. traditional system) did not markedly affect the plasma cortisol level of buffalo cows. Terzano et al. (1997), studying the effect of feeding systems and puberty onset on blood metabolites in buffalo heifers, reported that serum cholesterol level was not affected by the feeding system (1.93 mmol/l) but it was significantly affected by puberty, showing an increasing trend with a significant difference after puberty (1.83 vs. 2.03 mmol/l). The higher concentration of cholesterol with the advancement of age is probably a physiological adjustment to meet growth requirements.

In a recent study Cardoso et al. (2008) showed that the level of serum cholesterol decreased significantly in cattle suffering from left displacement of abomasum.
2.3.4 Serum Calcium

Most calcium in the body, about 90 percent, is in the bones, where it can be reabsorbed by blood and tissue, but about one percent is used for nerve impulses and muscle contractions (including the heart, kidney, and other organs). Calcium participates in the protein structuring of RNA and DNA, and also contributes to the formation of intracellular cement and cell membranes. It helps in normalizing blood clotting action, to metabolize the body's iron and it is more effective when combined with: vitamins A, C and D. Blood calcium levels show limited variability during lactation and dry milk period (Bertoni and Piccioli, 1994); higher levels have been found in the last month of pregnancy and lower ones at the end of the lactation period (Montemurro et al., 1997). A seasonal variation has been evidenced with higher values during the winter. Ca/P ratio is maintained at 1.4-1.6 (Montemurro et al., 1995). Campanile et al. (1997) found constant values of about 10 mg/dl, confirmed by Terzano et al. (2000) who found 8.87-10.63 mg/dl of Ca blood levels in adult buffaloes. In buffalo species calcium excesses could alter the Ca/P ratio during the dry milk period, inducing parathyroid hypo activity which would cause magnesium to increase and calcium to decrease at the beginning of the lactation due to a non immediate calcium mobilization by the bones. The altered Ca/Mg ratio favours utero-vaginal muscular release, responsible for uterus atony and eventually uterine prolapse (Campanile et al., 1997).

2.3.5 Serum Phosphorus

Phosphorus is the second most plentiful "essential mineral"
in the body and is a key component of DNA, RNA, bones, teeth, and many other compounds required for life. It plays an important role in the energy metabolism of cells, affecting carbohydrates, lipids and proteins. Phosphorus also stimulates muscle contraction and contributes to tissue growth and repair, nerve-impulse transmission, central nervous system health, and proper heart and kidney function. Phosphorus deficiency during buffaloes' dry milk period is responsible for the most frequent causes of vaginal and/or uterine prolapse in this species. If the diet is deficient in P before calving, calcium levels decrease upon calving while phosphatemia is normal (Campanile et al., 1997). On the other hand, diets rich in silage and/or concentrates, have been associated with high P and Cu haematic values and subclinical metabolic acidosis that is frequently connected with uterine prolapses and endometritis (Campanile et al., 1997). Phosphorus levels in animals have been found to be quite stable at six mg/dl (Campanile et al., 1997). An increasing trend has been evidenced starting from the pre-partum period (6.3 mg/dl) to 160 days of lactation (7.9 mg/dl) (Montemurro et al., 1997). In water buffalo mature females, inorganic phosphate was significantly higher compared to that of immature females (Canfield et al., 1984). Buffalo heifers showed higher P blood levels in winter (Montemurro et al., 1995). Buffaloes suffering from post-parturient haemoglobinuria showing a decrease in the reduced glutathione content in the red cells, also exhibited severe hypophosphataemia (Chugh et al., 1998).

The Absorption of Ca and P is better from diets containing Ca: P ratio 2:1. Even a higher ratio has been suggested to be associated with infertility in cattle. The disturbed Ca to P ratio has a blocking action on the pituitary and consequently on
2.4 REPRODUCTIVE PERFORMANCE

The reproductive efficiency of a dairy herd can be measured in several ways, such as by measuring pregnancy rate, percentage of cows calving each year, average calving interval, average number of days dry, and number of live calves born each year. Although each of these measures affects the profitability of the dairy business in a slightly different way, the calving interval affects both the total milk production of the dairy herd and the number of calves born. In most modern dairies, the general practice is to breed cows early, with the aim of establishing a calving interval of 12 to 13 months, which is considered optimum; hence, calving interval is considered an important index of reproductive performance (Roberts, 1986; Arbel et al., 2001).

Roche et al. (2007) conducted a study on the correlation of reproductive performance with BCS and body weight and found that all reproductive response measures were negatively affected when BCS and BW measures indicated an increased severity and duration of the postpartum negative energy balance.

2.4.1 Service Period (SP)

Service period is the period between calving to conception of an animal. Considerable variations in the service period in different countries have been reported. A significant positive correlation between service period and lactation milk yield has been reported by Basu and Ghai (1978).
Polikhronov (1965) reported that generally both lactation length and milk yield were greater when the service period was longer.

In dairy cattle, possibility of extending lactations has received attention as an alternate to maximize the peak yield and minimizing the calving intervals (Knight, 1997; 1998). Extended lactations can be accomplished by planned increase in calving interval (Bertilsson et al., 1997).

Extending the lactation, however, has its problems for high yielding dairy cows. It is sometimes difficult to get cows pregnant at the desired time 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). According to Schmidt (1971), pregnancy has an inhibitory effect on the milk yield of dairy cows, particularly during the later part of lactation.

Thus 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 calving period, 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 animals.
2.4.2 Calving Interval (CI)

The calving interval is the measure most commonly used to assess the overall herd reproductive performance in dairy herds (Esslemont, 1992). The reductions in milk production and profit caused by extended calving intervals have been demonstrated frequently (Funk et al., 1987). Calving interval can be calculated as the duration of the interval between the two most recent calvings for all parturient cows in a herd.

Calving interval (CI) has two components: 1) calving-to-conception interval (CCI) or days open, which is considered to be the most important component determining the length of the calving interval, and 2) gestation length, which is more or less constant, varying slightly due to breed, calf sex, litter size, dam age, year, and month of calving, and little can be done to significantly manipulate the gestation length (Mukasa-Mugorwa et al., 1991). The CCI itself is influenced by cow and management/environment-related factors, such as method and efficiency of heat detection, type and efficiency of breeding service and the ability of the cow to resume regular ovarian cyclicity after calving, display an overt heat signs, and conceive with the given service.

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).

Mclendoz and Pinedo (2007) correlated the associations between reproductive performance and milk yield and found that CCI had increased over time and was related negatively to the...
increase in milk yield experienced by central-southern Chilean Holstein cattle during the last 15 year.

2.4.3 Age at First Calving (AFC)

The time between birth and first calving represents a period in which replacement heifers are not generating income. Instead this rearing period requires considerable capital expenditures including feed, housing, and veterinary expenses. These expenses constitute 15 to 20% of the total expenses related to milk production (Heinrichs, 1993). A basic approach to reducing this cost is to reduce the amount of time between the heifer's birth and her first freshening. Age at first calving (AFC) has a significant influence on the total cost of raising dairy replacements with older calving heifers being more expensive to raise than younger (Tozer and Heinrichs, 2001). Furthermore, reducing AFC can also improve the profitability of the enterprise by increasing lifetime milk production and milk production per year of herd life (Lin et al., 1988). AFC can be reduced by a combination of increasing prepubertal average daily gain and decreasing age at breeding (Gardner et al., 1988; Van Amburgh et al., 1998; Radcliff et al., 2000) or by reducing age at breeding alone (Lin et al., 1986; Ettema and Santos, 2004).

Universal recommendations for one particular AFC might be an incorrect management goal for all cattle on all farms, since the recommendation might not represent the management goals and/or capabilities of a particular production system or farm. The farm economics depends on reproductive life span of dairy animals, so it is very important to show estrus as early as possible for a heifer. By showing estrus as early as possible, a female animal can contribute more on the reproductive point of
2.4.4 **Number of Services per Conception (NSC)**

Service per conception is another criterion for the measurement of reproductive efficiency of an animal and it directly affects the conception rates. Increased number of services per conception and low conception rate always leads to increase in age at first calving, service period, calving interval and ultimately affects the overall productivity of dairy animals.

The differences in management (production) systems and environmental conditions under which cattle are maintained could greatly affect the conception rates by decreasing the number of services per conception. Thus, in case of organized farms, where the animals are properly managed, the NSC is lower than small holder level.

In organized farms, NSC of 1.5 (Bashir *et al.*, 2007) 1.62 (Gebeyehu *et al.*, 2005; Mondal *et al.*, 2005) have been reported; whereas at field level, higher values like 2.90 and 3.92 in cattle & buffaloes (Thirunavukkarasu, 2007).

NSC can be correlated with various factors like lactation status, number of parity, nutritional status as well as the reproductive disorders like endometritis etc. Gebeyehu *et al.* (2005) conducted a research on correlation of NSC with parity number in the cattle of Ethiopia and found that NSC was affected by the parity of cows.

Sutradhar *et al.* (2008) correlated the service per conception with the lactation yield and found that cows that required less number of services per conception (1-2 services per
conception) comparatively produced more milk (461.52±151.89 liter) than the cows (452.84±96.60 liter) that required more number of services per conception (3-6).

In a recent study, Bhagat et al. (2008) studied various socio economic factors that may affect the conception rate in cattle under field conditions. They found that education level of farmers & participation of female members of family, total land holding capacity of farmer, occupation of farmers, type of housing of animals and the number of animals per family significantly affects the conception rates.

2.5 REPRODUCTIVE PROBLEMS

There is a need in the Indian region for transferring appropriate improved methods for feeding, breeding and management of dairy cattle to the small-scale farmers. Poor oestrus detection is often a major cause of poor reproductive performance. Prolonged post-partum anoestrus is another major cause of economic losses in cattle production in tropical countries (Hansel and Alila, 1984). Duration of this period is influenced by stressors such as high temperature, suckling and over-crowding (Ovedipe et al., 1982). However, it is recognized that the most important factors to consider in attempts to improve fertility are accurate detection of oestrus, correct timing of insemination and providing appropriate management and feeding to permit fertilization, early embryonic development and maintenance of pregnancy (Cox et al., 1987).

Two types of anoestrus occurs in cattle and buffaloes. In the first form, the animal possesses a palpable CL in one ovary, but has not been detected in oestrus due to sub oestrus or silent
oestrus, whereas in the second form, the animal has no palpable CL (true anoestrus). In most cases, the disorder resolves spontaneously with the arrival of more favourable climatic conditions and adequate feeding. In the past, the silent oestrus was believed to be a major problem in buffaloes, but now evidence suggests that it is due to the poor oestrus detection in these herds. The blood levels of Ca, P, glucose and total protein are found to be lower in anoestrus than in cyclical animals (Arthur et al., 1996).

Repeat breeding is another important cause of low reproductive efficiency in dairy animals. The incidence of repeat breeding may vary from 15-32% and seems to be lower in animals kept individually on small holdings than in large herds (Arthur et al., 1996). Similarly, the incidence is lower in heifers than adult animals up to the III parity.

Ghanem et al. (2002) studied the factors leading to endometritis in dairy cows. They found the incidence of endometritis as 22.4% and concluded that the most prominent risk factors leading to the occurrence of endometritis were retained placenta, still birth, external interference by herdsmen during calving and difficult birth. The cows in the first parity had a higher incidence of endometritis than cows in subsequent parities.

In a recent research, Das et al. (2008) conducted a study on the incidence of periparturient diseases among Jersey cows in an organized farm. Their results revealed that the highest incidence of diseases was in 5th lactation, followed by 3rd, 4th, 2nd, 6th and 1st lactation.

The prevention and treatment of reproductive tract disorders in the dairy cow have been the basis of regularly
scheduled veterinary programs for herd health. In the early decades, the emphasis has been primarily the control of infectious diseases and nonspecific infections affecting the reproductive tract, improved estrus detection, monitoring of breeding techniques, education about semen handling, and diagnosis and treatment of hormonal imbalances.

2.6 FACTORS INFLUENCING THE REPRODUCTIVE AND LACTATION PERFORMANCE OF DAIRY ANIMALS

The performance of animals depends not only on their genetic merits, but also on other factors such as nutrition, management, health, and environment. Many factors influence the reproductive performance of lactating dairy cows. Management factors such as accuracy of heat detection, use of proper inseminating techniques, proper semen handling, and appropriate herd health policies can directly influence the reproductive performance of a dairy herd. In addition, other factors beyond the immediate control of management may impact fertility; these factors include milk production of the cow, age of the cow, and season of year (Hillers et al., 1984). A variety of environmental factors affect the onset of ovarian cycles in the postpartum period and the most important of these are suckling, milk yield, nutritional status, and season (Peters, 1984). Swensson et al. (1981) suggested that malnutrition, disease, milk let-down interference, weak heat symptoms, and inbreeding are factors that commonly result in very low fertility in unimproved breeds.

Msangi, Bryant & Thorne (2005) did a longitudinal study
in Tanzania to examine factors influencing milk yield in smallholder crossbred cows. They investigated the effects of location (district), calving season, body condition score (BCS) at calving, calving year, herd size, source of labour (hired or family labour), calf-rearing method (bucket-fed or partial suckling), and parity number, and found that calving year, calf-rearing method and BCS significantly influenced the daily milk yield. This group (Msangi, Bryant & Thorne, 2005) demonstrated that milk production was mainly influenced by BCS at calving, at which time the lactation milk yield increased quadratically from score 1 to 3; they concluded that BCS at calving may provide a simple single indicator of the nutritional status of a cow. In addition, Muraguri, McLeod & Taylor (2004) from Kenya reported that commercial concentrate supplementary feeding of lactating smallholder cows led to a significantly higher mean daily milk yield than that of non-supplemented ones throughout the year (18.6% higher annual milk off-take).

With respect to effect of breed, it has been found that crossbreeding has improved the age at first calving and oestrous manifestation of crossbred cows, compared with the local ones, kept under equal and satisfactory feeding, management, and health-control regimes (Swensson et al., 1981). Moreover, Albero (1983) showed that in 14 small dairy farm cooperatives located in the central highlands of Ethiopia, F1 heifers performed significantly better than did zebu (CIs of 371 versus 421 days and total milk yield per lactation of 2013 versus 429 kg, respectively). However, a decline in both the productive and reproductive performance with increasing fractions of Bos taurus above the F1 crosses was reported in medium-/low-input production systems (Madalena et al., 1990).
In smallholder dairy production systems, reports vary among the different investigators with regard to the effects of certain factors on the reproductive and lactation performance. For example, Msanga and Bryant (2004) found no difference in the productivity of cows, measured as annual milk off-take, between those that suckled their calves and those whose calves were bucket reared and whose calf weights were similar at one year of age. On the other hand, Msanga and Bryant (2003) observed an early peak lactation yield in bucket-rearing cows, while suckling cows had a flatter but more persistent (sustained) curve; the lactation persistency was maintained to a significantly greater extent in suckled than in bucket-rearing cows. Moreover, Msanga et al. (2000) from Tanzania reported that the lactation yields of smallholder dairy cows were significantly influenced by factors such as year of calving, district, proportion of Holstein genes, and herd size, while lactation length was significantly affected by district and herd size. With respect to reproductive performance, Msanga and Bryant (2003) found no significant differences in the interval from calving to first oestrus, insemination and conception between two crossbred genotypes (60–80% and >80% *Bos taurus* inheritance), between cows whose calves were reared by suckling or bucket. In contrast, Obese et al. (1999) from Ghana reported that calving interval was significantly influenced by factors such as location, season of calving, parity, and BCS in smallholder dairy herds.