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STRESS IMPEDES REPRODUCTIVE PHYSIOLOGY OF DAIRY ANIMALS UNDER SUBTRIPICAL CONDITIONS - A REVIEW

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ABSTRACT

Dairy animals in the tropics face numerous challenges under tropical environments. They have to maintain their primary body functions within optimum ranges during the extreme seasonal variations, especially the thermal stresses during summer. The malnutrition and prevalence of diseases exert further stresses. Under such circumstances the animal has to re-visit its priorities for the body functions and survival remains the topmost priority over growth, productivity and fertility. Reproduction gets the last priority for nutritional partitioning and hence it is the first to be affected by any type of stress. The local breeds of dairy animals are well adapted to local environment of temperature variation, feed availability and diseases prevalence. However the stress factors do affect the reproductive physiology and lactation, adversely. Resistance to stress is reduced with the genetic improvement coupled with productivity enhancement of animals. The genetically improved animals exhibit repeat breeding probably due to delayed ovulation under stress conditions. There is a need to investigate the relationship among various stressors like higher milk yield, abnormal levels of blood metabolites and ambient temperature, with reproductive physiology. Relationship of stress indicators like reactive oxygen species and enzymes with pituitary, adrenal and ovarian hormones needs exploration. The stress comprises nutritional, health and thermal factors and is revealed by the inability of an animal to cope with its environment, a phenomenon that is often reflected in a failure to achieve genetic potential. The author has reported reproductive and productive disorders associated with crossbreeding in cattle. An important cause of reproductive problems in crossbred cattle in Philippines was under-nutrition, particularly at critical periods of the cow's reproductive life, reflected in the slow recovery from loss in body weight and condition score during the early postpartum period and the increased plasma BHB values at peri-partum period in some cows, indicative of negative energy balance, and the flat lactation profile. It has been suggested that a variety of endocrine regulatory points exist whereby stress limits the efficiency of reproduction. Negative feedback effects appear to operate mainly at the pituitary level during transport but at the hypothalamus during hypoglycemia. The endocrine evidence showed that stressors interfere with precise timings of reproductive hormone release within the follicular phase. Stressors also delay the onset of the luteinizing hormone (LH) surge. The author has concluded that excess intake of crude protein, associated with higher serum urea levels and low energy intake, associated with poor body condition, are the key factors for low reproductive efficiency. It may be corrected by adopting a proper feeding strategy. We also reported a decline in milk with advancement pregnancy was slight up to a point which was declared as joining point; thereafter the decline was much greater, showing a pregnancy stress on milk yield. Milk production stress was found to lower milk progesterone concentration in buffaloes. This review concludes that dairy animals need an optimum range of metabolites, body condition score, nutritional status and management conditions to express reproductive cyclicity at its best level.

Key words: Dairy, cows, cattle, buffalo, reproduction, stress, nutrition, body condition.

INTRODUCTION

The geographical locations of various regions constitute environmental conditions which affect the performance of living organism favorably or adversely. Dairy animals in the tropics face numerous challenges under tropical environments. The hypothalamus, controlling most of the body systems, regulate functions of various organs in a coordinated way. Animals have to maintain their primary body functions within optimum ranges during the extreme seasonal variations, especially the thermal stresses during summer. The malnutrition and prevalence of diseases exert further stresses. Under such circumstances the animal has to re-visit its priorities for the body functions and survival remains the topmost priority over growth, productivity and fertility. Reproduction gets the last priority for nutritional partitioning and hence it is the first to be affected by any type of stress (Oltenacu et al., 1980). Being in the original habitats, the local breeds of dairy animals are well adapted to local environment of climatic variation, feed availability and diseases prevalence. However the stress factors do affect the reproductive physiology and lactation, adversely (Halliwell and Gutteridge, 1999). Resistance to stress is reduced with the genetic improvement coupled with productivity enhancement of animals. The genetically improved animals exhibit repeat breeding probably due to delayed ovulation under stress conditions. There is a need to investigate the relationship among various stressors like higher milk yield, abnormal levels of blood metabolites and ambient temperature, with reproductive physiology. Relationship of stress indicators like reactive oxygen species and enzymes with pituitary, adrenal and ovarian hormones needs exploration.

Dairy animals in the tropics face numerous challenges under tropical environments. They have to maintain their primary body functions within optimum ranges during the extreme seasonal variations, especially the thermal stresses during summer. The malnutrition and prevalence of diseases exert further stress. Under such circumstances the animal has to re-visit its priorities for the body functions and survival remains the topmost priority over growth, productivity and fertility. Reproduction gets the last priority for nutritional partitioning and hence it is the first to be affected by any type of stress.

Energy Status: Energy is provided by feed ingredients through supply of various nutrients. The ruminal fermentation of carbohydrates, proteins and fats provides volatile fatty acids, which in turn, are converted into blood metabolites and utilized for synthesis of various products and tissues. Hypothalamus coordinates the body functions and prioritizes one over the other, for supply of nutrients substrates. In the genetically improved dairy animals the blood metabolites are channelized for milk synthesis as a top priority phenomenon.

Rasby *et al*. (1992) reported that nutrition restriction has a negative influence on LH release. Animals in anestrous showed decrease in diameter of the dominant follicle and in ovulation rate to the GnRH treatment. Nutritional status of an animal is reflected by the BCS. Several studies also demonstrate the negative effect of low BCS on ovarian cyclicity and pregnancy rates in beef cows (D'occhio *et al*., 1990; Viscarra *et al*., 1998). Furthermore, investigations on postpartum reproduction indicate that BCS is a useful indicator of energy status and rebreeding potential (DeRouen *et al*., 1994). It was suggested that buffaloes may have to present BCS $\geq$ 3.5 for a satisfactory response to the treatment with GnRH and prostaglandins for fixed time artificial insemination (FTAI).

Ovarian activity, estrus and conception were recorded in a total of 75 swamp buffalo cows after estrous synchronization at two mating seasons and at two levels of nutrition. It was concluded that ovarian inactivity associated with poor nutrition could be an important cause of low reproductive rates in swamp buffalo cows, and that the condition could be prevented or corrected by adequate feed intakes. In peri-urban dairy farmers in north-western Pakistan, shortest postpartum ovulation interval was noted during autumn (August to October) and the incidence of silent ovulations was lowest (Qureshi et al., 1999a). It coincided with the minimum intake of crude protein (CPI) and maximum intake of metabolizable energy (MEI, $p<0.01$). It was also associated with higher calcium and zinc intake and lower phosphorus, copper and magnesium intake.

In another study Qureshi *et al*. (2002) reported that BCS and postpartum ovulation interval were correlated with ME intake ($p<0.01$). Prepartum ME intake was higher in oestrous as compared to anoestrous animals ($p<0.05$). Higher and lower ME intakes were associated with anoestrus, while a moderate energy intake was associated with a postpartum estrus interval (PEI) of less than 75 days. BCS was negatively correlated with PEI ($p<0.01$) and was higher in estrous buffaloes than anestrous ones. It was concluded that excess intake of crude protein, associated with higher serum urea levels and low energy intake, associated with poor body condition, are the key factors for low reproductive efficiency.

Seasonality: Seasonality is associated with reproductive activities through changing daylight length, availability of fodders mass and changes in ambient temperatures. This has led to a seasonal pattern of breeding in most of the domestic animals. Buffalo is a photoperiodic species and like sheep, it has to be considered a "short day" species. They have heats throughout the year but are more fertile when daylight hours decrease.

According to Zicarelli (1995), this characteristic is due to their tropical origins; in fact, in these areas the availability of forage coincides with the period in which dark hours increase. Therefore, it has been supposed that animals which calve in the most suitable period for survival of the offspring were selected. It seems that they have retained this characteristic even when transferred to places where forage is always available. In countries like Italy, where market demand requires a concentration of deliveries in the spring-summer period (not corresponding to buffalo reproductive activity) the out-of-season technique is widely applied. As a result, buffaloes which are less sensitive to photoperiodic effects have been selected. When the out-of-season technique has been applied for long periods a lower loss of fertility was observed (15% vs. 30%) compared to the farms in which it has been adopted for shorter periods (Campanile, 1997).

It was suggested that that photoperiod has a marked influence on buffalo reproduction in certain areas of the world, however in some tropical areas like in Brazil, mainly in the Amazon valley and areas nearest of the equator the light seems to have a minimal effect or no effect on the reproductive cues? however the nutrition and heat stress measured throughout temperature/humidity indexes (THI) play an important role in the reproductive functions of buffaloes (Vale, 2007). It was also suggested that THI >75 has a negative effect on reproductive performance of buffaloes.

Opposite trend of breeding has been reported in buffaloes and cows which has been noted as a blessing for countries like Pakistan (Shah *et al*., 1989). Qureshi *et al*. (1999a) reported that the buffaloes calving during the normal breeding season (NBS, August to January) ($p<0.01$) showed postpartum estrus interval of 55.95 days versus 91.15 days in those calving during the low breeding season (LBS, February to July). Milk progesterone levels (MPL) in the LBS remained lower than the NBS ($p<0.01$). Shortest postpartum ovulation interval was noted during autumn (August to October), followed by winter (November to January), summer (May to July) and spring (February to April). The incidence of silent ovulations was higher during LBS than NBS (70.6% versus 29.4%). In a concurrent study (Qureshi *et al*., 1999b, 2002), milk progesterone levels in buffaloes showed a pattern opposite to atmospheric temperature. In NBS calvers serum glucose levels were higher ($p<0.01$) and magnesium levels were lower ($p<0.01$) than performance in buffaloes calving in the LBS coincided with a low BCS ($p<0.01$). Fat corrected milk production (FCM) was higher in NBS than LBS ($p<0.01$) calvers.

Sousa *et al*. (2006) in the Ribeira Valley of Brazil, state (Latitude 14 to 33o South) found that 86 % of female buffaloes did not express any seasonal anoestrus in a long photoperiod season. The same author used melatonin implants in a group of animals in the same environmental conditions and could not observe any improvement in the animals cycle activity and the fertility did not show any statistic significant difference ($p<0.05$). The calving distribution in the Amazon valley is completely different of the other Brazilians regions and do not have any influence of the photoperiod as reported by Vale *et al*. (1990), Zicarelli and Vale (2002). Ribeiro (2002) found the yearly calving distribution in the buffalo production system near of the Equator line, The same results were also observed by Vale *et al*. (1996) with a little difference concerning the peak of calving which has occurred between November and December.

Nutritional effects on seasonality of reproduction are more evident in countries where buffaloes calve during the most favorable periods (Campanile, 1997). Negative phenomena may be observed in countries where the calving calendar is modified by applying the out of breeding season mating technique (Zicarelli, 1997). This technique is applied, in the Mediterranean region where there is a requirement for mating programs in buffaloes to be conducted during the spring-summer period (unfavorable for the reproductive activity since buffalo is a short-day species), so that calving coincides with the yearly peak in demand for buffalo milk. This creates a potential conflict between the seasonal nadir in reproduction and the need to establish pregnancies, because the increase of day-length determines a seasonal decline in reproductive activity, which is manifested by a reduced incidence of estrous behavior, a decrease in the proportion of females that undergo regular estrous cycles and generally lower conception rates. It was observed that embryonic loss in animals mated by artificial insemination is 20-40% during seasons characterized by high number of light hours (Campanile *et al*., 2005), whereas values of around 7% were recorded in Brazil during decreasing light days (Baruselli *et al*., 1997).

In contrast to the previous work, an embryonic mortality rate of 20% was reported for buffaloes close to the equator (Vale *et al*., 1989). In any case, embryo mortality in buffalo occurs later than in bovine, usually between 25 and 40 days from AI (Campanile *et al*., 2005). In buffaloes naturally mated (Vecchio *et al*., 2007), independently from the conception period, 8.8% and 13.4% showed respectively embryonic mortality between 28-45 days (embryonic mortality-EM) days and between 46-90 days (fetal mortality – FM) of pregnancy. Campanile and Neglia (2007) found no differences between the incidence of EM in relation to the conception period, while a high incidence ($P<0.01$) of FM was found during a period of increasing daylight length (transitional period: December- March) Compared to the April-July period. This review concludes that dairy animals need an optimum range of metabolites, body condition score, nutritional status and management conditions to express reproductive cyclicity at its best level.

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