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REVIEW ARTICLE

Genetic Basis of Estrous in Bovine: A Review

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Abstract

Worldwide there is a lot of interest in bovine as an animal to meet the growing demand of meat and milk in developing countries, but the productive potential of bovine is a major constraint leading to low productivity. The major reason for this low productivity is due to slow reproductive efficiency that is caused by late maturity, poor expression of estrous, silent heat, irregular estrous cyclicity, seasonality in breeding and anoestrous condition. Out of all these reasons of low productivity the major reason is that bovine's exhibit silent heat that is not easily detectable. Estrous cycle as previously been discussed by many researchers is majorly affected by environmental and nutritional factors. The major focus in this paper is that apart from environmental and nutritional factors, genetic factors also play an important role in controlling the estrous behavior in bovine. Through different techniques like RT-PCR, Microarray, PCR-RFLP, SNP etc it has been estimated that almost 269 genes plays a significant role in estrous behavior. These genes undergo some significant changes at transcript levels during estrous cycle. By going through different papers and previously published papers it has been found that there are some major genes involved in controlling estrous behavior in bovine. Until now lot of research have been done in this aspect to find different polymorphisms in order find the different genes associated with estrous in bovine. Among the 269 gene the most studied genes and their related polymorphisms include CYP11A1, CYP19A1, CYP17A1, HSD17B, HSD3B, ERα, ERβ, OXT, AVP, Leptin, and IGF1, GnRH, GnRH-R, etc. The gene CCK, POMC, MCHR1, GABRA6, HTR2A and DRD2 these are released in at least one brain area but are related to the modulation of emotional states like anxiety and also are involved in sexual motivation. The gene CYP19A1 belonging to P450 family is the major gene involved in the production of estrogen, a hormone that plays a significant role in estrous cycle. CYP11A1 is involved in the conversion of cholesterol into estrogen or steroids with pregnenolone formed. The estrogen receptors are the transcriptional factors that bind to estrogen and regulate their transcriptions. These have two isoforms ERα and ERβ each are encoded by separate genes ER1 and ER2 respectively. Other than this some genes like oxytocin gene OXT. It is released in the brain where it acts on specific oxytocin receptor eliciting the behaviors like mating and partner bonding. In the presence of estrogen it is involved in mating. It is also involved in controlling the length of estrous. AVP gene is also involved in estrous behavior, whose expression is under the influence of progesterone and estrogen. Hence from the above mentioned discussion it can be concluded that apart from environmental, nutritional factors genetics also plays a pivotal role in controlling the estrous behavior in bovine.

Introduction

In the developing countries bovine species are mostly considered due to their high milk and meat yield also due to their tolerance to hot and humid climate, lean meat, draught ability and a reasonable growth rate on roughage feed (Mondal et al. 2007). Although bovine species are playing a major role in the national economy of many developing countries but the major constraint in the exploitation of production efficiency of bovine lies inherently in the low reproduction. The main reason for the low reproduction of bovine is due to late maturity, poor expression of estrous, silent estrous, irregular estrous cycles, seasonality in breeding, anestrous, low conception rate, long postpartum, repeat breeding etc (Mondal et al. 2007). Estrous is the period during reproductive cycle when females become sexually accessible. Estrous detection in these species is difficult due to the lack of expert personnel, high expression of silent heat, poor expression of estrous behavior, and also due to high variation in duration of estrous cycle (Thakur et al. 2013). Among the above mention factors that leads to the low reproduction in bovine, the major constraint in the reproductive inefficiency of bovine lies in the fact that they exhibit silent estrous condition. Among bovine species buffalo are the one whose reproduction efficiency is most affected by silent estrous. Silent estrous is that condition in which buffalo doesn't exhibit the behavioral signs of estrous but the physiological symptoms of heat are present.

Buffalo has recently gained a lot of awareness due to its high milk yield with high fat percentage, tolerance to hot and moist weather, lean meat, draught ability and a reasonable growth rate on roughage feeding. Buffalo, as a domestic animal with its predominant home tract in South East Asia and Mediterranean, has found great acceptance in the rural economies of Asia and Africa. Important buffalo producing Asian countries are Pakistan, China, India, Philippines, Burma, Ceylon, Indonesia and Egypt. World buffalo population has reached to 130 million. Asian buffalo holds the greatest promise and potential for production, when compare with all domestic animals.

Buffalo breeding, like any other branch of animal husbandry, is an entrepreneur in nature, and its success depends to a great extent on the understanding of the entire process of its reproduction and the various factors involved in it (Buffalo Breeding. Booklet No. 591). Buffalo is the most valuable and multipurpose animal and is being highly liked by the people of the sub-continent. It is also called the Black Gold of Pakistan due to their flexible qualities.

Duration of the oestrous cycle

The duration of the estrous cycle ranges from 17 to 26 days, with a mean of approximately 21 days. However, there is larger irregularity of estrous cycle duration in buffalo, with a greater occurrence of both abnormally short and long estrous cycle, credited to a variety of factors including unfavorable environmental situation, nutrition and irregularities in secretion of ovarian steroid hormones (Marai and Habeeb. 2010).

Factors effecting estrous behavior

According to many researches there are many factors that affect the expression of estrous behavior in bovine species. These factors include environment (temperature, season and light), age and body weight, hormonal imbalance, nutrition and level of production. Environment includes the affect of temperature, season and light.

Temperature has a sound affect on the expression of estrous in bovine as in extreme cold and hot conditions the sexual activity is less as a result low conception occurs. It also affects the length of estrous (Suthar and Dhami. 2010).

According to a research, bovine reproduction also depends upon the plant, soil and climatic factors particularly in tropical and subtropical parts of the world. Apart from temperature and season, light also affects the estrous cycle that is the duration and intensity of light to which the animal is exposed.

Nutrition affects the estrous cycle in a way that due to poor nutrition and starvation of animals for a longer period deficiency of vitamins and minerals occur that prevents the formation of follicles.

Age and weight of the bovine species also affects the expression of estrous. Hormonal imbalance and level of production also affects the expression of estrous. If hormonal imbalance occurs it would affect the duration of estrous cycle and also will result in different diseases in bovine species. From research it has been found that the high producing bovine species have some low expression of estrous behaviors that in turn affects the overall reproduction of the species and results in low production (Suthar and Dhami. 2010).

Silent heat

Silent heat is the major issue for the production of buffaloes. Season of the year exert a major effect on incidence of silent heat, studies showed that percentages of silent heat were 85 and 56 for hot and mild seasons, respectively and also found that occurrence of the silent heat was higher in the buffaloes calving during the hot season (35.7 %) than in those calving in the mild season (27.3%) Anoestrus resulting by thermal stress may be the cause in the silent heat in buffaloes.

Outcome of silent estrous

There are different types of outcome of silent estrous consequently leading to economic losses. Some of them described as.

1. Calving interval and Service period: The buffalo shows a rapid uterine inovulation and fast reassume of the postpartum ovarian activity for if they conceive again, without arrears in the reproductive expression. Duration of longer service is required for those females that are retained all time with their calves as contrast to those females that have limitation of the sucked during day time. Depending upon the handling of the property can adopted techniques, temporary or ultimate to increase the efficiency of reproduction. A large difference between calving is reasonable, 77-340 days in the Amazon.

There is direct association among the duration of service time and the period between the calving and the first estrous and number of services for conception. Time of service is mostly influenced by features comprising the parturition, kind of management and calving season. Significant smaller period of postpartum estrous are found in those buffaloes that calve in the favorable season of reproduction as compared to those that calve out of season. It is also reported that there is larger calving interval for those buffaloes that calve during flooded season as compare to those that calve during drought time, as well as buffaloes increased in region of cultivated pasture (Ribeiro. 2002).

A study reported that the service duration is directly associated to interval of calving. When the service period is extended, the calving interval also extended leadings to the higher cost of milk due to longer or shorter gestation period. The service duration is negatively associated to average milk yield of animal. Time of about 60-80 days consider highly desirable. Current studies shows that service duration is obviously higher, this period can be decreased to a desirable worth, if estrous detection and insemination is appropriately and timely. The consequence of parity on duration of service was not important in Nili-Ravi buffaloes (Hussain et al. 2006).

2. Rate of Conception: Type of estrous signs considerably influence the rate of conception. The animals that have passed mucus at the moment of insemination show maximum rate of conception. At the time of estrous the extent of uterine tone, had a deep consequence on conception rate. Conception rate directly associate to the intensity of uterine tone, when tone is high it is obvious and when tone is low it also very less. Detection of estrous at appropriate time is the major significant factor of herd management. If this heat detection is neglected, leads to many difficulties linked to fertility. The animals that have formerly been inseminated and failed to conceive will frequently pass unobserved due to insufficient estrous detection. This consequently leads to an excessively long service period. It is assumed that in our animals several estrous cycle passed unobserved resulting in long service period. This condition reveals the difficulty of estrous in buffaloes and cows. The intensity of estrous signs had an important result on conception rate. Estrous signs like mucus discharge and uterine tone have an important affect on conception rate. These signs are considered as the most reliable heat signs base on conception rate. The rate of conception in buffaloes is greater than cattle (Anzar et al. 2003).

3. Repeater animals: Involvement of several times services for conceiving are called repeater animals. It is the most important and very ordinary problem occurring in buffalo causes sub fertility. This is the major problems for the dairy industry (Kumar et al. 2011).

Economic loss: Reproductive efficiency in buffalo is mainly reduced by many reasons; the main reasons are relatively long calving interval and delayed maturity. Study showed that normally calving interval is high in those countries that containing buffaloes in high amount. The extended calving interval causes many sufferings like; reduction in milk yield, extra feed expenses and culling rate. Insufficient heat detection, after calving delayed recommencement of ovarian movement and ovarian dysfunction are the major cause of failure in reproduction. It is noted that in Pakistan, for every one day increase in rate of conception resulting loss of 12-14 rupees (Shah. 2007).

Role of genetic variation in estrous behavior

Although the above mentioned factors have a sound affect on the expression of estrous behavior in bovine but according to the current researches, it has been found that apart from all these mentioned factors there must be some role of genetic variability that leads to the poor expression of estrous behavior in bovine as a result it becomes difficult to detect estrous in bovine. Although in past endocrinological mechanisms have been used to study the estrous cycle but understanding the regulation of estrous behavior is only starting to emerge. These genomic studies can help us in understanding the different regulatory mechanism that leads to poor expression of estrous in bovine (Boer et al. 2010).

By studying the differential expression of genes between different points of reproductive cycles or between different species of bovine with different fertility traits can help in indicating which genes and pathways are involved in regulating the estrous behavior in bovine. This review mainly focuses on the recent insights from several research areas regarding the genomic regulation of estrus in bovine.

In brain the regulation of female sexual behavior is regulated by different parts that are accurate nucleus (ARC), ventromedial nucleus (VMN) and preoptic area (POA) of the hypothalamus. Apart from these areas of hypothalamus, the hippocampus and amygdala are mainly involved in the regulation of behavioral aspects of estrus.

Amygdala and hippocampus are involved in the reduction of anxiety and aggression as a result facilitates the sexual behaviors that arise from the generalized arousal of brain. Estradiol E2 is mainly involved the up and down regulation of number of genes in these areas of brain that are believed to be involved in estrus (Boer et al. 2010).

In bovine at present microarray analysis have revealed 269 genes that shows significant changes at the transcript level during estrus cycle in different circumstances (Katrin et al. 2008). Among these 269 genes the major studied genes and there polymorphisms are CYP11A1 (cytochrome P-450 11A1 gene), CYP19A1 (cytochrome P-450 19A1 gene), CYP17A1 (cytochrome P-450 17A1 gene), HSD17B1 (17b-hydroxysteroid dehydrogenase1 gene), HSD3B1 (3b-hydroxysteroid dehydrogenase 1 gene) (Sara et al. 2006), OXT (oxytocin gene), AVP (arginine vasopressin gene) (kommadath et al. 2011), Leptin and IGF1 (insulin like growth factor1) (Chagas et al. 2007), ERα, ERβ (estrogen receptor alpha and beta) (Hewitt and Korach, 2002). The genes CCK (Cholecystokinin gene), POMC (Proopiomelanocortin gene), MCHR1(melanin-concentrating hormone receptor1), GABRA6 (gamma-aminobutyric acid A receptor alpha 6), HTR2A (5-hydroxytryptamine receptor 2A) and DRD2 (dopamine receptor D2) are released in at least one brain area but are related to the modulation of emotional states like anxiety and also are involved in sexual motivation (Kommadath et al. 2011).

As estrogen is an important hormone affecting growth, differentiation, function of different tissues like mammary glands, uterus, ovaries, prostate and testis (Hewitt and Korach, 2002). Any mutation in the gene causing the synthesis of estrogen or involved in the biosynthesis pathway of estrogen might have an effect on the expression of estrus behavior in bovine. The genes involved in the biosynthesis pathway of estrogen are CYP11A1 (cytochrome P-450 11A1 gene), CYP19A1 (cytochrome P-450 19A1 gene), CYP17A1 (cytochrome P-450 17A1 gene), HSD17B1 (17b-hydroxysteroid dehydrogenase1 gene), HSD3B1 (3b-hydroxysteroid dehydrogenase 1 gene) (Sara et al. 2006). CYP11A1 is involved in the conversion of cholesterol into estrogen or steroids with pregnenolone formed. CYP19A1 (cytochrome P-450 19A1 gene) it codes for aromatase that is involved in the estrogen synthesis. It converts the testosterone into estradiol that is involved in the regulation of a number of genes in brain areas that controls the estrous behavior.

Leptin, IGF-1 and GH work synergistically leading to the production of estradiol, an important hormone of estrus cycle. Oxytocin causes anxiety effect in the presence of estrogen, by this mean supporting mating and courtship (McCarthy et al. 1997). The estrogen receptors are the transcriptional factors that bind to estrogen and regulate their transcriptions. These have two isoforms ERα and ERβ each are encoded by separate genes ER1 and ER2 respectively (Hewitt and Korach. 2002).

Conclusion

Hence, it can be concluded that apart from affect of natural environmental and nutritional factors on estrous behavior, genetic variability might have a sound affect on the regulation of estrous behavior in bovine. As mutation in the genes involved in estrous behavior can cause the low expression of estrous symptoms in bovine leading to their low reproduction. By studying this genetic variability we can understand the underlying mechanisms involved in the regulation of estrous behavior in bovine.

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