Introduction

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A. Kumaresan and A. K. Srivastava

Abstract

Over a period of time, there has been a decline in fertility of bovines. Probably, intense selection for milk production coupled with a variety of physiological and management factors could be attributed for the decline in fertility. On the other hand, the demand for milk and meat is increasing. This situation warrants a thorough understanding of underlying etiology for reduced fertility so that the fertility can be restored in infertile/subfertile bovines. This book provides a platform to the readers to gain an understanding of current concepts in the bovine reproduction starting from herd fertility trends and targets, molecules and mechanisms governing reproduction, novel approaches for estrus detection, scope for improving reproduction efficiency using timed breeding protocols, emerging concepts on epigenetic bearing on fertility, and semen cryopreservation and quality control.

Keywords

Bovine · Fertility · Nutrition · Controlled breeding · Semen quality

A. Kumaresan (✉)
Theriogenology Laboratory, Southern Regional Station of ICAR-National Dairy Research Institute, Bengaluru, Karnataka, India
e-mail: A.Kumaresan@icar.gov.in

A. K. Srivastava
Agricultural Scientists Recruitment Board, Krishi Anusandhan Bhavan-I, New Delhi, India

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Reproduction is a biological process through which continuity of the species is ensured. Optimum reproduction efficiency is the basic prerequisite for obtaining success in bovine farming. Before the period when commercial bovine rearing started, the animals were in their natural way of living as a herd comprising of males and females wherein the potential males identified the animals in estrus and served them. Although the reproductive efficiency in such herds is not clearly quantified, it is true that a majority of the reproductive disorders and inefficiencies observed currently in commercial scale bovine farming did not either exist or were documented. In the process of commercialization, the males and females were separately reared under different locations and the females were served artificially using the semen collected from the potential males. Additionally, intense selection was applied for either milk (in dairy bovine) or meat (in beef bovine) production, leaving aside the reproduction, resulting in altered reproductive physiology in high-yielding bovines. Moreover, the heritability of reproductive parameters is low to moderate. All these collectively resulted in reduced reproductive efficiency in bovines.

It is often said that "reproduction is a luxurious phenomenon" for an individual. Primarily, a cow gives higher priority to her own maintenance followed by growth, lactation, fetal growth, and then breeding. Therefore, to achieve high reproduction efficiency, all the basic and necessary needs of the animal should be fulfilled, and when all her body requirements are fulfilled, she diverts her energy toward reproduction. To obtain maximum reproductive efficiency in bovines, matching of genotypes to proper production environment in terms of appropriate husbandry practices is very much essential. The aim should be to ensure that the intervals from calving to conception are short and the rates of conception to natural or artificial breeding are high so that the calving intervals are short and a greater number of calves and lactations could be achieved in the reproductive lifetime of a cow. One of the major reasons for reduced lifetime milk production by an individual dairy animal is transient loss of fertility or infertility. The causes of infertility in dairy animals are many and can be complex. They relate to follicle development and maturation, onset of estrus, successful coitus/insemination, ovulation, fertilization, implantation, the development and delivery of the normal fetus and its membranes, proper uterine involution and cleansing, resumption of ovarian cyclicity, and estrus expression. Anything interfering with the routines of this cycle, such as diseases, poor nutrition, inadequate herd management, hereditary and congenital factors, hormonal disturbances, or environmental changes, makes the animal infertile, if only temporary in occurrence.

In the recent past, because of advancements in techniques for understanding the molecular events controlling the fertility/infertility, several new concepts have been evolved in bovine fertility management. Updating knowledge on the recent concepts in fertility management is essential for their application in improving the reproductive efficiency of bovines. It is against this backdrop, this book is brought up with the aim to appraise the readers about the recent developments accumulated in the area of fertility management and to provide an updated knowledge on current concepts for improving reproduction efficiency in male and female bovines.

The first chapter introduces the global trends in reproductive efficiency of bovines, the plausible reasons for declining fertility in bovines, benchmarks for bovine reproduction assessment, long-term and short-term approaches for fertility enhancement, and the developments in controlled breeding programs for improving individual bovine fertility. Because onset of puberty and subsequent reproductive processes are the consequences of interactions of the hypothalamo-pituitary-gonadal axis mainly through the stimulation of gonadotropin-releasing hormone (GnRH), understanding the GnRH stimulators is essential to augment fertility. Accordingly, the second chapter exclusively discuss on the role of kisspeptins, the most potent GnRH-secretagogue in mammalian species, in bovine reproduction. This chapter provides an overview of our current knowledge on kisspeptin-kisspeptin receptor system with a special focus on the role of kisspeptin-KiSS1/R system in bovine reproduction. As indicated earlier, the cow's priority for reproduction depends upon how sound is her nutritional status; only when she is in adequate energy balance one can expect her to reproduce efficiently. A thorough understanding of the nutritional requirements of bovines and about the nutrients required for efficient reproduction, their function, level of feeding, and feeding strategies is important to achieve optimum reproductive efficiency. Therefore, the third and fourth chapters provide insights on the role of metabolic hormones and nutritional strategies to improve reproductive efficiency in cattle and buffaloes including low-cost feed formulations using the available resources.

Proper estrus detection is one of the major bottlenecks in bovine farms; generally estrus in bovines is detected either manually or using automated aids; however, their efficiency varies with the scale of operation. Salivary fern pattern is used in human beings to precisely determine the fertile period. Very recently, the concept of use of salivary fern pattern or micromolecules as a noninvasive tool for estrus in bovines has gained momentum. In this regard, a chapter has been dedicated to detail the use of salivary fern pattern and salivary molecules as an aid for estrus detection in bovines. Identification of animals at estrus and inseminating them at right time does not guarantee conception unless the cow has a healthy uterine environment. Knowledge about the expression and regulation of endometrial Toll-like receptors (TLRs) during the reproductive cycle is important to understand the clearance of uterine infections in the bovine. The sixth chapter details the expression pattern of TLRs in the endometrium, regulation by phases of the estrous cycle, and their significance in the uterine health. Upon successful fertilization, the developing embryo must provide a signal to the mother so that she recognizes the presence of the embryo in the uterus and maintain the pregnancy; this process is called as maternal recognition of pregnancy (MRP). Understanding the mechanism of MRP will pave the way forward to develop a therapy intended to rescue the pregnancy losses by improving embryo survival. The seventh chapter provides a deep understanding and recent concepts on MRP in bovines.

Difficulties in estrus detection can be overcome by using timed artificial insemination of cows. During recent years, there have been a lot of advancements in understanding the role of hormones, which facilitated development of different protocols for either timed breeding or estrous synchronization. The eight chapter

elaborately discusses the physiology of estrous cycle and approaches for estrous synchronization and controlled breeding besides explaining different protocols and their advantages and disadvantages. Among the several reasons for postpartum infertility, uterine infection alone accounts for more than 30%. A better understanding of the pathogens causing uterine infection, host immunity, impact of uterine infection on production and reproduction, and identifying risk factors associated with development of uterine infection would help in developing effective preventive and therapeutic strategies for downsizing the incidence of uterine infection in dairy animals to ensure increased production and profitability besides supply of safe milk and milk products to the consumers. Accordingly, the ninth and tenth chapters are dedicated to herd health concept for understanding and minimizing the incidence of uterine infection in bovines besides detailing the effective preventive and therapeutic measures including alternate approaches to the use of antimicrobials in treatment of uterine infection. The molecular advancements in understanding the development of uterine infection or elimination of microbial contaminants from the uterus are also detailed in these chapters.

Currently, cryopreserved semen is used for artificial breeding of bovines. Procedures involved in sperm cryopreservation including extension, cooling, freezing, and thawing reduce the sperm fertility: approximately 50% of spermatozoa become immotile during the process. Therefore, bovine sperm cryopreservation protocol needs improvement for harvesting higher proportion of viable and fertile sperm cells after thawing. The tenth chapter details the advancements in extenders, process of cryopreservation, and the measures for minimizing the cryopreservation associated damages to spermatozoa. Because of the immense contribution of buffaloes in terms of milk and meat, and uniqueness of spermatozoa that differs in several aspects from that of cattle bulls, a special chapter on buffalo semen cryopreservation is also included in the book. This chapter elaborates the factors affecting cryo-survivability of buffalo spermatozoa and supplementation of the freezing medium with novel cryoprotectants, antioxidants, and other new components such as proteins or nanoparticles for reducing the cryodamage to spermatozoa.

The role of male fertility is immense in bovines, because semen from one bull is used to artificially breed several thousands of cows. Currently, the breeding bulls are selected based on breeding soundness evaluation (BSE) that assesses the mating and semen production ability of the bull. The traditional semen quality assays performed as a part of BSE do not reflect the sperm fertilizing potential. Therefore, a lot of researches have been carried out to develop tests that have a good relationship with sperm fertility. In the recent past, along with advancements in high-throughput sperm analysis, techniques such as flow cytometry, several sperm function tests have been found to have high correlation with fertility. A battery of tests needs to be carried out to arrive at prediction of fertility with fair accuracy. Chapter 13 provides a deep insight into the advances in sperm quality assessment and suggests the tests that have very high potential to be used in fertility prediction. The last two chapters are dedicated to improving sperm fertility using proteins associated with sperm fertility and sperm survival during its tortuous journey in the female reproductive tract. Chapter 14 introduces a novel concept of coating sperm with β-defensins to protect

sperm from maternal immunologic aggression. Finally, the 15th chapter deals with the emerging concept of epigenetic bearing on fertility including a comprehensive understanding of mechanisms of epigenetic modifications in germ cells and attempts to correlate the implications of DNA methylation during epigenetic reprogramming, epigenetic potential of the nuclear proteome, and abnormal protamine expression with the fertility.