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Non-Infectious Causes of Infertility in Dairy Cows: A Review

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Abstract: Infertility has been linked to numerous factors in higher producing dairy cattle. Although infectious agents affect fertility, many non-infectious factors cause infertility in dairy cows. Thus, major non-infectious causes of infertility in dairy cattle include congenital abnormalities, acquired lesions, nutritional, seasonal and environmental causes. These causes are believed to be overlooked during investigation into causes of infertility, which may result in severe economic losses. Impairment or failure of reproduction can affect any of the following: the production and ovulation of viable ova, Ovum transport, Expression and detection of estrus, fertilization, the fertilized ovum and early embryo stage after fertilization, the late embryo/early fetus stage and the late fetus stage (Especially abortion in the third trimester of pregnancy). This paper reviews knowledge of the causes of infertility in dairy cows, with specific emphasis on non-infectious causes.

Key words: Dairy Cows · Economic Loss · Infertility · Non-Infectious

INTRODUCTION

Fertility is one of the key determinants of the lifetime performance of a cow. For beef cows and for pastoral dairy cows, it is necessary for a calf to be produced every 365 days. Regular breeding depends upon the normal function of the reproductive system [1]. In order to breed regularly, the cow has to have functional ovaries, display oestrous behaviour, mate, ovulation, fertilization, conceive, sustain the embryo through gestation, calve and resume oestrous cyclicity and restore uterine function after calving [2]. Fertility is a multi-factorial trait and its deterioration has been caused by a network of genetic, environmental, nutritional and managerial factors and their complex interactions make it difficult to determine the exact reason for this decline [3]. When the function of the reproductive system is impaired, cows fail to produce a calf regularly. When this occurs, the term 'Sterility' is used; whereas the term 'Infertility' either is considered to be synonymous with sterility, or may imply a delayed or irregular production of the annual live calf. The term 'subfertility' is probably a more appropriate term for the latter [1]. In general Cattle are deemed infertile when they are neither normally fertile nor completely sterile [4].

Causes of infertility are many and can be complex [5]. Although nonspecific infections due to opportunist pathogens are still important, by far the greatest cause of infertility is due to management and other non-infectious factors. The ultimate manifestation of infertility is failure to produce offspring [6]. Infertility is a major cause of economic losses and a major limitation to the achievement of optimum efficiency in the live stock production system [1]. Thus, economic losses associated with infertility problems included the cost of veterinary intervention, expected cost due to calf loss; cost of cows culled and cost of milk loss [7, 8]. Therefore, the objective of this paper is to address non-infectious causes of infertility in dairy cow, specifically causes related to hormonal, congenital and functional abnormalities, nutritional and acquired lesions and other causes of infertility.

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Functional Causes of Infertility

Cystic Ovaries: The definition of cystic ovary is the presence of large fluid filled structure on the ovary greater than 2.5 cm in diameter which are either abnormal or have developed in abnormal manner [9]. The cyst may persist for more than 10 days or regress and be replaced by another cyst. It is a hereditary disease and the cysts are caused by a lack of LH surge. The LH may actually be present, but may not be released. This results in no ovulation and minimal luteinization. Stress may also contribute to lack of LH release and result in cystic ovaries [7].

There are two types of cysts, follicular and luteal. Follicular cysts are follicle-like structures more than 2.5 cm in diameter that persist on the surface of the ovary for more than 10 days. They grow in a disorderly manner, fail to regress or undergo atresia and instead accumulate fluid. Since there is no ovulation, such cows are infertile until normal cycles resume [10]. While luteal cysts are thus less frequent than follicular cysts. Careful diagnosis is needed to differentiate them from cystic corpora lutea, which are not pathological. Luteal cysts have a larger antrum surrounded by several layers of luteal cells, which continuously elaborate progesterone, rendering the cow anoestrous. Continuously high progesterone levels may therefore be indicative of luteal cysts [11].

Other Causes of Anoestrus: Anoestrus is a major problem in the tropics and subtropics, where inadequate nutrition, high ambient temperature, high parasite burdens and disease exacerbate the problem. Low body weight and poor body condition, compounded with lactation stress, can further extend the postpartum anoestrous period [1]. Thus, anoestrous cows have small, flaccid uteri and small, inactive ovaries with no palpable corpus luteum or follicle. In contrast, cycling cows are identified by the size and tone of the uterus and the presence of the corpus luteum or follicle or both on either of the ovaries. Nevertheless, cows may show anoestrus despite having normal ovarian structures [12].

Acquired Lesions

Obturator Paralysis: Obturator paralysis is caused by fetal pressure on the obturator nerves as they pass from the lumbosacral plexus along the medial surface of the ilia and through the obturator foramen on the pelvic floor. There is often a history of dystocia and the fetus becoming lodged for a period of time within pelvis. The affected cow becomes unable to adduct her hind limbs and in severe cases unable to rise [13].

Uterine Torsion: Uterine torsion can occur during pregnancy or as a result of dystocia at parturition. When the uterus twists in some degree from normal the fetus and its membrane rotate with uters, meaning that there is a compression of blood supply to the foetus in the womb and death is often the case if intervention is not fairly prompt [13].

Congenital Morphological Causes: Most developmental problems in cattle, as in other species, result from genetic abnormalities, which can either be inherited from one or both parents or result from chromosome damage during oocyte development, fertilization and early embryo development. It is likely that a very high percentage of inherited abnormalities results in fertilization failure or death within a short time of conception. Occasionally, however, calves are born with inherited defects that may affect their survival or reproductive ability. Bovine leukocyte adhesion deficiency is an example of an inherited condition that normally results in the early death of homozygous carriers [14]. Congenital causes of infertility include developmental abnormalities of the ovaries, oviducts, uterus, cervix, vagina and vulva. Some are lethal; but few have a morphological significance and others obtain a functional significance. Common morphological conditions include ovarian (Gonadal) hypoplasia and aplasia, anomalies of the tubular genitalia, hermaphroditism, freemartinism and double cervix [15].

Gonadal (Ovarian) Hypoplasia: Gonadal hypoplasia is not easily diagnosed and in cases of bilateral ovarian hypoplasia heifers do not develop secondary sexual characteristics. They are anoestrus and infertile. Where the condition is unilateral, normal sexual organs and oestrous activity may be observed. Such animals are fertile, although less so than normal [1]. The condition is potentiated by an autosomal recessive gene with incomplete penetrance and therefore the incidence of gonadal hypoplasia can be reduced by using only animals (Both male and female) with normally developed sexual organs as breeding stock [15].

Freemartinism: Freemartinism is a distinct form of intersexuality which arises as a result of a vascular anastomosis of the adjacent chorioallantoic sacs of heterozygous fetuses in multiple pregnancies. As a result, although the external genitalia of freemartin heifers appear normal, the internal genitalia are grossly abnormal. Typically, the gonads are either vestigial or have undergone masculinisation [16]. If the placentae merge, the circulatory systems of the twins become

interconnected. If one of the twins is a female, the development of the female sexual organs will be affected. This may be due in part to the effect of androgens or other hormones from the male circulation [14].

Nutritional Causes of Infertility: It is frequently impossible to determine accurately a specific nutritional cause of infertility, because the clinical signs appear sometime after the deficiency has occurred [17]. Nutrition often directly affects reproductive capabilities. Calving intervals in excess of 12 months are often caused by nutritional stress (Deficiency) at some point, either before the calving season or during the subsequent breeding season, which results in thin body condition and poor reproductive performance. The number one nutritional reason for poor reproductive performance is the lack of energy [18]. Starvation may result in placental insufficiency and abortion; however, it rarely occurs in modern dairy practice [19].

Deficiency of Energy: High-producing dairy cows require sufficient nutrients to facilitate the dramatic increases in energy requirements for milk production that peaks 4-8 weeks postpartum. This requirement is only partially offset by increased feed consumption (Due to limitations in intake and appetite), with the remainder being met by mobilization of body reserves, resulting in animals entering negative energy balance [20]. A variety of metabolic, hormonal and environmental factors influence individual cow response to negative energy balance and associated adverse health, productive and reproductive consequences [21].

Therefore; physiological consequences of NEB are loss in body condition score (BCS) as body reserves are mobilized; low circulating concentrations of glucose, insulin, insulin-like growth factor I (IGF-I) and cholesterol; and higher concentrations of fatty acids and urea compared with cows in positive energy balance [22]. These are subsequently associated with an increased risk of metabolic diseases (That largely occur within the first month of lactation), reduced immune function and a reduction in subsequent fertility [23].

When cows experience a period of NEB, the blood concentrations of non-esterified fatty acids increase, at the same time that IGF-I, glucose and insulin are low. These shifts in blood metabolites and hormones might compromise ovarian function and fertility. It has also been reported that energy balance and dry matter intake might affect plasma concentrations of progesterone, which may interfere with follicle development and maintenance of pregnancy [24]. In general the most severe effect of inadequate nutrition is the cessation of cyclical activity although other less severe manifestations are silent estrus, ovulatory defects, fertilization failure and embryonic or fetal death [1].

Imbalance of Proteins: Although protein is essential element in the animal diet, it can inhibit fertility when fed at high levels. The amino acids in excess protein are converted to the waste product urea. Urea is toxic to oocytes. In addition, urea can cause lowered uterine pH, which in turn reduces embryo survival [25] and if blood urea nitrogen (BUN) is greater than 20 mg/dl cows may have low conception rates [7].

One other consequence of feeding excess protein is reduced energy balance. This effect occurs because excretion of excess protein nitrogen requires energy. As a practical matter, effects of excess protein on fertility can be reduced by limiting the crude protein content of the diet to less than 19% and limiting the ruminal degradable protein (RDP) to less than 10% of diet DM [25].

There is quite a large volume of published research, which indicates that feeding excess RDP has a negative effect on fertility. Thus feeding high levels of RDP delays the first ovulation or oestrus, reduces the conception rate to first insemination, increases the number of days open and lowers the overall conception rate [26].

Deficiency of Micronutrients: Most micronutrient deficiencies exert their effects upon reproduction through depression of the activity of rumen microflora; reduction in enzyme activity affecting energy and protein metabolism and the synthesis of hormones; and the integrity of rapidly dividing cells within the reproductive system [9].

Deficiency of Manganese: Manganese has a ubiquitous role in reproductive function, being involved in steroid synthesis. Both the pituitary gland and ovaries are relatively rich in this trace element. A variety of reproductive disorders which depress fertility in cows had been referred to manganese deficiency; these include anoestrus, poor follicular development, delayed ovulation, silent oestrus and reduced conception rates [1].

Deficiency of Iodine: There are many congenital defects in animals that are known to be caused by deficiencies of specific nutrients in the diet of the dam. Fetal Goiter increased neonatal mortality in all species, prolonged gestation in horses and sheep. Iodine deficiency may be due to a primary deficiency, or induced by nitrate or Brassica species [16]. Iodine deficiency caused abortion

[19]. Thyroxine deficiency is associated with non-specific signs of poor growth and poor 'Doing', together with loss of libido and inhibition of oestrous behaviour [27].

Calcium Deficiency: Calcium deficiency is an important cause of recumbence. Post parturient recumbence is a major problem in cattle. It can be acute or rapidly responsive to appropriate therapy or more chronic, less responsive and may progress to the downer cow syndrome. The highest incidence is in dairy cows beyond their second lactation in the first 48 hours after calving. The condition is commonly known as milk fever [13].

Selenium and Vitamin E Deficiency: It is difficult to separate the effects of selenium and/or vitamin E deficiency since both have a ubiquitous antioxidant function which protects a wide range of biological systems from oxidative degradation. Reactive oxygen species (ROS) are the partially reduced products of oxygen produced in all aerobic cells. The principal ROS are the super oxide anion, hydrogen peroxide, hydro peroxides, singlet oxygen and nitrite radical. These compounds can be beneficial to organisms as cell regulators, but in high doses they become toxic, often leading to cell death [28]. Selenium is found in the antioxidant glutathione peroxidase and is responsible for protecting tissues against oxidative stress by catalyzing the reduction of peroxides and organic hydro peroxides [29].

Deficiency of Other Vitamins: Vitamin A deficiency induced by feeding potato tops or water with high nitrate content has been associated with congenital blindness in calves [16]. Vitamin A has no effect on fertility, but may cause irregular cycles. Carotene is needed by the corpus luteum development, its deficiency in a cow may have decrease the secreton of progesterone and induce irregular cycles. Vitamin D deficiency suppresses signs of estrus and delays ovulation. Vitamins and minerals are often suspected in infertility and anestrus but little hard evidence supports these claims [7].

Reproductive Phytio-Toxicants: Reproductive toxicology is the study of toxicant exposures that adversely affect sexual behavior, gametogenesis, conception, development, parturition, or healthy maturation of progeny. Even under normal physiologic conditions, reproductive function is subject to failure. It is therefore not surprising that exposure of this system to toxic insult interferes with the complex biologic processes that culminate in healthy offspring. The true incidence of toxin-induced reproductive dysfunction is unknown but presumably is well below that due to infectious and management related causes. Bovine reproductive toxins are derived primarily from plants [21].

Animals may not usually eat toxic plants, but may only do so during adverse seasonal conditions. For example, in the dry season or during drought, many toxic plants remain green and more succulent due to a deep root system and thus become attractive for eating by starving animals. Also during dry spells, plants that accumulate nitrate become more toxic as the plant takes up nitrate at night. During the day the plant wilts and in the wilted state the plant cannot reduce nitrate to ammonia and therefore plant nitrate levels increase and become more toxic [30]. Reproductive toxicants also cause abortion. For example, needles from the Ponderosa pine tree, Lodge pole pin and common Juniper cause abortion known as Pine Needle Abortion primarily when consumed during last trimester [31].

Hormonal Causes of Infertility

Silent Heat: Silent heat is generally not a problem and usually is manifested by unobserved heats by farmer. However, the first postpartum heat is normally silent, because there are no estrogen receptors. This is a result of the low postpartum progesterone [7].

Follicular Atresia: The condition means regression of the growing follicles caused by insufficiency of proper gonadotropin stimulation or due to hormonal imbalance. The atretic follicles fail to grow beyond its size, lose their turgidity and never ovulate. The condition was manifested clinically by a history of anestrum in the affected females [32].

Other Causes of Infertility

Season: Environmental factors such as use of a bull in the herd; poor nutrition or the loss of the body reserve (Negative energy balance) and housing elements can affect fertility. However, most studies report seasonal effect as a major environmental factor affecting fertility. Although heavy rain, strong wind, or high humidity can reduce fertility; high temperature has strongly linked to low fertility. Moreover, in warm countries, summer heat stress is a major factor in impairing fertility [33].

Heat stress (HS) can be defined as any combination of environmental factors leading to the deterioration of conditions in comparison with the optimum conditions prevailing in the thermal comfort of animals [34]. It causes infertility in farm animals and represents a major source of economic loss. Dairy cattle are particularly sensitive to

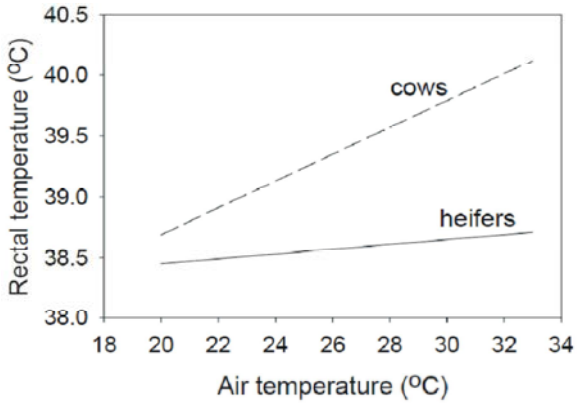

Fig. 1: The relationship between air temperature and rectal temperature for non-lactating heifers and lactating cows [36]

heat stress because of the metabolic heat produced in lactating cows associated with milk production. The more milk a cow produces the more heat she produces and the more sensitive she is to heat stress. Therefore, there is an additive effect of heat stress and greater milk production for decreasing conception rate in dairy cattle [25].

The bovine thermo-neutral Zone (TNZ) is between 16°C to 25°C. Within this range (Figure 1), animals maintain a physiological body temperature of 38.4°C to 39.1°C. Ambient temperatures above 20°C to 25°C enhance heat gain beyond that lost from the body inducing a state of HS with elevated internal body temperature. Animals try to restore thermal balance through mechanisms which reduce heat production gain (Reduced food intake, metabolism and activity; shade seeking; etc.) and/or enhance heat loss by increasing water intake; bathing in ponds or mud; increased sweating respiration and salivation; redistributing blood flow towards peripheral integuments; etc [35].

The effect of lactation on body temperature (Figure 1) of heifers and lactating cows in Wisconsin indicated that at an air temperature of 30°C, the predicted rectal temperature of a heifer is 38.7°C, only slightly above the typical body temperature of 38.5°C. For lactating cows at an air temperature of 30°C, the predicted body temperature is 39.8°C. A good ballpark figure is that reproduction starts to suffer when cows have a body temperature of 39.5°C. Accordingly, the lactating cow at an air temperature of 30°C is at risk of infertility because of heat stress [25].

Repeat Breeding: Repeat breeding is one of the major infertility problems of herds. The incidence of repeat breeding in dairy cows, worldwide, ranges from 3 to 10%. The potential causes of the repeat breeding mainly include subclinical endometritis, nutritional deficiency, specially trace minerals and vitamin A, age of the dam, improper heat detection and endocrine dysfunction [37].

CONCLUSIONS AND RECOMMENDATIONS

It could be concluded that infertility is not caused by a single entity and it is multifactorial condition. Major factors associated with causes of infertility in dairy herds include poor feeding management of dry and early postpartum cows, inefficient heat detection and breeding programs, different types of functional and congenital morphological problems and the lack in the adoption of heat stress relief systems and strategies. Evaluation of herd fertility is very important issue to control impairment of fertility. Managing fertility so that it is maintained at optimum level requires the active collaboration of herd manager, farm owner and the veterinarian. The detection of estrus continuous to present difficulties and , although progress has made in regard to estrus synchronization and artificial insemination, the reproductive performance of dairy cows has not improved substantially. Based on the above conclusion the following recommendations are forwarded: Treatment of anoestrus and other factors can be done after evaluation. Dietary management and regular veterinary visits catch the problem early before it becomes an established problem. Having access to accurate records (Identify cows, last calving date, first and subsequent service, or artificial insemination dates, confirmation of pregnancy and dates when cows were culled or left the herd) is to be considered in the management of fertility. Since, maximizing fertility is a team game; consult and listen for your vet, nutritionist, farm advisor and keep good records.

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