

Physiological Communication

Synchronous Stimulation of Reproductive Cycle in Cows and Heifers

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ABSTRACT

Estrous synchronization allows monitoring the estruation onset and ovulation in the cows or heifers with normal estrous cycles. For dairy cattle, grouping the cows with regular estrous cycles facilitates artificial insemination and accelerates genetic improvement. The number of days needed for artificial insemination is significantly reduced. Therefore, the authors studied the efficacy of the combined use of the gonadotropin-releasing hormone, prostaglandin, and progesterone preparations for stimulating estruation has been studied. The combined use of hormones and prostaglandins is effective in stimulating the arousal stage in cows and heifers. The authors developed a complex scheme of induction (stimulation) and synchronization of reproductive function in cows and heifers. Experimental testing of this technique was carried out in 2017-2019 based on the "Russia" CJSC in the Kanevsky district (Russia). 106 animals were examined. The analysis of literary sources shows that the yellow body of ovary hormones has a specific effect on the genitals. The results of this study were showed that during inflammatory processes in the genitals of cows, the follicles undergo luteinization and can transform into the persistent yellow body, thus causing the absence of the estrous cycles. The studied was confirmed that one-time diagnostics during rectal examination does not provide grounds for distinguishing the persistent yellow body from the yellow body of the cycle. For determining the persistent yellow body, a two-time study in the intervals of three to four weeks is required. Prolonged infertility caused by the progesterone hormone leads to a shortfall in calves and milk. Therefore, the persistent yellow body treatment should be performed in time.

KEY WORDS: ANOVULATION, CYSTS, ESTRUATION, FOLLICLES, PROSTAGLANDINS, PROGESTERONE, PERSISTENT YELLOW BODY, REPRODUCTION.

INTRODUCTION

Increasing the production of milk and beef is impossible without the constant introduction of new technologies and innovative solutions. Therefore, the creation of large dairy farms and specialized complexes on an industrial basis has led to the emergence of the cattle reproduction problem (Koba et al. 2017; Koshchaev et al. 2018; Troshin et al. 2018b). In particular, the changing conditions of livestock keeping, feeding, and care cause metabolic disorders, disrupt the functions of the pituitary-hypothalamic system and the neurohormonal regulation in the organism and, therefore, cause dysfunction of the genital organs of the animals, which entails a decrease of their fertility and milk productivity (Troshin et al. 2018a; Semenov et al. 2019).

Among the factors influencing the increase in fertility are the conditions for keeping livestock and the observance of the synchronization of sexual heat. The correct approach allows one to control the time of arrival of cows or heifers with normal cycles in heat and ovulation. Also, the time required for identifying the symptoms of estruation is significantly reduced, which simplifies the work schedule by shortening the period of estruation identification and artificial insemination (Anisimova et al. 2018, 2019; Kulikova et al. 2019). In solving the problem of estrous cycles induction and synchronization in cows, two approaches have been established: 1. Suppression of follicular growth in the ovaries through the use of gonadotropic drugs. 2. Induction of the yellow body lysis, followed by follicular growth stimulation. For suppressing the ovaries' gonadotropic function, domestic and foreign science suggests using natural and synthetic prostaglandins (progesterone and its derivatives) for a period equal to the duration of the luteal period of the estrous cycle (Troshin et al., 2018, Nazarov et al., 2021).

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Received 15/06/2021 Accepted after revision 29/08/2021

Published: 30th September 2021 Pp- 1289-1293

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Published by Society for Science & Nature, Bhopal India.

Available at: <https://bbrc.in/>

Article DOI: <http://dx.doi.org/10.21786/bbrc/14.3.57>

For female cattle, this period is 15 – 36 days, while the estrus and estruation in the animals occur on the fifth to the sixth day, and ovulation occurs on the seventh day after the treatment. Progesterone and its derivatives are taken orally (with food or water), intravaginally, intramuscularly, and subcutaneously. It is very important to use the correct dosage for obtaining good results from using prostaglandin. The dosage and frequency of injections depend on the type of product used. Prostaglandin may be used for all nonpregnant cows. If an injection is made to a pregnant cow or a heifer, it may cause an abortion, depending on the stage of pregnancy, as a result of the influence on the formed yellow body. When injected in a cow that has already formed a yellow body (usually, on the sixth through 17th day of the estrous cycle), prostaglandin will cause its premature resorption (Troshin et al., 2018, Sarsadskikh & Abramov, 2020, Nazarov et al., 2021).

At the beginning of the cycle, before the yellow body forms (days one through five), prostaglandin will have no effect. Likewise, when the yellow body regresses at the end of the cycle (days 18 through 21), prostaglandin will not be effective either, but cows at this stage of the cycle should reach estruation at about the same time as the treated animals. The joint use of the gonadotropin-releasing hormone (GnRH) with prostaglandins for good estruation synchronization and monitoring the time of ovulation, according to the analysis of the literature data, proved to be effective and harmless to animals. Certain synchronization drugs were not approved for unlimited use. Therefore, one had to read the attached instructions from the standpoint of the restrictions of their use (Sarsadskikh & Abramov, 2020, Nazarov et al., 2021).

However, in the production conditions, serious shortcomings were revealed in the use of these methods, in particular, the laboriousness of their use, maintaining the dosage of progestogens, and the fertilization rate of the animals did not exceed 42 %. This work aims to develop a system for hormonal synchronization of the stages of the sexual cycle in cows and heifers. Following the objective, the following tasks were set: 1. Developing a system for synchronizing the arousal stage of estrous cycle that would be capable of fruitfully inseminating large numbers of cows and heifers in a short time. 2. Preventing the period of mass calving in

dairy cattle breeding for economic purposes and reducing the postpartum period. 3. Substantiating the use of hormones and prostaglandins for arousal stage synchronization in cows, when the identification of estruation was difficult or impossible due to some production reasons.

MATERIAL AND METHODS

Given the above, and due to the adopted program for increasing the cattle population at farms, the staff of the Department of Anatomy, Veterinary Obstetrics, and Surgery of the Kuban State Agrarian University performed scientific research on developing methods for accelerated (extended) reproduction of a cattle herd. As a result of these studies, a complex scheme of induction (stimulation) and synchronization of the reproductive function in cows and heifers was developed, which included two stages:

1. Induction of the reproductive function using a complex preparation (patent for the invention of the Russian Federation No. 2707193, dated November 24, 2019, authors: Nazarov, Kazarinov, et al).
2. Estrous (estrus, estruation) synchronization with the use of drugs from the group of progestogens and prostaglandins.

The experimental testing of this method was performed in 2017 – 2019 under the aegis of ZAO Russia in the Kanevskoy district. For developing a system of hormonal synchronization of the arousal stage of estrous cycles, the cows and heifers were subjected to clinical and obstetric-gynecological examinations. The anamnestic data, entries in the insemination and calving books were considered, and the feeding, keeping, use, and the animal insemination technologies were analyzed. All the cows that had not reached estruation within 25 – 30 days after calving, the heifers – one month after reaching the physiological maturity (that reached 70 % of the live weight of adult cows of the same breed in 14 – 17 months), and the cows repeatedly (three and more times) reaching estruation were studied. During the gynecological examination, attention was paid to the state of the vagina, uterus, and the ovaries; and their size, shape, consistency, uterus response to massage, the presence or absence of ovarian hypofunction, follicles, yellow bodies, and cysts were determined (Nazarov et al. 2016; Skvortsova et al. 2018).

Table 1. The content of sex hormones in the blood of the cows with ovarian hypofunction (nmol/l)

No.	Hormones	Without considering the ovarian cyclicity	Follicular growth wave	Follicular atresia
1	Progesterone	1.68 ± 0.269	0.51 ± 0.096	2.97 ± 0.458
2	Estradiol-17β	0.69 ± 0.032	0.63 ± 0.056	0.77 ± 0.028
3	The P/E ratio	2.44	0.81	3.86

The functioning persistent yellow body was diagnosed by a double rectal examination of the cows with an interval of three to four weeks. The amount of progesterone in the blood of the cows with the persistent yellow body was

quite sufficient for inhibiting the function of the pituitary-hypothalamic system with the termination of follicular maturation. The clinical symptoms of a persistent yellow body in cows are associated with disrupted sexual cyclicity

due to the changes in its hormonal function. This violation is most often manifested in a complete depression of the ovarian function, and less often — in the inferiority in the form of anovulatory estrous cycles. In the case of anovulatory estrous cycles, cows have estrus and estruation, but insemination is ineffective (Varenikov et al. 2014; Ratoshny et al. 2018; Tuzov et al. 2018;).

In the endometrial cells, progesterone induces 17 β -hydroxysteroid dehydrogenase, which is a key enzyme in the metabolism of estradiol, and transforms it into inactive estrone. It actively reduces the content of prostaglandins in the myometrium by decreasing the synthesis and increasing the activity of the enzymes responsible for their decomposition. Gestagens reduce the sensitivity of the myometrium to the contractile action of serotonin and histamine and increase the expression of β -adrenergic receptors in the myometrium, which have an inhibitory and uterine-relaxing effect. In the endometrium, progesterone causes proliferative changes that create the conditions for embryo implantation. High concentrations of progesterone block the release of pituitary gonadotropic hormones

(FSH and LH), which play a fundamental role in the regulation of folliculogenesis, ovum development, and the manifestations of the symptoms of estruation. FSH leads to the synthesis of estrogens in the follicle, which, by increasing the number of FSH receptors, contribute to FSH accumulation, further follicles maturation, and an increase in the estradiol secretion; other follicles undergo atresia at this time (Kryukov et al. 2018).

RESULTS AND DISCUSSION

Based on the analysis of the literature data and practical observations, a system for the synchronous stimulation of estruation in cows and heifers was developed. The system was experimentally tested in 2017 – 2019. Of the 106 cows subjected to synchronous hormonal stimulation of the arousal stage, 65.1 % showed full-fledged estruation. Sixty-nine out of the 106 cows subjected to the induction and synchronization with subsequent fruitful insemination calved and 65 live calves were born, i.e., the calf crop was 61.3 % per 100 cows. It should be noted that before the studies, the gross calf crop was 51 % per 100 cows.

Table 2. The effectiveness of the hormonal induction of sexual cyclicity in the cows with ovarian hypofunction, given the functional state of the gonads

Groups of the cows	The number of the cows subjected to hormonal stimulation	The number of the cows that showed estruation		Calved	
		animals	%	animals	%
Experimental 1	106	69	65.1	65	61.3
Experimental 2	186	158	84.9	119	63.9

In 2018 – 2019, the staff of the Department performed a similar production experiment in the induction and synchronization of the arousal stage in 186 cows. Out of the 186 cows subjected to the induction and synchronization of the arousal stage followed by artificial insemination, 158 animals showed full-fledged estruation and were fertilized. In April to May 2019, 119 animals calved; the calf crop was 63.9 % per 100 cows. Earlier, this farm had obtained 47 calves per 100 cows on average; therefore, this method allowed increasing the calf crop by 21.1 %. Out of the 186 cows subjected to induction and synchronization, 28 cows did not show full-fledged estrous cycles, which was associated with the effect of the dairy dominant on the reproduction function. Alimentary abortions were diagnosed in two cows.

The obtained positive results of using the system (method) of the arousal stage induction and synchronization in cows provide grounds for recommending it for wide practical use in the accelerated (expanded) cattle reproduction in cattle breeding. It allows to promptly perform total artificial insemination of the animals, compacted (catch-up) calving in the most favorable and profitable for farm periods (seasons), and to significantly increase the calf crop. For the widespread introduction of this method at dairy farms, it is necessary to have a sufficient number of full-fledged

animals with a normal reproductive capacity. In forming groups of cows for the induction and synchronization of their sexual function, it is advisable to use the animals of medium nutrition state and above two months after calving. A high therapeutic effect for the functional disorders of the ovaries in cows may be obtained only with the differentiated use of the gonadotropic, progestogenic, and other drugs. The dosages, the frequency, and the schemes of use depend on the specific state of the sexual function. In this regard, veterinarians must be proficient in the methods of gynecological examination of animals. Depending on the diagnosis, the following methods of using hormonal and other drugs for regulating the sexual function in the cows with functional ovarian disorders were studied during the gynecological examination of the animals (Nazarov et al., 2021).

The cows with functioning persistent yellow bodies were parenterally injected with 100 ml of the complex drug: on the first day, 2 ml of ovarelin, on the second day, 1.55 g of natural progesterone one time vaginally (the PRID Delta device) per animal for seven days. The PRID Delta was introduced with a special device (applicator), and two days after the removal of the device, 0.5 % dinoprost was used in a dosage of 5 ml per animal. The cows were inseminated 48 hours after the dinoprost administration.

The exogenous progesterone, acting on the hypothalamic-pituitary system, inhibited or stopped the functional activity of the yellow body, while the prostaglandins introduced on this background activated the growth, maturation, and ovulation of the follicles. This joint use of progesterone and prostaglandins makes it possible to fertilize 70 – 75 % of the animals in a month, compared to 5 – 7 % in the reference.

The introduction of progesterone alone in optimal dosages on the background of functioning yellow bodies did not ensure maturation and ovulation of the follicles. They were subjected to cystic atresia. The joint use of hormones and prostaglandin is effective for estrous synchronization, regardless of the stage of the estrous cycle that may be observed in healthy animals at the time of their introduction. The use of these drugs at the initial stage of the estrous cycle (days one through seven) suppresses the forming yellow body, which results in a rapid decrease in progesterone production. The injected progesterone prevents the ovaries from starting a new cycle until it is stopped. The use of progesterone after seven days of the estrous cycle will not cause yellow body regression. However, by the time of the termination of its administration in the animals in the second half of the estrous cycle, a natural regression of the yellow body will occur, and in those in the first half of the estrous cycle, it will regress in response to the introduction of prostaglandin. Therefore, the injected progesterone will again delay estruation of the animal (Sarsadskikh & Abramov, 2020, Nazarov et al., 2021).

Progesterone inhibits estrus, general arousal, heat, as well as the growth and maturation of follicles in the ovaries and ovulation. It ensures the transfer of the uterine glands from the proliferation phase to the secretion phase and prepares the endometrium for the nidation of the zygote. It also blocks the contractile function of the uterine muscles, maintaining normal conditions for the development of the embryo and fetus, preventing their death, and promoting the development of the secretory tissue of the mammary gland. In terms of structure and direction of action for obstetric and gynecological practice, of particular interest is PHF2 alpha, formed in the membranes of the epithelial cells of the endometrium. According to the principle of feedback, it regulates the function of the corpus luteum. The effectiveness of hormonal programs for synchronization of sexual cycling and ovulation in cows depends on the presence or absence of an inflammatory process in the uterus and corpus luteum in the ovary at the time of their inclusion in the synchronization program. When cows were inseminated after 67-73 days, the fertilization rate of clinically healthy animals was 30.7%, with a history of subclinical endometritis – 29.1%, and clinically pronounced endometritis – only 23.3% (Lobodin, 2006, Nazarov et al., 2021).

All animals with cycles can be treated using the proposed program, regardless of the stage they were in at the moment of its start. This program provides the possibility to perform insemination based on the symptoms of estruation, or use it for synchronized artificial insemination.

CONCLUSION

Thus, the intensification of reproduction and the prevention of infertility in cattle, along with the natural factors of sexual function regulation and stimulation (full-fledged feeding, active exercise) include the use of prostaglandins and hormonal drugs, which are highly effective stimulants for the treatment of sexual dysfunction caused by functional disorders of the ovaries in the form of persistence or decreased function of the yellow body. The hormone and prostaglandin synchronization program may be started at any stage of the estrous cycle. The combination of natural progesterone, gonadotropin-releasing hormone, and prostaglandin allows a shortened estrous synchronization and ovulation program.

Conflict of Interest: Authors declares no conflicts of interests to disclose.

Ethical Clearance Statement: The Current Research Work Was Ethically Approved by the Institutional Review Board (IRB) of Agrarian University, Krasnodar, Russian Federation, 350004 Russia.

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