

## Biotechnology of regulation of reproductive functions of *Bos primigenius taurus*

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**Abstract.** Since cattle are biologically capable of giving birth to only one calf per year, they are considered a single-fruited animal species. One of the cardinal methods of solving the problem of accelerated reproduction of livestock is biotechnological regulation of reproductive function in cows and synchronisation of their sexual activity. The aim of the study is to investigate the peculiarities of the reproductive function of Red Steppe cows under the influence of various methods of its regulation using modern hormonal agents. To evaluate the reproductive function of cows, generally accepted zootechnical methods were used, methods of variation statistics were used to calculate data, and biotechnological methods were used to regulate sexual activity in cows. Based on the analysis of the state of reproduction of the cattle herd, it was established that 164-187 cows and 85-96 heifers are artificially inseminated annually, which ensures the yield of calves per 100 cows of 89-91 heads and the annual introduction of 36 to 40 first-born calves per 100 cows. The shortened service period contributes to both a higher calf yield and an increase in milk yield, which is a desirable production effect. However, calving to conception interval, necessary to prepare the cow's body for a new insemination, can be reduced to at least 30 days. Insemination of heifers with artificial insemination devices should be started when they reach a live weight of  $314 \pm 6.5$  kg, which will allow to obtain fertility from the first insemination at the level of 73.7-77.8% and thereby prevent obesity of heifers, which mainly reduces the percentage of fertility from the first insemination. It is necessary to establish obstetric and gynaecological examinations and treatment of problematic replacement heifers and cows, and it is advisable to use prostaglandin  $F_{2\alpha}$  analogues in combination with vitamins or biologically active drugs to stimulate the sexual function of cows and heifers. The

### Article's History:

Received: 20.08.2023

Revised: 29.10.2023

Accepted: 12.12.2023

### Suggested Citation:

Gill, M., Karatieieva, O., & Tymofiv, M. (2023). Biotechnology of regulation of reproductive functions of *Bos primigenius taurus*. *Ukrainian Black Sea Region Agrarian Science*, 27(4), 36-51. doi: 10.56407/bs.agrarian/4.2023.36.

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use of prophylactic drugs will help to synchronise the heifers' sexual desire and increase their fertility during insemination. And the organisation of cattle reproduction and the proposed biotechnological ways to improve artificial insemination of the red steppe breed breeding stock will significantly improve their reproductive status, which will increase the overall economic efficiency of the industry

**Keywords:** prostaglandins; sexual desire; service period; insemination index; dry period; artificial insemination

## INTRODUCTION

Modern livestock farming, including cattle breeding, requires intensive reproduction, which is impossible without stimulating and synchronising the sexual function of heifers and cows for the full operation of the industry, i.e. obtaining one calf per year and planned predictable artificial insemination. Therefore, improving methods to maximise the reproductive potential of females requires a comprehensive understanding of the processes that control follicle development (Melnik *et al.*, 2022).

Various strategies and biotechnological techniques are used to achieve optimal reproductive function or reproductive health management. Although exogenous agonists of human chorionic gonadotropin (hCG) and gonadotropin-releasing hormone (GnRH) (A) are commonly used to trigger ovulation during estrous cycle synchronisation, little is known about their effects on the ovarian follicle (Ziecik *et al.*, 2021).

According to A. Abbara *et al.* (2018a), even an accurate estrus timing does not compensate for the variability of the interval between its onset and the actual time of ovulation. Hormonal treatment has been used by the authors in various studies to control the reproductive functions of cows and heifers, which allows overcoming this problem and synchronising ovulation. Follicle recruitment and atresia are important processes associated with the rate of ovulation in cattle. Follicle-stimulating hormone (FSH) regulates the distribution, differentiation and steroidogenic function of granulosa cells and thus has a significant impact on follicle growth and development. Although local factors such as growth factors and steroid hormones can regulate follicular development by controlling gonadotropin receptor expression or modulating other related processes, the dominant role of FSH cannot be ignored (Abbara *et al.*, 2018b).

According to M. Besbaci *et al.* (2020), one of the strategies to improve bovine fertility is the administration of GnRH or hCG during the luteal phase, which increases progesterone (P4) secretion and slows luteolysis. P4 insufficiency is associated with a decrease in the number of pregnancies per AI (P/AI), abnormally early embryo development, and reduced maternal pregnancy recognition signalling. The authors also found that by

inducing luteolysis in cows with PG F<sub>2α</sub>-sensitive CL and subsequent treatment with exogenous P4 at subluteal concentrations, treatments 2 and 3 induced follicular persistence in a large proportion of cyclical cows.

Programmes for hormonal control of the estrous cycle of cattle were used by R.C. Bonacker *et al.* (2020) for the widespread use of reproductive technologies such as fixed-time artificial insemination (FTAI) in beef and dairy cattle. For example, scientists demonstrate an approach to stimulating follicular maturity by administering PG F<sub>2α</sub> and treating with a CIDR insert for seven days before GnRH administration. Similar studies were conducted by E.M. Cabrera *et al.* (2021). Holstein cows during lactation were subjected to a double diagnosis (DO) procedure for the first artificial insemination (TAI) after an independence period of 73 days. The researchers concluded that administration of a dose of hCG ≥ 2000 IU induced a greater ovulatory response in lactating Holstein cows than 100 µg GnRH or 1000 IU hCG and resulted in the greatest quantitative increase in plasma P4 concentration between 7 and 14 days.

Therefore, the purpose of the research was to use biotechnological methods to regulate the reproductive function of *Bos primigenius taurus* females using new generation hormonal drugs, which will have a positive impact on reproduction management in lactating dairy cows and will allow artificial insemination at a certain time of ovulation and eliminate the need to detect estrus.

## LITERATURE REVIEW

The difficult economic and social situation in the livestock sector poses great challenges for agricultural workers to further ensure a sustainable increase in livestock production (Gonchar & Sotnichenko, 2015; Pidpala *et al.*, 2018). One of the aspects of such tasks is the use of biotechnological solutions to increase the reproductive capacity of animals (Bezuhlyi, 2002; Kamenska, 2013; Kruglyak, 2016).

According to M.P. Zhuravel & M.V. Davydenko (2005), in order to obtain calves from cows every 10.5 months and thus have a yield of 110-115 calves per 100 cows, it is necessary to use the potential fertility of animals wisely – with the use of biotechnological solutions – to ensure high organisation of their reproduction. Such

intensification of reproduction allows to increase calf yield by at least 10-15%, increase milk productivity of each cow by an average of 250-300 kg of milk per year, and extend the life of animals, which is confirmed by a number of scientists (Ponomarenko, 2005; Ugnivenko & Demchuk, 2018; Fedorovych, 2019).

According to I.V. Ponomarenko (2005), the constant growth of livestock and animal productivity is closely related to the state of the reproductive function of the breeding stock. The presence of pathological processes both in the reproductive apparatus and in the whole organism complicates the fertilisation processes, leads to changes in the reproductive function of animals, an increase in infertility, and the percentage of infertile cows in the structure of the animal herd, which reduces the level of profitability of milk production, increases milk production costs, and increases its cost (Ostashko, 1995; Zvierieva *et al.*, 2001).

According to V.F. Stakhovsky (2009) and O.V. Kruglyak (2016), the main task in cow reproduction is to intensify the reproductive function of cows, including biotechnological solutions, prevention and elimination of infertility. Improvement of breeding decisions in the use of biotechnological products is also reflected in the studies of V.M. Chukhriy *et al.* (1998), V.M. Nadtochiy *et al.* (2011), G.P. Gryshchuk (2012). At the same time, the use of artificial insemination of the breeding stock of cows is proposed by V.V. Vechorka (2010).

To intensify and restore the reproductive function of cows, a variety of methods and means are successfully used in practice (Bushtruk, 1998; Pabat & Vynychuk, 2001; Guntik, 2003). And, as a number of scientists point out, stimulation and synchronisation of reproductive function is one of the links in the complex system of prevention and elimination of infertility and increase of reproductive function of cows (Yablonskyi, 1995; Yablonskyi *et al.*, 2011; Bobryk, 2020).

The use of biotechnological techniques in synchronising estrus in cows has been reported by a number of American scientists. For example, J.R. Pursley *et al.* (1995) reported synchronisation of ovulation time in cattle using GnRH and PG F<sub>2α</sub>. Lactating dairy cows aged 36 to 280 days after calving and young heifers aged 14 to 16 months were injected intramuscularly with 100 µg of GnRH at a random stage of the estrous cycle. Seven days later, cattle received PG F<sub>2α</sub> for corpus luteum (CL) regression. Lactating cows and heifers received a second injection of 100 µg GnRH 48 and 24 hours later, respectively. The lactating cows were artificially inseminated 24 hours after the second GnRH injection. All cows and heifers ovulated with a newly formed dominant follicle between 24 and 32 hours after the second GnRH injection. Ten of the 20 cows were ready

for timely artificial insemination. Therefore, the studies confirmed a great impact on reproduction management in lactating dairy cows and allow artificial insemination at a certain time of ovulation and eliminate the need to detect estrus.

Thus, timely detection of cows in heat, regulation of estrus with biotechnological products and elimination of negative factors affecting cow fertility will help develop appropriate measures to improve the reproductive capacity of dairy cows, increase the frequency of pregnancy during the first artificial insemination and, as a result, determine the economic efficiency of the industry.

## MATERIALS AND METHODS

The research was conducted in the period from 2018 to 2020 in the conditions of the Additional Liability Company (ALC) Pivdennyi Kolos of the Novo Odesa district of the Mykolaiv region on cows of the red steppe breed in compliance with the technological standards of use and maintenance of farm animals (Ostashko, 1995; Bezuhlyi, 2002; Zhuravel & Davydenko, 2005). Also, all ethical standards of animal treatment were observed in accordance with the Code of practice... (2014) and Law of Ukraine No. 3447-IV (2006). The development of the livestock industry was analysed according to the documentation of zooveterinary and breeding records. The results of obstetric and gynaecological examination of 195 cows were used in the work. An analysis of the reasons for the shortfall in calf production in 2018-2020 was carried out in accordance with the Order of the Ministry of Agrarian Policy of Ukraine No. 230 (2001). The research used a technician's calendar and a stand for the physiological state of cow reproduction on the farm. During artificial insemination of cows and heifers, the rectocervical method of sperm injection into the genital tract at the animal housing facilities and in the artificial insemination arena was used, which is in accordance with Order of the Ministry of Agrarian Policy of Ukraine No. 230 (2001).

Semen was used in uncoated granules and paitets, stored at -196°C in liquid nitrogen and delivered from the private enterprise Genetics and Selection (Kyiv). The reproductive function of cows was studied according to the following traits and indicators: postpartum period; fertility from the 1<sup>st</sup> insemination; calving to conception interval (CCI), insemination index. To study the effectiveness of insemination of cows depending on the period after calving (index period), all cows were divided into 4 groups with different terms of coming into heat and insemination according to the insemination period after calving: Group I – up to 30 days; Group II – 31-60 days; Group III – 61-90 days; Group IV – 91 days and more.

To study the effect of reproductive capacity on cow milk production, 53 cows were selected, and four groups were formed according to the year of birth and the serial number of their lactation in 2018, 2019 and 2020. For each animal in these groups, as well as for the whole farm, the following milk yield traits were determined and analysed: milk days, lactation yield, average daily yield, fat content and amount of milk fat. The cows were also studied for signs of reproductive capacity: the number of dry days, the yield and sex of the offspring, and the duration of the calving to conception interval (CCI).

In the production environment of Pivdennyi Kolos, the sexual activity is determined visually by the “immobility reflex” when observing animals in the herd during a walk and before morning and evening milking. Determine the sexual activity at least three times during the daylight hours: at 6-9 am, 2-3 pm and 5-7 pm. When the “immobility reflex” is established, animals are separated from the herd to special places for standing, where they are kept before insemination and afterwards until the signs of sexual desire cease.

The biometric analysis of the data was carried out in accordance with accepted methods of analysis (Povod *et al.*, 2015). The correlation analysis of the relationship between the milk production of cows of different groups and their reproductive capacity was carried out by the following characteristics: “dry days ↔ milk yield”, “milk yield (lactation) ↔ calf yield”, “average daily milk yield ↔ calf yield”, “calving to conception interval ↔ calf yield”, “calving to conception interval ↔ milk yield”, “milk yield for I-VI lactation ↔ calf yield”, using the formula:

$$r = \frac{\sum xy - \frac{\sum x \times \sum y}{n}}{\sqrt{(\sum x^2 - \frac{(\sum x)^2}{n}) \times (\sum y^2 - \frac{(\sum y)^2}{n})}}, \quad (1)$$

where  $r$  – the correlation coefficient,  $x$  – the first of the indicators between which the correlation is determined,  $y$  – the second of the indicators. For the calculation, computer equipment with the Microsoft Excel application was used.

To study the issue of regulation and synchronisation of sexual desire of repair heifers using an analogue of prostaglandin  $F_{2\alpha}$  – Estrophan and its use in combination with the drugs Tetravit and Catozal, three groups of 18 heifers were formed; after their treatment with the drugs, insemination was carried out. During the study of

the effect of live weight of repair heifers on their fertility, seven groups were formed by weight categories, and to study the effect of the age of first insemination on fertility, five groups were formed, after insemination, the results of fertilisation from the first insemination were calculated. The comparative evaluation of animals of different groups in terms of the development of the trait under analysis was carried out by determining the absolute difference ( $d$ ) between the mean values and their errors ( $S_d$ ), and the level of probability of this difference ( $p$ ) was determined by the standard values of the Student's t-test (Kravchenko, 1973). On the basis of the research and the results obtained, the relevant conclusions are drawn and specific proposals for production are provided.

## RESULTS AND DISCUSSION

Stable reproduction is a prerequisite for ensuring the efficiency of cattle breeding. Milk production depends on this to the greatest extent, as lactation activity is inextricably linked to the full functioning of the reproductive function and the production of offspring (Motta *et al.*, 2020). The distinctive features of red steppe cattle are their strong constitution, satisfactory milk production, good fattening and meat qualities, and high adaptability to harsh natural and climatic conditions. At the same time, the animals are highly resistant to leukaemia, tuberculosis and limb diseases. Deviations in reproductive function in red steppe animals are somewhat less common than in black-and-white cattle. However, under conditions of industrial technology, they often have problems with reproduction. Due to the disturbance of the hormonal balance of the body and, above all, the gonadotropic function of the pituitary gland, the susceptibility to functional disorders of the reproductive organs increases (Fricke & Wiltbank, 1999).

An analysis of the state of reproduction of the cow population is given in Table 1, which shows that over the years studied, there has been an increase in the number of cows. Thus, in 2018 there were 175 cows, in 2019 there were 185 cows, and in 2020 there were 195 cows. Every year, 96-98% of them are inseminated, but the yield of calves is not stable and was 89 calves per 100 cows in 2018, 91 calves in 2019, and 90 calves in 2020, respectively. In this regard, the reasons for the shortfall in calf yield over the past three years were investigated.

**Table 1.** The state of reproduction of the cow population in the conditions of Pivdennyi Kolos

Index	The research year					
	2018		2019		2020	
	heads	%	heads	%	heads	%
Availability of cows as of 01.01.	175	100	185	100	195	100
Inseminated cows	164	94	180	97	187	97

Table 1, Continued

Index	The research year					
	2018		2019		2020	
	heads	%	heads	%	heads	%
Cows were lodged	145	83	161	87	167	86
Inseminated heifers	85	-	92	-	96	-
Heifers were lodged	66	-	84	-	90	-
The first calf was introduced to the herd including per 100 cows	64	-	81	-	86	-
	36	-	43	-	44	-
Calf yield per 100 cows	89	-	91	-	90	-
Aborted cows	2	1.1	3	1.6	4	2.0
Stillborn calves	2	1.4	4	2.5	5	2.9
Cows lost in the first quarter	14	8.0	9	4.8	8	4.1
Incalvers which dropped out	3	1.8	2	1.1	3	1.6
Barn cows and cows, which calved IV qr., but were inseminated in II qr. next year	9	5.1	6	2.2	8	4.1
Calves not received	30	17.1	24	13.0	26	13.3

**Source:** authors' own development

The research revealed that 80 calves were lost in just three years. The main reason for this in 2018-2020 was the death of 31 cows, and the second reason for culling was cow fatness or the extension of the calving to conception interval – 23 cows. In addition, eight pregnant cows were culled for various reasons: disease, injury, forced slaughter, etc. An important role in the prevention of postpartum diseases and infertility is played by obstetric and gynaecological examination, a set of diagnostic, preventive and therapeutic measures aimed at ensuring the normal course of pregnancy, childbirth and the postpartum period in cows, and preserving the viability of the young animals born to them.

K. Moore & W.W. Thatcher (2006) in their research came to a similar conclusion, namely, that existing

intensive commercial systems for keeping lactating dairy cows require careful management of breeding, treatment and preventive measures even before the introduction of follicular waves, CL regression and ovulation induction in programming, which will solve the problem of increasing the reproductive efficiency of high-yielding dairy cows. The analysis of Table 2 shows that the number of pregnant cows on the farm on the day of the inspection was 106 heads or 54%, which corresponds to the norm, while 15 heads or 7.7% of problem cows were identified, which is slightly below the norm and convincingly confirms the existence of an established obstetric and gynaecological examination and prevention and treatment of problem cows.

**Table 2.** The results of obstetric and gynaecological examination of cows in the conditions of Pivdennyi Kolos in June 2020

Index	Name of cow service operators (milkmaids)				
	O.M. Sirova	O.P. Moroz	H.K. Bobchuk	I.V. Yefimova	O.V. Manko
Number of cows, heads	35	42	39	41	38
Incalvers, heads	23	18	25	21	19
Cows after calving, heads	4	3	5	8	6
Inseminated cows, heads	10	11	8	9	10
Problem cows (heads) through:					
ovarian hypofunction	1	-	1	1	-
persistent yellow body	-	1	1	-	-
ovarian cyst	-	-	1	1	1
endometritis	1	1	1	1	1
abortion	1	-	-	-	1

**Source:** authors' own development

It is worth noting that at the time of the herd examination, there was an increase in the number of cows after insemination – 48 heads, which is 24.6%, which can be considered conditionally pregnant, respectively,

which will increase the percentage of pregnant cows in the farm. In the course of the research, it should be noted that the gynaecological examination of cows combines diagnostic, preventive and therapeutic

measures, which, in turn, are aimed at timely detection of postpartum complications, infertility and restoration of reproductive capacity.

In their research, R.B. Walsh *et al.* (2007) also point out that there are many factors that affect the time to first ovulation and whether normal estrus and ovulation cycles will be maintained, including cow breed, parity, season, BCS (Body Condition Scoring), postpartum illness and different types of feeding. The authors' attention was focused on the link between postpartum negative energy balance and the restoration of cyclicity in dairy cows. Scientists emphasise the important link

between perinatal health and reproductive function and performance.

Similar results were obtained by J. Denis-Robichaud *et al.* (2018). Prolonged postpartum anovulation is a problem because it is associated with increased time to first insemination and reduced risk of conception and usually affects 20% of cows in dairy herds and is caused by various gynaecological diseases. An analysis of the work of artificial insemination technicians in 2018-2020 found that 57-64% of cows and 64-70% of heifers conceive from the first insemination (Table 3).

**Table 3.** Performance of artificial insemination technicians in 2018-2020

Index	2018 year				2019 year				2020 year			
	cows		heifers		cows		heifers		cows		heifers	
	heads	%	heads	%	heads	%	heads	%	heads	%	heads	%
Inseminated	164	100	85	100	180	100	92	100	187	100	96	100
Fertilized from insemination:	108	65.8	54	63.5	124	68.9	71	77.2	125	66.8	58	60.4
↳ the first												
↳ the second	25	15.2	12	14.1	24	13.3	13	14.1	27	14.4	18	18.8
↳ the third	12	7.4	-	-	13	7.2	-	-	15	8.1	14	14.6
Calved	145	88.4	66	77.6	161	89.4	84	91.3	167	89.3	90	93.8
Not Inseminated	19	11.6	19	22.4	19	10.6	8	8.7	20	10.7	6	6.2

**Source:** authors' own development

Thus, it was found that thanks to these biotechnologies, 36 to 40 first-born calves per 100 cows are introduced into the main herd annually. At the time of the study, the farm used bull semen frozen in the form of open pellets or straws (paietas). The artificial insemination technician at the base farm also takes into account additional signs of the stage of sexual cycle excitation, which most often precede heat – general anxiety, desire for other animals, poor appetite and reduced milk production, back bending, increased reaction to his voice or the milker, rubbing of the tail root, traces of mucus on the tail and hind limbs, and the manifestation of a hugging reflex to other cows. In addition, the artificial insemination technician has rectal diagnostics of the degree of follicle maturation, accurately determines the time and frequency of insemination, the course of estrus and the duration of heat.

Thus, the main factors that ensure high fertility of animals with the rectocervical method of insemination are the massage of the genitals during their examination and insemination of the animal, which increases uterine motility, promotes the movement of sperm through the oviducts and accelerates ovulation. The

use of disposable sterile plastic instruments allows insemination to be performed under aseptic conditions and requires little time for instrument processing. In addition, the deep insertion of sperm into the cervical canal prevents its backflow into the vagina, promotes faster sperm movement and maintains a high fertilisation rate. And examination of the internal genitalia before insemination makes it possible to monitor the development of follicles, identify sick animals and prescribe timely treatment. It is particularly important to note that this reproduction biotechnology allows for one-time insemination of cows and heifers in one heat, which increases the efficiency and economic feasibility of artificial insemination.

However, the analysis of herd reproduction that was carried out does not fully reveal the reasons for the decline in calf yield, so the impact of the period of time of arrival at the first heat after calving (independence period) on the effectiveness of insemination of cows, the impact of the number of inseminations (insemination index) on the reproductive capacity of cows was investigated, the analysis of which is presented in Table 4.

**Table 4.** Insemination efficiency of cows depending on the period of insemination after calving

Lines of insemination of cows after calving	Number of cows		Independence period, days	Fertilization from the 1st insemination, %	Service period, days	Insemination index
	heads	%				
Till 30 days	197	35.5	28.6±2.14	49.7	65.1±3.15	1.6±0.12
31-60 days	215	38.7	54.3±5.18	61.5	88.5±4.72	1.8±0.34
61-90 days	125	22.5	78.6±8.01	73.3	103.1±8.51	2.1±0.27
91 and more	18	3.3	120.4±16.31	58.8	118.2±9.11	3.2±0.45
On the farm	555	100.0	54.1±7.38	60.7	85.5±6.17	1.9±0.30

**Source:** authors' own development

The calculated data indicate that the average independence period in cows was  $54.1 \pm 7.38$  days, the lowest in group 1 –  $28.6 \pm 2.14$  days, the highest in group 4 –  $120.4 \pm 16.31$  days, respectively. Therefore, the calving to conception interval was the highest in the 4<sup>th</sup> group of cows –  $118.2 \pm 9.11$  days, and the lowest in the 1<sup>st</sup> group –  $65.1 \pm 3.15$  days, while the average calving to conception interval on the farm was  $85.5 \pm 6.17$  days, which is slightly higher than optimal.

The fertility from the 1<sup>st</sup> insemination averaged 60.7%, which is a normal indicator. The analysis shows that the highest insemination efficiency was after 61-90 days after calving and was 73.3%, respectively. In addition, there is a straightforward proportional relationship between the independence and calving to conception interval and the insemination index. Cows that were inseminated in the first month after childbirth had the lowest insemination index –  $1.6 \pm 0.12$  with a minimum independence period of  $28.3 \pm 2.15$  days and a calving to conception interval of  $65.1 \pm 3, 15$  days, and in cows inseminated after the 91<sup>st</sup> day, the insemination index is the highest –  $3.2 \pm 0.45$  with a maximum independence period of  $120.4 \pm 16.31$  and calving to conception interval of  $118.2 \pm 9.11$  days.

In the scientific literature, there are ambiguous statements regarding cow fertility and how much it depends on the length of the calving to conception interval. Thus, F. López-Gatius (2012) points out that the reasons for the decline in fertility are multifactorial and cannot be attributed solely to increased milk production. In fact, by improving feeding and housing practices, individual milk production can be positively related to high fertility,

but heat stress, the sire bull and the artificial insemination operator remain the main factors that negatively affect herd fertility. And the latter does not depend on the duration of the period from launch to calving.

At the same time, B. Tadesse *et al.* (2022) obtained the opposite results. Thus, the authors point out that 37% of cows that did not conceive during the first artificial insemination are associated with a large number of days of stall housing and with reproductive processing. At the same time, scientists link the length of the calving to conception interval to the season of the year. Based on the season of artificial insemination, a significant difference in insemination in winter and spring was found in 13% of animals. Cows that did not conceive during the first insemination but conceived during the 2<sup>nd</sup> and 3<sup>rd</sup> inseminations had an average interval between calving and insemination of 45.04 days longer than cows that were conceived during the first insemination.

On the farm, the artificial insemination technician practices a single insemination of cows during heat by establishing the optimal insemination time according to the degree of follicle maturation during rectal examination. However, it is necessary to take into account the survival rate of sperm in the genital tract, which is almost impossible. In this regard, according to the instruction Order of the Ministry of Agrarian Policy of Ukraine No. 230 (2001), it is recommended to inseminate twice in one heat with an interval of 12 hours. Thus, single insemination of cows in a farm may be one of the reasons for the decrease in cow fertility. Therefore, the effect of the number of inseminations on the reproductive capacity of cows was studied (Table 5).

**Table 5.** Relationship between cow reproductive capacity and insemination index (2018-2020)

Index	Number	Insemination index				
		1	2	3	4	5 and more
Calving is taken into account, in %	658 100	385 58.5	186 28.3	51 7.8	24 3.6	12 1.8
Average service period, days	-	74.3± 3.51	95.1± 4.12	114.7± 6.28	128.7± 11.13	146.3± 21.31

**Source:** authors' own development

Thus, it was found that the insemination index – “1”, the duration of the calving to conception interval is  $74.3 \pm 3.51$  days and with its increase, an increase in the calving to conception interval is observed. And, in turn, cows that were not inseminated after the fifth or more inseminations had a calving to conception interval of  $146.3 \pm 21.31$  days, respectively, i.e. these cows were problematic and were subject to rectal gynaecological examination, or treatment and stimulation, as well as culling for reproductive system problems.

The effectiveness of the use of artificial insemination and synchronisation of estrus is also indicated by M.F. Sá Filho *et al.* (2013). Thus, the authors note that the comparison of the reproductive efficiency of breeding programmes that used natural service (NS), artificial insemination after detection of estrus (ED) and timed artificial insemination (TAI). The researchers concluded that the inclusion of TAI programmes at an early stage of estrus increased the reproductive capacity of beef and dairy cows and reduced the number of artificial inseminations per cow, i.e. the insemination index was at an optimal level.

C.M. Tippenhauer *et al.* (2021) indicate that the number of inseminations of cows is influenced not

only by the period of insemination, but also by the type of semen. Specifically, when artificial insemination of cows was used between 1 and 18 hours after peak estrus activity, the effectiveness was highest regardless of the type of semen (fresh or frozen). Cows inseminated within six hours before the peak estrus activity with frozen semen had a higher insemination rate compared to cows inseminated with fresh semen and inseminated with 1-2 inseminations. Cows inseminated with fresh semen within five hours before peak activity had a higher efficiency compared to cows inseminated with frozen semen; they were inseminated with 2-3 inseminations. And cows inseminated with frozen semen in the period from 13 to 18 hours after peak activity had higher fertilisation efficiency compared to cows inseminated with fresh semen, and it took 3-4 insemination procedures to inseminate them.

During the experiment, the influence of reproductive capacity on the milk production of Red Steppe cows and the dynamics of this relationship depending on the calendar year was determined. The research has established (Table 6) that there is a negative correlation between the duration of the period from launch to calving and subsequent milk yield during the study period.

**Table 6.** The relationship between the reproductive capacity of cows and their milk production for the period 2018-2020

Signs that the relationship is defined between	Index coefficient of correlation by years		
	2018	2019	2020
Dry days ↔ Milk yields	-0.23	-0.10	-0.32
Milk yields for lactation ↔ Release of calves	+0.07	+0.19	+0.11
Average daily milk yield of calves ↔ Release of calves	+0.03	+0.10	+0.07
Service period ↔ Release of calves	-0.01	+0.10	-0.12
Service period ↔ Milk yields	-0.12	-0.19	-0.09
Milk yields for I lactation ↔ Release of calves	+0.07	+0.08	+0.10
Milk yields for II lactation ↔ Release of calves	+0.10	+0.05	+0.06
Milk yields for III lactation ↔ Release of calves	+0.21	+0.29	+0.19

**Source:** authors' own development

The reason for this phenomenon is that early cow start-up leads to a shortfall in milk production. Then the duration of the period from launch to calving was brought to the optimum value of 45-60 days. There was some difference between years in this indicator: the lowest value of the negative correlation was in 2017, which, as previously established, was the most favourable for the animals on this farm.

When determining the relationship between milk yield per lactation and calf yield, a positive correlation was found. It was particularly high in 2019, due to high milk yields and a sufficient level of reproduction shown

by the cows on the farm that year. It has been established that a higher number of offspring born helps to increase the milk production of cows, i.e. these two most indicative parameters have a mutual positive influence on each other, which is certainly effective for the operation of a dairy farm.

It is worth noting that a similar trend is observed when identifying the relationship between average daily milk yield in cows and calf yield: a positive correlation between these indicators with a similar trend, which confirms the above conclusion about the relationship between the number of calves and the amount

of milk produced. There is a weak positive correlation between the length of the calving to conception interval and calf yield, which was only established in 2019; in all other years, the correlation was negative. This is due to the fact that a shorter calving to conception interval indicates a faster recovery of the cow after calving and her greater readiness for the next pregnancy.

In addition, the relationship between the duration of the period from launch to calving and milk yield in cows was investigated. Based on this, a negative correlation was found regardless of the year under study. This confirms the conclusion made earlier that reducing the period from launch to calving from an excessively long 82-90 days to an optimal 30-60 days is likely to increase the milk yield of the farm's cows. When studying the relationship between reproductive capacity and milk production of Red Steppe cows for a certain lactation, a mutual positive influence of these traits was established. The highest correlation coefficients were found between the traits "milk yield for the third lactation" and "calf yield" obtained from cows at this time.

Many hypotheses regarding the relationship between the level of milk production and the reproductive capacity of cows have been described by world scientists. For example, a number of scientists (Patton *et al.*, 2007) do not link the level of cow milk yield with their fertility. The relationship between the components and indicators of energy balance (EB) in early lactation and fertility in Holstein cows was investigated. Milk production, dry matter intake (DMI), BCS, endocrine and metabolite data from 96 cows were analysed using multivariate logistic regression and survival analysis. Fertility variables studied included the interval to onset of luteal activity (C-LA), calving to conception interval

(CCI) and conception to first insemination ratio (CON1). The average daily EB, milk protein content and DMI during the first 28 days of milk production were positively related to CON1. Cows with lower fatness ( $\leq 2.25$ ) at first insemination had lower CON1. Positive associations were found between EV, milk protein content, DMI and the probability of a shorter interval to C-LA. Cows with higher DMI and more positive EB had an increased probability of a shorter CCI, while lower BCS supervision was associated with an increased probability of a longer CCI. Thus, milk yield was not associated with any of the fertility variables studied (Patton *et al.*, 2007).

R.L. Nebel & M.L. McGilliard (1993), on the contrary, indicate correlations between reproductive traits and milk yield, namely, higher milk yields are phenotypically and genetically associated with reduced reproductive capacity in lactating cows. D. Raboisson *et al.* (2014) found an average positive correlation between age and milk yield, and age and reproductive capacity. Thus, when analysing age-related changes in the reproductive capacity of cows, it was found that the duration of the calving to conception interval decreased with the age of the animals. The duration of the period between calvings was optimal on average for cows, while its reduction with age was observed. The authors noted that with increasing age of cows, the number of inseminations for fertilisation increased. Currently, in the field of cattle breeding, the developed promising methods of biotechnological regulation of sexual functions in animals through the use of synthetic analogues of prostaglandins  $F_{2\alpha}$  are widely used. Data on the effect of various drugs to regulate and synchronise the sexual desire of replacement heifers are shown in Table 7.

**Table 7.** Use of prophylactic drugs for regulation and synchronisation of sexual desire in replacement

Purpose of the group	Quantity, heads	Raised sexual desire after processing				Not raised sexual desire		Fertilization from the 1 <sup>st</sup> insemination	
		first		second		heads	%	heads	%
		heads	%	heads	%				
Control group	18	-	-	-	-	7	38.9	10	55.5
II research group	18	7	38.9	9	50.0	2	11.1	14	77.8
III research group	18	8	44.4	9	50.0	1	5.6	16	88.9

**Source:** authors' own development

The experiments proved that the highest percentage of heifers coming into heat from the first treatment was observed in the group where the drug Catozal was used – 44.4%, and the second group was the group that was injected with the hormonal drug Estrophan along with the vitamin Tetravit – 38.9%. After 11 days, the heifers that did not come into heat were re-injected

with the drugs and the following results were obtained: in both experimental groups, the same number of heifers came into heat – nine heads each, which is 50%. Females of the control group, where heifers were not administered any drugs at all, did not become pregnant, and two (11.1%) animals of the second experimental group did not become pregnant after the

second treatment and one head did not become pregnant in the third experimental group, which is 5.6%, respectively. In the control group (no stimulants were used), 10 heifers conceived from the 1<sup>st</sup> insemination, which is 55.5%, in the II experimental group, where Estrofan and Tetravit were used, 14 heifers conceived from the 1<sup>st</sup> insemination, which is 77.8%, in the III experimental group, where Catozal was used, 16 heifers conceived from the 1<sup>st</sup> insemination, which is 88.9%.

Various hormonal preparations are widely used for the treatment, prevention and regulation and synchronisation of the reproductive function of cows in the world. The use of biological products after calving cows reduced the risk of uterine subinvolution, endometritis and mastitis and improved the reproductive performance of cows. It has been shown that after the use of SalusPE, 100% of cows are inseminated, of which 60% are inseminated in the first heat and 40% in the second heat. The fertilisation index was 1.4 (Barkema *et al.*, 2015).

A.W. Jonczyk *et al.* (2022) confirm the effectiveness of the method of intracellular administration of drugs/hormones, which can be a common tool for cattle reproduction. Arab scientists recommend the use of

cloprostenol, which is an analogue of prostaglandin F<sub>2</sub> (PG F<sub>2</sub>), but obtained synthetically, which acts as an agonist of the FP receptor and can cause luteolysis. Luteolysis is a key event in Ovsink's programmes for lactating dairy cows. The authors note that 20% of cows treated in the Presink/Ovsink programme experienced delayed or incomplete luteolysis with dinoprost tromethamine. Cows need to have complete luteolysis to have a chance of getting pregnant (Shahzad *et al.*, 2023).

The next stage was to study the effect of treatment of repair heifers with biologically active preparations (Estrofan + Tetravit, Catozal) on their reproductive capacity after calving and milk production (Table 8). It was established that the use of Estrofan together with Tetravit and Catozal does not reduce the milk yield of first-born cows, since according to the results of control milk yields for the first month in this group, the average daily yield was 16.7 kg, for the second – 18.1 kg and for the third – at the level of 17.9 kg. Further, analysing the service period for the first-born group, it was found that the minimum was 30 days, the maximum was 86 days, and the average for the group was almost 58 days, which is typical for this farm.

**Table 8.** Influence of prophylactic drugs on reproductive capacity and milk production of repair heifers

Alias	Inv. No.	Date of calving	Sex of offspring	Date of last insemination	Service period, days	Control yield of milk, kg		
						1	2	3
Mayka	124	20.01	heifer	6.06	76	15	19	20
Kvitka	262	21.01	heifer	20.02	30	17	19	18
Galka	420	22.01	heifer	15.03	49	17	18	17
Ruchka	164	23.01	bull-calf	19.04	86	13	15	14
Rosa	664	23.01	bull-calf	16.03	50	20	22	23
Litnia	652	24.01	bull-calf	26.03	61	19	18	17
Chereshenka	518	25.01	bull-calf	17.03	51	17	18	20
Mala	428	26.01	heifer	17.03	51	18	17	16
Pava	162	28.01	bull-calf	16.03	50	12	15	16
Sova	540	29.01	bull-calf	14.04	75	19	20	18
Average by group					57.9	16.7	18.1	17.9

**Source:** authors' own development

Planned reproduction of cattle involves the regulation of the estrous cycle and the use of artificial insemination. Cycle control involves the administration of exogenous progesterone for 5-8 days in a controlled manner, which allows females to synchronise their ovulation (Helbling *et al.*, 2018). Synchronisation of estrus using prostaglandin F<sub>2α</sub> (PG F<sub>2α</sub>) and a combination of PG F<sub>2α</sub> and gonadotropin-releasing hormone was also used in Indonesian research. The estrus response can be enhanced by providing PG F<sub>2α</sub> and a combination of PG F<sub>2α</sub>-GnRH to allow for precise timing of mating using artificial insemination. Therefore, scientists

concluded that the use of PG F<sub>2α</sub> was more effective for the duration and intensity of estrus, and the PG F<sub>2α</sub>-GnRH combination was more effective for stimulating estrus (Astuti *et al.*, 2020).

A. Ayad *et al.* (2015) in the research used norgestomethate Crestar on estrus synchronisation and reproductive function of dairy cows. Treatment with norgestomethate Crestar, which was carried out for 9-10 days, did not improve the reproductive performance of dairy cattle. Nevertheless, the authors point out that this hormonal protocol can be used to obtain high estrus rates in cows to correctly determine the time of insemination. In

addition to the above studies, the influence of live weight of repair heifers on the results of artificial insemination was studied. For this purpose, seven groups of heifers

were formed depending on their live weight at the first insemination (Table 9), using thawed semen from the red steppe bull Pilot 1069 by the rectocervical method.

**Table 9.** Influence of live weight of repair heifers on their fertilisation after artificial insemination

Weight category, kg	Average weight, kg	Number of heads inseminate	Fertilized from the 1 <sup>st</sup> insemination	
			Heads	%
Up to 280	271±6.3	17	8	47.1
281-300	292±4.7	21	14	66.7
301-320	314±6.5	19	14	73.7
321-340	328±9.2	12	9	75.0
341-360	352±7.7	9	7	77.8
361-380	375±3.8	7	5	71.4
381 and more	393±5.2	6	4	66.7
Total	-	91	61	67.0

**Source:** authors' own development

It was established that the first group of heifers had an average live weight of 271 ± 6.3 kg and 8 heads, or 47.1%, were fertilised from the first insemination in this group. The second group of heifers weighed 292 ± 4.7 kg, and 66.7% of this group were fertilised from the first insemination. The highest percentage of fertilisation – 77.8 was in the fifth group of heifers with a live weight of 352 ± 7.7 kg, and further, with an increase in

live weight, there is a decrease in the percentage of fertilisation from the first insemination, which in the group of heifers weighing 393 ± 5.2 was 66.7%. Since live weight does not sufficiently reflect the optimal time of insemination of heifers, therefore, in further experiments, the effect of the age of first insemination on their fertilisation was studied. For this purpose, heifers were selected and 5 age groups were formed (Table 10).

**Table 10.** Influence of age at first insemination on fertility of replacement heifers

Age group, months	Average age, months	Number of heads inseminate	Fertilized from the 1 <sup>st</sup> insemination	
			Heads	%
16 - 18	17.5 ± 1.5	18	14	77.8
19 - 20	19.6 ± 1.1	29	21	72.4
21 - 23	22.1 ± 1.8	24	15	62.5
23 - 24	23.4 ± 1.0	15	9	60.0
Elder than 24 months	26.8 ± 2.7	5	2	40.0
Total	-	91	61	67.0

**Source:** authors' own development

Analysis of the table data shows that in the first group of heifers the average age was 17.5 ± 1.5 months. It was established that during artificial insemination, 14 out of 18 heads were fertilised from the first insemination, which is 77.8%; this is the highest fertility rate from the first insemination. With increasing age of heifers, there is a decrease in fertility from the first insemination, which was the lowest – 40% in heifers with an average age of 26.8 ± 2.7 months.

Many global scientists have concluded that achieving pregnancy for lactating dairy cows in the range of every 365 days optimises profitability for most cows and depends on the length of the voluntary

waiting period (VWP) and reducing the number and variation of days to conception after cows become eligible for pregnancy (Stevenson & Britt, 2017; Stangaferro *et al.*, 2018; Fyl, 2020). Through the introduction of reproductive management programmes and technologies that better control artificial insemination rates and significantly increase pregnancies per artificial insemination (P/AI) for the first and subsequent artificial insemination operations. Therefore, combining an effective management programme with a service period that optimises the time to pregnancy during lactation can be a feasible strategy to increase herd profitability.

The use of synchronisation programmes is a standard component of efficient cow management in dairy herds. Many of them are based on measures that allow for timed insemination (TAI) to avoid the practical difficulties associated with detecting cows in heat. Almost all of the measures involve injections of prostaglandin  $F_{2\alpha}$  (PGF) and gonadotropin-releasing hormone (GnRH) at strategically timed intervals, which determines the economic efficiency of the industry as a whole.

## CONCLUSIONS

The analysis of the reproduction status shows that there is an annual shortfall in calf production, and the main reasons are: cow retirement, as well as beef cows and cows with an extended calving to conception interval. It has been established that pregnant cows left the herd for various reasons, such as injuries, diseases of various types, forced slaughter, etc. Reducing the calving to conception interval will contribute to a higher calf yield in cows, which has a positive impact on milk production. At the same time, it should be borne in mind that the calving to conception interval can be reduced to a number that is not less than 30 days, i.e. the period required to prepare the cow's body for new insemination.

The calculations of the correlation coefficient between the main signs of reproductive capacity and milk production of Red Steppe cows allowed us to establish a mutual positive influence between them. The conclusion made earlier about the best functioning of all organs and systems of the cow's body during the third lactation was confirmed. It also confirms the statement about the plasticity of the cows' organism and their active response to the favourable conditions of a particular year by increasing productivity and fertility. It has been established that the use of prophylactic drugs

contributes to the synchronisation of heifers' sexual desire and increases their fertility during insemination. The latter should be started when heifers reach a live weight of  $314 \pm 6.5$  kg, which will allow to obtain fertilisation from the first insemination at the level of 73.7-77.8%, and an increase in heifer weight leads to obesity, and therefore reduces the percentage of fertilisation from the first insemination. The optimal age for artificial insemination of heifers is  $17.5 \pm 1.5$  months, and an increase in the age of heifers leads to overgrazing and culling them from the farm.

To diagnose problem cows in terms of reproductive function, it is worthwhile to conduct an early check on the 25-30<sup>th</sup> day of pregnancy in inseminated cows using ultrasound diagnostics. It is necessary to establish obstetric and gynaecological examination and treatment of problematic replacement heifers and cows, and it is advisable to use prostaglandin  $F_{2\alpha}$  analogues in combination with vitamins or biologically active drugs to stimulate the sexual function of cows and heifers. The maximum number of Red Steppe heifers should be inseminated at the age of 16-18 months with a live weight of 314-360 kg to achieve a fertility rate of 75-77% from the first insemination. The prospect of further research on this topic may be the search for new insemination programmes that can increase the level of these two hormones during oestrus, which can help solve the problem of low fertility in lactating dairy cows.

## ACKNOWLEDGEMENTS

The authors express their gratitude to the management and specialists of Pivdennyi Kolos for the opportunity to conduct research in the company.

## CONFLICT OF INTEREST

None.

## REFERENCES

- [1] Abbara, A., Clarke, S.A., & Dhillon, W.S. (2018a). Novel concepts for inducing final oocyte maturation in in vitro fertilization treatment. *Endocrine Reviews*, 39(5), 593-628. doi: [10.1210/er.2017-00236](https://doi.org/10.1210/er.2017-00236).
- [2] Abbara, A., Islam, R., Clarke, S.A., Jeffers, L., Christopoulos, G., Comninou, A.N., ... Dhillon, W.S. (2018b). Clinical parameters of ovarian hyperstimulation syndrome following different hormonal triggers of oocyte maturation in IVF treatment. *Clinical Endocrinology*, 88(6), 920-927. doi: [10.1111/cen.13569](https://doi.org/10.1111/cen.13569).
- [3] Astuti, P., Airin, C.M., Widiyanto, S., Sarmin, S., Hana, A., Maheshwari, H., & Sjahfirdi, L. (2020). Estrus synchronization using prostaglandin  $F_{2\alpha}$  (PGF $_{2\alpha}$ ) and combination of PGF $_{2\alpha}$  and gonadotropin-releasing hormone in ongole crossbred. *E3S Web of Conferences*, 151, 01009. doi: [10.1051/e3sconf/202015101009](https://doi.org/10.1051/e3sconf/202015101009).
- [4] Ayad, A., Salaheddine, M., Touati, K., Iguer-Ouada, M., & Benbarek, H. (2015). Evaluation of norgestomet Crestar® on oestrus synchronization and reproductive performance of dairy cows in Algeria. *Asian Pacific Journal of Reproduction*, 4(1), 54-60. doi: [10.1016/S2305-0500\(14\)60059-2](https://doi.org/10.1016/S2305-0500(14)60059-2).
- [5] Barkema, H.W., von Keyserlingk, M.A.G., Kastelic, J.P., Lam, T.J.G.M., Luby, C., Roy, J.-P., ... Kelton, D.F. (2015). Invited review: Changes in the dairy industry affecting dairy cattle health and welfare. *Journal of Dairy Science*, 98(11), 7426-7445. doi: [10.3168/jds.2015-9377](https://doi.org/10.3168/jds.2015-9377).

- [6] Besbaci, M., Abdelli, A., Minviel, J.J., Belabdi, I., Kaidi, R., & Raboisson, D. (2020). Association of pregnancy per artificial insemination with gonadotropin-releasing hormone and human chorionic gonadotropin administered during the luteal phase after artificial insemination in dairy cows: A meta-analysis. *Journal of Dairy Science*, 103(2), 2006-2018. doi: [10.3168/jds.2019-16439](https://doi.org/10.3168/jds.2019-16439).
- [7] Bezuhlyi, M.D. (2002). *Biotechnology methods of reproduction of agricultural animals*. Kharkiv: Institute of Animal Husbandry of the National Academy of Sciences of Ukraine.
- [8] Bobryk, V.H. (2020). *Optimization of the reproductive function of cows of the Swiss breed in the "Ekaterinoslavskiy" MVK in Dnipro*. (Master's thesis, Dnipro State Agrarian and Economic University, Dnipro, Ukraine). Retrieved from <https://dspace.dsau.dp.ua/handle/123456789/4174>.
- [9] Bonacker, R.C., Stoecklein, K.S., Locke, J.W.C., Ketchum, J.N., Knickmeyer, E.R., Spinka, C.M., & Thomas, J.M. (2020). Treatment with prostaglandin F<sub>2α</sub> and an intravaginal progesterone insert promotes follicular maturity in advance of gonadotropin-releasing hormone among postpartum beef cows. *Theriogenology*, 157, 350-359. doi: [10.1016/j.theriogenology.2020.08.018](https://doi.org/10.1016/j.theriogenology.2020.08.018).
- [10] Bushtruk, M. (1998). *Estimation and selection of bulls black and white breed according to their reproductive features*. (Doctoral dissertation, M.V. Zubets Institute of Animal Breeding and Genetics of the National Academy of Sciences of Ukraine, Chubynske, Kyiv region, Ukraine).
- [11] Cabrera, E.M., Lauber, M.R., Peralta, E.M., Bilby, T.R., & Fricke, P.M. (2021). Human chorionic gonadotropin dose response for induction of ovulation 7 days after a synchronized ovulation in lactating Holstein cows. *JDS Communications*, 2(1), 35-40. doi: [10.3168/jdsc.2020-0024](https://doi.org/10.3168/jdsc.2020-0024).
- [12] Chukhriy, B.M., Klevets, L.O., & Chaikovska, O.I. (1998). Bull blood groups as genetic markers of sperm quality. *Cytology and Genetics*, 32(2), 74-79. Retrieved from [https://scholar.google.com.ua/scholar\\_host?q=info:EIStE9DXw5EJ:scholar.google.com/&output=viewport&pg=74&hl=uk&as\\_sdt=0,5](https://scholar.google.com.ua/scholar_host?q=info:EIStE9DXw5EJ:scholar.google.com/&output=viewport&pg=74&hl=uk&as_sdt=0,5).
- [13] Code of practice for the housing and care of animals bred, supplied or used for scientific purposes. (2014). Retrieved from [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/388535/CoPanimalsWeb.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/388535/CoPanimalsWeb.pdf).
- [14] Denis-Robichaud, J., Cerri, R.L.A., Jones-Bitton, A., & LeBlanc, S.J. (2018). Performance of automated activity monitoring systems used in combination with timed artificial insemination compared to timed artificial insemination only in early lactation in dairy cows. *Journal of Dairy Science*, 101(1), 624-636. doi: [10.3168/jds.2016-12256](https://doi.org/10.3168/jds.2016-12256).
- [15] Fedorovych, V.V., Fedorovych, E.I., Mazur, N.P., & Dyachenko, O.B. (2019). Formation of milk productivity of cows of the Ukrainian red-spotted breed, depending on indicators of reproductive capacity. *Scientific and Technical Bulletin of the State Research Control Institute of Veterinary Medicines and Feed Additives and the Institute of Animal Biology*, 20(1), 169-177. Retrieved from <http://www.irbis-nbu.gov.ua/>.
- [16] Fricke, P.M., & Wiltbank, M.C. (1999). Effect of milk production on the incidence of double ovulation in dairy cows. *Theriogenology*, 52(7), 1133-1143. doi: [10.1016/S0093-691X\(99\)00205-8](https://doi.org/10.1016/S0093-691X(99)00205-8).
- [17] Fyl, S.I. (2020). *The role of selective and genetic factors in the formation of highyielding herds of Black-and-White cattle*. (Doctoral dissertation, M.V. Zubets Institute of Animal Breeding and Genetics of the National Academy of Sciences of Ukraine, Chubynske, Kyiv region, Ukraine).
- [18] Gonchar, O.F., & Sotnichenko, Yu.M. (2015). Breeding aspects of reproductive capacity formation in dairy cows. *Animal Breeding and Genetics*, 50, 200-207. Retrieved from [http://digest.iabg.org.ua/images/digest/50/Animal\\_breeding\\_and\\_genetics\\_50.pdf#page=200](http://digest.iabg.org.ua/images/digest/50/Animal_breeding_and_genetics_50.pdf#page=200).
- [19] Gryshchuk, G.P. (2012). Effect of fetoplacental and estrophan on the reproductive function of cows. *Veterinary Medicine of Ukraine*, 2(192), 21-23. Retrieved from <http://ir.polissiauniver.edu.ua/handle/123456789/2312>.
- [20] Guntik, L.M. (2003). An improved method of cryopreservation of bull semen. *Animal Breeding and Genetics*, 35, 39-43. Retrieved from <http://www.irbis-nbu.gov.ua/>.
- [21] Helbling, I.M., Busatto, C.A., Fioramonti, S.A., Poeso, J.I., Santiago, L., Estenez, D.A., & Luna, J.A. (2018). Preparation of TPP-crosslinked chitosan microparticles by spray drying for the controlled delivery of progesterone intended for estrus synchronization in cattle. *Pharmaceutical Research*, 35, 66. doi: [10.1007/s11095-018-2363-z](https://doi.org/10.1007/s11095-018-2363-z).

- [22] Jonczyk, A.W., Piotrowska-Tomala, K.K., & Skarzynski, D.J. (2022). Comparison of intra-CL injection and peripheral application of prostaglandin F<sub>2</sub> $\alpha$  analog on luteal blood flow and secretory function of the bovine corpus luteum. *Frontiers in Veterinary Science*, 8, 811809. doi: [10.3389/fvets.2021.811809](https://doi.org/10.3389/fvets.2021.811809).
- [23] Kamenska, I.S. (2013). Reproductive ability and linear growth of offspring of different lines of the Simmental breed. *Bulletin of the Sumy National Agrarian University. Series: Livestock*, 1, 144-148. Retrieved from [https://scholar.google.com.ua/scholar?cluster=600899134617405797&hl=uk&as\\_sdt=0,5](https://scholar.google.com.ua/scholar?cluster=600899134617405797&hl=uk&as_sdt=0,5).
- [24] Kravchenko, M.A. (1973). *Breeding farm animals*. Moscow: Kolos.
- [25] Kruglyak, O.V. (2016). Organizational and economic mechanism of preservation of biodiversity of agricultural animals of Ukraine. *Balanced Nature Management*, 4, 66-75. [https://scholar.google.com.ua/scholar?cluster=12668679209404317628&hl=uk&as\\_sdt=0,5](https://scholar.google.com.ua/scholar?cluster=12668679209404317628&hl=uk&as_sdt=0,5).
- [26] Law of Ukraine No. 3447-IV "On the Protection of Animals From Cruelty". (2006, February). Retrieved from <https://zakon.rada.gov.ua/laws/show/3447-15/ed20060221#Text>.
- [27] López-Gatius, F. (2012). Factors of a noninfectious nature affecting fertility after artificial insemination in lactating dairy cows. A review. *Theriogenology*, 77(6), 1029-1041. doi: [10.1016/j.theriogenology.2011.10.014](https://doi.org/10.1016/j.theriogenology.2011.10.014).
- [28] Melnik, V., Karateeva, H., Kravchenko, H., & Kogut, E. (2022). Hematological and biochemical blood indicators of young gilts after estrus synchronization. *Scientific Papers. Series D. Animal Science*, 65(1), 289-294. Retrieved from <http://dspace.mnau.edu.ua/jspui/bitstream/123456789/13016/1/Art38.pdf>.
- [29] Moore, K., & Thatcher, W.W. (2006). Major advances associated with reproduction in dairy cattle. *Journal of Dairy Science*, 89(4), 1254-1266. doi: [10.3168/jds.S0022-0302\(06\)72194-4](https://doi.org/10.3168/jds.S0022-0302(06)72194-4).
- [30] Motta, J.C., Madureira, G., Silva, L.O., Alves, R.L., Silvestri, M., Drum, J.N., ... Sartori, R. (2020). Interactions of circulating estradiol and progesterone on changes in endometrial area and pituitary responsiveness to GnRH. *Biology of Reproduction*, 103(3), 643-653. doi: [10.1093/biolre/ioaa065](https://doi.org/10.1093/biolre/ioaa065).
- [31] Nadochiy, V.M., Nadochiy, V.P., & Osipenko, O.P. (2011). Relationship of sperm production indicators with indicators of the humoral factor of non-specific resistance in breeding bulls. *Technology of Production and Processing of Livestock Products: A Collection of Scientific Papers*, 5(82), 19-23. Retrieved from <https://rep.btsau.edu.ua/handle/BNAU/528>.
- [32] Nebel, R.L., & McGilliard, M.L. (1993). Interactions of high milk yield and reproductive performance in dairy cows. *Journal of Dairy Science*, 76(10), 3257-3268. doi: [10.3168/jds.S0022-0302\(93\)77662-6](https://doi.org/10.3168/jds.S0022-0302(93)77662-6).
- [33] Order of the Ministry of Agrarian Policy of Ukraine No. 230 "On Approval of the Instructions on Artificial Insemination of Cows and Heifers". (2001, August). Retrieved from <https://zakon.rada.gov.ua/laws/show/z0852-01#Text>.
- [34] Ostashko, F.I. (1995). *Biotechnology of reproduction of cattle*. Kyiv: Agrarian Science.
- [35] Pabat, V., & Vinnychuk, D. (2001). Reproductive function of cows. *Tvarynyystvo Ukrainy*, 1, 10-11.
- [36] Patton, J., Kenny, D.A., McNamara, S., Mee, J.F., O'mara, F.P., Diskin, M.G., & Murphy, J.J. (2007). Relationships among milk production, energy balance, plasma analytes, and reproduction in Holstein-Friesian cows. *Journal of Dairy Science*, 90(2), 649-658. doi: [10.3168/jds.S0022-0302\(07\)71547-3](https://doi.org/10.3168/jds.S0022-0302(07)71547-3).
- [37] Pidpala, T.V., Ostapenko, O.M., Yasevin, S.I., Droviak, O.V., Marykina, O.S., & Hrebeniuk, N.V. (2018). *Intensive technologies in dairy farming*. Mykolaiv: Mykolaiv National Agrarian University. Retrieved from <https://dspace.mnau.edu.ua/jspui/bitstream/123456789/5472/1/Pidpala%20mono.pdf>.
- [38] Ponomarenko, I.V. (2005). The relationship between the reproductive capacity of Ukrainian Black-and-Red and Red-Spotted dairy cows with milk productivity. *Scientific Bulletin of the Lviv State Academy of Veterinary Medicine Named After S.Z. Gzhitskyi*, 7(2), 232-235.
- [39] Povod, M.H., Nezhlukchenko, T.I., Papakina, N.S., Baranovskyi, D.I., Cill, M.I., & Khalak, V.I. (2015). *Genetics with biometrics*. Kherson: OLDI-PLluS.
- [40] Pursley, J.R., Mee, M.O., & Wiltbank, M.C. (1995). Synchronization of ovulation in dairy cows using PGF<sub>2</sub> $\alpha$  and GnRH. *Theriogenology*, 44(7), 915-923. doi: [10.1016/0093-691X\(95\)00279-H](https://doi.org/10.1016/0093-691X(95)00279-H).
- [41] Raboisson, D., Mounié, M., & Maigné, E. (2014). Diseases, reproductive performance, and changes in milk production associated with subclinical ketosis in dairy cows: A meta-analysis and review. *Journal of Dairy Science*, 97(12), 7547-7563. doi: [10.3168/jds.2014-8237](https://doi.org/10.3168/jds.2014-8237).

- [42] Sá Filho, M.F., Pentead, L., Reis, E.L., Reis, T.A.N.P.S., Galvão, K.N., & Baruselli, P.S. (2013). Timed artificial insemination early in the breeding season improves the reproductive performance of suckled beef cows. *Theriogenology*, 79(4), 625-632. doi: [10.1016/j.theriogenology.2012.11.016](https://doi.org/10.1016/j.theriogenology.2012.11.016).
- [43] Shahzad, A., Majeed, A., Lahi, A.A., Alqahtani, T., Alqahtani, A.M., Bashir, K., ... Fu, Q. (2023). Preparation and characterization of dummy template molecularly imprinted polymers coupled with HPLC for selective extraction of spiked cloprostenol from milk samples. *Arabian Journal of Chemistry*, 16(9), 105045. doi: [10.1016/j.arabjc.2023.105045](https://doi.org/10.1016/j.arabjc.2023.105045).
- [44] Stakhovsky, V.F. (2009). A new method of using cryopreserved bull semen after thawing. *Animal Breeding and Genetics*, 43, 310-314. Retrieved from [https://scholar.google.com.ua/scholar?cluster=14711424533604455038&hl=uk&as\\_sdt=0.5#](https://scholar.google.com.ua/scholar?cluster=14711424533604455038&hl=uk&as_sdt=0.5#).
- [45] Stangaferro, M.L., Wijma, R., Masello, M., Thomas, M.J., & Giordano, J.O. (2018). Economic performance of lactating dairy cows submitted for first service timed artificial insemination after a voluntary waiting period of 60 or 88 days. *Journal of Dairy Science*, 101(8), 7500-7516. doi: [10.3168/jds.2018-14484](https://doi.org/10.3168/jds.2018-14484).
- [46] Stevenson, J.S., & Britt, J.H. (2017). A 100-year review: Practical female reproductive management. *Journal of Dairy Science*, 100(12), 10292-10313. doi: [10.3168/jds.2017-12959](https://doi.org/10.3168/jds.2017-12959).
- [47] Tadesse, B., Reda, A.A., Kassaw, N.T., & Tadege, W. (2022). Success rate of artificial insemination, reproductive performance and economic impact of failure of first service insemination: a retrospective study. *BMC Veterinary Research*, 18(1), 1-10. doi: [10.1186/s12917-022-03325-1](https://doi.org/10.1186/s12917-022-03325-1).
- [48] Tippenhauer, C.M., Plenio, J.L., Madureira, A.M.L., Cerri, R.L.A., Heuwieser, W., & Borchardt, S. (2021). Timing of artificial insemination using fresh or frozen semen after automated activity monitoring of estrus in lactating dairy cows. *Journal of Dairy Science*, 104(3), 3585-3595. doi: [10.3168/jds.2020-19278](https://doi.org/10.3168/jds.2020-19278).
- [49] Ugnivenko, A.M., & Demchuk, S.Yu. (2018). Involution of reproductive organs and reproductive functions in beef cows. In *Modern scientific idea '2018* (pp. 21-22). Retrieved from <https://www.sworld.education/konferbe5/be5-sbor.pdf#page=21>.
- [50] Vechorka, V.V. (2010). *Evaluation of productive qualities of Holstein animals of Canadian selection depending on genotypic and paratypic factors*. (Master's thesis, Kherson State Agrarian University, Kherson, Ukraine). Retrieved from <http://repo.snau.edu.ua/handle/123456789/126>.
- [51] Walsh, R.B., Kelton, D.F., Duffield, T.F., Leslie, K.E., Walton, J.S., & LeBlanc, S.J. (2007). Prevalence and risk factors for postpartum anovulatory condition in dairy cows. *Journal of Dairy Science*, 90(1), 315-324. doi: [10.3168/jds.S0022-0302\(07\)72632-2](https://doi.org/10.3168/jds.S0022-0302(07)72632-2).
- [52] Yablonskyi, V.A. (1995). *Practical obstetrics, gynecology and artificial insemination of farm animals*. Kyiv: Urozhai.
- [53] Yablonskyi, V.A., Khomin, S.P., Kalynovskyi, H.M., Kharuta, H.H., Kharenko, M.I., Zaviriukha, V.I., & Liubetskyi, V.I. (2011). *Veterinary obstetrics, gynecology and biotechnology of animal reproduction with the basics of andrology*. Vinnytsia: Nova Knyha.
- [54] Zhuravel, M.P., & Davydenko, V.M. (2005). *Technology of reproduction of agricultural animals*. Kyiv: Vydavnychi Dim "Slovo".
- [55] Ziecik, A.J., Klos, J., Gromadzka-Hliwa, K., Dietrich, M.A., Slowinska, M., Likszo, P., ... Kaczmarek, M.M. (2021). Endocrine and molecular milieu of ovarian follicles are diversely affected by human chorionic gonadotropin and gonadotropin-releasing hormone in prepubertal and mature gilts. *Scientific Reports*, 11(1), 13465. doi: [10.1038/s41598-021-91434-6](https://doi.org/10.1038/s41598-021-91434-6).
- [56] Zvierieva, H.V., Yablonskyi, V.A., Kosenko, M.V., Khomyn, S.P., Kharuta, H.H., & Kalynovskyi, S.P. (2001). *Recommendations for the prevention of infertility in livestock*. Kyiv: Naukovyi Svit.

## Біотехнологія регуляції відтворювальних функцій порід *Bos primigenius taurus*

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**Анотація.** Оскільки велика рогата худоба біологічно здатна народжувати лише одне теля в рік, її прийнято вважати одноплідним видом тварин. Одним із кардинальних методів вирішення проблеми прискореного відтворення худоби є біотехнологічна регуляція відтворювальної функції у корів та синхронізація їх статевої охоти. Метою дослідження є вивчення особливостей репродуктивної функції корів червоної степової породи під впливом різних методів її регуляції із застосуванням сучасних гормональних засобів. Для оцінки відтворювальної функції корів використано загальноприйняті зоотехнічні методики, для обрахунку даних застосовано методи варіаційної статистики, а для регуляції статевої охоти у корів біотехнологічні методи. На основі аналізу стану відтворення стада великої рогатої худоби встановлено, що щорічно штучно осіменяють 164-187 корів, 85-96 телиць, що забезпечує вихід приплоду телят на 100 корів 89-91 голів і щорічне введення в стадо від 36 до 40 первісток на 100 корів. Забезпечення скорочення сервіс-періоду сприяє як більшому виходу телят у корів, так і збільшенню надоїв, що є бажаним виробничим ефектом. Однак період необхідний для підготовки організму корови до нового осіменіння можна скоротити як мінімум до 30 днів. Осіменіння телиць апаратами штучного осіменіння слід починати при досягненні ними живої маси  $314 \pm 6,5$  кг, що дозволить отримати заплідненість від першого осіменіння на рівні 73,7-77,8 % і тим самим упередити ожиріння телиць, через що в основному знижується відсоток заплідненості від першого осіменіння. Необхідно налагодити акушерсько-гінекологічну диспансеризацію та лікування проблемних ремонтних телиць і корів, а також доцільно використовувати аналоги простагландину  $F_{2\alpha}$  в комплексі з вітамінами або біологічно активними препаратами з метою стимуляції статевої функції корів і телиць. Застосування профілактичних препаратів буде сприяти синхронізації статевого потягу телиць та сприяти підвищенню їх плодючості під час осіменіння. А організація відтворення стада великої рогатої худоби та запропоновані біотехнологічні шляхи вдосконалення штучного осіменіння маточного поголів'я червоної степової породи значно покращить їх відтворювальний статус, що підвищить в цілому економічну ефективність галузі

**Ключові слова:** простагландини; статева охота; сервіс-період; індекс осіменіння; сухостійний період; штучне осіменіння