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ORIGINAL ARTICLE

The influence of the season on the efficiency of fertilization and the manifestation of postpartum pathology in dairy cows

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The study aimed to determine the effect of seasonal factors on the effectiveness of fertilization and the manifestation of postpartum pathology in Brown Swiss cows at one of the commercial dairy complexes. We studied weather conditions, the results of artificial insemination, and the manifestation of postpartum pathology among cows over several years. The correlation between weather conditions and the percentage of insemination of cows was moderate. The use of analysis of variance allowed to establish that seasonality did not significantly affect the effectiveness of artificial insemination of dairy cows. However, the existence of seasonality in the manifestation of postpartum pathology in cows should serve as a guide to management decisions by livestock breeders and veterinarians.
Keywords: Seasonality, brown cows, artificial insemination, endometritis, postpartum paresis, retained placenta.

Introduction

The variability of weather conditions associated with climate change and, in particular, the increase in the number and duration of heatwaves in summer are becoming a serious social problem not only for most of Europe but also for the continental climate of Ukraine (Shevchenko et al., 2021).

Even with a high level of uncertainty in global warming forecasts, it is already necessary to look for effective livestock management strategies in adverse (extreme) conditions, rather than just being guided by selection for maximum productivity (Gaughan & Cawdell-Smith, 2015).

After calving, cows have two to five months to be fertilized again if we want to maintain sustainable productivity. However, most highly productive animals have limited estrus compared to cows studied by researchers 40 years ago (Sheldon et al., 2011).

Almost half of the modern dairy cattle cannot produce the first dominant follicle in the postpartum period; many animals have abnormal estrus with anovulatory anestrus, cystic ovarian disease, or prolonged luteal phase, primarily under the action of various stressors (Sklyarov et al., 2020; Mylostyvyi & Izhboldina, 2021).

The increase in average and maximum temperatures in recent decades has been associated with a decrease in the insemination efficiency of cows (Borş et al., 2019). Under the influence of high temperatures in the granulosa cells, the nucleoli's fragmentation (Sirotkin et al., 2021) released less progesterone, including due to impaired response to FSH. There were changes in the components of follicular fluid and the growth of inflammatory mediators in preovulatory follicles (Rispoli et al., 2020). In the summer, sperm abnormalities became more frequent (Zaher et al., 2020), decreased concentrations and motility were observed (El-Zeftawy et al., 2020), and anatomical changes in the diameter of the external epididymal caudal duct in the testes caused azoospermia in the fetus.

However, Romanian scientists (Borş et al., 2019) believe that climate change, while affecting some productive and reproductive parameters of medium-yielding cows in temperate continental climates, is not as critical as other researchers report.

We suggested that weather conditions should significantly affect the reproduction of cows during year-round keeping in naturally ventilated barns (NVB), as weather conditions will directly affect the animal's body throughout the year. Therefore, our work aimed to determine the percentage of influence of seasonal factors on fertilization and the manifestation of postpartum pathology in cows of the Brown Swiss breed at one of the commercial dairy complexes in the continental climate of Ukraine.

Materials and Methods

The research was performed as part of the research work "Ensuring sustainable development of livestock and natural resistance to environmental and technological factors." (state registration number 0120U103848). This experiment was conducted following the requirements for humane treatment of animals and approved by the Commission on Bioethics.

The research was conducted at a commercial dairy complex for breeding Brown Swiss cattle near the Dnipro (48°34′03.1″N, 34°54′47.0″E) in the central part of Ukraine, which according to the Köppen climate classification, belongs to the humid continental climate with hot summer (Dfa). In short, dairy cows were kept unleashed in NVBs. Cows received a year-round feed mix based on corn silage, nutritionally balanced according to the recommendations of the National Research Council (NRC, 2001). There were fodder alleys and group drinking fountains with free access. Productivity of cows on average on a herd made about 30 kg a day on a cow. Data on weather conditions (air temperature and relative humidity) from January 2019 to December 2020 were obtained from the nearest weather station; the distance from which to livestock facilities in a straight line did not exceed 21 km. The indicators were taken into account every hour to calculate average values for the day, season, and year. The temperature-humidity index (THI) was calculated by Kibler (1964).

Data on the effectiveness of insemination of cows and the manifestation of postpartum pathology were collected in the dairy complex by analyzing veterinary reporting. Artificial insemination of cows was performed by the cervical method with fixation of the uterus through the rectum. Disposable catheters (Minitüb GmbH, Tiefenbach, Germany) were used for this purpose. Sperm supplier "Limited Liability Company Semex Alliance Ukraine". Synchronization of cows in the absence of natural sexual cyclicity was performed on the 85th day after birth using the protocols "Ovsynch"/"Presynch" depending on the physiological (clinical) condition of the animals. Diagnosis of pregnancy was performed on days 31-37 after insemination.

Systematization of the initial data before analysis of variance was carried out according to the principle described in our previous work (Mylostyvyi et al., 2021). The share of exposure (%) of the seasonal factor was determined by the method of biometric analysis (Kovalenko et al., 2010) based on the results of ANOVA in the program Statistica 12 (StatSoft, Inc., Tulsa, OK, USA).

The obtained digital data were presented as means (Mean) and standard error of the mean (SE). The relationship between traits was determined by Spearman's rank correlation method. The difference between the samples, determined by the Mann-Whitney U-test, was considered significant at P <0.05.

Results

We found that the weather conditions for individual seasons during 2019-2020 had no significant differences (Table 1). The difference in air temperature was only 0.1–1.6°C; the relative humidity was 1.1–8.0%, the temperature-humidity index was 0-2.0 units.

Season	Indicator[1]		
	Temperature, °C	Relative humidity, %	THI, units
Winter	-0.4 ± 3.79/-0.3 ± 3.14	86.6 ± 9.79/83.0 ± 9.54	33.2 ± 6.12/33.9 ± 4.79
Spring	11.2 ± 6.49 /10.0 ± 4.43	64.0 ± 14.44/56.0 ± 15.52	52.8 ± 9.28/51.5 ± 5.94
Summer	22.3 ± 2.98/22.5 ± 3.21	59.3 ± 9.76/58.2 ± 10.99	68.1 ± 3.8/68.1 ± 4.03
Autumn	10.6 ± 6.84/12.2 ± 7.39	71.9 ± 18.69/68.3 ± 17.63	51.4 ± 9.76/53.4 ± 10.8

Note: [1] In the table, data for 2019 and 2020 are indicated by fractions. Indicators for these years are calculated on average daily values.

Table 1. Parameters of the external environment in the location of the dairy complex according to the nearest weather station (Mean ± SE).

The difference in the average annual values of these indicators was 0.2°C, respectively; 4.3% and 0.5 units THI (Fig. 1). The lack of a significant difference in the main parameters of the air environment between these years allowed us to combine the data for mathematical analysis.

Seasonal differences in insemination efficiency over the years were revealed. In 2019, the percentage of insemination of cows was highest in spring and summer (41-42), and the lowest was in winter (37), while in 2020, the situation was different, as animal fertility was highest in winter and spring (36-41%). It is likely that this situation was influenced by technological (management) decisions, not just weather conditions, especially in the absence of a significant difference in weather conditions by year.

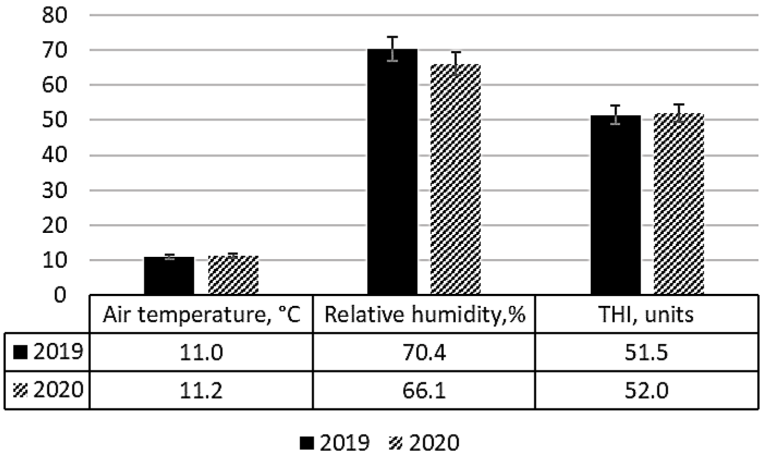

Fig. 1. Average annual values of temperature, relative humidity, and THI within the research period.

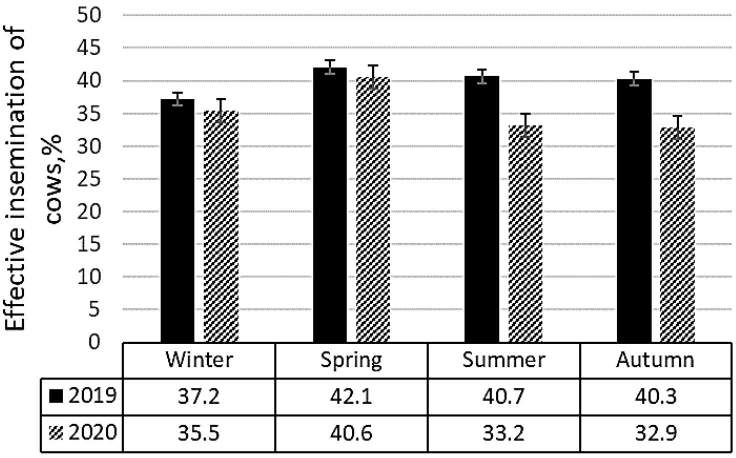

Fig. 2. Seasonal dynamics of the percentage of the fertility of dairy cows in 2019-2020. The difference between the indicators is insignificant.

We noted that the relationship between the parameters of the air environment and the percentage of the fertility of cows revealed a relationship of different strength (Table 2). The paired relationship (*r*) between temperature and humidity and the % of fertilization in spring (+0.48) and summer (+0.52) was significant. However, the correlation between THI and the percentage of fertilization during all seasons was negatively low, increasing to 0.2-0.3 in spring and summer.

Season	**Air parameters**	
	Temperature × humidity	**THI**
Winter	-0.102	-0.075
Spring	+0.482*	-0.198
Summer	+0.517	-0.291
Autumn	-0.209	-0.186

Note: * Reliability of the relation P<0.05.

Table 2. Correlation (*r*) between air parameters and the percentage of the fertility of cows.

The impaired reproductive function of animals due to the pathology of the postpartum period may be the cause of the low efficiency of artificial insemination. The analysis revealed seasonal differences in the manifestation of postpartum pathology in cows (Table 3). In particular, cases of retained placenta were more frequent in spring (23-26%) and slightly lower in winter (13-15%). Diseases of the uterus were more typical in the summer-autumn period (22-25%), while cases of postpartum paresis did not have a pronounced seasonal manifestation.

Pathology	Season[1]			
	winter	**spring**	**summer**	**autumn**
Retained placenta	14.7/13.3	23.3/26.3	14.0/17.7	16.3/16.3
Endometritis	13.7/23.7	16.7/17.7	25.3/21.7	23.7/23.0
Postpartum paresis	3.0/0.7	0.3/1.0	0.7/0.3	0.7/0.3

Table 3. Seasonal manifestation of postpartum pathology in dairy cows in the dairy complex (average herd values in the %).

In the table, data for 2019 and 2020 are indicated by fractions. We found (Table 4), although the percentage of influence of seasonal factor on fertile insemination of cows was insignificant (only 3%), the share of influence of the season on the manifestation of postpartum pathology was large (13-53%). Moreover, the effect of the season on the retained placenta was significant (P <0.05).

Indicator	ANOVA parameters		
	η_x^2,%	**F**	**p-value**
Fertilization	3.1	3.17	0.0782
Retained placenta	53.3	6.77	0.0037
Endometritis	13.2	0.94	0.4437
Postpartum paresis	22.7	2.45	0.1009

Note: η_x^2,% -the share of influence of the studied factor; F-Fisher's test; p-value-the degree of probability of the result.

Table 4. The influence of the season on the percentage of fertilization and the manifestation of postpartum pathology in brown cows.

This result of analysis of variance suggests that livestock breeders and veterinary specialists should consider the influence of seasonal factors on the manifestation of postpartum pathology in cows in the system of preventive measures.

Discussion

High and low ambient temperatures can affect the well-being, productivity, and reproduction of dairy cows. It is known that periods of summer heat are accompanied by the manifestation of heat stress in cows (Maggiolino et al., 2020). Under metabolic stress associated with the postpartum period (Sordillo & Raphael, 2013), dairy cattle also suffer from oxidative stress, which is accompanied by tissue and cell damage (Sordillo & Aitken, 2009). Even after the cows return to a comfortable environment, the effects of HS can persist for a long time, adversely affecting subsequent lactation (Tao & Dahl, 2013) and even the productivity and health of daughters (Dahl et al., 2016).

Higher manifestations of certain infections among cattle at extremely high temperatures in summer may cause a profound transition from cellular to humoral immune response (Lacetera et al., 2005). Therefore higher incidence of so-called "industrial diseases" associated with high milk yields may depend on the seasonal factor. High-yielding cows may be more susceptible to hot weather due to the need for additional heat transfer (Lees et al., 2018).

It is known that the success of artificial insemination depends on the effective detection of animals in the hunt and the optimal time of insemination. This is especially important for repair heifers, where fertilization is crucial in shaping their further productivity. In particular, Hungarian scientists (Fodor et al., 2020) report that the highest milk yield after the first lactation was in heifers, with the first calving at 22 to 25 months. Animals with an earlier age of fertilization in the herd had a higher safety before calving, with each additional month of infertility increasing the risk of culling heifers by 5%. The use of various additional tools for the timely detection of animals in the hunt can significantly increase the efficiency of reproduction control. Marques et al. (2020), examining the effectiveness of the Automatic Hunting Detection (AED) device in Holstein cows, found that high-yielding cows with AEDs were more likely to fertilize after the first insemination (6%). In contrast, no significant differences between groups were observed among low-yielding cows. The activity monitoring system also had good results in detecting hunting in pasture conditions (Pereira et al., 2020).

The effectiveness of fertilization depends on the postpartum period and the state of recovery of the reproductive organs of animals after birth. Infertility in dairy cattle is associated with pathogenic bacteria in the uterus, even a few months after birth. There are reports (Horlock et al., 2020) that after intrauterine infusions to heifers of pathogenic bacteria of the endometrium (*Escherichia coli, Trueperella pyogenes*) in the experimental conditions, revealed pathological changes in the transcriptome of endometrial cells, fallopian tubes, and granulosa cells even three months after control. These data suggest convincingly that long-term changes in the reproductive organs after bacterial infections of the uterus can cause prolonged infertility in cows.

Scientists argue that uterine diseases can also be the cause of ovarian dysfunction. Although almost half of the clinical diseases in high-yielding dairy cows occur within three weeks after calving (Vallejo et al., 2019), the predisposition to clinical manifestations of disease and the development of pathological disease should not be forgotten conditions occur during the prenatal period. However, the accumulated years of knowledge (Nowicki et al. 2017) about the functioning of the reproductive system and the proper use of hormonal drugs (which is more than 20 years since the first implementation of Ovsynch protocols) allows to control the sexual cycle of cows in reproductive management and is used in many ovarian disorders as a therapeutic method.

Conclusion

The percentage of influence of the seasonal factor on the fertility of cows was low and amounted to about 3%. However, seasonality affected cases of postpartum pathology in cows. Cases of retained placenta were more frequent in spring and lowered in winter. Endometritis was more typical in summer and autumn. Postpartum paresis had no seasonal manifestations; its cases among dairy were few. The share of the influence of the season on the manifestation of postpartum pathology was 13-53%.

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