

## Adaptive approaches to reproductive management of high-yielding dairy cows under thermal stress

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### Abstract

Heat stress represents a major constraint for reproductive efficiency in modern dairy herds, particularly in high-producing cows. The present study evaluated the influence of seasonal variation in the temperature–humidity index (THI) on the reproductive performance of Holstein cows. It assessed the effectiveness of hormonal synchronization protocols under thermal load. The research was conducted at the private agricultural enterprise "Fortuna" in the Chernihiv region, Ukraine. A total of 165 Holstein cows were divided into three groups according to milk productivity: 4500 to 6000 kg, 6000 to 7500 kg, and 7500 to 9000 kg per lactation. Seasonal dynamics of conception rate and service period duration were analyzed in relation to monthly THI values. The results revealed a pronounced seasonal pattern of reproductive performance. During thermoneutral periods in spring and autumn, the conception rate ranged from 44.1 to 56.2 percent. In contrast, during the summer months, when THI ranged from 74 to 79 units, fertility declined sharply to 20.1–31.9 percent. The negative impact of heat stress was most evident in high-yielding cows, where conception rate during the summer period was 2.8 times lower than the autumn peak, and the service period increased by 18 to 49 days. More than 61 percent of cows in this Group exceeded a 100-day service period, indicating substantial reproductive maladaptation under thermal stress. Application of hormonal synchronization protocols improved reproductive outcomes during periods of elevated environmental temperature. The Double Ovsynch protocol demonstrated greater efficiency than the standard Ovsynch scheme, increasing conception rate in high-yielding cows by 8.4 % during the summer period. The results indicate that thermal stress induces metabolic and endocrine disturbances that impair follicular development and reduce reproductive efficiency. Overall, the findings demonstrate that effective reproductive management under conditions of increasing climatic pressure requires the combined use of reproductive biotechnologies and improved environmental management. Integration of hormonal synchronization protocols with strategies to reduce metabolic and thermal stress represents an important approach for maintaining fertility in high-producing dairy herds.

**Keywords:** Holstein cows; temperature–humidity index; heat stress; conception rate; hormonal synchronization; reproductive management.

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### 1. Introduction

Heat stress represents one of the most significant challenges in modern dairy production and causes considerable economic losses worldwide. This condition arises when high ambient temperatures combined with elevated air humidity create an imbalance between heat accumulation and the animal's capacity for effective thermoregulation. According to recent studies, heat stress triggers a cascade of negative physiological changes, ranging from reduced dry matter intake to profound metabolic disturbances, which ultimately lead to decreased milk production and impaired reproductive performance (Khan et al., 2023).

Recent scientific literature has increasingly focused on the molecular and systemic mechanisms responsible for reduced fertility under hyperthermic conditions. Heat stress has been shown to damage oocytes during maturation in antral follicles, leading to molecular alterations in granulosa cells (Khan et al., 2020; Kim et al., 2026). In addition to its direct effects on gametes, elevated environmental temperatures modify the profile of free fatty acids in blood serum, reflecting metabolic stress in high-producing dairy cows (Mylostyvyi et al., 2021). Intensification of dairy production requires stable herd reproduction; however, disturbances of metabolic homeostasis lead to gonadal dysfunction and increase the incidence of uterine inflammatory diseases (Wolfenson & Roth, 2018). Climate projections indicate

further increases in thermal load, making accurate assessment of barn microclimate an essential component of sustainable dairy production systems (Mylostyvyi et al., 2020).

Reproductive problems are particularly pronounced in high-producing dairy herds, where increased metabolic heat production amplifies the effects of environmental hyperthermia. Previous studies emphasize that the adaptive capacity of cows under such conditions depends on both physiological and cellular responses (Gujar et al., 2023). In this context, the temperature–humidity index (THI) remains a key indicator of thermal stress and an important predictor of reproductive performance in Holstein dairy cattle, influencing both the duration of the service period and conception rate (Moore et al., 2024). Consequently, animal welfare under conditions of global climate change has become not only an ethical concern but also a major economic factor affecting the sustainability of dairy farming (Hoffmann et al., 2021).

To mitigate the negative consequences of heat stress, modern research proposes integrated management strategies that combine technological cooling solutions with improvements in reproductive biotechnology (Sumi et al., 2022; Oliveira et al., 2025). An important long-term strategy is genetic selection for stress resistance via superior sires, which can accelerate the development of thermotolerant dairy populations. The use of such sires contributes to the transmission of adaptive traits to offspring and supports the formation of climate-resilient herds with stable productivity (Pryshedko et al., 2023). In addition, previous studies have reported a relationship between stress resistance and the preservation of sperm quality and morphometric characteristics of reproductive organs in breeding animals (Chernenko et al., 2019; Chernenko et al., 2022).

Nevertheless, the rapid correction of reproductive disturbances in commercial dairy herds often relies on the application of modern hormonal synchronization protocols. Among these, Ovsynch and its modifications, including Double Ovsynch, have demonstrated promising results in stabilizing reproductive performance under unfavorable environmental conditions (Cartwright et al., 2023; Berean et al., 2025). However, the interaction between thermal load and endocrine responses in dairy cows on industrial farms in Ukraine remains insufficiently investigated (Mylostyvyi et al., 2023b; Chabanenko et al., 2024).

Despite a considerable body of available data, the role of reproductive biotechnologies in mitigating seasonal fertility losses during hot periods in Ukraine remains underinvestigated. Therefore, this study aimed to evaluate the influence of seasonal fluctuations of the temperature–humidity index on reproductive performance of dairy cows with different levels of productivity and to compare the effectiveness of synchronization protocols for reducing the negative effects of heat stress.

## 2. Materials and methods

The experimental part of the study was conducted at the private agricultural enterprise “Fortuna” in the Ichnia district of the Chernihiv region, Ukraine, on Holstein dairy cows. The animals were maintained under an industrial production system in naturally ventilated housing facilities.

To evaluate the dynamics of conception rate throughout the calendar year in relation to milk productivity, three ex-

perimental groups of cows were formed. Group I consisted of high-yielding cows with annual milk yields of 7500–9000 kg ( $n = 52$ ). Group II included cows with a medium productivity of 6000–7500 kg ( $n = 55$ ). Group III comprised lower-producing animals with milk yield of 4500 to 6000 kg ( $n = 58$ ).

The farm's feeding system used a total mixed ration comprising maize silage, hay, compound feed, and a complex of macro- and micro-mineral supplements. The rations were balanced according to the age, live body weight, physiological status, and production level of the animals. Feed distribution was carried out twice daily.

The influence of climatic conditions was evaluated through monthly monitoring of microclimatic parameters in the barns. The degree of thermal load was assessed using the temperature–humidity index. The THI was determined according to the methodology described by Mylostyvyi et al. (2023a).

Artificial insemination outcomes were obtained from veterinary records maintained at the dairy complex. Artificial insemination was performed using the rectocervical method with disposable catheters produced by Minitüb GmbH (Tiefenbach, Germany). Frozen semen was supplied by Semex Alliance (Ukraine). In the absence of spontaneous oestrus activity, cows were subjected to hormonal synchronization of ovarian cycles on day 85 after calving using protocols based on the Ovsynch scheme.

Hormonal stimulation of ovarian cycles and synchronization of ovulation were carried out using the Ovsynch protocol, consisting of GnRH administration on day 0, PGF $_{2\alpha}$  on day 7, and GnRH on day 9, as well as the Double Ovsynch protocol.

Pregnancy diagnosis was performed using linear ultrasound echography with a 7.5 MHz transrectal transducer (Kaixin KX5200, Xuzhou Kaixin Electronic Instrument Co., Ltd, Jiangsu, China). Ultrasonographic examinations were conducted at 31 to 37 days after artificial insemination and repeated at 56 to 58 days to confirm pregnancy and detect possible embryonic loss.

The conception rate was calculated as the ratio of pregnant cows to the total number of inseminated cows. The service period was defined as the interval between calving and successful conception.

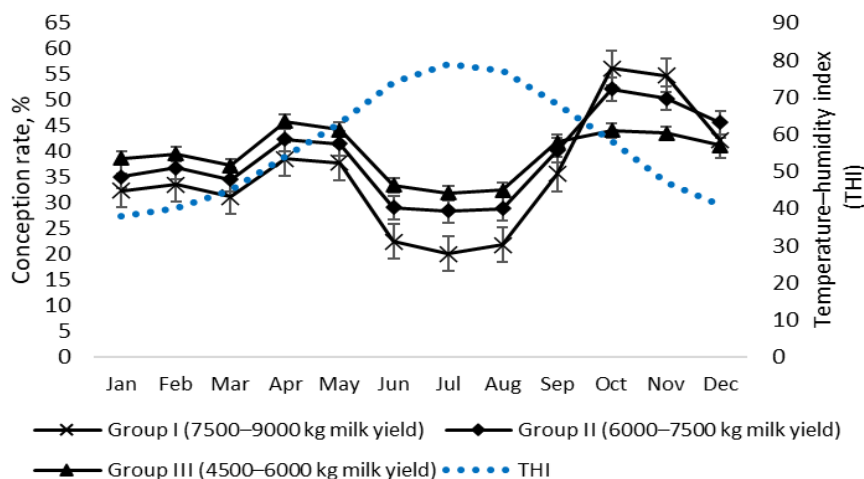
During the study, the following reproductive indicators were evaluated: onset and duration of oestrus; completeness of behavioral oestrus expression; duration of the service period and calving interval; conception index; and percentage of conception after the first insemination.

Calvings were monitored over 2 years at the dairy farm, where parturitions occurred in a designated maternity unit. After remaining with the cow for approximately one hour and receiving the first portion of colostrum through assisted feeding, newborn calves were transferred to individual pens in the calf housing area. Cases of stillbirth and calf mortality were excluded from the analysis.

Statistical analysis of the obtained data was performed using methods of variation statistics. The recorded data were expressed as mean  $\pm$  standard error. The relationship between selected parameters was assessed using Spearman's rank correlation coefficient. Differences between groups were evaluated using the Mann-Whitney U test with  $\alpha = 0.05$ . Statistical calculations were performed using Statistica software version 12.0 (StatSoft Inc., USA).

### 3. Results and discussion

The analysis of seasonal microclimatic dynamics showed that during June to August, the temperature–humidity index ranged from 74 to 79 units, corresponding to a period of pronounced thermal load. The highest THI values were recorded in July, coinciding with the lowest conception rates across all experimental groups. In contrast, during spring and autumn, the THI remained within the range of 54 to 68, corresponding to more favorable conditions for the expression of reproductive function.



**Fig. 1.** Seasonal dynamics of conception rate in dairy cows with different productivity levels in relation to the temperature–humidity index (THI)

However, during the summer months from June to August, a pronounced depression of reproductive function was observed. The conception rate of the experimental animals declined to an absolute minimum of 20.1–31.9 %. It is noteworthy that the magnitude of this decline depended directly on milk productivity, as shown in Figure 1.

In Group I cows, which represented the high-yielding animals, the negative impact of heat stress occurred earlier and was more pronounced. During the summer months, the conception rate in this Group was 2.8 times lower than the autumn peak. This observation is consistent with the findings of [Țogoe & Mincă \(2024\)](#), who reported that high-producing cows generate considerably more metabolic heat, thereby intensifying the effect of external hyperthermia.

During lactation, the high metabolic rate leads to the conversion of more than one-third of dietary energy into heat. Maintaining thermal homeostasis during the summer period therefore requires additional energy expenditure, leading to a negative energy balance. As a consequence, endocrine disturbances occur alongside alterations in blood oxygen transport and the development of oxidative stress in ovarian tissues ([Rodríguez-Godina et al., 2024](#); [Dodd et al., 2025](#)).

The analysis of reproductive performance in the studied herd confirmed that heat stress negatively affected the duration of the service period, and the magnitude of this effect was directly related to milk productivity ([Chavarría et al., 2024](#)). In cows of Group I, the service period increased by 18 to 49 days compared with the thermoneutral period. The proportion of cows with a service period exceeding 100 days reached 61.2 percent in this Group, indicating a pronounced maladaptation of the reproductive system. Such deviations

The reproductive performance of Holstein cows showed a clear seasonal pattern in conception rates throughout the year, closely associated with changes in the thermal environment. As shown in Figure 1, the highest conception rates were observed during the spring (April and May) and autumn (October and November) periods, when the proportion of successful inseminations reached peak values of 44.1–56.2 %. These results can be explained by the presence of thermoneutral environmental conditions and the positive influence of increased daylight length on the neuroendocrine regulation of reproductive processes.

are not random and result from the combined action of metabolic and neuroendocrine factors ([Skliarov et al., 2022](#); [Santiani et al., 2023](#)).

A key underlying mechanism is the intensification of negative energy balance. High-yielding dairy cows are characterized by an elevated metabolic rate, in which the synthesis of large quantities of milk is accompanied by intensive hepatic and ruminal activity that generates substantial endogenous heat. Under conditions of external hyperthermia, the animal is unable to dissipate excess heat efficiently, which forces a reduction in dry matter intake in order to limit endogenous heat production ([Ferag et al., 2024](#)). The resulting energy deficit suppresses reproductive processes, which are among the most energy-demanding physiological functions, and consequently delays the first ovulation after calving.

Endocrine dysfunction under heat stress manifests as suppression of the hypothalamic–pituitary–gonadal axis. In particular, a reduction in both the amplitude and frequency of luteinising hormone pulses is observed, which is critical for follicular maturation. This disturbance leads to widespread silent oestrus or anovulatory cycles. Furthermore, the corpus luteum formed under hyperthermic conditions is frequently functionally inadequate, and reduced progesterone synthesis fails to ensure proper endometrial preparation for implantation, thereby increasing the risk of early embryonic loss ([Gómez-Guzmán et al., 2024](#); [Kovačić et al., 2024](#)).

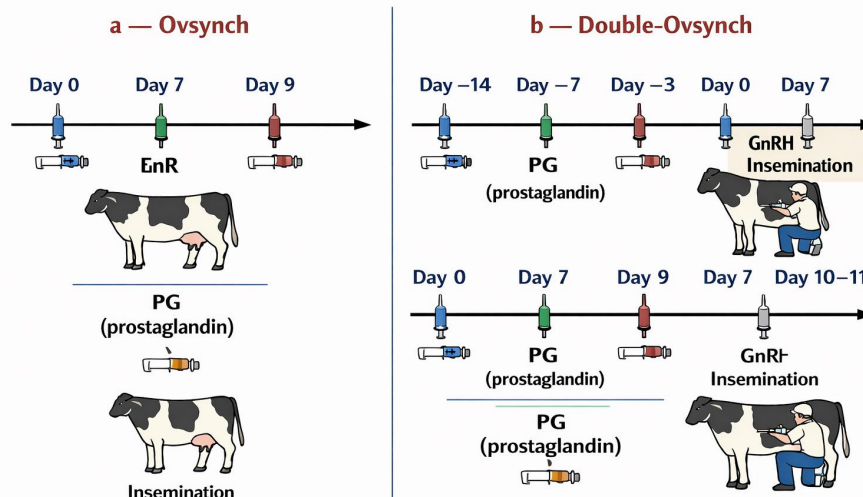
The cumulative effect in high-producing cows results in an adaptive crisis, in which the combination of lactational dominance and thermal load leads to the loss of one or more estrous cycles ([Van Wettere et al., 2024](#)). An extension of

the service period by up to 49 days effectively reduces reproductive output, resulting in a substantial decline in the cow's lifetime productivity. These circumstances justify the use of advanced biotechnological protocols, such as Double Ovsynch, which allow artificial regulation of the hormonal background and a reduction in the calving interval even under unfavorable environmental conditions (Pascottini et al., 2025; Pérez-Reboloso et al., 2025).

The obtained data therefore indicate that the critical reduction in conception rate during the summer period, which reached 20.1 percent in Group I, was associated not only

with negative energy balance but also with disturbances in the endocrine regulation of the reproductive cycle. To correct these disturbances, biotechnological protocols were applied, the mechanism of which is presented in Figure 2.

The analysis of the application of these schemes under heat-stress conditions indicates that the Ovsynch protocol (Figure 2a) provides strict ovulation timing, particularly during silent oestrus, which is common during hot weather. However, in high-yielding cows exposed to air temperatures above 27 °C, a reduced ovulatory response to the first GnRH injection was frequently observed.



**Figure 2.** Schematic representation of hormonal synchronization protocols used for reproductive management in dairy cows (a – Ovsynch; b – Double-Ovsynch)

The application of the Double Ovsynch protocol, presented in Figure 2b, proved to be more effective for animals of Group I. The presynchronisation stage increased progesterone concentrations before the final stage of the protocol, which promoted improved oocyte maturation. As a result, conception rate in high-yielding cows increased by 8.4% compared with the standard Ovsynch protocol during the summer period.

Thus, the visualization of the timing of hormone administration shown in Figure 2 allows clear identification of the key points of biotechnological intervention in the ovarian activity of animals experiencing metabolic stress. The use of the Ovsynch scheme enables restoration of reproductive cyclicity even under elevated environmental temperatures. However, the efficiency of hormonal treatment varied between productivity groups. In cows with medium and lower productivity levels, the conception rate after synchronization was 12.4 to 15.6 percent higher than in high-yielding animals.

Heat stress acts at the molecular level, impairing oocyte quality and inhibiting the development and functionality of the corpus luteum. Although biotechnological methods of hormonal regulation represent an effective tool for managing reproduction, they cannot fully restore reproductive performance to optimal levels without the implementation of cooling systems. The present findings support the hypothesis proposed by Pascottini et al. (2025) that a comprehensive strategy is required. Such an approach should combine hormonal stimulation with improvements in housing conditions

and nutritional management in order to maintain metabolic homeostasis.

#### 4. Conclusions

Seasonal variation in the temperature-humidity index significantly affected the reproductive performance of Holstein dairy cows. During the summer period, when THI ranged from 74 to 79 units, conception rates declined sharply across all productivity groups, reaching minimum values of 20.1 to 31.9 percent.

The negative effect of heat stress was most pronounced in high-yielding cows with annual milk production of 7500 to 9000 kg. In this group, the service period increased by 18 to 49 days, and the proportion of cows with a service period exceeding 100 days reached 61.2 percent, indicating considerable reproductive maladaptation under thermal load.

Application of hormonal synchronization protocols improved reproductive outcomes during periods of elevated temperature. The Double Ovsynch protocol demonstrated higher efficiency in high-producing cows, increasing conception rate by 8.4 percent compared with the standard Ovsynch scheme.

Future research will focus on the combined use of reproductive biotechnologies with antioxidant preparations and nutraceuticals to reduce oxidative stress in oocytes. Particular attention should also be given to the development of integrated systems for real-time monitoring of the temperature-humidity index to allow adaptive application of hormonal protocols in response to predicted heat waves.

## Conflict of interest

The authors declare no conflict of interest.

## References

- Berean, D. I., Bogdan, L. M., & Cimpean, R. (2025). Comparative Evaluation of Ovsynch and Double Ovsynch Protocols with Single and Double Insemination in Holstein Dairy Cows: Reproductive Performance and Cost Analysis. *Animals*, 15(16), 2380. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Cartwright, S. L., Schmied, J., Karrow, N., & Mallard, B. A. (2023). Impact of heat stress on dairy cattle and selection strategies for thermotolerance: a review. *Frontiers in Veterinary Science*, 10, 1198697. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Chabankenko, D. V., Zhelavskiy, M. M., Skliarov, P. M., Gutyj, B. V., Wrzecińska, M., Lone, F. A., Rana, S., Khmeleva, O. V., & Mylostyvyi, R. V. (2024). Postpartum complications in cows: diagnosis, treatment, prevention. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 7(1), 60–67. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Chavarría, I., Alvarado, A. S., Macías-Cruz, U., Avendaño-Reyes, L., Ángel-García, O., Contreras, V., Carrillo, D. I., & Mellado, M. (2024). Unmasking seasonal cycles in a high-input dairy herd in a hot environment: How climate shapes dynamics of milk yield, reproduction, and productive status. *Journal of Thermal Biology*, 123, 103944. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Chernenko, O. M., Prishedko, V. M., Mylostyvyi, R. V., Shulzhenko, N. M., Orishchuk, O. S., Chernenko, O. I., Tsap, S. V., & Khmeleva, O. V. (2019). Welfare and sperm quality with a focus on stress resistance of *Bos taurus*. *Ukrainian Journal of Ecology*, 9(4), 493–498. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Chernenko, O., Bordunova, O., Shulzhenko, N., Mylostyvyi, R., Chernenko, O., & Prishedko, V. (2022). Comparison of morphometric and histological properties of testicles and sperm production in breeding bulls with different reaction to stress. *Veterinarska Stanica*, 54(2), 193–209. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Dodd, G. R., Miglior, F., Schenkel, F. S., Campos, I. L., Jahnel, R. E., & Baes, C. F. (2025). Modeling heat stress effects on first service to conception rates in Canadian Holstein dairy cattle. *Journal of Dairy Science*, 109(3), 2727–2742. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Ferag, A., Gherissi, D. E., Khenenou, T., Boughanem, A., Moussa, H. H., Kechroud, A. A., & Fares, M. A. (2024). Heat stress effect on fertility of two imported dairy cattle breeds from different Algerian agro-ecological areas. *International Journal of Biometeorology*, 68(12), 2515–2529. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Gómez-Guzmán, J. A., Parra-Bracamonte, G. M., & Velazquez, M. A. (2024). Impact of heat stress on oocyte developmental competence and pre-implantation embryo viability in cattle. *Animals*, 14(15), 2280. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Gujar, G., Tiwari, M., Yadav, N., & Monika, Dr. (2023). Heat stress adaptation in cows – Physiological responses and underlying molecular mechanisms. *Journal of Thermal Biology*, 118, 103740. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Hoffmann, G., Silpa, M. V., Mylostyvyi, R., & Sejian, V. (2021). Non-Invasive Methods to Quantify the Heat Stress Response in Dairy Cattle. *Climate Change and Livestock Production: Recent Advances and Future Perspectives*, 85–98. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Khan, A., Khan, M. Z., Umer, S., Khan, I. M., Xu, H., Zhu, H., & Wang, Y. (2020). Cellular and Molecular Adaptation of Bovine Granulosa Cells and Oocytes under Heat Stress. *Animals*, 10(1), 110. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Khan, I., Mesalam, A., Heo, Y. S., Lee, S.-H., Nabi, G., & Kong, I.-K. (2023). Heat Stress as a Barrier to Successful Reproduction and Potential Alleviation Strategies in Cattle. *Animals*, 13(14), 2359. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Kim, T.-G., Kim, S.-H., Kim, S.-J., & Lee, W.-J. (2026). Heat stress disrupts the ovarian microenvironment in cattle: An in vivo analysis of hormonal alterations, oxidative stress-induced apoptosis, and reduced pregnancy outcomes. *Animal Reproduction Science*, 287, 108111. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Kovačić, M., Ivezić, V., Dobos, A., Mikuška, A., Šuker, L., Pećin, M., Samardžija, M., & Đuričić, D. (2024). The influence of cloudiness, hours of sunshine and precipitation on the occurrence of oestrus in cows and heifers in a temperate climate. *Journal of Animal Behaviour and Biometeorology*, 12(3), 2024021. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Moore, S. S., Costa, A., Penasa, M., & De Marchi, M. (2024). Effects of different temperature-humidity indexes on milk traits of Holstein cows: A 10-year retrospective study. *Journal of Dairy Science*, 107(6), 3669–3687. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Mylostyvyi, R., Izhboldina, O., Chernenko, O., Khramkova, O., Kapshuk, N., & Hoffmann, G. (2020). Microclimate modeling in naturally ventilated dairy barns during the hot season: Checking the accuracy of forecasts. *Journal of Thermal Biology*, 93, 102720. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Mylostyvyi, R., Lacetera, N., Amadori, M., Sejian, V., Souza-Junior, J. B. F., & Hoffmann, G. (2023a). The autumn low milk yield syndrome in Brown Swiss cows in continental climates: hypotheses and facts. *Veterinary Research Communications*, 48(1), 203–213. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Mylostyvyi, R., Sejian, V., Izhboldina, O., Kalinichenko, O., Karlova, L., Lesnovskay, O., Begma, N., Marenkov, O., Lykhach, V., Midyk, S., Cherniy, N., Gutyj, B., & Hoffmann, G. (2021). Changes in the Spectrum of Free Fatty Acids in Blood Serum of Dairy Cows during a Prolonged Summer Heat Wave. *Animals*, 11(12), 3391. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Mylostyvyi, R., Skliarov, P., Izhboldina, O., Chernenko, O., Lieshchova, M., Gutyj, B., Marenkov, O., & Rahmoun, D. E. (2023b). The effectiveness of an automated heat detection system in Brown Swiss heifers when using sexed semen at a large dairy unit. *Veterinarska Stanica*, 55(2), 157–167. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Oliveira, C. P., Sousa, F. C. de, Silva, A. L. da, Schultz, É. B., Valderrama Londoño, R. I., & Souza, P. A. R. de. (2025). Heat Stress in Dairy Cows: Impacts, Identification, and Mitigation Strategies—A Review. *Animals*, 15(2), 249. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Pascottini, O. B., Crowe, A. D., Ramil, U. Y., Hostens, M., Opsomer, G., & Crowe, M. A. (2025). Perspectives in cattle reproduction for the next 20 years: A European context. *Theriogenology*, 233, 8–23. [\[Crossref\]](#) [\[Google Scholar\]](#)
- Pérez-Reboloso, E., García, J. E., Morales, J. L., Calderón, M. G., Alvarado, A. S., Macías-Cruz, U., Avendaño-Reyes, L., Mellado, J., & Mellado, M. (2025). Time series modeling of retained placenta, metritis, and ketosis in Holstein cows and heifers and its association with climate variables in a hot-arid zone. *Agricultural Science and Practice*, 12(3), 27–37. [\[Crossref\]](#) [\[Google Scholar\]](#)

- Pryshedko, V., Halaktenov, D., Zaitseva, O., & Misnyi, T. (2023). Use of sexed bulletin sperm as a biotechnological tool for intensifying dairy cattle reproduction. *European Science*, sge42-03, 131–150.  
[\[Crossref\]](#) [\[Google Scholar\]](#)
- Rodríguez-Godina, I. J., García, J. E., Morales, J. L., Contreras, V., Véliz, F. G., Macías-Cruz, U., Avendaño-Reyes, L., & Mellado, M. (2024). Effect of heat stress during the dry period on milk yield and reproductive performance of Holstein cows. *International Journal of Biometeorology*, 68(5), 883–890.  
[\[Crossref\]](#) [\[Google Scholar\]](#)
- Santiani, A., Juárez, J., Allauca, P., Roman, B., Ugarelli, A., & Evangelista-Vargas, S. (2023). Cryopreservation effect on sperm viability, mitochondrial membrane potential, acrosome integrity and sperm capacitation of alpaca spermatozoa detected by imaging flow cytometry. *Reproduction in Domestic Animals*, 58(4), 560–563.  
[\[Crossref\]](#) [\[Google Scholar\]](#)
- Skliarov, P., Kornienko, V., Midyk, S., & Mylostyvyi, R. (2022). Impaired reproductive performance of dairy cows under heat stress. *Agriculturae Conspectus Scientificus*, 87(2), 85–92.  
[\[Abstract\]](#) [\[Google Scholar\]](#)
- Sumi, R. J., Das, Z. C., Hoque, M. N., Rahman, A. N. M. A., Islam, M. T., & Talukder, A. K. (2022). Heat stress effects on fertility and reproductive health problems of dairy cows in a selected area of Bangladesh. *Journal of Animal Reproduction and Biotechnology*, 37(4), 266–275.  
[\[Crossref\]](#) [\[Google Scholar\]](#)
- Țogoe, D., & Mincă, N. A. (2024). The Impact of Heat Stress on the Physiological, Productive, and Reproductive Status of Dairy Cows. *Agriculture*, 14(8), 1241.  
[\[Crossref\]](#) [\[Google Scholar\]](#)
- Van Wettere, W. H. E. J., Culley, S., Swinbourne, A. M. F., Leu, S. T., Lee, S. J., Weaver, A. C., Kelly, J. M., Walker, S. J., Klee-mann, D. O., Thomas, D. S., Hayman, P. T., Gatford, K. L., Kind, K. L., & Westra, S. (2024). Heat stress from current and predicted increases in temperature impairs lambing rates and birth weights in the Australian sheep flock. *Nature Food*, 5(3), 206–210.  
[\[Crossref\]](#) [\[Google Scholar\]](#)
- Wolfenson, D., & Roth, Z. (2018). Impact of heat stress on cow reproduction and fertility. *Animal Frontiers*, 9(1), 32–38.  
[\[Crossref\]](#) [\[Google Scholar\]](#)