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Dnipro State Agrarian and Economic University; Ukraine

Scientific supervisor: Mylostyvyi Roman Vasylovych, PhD in Veterinary Sciences, Associate Professor of the Department of Animal Feeding and Breeding Technologies
Dnipro State Agrarian and Economic University; Ukraine

THERMAL LOAD AND MILK PERFORMANCE IN DAIRY COWS UNDER NATURALLY VENTILATED HOUSING CONDITIONS

Environmental conditions influence dairy cattle productivity, milk composition and animal welfare. Previous studies have demonstrated associations between stress resistance and milk processing properties [1], as well as reproductive characteristics in breeding bulls [2]. Animal-based monitoring, including rumination behaviour [3] and physiological indicators such as blood cortisol [4], provides additional information on stress responses. However, routine production records combined with meteorological observations remain a practical basis for herd-level assessment. The integration of the temperature–humidity index (THI) with productivity and welfare indicators has been proposed for evaluating heat stress in dairy cattle [5]. The relevance of housing conditions is further supported by studies of microclimate modelling in naturally ventilated barns [6] and productive longevity under different housing technologies [7].

The aim of this study was to evaluate seasonal and temporal associations between thermal load and milk performance in dairy cows maintained under naturally ventilated housing conditions.

The study was conducted in 2025 at the Yekaterynoslavskyi Dairy Production Complex, located in the Dnipro district of Dnipropetrovsk region, Ukraine. The analysis included 365 daily observations obtained from primary herd production records and meteorological data. Milk yield, fat and protein concentrations, and fat- and protein-corrected milk (FPCM) were evaluated. Outdoor THI was calculated from air temperature and relative humidity, while indoor THI for hangar-type and frame-type barns was estimated using previously developed regression equations [6]. Seasonal comparisons, correlation analysis and regression models adjusted for nonlinear calendar trends were applied. Temporal dependence was addressed using heteroskedasticity- and autocorrelation-consistent standard errors. Current THI, antecedent exposure windows and threshold exceedances were examined.

Mean outdoor THI increased from 37.45 ± 8.07 in winter to 63.76 ± 6.78 in summer. During summer, estimated indoor THI averaged 64.31 in the hangar-type barn and 64.52 in the frame-type barn. Outdoor THI reached or exceeded 68 on 39 days, whereas the corresponding modelled values indicated 39 and 41 days for the two barn types, respectively.

Seasonal changes in milk production revealed contrasting trends in milk yield and composition. Mean daily milk yield increased by 4.4%, from 35.20 kg/cow in winter to 36.76 kg/cow in summer. However, milk fat concentration decreased from 3.97% to 3.66%, and protein concentration from 3.49% to 3.21%. Consequently, FPCM declined by 1.7%, from 35.56 to 34.95 kg/cow/day. These results indicate that higher actual milk yield during summer was accompanied by lower composition-corrected productivity.

For the annual dataset, THI showed a weak negative correlation with FPCM ($r = -0.227$; $p < 0.001$). However, this association was not statistically significant after adjustment for calendar trends ($B = -0.0030$ kg/cow/day per THI unit; $p = 0.847$). In summer, current THI was negatively associated with FPCM ($B = -0.0464$ kg/cow/day per THI unit; $p < 0.001$; $R^2 = 0.240$). A stronger association was identified for mean THI over the preceding three days ($B = -0.0660$ kg/cow/day per THI unit; $p < 0.001$; $R^2 = 0.302$), indicating the relevance of short-term antecedent thermal exposure.

During May–September, days with outdoor THI ≥68 were associated with lower FPCM after adjustment for calendar trends ($B = -0.255$ kg/cow/day; $p = 0.033$). However, this relationship depended on the observation period and model specification, preventing interpretation of THI 68 as a confirmed biological threshold. Although several antecedent THI indicators were significantly associated with FPCM, their inclusion did not consistently improve short-term forecasting accuracy compared with models based on previous milk performance.

In conclusion, the study conducted at the Yekaterynoslavskyi Dairy Production Complex demonstrated that associations between thermal load and milk performance depended on season and exposure duration. During summer, antecedent three-day THI showed a stronger negative association with FPCM than current THI, whereas the annual relationship was not statistically significant after adjustment for calendar trends. Increased milk yield during summer was accompanied by reduced milk fat and protein concentrations, resulting in lower composition-corrected productivity. These findings support the combined use of meteorological observations, antecedent thermal exposure and milk composition indicators for herd-level monitoring under naturally ventilated housing conditions.

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