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СТУДЕНТСЬКОЇ НАУКОВОЇ
КОНФЕРЕНЦІЇ

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УКРАЇНСЬКІ І СВІТОВІ
НАУКОВІ ДОСЛІДЖЕННЯ**

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STRESS RESILIENCE IN CATTLE: FROM INDIVIDUAL BIOLOGICAL VARIABILITY TO PRECISION HERD MANAGEMENT

Stress resilience is an important biological characteristic of cattle maintained under intensive production conditions. Modern dairy and breeding systems expose animals to numerous environmental and technological challenges, including thermal load, changes in housing conditions, handling procedures, and high production demands. Although animals within the same herd are generally exposed to similar management conditions, their biological responses to these challenges may differ considerably. Such individual variability is important because the consequences of stress may extend beyond short-term physiological reactions and affect economically relevant traits.

One manifestation of this variability is the relationship between stress resistance and the technological properties of milk. Studies in Ukrainian Red Dairy cows demonstrated that animals differing in stress resistance also differed in characteristics relevant to rennet cheese production. Milk obtained from cows with low stress resistance showed less favourable technological properties, including prolonged coagulation processes and poorer suitability for cheese production, while differences were also observed in the organoleptic characteristics of the resulting cheese [1]. These findings indicate that individual stress responsiveness may have consequences extending from the animal itself to the technological quality of the product obtained from it.

The importance of stress resistance is not restricted to dairy cows. Research in breeding bulls has demonstrated associations between the response to stress and reproductive characteristics. Bulls with higher stress resistance had more favourable morphometric and histological characteristics of the testes and epididymides, while animals with lower stress resistance showed a higher proportion of rejected ejaculates because of insufficient sperm quality [2]. Thus, differences in stress responsiveness may be associated with reproductive function and should be considered among the biological characteristics relevant to the productive use of breeding animals.

These observations raise an important practical question: how can differences in the ability of cattle to respond to environmental and technological challenges be recognised

under production conditions? Physiological biomarkers provide one level of assessment. Cortisol is closely involved in the stress response and regulation of adaptation, and changes in its serum concentration have been demonstrated in dairy cows exposed to acute and chronic heat stress [3]. However, physiological measurements usually require animal handling and provide information for a particular sampling point rather than continuous information about the animal's state.

Behavioural monitoring offers a complementary approach. Rumination is closely related to feeding and digestive activity and can also provide useful information for monitoring health and welfare. A sensor-based approach developed for dairy cows demonstrated that individual rumination cycles and regurgitation events can be recorded with high agreement between sensor measurements and visual observations [4]. Such technologies create opportunities for repeated or continuous collection of animal-based information without relying exclusively on periodic clinical or laboratory examinations.

The interpretation of animal-based indicators nevertheless requires information about the environment in which the response occurs. Heat stress illustrates this relationship particularly clearly. The temperature-humidity index (THI) provides a practical measure of thermal load, but environmental exposure alone does not fully describe its consequences for the herd. An integrated herd-level assessment combining THI with milk production, feed intake, mastitis, and lameness showed that maximum daily THI, cumulative heat load, and insufficient night-time cooling were associated with different components of productivity and welfare [5]. Including animal-related indicators therefore provides a more biologically informative interpretation of environmental stress than consideration of climatic variables alone.

This distinction between environmental exposure and biological response is central to understanding stress resilience. Animals experiencing the same external conditions do not necessarily respond identically, as demonstrated by differences associated with stress resistance in both cows and breeding bulls [1, 2]. At the same time, the response of an individual animal is multidimensional. Endocrine changes, behavioural alterations, reproductive characteristics, production traits, and product quality represent different levels at which the consequences of stress and adaptation may become apparent.

Housing and production technology provide the broader context in which these responses develop. Earlier observations in Holstein cattle showed that technologies and housing systems were associated with differences in the longevity of productive use [6]. Productive longevity is determined by many interacting factors and cannot be considered a direct measure of stress resistance. Nevertheless, its relationship with production conditions emphasises that successful long-term use of high-producing cattle depends on the compatibility between the biological characteristics of the animal and the environment in which production takes place.

This perspective supports a transition from isolated indicators towards multilevel assessment. Environmental indices such as THI characterise the challenge imposed on animals, physiological markers such as cortisol reflect internal regulatory responses, and behavioural monitoring provides information that can be obtained repeatedly under practical conditions. Productive, reproductive, and welfare indicators subsequently reveal whether animals are able to maintain biologically and economically important functions during exposure to these challenges.

Precision livestock technologies are particularly relevant to this transition because they increase the temporal resolution of animal observation. Continuous or high-frequency

behavioural records can potentially identify deviations that would remain undetected between scheduled examinations. Their greatest value, however, is likely to arise when sensor information is interpreted together with environmental, physiological, and production data rather than as an isolated diagnostic signal. This creates the basis for recognising not only when environmental conditions become challenging, but also how individual animals or herds respond to those conditions.

From a management perspective, this approach may help distinguish environmental exposure from biological susceptibility. The same level of thermal or technological challenge may be tolerated differently by different animals, and management decisions based exclusively on herd averages may therefore overlook individuals with less favourable responses. Combining environmental monitoring with animal-based indicators can support more targeted observation and identify situations in which additional physiological, veterinary, or management assessment is warranted.

In conclusion, stress resilience in cattle is a multidimensional characteristic whose consequences can be expressed through physiological responses, behaviour, reproductive function, technological properties of milk, and long-term productive performance. Evidence from dairy cows and breeding bulls demonstrates substantial individual variability in responses to stress, while modern environmental and sensor-based monitoring provides new opportunities to observe these responses under production conditions. Integrating environmental exposure, physiological biomarkers, behavioural information, and production and welfare indicators offers a promising framework for precision herd management aimed at maintaining animal health, reproductive function, product quality, and sustainable productivity.

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