Abstract

In the current research, a method for measuring telomere length in cattle blood cells was established using qPCR. It was found that, alongside environmental factors such as nutrition and health status, the genetic component has the most significant influence on explaining variability in telomere length. The study revealed an inconsistent correlation between the telomere length of cows and their calves on the day of calving; calves on their birth date exhibited either longer or shorter telomeres compared to their mothers. This suggests that telomere heritability may be influenced by external (epigenetic and environmental) factors during pregnancy (or the mother's lifespan).

The effect of maternal age on calf telomere length was significant, accounting for approximately 5% of the variability. Interestingly, younger cows (average age of 1,642 days) gave birth to calves with shorter telomeres compared to their own, while older cows (average age of 1,887 days) gave birth to calves with longer telomeres relative to their own, contrary to what would be expected based on the effect of age on telomere length. Moreover, an analysis of additional independent variables, such as the cow's telomere length on the day of calving and dystocia (a categorical trait value), yielded a significant model. This model explained the variability in telomere length difference through the cow’s telomere length on the day of calving, her age at calving, and the breeding value for dystocia. These findings suggest that stress conditions during pregnancy and calving may influence the offspring’s telomere length.

The described results do not allow precise determination of the relative contributions of genetic versus environmental factors to the variability in offspring telomere length. Multivariate models added to the research, point to the limited influence of other environmental variables, such as the season of calving and inflammation during pregnancy. Therefore, at this stage, the cow's telomere length was chosen as a proxy for the cumulative effect of all influencing factors on her status and contribution to the offspring's telomere length at birth, until further knowledge is acquired to support constructing a predictive model.

According to the prevailing paradigm in the literature, telomere length tends to shorten over time. However, studies indicate that lifespan and environmental conditions can influence telomere dynamics in various ways. For instance, nutrition,

environmental stress, and health status can alter the rate of telomere shortening or even lead to their elongation.

In the current study, telomere length significantly shortened from calving to the age of two months under both group and individual rearing systems. During this period, calves may experience biological stress due to illnesses (respiratory diseases, diarrhea, and dehydration), which negatively affect cellular function and lead to telomere shortening. However, from two months to eight months of age, renewed telomere elongation was observed. This phenomenon may indicate the activation of DNA repair mechanisms or adaptive mechanisms independent of telomerase activity. These findings align with studies showing that growth and development processes promote cell proliferation and renewal, with DNA repair mechanisms extending telomeres during recovery from stress periods.

Cortisol is a stress hormone that exhibits complex patterns of variation influenced by "personality" traits and environmental conditions. While cortisol concentrations in hair were similar on the day of calving under both rearing systems (group and individual), by two months of age, cortisol levels were significantly higher in calves raised under group rearing conditions, likely due to the increased social stress associated with group living. These findings support the current understanding of the relationship between stress and telomere length. Indeed, in the scientific literature, cortisol is described as a central stress hormone that, at elevated levels, can contribute to telomere shortening.

This study also reports that under group rearing regime, high cortisol levels at two months of age were associated with significant telomere shortening. By five months of age, cortisol levels in the hair of group-reared calves decreased compared to their levels at two months, whereas cortisol levels in individually raised calves increased significantly during this period. This rise in cortisol concentration in the individual rearing system may stem from the social stress experienced by the calves when transitioning from individual housing to group housing. Additionally, it is noteworthy that after two months of age, as cortisol levels decreased in the group rearing system, telomere length began to increase, continuing up to eight months of age. This phenomenon may indicate the activation of DNA repair mechanisms and increased telomerase activity in response to the initial stress.

The relationship between cortisol concentration and telomere length was examined separately for individual and group rearing systems to determine whether cortisol

concentrations in hair on the day of calving (reflecting hormone accumulation during pregnancy) influence telomere length later in development (at ages 2, 5, and 8 months). In the individual rearing system, a significant inverse relationship was found between hair cortisol concentration at birth and telomere length at two months of age, in both linear and polynomial models.

One of the fundamental research questions was whether telomere length in calves could be considered a cause or an outcome. Based on the findings described above, it can be hypothesized—at least under the individual rearing system—that telomere length in calves is an outcome and that cortisol concentrations at the time of calving influence telomere length later in life. Unlike cortisol, testosterone levels were found to increase as a function of calf age, regardless of the rearing system. In the individual rearing system, the rise in testosterone levels was steep and significant starting at two months of age, compared to the more moderate increase observed in the group rearing system. An analysis of the relationship between telomere length and testosterone accumulation in hair revealed that telomere length at birth could predict testosterone concentrations in the calves' hair at 8 and 12 months of age, in both group and individual rearing systems. This finding suggests that telomere length at birth may serve as a marker for future male hormonal development and may contribute to understanding how telomeres are linked to physiological and behavioral functions.

In livestock, and particularly in cattle, feed efficiency is of significant economic importance, as feed constitutes the most substantial cost in animal husbandry. We sought to examine whether telomere length at an early age (birth and two months) correlates with this economic trait and how the rearing system (group or individual) influences this relationship. At birth, no correlation was found between calf telomere length and feed efficiency. However, by two months of age, the correlation approached significance ($R^2 = 0.18$; $P = 0.07$). In contrast, maternal telomere length on the day of calving exhibited a negative correlation with feed efficiency ($P = 0.07$). Overall, the correlation between hormone concentrations at calving and at two months and feed efficiency was negative and significant, except for testosterone concentration at calving. Regarding the influence of the rearing system, feed efficiency was significantly higher under group rearing compared to individual rearing. This difference stemmed from higher weight gains in calves raised in groups compared to those raised individually, despite similar overall feed intake (in kilograms) between the two groups.