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Original Paper

Evaluation of growth intensity in dairy cattle

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The growth intensity of cattle significantly affects their future production and reproduction performance. Despite this fact, many breeders underestimate the rearing of calves and heifers. Our study aimed to evaluate the growth intensity of Holstein calves and heifers in PD Devio Nové Sady based on non-contact measurement of live weight and body measurements through the analysis of digital images using the app AGRONINJA beefie3d™. The growth intensity analysis was based on the standard Penn State protocol, which uses the Hoffman method to estimate growth standards. A total of 143 calves and heifers were evaluated in three independent measurements. Obtained data were compared to an optimal growth curve determined based on the weight and wither height of dairy cows on the third lactation and using a system of growth intensity requirements. The results showed several deficiencies in the growth intensity of animals on the selected farm. We observed a growth deficit in the height of the evaluated calves from 3 to approximately 4.5 months of age. In addition, we observed that heifers older than eight months exceeded the set weight optimum. We also found a significant decrease in growth intensity due to the disease which occurred in the herd. The results of this study showed that regular recording of data related to body measurements and weight, as well as their comparison with the required values, makes it possible to reveal and, at the same time, eliminate many deficiencies in the breeding of heifers that will form the future production herd.

Keywords: Holstein breed, growth intensity, heifers

1 Introduction

For the economic profitability of dairy herd management, it is essential to keep healthy heifers that can fulfil their genetic potential for mammary gland development and subsequent milk production. The growth and development of the mammary gland in cattle can be divided into several periods, which are involved in specific changes in the shape of the udder and the percentage representation of the secretory tissue. Alongside the genetic potential of animals, the growth and mammary gland development after birth are significantly influenced by the growth intensity of calves (Zigo, 2015). Moreover, the growth intensity of calves, together with nutrition, significantly affect the health status and lifetime milk production of dairy cows (Cao a Amburgh, 2020). Geiger et al. (2017) showed that even if milk production in the first lactation is associated with feeding intensity and daily gain of calves in the preweaning period, overfeeding calves is undesirable.

Dickrell (2019) dealt with the maturity of heifers, i.e. the criteria that a heifer must meet at the first calving. This study showed that the maturity of heifers is affected mainly by their weight at first calving. The body weight of the heifers at the first calving subsequently affects milk production, the health of cows during the first lactation, lifetime productivity and the overall performance of the herd. Freshly calved heifers need to be at 85% of mature body weight (heifers right before calving should be 95% of mature body weight). Otherwise, heifers will continue to grow during the first lactation, reducing milk production. Every kilogram of missing body weight will reduce milk production by 3 kilograms. If heifers calve early, they have to grow faster to reach mature body weight (Dickrell, 2019).

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The growth intensity of heifers significantly affects not only milk production during lactation but also reproduction traits. The growth intensity mainly affects the age at first calving. Heifers calved at 23 or 24 months are more cost-efficient than heifers that calve later. These heifers achieve better reproduction and production performance than heifers calved at an older age. Specifically, Holstein heifers should achieve an average daily gain of 750 g to calve at 24 months of age (Palczynski et al., 2020). Bazeley et al. (2016) monitored the growth intensity of cattle on 20 farms. They found that heifers with reduced growth intensity in the first 180 days of life could not reach the weight achieved by the herd average in the later period and thus did not reach the required weight at first insemination. Dolešová (2018) stated that age and live weight are crucial for the first insemination of heifers. However, many cattle breeders still make decisions only based on age and not live weight. In practice, it turns out that on farms where heifers are inseminated only based on age, this is often done too late. Moreover, the growth capacity of heifers is often underestimated, especially on intensive dairy farms where heifers are often reared more intensively. Late insemination of higher-weight heifers may adversely affect reproduction performance and cause calving difficulties. From today's point of view, many problems are occurring in Slovak farms. One of the main problems is that reducing the insemination index of heifers and cows and the age at first calving is still not possible. One solution can be to introduce protocols for assessing the weight and growth intensity of calves and heifers, which are the basis of the future herd. Unnecessary overfeeding spends a lot of money on feed that is not used for proper growth but instead leads to fat deposition, which can increase the insemination index and other reproduction traits as well as increase breeding costs (Kasarda, 2017).

Regular body weight measurement in cattle is important for assessing animal growth intensity (Caminotte et al., 2020). Le Cozler et al. (2008) reported that in addition to weight, it is also necessary to record height because only weight does not fully reflect the growth capacity of heifers. On the other hand, monitoring animal growth through conventional weighing and measuring can be very stressful and time-consuming for farmers (Caminotte et al., 2020). For this reason, a non-contact measurement utilising electronic devices could replace traditional methods. The main advantage of non-contact methods is the time efficiency, which allows more data to be collected on a regular basis (Huang et al., 2018). In the last few years, many authors have discussed various non-contact methods for measuring weight and body measurements of cattle. Batanov et al. (2019) compared the accuracy of contact measurement using a measuring stick and tape with the analysis of digital images. They found that the deviation of the digital measurement from the contact measurement was about 2%. The metacarpus girth was the only measurement recorded with a relatively high deviation. Martins et al. (2020) analysed the body weight of Holstein dairy cows and heifers using Microsoft Kinect 3D cameras. In determining body weight, this method achieved 89% accuracy for lateral perspective images and 96% for dorsal perspective images. Huang et al. (2018) used LiDAR-based technology to evaluate the body measurements of cows. They used a special depth camera with a high frame rate, which can create 3D records of objects in real-time. The results of the measurements were compared with the measurements from the classic contact method. After comparing the results, they found that they could record body measurements with an accuracy of 2 mm and an error rate of 2% using this technology.

This study aimed to evaluate the growth intensity of calves and heifers in PD Devio Nové Sady. For this purpose, non-contact measurement of live weight and body measurements through the analysis of digital images was used. The main aim was to detect animals with non-optimal growth intensity, identify possible causes and propose solutions that could be applied in the analysed herd.

2 Material and methods

Phenotypic data were collected on the PD Devio Nové Sady farm during three independent measurements in 2021 and 2022 to eliminate possible seasonal and temporary effects of a production environment. A total of 143 analysed animals were divided into five age categories (Table 1). The body weight and wither height were estimated based on the digital image analysis by AGRONINJA beefie3d™ mobile app.

The growth intensity of animals was analysed using the Standard Penn State protocol (Heinrichs et al., 1992; Kertz et al., 1998). This protocol is based on the Hoffman method for estimating the growth standard, where the peak of the growth curve for the weight and height is based on the body weight and height of dairy cows at the third lactation. The aim was to optimise growth intensity by setting a target age at first insemination and growth intensity. The final calculation was derived from collected phenotypic data and the growth rate requirement system described in the 2001 Nutritional Requirements for Dairy Cows (NRC). The following input information was required for the calculation:

- average body weight and height of cows in the third lactation. This calculation does not include

Table 1 Number of analysed animals by age category and measurement

Age (months)	Number of animals			
	measurements			total
	May 2021	November 2021	February 2022	
3–6	12	13	10	35
6–9	17	18	11	46
9–12	6	14	4	24
12–15	10	5	2	17
15+	3	12	6	21
Total	48	62	33	143

culled cows whose body weight is, therefore, not representative of the average of the entire herd. We can use these to determine the height at the withers or the hips,
- the average birth weight of calves,
- the target for average daily gain before weaning: average insemination index of the herd (heifers) and age at first calving. If there are no values entered, double the calves' birth weight is entered by default.

Based on the entered information, the following indicators were calculated in the protocol:
- age and body weight of heifers at first insemination,
- age and size of heifers at first conception and the required average daily gain from the age of two months (weaning)
- size at calving and required average daily gains from conception to calving.

The calculation was based on the assumption that the body weight at first conception should represent 55% of the adult body weight and 85% of the adult body weight at the first calving, following the requirements described in NRC (2001). At the same time, this methodology assumes that height at the withers and height at the rump change at the same rate throughout growth, i.e. only one indicator can be used in the measurement for both heifers and adult cows (Heinrichs et al.,1992; Kertz et al.,1998). Therefore, the input parameters of the protocol applied in this study were as follows:
- average body weight of cows in the third lactation: BW (kg): 633,
- the average height at the withers of the cows on the third lactation Ht (cm): 145,
- average birth weight of calves (kg): 37.5,
- estimated weaning weight (kg): 75,
- average insemination index of the herd (heifers): 1.9,
- age at first calving, AFC (months): 25.

3 Results and discussion

The first measurement was performed in May 2021. The obtained results showed that the growth curve of evaluated heifers up to 8 months followed the optimal curve with minor deviations. However, from about eight months of age, the weight of evaluated heifers slightly exceeded the optimum growth curve. This is probably due to the excess energy in the ration fed to heifers from 6 to 7 months of age. The rapid growth rate from 3 to 12 months of age could decrease milk production due to an increase in mammary adipose tissue and its parenchymal content. In addition, increased feeding intensity before sexual maturity causes changes in the secretion of hormones in the lactogenic complex, resulting in a reduced number of secretory cells in the mammary gland (Mourits et al., 1999; Daniels, 2010).

The height of the analysed heifers generally followed an optimal growth curve. The most significant difference from the optimum was found mainly for animals at 4 months of age whose height was below the optimum level. This is probably the result of a lack of protein in the feed ration. For proper growth and development of the calf, it is necessary to take at least two litres of high-quality colostrum within two hours after birth and, during the next two hours, to take another two litres. Generally, calves should receive at least six litres of colostrum during the first 24 hours of life. If colostrum nutrition is underestimated, the calf may lag in growth even in the later period. In addition, such calves are more sensitive to diseases because colostrum provides passive immunity (Nejdlová, 2012). For optimal growth rate during milk nutrition, a calf with a live weight of 50 kg should take 0.92 kg of calf milk replacer (CMR) dry matter. If the calf is fed with 5 litres of milk replacer per day, diluted in a ratio of 1 : 8, it consumes only 0.625 kg of CMR dry matter per day. If a CMR contains 200 g of nitrogenous substances (NS) in 1 kg of dry matter, it will take up only 125 g of NS per day, which is not enough. Top farms dilute CMR with water at a ratio of 1 : 6 (166 g of CMR per litre of water). Another option is to feed a higher-quality CMR (with a higher proportion of NS and milk protein). Even if higher-quality CMR means a higher price, the cost of higher-quality feed during the calf-rearing period is usually lower than the loss caused by late calving heifers (Šimko, 2013). Figure 1 compares the height and weight of evaluated animals with the optimal growth curve.

Based on the obtained data in the second measurement, it can be concluded that the weight of heifers up to eight months followed the optimum growth curve, while most heifers older than eight months showed the same deviations from optimal growth as in the first measurement. Regarding height, a downward deviation was observed compared to the determined optimum. This decrease was most pronounced in younger animals; consequently, the difference between the evaluated animals and the optimal growth curve decreased. From 13 months, the observed deviation was much smaller than in younger animals, but there was still some deviation. Only three heifers older than 13 months followed the optimum curve accurately. A comparison of results obtained in the first and second measurements showed that the average height of the animals was lower in the second measurement compared to the first. This was most probably caused by the prevalence of bovine viral diarrhoea (BVD) in the herd. This disease occurred in the herd for several months and manifested mainly in younger animals. In addition to the growth retardation during the disease manifestation, heifers also lagged in growth after overcoming the disease. Shamay et al. (2005) reported that increasing feed intake could not compensate for this deficit when skeletal growth slows down. Soberon et al. (2012) found that animals that overcome diseases such as BVD and BRD (bovine respiratory disease) at an early age have long-term production performance, which can be partly attributed to reduced growth intensity. Brestenský et al. (2015) stated that with reduced growth intensity, there is insufficient development of the heifer's reproduction system, especially the ovaries, which can cause reproduction disorders at a later age. Despite the considerable lag in the height of the evaluated animals, it was observed that they exceeded the optimal weight from the age of approximately eight months. This phenomenon was also observed in the first measurement, most probably due to a switch to a different feed ration with higher energy content at about six to seven months of age. Drackley (2008) argues that heifers should be fed a ration that allows adequate growth without excess fat deposition. Figure 2 shows a comparison between observed height and weight and the optimal growth curve.

Obtained results from the third measurement were consistent with the first measurement. In the third group of animals, the same deviation from the optimal weight upwards and the same deficit in height were found. This only confirms the conclusions drawn from the first measurement results, as there were no significant changes in the feed ration composition on the analysed farm. A comparison between the optimal growth intensity and observed trends in the third group is shown in Figure 3.

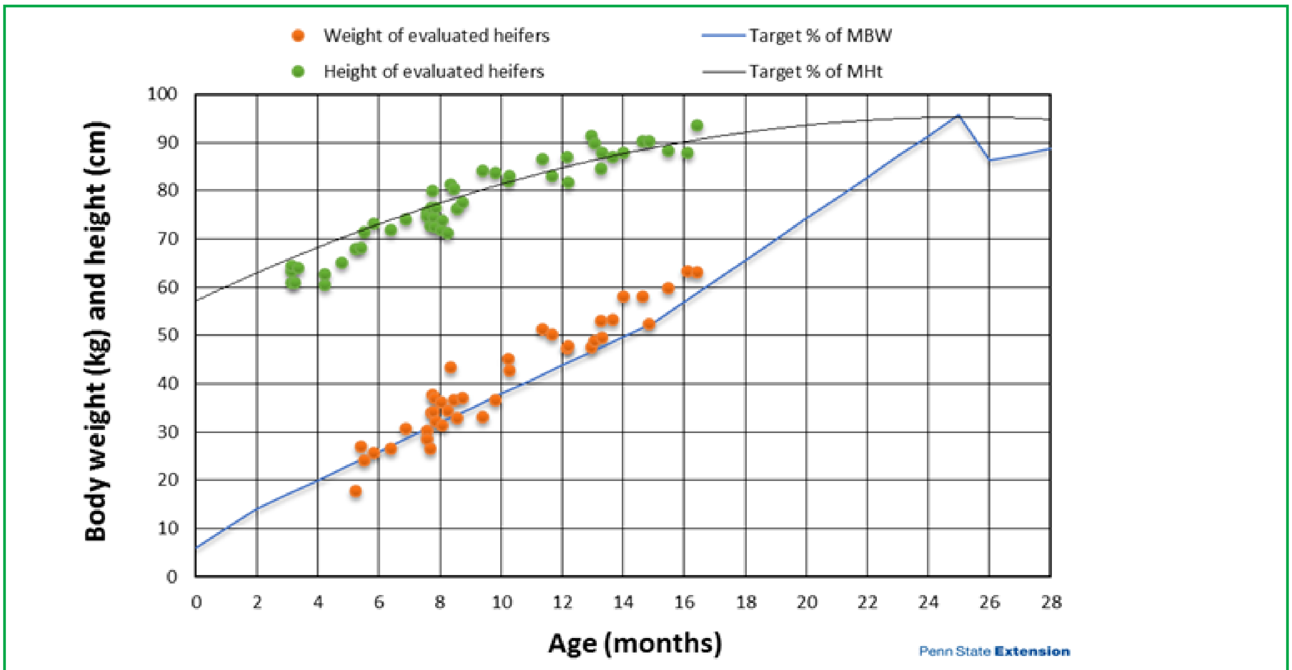

Figure 1 Comparison of values observed in May 2021 with the optimal growth curve

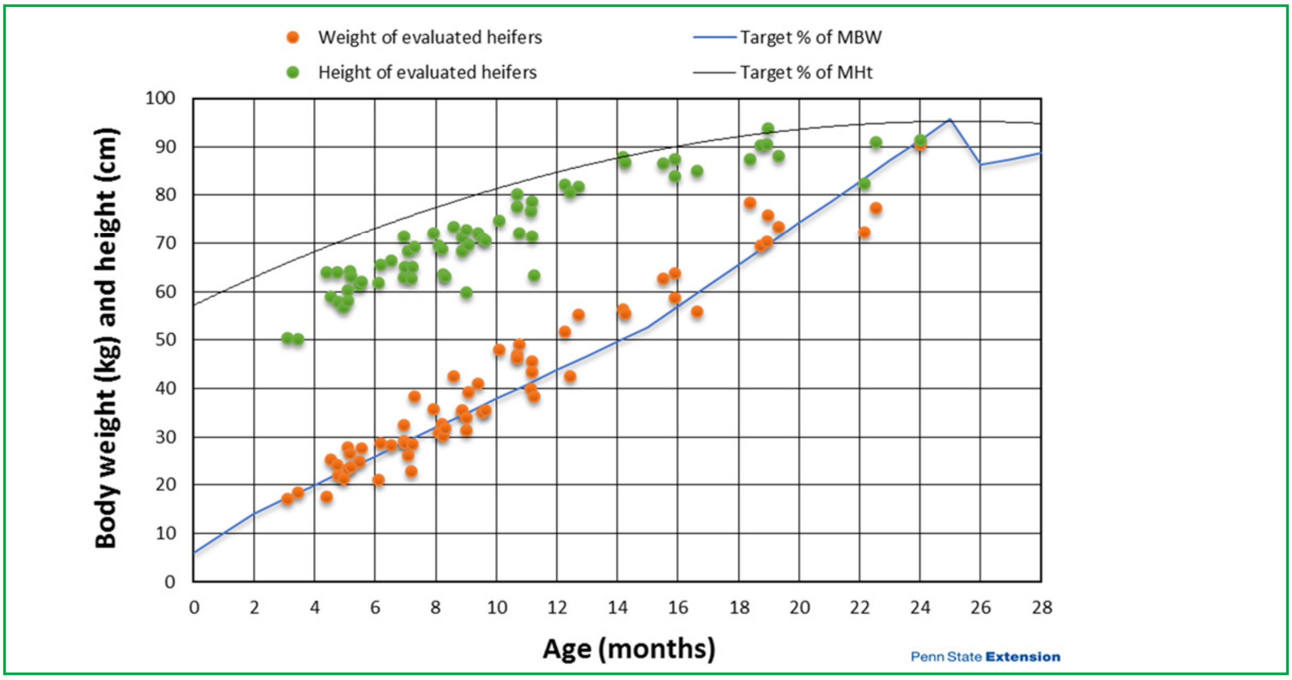

Figure 2 Comparison of values observed in November 2021 with the optimal growth curve

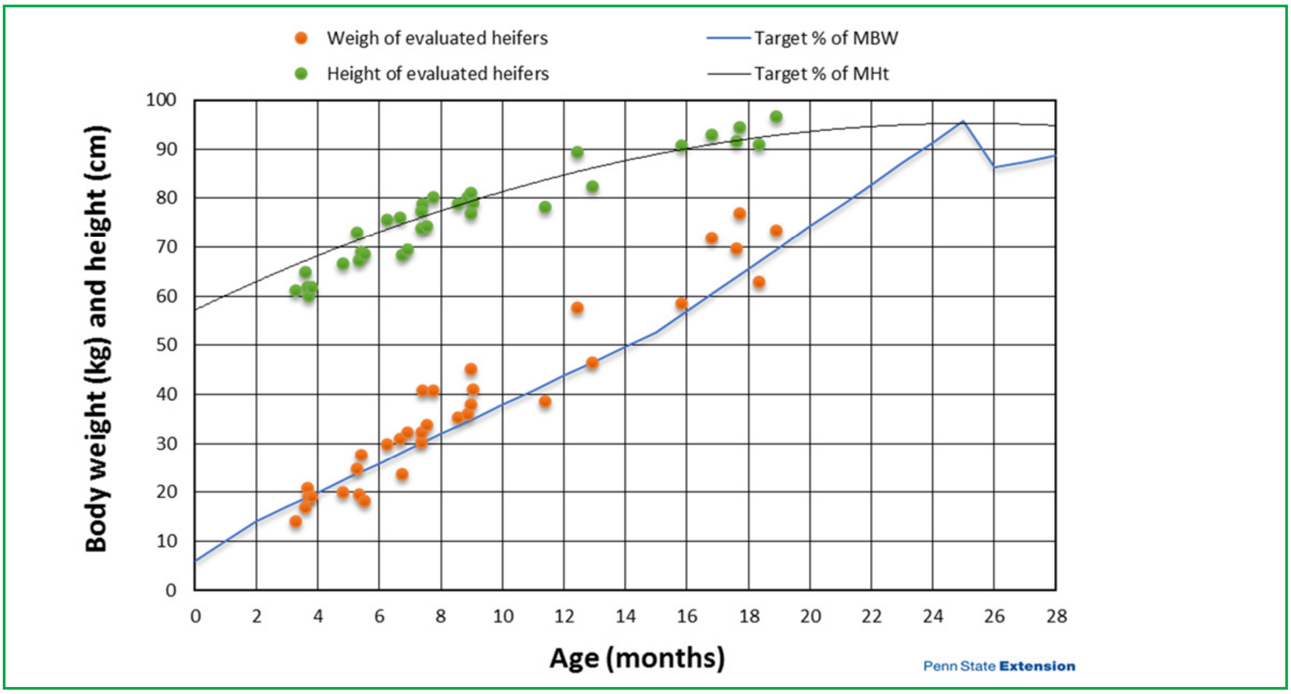

Figure 3 Comparison of observed values in February 2022 with the optimal growth curve

The main objective of rearing young cattle should be continuous growth to develop the body frame without storing excess fat. However, efforts to compensate for growth deficits have been shown to lead to excessive fat deposition (Radcliff et al., 1997). Handcock et al. (2020) found that overfeeding heifers leads to a lower pregnancy rate and a decline in reproductive performance.

4 Conclusions

The obtained results showed that the analysed group of Holstein calves and heifers showed deviations from optimal growth intensity due to the effect of three factors. The first one with the most significant effect on the growth intensity of animals was the occurrence of diseases in the herd. The second reason was the over-conditioning of the animals older than eight months.

Here it would be recommended to reduce the proportion of energy in the feed ration given to animals from 6 to 7 months to avoid unnecessary overfeeding. The third deviation from the optimum was a deficit in height up to the age of approximately 4.5 months, most probably due to neglected colostrum and milk nutrition, poorly executed weaning or poorly balanced feed ration after weaning. Based on observed results and on-farm data, the most likely cause is protein deficiency in the CMR, which can be solved by increasing the protein proportion in the CMR. All recommendations can lead to an optimisation of the growth intensity of calves and heifers on the PD Devio Nové Sady.

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