CHAPTER 19

PHENOTYPIC CORRELATIONS BETWEEN LINEAR TRAITS AND GROWTH CURVES OF HOLSTEIN CALVES

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ABSTRACT: The selection of productive traits have great importance for the good performance of dairy farms. Strategies are developed with the aim of promoting the genetic improvement of the desired traits in future generations. The general objective of this study was to establish the growth curve of the Holstein breed, considering factors that contribute to precocity, especially in relation to body weight and withers height. Monthly measurements of body weight and withers height, as well as rump measurements, were carried out, enabling the monitoring of the development of Holstein calves in a dairy farm in São José dos Pinhais, Paraná. The results showed high and positive correlations (r) between the different measurements, as follows: (a) withers height x rump length: r = 0.91; (b) rump ileus width x body weight: r = 0.86; (c) rump ischium width x body weight: r = 0.96; (d) rump ileus width x rump ischium width: r = 0.84; (e) rump length x rump ileus width: r = 0.84 and (f) rump length x rump ischium width: r = 0.98. Average daily weight gain was highest in the first six months of age, followed by a slowdown due to pre-puberty behavioral factors. The importance of growth curves for breeding programs is emphasized, demonstrating the need for efficient management to optimize future reproductive performance. The correlation between body development and the anticipation of heat externalization in calves is relevant for reproductive management.
KEYWORDS: Growth curve; Herd monitoring; Heifers.

INTRODUCTION

The body development of calves is the initial challenge in dairy cattle farming because it is the group of animals that will have the responsibility of replacing the cows in the herd. The goals established by the technical areas for the Holstein breed include: mortality of less than 10% and weaning at 60 days, when it is recommended that it presents 2.5 times

the birth weight, with consumption of 2.0 kg of concentrate/day, making it possible to reach sexual maturity early, at 13 months, with 60% of adult weight.

To achieve this goal, it is necessary to minimize the incidence of diseases in the first four months of life, following prophylaxis recommendations (AZEVEDO et al., 2016). Genetic characteristics related to the progenitors influence body development, and allied to these, nutritional factors. Right at birth, calves are monogastric and unable to use solid food in their diet, but with physiological and biochemical aptitude for milk use. However, with correct feeding management, in 45 days they can be weaned and considered ruminants (COELHO et al., 2009).

Attention to the category of calves begins during pregnancy. It is the period characterized by dramatic metabolic changes in the pregnant cow, which should have their effect minimized under the provision of an anionic diet. Cows have their lactation interrupted at 60 days before the expected date of calving, and this period is called the transition period. Meeting nutritional needs is directly related to the development of the fetus and the beginning of the cow's lactation curve in the postpartum period (WEICH et al., 2013).

With reference to the weaning phase, solid food should be provided to calves during the lactation period, promoting the development of rumen papillae. This is achieved with hay, and so weaning can take place at 60 days of age. At this stage, fermented foods, such as silage, are not yet recommended. After three months of age, the combination of silage and hay can be used, but only of optimal quality. It is important that water is constantly available to make up for the lack of saliva in the young calf and thus ensure a good fermentation in the rumen, thus stimulating the intake of concentrate (SANTOS et al., 2002). The concentrates fed to the calves must have a high grain size or coarse texture to cause the movement of the reticulum-rumen, rumination, salivation and the maintenance of adequate pH (COELHO et al., 2009).

It is of great importance to pay special attention to health care, with the administration of antiparasitic drugs from 60 days onwards, and the vaccination calendar established, taking into account: pneumoenteritis, brucellosis, clostridiosis (anthrax and botulism) and rabies. In the region studied, there is also a need for vigilance with reference to babesiosis and anaplasmosis. Vaccination against foot-and-mouth disease should be carried out in the states where it occurs, and Paraná is a free area without vaccination (OMSA, 2021).

The reproductive development of females depends on the age at which they give birth for the first time. Among the advantages of impregnating younger heifers are: shorter time to obtain return on investment, increased number of calves produced and lactations, translating into increased reproductive and productive life, and faster selection in the herd by reducing the interval between generations (COZLER et al., 2019). The high speed of growth in calves is desirable in dairy farms to result in the production of high quality heifers, which show early sexual maturity with minimal cost (BORO et al., 2016).

GOAL

The objective of the present study was to delineate the growth curve of the Holstein Breed in relation to body weight and withers height, considering the factors that impact positively sexual precocity, allowing the first birth to occur at two years of age. In addition, to estimate the phenotypic correlations between body weight, withers height, and rump length; and to obtain the mathematical models that explain the curves of body weight, withers height, and rump length in relation to age.

MATERIAL AND METHODS

In the period between March 2023 and March 2024, the development of forty-six Holstein heifers was monitored, from the suckling stage to one year of age, in a dairy farm located in São José dos Pinhais, Paraná. At the time of birth, each calf received four liters of colostrum and sanitary care was immediately performed, especially the treatment of the navel. In the first 60 days of life, milk was fed in the morning and late afternoon, corresponding to 10% of the body weight per day. After consumption, at the time of washing the buckets, good quality water was provided, remaining ad libitum. There was also the gradual introduction of 20% protein concentrate, in increasing amounts, from 0.5 to 2.0 kg per day.

At 50 days of age, they had access to hay. After this period, the weaning process was implemented, with the gradual remove of milk until 60 days, when the calves began to be fed exclusively with concentrate and hay. Silage was introduced after 100 days. The handling system adopted on this farm is semi-intensive, with the calves remaining for the first four months in a collective calf, where they share the space with animals of the same age group, and later transferred to a paddock formed by Tifton pasture (*Cynodon spp*), with a covered trough for concentrate and silage. In this phase, they consumed 0.9 to 1.8 kg/head/day of concentrate.

To evaluate development, monthly measurements were performed of the following dimensions: (1) withers height, (2) rump width at the ileum (RWI), (3) rump width at the ischium (RWIsc), (4) rump length (RL – measured from the sacral tuberosity of the ileum to the ischial tuberosity, following the line of the spine), (5) body weight (by chest circumference), and (6) withers height (from the withers to the ground). These measurements allowed us to estimate (7) croup surface area (ASR) and (8) average daily weight gain (ADWG). The database consisted of 4.416 pieces of information (n = 4.416).

Pearson's linear correlation coefficient (r) was calculated in order to investigate the relationships between data variability. For the study of multiple regressions, their accuracy and correlation studies, the statistical program Assistat® version 7.7 pt was used. The study of correlations is an important tool in genetic improvement and herd management, because it allows the use of positive bulls for one characteristic to obtain the concomitant improvement of others.

RESULTS

Rump development

The measurement of the rump is an important part of information in progeny tests, and should be a criterion for the selection of dairy heifers, because the greater the width, the easier it will be for the animal to give birth, in addition to providing better dorsal support of the udder (ARMELIN and HARTMANN, 2021). The study addressed the behavior of the rump surface in relation to calf development and its trend line. To calculate the rump surface area, the following equation was used: RSA = ((RWI + RWIsc) / 2) x RL (rump lenght).

There was a decrease in growth rate between 7 and 12 months of age, considered the prepuberty period. The trend line was obtained with the coefficient of determination: R^2 = 0.9115. The development of the rump surface in proportion to age can be seen in Figure 1.

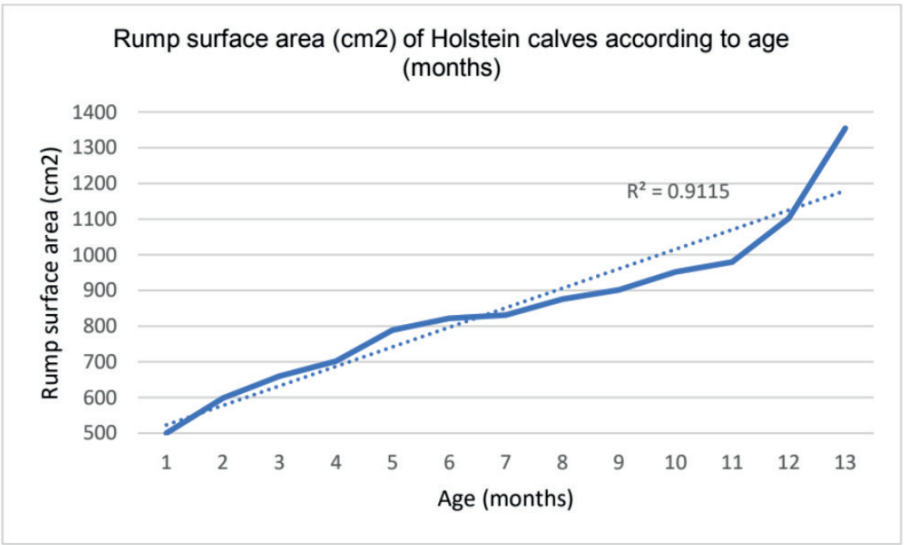

Figure 1 - Rump surface and age of Holstein calves in São José dos Pinhais, PR, from March 2023 to March 2024. N = 46.

Source: Cardoso e Hartmann (2024)

With reference to rump development, growth acceleration was observed after 12 months of age. There was uniform development between rump length and rump ileus width up to 9 months, as shown in Figure 2.

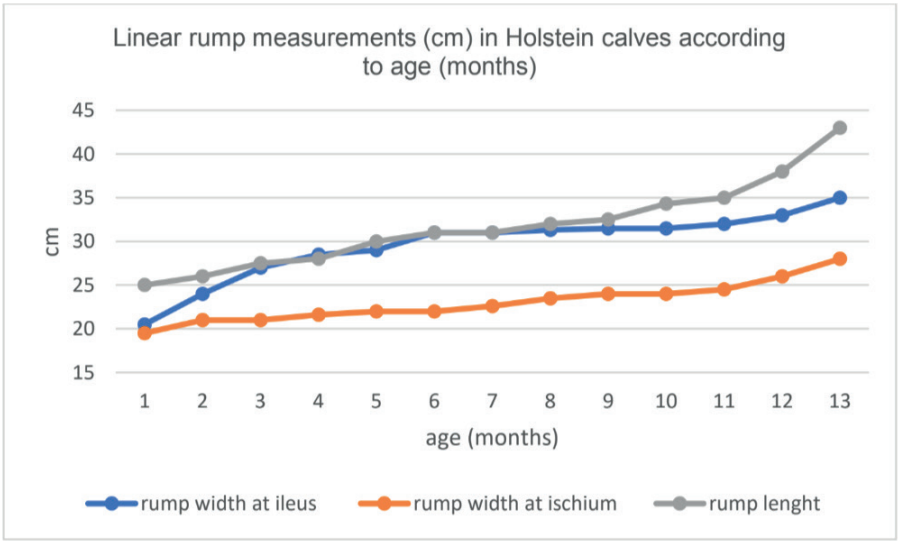

Figure 2 - Development of rump measurements in Holstein calves in São José dos Pinhais, PR, from March 2023 to March 2024. N = 46.

Source: Cardoso e Hartmann (2024)

The correlations calculated were: (a) withers height x rump length: r = 0.91; (b) rump width at ileus x body weight: r = 0.86; (c) rump width at ischium x body weight: r = 0.96; (d) rump widht at ileus x rump widht at ischium: r = 0.84; (e) rump length x rump widht at ileus: r = 0.84 and (f) rump length x rump widht at ischium: r = 0.98.

The correlation between body weight and withers height was: r = 0.95.

These correlations showed high values, indicating that, when selection occurs for one characteristic, there is simultaneously improvement of another among those studied.

Withers height and body weight

The results of the height and weight measurements can be seen in Figure 3, as well as the regression curves that allowed the development of the respective trend line equations, with a high degree of accuracy. A high correlation between height and birth weight until the age of 12 months was observed: r = 0.96.

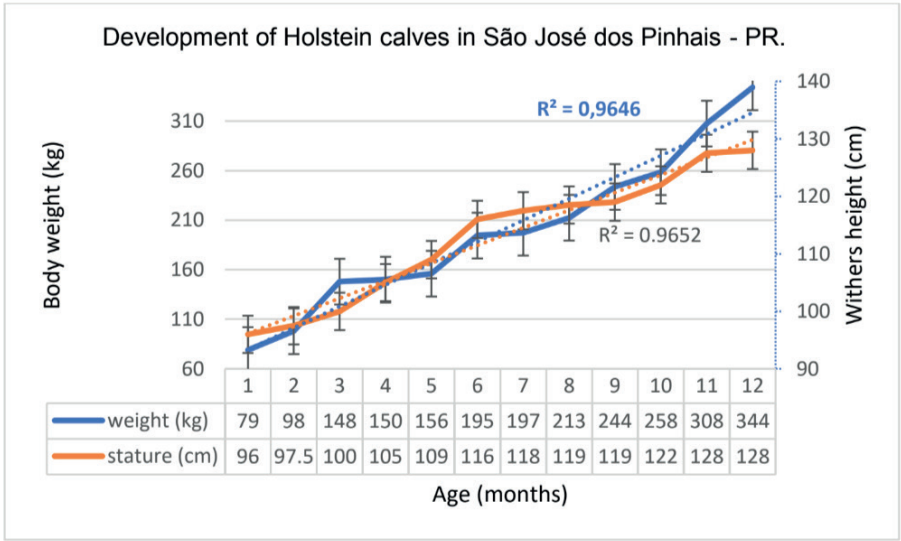

Figure 3: Body weight and withers height of Holstein calves in São José dos Pinhais, PR, Brazil. N = 46.

Fonte: Cardoso e Hartmann (2024)

The trend lines showed high data reliability, being respectively: $R^2 = 0.9646$ for body weight and $R^2 = 0.9652$ for withers height.

Average Daily Weight Gain (ADWG)

The average daily weight gain (ADWG) was calculated monthly, with the average weights, using the equation:

ADWG = weight 2 - weight 1 / days of interval

Thus, calves in the age group between birth and weaning (60 days) had a ADWG of 0.883 kg on average (n = 46). After weaning, a decrease in feed conversion and weight gain was observed, resulting in a ADWG of 0.806 kg, in the categories of calves and heifers from 61 days to 365 days of age. These values are adequate, because in this category special attention should be paid to avoid overweight, which would result in the accumulation of adipose tissue in the mammary gland.

DISCUSSION

The data showed a higher rate of weight gain in the period between birth and the age of six months. However, a subsequent deceleration in the growth rate is observed, probably due to behavioral factors intrinsic to the pre-puberty phase, negatively influencing dry matter intake. Management elements, such as feeding, disease and parasite control, and environmental conditions, have a direct influence.

The knowledge of growth curves helps genetic improvement programs for the selection of animals with precocity and higher expected yields (BERGAMASCO et al., 2001).

Management should be directed towards obtaining reproductive precocity to reduce costs on the farm. In addition, it is essential to consider the morphology of the female calves, especially the rump, which plays an important role in the ease of calving, postpartum recovery, and mobility of the animal. The ideal rump should be wide, long in the lateral and posterior vision, gently joined to the loin, and the hip joint should be well separated, without fat accumulation (VALLOTO e PEDROSA, 2018). These morphological aspects are decisive to ensure not only the current performance of the cows, but also the longevity and future productivity in the dairy context.

Growth refers to an increase in linear size, weight, fat accumulation in tissues, and nitrogen and water retention. Growth is a highly complex and integrated process that involves increasing of the number and size of cells and the deposition of substances within them. It involves interaction between nutrients, environment, genotype, hormones and receptors for these hormones from different tissues (BORO et al., 2016).

Evaluating the peak of Luteinizing Hormone (LH), Getzewich (2005) concluded that puberty in Holstein heifers occurs around 11 months of age. It has been observed the anticipation of the exteriorization of heat in calves in recent years. This fact is relevant, and should be observed concomitantly with body development, especially in relation to weight, height, body length, and rump length and width, enabling heifers to enter at reproductive management without, however, hindering their growth (HARTMANN et al., 2023). Sexual maturity is highly dependent on growth rate, as it is a function of body weight rather than age (BORO et al., 2016).

Puberty in females is defined as the age at which there is ovarian cyclicity. The onset of puberty is characterized by an increase in the concentration of progesterone in the plasma, reaching levels above 1 ng/mL, which can occur from 6 to 10 months of age, depending on genetic and environmental factors (MADGWICK et al., 2005). Puberty occurs when the heifer's weight is between 40 and 50% of the adult body weight, regardless of age, but the onset of reproductive life should occur when the heifers reach 55-60% of the adult body weight. The growth rate should be maintained during gestation in such a way that heifers weigh 80 to 85% of mature body weight at first calving. Lower growth rate is associated with a late onset of puberty (BORO et al., 2016).

The mean values of weight gain in the prepubertal period found in the present study were 0.790 g/day (± 0.040), between 150 and 320 kg, in agreement with reports by Zanton and Heinrichs (2005). According to these authors, the average daily weight gain in prepubertal age is related to allometric growth of the mammary gland and, as a consequence, there is a maximization of milk production in the first lactation. On the other hand, high ADWG values, above those obtained, are harmful because they promote the reduction of somatropin circulation, and result in a reduction in the development of the mammary gland.

FINAL THOUGHTS

The correct management of calves is an important element to ensure the best development of the animals and, consequently, the maximum productivity of the farm, considering that it is the category that will replace adult cows in the future. Dairy farms want to obtain animals with high milk productivity, so the main challenge lies in meeting several factors, including genetics, environment, nutrition and management, to achieve the expected goals.

In this context, monitoring and evaluating the morphological conditions of female calves becomes essential to achieve the desired results. In addition to contributing to the improvement of farm management, this practice provides valuable data that guides possible improvements or adjustments, providing a clear direction to improve herd performance.

CONCLUSION

Monitoring height and weight is recommended, as these are highly correlated phenotypic characteristics, with the aim of showing early sexual maturity at the appropriate weight. The high correlation observed between withers height and rump length (r = 0.91) and between rump length and rump width at ischium allows us to infer that the selection of female calves by height results in animals with longer and wider rumps. In adult cows, it is observed that this factor brings benefits to the greater length of the mammary gland and factors related to the ease of calving and development of the udder.

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