

Potential Utilization of Automatic Cows Weighing for Evaluation of Health and Nutritional Condition of Herd

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Abstract

Weight of cows affects a large number of factors. Regular weighing and data processing can detect differences that may indicate disorders requiring nursing interventions, e.g. nutritional deficiencies, incorrect fetal development and health problems. The current weighing systems operate as stationary - the animal is fixed, identified and weighed. However, the procedure is time consuming and operation, and that is why this system is used minimally. That implies the need of complete automation of all activities associated with the weighing, which enables introduction of pass – through weight. The aim of this thesis was to develop a methodology for evaluating health and nutritional status of the herd based on data from an automated system for weighing a live weight of dairy cows. There was used in the weighing unit for milking robots Astronaut A3 (Lely company) to obtain weight data of individual cows. There were selected dairy cows with the longest period of lactation or already drying off, and especially dairy cows with various health problems for study. Limiting values of weight changes were established after assembling a general equation of mass curve. In the sphere of the diseases there was manifested only ketosis in the weight curve with a loss of 10.2 kg / day (38% weight loss). Additionally, the completion of growth during the first 2 periods of lactations and weight gain due to advanced pregnancy were confirmed. The maximum daily weight difference recorded in healthy animals was 7 %, equivalent to 40 - 45 kg. The results of the study will be applied for compiling algorithm that will be implemented in the complete management system of cattle breeding, monitoring the dairy cows every day and highlight possible deviations exceeding of physiological changes in weight.

Keywords: cattle breeding, management, nutrition, weighing.

1. Introduction

Weight of cows affects a large number of factors (age, gravity, feed and water intake, milking). Regular weighing and data processing can detect differences that may indicate disorders requiring nursing interventions, e.g. nutritional deficiencies (group of animals) or incorrect fetal development or health problems (individual animals). Under common conditions, the body weight of a healthy dairy cow changes during lactation on a relatively regular basis. There is a dramatic weight loss after calving and there is an increase in weight during lactation as the increase in weight of a dairy cow

is associated with the development of the fetus. At the same time it must be borne in mind that the weight of a dairy cow can change significantly during the day (due to drinking, urinating, milking, feed intake etc.) [1]. Therefore it is important to weigh quite often and mainly, if possible, under the same conditions such as when leaving the milking house and to weigh dairy cows after every milking. Current weighing is based on a stationary weighing system - the animal is fixed, identified and weighed. However, the procedure is time consuming and technically demanding and therefore this system is used minimally. That implies a need of complete automation of all activities associated with weighing (animals stepping on to the scale, weighing, identifying, recording and transmitting data to a computer, stepping down from the scale,

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zeroing the scale). Regarding the technological systems used for breeding dairy cows, the most accurate weight has been determined during robotic milking. The floor of the robot box consists of a tensometric scale that can also determine, apart from the accurate weight of the dairy cow, its position in the robot, resp. the central weighing point, which is important for guiding the arm.

The key period in the life-cycle of a dairy cow are 3 weeks before calf delivery and 3 weeks after the delivery the so-called "around-the-delivery" (transit) period which is decisive for maintaining the good health condition and the whole yield and reproduction, i.e., in fact, return of the whole breed. Puerperal paresis, afterbirth retention, disorders of involutions, rumen acidosis, ketosis, abomasal displacement, laminitis and mastitis occur quite often and it is not rare that it is an interrelated complex of health disorders when an occurrence of one supports development of another – newly called as syndrome of puerperal crisis of dairy cows [2]. If timely diagnosed and a therapy is started there are assumptions for successful management of the issues mentioned above [3].

2. Materials and methods

The farm Basík in Zárybničná Lhota where 65 dairy cows of the Holstein breed are bred was selected for determining the daily weight of cows. A weight curve was created using the weight, age, health condition, lactation stage and pregnancy and the limit values of the changes in weight. Lely Astronaut A3 was used for weighing the individual dairy cows. Apart from the weight, other data such as the number of the dairy cow, date of birth, stage of lactation, date of last calving, date of successful insemination, occurrence of health disorder were also important. 21 dairy cows with the longest lactation, eventually dry dairy cows and dairy cows having health problems were selected. It was not possible to work with a greater number of dairy cows as the Lely programme can process data of current lactation i.e. the data are deleted after calving. 7 dairy cows in their 1st lactation, 8 dairy cows in their 2nd lactation, only 1 dairy cow in its 3rd lactation and 5 dairy cows in their 4th lactation were available.

The set of data from the Lely programme was transferred to Excel and, subsequently, the average weight was computed based on the values measured during the day. It was necessary to create a general weight curve in order to propose the algorithm. A line chart in which the chart function was inserted whereas the linear function had been selected as the most suitable for description of the daily weight measurements was used for showing the weight curve of the individual dairy cows.

This function is generally described as $f: y = ax + b$, $D(f) = \mathbb{R}$, whereas a line is the graph of the linear function. This function can occur as increasing ($a > 0$), decreasing ($a < 0$) or not-increasing, not-decreasing, i.e. constant ($a = 0$).

For the purpose of the case observed, the axis y was defined as the axis of weight (m) and the axis x was defined as the axis of days of lactation (d). The weight m is given in kg and days of lactation d are given in days. The co-efficient a indicates the daily gain or loss that was marked as p and co-efficient b was the initial weight m_p , when the weight of the dairy cow was determined on the day of calving then we marked the initial point of the course of the function m_o . The equation of our line is:

$$m = m_p + pd,$$

when we know the weight at calving $m = m_o + pd$

The individual charts of weight vs. days of lactation show, however, parts of increasing, constant and decreasing function. The weight curve can be, thus, described as a sum of individual parts of the function with entering the breakpoints. If we know the weight at calving, the equation is:

$$m = m_o + a_1d_1 + a_2d_2 + \dots + a_nd_n + a_kd_k$$

n – number of breakpoints

k – last day of lactation with measured weight

a_1 – weight gain/ loss between the initial weight and the first breakpoint

a_n - weight gain/ loss between the individual breakpoints

a_k - weight gain/ loss between the last breakpoint and the last day of lactation with measured weight.

When processing the weight curves of the individual dairy cows, weight gains (losses) were computed for the individual sections of the weight curves. Further, basic statistical characteristics of the individual lactations were computed with STATISTICA programme.

3. Results and discussion

When the weight curves of all dairy cows were created, several factors that had had some influence on their behaviour were recorded. These were growing up, lactation stage and pregnancy. The dairy cows were ordered according to their lactations. Beginning, breakpoints and end of the weight curve were deducted from every curve. In order to prepare the algorithm used for evaluation of the behaviour of the weight curves it was necessary to confirm the following hypotheses:

1. Diseases and metabolic disorders influence the change in weight.
2. Dairy cows grow-up at the age of 4 and 5 years.

3. The weight increases due to more intensive growth of the fetus and envelopes of the fetus in the last third of pregnancy.
4. The maximum daily weight difference does not exceed 10 %.

Ad 1) There was a dairy cow diagnosed with ketosis and a dairy cow diagnosed with mastitis in 2 quarters in the animal group observed. When evaluating the data it was found out that the dairy cow suffering from the metabolic disorder lost weight by 38% i.e. 286 kg during 29 days, which corresponds to the loss by 10.2 kg per day. The average weight loss after delivery of the healthy dairy cows was 31 kg for the same period of time (see Figure 1).

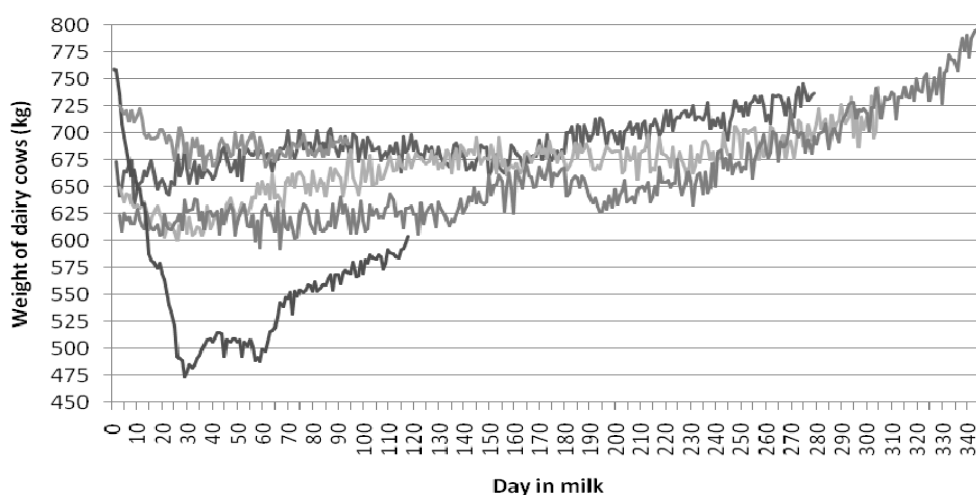


Figure 1: Behaviour of the weight curves of dairy cows in their 4th lactation.

During the period of 10 days before diagnosing mastitis neither after it any decrease in weight did not show on the weight curve that would have eventually notified of inflammatory affection.

Ad 2) The weight of a dairy cow changes not only during lactation but also according to the stage of lactation, which can be seen in table 1.

It can be noticed that the weight really increases gradually along with the stage of lactation. The difference in weight between the 1st and 2nd lactation is 49 kg and between the 2nd and 4th lactation is 7 kg. The weight difference between lactations decreases, which is the result of growing up between the first two lactations. Findings of other studies confirm this, too: The biggest differences were between the 1st and 2nd lactation i.e. 40 kg, whereas the difference between the 2nd and 3rd lactation was just 27 kg.

According to them, the body weight increases with the parity as dairy cows grow up and they are not of mature size before they are 4 to 5 years old [4]. The result is confirmed by another study in which the average weight of dairy cows in their 1st lactation was 553 kg, in their 2nd lactation was 611 kg and in their 3rd lactation was 654 kg. The weight difference between lactations decreases, too [5]. Dairy cows are physically mature i.e. they grow up between their 4th and 5th year [4].

When the average of the initial weights, last measured weights during individual lactations when the average length of pregnancy was 140 days was gained, it was found out the following (see Table 2).

Table 1: Average and limit values of weight according to lactations

Laktation	Average weight	Min.	Max.	Variance	Standard deviation
1st	617	489	820	4805,75	69,32
2nd	666	537	813	3068,83	55,4
3th	646	608	725	558,1	23,62
4th	673	593	796	1277,51	35,74

Table 2. Average weights according to the stage of lactation

Laktation	Average age at beginning of lactation	Average beginning weight	Average final weight
1st	2 roky	560 kg	676 kg
2nd	3 roky	622 kg	733 kg
3th & 4th	5 let	686 kg	706 kg

The dairy cows in their 1st lactation (at the age of 2 years at the beginning of lactation) had the average weight of 560 kg and the average final weight of 676 kg whereas the average length of lactation and pregnancy was 186 and 132 days.

The dairy cows in their 2nd lactation (at the age of 3 years at the beginning of lactation) having the average lactation 303 days long and being pregnant for 136 days reached the initial weight of 622 kg and the last measured weight of 733 kg.

The initial weight of the dairy cows in their 3rd and 4th lactation, i.e. dairy cows already mature (at the age of 5 years at the beginning of the lactation) was 686 kg and the average last measured weight was 706 kg. Whereas the average period of pregnancy was longer than during previous lactations (153rd day) and the average length of lactation was 251 days.

The difference in the initial and final weights was 116 kg for the first lactation, 111 kg for the second lactation and only 20 kg for the third lactation for comparable days of lactation and pregnancy. Thus it can be said that this hypothesis has been confirmed.

Ad 3) Another factor influencing the behaviour of the weight curve was pregnancy of the animals. The embryo grows relatively fast at the beginning of its development, however, the absolute increase in the matter is small. As the pregnancy continues this changes and the biggest absolute growth of the fetus is in the last weeks and days of pregnancy [6]. It grows most during the last three months of pregnancy, i.e. from the 190th day of pregnancy [7]. Due to a low number of advanced pregnant dairy cows the raised increase from the 190th day of pregnancy has been confirmed only for 2 dairy cows when the increase in weight rose on the 191st and 229th days of pregnancy. A significant increase in weight of a dairy cow was measured in its 188th day of pregnancy. The increase in weight of other dairy cows (3 pieces) occurred already on the 106th to 139th day of pregnancy.

Ad 4) The analysis of data has confirmed this hypothesis as the maximum daily weight difference was 7%, which is 40 to 45 kg according to the weight of a dairy cow. The decrease in weight was recorded mainly during the first third of lactation when the dairy cows had difficulties to cope with the negative energetic balance. This should not exceed the so-called physiological limit, which means the loss of the live weight higher than 0.5 kg per day. When this limit is exceeded, deterioration of fertility, health condition and metabolic stress can be expected [8]. An important task was to observe not only the amount of weight loss after delivery but also the period a dairy cow needed for reaching the initial weight and whether this period was influenced by the stage of lactation. The ascertained average values of the individual lactations given in Table 3 were compared with the results of other researches. The day when the maximum weight loss was reached shortened along with the stage of lactation, however, the loss in kilograms was increasing. It can be said that the weight of dairy cows in their first lactation was decreasing longer; however, the total loss was lower contrary to the dairy cows in their third and fourth lactation.

Table 3. Weight decreases and return to the initial weight

Lactation		Minimum weight (day lactation)	Weight loss %	Weight loss (kg)	Return to the initial weight (day of lactation)
1st	Average value	36	5	30	86
	Range of value	26 – 44	2 – 7	12 – 41	65 - 102
2nd	Average value	34	3	17	78
	Range of value	32 – 35	3	15 – 18	40 - 115
3th & 4th	Average value	23	6	42	78 a více
	Range of value	17 – 27	5 – 8	30 – 59	78 a více

The losses in weight were subject to study of VAN STRATEN (2008) who identified the decrease in weight of first-calvers by 6.5 %, of dairy cows in their 2nd lactation by 8.4 % and of dairy cows in their 3rd and higher lactation by 8.5 %. The average day of lactation when the loss reached maximum was increasing along with the increasing lactation, in particular, it was the 29th day in the 1st lactation, the 34th day in the 2nd lactation and the 38th day in higher lactations. Another experiment showed a decrease in weight of first-calvers by 40%, of dairy cows in their 2nd lactation by 20%, whereas there were dairy cows whose weight did not decrease fewer than 95% of the initial weight in both groups. The minimum values were gained on the 20th to 60th day for first-calvers and on 20th to 100th day for dairy cows in their 2nd lactation [10]. The amount of decrease is not affected by the stage of lactation [11]. However, the study suggests at the same time that the first-calvers do not use reserves so intensively than the dairy cows in their higher lactation do. The decrease in weight finishes between the 30th to 33rd day after delivery \pm 15 days for first-calvers and \pm 25 days for older cows. The behaviour of the weight curve was as follows: puerperal weight of the first-calvers at the level of 540 kg decreased during 6 weeks to 514 kg, and then it increased to more than 580 kg during lactation [5]. During the first stage of lactation

there should not be a decrease higher than 1 point without condition score, which corresponds to 67 kg, whereas already the decrease by 35 kg influences reproduction [12]. The loss of 1 point of condition score is compared to the decrease by 40 -50 kg of weight [3]. All dairy cows in their 1st and 2nd lactation returned to their initial weight during 40 -102 days of lactation i.e. within 100th day of lactation. Only one out of the dairy cows in their higher lactation who lost weight after delivery returned to the initial weight (78th day of lactation). This difference can be partially explained by that dairy cows in their first and second lactation compensate the decrease in weight after delivery by gain when maturing.

4. Conclusions

The results ascertained suggest the following: In most cases there is a loss in weight which stops individually in the period of the 17th to 45th day of lactation, the daily loss being 0.30 – 1.70 kg/ day after calving. The total decrease in weight during this period should not exceed 8% of the total weight of the dairy cow.

When the decrease stops, dairy cows start putting on weight gradually, the weight reaches the initial (puerperal) weight during 40 – 100 days of lactation, resp. during the first 100 days of lactation. Another increase in weight is individual and it can accelerate from the 100th to 200th day of pregnancy. The gain during lactation lies within the range of 0.1 – 1.6 kg.day⁻¹.

Acknowledgements

This work was supported by University of South Bohemia in Project MSM 6007665806.

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