THESIS OF Ph.D. DISSERTATION

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RELATIONSHIP BETWEEN CONDITIONAL CHANGES, MILK YIELD AND FERTILITY OF DAIRY CATTLE.

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Abbreviations used in the thesis:

BCS = Body Condition Score
305 NT = 305 days standard milk yield
LNT = Largest daily milk yield
ÁNT = Average daily milk yield
DIM = days in milk
ÚFI = Open days
TI = Conception rate
SK = thin (weak) condition (BCS=1,0-2,9)
NK = normal condition (BCS=3,0-3,9)
KK = fat condition (BCS=4,0-5,0)
DIM = Days in milk
FFA = free fatty acids
NEFA = Non-esterified (free) fatty acids
AST = aspartate amino-transferase (liver-enzyme)
NSBÜ = Net acid-base empty
PC = Primiparous cow
MC = Multiparous cow
TMR = total mixed ration

1. OBJECTIVE

It is obvious, that the estimation of feeding and physical conditions of dairy cows by condition scoring is a useful mean for the management to determine the body fat reserves. This statement is particularly true to the Holstein-Friesian breed that possesses perfect genetic potential for milk yield. Condition scoring, as a method, is a cheap and effective monitoring system for preventing several problems. The livestock must be kept in optimal condition in order to ensure the expected milk yield and veterinary condition for long terms. It is still an actual question that how much the ideal condition score is, in the different phases of lactation, according to the Hungarian breeding and feeding conditions. Another crucial point is to demonstrate the relationship between condition scores, milk yield, conception rates and metabolic disease.

The primary aim of writing my thesis was to support the justification of the easily attainable and efficient method of condition scoring with the help of the farm veterinary and nutrition management, to better the sanitary conditions and performances of the cows, and to clarify the relationship between condition, number of lactations, particular conception rates, blood and urine parameters. I also want to draw attention to the critical time periods of veterinary and feeding around and after calving, and examine the indicators among extremely hot weather conditions.

My other objective was to make suggestions for experienced professionals by revealing mistakes and risks, with the help of which they would be able to better the thrift of their activities.

2. MATERIAL AND METHOD

I made frequent condition scoring on the dairy-farm of Kiscséripuszta of Enyingi Agricultural PLC. between 01. 06. 2001. – 19. 12. 2001. 1850 Holstein –Friesian cows were kept on the farm; that time this was the biggest dairy farm in Hungary. The animals were kept in free-stall barns for 90 – 100 animals and they were fed with TMR forage. The groups over 15 litres were milked three times a day. I made the condition scoring on a 1-5 scale, on the monthly test day, so the daily milk yield, the condition score and the days after calving were all available. I processed the data of altogether 5707 condition scoring.

I also made monthly condition scoring in Aba on the dairy farm of Kajtorvölgye Agricultural Co-operative – on the test days – in the 1-5 scale system. I ranked the condition scores to three groups: „thin" BCS=1,5-2,9 (SK); „normal" BCS=3,0-3,9 (NK) and „fat" BCS=4,0-5,0 (KK).

The farm represented well the ordinary Hungarian dairy farms, as regards breeding and feeding, and the neatly recorded musters of RISKA farm management program dated back to several years. On the farm with free-stall barns 400-450 cows were raised, the animals were milked twice a day. I processed the data of 3586 lactation altogether. Recorded data: Condition score (BCS), average daily milk yield (ÁNT), days of lactation after calving (TNSZ), number of completed lactations, 305 days of milk yield (305 NT), open days (number of days elapsed from calving to the next conception) (ÚFI), and the conception rate (TI).

Furthermore, blood and urine tests were made 94 times on 2247 high yielding cows raised on some other dairy farms of the country from 1998 to June, 2004.

Random samples were taken in the morning by a veterinary surgeon from clinically healthy cows 3-5 hours after feeding; in the meantime I made the condition scoring in a 1-5 scale system.

Time periods devoted for sample taking and the group of cows:

- Preparatory/pre-fresh group, (1-14 days before expected calving)
- Newly calved cows in calving barn (1-6 days after calving)
- Reception/fresh group (7-30 days after calving)
- Group of cows providing high daily milk yield (31 days after calving).

The samples were analysed by the laboratory of the Department of Animal Hygiene of the Faculty of Veterinary Science of Szent István University. The analysed parameters: haemoglobine, plasma aceto-acetic-acid, FFA/NEFA, AST, glucose and carbamid concentration, and urine pH, carbamid and NSBÜ values. The results were classified according to the average days of lactation (TNSZ): −12 (before calving), 3, 18, 44, 76, 104, 133 and 218 days.

I had been collecting the high temperature periods for several years on the basis of meteorological data then I examined the effects of heat stress on the dairy cows by analysing the samples according to the previously mentioned way. I chose the experimental and control periods on the basis of the measured data of three meteorological stations (Győr, Siófok and Szeged) about the highest daily maximum temperature. Samples of 913 cows were taken from the control period (209 PC and 704 MC), and other samples of 835 animals (199 PC and 636 MC) from the experimental period. I have taken the samples on 85 dairy farms by taking the principles into consideration i.e. the location of the farms in the coverage of the aforementioned three meteorological stations.

The programs used in data processing and evaluation: Microsoft Excel 2003, StatSoft Inc., Stastistica 7. 1984-2007 program package.

3. RESULTS AND DISCUSSIONS

3.1. Relationship between condition, milk yield (305 NT and LNT), and conception rates (ÚFI and TI)

The results of processed data gained in Enying made it obvious that the highest milk yield can be reached in the 4th month of lactation (30,70 kg/day). The produced milk yield was also very high on the 2nd test day (30,30 kg/day) but that was followed by a fall on the lactation curve that was possibly caused by feeding mistakes. Parallel to a rise in milk yield, the condition scores fall. The BCS reached the lowest point in the 2nd month (3,03) then it began to rise continually and by the 8th month it reached the average of the first scoring (3,20). The average of BCS does not fall under 3,0 that does not suggest lack of intensified negative energy. The fluctuation of the lactation curve at some spots (3rd and 5th month) during group-feeding indicates mistakes due to using the next TMR. The condition curve breaks, too, in the 6th month, the rise stops, the BCS stagnates (3,1) and this phenomenon also verifies insufficient feeding in the 5th month.

The milk yield results are tight ($P \leq 0,001$) but the data of condition resulted in medium ($P \leq 0,01$ and $P \leq 0,05$) significant differences towards lactation. The data mean trends of livestock in the case of condition and daily milk yield.

The trends of **milk yield** were analysed by each lactation on the bases of the data of Kajtorvölgy. The first lactation cows were the weakest (24,1 kg and 6079 kg) in the highest daily-, and 305 days long- milk yield. They fell behind by 19% from the 305 days long peak (3rd lactation) and by 17 % from the production of the second lactation cows. As opposed to other lactations they had optimal persistence (72,7).

On the basis of both indicators the most milk yield was produced by third lactation cows (31,9 kg and 7514 kg).

The daily milk yield of first lactation cows on the basis of the first seven test days ($P \leq 0,001$) shows significant difference from the production of all the rest lactation cows.

The shortest **time until next conception** (**ÚFI)** (126 days) elapsed in the 7th lactation, the longest was detected (173 days) in the 10th lactation. According to the available data neither logical nor statistical trends supported the idea that there is a relationship between the time elapsed until next conception and the number of completed lactations.

The analysis of **conception rates (TI)** shows that the 70,3 % of the animals get pregnant within the acceptable 150 days after calving, with an indicator below 3. *The sequential differences of the ÚFI values refer to mismanagement. Between the two sequential insemination, not the biologically crucial 20-22 days elapse but 37-53 days. Inseminations were not carried out during the time of oestrus so that the time until the next conception was unnecessarily lengthened. This phenomenon can also conceal the statistically probable biological relations.*

At the first scoring the BCS that belongs to the first four indicators was beyond three (3,05-3,08). The indicators of such cows which condition scores were between 5-7 fell under three after calving. Though at $P \leq 0,05$ probability level I have found differences at the first scoring between 5 and 2 TI.

These results do not verify the close relationship between the conception rate and the condition scores. It is observable, that the provided condition scores did not differ significantly from the ideal values (they

dispersed around 3) so this could not be the reason for the lengthened time of open days.

The **305 days long milk yield (305 NT)** was the lowest (6474 kg) in case of such cows that got pregnant at the first insemination. The difference between their production is significant at high probability level (P≤0,001) except for groups of 8 TI. The statistical test is at P≤0,01 probability level at the groups with 2 and 4; 2 and 6; 9 and 2; 3 and 9; and 3 and 6 conception rates. It can be seen from these figures that the relation of 305 days long milk yield with TI is stronger than with condition scores.

Analysing the **largest daily milk yield** (LNT) the lowest value was produced by those cows that belong to indicator 1 (27,01 kg LNT). The largest daily milk yield was produced by the group of cows that belong to indicator 8 (36,07 kg LNT). There was a significant (P≤0,01) difference in milk yield between the groups belong to indicator 1 and to indicator 2-6. The difference between the groups with 4 and 2 TI were also significant on P≤0,05 probability level. Similarly to condition, the largest daily milk yield shows statistically demonstrable relation only in case of such cows that got pregnant due to the first insemination.

According to the scientific literature and my own experience, the most critical period of lactation for the high productive dairy cows is the first 100 days. It is especially true to first lactation cows. In my database the **first three scoring** and the test days took place in this interval. As regards condition scores I grouped the cows into three category (thin BCS = 1,0-2,9; normal, BCS = 3,0-3,9 and fat BCS = 4,0-5,0) then I did the statistical counts. Besides daily milk yield, I analysed the figures of LNT, 305 NT, the ÚFI and TI. By summarizing the results, it can be stated that as regards milk

yield the members of the thin group by all means surpass the production of the fat group and even the normal group occasionally.

Poor conception rates of the thin group are often associated with the high milk yield. This phenomenon is true to the fat animals with reverse sign; they show good results in the field of breeding biology besides poor milk yield. Concerning the results and regarding the economic point of view – if there is no other veterinary danger – the management should strive for optimizing the condition scores between the range of **BCS=2,5 – 3,9** limit values in the first 100 days of lactation.

The results of the analysis concentrating on revealing the correlation coherence between condition and milk yield suggest that especially such condition scoring that are made during the first 30 days give sufficiently useful information about the expected milk yield and the length of time until next conception. At the first test day between the BCS and ÚFI $r = 0,51$, the TI $r = 0,42$, the 305 NT $r = 0,71$, the LNT $r = 0,64$ we can find tight, significant ($P \leq 0,001$) relationship. The tightness of the correlation is not smaller than $r = 0,25$. Thus 100 days after calving the condition scoring can also provide useful information about the expected milk yield and reproductive procedures.

3.2. The results of blood and urine tests

The condition during calving can be regarded as ideal (BCS = 3,48) then usually it starts to decrease until the 44th day (2,65) but it does not fall to 1 score. Practically the BCS stagnates until the 133rd day of lactation (2,68 − 2,69) then it starts rising gradually (2,89). Among all the groups, at high probability level ($P \leq 0,001$) I have found significant differences regarding the average of BCS.

The results of metabolic profile tests show that averagely 18 days after calving the glucose reaches the lowest point (2,45 mol/l), while generally only 3 days after calving FFA/NEFA (0,256 mol/l) reach the peak that indicates sub-clinical fat mobilisation disease.

Two weeks later, due to severe lack of energy the aceto-acetic-acid (0,108 mmol/l) exceeds the top limit of the physiological value, which refers to such chronic procedures that can lead to chetosis. The next indicator, the hemoglobine (5,58 mol/l) reaches the lowest point averagely 44 days after calving. The fall of condition (BCS = 2,65) compared with the value of BCS at the time of calving is 'only' 0,83 score.

The AST (109 U/l) concentration shows a high value 3 days after calving and even later does not decrease below the physiological value (80 U/l). The damage of liver cells can be just partly traced back to increased fat burning. In every group, after calving, the carbamid concentration of blood exceeded the maximal reference value (5,0 mmol/l), thus increased the overburden of liver capacity and caused negative energy deficit to the organism. In urine, the carbamid values exceeded the maximum of normal values (300 mmol/l) only 133 days after calving.

Obviously incorrect feeding practice is the hidden cause of such results.

The NSBÜ values indicate acid burden even before the calving days (80,34 mmol/l), that still does not change directly after calving (84,95 mmol/l). The danger of sub-clinical rumen acidosis ceases averagely 18 days after calving. To avoid acidosis chemical buffers are fed after calving, mostly sodium bicarbonate and magnesium oxide. These compounds can quickly increase the pH in the rumen, though they are not utilized between

the optimal 6,5-7,0, but alkalize the liquid of the rumen, and in more severe cases it can even cause rumen atony.

Incorrect feeding practice is proved by the results of the urine pH: averagely 18 days after calving the values exceeded the top limit of the physiological value (pH = 8,4).

To my mind among Hungarian feeding and breeding conditions, the **decreasing BCS, compared to the calving conditions, should not exceed 0,83 score.**

The trends of the changing values of hemoglobine, glucose, aceto-acetic-acid, FFA/NEFA and AST tightly follow the curve of condition change. Correlation counting enables us to verify only medium or slightly significant relations among the parameters.

During factor analysis I could differentiate three group factors and one individual. The demonstrated factors possess the following percentages from the total variance in sequence 1) 19,7 %; 2) 13,3 %; 3) 12,1 %; and 4) 11,6 % and they explain the changes of variance, i.e. 56,7% in the four factors altogether.

The 4 defined factors:

1) The factor of acid-base balance (urine pH and NSBÜ): group factor

2) The factor of protein supply (carbamid plasma and urine): group factor

3) The factor of condition (BCS and hemoglobine): group factor

4) The factor of liver functioning (AST): individual factor

The results of factor analysis statistically verify my practical observation that the rumen is extremely acidified by feeding even before and directly after calving. The falling pH of rumen liquid facilitates other harmful procedures.

Nowadays, if the mistakes are recognized, an incorrect method is used in practice, namely overdosing chemical buffers (mainly baking soda and magnesium oxide). Although the appetite of the animal is moderate and barely rises in the first 2 weeks after calving. The self-sacrificing body of the animal promotes fat mobilisation, its condition decreases, while the keton body concentration increases dangerously. In the meantime, liver cells get damaged at an increased degree that undermine the performance of the liver.

The carbamid concentration of the blood exceeded the maximum reference value (5,0 mmol/l) in each group after calving, burdening the liver performance and increasing the negative energy deficit of the organism. The carbamid values in urine exceeded the maximum of normal values (300 mmol/l) only 133 days after calving. The incorrect feeding practice can be blamed for these results. The daily feed portion for cows contains too much protein, that can be solved in the rumen, for which there is not sufficient easily solvable carbohydrate. Too much ammonia is generated in the rumen which by transforming into carbamid, burdens the functioning of the liver, disturbs the reproductive procedures and withdraws energy from the organism that still lacks energy.

3.3. The results of blood and urine samples taken in extremely hot weather conditions

The analysis of the results of blood and urine samples that were taken in extremely hot weather conditions indicates that hot weather has a harmful effect on the organisms of high productive cows. According to my research nearly all the variances of assessed parameters were significant, namely on high probability level (P≤0,001) I found differences in concentration of blood haemoglobine, aceto-acetic-acid, FFA/NEFA, AST, carbamid and urine pH and NSBÜ in the experimental and control period. On the bases of the unfavourably differing parameters because of hot weather conditions, and the frequency of differing physiological values **it can be stated that the multiparous cows do not tolerate such period of time than the primiparous ones.**

It can also be stated that harmful procedures, that are damaging the body happens more rapidly and dynamically in case of cows with fat condition scores (BCS = 4,0-5,0).

The incorrect feeding practice (overdosing protein and buffers, bad quality mass forage) can increase the risk of heat stress to such an extent, that it can make us face veterinary problems even on subclinical level. The results show considerable haemoglobine decrease, hypoglicaemia, fat mobility disease, chetosis and liver damage.

4. NEW SCIENTIFIC ACHIEVEMENTS

1. **The condition score has a slight effect** (P≤0,05) **on conception rate (TI)** if the score does not fall under BCS=3,0. **A significant (P≤0,001) relation was observable in increasing the rate of TI if the BCS<3,0.**

   - **Milk yield has more significant effect on TI** (305 NT relation, P≤0,001; the LNT relation, P≤0,01) **than condition**, if the decrease of BCS is not so rapid after calving (60 days after calving it does not reach 1 score) and the BCS does not fall under BCS=2,75.

   - According to the analysis of the data of the first three months, I have drown the conclusion that as regards milk yield (305 NT and LNT) and breeding biology (ÚFI and TI) **the optimal condition score range is BCS = 2,5-3,9** in this period of time.

   - As for correlation counting the results of condition scoring (BCS) **in the first 30 days** show **stronger relation with milk yield rates than average (305 NT, r = 0,71 and LNT, r = 0,64)** but they suggest **average influence on conception rates (ÚFI, r = 0,51 and TI, r = 0,42).**

2. On the bases of blood and urine tests it can be stated that **the trends of the changing values of hemoglobine, glucose, aceto-acetic-acid, FFA/NEFA and AST tightly follow the curve of condition change.**

3. Condition reaches its lowest score on average **44 days after calving**, when the rate of decrease is **0,83 score**. According to blood tests, even besides such condition decrease, sub-clinical fat mobility disease, chetosis and extensive liver cell damage occur.

4. **During factor analysis I could differentiate three group factors and one individual.** The demonstrated factors possess the following percentages from the total variance in sequence 19,7 %; 13,3 %; 12,1 %; and 11,6 % while they also explain the changes of variance, i.e. 56,7% in the four factors altogether.

   The defined four factors according to their caliber:

   - The factor of acid-base balance (urine pH and NSBÜ): group factor
   - The factor of protein supply (carbamid plasma and urine): group factor
   - The factor of condition (BCS and hemoglobine): group factor
   - The factor of liver functioning (AST): individual factor

5. By analysing blood and urine tests taken in extremely hot weather conditions I found significant (P≤0,001) differences in the concentration of blood hemoglobine, aceto-acetic-acid, FFA/NEFA, AST, carbamid and urine pH and NSBÜ. **It can be stated from the results that the multiparous cows tolerate heat stress not as well as the primiparous ones.**

5. LIST OF PUBLICATIONS MADE IN THE THEME OF THE DISSERTATION

Refereed journal articles in Hungarian language:

Gergácz Z. - Báder E. – Brydl E. – Könyves L. – Kovács A. (2007): Extrém időjárási évek hatása a vér-, vizelet paramétereire teheneknél. „KLÍMA-21" Füzetek. Kiadó: MTA KSZI. 49. szám 75-79. old. A VAHAWA konferencia (2006. március 9. MTA Budapest) kiadványában megjelent írás teljes terjedelemben.

Gergácz Z. – Báder E. – Brydl E. – Könyves L. – Kovács A. (2006): Extrém klímájú évek hatása tejelő tehenek vér-vizelet paramétereire, a kondíció függvényében. (Relationship among extreme weather situations, blood and urine parameters and body conditions in lactation cows). Állattenyésztés és Takarmányozás, Vol. 55. Különszám. 47-48. old.

Báder E. – Gergácz Z. – Muzsek A. – Kovács A. – Györkös I. – Báder P. (2006): Termékenység alakulása tejelő tehénállományokban. (Fertility trends in milking cow breeds). Állattenyésztés és Takarmányozás, Vol. 55. Különszám. 31 - 32. old.

Muzsek A. – Szili J. – Báder E. – Gergácz Z. – Kovács A. – Györkös I. – Báder P. (2006): A kondíció hatása a tejtermelésre és a termékenységre. (The impact of condition on milk production and fertility). Állattenyésztés és Takarmányozás, Vol. 55. Különszám. 73 - 74. old.

Refereed journal articles in foreign language:

Gergácz Z. – Báder E. – Brydl E. – Kovács A. – Szűcs. E. (2008): Extreme meteorological conditions and metabolic profile in high yielding Holstein-Friesian dairy cows (Conditiile meteorologice extreme si profilul metabolic al vacilor de rasa holstein-friza cu productii mari de lapte). Lucrari stiintifice zootechnie si biotechnologii. Scientifical Papers Animal Sciences and Biotechnologies. Universitatea de Stiinte Agricole si Medicina Veterinara a Banatului Timosoara Facultetea de Zootehnie si Biotehnologii. Vol 41 (2) 2008. 417-428. p. ISSN 1221-5287

Kovács A. – Báder E. – Gergácz Z. – Bartyik J. – Pongrácz L. – Szűcs E. (2008): Effect of Holstein-Friesian heifers' growth and development on milk productions in the first lactation (Efectul cresterii si dezvoltarii vitelelor de rasa holstien-friza asupra prouctiri de lapte din prima lactatie). Lucrari stiintifice zootechnie si biotechnologii. Scientifical Papers Animal Sciences and Biotechnologies. Universitatea de Stiinte Agricole si Medicina Veterinara a Banatului Timosoara Facultetea de Zootehnie si Biotehnologii. Vol 41 (2) 2008. 451-459. p. ISSN 1221-5287

Full text in the proceedings:

Gergácz Z. – Báder E. – Brydl E. – Könyves L. – Kovács A. (2005): Extrém időjárási viszonyok hatása a vér- vizelet paramétereire a kondíció függvényében elsőborjas teheneknél. 16. Magyar Buiatrikus Kongresszus, 2005. október 5-8. Balatonfüred, előadások/proceedings, 110-114p.

Abstract communications:

Z. Gergácz – E. Báder – E. Szűcs – A. Kovács – L. Könyves – E. Brydl (2008): Relationship between Body Condition and Metabolic Parameters in Dairy Cows according to Different Days in Milk. Magyar Állatorvosok Lapja, 130. évfolyam, II. különszám, 43. oldal.

Báder E. – Gergácz Z. – Brydl E. – Könyves L. – Kovács A. (2006): Extrém klímájú évek hatása a vér-vizelet paramétereire a kondíció függvényében, többször ellett teheneknél. VAHAVA Zárókonfenrencia MTA Budapest, 2006. március 9. CD kiadvány. Kiadó: AKAPRINT KFT. ISBN-10:963-508-542-7

Oral presentations:

In Hungarian language:

Gergácz Z. – Báder E. – Muzsek A. – Szili J. – Györkös I. – Báder P. – Kovács A. (2003): Az üszők előkészítés előtti kondíciójának hatása, az első és második laktációs tejtermelésre, IX. Ifjúsági Tudományos Fórum, Keszthely. 2003. március 20. (előadás)

Gergácz Z. – Brydl E. – Báder E. – Kovács A. – Könyves L. – Tirián A. (2004): Kondíció valamint a vér és a vizelet paramétereinek összehasonlító vizsgálata. Agrártermelés – harmóniában a természettel, XXX. Óvári Tudományos Napok, 2004. október 7, CD-kiadvány (előadás)

In foreign language:

Gergácz Z. – Báder E. – Muzsek A. – Báder P. – Szili J. – Kovács A. (2003): The effect of condition of heifers before preparation on milk yield int he first and second lactation. 4th International Conference of PhD students, University of Miskolc, 11-17 August 2003.

Gergácz Z. – Báder E. – Szűcs E. (2008): Critical points in the feeding of high yielding dairy cows. XXXII. Óvári Tudományos Nap. 2008. október 9. Mosonmagyaróvár, Welanimal Meeting Szekció. ISBN 978-963-9883-05-5. CD kiadvány.

Poster presentations:

E. Báder - Z. Gergácz - I. Györkös- P. Báder- A. Kovács (2005): Time of insemination in Hungarian dairy herds, 56th Annual Meeting of the European Association for Animal Production at Uppsala, Sweden, from 5-8 June, 2005, Book of abstracts No. 11, 262p.

Báder E. – Gergácz Z. – Brydl E. – Könyves L. – Kovács A. (2006): Extrém klímájú évek hatása a vér-vizelet paramétereire a kondíció függvényében, elsőborjas teheneknél. VAHAVA Zárókonfenrencia MTA Budapest, 2006. március 9. CD, poszterek. Kiadó: AKAPRINT KFT. ISBN-10:963-508-542-7.