Ph. D. THESIS

Correlation between body condition scoring and some quality parameters of Holstein-Friesian cattle

Edit Mikó

Supervisors:
Dr. István Komlósi Ph.D.
Associate Professor
Dr. Imre Mucsi C.Sc.
Professor

UNIVERSITY OF DEBRECEN
PHD SCHOOL OF ANIMAL HUSBANDRY
Debrecen, 2011

I. THE BACKGROUND OF THE RESEARCH

The Holstein-Friesian cow is the first among milking cows in the world nowadays. This type gives 97 per cent of the controlled milking herd in our country. The Holstein-Friesian cattle are very sensitive to changes in their environment, which is particularly true for feeding. The cows have different needs compared to the feed consumed at the different stages of lactation

Care should be taken at the beginning of lactation, because it is difficult to satisfy the nutrition needs of the high production dairy cows, therefore the cows lose from their body reserves due to the high milk production. In most cases the excellently producing cows with ideal appearance get out of the production earlier than the others.

The significant milk production yields are shown in the production parameters of the Hungarian stocks; in December 2010 the stock average ranked first place in Hungary was 33.38 kg (ÁTKFT, 2010).

The breeders have to face many problems beyond the outstanding milk production. In recent decades the useful lifetime decreased, reproductive disorders and common metabolic disorders appeared, so infertility is common and, re-conception is delayed etc. (BERTA, 2010).

It is because of these problems, among others, that Hungarian and international breeding management organisations have increased concern regarding the body strength and the useful lifetime of the animal in addition to milk production. The body condition scoring also has been part of the linear type classification in Hungary since 2007.

The Hungarian (BRYDL, 1994; BÁDER et al., 2002; GERGÁCZ, 2009; TŐZSÉR et al., 1995) as well as the international (EDMONSON et al., 1989; HADY et al., 1994; RUEGG and MILTON, 1995) literature refers to the advantages of the body condition scoring system.

Using the body condition system in our country has been mainly adopted for meat type herds. This method is not widespread in farm practice, which is particularly true for dairy farms.

The advantage of the body condition scoring system of dairy cattle is that the grouping of stocks is easier with it and the deficiency of feeding and keeping system can be detected.

The body condition scoring system is a little labour-intensive, but the application of the method will be returned in milk production. The use the method in the practice is worth considering based on economic and physiological criteria.

II. THE OBJECTIVES OF THE RESEARCH

My examinations were carried out on large scale dairy farms in Hungary. In my work I analysed the possibilities of use, the advantages and significance of the body condition scoring system in the main fields of cattle breeding (milk production, reproduction). I examined the connection between the functional type traits and the BCS. I analysed the phenotypic and genetic correlations and the h^2 value of the body condition.

In my paper my objective was to find the answer to the following questions:

1. Production and breeding parameters analysis:

My objective was to find the answer, what relationship can be observed between body condition and milk production in the examined stocks. How does the condition of the cows change during the lactation? Is there a difference between the body condition of the first-lactation and the several-lactation cows? How does the environment (farm) might affect the condition of cows?

The reproductive disorders cause considerable economic damage in milking stocks. My objective was to investigate the relationship between different reproductive parameters (number of days until the first insemination, fertility index, service period, open days) and the BCS. I tried to find out how the body condition at calving, the lowest body condition after calving and the body condition changes after calving influenced the analysed reproductive parameters.

In the study I tried to find a correlation between the live weight and the BCS during the lactation. I analysed the changes of body weight and BCS. I tried to find the answer to the questions, how the BCS and the BW change during the lactation

2. The investigation of correlation between the BCS and the functional type traits:

During the analysis of estimated body condition scores at type-classification I tried to find the correlation between the BCS and the linear type traits. Furthermore I examined the connection between the final class and the linear condition

3. The heritability of the body condition:

I tried to find the answer, how the heritability value of the condition varies in the different periods of lactation. Furthermore I examined the phenotypic and genotypic correlation between the estimated BCS on certain days of lactation.

In my work I try to demonstrate the, advantages, usefulness and practicality of the body condition scoring system. My objective is to popularize the method in our country.

III. THE METHODS OF THE RESEARCH

My examinations were carried out on three dairy farms of Pushkin Milk Ltd Szegvár Central Farm („A"), Sáp Farm („B"), Vangel Farm, („C"). During my work I performed body condition scoring (BRYDL (1994)) between 01/25/2007 and 10/27/2009. Body condition scoring took place in the same week as milk recording. Body condition scores were measured on a scale from 1 (thin) to 5 (fat) with increments of 0.5 (BRYDL, 1994). On farm „C" I recorded the body condition scores and the body weight as well. After body condition scoring on farm"B" I also recorded the data of lame cows. The data of measurements was recorded by RISKA dairy management software.

The results of livestock judging were processed from the data of Kinizsi 2000 dairy farm in Fábiánsebestyén („D") and the Vajhát dairy farm of Hódmezőgazda LTD Co. („E"). Livestock judging was done by the expert of the Holstein-Friesian Breeders Association.

BCS is considered to be a subjective measure of body tissue reserves (WALTNER et al., 1993; DOMECQ et al. 1997; KOMARAGIRI and ERDMAN, 1997; MARKUSFELD et al., 1997; PRYCE et al., 2001, DECHOW et al., 2002; VEERKAMP et al., 2002; BEWLEY et al., 2008; BEWLEY et al., 2010). Evaluating the reliability of the BCS evaluation several authors (AGABRIEL et al., 1986; TRACHSEL et al., 2000; VEERKAMP et al., 2002) made repeatability examinations. During my examinations the body condition scoring of 50 cows was carried out in three replications. Repeatability coefficients were calculated with the method adapted from ANTAL et al. (1978). According to my calculations the correlation coefficient was 0.84. In my study the data of the cows were grouped according to BCS.

I analysed the BCS at the different stages of lactation and I made the following groups:

- BCS at calving: The BCS at calving included the data of cows which were scored around the expected calving date ±10 days;
- BCS at milk recording
- Differences of BCS I.: BCS at milk recording- BCS at calving
- The smallest score measured after calving
- Differences of BCS II.: The smallest score measured after calving - BCS at calving

Furthermore I analysed which day of their lactation the cows reach the minimum of their body condition (energy-deficiency period)

I wanted to point out the connection between the BCS and the negative energy balance period.

I wanted to point out the connection between the milk quantity and the BCS at milk recording when examining the relationship between milk production and BCS Furthermore I examined the milk production yield on the 100th day of lactation with regard to BCS.

During the analysis of reproductive performance I introduced five reproductive parameters such as the number of days until the first insemination, the length of service intervals, the fertility index, the open days, and the number of pregnant cows, which became pregnant at the first insemination.

First I examined the difference between the farms then between the cows of different lactation. Next I examined the connection between the reproductive parameters and the BCS.

I analysed the interaction between the farms, the number of lactations and the BCS in all cases

I studied the relationship between body condition and weight; the data were processed with correlation analysis (Pearson's correlation coefficients) and linear regression analysis methods.

Regression analysis was applied to discover how much BW kg difference is associated with the differences in BCS at milk recording.

Furthermore, I showed the changing of the two parameters compared to that of the calving status.

I examined the tightness between BCS and BW changes with the method of correlation analysis.

I analysed the connection between the linear type traits, the final class and the linear condition.

In both cases I compared the difference among the scores of the lactations.

During the analysis of final class the details of the cows were grouped according to the BCS at classification. While examining the heritability of the condition, the dataset consisted of 1981 cows born of 420 bulls. I tried to find the answer, how the heritability value of the condition-change in the different periods of lactation.

BSC was carried out at parturition, on the 30th, 60th, 90th and 120th days of lactation. I examined phenotypic and genotypic correlation between the estimated BCS at the above-mentioned dates. The variance-covariance components were estimated with VCE-6 (Groeneveld et al. 2008) software.

SPSS for Windows 11.0 program was used for the analysis. The data were analyzed by the method of variance. The homogeneity was examined with of the Levene test. The Tamhane test (in case of heterogeneity) and the LSD test or Tukey-test (in case of homogeneity) were used to compare the group-pairs. The interaction between the farm and the other effects was

investigated with univariate analysis, multiple factor analysis of variance (Univariate) method. The relationship between variables was examined with correlation analysis tests (Pearson's correlation coefficient, Spearman's rho) and linear regression analysis.

The biometric calculations and notations required for data procession were used according the guidelines set by ANTAL et al. (1978), SVÁB, (1981) and (HUZSVAI, 2004-2010).

The results obtained during the tests are presented in tables or in graphical form. In the graphs the mean and the 95% confidence interval values are presented as well as the number of elements. Significant differences (P <5%) are marked with different letters. The formal establishment of the GIMP graphics was carried out using 2.6.11 editing program. The statistical techniques applied during the research are presented in Table 1.

Table 1. The used statistical techniques

Statistical methods		**Parameters**
One-Way ANOVA		Connection between the BCS and – milk production – the reproductive parameters – body weight – appearance parameters
Levene test	homogeneity of variance	
Tamhane test (in case of heterogeneity) and the LSD test or Tukey-test (in case of homogeneity)	compare the group-pairs	
Pearson’s correlation		
Multiple factor analysis of variance (Univariate)		The interaction between the farm and the other effects
Spearman's rho		Correlation between body condition and the appearance parameters.
Repeatability examinations		The reliability of the BCS
Linear regression analysis		Correlation between body condition and live weight
Estimate of the variance-covariance components		The heritability of the condition and the phenotypic and the genotypic correlation
Normality test		Distribution analysis

IV. THE MAIN OBSERVATIONS IN THE PAPER

Relationship between BCS and daily milk yield

In the first part of my investigation I was trying to find out to what extent the current nutritional status of the cows influence their daily milk production. I was looking for a connection between the body condition at calving and milk production as well as body condition change and milk production. I also examined whether the production of cows and their body condition differ on each farm, and I tried to find a relationship in the joint effect of the farm and the body condition.

The average milk yield of the farms and the average body condition are shown in Figure 1.

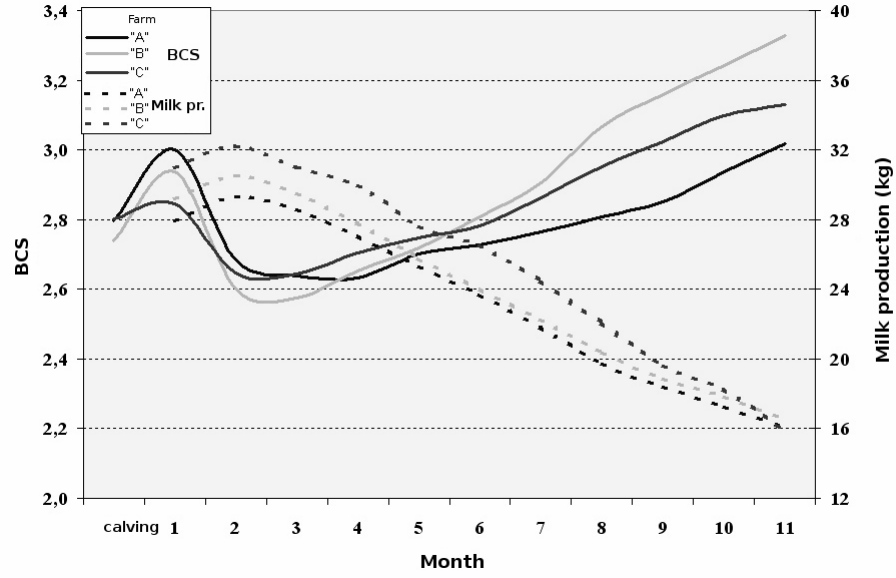
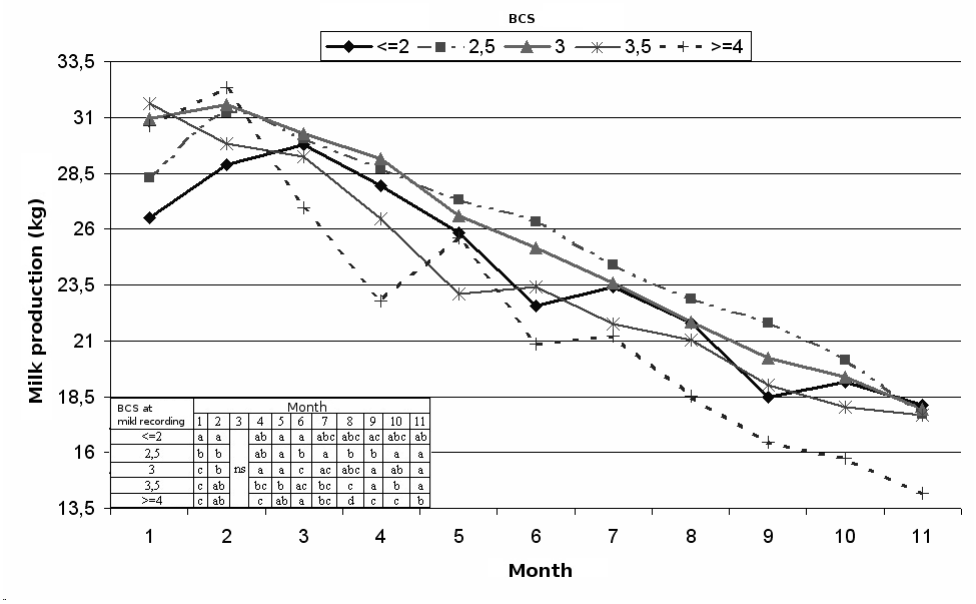


Figure 1. The lactation curve and the BCS on the farms examined

The lactation curve is similar on all three farms. The peak of milk production was achieved in the second month of lactation, and then a gradual, but very steep decline followed. When comparing the data of the three dairy farms we can see that the results of farm "C" stand out. During the first two months between each of the three plant production significantly (P <5%) experienced a difference. At the middle stage of lactation, it was only the production of farm "C" that was different from the other two. At the end of lactation milk production showed no difference between the stocks. The lowest body condition scores of the cows occurred at the same time as they reached their peak milk yield.

When examining the relationship between the daily milk yield and the body condition I found that the measured milk amount at the milk recording in certain stages of lactation differs depending on the nutritional treatment of the cows. The results are shown in Figure 2. At the first milk recording the largest (31.62 kg) milk yield was produced by cows belonging to the 3.5 BCS group. Analyzing the second milk recording I found that those cows produced the most milk (32.32 kg), the condition of which was 4.0 BCS or higher. The largest milk yield difference (3.45 kg) in this month was found between cows of the smallest and the largest BCS, but this difference was not significant.



BCS at mikl recording	Month										
	1	2	3	4	5	6	7	8	9	10	11
<=2	a	a		ab	a	a	abc	abc	ac	abc	ab
2,5	b	b		ab	a	b	a	b	b	a	a
3	c	b	ns	a	a	c	ac	abc	a	ab	a
3,5	c	ab		bc	b	ac	bc	c	a	b	a
>=4	c	ab		c	ab	a	bc	d	c	c	b

Figure 2. Milk production parameters with regard to body condition at milk recording

At the third measurement the relationship between milk production and body condition was not identified. At the next milk recording the cows in the 3.0 BCS group got to the first place in milk production. During the remainder of lactation the most milk was produced by cows, with body condition 2.5. The worst production indicators were found in the last (BCS> 4) group of cows.

The relationship between the BCS at calving and the daily milk yield was evaluated and illustrated in Figure 3, where the differences between groups were also presented. Based on the variance analysis of I concluded that the groups formed on the basis of body condition at calving there is a significant difference in milk production until the seventh month of lactation. Subsequently, the relationship between these two parameters was not confirmed.

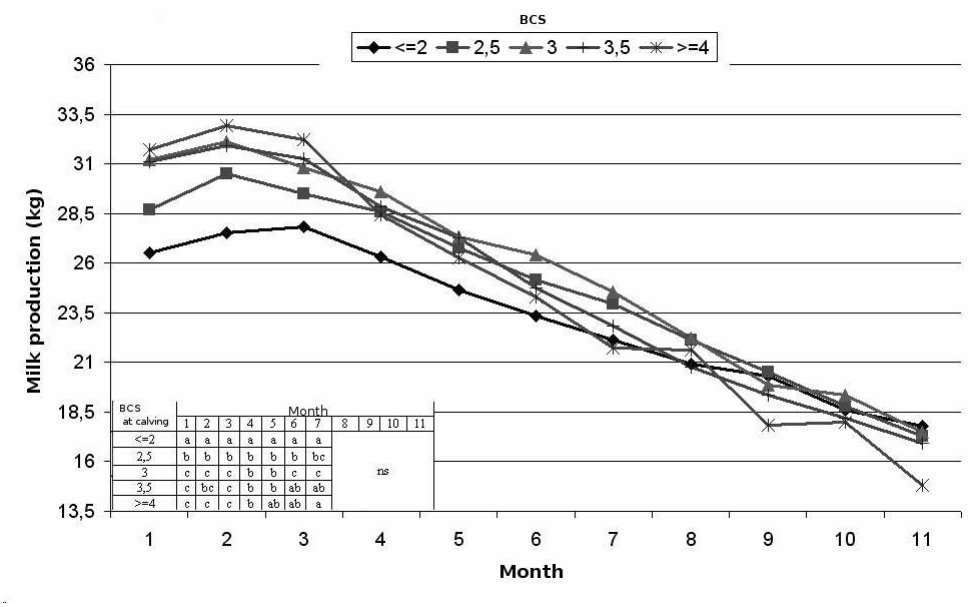


Figure 3. Milk production parameters with regard to body condition at calving

The least amount of milk was produced by the cows with a BCS below 2.5 at calving. These results coincide with that of WALTNER et al., 1993; RUEGG és MILTON, 1995; BEWLEY és SCHUTZ, 2008, so the cows with low BCS at calving (BCS<2.0) are not able to fulfil their potential milk production.

At the beginning of lactation the highest amount of milk was produced by cows with the largest BCS at calving (BCS> 4). However after the third month of lactation the production of this group decreases the most spectacularly. Considering all the above we can conclude that at the beginning of the lactation the cows used up the accumulated fat reserves for the production needs, but later as these fat reserves disappear and the milk production decreases because of liver steatosis.

All body condition changes of cows mean a reaction to the changes in the body or in the environment. It is especially important to follow the body condition changes at the beginning of lactation, since in this period the energy uptake of the cows is not able to cover their energy needs. In the examined stocks the condition changes are shown as compared to the status at calving; the results are shown in Figure 4.

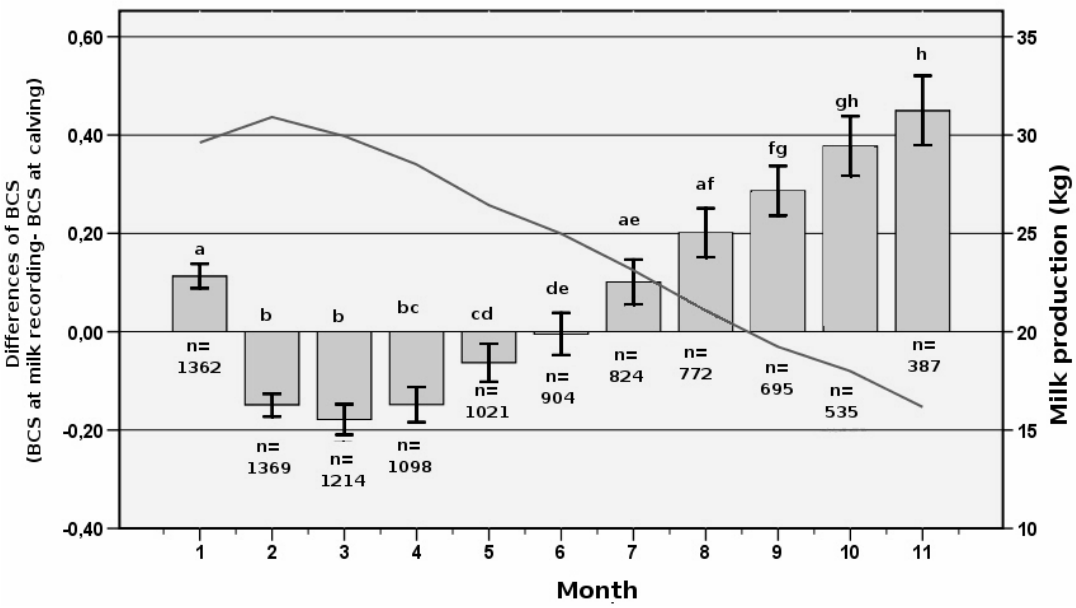


Figure 4. Daily milk production and body condition changes during lactation

In the first month of lactation there is an improvement in the body condition of the cows, while in the following two months a decrease can be observed. In spite of the fact that the peak yield appeared in the second month the body condition started to improve only from the fourth month of lactation. The body condition the cows had at calving was reached again only in the sixth month. It was followed by a steady increase.

Relationships between body condition and the 100-day lactation milk production

While studying the correlation between body condition and the milk yield produced until the 100th day of lactation I tried to find out how the body condition at calving, the lowest body condition after calving and the changes between the two influenced the milk production of the stocks. Furthermore I examined the effect of these body condition changes on the length of the energy deficiency period. Milk production until the 100th day is similar on all farms as it shows in the daily results (Figure 1). The highest amount of milk was produced on farm “C”, 247 kg more than on farm “A” and 186 kg more than on farm “B”. This difference was confirmed numeracy-statistically on level P <5%.

The cows were divided into five groups according to their estimated body condition at calving BCS=2 (n=184), BCS=2.5 (n=798), BCS=3 (n=488), BCS=3.5 (n=137), BCS> 4 (n=81). The results are consistent with the statements of PEDRON et al., (1993); RYAN et al., (2003); ROCHE et al., (2004)) who reported positive correlation between milk production and BCS at calving.

When examining their body condition at calving and their milk yield I found that the amount of mild increased together with the increasing body condition. The production difference, however, was not significant in groups of higher BCS. The longest energy-deficiency period (75.4 day), occurred in case of cows with the highest BCS (BCS>4). These results coincide with the statement of Roche et al.(2009), so a higher BCS level at calving are associated with a larger negative energy balance duration.

No significant difference was observed in the milk yield of the groups with the lowest after-calving BCS (BCS=1.5-2 (n=415); BCS=2.5 (n=1098); BCS=3.0-3.5 (n=169). The bottom was reached sooner by the cows with the lowest BCS, which was 2.5 volt (38.5 day). The energy deficiency period was the longest in case of cows with a BCS of 1.5–2.

The data of the cows were divided into four groups based on the BCS at calving and the lowest BCS, $BCS_{changing}$ =0 (n=951), $BCS_{changing}$=0.5 (n=471), $BCS_{changing}$=1 (n=164), $BCS_{changing}$ =1.5-2 (n=85). The milk yield of the cows was between 2937 kg and 3293 kg, which were increasing together with the decreasing BCS, thus proving the unselfish characteristic of the species.

In case of cows whose BCS did not decrease after calving, the improvement in BCS started on the 22nd day after calving. In case of the next group ($BCS_{changing}$ =0.5) the energy deficiency period was 40 days longer than that of the previous group. However, in case of those, where no BCS decrease was found, there was no significant difference in the length of body condition change.

Body condition in different lactations

I examined the milk production of the different lactation cows (cows in 1.; 2. and 3. lactation) and their body condition. The results are presented in Figure 5.

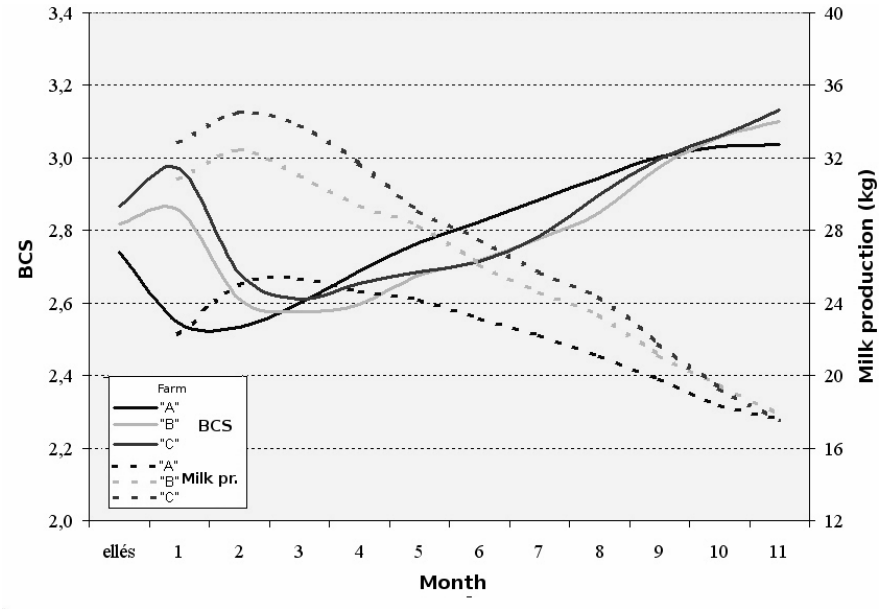


Figure 5. Daily milk yield and BCS at milk recording in different (1., 2., 3.) lactations

The cows reached their peak yield in their third lactation. The production of the first lactation group is significantly behind the ones that calved several times. It can also be observed that the curve of the first-calving cows is less steep than that of the ones that calved several times.

We can also observe body condition differences depending on which lactation the cows have; the improvement of the body starts from the third month. The first-lactation cows are exceptions since their condition begins to improve as early as in the second month.

Body condition at calving was different by lactations. Cows in their firs lactation had the lowest body condition (2.74). In further lactations the nutrition status of the animal showed an improving tendency. The statistical analysis proved a significant difference between the data of the first-calving cows and the ones that calved several times. The lowest BCS after calving did not show a significant difference, the average value was between 2.44 and 2.46.

The least favourable body condition status was observed in the third lactation ($BCS_{changing}$=0.43).

It must be highlighted, however, that even the results of the first-lactation cows, which show the best parameters, is only 0.13 better than that of the previously presented group, while on P <5% level this difference proved to be significant.

Finally, while examining the different lactations, I tried to find out how the energy deficiency period changes. The first-lactation cows were in negative energy balance for the shortest time (42.24 days), while the third-lactation cows for the longest time (50.62 days). The statistical analysis confirmed significant difference only between these two groups on level P <5%.

Relationship between body condition and reproduction

When examining the correlation between body condition and reproduction I analysed four parameters on all farms with regard to the number of lactations, and my results are presented in Table 2. Next I tried to find correlation between body condition and reproduction (Figures 6-8).

Table 2. Reproduction parameters on the farms with regard to the number of lactations

Parameters		Farm			Lactation number		
		"A"	"B"	"C"	1.	2.	3.
		n=446	n=308	n=351	n=323	n=263	n=200
Days to first service	$\bar{X}$±s	103.3±41.4 [a]	103.2±41.3 [a]	96.6±43.1 [b]	102.1±41.9	99.6±45.8	103.4±40.2
Open days (day)	$\bar{X}$±s	157±74.7 [a]	152±75.5 [ab]	143±73.7 [b]	148.6±74.2	153.7±81.2	154.8±73.4
Service period (day)	$\bar{X}$±s	53.9±64.9	49.3±65.8	46.1±60.3	46.5±64.1	54.1±69	51.4±63.3
Fertility index	$\bar{X}$±s	2.4±1.65 [a]	2.12±1.49 [ab]	2.19±1.45 [a]	2.1±1.4	2.4±1.8	2.4±1.6
Pregnant to first service (%)	$\bar{X}$±s	37.6%	43.2%	41.9%	44.6%	41.4%	39%

Values indicated with different letters differ significantly (P<5 %)

The number of days between the service period (the period between calving and the next pregnancy) and the first insemination is the lowest on farm “C”. The latter one is significantly different from the average of the other two farms. The service period shows mathematical-statistical difference only in case of the stocks on farm “A” and on farm “C”. From the results of the groups made on the basis of the lactation number I observed that the reproduction parameters of the first-lactation cows are the best, with the exception of the days until the first insemination. The variance analysis did not confirm significant difference between either parameter of the different lactation cows.

The BCS of the cows at calving changed between 2 and 5. When making the groups I put the animals with 3.5 and 5 BCS into the same group because of their low number (n=50). The data are illustrated in Figure 6. The number of the days until the first examination is significantly different among the groups (P <5%). This period is the shortest in case of cows with 2.5 and 3.5 BCS. The involution period was the longest in case of cows with 2 BCS. When comparing the groups, significant difference can be found between the group pairs 3.5-2 and 2.5-2.

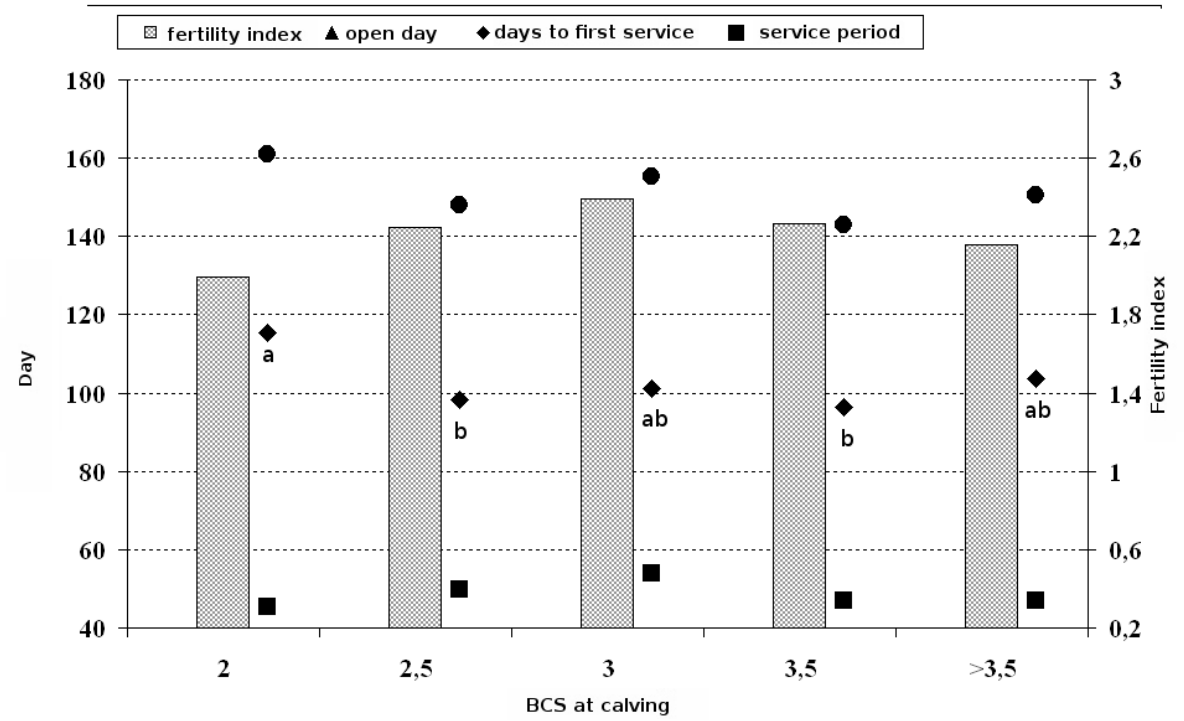


Figure 6. Reproduction parameters with regard to the BCS at calving

The number of inseminations is varied according to the individual cow; in the present stock it is between 1 and 12. 40.4% of the cows got pregnant at the first insemination. At calving, (extreme values of body condition) extremes are represented by the groups 2 BCS (44.9%) and >3.5 BCS (36%). When examining the body condition at calving, the fertility index extremes have an average between 1.99 and 2.39. We can claim that the insemination index of the stock is quite favourable.

Out of the groups made according to the BCS at calving the cows with 3.5 BCS got pregnant within the shortest time (service period), however, no significant difference is confirmed among the groups. The extremes are represented by the cows with 3.5 and 2 BCS (146 and 164 days, respectively).

When grouping the cows on the basis of the lowest BCS it can be observed that the number of days until the first insemination is most favourable in case of the animals with a BCS not lower than 3. In this group it can also be observed that this period falls into the ideal 70-90-day interval (BÁDER et al., 2004). Between the group pairs the statistical trial confirmed a significant difference (P <5%).

In case of the insemination index I got opposite results to that of the number of days until the first insemination. Here the lowest value appeared in the group of cows with 1.5-2.0 BCS.

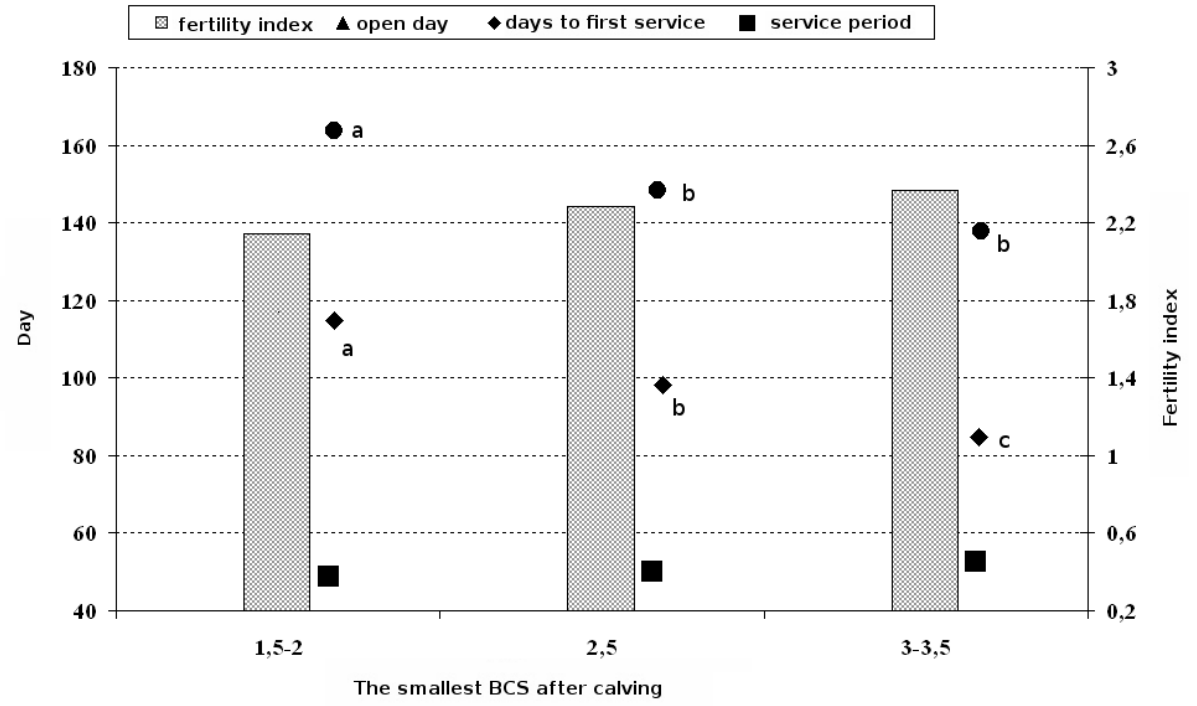


Figure 7. Reproduction parameters with regard to the lowest BCS after calving

When demonstrating the percentage of the inseminations within the groups, in case of the first group 41.9% of the cows got pregnant at the first insemination, while in case of cows with 3-3.5 BCS this ratio was 31.1%. The results of the cows with 2.5 BCS were only a little behind the results of the 1.5 BCS cows, considering both the insemination index and the pregnancy numbers. 21.7% of the cows with 3-3.5 BCS needed at least four inseminations to get pregnant. This rate was 13.3% and 17.4% in the other two groups, respectively. The variance analysis, however, did not confirm significant correlation in the changes of the insemination index.

When examining the time of the new conception the variance analysis confirmed a significant difference between the group of 1.5-2.0 BCS cows and the groups with higher BCS.

The shortest service periods occurred with cows with the lowest BCS not lower than 2.5-3.0 after calving.

There is a ten-day difference between the average service periods of the BCS groups of 2.5 and 3-3.5, but it did not prove to be significant.

Next I examined the effect of the difference between the lowest BCS after calving and the BCS at calving; the values are shown in Figure 8.

When analysing the BCS changes it can be observed that conception occurred at latest in the cows with a BCS loss more than 1. This result confirms the negative correlation between milk

yield and reproduction, while being in energy deficiency period the animal will not be conceived. No significant difference was found, however, between the groups with deteriorating BCS after calving.

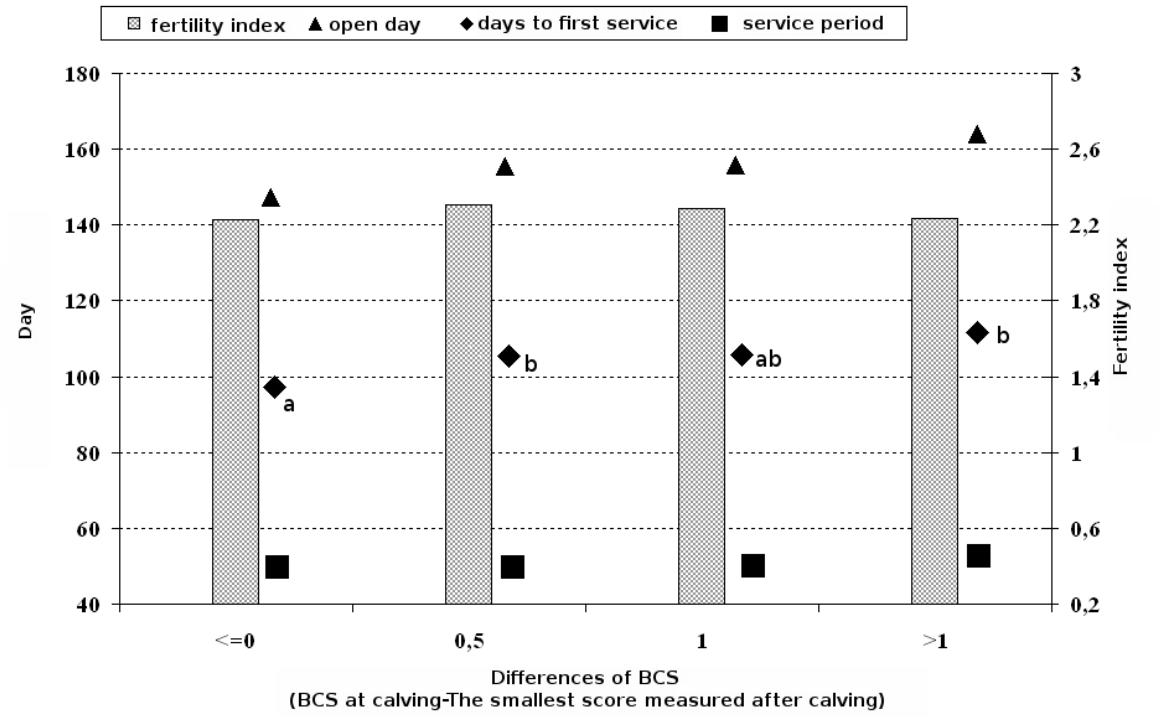


Figure 8. Reproduction parameters with regard to the decreasing BCS after calving

When looking at the insemination index we can find that there is no considerable difference between the examined parameters of the groups. The difference between the extremes of the averages is only 0.08, therefore the condition change after calving obviously does not have any effect on the insemination index. Considerable differences can be found exclusively in the reliability interval in groups that lost one or more BCS; their values are 1.96-2.61, and 1.88-2.59 respectively.

When examining the correlation between body condition change and the number of the days until the new conception it can be observed that after calving those cows got pregnant again within the shortest time (147 days), which did not lose their BCS after calving. The group that lost the most BCS got pregnant again averagely after 165 days. The widest confidence interval can also be observed in this group. However, the differences between the averages were not confirmed numeracy-statistically.

To sum up my results and other literature references (BUCKLEY et al. (2003), SAMARÜTEL et al. (2006); SANTOS et al. (2001)) I concluded that the decreasing BCS affect negatively the reproduction parameters.

Relationship between body condition and live weight

In the study I tried to find a correlation between the live weight and the estimated BCS as well as between the BCS and live weight changes. The data were analysed separately in the first, second and third lactation. The results are shown in Table 3-5 and in Figure 9.

In the first lactation period the live weight of the cows changed between 400-540 kg at calving. In the postpartum period a steady increase in the body weight can be observed (Table 3). Further on in the lactation period the weights of the cows differ significantly compared to their weight at calving (except for the first month).

Table 3. Changes in live weight and BCS during the lactation and the phenotypic correlation between the two characteristics (Lactation 1)

		BCS	BW (kg)	Phenotypic correlations between BW and BCS
Month of lactation	n	$\bar{X}$ ±s	$\bar{X}$ ±s	
0 (calving)	81	2.40±0.41[a]	459±45.6 [a]	0.734**
1	43	2.50±0.53 [ab]	478±50.31 [ab]	0.680**
2	84	2.37±0.33 [ab]	491±53.19 [bc]	0.504**
3	108	2.85±0.64 [abc]	538±38.45 [cd]	0.544**
4	100	2.69±0.74 [abc]	525±47.67 [cd]	0.475**
5	84	3.00±0.32 [c]	553±44.29 [d]	0.452**
6	82	3.04±0.51 [c]	558±67.10 [d]	0.628**

** P <1%

Values indicated with different letters differ significantly (P<5 %)

The correlation analysis confirmed a tight positive correlation between the body weight and body condition at calving.

At certain stages of lactation the BCS differences can be associated with certain body weight differences; to determine this I applied regression analysis method. In the first lactation the BCS of the cows changed between 1.5 and 4.0 the strongest correlation was found between the body weight and the body condition at the first milk recording (r^2 =46). The value of the regression coefficient was the highest this month (89 kg).

The body weight of the second-lactation cows changed between 420 kg and 760 kg in the examined period, however the average weight was between 539 kg and 601 kg. Significant differences could be observed only between the body weight at calving and in the second month and also between the body weights in the second and after the fifth months (Table 4).

Table 4. Changes in live weight and BCS during the lactation and the phenotypic correlation between the two characteristics (Lactation 2)

		BCS	BW (kg)	Phenotypic correlations between BW and BCS
Month of lactation	n	$\bar{X}$ ±s	$\bar{X}$ ±s	
0 (calving)	87	2.77±0.78 [a]	601±64.0[a]	0.496**
1	37	3.60±0.75[b]	586±79.48[abc]	0.529**
2	50	2.50±0.52[acd]	539±55.83[b]	0.233**
3	58	2.32±0.46[c]	*557±68.72*[bc]	0.650**
4	59	2.54±0.48[acd]	572±67.96[abc]	0.676**
5	64	2.64±0.84[acd]	561±92.14[abc]	0.448**
6	72	2.90±0.55[ad]	592±70.86[ac]	0.351**

** P <1

Values indicated with different letters differ significantly (P<5 %)

The body condition improved almost by one BCS after calving, while in the following month it decreased exactly by the same value. The status they had at calving is restored only after the fifth month of lactation.

In the second lactation the values of BCS were between1,5 and 5,0. When comparing the data by milk recordings the 0.5 BCS difference proved a body weight difference between 24 kg and 84 kg. In the regression functions the regression constant extremes were between 360 kg and 488 kg.

The body condition of the third-lactation cows (Table 5) was increasing after calving (by 0.4 on average), then a decrease followed until the fourth month. By then the cows reached the body condition they had had at the beginning of the lactation. The variance analysis did not confirm a significant difference between the body condition scores of the period after the first and before the fifth months.

Table 5. Changes in live weight and BCS during the lactation and the phenotypic correlation between the two characteristics (Lactation 3)

		BCS	BW (kg)	Phenotypic correlations between BW and BCS
Month of lactation	n	$\bar{X}$ ±s	$\bar{X}$ ±s	
0 (calving)	69	2.46±0.58[a]	592±62.6[a]	0.692**
1	45	2.86±0.72[b]	589±72.07[ab]	0.444**
2	52	2.30±0.42[a]	555±64.51[a]	0.565**
3	53	2.21±0.39[a]	557±75.88[a]	0.503**
4	50	2.58±0.47[ab]	597±77.62[ab]	0.551**
5	53	2.79±0.39[ab]	624±88.48[ab]	0.558**
6	45	3.01±0.53 [b]	638±69.63[b]	0.389**

** P <1%, Values indicated with different letters differ significantly (P<5 %)

The largest difference between the body weights during the lactation was 83 kg (2nd and 6th months, and this difference proved to be significant (P <5%). Based on the results of the correlation between the parameters we can claim that the strongest correlation is between the BCS at calving and the body weight at calving (r=0.69). The BCS at the weighing show a medium tightness with the body weight, the correlation coefficient values change between r=0.40 and r=0.57.

The extreme values of BCS were 1.5 and 4.5. The body condition difference (0.5 BCS) confirmed 39 kg and 86 kg body weight differences in various periods of the lactation.

When examining BW, I found coincidence between my and HORAN et al. (2005) work, namely, the lactation number affected the body weight changes from calving to the peak of the lactation. Meikle et al. (2004) also found a tight relationship between body weight and body condition independently from the number of lactation (r = 0.76 in first lactation and r = 0.74 in later lactation).

With the examination of the BCS and live weight correlation I tried to fin out how the BCS at calving and the body weight at calving change together during the lactation. The results were presented in Figure 9.

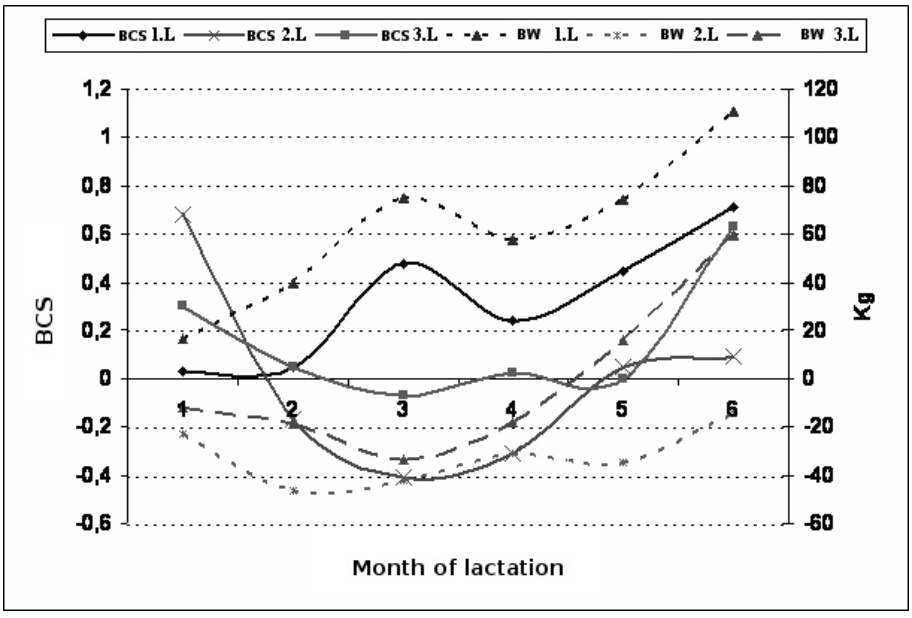


Figure 9. Changes in live weight and body condition compared to the status at calving

In the first lactation the BCS changed between 0.03-0.71, while the extreme values of body weight were between 17 kg and 110 kg. A slight decrease can be experienced in case of both parameters in the 4th month of the lactation. The increase in body weight can be associated

with the growth of the cows. The statistical analysis confirmed a significant difference both in case of BCS and the live weight.

It is clear from the correlation analysis that the live weight change is in close connection with the body weight at the milk recording (r=0.69) and the BCS change (r=0.64). The BCS obtained at the livestock-judgement is only in medium correlation (r=0.41) with the body weight change.

In the second lactation the body weight changes show an opposite tendency to that of the data of the first-calving group. The average live weight of this groups decreasing until the second month postpartum, then it is improving in the third and fourth months. It is again followed by a fall-back, and then finally the body weight is growing from the fifth month of the lactation. However, the cows do not reach the status they had at calving. The change did not prove to be significant in either case. The results of the correlation calculation show a less tight correlation (r=0.52; r=0.50) between certain variables than it was with first-calving cows. A medium-tight negative correlation (r=-0.63) was found between the body condition at calving and the body condition change.

When examining the results of the third lactation it can be observed that the body weight loss occurs after calving in this lactation as well. The cows reach their body condition at calving after the fourth month and then a considerable improvement follows as a tendency already experienced in the first lactation.

The tendency is similar in case of the changes in body condition and body weight except for the period between the 4^{th} and 5^{th} months, when a light decrease can be found in the body condition with a steadily increasing body weight.

The correlation examinations confirm a tight (r=0.65) correlation between the body weight change and the instantaneous situation.

The relationship between the body condition and the appearance parameters

When examining the appearance parameters I tried to find out what effect the body condition has on the descriptive linear characteristics and the main judgement characteristics.

In the results of the descriptive linear characteristics I found differences between the ones with different lactation numbers. The average values of the characteristics are seldom in the ideal interval. The body condition is the most favourable in the first lactation, later it decreases. The results of the rank correlation analysis in the first and second as well as the first and third lactations confirmed a medium or tight correlation. Considering the BCS there

is a loose correlation (r_r=0.29) between the first and second lactation, while there is a medium (r_r=0.50) correlation between the first and the third lactation. These results suggest that we can not predict the further lactation results on the basis of the estimated body condition in the first lactation.

The results of the relationship between the body condition and the linear descriptive characteristics in case of body measurement are weak (r=0.09), or medium (r=0.29) and except for the angularity (between r=-0.39 and r=-0.50) they are positive. Pryce et al. (2000) also found a negative relationship between body condition and sharpness.

The relationship between stature and body condition is not confirmed, the strength shows weak correlation, the value of the correlation coefficient is the largest in the first lactation. KADARMIDEEN and WEGMANN (2003) also showed a loose correlation (r = 0.17), however DECHOW et al. (2003) obtained a tight relationship (r=0.73) between the two parameters.

The relationship between the body condition and the main judgement characteristics (with regard to this examination) was illustrated in Figure 10-12.

The values of the body score (Figure 10) change between 77.58 and 84.23. It can be observed that the increasing number of lactation as well as the improving body condition has a positive effect on the body score.

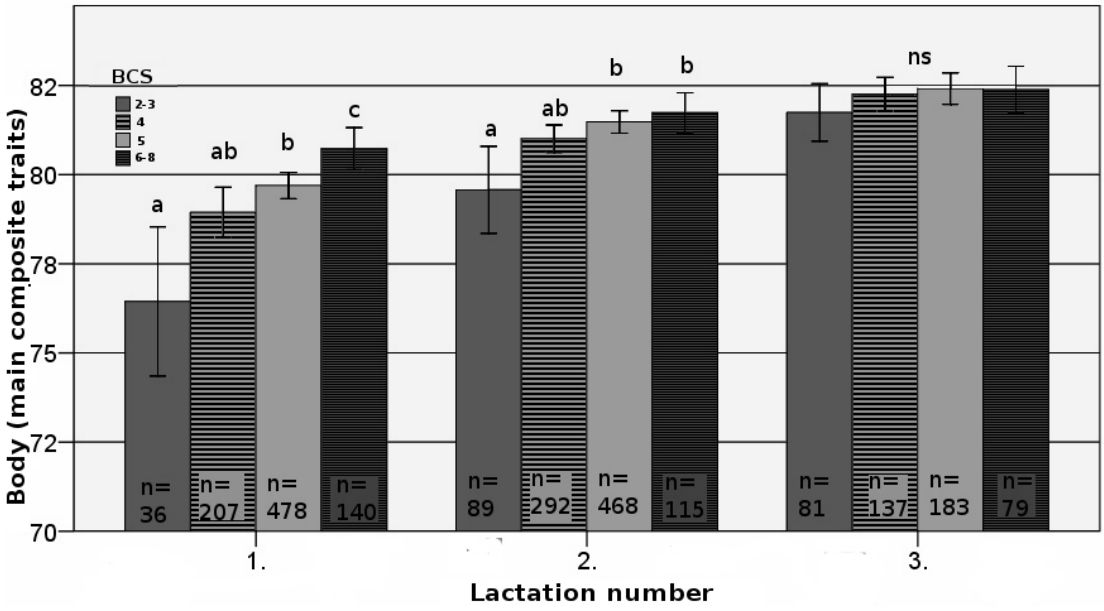


Figure 10 Body score of cows with different BCS in each lactation

In the figure it is visible that the strongest correlation is between the body condition and the body score of the first lactation cows. Significant difference was found in case of the second-lactation cows. There is a loose correlation between the body condition and body score in the first (r=0.20) and in the second (r=0.14) lactation. In the third lactation there is no correlation (r=0.06) between the two characteristics.

When analysing the relationship between the legs and the body condition I also concluded that the improving body condition has a positive effect on the legs. The legs of the cows with 2-3 BCS significantly (P <5%) falls behind the groups with a higher body condition. With the changes in the number of lactations no considerable difference can be detected in the legs. The correlation analysis confirms a positive, medium tightness in the relationship between the body condition and the legs, (between r=0.19 and r=0.31) within the lactation groups. The results suggest that the food uptake of the cows with better-structured, normal feet is higher than that of the animals with a worse foot-structure.

When investigating the relationship between the body condition and the dairy strength. I found a negative correlation between these two characteristics. (Figure 11)

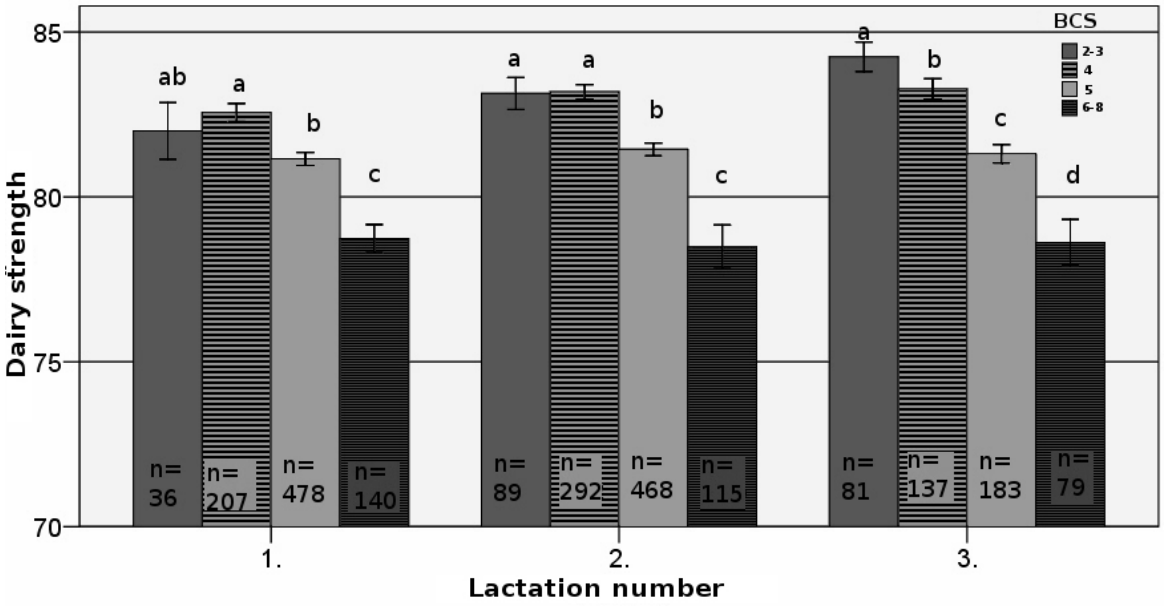


Figure 11 Dairy strength values of cows with different BCS in each lactation

The results of Figure 11 demonstrate the unselfish character of the animal. The most scores for dairy strength were given to the cows that obtained only two, three or perhaps four linear score at the body condition scoring. Concerning the tightness of the relationships there are medium correlations in each lactation; a negative correlation (with extremes of r=-0.51 and r=-0.57) was confirmed between the dairy strength and the body condition. The strongest

relationship is in the third lactation (r=-0.57). These results are identical to those of DECHOW et al. (2003)(r= -0,73) és KADARMIDEEN and WEGMANN (2003) (r=-0,35).

Considering the udder scores there is no significant difference between the results of the first and second lactation cows. Following the third lactation the udder scores are significantly behind that of the previous lactations. Even the highest value is below the value of the 'good' class that is below 75 scores. When comparing the udder scores of the cows from BCS point of view there is a tendency of the low body condition associated with a low udder score. The correlation analysis confirmed only a loose correlation (r=0.03 and r=0.13 between the udder score and the body condition.

When examining the final class (Figure 12) it was again the scores of the cows with the weakest condition that were the lowest. It is especially true for the first lactation cows. In the first lactation the most scores were given to the group with the ideal (5) body condition. The variance analysis confirmed a significant (P <5%) difference between the groups.

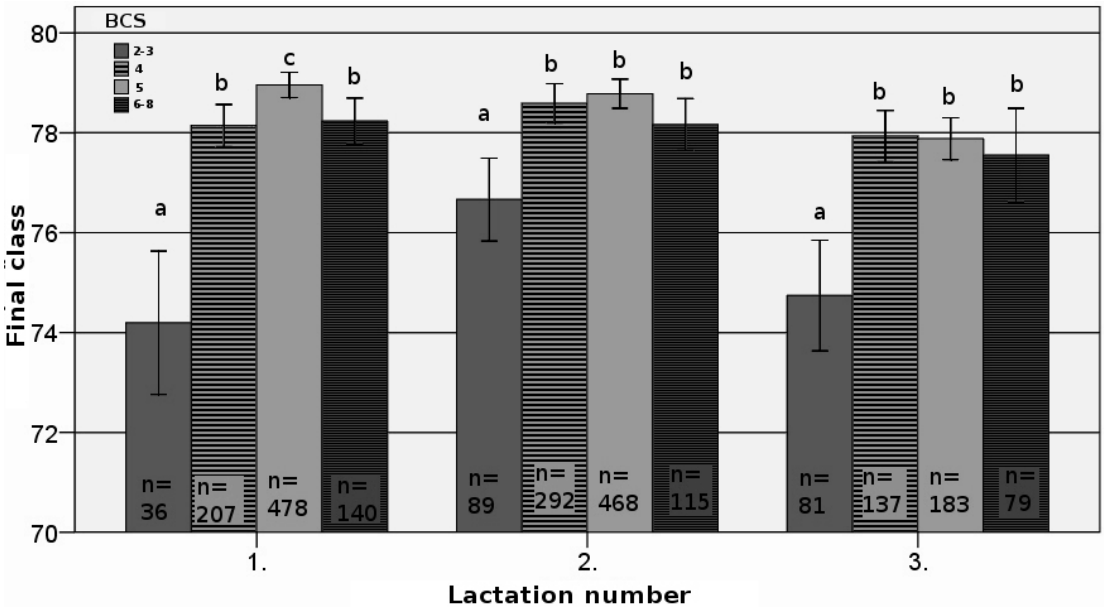


Figure 12 Final class of the cows with different BCS in each lactation

No significant difference was confirmed between the second-lactation groups made according to the body condition. Exceptions are the cows with 2-3 BCS, since their final classes are different from that of the other groups and this difference is statistically confirmed. The Final class of the third-lactation cows follows a similar tendency as the second-lactations ones. When examining the tightness of the correlations we can claim that regardless of the number of lactation there is a weak positive (r=0.09 and r=0.16) correlation between the linear BCS and the final class. Also loose or very loose relationship has been reported between the

condition and the final score in the work of DECHOW et al. (2003) (r = 0.08), KADARMIDEEN and WEGMANN (2003) (r = 0.13), and VEERKAMP BROTHERSTONE (1997)(r =- 0.07).

The heritability of the body condition

In the next part of my examination I investigated how the h^2 value of the body condition changes from calving to the 120th day of the lactation. The results of the examination are compiled in Table 6.

Table 6. BCS heritability values on certain days of lactation (on the diagonal), genetic (above the diagonal), phenotypic (under the diagonal)

	BCS (calving)	BCS (30th day)	BCS (60th day)	BCS (90th day)	BCS (120th day)
BCS (calving)	**0.25**	0.68	0.47	0.64	0.68
BCS (30th day)	0.36	**0.43**	0.72	0.89	0.78
BCS (60th day)	0.24	0.55	**0.49**	0.80	0.61
BCS (90th day)	0.31	0.49	0.59	**0.38**	0.95
BCS (120th day)	0.22	0.43	0.52	0.62	**0.41**

The heritability value of body condition is between 0.25 and 0.49. I obtained the highest h^2 value in case of BCS in the third month of lactation. Considering the results we can conclude that the h^2 value is the lowest at calving since the environmental conditions determine the body condition in this period much more than the genetic basis. The body condition at calving is in medium genotype correlation with the body condition in later stages of lactation, the strongest correlation (r=0.68) was observed with the BCS on the 30th and on the 120th days of lactation. The strongest genotype correlation (r=0.95) was observed between the BCS on the 90th day of lactation and that of the 120th day, while the correlation between the 90th and 60the day BCS is also very tight. Phenotypic correlations show a medium tightness except for that of at the calving.

V. THE NEW SCIENTIFIC RESULTS OF THE PAPER

Based on the examinations during my research I can conclude that:

1. The least of all uneven milk production during the lactation was observed between 2.5 and 3.0 BCS. The amount of milk produced until the 100th day of the lactation was unfavourably affected by the low body condition at calving (BCS=2.0).
2. The length of time until the first insemination was negatively influenced by the body condition decrease after calving. This period was the shortest in the groups with BCS 2.5-3.5 at calving. The fertility index was not affected by the BCS.
3. There was medium or tight correlation (r=0,49-0,56) between the body condition and the body weight at calving. In different stages of lactation the 0.5 BCS difference meant 24 kg (2. lactation) and 89 kg (1. lactation) body weight difference with the different number of lactation.
4. The result of the type classification are decreasing with the increasing number of lactation; the linear characteristics show loose correlation with the body condition. The condition has loose negative correlation with the angularity and loose positive correlation with the strength.
5. The increase in the number of lactations as well as the improving body condition had a positive effect on the body score. When investigating the relationship between the body condition and the dairy strength a negative correlation was found between these two attributes. Therefore I suggest that classification should be made later, probably in the 5th or 6th month of the lactation.
6. The heritability value of body condition is between 0.25 and 0.49. Body condition scoring should be carried out after the 30th day of lactation as the genetic difference between the animals can be seen better in this period.

VI. THE APPLICATION OF THE RESULTS IN PRACTICE

The results of my study show that the body condition of the cows can be associated with their mild production and their reproduction as well. I found correlation between body weight and body condition. The above mentioned correlation can be utilised especially well in case of dairy stocks where weighing the cows would mean extra labour and unnecessary disturbance of the animals. The estimated body condition scores at type-classification can be utilised as valuable information sources because the dairy type can be detected with them. Based on the findings of the heritability examinations the breeders can also detect genetic differences in their stock using the results of the judgement made around the 30^{th} day of lactation.

Based on this research the integration of the regular body condition scoring into the technology is especially important. The results of livestock judgement should be evaluated periodically (after the milk recording, when the animals are selected into feeding groups). To sum up, the level of management can be controlled by using the BCS system

VII. PUBLICATIONS IN THE THEME OF THE DISSERTATION

Reviewed scientific publications

- MIKÓ, J.-né (2006): A tejtermelő szarvasmarhatartás adatgyűjtésének és feldolgozásának fejlődése. Agrár- és Vidékfejlesztési Szemle. 1. évf. 2006/1. sz. 21-26 p. ISSN 1788-5345.
- MIKÓ, J.-né (2007): A hazai holstein-fríz állományok tenyésztésének kiemelt területei – I. Szaporasági mutatók elemzése. Agrár- és Vidékfejlesztési szemle. A SZTE MGK Tudományos Folyóirata 2. évf. 2007/1. sz. 11-16 p. ISSN 1788-5345.
- MIKÓ, J.-né – KOMLÓSI, I.– MUCSI, I. (2007): Hazai holstein-fríz állományok tenyésztésének kiemelt területei: II. A tehenek kondíciójának vizsgálata. Agrár- és Vidékfejlesztési Szemle. A SZTE MGK tudományos folyóirata. 2. évf. 2007/2. 135-139. ISSN 1788-5345.
- MIKÓ, J.-né – MUCSI I. – KOMLÓSI I (2008): Holstein-fríz tehenek kondíciópontszámának értékelése Agrártudományi közlemények (31.) Acta Agraria Debreceniensis 2008/31 57-61. ISSN 1587-1282
- MIKÓ, J.-né – MUCSI, I. - KOMLÓSI, I (2009): A tejelő tehenek kondíciópontozásos rendszere (irodalmi áttekintés) Agrár- és Vidékfejlesztési Szemle. A SZTE MGK tudományos folyóirata. 4. évf. 2009/2. 145-156 p ISSN 1788-5345.
- MIKÓ, J.-né - MUCSI, I. - KOMLÓSI, I (2009): A tehéntej mennyiségi és beltartalmi értékeinek valamint az állat kondíciójának alakulása a laktáció során Agrártudományi közlemények Acta Agraria Debreceniensis 2009/37. 69-73 p. ISSN 1587-1282
- MIKÓ, J.-né – MUCSI, I. – KOMLÓSI, I (2010): Holstein-fríz tehenek ellés utáni kondícióváltozásának és reprodukciós mutatóinak kapcsolata Agrártudományi közlemények Acta Agraria Debreceniensis. 2010/40.49-52 p. ISSN 1587-1282
- MIKÓ, J.-né – MUCSI, I. – SZENDREI, Z.– KOMLÓSI, I (2010): Az ellés utáni kondícióváltozás és a tejtermelési mutatók kapcsolata Holstein-fríz tehenekben (Correlation between body condition change and milk production parameters of Holstein-Friesian cows after calving) Állattenyésztés és Takarmányozás 59. 5–6. 373–385.p

Conference proceedings in Hungarian

- KISS, E-né – MIKÓNÉ JÓNÁS, E. (2006): Holstein-fríz génösszetételű tehénállomány laktációs tejtermelési és szaporodási mutatóinak elemzése. XXXI. Óvári Tudományos Nap. 2006. okt. 5. Mosonmagyaróvár. Előadások és poszterek összefoglaló anyaga 43 p. (Teljes anyag CD-n is).
- KISS E.-né, MIKÓNÉ JÓNÁS E. (2006): A laktációs tejtermelési színvonal hatása holstein-fríz génösszetételű tehénállomány szaporodásbiológiai paramétereire. (The effect of the lactation standard on the reproductive parameters of Holstein-Friesian dairy cows). Kérődző állatfajok mai helyzete és perspektívái az Európai Unióban c. tudományos konferencia. Szent István Egyetem, Mezőgazdaság- és Környezettudományi Kar, Gödöllő. 2006.04.10. 04.11. CD kiadvány (Állattenyésztés és Takarmányozás Különszám) 2006. Vol. 55. 52-53 p.
- MIKÓ, J.-né – KISS, E.-né (2006): A tejtermelő szarvasmarhatartás adminisztrációs feladatainak fejlődése az analitikus adatfeldolgozástól a digitálisig. X. Nenmzetközi Agrárökonómiai Tudományos Napok. Károly Róbert Főiskolai Gyöngyös. 2006. március 30-31. Előadások összefoglalói 137 p.
- MIKÓ, J.-né – KISS, E-né (2006): A Számítástechnikai lehetőségek fejlődése a szarvasmarhatenyésztésben. XII. Ifjúsági Tudományi Fórum. Pannon Egyetem Georgikon Mezőgazdaságtudományi Kar Keszthely, 2006. április 20. CD
- MIKÓ, J.-né , HÓDINÉ SZÉL, M. (2006): A perzsitencia-értékszám alakulásának vizsgálata Holstein-fríz populációban. (Analysis of the milk persistence value in a Holstein-Friesian cattle population.) Európai Uniós Kutatási és Oktatási Projektek Napja. c. konferencia. SZTE MFK Hódmezővásárhely. 2006. okt. 6. CD kiadvány.
- MIKÓ, J.-né - MUCSI, I. – KOMLÓSI, I (2007): Holstein-fríz tehenek kondíciópontszámának értékelése Európai Kihívások IV. Nemzetközi Tudományos Konferencia Szeged, 2007. október 12.
- MIKÓ, J.-né – KÁITY, Á. – KELLER, T. – KOMLÓSI, I. (2008): A tehenek kondíciójának és tejtermelésének elemzése (The evaluation of body condition scoring and milk production of Holstein-Friesian cows) Agrár- és Vidékfejlesztési Szemle. A SZTE MGK Tudományos folyóirata 3. évf. 2008/1 ISSN 1788-5345. .(Összefoglaló).

Multifunkcionális mezőgazdaság c. nemzetközi tudományos konferencia előadásai és poszterei CD-n.

- MIKÓ, J.-né (2008): Holstein-fríz tenyésztők munkáját támogató mutatók értékelése A Magyar Biológiai Társaság Szegedi Csoportjának 403. ülése 2008. október 31 (konferencia előadás)
- MIKÓ, J.-né (2009): A kondíció és a tejmennyiség alakulása eltérő fejési technológiát alkalmazó tehenészetekben VIII. Wellmann Oszkár nemzetközi tudományos konferencia Hódmezővásárhely 2009. április 23.
- MIKÓ, J.-né (2009): A tejelő tehenek kondícióváltozásának hatása a tejtermelésre a laktáció kezdetén Magyar Biológiai Társaság Szegedi Csoportjának 411. szakosztályi ülése, SZTE MGK Hódmezővásárhely 2009. október 30
- MIKÓ, J.-né (2010): Holstein-fríz tehenek ellés utáni kondícióváltozásának és tejtermelési mutatóinak kapcsolata a laktáció első száz napján (Correlation between body condition change and 100 days milk production parameters of holstein-frisian cows after calving**)** IX. Wellmann Oszkár nemzetközi tudományos konferencia Hódmezővásárhely 2010. április 22.
- MIKÓ, J.-né (2010): A holstein-fríz szarvasmarhák kondíciója és egyes értékmérő tulajdonságai közötti összefüggések Magyar Biológiai Társaság Szegedi Csoportjának 417. szakosztályi ülése, SZTE MGK Hódmezővásárhely 2010. október

Conference proceedings in foregin language

- KISS, E-né – MIKÓNÉ JÓNÁS, E. (2006): The effect of the lactation standard on the reproductive parameters of Holstein-Friesian dairy cows University of Agricultural Sciences and Veterinary Medicine of the Banat Timosiara – Romania. Faculty of Farm Management Facultatea de Management Agricol. Scientific Symposium. Timisoara 2006. 45-52 p
- MIKÓNÉ JÓNÁS, E (2007): The effect of body condition scoring on production efficiency in a holstein friesian stock. International Scientific Symposium. 23.02.2007 Banat's University of Agricultural Sciences and Veterinary Medicine Timisoara. Management of Durable Rural Development. 343-350 p.
- MIKÓNÉ JÓNÁS, E (2011): The influence of somatic cell count, body condition and lameness on dairy cow milk production. X. Oszkár Wellmann International Scientific Conference Hódmezővásárhely 5th May, 2011