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**EFFECT OF BODY CONDITION ON DAIRY AND
REPRODUCTIVE PERFORMANCE IN HOLSTEIN-FRIESIAN
COWS**

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INTRODUCTION

Having been recognized the significance of body condition of dairy cows for performance, reproduction and health status; attempts have been made to find optimum range of body condition in comprehensive studies. Research findings (Wildman *et al.*, 1982) reveal that dairy cows produce more milk in their next lactation when they are slightly overconditioned at calving. In replenishing body condition during late lactation the animals are more efficient while they are still milking than during the dry period (Etgen *et al.*, 1987). *“The cows should be in desirable body condition when dried off and maintain this condition until calving. A slight excess of body condition is required because, after calving, high-producing cows frequently cannot consume enough feed to meet their nutrient requirements”* the authors emphasize. Overconditioned cows may not have strong appetites at calving and are prone to develop metabolic disorders (ketosis, milk fever). On the other hand underconditioned cows may calve with strong appetite but lack of adequate stores of energy to make use of their genetic potential and they are predisposed to ketosis. From the point of view of body condition the nutrition and nutritional status of the cow is well known. Monitoring and appraisal of body condition score may be a useful tool in maintaining appropriate status of cows for efficient milk production, reproductive performance and health status.

For doing this, to assess nutritional status, i. e. fat reserves in dairy cows a scoring procedure has been established and appraisal systems of fat stores have been developed by numerical rating of specific anatomical points of the animals' body. Body condition score (BCS) systems for dairy cows were evaluated and reviewed by Broster and Broster (1998) in detail. Palpation of width behind the shoulders and the lumbar vertebrae, the pin and hook bones (tail head) was used to assess fatness of the cow. Calibration was made by standard photographic charts. Based on this procedure body condition scoring have been developed and applied in everyday practice for dairy cows (Earle, 1976; Mulvany, 1977; Wildman *et al.* 1982) with wide variation of numerical scales. In the system developed by Earle (1976) e. g. the scale is 1, 2...7, 8 within the range from very thin to very fat cows or 1...5 (Mulvany, 1977). Thus, body condition score (BCS) is a discrete variable with limited number of readings. For this reason, decrease in division size were initiated and using means of separate values obtained by two trained operators independently were started. With quarter points more exact scaling can be achieved as Györkös (2002) stated. For assessment BCS in Holstein-Friesian cows Kim and Suh (2003) used also a 5-point scale with quarter-point divisions.

The aim of this study was to establish optimum range in BCS for efficient dairy and reproductive performance, and find new approaches to develop a novel tool to assess variation in condition throughout the production cycle of the cows.

MATERIALS AND METHODS

Animals

Body condition scoring has been made at the dairy operation of *Formilk Ltd., Telekgerendás (Hungary)* in Holstein-Friesian dairy cows postpartum throughout their full lactation periods at each milk recording in monthly intervals with the Virginia system developed by *Wildman et al.* (1982) using a scale within the range 1...5 from very thin to very fat cows with quarter point division sizes. Database covered four subsequent parities (N=452). Number of lactations evaluated for 1st, 2nd, 3rd and 4th parities were 187, 136, 93 and 36, respectively. Mean values for milk production traits, reproduction performance and body condition score (BCS) are presented in *Table 1*. Overall means and SE of milk yield adjusted for 305 day standard lactation, butterfat yield and percentage, milk protein yield and protein percentage, average daily milk yield, peak daily yield, persistency, days open (DO), conception rate (CR), BCS_m and SD_{BCS_m} were 8788±82.8 kg; 303.1±2.9 kg, 3.49±0.024 %; 285.8±2.5 kg; 3.26±0.18 %, 29.4±0.53 kg; 39.1±1.06 kg; 68.5±0.55 %; 99.2±1.74; 1.89±0.043; 3.66±0.034, and 0.66±0.138, respectively. Average for body condition score (BCS_m) was calculated from 12 subsequent simultaneous scorings appraised at each milk recording in monthly intervals, as indicated above. The change of condition throughout the lactation was characterised by the standard deviation of average body condition score (SD_{BCS_m}).

Data processing

Records were processed by softwares of SPSS 12.0.1 for Windows program package (*SPSS. Inc.. USA, 2004*). Descriptive statistics were calculated and curvilinear regression analysis was used for estimation of linear and quadratic effects. Level of probability was estimated by ANOVA. The regression of traits of economic importance was calculated from overall database.

RESULTS AND DISCUSSION

Actual differences among parities for traits of economic importance and functional properties

Significant differences were established among means of four parities 1–4 for all traits of economic importance ($P<0.001$) but butterfat percentage ($P>0.05$) (*Table 1*). Obvious increase in standard lactation yields for milk, butterfat and milk protein were recorded in subsequent lactations. No consistent trend were present for butterfat percentage ($P>0.05$). Milk protein percentage, however, seemed to decrease continuously over subsequent parities. The highest average of daily milk yield was recorded in the 4th parity; however, the highest peak yield was present in the 3rd parity. In accordance with peak yields persistency gradually decreased from 1st to 3rd and 4th lactation at high level of probability ($P<0.001$). No differences could be observed between parities for reproduction performance in terms of days open (DO), however conception rate (CR) among parities seemed to differ between 1st and subsequent parities. The average body condition score over 12 measurements during the full lactation period (BCS_m) reveal actual differences among parities.

Lowest values for BCS_m were found in first calvers. Overall condition of cows improved after the second calving and attained maturity level in the 3rd and 4th parity. Smallest change of condition (SD_{BCSm}) was found in the first parity, intermediate ones in the 2nd and 3rd parity and largest one in the 4th parity. BCS from delivery until drying off of cows reflects inverse shape than it was the case of daily milk yield (*Fig 1.*) Highest postpartum BCS values were present with lower values at the 2nd milk recording which tended to increase continuously until drying off with marked differences between the 1st and 2nd, or 3rd and 4th recordings until the end of lactation. The condition of 1st and 2nd calvers has lower starting points than their counterparts after the 3rd and 4th delivery. Then, condition tended to gain at a higher rate with minor but actual differences between parity 1 and 2 in comparison to parity 3 and 4. This phenomenon is in accordance with the generally accepted view by *Etgen et al.* (1987) that cows should be in desirable body condition when dried off and maintain this condition until calving. Thus, a slight excess of body condition is required because, after calving, high-producing cows frequently cannot consume enough feed to meet their nutrient requirements. The obvious consequence is depression in milk yield. The significance of condition at calving time for reproduction performance was well illustrated in scientific studies (*Muzsek, 2002*). Therefore, body condition scoring has to be performed after calving until the 60th day in milk, between 61st-120th, and the 121st-210th day, and at drying off as well as in the dry period (*Szili et al., 2003*).

Regression analysis of traits of economic importance on BCS_m , BCS recorded postpartum (BCS_1), midlactation (BCS_5) and prior to drying off (BCS_{11}), as well as SD_{SCSm}

In order to be able to find optimum ranges for BCS_m , SD_{SCSm} , BCS_1 , BCS_5 , and BCS_{11} , curvilinear regressions of selected traits were estimated for functional and economic importance on BCS variables given above in search for linear and quadratic effects. Equations and graphs for milk production in *Fig. 2-4* as well as reproductive performance are given in *Fig. 5-6*, respectively.

Milk production. As far as dairy performance is concerned regression analysis reveals marked linear and quadratic effects with high values of coefficients of determination ($R^2 = 0.93-0.97$) and at high levels of probability ($P_1 < 0.001$; $P_q < 0.01$). The relationship between body condition at calving and productivity of dairy cows has been reviewed by *Stockdale* (2001) in detail. Recent research on the influence of body condition at calving on subsequent milk production suggests considerably less advantage for improvements in body condition than had been previously thought. In this study, highest standard milk yields adjusted for 305 days and improved persistency (*Fig 3*) were present if BCS_m varied from 3.0 to 4.0, whereas for butterfat percentage (*Fig. 2*) the range shifted to 3.5-4.5. Best dairy performance was achieved in the range of SD_{SCSm} for milk yield from 0.75 to 1.0, but for butterfat percentage and persistency the lower optimum slightly decreased to 0.625. Findings are in agreement with previous reports since there is no debate among dairy farmers and scientists that ideal BCS should be 3.5 within the range from 3.0 to 4.0, especially at calving. Just the same result was recorded in this study. Optimum values published by *Várhegyi and Várhegyiné* (1999) are 3.25-3.75 post partum. At calving, however, improved persistency was established in body condition score (BCS_1) at lower range from 2.75 to 3.75, a phenomenon that there are cows that are

able to make use and mobilize their body reserves for milk production. On the contrary, higher BCS₁ values tend to decrease persistency, a phenomenon which has been reported by Muzsek (2002, 2004), as well. In the middle of lactation, the desired BCS₅ values ranged between 2.75–3.75 for standard lactation milk yield and 3.25–4.25 for butterfat percentage. In scientists' general view the ideal condition at drying off should be 3.5. Values between 3.0 and 3.5 are acceptable; however, the recommended ranges may vary from 3.5 and 3.75 or 3.5 and 4.0. Some breeders are satisfied even with 2.5 body condition score at drying off. In this study the optimum range for BCS₁₁ prior to drying off varied between 3.25–4.5; 3.25–4.25 and 3.75–4.5 for standard lactation yield, persistency and butterfat content, respectively. Etgen *et al.* (1987) reported that the cow is more efficient in replenishing body condition during late lactation while she is still milking than during the dry period. Cows should be in desirable body condition when dried off and maintain this condition until calving. A slight excess of body condition is required because, after calving, high-producing cows frequently cannot consume enough feed to meet their nutrient requirements. Views by Wildman *et al.*, (1982) seem to coincide with this statement: *"dairy cows produce more milk in their next lactation when they are slightly over conditioned at calving. Properly conditioned cows have a rounded appearance in the chine and loin areas. The hips and pins are less pronounced and rounded, and some patchiness around the tail head is evident."* In pregnant heifers detrimental effect of lower condition is smaller as compared to that of excess body condition both in first and second lactation, as well (Báder *et al.*, 2001; Györkös *et al.*, 2001; 2003). Results of this study, however, reveal that the consequence both of excess and deficiency in condition may be harmful for dairy performance.

Reproductive performance. Body condition at calving may also affect subsequent reproductive status and performance, as well as health of cows. The effects of body condition on pregnancy rate at first AI may be highly heterogeneous, while considering the days open findings present homogeneous results. In dairy cattle, to establish the effects of BCS at parturition and at first AI, and that of body condition change during the early lactation period were analysed on pregnancy rate at first AI and days open by López-Gatius *et al.* (2003). In the study cited, clear association between body condition category and pregnancy rate at first AI was detected only when the effect of low score at parturition was analyzed. Animals with high BCS at parturition showed a significant reduction in days open when compared to cows with an intermediate or low body condition. Severe loss in BCS during early lactation is related to a significant increase in days open, while a slight or moderate body condition change, either loss or gain in score, was not significantly related to days open. The number of days open, however, seems to be a good indicator of the effects of BCS or change in score on reproductive performance in dairy cattle. Findings of this study (Fig. 5, first graph) reveal that cows with overall low body condition during the lactation (BCS_m) tend to conceive earlier post partum than their counterparts being overconditioned. The shape of the regression shows obvious linearity ($P_1 < 0.001$) and lack of quadratic effects ($P_q > 0.05$). Namely, delayed rebreeding in overconditioned cows has been recorded. Human example shows as well that people suffering from malnutrition with extremely low body condition may even conceive earlier than women of high obesity. Similarly, overconditioned cows may conceive later post partum the consequence of which is extended service period i. e. high number of days open (second graph). Highest number of days open was present in cows with high variation in body condition during lactation. Decrease in

number of days open was recorded in cows out of range from 0.75 to 1.25 for SD_{SCSm} . In conclusion, cows with either high or low stability in body condition during lactation may be able to have lower numbers for days open. Animals with a high body condition score at parturition (BCS_1) showed a significant increase in days open when compared to animals with an intermediate or low body condition. Similar tendencies were established for body condition recorded either at the 5th month (BCS_5) or the end of lactation before drying off (BCS_{11}).

Similar tendencies in conception rate were observed as it was the case for days open (Fig. 6). High average body condition scores during lactation (BCS_m) may result in increase of conception rate. Consequence of variation range within limits from 0.65 to 1.0 in standard deviation of mean for body condition score (SD_{SCSm}) may contribute to higher number of AI service needed to rebreed open cows post partum. Lower number of service is needed for conception rate out of this range in both directions. Obvious evidence for the negative and statistically significant, linear and quadratic effects of higher body condition scores post partum (BCS_1), or recorded either in midlactation phase (BCS_5) or just before drying off (BCS_{11}) has been also demonstrated at high level of probability ($P < 0.001$; $P_q < 0.05$).

Etgen et al. (1987) reported that condition score estimates changes in body fat content, condition changes will follow weight change patterns of cows. For this reason cows need to calve in lower condition, but consistency is the key word when dealing with reproduction. Quite a lot of cows calve in low body condition scores and still have excellent rebreeding rates when no extraordinary stress occurs during the critical period from two months before calving.

CONCLUSIONS

The average body condition score calculated from twelve consecutive appraisals at subsequent milk recordings (BCS_m) reveal actual differences among parities. The lowest values were found in first calver cows. Smallest change of condition (SD_{BCSm}), a trait to characterize variation of body condition during the full lactation period, was found in the first parity, intermediate ones in the 2nd and 3rd parity and largest one in the 4th parity.

Body condition score estimates (BCS) from delivery until drying off reflects inverse shape than that of daily milk yield. Intermediate postpartum BCS values varied within the range from 3.1 to 3.6 and decreased thereafter to lower levels until the 2nd recording and from this point on they tended to increase continuously until drying off with marked differences between recordings. This tendency has been continued up to the end of lactation. The body condition of 1st and 2nd calvers had lower starting points than their counterparts after the 3rd and 4th delivery. Then, condition tended to gain at a higher rate with minor but actual differences between parity 1 and 2 in comparison to parity 3 and 4 again.

Regression analysis reveals marked linear and quadratic effects with high values of coefficients of determination ($R^2 = 0.93\text{--}0.97$) and at high levels of probability ($P < 0.001$; $P_q < 0.01$). Based on average body condition calculated from subsequent scorings at milk regular monthly intervals during lactation (BCS_m), the highest standard milk yields adjusted for 305 days and improved persistency were present in

cows when this trait varied within the range from 3.0 to 4.0. The best dairy performance was achieved as SD_{SCSm} ranged between 0.75 and 1.0. Results of this study are in agreement with previous reports that ideal body condition for standard lactation milk yield should be 3.5 within the range from 3.0 to 4.0 especially at calving (BCS_1). In the middle of lactation the optimum BCS_5 values ranged between 2.75–3.75 and prior to drying off BCS_{11} values varied between 3.25–4.5.

Findings of this study reveal that cows with overall low body condition during lactation (BCS_m) tend to conceive earlier post partum than their counterparts being overconditioned. The shape of the regression shows obvious linearity ($P_1 < 0.001$) and lack of quadratic effects ($P_q > 0.05$). Decrease in number of days open was recorded in cows out of the range from 0.75 to 1.25 for SD_{SCSm} . Thus, cows with either high or low stability in body condition during lactation tend to have lower number of days open. Animals with a high body condition score either at parturition (BCS_1) and in midlactation phase (BCS_5) or even prior to drying off (BCS_{11}) tend to have significant increase in days open when compared to animals with an intermediate or low body condition. For conception rate similar conclusions could be drawn from the findings of this study.

SUMMARY

Body condition scores (BCS) were registered in Holstein-Friesian dairy cows at monthly intervals within the framework of National Milk Recording Scheme using a 1-5 scale established by *Wildman et al.* (1982). The division size between scores was reduced to 0.25 to improve accuracy. The change of BCS was characterized by SD of recordings throughout the lactation lasting for 345 days in milk- Distribution of cows among 1st to 4th parities were 186, 136, 93, and 36. Overall means and SE of milk yield adjusted for 305 day standard lactation, butterfat yield and percentage, milk protein yield and protein percentage, average daily milk yield, peak daily yield, persistency, days open (DO), conception rate (CR), BCS_m and SD_{BCSm} were 8788 ± 82.78 kg; 303.1 ± 2.91 kg, 3.49 ± 0.024 %; 285.8 ± 2.54 kg; 3.26 ± 0.178 %, 29.4 ± 0.53 kg; 39.1 ± 1.06 kg; 68.5 ± 0.55 %; 99.2 ± 1.74 ; 1.89 ± 0.043 ; 3.66 ± 0.034 , and 0.66 ± 0.138 . respectively. Average for body condition score (BCS_m) was calculated from 12 subsequent simultaneous scorings which were recorded at each milk recording in 30 day intervals. The change of condition throughout the lactation was characterised by the standard deviation of average body condition score (SD_{BCSm}). In this study, curvilinear relationships between BCS and production and reproduction traits have been established at high level of probability with significant linear and quadratic effects at high level of probability ($P < 0.001$, < 0.01 , in a few cases $P < 0.05$). Regression analysis reveals that for milk yield the optimum range of BCS in the post partum and midlactation period varies between 3.0-4.0, and 3.5-4.5 just prior to dry period. Favourable effect in cows with lower BSC in all phases of reproduction cycle has been established, as well.

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Table 1 Milk production, reproduction, and body condition score (number of animals, mean values, and standard error of means)

Item	Parity				Overall	S. E.
	1 st	2 nd	3 rd	4 th		
Number of cows	187	136	93	36	452	-
Days in milk ^a	346	345	343	346	345	1.00
Milk yield for 305 days (kg)	8375	8999	9087	9365	8788	82.78
Butterfat yield (kg)	288.2	316.7	310.0	313.0	303.1	2.91
Butterfat percentage ^a (%)	3.48	3.55	3.44	3.38	3.49	0.024
Milk protein yield (kg)	274.0	295.2	291.4	297.2	285.8	2.54
Milk protein percentage, (%)	3.29	3.28	3.21	3.18	3.26	0.178
Average daily milk yield (kg)	29.5	28.4	29.8	31.5	29.4	0.53
Peak daily yield (kg)	34.5	40.6	47.8	39.5	39.1	1.06
Persistency	72.0	67.5	64.6	64.8	68.5	0.55
Days open (DO)	-	99	98	102	99.2	1.74
Conception rate (CR)	1.45	2.18	2.23	2.08	1.89	0.043
Body condition score (BCS _m)	3.55	3.63	3.83	3.80	3.66	0.034
SD of BCS _m ^b	0.60	0.69	0.68	0.73	0.66	0.138

^a Differences among parities for means of all variables are statistically significant at $P < 0.001$ vs. $P < 0.01$ level of probability but variables days in milk and butterfat percentage marked by superscript ^a, $P > 0.05$).

^b SD_{BCSm}

Fig. 1 Average body condition score in the lactation by parities 1-4

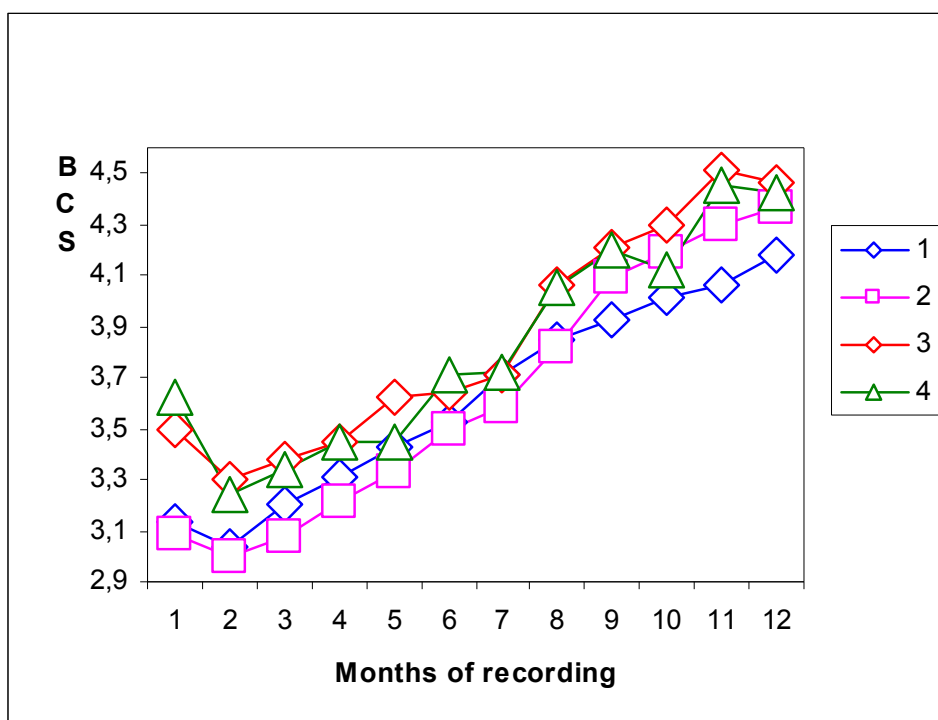
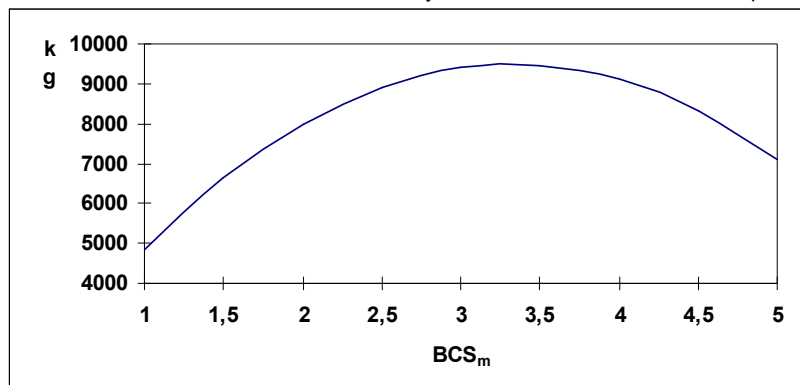
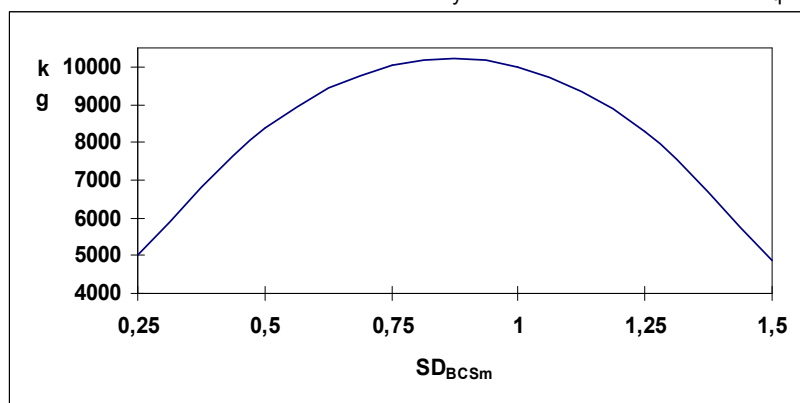


Fig. 2 Regression of standard lactation yield for 305 days (y) on body condition score (x)

$$y = 5717x - 860x^2; R^2 = 0.97; SE_{xy} = 1702; P_l < 0.001; P_q < 0.001$$



$$y = 23510x - 13514x^2; R^2 = 0.93; SE_{xy} = 2426; P_l < 0.001; P_q < 0.001$$



$$y = 5437x - 774x^2; R^2 = 0.94; SE_{xy} = 2163; P_l < 0.001; P_q < 0.001$$

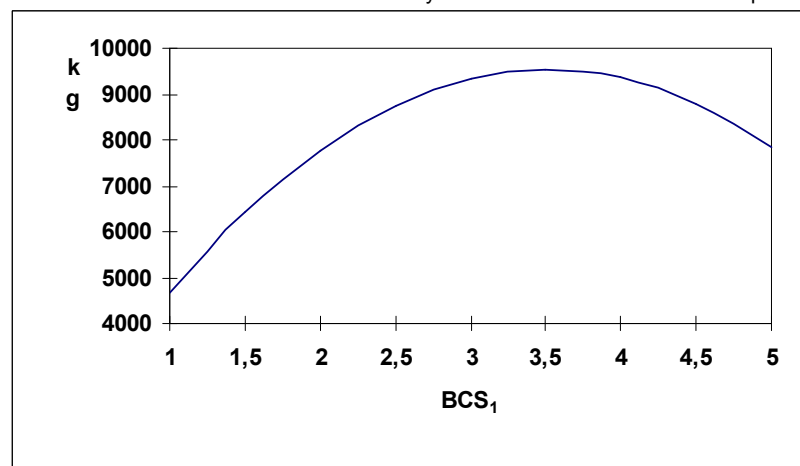
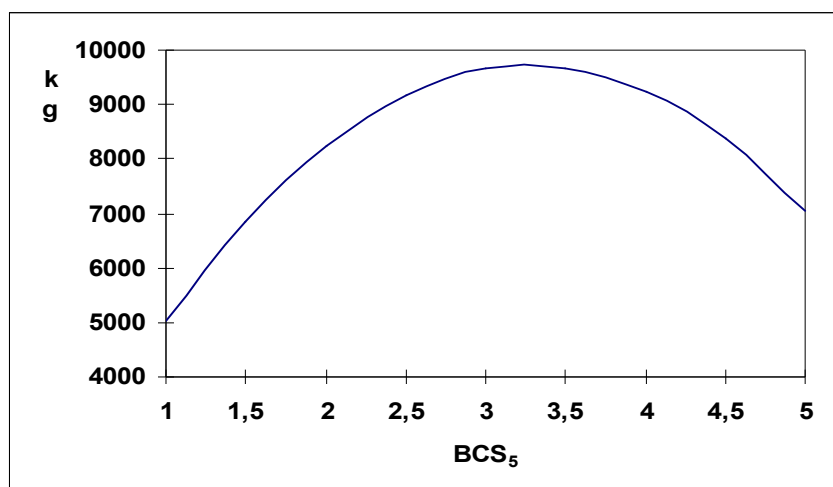


Fig. 2 ctd.

$$y = 5937x - 906x^2; R^2 = 0.96; SE_{xy} = 1895; P_l < 0.001; P_q < 0.001$$



$$y = 5005x - 649x^2; R^2 = 0.96; SE_{xy} = 1808; P_l < 0.001; P_q < 0.001$$

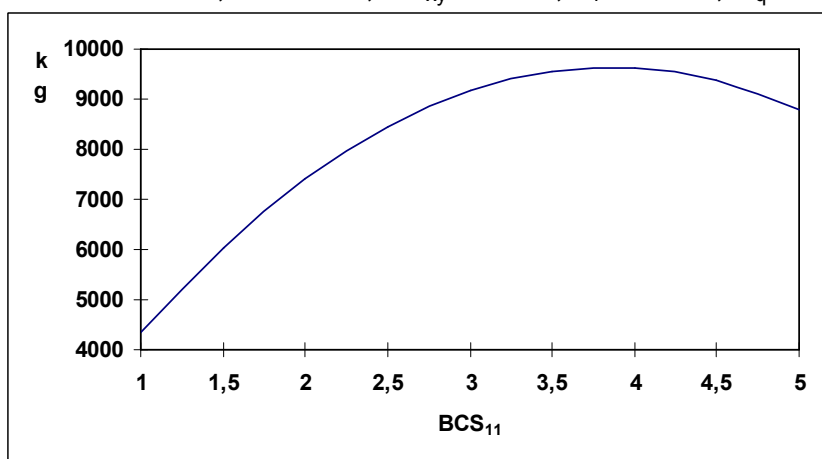
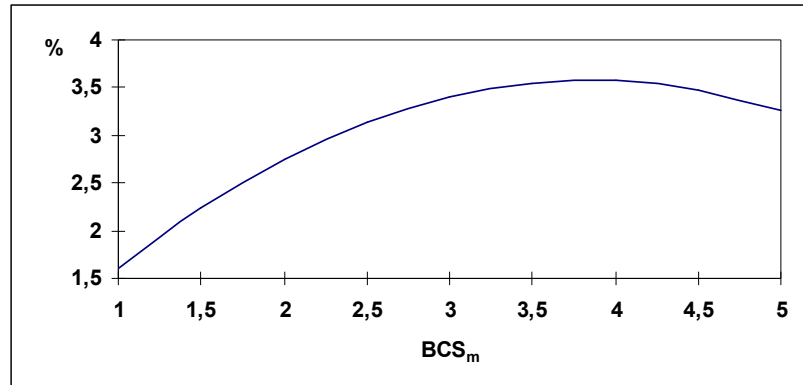
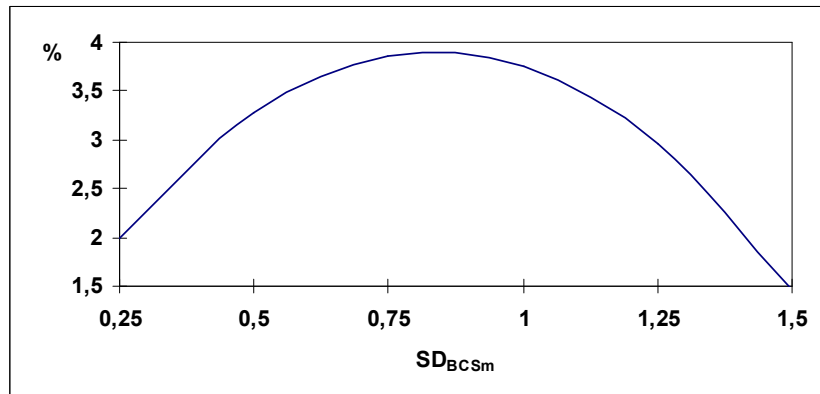


Fig. 3 Regression of butterfat percentage (y) on body condition score (x)

$$y = 1.85x - 0.24x^2; R^2 = 0.98; SE_{xy} = 0.53; P_l < 0.001; P_q < 0.001$$



$$y = 9.34x - 5.57x^2; R^2 = 0.94; SE_{xy} = 0.82; P_l < 0.001; P_q < 0.001$$



$$y = 2.09x - 0.30x^2; R^2 = 0.97; SE_{xy} = 0.63; P_l < 0.001; P_q < 0.001$$

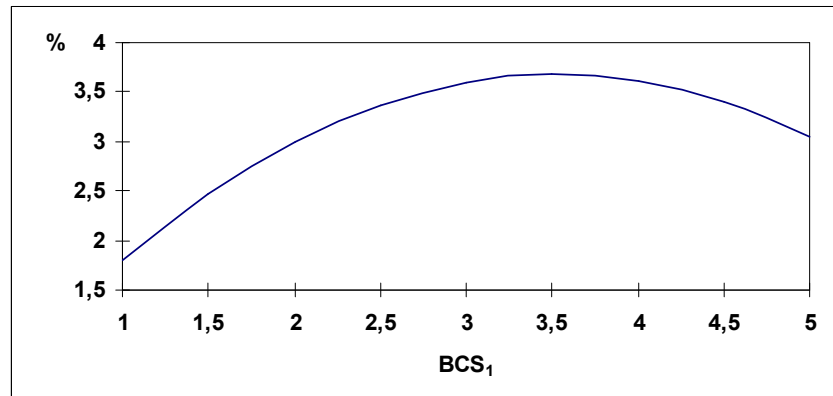
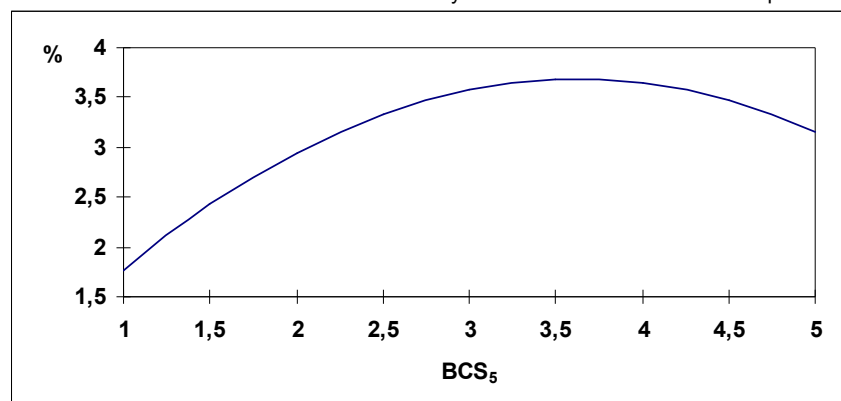


Fig. 3 ctd.

$$y = 2.04x - 0.28x^2; R^2 = 0.97; SE_{xy} = 0.63; P_l < 0.001; P_q < 0.001$$



$$y = 1.79x - 0.22x^2; R^2 = 0.98; SE_{xy} = 0.55; P_l < 0.001; P_q < 0.001$$

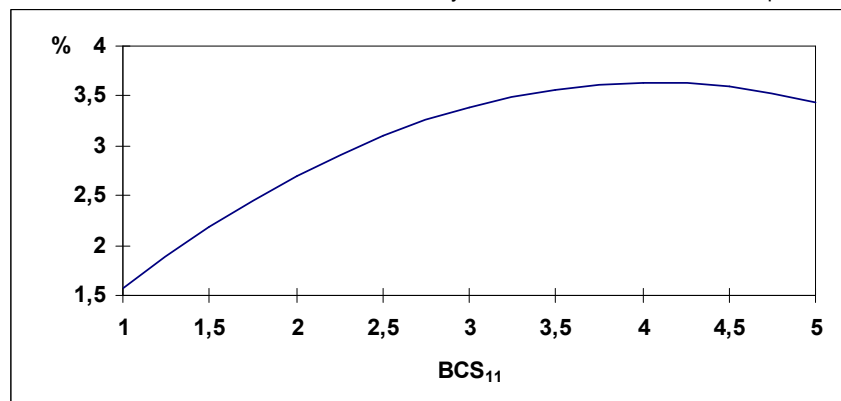
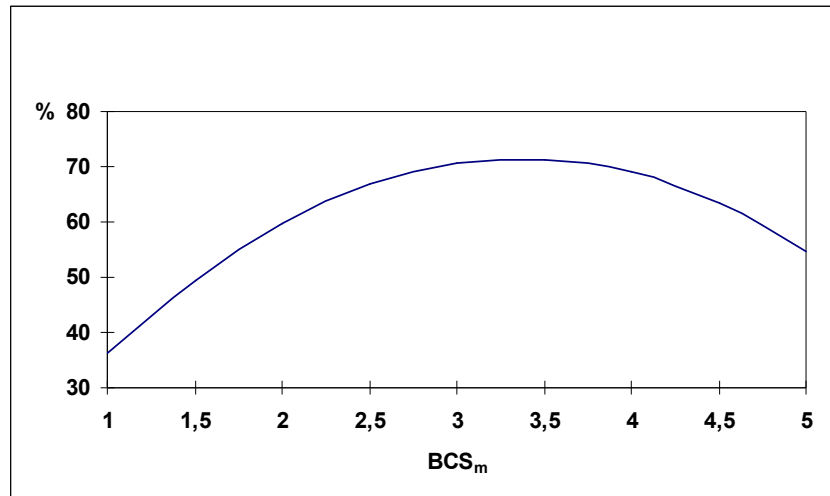
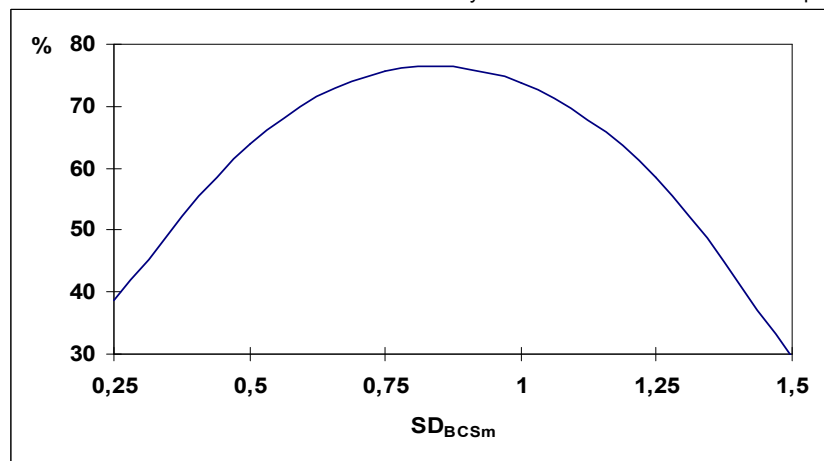


Fig. 4 Regression of persistency (y) on body condition score (x)

$$y = 42.47x - 6.31x^2; R^2 = 0.97; SE_{xy} = 11.18; P_l < 0.001; P_q < 0.001$$



$$y = 182.13x - 108.25x^2; R^2 = 0.93; SE_{xy} = 17.81; P_l < 0.001; P_q < 0.001$$



$$y = 45.41x - 6.98x^2; R^2 = 0.96; SE_{xy} = 13.25; P_l < 0.001; P_q < 0.001$$

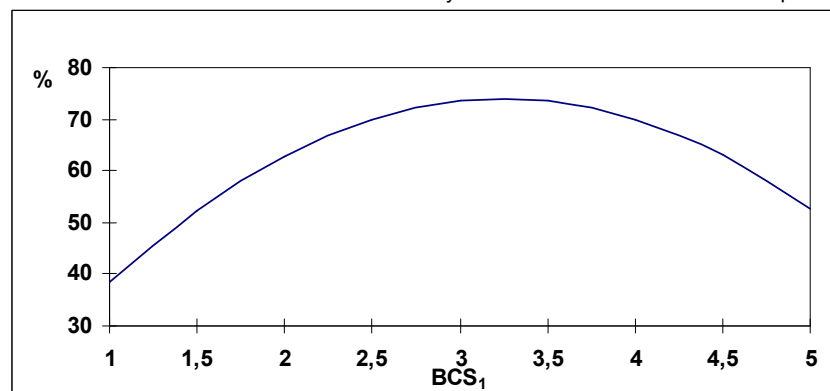
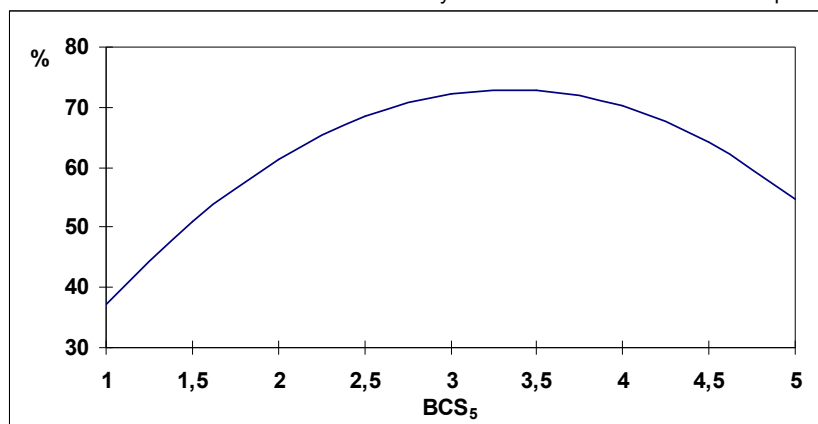


Fig. 4 ctd.

$$y = 42.82x - 6.57x^2; R^2 = 0.97; SE_{xy} = 12.57; P_l < 0.001; P_q < 0.001$$



$$y = 39.55x - 5.38x^2; R^2 = 0.97; SE_{xy} = 12.08; P_l < 0.001; P_q < 0.001$$

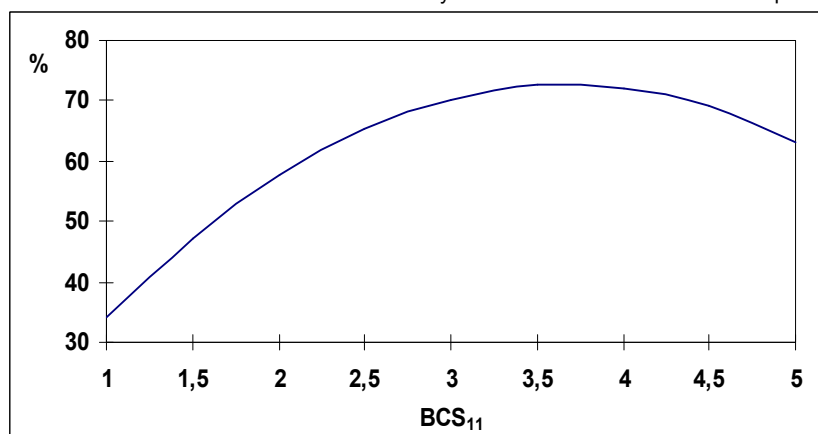
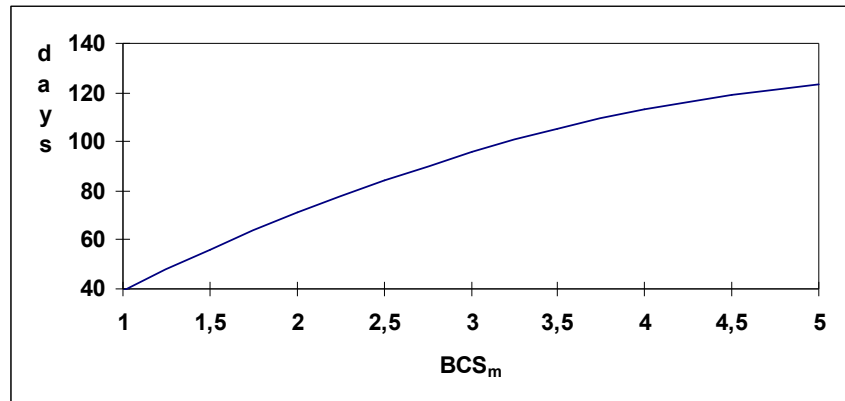
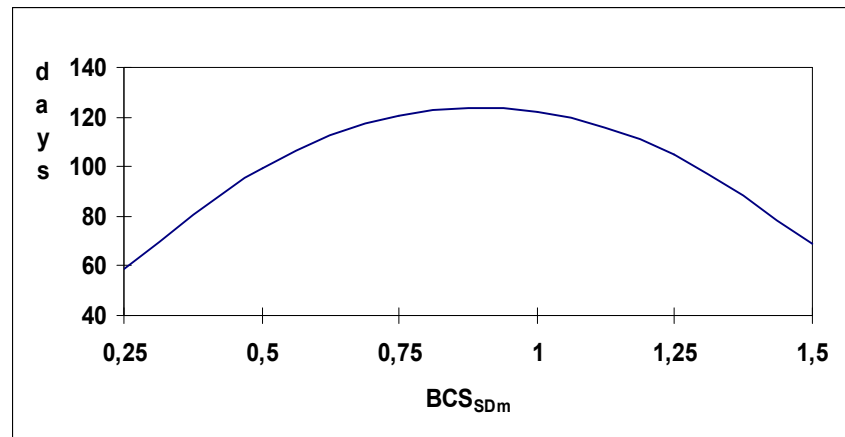


Fig. 5 Regression of days open (y) on body condition score (x)

$$y = 42.86x - 3.65x^2; R^2 = 0.60; SE_{xy} = 86.90; P_l < 0.001; P_q > 0.05$$



$$y = 274.61x - 152.41x^2; R^2 = 0.59; SE_{xy} = 87.78; P < 0.001; P < 0.001$$



$$y = 56.22x - 5.73x^2; R^2 = 0.63; SE_{xy} = 91.01; P < 0.001; P < 0.01$$

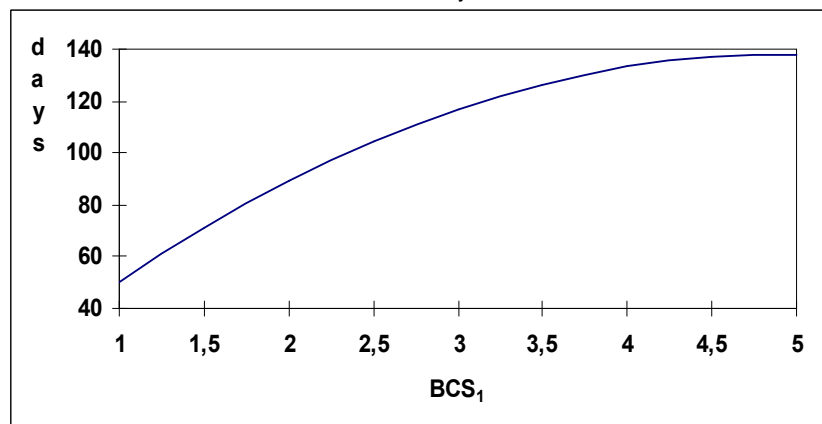
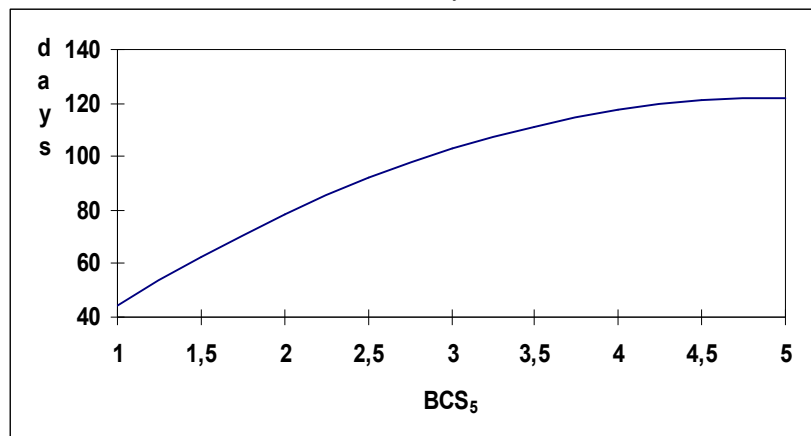


Fig. 5 ctd.

$$y = 49.08x - 4.94x^2; R^2 = 0.58; SE_{xy} = 88.10; P < 0.001; P < 0.01$$



$$y = 38.42x - 3.12x^2; R^2 = 0.60; SE_{xy} = 84.66; P < 0.001; P > 0.05$$

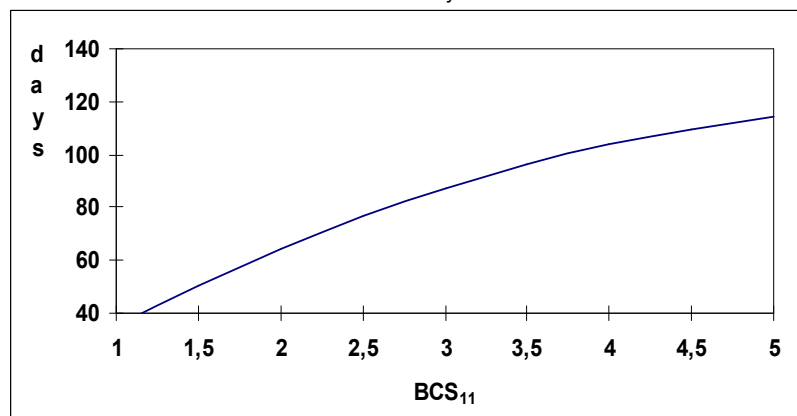
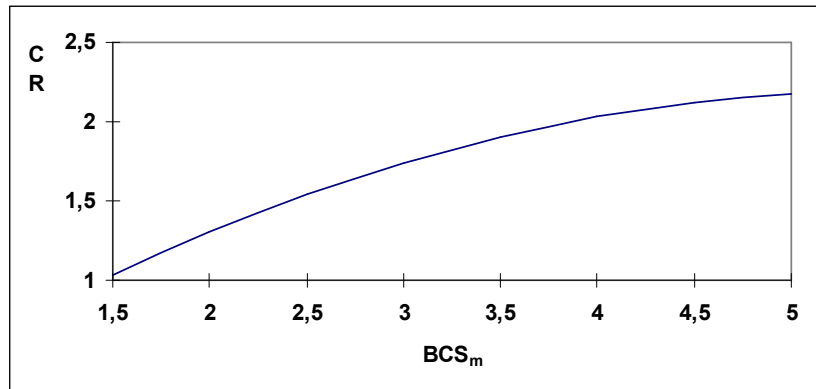
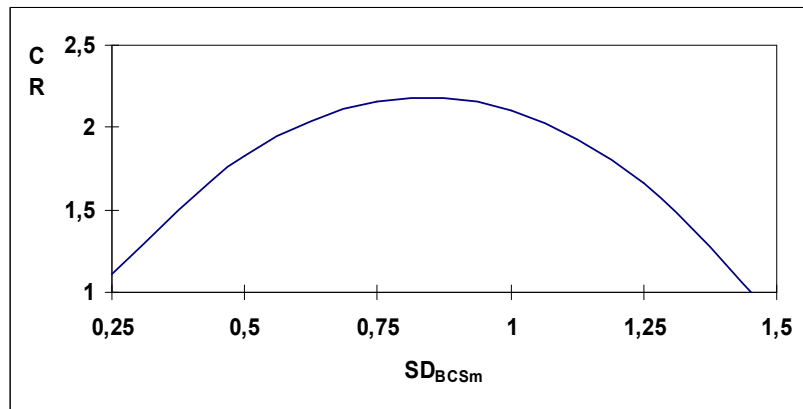


Fig. 6 Regression of conception rate (y) on body condition score (x)

$$y = 0.801x - 0.074x^2; R^2 = 0.67; SE_{xy} = 1.36; P_l < 0.001; P_q < 0.05$$



$$y = 5.19x - 3.09x^2; R^2 = 0.64; SE_{xy} = 1.41; P_l < 0.001; P_q < 0.001$$



$$y = 1.054x - 0.125x^2; R^2 = 0.66; SE_{xy} = 1.44; P_l < 0.001; P_q < 0.001$$

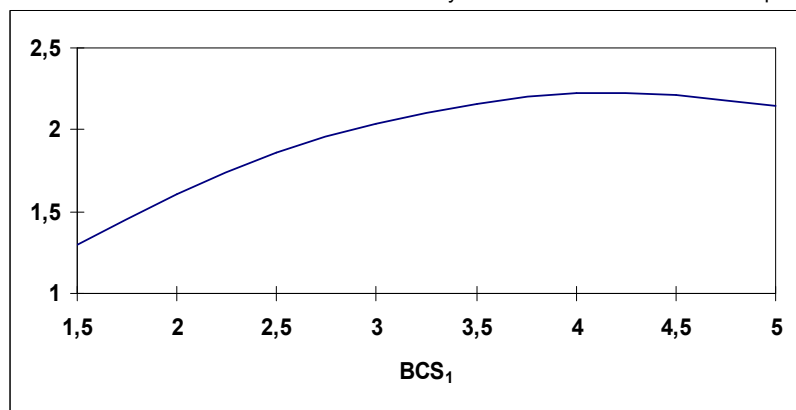
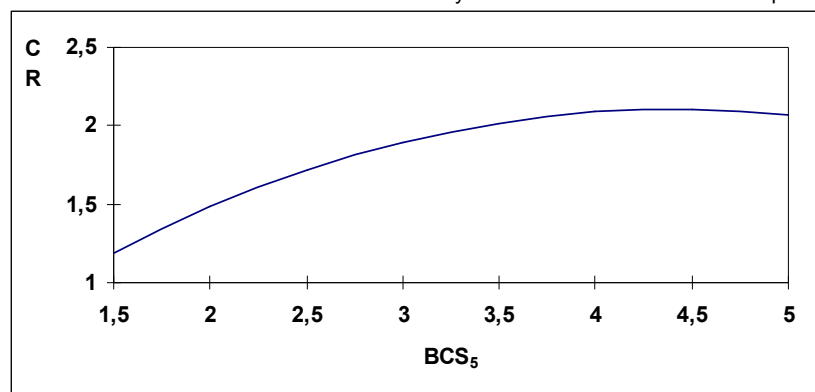


Fig. 6 ctd.

$$y = 0.959x - 0.109x^2; R^2 = 0.66; SE_{xy} = 1.38; P_l < 0.001; P_q < 0.001$$



$$y = 0.741x - 0.066x^2; R^2 = 0.66; SE_{xy} = 1.36; P_l < 0.001; P_q < 0.05$$

