Praca oryginalna *Original paper*

Effect of cows' body condition during the periparturient period and early lactation on fertility and culling rate

TOMASZ A. NOWAK, JĘDRZEJ M. JAŚKOWSKI, JAN OLECHNOWICZ, DOROTA BUKOWSKA

Department of Veterinary Medicine, Faculty of Breeding and Biology of Animals, Poznań University of Life Sciences, Wojska Polskiego 52, 60-625 Poznań, Poland

Nowak T. A., Jaśkowski J. M., Olechnowicz J., Bukowska D.

Effect of cows' body condition during the periparturient period and early lactation on fertility and culling rate

Summary

The aim of the study was to determine the effect of body condition score (BCS) of cows during the last weeks of pregnancy and in the first months of lactation on the incidence of postpartum complications. A total of 528 cows were included in the study. No significant effect was found of BCS of cows ap on the incidence of dystocia, corpus luteum pseudograviditatis, ovarian cysts, repeat breeders, infertility and the service period (SP). In turn, BCS before calving had an effect on the incidence of the retention of the placenta, puerperal metritis and clinical endometritis (MET), ovarian afunction (OA), the first service conception rate (FCR) and pregnancy rate (PR). The pregnancy rate was 2.67 in the group of lean cows and this was higher ($p \leq 0.05$) than in the other groups of cows. The highest FCR of 46.3% was recorded in fat cows before calving (BCS > 4.0). It was higher than in cows with BCS of 3.0 and 2.5 ap ($p \leq 0.01$ and $p \leq 0.05$, respectively). The lowest FCR of 11.1% was recorded in the group with BCS of 2.0. The mean BCS of cows after calving was 2.52 and its loss amounted to 0.74 points, i.e. 22%. Body condition loss did not have an effect on the frequency of ovarian afunction, ovarian cysts, the percentage of repeat breeders and the length of service period. The frequency of MET in the HBCL group was 29.5% and it differed significantly ($p \leq 0.05$) from the frequency of this complication in MBCL and LBCL groups. In the HBCL group OA was significantly more frequent (at $p \leq 0.05$) than in LBCL cows (8.7 vs. 2.1%), similarly as it was for corpus luteum pseudograviditatis (14.7 vs. 4.1%), while higher values were recorded both for FCR (41.4 vs. 37.3 in group II at $p \leq 0.05$ and 32.6 in group III at $p \leq 0.01$) and pregnancy rate (2.24 vs. 2.05 at $p \leq 0.05$ in group III and 2.06 at $p \leq 0.05$ in group II).

In the analyzed population a total of 24.2% cows were culled. The higher the antepartum BCS of cows and the higher its postpartum loss, the higher the risk of culling due to infertility and the total culling risk, as well as the risk of death.

Keywords: cows, body condition scoring (BCS), periparturient disturbances, fertility, culling rate

The effect of body condition scores (BCS) in the periparturient period has been investigated in many studies (4, 13, 23). Results indicate that excessive body condition of cows before parturition and its considerable loss after calving have a negative effect on their fertility (7, 13, 21, 22). According to the cited authors there is a relationship between loss of body condition after parturition and the volume of negative energy balance, and fertility of cows. In many studies cows of the Holstein-Friesian breed were model animals. However, the population of dairy cattle in Poland varies considerably in terms of the genetic structure, yield, feeding and management conditions (2, 11). Thus it may not be excluded that the effect of body condition in the periparturient period on fertility of cows in Poland may be different from that observed in other populations of these animals.

The aim of the study was to determine the effect of body condition of cows during the last weeks of pregnancy and in the first months of lactation on the incidence of post parturition complications and their fertility.

Material and methods

Numerical data were collected in the years 2000-2002 in 6 herds of dairy cows. All of them were kept in stanchion barns. Animals were fed maize silage supplemented with an addition of concentrate and fodders. A total of 528

primiparous and multiparous cows were included in the study. From this group, 128 cows were culled for different reasons and at different times after calving. Thus, 400 pregnant cows were finally included in the analysis of the effect of body condition on fertility.

Body condition scoring (BCS). Cows were assessed in terms of body condition scores (BCS) according to the scale proposed by Edmondson et al. (6). The body condition of each cow was estimated during the last two weeks of pregnancy and the assessment was continued at monthly intervals up to the fifth month after calving. In all cases it was performed by the same individual. Depending on their body condition animals were divided into five groups. A group of less than thin cows (LTC) consisted of cows with BCS ≤ 2.5 (2.0), while groups of thin cows (TC), medium cows (MC), more than medium cows (MMC) and fat cows (FC) were composed of cows with BCS of 2.51--3.0, (2.5), 3.01-3.5 (3.0), 3.51-4.0 (3.5) and 4.0 > points (4.0), respectively. The loss of body condition in cows is an absolute value, thus animals were divided into three groups depending on the percentage of body condition loss post partum (pp). The value of BCS of a cow ante partum (ap) was assumed as 100%. The group of low body condition lowering (LBCL) included animals with a slight, i.e. > 10% loss of body condition, medium body condition lowering (MBCL) consisted of cows with a medium (10--20%) loss of body condition pp, while the group of high body condition lowering (HBCL) was comprised of animals with a high (> 20%) loss of body condition pp.

Collected data. The following individual data of cows were included in the analysis: lactation rank, body condition score (BCS), periparturient and postpartum complications, pregnancy rate and first conception rate (FCR) service period and the percentage of repeat breeders, as well as the cause of culling.

Statistical analysis. Collected numerical material was analyzed using the one-way analysis of variance with an ABS-10 algorithm including further PC modifications.

Results and discussion

On average experimental cows were in their 2.68 lactation and had a 74.4% share of Holstein-Friesian genes in their genotype. The average body condition score of cows ante partum (ap) was 3.36. The greatest number of cows (i.e. 44.5%) ante partum had a medium body condition (BCS = 3.0), followed by 26.6% cows with scores higher than medium (BCS = 3.5), and a comparable percentage, i.e. 14.4%, of lean animals (TC, BCS = 2.5), while the least numerous groups consisted of extremely thin (BCS = 2.0) and fat cows (BCS > 4.0 >), accounting for 11.1 and 3.4%, respectively.

Table 1 presents the frequency of selected diseases and fertility disorders in cows and some reproduction indices depending on their body condition before calving. Dystocia (D) was reported in 0.8% cows. Its cases were recorded most frequently in group TC (1.7%), being less frequent in cows with medium body condition (BCS = 3.0), whereas in the other groups dystocia was not recorded. No significant relationship was found between BCS before calving and the incidence of dystocia ($p > 0.05$). The milk fever and downer cow syndrome (MFD) was reported in 4.3% of cows. It was found most frequently in group ETC with BCS = 2.0 (22.2%), while it was the least frequent in group FC (2.4%). In the other cases no differences were observed in the frequency of MFD in terms of BCS of cows before calving ($p > 0.05$).

The average frequency recorded for the retention of the placenta (RS) was 5%. It was lowest in group TC, in which this complication was not reported in any cow and it differed at $p \leq 0.05$ from the frequency of placenta retention in the group of cows with body condition of 2.0 (0 vs. 11.1%). The frequency of this complication in the other groups of cows did not differ significantly ($p > 0.05$). Puerperal metritis and clinical endometritis were recorded in 23% cows. It was diagnosed most often, i.e. in 30.6% of the population, in MC cows, while it was the least frequent (1.7%) in TC cows ($p \leq 0.01$). No significant differences in terms of the incidence of the above mentioned complications were found between ETC cows and MC and FC cows ($p > 0.05$). Postpartum anoestrus was recorded in 22.7% of cows, which in 6.7% of the cases was caused by an afunction of the

Tab. 1. Incidence of fertility disorders and selected reproduction indexes in cows depending on their body condition before calving

List	BCS					Total
	ETC	TC	MC	MMC	FC	
	2.0	2.5	3.0	3.5	4.0 >	
No. of cows (n)	9	60	180	110	41	400
Dystocia (D)	0^{a}	1.7^{b}	1.1	0^{a}	0^{a}	0,8
Milk fever and downer cow syndrome (MFD)	22.2	6.7	3.9	2.7	2.4	4.25
Retention of placenta (RS)	11.1^{b}	0^{a}	3.9	8.1	7.3	5.0
Puerperal metritis and clinical endometritis	11.1	1.7^{B}	30.6^{A}	24.5	19.5	23.0
Ovarian afunction (OA)	11.1^{b}	0^{a}	10.5^{b}	2.7^{a}	9.8	6.7
Corpus luteum pseudograviditatis (CLP)	0	5.0	15.6	10.0	12.2	11.7
Ovarian cysts (CYST)	0	6.7	3.3	3.6	7.3	4.25
Repeat breeders (RB)	0	6.7	3.3	3.6	2.4	3.75
First conception rate (%) (FCR)	11.1^{B}	32.0^{b}	40.5^{A}	39.0^{A}	46.3^{aA}	38.8
Pregnancy rate (PR)	2.67^{aA}	2.33^{b}	2.06^{B}	2.08^{B}	2.07	2.07
Days open	139.7	139.5	116.5	124.5	124.9	123.6

Explanation: arithmetic means in lines denoted with different lower case letters differ statistically significantly at $p < 0.05$, those denoted with capital letters differ at $p < 0.01$

ovaries (OA), 11.7% by the presence of corpus luteum pseudograviditatis (CLP), while in the other 4.25% of cases – by ovarian cysts.

In the group of cows with a body condition before calving of 2.5 and 3.5 no OA cases were recorded or they were found in 2.7% of cows, while in ETC cows (BCS = 2.0) and in MC cows (BCS = 3.0) they were reported more frequently, i.e. in 11.1 and 10.5% of cows ($p \leq 0.05$). This disorder was also found relatively rarely in group MMC (2.7%).

Corpus luteum pseudograviditatis (CLP) was reported in 11.7% of cows. No significant differences were observed in the frequency of this dysfunction in cows differing in their body condition before calving ($p > 0.05$). Ovarian cysts were found in 4.25% of cows. Their frequency in individual groups ranged from 3.3 to 7.3% and it did not differ significantly ($p > 0.05$). The percentage of repeat breeders (RB) was on average 3.75% (ranging from 0 to 6.7%). No significant dependence was observed between BCS of cows before calving and RB ($p > 0.05$).

The average number of inseminations per conception was 2.07, with the individual number of inseminations per conception ranging from 1 to 11. Insemination index (II) in the group of thinnest cows was 2.67 and it was higher than 2.33 ($p < 0.05$), 2.08 ($p < 0.01$) and 2.06 ($p < 0.01$), respectively, in groups II, MMC and MC. The difference between the thinnest and the fattest cows in terms of II was slight ($p > 0.05$). The first service conception rate (FCR) for analyzed cows was 38.8%. The highest FCR (46.3%) was recorded in group FC (BCS > 4.0). It was higher than 40.5 and 39% in groups MMC and MC, respectively ($p \leq 0.05$), and 32 and 11.1% in groups TC and ETC ($p \leq 0.01$).

The mean number of days open for all cows was 123.6 days. The period was shortest in the group of MC cows (BCS of 3.0, 116.5 days), whereas it was longest in TC cows (BCS = 2.0 and 2.5, 139.7 and 139.5 days). No significant effect of BCS before calving on service period was found ($p > 0.05$).

The mean lowest body condition of cows after calving was 2.52 points. Its average loss – in comparison to the value ante partum (ap) in analyzed cows – was 0.74 points (0.2 to 1.47), i.e. 22%. Groups with a slight (LBCL), medium (MBCL) and high (HBCL) loss of body condition after calving were classified to comprise 12.3, 24.8 and 62.9% of cows.

No effect of BCS in cows before calving was observed on its loss post partum (pp) ($p > 0.05$). However, a distinct downward trend was found for body condition pp with an increase in body condition scores in cows during the dry period. For example, cows with a body condition score of 2.0 points lost on average 0.4 points after calving, while fat cows – 1.2 points.

Table 2 presents the frequency of selected fertility diseases in cows and certain reproduction indices depending on the percentage loss of body condition after calving. The total frequency of puerperal metritis and clinical endometritis was 23%. This complication was recorded with similar frequency (10.2 and 13.1%) in groups I and II, respectively ($p > 0.05$). In turn, in group HBCL it was reported in 29.5% of cows, significantly more frequently than in cows from groups I and II ($p \leq 0.05$ and $p \leq 0.05$).

Corpus luteum pseudograviditatis (CLP) was recorded on average in 6.7% of cows, significantly more frequently in HBCL than in LBCL cows (8.7 vs. 2.1%; $p \leq 0.05$). The frequency of (LOH) in MBCL cows after calving did not differ significantly from the incidence of this complication in HBCL and LBCL cows ($p > 0.05$). The CLP was recorded in 11.7% of cows. In the group of cows with a slight loss of body condition after parturition it was found in 4.1% of the animals, while in the group with a large loss of body condition in 14.7% of cows ($p \leq 0.05$). The frequency of CLP in cows with a medium loss of body condition after calving did not differ significantly from the incidence of this complication in cows with a slight and large loss of body condition after parturition ($p > 0.05$). Ovarian cysts were diagnosed in 4.25% of cows. Differences in the frequency of this disorder in cows in terms of the percentage loss of body condition after calving were not statistically significant ($p > 0.05$). Similarly, the average percentage of barren cows was 3.75%; however, differences in the frequency of this complication depending on the percentage loss of BCS in cows after calving turned out to be non-significant ($p > 0.05$).

The first conception rate (FCR) for all analyzed cows was 38.8%. The percentage of cows impregnated after the first insemination was 41.4% in group HBCL and it was higher that 37.3 and 32.6% recorded for groups II and I, respectively ($p \leq 0.05$ and $p \leq 0.01$). The

Tab. 2. Incidence of selected fertility disorders in cows and selected reproduction indexes depending on body condition loss (%) after calving

List	Body condition score (BCS) (%)			Total
	LBCL < 10	MBCL 10-20	HBCL > 20	
No. of cows	49	99	252	400
Puerperal metritis and clinical endometritis	10.2^{a}	13.1^{a}	29.5^{b}	23
Ovarian afunction (OA)	2.1^{a}	4.1	8.7^{b}	6.7
Corpus luteum pseudograviditatis (CLP)	4.1^{A}	8.1	14.7^{B}	11.1
Ovarian cysts (CYST)	4.1	3.0	4.8	4.25
Repeat breeders (RB)	2.1	3.1	4.3	3.75
First service conception rate (FCR)	32.6^{a}	37.3^{a}	41.4^{b}	38.8
Pregnancy rate (CP)	2.24^{A}	2.06^{A}	2.05^{C}	2.08
Days open	123.4	124.4	123.3	123.6

Explanation: a, b – $p < 0.05$, A, C – $p < 0.01$

mean FCR in groups I – III ranged from 2.05 to 2.24. The mean quantity of semen used per impregnated cow in group I was 2.24 portions and it was higher than 2.05 and 2.06 portions in groups III and II ($p \leq 0.05$).

The mean number of days open in all groups of cows was comparable and amounted to 123.6 days. No relationship was found between loss of body condition after calving and service period in experimental cows ($p > 0.05$).

Table 3 presents a dependence between body condition of cows before parturition and the percentage of culled and dead cows. In the groups of cows with BCS 2.0 and 2.5 before calving the percentage of eliminated cows was jointly 25% and 24%, respectively. In the group of cows with BCS 3.0 and 3.5 it was 20.4 and 23.5%, respectively, and in both cases it was significantly lower ($p < 0.01$ and $p \leq 0.01$, respectively) than the 37.8% recorded in the group of the fattest cows (BCS > 4.0). Cows culled due to infertility amounted to 14.5 and 10.5% in the group of animals with BCS > 4.0 and 3.5, i.e. it was significantly more ($p < 0.05$) than 4.8, 2.5% and 0 in groups of cows with BCS of 3.0, 2.5 and 2.0, respectively. The total percentage of culled cows in groups with BCS 2.0, 2.5, 3.0, 3.5 and > 4 was 25, 21.5, 17.7, 20.1 and 33.3%, respectively. A unique group in this list consists of the percentage of dead cows pp. It increased from 0 in the group of cows with BCS 2 to 2.5, 2.7, 3.4 ($p < 0.05$) and 4.5 ($p < 0.05$) in the groups of cows with BCS 2.5, 3, 3.5 and > 4, respectively.

Table 4 presents the effect of body condition loss after calving on the percentage of culled cows. The total percentage of culled cows and the percentage of those culled due to infertility was 21.3 and 6.5%. The lowest number of cows, i.e. 13.7%, were culled in the LBCL group. In the MBCL and HBCL groups the percentages of culled cows were higher, amounting to 16.5 ($p < 0.05$) and 25.3% ($p < 0.01$).

Cows culled due to sterility in the HBLC group constituted 10.9%, which was significantly more ($p < 0.05$) than 0 in the LBCL and MLBC groups.

The mean BCS of cows before calving was similar to the figures reported by other authors (2, 19, 23). Prandi et al. (21) assessed the body condition of cows before calving in 117 herds of Holstein-Friesian cows at 3.1. According to Borkowska (2), the body condition of dry cows kept at privately-owned farms was 4.04, with as many as 68.4% cows having BCS over 4.0, while 17.5% were fat (BCS 5.0). At the beginning of the dry period the body condition of Red-and-White cows was assessed at 3.39 (1).

No significant dependence was found between lactation rank in cows and their BCS before calving. This could have resulted from the fact that the assessment reported in this study was conducted only on cows in the drying off period. Similarly, it was also of some importance that the analyzed population exhibited a relatively low range of values for this trait (on average 2.68 lactations), which could have affected obtained results.

Tab. 3. The dependence between body condition of cows before calving and the percentage of culled or dead cows

List	BCS				
	2.0 (ETC)	2.5 (TC)	3.0 (MC)	3.5 (MMC)	4 > (FC)
Culling (total)	25	21.5	17.7	20.1	33.0
Due to infertility	0^{a}	2.5	4.8	10.5^{b}	14.5^{b}
Dead cows	0^{a}	2.5	2.7	3.4^{b}	4.5^{b}
Total	25	24	20.4^{a}	23.5	37.8^{b}

Explanation: a, b – $p < 0.05$

Tab. 4. The effect of body condition loss after calving on the total percentage of culled cows

Body condition loss percentage (groups)	No. of cows	Percentage of culled cows	
		total	due to infertility
< 10 (LBCL)	80	13.7^{aA}	0^{a}
10-20 (MBCL)	127	16.5^{b}	0^{a}
> 20 (HBCL)	304	25.3^{B}	10.9^{b}
Total	511	21.3	6.5

Explanation: arithmetic means in columns denoted with different lower case letters differ statistically significantly at $p < 0.05$, while those denoted with capital letters differ at $p < 0.01$
Remark: The number of cows was reduced by subtracting the number of dead cows

Generally no special dependence was found between varied body condition of cows before calving and the incidence of some postpartum complications, although in certain categories of body condition significant differences were recorded between the frequency of the retention of fetal membranes, puerperal metritis and clinical endometritis as well as corpus luteum pseudograviditatis. This lack of a distinct dependence could have resulted from a relatively small population of cows with extreme BCS before calving.

According to American data the mean FCR was 48%; it was lower in Holland, where after the first insemination 42.8% cows were impregnated (12, 15, 16). Similarly, lean cows before calving had a reduced first pregnancy rate (FCR) (10). It was shown that a low conception rate, characteristic of cows with extremely low BCS ante partum, could have been caused by insufficient progesterone priming in the period before estrus, in which the insemination procedure was performed, and a higher sensitivity of the corpus luteum to damage or luteolysis (3, 17). A significant correlation between BCS of cows at calving and the number of days open as well as the length of calving interval was recorded by Adamski and Onyszko (1). The period from calving to the first postpartum estrus was shorter in cows in which BCS ante partum was assessed at < 4.0; in those cows luteal ovarian activity

was restored earlier (16). Less distinctly manifested estrus symptoms, being e.g. the effect of the presence of dominant follicles with smaller dimensions on ovaries, result in a misdiagnosis of estrus or insemination at its incorrectly selected moment (18).

Waltner et al. (24) did not find a significant effect of body condition before calving on the frequency of calving and postpartum complications. Those authors simultaneously emphasized that the body condition of cows is not a key factor in relation to reproduction disorders.

Taking into consideration selected fertility indices it seems that values of some of these indexes may be to some extent related with the ante partum body condition of cows, especially in cows with low body condition scores. Such cows had the lowest FCR and the highest conception rates. In spite of this it needs to be stressed that service period in cows differing in body condition before calving varied, although these differences turned out to be statistically non-significant.

The mean minimum body condition score after calving was 2.52 and it was similar to the BCS of cows reported in another study, which was assessed at 2.6 (21). The minimum value was found for cows at different times after calving, mostly in the second, less frequently in the first and third month of lactation. Similar data were reported by other authors (1, 27). The average body condition loss was 0.74 points, i.e. 22%. The mean loss of BCS in Holstein-Friesian cattle was approx. 15% (19). Cows kept at privately-owned farms in Poland lost in comparison to body condition after calving 0.57 points, i.e. 13.3% (2). Some authors stated that a higher loss of body condition pp was recorded in those cows which before calving exhibited an extreme body condition (3, 7).

Numerous authors (7, 8, 15, 19) indicated that a considerable effect of body condition loss in cows after calving depended on the frequency of postpartum complications and on fertility. Loeffler et al. (16) stated that a considerable loss of body condition in cows post partum has a negative effect on their fertility, comparable to the effect of postpartum complications, and high yields. According to those authors a low FCR is to a considerable degree the effect of the volume of postpartum energy deficit, especially evident in those herds in which the feeding plane does not correspond to the increasing requirements of cows. In such herds a weakened expression of estrus symptoms and the extension of the period to the first postpartum estrus are observed. Cows losing 1 point of their BCS after calving were 1.5 times more difficult to impregnate than those in which body condition loss was lower (5). Such a trend was distinct especially in relation to primiparous cows. According to other studies a loss of more than 1.0 point BCS in the postparturition period resulted in a 17% FCR loss (9). Prandi et al. (21) showed that a 20% BCS loss in the first month after parturition in comparison to the body condition of cows 10 days ante partum significantly deteriorated fertility. According to other studies a loss of BCS by 0.7 points between day 14 and 28 pp was accompanied by a probability of the occurrence of the first postpartum estrus and impregnation reduced by 35 and 30%, respectively, which as a result had a significant effect on the extension of the postpartum anestrus and number of days open (13). Insufficient body condition, resulting from the deficit of energy and protein, may cause endometrium epithelial dysfunction, insufficient progesterone secretion and extended retention of the corpus luteum (14). Similarly, an energy deficit connected with loss of BCS may result in an inhibited growth of ovarian follicles after calving, their atresia, or transformation into ovarian cysts.

However, some authors did not confirm a dependence between BCS loss after calving and FCR as well as the number of insemination procedures required for pregnancy of cows (21, 22). Cows with a higher body condition during the first 30 days after calving more frequently exhibited metritis and ovarian cysts in the successive lactation (9).

A moderate effect on fertility in the analyzed population of cows was found for the postpartum body condition loss. In relation to puerperal metritis and clinical endometritis, corpus luteum pseudograviditatis, a significant increase was recorded in the incidence of these disorders with an increase in body condition loss after calving. Such an increase – although statistically insignificant – pertained also to cows with ovarian cysts and infertile cows. A considerable loss of body condition after calving did not have the expected negative effect on FCR and pregnancy rates. What is equally interesting – irrespective of the volume of body condition loss after calving – the service period was comparable in all groups of cows. This fact may indicate that a decisive effect on the values of reproduction indices could have been exercised by the adopted reproduction organization, especially culling, rather than body condition of cows after calving or its percentage loss. Based on the recorded results it also seems that the number of days open was significantly differentiated not by the volume of body condition loss after calving, but rather by the body condition of cows before calving.

Body condition of cows before calving had a significant effect on the total percentage of culled cows and the percentage of cows culled due to infertility. In both cases it was lower in lean cows than in fat cows. Moreover, it should be pointed out that the wastage rate in the first two moths post partum increased in speed in proportion to the increase in BCS ante partum. A higher culling risk of cows with excessive body condition before calving was reported by many authors (12, 20). It resulted in an increased frequency of metabolic diseases, elevated lipolysis, fatty liver, leg diseases, etc., thus increasing the risk of culling. Body condition loss after calving, unmitigated by the supply of

feed energy, on the one hand may be the effect of extreme body condition before calving, while on the other hand the starting point and at the same time the result of a deepening energy deficit. In extreme cases this may lead to ketosis, further deterioration of metabolic functions and an increased culling rate.

In conclusion, body condition of cows before calving and the volume of its loss in the first months after calving had a moderate effect on the frequency of calving complications and the value of selected fertility indices. In turn, the effect of varied body condition of cows was manifested in considerable differences in culling rates.

References

1. *Adamski M., Onyszko P.*: Analiza współzależności kondycji ciała krów czerwono-białych z niektórymi parametrami mleczności i rozrodu [An analysis of interdependencies of body condition of Red-and-White cows and selected milk production and reproduction parameters]. Zesz. Nauk. Przegl. Hod. 2000, 51, 85-92.
2. *Borkowska D.*: Analiza wpływu wybranych czynników na kondycję krów z gospodarstw indywidualnych [An analysis of the effect of selected factors on body condition of cows in privately-owned farms]. Medycyna Wet. 2000, 56,743-745.
3. *Bullman D. C., Lamming G. E.*: Milk progesterone levels in relation to conception, repeat breeders and factors influencing acyclicity in dairy cows. J. Reprod. Fert. 1978, 54, 447-458.
4. *Burke J. M., Hampton J. H., Staples C. R., Thatcher W. W.*: Body condition influences maintenance of a persistent first wave dominant follicle in dairy cattle. Theriogenology 1998, 49, 751-760.
5. *Domeq J. J., Skidmore A. L., Lloyd J. W., Kaneene J. B.*: Validation of body condition scores and milk yield in large dairy herd of high yielding Holstein cows. J. Dairy Sci. 1997, 80, 101-112.
6. *Edmonson A. J., Lean I. J., Weawer L. D., Farver T., Webster G.*: A body condition scoring chart of Holstein dairy cows. J. Dairy Sci. 1989, 72, 68-78.
7. *Ferguson J. D., Galligan D. T., Thomsen N.*: Principal description of body condition score in Holstein cows. J. Dairy Sci. 1994, 77, 2695-2703.
8. *Ferguson J. D., Otto K. A.*: Managing body condition scores in dairy cows. Proc. Intermountain Nutr. Conf., Salt Lake City, UT, Utah State University, Logan 2001, 1, 65-82.
9. *Gearhart M. A., Curtis C. R., Erb R. D., Smith C. J., Sniffen L. E., Chase L. E., Cooper L. D.*: Relationship of changes in condition score to cow health in Holstein. J. Dairy Sci. 1990, 73, 3132-3145.
10. *Gröhn Y. T., Rajala-Schulz P. J., Allore H. G., De Lorezo M. A., Hertl J. A., Galligan D. T.*: Optimization replacement of dairy cows: modeling the effects of diseases. Prev. Vet. Med. 2003, 61, 27-43.
11. *Guliński P., Litwińczuk Z., Młynek K., Niedziałek G.*: Ocena kondycji krów utrzymywanych w indywidualnych gospodarstwach województwa siedleckiego [Body condition scoring of cows kept on privately-owned farms in the Siedleckie province]. Zesz. Nauk. Przegl. Hod. 1994, 14, 289-299.
12. *Jaśkowski J. M., Olechnowicz J., Nowak W.*: Niektóre przyczyny obniżającej się płodności u krów mlecznych [Some causes of deteriorating fertility in dairy cows]. Medycyna Wet. 2006, 62, 385-389.
13. *Jorritsma R., Jorritsma H., Schukken Y. H., Wentink G. H.*: Relationships between fatty liver and fertility and some periparturient diseases in commercial Dutch dairy herds. Theriogenology 2000, 54, 1065-1074.
14. *Kolb B.*: Biochemie und Pathologie der Fortpflanzung. VEB Gustav Fischer Verlag, Jena 1984, pp 153.
15. *Lemie G. E., Stalheim P. S., Lemie M. R., Verdun L., Tiemann M., Bruning T. R.*: Monitoring reproductive performance of small dairy herds in veterinary practice. Can. Vet. J. 1991, 32, 551-557.
16. *Loeffler S. H., de Vries M. J., Schukken Y. H., de Zeeuw A. C., Dijkhuizen A. A., de Graaf F. M., Brand A.*: Use of AI technical scores for body condition, uterine tone and uterine discharge in a model with disease and milk production parameters to predict pregnancy risk at first AI in Holstein dairy cows. Theriogenology 1991, 51, 1267-1284.
17. *Looper M. L., Lents C.A., Wettermann R. P.*: Body condition at parturition and postpartum changes do not influence the incidence of short-lived corpora lutea in postpartum beef cows. J. Anim. Sci. 2003, 81, 2390-2394.
18. *Markusfeld O., Ezra E.*: Body measurements, metritis, and postpartum performance of first lactation cows. J. Dairy Sci. 1993, 76, 3771-3777.
19. *McCann J. P., Loo S. C., Aalseth D. L., Abribat T.*: Differential effects of GH stimulation on fasting and prandial metabolism and plasma IGFs and IGF-binding proteins in lean and obese sheep. J. Endocrinol. 1997, 154, 329.
20. *Olechnowicz J., Jaśkowski J. M.*: Kondycja, zaburzenia rozrodu i produkcja mleka u krów [Body condition, reproduction disorders and milk production in cows]. Medycyna Wet. 2005, 61, 972-975.
21. *Prandi A., Messina M., Tondolo A., Motta M.*: Correlation between reproductive efficiency, as determined by new mathematical index, and the body condition score in dairy cows. Theriogenology 1999, 52, 1251-1265.
22. *Schwager-Suter R., Stricker C., Erdin D., Kunzi N.*: Relationship between body condition scores and ultrasound measurements of subcutaneous fat and m. longissimus dorsi in dairy cows differing in size and type. Anim. Sci. 2000, 71, 465-470.
23. *Veerkamp R. F., Oldenbroek J. K., van der Gaast H. J., van der Werft J. H. J.*: Genetic correlation between milk yield, energy balance, and live weights. J. Dairy Sci. 2000, 83, 577-583.
24. *Waltner S. S., McNamara J. K., Hillers J. K., Brown D. L.*: Validation of indirect measures of body fat in lactating cows. J. Dairy Sci. 1994, 83, 577-583.

Author's address: Prof. dr hab. Jędrzej M. Jaśkowski, Azaliowa 23, 62-002 Złotniki, Poland; e-mail: jasko@up.poznan.pl