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The effect of feeding level of pre- and postpubertal heifers on their reproductive function and later milk production

K. Bilik[1], J. Strzetelski[1], S. Osięgłowski[2] and P. Gogol[3]

[1]Department of Animal Nutrition,
[2] Experimental Station in Pawłowice,
[3] Department of Animal Reproduction,
Research Institute of Animal Production
32-083 Balice, Poland

ABSTRACT

Thirty-three heifers were assigned to 3 analogous groups of 11 animals each in which three different levels of feeding were used from 6.5 to 10 months (first period) and from 11 to 12 months of age (second period): the feeding level recommended by the IZ-INRA system (1997) (group C), lower and then 20% higher in subsequent periods in relation to group C (group D), and 20% higher in both periods in relation to group C (group H). Body weight gains in different rearing periods were assumed as follows (g/day): 700 (C), 560 and 840 (D), 840 (H), and from 13 months of age to 3 weeks before calving 700 g/day in all the groups. Next the heifers were fed the rations specified for primiparous cows assuming maximum production at peak of lactation to be 35 kg milk per day. The varying level (group D) of feeding prepubertal and postpubertal heifers was found to have no adverse effect on ovarian size and status at 12 months of age and on subsequent growth and development of these animals, while having a beneficial effect on their milk performance during the first lactation. The high feeding level (group H) from 6.5 to 12 months of age led to increased daily weight gains and accelerated the date of reproductive performance of heifers compared with their age-mates from group C.

KEY WORDS: heifers, feeding level, growth, ovarian development, milk yield

INTRODUCTION

Studies on Holstein-Friesian cattle have shown that the feeding level of heifers of dairy breeds during their growth affects the development of the mammary gland and consequently, the cow's subsequent milk production (Sejrsen and

Purup, 1997). The most intensive development of the udder parenchyma takes place in the period prior to the attainment of sexual maturity (Choi et al., 1997). An excessive level of feeding energy during this period and daily weight gains that are different from the optimum value specified for a given breed may result in excessive fattness of the mammary gland, a process that inhibits the growth of parenchymal tissue that produces milk (Foldager and Sejrsen, 1991). At present, most of the high-producing cows in Poland are Black-and-White breed with a higher proportion of Holstein-Friesian genes. There are no uniform recommendations in Poland yet for the feeding level of prepubertal and postpubertal heifers derived from these crossbreeds.

The aim of the present work was to determine the effect of various feeding levels of Black-and-White heifers with a high proportion of HF genes before and after the attainment of sexual maturity on their growth, on ovarian size and status at 12 months of age, and on their reproductive and milk performance.

MATERIAL AND METHODS

Thirty-three Black-and-White heifers with a high (>75%) proportion of HF genes were investigated from 6.5 months of age to 100 days of lactation. The animals were assigned to 3 analogous groups of 11 animals each in which three different levels of energy feeding were used from 6.5 to 10 months and from 11 to 12 months of age: that recommended by the IZ-INRA system (1997) in group C, lower and then 20% higher in subsequent periods in relation to group C (group D), and 20% higher in both periods in relation to group C in group H (Table 1). In all of the groups, the protein to energy ratio ranged from 95-100 g PDI/UFL. From 13 months of age to 3 weeks before calving, all of the heifers received a

TABLE 1

Experimental design

Period of experiment age, month of	Groups		
	C	D	H
	predicted body weight gains, g/day, and feeding level, %		
6.5 - 10	700 (100)	560 (-20)	840 (+20)
11 - 12	700	840 (+20)	840
13 - 3 weeks before calving	700	700	700
From 3 weeks before calving to 100 days of lactation	the level of feeding as for primiparous cows according to the INRA system, PM[1] = 35 kg milk day $^{-1}$		

[1] peak milk production

ration to achieve 700 g daily weight gain. Next, the heifers were fed rations specified by the IZ-INRA system for primiparous cows assuming 35 kg milk production at the peak of lactation. At 12 months of age, 21 randomly chosen heifers (7 from each group) were examined ultrasonographically to determine ovarian size and function. For this purpose we used the C 9100 Oculus apparatus (Picker International GmbH 32 339 Esplecamp, Germany) equipped with a convex 6.5 MHz probe enabling a resolution of about 2 mm. Chemical feed analyses were performed according to AOAC (1990).

Statistical calculations were made using one-factor analysis of variance, and the results of milk performance were analyzed with one-factor analysis of covariance with two accompanying variables (age at first calving and calving season), using the SAS statistical package (1989) and the GLH procedure. The results of calving percentage of heifers and cows were analyzed with the χ^2 test.

RESULTS

The right ovary of heifers from group H was larger than that of their age-mates from the other groups ($P<0.01$ and $P<0.05$) (Table 2). There were no significant differences among the groups for the size of left ovary and for the size and number of ovarian follicles ($P>0.05$). One to three large follicles 9-15 mm in diameter and from several (3-7) to more than a dozen (12-16) small follicles 3-8 mm in diameter were found on the ovaries of the majority of the heifers. The *corpus luteum* was present in 4 heifers from group D, in 5 from group C and in 6 from group H.

TABLE 2

Ovarian size and status in heifers

Item	Groups			RMSE [1]
	C	D	H	
Length of right ovary, mm	30.14^{B}	28.00^{B}	43.00^{A}	4.58
Width of right ovary, average, mm	19.28^{Bb}	17.57^{Bb}	24.57^{Aa}	3.53
Length of left ovary, average, mm	29.57	32.57	29.43	7.18
Width of left ovary, average, mm	23.57	22.71	21.14	5.97
Diameter of follicles on right ovary, mm	7.18	5.90	7.37	2.60
Diameter of follicles on left ovary, mm	6.13	5.40	6.51	1.84
No of follicles on right ovary, average	5.80	6.71	6.85	4.50
No of follicles on left ovary, average	5.71	7.14	3.57	4.15

[1] $\sqrt{S^2}$

The low level of energy feeding (group D) of heifers from 6.5 to 10 months of age caused daily weight gains to decrease by about 23 and 33% and body weights at 10 months of age to decrease by about 6 and 10% compared with groups C and H, respectively. The highest daily weight gains of heifers from 6.5 to 10 months of age were found in group H ($P<0.01$ and $P<0.05$), and the lowest in group D (Table 3). From 11 to 12 months of age, heifers from group C had lower weight gains ($P<0.05$) than those from groups D and H, with no significant differences being found among them. During the next period (13-18 months of age), daily

TABLE 3

Body weight, daily gains, growth efficiency and reproductive performance of heifers and milk yield of primiparous cows

Item	Groups			RMSE
	C	D	H	
Body weight, kg, at age, months				
6.5	209.0	209.3	209.1	26.37
10	288.8^{ab}	271.1^{b}	301.5^{a}	32.66
12	332.1	323.2	352.3	34.11
18	434.3	430.9	443.8	26.23
Body weight 7 days before calving	635.6	644.0	631.0	28.55
Daily weight gains in periods, kg				
6.5 – 10	0.688^{Ab}	0.533^{Bc}	0.794^{Aa}	0.099
11 – 12	0.709^{Bb}	0.854^{Aa}	0.833^{Aa}	0.057
13 – 18	0.625^{A}	0.657^{A}	0.558^{B}	0.067
19 – calving	0.662	0.696	0.683	0.096
Growth efficiency in periods[1]				
6.5 – 18	10.22	10.09	9.76	1.91
19 – calving	6.83	7.14	7.05	0.82
Age of heifers at calving, months[2]	28.0	27.9	27.0	0.72
Insemination or embryo transfer index	1.8	1.8	1.5	1.01
Pregnancy, of which after 1st treatment, %	55.5	55.5	66.6	-
Milk yield, 100-day lactation, kg	2984.6	3195.6	3074.5	420.69
Milk production in peak lactation, kg/day	32.7	35.1	34.0	3.86
Efficiency of UFL, PDI utilization[3]				
milk kg/ 1UFL	1.4	1.51	1.46	0.181
milk kg/ 100 g PDI	1.42	1.47	1.44	0.186

[1] daily gain of body weight, kg / DM (kg. day $^{-1}$) x 100

[2] embryo transfer and insemination

[3] average (%): fat 4.18, protein 3.20, lactose 4.80

weight gains decreased in group H compared with the other groups ($P<0.05$). During the period from 19 months of age to calving, there were no significant differences in daily weight gains among the groups. The varying (group D) and high (group H) feeding levels of heifers from 6.5 to 12 months of age did not reduce the parameters of reproductive performance in comparison with group C. There were no significant differences among the groups ($P>0.05$) in terms of milk production for the first 100 days of lactation. However, during this period primiparous cows from group D were characterized by a slightly (about 7 and 4%) higher milk yield and better conversion of the ration's energy (UFL) and protein (PDI) per kg milk production compared with groups C and H.

DISCUSSION

Data on ovarian growth indicate that all of the heifers attained sexual maturity by 12 months of age regardless of the feeding level. The results of studies on ovarian size and diameter of ovarian follicles are in agreement with the results of other authors (Sirois and Fortuen, 1988; Grygar and Kudlać, 1997) obtained with dairy breed heifers. They point out that the course of the ovarian cycle is characterized by a wavelike pattern of follicular growth and regression (Roche and Boland, 1991; Evans et al., 1994).

The parameters of growth are similar to the currently recommended standards for dairy heifers (Hoffman, 1997; Trela et al., 1997). The reproductive parameters obtained in particular groups showed that neither the varying (group D) nor the high (group H) level of energy feeding had a negative effect on the reproductive performance of prepubertal and postpubertal heifers. Accelerated reproductive performance and thus a younger at first calving when feeding rations higher in energy from 6.5 to 12 months of age were also reported by Peri et al. (1993) for Israeli Friesian heifers.

The beneficial effect of the varying level of energy feeding from 6.5 to 12 months of age on the productivity of cows during lactation and on the conversion of the ration's energy and protein per kg of milk production was also reported by other authors (Park et al., 1987; Peri et al., 1993; Choi et al., 1997) for Holstein-Friesian heifers during their growth from about 6 months of age to calving.

These authors report that the varying level of energy feeding during the period prior to and after the attainment of sexual maturity stimulates compensatory growth, which is accompanied by better development of the mammary gland's parenchymal tissue than with standard feeding and consequently, by a higher milk yield during lactation. It is worth noting, however, that the high feeding level applied in group H during the sexual maturation of heifers did not reduce milk production compared with heifers from group C, while advancing the beginning of reproduc-

tive performance and the date of first calving. A similar relationship was found for HF heifers (Vicini et al., 1995; Hinders, 1997; Pirlo et al., 1997). It seems that Black-and-White dairy heifers (with a high HF blood share) can tolerate higher feeding levels than previously recommended for the period of sexual maturation without negative consequences for their subsequent reproductive and milk performance.

CONCLUSIONS

Varying the level of energy feeding of Black-and-White heifers with a high proportion of HF genes from 6.5 to 12 months of age in relation to the requirement specified by the IZ-INRA system (1997) for a weight gain of 700 g/day has a beneficial effect on milk production during the first lactation and on the conversion of energy (UFL) and protein (PDI) per kg milk production.

Advancing the growth of heifers prior to and after the attainment of sexual maturity does not adversely affect the parameters of reproductive performance or the milk yield of these animals during the first 100 days of lactation, making it possible to lower the age of first calving.

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STRESZCZENIE

Wpływ poziomu żywienia jałówek w okresie przed i po uzyskaniu dojrzałości płciowej na wskaźniki rozrodu i ich późniejszą użytkowość mleczną

Trzydzieści trzy jałówki przydzielono do 3 analogicznych grup (po 11), w których od 6,5 do 10 (pierwszy okres) i od 11 do 12 (drugi okres) miesiąca życia stosowano trzy różne poziomy żywienia: w grupie C zalecany przez normy IZ-INRA (1997), w grupie D - niższy, a następnie wyższy o 20% w kolejnych okresach w stosunku do grupy C, w grupie H - wyższy w obydwóch okresach w porównaniu z grupą C. Założono, że w poszczególnych okresach wychowu przyrosty masy ciała będą wynosić odpowiednio (g/dzień): 700 (C), 560 i 840 (D), 840 (H), zaś w okresie od 13 miesiąca życia do 3 tygodnia przed wycieleniem we wszystkich grupach - 700 g/dzień. Następnie jałówki żywiono dawkami przewidzianymi dla krów pierwiastek zakładając, że produkcja maksymalna w szczycie laktacji wyniesie 35 kg mleka na dzień. Stwierdzono, że zróżnicowany (grupa D) poziom żywienia jałówek przed i po uzyskaniu dojrzałości płciowej nie wpłynął ujemnie na wielkość i stan czynnościowy jajników w wieku 12 miesięcy oraz późniejszy wzrost i rozwój tych zwierząt, natomiast korzystnie wpłynął na ich użytkowość mleczną w okresie pierwszej laktacji. Wysoki poziom żywienia (grupa H) w okresie od 6,5 do 12 miesiąca życia spowodował zwiększenie dziennych przyrostów i przyśpieszenie terminu użytkowania rozrodczego jałówek w porównaniu z rówieśnicami z grupy C.