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EVALUATION OF SOW BODY DEVELOPMENT THROUGHOUT THE REPRODUCTION CYCLE AND ITS INFLUENCE ON REPRODUCTIVE PERFORMANCE IN THE DANUBE WHITE BREED

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Abstract

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The dynamics of body development have been estimated in 757 Danube White sows in four periods of their reproduction cycle: at 90 kg of live weight; at mating; at 30-day gestation; and at 110-day gestation. Subject of control were the sow productivity traits: live weight; backfat thickness at points X_1 and X_2; depth of *m. longisimus dorsi*; and lean meat percentage. Subject of analysis were the reproductive ability of sows from first to seventh and more litters. The controlled sow's reproduction traits were litter size at birth and at 21-st day, as well litter weight at birth and at 21-st day. The results representing reproduction capacity in relation to body development during gestation indicated that the sows with thicker backfat have litters with larger size ($P \leq 0.001$) and weight ($P \leq 0.01$) at farrowing. Maintaining backfat of appropriate and constant thickness (18-20 mm) throughout the reproduction cycle of the Danube White sows is more essential for their reproductive efficiency and welfare than controlling it by standard testing or at the time of mating.

Keywords: sow, backfat, weight, born alive, litter weght

Introduction

Maintaining live weight and backfat of sows in optimal ranges (in accordance with the lineage and the housing and feeding technology) during the whole reproduction cycle ensures optimal reproductive efficiency.

Most of the studies find that reducing backfat during the reproduction cycle, and especially during the lactation, is associated with longer weaning-to-estrus interval, disorders of pregnancy, and hence lower productive longevity (De Rensis et al., 2005; Serenius et al., 2006), as well as with higher risk of involuntary culling (Young et al., 1990, 1991; Kongsted, 2006).

It is noteworthy that some producers additionally control backfat at mating and after farrowing. In this relation, an extended study – in different stages of reproduction cycle – on backfat thickness and energy intake during the concurrent lactation will contribute for the optimization of the reproductive capacity of sows.

The objective of the study was evaluation of body development of Danube White sows and its influence on their reproductive performance.

Materials and Methods

The study was carried out at Agricultural Institute – Shumen for the period 2012-2013. Subject of investigation were the dynamics of live weight, backfat thickness, and percentage of lean meat in Danube White sows.

Body development was estimated in 757 sows. The control of productive traits was carried out in four periods: period I – at 90 kg of live weight; period II – at mating; period III – at gestation day 30; and period IV – at gestation day 110.

Subject of control were the following traits: live weight; backfat thickness measured at topographic point X_1 (located between third and fourth lumbar vertebrae, 7 cm off the midline); and X_2 (located between third and fourth last ribs, 10

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cm off the midline); depth of *m. longisimus dorsi* (MLD); and lean meat percentage.

Estimates were obtained for the reproduction traits of the sows from first to seventh-plus farrowing (parity). The following traits were subjected to control: litter size at birth and at 21-st day, as well as litter weight at birth and at 21-st day.

From mating to 30-day gestation the sows were kept in individual boxes, and afterwards to 110-day gestation – in group boxes. The feeds were correspondent to the technological category and in compliance to the Bulgarian state standard BDS 1642-96 (1996).

The data was processed by the software package LSMLMW&MIXMDL version PC-2 (Harvey, 1990).

The following statistical model was used:

$$Y_{(i\text{-}k)} = \mu + T_{i(1\text{-}4)} + L_{j(1\text{-}10)} + e_{(i\text{-}k)} ,$$

where μ is the general mean of the trait, $T_{i(1\text{-}4)}$ – the fixed effect of period of testing, $L_{j(1\text{-}7)}$ – the fixed effect of parity, $e_{(i\text{-}k)}$ – residual effect.

The significance of the differences among different levels of each factor was established in correspondence to the Student's distribution (Hayter, 1984):

$$(y_i\text{-}y_j) / S \sqrt{(1/n_i+1/n_j)/2} ,$$

where y_i-y_j is the difference between the mean values of the levels of the factor, S – standard deviation, n_i and n_j – number of animals within the respective levels.

Results

The results of the evaluation of sow productivity and reproduction capacity of the Danube White breed are presented in Table 1. The results indicate that backfat thickness at points X_1 and X_2 was respectively 19.3 and 17.3 mm. The number of born alive piglets was 9.47, and the number of non surviving piglets to the 21-st day is 0.41.

The coefficients of variation of the sow productivity traits – live weight and backfat thickness – were in the range from 14.09 to 15.70%, while the variability of the trait lean meat was low – 0.92%. The variability of the reproductive traits was found to range from 11.6 to 24.6%, the lowest values being established for litter size and weight at the 21-st day.

The established regression coefficients of the productivity traits on backfat thickness and depth of MLD are highly significant (P ≤ 0.001), and on litter live weight at 21-st day the degree of statistical significance is variable – P ≤ 0.01 and P ≤ 0.001. Highly significant are also the regression coefficients among the reproductive traits (P ≤ 0.001).

The F-test from the ANOVA is presented in Table 2. Period of testing have shown to exert highly significant effect on the traits live weight and backfat thickness of sows (P ≤ 0.001), and moderately significant on lean meat percentage (P ≤ 0.01). Parity has most pronounced effect on sows' live weight, litter size at birth, and litter weight at birth and at the 21-st day. Its effect on backfat and piglets' survival to 21-st day is also significant (P ≤ 0.05).

Table 1
Mean values and variability of the studied traits in Danube White sows and their regression on depth of *m. longisimus dorsi* (MLD), backfat thickness (BFT= $X_1 + X_2$), litter weight at birth (LW_B), and litter weight at 21-st day (LW_{21})

Traits	Sow live weight	Backfat thickness at X_1	Backfat thickness at X_2	Lean meat percentage	Litter size at birth	Litter weight at birth	Litter size at 21-st day	Litter weight at 21-st day
LSM	150.22	19.31	17.33	51.80	9.47	13.91	9.06	48.70
SE	0.905	0.113	0.113	0.020	0.093	0.143	0.044	0.236
SD	49.73	6.39	5.16	4.80	2.51	3.78	1.08	7.99
C	14.48	14.09	15.70	0.92	23.70	24.67	11.60	11.66
Rhy/MLD	0.811 ± 0.1 xxx	0.121 ± 0.017 xxx	-0.121± 0.017 xxx	0.135 ± 0.003 xxx	0.014 ± 0.014	0.014 ± 0.021	0.001 ± 0.006	0.001 ± 0.035
Rhy/BFT	0.966 ± 0.083 xxx	0.590 ± 0.010 xxx	0.410 ± 0.010 xxx	-0.468 ± 0.002 xxx	-0.002 ± 0.009	0.006 ± 0.013	-0.004 ± 0.004	-0.017 ± 0.022
Rhy/LW_B	1.856 ± 3.143	-0.218 ± 0.393	0.218 ± 0.0393	-0.018 ± 0.069	-3.194 ± 0.324 xxx	4.123 ± 0.495 xxx	0.073 ± 0.152	0.725 ± 0.820
Rhy/LW_{21}	6.008 ± 1.262 xxx	-0.516 ± 0.158 xx	0.416 ± 0.158 xx	-0.032 ± 0.028	-0.134 ± 0.130	-0.138 ± 0.199	-0.210 ± 0.061 xxx	7.567 ± 0.329 xxx

Significance level: x – P≤0.05, xx – P≤0.01, xxx – P≤0.001

The table also presents the coefficients of determination. The values regarding the sow productivity ($R^2 = 0.73 – 0.99$) show that the factors in the model have been fitted to explain the variability to a very high degree. The coefficient of determination for 21-day litter weight is relatively high ($R^2 = 0.50$), while for the other reproductive traits R^2 has low values.

The effect of testing period on sow productive traits is shown in Table 3. The analysis of the results established a reasonable gain of live weight up to gestation day 110 (from 101.1 to 198.8 kg). The differences among the live weights at the different periods are highly significant ($P \leq 0.001$).

With the advance in pregnancy, sows' backfat thickness at X_1 was found to decrease from 19.73 to 18.25 mm ($P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$). About the backfat at point X_2, there was established an increase by 1.48 mm during gestation. The estimate of the trait at 110-day gestation (18.39 mm) significantly differs from the other periods ($P \leq 0.001$), the difference with 30-day gestation being 1.16mm ($P \leq 0.05$).

With respect to the trait lean meat percentage, the differences among the testing periods have shown to be inconsiderable.

As the results in Table 4 indicate, the advancement of parity is associated with a gradual increase in sows' live weight at mating and at days 30 and 110 of pregnancy ($P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$). Backfat measured at location X_1 has shown to be thicker than that at X_2. The established differences in backfat thickness among parities are in the range of only few millimetres and are not significant in general. The established significant differences in X_1 and X_2, concerning only parity VII ($P \leq 0.05$), are to be attributed to the changing feeding and management conditions observed over the productive life of the sows.

With every successive farrowing there is a tendency for decrease in backfat thickness at location X_1, while at X_2 the tendency is opposite. This tendency characterizing the differences between X_1 and X_2 could be explained with the uneven adipose tissue deposition in the body.

Parity had not affected lean meat percentage measured at mating and at days 30 and 110 of gestation (Table 4).

The results about the reproductive ability of sows in relation to their body development during pregnancy indicate that those with greater backfat thickness had greater number of live-born piglets ($P \leq 0.001$) and greater litter weight at farrowing ($P \leq 0.01$) (Figures 1 and 2). Similar is the tendency about the effect of meat percentage in carcass. Opposite is only the tendency regarding X_1 backfat and meat percentage measured at 30-day pregnancy. As for the changes in

Table 2
Analysis of variance

Sources of variance	df	Live weight of sows	Backfat at X_1	Backfat at X_2	Lean meat percentage	Litter size at birth	Litter weight at birth	Litter size at 21-st day	Litter weight at 21-st day
Period of testing	3	xxx	xxx	xxx	xx	n.s	n.s	n.s	n.s
Parity	6	xxx	x	x	n.s	xxx	xxx	x	xxx
R^2		0.812	0.822	0.727	0.990	0.211	0.190	0.064	0.504

Significance levels: xxx – P≤0.001, xx – P≤0.01, x – P≤0.05, n.s. – P>0.05

Table 3
Effect of period of testing on sow productivity traits (LSC ± SE)

Traits	Overall LSC	Period of testing			
		I	II	III	IV
		n= 207	n= 140	n= 207	n= 203
Live weight, kg	155.719 ± 0.904	101.126 A ± 1.588	155.859 B ± 1.894	167.077 C ± 1.576	198.812 D ± 1.626
Backfat thickness at X_1, mm	19.35 ± 0.113	20.02 Ax ± 0.199	19.73 a ± 0.237	19.41 Bby ± 0.197	18.25 z ± 0.203
Backfat thickness at X_2, mm	17.29 ± 0.113	16.61 A ± 0.199	16.91 A ± 0.237	17.23 Bx ± 0.197	18.39 By ± 0.203
Lean meat percentage	51.80 ± 0.020	51.88 ± 0.035	51.79 ± 0.041	51.81 ± 0.034	51.71 ± 0.036

Significance of differences among values in rows designated with different symbols:
A,B,C,D – P≤0.001, a,b – P≤0.01, x,y,z – P≤0.05

Table 4
Effect of parity on sow productivity traits from mating to 110-day gestation (LSC ± SE)

Traits	Overall LSC	First	Second	Third	Fourth	Fifth	Sixth	Seventh
Mating								
n	140	19	37	27	20	19	7	11
Live weight	155.81 ± 1.61	110.94 Ax ± 4.03	127.34 Ay ± 2.82	161.20 Ba ± 3.35	163.85 BΔ ± 3.81	169.09 B ± 3.89	171.43 B ± 6.42	186.80 Bbθ ± 5.30
Backfat X_1	19.08 ± 0.26	18.86 ± 0.64	18.75 ± 0.45	18.71 ± 0.53	18.81 ± 0.60	19.08 ± 0.62	20.30 ± 1.02	19.06 ± 0.84
Backfat X_2	16.31 ± 0.26	16.53 ± 0.64	16.64 ± 0.45	16.68 ± 0.53	16.57 ± 0.60	16.32 ± 0.62	15.10 ± 1.02	16.33 ± 0.84
Lean meat %	52.25 ± 0.07	51.98 ± 0.18	52.26 ± 0.12	52.42 ± 0.15	52.28 ± 0.17	52.26 ± 0.17	52.34 ± 0.28	52.18 ± 0.23
Gestation day 30								
n	207	40	47	38	30	25	11	16
Live weight	170.78 ± 1.35	123.85 A ± 2.82	146.99 B ± 2.55	174.48 C$± 2.81	179.68 Ca ± 3.19	184.43 Cy ± 3.45	182.76 Cy ± 5.23	203.24 C£bx ± 4.34
Backfat X_1	20.30 ± 0.21	20.45 ± 0.44	20.55 ± 0.40	19.74 ± 0.44	20.71 ± 0.50	21.22 x ± 0.54	21.23 ± 0.82	18.19 y ± 0.68
Backfat X_2	18.01 ± 0.21	17.86 x ± 0.44	17.76 x ± 0.40	18.57 ± 0.44	17.60 x ± 0.50	17.09 x ± 0.54	17.08 x ± 0.82	20.12 y ± 0.68
Lean meat %	50.99 ± 0.03	50.94 ± 0.05	50.99 ± 0.050	50.97 ± 0.05	51.02 ± 0.06	51.18 ± 0.07	51.02 ± 0.10	50.81 ± 0.08
Gestation day 110								
n	203	40	45	38	30	25	10	15
Live weight	203.77 ± 2.09	164.21 Aa ± 4.26	177.71 Ab ± 3.96	209.36 Bx ± 4.28	214.02 B ± 4.84	215.30 B ± 5.22	218.20 B ± 8.31	227.59 By ± 6.77
Backfat X_1	19.27 ± 0.24	18.21 ± 0.50	19.90 ± 0.46	19.92 ± 0.50	20.21 ± 0.56	19.73 ± 0.61	19.44 ± 0.97	17.49 ± 0.79
Backfat X_2	18.90 ± 0.24	19.96 ± 0.50	18.26 ± 0.46	18.25 ± 0.50	17.96 x ± 0.56	18.43 ± 0.61	18.73 ± 0.97	20.68 y ± 0.79
Lean meat %	51.29 ± 0.03	51.24 ± 0.07	51.37 ± 0.07	51.24 ± 0.07	51.36 ± 0.08	51.32 ± 0.09	51.29 ± 0.14	51.18 ± 0.11

Significance of differences among values in rows designated with different symbols (beneath value) within groups of symbols: A, B, C – P≤0.001, £,$ – P≤0.001, a,b – P≤0.01, x,y – P≤0.05, Δ,θ – P≤0.05

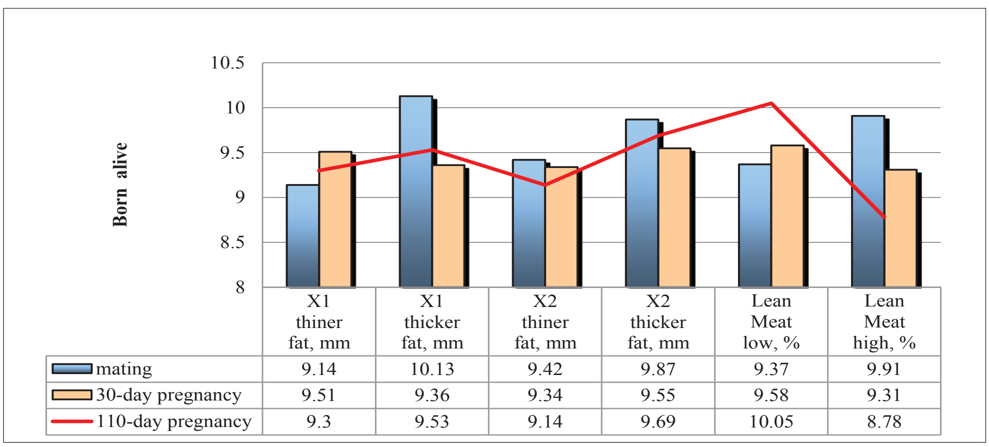
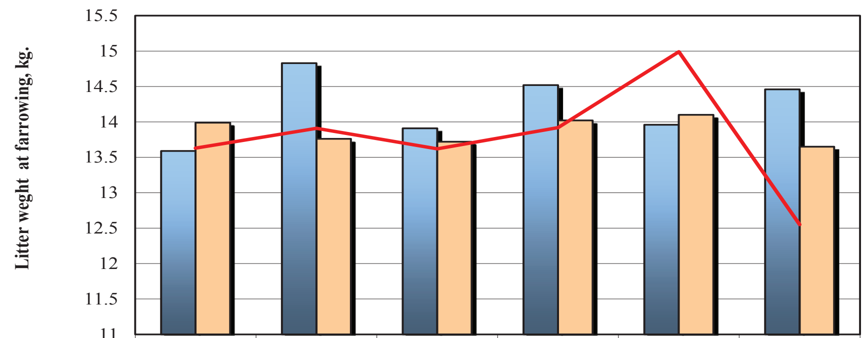
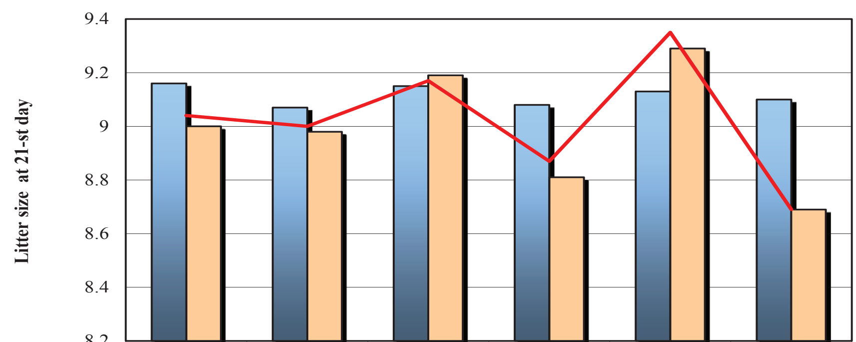


Fig. 1. Effect of changes in backfat thickness and lean meat percentage during pregnancy on litter size at birth



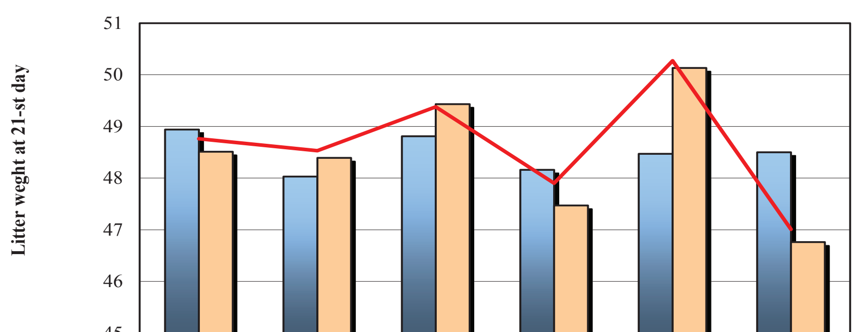
	X1 thiner fat, mm	X1 thicker fat, mm	X2 thiner fat, mm	X2 thicker fat, mm	Lean Meat low, %	Lean Meat high, %
mating	13.59	14.83	13.91	14.52	13.96	14.46
30-day pregnancy	13.99	13.76	13.72	14.02	14.1	13.65
110-day pregnancy	13.63	13.91	13.62	13.92	14.99	12.55

Fig. 2. Effect of changes in backfat thickness and lean meat percentage during pregnancy on litter weight at birth



	X1 thiner fat, mm	X1 thicker fat, mm	X2 thiner fat, mm	X2 thicker fat, mm	Lean Meat low, %	Lean Meat high, %
mating	9.16	9.07	9.15	9.08	9.13	9.1
30-day pregnancy	9	8.98	9.19	8.81	9.29	8.69
110-day pregnancy	9.04	9	9.17	8.87	9.35	8.69

Fig. 3. Effect of changes in backfat thickness and lean meat percentage during pregnancy on litter size at 21-st day



	X1 thiner fat, mm	X1 thicker fat, mm	X2 thiner fat, mm	X2 thicker fat, mm	Lean Meat low, %	Lean Meat high, %
mating	48.94	48.03	48.81	48.16	48.47	48.5
30-day pregnancy	48.51	48.39	49.43	47.47	50.13	46.76
110-day pregnancy	48.76	48.53	49.38	47.9	50.27	47.01

Fig. 4. Effect of changes in backfat thickness and lean meat percentage during pregnancy on litter weight at 21-st day

litter size and weight at the 21-st day, it was established that the sows with thinner backfat and respectively lower meat percentage measured at the different stages of gestation are marked with better productive performance (Figures 3 and 4). The Figures show the reproductive abilities of the sows in relation to the changes in meat percentage measured at the different stages of pregnancy. It is noteworthy that the results about the meat percentage checked at gestation day 110 are in keeping with this tendency. They show that the sows with higher percentage of meat at the end of pregnancy had lower reproduction capacity ($P \leq 0.001$).

Discussion

The constructed model in this study was fitted to high degree of determination for the sow productivity traits, the factor period of testing showing to have highly significant specific ($P \leq 0.001$). The established values representing the dynamics of body development from conception and over the whole gestation period were found to normally increase. The results characterizing the backfat thickness measured throughout the reproductive cycle are ranging closely – within about 2 mm. That justifies the consideration of the studied Danube White sows as marked with appropriate backfat to ensure optimal reproductive capacity. Relevantly, Zaleski and Hacker (1993) have found that both too thick backfat and too poor deposition of fat reserves in the sow's organism lead to reproductive disorders.

The established herein decline in reproductive ability of sows in response to diminished backfat thickness at mating are consistent with our previous studies finding low or negative genetic correlation coefficients between them – from $r_g = 0.05$ to $r_g = -0.265$ (Apostolov et al., 2014). In the present study was established that the sows with higher backfat thickness and lean meat measured at 30- and 110-day gestation have lower reproductive capacity. This is in keeping with the study of Maes et al. (2004) reporting negative relationship between backfat and incidence of stillbirth. The results regarding the association between reproduction and lean meat percentage imply that the protein and energy requirements of pregnant sows need more adequate care. On the basis of these results, we can assert that the selection for improvement of meat percentage affects the reproduction capacity of the Danube White sows. Similar are the studies of Dourmand et al. (1994), Sterling and Lundeheim (1995) and Everaert et al. (2007), noting that the selection on sow productivity towards higher growth rate and lower backfat thickness exerts considerable influence on reproduction of sows, especially at first parity. McKay (1993) also observed that the selection for thinner backfat results in lower survival of piglets to weaning. On the other hand, contrary are the results of Szulc et al. (2013) establishing better reproductive performance in the sows with meat percentage as high as over 60%.

Conclusions

Maintaining backfat of appropriate thickness (18-20 mm) throughout the reproduction cycle is more essential for the reproductive efficiency and welfare of Danube White sows than controlling it by standard testing or at the time of mating.

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