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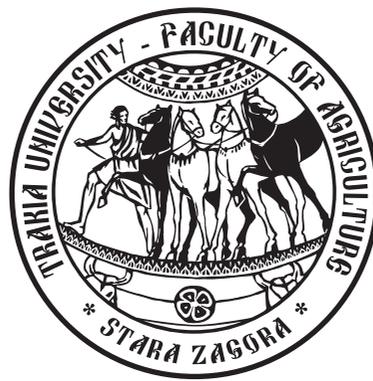
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Genetics and Breeding

Effect of the age at first calving on test day production traits in black-and-white cows

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Abstract. The research has been carried out with cows of the Bulgarian black-and-white cattle in 10 farms from various regions in the country. The cows calved in the period 1995–2006. A total of 1460 cows are included with 2852 lactations from Ist to IIIrd and respectively 27228 test day records. The age at first calving has reliable effect on test day milk yield, milk fat and % of fat. Cows that calved for the first time at an age of 27 to 30 months have the highest test day milk yield and milk fat followed by the ones that calved respectively on 24-27 and 30-33 months, with small difference between them. The cows that calved at the age of 27-30 months had the highest daily milk yield in the lactation peak – 19.78 kg. In the test day % of fat the tendency is for higher values in cows that calved for the first time at a greater age.

Keywords: age at first calving, test day milk yield, milk fat, % milk fat, black-and-white cows

Introduction

The age at first calving is one of the main factors influencing the efficiency of dairy farms both through direct costs for replacement animals (Tozer and Hendrichs, 2001) and through their potential effect on the qualities of cows afterwards (Pirlo et al., 2000; Nilforooshan and Edriss, 2004). The age at first calving is a trait that is influenced greatly by various factors – hereditary and environment. A number of authors report a difference in the age of calving of cows from various dairy breeds depending on their maturity rate (Mourits et al., 2000). With cows from the same breed differences are reported in the various countries (Hare et al., 2006; Pirlo et al., 2000; Perez et al., 1999; Berry and Cromie, 2008), conditions of rearing and nutrition, etc. (Ruiz-Sanchez et al., 2007). Very often it results from various management or subjective decisions of owners, whereas the optimum age of first calving depends on the existing economic situation, such as price of milk, price of culled cows, price of forage (for pasture rearing that will include favorable land price), as well as other costs – for buildings, labor, etc. (Berry and Cromie, 2008). Regardless of what factors it results from the age at first calving has effect on productivity (Pirlo et al., 2000; Nilforooshan and Edriss, 2004), the type of calving and fertility of cows (Simerl et al., 1991; Ettema and Santos, 2004), the duration of their use (Ojango et al., 2005; Berry and Cromie, 2008; Haworth et al., 2008) and generally on the economic efficiency of milk production (Pirlo et al., 2000). Studies are directed mainly towards the effect of age at first calving on milk productivity per lactation. Recently for selection of dairy breeds in many countries the breeding value assessment is applied by using Test day models. Their application, in addition to all other advantages allows to assess the shape and parameters of the lactation curve (Stanton et al., 1992). In that regard the studies on the effect of the age at first calving are rather limited.

The objective of the research is to study the effect of the age at first calving on test day milk, milk fat, % of fat and shape of the

lactation curve in black-and-white cows.

Material and methods

The study has been carried out with cows of the Bulgarian black-and-white cattle. A total of 10 farms are included in it from Sofia, Stara Zagora, Plovdiv and Targovishte regions. The cows calved in the period 1995–2006. A total of 1460 cows are included with 2852 lactations from Ist to IIIrd and respectively 27228 test day records. The cows are daughters of 125 sires. The data about origin, productive traits have been taken from the breeding cards, books and files at the respective Regional Offices for Selection and Reproduction in Animal Husbandry.

The relevant modules of the software packages MS EXCEL and STATISTICA of StatSoft have been used for the basic statistical processing. The following basic model has been used to assess the effect of age at first calving on test day productive traits:

$$Y_{ijklmno} = \mu + H_j + Y_k + M_l + L_m + Ag_n + e_{ijklmno}$$

Where: $Y_{ijklmno}$ is the dependent variable (test day milk yield, milk fat and % of fat of cow o for lactation stage i); μ is the population mean; H_j is the fixed effect of herd; Y_k is the fixed effect of year of test; M_l is the fixed effect of month of test; L_m is the fixed effect of lactation; Ag_n is the fixed effect of age at first calving; $e_{ijklmno}$ is the random residual effect.

Through the analysis of variances (ANOVA) the least square means (LSM) and the least-square estimates (LSE) have been obtained for each model by classes of fixed factors comprising the sum totals of square means calculated as a deviation from the mean value of the trait obtained by the model.

The fixed effects included in the Test day models are herd (10 herds), year (12 years) and month of test (12 months), number of lactation (3 lactations).

The age at first calving is included as fixed effect in classes respectively: up to 720 days (up to 24 months), from 721 to 810 days

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(from 24 to 27 months), from 811 to 900 days (from 27 to 30 months), from 901 to 990 days (from 30 to 33 months), from 991 to 1080 days (from 33 to 36 months), and over 1081 days (over 36 months),.

Results and discussion

The average age at first calving of cows from all herds included in the study is 891.21 days or 29.7 months (Table 1). The main share of cows in the herds included in the study (76.9%) has calved at the age of 24 to 33 months. The greatest is the number of cows that calved for the first time at the age of 27-30 months (34%), followed by these at 30-33 months (22.9%) and at 24-27 months (20%) (Figure

1). The number and respectively the relative share of cows that calved up to the age of 24 months, respectively with conception up to 15 months of age, is rather small – 6%. This is a very high age for first calving of cows in the black-and-white breed. The Bulgarian black-and-white breed is of the Holstein-Friesian type and in recent years semen from Holstein bulls from various countries is very widely used. The recommended age of first calving for cows of the Holstein breed is about 24 months. Regardless of that, rather varying data about age at first calving are pointed out for the different countries. Petraskeiene et al. (2007) study the first three lactations of black-and-white cows in Latvia. They point out that the basic share of cows - 55% calve for the first time at the age of 24 to 29 months.

Relatively higher age at first calving for the Holstein cows in Italy

Table 1. Descriptive statistics for basic reproductive and productive traits

Traits	N	Means	SD	CV
AFC ₁ (days)	1460	891.210	137.84	15.47
Test day milk yield (kg)	27228	14.350	4.65	32.53
Test day fat yield (kg)	27228	0.547	0.18	33.12
Test day % fat	27228	3.850	0.62	16.13

¹Age at first calving

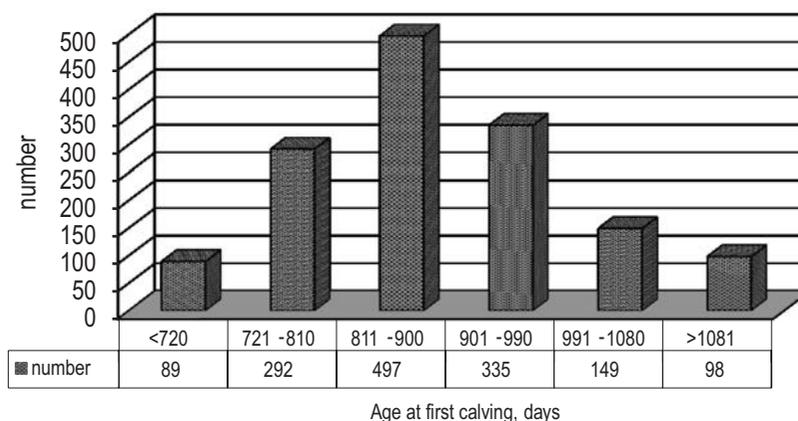


Figure 1. Distribution of the cows by age at first calving

is reported by Pirlo et al. (2000) – an average of 28.2 months and in Spain - Perez et al., (1999) – 28.6 months. A number of authors report lower average values for age at first calving for cows of the Holstein-Friesian and the black-and-white breeds in other countries. According to Hare et al., (2006) the average age at first calving for the Holstein cows in the USA is 26.9 months. Nilforooshan and Edriss (2004) report almost the same age at first calving for the cows in Iran – 26.84 months.

To maximize productivity and reduce rearing and replacement costs, the average age at first calving for the Holstein cows is recommended to be up to 24 months, at live weight above 560 kg at first calving (Heinrichs and Vasquez-Anon, 1993; Tozer and Heinrichs, 2001). Nevertheless, the analysis of the age at first calving of the Holstein cows in the USA shows that only 2.7% of dairy

farms actually achieve these results (Losinger and Heinrichs, 2000).

In a number of countries there is an ambition for the Holstein cows to conceive at an earlier age without taking into consideration the statistics of their development. Mourits et al. (2000) report that in the Netherlands about 81% of farmers start heifer insemination at ≥ 15 months. Basically the time of conception is determined by age (95%). Factors such as physiological development of animals are paid less attention. Only 27% and 17% of the polled farmers' reply that the height at withers or the live weight respectively influence their decision for insemination. As a result of that authors report that out of 3000 ad hoc dairy farms in the Netherlands, 29% achieve age at first calving below 24 months, 51% from 25 to 27 months and 20% over 27 months.

In Bulgaria, as in many other countries live weight and the

development of young breeding animals are not kept control of. Farmers make their decisions for heifer conception based on their subjective opinion, often related to expectation for better development of animals. One has to have in mind the fact that feeding provides an average daily gain of about 700 g, in which heifers reach the desired development and live weight not earlier than 17 – 18 months of age. Another factor that does not stimulate the earlier conception of heifers is that in the past 10-15 years the replacement percentage in dairy hers in out country is very low, emergency culling is mainly practiced. Market demand of breeding animals is not very high either. The milk quota arrangements that have come into effect in recent years restricting the expansion of the herd size also reduces their demand (Pirlo et al., 2000). That confirms the statement made by Berry and Cromie (2008) that the age at first calving of dairy cows depends largely on the economic conditions in the relevant country.

Table 2 presents the results from the analysis of variance of

traits studied, including the age at first calving, on the three Test day productive traits – milk yield, milk fat and % fat. The analysis revealed that the age at first calving has significant effect on the three studied traits, on milk yield and milk fat respectively at $P < 0.001$, and on % fat at $P < 0.01$. Figure 2 presents the effect (LSM) of the age at first calving on the Test day milk yield for the first three lactations. The highest is the Test day milk yield of cows that calved for the first time at the age of 27-30 months – 15.7 kg. The next age group is the ones that calved at the age of 24 to 27 months – 14.07 kg and after it with very small difference are the ones that calved from 30 to 33 months of age – 13.95 kg of milk. Both cows with low – below 24 months - and the ones with high age at first calving – over 33 months, have lower milk yield than the specified age groups and there is a tendency for lower productivity of cows that calved at very young age – less than 24 months.

Haworth et al. (2008) report as optimum age at first calving for the Holstein cows in Australia tow and a half years (30 months),

Table 2. Results of analyses of variance of traits studied

Variable	Degrees of freedom (n – 1)	Test day productive traits					
		Milk yield, kg		Fat yield, kg		% fat	
		F	P	F	P	F	P
Year of test	11	61.27	***	602.00	***	24.03	***
Month of test	11	45.86	***	26.40	***	85.00	***
Herd	9	734.80	***	801.58	***	109.20	***
Lactation	2	214.73	***	218.28	***	4.32	*
Age at first calving	5	15.27	***	28.82	***	6.72	**

* - $P < 0.05$; ** - $P < 0.01$; *** - $P < 0.001$

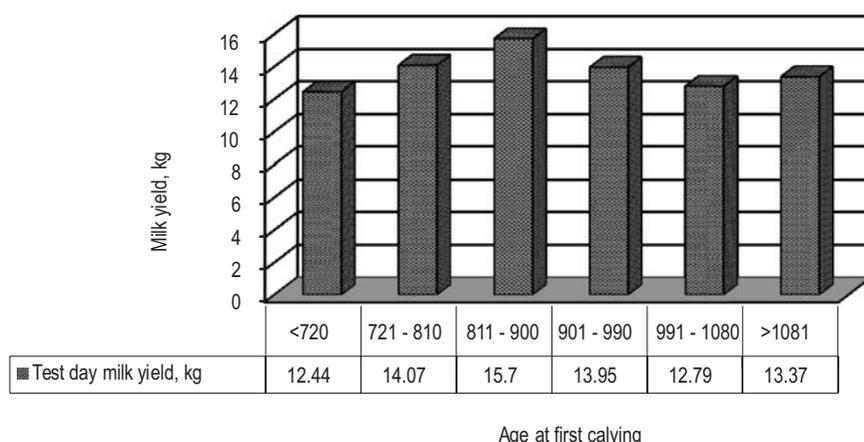


Figure 2. The effect of age at first calving on test day milk yield

since these cows have the highest milk yield at first lactation, lifelong productivity and prolonged usage. For the test day milk fat trait almost the same trends is reported as in milk yield – figure 3. Here again the highest is test day productivity for cows of age group from 27 to 30 months. Unlike the test day milk yield trait the second in kg of milk fat is the age group from 30 to 33 months, followed with very small difference by age group from 24 to 27 months at first calving. That is mainly accounted for by the lower test day % fat in cows that calved at a lower age (24-27 months) (Figure 3). Again the lowest is the value of the test day milk fat for cows that calved at the youngest age – less than 24 months.

With the test day % fat the same relation as in the other two productive traits is not recorded (Figure 4). With that trait higher values of test day % fat are generally recorded for cows that calved for the first time at an older age, after 27 months. The lowest is the test day % fat in milk in cows that calved for the first time at a young age – 24-27 months, followed by a slightly higher % fat – under 24 months. Regardless of that, the age group of the cows that calved for the first time from 27 to 30 months of age behaves fairly well and in them the % of fat is insignificantly lower – 3.86 % than that of the first two groups with the highest values – 3.88 and 3.87%. Pirlo et al. (2000) also reported reduced age at first calving seemed to have a

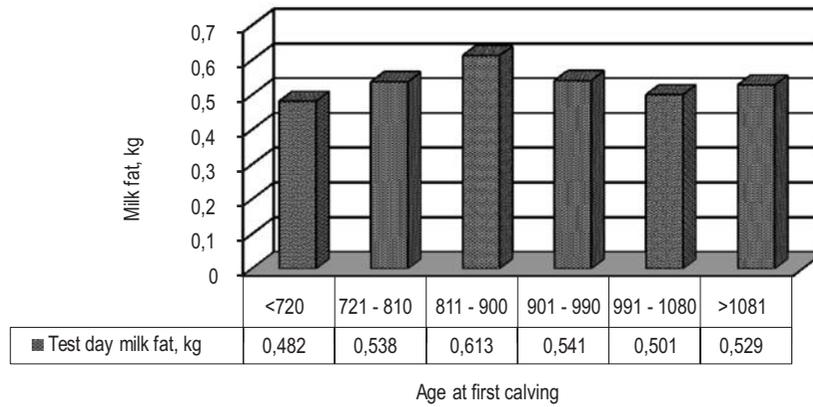


Figure 3. The effect of age at first calving on test day milk fat, kg

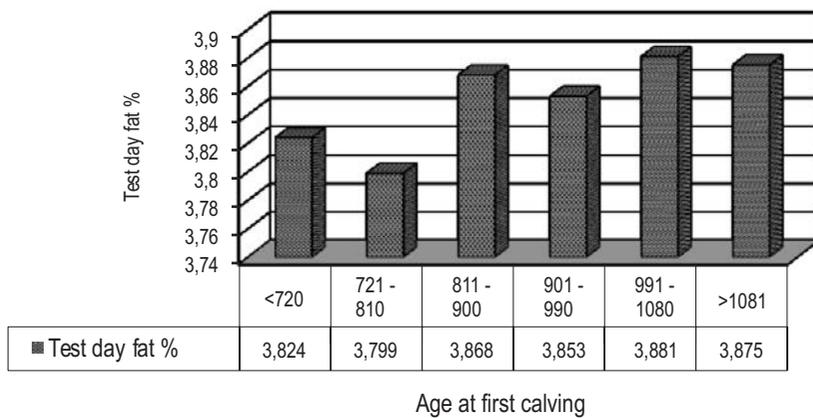


Figure 4. The effect of age at first calving on test day fat %

negative effect on first lactation fat percentages. Totally for the three studied test day traits the tendency is that cows that calved for the first time at the age from 27 to 30 months have the best productive characteristics. The effect of the age at first calving on the variation of test day productive traits is clearly outlined by lactation months, presented by their lactation curves.

Figure 5 presents the effect of the age at first calving on the shape of the lactation curve of cows for the first three lactations. The data reveal that cows that calved for the first time at the age of 27-30 months reach the highest milk yield at the beginning of lactation – up to day 30 (19.35 kg) and the highest milk yield at the lactation peak (19.78 kg). They maintain a relatively high milk yield up to the 10th lactation month (12.52 kg). These animals have a relatively stable lactation curve throughout the entire lactation and the proportion of daily milk yield at lactation day 60 to that at day 300 is 63.3%. Next in maximum milk yield reached at the beginning of lactation are the cows that calved for the first time at the age of 24-27 months (18.26 kg), followed by a very small difference by the ones that calved for the first time at 30-33 months (17.76 kg). With these age groups the relative share of the daily milk yield at day 60 to that at day 300 is lower, too (respectively 59.1 and 61.3%), and that is more markedly shown in the cows that calved at a younger age – 24-27 months.

The steepest, with rapidly decreasing milk yield after reaching the peak (17.35 kg) and the lowest milk yield at the end of lactation – 8.98 kg, is the curve of cows that calved at the youngest age – less than 24 months. With them the relative share of the daily milk yield at day 60 compared to that at day 300 is the lowest of all age groups – 51.8%. The lowest values for test day milk yield as a whole and at the lactation peak are the cows that calved after the age of 33 months.

However, they maintain stable milk yield to the end of lactation. The relative share of daily milk yield at day 60 to that at age 300 is 62.3 and 62.1% for both age groups with age at first calving above 33 months. With the test day milk fat trait the tendency is almost identical with the one at test milk quantity, therefore we shall not present it diagrammatically.

Unlike our results Berry and Cromie (2008) established linear correlation between the age at first calving and milk yield at the lactation peak. The increase is respectively 0.007 kg for each day of age. Our study did not reveal such linear correlation. Milk yield at lactation peak is lower both for the ones that calved for the first time at a very young age and at an older age. Cows that calved for the first time at the age from 27 to 30 months reach the highest milk yield at lactation peak and also maintain the highest daily milk yield by lactation periods. The next by these statistics with very small differences between them are the cows the calved for the first time at the age of 24 to 27 months and 30 to 33 months.

Figure 6 presents the variation of test day % fat in milk by stage of lactation. The greatest is the variation in the values of % fat by lactation months of cows that calved for the first time at the age of 24 to 27 months. In them the % fat for the first month is the lowest of all (3.78%), and it also drops to the lowest values at the beginning of lactation (3.6%), afterwards it rises to the values of the other age groups (4.03%). A similar, although with slightly higher values is the curve of the percentage of fat in cows that calved for the first time under 24 months of age. The slightest is the variation in the % fat at the beginning (3.98%), in the middle (3.76%) and at the end (4.05%) of lactation of cows that calved at the oldest age – over 36 months. With cows that calved at young age – below 27 months, the

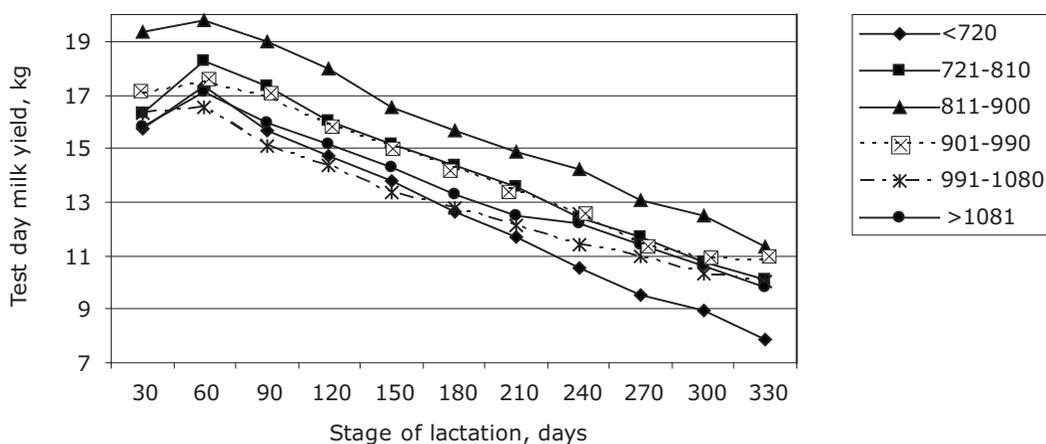


Figure 5. The effect of age at first calving on lactation curve

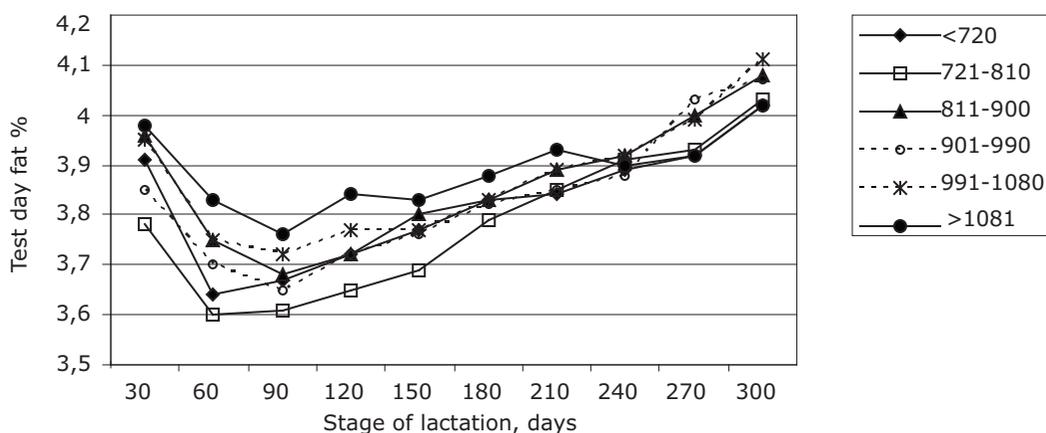


Figure 6. The effect of age at first calving on variation of test day fat % by stage of lactation

test day % fat in milk varies greatly by stages of lactation, whereas with those that calved at an older age the variation is weaker and the curve is more stable. The reported weaker variation of test day % fat by stages of lactation in cows at an older age results in the reported higher average % fat (Figure 4).

The results obtained presume that cows that calved for the first time at the age of 27 – 30 months respectively have the relevant optimum physical development. That makes it possible for the organism to achieve higher milk yield and optimum % fat in milk both at the beginning of lactation and to maintain these at a relatively good level till the end. The calving of cows at a younger age is probably related to lower live weight and total development of the organism, which does not allow the achievement of higher productivity at the beginning and its maintenance during lactation. The older age at calving – over 33 months is also related to lower milk yield, although a slightly higher % fat is achieved. Though, with lower productivity at the beginning of lactation these animals have more stable lactation curve. Most probably that is accounted for by the effect of other factors correlated with age and the poorer udder tissue proportion. The decrease in milk yield in late-bred heifers may be due to other factors correlated with age. Further, it seems that mammary development was diminished in late-bred heifers (Nilforooshan and Edriss, 2004). Other authors also point out that the effect of age at first calving has no strictly linear nature, although their studies refer mainly to lactation productivity (Ruiz-Sanches et al., 2007; Nilforooshan and Edriss, 2004). Petraskiene et al. (2007) obtained that the increase of age at first calving until 42 month statistically significantly decreased productivity of the first three

lactations. Furthermore, the decreased age at first calving in heifers younger than 22 month decreased milk yield, fat and protein content of the first and subsequent lactations.

Conclusions

The average age at first calving of the black-and-white included in the study is 891.23 days or 29.7 months. The greatest share – 34 % of the cows calved for the first time at the age of 27-30 months.

The age at first calving has significant effect on the Test day milk yield, milk fat and % fat. The highest is the test day milk yield and milk fat for cows that calved for the first time at the age of 27 to 30 months, followed by the ones that calved at 24-27 and 30-33 month, respectively, with small difference between them. The cows that calved at the age of 27-30 months reached the highest daily milk yield in the lactation peak – 19.78 kg. With test day % fat the tendency is for higher values in the cows that calved for the first time at an older age.

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Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows, IXth International Conference on Production Diseases in Farm Animals, Sept.11 – 14, Berlin, Germany, p. 302 (Abstr.).

Thesis:

Penkov D, 2008. Estimation of metabolic energy and true digestibility of amino acids of some feeds in experiments with muscus duck (*Carina moshata*, L). Thesis for DSc. Agrarian University, Plovdiv, 314 pp.

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