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Age of Productive Life and Milk Yield Level in Holstein Dairy Cows in Bulgaria

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A B S T R A C T

The aim of the present study was to establish the age of productive life and milk yields of different lactations in Holstein cows, born in the period from 2010 to 2017 using the Test day approach. The object of the study are cows of the Holstein dairy breed, bred on 18 farms in different regions of the country. An analysis of 333,721 records of milk productivity data for the control day was performed for 22,464 animals born in the period 2010-2017. The data for the records of origin and productivity are provided by ARCHSHPB - Dobrich. To analyze the factors influencing the assessed traits - milk yield for the control day, fat and protein content, a mathematical model was formulated based on the following hypothesis: variation in milk yield and quality of milk for the control day is caused by genetic and environmental factors - individual, consecutive lactation, farm, breeder, month of production, effect of the genetic value of the individual and random, not studied and described in the model, factors. A control day model was used in which each daily milk control was considered as a separate observation. The data processing was performed using the software products Pest (Groeneveld) and SYSTAT 13. The number of animals that attained 4th and subsequent lactation was low. The influence of the environmental factor farm on the three studied traits was very significant. The sire, test-day month and parity has statistically significant influence on milk yields. The highest average daily milk yield in cows was observed during the third lactation. Neither milk fat nor milk protein contents demonstrated consistent variations.

Introduction

During the last 100 years, the set of traits evaluated for genetic selection in dairy cattle populations has increased to meet the requirements of the industry and the society. In the beginning of the 20th century, milk producers were interested in increasing milk production without having a systematic selection strategy. The development of more complex traits' analytical techniques and their inclusion in selection programmes has resulted in rapid growth of cattle productivity and genetic progress achievement. Until the end of the past century, the focus of selection has moved away from the production towards a more balanced rearing philosophy. This change occurred partly because of the more common health and productivity problems, and partly due to social pressure and animal welfare concerns. The longetivity, fertility, health and utility are already integrated in selection indices /Miglior *et al.*, 2017/. During the last 4 decades, the milk yield of many cows has increased twice, yet this was also

accompanied with impaired reproductive ability, increased number of health issues and lower productive lifespan in modern farms.

The selection towards high milk yield and associated high profit is on the account of animal welfare. The aim of the new breeding strategy was improvement of fitness and better tolerance to metabolic stress of dairy cows /Oltenacu and Algers, 2005/.

The main factors influencing the lactation curve according to Albarrán-Portilloa and Pollott (2011) are genetic effects of the individual, the herd and lactation number, comprising 74% of all factors ($P<0.001$).

In the view of Karadas and Birinci (2019) the breed is the most important factor of milk yield as demonstrated by all scientific hypotheses and applied algorithms, followed by calving month, control of mastitis before milking, provision of feed and duration of lactation.

The environment has also a direct impact on milk production – rearing technology, physiological state (lactation stage and number; age at first insemination or calving season etc. (Tančin *et al.*, 2018).

The first-lactation milk production is an important economic trait. The age at first calving is deemed to be an important predictor of subsequent milk yield. The higher parity of the dam is associated with lower yields of its progeny /Eetvelde *et al.*, 2020/.

Numerous authors have investigated the effect of the average age at first calving on milk yields of animals, their productive lifespan and the milk yield of their progeny /Sherwin *et al.*, 2016; Le Cozler *et al.*, 2019; Handcock *et al.*, 2020; Ignatova *et al.*, 2020; Han *et al.*, 2021/.

The aim of the present study was to establish the age of productive life and milk yields of different lactations in Holstein cows, born in the period from 2010 to 2017 using the Test day approach.

Materials and Methods

Analysis of 333,721 test-day milk yield records from 22,464 Holstein cows, offspring of 1,752 bulls, reared in 18 farms in different regions of the country, born from 2010 to 2017 was performed. The number of surveyed consecutive lactations was as follows: 1st lactation – 21,093; 2nd – 13,283; 3rd – 7,104; 4th – 3,161; 5th – 1,120; 6th - 277; 7th - 68.

Statistical design

The data from records on the origin and productivity were provided by the Association of Black-and-White cattle breeding in Bulgaria, Dobrich. The analysis of data was based on principles allowing achievement of unbiased estimation of studied variables. Factors influencing the studied traits were analysed by means of a mathematical model on the basis of the following hypothesis: The variation of test-day milk yield and milk composition was influenced by genetic and environmental factors: cow, lactation number, farm, sire, production month, effect of individual genetic value and random effects which were not analysed and not described by the model.

In the test-day model, each test-day milk yield was used as a separate productivity record.

The following mixed linear model was designed to make an unbiased estimation of studied traits:

$$Y_{ijklmno} = \text{Farm}_i + FBirthing_j + PL_k + Testdim_l + Sire_m + A_n + eij\kappa lmno$$

where:

$Y_{ijklmno}$ – oth observation of the trait;

$Farm_i$ – fixed effect of the ith farm;

$FBirthing_j$ – random regression effect of jth age at first calving;

PL_k – fixed effect of the kth lactation;

$Testdim_l$ – random regression effect of l^{th} day in milk to the respective test-day from the respective lactation of the cow;

$Sire_m$ – random effect of the sire;

A_n – n^{th} random additive genetic effect of the individual;

$e_{ijklmno}$ – random effect of unobserved factors;

Data analysis was made with software products Pest (Groeneveld) and SYSTAT 13.

Results and Discussion

Table 1 presents the statistical parameters of studied traits. The average milk yield of animals born between 2010 and 2017 was 28.26 kg, with maximum and minimum values of 89.50 and 8.00 kg, respectively.

Similar milk fat content was reported for Holstein dairy cows from Slovakia and Estonia – 3.80% (https://my.icar.org/stats/list).

The average age at first calving was 808 days, with standard error of the mean of 0.778. A substantial difference between minimum and maximum values of this parameter was noted. The possible reason was the fact that in the different farms, the desire of farmers was to shorten the non-productive lifespan of heifers and thus, inseminated them earlier. Sawa *et al.*, (2019) and Fodor *et al.*, (2020) reported data about the effect of age at first calving on milk yield – the animals that calved at 22 to 24 months of age demonstrated the highest first lactation milk yield. Calving before 22 months of age decreased milk production, whereas the first calving after 26 months of age also resulted in gradual reduction of milk yields.

The effect of the age at first calving was investigated by Sawa *et al.*, (2019), who affirmed that cows should preferably give birth for the first time at an age from 22.1 to 26.0 months. This, in the belief of authors, would contribute to production of more milk by about 24% during the entire productive lifespan of cows ($p<0.01$). The higher age at first calving (especially after 28 months) resulted in considerably reduced first lactation milk yields and milk yields during the lifespan, shortened the productive lifespan, reduced the number of calvings and increased the risk from higher culling rates /due to low milk yields and udder diseases/.

Table 2 shows that the main part of the variance for studied traits was described by the factors farm and test-day month. The sire and days in milk had also a significant effect on daily milk yield. The lactation number had a statistically significant effect on daily milk yield whereas the sire – on milk fat content. The age at first calving had no effect on milk yield and milk fat content yet its impact on milk protein percentage was relevant.

Du *et al.*, (2020), indicated that some non-genetic factors as lactation number, days in milk and calving season had an effect on milk yield and should be therefore taken into consideration by the dairy farm management.

Our results are compatible to those from a study performed by Yordanova (2015), stating also that the major part of effects of various factors on milk yields was described by the farm and days in milk.

M'hamdi *et al.*, (2012) concluded that the milk yield and days in milk were influenced by the calving year and calving season. The age within a specific lactation also influenced the days in milk and the milk yield.

Varotto *et al.*, (2015) affirmed that days in milk had a highly significant influence on milk yields.

Fig. 1 demonstrates that out of the studied 22,464 animals 15,060 (67%) were in their first lactation, less than one-third (4,710) – in second lactation, whereas the number of cows in 5^{th} and subsequent lactation was insignificant – 257. The results outlined a clear trend towards short productive lifespan in Bulgarian highly producing herds. A possible reason is the striving of Bulgarian dairy

farmers to increase milk yields, as well as the deficiency of management skills related to key technological elements, e.g. the nutrition of highly-yielding cows.

Similar results were reported by authors from other countries with high-yielding herds. In Sweden, between 35 and 40% of cows were culled from herds every year and this occurred at an average age of 60.5 months, whereas longetivity is an important economic trait for dairy products production (Sverige, 2017; Pritchard *et al.*, 2013 от *Alvåsen et al., 2018*).

The increase of the productive lifespan of the herd is essential for the efficiency of the farm, in a way that the long productive lifespan presumed lower costs to produce replacement animals for the herd.

Archer *et al.*, (2013); Boulton *et al.*, (2017), from *Alvåsen et al., (2018)* have found out that the increase in productive lifespan of dairy cows would improve the economic efficiency of dairy cattle farming as cows usually have to attain second lactation to produce enough milk and compensate the rearing costs during the non-productive growth period and the time to sexual maturity. Figure 2 demonstrates that the highest daily milk yield was attained during the 3rd lactation (29.68 kg, similar to average value for the 2nd lactation: 28.4 kg). The possible reason may be the fact that the cows with the highest milk yields are culled at an earlier age.

Tančin *et al.*, (2020) reported results, comparable to ours. They observed the highest milk yield during the second lactation in a study performed on substantially lower number of animals (n=482). Similar data were published by Lehmann *et al.*, (2016) - higher daily milk yields in cows during the first and second lactations in a study in 4 Danish commercial dairy farms.

The effect of the lactation number on milk yields was carried out also by Vrhel *et al.*, (2021).

Fig. 3 presents the results for milk fat and protein contents for the different lactations. A consistent variation was not established, with rather comparable results - between 3.78 and 3.84 for milk fat and between 3.18 and 3.25 for milk protein. ICAR data from the Netherlands showed that Holstein cows produced milk with 4.3% fat content and 3.54% protein content (data for 2019). Milk of cows farmed in Latvia had parameters similar to those of our study - 3.90% fat content and 3.26% protein content.

Table.1 Statistical parameters of studied traits.

Traits	Mean	Min	Max	Std. Dev.	Std.Error
Daily milk, kg	28.26	8.00	89.50	9.00	0.015
Fat, %	3.82	1.50	7.20	0.77	0.001
Protein, %	3.24	1.51	6.70	0.27	0.001
First calving age, days	808	583	1324	116.66	0.778

Table.2 F-values and level of statistical significance of factors influencing the studied traits

Traits Factors	Daily milk, kg	Fat, %	Protein, %
Farm	16.383***	109.998***	114.193***
Parity	2.683**	1.441	19.617***
First calving age	0.588	1.377	8.159**
DIM, days	17.650***	2.569***	2.651***
Sire	1.446***	1.026	1.183**

Fig.1 Number of cows at the respective lactation

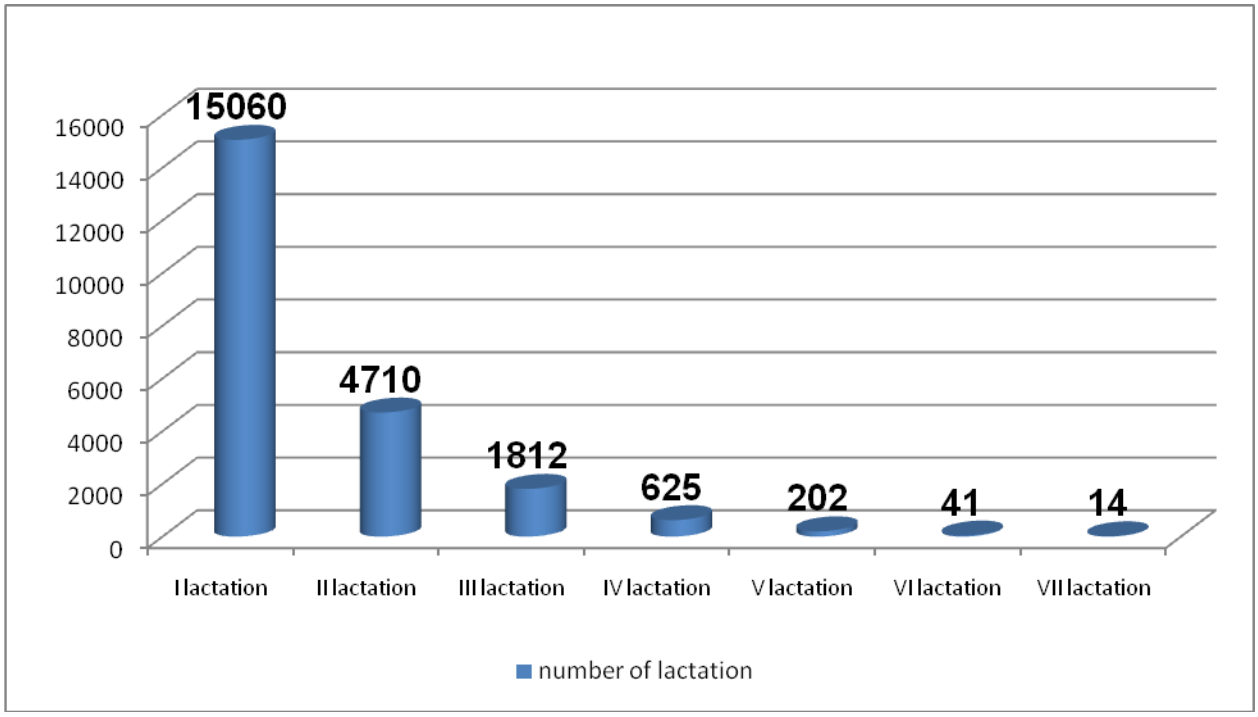


Fig.2 Average daily milk on different parity /lactation/

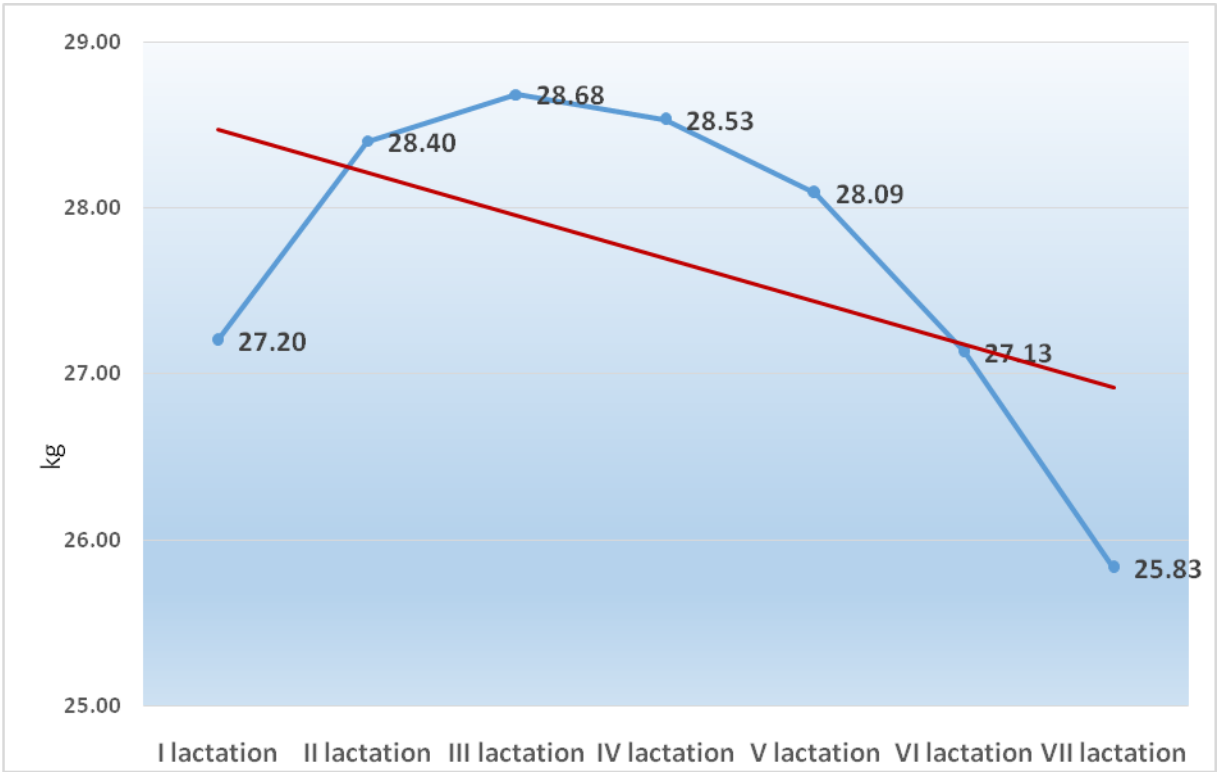
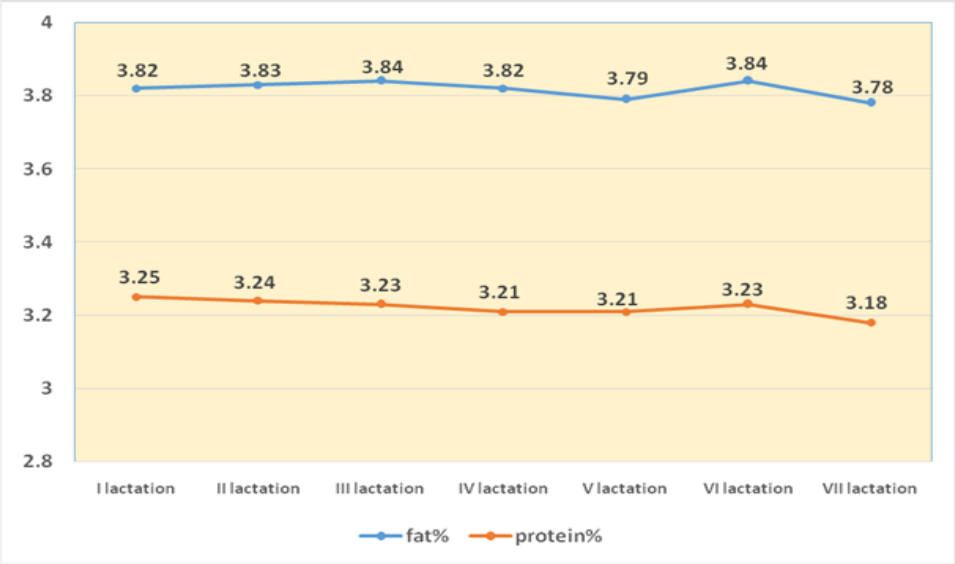


Fig.3 Fat and protein on different parity /lactation/



A study performed by Kro *et al.*, (2020), aimed to assess the effect of lactation number of milk yield, milk fat content and milk solids-non-fat in crosses of Holstein cows.

The results showed that milk yield (kg) was statistically significantly higher ($P<0.01$) as lactation number increased compared to primiparous cows. The total milk fat percentage was considerably higher in primiparous compared to multiparous cows.

The number of animals that attained 4th and subsequent lactation was low. The influence of the environmental factor farm on the three studied traits was very significant. The sire, test-day month and parity has statistically significant influence on milk yields. The highest average daily milk yield in cows was observed during the third lactation. Neither milk fat nor milk protein contents demonstrated consistent variations.

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