Estimation of environmental effects of test day milk yield in White Maritza sheep

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Abstract

The objective of this research was to estimate environmental effects of test day milk yield (TDMY) in White Maritza sheep breed. Test day milk yields were collected from 1992 to 2015 (24 years) and milk yield recordings were made in 18 flocks. We evaluated 8768 milk yield records in the test day. In the structuring the database, the following environmental effects were defined: animal; flock; year-season of lambing effect (YS); parity effect (Par); litter size at birth (LS); age of ewe at lambing (AgeL); age of ewe at test day (AgeTD); suckling period (Suck); ewe test day (ETD); flock test day (FTD); flock-year-test day (FYTD); stage of lactation period (DIM); stage of lactation period defined at 3-day intervals (DIM3). Average TDMY was 764.47 mL. The test day milk yield was highest (1074.34 mL) in the first test day of ewes, and gradually decreased in the last test day (233.33 mL). All mentioned environmental effects had influenced TDMY with high degree of probability $p<0.001$). The largest proportion in the total phenotypic variation had FYTD (44.96 %). Factors that significantly influenced all of the studied traits varied: Animal (34.51%), AgeTD (34.24%), DIM (31.22%), DIM3 (30.08%), ETD (25.28%) and AgeL (24.24%). Considering the significant influence of the described environmental effects on the test day milk yield in the population of White Maritza sheep breed, they should be taken into account when estimating the genetic parameters, designing breeding programs and for defining the best evaluation model.

Key words: test day milk yield; environmental effects; White Maritza sheep breed

Introduction

The high demand for sheep milk as a raw material for the production of cheese, yellow cheese and other dairy products in short- and long-term period will form a favorable market environment for dairy and dual purposes sheep breeds. In Bulgaria, there are nine breeding organisations for 18 native sheep breeds which perform breeding programmes approved by the Ministry of Agriculture (MA). Over the years, the breeding programmes of most native sheep breeds were focused on preserving native sheep breeds as genetic resources and overcoming the risk of extinction by increasing their population size (Dimov and Vuchkov, 2021). However, in the long term, the productivity of these native breeds is important for their competitiveness over farmer choice.

In the breeding programs of prospective Bulgarian sheep breeds suitable for milk production the milk yield is an important trait for selection. The milk yield is a trait that is strongly influenced by environmental factors (Macciotta, et al. 1999, Oravcova et al., 2006, Ciappesoni et. al., 2004), therefore it is necessary to take into account environmental effects when assessing genetic parameters and breeding values.

Normally, when analyzing the test day milk yield data in sheep, many authors take into account the effects of year, flock, parity, month of

lambing, litter size, on test day milk yield (Oravcová et al., 2005; Oravcová et al., 2006; Bauer et al., 2012). In connection with the use of more complex linear models for estimations of genetic parameters and breeding values many authors describe the influence of the environment by adding differently the influence of the stage of lactation (DIM factor) or combine two or three environmental factors in one - flock-year, flock-year-month, flock-year-season, year-season (Ruiz et al., 2000; Riggio et al., 2007; Komprej et al., 2011). This is done especially in unbalanced data-base (Oravcová et al., 2006).

The White Maritza is dual purpose sheep breed for milk and meat, typical for lowlands. Good milk yield and prolificacy (Dimov, 1998) and also high live weight (Dimov, 2011) make this sheep breed competitive among other native breeds in the country.

For years, the selection in White Maritza sheep breed for milk yield was based on milk yield per milking period. The new breeding programme for this breed (Dimov and Zhelyazkova, 2022) has planned the use test day models for breeding value estimations. This requires including flocks, year, lactation stage, test day and other nongenetic effects.

The study and analysis of environmental factors are essential in choosing a model for estimating genetic parameters. Environmental effects affect the accuracy and precision of estimating genetic parameters and predicting breeding values. Independent analysis of some environmental factors is not always effective enough and much of the overall phenotypic variation remains undiscovered in the residual variance. Therefore, when structuring the database, many authors make different combinations (year + season; flock + control; flock + year + test day, etc.).

The aim of this study was to estimate environmental effects on TDMY from point of view to theirs use in test day models for estimating genetic parameters and breeding values for milk yield of White Maritza sheep breed.

Material and methods

The availability of suckling period and hand milking are two distinctive features in the production system in which the flocks of White Maritza sheep breed are raised. Also, during the winter period (around 5 months) the flocks are kept indoor and the feeding was predominantly with alfalfa hay and straw combined with grain (corn and barley). Grazing period lasts around 7 months. Usually, the farmers used common pastures sometime combined with post-harvest cereal waste.

The TDMY data used for this analysis were provided by the Breeding association of native Maritza sheep breeds (White Maritza sheep breed and Patch-faced Maritza sheep breed). The White Maritza sheep breed is a multipurpose native sheep breed (milk, meat and wool) in Bulgaria (Dimov, 2011).

Test day milk yield database was structured on the base of milk recording procedure that lasted 24 years (from 1992 to 2015). Milk yield recordings were made in 18 flocks with different duration of the procedure in the herds over the years. The composition of the flocks was of sheep of different ages and there are no ones that are formed by age. Some limitations in data base were made before the data were processed. The database included sheep with test day milk yield from 0.1 to 4 L, with suckling period of 30 to 150 days, with minimum of 3 test days' records per milking period. The number of lambs born is with 2 levels. Due to the relatively small number of cases of ewes with triplets, they were included in the group of 2 sheep lambs.

Due to the long lambing campaign over the years, in order to take into account this effect, the lambing season was divided into 3 levels. The first level included ewes that were lambed in August, September, October and November. On the second level were included ewes that were lambed for December, January or February. In the third level were included ewes that were lambed from March, April, May and June. Thus, the seasonal effect was formulated, which was combined with the effect of the year and it was obtained „year-season ".

The long period (24 years), in which the data from the milk recordings were accumulated and the short period of the continuity of breeding activity in the individual farmers – 4.99 years

(Zhelyazkova et al., 2018), made it necessary concatenation of the factors flock-year-test day (FYTD).

Milk recordings were organized in accordance to ICAR rules for AC method (ICAR Barillet et al., 1992). The rule for the coverage of the maximum part of the milking period, regardless of its duration, has been complied during the test day records over the years.

As noted above in the majority of the flocks, there is a long lambing campaign. After completing milk recording in milking period in the flocks of White Maritza sheep, different ewes have a different number of test days per lactation from 3 to 8.

Statistical analysis was performed by using the GLM procedure of the SPSS 19.0 for Windows (IBM, 2009).

Results and discussion

The average test day milk yield (TDMY) in White Maritza sheep was 764.47 mL with a relatively wide range of variation from 100 to 3875 mL, which determines a high coefficient of variation – 56 %, which is typical of this trait. The average milk yield on test day in the White Maritza sheep was particularly lower than that of the specialized sheep breeds like East Frisian sheep - 2.33 kg (Hamann et al., 2004), Asaf (Spanish) - 1660 mL (Gutier et al., 2007), Chura - 956 mL (Othmane et al., 2002), Lacon - 1820 mL (Hernandez et al., 2011), Sfakia dairy ewes – 0.86 kg (Volanis et al., 2002), Bulgarian dairy synthetic population – 0.896 L (Krastanov et al., 2018). Similar milk yield – 0.773 L was reported for Bulgarian dairy synthetic population by Stancheva et al. (2018). The litter size for White Maritza sheep for the period from 1991 to 2015 in this study was 1.39, which is slightly lower than the value of the same trait found in other studies for this breed - 1, 52 (Dimov, 1999) and 1.47 (Vuchkov, 2009) and were similar with Bulgarian dairy synthetic population 1.335 - 1.412 (Stancheva, 2003) and 1.36 (Zhelyazkova et al., 2014). The average age of the sheep in the data used at the date of lambing is 1382.53 days, which in years is equal to 3.79 years (Table 1).

The database includes 8768 records of 987 ewes with an average of 2.06 lactations. The data in Table 2 show that 6.32% of the milk production records on the test day milk yield belonged to ewes that lambing at the age of one year (at first year). The highest relative share in the records of milk production on the test day is occupied by the gradients of sheep aged 2 and 3 years (22.51% and 21.62%), and 7.55% of the records in the database belong to sheep that are from 7 to 10 years of age calculated on the date of lambing. The relative share of age groups, which are at 4, 5 and 6 years of age /18.81%, 14.02% and 9.18% / is 42.61%. This fact, characteristic of the database of the White Maritza sheep breed, is a solid reason to take into account the age factor of the sheep when estimating the breeding value of animals in database. In the current state of the population of the White Maritza breed, the ewes of different ages are bred in the flocks. Re-evaluating of some breeding programs for sheep breeds in the country approved by the Ministry of Agriculture and Food, in which milk recording is carried out only on the first and second lactation in a situation where the flocks are not

Table 1. Descriptive statistics for traits: test day milk yield (TDMY), age at lambing (AgeLam), days in milk (DIM), suckling period (Suck) and litter size (LS)

Traits	N	$\bar{x}$	S.D.	CV, %	Min	Max
TDMY, mL	8768	764.47	431.74	56	100	3875
AgeLam, days	2026	1382.53	632.85	46	362	3729
Suck, days	2026	68.10	19.06	28	30	150
Litter size, n	2026	1.39	0.49	35	1	2,>2

formed by age is necessary. This is important and affects the cost of data (increases it) for the trait milk yield.

The database for the White Maritza sheep breed is dominated by records for milk yield, which were established at the 1st, 2nd and 3rd test day, or a total of 69.33% of the total number of records (Table 3). The number of test day that have 6th, 7th and 8th sequences of recording is relatively small. The test day milk yield is highest at the beginning of the lactation period of the 1st test day (1074 mL) and gradually decreased to 233.33 mL at the end of lactation (Table 3). The number of test day milk yield is relatively small, which is established at the 7th and 8th test day. These records are available only in flocks in which the breeding of the sheep in the flock is carried out in two rounds every 2-3 months in order to facilitate the care of the sheep during the lambing campaign and the newborn lambs.

The drying of the sheep is carried out by decision of the farmer, taking into account a number of factors, but in the flocks of White Maritza sheep breed this usually happens in August. The drying of sheep is an important management measure that is undertaken by the farmer is carried out at the same time for all sheep in the flock. This is the reason why some ewes develop a relatively long milking period (210, 240 days and in rare cases up to 270 days), and others shorter (90 - 120 days). The shorter milking period is most often the result of later lambing of the sheep. The average DIM value of the first test day - 82.73 days was indicator, that the milk recording procedure in the flocks of White Maritza sheep during the milking period begins later than in the flocks of specialized dairy sheep breeds. This is a result of the traditional production system in which the suckling period is 68.10 days with considerable variation (30-150 days). Normally in similar production systems suckling period for Patch-faced Maritza breed is 62.50 days for (Zhelyazkova and Dimov, 2022). Ivanova (2013), Zhelyazkova et al. (2014) reported 60 and 63.75

Table 2. Distribution of test day milk yield records in classes according to age of lambing (rounded to whole years) and relative share of age groups

Age at lambing, Years	Records, n	Share of age groups, %
1	128	6.32
2	456	22.51
3	438	21.62
4	381	18.81
5	284	14.02
6	186	9.18
7-10	153	7.55
Total	2026	100

Table 3. Raw means and standard deviations of TDMYs, and DIMs depending of sequence of test days for White Maritza sheep breed and relative share of the records in the test days

Sequence of test days	Records	Relative share of records	DIMs, days	TDMYs, mL
	n	%	$\bar{x}$ ± SD	$\bar{x}$ ± SD
1	2026	23.11	82.73±20.36	1074.34±493.10
2	2026	23.11	114.46±21.69	872.25±407.46
3	2026	23.11	145.22±22.15	682.01±323.21
4	1507	17.19	175.98±20.87	560.04±285.40
5	817	9.32	202.76±17.89	472.65±230.00
6	326	3.72	230.32±16.64	412.62±199.30
7	34	0.39	248.29±10.37	332.54±167.29
8	6	0.07	274.17±7.60	233.33±121.11

days suckling period of Bulgarian dairy synthetic population.

Breeders of the White Maritza sheep breed do not practice early weaning of lambs and due to their desire to get better breeding lambs, they leave the lambs to suck longer. All flocks of the White Maritza sheep breed included in this study participate in the breeding program and the farmers carry out their own reproduction of the flocks. There is an exchange between the flocks by buying and selling mainly male animals (lambs and rams).

Analysis of environment effects on test day milk yield (Table 4) shows that the different environmental factors in the database for the White Maritza sheep breed have a significant effect on test day milk yield with a very high probability ($p < 0.001$). The flock factor considered alone determines only 10.36% of the total phenotypic variation. However, the combination of factors "flock", "year", "flock test day" determines a significant part of the total phenotypic variation - 44.96%. Another important environmental factor is DIM. Considered as a fixed effect, the lactation stage determines approximately one third of the total phenotypic variation in both variants of its definition, 31.22% and 30.08%, respectively. For the purposes of the analysis in the mixed model, DIM3 is more appropriate (during 3 days). The effect of the animal is significant and determines 34.51% of the total phenotypic variation. The importance of the factors age of the sheep (in lambing and on the test) and sequence of test day (for the flock and for the sheep) and

Table 4. Analysis of environment effects on test day milk yield for White Maritza breed and proportion of total variation (n=8768)

Environment effects	df	SS	F	P	%
Animal	985	563409641.721	4.163	***	34.51
Flock	17	169138568.429	59.486	***	10.36
YS	62	93675296.307	8.546	***	5.74
Par	6	7645669.178	6.870	***	0.47
LS	1	9055409.957	48.892	***	0.55
AgeL	921	395706400.563	2.725	***	24.24
AgeTD	1686	558949187.628	2.186	***	34.24
Suck	103	83554805.201	4.537	***	5.12
ETD	7	412793079.523	423.486	***	25.28
FTD	7	251382277.620	227.757	***	15.40
FYTD	393	733990968.120	17.404	***	44.96
DIM	241	509652499.280	16.056	***	31.22
DIM3	79	491039793.297	47.304	***	30.08
TOTAL	8767	1632622622.012			

*Note: Animal - permanent effect of the animal; YS - year-season of lambing effect; Par - parity effect; LS – litter size; AgeL - age at lambing; AgeTD - age at test day; Suck – suckling period; ETD – ewe test day; FTD-flock test day; FYTD – flock-year-test day; DIM - effect of stage of lactation from day 30; DIM3 - effect of stage of lactation defined in three-day intervals starting from day 30; df – degree of freedom; SS – sum of squares; F – Fisher's criterion; P – degree of probability *** - p<0.001; POV,* **% -** *Proportion of variation caused by environmental effects, %.*

*Легенда: Animal – ефект на животното; Flock – стадо; YS - стопанска година+сезон на агнене; Par - поредност на агненето; LS – брой родени агнета; AgeL - възрастта на овцата в деня на оагването; AgeTD - възрастта на овцата в деня на контролата; Suck - бозайния период; ETD – контролен ден на овцата; FTD-контролен ден на стадото; FYTD – стадо-година-контролен ден; DIM - стадии на лактация, започвайки от 30 ден; DIM3 - стадии на лактация, определен в тридневни интервали започвайки от 30 ден; df - степен на свобода; SS – сума на квадратите; F –критерий на Фишер; P – степен на вероятност ***-p<0.001; % - процето влияние на средовите фактори спрямо общо вариране.*

their high contribution to the total phenotypic variation (Table 4) is sufficient reason to include them in mixed models and in the database for the White Maritza sheep breed. The factors "year + season" and suckling period are statistically proven, but determine a smaller proportion of the total phenotypic variation.

Conclusion

These analyses showed that the test day milk yield of White Maritza sheep breed is significantly affected by many environmental effects.

Considering the significant influence of the described environmental effects on the test day milk yield in the population of White Maritza sheep breed, require they should be taken into account when estimating the genetic parameters, designing breeding programs and for defining the best evaluation model. This requires the implementation of sustainable good breeding practices in the herds of White Maritza sheep breed, which are related to the recording of detailed data and events regarding the procedure for measuring the milk yield in the herds. The availability of detailed and accurate records in the herds included in the breeding program will allow the environmental variance to be decomposed into multiple causal components and will reduce its influence in the evaluation of genetic parameters and breeding values.

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