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Persistency Within and Between Lactations in Morning, Evening and Daily Test Day Milk in Dairy Goats (short communication)

Dedicated to Prof. Dr. Dr. h.c. mult. Ernst Kalm on the occasion of his 65th birthday

Abstract

Persistence in dairy animals can be used as selection criteria. Peak value in lactation can be used to predict total lactation production if within lactation persistence is high. This will provide information on early lactation and shorten generation interval. Major purpose of this study was to determine persistency within and between lactations of Turkish Saanen goats in morning, evening and daily milk yields. Two different methods were employed. One used ratios of the succeeding test days as dependent variables. The multivariate analyses indicated that effects of parity (P=0.05), year (P < 0.01), lactation length (P=0.05) and parity by year interaction (P < 0.01) were large. The other approach was to use within correlations and measure changes in milk production in different parities by using repeated measures analysis and modeling covariance structure using compound symmetry. The within correlations can be used as indicators of persistency. Effects of parity, test day and days in milk (DIM), DIM^2, ln(DIM) and [ln(DIM)]^2 on morning and evening values and total daily milk weights were analyzed to characterize the lactation curve. Values of DIM and repeated measure id number of the goats were added to the model within parity. Within lactation correlations were estimated as 0.22 for morning, 0.28 for evening and 0.27 for daily milk yield. Evening milk tests can alone be used to estimate lactation milk yield, instead of the total test day milk yield. Milk yield increased until lactation four, and decreased in lactation five in morning, evening and daily milk yields. There was a sharp increase from first lactation to second (ranged from 22.0 to 26.8%) and second lactation to third (ranged from 20.0 to 22.2%).

Key Words: persistency, morning milking, evening milking, test day, Turkish Saanen goats

Zusammenfassung

Titel der Arbeit: **Persistenz innerhalb und zwischen Laktationen in Morgen-, Abend- und Gesamttesttags-milchmenge bei Milchziegen** (Kurzmitteilung)

Die Persistenz kann bei Milchtieren als Selektionskriterium angewendet werden. Außerdem könnte bei einer guten Persistenz innerhalb der Laktation der Pikwert zur Schätzung der Laktationsleistung herangezogen werden. Das würde wiederum das Generationsintervall verkürzen. Ziel dieser Arbeit war es die Persistenz innerhalb und zwischen den Laktationen für die Morgen- bzw. Abendgemelke und die tägliche Milchmenge bei Türkischen Saanen Ziegen zu ermitteln. Zwei unterschiedliche Methoden kamen zur Anwendung. Die Effekte Laktationsnummer (P=0,05), Jahr (P < 0,01), Laktationsdauer (P < 0,05) und Laktationsnummer * Jahr Interaktion (P < 0,01) waren für den Persistenzwert, der auf die Verhältnisse der nachfolgenden zur vorherigen Testtagswerte beruht, signifikant. Ein anderer Ansatz war die Wiederholbarkeit der Milchmenge innerhalb der Laktation und die Testtagsmilchmengen-Mittelwerte für die einzelnen Laktationsnummern mit einem statistischen Modell, basierend auf der Kovarianzstruktur „compound symmetry“. Die Wiederholbarkeit kann als ein Indikator für die Persistenz herangezogen werden. Das Modell beinhaltet die fixen Effekte Laktationsnummer, Testtag und Laktationstag (DIM, DIM^2, ln(DIM) und [ln(DIM)]^2). Die Wiederholbarkeiten für die Morgen-, Abend- und Gesamttesttagsmilchmenge sind in der Reihenfolge 0,22, 0,28 und 0,27. Nach diesen Ergebnissen könnte die Abendtesttagsmilchmenge zur Laktationsleistungsermittlung herangezogen werden. Die Testtagsmilchmenge steigt in den ersten vier Laktationen und sinkt in der fünften Laktation für die Morgen-, Abend- und Gesamttesttagsmilchmenge. Insbesondere der Anstieg von der ersten zur zweiten (rangiert von 22,00 % bis 26,80 %) und von der zweiten zur dritten Laktation sind bedeutungsvoll (rangiert von 20,00 % bis 22,20 %).

Schlüsselwörter: Persistenz, Morgengemelk, Abendgemelk, Testtag, Türkische Saanen Ziegen

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Introduction

Dairy cattle breeders use test day records to estimate breeding values instead of using all the lactation records. Using less number of records may decrease accuracy, but in many cases the reduction may be attributable to chance. SWALVE and GUO (1999) reported that it is still debatable what kind of criterion for the persistency of lactation production should be used and thus, future research should make use of data from daily recordings since by this the impact of the data structure can be analyzed by mimicking different recording scenarios. Though automatic recording has made it possible to record all yields (OUWELTJES, 1998), there is still some cost associated with it. Peak value or first test day milk in lactation can be used to predict total lactation production if within lactation persistency is high. SOELKNER et al. (2000) included persistency in the category of functional traits in cattle and reported that a rough average over populations of the relative economic importance of dairy vs. beef vs. functional traits was 37:18:45. High persistency will provide information on early lactation and shorten generation interval. Persistency estimates in a dairy herd may give an idea on how much information early records, or less number of records provide. Based on this information, animals may be culled or selected using a few tests (high persistency), or using all tests (low persistency). As persistency increases, the number of tests required to estimate the lactation milk yield may decrease.

Morning and evening milk tests are added to calculate the test day milk yield. It is possible to use only morning or evening test instead of measuring both. ISLAM (2001) reported that higher milk collection occurred at morning (52.77%) than evening (47.24%), and morning, evening and daily milk fat varied throughout the year without a specific trend. Morning milk yields were 6% lower than evening milk yields in the study of OUWELTJES (1998). In the same study, differences became smaller as lactation advanced, and were smaller for heifers than for older cows.

Increased persistency of lactation translates into considerable benefits for the dairyman and flattening the declining portion of the lactation curve promotes a more efficient lactation (CAPUCO et al., 2003). Thus, persistency can be used as selection criteria in dairy animals.

Major purpose of this study was to estimate morning, evening and total daily milk yield within lactation correlations (persistency) for Turkish Saanen goats and estimate milk yields for the animals in different lactations. Two methods were used to estimate persistency; one method used the ratio of succeeding test days and the other calculated within correlation in a repeated measures analysis, modeling the covariance structure.

Materials and Methods

Data included 918 records collected on 80 Turkish Saanen kids raised in Uvecik Research Center, Canakkale, Turkey. The goats were kept on pasture during the day and were given 500 gr. commercially available concentrate feed and 1.2 kg dried vetch every day. Concentrate feed was given two times a day before milking. All milking was done with a milking machine. Test days were taken monthly. The milk recording was done at the university premises (Uvecik Research Center) by the university personnel. Mean lactation length was 235 ± 42 days. The weaning age of kids ranged from 36 to 42 days.

METRY et al. (1994) estimated persistency as the ratio of milk yield in the second 100 d of lactation to milk yield in the first 100 d of lactation. In this study, persistence was

estimated using two methods. First, ratios of the milk yields measured at the test days were calculated by dividing succeeding tests to each other in the order of the test. In other words, first morning milk yield was divided to second morning milk yield, second test day yield was divided to third, third divided to fourth etc. The same was done for evening milk also. Total of 12 milk tests resulted in 10 ratios. Then the ratios were analyzed using the following multivariate model and proc GLM procedure of SAS V8 (SAS Institute Inc., 1999):

$Y_{iklm} = \mu + A_i + B_k + C_l + e_{iklmn}$ [1]

where;

Y_{iklm} = persistency values 1 through 10 (5 morning, 5 evening and 5 total daily milk values),

μ = overall mean

A_i = fixed effect due to parity (1, …, 5),

B_k = fixed effect due to year (2001,…, 2003),

C_l = covariate, lactation length

e_{iklm} = random element assumed to be normally and independently distributed with mean of zero and variance σ^2_e.

Year by parity interaction was included in the model also. Least squares of the ratios for different parities were estimated. Difference tests were adjusted by the Tukey method (TUKEY, 1953). Since the data was unbalanced, adjustments were approximated using a method defined by KRAMER (1956).

Using another approach, within correlation was accepted as persistency within lactation. Increased correlation means increased persistency. Test day was calculated as the day of the test to account for the day the test was done. Test day records and parities were taken as repeated measurements. The subject was the id number of the goats and id number was included within parity in the model. Days in Milk (DIM) was included to account for the total number of days the animal stayed in lactation. Because shape of the lactation has to be accounted for, three transformations of DIM as well as its original value were added (SWALVE, 1995). The model is similar to that proposed by PTAK and SCHAEFFER (1993) in terms of the characterization of lactation. Defining lactation curves in goats have been done using variety of functions (FERNANDEZ et al., 2002; McMANUS et al., 2003; GROENEWALD and VILJOEN, 2003), while this method of characterization has not been used in goats. Predicted values were produced by using estimates of the factors obtained from model 2 (solution) for days from 7 to 280, with increments of 7. These predictions showed that the model characterized the lactation in good order.

Analyses regarding this approach was accomplished using proc MIXED of SAS V8 (SAS Institute Inc., 1999). Statistical model to obtain within lactation correlations and the other corrected values was:

$$Y_{ijklm} = \mu + A_i + B_j + \sum_{k=1}^{4} b_{kl} X_k + D_m (B_j) + e_{ijklm} \quad [2]$$

where;

Y_{iklm} = test day record for morning, evening, or daily milk yield,

μ = overall mean

A_i = fixed effect due to test day (1, …, 21),

B_j = fixed effect due to parity (1, …, 5),

X_k = covariates:

C_1 = DIM/c where c is constant, set to 300 days,

$C_2 = (DIM/c)^2$

$C_3 = \ln(c/DIM)$

$C_4 = ((\ln(c/DIM))^2$, the subscript l denotes that regression were nested within parity

D_m = repeated effect of the subject within parity (all animals),

e_{ijklm} = random element assumed to be normally distributed with mean of zero and variance σ^2_e.

The error term was not assumed to be independently distributed because the data was repeated in time and thus, the covariance matrix was modeled to account for the dependencies in errors, using compound symmetry. The compound symmetry structure was used to obtain a single within correlation value. In addition to overall within lactation correlation estimates, five data sets were created for the five parities and within correlations were estimated in those data sets for evening milk tests. Model 2 was used to estimate those values, with the exception of parity in the model.

Predicted values were produced by using estimates of the factors obtained from model 2 (solution) for days from 7 to 280, with increments of 7. Then these predictions were plotted to see changes of the morning, evening and daily milk yields.

Results

Multivariate analyses of persistency showed that effects of parity (P=0.05), year (P < 0.01), lactation length (P=0.05) and parity by year interaction (P < 0.01) were large. Persistencies for different parities were estimated (Table 1). For the morning tests, most of the differences among the parities were non-significant except for the early stages of lactation (test1/test2). Persistency takes its optimum value when it is one. Values larger than one indicates a decrease, those smaller than one indicates an increase in milk yield. In early stages of lactation, animals in their fourth lactation tended to have numbers higher than one, which indicates that they had a milk yield decrease in their second test day. However, animals having their first, second or third lactation tended to have an increase in their second test days. The increases were rather stable; all were around 0.90. The non-significant differences in later ratios indicated that goats in different parities may have similar persistencies except in the early stages of lactation. The same statements were true for early stages of evening milk though numbers were a little bit closer to ratio one. Total daily milk showed a similar trend also, and the tendency was closer to evening milk than morning milk.

Table 1
Least Squares Means of persistency ratios for different parities (LS-Mittelwerte für die Persistenz in unterschiedlichen Laktationsnummern)

Parity	M1*	M2	M3	M4	M5	E1*	E2	E3	E4	E5	T1	T2	T3	T4	T5
1	0.90^{a}	1.29^{a}	1.41^{a}	1.35^{a}	1.25^{a}	0.88^{ab}	1.00^{ac}	1.36^{a}	1.32^{a}	1.12^{a}	0.88^{a}	1.13^{ab}	1.38^{a}	1.33^{a}	1.17^{a}
2	0.96^{ab}	1.35^{a}	1.30^{a}	1.19^{a}	1.38^{a}	0.81^{a}	1.37^{b}	1.07^{a}	1.32^{a}	1.54^{a}	0.89^{a}	1.13^{a}	1.17^{a}	1.23^{a}	1.44^{a}
3	0.92^{a}	1.22^{a}	1.22^{a}	1.41^{a}	1.28^{a}	0.87^{a}	0.93^{c}	1.10^{a}	1.18^{a}	1.38^{a}	0.89^{a}	1.07^{ab}	1.15^{a}	1.28^{a}	1.33^{a}
4	1.32^{b}	1.05^{a}	1.37^{a}	1.12^{a}	1.27^{a}	1.35^{b}	0.81^{c}	1.41^{a}	0.94^{a}	1.45^{a}	1.30^{b}	0.93^{b}	1.37^{a}	1.02^{a}	1.34^{a}

* Morning1-Morning5, Evening1-Evening5, Total daily 1-Total daily 5

[a, b, c] Parity values with different superscripts differ (P < .05).

The within lactation correlations can be used as indicators of persistency. Within lactation correlations were estimated as 0.22 for morning, 0.28 for evening and 0.27

for daily milk yield. Evening persistency was higher than both total daily and morning test persistency, which makes it a more reliable test to use in total lactation estimates.
Persistency values for different parities were estimated for evening milk also, which were 0.17, 0.61, 0.26, 0.23 and -0.01 for parity 1 to 5, respectively. The highest persistency occurred in the second lactation, which indicated that minimum number of evening tests can be used in second lactation to estimate the lactation milk yield, or to rank the animals. Estimates in first lactation or in lactations later than fourth should be based on as much tests as possible since the persistency is low.
In this study, there were sharp increases in first three lactations in morning, evening and daily milk yields (Table 2). There was a distinct increase from first lactation to second (ranged from 22.0 to 26.8%) and second lactation to third (ranged from 20.0 to 22.2%). The increase tended to level out in fourth lactation and started to decrease in fifth.

Table 2
Least Squares Means of morning, evening and total daily milk yields and its percent deviation among parities (LS-Mittelwerte für die Milchmengenmerkmale, Morgen-, Abend- und Gesamttesttagsgemelk und die prozentualen Anstiege zwischen den Laktationen)

Parity	Morning	Difference %	Evening	Difference %	Total	Difference %
1	622.94	-	551.16	-	1193.00	-
2	851.02	26.8	706.48	22.0	1586.06	24.8
3	1066.26	20.0	907.63	22.2	1994.35	20.5
4	1206.32	11.6	922.42	1.6	2009.22	1.0
5	1028.19	-17.3	691.05	-33.5	1490.40	-34.8

Discussion

Research has shown that persistency of milk yield in first lactation being higher compared to later lactations is mainly due to later and lower peak yields in first lactation (CDN, 2004). GROENEWALD and VILJOEN (2003) reported that total and peak milk yield increased with increasing parity up to about the third or fourth parity, while peak yield was later for first than for later parities in Saanen goats. BAFFOUR-AWUAH et al. (1996) calculated persistency as ratios in Holstein Friesian cows and reported that the ratios had moderate heritabilities and had positive genetic correlations with the partial yield in early lactation. LAES-FETTBACK and PETERS (1995) evaluated three Egyptian Goat breeds Baladi, Zaraibi and Damascus, and reported that all the breeds had high persistency, with a slightly higher yield during the initial part of lactation in Zaraibi and Damascus.
Evening persistency was higher than both total daily and morning test persistency in this research. As persistency increases, the number of tests to estimate the lactation milk yield decreases because there are not as much deviations as would from a curve with smaller persistency value. NORMAN et al. (1999) wrote that because 60 % of the US cows on test are enrolled in an AM-PM plan in which intervals between tests have increased, new procedures that more accurately predict lactation yields for such plans should be considered as replacements for test interval method. In an AM-PM method, only one of the two milk weights is recorded on the monthly test date.
The highest persistency occurred in the second lactation in this research. PEREZ-CABAL and ALENDA (2003) suggested that lifetime profit can be accurately estimated from data in the second lactation. TEKERLI et al. (2000) reported that persistency was higher during first lactation in cattle. The same authors also stated that

peak and lactation yields were lower in first lactation, which is consistent with findings of this research.

In this research, there were increases from first lactation to second, second lactation to third and the increase leveled out in fourth lactation and started to decrease in fifth. This is consistent with findings of GROENEWALD and VILJOEN (2003). BOEMKES et al. (2004) reported that milk yield was highest in fourth lactation in German Improved Fawn goats. FIRK et al. (2002) reported that milk yield, milk flow rate and electrical conductivity increased with increasing number of parity in Holstein Friesian cows.

During a bovine lactation, milk yield increases during early lactation as a consequence of increased activity per cell, whereas this increase is supplemented by mammary growth in goats. Following peak lactation, milk yield declines due to gradual regression of the epithelium by apoptotic cell death. During late lactation, the decline in milk yield due to declining cell numbers is supplemented by decreased secretory activity by cell (CAPUCO et al., 2003). Increasing milking frequency (4 vs. 2 times) increases milk during treatment and for the remainder of lactation (BAR-PELED et al., 1995; HALE et al., 2003). This may be the result of increased mammary cell proliferation (HALE et al., 2003), or due to increased stimulations on regions of mammary gland increasing blood flow and oxygen tension (CAPUCO et al., 2003). Perhaps evening milk is more persistent because the mammary gland is already stimulated in the morning and more oxygen is flowing in the gland due to the day's activities such as walking and feeding. On the other hand, the cell proliferation theory would suggest the opposite, because GH (Growth Hormone) is secreted at night and should be more effective on the morning milk due to increased proliferation and because the repair functions work during night time. In this study, morning milk was secreted more while evening milk had higher persistency.

It is clear now that photoperiod has significant effects on milk production and persistency. Lactating dairy cows exposed to long-day photoperiods (16 to 18 h of light) produce more milk than cows exposed to short-day (<12 h light) photoperiods and lactation of cows on long-day photoperiods appears more persistent than that of cows on short days (DAHL et al., 2000). Increasing exposure to light reduces the duration of melatonin secretion. A long day pattern of melatonin secretion increases circulating prolactin and insulin-like growth factor I (IGF-I) concentrations and these endocrine shifts are consistent with observed effects on lactation, and body growth and composition in cattle (DAHL et al., 2002). Effects of photoperiod on persistency may play a role on the differences of morning and evening milk persistency because there are light and melatonin secretion differences between morning and evening times. The difference may be dependent on many factors such as day of the test and year.

More research on the subject is required to explain the physiological reasons and mechanisms of evening milk having higher persistency in goats.

Conclusions

Evening milk had higher persistency in Turkish Saanen goats compared to morning milk. Milk yield increased until lactation four and then decreased. Evening milk tests can alone be used to estimate lactation yield instead of the total test day milk yield. Second lactation milk yield had the highest persistency when the evening milk tests were used. There were sharp increases in first three lactations. Further research is

required to explain the physiological reasons and mechanisms of evening milk having higher persistency in goats and to evaluate possibilities of using evening milk alone to estimate lactation yield instead of the various models such as AM-PM tests, monthly or trimonthly tests.

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