

Persistency of milk yield in Anglo Nubia x Criolla goats

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A study was made using 6 140 milk yield records on the test day, from ten fortnightly milk test recordings of 631 lactations corresponding to 383 Anglo Nubia x Criolla goats located in six herds in Loja, Ecuador, during the period from 2011 to 2013. The purpose was to determine the non-genetic factors affecting lactation persistency and to estimate their correlation with total milk yield, milk yield adjusted to 152 d and lactation length. A linear, mixed generalized model was applied through the GLIMMIX procedure of SAS. As fixed effect were considered the herd, kidding year, season, number of lactation and youngs. Lactation length was considered as linear covariable and the random effect was associated with each goat dwelling in the herd. For estimating Pearson's correlations, the CORR procedure of SAS was applied. Persistency was of 69.4 %. The non-genetic factors were significant, except for litter size. The phenotypic correlations of total milk persistency, adjusted milk and lactation length were 0.20, 0.16 and 0.14, respectively. It is concluded that lactation persistency had a low phenotypic correlation regarding milk yield and lactation length. Further investigations should be conducted with greater number of samples and genealogical information for recommending its inclusion in genetic breeding programs.

Key words: *goats, persistency, lactation, correlation, crossing*

Persistency of milk yield has different definitions. In this paper is considered that described by Gengler (1996) who stated that persistency can be defined as the ability of a dairy female for maintaining, more or less constant, its production throughout lactation.

The knowledge of milk yield persistency is of great importance, since it is one of the main characteristics defining the shape of the lactation curve, besides being correlated with the initial production (El Faro 1996).

Results from different studies coincide in that non-genetic factors affecting goat lactation persistency are kidding number (Palas and Savas 2005, Waheed and Khan 2013 and Marete *et al.* 2014), kidding season (Marete *et al.* 2014), kidding year (Palas and Savas 2005 and El-Wakil and Fooda 2013), lactation length (Palas and Savas 2005) and type of kidding (Marete *et al.* 2014). Nonetheless, in Loja province in Ecuador, where there is the highest goat population of the country with 110 395 heads (Anon 2003), there are no studies related to lactation persistency in this species.

The objective of this study was to identify the main non-genetic factors affecting lactation persistency in Anglo Nubia x Criolla goats, as well as to estimate the existing correlation with milk yield and lactation length.

Materials and Methods

Data from 6 140 milk production records from the period 2011-2013 on the test day (TDP) were utilized. Ten fortnightly milk test recordings and 631 lactations of 383 Anglo Nubia x Criolla goats were considered. Animals were located in six herds of the neighborhood Cabeza de Toro, Zapotillo canton, Loja province, Ecuador. This region is situated 42°23'00" South latitude and 80°15'00" West latitude at an altitudinal

range from 450 to 835 masl. Two well-marked climatic seasons characterize the zone throughout the year: the rainy season from January to April with an average temperature of 27.3° C and the dry season from May to December with a temperature of up to 24.5° C. Annual mean temperature is of 25.1° C (Anon 2014).

Herds are on clayish soils with topographic conditions corresponding to poor uneven stony fields, with slightly undulating hills. They are localized in Cabeza del Toro hill (Anon 2014).

Feeding was based on an extensive browsing system and free grazing. During the morning there was free grazing and in the afternoons the dams and the replacing goats were shut together in the same corral; while kids were housed separately in rearing corrals. Goats mainly consumed tree species as *Acacia macracantha*, *Prosopis pallida*, *Sapindus saponaria*, *Erythrine smithiana*, *Fabebura crhysantha* and *Cordia lutea* and grass species as *Holcus lanatus*, *Pennisetum purpureum* and *Cynodon nlemfuensis*. Also, 10 g/animal/d of mineral salt were supplied. The reproductive management was carried out by controlled natural mating. The first mating season started in December and January and second in June and July. Visual appreciation was used for estrus detection. Bucks were maintained in the corrals of the females fit for reproduction (minimum live weight of 25 kg at first service), with a ratio per male of 25 females.

From the fifth day after kidding, goats were incorporated to manual milking which was carried out once daily in the morning (from 6:00 a.m. to 8:00 a.m.) and without kid support. No supplementation was supplied to the dams during or prior to milking. Individual measurement of milk yield was conducted every 15 d approximately, during a period of five months

for a total of 10 milk test recordings. On the test day, a thorough milking was carried out, so as the milk calculated from this information was considered as the total female production, without considering that drunk by the kid. However, it is known that the she-goat stores a milk percentage for suckling the young.

Kid rearing was by natural lactation. Suckling was carried out for two hours, approximately. During the first 15 d of birth, kids suckled in the morning hours and after milking. Later, they suckled in the afternoon (4:00 p.m. to 6:00 p.m.). Kids were separated from their dams after the morning suckling and maintained in a general corral until 4:00 p.m. when dams returned from grazing. Later, the second suckling was realized. From 15 d of birth, young were only suckled in the morning hours, subsequently they grazed with their dams from 9:00 a.m. to 4:00 p.m. Then they were separated in a corral for youngs. Kid weaning was realized between 50 and 60 d of age, with an average live weight of 8 kg. Persistency (P) was estimated according to the criteria of Johanson and Hansson (1940). These authors determined the persistency as the proportion between milk production in different parts or lactation stages representing the times prior to the peak, including it and afterwards. The formula used for the calculation was:

$$P = \left\{ \frac{\text{Milks} * 100}{\text{Milk p}} \right\}$$

Where:

Milks: Accumulated milk production in the second half of lactation (from six to ten fortnightly milk test records)

Milkp: Accumulated milk production in the first half of the lactation curve (from one to five fortnightly milk test records). Both productions were calculated by the method of Fleischmann (1945).

Persistency distribution was analyzed through SAS/INSIGHT. The no-normality of the persistency was established by the results of the test of goodness adjustment for the normal distribution ($P < 0.001$), according to Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises and Anderson-Darling.

According to the type of distribution followed by the persistency (Gamma), the corresponding linking function ($\mu = \log(\lambda)$) was used. In addition, the GLIMMIX allows obtaining the re-transformed values, according to the

inverse function to the linking function ($\mu = \exp(x\beta)$).

In table 1 are shown the number of observations per herd, year and kidding season, number of lactation and litter size.

A mixed generalized linear model was applied through the GLIMMIX procedure of SAS, version 9.3 (2013), that considered the fixed effects of the herd, kidding year, kidding season, number of lactation, litter size, lactation length as linear covariable and associated random effect each she-goat dwelling within the herd:

$$Y_{ijklmnop} = \mu + \beta(D_i - \bar{D}_i) + H_j + A_k + E_l + L_m + R_o + C_n(H_j) + e_{ijklmnop}$$

Where:

$Y_{ijklmnop}$ = expected phenotypic value of the lactation persistency, according to the specific linking function

μ = medium or interception

$\beta(D_i - \bar{D}_i)$ = linear covariable of the i-th lactation length ($i=1, \dots, 631$)

H_j = fixed effect of the j-th herd ($j=1, \dots, 6$)

A_k = fixed effect of the k-th kidding year ($k=2011, 2012, 2013$)

E_l = fixed effect of the l-th kidding season ($l = \text{rainy, dry}$)

L_m = fixed effect of the m-th lactation ($m= 1, 2$)

R_o = fixed effect of the o-th litter size ($o=1, 2$)

$C_j(H_j)$ = random effect of the j-th she-goat dwelling in the i-th herd

$e_{ijklmno}$ = random error due to each NID-(0, s_2e) observation

Tukey's-Kramer's test was applied for multiple mean comparisons from the least squares according to Kramer (1956). The procedure of CORR from SAS was used for estimating Pearson's correlations between persistency and total milk production (TOTM), total adjusted milk production (AJUSTM) at 152 d and lactation length (LACL). Total milk production was adjusted to 152 d, since it agreed with the period of fortnightly milk test recordings.

Results and Discussion

In table 2 are shown the general statistics for lactation persistency. The general mean obtained in this study ($69.4 \pm 0.7\%$) was higher than those referred by Takma *et al.* (2009) in Turkey in Bornova she-goats (25 % White German x 25 % Maltese x 50 % Anglo Nubian crosses) with estimates of $59.2 \pm 3.5\%$ and in the Saanen breed

Table 1. Observations per herd, year and kidding season, number of lactation and litter size

Herds	Obs.	Kidding year	Obs.	Kidding season	Obs.	No. of lactations	Obs.	Litter size	Obs.
1	167	2011	79	Lluvia	158	1	378	1	434
2	92	2012	416	Seca	473	2	253	2	197
3	44	2013	136						
4	55								
5	135								
6	138								

Obs. Observations

with 52.6 ± 2.8 %. Also, it surpassed what was reported by El-Wakil and Fooda (2013) in Dhofari goats with 64.2 ± 14.9 % in lactations of 226 d as average and that quoted by Waheed and Khan (2013) in Beetal goats in Pakistan with 60.2 ± 1.3 %.

Table 2. Statistics of lactation persistency in Anglo Nubia x Criolla goats

Statistics	Persistency
Mean, %	69.4
Standard deviation	17.9
Coefficient of variation, %	25.8

The high persistency values could be due to the non-specialized milk production genotype of these goats (Anglo Nubia x Criolla) that do not show high peak productions (615 g/d) bringing about as result more persistent lactations, compared to specialized breeds (1 800 g/d). According to Montaldo *et al.* (2007), these have a more pronounced slope in the production when its milk peak is high. In the same way, the extensive feeding system, based mainly on browsing, and in a lower percentage on grazing, could have influenced on the lower production peak, provoking in this way greater lactation persistency, mainly in the season of pasture shortage.

Studies related to lactation persistency in goats are scarce and do not offer information on the coefficients of variation allowing to know if by controlling the environmental factors influencing on milk production

more persistent lactations can be obtained. However, on utilizing the method used in this study for estimating the persistency, Chegini *et al.* (2013) reported coefficients of variation of 20.3 % in Holstein cows.

The significant effect of the herd, calving year, calving season, number of lactation, were evidenced as well as the lactation length ($\beta = 0.002081 \pm 0.00004$) as linear covariable in the lactation persistency (table 3). Litter size did not affect the persistency agreeing with the results of Waheed and Khan (2013) using Beetal goats in Pakistan.

In table 4 are shown means obtained for the herd effect where differences in persistency of the herds under study are set out and that could be caused by the specific management practices of each goatherd. Also, feeding differences between herds can be seen as a consequence of the unequal availability of trees and shrubs. This performance could also obey to genetic factors associated with the uncontrolled effect of the buck. The highest mean in the persistency of milk production corresponded to the second herd. This could be due to the genetic effect of the buck used in direct mating. In addition, environmental differences could influence that mainly obey to the management during milking, since in this herd there was stability among the workers devoted to this activity, differing from the rest, in which there were variations.

Under the semi-arid conditions in Pakistan, Waheed and Khan (2013) found significant effect of the herd on the lactation persistency in Beetal goats. However, these authors do not offer explanations of the possible causes of the variation between herds. Glória *et al.* (2012)

Table 3. Analysis of variance of the fixed effects in lactation persistency in Anglo Nubia x Criolla goats

Effects	d.f	Error	F value	P value
Herd	5	377	20.23	<.0001
Kidding year	2	242	62.30	<.0001
Kidding season	1	242	13.24	0.0003
Number of lactation	1	242	17.46	<.0001
Lactation length	1	242	21.28	<.0001
Litter size	1	242	0.06	0.8085

Table 4. Effect of the herd on the lactation persistency in Anglo Nubia x Criolla goats

Herds	Means,%	SE±
1	83.2 ^b	1.8
2	88.4 ^a	2.3
3	70.6 ^c	2.4
4	64.9 ^d	2.2
5	73.3 ^c	1.5
6	74.7 ^c	1.7

^{a,b,c,d} Different superindices in the same column differ significantly at $P < 0.05$ according to Kramer (1956)

reported that in bovines this effect was also significant in Friesian and Ayrshire cows crossed to indigenous breeds of Sudan (Fadlelmoula *et al.* 2007) and in F1 cows from Holstein-Gyr, Holstein-Guzerat, Holstein Nellore and Holstein-Zebu crosses in Minas Gerais, Brazil. These authors argued that differences between herds probably were due to differences in the management practices of each one, mainly during milking. Also, the variations in the nutritional management and in the forage quality could have influenced for guaranteeing high milk productions during lactation.

According to Fadlelmoula *et al.* (2007), contrasts in persistency between herds are probably related to management differences. Glória *et al.* (2012) stated that the management practices to improve animal welfare, particularly during milking, can attain better expression of the milk potential and prevent in this way milk hiding.

Means obtained for the effects of year and kidding season are shown in tables 5 and 6, respectively. Persistency of milk production presented unstable performance during the years of study (table 5). The highest values were reached by goats in the third year, regarding the first and second year of kidding. These results could be mainly due to variations in the climatic conditions (abundant or scarce rainfall) that influenced on pasture availability, as well as uncontrolled management variations.

Table 5. Effect of the kidding year on lactation persistency in Anglo Nubia x Criolla goats

Years	Means, %	SE ±
2011	71.8 ^b	1.5
2012	64.9 ^c	0.9
2013	79.1 ^a	0.9

^{a,b,c,d} Different superindices in the same column differ significantly at $P < 0.05$ according to Kramer (1956)

Table 6. Effect of the kidding season on lactation persistency of Anglo Nubia x Criolla goats

Kidding season	Means, %	SE ±
Rainy season	79.0	2.0
Dry season	72.1	0.9

Climatological data of the area under study (Anon 2014) showed higher rainfall mean during the rainy season in 2013 (258 mm), regarding 2011 (107 mm) and 2012 (89 mm). Moreover, in 2013 there was rainfall as well from October to December. This did not occur in 2011 and 2012. The effect of kidding year in lactation persistency was reported too by authors as Palas and Savas (2005) in Saanen goats in Turkey; El-Wakil and Fooda (2013), in Dhofari goats, in Egypt and Marete *et*

al. (2014) in Kenya Alpine goats.

The effect of the kidding season on lactation persistency (table 6) demonstrated that goats kidding in the rainy season had higher persistency regarding those kidding in the dry season ($P < 0.001$). Marete *et al.* (2014) using Alpine goats in Kenya also obtained higher persistency values in the rainy period. This result could be related to the higher availability and quality of the pastures and with the more favorable environmental conditions in the rainy period. Different authors reached similar conclusions in other species (Jakobsen *et al.* 2002, Tonathi *et al.* 2006, Fodlelmoda *et al.* 2007, Nagasaku *et al.* 2007, Pérez *et al.* 2007 and De Andrade *et al.* 2010).

The effect of the lactation number on persistency (table 7) showed better performance in primipara goats ($P < 0.001$). This performance agrees with data obtained by Palas and Savas (2005), Waheed and Khan (2013) and Marete *et al.* (2014) in different goat species. According to the results from these authors first lactation was more persistent than the subsequent ones.

Table 7. Effect of the number of lactation on lactation persistency in Anglo Nubia x Criolla goats

Number of lactation	Means, %	SE ±
1	79.1	1.9
2	71.9	0.9

A similar performance was also observed in bovine cattle in studies of Abubakar and Buvanendran (1981) in Friesian-Bunaje primipara cows in Nigeria; in the results of Tekerli *et al.* (2000), in Holstein; in the experiments of Cobuci *et al.* (2001) in Guzerá cows, as well as in the reports of Osorio and Segura (2005), Holstein x Zebu and Holstein x Sahiwal crosses. There was also similar performance in the experiments of Fadlelmoula *et al.* (2007) in crossbred cows in Sudan and in the studies of Lemus *et al.* (2008) in Holstein cows in Mexico.

According to Castillo *et al.* (2002), the maturing process taking place in young animals and that counteracts the normal decrease of milk production could account for this common performance in dairy species.

In bovines, Glauber (2007) considered that calving influences on lactation persistency being this higher in first calving cows. In addition, according to this author, the gestation itself decreases persistency, since beside the hormonal changes, due to the gestation stage, dairy cows are exposed to complex metabolic demands between gestation and lactation that influence on cell dynamics.

Glória *et al.* (2012) reported that the highest persistency value observed in the first lactation is related to the largest service period that prevents a negative effect of the fetus on milk production. Bachman *et al.*

Table 8. Pearson's correlations between persistency and production traits in Anglo Nubia x Criolla goats

	P	TOTM	ADJUSTM	LACL
P	1.00000	0.19891 <.0001	0.16222 <.0001	0.14373 0.0003
TOTM		1.00000	0.84585 <.0001	0.61945 <.0001
ADJM				0.11404 0.0041
LACL				1.00000

(1988) and Capuco et al (2003) reported that the negative effect of pregnancy on milk production coincide with the extent of estrogen secretion by the fetus-placental unit. In table 8 is set out the phenotypic correlation of lactation persistency with different productive traits. Lactation persistency showed low phenotypic correlations with total milk production, milk production adjusted to 152 d and lactation length. These results could be due to the fact that herds studied have not been subjected to genetic breeding programs for milk production and persistency.

El-Wakil and Fooda (2013) in an extensive system with Dhofari goats and under semi-arid conditions, obtained similar results with estimates of the phenotypic correlations of persistency with total and accumulated milk production of 0.26 and 0.23, respectively, during 90 d.

Several authors (Danell, 1982, Tonhati *et al.* 2001 and Cobuci *et al.* 2003) suggest that persistency is a trait that must be included in the breeding programs, since the selection for milk production do not guarantee the genetic improvement of lactation persistency. In this study heritability estimates or genetic correlations between lactation persistency and milk production were not obtained. Therefore they must be considered in future studies.

It is concluded that lactation persistency in Anglo Nubia x Criolla goats was affected by the effects of herd, kidding year, kidding season, number of lactation and lactation length. Moreover, it showed low phenotypic correlation with milk production and lactation length. Therefore, further investigations on this trait are required with larger number of samples and with genealogical data for estimating their heritability. Also, genetic correlations with other traits of interest are suggested so as to recommend their inclusion in genetic breeding programs.

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Received: September 24, 2014