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Persistency of lactation and comparison of different persistency measures in indigenous and crossbred cows at Bako, Ethiopia

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Abstract

Persistency of lactation in indigenous and crossbred cows was studied using milk data collected at Bako Agricultural Research Centre. Persistency was measured using three methods vis-à-vis as the ratios of milk yield during the second (P2:1) and third (P3:1) 100 days of lactation to milk yield during the first 100 days of lactation, and using persistency index (PI). The overall mean P2:1, P3:1 and PI were 78.0±0.67, 59.2±0.58 and 85.7±0.70 percent, respectively. P2:1 was significantly ($P<0.01$) affected by sire breed, calving season and initial milk yield, while P3:1 and PI were significantly (at least $P<0.05$) affected by sire breed, calving season, calving weight and initial milk yield. Among the sire breed categories, Simmental crosses had significantly the highest P2:1 (86.7±1.93%), P3:1(67.9±2.14%) and PI (90.5±1.65%) while the Horro had the lowest values of these traits. Cows that calved during Bona (December to February) had the highest P2:1 (88.2±1.58%). The lowest P3:1 (46.9±2.22 %) and PI (77.2±1.82%)
were recorded for cows that calved during Arfasa (March to May). Calving weight was linearly related to P3:1 (b = -0.08±0.02; $P < 0.001$) and PI (b = -0.04±0.02; $P < 0.05$). Similarly, initial milk yield was linearly and negatively related to P2:1 (b = -1.14±0.31; $P < 0.001$), P3:1 (b = -0.88±0.38; $P < 0.05$) and PI (b = -0.65±0.31; $P <$
0.05). All persistency values obtained in this study were lower for indigenous breeds than crossbreds indicating that these traits were improved through crossbreeding. Persistency was also affected by calving season, calving weight and initial milk yield, which are probably related to the availability of feed. Thus, improving the feeding system through strategic supplementation might improve persistency in both indigenous and crossbred cows. Besides, due to shorter lactation length of most indigenous cows and for periodic assessment of

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persistency of crossbred cows to make improvement interventions in the meantime, P2:1 and P3:1 are more appropriate compared to persistency index.

Key words: persistency, persistency index, Horro, Boran, Jersey, Friesian, Simmental

Introduction

Persistency is a measure of the shape of the lactation curve. It is a dimension less quantity (Wood, 1969; Cobby and Le Du, 1978) that can only be used for comparison of lactations. It is defined as the rate at which milk yield fall off from the maximum (Sanders, 1930); the degree to which milk yield in early lactation is maintained (Mahadevan, 1951); the ability of the cow to continue to produce at a higher level throughout the lactation (Cupps, 1966 as cited in Grossman *et al.*, 1999); the extent to which peak yield is maintained (Wood, 1967) or the ability to maintain a more or less constant yield during the lactation (Mahadevan, 1951). As a result of different definitions of persistency, persistency measures are inconsistent. Persistency measures have been expressed as ratio (or rate) of yields of different periods of the lactation (Madsen, 1975; Solkner and Fuchs, 1987; Ibeawuchi, 1988); as measures derived from variations of test day yields (Solkner and Fuchs, 1987; Grossman *et al.*, 1999); as measures constructed of parameters estimated from mathematical models of the lactation curves (Wood, 1968; Gravert and Baptist, 1976; Rowlands *et al.*, 1982) or using the number of days during which the level of constant yield is maintained (Grossman *et al.*, 1999).

Persistency has been studied in indigenous and crossbred cows in Ethiopia (Kiwuwa *et al.*, 1985; Gashaw, 1994; Mureja, 1994) and elsewhere in exotic and crossbred cattle (Madalena *et al.*, 1979; Ibeawuchi, 1988). All studies reported that persistency is affected by both genetic and non-genetic factors indicating that it is a trait specific to a breed, herd management practice and environmental condition. Thus, persistency, need to be estimated for a breed under the existing level of management of the farm in order to make follow up and on time adjustments in the feeding and management practices of the farm (Madsen, 1975). For instance, Solkner and Fuchs (1987) indicated that a flat lactation curve is of economic interest because it is easier to feed, the physiological strain on the cow by high daily milk yield (which often causes reproductive or metabolic disorders) is diminished and the proportion of roughages in the diet can be increased. Madsen (1975) also indicated that a flat lactation curve (higher persistency) needs less concentrate during the lactation than a cow with the same total yield and steep lactation curve. Besides, the methods of calculating persistency are different, and hence it is appropriate to assess the suitability of different, if not all, persistency measurements developed elsewhere and recommend appropriate method for lactation yield of indigenous and crossbred cows. This study was, therefore, aimed at assessing persistency of indigenous and crossbred cows using different persistency measures and identifies the effects of genetic and non genetic factors affecting persistency of lactation in the centre.

Materials and Methods

The study was conducted based on data from Bako Agricultural Research Centre of Oromia Agricultural Research Institute. Details of the centre's climatic condition, livestock management, breeding and health care are indicated in previous works (Gebregziabher and Mulugeta, 1996).

Three persistency measures (P2:1, P3:1 and persistency index) were used to calculate persistency of milk yield of indigenous and crossbred cows:

1. P2:1:- the ratio between milk yield from 101 to 200 days after parturition and milk yield in the first 100 days of the lactation (Madsen, 1975)
2. P3:1:- the ratio between milk yield from 201 to 300 days after parturition and milk yield in the first 100 days of lactation (Madsen, 1975)
3. Persistency index (PI; Ibeawuchi, 1988):- To calculate persistency index (PI) each lactation curve was divided into four equal parts of ten weeks each after excluding the first five weeks that represented the initial rising phase of the lactation curve. The total ten weekly yield of each of the four periods was then calculated and the following ratios established $R_1 = X_2/X_1$; $R_2 = X_3/X_2$ and $R_3 = X_4/X_3$; where X_1, X_2, X_3 and X_4 were total milk production during the first, second, third and fourth period. R_1, R_2 and R_3 were then used to calculate the following weighting factors (W_1, W_2 and W_3); $W_1 = R_1/(R_1 + R_2 + R_3)$; $W_2 = R_2/(R_1 + R_2 + R_3)$; $W_3 = R_3/(R_1 + R_2 + R_3)$. The

persistency index (PI) expressed in percentage was calculated for each cow as $PI = (W_1 * X_2/X_1 + W_2 * X_3/X_2 + W_3 * X_4/X_3) * 100$.

P2:1 and P3:1 do not allow use of milk yield data of cows with lactation lengths shorter than 190 and 290 days, respectively and such data were not included for calculating P2:1 and P3:1. Furthermore, persistency index was calculated based on milk yield data of 315 days lactation length. Short (<305 days) and long (>315 days) lactation lengths were not considered for calculating persistency index. Besides, cows with very long lactation length milk data of the first 315 days were utilized for the study. Thus, lactation records of 559, 315 and 234 were considered during the final analysis.

Persistency index, P2:1 and P3:1 were analysed using the General Linear Model of the Statistical Analysis System (SAS, 1999), which included fixed effects (sire breed, parity and calving season) and two covariates (calving weight (body weight of the cow shortly after calving) and initial milk yield (the first milk yield after the colostrums period)). Five sire breed categories (Jersey for Jersey x Boran and Jersey x Horro; Simmental for Simmental x Boran and Simmental x Horro; Friesian for Friesian x Boran and Friesian x Horro; Boran for pure Boran and Horro for pure Horro); six parity groups (one to six with the sixth parity including parities six and above pooled together) and four calving season categories *Gana* (June to August; main rainy season), *Birra* (September to November; post rainy season with small showers), *Bona* (December to February; dry season) and *Arfasa* (March to May; beginning of the rainy season) were considered as fixed effects. The General Linear Model used for the analysis was:

$Y_{ijkl} = \mu + SB_i + P_j + CS_k + b_l X_l + b_2 X_2 + e_{ijkl}$ Where:

Y_{ijkl} = l^{th} observation in the i^{th} sire breed, j^{th} parity and k^{th} calving season

μ = the overall mean common to all observations

SB_i = the effect of i^{th} sire breed (sire breed with i = 5) P_j = the

effect of j^{th} parity of the cow (j = 6)

CS_k = the effect of k^{th} calving season (k=4)

X_1 and X_2 are the effects of calving weight and initial milk yield, and b_1 and b_2 are corresponding slopes, respectively

e_{ijkl} = random error associated with l^{th} individual observation

Results

Results of analysis of variance of persistency are presented in Tables 1& 2. Persistency expressed as P2:1 was significantly (P<0.01) affected by sire breed, calving season and initial milk yield, while P3:1 and PI were significantly (at least P<0.05) affected by sire breed, calving season, calving weight and initial milk yield (Table 1). The effect of parity on P2:1, P3:1 and PI was not significant (P>0.05).

Table 1. Mean squares from analysis of variance of P2:1, P3:1 and persistency index (PI)

Source	Degree of freedom	Mean square		
		P2:1	P3:1	PI
Sire breed	4	7017.5^{***}	2797.6^{***}	348.5^{*}
Calving season	3	12812.8^{***}	4867.9^{***}	1881.6^{***}
Parity	5	498.3^{ns}	116.9^{ns}	51.2^{ns}
Calving weight	1	954.6^{ns}	3554.9^{***}	695.7^{*}
Initial milk yield	1	6525.5^{***}	1590.9^{*}	660.3^{*}
Error degree of freedom		544	300	219
Error mean square		313.1	292.9	147.9
R^2 (coefficient of determination)		32.2	25.0	21.6
Coefficient of variation		22.7	28.9	14.2

Significance level *** = *P* < 0.001; ** = P<0.01, * = *P* < 0.05 and ns (not significant) = P >0.05

The overall mean P2:1, P3:1 and PI were 78.0±0.67, 59.2±0.58 and 85.7±0.70 percent, respectively (Table 2). Among the sire breed categories, Simmental crosses had significantly the highest P2:1 (86.7±1.93%), P3:1(67.9±2.14%) and PI (90.5±1.65%) while the Horro had the lowest values of these traits indicating that Simmental crosses were more persistent compared to the other sire breeds. Cows that calved during Bona (December to February) had the highest P2:1 (88.2±1.58%). The lowest P3:1 (46.9±2.22 %) and PI (77.2±1.82%) were recorded for cows that calved during Arfasa (March to May). The effect of calving weight on P3:1 (P < 0.001) and PI (P < 0.05), and initial milk yield on P3:1 (P < 0.05), P2:1 (P < 0.001) and PI (P < 0.05) were significant. Calving weight was linearly and inversely related to P3:1 (b = -0.08±0.02) and PI (b = -0.04±0.02). While initial milk yield was linearly and inversely related to P2:1 (b = -1.14±0.31), P3:1 (b = -0.88±0.38) and PI (b = -0.65±0.31) (Tables 1&2).

Table 1. Source of variation, number of observations (N) and least squares means (± SE) P2:1, P3:1 and persistency index (PI)

Source	P2:1 (%)		P3:1(%)		PI (%)	
	N	Mean±SE	N	Mean±SE	N	Mean±SE
Overall mean	559	78.0±0.67	315	59.2±0.58	234	85.7±0.70
Sire breed classes		***		***		*
Friesian crosses	147	81.1^{bc}±1.62	105	58.9^{b}±1.83	73	85.2^{b}±1.53
Jersey crosses	155	81.9^{ab}±1.53	91	59.6^{b}±1.99	72	86.5^{ab}±1.60
Simmental crosses	106	86.7^{a}±1.93	81	67.9^{a}±2.14	73	90.5^{a}±1.65
Pure Horro	128	61.4^{d}±1.93	31	41.9^{c}±3.47	11	80.4^{b}±3.98
Pure Boran	23	73.1^{c}±3.87	7	57.1^{b}±6.70	5	82.1^{b}±5.69
Parity		Ns		Ns		Ns
1	77	80.6±2.31	51	58.8±3.03	40	86.8±2.53
2	89	77.2±2.03	52	57.9±2.79	40	86.2±2.33
3	128	75.7±1.68	75	55.1±2.31	52	83.9±2.10
4	108	79.1±1.88	62	58.4±2.59	51	84.9±2.16
5	83	74.2±2.09	48	55.8±2.80	32	83.7±2.56
6	74	74.3±2.25	27	56.9±3.64	16	83.9±3.17
Calving season classes		***		***		***
Gana (June –August)	93	67.9^{c}±1.98	52	56.3^{b}±2.75	44	89.4^{a}±2.28
Birra (Sept. – Nov.)	121	81.4^{b}±1.75	71	64.7^{a}±2.41	41	89.1^{a}±2.33
Bona (Dec. – Feb.)	160	88.2^{a}±1.58	97	60.5^{ab}±2.32	68	83.9^{c}±2.01
Arfasa (March – May)	185	69.9^{c}±1.46	95	46.9^{c}±2.22	81	77.2^{d}±1.82
Regression variables						
Calving weight		-0.032±0.02 ns		-0.08±0.02***		-0.04±0.02*
Initial milk yield		-1.40±0.31 ***		-0.88±0.38 *		-0.65±0.31*

Means in a column within a group followed by different superscript letters vary significantly (*** = $P < 0.001$; ** = $P < 0.01$, * = $P < 0.05$ and ns = $P > 0.05$)

Discussion

Economy of dairy production depends on the lactation yield, mainly a function of persistency, peak yield and lactation length. Highly persistent cows have more milk, longer productive life and are considered as efficient producers, thus provide regular source of income to the farmers throughout the year (Kumar *et al*., 1999). Cows are persistent if they tend to maintain their peak yield within a lactation period (Grossman *et al*., 1999). The P2:1

(78.8±0.67%) and P3:1 (59.2±0.58 %) obtained in this study for indigenous and crossbred cows is comparable to what was reported for Holstein Friesian (Mureja, 1994), Simmental (Solkner and Fuchs, 1987) and Red Danish (Madsen, 1975) cattle. Besides, the overall PI of 85.7±0.70% obtained in this study is comparable to the 71% (Kumar *et al.*, 1999) for Tharparkar cows and 82.8% for F_1 Friesian x White Fulani cattle in a tropical environment (Ibeawuchi, 1988). Similarly, Gashaw (1994) reported mean P2:1 and P3:1 of
74.5 ± 1 and 57.4 ± 1.3 percent, respectively for Arsi Friesian crossbred cows. The difference among the reports is related to differences in genotypes studied, management of the different farms and other non-genetic factors (Ibeawuchi, 1988; Gashaw, 1994; Mureja, 1994).

Under favourable conditions, unbred cows produce each month 94% of their milk yields during the preceding month (Chilliard, 1992). Low persistency could be inherited or occur due to under feeding, exhaustion of body reserves or other unknown mechanisms (Chilliard, 1992). The decrease in milk yield after lactation peak (that determines milk persistency) results primarily from the decrease in the number of secreting cells and sustaining the metabolic activity of secretory cells which is related to adequacy of feeding and management that enables expression of mammary cell secretory potential (Chilliard, 1992). The same annual yield could be obtained either with higher peak milk yield and lower persistency or inversely. Low persistency could be inherited, or due to under-feeding or exhaustion of body reserves. The extent and duration of body fat and protein mobilization after calving depends on milk potential, feeding level and quality, and initial body condition. However, when comparing different breeds of cows with the same milk yield, it was suggested that body weight loss was lower in dairy breeds because of their higher feed intake capacity (Chilliard, 1992).

Crossbreds were more persistent than indigenous breeds (Table 2) that could be attributed to the expression of heterosis in the crossbred progenies as a result of breed additive gene effect when *Bos indicus* (Horro and Boran) is crossed with the *Bos taurus* (Simmental, Jersey and Friesian). Similar works by Kiwuwa *et al.* (1985) in indigenous and crossbred cows attributed the low persistency of the F_1 Jersey x Arsi and F_1 Friesian x Arsi crosses during the last phase of lactation to the characteristic of the breed as the Arsi maternal parent breed gene gave very low coefficient of persistency during the last phase of lactation. The highest proportion of the indigenous breeds had shorter lactation lengths. Due to this fact, persistency index (PI) is not appropriate but P2:1 and P3:1 could be used jointly or independently to assess persistency at different stages of the lactation period for both indigenous and crossbred cows.

The effect calving season on persistency of milk production observed in this study is in agreement with previous reports by Ibeawuchi (1988) and Mureja (1994). El Amin and Osman (1971), however, didn't find any significant effect of calving season on persistency. The differences among reports on the effect of calving season on persistency could be due to variations in the feeding and management levels. A cow's nutrient requirement for different body functions has to be met in order to get high and persistent production. The feeding system followed in most farms does not take into consideration the milk yield and seasonality in feed supply from grazing. Cows calving during the rainy season graze better pasture, which might have helped the cows to maintain higher levels of milk yield for a longer period compared to cows that calved during dry season.

Calving weight and initial milk yield were negatively related to P3:1 and PI (Table 2). Cow weight at calving was linearly and inversely related to P3:1 and PI probably associated with the age of the cows and availability of body reserve for high milk production. Relatively heavier cows at calving showed lower persistency compared to lighter cows at calving. The closer relationship which exist between milk yield and energy balance is highly correlated during early lactation. Individual cows meet their energy demands through combinations of feed intake and mobilization of body reserve (Butler *et al*., 1981). Thus, heavier cows and cows with greater body reserves at calving and the ability to use these reserves during the postpartum period can partly overcome the negative energy balance during earlier lactation (Coppock, *et al*., 1974; Butler *et al*., 1981). Moreover, the ability to rapidly mobilize body reserve for milk production during early lactation unless compensated by better feeding and management of the cows might not enable the cows to maintain its higher yield for longer lactation period. Thus, lower persistency values were observed for persistency measures that consider late lactation data such as P3:1 or long lactation period such as persistency index than persistency measures that consider early lactation data. Similar results were reported by Collins-Lusweti (1991) in Holstein Friesian and Jersey cows in Zimbabwe.

Conclusion and recommendation

Persistency values for crossbred cows were higher than indigenous breeds indicating that crossbreeding improved persistency. P2:1 and P3:1 measures persistency under different stages of lactation, while PI considers the total lactation yield beyond the peak period to calculate the index. Thus, comparison of these three measures as a tool to make management decisions on time, leads to a conclusion that P2:1 and P3:1 have better indicative power as to the status of the cow's daily milk yield for both indigenous and crossbred cows. Besides, due to the short lactation length of indigenous cows, PI could not be used to determine persistency. Therefore, P2:1 and P3:1 could be used to the persistency of indigenous breeds.

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References

Butler, W. R., Ewerett, R. W. and Coppock, C. E. 1981. The relationship between energy balance, milk production and ovulation in postpartum Holstein cows. *J. Anim. Sci.* 53: 74 - 748.

Chilliard, Y. 1992. Physiological constraints to milk production: factors, which determine nutrient partitioning, lactation persistency and mobilization of body reserve. *Wld. Rev. Anim. Prod.* 27 (1) 19 - 26.

Cobby, J. M. and Le Du, Y. L. P. 1978. On fitting curves to the lactation data. *Anim. Prod.* 26 (2) 127 - 133.

Collins-Lusweti, E. 1991. Lactation curve of Holstein-Friesian and Jersey cows in Zimbabwe. S. Afr. J. Anim. Sci. 2(1): 1-15.

Coppock, C. E., Neller, C. H. and Wolfe, S. A. 1974. Effect of forage concentrate ratio in complete feeds fed adlibitum on energy intake in relation to requirements by dairy cows. *J. Dairy Sci.* 57: 1371.

El-Amin, F. M. and Osman, A. H. 1971. Some dairy characteristics of Northern Sudan zebu cattle. 1. The components of the lactation curve. *Trop. Agric. (Trinidad)*. 48 (3) 197 - 200.

Gashaw Meles. 1994. Comparative study of milk yield and lactation persistency of crossbred cattle at Asela livestock farm, Arsi, Ethiopia. MSc Thesis, Alemaya University of Agriculture.

Gebregziabher Gebreyohannes and Mulugeta Kebede. 1996. Fertility of Horro and crossbred (F_1) cows at Bako Research Centre. In: ESAP Proceedings of the Fourth National Conference of Ethiopian Society of Animal Production (ESAP). 18-19 April 1996. Addis Ababa, Ethiopia. P. 120-126.

Gravert, H. O. and Baptist, R. 1976. Breeding for persistency of milk yield. *Livest. Prod. Sci.* 3 27 - 31.

Grossman, M., Martz, S. M and Koops, W. J. 1999. Persistency of lactation yield: a novel approach. *J. Dairy Sci*. 82 2192 - 2197.

Ibeawuchi, J. A. 1988. Persistency of milk production in F_1 Friesian x White Fulani cattle in a tropical environment. *Bull. Anim. Hlth. Prod. Afr*. 36 215 - 219.

Kiwuwa, G. H., Getachew, W. and Mukassa-Mugerwa, E. 1985. Persistency and milk secretion coefficients of the indigenous and crossbred cattle at Asela-Ethiopia. *Indian J. Anim. Sci.* 55 (2) 116 - 121.

Koley, N., Chowdhury, G. and Mitra, D. K. 1981. Note on the genetic studies on milk yield, days to attain peak yield and initial milk yield in Jersey x Hariana crossbred cows at first lactation. *Indian J. Anim. Sci*. 51 545 - 546.

Kumar, V., Yadav, R. S. and Mehla, O. P. 1999. Effect of persistency on milk yield under organized farm management condition. *Indian J. Anim. Sci*. 69 (2) 134 -138.

Madalena, F. E., Martinez, M. L. and Freitas, A. F. 1979. Lactation curves of Holstein Friesian and Holstein Friesian x Gir cows. *Anim. Prod*. 29 (1) 101 - 107.

Madsen, O. 1975. A comparison of some suggested measures of persistency of milk yield in dairy cows. *Anim. Prod.* 20 191 - 197.

Mahadevan, P. 1951. The effect of environment and heredity on lactation. II. Persistency of lactation. *J. Agric. Sci.* 41 89 - 93.

Mureja Shibru. 1994. Milk production and persistency characteristics of Holstein Friesian cattle on the Holetta Government dairy farm, Ethiopia. MSc Thesis, Alemaya University of Agriculture.

Rowlands, G. J., Lucey, S. and Russell, A. M. 1982. A comparison of different models of the lactation curve in dairy cattle. *Anim. Prod.* 35 135 - 144.

Sanders, H. G. 1930. The analysis of the lactation curve into maximum yield and persistency. *J. Agric. Sci.* 20 145 - 185.

SAS 1999. SAS User's Guide, Cary, North Carolina, U.S.A., SAS Institute Inc.

Solkner, J. and Fuchs, W. 1987. A comparison of different measures of persistency with special respect to variations of test-day milk yields. *Livest. Prod. Sci.* 16 305 - 319.

Wood, P. D. P. 1967. Algebraic model of the lactation curve in cattle. *Nature, Lond.* 216 164 - 165.

Wood, P. D. P. 1968. Factors affecting persistency of lactation in cattle. *Nature, Lond.* 218 894.

Wood, P. D. P. 1969. Factors affecting the shape of lactation curve in cattle. *Anim. Prod.* 11 307 – 316.