American-Eurasian Journal of Agronomy 2 (1): 36-42, 2009
ISSN 1995-896X

Milk Production of Imported Heifers and Tunisian-Born Holstein Cows

B. Rekik, R. Bouraoui, A. Ben Gara, H. Hammami, M. Hmissi and H. Rouissi

Département Des Productions Animales, ESA Mateur, 7030 Tunisia

Abstract: Test day (TD) records of milk, fat and protein yields and somatic cell scores (SCS) were studied in Holstein cows in Tunisia. There were 43114, 32923 and 24633 lactation records collected on first, second and third parity cows between 1992 and 2004 in 182 herds. Records were of cows born in Tunisia (22000 cows) and those imported from Europe (10830 cows) and North America (850 cows). Variation of total days in milk (DIM) per lactation was studied in function of the herd, calving year x calving season interaction and the origin of the cow. Test-day records were analyzed using a linear model that included calving year x calving season and herd x test-day date interactions, calving season, calving year and origin of the cow. The effective length of lactation was affected by all factors included in the model ($p< 0.0001$) in all lactations. Test- day milk, protein and fat yields and TD SCS varied ($p< 0.01$) with management and climatic factors (calving year x calving season and herd x test-day date interactions and year and season of calving). A cow produced 18.8 kg, 0.61 kg and 0.58 kg of milk, fat and protein yields on a daily basis in all lactations, respectively. Average SCS was 2.8 in the three lactations. The origin of the cow was an important ($p < 0.05$) source of variation for DIM, yields and SCS in all lactations except for first lactation cell scores ($p>0.05$). Cows born in Tunisia seemed to perform better than imported cows in the first lactation while imported cows showed clearly better performances in later lactations. North American cows produced the highest yields and had the lowest SCS among all cows in the second and third lactations. Imported high producing cows seemed able to adjust to Tunisian management conditions following their first lactation.

Key words: Holstein cows % Milk production % Origin % Somatic cell score

INTRODUCTION

Tunisian cow population size reached 455000 in recent years. Around 182000 of these cows are Holsteins. In the absence of a national genetic evaluation, breeding strategies are based on the import of pregnant heifers and semen from the USA, Canada and European countries [1]. The official A4 national recording system dates back to the early 1960's. Although only around 10% of pure bred cows are being enrolled in the recording system [2], the system is being changed to an A6 scheme to alleviate expenses and increase the number of the enrolled Holstein cows.

Milk yield has been the main breeding objective in Tunisian Holsteins with no or little emphasis on conformation and health. Replacement heifers are locally chosen on an intra herd cow index while proofs of foreign bulls are used to select sires. Production levels were limited compared to the breed performance in countries with developed dairy industries [2-4]. Limited production levels and low to moderate genetic parameters of milk traits have been explained by unsatisfactory overall management [3, 5, 6] and harsh climatic conditions [3, 7].

Milk yield and composition traits were found sensitive to management system and production environment. Varying levels of genotype by environment interaction for milk yield were reported in several studies [3, 8, 9]. This interaction is more important when genotypes are managed under conditions different from where they were selected [10]. The objective of this study was to examine phenotypic variation of total days in milk (DIM) and test- day (TD) milk, protein and fat yields and somatic cell score (SCS) under Tunisian management conditions with the origin of the cow.

MATERIALS AND METHODS

Data: Milk production and pedigree data sets were obtained from the centre for genetic improvement of the pasture and office (OEP), Tunis. The initial production data set included 153885 lactations of Holstein- Friesian cows from 182 herds during the 1992 - 2004 calving period.

Corresponding Author: B. Rekik, Département des Productions Animales, ESA Mateur, 7030 Tunisia

Only the first thirteen test- day records were used in the analysis. Each record comprised the cow identification, herd, lactation number, calving date, TD date and TD milk, fat, protein yields and SCS. The origin (Tunisia, the USA, Canada, Germany, France, Italy, the Netherlands, etc.) of the cow was obtained from the pedigree data set that in addition included the sire and dam of the cow and the birth date. Only the first thirteen TD records of the first three lactations were retained. Records with erroneous calving and TD dates and/or biologically unacceptable milk (<1 kg or > 80 kg), fat (% fat was < 0.75 or > 6.75%) and protein (% protein was <1 or > 5 %) yields were omitted. No edits were made on somatic cell counts. After edition, 100670 production records remained. These records were of cows (22000 cows) born in Tunisia (TN) and those imported from Europe (10830 cows) and North America (850 cows). Cows from the European countries were grouped under EU and those from North America were represented by USA. Total DIM was computed as the interval in days from calving to the date of the last test plus 14 days. Somatic cell score was computed as SCS = $\log_2$ (CCS/100000) + 3 [11].

Analysis: Days in milk and TD milk, protein and fat yields and SCS were analysed using the following (1) and (2) linear models, respectively, via the General Linear Model (GLM) procedure in [12]:

$$Y_{ijklm} = \mu + H_i + YS_{jk} + O_l + e_{ijklm} \qquad (1)$$

Where $Y_{ijkl\,m}$ = total DIM, μ = general mean, H = fixed herd effect, YS = fixed effect of the year (k=1993,…, 2004) and season (autumn, winter, spring and summer) interaction and O = fixed effect of the origin of the cow (TN, EU or USA).

$$Y_{ijklm} = \mu + HD_i + YS_{jk} + O_l + IVC_m + e_{ijklm} \qquad (2)$$

Where $Y_{ijkl\,m}$ = test- day milk, protein, or fat yield or SCS, μ = general mean, HD = fixed effect of the herd x TD date interaction, YS = fixed effect of the year (k=1993,…, 2004) and season (autumn, winter, spring and summer) interaction, O = fixed effect of the origin of the cow (TN, EU or USA), IVC = interval from calving to the time of the test in weeks and e_{ijkln} : are random errors that were assumed normally distributed with mean = 0 and a constant variance ($*_e^2$) for both models.

RESULTS AND DISCUSSION

Milk Production Levels: Means of TD Milk, protein and fat yields and SCS for the first three lactations per origin of the cow are given in Table 1. Observed daily mean production levels were in favour of Tunisian born and cows imported from Europe in the first lactation. Those imported from North America had mainly lower milk and fat TD yields than their EU imported and Tunisian born counterparts. In later lactations, the observed TD milk production levels were comparable among cows from different origins. However, there is a large heterogeneity of measured TD milk, protein and fat yield levels in all lactations (standard deviations are large). This heterogeneity is the result of variation in DIM in addition to actual differences in production levels. Total days in milk and daily yields were considered jointly to determine total milk production throughout lactation. Total milk protein and fat yields were computed using the interval method. Table 2 gives the numbers of records and means of DIM and total milk, protein and fat yields for the first three lactations per origin of the cow. As for means of observed TD yields, Tunisian born cows had the highest mean DIM among all cows in the first lactation. Consequently, they produced the largest total milk and protein fat yields during this lactation. Heifers imported from EU had the lowest DIM and milk and protein yields but the highest fat yield, whereas USA heifers had intermediate DIM and yields. Overall, this situation was reversed in later lactations being in favour of USA cows, mainly in the second lactation. These mean performances for were below mean production levels of Holstein cows in countries with developed dairy industries. Projected to 305 days (results not shown), mean performances for milk yield for example were below 6500 kg in all lactations regardless of the origin of cows [1, 2], which is equivalent to almost 2100 kg lower than the breed 305-d mean performance in the USA [2, 13, 14]. Low performance levels were attributed to limited management and health care [1, 2, 3], harsh climatic conditions and scarce high quality feed resources [7]. Bouraoui et al. [5] reported that in some herds, management conditions were way below requirements for animal welfare.

Milk traits are subject to variation under the effects of environmental and management factors [2, 13, 14]. Total DIM (model 1) were affected by herd, year- season interaction and origin of the cow (p<0.0001). The proportion of variation explained by these factors was

Table 1: Numbers of TD records (N) and means (in kg) of TD Milk, protein and fat yields and SCS for the first three lactations per origin of Holstein-Friesian cows in Tunisia

		Lactation		
Origin	Trait	1st lactation	2nd lactation	3rd lactation
TN	N	30760	21272	13590
	Milk	17.60 (7.41)	18.85 (8.56)	19.45 (8.60)
	Protein	0.55 (0.23)	0.59 (0.27)	0.62 (0.27)
	Fat	0.56 (0.26)	0.61 (0.31)	0.64 (0.32)
	SCS	3.64 (2.06)	3.84 (2.12)	4.07 (2.14)
EU	N	11448	10764	10292
	Milk	17.25 (7.21)	18.32 (7.92)	19.43 (8.64)
	Protein	0.53 (0.22)	0.58 (0.25)	0.61 (0.27)
	Fat	0.56 (0.25)	0.61 (0.29)	0.66 (0.33)
	SCS	3.77 (2.06)	3.90 (2.03)	4.05 (2.06)
USA	N	906	887	751
	Milk	15.73 (6.65)	19.07 (7.59)	18.68 (7.29)
	Protein	0.49 (0.21)	0.63 (0.24)	0.59 (0.22)
	Fat	0.54 (0.28)	0.64 (0.29)	0.66 (0.31)
	SCS	3.59 (1.98)	3.51 (2.29)	4.31 (2.14)

(.): Standard deviation.

Table 2: Means of total days in milk (DIM in days) and of milk, fat and protein yields for the first three lactations per origin of Holstein-Friesian cows in Tunisia

		Lactation		
Origin	Trait	1st lactation	2nd lactation	3rd lactation
TN	DIM	259 (139)	249 (133)	247 (130)
	MY	3871 (2093)	4224 (2133)	4329 (2135)
	PY	158 (86)	166 (86)	165 (85)
	FY	153 (84)	172 (89)	172 (90)
EU	DIM	217 (140)	215 (136)	207 (137)
	MY	3310 (1873)	4200 (2040)	4461 (2227)
	PY	143 (85)	176 (88)	180 (89)
	FY	167 (90)	197 (93)	204 (99)
USA	DIM	249 (127)	242 (128)	300 (126)
	MY	3430 (1757)	4333 (1912)	3718 (1762)
	PY	129 (72)	179 (77)	152 (69)
	FY	152 (82)	195 (85)	169 (80)

(.) Standard deviation, MY: total milk yield in kg, PY: Total protein yield in kg, FY: Total fat yield in kg

around 40% ($0.37 < = R^2 < =0.4$ in the three lactations). Table 3 gives mean squares of variables from the analysis of variance of TD milk, fat and protein yields and SCS in the three lactations. All factors in model 2 were important sources of variation of milk production traits. ($p < 0.05$). The coefficient of determination ranged from 0.41 to 0.59 and was the lowest for SCS and the highest for milk yield among all traits regardless of the rank of lactation. The origin of cows, the focus of this study, had a large impact on milk production in all lactations in this study. Least squares solutions of origin of the cow for milk, protein and fat yields per lactation are illustrated in Fig. 1, 2 and 3. Corrected for management (herd, interval from calving to the time of the test) and environmental (year, season), the effect of origin of the cow revealed that Tunisian born cows had the highest milk, protein and fat yields in the first lactation. However, USA heifers showed an increasing production levels from lactation 1 to lactation 3. The latter had the highest yields for milk, protein and fat in the third lactation. Those imported from EU had unsatisfactory performances in the second and third lactations. Tunisian born cows overproduced imported cows in the first lactation because they were in the environment where they were born. Heifers from

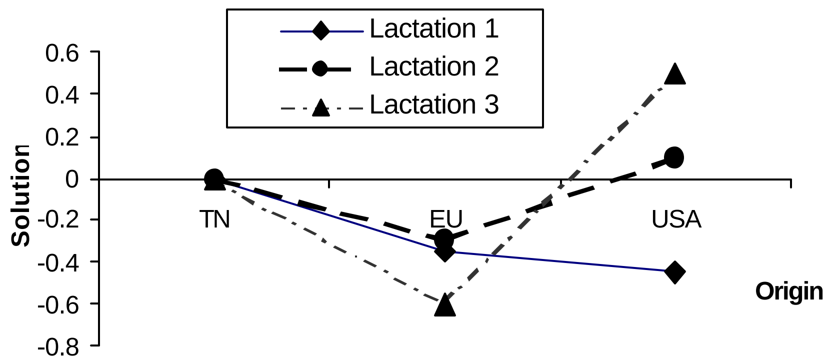

Fig. 1: Least squares solutions of origin of the cow for test-day milk yield in the first, second and third lactations

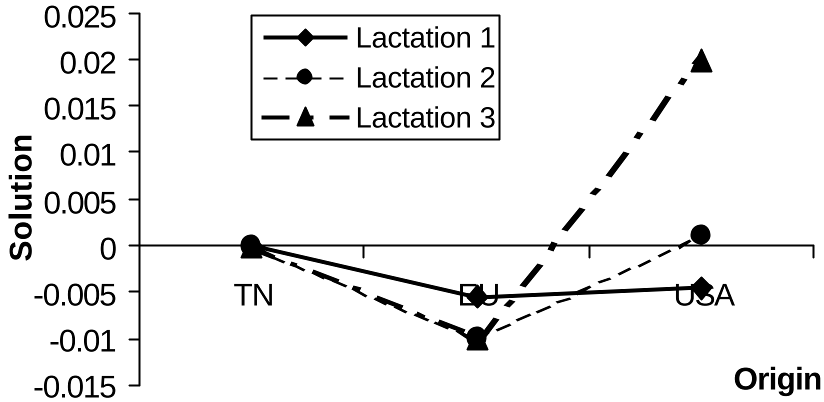

Fig. 2: Least squares solutions of origin of the cow for test-day protein yield in the first, second and third lactations

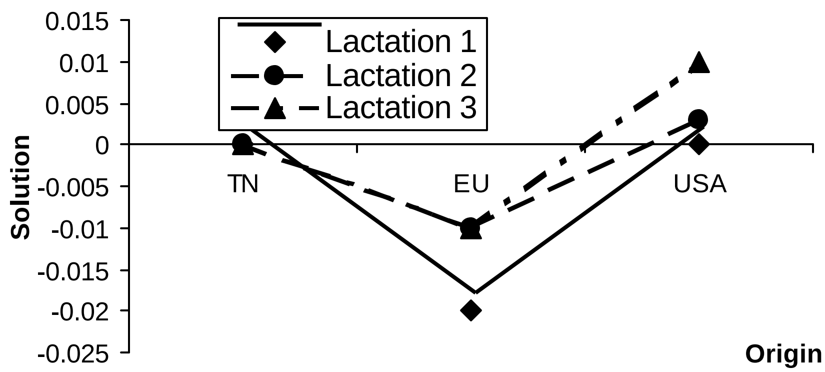

Fig. 3: Least squares solutions of origin of the cow for test-day fat yield in the first, second and third lactations..

Table 3: Mean squares of variables from the analysis of variance of test- day milk, fat and protein yields and somatic cell score (SCS) for Holstein-Friesian cows in Tunisia

		Lactation		
Trait	Variable	1st lactation	2nd lactation	3rd lactation
	HD	422.20**	336.19**	260.95**
Test- day	YS	112.19**	220.35**	150.28**
milk yield	IVC	808.51**	1538.51**	1327.59**
	O	188.13**	107.71*	369.32**
	R^2	0.59	0.58	0.59
	HD	0.40**	0.35**	0.27**
Test- day	YS	0.08**	0.16**	0.11**
Protein yield	IVC	0.41**	1.11**	0.95**
	O	0.06*	0.15**	0.41**
	R^2	0.55	0.55	0.56
	HD	0.45**	0.41**	0.34**
Test- day	YS	0.08**	0.15**	0.17**
Fat yield	IVC	0.34**	1.05**	0.98**
	O	0.52**	0.30**	0.16*
	R^2	0.49	0.50	0.51
	HD	10.11**	8.87**	6.83**
Test- day	YS	3.21**	2.73**	1.68**
SCS	IVC	2.42**	1.55**	2.12**
	O	0.66^{NS}	9.68**	3.28**
	R^2	0.41	0.44	0.45

HD = fixed effect of the herd x TD date interaction, YS = fixed effect of the year and season interaction, O = fixed effect of the origin of the cow (TN, EU or USA), IVC = interval from calving to the time of the test in weeks. R^2 = coefficient of determination.

**: p< 0.01, *: p<0.05

North America seemed to progressively adjust for the new environmental and management conditions, while those imported from the EU were not able to overcome environmental differences between Tunisian and cold EU climate.

Results on USA cows should be regarded with caution because of limited records in comparison to information on other cows in the data. One possible explanation to differing responses to the new environment between USA and EU heifers is that USA cows could have came from regions (California, Florida) in the US with climatic conditions comparable to Tunisian conditions. This is pure speculation because there is no indication in the data on areas from where heifers were imported from the USA. On the other hand, EU conditions are cold and production systems are varied from conventional to grazing. Differences in production levels were reported between conventional and grazing systems [8]. Hammami et al. [10] reported that genotype by environment interaction is more important when differences in production conditions are very different and that animals are ranked alike when they produce in environments similar to where they were selected. These authors have concluded in a previous study (2008b) that superior genes would not perform as well in less favourable environment. They even added that low to medium input production systems should consider the use of semen of sires selected in low to medium input systems in countries with leading dairy industries.

Somatic Cell Score: Recorded mean SCS Table 1) scores ranged from 3.64 (156000 cells/ml) to 4.31 (249000 cells/ml). They are in the same range of the mean SCS reported by Rekik et al. [11] from the whole same data. Mean levels increased with the rank of lactation [15, 16]. Standard deviations were large (> 2) indicating that an important proportion (> = 1/6) of cows had clinical mastitis [15]. SCS variation was subject to the effects of herd- TD date and tear- season interactions, lactation stage (IVC) and origin of the cow (model 2). Least squares solutions of origin of the cow for TD SCS in the first, second and third lactations are shwon in Fig. 4. Cows from the three origins

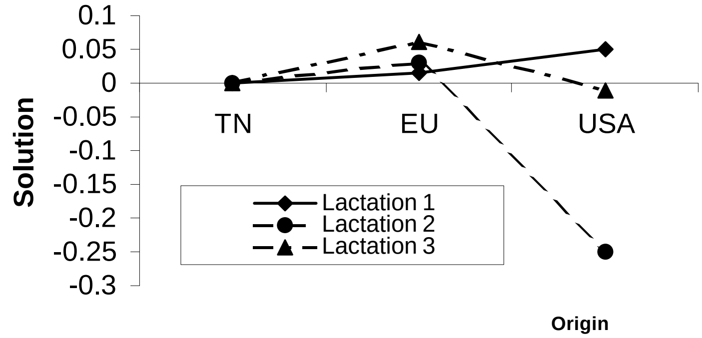

Fig. 4: Least squares solutions of origin of the cow for test-day somatic cell scores in the first, second and third lactations

had comparable SCS in the first lactation. However, unlike for milk, protein and fat yields, imported cows (mainly USA cows) had the lowest SCS in the third lactation. These results suggest that imported cows were able to produce more milk and to be less exposed to mastitis infection in later lactations. Selection of replacement cows in Tunisia are chosen maily on milk yield while imported heifers were probabaly selected in their country of origin on health in addition to milk production.

Phenotypic analysis of milk production data of Tunisian born and imported heifers showed that the mean length of lactation was short for all cows (< 300 d) in the first three parities although it was slightly in favour of locally born cows. Daily production levels were 18.8 kg, 0.58 kg and 0.61 kg for milk, protein and fat yields, respectively. Origin (TN, EU and USA) of the cow was an important source of variation of milk production and SCS. Tunisian cows had the highest production levels in the first but imported heifers (mainly from the USA) produced more milk in the subsequent lactations, while SCS were comparable among all cows in the first lactation and in favour of imported animals in later parities. Imported cows showed difficulties to express their potential for milk production in the first lactation but were able to adjust to new management conditions with the rank of lactation and to maintain relatively low mastitis infection rates compared to Tunisian cows. Mean production levels of Tunisian and imported cows remain lower than the breed performances in countries with more favourable production conditions. Importation of heifers in Tunisia should be further evaluated (culling, herd life, etc.) because it may not be a durable strategy to improve milk production. Selection of superior animals within the Tunisian cow population with emphasis on conformation and health may be a better alternative.

ACKNOWLEDGMENTS

Authors are thankful to the National Centre for Genetic Improvement (OEP) at Sidi Thabet, Tunis, for providing the data.

REFERENCES

1. Hammami, H., B. Rekik, H. Soyeurt, A. Ben Gara and N. Gengler, 2008. Genetic parameters for Tunisian Holsteins using a Test-Day Random Regression Model J. Dairy Sci., 91(5): 2118-2126.
2. Rekik, B., A. Ben Gara, M. Ben Hammouda and H. Hammami, 2003. Fitting lactation curves of dairy cattle in different types of herds in Tunisia. Livest. Prod. Sci., 83 (2-3): 309-315.
3. Hammami, H., B. Rekik, H. Soyeurt, C. Bastin, J. Stoll and N. Gengler, 2008. Genotype x Environment Interaction for Milk yield in Holsteins Using Luxembourg and Tunisian Populations. J. Dairy Sci., 91 (9): 3661-3671.
4. World Holstein-Friesian Federation, 2006. (Online. Available http://www.Whff.info/). Accessed 24/04/2008.
5. Bouraoui, R., B. Rekik, R. Yozmane and B. Haddad, 2008. Assessing animal welfare through management, productive and reproductive performances and health care in a large dairy herd in the North of Tunisia. Research J. Dairy Sci., 2 (4): 68-73.
6. Rekik, B. and A. Ben Gara, 2004. Factors affecting the occurrence of atypical lactations for the Holstein-Friesian cows. Livest. Prod. Sci., 87(2-3): 245-250.
7. Bouraoui, R., M. Lahmar, A. Majdoub, M. Djemali and R. Beleyea, 2002. The relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate. Anim. Res. 51(6): 479-491.

8. Boettcher, P.J., J. Fatehi and M.M. Schutz, 2003. Genotype x environenment interactions in conventional versus pasture-based dairies in Canada. J. Dairy Sci., 86(1): 383-389.
9. Veerkamp, R.F., G. Simm and J.D. Oldham, 1995. Genotype by environment interaction: Experience from Langhill. In: Breeding and Feeding the High Genetic Merit Dairy Cow. T.L. Lawrence, J.F. Gordon and A. Carson (Eds.). Midlothan, Scotland, British Society of Animal Science, Occasional Publications, 19: 59-66.
10. Hammami, H., B. Rekik, H. Soyeurt, C. Bastin, E. Bay, J. Stoll and N. Gengler, 2009. Accessing Genotype by Environment Interaction Using Within- and Across-Country Test-Day Random Regression Sire Models. J. Anim. Breed. Genetics (In Press).
11. Rekik, B., N. Ajili, H. Bel Hani, A. Ben Gara and H. Rouissi, 2008. Effect of somatic cell count on milk and protein yields and female fertility in Tunisian Holstein cows. Livestock Sci., 16 (1-3): 309-317 .
12. SAS User's Guide, Version 6.10 for Windows, 1989. SAS Inst. Inc., Cary, NC.
13. De Vliegher S., H.W. Barkema, H. Stryhn, G. Opsomer and A. De Kruif, 2005. Impact of early lactation somatic cell count in heifers on milk yield over the first lactation. J. Dairy Sci., 88(3): 938-947.
14. Miller, R.H., H.D. Norman, G.R. Wiggans and J.R. Wright, 2004. Relationship of test day Somatic cell score with test day and lactation milk yields. J. Dairy Sci., 87(7): 2299-2306.
15. Rupp, R., D. Boichard, C. Bertrand and S. Bazin, 2000. Bilan national des numérations cellulaires dans le lait des différentes races bovines laitières françaises. INRA Prod. Anim., 13 (4): 257-267.
16. Coulon, J.B., F. Dauver and G.P. Garel, 1996. Facteurs de variation de la numération cellulaire du lait chez des vaches laitières indemnes de mammites cliniques. INRA Prod. Anim., 9(2): 133-139.