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Environmental sensitivity for milk yield in Luxembourg and Tunisian Holsteins by herd management level

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ABSTRACT

Milk production data of Luxembourg and Tunisian Holstein cows were analyzed using herd management (HM) level. Herds in each country were clustered into high, medium, and low HM levels based on solutions of herd-test-date and herd-year of calving effects from national evaluations. Data from both populations included 730,810 test-day (TD) milk yield records from 87,734 first-lactation cows. A multi-trait, random regression TD model was used to estimate (co)variance components for milk yield within and across country HM levels. Additive genetic and permanent environmental variances of TD milk yields varied with management level in Tunisia and Luxembourg. Additive variances were smaller across HM levels in Tunisia than in Luxembourg, whereas permanent environmental variances were larger in Tunisian HM levels. Highest heritability estimates of 305-d milk yield (0.41 and 0.21) were found in high HM levels, whereas lowest estimates (0.31 and 0.12, respectively) were associated with low HM levels in both countries. Genetic correlations among Luxembourg HM levels were >0.96, whereas those among Tunisian HM levels were below 0.80. Respective rank orders of sires ranged from 0.73 to 0.83 across Luxembourg environments and from 0.33 to 0.42 across Tunisian HM levels indicating high re-ranking of sires in Tunisia and only a scaling effect in Luxembourg. Across-country environment analysis showed that estimates of genetic variance in the high, medium, and low classes of Tunisian environments were 45, 69, and 81% lower, respectively, than the estimate found in the high Luxembourg HM level. Genetic correlations among 305-d milk yields in Tunisian and Luxembourg HM environments ranged from 0.39 to 0.79. The largest estimated genetic correlation was found between the medium Luxembourg and high Tunisian HM levels. Rank correlations for common sires' estimated breeding values among HM environments were low and ranged from 0.19 to 0.39, implying the existence of genotype by environment interaction. These results indicate that daughters of superior sires in Luxembourg have their genetic expression for milk production limited under Tunisian environments. Milk production of cows in the medium and low Luxembourg environments were good predictors of that of their paternal half-sisters in the high Tunisian HM level. Breeding decisions in low-input Tunisian environment should utilize semen from sires with daughters in similar production environments rather than semen of bulls proven in higher management levels.
Key words: environmental sensitivity, genotype by environment interaction, genetic correlation, herd management level

INTRODUCTION

The ability of a genotype to alter phenotypic expression in response to environmental differences is known as phenotypic plasticity or environmental sensitivity (Falconer and MacKay, 1996). In animal breeding, genetic variation in response to environmental differences is used as a definition of genotype by environment interaction (**G × E**). Investigations on G × E within and across countries have been mostly based on the region or country border as a criterion for global environmental definition (Carabaño et al., 1989, 1990; Schaeffer, 1994; Rekaya et al., 2001; Ojango and Pollot, 2002; Fikse et al., 2003a; Hammami et al., 2008). However, environments across countries could be more similar than those within countries, and herds from different countries can share similar environmental characteristics compared with herds within the same country. Clustering of herds across countries using descriptive variables and ignoring country borders has been implemented in other studies (Weigel and Rekaya, 2000; Fikse et al., 2003b; Zwald et al., 2003; Cerón-Muñoz et al., 2004).

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Experimental studies investigated G × E in which environments were designed to differ with respect to feeding levels and systems (Veerkamp et al., 1995; Kolver et al., 2002; Beerda et al., 2007). In general, using experimental herds with good quality data to assess G × E is more illustrative but is expensive and difficult to realize especially in developing countries. To overcome the lack of information about environmental characteristics, some proxies to feeding level and management were used to form homogeneous environments in studies on G × E in tropical and temperate regions. Herds were stratified by mean herd milk yield level (Kolmodin et al., 2002; Berry et al., 2003; Hayes et al., 2003) or by within-herd milk yield standard deviation (**HYSD**) (Stanton et al., 1991; Cienfuegos-Rivas et al., 1999; Costa et al., 2000; Raffrenato et al., 2003). Most studies on G × E by character state or reaction norm models (Stanton et al., 1991; Weigel and Rekaya, 2000; Kolmodin et al., 2002; Raffrenato et al., 2003) used lactation records. Computing facilities have led to the use of test-day (**TD**) models worldwide in genetic evaluations. The use of TD records improved the accuracy of EBV. Hayes et al. (2003) reported that TD records are better suited to investigate within- and between-cow variations in different environments than lactation yields because they better account for environmental effects peculiar to each TD throughout the lactation.

In Tunisia, Holsteins are mostly managed on small farms with little to no land. Nevertheless, large-scale farms exist and are located in the north of the country. Farms present a wide range of environments and intensities of production varying from intensive to extensive systems. Herds also differ with respect to health care, feed resources, and feeding system within and across production sectors. Rekik et al. (2003) reported that the effect of production sector was highly significant on lactation curve parameters in Tunisia. Mean milk yield in 305 d ranged from 5,456 kg in cooperative herds to 8,337 kg in private herds.

As in most European countries, dairy farms in Luxembourg can be summarized as high-input production systems. Feed resources are varied and they are supported by relatively high use of fertilizers, buffer feeds (i.e., maize silage and brewers grains), and concentrates, which are usually fed to improve milk production (van Arendonk and Liinamo, 2003). Grazing is widespread in Luxembourg where climatic and pedological conditions favor the development of naturally dominant meadows and pastures. Organic farming, with fodder grass being the organic product of choice, is gaining popularity in Luxembourg as a low-input form of dairy herd management (**HM**), where reduced costs of feeding and equipment may lead to greater net profit even if milk production is decreased.

In a previous study, Hammami et al. (2008) found evidence of a large G × E for milk yield and persistency using Luxembourg and Tunisian Holstein populations where lactation performance in each country was considered as a different trait and the country border delimitation was defined as an environmental criterion. However, these authors did not account for differences between herds in management practices within country or how genotypes respond to HM level within these 2 geographically distinct environments. Calus et al. (2002) suggested that clustering herds in groups of similar production systems or intensity of production might be more effective to investigate G × E effects than only considering sire-herd-year-season differences. Fikse (2004) reiterated that breeding programs should have more advantages when the international genetic evaluation is run using performance records in a production system rather than on a country basis. Furthermore, the environmental definition and the heterogeneity of variance may affect the magnitude of G × E and therefore, genetic evaluation and selection accuracy.

The assumption of homogeneous variance across herds with different management levels has no major effect on the evaluation of sires when the latter are equitably used in those herds and that heritability is greatest in the more variable environment (Vinson, 1987; Boldman and Freeman, 1990). Otherwise, ignoring the heterogeneity of variance can lead to bias in genetic evaluations. This bias may have severe consequences as the intensity of selection increases and might then limit the effectiveness of breeding programs (Hill, 1984; Vinson, 1987). Fahey et al. (2007) investigated the effect of heteroscedasticity on genetic parameter estimates for production traits between grazing and confinement herds in the United States to ascertain if that unmasked underlying G × E effects. They found only modest evidence for G × E that did not arise solely from heteroscedasticity. Raffrenato et al. (2003) reported that clustering Sicilian herds by management level was effective in identifying heterogeneous genetic variance. Breed differences in environmental sensitivity to micro- and macro-environmental change could be detected by the examination of heterogeneity of variance (Lynch and Walsh, 1998). Quantifying the environmental sensitivity of dairy sires in different environments is important for making breeding decisions and implementing efficient selection strategies suitable for each specific environment. This can allow the differentiation of sires ranking similarly (desirable) across different herd environments from those ranking differently in one specific environment versus another.

There are differences in management practices between and within herds in Luxembourg and Tunisia. These within- and across-country differences may be