Differences between "Slick" Holsteins and "Wild type" Holsteins

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Introduction

One of the greatest challenges to dairy production in subtropical and tropical regions of the world is heat stress. In the future, climate change may also expose the temperate regions of the world to hotter and longer hot seasons perhaps with higher relative humidity (West, 2003). Because the principal dairy breeds have been mostly selected from temperate regions, climate change might increasingly expose dairy cows in all parts of the world to chronic heat stress, negatively affecting dairy productivity.

For European cattle breeds localized in the tropics, heat stress is chronic and usually there is only small heat relief at night, if any (Berman, 2011). In addition, year round intense radiant energy significantly adds to the heat load to these animals. The tropics are particularly harsh to European lactating dairy cows that generate a large amount of metabolic heat (Wheelock et al. 2010). In tropical conditions, the high environmental temperature, coupled with metabolic heat production and diminished cooling capability because of high humidity, results in higher body temperatures, depressed dry matter intakes, and low

milk production (West, 2003). As the prospect of global warming threatens extended periods of aggravated environmental stress across the world, severe negative effects on the productivity, reproduction, and welfare of dairy cattle would be a dire consequence of climate change worldwide (Berman, 2011).

To minimize the effects of heat stress, three management strategies have been identified: 1) physical modification of the environment, 2) improved nutritional management practices, 3) **genetic development of heat-tolerant breeds** (Beede and Collier, 1986). Unfortunately, heat tolerance is negatively correlated with production (−0.3; Ravagnolo and Misztal, 2000). Therefore, if selection for higher milk production continues while ignoring heat tolerance, the result would be a progressive decrease in heat tolerance in dairy breeds (West, 2003). However, because the negative correlation between milk production and heat tolerance is small, a combined selection for milk production and heat tolerance is possible (West, 2003). Upon the uncertain effects of climate change might have in dairy cattle productivity, research of intrinsic differences exhibited by heat tolerant breeds would be invaluable in the quest to genetically select for thermal tolerance. The ultimate goal is to maintain high milk production efficiency in warmer climates.

Heat tolerant bovines

European cattle arrived to the island of Puerto Rico in **1511** with the Spanish conquest. For more than 500 years farmers in Puerto Rico selected the more adapted animals to heat and humid environment of the island (Molina, 2001). In the 1950's there was a large influx of European dairy breeds into the island from the United States, primarily Holstein cattle (Molina, 2001). Farmers in Puerto Rico then started crossing the "new" Holsteins with their *criollo* cattle. Sixty-five years later we find in the island registered Holsteins with higher milk production (Figure 1) and shorter calving interval (Figure 2) than their wild-type contemporaries (Pantoja et al 2005).

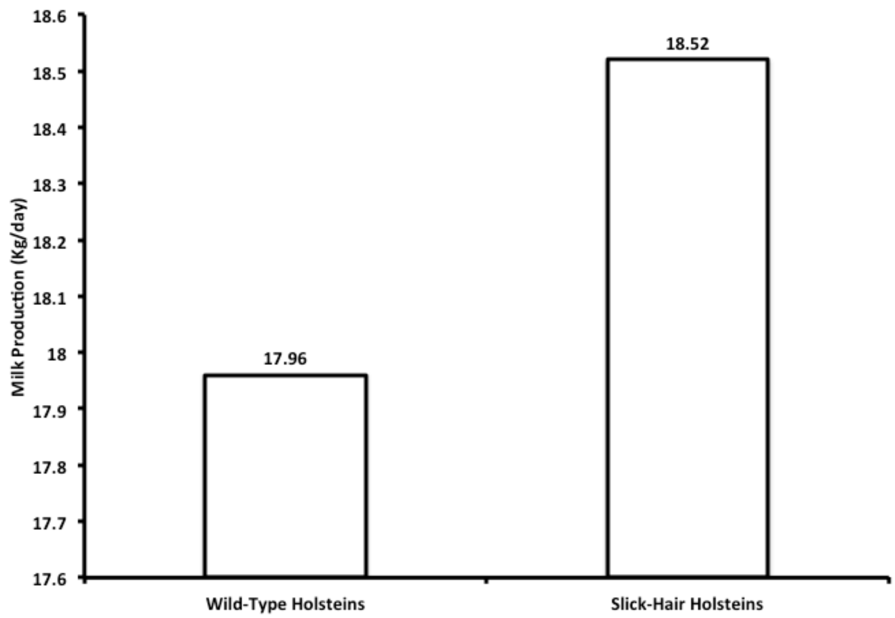

Figure 1. Comparison of milk production between wild type Holsteins and Slick hair Holsteins in Puerto Rico. DHI records were use to compare the production of 54 slick hair Holstein cows against their contemporaries. Wild type and slick-hair dairy cows were distributed across 12 dairy farms across the island.

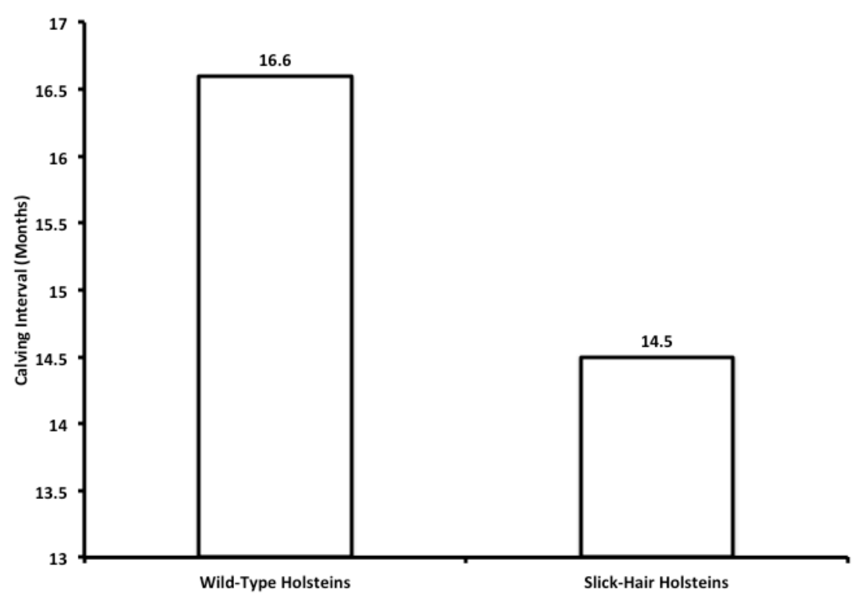

Figure 2. Comparison of the calving interval between wild type and Slick hair Holsteins in Puerto Rico. DHI records were used to compare the production of 54 slick hair cows against their contemporaries. Wild type and slick-hair dairy cows were distributed across 12 dairy farms across the island.

Dairy farmers in Puerto Rico used to call these Holsteins "*rabifinas"* which literally translates to "slick tails", describing their very fine tails that are almost devoid of hair (Figure 3). These "*rabifinas*" Holsteins also exhibit a very short, sleek, and mostly glossy coat very similar to the phenotype described by Olson et al. in 2003, after introducing the *Slick* gene from the Senepol into Holstein cows. However, in Puerto Rico farmers have selected "*rabifinas*" for decades before Senepol cattle were introduced into Puerto Rico in 1983. Moreover, the use of Senepol cattle as a commercial beef breed was extremely limited until the late 1990's. According to the testimony of some of the dairy farmers with *rabifina"*, Senepol bulls have never been used in their dairy herds (López-López, 2015; Borges, 2015). This presents the possibility that the mutation that causes the *Slick* phenotype of the *rabifinas* **might be different** that the gene responsible for this phenotype in Senepol cattle (Olson et al. 2013). Alternatively, Senepol and "*rabifinas"* **might share exactly the same mutation**.

Although Senpol cattle were traditionally thought to be decedents of Red Poll x N'Dama cattle, recent evidence indicates that Senepol is 89% European, 10.4% Zebu and only 0.6% of African ancestries (Flori et al. 2012). Indeed, *de Alba* (1987) questioned the N'Dama contribution into the Senepol breed and suggested that *Criollo* cattle (presumably mostly of European decent) imported into St. Croix **from Puerto Rico** (Vieques Island) could have been major contributors to the Senepol breed along with the Red Poll and some Zebu blood. Therefore, it could be possible that Senepol and Holsteins "*rabifinas"* could share a common ancestor that imparted the *slick* gene to both. In the quest to better understand genetic adaptations to heat stress, it would be important to characterize intrinsic differences between different cattle populations that exhibit the *Slick* phenotype and their non-slick breed members.

Slick genotype

A valuable strategy to decrease the severity of heat stress impact on dairy cattle is the selection of animals with improved thermo-tolerance. Indeed, specific single nucleotide polymorphisms (**SNP**) have been associated with thermo-tolerance in Holsteins (Hayes et al., 2009; Dikmen et al., 2012; Dikmen et al., 2013). However, only a few specific genes have been associated with heat tolerance (Ravagnolo and Misztal, 2000). One such gene is the slick hair gene (*slick*). The *Slick* phenotype was originally described by Tim Olson and collaborators in Senepol cattle that originated in the Caribbean island of St. Croix, and inherited as a single dominant gene (Olson et al. 2003). The *Slick* haplotype provides cattle animals with "short and sleek hair" and sometimes a "glossy coat" (Olson et al., 2003). Since then, the *Slick* locus has been mapped in bovine chromosome (Chr) 20 (Mariasegaram et al., 2007; Flori et al., 2012).

By 2003 Olson et. al have successfully introduced the slick-gene into Holsteins by crossbreeding Senepol with Holstein cows. The resulting offspring (slick-haired Holstein) have been shown to had lower vaginal temperatures and lower respiration rate than wild-type Holstein cows (Dikmen et al., 2008). In this experiment however, although slick-haired Holsteins showed greater sweating rates in unclipped areas of skin, clipping the hair at the site of sweating measurement eliminated the difference between slick-haired and wild-type cows (Dikmen et al., 2008). This result presents the possibility that the main impact of the *slick* gene on thermo-tolerance could be primarily associated with an improvement in the ability to dissipate heat through sweating. Indeed, in a later study with the objective to evaluate if the effect on lactation performance of slick hair cows can be simulated through **hair clipping,** it was found that milk yield was higher

(13.4 vs. 10.8 ± 0.26 kg/d; P = 0.003) when cows hair were clipped (Mejía et al. 2010). The fact that clipped hair cows showed a decrease in rectal temperature and an increase in milk production, further suggests that the main effect of slick-haired genotype is through modification of hair length. The short hair length caused either by the *Slick* haplotype or by hair clipping could result in reduced insulation to conductive and convective heat loss in the hair coat, resulting in an improved thermo-tolerance (Berman, 2004).

A more recent study compared the thermoregulation capacity of lactating *Slick* Holsteins hair phenotype with relatives not inheriting the *Slick* haplotype or with wild-type Holstein cows (Dikmen et al. 2014). It was found that vaginal temperatures or rectal temperatures were lower in slick-haired cows than in relatives and wild-type cows. Moreover, the increase in respiration rate caused by heat stress during the day was lower for *Slick* cows than for relatives or wild- type cows. Furthermore, sweating rate was higher for *Slick* cows than for cows of the other two types. The superior thermoregulatory ability of Holsteins with slick hair compared with non-slick animals also resulted in a less drastic depression in milk yield during the summer (Dikmen et al., 2014). Importantly, in this experiment **cows that were relatives of slick cows but that did not inherit the *Slick* phenotype still exhibited enhanced thermoregulation when compared with wild-type Holsteins.** This evidence strongly suggests the *Slick* haplotype is not the only gene conferring thermo tolerance (Dikmen et al., 2014) and that unknown intrinsic differences that offer thermo tolerance through more complex mechanisms than just hair length might exist between *Slick* and wild animals. Indeed, in this same experiment, seasonal alterations in percentage of fat, protein, and lactose in addition to somatic cell counts were intensified in *Slick* cows (Dikmen et al., 2014). These results strongly indicate that the *Slick* haplotype is associated with the regulation of milk synthesis and the immune response. Undoubtedly more research is necessary to explore possible intrinsic differences that might exist between slick and non-slick Holstein cows.

General hypothesis

Our hypothesis is that under heat stress conditions, there will be intrinsic differences between “wild type” and “Slick” Holsteins in terms of **many productions traits**.

Figure 3. Comparison of the hair phenotype between wild type Holsteins and Slick hair Holsteins in one dairy farm of Puerto Rico. Photos B and D show an example of the "slick" appearance of the Holsteins adapted to the tropical conditions of Puerto Rico.

Preliminary data

Since September 2013 we have been observing the behavior of *Slick* registered Holstein cows in a commercial dairy farm in Puerto Rico. Throughout these 18 months we have been able to document, through DHI test day records, the generally higher milk production of Slick cows compared to their non-Slick contemporaries (Figure 4). Additionally, on average, Slick registered Holsteins have a shorter calving interval by 1.97 months. While non-Slick present a calving interval of 15.76 months on average, *Slick* cows have a calving interval of 13.79 months (Figure 5).

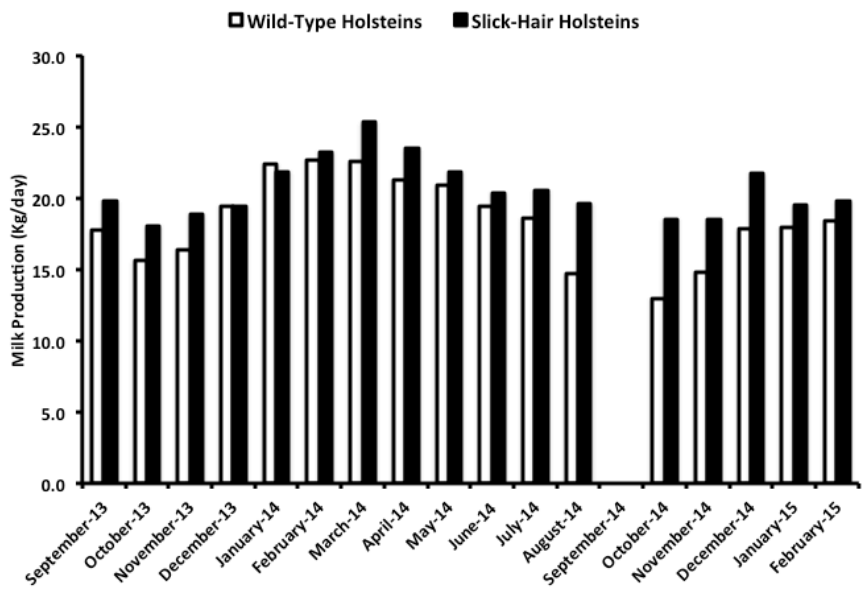

Figure 4. Comparison of milk production between wild type Holsteins and Slick hair Holsteins in one dairy farm of Puerto Rico. DHI records (DHI 202) were used to compare the production of 19-26 slick hair cows against their 61-96 wild type contemporaries (animal numbers varied depending on the test date).

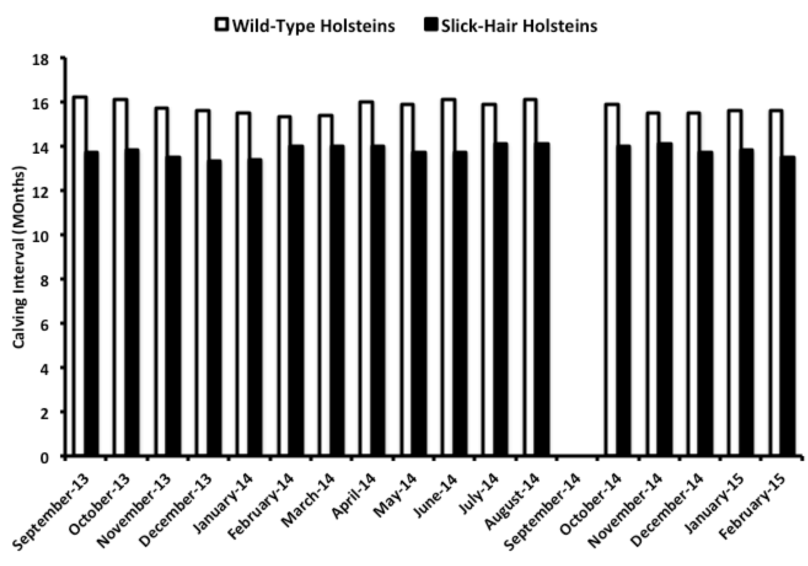

Figure 5. Comparison of calving interval between wild type Holsteins and Slick hair Holsteins in one dairy farm of Puerto Rico. DHI records (DHI 202) were used to compare the production of 19-26 slick hair cows against their 61-96 wild type contemporaries (animal numbers varied depending on the test date).

Preliminary data generated in another commercial dairy herd in Puerto Rico using three commonly employed dairy breeds (n=4 per breed) demonstrated that slick-haired Holsteins have lower (P=0.0055) vaginal temperature relative to Jersey and wild-type Holsteins over a 5 day period (Figure 6) and under different environmental scenarios (P<0.05; Figure 7) (Rodríguez et al. 2014).

Furthermore, we have documented differences in genotypic between Slick and non-Slick Holsteins. For example genotypic frequencies at position A-278G from the promoter region of the FSH receptor are different between Slick and Non Slick dairy cows (Figure 8) (Patiño et al 2014).

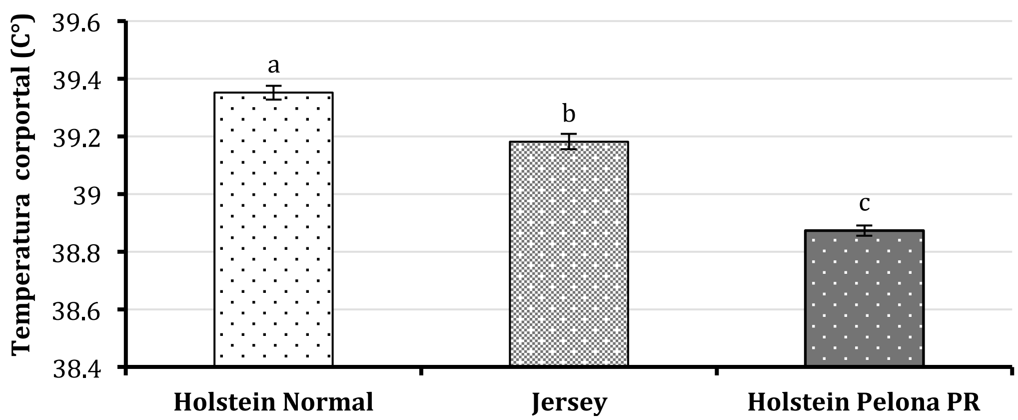

Figure 6. Average vaginal temperature of three dairy cattle breeds over a 5 d period managed under tropical dairy system. Means with different superscripts differ (P<0.05).

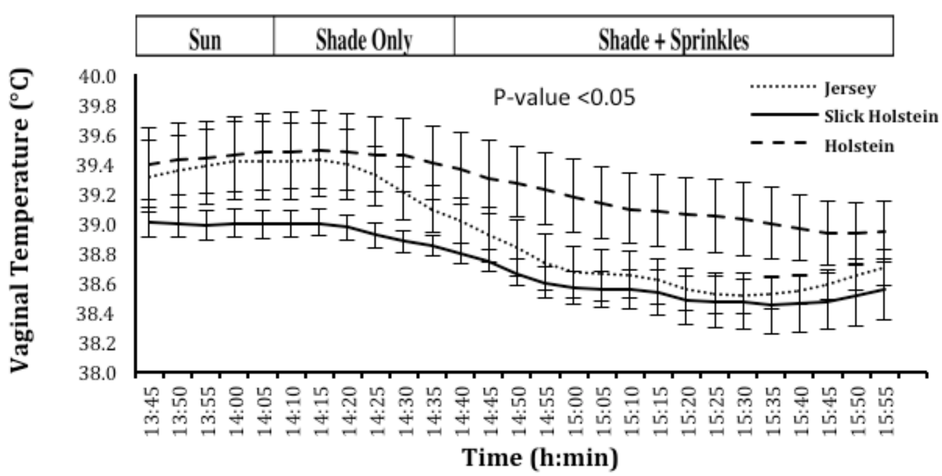

Figure 7. Vaginal temperatures among dairy breeds under exposed to different environmental scenarios (sun, shade only and shade plus sprinkles) in a dairy herd in Puerto Rico.

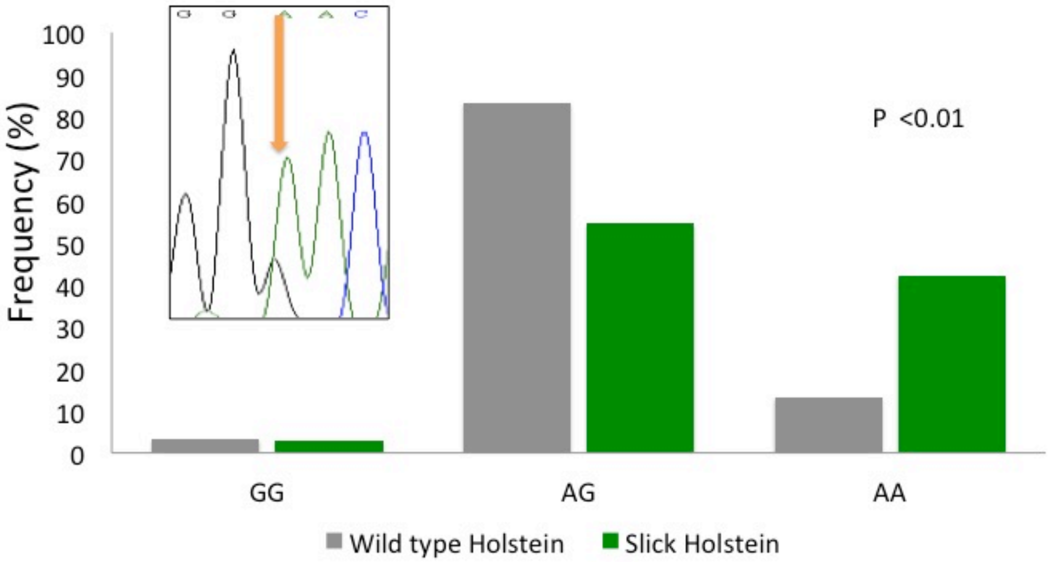

Figure 8. Genotypic frequencies at position A-278G from the promoter region of the FSH receptor in Slick and Non Slick (Wild type Hostein cows).

Rationale and Significance

a. Rationale

It is well established that cattle with the Slick hair phenotype are more heat tolerant than their non-slick counterparts. However, it is still to be determined the level in which the improved heat tolerance in these animals translates into **other advantageous characteristics for milk production**. We propose to compare *Slick* and non-*slick* Holsteins and under typical dairy production conditions of the tropics, evaluate their physiological adaptations that will contribute to our understanding of the heat stress tolerance of the *Slick* phenotype.

b. Relationship of the project's objectives to the program area priorities

With this project we aim to contribute to our knowledge of the physiologic characteristics that provide dairy cattle with thermo tolerance. Dairy cattle better adapted to heat stress would have more efficient lactations under heat stress and likely would have better feed efficiencies that non-adapted animals. Furthermore, thermo tolerant dairy cattle would be less susceptible to metabolic disorder (i.e. ketosis) as feed intake would be less affected under heat stress conditions. With the uncertainties presented by global warming, a better understanding of dairy cattle adaptations to heat stress certainly has national and global importance. The understanding of heat tolerance in dairy cattle would be essential to promote and efficient, environmentally sustainable and profitable dairy industry, allowing it to keep its competitive advantage within a warmer global climate, and significantly contribute to the food security of Puerto Rico.

c. Long-range improvement in the sustainability of the agriculture and food systems of Puerto Rico

Dairy products contribute importantly to the food security and economy of Puerto Rico. With fewer, but more efficient heat tolerant dairy animals to produce a given amount of milk, we would significantly minimize the environmental impact of dairy production under heat stress conditions. Heat tolerant dairy cattle would reduce production costs, as they would need less heat abatement technology minimizing the use of fossil fuels. With the uncertain effects that climate change might impose on dairy production, knowing the intrinsic differences and physiological mechanisms that provides animals with thermo-tolerance would be essential to improve the sustainability of the agriculture of Puerto Rico under the possibility of a warmer climate.

Objectives and Expected Results

a. Long-term objective(s)

Our long-term goal is to contribute to the complete characterization of the adaptations present in dairy cattle adapted to thermal stress. Knowing the intrinsic genetic and metabolic differences that these cattle posses would significantly help us select animals better prepared to face the uncertainties of climate change, ultimately improving animal welfare and milk production profitability in a warmer environment.

b. Supporting objectives

a. Our overall objective is to characterize intrinsic differences that might exist in bovines adapted to hot and humid conditions.

Expected Impact of Results

Finding more meaningful differences between Slick and Non-Slick bovines under heat stress will solidify the Slick phenotype as an important adaptation to be selected for to improve milk production in hot environments. These data will help us justify the strengthening of the selection efforts for this genotype at the University of Puerto Rico for the benefit of the dairy industry of the Island.

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