A Comparison of the Efficiency and Profitability of Holsteins and Jerseys

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Abstract

The efficiency and profitability of Holstein and Jersey cows has been scrutinized, compared, and debated for many years. In response, this study was conducted with the objective of incorporating reviews and results collected from numerous studies relating to Holstein and Jersey efficiency and profitability to determine if a breed advantage existed in any or all related areas. Articles reviewed were obtained from the Journal of Dairy Science, the New Zealand Journal of Agricultural Research, and the Journal of Dairy Research. Jerseys were found to demonstrate breed advantages in pasture systems, longevity, stayability, productive life, calving ease, reproduction, heat stress under normal conditions, and hybrid vigor contribution. Jersey advantages were also found for environmental impact, keratin retention during milking, mastitis, response to S. aureus, and component pricing systems. The Holstein breed demonstrated an advantage dealing with hormones and outside stress factors during hot weather, response to E. coli infections, calf mortality rates, feed efficiency in confinement systems, and success in fluid production markets. Variances were detected in responses to fat and protein supplementation, blood plasma responses in calves, and fatty acid composition of milk without a clear breed advantage being defined. Overall, breed differences and interactions were discovered in every area examined. While Jerseys excelled in a greater number of areas, an overall advantage was difficult to discern due to the various benefits offered by both breeds.

Key Words: Jersey, Holstein, Sustainability, Profitability, Efficiency

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Introduction

The efficiency of both Holstein and Jersey cows has been scrutinized, evaluated, and debated for many years. The level of interest in this matter continues to increase significantly, especially within the last few years. This is largely due to low milk prices, high feed costs, continued climate changes, and the rising desire for sustainability. Efficiency is an important factor in the overall profitability of every dairy farm. Efficiency is not limited to feed measures, but rather the use of any and all outside factors in a profit enhancing way. While many studies have been executed that evaluate differences between the Holstein and Jersey breeds in individual areas, these findings have not been compiled into one complete report. This study summarizes the findings of numerous studies in multiple areas related to profitability including: feed efficiency, response to rBST and Monensin, milk component responses to dietary fat and protein supplementation, reactions to mammary infections, longevity and productive life, reproduction, environmental impact, calves, heat stress, and hybrid vigor.

Feed Efficiency Variation By Breed

With a large percentage of United States corn now allocated to the production of ethanol, the price of corn has skyrocketed. As a result, the cost of feed inputs has significantly increased. While dairy producers have always been relatively concerned with the amount of milk they receive for the feed inputs they purchase, it is scrutinized more than every. Feed conversion to product is critical to the overall economic profitability of the business, especially with feed costs accounting for eighty percent of the total variable costs associated with milk production (Prendiville et al., 2009). Feed efficiency may be greater for individual breeds when compared to others, and the following section contains articles that were reviewed relative to this discussion.

Blake et al. (1996) performed a study examining the comparative feed efficiencies of the Holstein and Jersey breeds. Their objective was to determine if the two breeds demonstrated a difference in regards to converting dietary protein into milk protein or energy when fed ad libitum diets. When analyzing their results, a two percent higher dry matter digestibility and a four percent nitrogen higher nitrogen digestibility over the Holsteins was discovered for the Jerseys throughout each trimester. However, the difference in N efficiency was negligible when dry matter was considered. The study determined that while Holsteins consumed one-third and one-fifth more dry matter, the Jerseys intake was a higher percentage of their body weight. While the overall energy efficiency of the breeds did not differ in the first trimester with dry matter considered, the Jerseys appeared 27% less energy efficient in the second trimester. It is believed that the Jerseys may have been depleting more adipose tissue due to the four percent increase in dry matter intake between the first and second trimesters, as well as apparent differences in tissue balances from breed potentials in milk (Blake et al., 1986). Since the breeds did not differ in dry matter intake digestibility, it was concluded that Holsteins and Jerseys similarly convert dietary nutrients to milk.

Another study (Aikman et al., 2008) investigated similar properties of digestibility, passage rate, consumption and rumination activity, dry matter intake, and lactation performance of Jersey and Holstein cows. Cows were fed diets calibrated for pregnancy and body weight starting seven weeks before their expected calving date and were fed an ad libitum lactation diet postpartum. The study involved six Jersey and six Holstein cows, all third lactation. The cows were housed in a tie-stall barn. The stated objective of this study was to compare the relative digestibility, rumination, intake, passage rate, and overall performance of the two breeds during late gestation and early lactation (Aikman et al., 2008).

The results of this study found Holsteins to be more than 200kg heavier and possessing a higher total dry matter intake than the Jerseys in the period prior to calving. This study found DMI to be similar between the two breeds. Holsteins also gained more weight during the last three weeks of the dry period, as compared to the Jerseys who remained at the same weight. The resulting production data was as expected, finding the yields of milk, fat, protein, lactose, and energy to be higher in the Holsteins, but with the Jerseys presenting a higher percentage of each component. The amount of milk produced per unit of body weight did not differ between the two breeds. The Jerseys were found to have a dry matter and NDF intake of approximately two-thirds the amount of the Holsteins. This higher intake resulted in a faster passage rate and less time spent consuming in the Holsteins as well. The Jerseys proved to have a higher rumination time for each kilogram of DMI or NDF, and spent a significantly longer time chewing per kilogram of BW in both the dry period and lactation (Aikman et al., 2008). There were no effects of breed on the resulting digestibility of DM, OM, starch, ADF or N, but the NDF digestibility was higher in the Jerseys. The total nitrogen intake, urine excretion, expulsion in milk, and retention was higher in the Holsteins; with both breeds maintaining a positive N balance throughout lactation. Overall, the study found the intake capacities of the breeds to be similar, and did not confirm the productive potential for milk energy to be different between the breeds.

A related study (French, 2005) was conducted to examine the dry matter intake and blood components of late gestation Holstein and Jersey cows that were not currently lactating. Fourteen Holsteins and an equal number of Jerseys were chosen according to expected calving date, and were examined between 23 d before and 1 d after parturition. The body condition score of both breeds did not differ and the weight gain in the last three weeks was also similar. As calving approached, both exhibited a decrease in dry matter intake. Holsteins experienced the largest drop in intake at thirty-five percent, while the Jerseys showed seventeen percent. Thus, it was shown that intake depression in late lactation was much less significant in the Jerseys. BHBA and plasma glucose did not differ between the breeds. Plasma NEFA levels were similar for the two breeds between twenty-one and five days before calving, but was greater in the Holsteins from four days onwards. There was a breed by day interaction before calving for energy balance. Holsteins demonstrated a much greater energy balance three weeks before calving, however, the Jerseys were seen to have a larger balance three days before calving thru one week postpartum. Finally, Jerseys in this study were found to be more efficient during the first seventeen weeks of lactation. This is thought to have an interaction with the greater plasma NEFA prepartum and lower energy balance postpartum in the Holsteins.

White et al. (2001) performed a four-year study in which milk production and economic factors were observed for seasonally calved Holsteins and Jerseys in both pasture and confinement systems. The objective was to investigate and compare confinement and pasture systems and the breed interactions with them. Cows were bred to calve either from January to March or August through October, and both breeds were included in each system. Each group began with thirty-six cows each season and cows that left the herd were replaced with similar ones. Feed costs per cow per day were averaged for each breed, system, and season to generate a total of twenty-eight means.

A significant treatment by breed interaction was found for total lactation production, as is expected between the two breeds. Jerseys were found to produce 23.3% less milk when compared to the Holsteins. Jerseys had much higher levels of fat and protein, also normal for the breed. In addition, pasture cows were noted to produce 11.1% less milk when compared to the animals in confinement. Daily feed costs were lower for the pasture cows when compared to confinement. Jerseys has a daily pasture feed cost of $2.08 versus $2.28 cents for Holsteins, demonstrating an advantage for the smaller breed at pasture. The confinement system was surprisingly different, with Holsteins having a daily feed cost of $2.82 versus a higher $3.03 for the Jerseys. Spring also lowered feed costs for $2.41 versus $2.69 for the fall calving cows. Holsteins did show to have a significantly higher total income ($6.97 vs. $5.52) over feed cost in both systems, with the lower feed costs in the Jerseys not overtaking the lower volume of milk. With mastitis being a large factor for profitability, the study experienced losses that ranged from zero for the spring pasture Jerseys to three percent of the total milk produced by the fall confine Holsteins. There was also found to be a lower incidence of mastitis in the pasture groups of all breeds versus the confinement animals. Throughout the study a total of twelve Holsteins were culled, one from pasture and eleven from confine, for mastitis. These animals incurred a total cost of $7249 for replacements and milk losses. Jerseys demonstrated a definite advantage in reproductive performance by twenty-percentage points throughout the study, and if breed numbers had been equal an estimated fifty more Holsteins than Jerseys would have failed to breed back. With the losses from culling and reproduction, there was a thirty-percent offset of the feed cost advantage possessed by the Holsteins. In conclusion, the study found no significant difference in income after feed costs between the systems, and Holsteins were shown to have a consistently higher milk income over feed costs versus the Jerseys (White et al., 2002).

A 1996 study by Mackle et al. compared the feed conversion efficiency, pasture intake, and milk production of Friesian and Jersey cows that were calved at two different liveweights in New Zealand. The objective of the study was to compare the feed conversion efficiencies (FCE), dry matter intakes on pasture, and weight changes of first lactation animals of the two breeds. Sixteen Friesians and an equal number of Jerseys received synchronized insemination at fifteen months of age. They were calved in and kept together as a group throughout the lactation. The pasture was rotated between morning and afternoon. A significant breed interaction was found for changes in calving live weights (CLW), with Jerseys experiencing a much larger reduction in CLW than the Friesians after calving. Jerseys also experienced a much larger reduction in calving liveweight when restricted feeding was implemented. During the first fifty-six days after parturition the both the high and low calving weight Jerseys lost more weight than either group of Holsteins. The high Jerseys lost a larger proportion of their CLW than the comparable Holsteins, and the low Jerseys gained a lesser proportion of their CLW than the low Holsteins after calving. No CLW and breed interaction was significant, but a more marked effect appeared in the Jersey cows. The Holsteins demonstrated an expected higher yield of components and milk, with the Jerseys producing these components at a higher percentage. Parallel to previously discussed studies, Holsteins in this study consumed 1.5 to 2.4 kg more dry matter than Jerseys. Jerseys were found to consume more DM per 100 kg of body weight than the Holsteins. CLW had an insignificant effect on average DMI throughout the lactation for both breeds. No significant breed by milk interaction was found, both breeds appeared to produce a similar level of milk based on the amount of DM consumed. Jerseys did produce more FCM, MS, and SCM per kg of dry matter intake than the Holsteins. It was suggested that this was due to a greater efficiency for milk fat production per unit of dry matter consumed, as the protein efficiency between the two breeds did not vary.

Several studies have been executed to determine the grazing efficiency of various breeds of dairy cattle. One such experiment conducted by Prendiville et al. (2010) was done with the objective of determining if grazing behavioral differences existed between Jersey, Holstein, and crossbred cattle existed and the effects of such differences on intake capacity and overall production efficiencies. 108 animals were used in the study, all first or second lactation animals. Grass dry matter intake (GDMI) was estimated for every cow four times throughout lactation, which provided 430 total records for data collection purposes. Graze analysis software was used to decipher grazing and ruminating information collected twice during lactation for each animal (Prendiville et al., 2010).

Milk production data proved to be normal. The Holstein cows produced a larger quantity of milk, the Jerseys produced a higher percentage of components, and the final milk solids yield was similar for both breeds. Total GDMI was higher for the Holsteins, but the Jerseys cows showed a larger amount of GDMI per 100 kg of body weight. Jerseys proved to produce a higher yield of milk solids per kg of GDMI and also yielded 32% more solids per 100 kg of body weight as well (Prendiville et al., 2010).

The study showed the amount of time grazing, the number of times eating and duration of both, the number of daily bites taken, and grazing speed were all similar for both breeds. However, the number of times mastication occurred, as well as the rate of cud chewing tended to be higher for the Jersey cows. On a per BW basis, a definite breed by grazing behavior interaction was evident. Per unit of body weight, the Jerseys demonstrated a longer amount of time spent grazing on a daily basis, took more bites each day as well as each minute, had a greater rate of GDMI, and a larger amount of feed contained in each bite. Per kg of GDMI a breed interaction was also found, with Holsteins ingesting 1 kg of GDMI faster than their smaller counterparts. The Jerseys took more mouthfuls and chewed their cud 36.5% more than the Holsteins cows per kg of GDMI. The number of rumination occurrences was similar between the breeds, however the Holstein cows spent more time ruminating each day. Per kg of BW the Jerseys ruminated 13.7 minutes longer and the number of ruminations was higher. In conclusion, this study found Jerseys to have a more assertive aptitude for grazing than the Holsteins, based on their observed advantage in bite rate, intake speed, and enhanced grazing time per 100 kg of BW (Prendiville et al., 2010).

Prendiville et al. performed a similar study in 2009 in which the objective was to determine the productive and energetic efficiencies between Holstein, Jersey, and crossbred cows over a lactation spent grazing on pasture. Their goal was to quantify the efficiency variable with the various performance traits. 110 cows of first and second lactation studied to determine the answers to the objective. Each individual animal was measured for DMI five times throughout lactation and compared with production data. There was a significant breed by production performance interaction found within the study. Milk yield was greatest in the Holsteins and lowest in the Jerseys. Lactose, protein and fat yields were the greatest for Jerseys versus the Holsteins. Change in total body weight over lactation was similar for all breeds involved. A definite breed interaction was found for gross efficiency measures. The total dry matter intake (TDMI), solids corrected milk (SCM), and milk solids (MLKS) per 100 kg of body weight (BW) were highest for the Jerseys. MLKS/TDMI and NEI/MLKS were preferential to the Jerseys as well. Energy balance, energy used for body weight changes, and RFI appeared similar for both breeds. Results indicated that the Jerseys required about eight percent less energy to produce 1 kg of MLKS when compared to their larger counterparts. Overall, the presumed superior intake per unit of body weight and total production efficiency traits of the Jerseys was confirmed in the study (Prendiville et al., 2009).

It was difficult to discern a winner for feed efficiency between the Holstein and Jersey breeds. A previously proposed advantage in pounds of milk per pound of body weight in the Jerseys could not be verified. However, definite breed differences did surface within various management styles. The Holsteins seemed to thrive more in enclosed settings fed TMR rations, producing more total milk and profit than the Jerseys. However, when put out to graze, the Jerseys expressed their dominance. In a grazing situation, the Jerseys proved to provide more total solids per unit of body weight, likely due to their lower maintenance requirements and smaller body size. Overall, the Jerseys demonstrated dominance in situations involving physical exertion, likely due to the higher energy requirement for movement in the Holsteins, while the larger breed thrived in low-energy output environments with set rations.

Longevity & Productive Life

The length of time a single cow lasts within a herd has a direct link to the level of profitability a farm will see. The longer a cow lives in the herd, the less replacements are needed, and the more room a dairy will have to either expand or sell excess animals. Productive life also highly correlates to the level of profit when feed prices are high or cull prices are down. According to a 1998 study by Jagannatha et al., about fifty-seven percent of dairy animals make it past the second lactation, and any increase in these successful animals increases overall profit. Rogers et al. (1999) adds that the economic value of productive life can yield as much as $5,900 with each additional month of life. Overall, productive life and longevity are very significant indicators of the amount of profit a farm can generate from a set herd size.

A study by Hare et al. (2006) evaluated survival rates and productive life data for 13.8 million dairy cows in the United States that calved between January 1980 and March 2005. Results showed that mean lactation lengths increased between parities two and seven in all breeds except the Holsteins, who showed a reverse effect. Jerseys showed a complete dominance in survival rate, having a much higher percentage reaching parities three, four, and five versus all other breeds from years 1980 to 1998. For survival to second lactation the Jerseys showed a 75% survival rate, with Holsteins following at 73%. For third lactation the Jerseys demonstrated a 56% survival rate versus 50% in Holsteins. For fourth lacation Jerseys survived 39% of the time, with Holsteins at 32%. Holsteins also showed a decline in survival from 39 to 28% from 1980 to 1998, with Jerseys suffering only a <3% drop. Jerseys maintained the highest survival rate for cows remaining in the herd at all advanced ages. The study also found that since 2000 the only breed with increasing numbers of animals on DHI testing were the Jerseys, hinting at the possibility that the longer survival of the breed is due to increasing demands. The mean number of lactations for all the breeds was under three, except for Jerseys, which were 3.2. Overall, the study showed a downward trend in the average number of completed lactations before animals left the herd. A similar tendency was found for productive life as well, with animals producing less total months before leaving the herd from 1980 onward, except the Jerseys, which increased in productive life. Mean productive life data across all years showed 33 months for Holsteins and 36 for Jerseys. The study did find, interestingly, that the mean productive herd life was longer for Registered cattle than grades by 2.4 to 6.5 months. Overall, the study found the Jerseys to have the longest productive herd life and determined the breed to be the only one increasing in such areas of longevity (Hare et al., 2006).

Another study by Garcia-Peniche et al. (2006) was conducted with the objective of determining breed by region interactions for traits related to longevity. The study measured these traits for five years in Holstein, Jersey, and Brown Swiss cows within seven regions of the United States. In single breed herds, stayability measures showed significant differences between breeds. The Brown Swiss demonstrated the greatest stayability in most of the areas, except in the Central and Southwest regions, where the Jerseys had advantage. The overall stayabilities of Brown Swiss and Jerseys were not significantly different, but both breeds had higher rates than Holsteins in all seven regions. The difference in the South Central and South East regions was greater than fifteen percent, likely due to the heat factor. On Holstein and Jersey mixed farms, the Jerseys also demonstrated a greater stayability than their larger counterparts in all regions. There was a clear breed interaction for reaching lactation number five, with Jerseys more likely to reach a fifth parity than Holsteins in all of the regions, in both single and mixed herds. In mixed herds it was found that Jerseys always lived longer than their larger herdmates, but a region difference was not established. In regards to herd life, the Jerseys had the longest life within herds of one breed in all regions. However, only mixed herds in the Central and Southeast regions showed a Jersey advantage in mixed herds. The smaller breed also withstood more total days in milk in all regions, and a very large difference was determined in the Central, South Central, and South East regions. It was believed that this greater advantage was due to a higher likelihood of heat stress in these areas. The study concluded that the Jersey advantage in these traits was likely attributed to a younger age at first calving and a shorter calving interval, allowing them to complete more lactations in the same number of years, and thus more total days in milk by five years (Garcia-Peniche et al., 2006). Age at first calving was not a factor in longevity; therefore the Jersey breed demonstrates health advantages not related to reproduction.

Throughout all studies reviewed, a significant difference in longevity and productive life traits can be seen between Holstein and Jersey breeds. Jerseys appeared to show a significant advantage in all categories, living longer, producing longer, and surviving to later lactations more frequent than Holsteins. A possible explanation for the greater number of lactations by age five and the larger number of days in milk may be the lower age at first calving experienced in Jerseys. However, their ability to survive, produce for longer, and maintain a lower cull rate may have several justifications. Firstly, the Jersey breed is the only breed currently experiencing positive growth in the United States. This positive growth may contain a greater desire to keep animals longer in order to expand herd numbers. Secondly, their smaller frame may result in less strain on their feet and legs, and other longevity related traits, thus allowing them to avoid culling longer. Regardless of cause, Jerseys maintain a significant advantage in overall stayability, longevity, and productive life in relation to their larger counterparts.

Breed Responses to Bovine Somatotropin & Monensin

Throughout the history of dairy production, there has been a steady decrease in the number of dairy cows and producers in the United States. According to 2011 statistics from the United States Department of Agriculture Economic Research Service, cow numbers have declined about one quarter since 1970. The number of farms has also significantly decreased from 650,000 farms to approximately 90,000. Even with these decreasing numbers, individual cow productivity has nearly doubled in the same time and the average herd size has increased fivefold (USDA, 2012).

The decreasing dairy cow population results in a constant pressure to increase milk per cow. Related efforts to achieve higher lactation yields have resulted in products like recombinant Bovine Somatotropin, from Monsanto, and Monensin, a feed supplement from Elanco Animal Health. Numerous studies have been conducted since the introduction of these products to determine the extent of their milk enhancing abilities. Contained in this section are articles drawing conclusions towards the reactions of both the Holstein and Jersey breeds to these milk-stimulating products.

West et al. (1990) performed a study examining the physiological responses of recombinant bST injections on lactating Holstein and Jersey cows during times of taxing heat and humidity. The researchers wanted to test the impact of rbST administration on the metabolic processes of lactating cows of both breeds in hot weather. The objective of the study was stated as:

> The objective of this study was to determine the effect of bST use in a hot, humid environment on blood acid-base chemistry, blood serum hormones and metabolites, and blood and milk fatty acids of lactating dairy cows.

Sixteen multiparous Holsteins and eighteen multiparous Jersey cows were used in the study. They were sorted into groups by milk production and ranked within the breed for assignment to experimental treatment groups. Based on the group, individual animals were injected intramuscularly daily with either 2ml of vehicle or 20mg of bST.

The results of the aforementioned study indicated a breed by treatment interaction. Milk temperature was taken daily to determine the body temperature of the animals. While it was found that the milk temperature of all the cows increased with the higher environmental temperatures, the increase found within Jerseys administered rbST was greater than the rise in Holstein milk temperature. The Jersey control group demonstrated a lower milk temperature than the control Holsteins, indicating a definite separation in reaction to the hormone (West et al., 1990).

A breed by treatment interaction was also shown in the blood bicarbonate (pCO2) content. Blood bicarbonate declines were used to determine that a more rapid respiratory rate was occurring. As the milk temperature of the cows increased, the respiratory rate became more rapid, resulting in a depressed blood pCO2. The study results stated a Holstein blood pCO2 of 31.82 (control) and 30.03 (bST) mm Hg, verses a blood pCO2 of 33.78 (control) and 28.85 (bST) mm Hg in the Jerseys. Due to the higher milk temperature in Jerseys administered the bST, the breed also experienced a drop in pCO2 in response to the added heat stress (West et al., 1990).

General conclusions of the study by West et al. (1990) stated that the milk temperatures of all animals involved increased with the addition of rbST injections. The authors stress the additional heat stress created by the additional milk production generated, and the need to protect both breeds from environmental stressors. These results provide an interesting look at the impact bST administration could have on the heat tolerance each breed retains.

West et al. (1990) prepared a similar study from the same group of animals, but instead measuring the effects of rbST on dry matter intake, milk yields, and body temperatures for the two breeds. A treatment by breed interaction was discovered at all levels of pretreatment production. Cows of both breeds in a lower production range demonstrated a greater response to the hormone than those producing at a higher level. While a significant effect was found at the -1 SD and mean productions, the response indicated from the Holsteins was much greater than the Jersey treatment groups. At the +1 SD range, there was actually a negative production response in Jerseys, contrasted with the still-positive reaction of the Holsteins. The researchers believe that the higher body temperature in Jerseys administered rbST explained the lower response to the hormone.

Jerseys did demonstrate an advantage in dry matter intake, with a lower total intake than controls at all levels, compared to the increased intake of Holstein treatment groups with the exception of the +1 SD of pretreatment energy intake. The +1 SD was defined as animals producing at a level one standard deviation above the average. Consequently, Jerseys administered rbST showed a lower mean body condition score when compared with Holsteins.

The authors concluded that the fat corrected milk yield increased greatly in both breeds. They suggest that the response to rbST injections is dependent upon the level of milk production during the pretreatment period. Overall, lower producing cows of both breeds had greater potential for improvement than higher producing counterparts. The reaction of

Jerseys to the rbST administration proved to be less than Holsteins, and was surprisingly negative at the +1 SD for milk. Thus, results of the study indicate that the high producing Jerseys were less than responsive to the addition of the hormone. It appears that Jerseys producing at a high level have a negative response to the hormone, possibly due to their lower body condition scores at this stage in comparison to the Holsteins. Lower producing Jerseys demonstrated a positive response, but at a lower rate than the Holstein. This is likely due to body condition as well.

A 1998 study by Vander Werf et al. examined the milk yield and compositional changes resulting from a Monensin feed supplement. The objective of this study was to determine the efficiency of monensin in dairy cows when it was fed via concentrates during two different trials (Vander Werf et al., 1998). It was additionally explained that the second trial, involving the Jerseys, was a confirmation study that was executed to determine the effect of a set level of monensin on both Holstein and Jersey cows over two different lactations (Vander Werf et al., 1998). Cows were randomly assigned to control and treatment groups. Treatment groups were then fed monensin at the rate of 150mg/kg of feed.

Results of this study demonstrated a significant difference in the response to monensin generated from both breeds. Both received a boost in overall total milk, fat, and protein yields. However, the percentage of fat was a small gain, and protein percentage responded negatively at -.3g/kg. An overall decrease in feed consumption did suggest a possible increase in protein utilization. The largest increase in milk yields were recognized by the highest genetic Holsteins, while the Jerseys showed significantly lower milk production response. Jerseys also proved to have a lower protein percentage response to the same high-energy diet as the Holsteins. It was suggested that the response could be due to a lower genetic ability to use the higher levels of propionic acid in the rumen for lactose and protein. Jerseys have a fat yield approximately the same as Holsteins, but they yield less overall protein and lactose. It was proposed that the smaller breed may also need more lipogenic precursors, and therefore the higher ratio of propionic acid to acetic and butyric acids in the rumen might result in less effective responses for the Jerseys (Vander Werf et al., 1998).

Overall, the study proves a highly noticeable difference in breed responses to the addition of monensin to lactating dairy cow diets. Holstein and Jerseys cows issued the same dose of monensin in the same environment gave two very different reactions. While Holsteins showed a very large increase in milk yield, Jerseys proved to increase significantly less. In addition, the total milk fat percentages were far less enhanced with the smaller breed.

Throughout the studies examined, definitive separation between the Holstein and Jersey breeds were evident. Within all the aforementioned studies, a breed by treatment interaction was clearly recognizable. With the administration of recombinant Bovine Somatotropin as a milk yield enhancement, the response generated from the Holsteins was superior to the Jerseys. The Holsteins demonstrated a larger percentage response to the hormone addition, and also showed to be less affected by the enhanced production during hot and humid weather. Jerseys proved to have higher spike in milk and body temperatures in hot weather with the hormone. The Jersey control groups within these studies were naturally cooler than Holsteins, indicating a temperature spike response large enough to overtake Holstein temperatures.

Jerseys also proved to be less responsive to monensin supplement as well. While they received an increase in overall milk, fat, and protein yields, the reaction of the Holsteins far surpassed them. The researchers in this study (Vander Werf et al., 1998) speculated a metabolic difference in Jersey usage of propionic acid due to lower total milk protein and lactose yields as compared to the larger breed. All in all, Holsteins appear to be more responsive towards hormonal and supplemental stimulators for milk production than Jerseys.

Holstein Vs. Jersey Calves

Lifetime success of a dairy female starts from the second she is born. Colostrum feeding, rates of growth, and how well she develops can all be traced to her level of production and viability throughout her life. Thus, it is beneficial to examine the responses of both breeds to factors occurring in the early stages of life. By doing so, it is possible to predict their prosperity once they begin producing. A determination of breed advantages in this area allows producers to maximize profits beginning on day one.

One very critically examined factor in young calves is the concentration of immunoglobulin within blood plasma, measured accurately before seventy-two hours of birth. A 1998 study by Quigley et al. examined this exact topic, with the objective being to determine whether colostrum management, plasma volume, sex, age at feeding, colostrum quantity, or breed had any relations. 97 Holstein calves and 49 Jersey calves were prevented from suckling their dams, and were fed either fresh or frozen colostrum. An initial blood sample was taken from each calf at twenty-four hours of age. Results of the study determined that plasma volume was indeed affected by birth weight, breed, and age at the time of sampling. The mean plasma volume was 9.71% of BW for Jerseys at 2250 ml versus a higher percentage of 9.94% of 3623 ml in the Holsteins. However, it was suggested that because the Jersey calves came from a single location while the Holsteins came from four, this might have impacted the accuracy of actual plasma levels across the Jersey breed. The study found that, regardless of breed, the further from birth calves were initially fed colostrum, the lower their resulting blood plasmas were. However, the Jerseys did show a higher percentage of plasma in relation to body weight after 24 hours than did the Holsteins, suggesting a possibility that plasma absorption in the smaller breed continues several hours longer (Quigley et al., 1998). Overall, a breed advantage was difficult to discern in this study due to lack of variety in original Jersey calf location, however it is suggested each breed exerts dominance at different advances in age.

Stanley et al. (2002) performed a study examining the interaction of glucose metabolism with the number of feedings per day in Holstein and Jersey calves. 18 Holstein and 15 Jersey calves were fed either once or twice a day on replacer. Blood was collected at five different intervals on a single day each week and analyzed for glucose, insulin, glucagon, and nonesterified fatty acids (NEFA). Calves began each their designated feeding routine at approximately one week of age. No differences in were detected in weaning or end of trial weights between calves of either feeding group. It was determined that plasma glucose concentrations were significantly higher in the Holstein calves, but that the Jersey calves had a considerably higher NEFA concentration. Plasma insulin and glucagon were similar in the two breeds. There was not a determined difference in levels by various sampling times, but it was noticed that the peak glucose concentration was at thirty minutes in Holstein calves and sixty minutes for Jerseys, with no affect for feeding frequency. It was additionally noticed that for insulin levels in once daily feedings, Holstein calves peaked at sixty minutes after feeding, while the Jerseys were much later at two hours post-feeding. Once daily fed calves did not demonstrate hyperglycemia. The Jersey calves exhibited an interaction between feeding time and feeding frequency that was not observed in the Holsteins, and displayed a higher NEFA concentration before the morning feeding than after. It is suggested that NEFA concentration is negatively correlated with calf starter intake. Therefore, it was proposed that since the Jersey calves displayed a larger starter intake as a percentage of their body weight, especially when fed once daily, that the NEFA levels were more depressed. Furthermore, the study suggested that there might be metabolic differences between the two breeds (Stanley et al., 2002).

From both studies, it is difficult to discern a definite advantage in calf success on a breed basis. However, considerable differences in behavior of these calves suggest different metabolic patterns between the breeds. It was noticed in both studies that Jersey calves were slower to absorb either colostrum or milk replacer. Jerseys were found to absorb colostrum for longer, indicating a wider range in which colostrum feeding is effect (Quigley et al., 1998). This may counter their disadvantage in absorption of colostrum initially, where Holsteins initially indicated a higher percentage of blood plasma. Jerseys were also found to reach peak levels of glucose and insulin at time periods double that of their Holstein counterparts (Stanley et al., 2002). This additionally backs the suggestion that Jerseys absorb nutrients at a slower rate. While a definite reason for the differences is unknown, a number of factors like body fat percentage, proportion of milk to body weight, and size may be attributed to this. All of these may indicate that due to a smaller mass, the Jerseys have less area in which to absorb the nutrients, taking them longer. As to whether calves of either breed exert dominance in the area of calves, it is unclear.

Heat Stress

Heat stress has proven to have a detrimental effect on the productivity of all dairy cattle breeds. It reduces reproductive capabilities by lowering ovarian and estrous functions and heat detection abilities due to decreased activity. It also lowers production by restricting appetite and reducing dry matter intake. In extreme cases, sickness or death may even occur. Many studies have investigated the extent to which heat stress affects cattle, yet only a couple were discovered to have compared the difference of effects between the Holstein and Jersey breeds. The following studies were reviewed after finding they made a comparison between the two.

A study by Harris et al. (1960) examined the influence of hot, summer weather in central Texas on lactating Holstein and Jersey cows. The objective of this study was to determine the effect of solar radiation and temperature on the physiological and production of both breeds of cattle. Animals of both breeds were either tied outside in direct sunlight or under galvanized metal shades. Results were measured on eight different test days, and animals were rotated between both areas. The Holstein cows were found to have higher body temperatures and respiratory rates, yet lower pulse rates than the Jerseys. It was believed that Holsteins experience a higher rate of respiratory action in an attempt to deal with the increased temperature and sunlight. The higher plane of production in the Holsteins was suggested as possible reason for a greater normal heat load than the Jerseys. The Jerseys did demonstrate a higher pulse rate in the outdoor location, yet an explanation was difficult to ascertain. The smaller breed also demonstrated a larger decrease in total production, but reasoning was also difficult to pinpoint. It is suggested that the decline in production may not be attributed to the heat, but rather the handling and stress upon the animals. Overall, the

Holsteins appeared to have a more significant physiological reaction to heat simply based upon increased body temperature and respiration rate. They reacted more dramatically to the heat, while the Jerseys appeared to react more directly to the added handling of the experiment.

The previously discussed study by West et al. (1990) examined bST responses during hot and humid weather. With the objective to determine the effect of bST use during times of increased heat stress, both Holstein and Jersey reactions were measured. The results, as previously discussed, included a larger increased milk temperature in Jerseys. This was interesting, as the control Jerseys had a lower milk temperature than the Holsteins. This indicated that during times of heat stress the Jerseys were more likely to respond to bST with higher physiological spikes. A definite difference in reaction to the bST during heat was noticed. General conclusions of the study by West et al. (1990) stressed that the additional milk production was the causative agent for the additional heat stress, indicating a greater need to protect injected animals of both breeds from the environment

West et al. (1990) prepared a similar study, also previously reviewed, from the same group of animals, that measured the effect of rbST on dry matter intake, milk yields, and body temperatures for the two breeds. Cows of both breeds in a lower production range demonstrated a greater response to the hormone than those producing at a higher level. A significant effect was found on milk production for animals producing one standard deviation below the average, especially in the Holsteins. On the other hand, Jerseys producing one standard deviation above average actually indicated a negative response to the addition of the hormone. Jerseys did demonstrate an advantage in dry matter intake, with a lower total intake than controls at all levels up to one standard deviation above average. Based on the results of both studies by West et al. it was recognized that the administration of rBST during periods of heat stress had a more significantly negative effect on Jersey performance than in there counterparts.

Based on the results of these few comparative studies, clear breed distinctions can be found. Jerseys were discovered to have an advantage in body temperature and respiratory rate under normal conditions, indicating an advantage in managing heat stress under typical circumstances. However, a distinct advantage was found in the Holstein ability to manage the added demands of rBST administration under the same heat stress situations. In the first study, by Harris et al. (1960) it was believed that a decrease in milk during times of heat was actually caused more so by the handling of the Jerseys. By these findings, it is possible that Jerseys experience a physiological response more pronounced than Holsteins to all external factors, whether human or hormonal. These higher physiological responses result in a loss of their advantage in managing the effects of higher levels of heat. Overall, the Jerseys appear to triumph under regular management conditions, while Holsteins are more apt to control additional factors impacting heat stress response.

Reproductive Comparison

A successful reproductive program is essential to the relative profitability of every dairy farm. Factors like days open, calving interval, DOAs, services per conception, and pregnancy rate are important in attainment of profits. It has been offered by the Missouri Dairy Growth Council that every extra day open carries a cost of \$0.50 to \$4.50 per cow, and each percent increase in pregnancy rate is worth \$35 per cow. It has commonly been suggested that a difference exists between Holstein and Jersey cows within these areas. The following studies related to reproduction were reviewed.

A 2002 study by Washburn et al. examined the variation of average days open and services per conception in Southeastern Holstein and Jersey herds. The objective was to determine if trends over time appeared within these two areas. It was found that rolling herd averages for both milk and fat total yields increased within both breeds. Over each three-year period, both breed average herd sizes increased. However, a breed by time interaction was found where the Jerseys increased 64% versus only 55% in Holstein herds. There was also a significant breed by time interaction for average days open. The total average days open was larger for the Holsteins. Over time, Holstein herds experienced an average of 139.4 days open while the Jerseys demonstrated an average of 128.6. However, the increase in days open was similar for both breeds over time. Services per conception were much different, with no breed interactions found. Both breeds showed a large decrease in total conception rate as well, dropping from an average of 52 to 53 percent down to 33 to 35 percent throughout the duration of the study. Increased milk and solids per cow may be causing these decreases in reproductive efficiencies due to higher demands on each animal. Animals producing milk at high levels tend to be diverting a large amount of energy to production. Many times high producing animals are found to be in a negative energy balance from these demands. If they are already at a negative balance, it is unlikely they will have additional resources to avert into becoming pregnant or exhibiting estrus. The mean number of days to first service increased in both herds, with Holsteins changing from 84.4 to 100.4 and Jerseys increasing from 78.2 to 96.2. Estrus detection rates were similar overall, with a slight advantage given to the Jerseys. Overall, the study determined that both breeds appear to be experiencing decreases in all the previously discussed areas of reproductive performance. However, Jerseys maintained an advantage throughout the time period in the areas of days to first service, conception rate, days open, and heat detection rates.

A similar study performed by Norman et al. (2009) examined reproductive information gathered from the USDA since 2005 in various pre-determined categories. The first area perused was the days from calving to first breeding (DFB). A downward trend in mean DFB breeding was found for Holsteins, however yearly differences did not show an obvious pattern for the Jerseys. The first breeding 70-day non-return rate (NRR70) demonstrated a decline of 54% to 45% in Holsteins versus 57% to 52% in Jerseys. First breeding conception rate was actually found to have increased, with the 2007 mean first breeding CR being 32% for Holsteins and 39% for Jerseys. The conception rate for all breedings in 2006 was lower for both, at 30% for Holsteins and 35% for Jerseys. The average number of breedings worsened from 1996 to 2006, changing from 2.1 to 2.5 for Holsteins and 2.0 to 2.3 for Jerseys. The interval between first and last breedings (BI) was also studied. This figure increased dramatically from 1996 to 2006 in both breeds. Holstein BI increased from 51 to 69 days, with Jerseys changing from 44 to 55 days. The trend over time was not as measurable for the Jerseys as it was the Holsteins. In both breeds, calving interval (CI) has shown to be declining in recent years. The 2006 average calving interval was 422 days for Holsteins versus 410 for Jerseys. Overall, Jerseys appeared to excel in all areas of reproduction in this study as well. While both breeds showed to be decreasing in reproductive proficiency over time, Jerseys maintained more successful statistics for all of these areas.

Another study by Dachir et al. (1983) examined the relationship between ovarian activity and milk yields of Holstein and Jersey cows within the same herd. Ovulation and estrous cycle patterns were observed and measures. The objective of this study was to determine if there were any reproductive factors related to the increased genetic potential of milk. Both Jerseys and Holsteins were examined for potential reproductive traits impairing milk yield. Both breeds were found to have similar ovulation and estrous cycle intervals. The postpartum interval to first ovulations varied for both breeds by parity. The primiparous interval was 27 days for Holsteins and 14 for Jerseys, and the pluriparous intervals were 20 vs 26 respectively. Variation was highest within the Jerseys. These data samples did not support an antagonistic relationship between milk yield and ovulation cycles. The average postpartum interval to first estrus results were similar to previous studies, with the advantage given to Jerseys at 41 days versus 61 in Holsteins. A correlation between FCM and this postpartum interval was not discovered in Holsteins, but the interval to first estrus increased in Jerseys with each additional 100kg of FCM. Milk yield was also related to days to first insemination and days open in the smaller breed, not had no relationship in the larger. A relationship was indicated for both breeds between estrous behavior and postpartum interval and/or the number of estrous cycles. The study concluded by stating that little association between decreased milk yield and ovarian activity. The increased postpartum interval for the highest yielding Jerseys was the sole relationship discovered within the study. This appears to demonstrate the idea that high producing animals have little extra energy in early lactation to further divert into reproductive capacities.

A study by Washburn et al. (2002) compared confinement and pasture-based Holstein and Jersey cows for reproduction, mastitis, and body condition differences. Pasture and confine groups did not vary significantly for reproductive performance. In both groups Jerseys had a higher percentage of animals inseminated (96.5 vs. 85.9), had a significant advantage in conception (59.6 vs. 49.5) and showed a vast difference in the number of animals becoming pregnant in seventy-five days (78.1 vs 57.9). The ability to rebreed was much lower in Holsteins as well. The confine group had a higher rate of mastitis than the pasture group, with the Holsteins having a higher incidence in both groups than the Jerseys (41.2 vs. 25.8). Holsteins also had twice the incidence of mastitis than the Jerseys as well. Holsteins also demonstrated a much higher culling rate, mainly due to udder health. Overall, a significant advantage in all the reproductive and health areas that were studied was given to the Jerseys. They demonstrated a much higher ability to conceive by seventy-five days and consequently lasted much longer within the examined herds. This was largely due to higher conception and pregnancy rates in the Jerseys. It is possible that the smaller maintenance requirements and lower production in the Jerseys allows them to consume the additional energy needed to enter positive energy balances sooner, resulting in the energy needed for reproductive purposes.

Olson et al. (2009) examined dystocia, stillbirths, and gestation lengths of Jerseys, Holsteins, and crossbred animals. The objective of the study was to determine the differences in these various traits for calves born into a designed breeding program. As expected, the pure Holstein animals had a significantly higher birth weight than the Jerseys. Twinning was much higher in Holstein dams (10.5%) than in Jersey dams (2.5%). No measurable differences in gestation length were discovered across the two breeds. Significant breed interactions were found for dystocia, with purebred Holstein calves 134.9 times ore likely to need assistance at birth than purebred Jersey calves. Stillbirths, however, did not differ between the two breeds. The study concluded that Jerseys held a noteworthy advantage in all aspects of calving, and that crossbreds inherited a portion of this as well.

Throughout all studies reviewed relating to reproduction traits in these two breeds, a Jersey advantage was clearly defined. The smaller breed conceived faster, easier, and sooner. They showed estrous and ovulation earlier and demonstrated shorter intervals to these variables after calving. In addition, they calved much easier with a lower instance of twinning, and needed almost no assistance at birth. Reasoning for these advantages is difficult to ascertain. Calving appeared to be easier simply due to a smaller calf size, and it is possible that calves are born at a weight that is a smaller percentage of their dam's bodyweight than in Holsteins. Easier parturition may be a partial explanation for the Jersey breed's superior ability to return to work and pregnancy faster than their larger counterparts.

Hybrid Vigor

The success of the Holstein breed for milk production and total yield has been highly regarded throughout time. The Jersey breed is also world renowned for high components and productive life traits. With these two very opposite advantages in mind, many producers have attempted to crossbreed their animals to find a perfect combination of the two. Many producers have reported higher calf survival rates, lower stillbirths, and better health and fertility traits that pure Holsteins, while still benefiting for a higher level of production than a pure Jersey. The studies below were reviewed for their relation to the subject of crossbreeding.

Heins et al. (2008) performed a study comparing seventy-six Jersey x Holstein crossbreds with pure Holsteins. Milk, fat and protein production was measured for both groups. In addition, variables such as conception rate, days open, and proportion of cows pregnant within a given time frame were also evaluated. As expected, the crossbred individuals had a lower total milk production when compared to the Holsteins (7,147 kg vs. 7,705 kg). However, for fat production characteristics the crossbreds remained similar to Holsteins. Fat percentages were 3.83 and 3.59 for crossbred and Holstein groups, respectively. The crossbreds did demonstrate a lower total protein yield (223 kg vs. 238 kg), but their protein percentage of 3.12 was higher than the 3.08 reported in the pure Holsteins. The procedure used to measure the total profitability of each group was simply the addition of the fat and protein in kilograms. On this basis, the JxH group had lower total components (497 kg) than the Holsteins (515 kg). On a percentage basis, it was reported that the crossbreds demonstrated 3.5% less fat and protein yield than purebred Holsteins. Somatic cell scores were not largely different, but the JxH group did appear to have a slightly greater SCS.

The possibility of breed interaction was also found in relation to conception rate, days open, and percent pregnant as well. During the first lactation the CR for JxH was 58%, not vastly different from the 53% observed in the pure Holsteins, suggesting that no significant breed interaction exists between crossbreds and purebred Holsteins for CR. For days open, the JxH group had a substantially lower mean than the pure Holsteins (127 d vs. 150 d). For individuals within a range of thirty-five to ninety-nine days open the crossbred group had a definite advantage, with 41% versus only 31% in the Holsteins. The same advantage was found for the number of cows over 250 days open, with the JxH group showing only 17% reaching this mark in comparison to the 33% of the Holsteins. While no significant difference was found for the percentage pregnant at 120 days postpartum, a much larger number of crossbreds were pregnant at the 150 (75% vs. 59%) and 180 (77% vs. 61%) day marks.

Overall, the researchers concluded that an advantage exists within JxH crossbred cattle. While they admit that the Holstein retains sole custody of the total milk production advantage, and a 3.5% advantage in total fat and protein yield, there is more to the equation. It was felt that once the days open were accounted for, the gap between the two yields in both areas becomes less significant. With crossbreds exhibiting a definite heterosis for reproductive capabilities from the Jersey breed, definite consideration in this area is required. With crossbreds breeding back more quickly, more frequently, and experiencing less stillborn calves there is a larger window for growth and profitability due to an increased number of replacements.

Bjelland et al. (2011) executed a similar study that compared purebred Holsteins to HxJ backcross cattle in the areas of production, reproduction, health, type, and growth. All animals had Holstein dams, which were mated to either unproven Holstein sires or first generation JxH crossbred sires to produce the two groups for evaluation. Interestingly, the backcross first parity animals required a greater proportion of assistance (11.2%) in comparison to the control group (3.7%). No substantial differences were noted in the health and disease frequency of the two groups of calves. However, pure Holstein calves were much heavier than those form backcross dams (43.5 kg vs. 40.5 kg). In contrast to the previous study reviewed, no difference was detected for gestation length, services per conception, days open, or days in milk at first breeding. It was suggested the similar days to first breeding was largely in part to the synchronization program at the farm, and also an excellent reproductive program overall. The study also suggested no difference in health traits for the backcross cows, indicating that no variability occurred for clinical mastitis, lameness, or other injuries. In addition, the culling rate at 24 and 36 months was very similar between the groups. However, a much higher percentage of backcross individuals were culled by 42 months of age (43.8% vs. 33.7% other or 36.5% control). Both groups of pure Holsteins had greater total milk production than the backcross group. Total fat and protein yields did not differ between the Holsteins and backcross groups, but the total daily fat corrected milk was higher for pure Holsteins. The researchers offered that, based on the results, the backcross individuals did not perform at the level of their Holstein herdmates. It is possible that the way in which the crossbreeding in this study was executed affected the total heterosis advantage from the addition of Jersey bloodlines. Because the animals were not half Jersey, but rather one-quarter Jersey, they would receive a much lower proportion of the Jersey trait benefits. This poses a problem to dairy farmers, as to the issue regarding what JxH crossbreds should be bred to in creating the next generation. If the heterosis advantages are not retained past the first generation crosses, this could pose a problem for total profitability.

A 2011 study by Xue et al. examined the total milk production and energy efficiency variables of both purebred Holstein and JxH crossbred cows when fed diets containing corn silage. Live weights were similar between the two groups. The study found no significant genotype interaction with the levels of feed intake, milk production, energy intake, energy output, of energy efficiency. With both 30% or 70% concentrate diets, the crossbred cows did exhibit greater silage, concentrate, and total dry matter intakes. The JxH individuals did have a more significant ECM yield, reminiscent of the higher fat and protein concentrations of their Jersey parent. For digestibility traits, no interaction appeared for dry matter, OM, energy, or nitrogen. The crossbred cows demonstrated significantly higher gross energy intake, urinary energy output, methane energy emission, and milk energy output. In conclusion, the study found no apparent effect of crossbreeding on the efficiency of metabolizable energy or energy partitioning.

A paper published by W. A. Montgomerie for the 53rd Annual Meeting of the European Association for Animal Production summarized the experiences of crossbreeding dairy cattle in New Zealand, where more than one-third of all replacement cattle are crossbred. The industry in New Zealand desires milk with the higher milk solids (fat and protein) from the Jersey breed, however wishes to eliminate the higher concentrations of other less valuable components prominent in Jersey milk as well. With neither breed sufficiently meeting their needs for processing, the country has resorted to crossbreeding approximately 35% of their animals, as of data collected in 2001. With a majority of animals on pasture, New Zealand farmers desire animals with lower feed requirements. They often evaluate efficiency based a milk solids yield per kilogram of metabolic liveweight. Using this measure, both Jersey and crossbred animals out-performed other breeds. Montgomerie recounts a recent study based on New Zealand data that found a higher net income per hectare with crossbreds than with either parent breed. This advantage was found by accounting for energy requirements, revenues from milk and beef, farm working expenses, and production, liveweight, and survival characteristics. Overall, he found that crossbreeding Holstein and Jersey cows resulted in a heterosis effect that was highly desirable under the grazing conditions throughout New Zealand.

A 2003 study by K. A. Weigel and K. A. Barlass involved summarizing the responses of comprehensive surveys sent to 528 United States dairy farms. Fifty usable surveys from twenty-two states were recovered and resulted in data for responses to areas such as facilities, milk recording plans, milk pricing, crossbreeding goals, breed selection, advantages, disadvantages, and future plans. Each producer included a score from one to five for questions relating to various traits fitting into these categories. Reasons for crossbreeding varied from fertility, health, survival, temperament, grazing ability, reduced body size, or decreased inbreeding. Producers with breeds other than Holstein stated milk production increases were their reasons for crossing their animals with Holstein. Scoring for the animal's ability to fit in the milk barn and parlor showed advantages to both Jersey and JxH crossbred animals over the Holstein. Holstein cows received the highest scores for milk production, while crossbreds and Jerseys both demonstrated higher scores for component percentages. The first generation Jersey crossbreds mated to Holstein cows exhibited the lowest scores for involuntary culling percentages. Scores regarding culling rate were the highest for Holstein cows. This indicates that a heterosis affect can be obtained for longevity by the use of Jersey crossbreeding. Conception rates were highest for the first generation Holstein crossbreds mated to Jersey cows and pure Jersey cows. Holstein conception rate was scored second to last, just ahead of Brown Swiss. These score results indicate a hybrid vigor effect for conception rate as well, indicating that the higher fertility of the Jersey breed may be passed on. Scores for calving problems were lowest for matings involving Jersey sires, including crossbred animals, as expected. Scores for Holstein matings to first generation Jersey crossbreds were also significantly lower than for purebred Holsteins, indicating an overall advantage to calving ease when some amount of Jersey blood is involved. Scored for calf mortality were the best for first generation crossbreds of either breed, demonstrating a higher survival rate for crossbred calves than either Holstein or Jersey calves Pure Jersey calves showed the worst survival rate scores, indicating that a larger amount of Jersey blood results in a negative impact on overall calf survival rates. When animals were sold for either beef or dairy, farmers were more pleased with prices commanded by pure Holsteins than with the crossbreds or Jerseys. This included responses for cull cows, steers, and bull calves. This illuminates the concern farmers express in relation to the lower prices received when animals are removed from the herd. Of the fifty herds that responded, forty planned to continue to crossbred, four intended to quit, and six did not disclose their plans. Overwhelming responses were given for the advantages to crossbreeding, including calving ease, fertility, component percentages, longevity, and calf vitality. Disadvantages included market prices, lack of herd uniformity, difficulty when choosing matings, and reduced milk volume. The researchers concluded that, based on the results of the survey, crossbreeding has legitimate value in improving the profitability and longevity in US dairy cattle.

It appears the producers in the United States are increasing using crossbreeding as a method to withstand volatile milk and feed prices, and that it is generally working to their benefit. Crossbreeding has been found, in all of the reviewed studies, to demonstrate some effect of hybrid vigor that is passed to the next generation. While milk production generally affects a farmer's bottom line, it is necessary to consider all other profitability aspects when designing a genetics program as well. With this in mind, considerable success in increasing fertility, productive life, component percentages, and efficiency has been found when using Jersey sires on Holstein dams, and possibly other crossbreds as well. Care must be taken when choosing matings, as it does become more difficult to decide which breed to use and too much of one breed present was seen to reduce the heritability of these benefits.

Responses to Dietary Fat and Protein

Fatty acid composition in milk is a frequently discussed variable in all areas of processing and nutrition. According to Beaulieu and Palmquist (1995), milk fat from Jersey cows contains less oleic acid and more short- and medium-chain fatty acids than the milk fat derived from their Holstein counterparts. It is believed that the fluidity and cheese making properties milk are affected by the concentration and composition of the fatty acids as well. With the affect of fatty acids on these compositional properties, many studies have been conducted in an attempt to identify any ability to manipulate these fatty acids using dietary fat or protein additions. The studies reviewed below have attempted to identify breed responses to the additional of fat and protein factors in dietary settings.

A 2001 study by Drackley et al. attempted to distinguish various breed responses to dietary fat or nonstructural carbohydrates in the diet. Their objective was to determine the change in milk fat composition when either breed was fed diets high (37% of DM) or low (27% of DM) in non-structural carbohydrates and supplemented either 0 or 2.5% of a mostly saturated fat source. The study did not show a significant difference in milk yield, milk fat percentage, or milk fat yield between breeds or diets. Supplemental fat was found to increase the milk fat content in all four groups, however total fat yield was not affected by the diet in either case. The content of C 4:0 was found to be larger in Holsteins, and C 6:0 was also slightly higher in Holsteins as well. However, the Jerseys tended to demonstrate a higher C 8:0 content, and C 10:0, C 12:0, C 14:0, and C 16:0 were all significantly greater in the milk fat of the Jersey group than in the Holsteins. The causes for these differences were not easily apparent. The average content of C 18:0 was slightly higher in the Jerseys as well, but it was not different enough to achieve significance. The levels of *cis*-monoenes C 14:1 and C 18:1

were much lower in the Jerseys, and the amount of C 16:1 was also lower but not enough so to become significant. With the addition of fat supplements, C 18:0 and cis-C 18:1 levels increased while the levels of short and medium chain fatty acids decreased in concentration. Very few interactions were found for breed and diet. It was discovered that milk C18:1 content was improved more in the Holstein group than the Jersey. A difference in C18:0 content was found from fat supplementation, with Jerseys increasing somewhat more, however the difference was not large enough to become significant. Supplemental fat also tended to decrease the ratio of *cis*-C 18:1 to C 18:0 in the Jersey cows, while oppositely increasing the ratio slightly in the Holstein cows. The researchers felt these results were consistent with their original opinion that Jersey cows have limited mammary stearoyl-CoA desaturase activity. This resulted in a decreased level of *cis*-C 18:1 in the milk fat of Jerseys that are fed a saturated fatty acid supplement that does not occur the same way in Holsteins.

A. D. Beaulieu and D. L. Palmquist (1995) also studied the effects of a high fat diet on the composition of milk in both Jersey and Holstein cows. The study involved increasing the daily intakes of calcium salts of palm fatty acid distillate and observing the affects on milk yield and milk fat composition within both breeds. As expected, the Holstein cows consumed more dry matter and yielded more milk, fat correct milk, and milk protein than the Jersey cows. However, the Jersey cows presented an equally predictable advantage in percentages of fat and protein. Overall, increasing the dietary fat levels had no affect on the yields of milk, fat, fat corrected milk, of the milk yield efficiency in either of the breeds. In addition, the concentration of fat and protein found in the milk did not differ when dietary fat levels were increased. However, the protein percentage did appear to decrease in the Holstein group while the Jersey group showed no effect. No breed interaction was found for the various increases in dietary fat on the milk fatty acid composition. It was noticed that the Jerseys contained a higher concentration of short and medium chain fatty acids and lesser amounts of palmitic and oleic acids within their milk fat than did the Holsteins. It is believed that due to the unchanged levels of milk fat yield, a change must be occurring in the amount of fat that was synthesized. It was found that when fat was added at a rate of .25 kg/d the de novo synthesis of fatty acid was more inhibited within the Jersey group than the Holstein. The increased levels of dietary fat did alter the ratio of milk fatty acids. For both breeds, the proportion of C8 to C14 was decreased and fatty acids with 16 and 18 carbons were increased. This excluded C 18:2, which was not affected by the fat supplementation. Three noticeable effects were found relating to dietary fat and its inhibition of de novo fatty acid synthesis and proportions of fatty acids within breeds and levels of fat supplementation. The first was that inhibition of de novo synthesis increased linearly from C6 to C12 in the Jerseys and from C6 to C10 in the Holstein cows. The second observation was that the inhibition experienced by the Jersey cows was larger than the Holsteins at the lower levels of fat supplementation, but that the Holsteins demonstrated a larger inhibition at the intermediate fat supplementation level. The third discovery made was that the butyrate synthesis was slightly depressed in Jersey cows fed supplemental fat, but increased in Holsteins under the same circumstances. In both breeds, the concentration of palmitate in milk fat increased with each level of dietary fat supplementation. The responses of C18:0 and C 18:1, and the corresponding ratio, revealed a definite breed interaction. The C 18:1 level increased in Holsteins with the increasing increments of dietary fat, while C18:0 remained unchanged. Thus, the ratio of C 18:1 to C18:0 tended to increase with the additional levels of fat supplementation as well. The Jersey cows experienced a much different reaction. The percentage of both C 18:1 and C18:0 in the milk fat increased with supplementation, causing the ratio to remain unchanged rather than increasing, as seen with the Holsteins. The researchers credit this different to either the decreased use of C18:0 or the decreased desaturation to C18:1, or both within the Jerseys. Overall, the study found that the two breeds did not respond differently to fat supplementation through energy utilization or milk yield, but rather through differences in fatty acid ratios and composition.

Rodriguez et al. (1997) performed a study that measured responses to degradable dietary protein and added fat. Rather than measure the reaction via milk fatty acids and milk composition, they chose to detect differences in milk and plasma urea nitrogen. Eight cows, evenly split between the Holstein and Jersey breeds, were fitted with ruminal and duodenal cannulas to determine these related effects. When supplemental fat was added to the diet, dry matter intake decreased for both breeds. This decrease was equal to 7.7% in Holsteins and 5.4% for Jerseys. Possible reasoning for the decrease in dry matter intake was attributed to metabolic control of energy intake. Ruminal pH was similar among diets, except at 1600 h where Jerseys had a greater pH when fed a 41% RUP diet versus those fed 29% RUP diets, and in Holsteins at 2000 h where those fed additional fat experienced a lower pH than those not fed the supplemental fat. Volatile fatty acid concentrations were not different by breed or diet, except at 0800 h where Jerseys had a lower overall VFA concentration than the Holsteins. Both breeds showed a decreased valerate concentration on the 41% RUP diet. This lower concentration of valerate occurred at 0000 h in the Holsteins and between 2000 and 0800 h in the Jerseys. Holsteins fed the 41% RUP diet demonstrated lower isobutyrate levels from 0000 to 0800 h in comparison to those on the 29% RUP diet. The Jerseys were found to have a higher isobutyrate concentration than the Holsteins at 0400 and 0800 h. The researchers did note a breed effect at 0800 h ad 1200 h, where Holsteins were found to have higher milk urea nitrogen (MUN) concentrations in comparison to the Jerseys. Milk protein content was not affected by the diet, however some differences were found with response to fat and rumen undegradable protein (RUP). The percentage of milk protein in Holsteins was found to be lower when fed dietary fat versus those fed no additional fat. In comparison, Jerseys fed 41% RUP diets experienced a drop in milk protein content versus those on the 29% RUP diets. Based on the results of this study, researchers felt that there was an increased resistance of protein to ruminal degradation when the higher RUP diets were fed.

Overall, results of the studies reviewed indicate a breed difference in many aspects regarding supplemental fat and protein within the diet. Jerseys are realized to have a different concentration of fatty acids within their milk, having more short and medium chain fatty acids. This correlated directly to their varying response to fat supplementation. Holsteins also underwent changes in fatty acid composition, but in a way that was much different than that of Jerseys due to a differing fatty acid concentration. Both breeds did not appear to benefit in milk production or protein, with some increase in milk fat noticed. In addition, protein supplementation had a limited affect on milk composition, hinting at a possible higher resistance to degradation.

Environmental Impact

The environmental impact of the dairy cattle industry has recently become more highly scrutinized. With global warming on the horizon of many social and economic agendas, it is important for the dairy industry to be mindful of its environmental effects as well. With this in mind, sustainability and reduced pollution are increasingly significant when planning for the future of dairy farms. Related to these areas of impact are manure and gas excretions and the use of feed, water, land, fertilizers, and fuels. Determining the breed effects on each of these variables allows farmers to establish their future goals and to decide whether or not an advantage between the Holstein and Jersey breeds exists. The studies reviewed below relate to the concept of environmental impact within the dairy industry and related factors.

J. L. Capper and R. A. Cady (2012) performed a study with the objective of determining the environment impact of Jersey or Holstein cows in producing enough milk to yield 500,000 tons of cheese with and without the use of rBST. Their model used data from DairyMetrics, which included milk yield and composition, age at first calving, calving interval, and culling rate data from 2009. Each group used in the study included lactating and dry cows, bulls, and replacement heifers. Inputs used included feedstuffs, water, land, fertilizers, and fossil fuels. Waste outputs were manure and greenhouse gas emissions. It was found that an extra 957,000 pounds of Holstein milk would be required to produce 500,000 tons of Cheddar cheese than it would with Jersey milk, due to the higher nutrient density in Jersey milk. Jerseys were found to produce .125 kg of cheese per kg of milk versus just .101 kg in Holsteins. However, the Jersey cow averages a yield of 2.6 kg of Cheddar cheese each day versus 2.9 kg for the Holsteins. For this reason, more lactating Jerseys are needed to make up the difference. This need is somewhat alleviated by the .8 month younger age at first calving in the smaller breed. With a smaller mature weight of 454 kg in the Jerseys has an energy requirement of only 54 MJ/d compared to 76 MJ/d for Holsteins which, with the increased yield of cheese per kilogram of milk, reduces the nutritional energy requirement per kilogram of cheese. The reduced size of the average Jersey also gave an advantage in the total population mass over Holsteins (360,000 t vs. 484,600 t). The Jersey breed also showed to require 1,592,000 t less feed, 98,000 fewer hectares of land, and 252,000,000,000 less liters of water to produce the same cheese yield as the Holsteins. In relation to waste, it is believed that due to the higher nutrient density of Jersey milk, less water would be discarded in the process of making the cheese. The yield advantage from using Jersey milk to produce the cheese educed total nitrogen and protein excretion by 17,234 t and 1,494 t and included a 2,259,000 t decrease in total manure output versus the Holsteins. The total carbon footprint, expressed as the sum of carbon dioxide, methane and nitro oxide emissions, were reduced by 20.5% with the use of Jersey milk. The Jersey carbon footprint was 6,442,000 t per 500,000 t of cheese yield compared with 8,104,000 for the Holsteins. Due to the fact that nutrient density is unaffected by the supplementation of rBST, making the quantity of milk required the same. With this in mind, the use of rBST in the Jersey group would require 11.5% less feed, 12% less water, and 8.4% less land to produce the cheese. This can be compared to 7.4%, 9.6% and 6.5% decreases in feed, water, and land in the Holsteins with the use of rBST. Manure excretion was reduced 8.5% in the Jerseys and 7.3% in the Holsteins using rBST. Using rBST also resulted in a carbon footprint reduction of 10% in Jerseys and 7.5% in the Holsteins. The study was concluded with the opinion that producing Cheddar cheese using Jersey milk uses many fewer resources, has less waste, and a lower total environmental impact than the Holsteins.

A 2010 study by Knowlton et al. examined the manure nutrient excretion of both the Holstein and Jersey breeds, with the objective of evaluating the feces, urine, and nitrogen excretions produced by the two breeds. As anticipated, the Jersey cows consumed only 71% of the Holsteins cows and produced only 62% of the milk volume as well. The Jerseys had a lower body weight (426 vs. 629 kg), and the DMI per unit of BW was not much different between breeds (3.90 vs. 3.55%). The Jersey cows had a lower total manure excretion, which was proportional to their lower dry matter intake. The Jerseys also excreted 35% less wet feces and 28% less urine than their larger counterparts. Manure from the Jerseys was found to be drier than that of Holsteins, but not significantly so. The nitrogen intake was lower in the Jerseys, which resulted in a lower excretion of nitrogen in fecal and urinary expulsions. The intake, fecal, and urinary N levels were reduced 29, 33, and 24 percent in the Jerseys cows versus the Holsteins. Total manure nitrogen excretion was found to be 323 g/d for the Jersey cows compared to 456 g/day for the Holstein cows. The levels of milk nitrogen secretion were lower for the smaller breed, but were proportional to their nitrogen intake. With these breed differences noted, the Jersey cows were found to have much lower levels of excretions and thus, environmental impact.

Overall, the Jersey breed appears to have a hold on the advantage in environmental impact categories. While 91,460 more of them are required to produce the same volume of milk, they overcome this disadvantage due to their lower body weight and denser product. With less total milk yield needed, lesser feed consumption, manure excretion, water usage, land requirements, and fossil fuels required, the Jersey proves to have hold on advantages in all concerns for environmental impact when related to cheese yield. However, no studies were found to have compared the breeds in a similar way for fluid milk production instead.

Infection Reactions

Mastitis is one of the most prevalent and costly health factors on dairy farms. Subclinical mastitis may result in losses of $110 per cow, according to Steven Ott from

USDA. Bar et al. (2008) suggested that the average cost of a clinical mastitis is $179 per cow. These costs may add up very quickly, especially on farms of a larger size. There are many causes of mastitis, including E. Coli and Staph. Aureus, two potent infection causing organisms that impact profitability and may result in the systematic culling of animals if not controlled. The following studies were reviewed upon determining their relevance to this topic.

Bannerman et al. (2008) examined the immune responses of both Holstein and Jersey breeds to Escherichia coli intra-mammary infections. 188 colony-forming units (CFU) were infused into a single quarter on 10 Holstein and 10 Jersey cows. Six hours after the initial infusion, E. coli was successfully recovered from 90% of the quarters exposed to it. E. coli was continually recovered from quarters between 12 and 42 h after the initial exposure. Ten days after initial infusion, all of the Holstein and nine of the Jerseys were clear of the infection. During the study, bacterial concentrations of infected quarters were similar in Holstein and Jersey cows. Within 6 hours of exposure, E. coli concentrations in the milk of the infected quarters were also similar between breeds. Overall milk production during the study was lower for the Jerseys, as expected. Decreased milk was found in Holsteins for 3 days following the initial infection. In comparison, the Jersey cows experienced decreased milk for 7 days following infection. In order to measure acute responses, body temperature, protein synthesis, and differential WBC counts were evaluated. Body temperature was found to be elevated for both breeds after infection, 12 to 24 h for Holsteins and 12 to 18 h for Jerseys. Both cows reached a similar temperature peak during the acute stage (39.59 vs. 39.57 degrees Celsius). Increases in SAA were detected earlier and for longer in the Holstein cows than in the Jerseys. In contrast to the Holstein reaction, Jersey cows had a 12 h delayed response for the increase of SAA and also showed a 24 h shorter duration for the increased levels. In both breeds, the same maximum SAA concentration increase was found to occur at 42 h after infection (251.81 vs. 232.35). Maximal concentrations of LBP were also detected at the 42 h mark as well, comparable between the breeds (493.84 vs. 474.67). Somatic cell count was determined before and after exposure to E. coli. Pre-infection SCC was greater in Jersey cows than Holstein cows (50,450 vs. 19,300). Increased SCC was detected between 6 and 12 h after infection within both breeds. Responses for SCC were similar for both breeds after infection as well. Post-infection SCC levels were elevated above pre-infected levels throughout the entire course of study. BSA levels were elevated 12 h after infection and were sustained at a higher level for 48 to 60h, and were comparable in both breeds. All of the cows developed clinical mastitis as a response to the E. coli introduction. While responses to the infection were similar, breed differences can be ascertained in the various response categories.

Bannerman et al. (2008) performed a similar study, instead evaluating the breed differences in relation to Staphylococcus aureus infections in the mammary system. The right front quarters of ten Holstein and ten Jersey cows were infused with 68 CFU of Staph. aureus. Staph. aureus was recovered from six Holstein and seven Jersey cows within 6 h of infusion, and was continually recovered from 18 to 120 h after. By 168 h and 240 h after infusion, only one Holstein and one Jersey cow were successfully able to clear the infection. The maximum concentration was found 18 h after introduction to the quarters in both breeds. Overall concentrations during the study were comparable between the breeds. Daily milk production was recorded before and after introduction of Staph. aureus. Milk production was higher in Holstein cows than in the Jerseys cows, which is accepted as normal. Milk production was extremely depressed in both breeds for the first two days after infection, but returned to normal levels around day three. On day ten and eleven, however, milk production was again found to be depressed in both breeds. Body temperature, acute phase protein synthesis, and differential WBC counts were evaluated. In this case, mean body temperature of both breeds did not fluctuate significantly from normal temperatures or exceed 39 degrees Celsius, indicating that no fever occurred. The infection did create synthesis of acute phase proteins, SAA, and LBP. Raised levels of SAA in the blood were found between 30 and 120 h after the initial infection. Maximal SAA levels in both breeds were found to be at 60 h after infection when average concentrations were 265 and 225 in Holstein and Jersey cows. Maximum LBP levels were detected in both breeds within 6 h of the initial increase, at levels of 119 and 88 for the Holstein and Jersey cows. A transient leukocytosis was found in both breeds within 30 h of infection, but the duration was longer in the Holstein cows and the magnitude of the response differed substantially from the Jersey cows. The overall neutrophil response accompanying the infection was higher in the Holsteins as well. SCC was also evaluated before and after infection. SCC was equivalent in both breeds prior to infection. Increases in SCC were observed after 6 h in both breeds, and remained from 18 h after infection through the end of the study. The overall responses in the area of SCC were similar, although the Holsteins exceeded Jerseys at 96 h and 240 h after initial infection.

A related study by Bitman et al. (1991) examined the lipid composition of teat canal keratin prior to and after milking in both Holstein and Jersey cows. In three separate experiments, keratin was taken from each individual teat on 40 Holstein and 20 Jersey cows before and after they were milked. Experiment three contained the Jersey cows. Keratin was weighed before and after milking. It was found that in both breed the amount of keratin collected after milking was less than before in all three experiments. A significant difference was found between breeds for the lost keratin amount during milking. Holsteins had an average weight of 3.1 mg of keratin before milking, but only 1.9 mg after milking. This, 39% of the keratin had been removed through the process of milking. For Jerseys, keratin weight averaged 3.5 mg before milking and 3.1 mg after, indicating that only 13% was lost. This was a significant change from the Holstein losses. Across all groups in the experiment, the neutral lipid concentration was 1.6 times larger prior to milking that afterwards. The researchers stated that this proved that while greater amounts of keratin was lost during milking, only a small amount of lipid was lost. No breed interaction was found for the concentration of neutral lipid of the total neutral lipid in each teat. However, Jerseys were found to have a higher amount of total lipid per teat than the Holsteins. The total pattern for lipid class order was similar for the Holstein and Jersey cows. The lipids in order of highest lipid concentration were TG, CHOL, FFA, CE, MG, and DG. TG, FFA, and CE are the lipid classes found to contain 95% of the fatty acids. All of the lipid classes experienced a change before and after milking, except DG. In Holsteins, TG accounted for 50% of total neutral lipid in keratin before milking, but was 62% after milking. A similar upwards change was noted in Jerseys, with TG increasing from 61 to 71% after milking. FFA and CE were also found in a higher proportion in the Holsteins than in the Jersey cows. When the TG:FFA ratio was assessed before milking, a breed difference was found as well. Jerseys had a ratio 2.2 times greater than Holsteins (6.0 vs. 2.7). After milking the difference remained similar, with Jerseys still 2 times higher than their larger counterparts. The keratin collected from Jerseys also had higher levels of SCFA than that collected from Holsteins. It was believed that the differences in keratin loss were due to the higher volume of milk exiting Holstein teat canals than in Jerseys. The higher fat content in Jerseys was also suggested as a possible difference, carrying a greater residual effect due to the higher lipid content.

Overall, significant differences were found in the reaction of the Holstein and Jersey breeds to infection. When the reaction to Staphylococcus aureus was examined, it was found that Jerseys tend to react for a short duration and had a less volatile response to the infection. In regards to Escherichia coli infections, Jerseys were actually found to have a longer reaction time with milk depression. Overall, both breeds experienced similar advantages in various aspects of both infection types. The largest difference was found to be in teat canal composition before and after milking. Jerseys were found to higher levels of keratin within each teat canal both before and after milking. In addition, a significantly less amount of keratin was lost during milk than in the Holsteins. It is possible that Holsteins pass a larger volume of milk through each canal during milking, removing a larger amount of keratin with it. The Holstein breed is commonly found to have higher incidence of mastitis, even with their generally lower SCC in healthy animals than in Jerseys. It is possible that the reasoning for higher mastitis rates, and as a result culling rates, is due the higher loss of keratin during milking. This exposes the udder to infection and bacteria at a higher level than in the Jerseys, as keratin is the protective barrier to the entrance of the teat canal. While it was difficult to find a breed advantage in reaction to several infection types, a clear advantage can be distinguished in the area of teat canal protection. This advantage is easily given to the Jersey cows.

Conclusion

Depending on the area examined, a clear breed advantage may or may not have been identified for the category as a whole. Jersey cows appeared to exert a clear advantage in the categories of reproduction, productive life and longevity, pasture based feeding systems, environmental impact, and in contribution to hybrid vigor. It did appear that the smaller breed was more susceptible to external factors, like stress from movement by humans or rBST in the presence of hot weather. Holsteins demonstrated an advantage in overall milk production, efficiency on TMR based diets, and in controlling the effects of outside stress factors like bST and handling in times of heat. Results of a study measuring the amount of milk lost by each breed in the event of pen moves, parturition, and the occurrence of other external factors causing stress would be interesting to compare. Even in categories where a breed advantage was not named, a significant difference was found between Holstein and Jersey cows in nearly every item compared. It is clear that while the two breeds belong to the same species, they react in uniquely different ways.

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