Comparisons of Holsteins with Brown Swiss and Jersey Cows on the Same Farm for Age at First Calving and First Calving Interval

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ABSTRACT

Our objective was to evaluate breed differences for heat-stress resistance as reflected by age at first calving and first calving interval. We examined the effect of geographic location and birth season on age at first calving, and geographic location and first calving season on first calving interval on Holsteins and Jerseys, and Holsteins and Brown Swiss located on the same farm. We defined 7 regions within the United States: Northwest, Central north, Northeast, Central, Central south, Southwest, and Southeast, and analyzed 7 individual states: Ohio, Wisconsin, Oregon, California, Arizona, Texas, and Florida. Brown Swiss were older than Holsteins at first calving (833 ± 2.4 vs. 806 ± 2.0 d in regions, and 830 ± 3.1 vs. 803 ± 2.4 d in states), but Holsteins and Brown Swiss did not differ for first calving interval. Jerseys were younger than Holsteins at first calving and had shorter first calving intervals. In data from individual states, Holsteins housed with Brown Swiss were older at first calving than were Holsteins housed with Jerseys (800 ± 2.7 vs. 780 ± 2.5 d). Holsteins housed with one breed or the other were analyzed as a separate data set, and referred to as “type of Holstein.” The interaction of “type of Holstein” with first calving season was highly significant for first calving interval. Geographic location and season effects were smaller for Jerseys than for Holsteins; thus, Jerseys showed evidence of heat-stress resistance with respect to Holsteins. Management modified age at first calving in Holsteins to more nearly match that of the other breed. Longer calving intervals might be partly due to voluntary waiting period to breed the cows.

(Key words: breed comparison, age at first calving, first calving interval, heat-stress resistance)

Abbreviation key: AFC = age at first calving, FCI = first calving interval, HB = farms with Holsteins and Brown Swiss, HJ = farms with Holsteins and Jerseys.

INTRODUCTION

Fertility in cows of all dairy breeds has diminished over time in the United States (VanRaden et al., 2003). Lopez-Gatius (2003) reported a similar fertility trend for Holstein cows in Northeastern Spain, but fertility was most affected under heat stress conditions at breeding. Heat stress disrupts reproduction in dairy cattle (Kadzere et al., 2002), and is a known problem in regions with warm or hot climates, especially if ambient humidity is also high. The United States has been subjectively partitioned to account for regional differences in production, reproduction, and health traits for genetic evaluations (Wiggans and VanRaden, 1991; Norman et al., 1995, 2000; Oseni et al., 2003; VanRaden et al., 2003; Zwald et al., 2003). VanRaden et al. (2003) divided the country into 5 regions for USDA evaluations of daughter pregnancy rates, and noted that the main differences in days open by month of calving occurred in the Southeast. Zwald et al. (2003) used a similar division for sire evaluations, but divided the Midwest and Southeast into Central north, Central, Central south, and Southeast regions. Cattle in these regions are likely to be subject to little heat stress year-round (Central north), heat stress during summers only (Central), heat stress with low humidity (Central south), and heat stress with high humidity (Southeast) (D. A. Wert, National Weather Service, Blacksburg, VA, 2004, personal communication).

Seasonal heat stress may have an impact on reproductive performance even in temperate regions. For example, Alnimer et al. (2002) found that pregnancy rate was higher for cows inseminated in winter (average daily ambient temperature of 10.9°C) than in summer (average daily ambient temperature of 20.2°C) using Italian data. The season of birth of the cow can affect milk production (Barash et al., 1996). Season of birth could also affect age at first calving (AFC) because energy requirements of the calf to maintain thermoneutrality increase with heat stress. At the same time, DMI diminishes. Such effects could delay onset of puberty and increase AFC (Fox and Tylutki, 1998). The effect of birth season on first calving interval (FCI) has not been reported.

Received June 15, 2004.

Accepted October 12, 2004.

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Table 1. Numbers of cows and herds in the Holstein-Brown Swiss datasets for analyses by region and state.

Regions	Cows			States	Cows		
	Holstein	Brown Swiss	No. of herds		Holstein	Brown Swiss	No. of herds
Northwest	467	141	8	Ohio	131	75	5
Central north	867	520	47	Wisconsin	234	211	18
Northeast	490	191	33	Oregon	344	109	3
Central	544	261	28	California	904	174	8
Central south	298	291	8	Arizona	2068	347	4
Southeast	152	67	10	Texas	282	285	6
Southwest	3335	649	16	Florida	98	31	2

Age at first calving and FCI impact profitability (Tozer and Heinrichs, 2001), but AFC has not been widely studied, even though there is evidence that it influences milk production and survivability (Durr et al., 1999). Rajala-Schultz and Frazer (2003), using data from Ohio, found that days from calving to conception increased in cows from 1992 to 1998, but remained stable for heifers. Age at first calving and FCI can be used to evaluate reproductive performance under heat stress.

Comparison of breeds for fertility is justified at an intraherd level because reproductive traits are highly influenced by management (Castillo-Juárez et al., 2000). In this study we used only farms with 2 breeds of cows, i.e., farms with Holsteins and Jerseys (**HJ**) and farms with Holsteins and Brown Swiss (**HB**).

The objective of this study was to evaluate breed differences for heat stress resistance by analyzing the effects of geographic location and birth season on AFC and the effects of geographic location and season of first calving on FCI on Holsteins and Jerseys, and Holsteins and Brown Swiss housed in the same farm. The United States was partitioned into 7 regions, and 7 states were studied individually for geographic location effects. Similar climatic conditions were assumed within regions or states, and cows of different breeds in the same farm were assumed to face the same environmental conditions.

MATERIALS AND METHODS

The USDA Animal Improvement Programs Laboratory provided data consisting of records with calvings from January 1, 1995 to June 30, 2001. Data from Brown Swiss and Jersey cows were merged with Holstein data when they had the same DHI herd codes. We also merged Brown Swiss or Jersey with Holstein cows when herd codes were different, but the farm address was the same. Two data sets resulted: one with HJ and one with HB farms.

The majority of the farms with 2 breeds had only a few cows of one of the breeds. For such farms, breed,

region, and season effects would be poorly estimated. Herd-year-season breed groups of 3 or more cows were required, but most of the farms included had more cows of each breed. Study of FCI requires cows that survive to calve a second time, whereas AFC only requires that cows calve once. In this study we used the same cows for both traits. The impact of requiring a second calving on AFC is unknown. The data used were restricted to cows with their first 2 calvings on the same farm with at least 310 d between calvings. Before edits, the data included 178,090 cows in 1387 herds with Holsteins and Brown Swiss with at least 5 cows per breed. These farms had only 5.2% Brown Swiss cows. After edits, records from 8273 cows in 150 HB farms remained, with 25.6% of the records from Brown Swiss cows. There were 222,528 cows in 2117 HJ farms with 12.8% of Jersey cows before edits, and 17,492 cows in 219 farms with 38.2% Jerseys after edits.

In a preliminary study, we fitted birth season and birth year for analysis of FCI. We found that birth season did influence FCI, but through an indirect relationship to season of first calving. Season of birth influenced insemination season, but conception season determined calving season. We chose to report only the effect of first calving season on FCI.

The states included in this study from the 7 regions of Zwald, et al. (2003) were:

1. Northwest: Idaho, Washington, and Oregon,
2. Central north: Michigan, Wisconsin, Iowa, Minnesota, and South Dakota,
3. Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Delaware, Maryland, and Vermont,
4. Central: Ohio, Indiana, Illinois, Kansas, Nebraska, Missouri, Kentucky, Tennessee, Virginia, and West Virginia,
5. Central south: Texas, Oklahoma, and Louisiana,
6. Southeast: Florida, Georgia, South Carolina, North Carolina, Alabama, Mississippi, and Puerto Rico.
7. Southwest: Colorado, New Mexico, Arizona, Utah, and California.

Table 2. Numbers of cows and herds in the Holstein-Jersey datasets for analyses by region and state.

Regions	Cows		No. of herds	States	Cows		No. of herds
	Holstein	Jersey			Holstein	Jersey	
Northwest	1384	370	19	Ohio	123	96	6
Central north	501	334	29	Wisconsin	161	86	12
Northeast	1181	546	59	Oregon	416	231	13
Central	964	517	32	California	4513	2095	34
Central south	312	243	14	Arizona	713	1829	2
Southeast	955	585	22	Texas	209	129	10
Southwest	5518	4082	44	Florida	435	204	4

Seven states were analyzed separately for each data set: Wisconsin, Ohio, Oregon, California, Arizona, Texas, and Florida. These states were chosen because they have temperate, warm-humid, and warm-dry climates, and both types of farms, i.e., HB and HJ, with reasonable numbers of Brown Swiss and Jerseys, and contained about 64% of the data. The number of herds and cows per region and state are presented in Tables 1 and 2, respectively.

Analyses were performed on each breed combination data set separately. The model was:

$$Y_{ijklmn} = \mu + b_i + r_j + s_k + br_{ij} + bs_{ik} + yr_l + h(r)_m + \varepsilon_{ijklmn}$$

where Y = age at first calving or FCI, μ = the general mean, b = breed, i.e., either Holstein and Brown Swiss, or Holstein and Jersey, r = geographic location, i.e., either regions or states, s = birth season of the cow when analyzing AFC, or first calving season, when analyzing FCI. Seasons were defined as spring (March–May); summer (June–August); fall (September–November), and winter (December–February), yr = year of birth of the cow for the analysis of AFC, or year of first calving for the analysis of FCI, h = herd, nested in r , and ε = the residual, assumed $\sim N(0, \sigma^2)$.

An additional data set with Holsteins from both types of farms was created and analyzed for the states with the same model, but with herd nested in state by “type of Holstein” (Holsteins in HJ farms and Holsteins in HB farms).

Data were analyzed using the MIXED procedure in SAS (SAS Institute, 1999), with the probability differences between least square means tested using the Tukey-Kramer option.

RESULTS

General P values of the analyses are mentioned at the beginning of each section. The specific probability differences between breeds, within regions or states, and within seasons are presented in Tables 3 to 8. The

P values obtained between regions or seasons, within breeds, are mentioned when appropriate.

Holstein and Brown Swiss

Age at first calving. In the analysis by regions, breed, geographic location, and the interaction of breed by geographic location were significant ($P < 0.01$). Birth season was not significant ($P = 0.11$), but breed by birth season ($P = 0.01$) was. In the analysis by states, all the effects were highly significant ($P < 0.01$). At first calving, Brown Swiss were older than Holsteins. Table 3 shows that breed differences were not significant in the Northwest, the Southeast or for the herds in Oregon, Arizona, and Florida. Table 4 shows that Brown Swiss were 18 to 25 d older for AFC than Holsteins for birth seasons other than fall. For cows born in fall, the differences between breeds were 36 d in regions and 43 d in the states, making the interaction of breed by birth season significant.

First calving interval. In the analysis by regions, the effects of geographic location and first calving season were highly significant ($P < 0.01$). The maximum FCI occurred in the Southeast and when cows calved in spring, and the minimum in the Southwest and when cows calved in fall. Breed and the interactions of breed by region were not significant. Breed difference approached significance in the Southeast ($P = 0.08$), with 22 d shorter FCI for Brown Swiss than for Holsteins (464 ± 9.0 d for Holsteins vs. 442 ± 10.8 d for Brown Swiss). In the analysis by states, the effects of geographic location ($P < 0.01$), first calving season ($P < 0.01$), and the interaction of breed by first calving season ($P < 0.01$) were significant. The shorter FCI of Brown Swiss relative to Holsteins approached significance for cows first calving in summer ($P = 0.07$), and in Florida ($P = 0.09$), with Brown Swiss having 27 d shorter FCI than Holsteins (436 ± 10.0 vs. 409 ± 15.8 d).

Holstein and Jersey

Age at first calving. In the analysis by regions, all the effects were significant ($P < 0.01$) except breed by

Table 3. Least squares means (SE) of age at first calving for breed by geographic location in Holstein-Brown Swiss herds in 7 regions and 7 states.

Regions	Holstein	Brown Swiss	P^1	State	Holstein	Brown Swiss	P^1
Northwest	795 (5.0)	809 (7.1)	0.75	Ohio	791 (9.9)	829 (10.8)	<0.01
Central north	803 (3.3)	838 (3.6)	<0.01	Wisconsin	800 (5.2)	822 (13.0)	<0.01
Northeast	802 (4.3)	832 (5.3)	<0.01	Oregon	815 (4.6)	831 (7.1)	0.65
Central	801 (4.2)	847 (4.8)	<0.01	California	820 (4.3)	862 (5.9)	<0.01
Central south	809 (5.7)	835 (6.5)	<0.01	Arizona	780 (1.8)	792 (3.6)	0.19
Southeast	819 (7.6)	834 (9.2)	0.96	Texas	811 (4.9)	836 (5.7)	<0.01
Southwest	812 (2.7)	833 (3.6)	<0.01	Florida	801 (8.2)	822 (13)	0.96

¹ P values defining the significance of difference between least squares means of breed, by region or state, using Tukey-Kramer tests.

geographic location ($P = 0.07$). Jerseys were younger than Holsteins at first calving in all regions. The differences were significant in the Central ($P = 0.04$), Central south ($P < 0.01$), and Southeast regions ($P = 0.02$); all of which are areas where heat stress is more likely. In the analysis by states, all the effects were highly significant ($P < 0.01$). Jerseys were younger at first calving than Holsteins in all states, except in Arizona, but the differences were only significant for the herds in Wisconsin ($P = 0.03$), California ($P = 0.03$), and Florida ($P = 0.02$). Table 5 shows that Jerseys were younger than Holsteins for all birth seasons in regions and states. Differences between breeds were significant ($P < 0.01$) for cows born in summer (regional data) or born in summer and fall (state data).

First calving interval. For the analysis by regions, all the effects were highly significant ($P < 0.01$). Jerseys had shorter FCI than Holsteins in all the breed comparisons in this study (Tables 6 and 7). Table 6 shows that the differences between Holsteins and Jerseys were largest in the Central south (35 d) and Southeast (26 d), when Holsteins increased FCI more than Jerseys. First calving interval was longest for both breeds in Central south. For the analysis by states, the effects of breed, geographic location, and first calving season were highly significant ($P < 0.01$), as well as the interaction of breed by first calving season ($P = 0.02$). Only the interaction of breed by geographic location was not

significant ($P = 0.12$). However, differences between Holsteins and Jerseys were significant for California, Florida, and Texas ($P < 0.01$), and approached significance ($P = 0.06$) for Arizona (Table 6). These cattle in these 4 states were more likely to have experienced heat stress at some point than the cows in the other 3 states. Jerseys had significantly shorter FCI than Holsteins for all first calving seasons in the analysis by regions, and for spring, summer, and winter in the analysis by states (Table 7).

Holsteins Housed with Brown Swiss and Holsteins Housed with Jerseys

We merged data from individual states from Holsteins housed with Brown Swiss and Holsteins housed with Jerseys to see if Holsteins performed similarly when managed with different breeds. For AFC, the effect of “type of Holstein” and the interaction of “type of Holstein” with birth season were highly significant ($P < 0.01$). Holsteins housed with Brown Swiss calved for the first time at older ages than did Holsteins housed with Jerseys (800 ± 2.7 vs. 780 ± 2.5 d, respectively). Table 8 shows that the maximum difference occurred in Arizona (46 d) and the minimum in Texas (2 d).

Holsteins housed with Jerseys usually had about a week shorter FCI than did Holsteins with Brown Swiss, but the differences between “types of Holstein” were

Table 4. Least squares means (SE) of age at first calving for breed by birth season in Holstein-Brown Swiss herds in 7 regions and 7 states.

Birth season	In regions			In states		
	Holstein	Brown Swiss	P^1	Holstein	Brown Swiss	P^1
Spring	805 (2.7)	829 (3.6)	<0.01	806 (3.2)	824 (4.5)	<0.01
Summer	807 (2.6)	829 (3.4)	<0.01	801 (3.1)	825 (4.3)	<0.01
Fall	802 (2.4)	838 (3.4)	<0.01	796 (2.9)	839 (4.4)	<0.01
Winter	811 (2.5)	835 (3.7)	<0.01	810 (2.9)	835 (4.5)	<0.01

¹ P values defining the significance of difference between least squares means of breed, by birth season in regions or states, using Tukey-Kramer tests.

Table 5. Least squares means (SE) of age at first calving for breed by birth season in Holstein–Jersey herds in 7 regions and 7 states.

Birth season	In regions			In states		
	Holstein	Jersey	P^1	Holstein	Jersey	P^1
Spring	814 (2.0)	806 (2.3)	0.07	782 (2.8)	781 (3.1)	0.99
Summer	812 (1.9)	797 (2.2)	<0.01	788 (2.9)	775 (3.1)	<0.01
Fall	803 (1.8)	797 (2.1)	0.23	784 (2.8)	772 (3.1)	<0.01
Winter	811 (1.9)	809 (2.8)	0.45	787 (2.8)	784 (3.1)	0.98

¹ P values defining the significance of difference between least squares means of breed, by birth season in regions or states, using Tukey-Kramer tests.

not significant. The interaction of “type of Holstein” with first calving season was highly significant ($P < 0.01$). The interaction occurred because Holsteins with Brown Swiss had shorter FCI for the herds in Florida (2 d) and Wisconsin (14 d) than Holsteins with Jerseys.

DISCUSSION

Fox and Tylutki (1998) predicted increased AFC in environments with heat stress. Our study showed variable results for the Southern regions. These differences were probably due to the size of the dairy herds, different management systems, and to true breed differences. Jerseys can reach the minimum required weight for insemination at younger ages than other breeds (Badinga et al., 1985; Ruvuna et al., 1986; Graves, 2003). We observed this result mainly in the southern regions, suggesting heat-stress resistance for Jerseys with respect to Holsteins. Jerseys were significantly younger than Holsteins at first calving when they were born in spring, summer, and fall, again suggesting heat-stress resistance for Jerseys.

We also observed evidence of heat-stress resistance for Jerseys compared with Holsteins for FCI, as the difference between breeds was greater in the southern areas of the country. Our results agree with VanRaden et al. (2003), who found that Jerseys had higher pregnancy rates than Holsteins or Brown Swiss. Our results are also in accordance with Ruvuna et al. (1983), who

reported longer days open for Holsteins than for Brown Swiss or Jerseys or their crosses, particularly in the warm season. Badinga et al. (1985) compared Holsteins, Brown Swiss, and Jerseys and found higher conception rates and fewer services per conception for Jerseys in Florida. Campos et al. (1994) reported higher fertility for Jerseys than for Holsteins in Florida.

Correa-Calderón et al. (2004) concluded that Brown Swiss showed evidence of heat-stress resistance when compared with Holsteins. In our results, Brown Swiss were older at first calving than Holsteins, regardless of region or season. This may be for a reason other than lack of heat-stress resistance. Pirlo et al. (2000) reported average AFC of 995 d from 1972 to 1995 for Brown Swiss in Italy, which is much higher than in the present study. Older AFC for Brown Swiss could be due to rate of maturity, independent of heat-stress resistance. Perhaps the genetic capability of Brown Swiss and management decisions could be confounded, as Brown Swiss have been reported to grow as fast as Holsteins (Ruvuna et al., 1986). Management effects must be important for AFC, because differences between Holstein and Brown Swiss were maximal in California (42 d) and minimal in Arizona (12 d). Brown Swiss had shorter FCI than Holsteins in the regions most likely to produce heat stress, but the differences were not significant. Possibly the small numbers of Brown Swiss reduced our ability to detect significant differences.

Table 6. Least squares means (SE) of first calving interval for breed by geographic location in Holstein–Jersey herds in 7 regions and 7 states.

Region	Holstein	Jersey	P^1	State	Holstein	Jersey	P^1
Northwest	414 (4.7)	400 (5.1)	0.15	Ohio	421 (9.0)	405 (9.6)	0.95
Central north	414 (4.7)	390 (5.1)	<0.01	Wisconsin	394 (7.7)	383 (8.5)	0.99
Northeast	409 (3.4)	399 (3.8)	0.71	Oregon	407 (5.7)	404 (6.2)	0.99
Central	423 (3.7)	402 (4.1)	<0.01	California	403 (2.6)	395 (2.9)	0.01
Central south	461 (4.9)	426 (5.6)	<0.01	Arizona	401 (9.1)	390 (9.1)	0.06
Southeast	439 (3.9)	413 (4.3)	<0.01	Texas	461 (5.8)	432 (7.1)	<0.01
Southwest	408 (2.3)	397 (2.5)	<0.01	Florida	446 (4.2)	424 (5.6)	<0.01

¹ P values defining the significance of difference between least squares means of breed, by region or state, using Tukey-Kramer tests.

Table 7. Least squares means (SE) of first calving interval for breed by first calving season in Holstein–Jersey herds in 7 regions and 7 states.

First calving season	In regions			In states		
	Holstein	Jerseys	<i>P</i> ¹	Holstein	Jerseys	<i>P</i> ¹
Spring	424 (2.0)	401 (2.3)	<0.01	418 (2.9)	397 (3.1)	<0.01
Summer	421 (2.5)	402 (2.7)	<0.01	417 (3.3)	402 (3.5)	<0.01
Fall	424 (1.9)	410 (2.2)	<0.01	423 (3.0)	415 (3.5)	0.45
Winter	427 (2.2)	402 (2.6)	<0.01	417 (3.0)	404 (3.4)	0.01

¹*P* values defining the significance of difference between least squares means of breed, by first calving season in regions or states, using Tukey–Kramer tests.

The Southwest included the largest number of cows of all regions for both HJ and HB herds. For the Southwest, AFC and FCI for both pairs of breeds were similar to northern regions, suggesting effective implementation of heat abatement procedures. Ray et al. (1992) reported that management practices had improved in Arizona. This state had the lowest AFC and FCI in both types of farms. Cooling techniques that involve sprinklers and fans are more effective in dry than in humid conditions and could be successfully used in Arizona.

Fertility is curtailed under heat stress (Jonsson et al., 1997; Kadzere et al., 2002) and insemination dates are influenced by calving dates. In frequency analyses not shown, we found that most first calvings occurred during the fall, followed by spring or winter, depending on region. Apparently the season to avoid for calvings was summer, especially for the southern regions. VanRaden et al. (2003), in a study of regional effects on days open in Holsteins, showed that days open fluctuate more across months of calving in the Southeast than in the other regions. Thus for some months, days open in the Southeast is lower than in any other region. This result indicates beneficial effects of voluntary management of days open (Oseni et al., 2003), and as a consequence, of calving interval. Larger standard errors in regions or states most likely to produce heat stress were partly due to relatively low numbers of cows and to

seasonality of first calving seasons, and thus, of insemination seasons.

Both types of farms (HB and HJ) were in each of the individual states analyzed. Thus, the differential behavior of Holsteins when paired with Brown Swiss or Jerseys was not the result of unequal distribution of the 2 types of farms throughout the country, but from homogenizing management decisions. Holsteins behaved like the breed with which they were paired, even when FCI was not significantly different between Holsteins from the 2 types of farms.

This study was concerned with breed differences for AFC and FCI, regardless of production level, pedigree quality, or the influence of other traits. Our purpose was to compare the behavior of 2 breeds per data set when they were subject to similar management decisions, under similar environmental conditions. Farms with relatively large numbers of cows of 2 breeds are rare in this country, but they are useful to study breed differences in routine management conditions.

CONCLUSIONS

Jerseys and, to a lesser extent, Brown Swiss showed evidence of heat-stress resistance in reproductive performance, relative to Holsteins. Longer calving intervals and older ages at first calving are not likely due entirely to effects of heat stress on fertility, but also to intentional extension of the voluntary waiting period to breed heifers or rebreed cows. Indirect evidence of heat abatement practices in some states was observed. Such practices can help reduce AFC and FCI, especially in regions with low humidity.

ACKNOWLEDGMENTS

The authors are grateful for financial support and data provided by AIPL, USDA. The senior author wishes to acknowledge partial financial support of Consejo Nacional de Ciencia y Tecnologia (CONACyT) Mexico.

Table 8. Least squares means (SE) of age at first calving for Holsteins housed with Brown Swiss (HB) or with Jerseys (HJ) in 7 states.

	HB Holsteins	HJ Holsteins	<i>P</i> ¹
Ohio	775 (11.9)	759 (8.9)	0.99
Wisconsin	802 (6.0)	775 (1.3)	0.16
Oregon	815 (4.8)	808 (5.7)	0.99
California	818 (5.4)	801 (3.1)	0.08
Arizona	780 (1.8)	734 (8.4)	<0.01
Texas	806 (5.6)	804 (5.3)	0.99
Florida	801 (8.2)	776 (3.5)	0.26

¹*P* values defining the significance of difference between least squares means of type of Holstein, by state, using Tukey–Kramer tests.

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