Holsteins in Puerto Rico: I. Influence of Herd, Year, Age, and Season on Performance[1]

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ABSTRACT

The effects of herd, year, age, season, and their interactions on milk and fat yield, fat percent, days in milk, days dry, and days open for purebred and high grade Holsteins in a tropical environment were determined by analysis of variance using DHIA records from Puerto Rico. There were 33,950 records for calvings from 1967 to 1973 in 62 herds. Herd effects were significant ($P < .05$) for all traits, but seasonal effects were significant only for milk yield, fat yield, and days open. Variation among herds significantly influenced all traits except milk yield. Age of calving affected all traits except lactation length and days open. A number of the interactions were also significant.

The statistical model explained 39, 40, 24, 17, 13 and 12% of the total variation in milk yield, fat yield, fat percent, lactation length, days dry, and days open, respectively. Total variances were 12,900,000 lb^2 for milk yield and 15,000 lb^2 for fat yield, which are comparable to those for temperate areas.

It is concluded that the factors affecting the performance of Holsteins in Puerto Rico do not differ markedly from those in temperate countries. The total variation appears large enough to permit selection for higher milk and fat yields. As in temperate regions, length of lactation, length of dry period, and time of rebreeding (days open) are largely influenced by decisions made on the part of herd owners.

INTRODUCTION

Whether dairying can be successful in the tropics remains an enigma. Some outstanding successes have been reported, but the objection is often raised that these come from government operated farms where conditions would not represent the general farming situation.

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There are numerous reports of *Bos taurus* breeds of dairy cattle failing to adapt to local conditions when imported into tropical areas. However, many of the experiments conducted with cattle imported to the tropics have done little more than test their ability to survive under low nutritional management (17). The opinion that improved dairy breeds are unsuited to tropical environments has led toward production of new strains of cattle from crosses of *Bos taurus* and *Bos indicus* types. The objective has been to produce animals adapted to local environments (12,15,19). This approach can be challenged because there is little evidence that measures of physiological adaptability, e.g., low respiration rate, are significantly correlated with animal performance (17).

In view of insufficient evidence to develop guidelines on breeding and management of dairy cattle in the tropics, it is especially appropriate to utilize records of performance of an improved *Bos taurus* type in a tropical environment, especially when collected from commercial dairy operations. This study deals with the effects of herd, year, age, and season on milk and fat yield, fat percent, lactation length, dry period, and days open of cows classified as Holsteins in DHIA herds in Puerto Rico.

PROCEDURE

The data consisted of 33,950 lactation records from 62 herds for cows calving from 1967 to 1973. Review of the records as received from USDA revealed it would be inappropriate to use all the records since biases in estimates of parameters would occur. To minimize biases the following restrictions were imposed: a) only lactation records coded as terminating normally would be considered; b) of these, 305 days would be the upper limit in length; and c) lactations of <60 days in duration would be excluded on the premise that environmental conditions occurring before or problems arising during parturition influenced the animal's health. These restrictions reduced the number of records to approximately 19,000 in 25 herds.

The statistical model used for the analysis of each trait was:

$$X_{ijklm} = \mu + H_i + Y_j + A_k + S_l + HY_{ij} + HA_{ik} + HS_{il} + YA_{jk} + YS_{jl} + AS_{kl} + HYA_{ijk} + HYS_{ijl} + HAS_{ikl} + YAS_{jkl} + HYAS_{ijkl} + e_{ijklm}$$

where,

X_{ijklm} = The observation of a trait on the mth cow in the lth season of the kth age group within the jth year and the ith herd;

μ = the population mean common to all records;

H_i = the deviation from the population mean resulting from the fixed effect associated with the ith herd;

Y_j = the fixed effect peculiar to the jth year;
A_k = the fixed effect attributable to the kth age group;
S_l = the fixed seasonal effect associated with the lth season;
HY_{ij} = the interaction between the jth year and the ith herd;
HA_{ik} = the interaction between the kth age and the ith herd;
HS_{il} = the interaction between the lth season and the ith herd;
YA_{jk} = the interaction between the kth age and the jth year;
YS_{jl} = the interaction between the lth season and the jth year;
AS_{kl} = the interaction between the lth season and the kth age group;
HYA_{ijk} = the interaction between the kth age, jth year, and ith herd;
HYS_{ijl} = the interaction between the lth season, jth year, and ith herd;
HAS_{ikl} = the interaction between the lth season, kth age, and ith herd;
YAS_{jkl} = the interaction between the lth season, kth age, and the jth year;
$HYAS_{ijkl}$ = the interaction between the lth season, kth age, jth year, and ith herd;
e_{ijklm} = the random error associated with each observation with expected mean zero and variance σ^2.

Since the model was multifactorial in design, herds with no representation in all subclasses were dropped to eliminate empty subclasses. This essentially removed herds with less than 100 records.

Years were divided into two groups; 1967-69 and later than 1969.

Age effects were examined in two classifications: <50 and >50 months.

Two seasonal classes were used, April-September and October-March.

The data were unbalanced in that unequal numbers of observations occurred in each subclass; thus, the method of unweighted means analysis was used (24,25).

RESULTS AND DISCUSSION

HERD EFFECTS

The averages for milk and fat yields and fat percentages varied widely among herds (table 1). The magnitude of the standard deviations indicates a wide variation among cows within herd for these traits. Herd effects were significant ($P<.05$) for milk yield, fat yield, and fat percent (table 2). The differences among herds may be partially explained on the basis of forage quality and quantity. In general, dairymen in Puerto Rico depend more on pastures as a source of feed than dairymen in cooler climates; however, differences in soils, temperature conditions, and precipitation existing in Puerto Rico are such that pastures may be adequate 3 to 4 months in some areas and in others up to 9 or 10 months (29). Rate of application of fertilizer and number of animals carried per unit of land also influenced the supplies of forages. Some dairymen depended largely on green chopped grasses or sugarcane as a source of

TABLE 1.—*Unadjusted means and standard deviations for milk yield, fat yield (in pounds), and fat percent for 25 herds*

Herd code	Milk yield		Fat yield		Fat percent	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
	Lb		*Lb*		%	
1	9517	2512	295	95	3.08	0.46
2	12067	3887	427	150	3.52	.41
3	10639	3758	356	132	3.34	.25
4	10505	2824	343	99	3.25	.22
5	12385	2970	398	108	3.21	.33
6	9251	2897	277	90	3.02	.39
7	7555	3388	244	110	3.26	.36
8	6277	3815	264	123	3.27	.28
9	9579	3702	321	134	3.34	.38
10	6662	3317	198	101	2.97	.33
11	8065	3577	266	121	3.32	.27
12	5313	2763	176	92	3.32	.25
13	5311	2391	169	77	3.18	.34
14	7715	3186	244	101	3.17	.20
15	5878	2609	187	86	3.17	.36
16	6430	2358	202	77	3.18	.37
17	7568	2697	238	88	3.15	.21
18	7823	3034	246	95	3.16	.21
19	7517	2739	240	101	3.32	.44
20	8061	2266	257	79	3.18	.39
21	5733	3412	189	114	3.27	.30
22	10014	3120	301	101	3.01	.35
23	8001	3491	242	106	3.08	.40
24	10364	2840	304	90	2.92	.37
25	8166	2919	246	95	3.01	.41
Overall	8457	3483	266	119	3.16	.37

forage instead of pastures, which no doubt contributed to herd differences. The usual rate of concentrate feeding was one pound per two pounds of milk, on a herd basis. Generally, all cows in milk received the same amount of concentrates each day; therefore, cows in early stages of lactation were sometimes grossly underfed. This was especially true during the poor seasons for pastures.

Herd size varied from about 40 to more than 300 cows. Based on experiences elsewhere (4,22), which showed a significant negative correlation between herd size and milk production, size of herd could have contributed to differences in herd performance.

The intensity of culling of cows also tended to vary among herds. A number of herds were in a stage of rapid expansion during the period of study. It was also evident that imported cows were frequently kept long after their peak years of production. In addition, several herds had problems with brucellosis that may have influenced length of lactation. Herd averages for fat yield tended to parallel milk yields, but herd averages for fat percent did not show a distinct relation to level of milk

TABLE 2.—*F-values from analysis of variance, tests of significance, and $R^2\%$ for the effects of herd, year, season, age, and the interactions*

Source	d.f.	Milk yield	Fat yield	Fat percent
		Lb	*Lb*	%
Herd (H)	24	67.86*	66.83*	26.43*
Year (Y)	1	3.55	26.45*	162.91*
Season (S)[1]	1	7.76*	5.83*	.28
Age (A)	1	125.24*	101.10*	9.16*
H × S	24	3.81*	3.78*	1.14
H × Y	24	14.99*	13.64*	12.74*
H × A	24	3.61*	4.28*	1.49
Y × S	1	.05	.06	6.14*
A × S	1	.40	.03	1.92
Y × A	1	7.66*	7.23*	1.88
H × Y × S	24	3.31*	3.30*	1.92*
H × A × S	24	.95	.84	.82
H × Y × A	24	1.62*	1.71*	.97
Y × A × S	1	.47	.18	1.07
H × Y × A × S	24	6.29*	5.96*	4.81*
Error mean square	10941	3,657,210	4,154	.006
$R^2\%$[2]		39.2	40.1	23.5

[1] Seasons: April to September and October to March.
[2] Squared multiple correlation coefficient.
* $P < .05$.

yield (table 1). In most herds the average fat percent was 0.3 to 0.5% below that for herds of Holsteins in temperate climates. Several factors no doubt contributed. The stress of high temperature (>85°F) often caused a suppression of appetite in the first month of lactation resulting in a rapid catabolism of body reserves that influenced the rate of fat secretion (18,20). Low roughage content of diets available in some herds, resulting from low yields of pastures, also caused fat percent to be less than normal.

YEAR EFFECTS

Year effects were significant ($P < .05$) for all three traits (table 2) which is in agreement with findings in both temperate and tropical areas (8,11,13,21,28,30). There was a consistent decline in the yearly averages from 1967 to 1970 (table 3). The tendency for yearly averages to decline was attributed to expansion in both the number of herds on DHIA and cows per herd. The low average for 1970 was due in part to serious floods in the main dairy region along the north coast. Increased rate of culling and greater dependence on concentrates to replace the destroyed pastures probably contributed to the rise in yields for 1971 and 1972.

It is possible, but unlikely, that the rate of importation of cattle could have affected yearly averages. Imports from 1967 to 1972 averaged about 1300/year (7), but the majority of the imports went to herds either not on DHIA at that time or those whose records were dropped during the screening process.

TABLE 3.—*Unadjusted means and standard deviations for milk and fat yield (in pounds) and percent fat by year of calving*

Year	Milk yield		Fat yield		Fat percent	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
	Lb		*Lb*		%	
1967	12692	2730	444	97	3.51	0.10
1968	10762	3716	367	128	3.40	.13
1969	9739	3639	321	128	3.29	.29
1970	7964	3700	255	121	3.22	.37
1971	8217	3647	255	123	3.11	.41
1972	8481	3082	264	99	3.13	.35

SEASONAL EFFECTS

Seasonal effects were significant ($P < .05$) for milk yield and fat yield but not for percent fat (table 2). The means and standard deviations by month of calving are in table 4. Although the four distinct changes in climatic conditions experienced in temperate regions do not occur in the tropics, two seasonal periods usually result from rainfall distribution, temperature changes, or a combination of the two. In the region where most of the herds were located, rainfall averages lower from mid-November to April than in other months. Even though the mean monthly temperature for the area was less than 6° F lower from December to February than for July, less rainfall, coupled with lower temperature, usually decreases the rate of growth of grasses up to 50% (29). Under reasonable grazing pressure the cooler season seemed to interfere with lactation yields less than in the period of high rainfall (April to August), as shown by the means of month of calving in table 4. A low dry matter content of the pasture forages, plus a lesser diurnal variation in daily temperature conditions which placed the cows under longer periods of temperature stress, appeared to be major inhibitors for cows calving from May through August (18,29).

The seasonal effects on milk and fat yields correspond to those observed in U.S. data (8), and the magnitude of the effects is large enough to warrant consideration for adjustment. Fat percent was less severely influenced by season than was milk or fat. Since the fat percent in all months is 0.3% or more below the characteristic value for the breed, it is evident that factors other than season of calving markedly influenced level of fat percentage.

TABLE 4.—*Unadjusted means and standard deviations for milk and fat yields (in pounds) and percent fat by months of calving*

Months	Milk yield		Fat yield		Fat percent	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
	Lb		*Lb*		%	
Jan.	8723	3694	277	125	3.18	0.35
Feb.	8320	3731	266	128	3.19	.35
Mar.	8606	3716	277	128	3.20	.39
Apr.	8523	3617	271	123	3.18	.39
May	8265	3606	260	119	3.14	.38
June	8380	3520	264	117	3.15	.36
July	8281	3289	266	110	3.20	.37
Aug.	8369	3610	271	123	3.23	.35
Sept.	8650	3912	279	136	3.22	.38
Oct.	8958	3639	288	125	3.20	.37
Nov.	8875	3599	284	123	3.20	.36
Dec.	8800	3575	277	121	3.16	.34

AGE EFFECTS

Milk and fat yields increased with age up to approximately 6 years, then declined (table 5). Age effects were significant ($P < .05$) for both traits (table 2). A significant association of age of calving with milk and fat yields has been found in both tropical and temperate areas (8,13,14,21,28,30,31). For example, Wunder and McGilliard (31) showed that 3-year-old cows produced more than 2-year-olds in about the same ratio as for Puerto Rico. Lush and Shrode (14) found that milk yield increased until the tenth year of age, then declined; but in Puerto Rico the decline came earlier, after the sixth year (table 5). However, a decline after the sixth year for Holsteins has been reported from temperate regions (2).

Fat yield did not decline until the ninth year, but fat percent was lowered after first calving. Corresponding observations have been made in the temperate region (2). Since the results from temperate areas are similar to those from Puerto Rico, it appears that changes in fat yield and fat percent are largely physiological traits which exhibit themselves irrespective of climatic conditions. A negative relationship between milk and fat percent similar to that reported from temperate areas (2,17) is seen in the Puerto Rico data.

TABLE 5.—*Unadjusted means and standard deviations for milk and fat yields (in pounds) and percent fat by age at calving (years)*

Age	Milk yield		Fat yield		Fat percent	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Years	*Lb*		*Lb*		%	
<2	5383	3164	178	108	3.32	0.30
2	7933	3128	255	106	3.23	.38
3	8111	3340	260	112	3.20	.35
4	8835	3595	282	121	3.17	.34
5	9159	3817	293	132	3.18	.38
6	9137	3870	288	132	3.16	.40
7	8864	3927	284	136	3.18	.37
8	8943	3905	288	136	3.20	.35
9	8620	3982	277	136	3.18	.32
10	8494	4079	273	136	3.21	.32
11	8523	3995	271	128	3.19	.31
12	8283	4400	264	147	3.10	.40

INTERACTION EFFECTS

Tests for the two-, three-, and four-way interaction effects showed that when herd was involved, the interactions were significant ($P < .05$), (table 2), especially for yield traits. The significant herd-year and herd-age interactions may have been due to variations among herds in culling rate or rate of additions to the herds. High supplementary feeding in some herds and not in others during some years-seasons would explain in part significance for the interactions.

Herd, year, age, season, and their interactions accounted for 39% of the variation in milk yield, 40% in fat yield, and 24% in fat percent as indicated by the squares of the multiple correlation coefficients R^2 (table 2). Components of variance, including herd, year-season, and month in one study in the United States (1), showed that without age effects in the model, 37% of the variation in milk and fat yields and about 25% of the variation in fat percent could be accounted for. In another study with a model that included herd, year, season, and age, 32% of the total variation in milk yield and fat yield and about 22% of that in fat percent was explained (8,26,27). Error variances of 36 to 52% have been reported with similar models (13,26). Total variance for milk and fat yields has tended to vary according to the population studied. VanVleck et al. (27) reported a total variance of 6,820,000 lb^2 for milk yield and 9,136 lb^2 for fat yield using only 305-day-lactation records. In the present study, the total variance was 12,980,000 lb^2 for milk and 15,000 lb^2 for fat. The higher values for variance no doubt were due in part to using a wider range in length of lactation (60 to 305 days) than used by VanVleck et al. Nevertheless, it is apparent that the amount of variation required for selection to be effective is present in the Holstein population of Puerto Rico. This is similar to the findings for temperate regions.

LACTATION LENGTH, DAYS DRY AND DAYS OPEN

Means and standard deviations for lactation length, days dry, and days open for the 25 herds are in table 6. Differences among herds were significant for all traits ($P < .05$), (table 7). Correlations of 0.50 to 0.60 between lactation length and yields of milk and fat occurred in both Puerto Rico (6) and elsewhere (17). Level of feeding is an important factor in length of lactation. Low levels of feeding prior to parturition bring about an earlier peak in daily yields and generally shorten the length of lactation (5,18). About 30% of the variation in the length of first lactation for Holsteins can be accounted for by variation in feeding (16).

Herd size does not appear to influence lactation length (4). Environmental factors have more influence on lactation length than genetic factors as indicated by heritability estimates (17).

Differences among herds in length of dry period may be caused by differences in level of feeding (17). That environmental conditions are the major causes for variation in length of dry period is supported by heritability estimates of near zero for this trait (17,23).

Differences among herds in days open could have been due to the relative importance given by herd managers to reproductive performance, i.e., due more to failure to detect estrus and breeding at the optimum time than to disease problems or heat stress.

The yearly averages for all herds (table 8) showed significant changes ($P < .05$), (table 7). Average lactation length tended to decline from 1967 to 1972 while days dry rose. The standard deviations increased from 1967 to 1972. No explanation can be offered for these trends; however, it was observed that length of time cows milked in first lactation declined after 1968 and so did the dry period following second lactation. This suggests that heifers were not grown out as well as in the earlier years.

Season of calving had a significant influence only on days open (table 7), whereas in temperate areas length of lactation was influenced by season of calving (5), and the month of calving significantly influenced length of dry period (23). Cows calving from May to October (table 9) were above average in days open, which agrees with findings from Florida (9) and Louisiana (5).

Age effects were significant only for days dry (table 7). There was a linear increase of days dry with age (table 10). In general, cows over 6 years of age had the longest dry periods. This is in agreement with results both from New York (23) and Venezuela (3), where age significantly influenced the length of the dry period. That lactation length and days open did not vary with age is in disagreement with some of the studies from the temperate region (5,10).

TABLE 6.—*Herd means and standard deviations for lactation length (days), days dry, and days open*

Herd code	Lactation length		Days dry		Days open	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	280	39.9	103	54.5	137	68.1
2	285	47.3	104	74.2	169	79.2
3	275	52.8	149	110.0	153	71.0
4	287	43.0	85	65.8	156	73.8
5	293	34.6	86	64.8	155	73.4
6	282	48.2	105	74.8	146	69.6
7	246	79.8	101	64.3	137	76.9
8	252	72.2	134	94.1	136	73.1
9	260	70.4	125	111.5	147	69.4
10	252	80.1	79	72.6	160	73.2
11	250	74.1	111	96.6	128	70.5
12	227	80.2	109	80.1	127	61.8
13	237	73.3	131	96.1	104	50.5
14	257	68.3	115	60.8	163	75.6
15	243	72.2	124	113.1	125	66.7
16	283	48.5	123	87.3	155	80.0
17	266	54.7	106	68.0	143	69.8
18	243	65.6	121	126.4	118	60.6
19	276	66.3	80	48.0	168	60.5
20	279	42.4	133	103.0	107	56.5
21	214	96.2	94	76.1	146	81.3
22	285	50.0	102	82.1	141	69.6
23	249	82.3	129	64.7	118	67.1
24	284	45.4	111	83.4	129	64.2
25	266	65.7	109	74.1	132	68.3
All	265	64.1	102	78.0	137	71.2

Herd-season, herd-year, and herd-year-season interactions were significant for lactation length, days dry, and days open (table 7). This suggests failure of adjustment on some farms to changes associated with seasons and years, especially to the managment of feed resources. The interaction of herd-year-age-season was also significant for the three traits.

The fitted model, with herd, year, age, and seasonal effects considered, accounted for 17, 13, and 12%, respectively, of the variation in lactation length, dry period, and days open, as indicated by the squared multiple correlation coefficients (R^2), (table 7). The heritabilities for these traits are small (17); thus the conclusion that environmental variation deter-

TABLE 7.—*F-values from analysis of variance and tests of significance for the effects of herd, year, season, age, and the interactions on lactation length, days dry, and days open*

Effects	d.f.	Lactation length	Days dry	Days open
Herd (H)	24	22.09*	5.19*	9.73*
Year (Y)	1	5.85*	14.98*	8.61*
Season (S)[1]	1	1.37	.80	13.94*
Age (A)	1	.35	22.76*	.47
H × S	24	4.52*	1.74*	1.91*
H × Y	24	9.45*	3.79*	3.96*
H × A	24	1.65*	1.54	1.49
Y × S	1	.07	.08	.26
A × S	1	.16	7.06	4.81*
Y × A	1	1.03	1.39	.03
H × Y × S	24	4.31*	2.30*	2.63*
H × A × S	24	1.29	.74	.71
H × Y × A	24	1.32	1.02	1.34
Y × A × S	1	.00	.00	.04
H × Y × A × S	24	6.47*	4.27*	4.65*
Error mean squares	10941	176	629	5851
R^2%[2]		16.8	12.7	11.7

[1] Seasons: April to September and October to March.
[2] Squared multiple correlation coefficient.
* $P < .05$.

TABLE 8.—*Means and standard deviations for lactation length (days), days dry, and days open by year of freshening*

Year	Lactation length		Days dry		Days open	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1967	296	15.8	96	76.7	171	89.5
1968	277	52.0	100	80.4	152	80.0
1969	273	55.1	89	81.2	165	82.2
1970	255	75.6	104	77.8	142	80.1
1971	262	67.4	118	95.5	148	80.9
1972	275	52.3	109	82.0	153	79.4

TABLE 9.—*Means and standard deviations for lactation length (days), days dry, and days open by months of freshening*

Months	Lactation length		Days dry		Days open	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Jan.	264	64.5	115	91.1	144	84.5
Feb.	257	69.8	114	89.1	148	85.4
Mar.	261	67.1	110	86.9	145	84.0
Apr.	262	67.6	115	83.3	146	87.2
May	259	73.1	111	77.6	151	85.4
June	264	65.1	119	91.0	158	84.6
July	265	63.5	109	82.4	159	77.5
Aug.	265	67.3	112	86.8	162	75.1
Sept.	265	66.8	107	86.1	159	75.9
Oct.	273	58.3	95	79.4	156	77.5
Nov.	272	56.8	97	79.0	148	80.1
Dec.	268	59.6	109	86.5	142	79.3

TABLE 10.—*Means and standard deviations for lactation length (days), days dry, and days open by age at calving (years)*

Age	Lactation length		Days dry		Days open	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Years						
<2	209	92.2	—	—	119	87.2
2	270	62.5	75	56.1	160	78.9
3	265	65.3	93	69.5	151	80.4
4	265	62.4	101	77.9	151	80.3
5	266	63.3	110	84.8	151	79.9
6	265	65.5	114	91.2	150	81.8
7	264	65.3	119	97.8	152	83.2
8	270	60.0	120	99.7	152	81.7
9	260	68.8	121	90.5	154	83.6
10	255	73.8	117	91.6	140	81.1
11	264	64.8	131	78.5	151	77.8
12	251	86.2	112	70.8	140	91.9

mines the expression of these traits more than genotype is justified. No doubt factors other than those examined influenced these traits.

Although it will be desirable eventually to make a study involving more herds over a longer time period, the results from the current study show that the influence of environment on the performance of Holsteins in Puerto Rico is relatively similar to that in cooler climates. The estimates of components of variance indicate that the influence of genotype is as strong in the tropics as in temperate regions, and the influence of the environment is neither more nor less.

RESUMEN

Se determinó el efecto del hato, el año, la edad, la estación y sus interacciones en la produccion de leche y grasa láctea, el contenido de grasa láctea, los días en producción de leche, los días en el período seco y los días en el período receptivo para vacas Holstein puras o de alto grado de pureza en un ambiente tropical mediante el uso de análisis de varianza. Se utilizaron alrededor de 1900 de los 33,950 registros de producción de leche completados en Puerto Rico por vacas Holstein en 62 hatos inscritos en la asociación para el mejoramiento de hatos lecheros del 1967 al 73. Los efectos del hato fueron significativos ($P < .05$) para todas las variables pero los efectos de la estación fueron significativos solo para la producción de leche, grasa y días en el período receptivo. La variación entre vacas influyó significativamente ($P < .05$) en todas las variables excepto en la producción de leche. La edad de la vaca al parir afectó todas las variables excepto la duración de la lactación y el período receptivo. Un número de las interacciones fue también significativo.

El modelo estadístico explicó el 39, 40, 24, 17, 13 y 12% de la variación total en la producción de leche, grasa, contenido de grasa, duración de la lactación, días en el período seco y en el receptivo, respectivamente. Las varianzas totales fueron 12,900,000 lb^2 para la producción de leche y 15,000 lb^2 para la producción de grasa, comparables a las de zonas templadas.

Se concluyó que los factores que afectan el comportamiento de vacas Holstein en Puerto Rico no difieren marcadamente de aquéllos en zonas templadas. La variación total es lo suficientemente amplia para permitir la selección de animales para una producción mayor de leche y de grasa. Al igual que en las zonas templadas, la duración de lactación y del período seco y el tiempo de días receptivos dependen mayormente de las decisiones de los ganaderos.

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