PREDICTION OF LACTATION PERFORMANCE FROM PREPUBERTAL SERUM STEROID LEVELS

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SUMMARY

Blood samples collected from 25 heifers at 100, 130, 160 and 190 days of age were analyzed for progesterone, androstenedione, testosterone, estrone and estradiol. The relation between steroid levels at each age and first lactation milk yield was assessed by linear regression analysis which showed day-130 androstenedione level to be the most highly correlated variable. Subsequently day-130 serum steroid levels in 99 heifers were studied and the relation to milk yield analyzed by multiple regression procedures, including breed as a variable. Although the data set was found to account for 22% (R^2) of the variation in 308-day 1st lactation mature equivalent, 18% was due to breed alone. Thus the reported usefulness of prepubertal steroid levels for predicting lactation performance was not confirmed.

INTRODUCTION

Several investigators have attempted to identify, in dairy heifers, phenotypic characters which correlate with subsequent lactation performance. Of the traits considered, which include mammary development (Tucker et al., 1973), body dimensions (Brum and Ludwick, 1969; Lin et al., 1985) and circulating steroid hormone levels (Allaire et al., 1981), only the last two have been reported to offer predictive value allowing early selection of calves for milk production. Brum and Ludwick (1969) reported early selection based on body measurements at 4 or 6 months of age to be nearly as accurate as selection based on milking records. Similarly, Lin et al. (1985) reported positive genetic and phenotypic correlations between prepregnant heifer body weights and first lactation production. Allaire et al. (1981) reported that progesterone and estrogen levels in prepubertal heifers are more highly correlated with first lactation milk yield than are body dimensions or pedigree.

It is difficult to perceive a physiological rationale for the relation between steroid levels in immature heifers and their first lactation milk production inasmuch as the low steroid concentrations in the preoubertal period would appear unlikely to influence mammary development or function. Nonetheless, the benefits of defining practical early selection criteria are compelling. Thus we were prompted to investigate more closely the posited relation and we attempted to confirm the reported correlation with a larger subject group, using a more detailed steroid profile which included androgen levels as well as the steroids measured by Allaire et al.

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MATERIALS AND METHODS

The heifers studied, all born in 1982, were from a Holstein line, an Ayrshire-based line and crossbred (McAllister et al., 1978). Blood samples (ca 30 ml each) were collected from 150 heifers when they reached the ages of 100, 130, 160 and 190 days of age. Although samples were also collected at 220 days of age, many animals showed signs of estrus by this time, which rendered questionable the relevance of steroid levels in these animals to anything other than the stage of the estrous cycle. Therefore, all the 220-day samples were discarded.

Experiment 1 was a survey to assess the possible correlations between steroid levels at different ages and first lactation milk production in 25 heifers for which complete first lactation records covering a wide range of yields were available.

In Experiment 2, the day-130 serum samples from the remainder of 99 heifers for which complete lactation records were available were analyzed. Blood samples from heifers which had short lactations for no apparent reason were included in this group. Estrone levels were not measured in this study because no estrone (i.e. less than 0.3 pg/ml) was detected in any of the 100 samples from the first 25 calves (i.e. in Expt. 1). Solvent extracts of the blood sera were chromatographically separated into progesterone, androstenedione, testosterone, estrone and estradiol fractions, which were then analyzed by specific radioimmunoassays using antisera raised in our own establishment. The resultant serum steroid data were subjected to linear regression analysis for each steroid, with respect to 308-day mature equivalent first lactation milk production.

The full set of day-130 steroid data and the corresponding 308-day ME milk yields were analyzed by a multiple regression procedure, treating milk yield as the dependent variable and steroid concentrations as independent variables and with the genetic line coded as a dummy variable.

RESULTS AND DISCUSSION

The results of Experiment 1 are summarized in Table 1. The progesterone levels were slightly higher than those reported by Allaire et al. (1981). No estrone was detected in any of the serum samples (and therefore not shown in the tables) and the estradiol levels at all ages were considerably lower than those found by Allaire et al. In contrast to the latters' findings, neither progesterone nor estradiol concentration, nor their sum, at any age, were correlated with milk production. Testosterone levels were also found to be unrelated to milk yield, but there was a significant negative correlation for day-100 and

day-130 androstenedione concentrations.

TABLE 1. Serum Steroid Levels at Different Ages and Correlation with Milk Production.

	Steroid Concentrations[a]			
Age (days)	Progesterone	Androstenedione	Testosterone	Estradiol
100	24.2 ± 3.7	32.7 ± 2.5	13.8 ± 1.5	1.1 ± 0.1
r =	-0.12	-0.42*	-0.03	-0.10
130	24.2 ± 3.2	37.3 ± 3.8	13.2 ± 5.0	1.2 ± 0.2
r =	-0.24	-0.45*	-0.12	-0.10
160	26.8 ± 3.0	42.4 ± 6.4	12.7 ± 1.4	1.2 ± 0.1
r =	-0.08	-0.31	-0.14	-0.07
190	34.2 ± 4.4	35.0 ± 3.2	13.0 ± 1.1	1.1 ± 0.1
r =	-0.03	-0.26	-0.08	-0.10
308-day ME milk production: 6328 ± 386 kg (1181 to 11,000)				

[a] pg/ml ± s.e.m, N = 25

* $P < 0.05$

In Experiment 2, only day-130 steroid levels were determined, inasmuch as the higher correlation was found for this sampling age in the first experiment. The steroid concentrations found (Table 2) were very similar to those found in Expt. 1, as was the range of milk yields. When these data were analyzed by multiple regression procedures which took into account breed effects, the complete data set was found to account for 22% of the variation in 308-day ME milk production. However, breed effects alone accounted for 18% of the variation (Table 2).

A literature search turned up only one previous report on androgen levels in prepubertal heifers: the testosterone level in 5 female veal calves, 13 weeks old, was reported to be 60 pg/ml of serum (Hoffmann and Rattenerger, 1977). The reason for the lower values found in the present study are not clear, although breed differences noted within our study (data not shown) suggest that different androgen levels may be expected in different breeds. Such was not the case, however, with respect to estradiol levels and the bases for the discrepancies between our findings and those of Allaire et al. (1981) are unlikely to be due to breed differences. The total estrogen levels reported by Allaire et al. in the first part of their study far exceed maximal physiological levels found in mature cycling cows. The peak estradiol levels found at estrus have been reported to be from 6-8 up to about 20 pg/ml with estrone levels of less than 2 pg/ml (Echterncamp and Hansel, 1971; Glencross et al., 1973; Peterson et al., 1975).

Even the lower estradiol values found in the latter part of the study of Allaire et al. approach normal estrous levels. The low estrogen concentrations found in the present study are more consistent with the minimal gonadal activity expected in immature animals and thus appear more reasonable.

TABLE 2. Relation of Day-130 Serum Steroid Levels and Breed Differences to Milk Production in Dairy Heifers.

Variable	Mean ± s.e.m.(pg/ml)	r	Variables Included in Model				
Breed	-	-	x	x	x	x	x
Progesterone	21.3 ± 1.3	0.02			x	x	x
Androstenedione	31.2 ± 1.7	0.02			x	x	x
Testosterone	14.9 ± 0.9	0.11		x		x	x
Estradiol	1.2 ± 0.9	0.05					x
R^2 for best fitting i-variable model			0.176	0.187	0.219	0.226	0.227

Allaire et al. put forward the argument that older (i.e. 300 day) heifers would constitute a more homogeneous group with respect to physiological maturity and therefore would be better experimental subjects offering better correlation with first lactation milk yield. However, such animals would be expected to be peripubertal and even if not seen in estrus at the time of blood collection, would be or should be suspected of having ovarian activity which would confound estimates of basal or prepubertal estrogen levels. The reported correlations therefore may have been entirely due to chance. Whatever the source or mechanisms responsible for the circulating steroids measured, the present study fails to confirm the premise of Allaire et al. (1981) that prepubertal steroid levels can be used to predict subsequent lactation performance.

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