EFFECTS OF HEAT STRESS ON DAIRY CATTLE PERFORMANCE. B. GENETIC ASPECTS

by

C. J. Wilcox
University of Florida
Gainesville, Florida

Surprising little is known on the degree to which the ability of individual animals to tolerate climatic stress is genetically influenced. There are differences among cows in nearly everything we can measure. We study these differences in order to reduce their detrimental effects, to devise management techniques to improve performance, and to develop genetic selection programs directed towards greater production. Final goal is greater profitability, either on an individual cow basis or on a total farm unit basis.

To study heat stress it is convenient to see how cows react ot changes in their climatic environment. Since this environment represents several things other than temperature, it perhaps is more proper to refer to climatic, rather than simply heat, stress. Discussion here, however, refers only to those climatic factors associated with hot climates. Florida is listed in most classification systems as being subtropical.

The cow adjusts to hot stressful conditions by changing her habits such as eating, drinking, walking, and seeking shade. These, and similar actions, are conscious changes because she is uncomfortable. Many other changes are not conscious, such as sweating, increased respiration, decreased rumen contraction, etc.

Her ability to change is called adaptation. She adapts as much as she can; if the stress imposed on her pushes her beyond her limit to adapt, in the ultimate, she dies. It is convenient also to divide the adaptation process into parts, realizing that our division is far from perfect.

Physiological adaptation involves those processes of the cow, conscious or not, which she performs to maintain her personal health and well-being and stay alive. They include many changes not mentioned, and indeed many which are either not known or little understood. Production adaptation involves those responses more related to the well-being of the herd owner, ie, milk yield and composition, growth, etc. These are, of course, under physiological control. To put this in proper perspective, the herd owner takes actions to reduce climatic stress as much as possible. He wants his animals to be comfortable, to maintain their general health, and to stay alive. The cows must, however, maintain their production performance during this time or he cannot afford to keep them. Unfortunately, physiological adaptation to climatic stress seems to be associated with lowered performance; hence it seems that the desired animal is one which has great ability to adapt physiologically while simultaneously maintaining productivity.

A clear example of this can be seen comparing the performance of Criollo and Brown Swiss herdmates in Venezuela. Data are from McDowell (1972). There is little interest in Criollo in Florida because of their low milk producing ability, but there is much interest in local cattle in tropical areas of the world because they are able to maintain rectal temperature, breathing rate and general well being under stress; they do this partly by eating less and giving less milk. They are physiologically adaptable but not production adaptable. The Brown Swiss, however, exhibits many signs of discomfort but maintains milk yield when stressed, but not nearly to the degree done by the native Criollo. In Table 1 is shown the decrease in milk yield with increasing temperature.

Temperature	Brown Swiss	Criollo
73.4 F	29.5 lb	18.1
75.2	29.1	16.8
77	28.9	16.1
78.8	28.7	15.9

Source: McDowell (1972). W. H. Freeman & Co.

Within this temperature range, the Brown Swiss declined less (.8 vs 2.2 lb., or 2.7 vs 12.2%). At even higher temperatures Brown Swiss declined more than Criollo in pounds, but less on a percentage basis.

Of direct interest to Florida is research completed on genetic aspects of climatic stress in Gainesville, with animals of five dairy breeds (76% Holsteins or Jerseys), by graduate students from two tropical areas, L. A. Rodriguez (Venezuela) and A. K. Sharma (India and Brazil). Climate during this research is shown in Table 2.

Table 2. Gainesville, FL Climate, 1959-1978.

MEASURE	MEAN	RANGE
Maximum temp.	80.9	49 - 97
Minimum temp.	57.2	21 - 75
Relative humidity	44.7	12 - 99
Solar radiation	447.1	164 - 756

We examined 17 measures of milk production performanc, counting milk yield, percentages and yields of constituents, titratable acidity, chloride content, and percent DNA reflectance, a measure of somatic cell count. Every measure of performance was affected by every measure (four) of climate studied.

Measures were on a within - cow basis and represented performance for 1 day; studied simultaneously were the stages of lactation and pregnancy. Effects of climate were quantified in two ways, the percent of the variability in performance associated with variability in climate, and the actual change in performance associated with changes in climate. The former gives an indication of sensitivity to climate (lack of ability to adapt); the latter gives an indication of economic loss to dairymen due to unfavorable climate and the amount which one could hope to recover by improving the environment.

In Table 3 are estimates of variances due to climate for Holsteins and Jerseys.

Table 3. Variation in performance due to climate.

Trait	Jerseys	Holsteins
Milk yield	2.1%	2.6
Fat %	10.2	5.1
Protein %	10.1	8.9
Chloride %	3.4	3.9
DNA reflect.	1.9	1.4

Source: Rodriguez and Wilcox (1977). University of Florida

These results, and others not in the table, suggest that Holstein milk yield is more sensitive to climatic stress than is Jersey, but Jersey composition is more sensitive. Both breeds' composition was more sensitive than yield.

Temperature effects on milk yield are slight when maximum temperatures fluctuate between 46 and 74 F. Slight declines appear at 75 F and above, but these are quite small until 85 F, at which time drops become appreciable. These results are based on about 18,000 samples and agree closely with climatic chamber studies based on just a few cows. Chloride content increased at temperatures above 70 F. This suggests a decline in lactose percent. Other percentages changed appreciable at 85%.

Decreases in Holstein milk yield approached 10% when maximum temperatures increased from 85 to 95 F, but Jersey losses were less than 2%. Jersey fat percentage decreased by about three times as much as did Holsteins, however.

Effects of maximum and minimum temperatures were about the same, with the latter becoming apparent about 24 F lower. The two measures are highly correlated, of course. Solar radiation ranged from 164 to 756 Langleys in our study. No effects on milk yield were apparent until radiation exceeded 200; at that point a steady decline occurred. In Jerseys, a 43% decline in yield was found if radiation reached 600. At mean radiation (447), loss in Jersey milk yield was 14% lower than at 200. Solar radiation was shown earlier to be slightly more important than temperature at the University of Florida in causing lower conception rates. It is obvious that it is a stressfull agent on yields as well; we are continuing our research in this area.

Losses due to humidity were surprisingly small. Very low and very high (rainy days) values were beneficial. Losses due to intermediate humidity were as much as 1.75 lbs. in Holsteins, but most of this was due to high temperatures rather than humidity alone.

In summary, climatic effects were shown to account for appreciable portions of the variation in milk composition and yield, as was well known. Maximum temperatures caused declines in yields at 80 or 85 F, and were drastic above 90 F. Jersey yields were less sensitive than Holstein yields to climate stress, but their milk composition was more sensitive. In both breeds, composition was more sensitive than yields. Solar radiation effects were real and measurable but small. Estimates now are available to assist dairymen in making management decisions as to the benefit available to them, with cows of different breeds, from altering the environment in which their cow live.