WIND CHILL FOR CATTLE[a]

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Summary

Cattle hides were exposed to cold-wind combinations ranging from -10°F to 35°F and 0 to 35 mph. Heat flow through hides (including hair) was measured and plotted as a function of wind velocity. Prediction equations for heat flow at different cold-wind combinations were formulated and compared with the human wind-chill index used by the U. S. Weather Bureau. Results indicate that wind-chill effects for humans and cattle are similar at low wind velocities (less than 25 mph) but differ at wind velocities greater than 25 mph. Over the range of wind velocities studied, a cubic relationship was found for cattle hides rather than the quadratic relationship of the human wind-chill index.

Introduction

Energy requirements of cattle during cold stress are increased by wind velocity (lowered effective temperature[1]). Recent attempts to account for increased maintenance costs during cold and wind have used the U. S. Weather Bureau wind-chill index. It is valid for bare skinned animals but its relevance to animals with external insulation (hair of cattle) is questioned. We attempted to test the validity of the U. S. Weather Bureau wind-chill index for cattle and to provide a prediction equation for cattle.

Experimental Procedure

A model system was used to determine rate of heat flow through cattle hides exposed to combinations of wind and cold. An insulated water bath maintained at 100°F was the "animal" heat source and hide sections represented animal insulatory barriers. Heat flow was measured by a RDF Model 20460 sensor placed between the water bath and hide. Wind velocity was created by a squirrel cage fan and controlled by a variable transformer. Freezers, coolers, and environmental conditions were used to obtain desired temperatures. A total of 140 observations was conducted on four cattle hides at temperatures ranging from -10°F to 35°F and wind velocities from 0 to 35 mph. All data were analyzed using regression analysis.

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[1]Effective temperature refers to the cooling or heating power of the environment and takes into account wet bulb temperature, radiation, and wind velocity in addition to dry bulb temperature.

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Results and Discussion

Heat loss from cattle exposed to cold is minimized by insulatory barriers. Cattle have tissue insulation (I_T), external insulation from hair (I_E), and the insulatory property of the air layer surrounding the animal (I_A). The insulatory barriers are additive so any factor that destroys or reduces one of the three reduces total insulation, increases rate of heat loss, and ultimely decreases production efficiency.

Air velocity increases heat loss by reducing insulation. The wind-chill effect results initially from reduced or destroyed I_A. With bare skinned animals, I_A is the only insulatory barrier affected by wind because I_E doesn't exist and I_T is not vulnerable to wind. Consequently, the effect of wind on I_A is responsible for the wind-chill effect for bare skinned animals. Human wind-chill indicies are shown in Figure 1a. The human wind-chill is quadratic with wind velocities above 30 mph having little added effect on the rate of heat loss. Since I_A is already destroyed, higher velocities have no additional effect.

When cattle hides where exposed to cold wind combinations using the model system described, air velocity increased the rate of heat loss. However, the rate of increase plotted as a function of wind velocity differed from that for bare skinned animals, assuming a cubic relationship (Figure 1b). Critical evaluation of the difference between the quadratic and cubic relationships for bare skinned and haired animals, shows that during low wind velocities (less than 25 mph) change in rates of heat loss are similar. However, at wind speeds greater than 25 mph, little additionaleffect is noted for the human wind-chill but substantial increases are measured for cattle hides. So when wind velocity exceeds 25 mph, wind-chill effects on cattle are different than for humans. This difference in wind-chill effect is explained by high velocity (greater than 25 mph) winds destroying I_E in cattle. The absence of I_E in bare skinned animals eliminates further insulatory destruction. Absolute heat loss is lower for animals with hair or fur in still air because of their greater total insulation.

Practical attempts to predict the cooling power of cold, windy environments for cattle with wind-chill indicies prepared for bare skinned animals are valid only at wind velocities less than 25 mph. Data presented suggest that wind velocities greater than 25 mph require wind-chill tables prepared specifically for cattle. To date, such equivalent temperature tables are not available. Until tables are available, those who use human wind-chill indicies are cautioned against underestimating the wind-chill factor for cattle exposed to wind velocities over 25 mph. In addition, the data suggest that management techniques that eliminate high wind velocities (greater than 25 mph) are more valuable than previously thought for cattle.

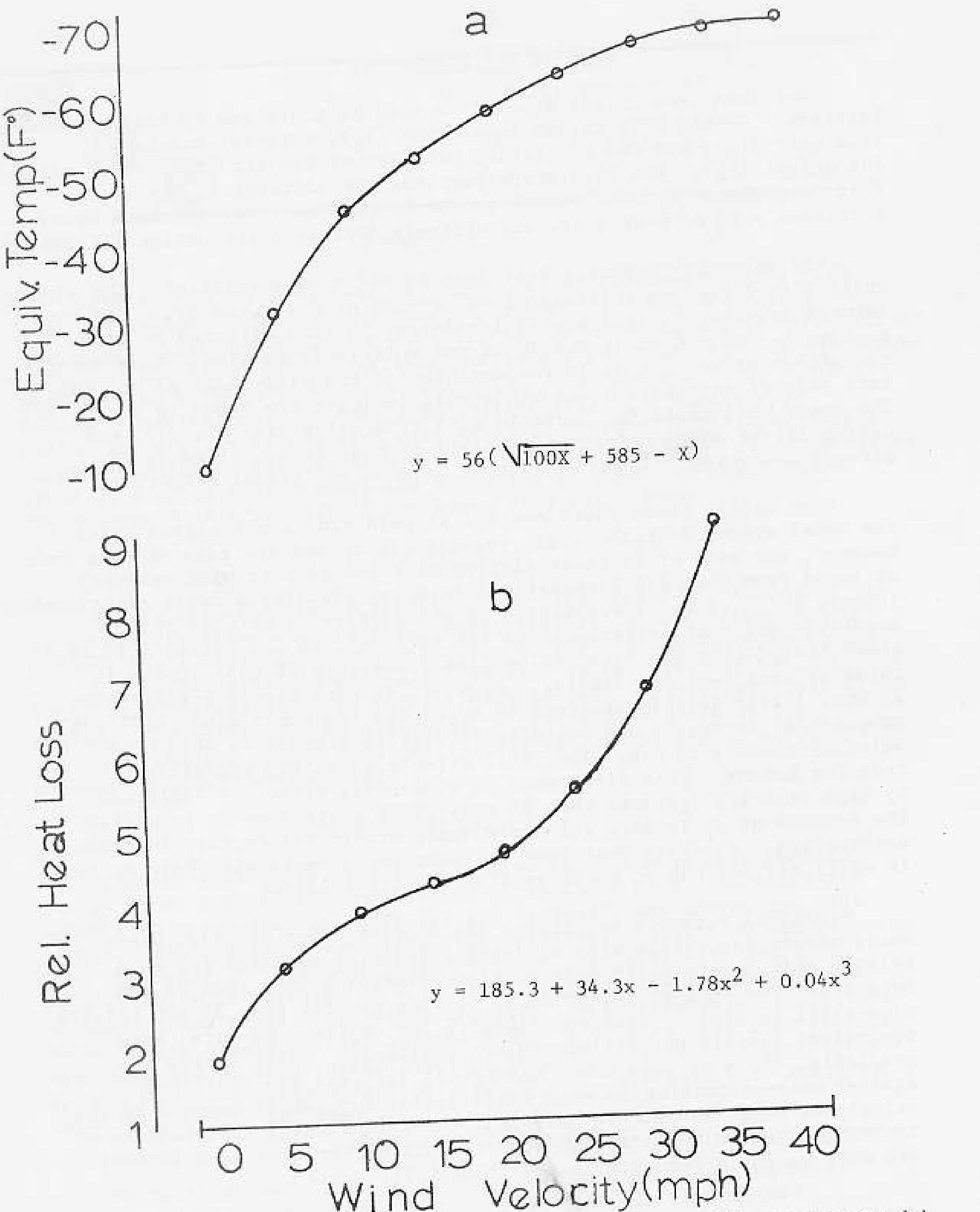

Figure 1. Wind-chill factor at $-10^{o}F$ for bare skinned animals (a) and for cattle (b).