Artificial Shades for Livestock

N. R. Ittner and C. F. Kelly

Following is a progress report of a coöperative study of the environmental factors influencing the development, production and health of animals in warm climates which was initiated in 1946 by the University of California, College of Agriculture and the USDA Bureau of Plant Industry, Soils, and Agricultural Engineering. The study is underway at the Meloland Field Station in the Imperial Valley.

Hot weather comfort for cattle may be considered an engineering problem in heat transfer.

There are four ways by which an animal can be cooled—convection, conduction, radiation, and evaporation.

Little heat can be lost by conduction from the animal because of the small area contacting the ground or floor.

Increasing heat loss by convection involves increasing the velocity or cooling of the air—an expensive process.

Increasing heat loss by evaporation from the skin which has been wet by sprays is being investigated.

Radiation seems most easily changed by artificial means—such as shades.

Shade Shelters

In the spring of 1947 five types of shelters were constructed at Meloland Field Station.

Four of these shade shelters—each 16′ by 24′ by 10′ high at the eaves—were for the purpose of testing the effectiveness of various materials in cutting off heat radiation of the sun.

The fifth shelter was of aluminum and was used to shade the working space in the corral, the squeeze chute, scale, etc. the roofs are gable with about an 18″ rise.

A brief description of each shelter follows:

1. Wood slat shade: The roof is of 1″ by 10″ boards spaced 1″ apart. The cracks run east and west. The floor is dirt.
2. Hay covered shade: The roof is about 6″ of coarse hay held in place between two layers of woven wire fencing. The floor under this shade is of concrete, with lines of 4″ drainage tile extending from end to end, each end opening into a concrete gutter. These tile lines are about 15″ on centers and about 7″ below the upper surface of the concrete.
3. Aluminum shade: The roof is of commercial standing seam aluminum sheets. The floor is of concrete, provided with a 2″ drain in one corner. Overhead, down the center of the shade, are several spray heads which may be used to produce a fine spray under the shade.
4. Galvanized iron shade: The roof is of old, corroded corrugated galvanized sheet iron, and the floor of dirt.

In June, 1947, the intensity of solar radiation under each shade was compared with that from the unshaded sky and sun by means of a flat plate radiometer—an instrument for measuring the total solar and sky energy incident upon a flat surface, developed by the Illumination Laboratory at the University of California.

In the radiometer tests, the hay covered shade cut off 1.7% more of the solar energy than did the aluminum shade, 2.3% more than the galvanized iron, and 8% more than the wood slat shade.

Shade Differences

There was a slight difference noted in the effect of ground radiation by the various shades: The hay and aluminum shades reduced the ground radiation 28% and the wood slat shade, 22%.

In August, qualitive measurements of radiation were made with a Hardy Dermal Radiometer. This instrument indicated a slightly different order of efficiency of the several shades in cutting off solar radiation, namely (1) aluminum, (2) hay, (3) wood slat, and (4) galvanized iron.

When an animal standing in the shadow of a shade is protected from the direct rays of the sun it is still receiving and giving heat by radiation from and to the surroundings. Observations in August, 1947, indicated that at times when the mid-day air temperature was about 100° F the temperature of the underside of the El Centro shades—the side radiating to the animals standing in its shadow—averaged, for the galvanized iron, 26° F above air temperature, for the aluminum shade 10° F, wood shade 9° F, and hay shade 5° F.

Herefords Studied

Between July 23 and September 15, 1947, three Hereford heifers were placed in the pens surrounding each of the four experimental shades.

They were fed fair quality alfalfa hay, a little cottonseed meal, with salt and water available.

The normal body temperature of a cow is between 101° F and 102° F while the comfort zone for respiration rate is between 20 and 50 per minute.

Between July 23 and September 3, 31 sets of body temperatures were taken on these heifers.

Body temperature averages were as follows: Hay roof, 103° F, aluminum roof 103.3° F, and wood slat roof 103.5° F. A wild heifer in the pen with the galvanized iron shelter prevented the collection of comparable body temperatures in the group.

The respiration rates of the heifers in all four pens averaged about 90 per minute.

The average rate of gain for all animals under the hay and aluminum shades again did a little better than those under the other two shades. Feed consumption

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Cattle lying in shadow of hay covered shade. Air temperature 102° F and ground temperature 99° F.

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followed the same pattern as the rates of gain. Salt consumption was normal in every case.

Ground Radiation

Ground heat radiation is of importance and must be considered in the problem of animal comfort in warm climates.

The flat plate radiometer indicated that in August, near mid-day, when the solar and sky radiation was at a maximum, the radiation from the ground to the under side of the cattle was from 50% to 60% lower. This was for areas of unvegetated hard ground away from the shade, no part of which had been in shadow during the day. The air velocity varied from 150 to 200 feet per minute.

Under the shades the radiation from the lower hemisphere—under the cattle—at the same time of day, was about the same as from the upper hemisphere—above the cattle.

The lowering of the temperature of the concrete under the aluminum shade by the water was of marked benefit in lowering the the amount of radiation.

On two adjacent plots, each 200 feet square, the air temperature over one—an alfalfa field—averaged 5° F lower at midday than over the second plot—plowed ground. The lower hemisphere radiation over the alfalfa plot was 30% as great as the upper hemisphere or sky and solar radiation, but over the plot of plowed ground it was 40%, as measured by the flat plate radiometer.

It may be possible to increase the animals' comfort by selection of the proper type of ground surface. For instance, at 11 a.m., on a day when the air temperature was only 89° F the following temperatures were observed in the sun:

Hard ground, tramped by cattle	124° F
Hard ground, in road	129° F
Soft ground, not tramped by cattle	132° F
Dry rotted manure in feed lot	148° F

Evaporation

Three shower heads were installed under the aluminum shade from July 28 to August 14. They gave a fine mist spray under 30 pounds pressure.

The cattle made little use of it and did not appear to be getting any beneficial effects from either the sprays or the wet floor.

From August 14 to September 14, only one shower head was used, but the hole was enlarged to give a coarse spray and the head brought down to within six feet of the floor.

The cattle began to make more use of the coarse spray and towards the end of the test one animal was using the shower as much as three hours a day.

Under the mist spray the animals got only a superficial dampening, but with the coarse spray they were wet to the skin. This soaking caused a decided drop in respiration rates and body temperatures. Wet animals quite often had body temperatures 2° to 3° lower than did dry animals and respiration rate drops of 20 or more per minute were noted a number of times a half hour after the cattle got wet.

Even when night temperatures did not drop below 80° F the heifers would not use the showers at night. Their use was confined to the late morning and most of the afternoon.

Convection and Radiation

Heat loss by convection and radiation in a given environment is also controlled by the surface temperature of the animal.

It is possible to approximate the heat interchange between an animal and its environment by using some of the data obtained as material for calculation. Calculating the net exchange by radiation we find that an unshaded cow is receiving 2,423 British Thermal Units more per hour than she is emitting, and that a cow under the shade is emitting 340 more BTU's per hour than she is receiving. It should be remembered that the situation has been idealized for calculation purposes by considering the cow as having flat surfaces.

Convection

An approximation of heat exchanged by convection also can be made by calculation.

The radiation and convection exchange can be summarized as follows:

Heat exchange	*Unshaded cow*	*Shaded cow*
By radiation (BTU per hour)	−2,423	+340
By convection (BTU per hour)	+1,856	+437
	−567	+777

The negative sign (−) indicates heat movement into the cow and the plus sign (+), movement away from the cow. The unshaded animal must lose a total of 1,344 BTU's more heat per hour than the shaded heifer, by vaporization—the sum of 567 and 777. This is equivalent to the evaporation of 1.3 pounds of water.

Studies to Continue

The investigations at Meloland Field Station will be continued in the summer of 1948.

A larger number of cattle will be available for the tests and more shades are being constructed.

The effect of shade size and height, louvres in the roof, cooling of walls and roof by evaporation, and the evaporative cooling of air, will be studied.

The subject of ground radiation will be given more attention.

A model weather station will be installed and the records obtained will allow for a correlation between the weather and the environment as modified by the shades.

The effect of radiation and air temperature on the surface temperature of the animals will be determined in greater detail.

N. R. Ittner is Associate in the Division of Animal Husbandry, Experiment Station, Imperial Valley Field Station.

C. F. Kelly is Agricultural Engineer, Bureau of Plant Industry, Soils and Agricultural Engineering, U.S.D.A. and Division of Agricultural Engineering, Experiment Station, Davis.

Cattle standing under shade covered with 1″ x 10″ boards spaced 1″ apart. Air temperature 103° F and ground temperature in shadow 104° F. In unshaded strips between board shadows, ground temperature was 148° F. High ground temperature may be reason for cattle not lying down.