A COMPARISON OF TEMPERATURE REGULATING ABILITIES
OF BRITISH VS. ZEBU CATTLE

by

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ABSTRACT

Hypothalamic cannulae were implanted in four female Zebu crossbred calves. The cannula equipped calves were pre-fitted with a hypothalamic thermocouple and physiological measuring equipment then subjected to a hyperthermal-stressful environment and data recorded. Results demonstrate the superior temperature regulating ability of Zebu animals and additionally show respiration not to be a primary factor in heat dissapation in large ruminants.

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To My Parents
Joyce and Charles Anderson

INTRODUCTION

In the United States, the beef industry primarily utilizes animals of either British or Zebu breeding in both the commercial and purebreed sectors respectively. Each breed group has advantages and disadvantages which are appropriate for different climates.

The British breeds, such as the Hereford and Angus, are typically the highest producers of quality meat; however, they are also most severely affected by high temperatures and humidity. As a result of their development in the cool climate of Northern Europe, they are well-adapted to temperature regimes found in Northern and Mid-western regions of America. Their utilization, however, in the tropical or semi-tropical climates of the Southern United States is usually at the cost of high production.

In sharp contrast, to the British breeds, animals of Zebu genotypes are well known for their ability to successfully inhabit areas of excessive temperature and humidity, such as the south and southwest. Having originated in India and other tropical/arid regions, Zebu breeds, such as the Brahman, traditionally produce a medium quality, lean, low-yielding carcass.

At present and in the recent past, crossbreeding programs have been undertaken in efforts to incorporate desirable qualities of the Zebu and British breeds. That is, to develop animals that will maintain good production in the tropics. The Santa Gertrudis and Brangus are examples of success with regard to these efforts.

The inherent ability to regulate internal body temperature is a major factor limiting total geographic utilization of cattle in the

United States. As a result, tests of temperature regulating ability of Zebu crossbred calves will be conducted and the data compared to previously collected information from British breed calves. The results of this study may allow the development of an optimum mixture of the different breeds of cattle.

LITERATURE REVIEW

TEMPERATURE REGULATION

Maintenance of internal body temperature is a fine balance between heat dissapation and heat conservation. [1]. Changes in metabolic state, environmental condition or both produce variations in the computor like regulatory mechanism. Failure of the body's temperature control centers causes hypothermia or hyperthermia.[2]

Hypothermia or a reduction of deep body temperature below normal, develops slowly as a result of exhaustion or inhibition of the metabolic cold defense mechanisms.[1] These mechanisms consist of heat conservation and production and include: (1) skin vasoconstriction; (2) shivering; and (3) secretion of norepinephrine, epinephrine and thyroxine.

Hyperthermia or elevated deep body temperature is characterized by alterations in the acid-base balance, dehydration, intravascular clotting and cerebral edema.[3] As a result of metabolic activity heat is being produced constantly in the body.[4] Exposure to external or environmental heat is additive to the physiologic heat.[4] There must therefore be some mechanism for heat dissapation; without which body temperature would rise to levels prohibitive to life. The physical methods available for heat loss include; (1) radiation; (2) conduction and convection; (3) vaporization of water from the skin and respiratory passages; (4) excretion of feces and urine. Under normal conditions about 75 percent of the heat lost from the body is dissapated by radiation, conduction and convection. The efficiency of these processes is reduced as environmental temperature and humidity increase.[1] As a result body temperature generally increases with an increased external heat load unless an adequate regulatory process exists [5].

Temperature Regulation in Cattle

In cattle, control of internal body temperature lies primarily in the hypothalamus located in the diencephalon or interbrain beneath the cerebral hemispheres [6]. The principle physiologic defenses against rise in body temperature are: (1) increased evaporation rate; (2) cutaneous vasodilatation; (3) increased heart rate; (4) panting; and (5) depressed appetite [4]. These defenses are mainly activated by increased blood temperature which signals the preoptic-anterior portion of the hypothalamus, (Stewart and Bailey 1972). The preoptic-anterior nuclei or "heat loss center" then solicits somatic responses via changes in blood hormones and nerve content [5].

In cattle, sweating is an efficient heat loss mechanism activated by wither an increase in skin warmth receptor or hypothalamic temperature[7]. In addition, panting or polypnea often occurs at high rectal temperatures and is effective in accelorating evaporative cooling in the upper respiratory passages of the bovine [3]. Cutaneous vasdilatation and increased heart rate serve to bring deep body heat to the surface for utilization in radiative and convective processes. Cattle experiencing heat stress normally show signs of depressed appetite in an effort to reduce heat generated by digestion [7]. There are distinct differences between Zebu or Brahman cattle and British breeds such as the Hereford and Angus with regard to temperature regulating abilities. Zebu cattle are known to be more adept at body temperature regulation because they are able to dissapate larger quantities of heat by way of evaporative heat loss [8].

This ability can be attributed to several phenotypic characteristics: (1) lightly pigmented skin; (2) greater skin surface area; (3) thin skin; and (4) large number and size of sweat glands [9]. This heat resistance depends, however, on an ample supply of water [8].

Hypothalamic Studies

Temperature regulation studies have been undertaken utilizing various temperature recording techniques, among these are those employing tympamic membrane temperature, determination of deep core temperature and rectal/colonic temperature determination [10]. However, with knowledge of hypothalamic regulatory centers, it became necessary to develop access to the hypothalamus. Recently, techniques for surgical access to the hypothalamus have been developed in laboratory animals which have subsequently been applied to large domestic animals.

Two models for hypothalamic access in cattle are available. The Hannah Dairy Institute model (1968), incorporates the use of a vital x-dimension and x-ray guidance to install a large water operated thermode in the hypothalamus. This procedure required a large craniotomy and the inserted apparatus causes considerable neural tissue destruction and subsequent death in 50 percent of the test animals [10].

Method B developed by Stewart and Bailey (1972), utilizes the Hannah x-dimension along with various precision methods, anatomical geometries and semi-stereotoxic devices to implant a 17-gauge cannulae. The cannulae is normally closed but openable for experimentation. This procedure allows for cannula installation in three (3) areas or nuclei of the hypothalamus.

Position 1 - preoptic-anterior

Position 2 - third/ventricle

Position 3 - ventromedial [10]

Animals cannulated by this method historically have a favorable survival rate with little effect from cannulae implantation

Environmental Input

There are two basic approaches to testing body temperature control mechanisms. (a) change the controller or hypothalamic temperature and observe the physiologic effects; or (b) change the environment and observe how equilibrium is re-established [11]. Previous studies at Texas A&M University have shown that the second method was easily developed and required less complex equipment although it did require an environmental chamber. In studies on British test animals it was reported that the test animal's rectal temperature rose substantially above hypothalamic temperature; after acutely raising the environmental temperature. Indicating a temporary regulatory disarray [12]. See Figures 1 through 5. This type of response had not been previously reported.

Justification

An animal model with pre-placed hypothalamic cannulae in cattle along with an environmental chamber could be utilized to test differences between breeds of cattle. Since Zebu cattle are known to be tolerent to conditions existing in tropical and subtropical climates, this model could be utilized in chosing animal types which would have the advantage of heat tolerance along with good meat production.

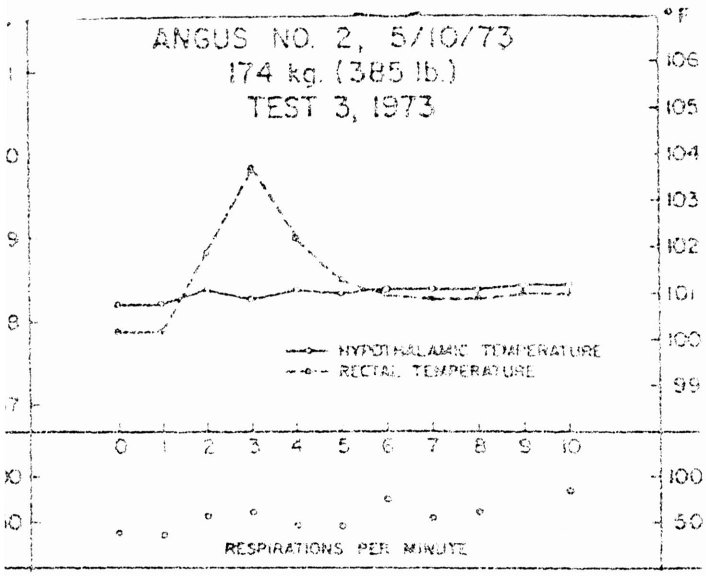
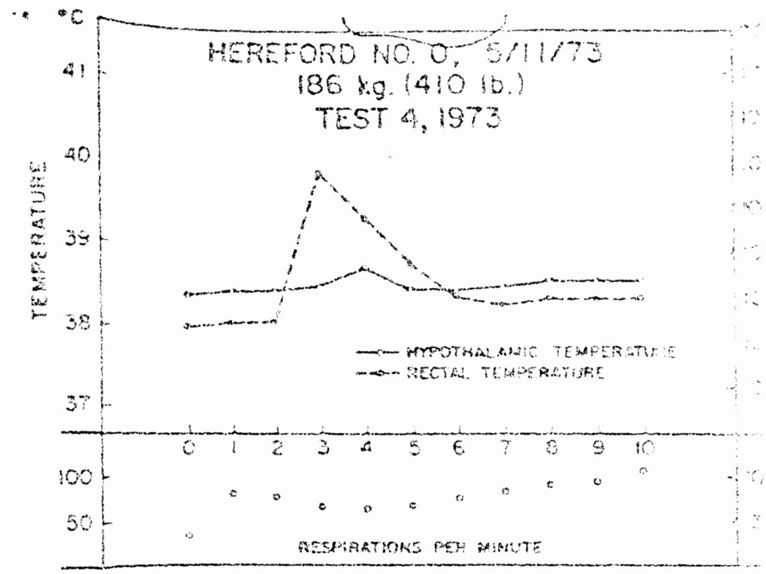


Figure 1



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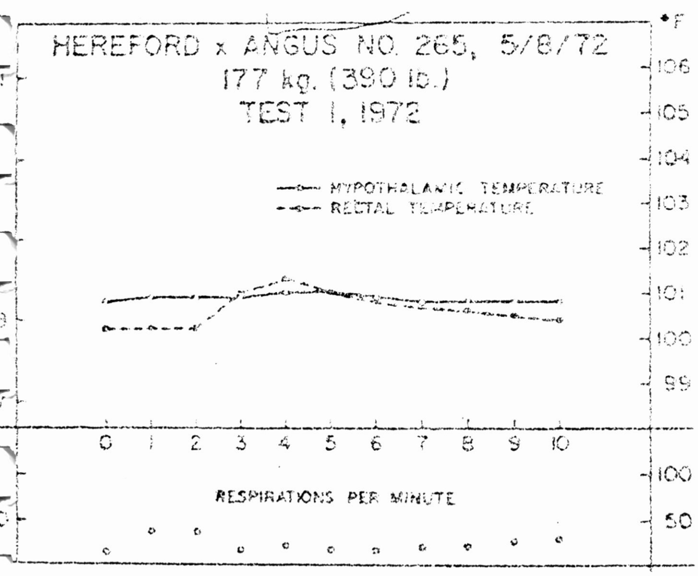


Figure 3

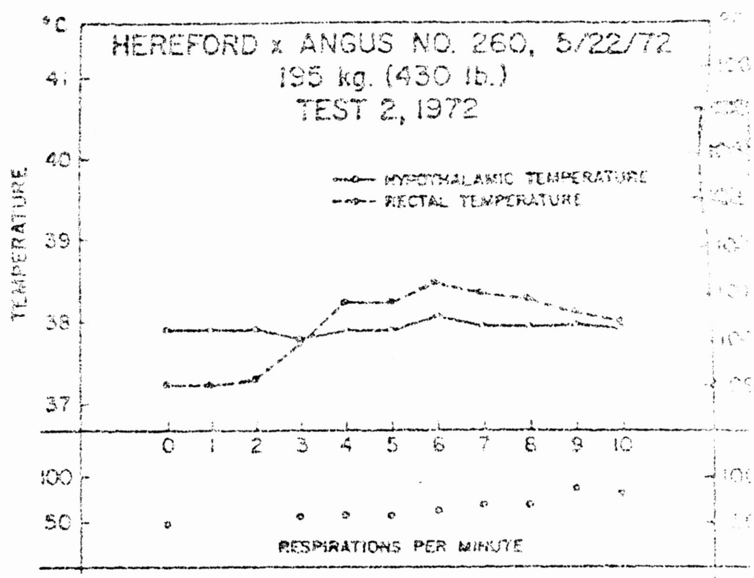


Figure 4

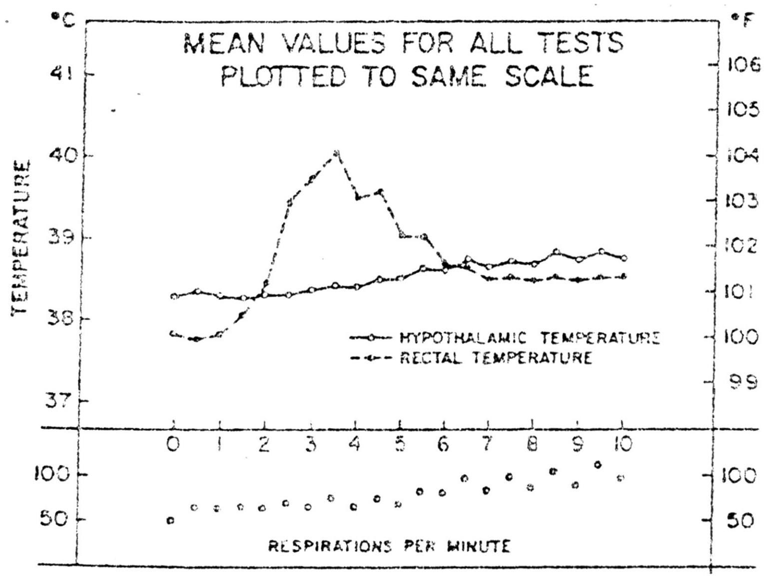

MEAN VALUES FOR ALL TESTS
PLOTTED TO SAME SCALE
°C
41
40
39
38
37
TEMPERATURE
°F
106
105
104
103
102
101
100
99
HYPOTHALAMIC TEMPERATURE
RECTAL TEMPERATURE
0 1 2 3 4 5 6 7 8 9 10
100
50
100
50
RESPIRATIONS PER MINUTE

Figure 5

MATERIALS AND METHODS

Animal Background and Care

Four female beef calves weighing between 113 and 201 kg were obtained from the Beeville Experiment Station of the Texas Agricultural Extension Service. The calves were of crossbred variety, containing between 1/8 to 1/4 Brahman and varying amounts of Hereford and Angus. The animals were kept in a fenced, well drained, one acre trap and provided a maintenance ration consisting of prairie hay, milo concentrate and water adlibidum. Limited grazing of native forage was available. After receipt, the calves were clinically evaluated and afforded a period of two weeks for stabilization.

Surgery

Candidate calves for cannulae installation were selected at random in weekly intervals and transported to a clean, well ventilated concrete stall. The animal was allowed no feed or water 36 hours prior to surgery. The calf was then weighed and .11 mg/kg xylazine pre-anesthic administered intramuscularly followed by 7 mg/kg thiamylal sodium intravanously, once the animal was secured in sternal recumbancy. The animal was intubated and maintained, on halothane administered via a circle type anesthetic machine with a precision vaporizer out of circle, for the duration of the procedure. The head was then placed in a semi-stereotoxic device, shaved and prepared aseptically. Cannulae were installed in positions 1 and 2 according to the procedures of Stewart and Bailey, (1972).

Post-Operative Care

The cannulae equipped calf was relocated in a clean stall and treated daily with furoxcin (Topazone) and 10 ml Benzathine Penicillen/Procaine Penicillen administered topically and intramuscularly respectively for 7 days. Following therapy and examination the calf was returned to pasture conditions.

Experimental Procedures

With the animal comfortably restrained in an environmental temperature chamber, the head was shaved and the area of the forehead scrubbed with benzalkonium chloride followed by repeated flushing with sterile physiological saline. Proceeding aseptically, the cannulae is opened and an ethylene oxide sterilized, 26-gauge, copper-constantan thermocouple inserted into position 1 and extended into the hypothalamic tissues 4 to 6 inches. In additon, 17-gauge hypodermic needles for use as subcutanious electrodes for physiologic data were inserted and a deep rectal probe introduced. All temperatures were recorded on a late model Honeywell potentiometer, with a printing interval of 5 seconds per point. Respiratory rates were detected using an impedence pneumograph and recorded by a recording ascillagraph (*). With the chamber closed and hypothalamic and rectal temperatures stabilized, the wet and dry bulb chamber temperatures were raised as rapidly as possible. The dry bulb temperature was stabilized within 5 to 7 minutes at approximately100°F, and data was recorded for 20 to 30 minutes. Following chamber temperature reduction, 100 mg chloroamphenical was injected into position 1 and the cannulae closed. In addition, 900 mg chloroamphenical was administered intravenously.

The animal was then returned to the pasture environment.

* PHYSIOGRAPH by Narco Biosystems., Houston, Texas.

RESULTS AND DISCUSSION

The environmental conditions developed in these studies were considered severe to animals with a large body mass. Consequently, these conditions were capable of testing the temperature regulatory ability of cattle.

The four cannulated animals were tested for their response to high temperature and humidity. The response observed were distinctly different from those reported in British breeds. (Figures 1-5). The phenomenom of temperature regulatory disarray marked by rise in rectal temperature above hypothalamic temperature was not observed in the trials. This is graphically represent in figures 6-9.

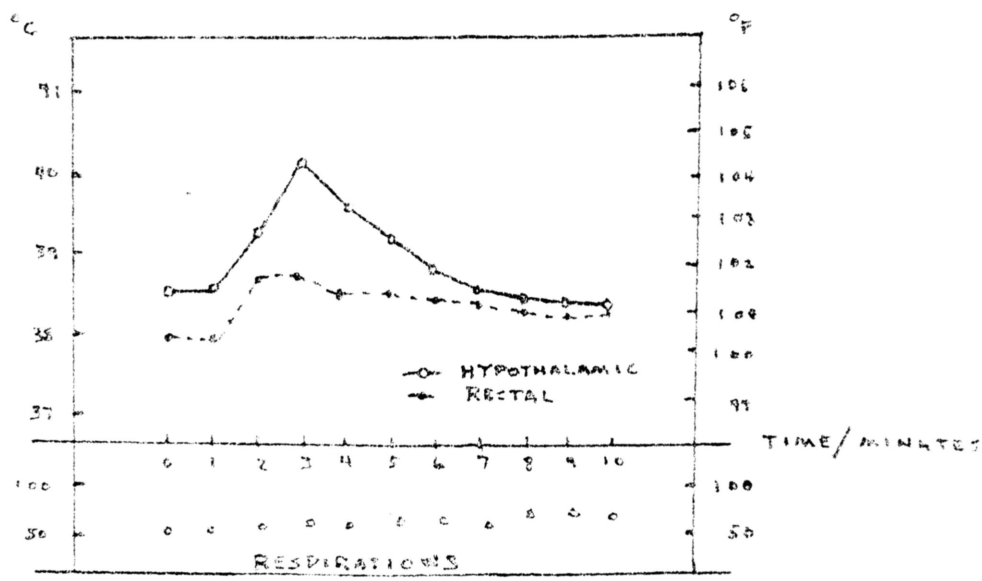
In the data collected from animal No. 0 an initial elevation of rectal temperature was observed. This was probably because of a mild meningitis due to faulty healing around the cannulae resulting in hyperpyrexia and hypernea.

Animals 9128 and 9102 showed an almost linear plot of rectal temperature. Indicating these animals inherent ability to rapidly regulate and stabilize body temperature. Results for animal 9076 depict similiar regulating ability. Recalling the test animals genetic make-up, -1/4 -1/8 Brahman provides sufficient influence on temperature regulation.

Additional comparative inferences may be made regarding the respiratory rates among British and Zebu animals under test conditions. There were seen no appreciable variations among breed types indicating that increased respiratory rates or panting are not a primary heat dissapation method.

In addition to physical differences between Brahman and British cattle indeed there also exist physiological variations. Brahman animals thermo-regulatory mechanism appears to be both more efficient and sensitive than that of British breeds. The results of this study suggest that some part Zebu less than 1/8 may be adequate for temperature regulation advantages in beef type cattle.

Figure 6

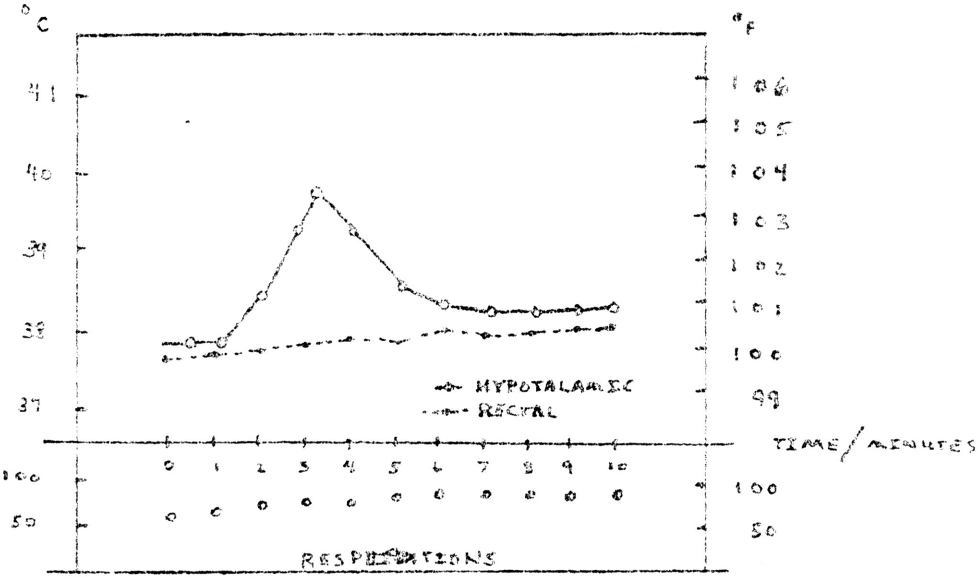


BRAHMAN X ANGUS

No. 9076

2/14/80

Figure 7

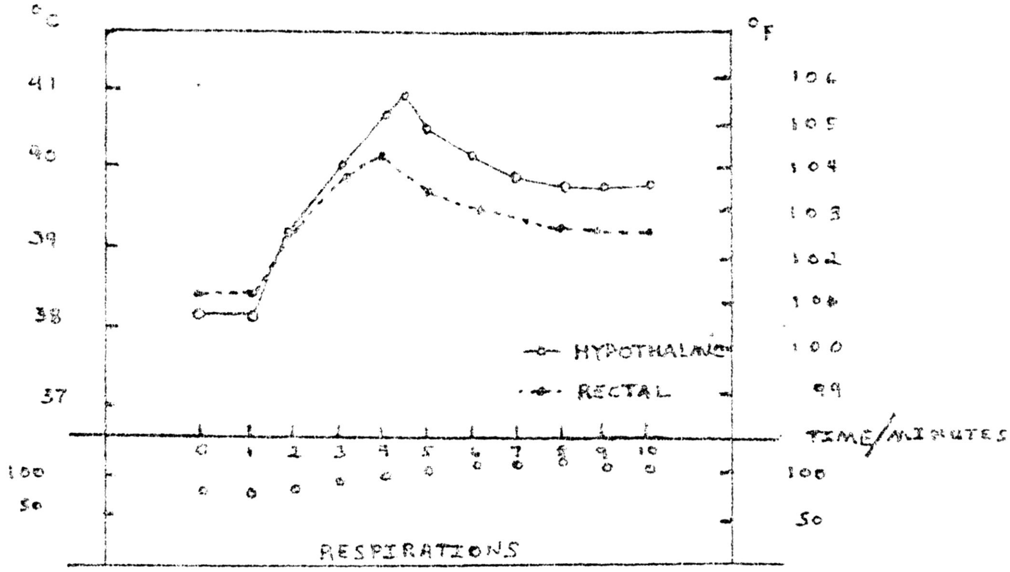


BRAHMAN X ANGUS

No. 9102

3/6/80

Figure 8

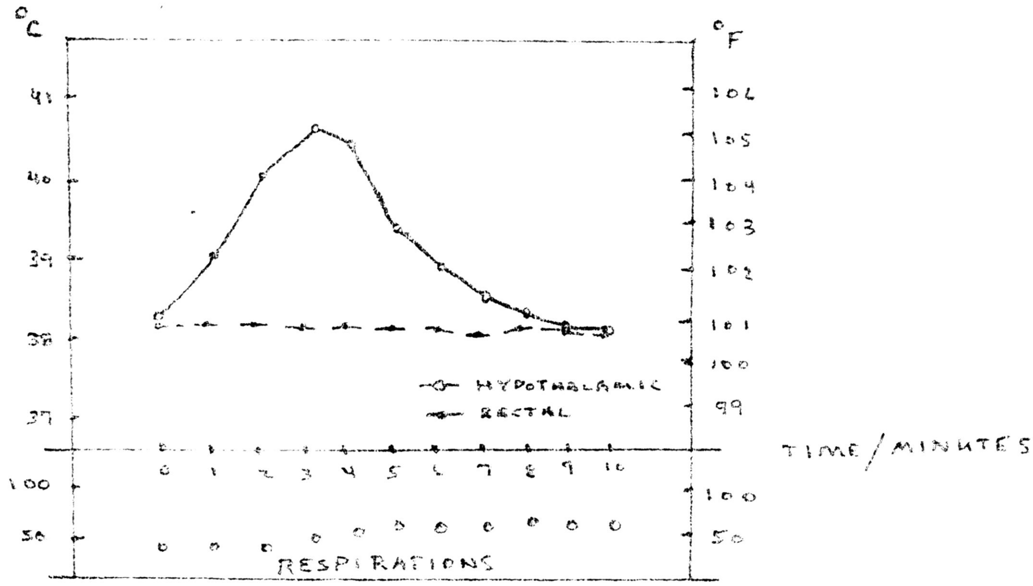


BRAHMAN X ANGUS

No. 0

4/3/80

Figure 9



BRAHMAN X ANGUS

No. 9128

4/10/80

CONCLUSION

The ability to regulate internal body temperature is a major factor affecting beef animal's ability to produce efficiently in certain geographic areas. Superior temperature regulators such as the Brahman are suited for utilization in tropical or semi-tropical environments. They do, however, provide us with a lower quality of meat than do the British breeds.

Crossbred animals containing 1/4 - 1/8 Brahman genotype are good temperature regulators. These types of animals appear to house a better regulatory mechanism than British breed cattle. In addition, respiratory rate is not a primary heat dissaption method in cattle encountering high heat and humidity.

This study suggests further investigation utilizing breeding programs which might quantify the optimum amounts of Brahman and British heritage. Success would yield an animal which, when utilized in tropical or semi-tropical areas, would produce high quality meat and regulate internal body temperature efficiently.

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