Developing algorithm for the evaluating of impact of heat stress about dairy cattle crossbred

Carlos Gutemberg de Souza Teles Júnior [a,*], Richard S. Gates [b], Ilda de Fátima Ferreira Tinôco[a], Matteo Barbari[c], Monique de Oliveira Vilela[a], Letícia Cibele da Silva Ramos Freitas[a], Márcia Gabrielle Lima Cândido[a], Rafaella Resende Andrade[a], Tatiany Carvalho dos Santos[a]

[a] Department of Agricultural Engineering of Federal University of Viçosa, Av. Peter Henry Rolfs, s/n Campus University of Viçosa CEP: 36570-900, Viçosa, Minas Gerais, Brazil.

[b] Department of Agricultural and Biological Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, USA.

[c] Department of Agrarian Management Systems, food and Forestry – GESAAF, Universita Degli Studi Firenze, Via San Bonaventura, 13, Firenze, Italy

*Corresponding author. Email: carlosgutembergjr@hotmail.com

Abstract

The aim of this study was to develop an algorithm to predict thermal environment for the creation of crossbred dairy cattle (½, ¾ and ⅞ Holstein-Zebu) and to assess of the impact of heat stress on their physiological parameters and productive performance. The algorithm was developed in the computer program VisuAlg 3.0. The prediction of the thermal environment was made based on the value of temperature and humidity index (THI). For the evaluation of the influence of the thermal stress caused by heat on the physiological parameters and productive performance of dairy cows were estimated based on the value of (THI), the rectal temperature (RT), the Surface Temperature (ST), the decline of the milk production (DMP) and the reducing the food intake of animals (RFI). To test the algorithm we considered the following scenario: air temperature (33°C), relative humidity (60%) and production potential in thermoneutral condition 20kg.cow^{-1}.day^{-1}. The prediction of thermal environment, performed by simulating the algorithm indicates that the animals are submitted to a condition of moderate heat stress, with (THI) 83.92. The rectal temperature and surface temperature values, estimated by the algorithm indicate that animals, regardless of the genetic group, are in thermal stress condition with an increase mean of 0.5°C in the rectal temperature and 1.5°C in surface temperature in relation for the animals created in thermoneutral environment. About the performance of the animals there was a 28.5% reduction in milk production of animals undergoing simulated thermal condition.

Keywords: heat stress, hot climate, milk yield, physiological parameters, precision animal production, productive performance

1. Introduction

Dairy cattle production is an activity present in all the regions of Brazil, constituting an important source of income and employment. (Lopes et. al., 2011). However it is necessary attention by producers to factors related to the production environment, particularly the temperature and relative humidity of the air, trying to avoid that these factors had a negative influence on the welfare and consequently animal performance.

Proper management of the production environment is of paramount importance, seeking to reduce the influence of climatic attributes about comfort and performance of animals (Nóbrega et al., 2011)

The temperature and relative humidity in the authoring environment are the main climatic variables that affect thermal comfort of animals, compromising productivity.

According to Oliveira et al. (2013), dairy cattle are strongly influenced by climatic factors, which under unfavorable conditions can negatively influence on productive performance and handling of animals.

Pinheiro et al. (2015) state that one of the parameters that most affect milk productivity in Brazil, is the influence of environmental factors around the animals, mainly due to the great diversity of microclimates and milk breeds created in Brazil.

According to Souza et al. (2010), the main factors responsible for causing the physiological discomfort that can lead animals the reduce its productive performance are, high ambient temperatures and direct solar radiation.

The occurrence of high temperatures throughout the day, especially during the summer, take animals to promote some changes in their physiological mechanisms, raising your body temperature, your respiratory rate and sweating (Pinheiro et al., 2015). According to Souza & Batista (2012), when submitted to challenge by heat the animals cannot dissipate satisfactorily their excess body heat, causing its thermal discomfort, raising its rectal temperature and respiratory rate above than values physiological normal, reducing its productive performance.

Rodrigues et al. (2010) state that when subjected to thermal discomfort caused by heat, the cows have their food consumption and production of milk reduced beyond other physiological changes, seeking to maintain its termoneutrality.

Know how these environmental factors influence the welfare and performance of animals is crucial to the success of production, where the use of some computer tools can assist in fast and accurate diagnosis of relationship animal vs environment.

The objective of this study was to develop an algorithm to predict the thermal environment of creating crossbred dairy cattle (½, ¾ and ⅞ Holstein-Zebu) due to Temperature and Humidity Index value (THI), and evaluation the impact of heat stress on their physiological parameters and productive performance.

2. Materials and Methods

The algorithm implemented to predict the thermal environment of dairy cattle production, and influence of heat stress on performance and physiological parameters of crossbred dairy cattle (½, ¾ and ⅞ Holstein-Zebu) was developed in the computer program VisuAlg 3.0.

The prediction of the thermal environment of dairy cattle production was based on the value of temperature and humidity index (THI) calculated by Equation (1) proposed by Buffington et al. (1982):

$$THI = 0.8 \times T_{air} + \frac{RH \times \left(T_{air} - 14.3\right)}{100} + 46.3 \tag{1}$$

Where (THI) is Temperature and Humidity Index, (T_{air}) is air Temperature and (RH) is Relative Humidity.

After the characterization and evaluation of the thermal environment based on ITU, if it appears that the animals are in heat stress conditions, the next step is to assess the influence of thermal stress on physiological parameters and yield performance of the same.

For the evaluation of the influence of the thermal stress caused by heat on the physiological parameters of crossbred dairy cows, were estimated based on the value of the (THI) and the genetic group (GG) of the studied breeds, the Rectal Temperature (RT) and the Surface Temperature (ST), through the equations (2) and (3) proposed by Azevedo et al. (2005):

$$RT = 60.2769 - 0.634222 \times THI + 0.00455446 \times THI^2 - 1.5725 \times GG + 0{,}023751 \times THI \times GG \tag{2}$$

Where (RT) is Rectal Temperature in [°C], (THI) is Temperature and Humidity Index, and (GG) is genetic group [½; ¾ and ⅞]

$$ST = 3.72 - 1.05 \times GG + 0.46 \times THI \tag{3}$$

Where (ST) is Superficial Temperature in [°C], (THI) is Temperature and Humidity Index, and (GG) is genetic group [½ , ¾ and ⅞]

Already the relation of thermal stress caused by heat, on the productive performance of the animals was evaluated based on the influence of the (THI) on the Decline in Milk Production (DMP) and the Reduction in Feed Intake (RFI) calculated using equations (4) and (5) proposed by Hahn (1993) and Hahn & OSBURN (1969) respectively:

$$DMP = -1.075 - 1.736 \times NP + 0.02474 \times THI \times NP \tag{4}$$

Where (DMP) is Decline in Milk Production in [$kg.day^{-1}.cow^{-1}$], (NP) is Normal Level Production in [$kg.day^{-1}.cow^{-1}$], and (THI) is Temperature and Humidity Index.

$$RFI = -28.23 + 0.391 \times THI \tag{5}$$

Where (RFI) is Reduction in Feed Intake in [$kg.day^{-1}.cow^{-1}$], and (THI) is Temperature and Humidity Index.

The implemented algorithm for the prediction of thermal environment and evaluation of the influence of heat stress on the physiological parameters and productive performance of the animals, follow the steps outlined in Figure 1.

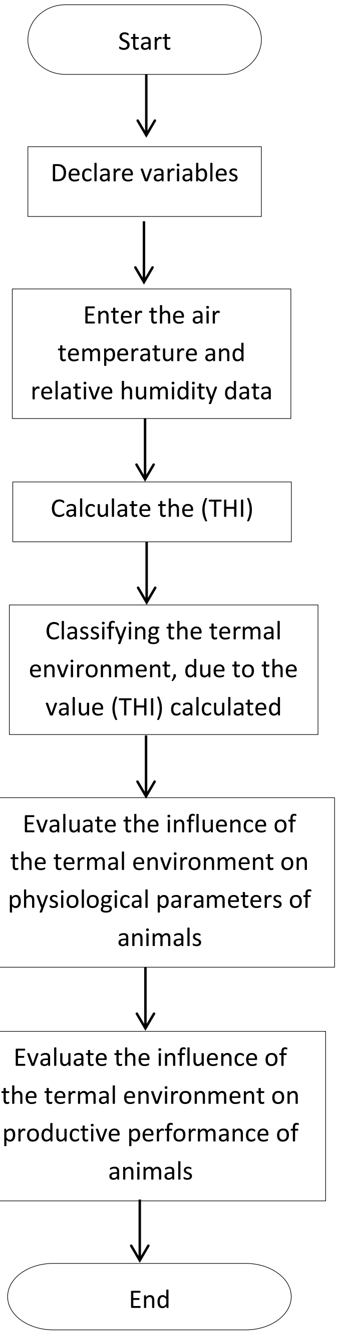

Figure 1. Algorithm execution steps flowchart

The first algorithm execution step is to declare the variables. The next step is to enter the program with the air temperature and relative humidity data (Figure 2).

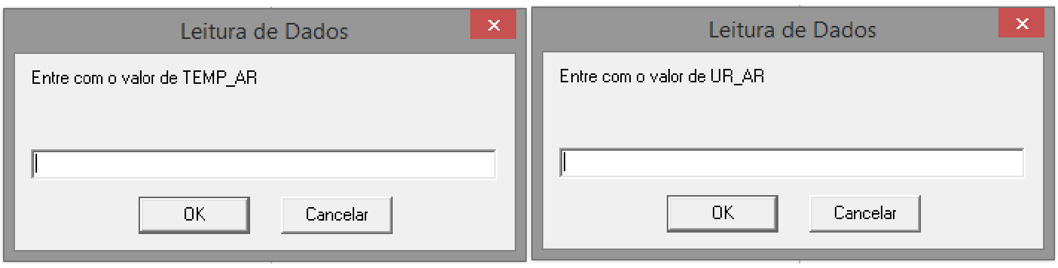

Figure 2 - Data Entry Window

Based on the data of air temperature and relative humidity was calculated (THI) from equation 1. The thermal environment was evaluated and rated based on the calculated value THI, taking into account the THI ranges proposed by Armstrong (1994), which indicates the following:

Table 1. Thermal environment classification based on the value of the Temperature and Humidity Index (THI) according Armstrong (1994)

Thermal Environment Classification	***Temperature and Humidity Index value (THI)***
Comfortable	below 72
Mild stress	between 72 and 78
Moderate stress	between 79 and 88
Severe stress	between 89 and 98

After classification of the thermal environment, we evaluated the influence of heat stress on the physiological parameters and productive performance of animals from Equations (2) to (5) respectively.

To test the algorithm was considered the following scenario:

Table 2. Conditions of the thermal environment and productive performance of the animals used for the simulation in the algorithm

Thermal Environment	***Animal productive performance***
Air temperature – 33°C Relative Humidity – 60%	milk production potential in thermoneutral condition 20kg.cow^{-1}.day^{-1}

3. Results and Discussion

The prediction of thermal environment, performed by simulating the algorithm indicates that the animals are subjected to a condition of moderate heat stress, with (THI) 83.92.

Table 3 shows the results of the evaluation of the influence of heat stress on the physiological parameters and productive performance of animals.

Table 3. Physiological parameters [rectal temperature - RT; The surface temperature - ST] and productive performance [reduction in feed intake - RFI; Drop in milk production - DMP] estimated by the algorithm based on proposed scenario*, for the different genetic groups of dairy cattle studied.

Genetic Group	*Physiological Parameters*		*Productive Performance*	
	RT (°C)	ST (°C)	RFI (kg.cow^{-1}.day^{-1})	DMP (kg.cow^{-1}.day^{-1})
½ Holstein-Zebu	39.3	41.8	4.6	5.7
¾ Holstein-Zebu	39.4	41.5	4.6	5.7
⅞ Holstein-Zebu	39.5	41.4	4.6	5.7

* Air temperature (33°C), relative humidity (60%) and yield potential in thermoneutral condition 20kg.cow-1.day-1.

The rectal temperature values estimated by the algorithm indicate that the independent of genetic groups evaluated, the animals are in thermal stress, with rectal temperatures on average 0.5°C above the observed in animals on a thermoneutral condition, which according Perissinotto & Moura (2007) should be in the range of 38.8°C.

In relation to the values of the surface temperature of the animals determined by the algorithm, it is observed that they were always above 41°C indicating a certain level of thermal stress of animals since according Azevedo et al. (2005) in conditions of surface temperature above 40°C the animals tend to cease grazing.

Whereas in thermoneutrality conditions the dairy cattle have a potential milk production 20kg.day^{-1}.cow^{-1}, it was observed that in the simulated thermal condition, the animals showed a reduction of 28.5% in its potential production milk. This result agree with what was found by Oliveira et al. (2013), who observed a 15% reduction in milk production in cattle with potential production of 20kg.day^{-1} subjected to heat stress.

In this of thermal stress condition simulated, it was found that the animals showed a reduction of their food intake approximately 5kg.dia-1. Porcionatto et al. (2009), state that this reduction in food intake is the primary cause of the reduction in milk production of the cows in heat stress.

4. Conclusions

Was found after simulation what the thermal conditions influenced the physiological parameters and productive performance of dairy cows. Independent of genetic group valued, it was found that there was a negative influence of the thermal environment on physiological parameters of the animal. In condition of heat stress, the dairy cows reduced their food intake which led to a decline in their milk production rate.

The algorithm is shown as a practical tool to assist the producer in decision making, helping in the evaluation of the thermal environment and of effect of heat stress on the physiological parameters and productive performance of animals, helping to improve the management of their production.

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