Bioclimatic zoning for quails in the dry period in the state of Paraíba, Brazil[1]

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ABSTRACT

Based on the temperature and humidity index, for quails from the 3rd to the 5th week of life, in the dry period in Paraíba state, Brazil, the objective was to carry out a bioclimatic zoning, identifying as regions suitable for the reproduction of quails and, when necessary, mitigating measures for greater animal comfort. The bioclimatic zoning was carried out for the mesoregions of the state, the climatic data used are from meteorological stations in the period from 1961 - 2015, from them maps were elaborated with the spatial distribution of the index, identifying as regions with ideal thermal comfort conditions for the animals. For quails in the third week, the Agreste mesoregion presents the best situation in the dry season, not requiring corrective measures to maintain the comfort of these animals. In the fourth week of life of the quails, the mesoregions that would provide THI values within the ZCT in the dry period would be the Zona da Mata paraibana and Sertão, while the ZCT for quails in the fifth week of life, could be found throughout the state of Paraíba.

Keywords: coturniculture; mitigation measures; mesoregions.

INTRODUCTION

Raising quails in tropical and subtropical climates such as Brazil which have high solar radiation and air temperature and high thermal amplitude in the relative air humidity can cause thermal discomfort conditions for the quails (Porto & Fontenele Neto, 2020). Furthermore, thermal stress is one of the bottlenecks in quail breeding, affecting the welfare conditions of birds, promoting physiological and behavioral changes such as reduced feed intake, increased water intake, tachycardia, tachypnea and agitation in attempts to dissipate body heat for the environment (El-Kholy *et al*., 2017; Santos *et al*., 2019). These changes can result in economic losses, since birds reduce weight gain, increase feed conversion, reduce the number and quality of eggs and carcasses, in addition to increasing the mortality rate (Kamel *et al*., 2017).

It is possible to obtain data from regions which have better conditions for quails and to elaborate bioclimatic zoning by identifying areas with possible occurrences of thermal stress, assisting producers in making decisions regarding the environmental management of animal facilities, thereby distributing them in regions which present greater comfort, as well as the application of mitigating measures when necessary, aiming at greater productive efficiency (Tavares *et al*., 2016).

Thus, the objective of the present work was to perform bioclimatic zoning based on the temperature and humidity index (THI) for raising quails from the 3rd to the 5th week of life in the dry period in the state of Paraíba, identifying the suitable mesoregions for breeding, and to propose mitigating measures for greater animal comfort when necessary.

MATERIAL AND METHODS

The bioclimatic zoning was carried out for the state of Paraíba, located in the Northeast region of Brazil, and presents an area of 56,440 km² corresponding to 0.662% of the national territory. Its position is between the parallels 6°02'12" and 8°19'18" south latitude, and between the meridians of 34°45'54" and 38°45'45" west longitude.

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According to Nobrega *et al.* (2014), the state of Paraíba is divided into four distinct mesoregions Zona da Mata paraibana; Agreste Paraibano; Borborema and Sertão Paraibano, hereinafter referred to as Zona da Mata, Agreste, Borborema and Sertão, as shown in Figure 1.

Paraíba presents four different types of climate according to the Köppen classification. The Aw climate (451.52 km²) characterizes the region as Tropical with a dry season in winter. The Am climate (677.28 km²) is characteristic of monsoon regions, and is the climate related to regions with a high annual volume of precipitation, such as the Zona da Mata. The As climatic type (32,340.12 km²) found in Zona da Mata, Agreste and Sertão, is characterized by a tropical climate with dry summer, and finally the Bsh climatic type (22,971.08 km²), which is characterized by a semi-arid dry climate with low latitude and altitude, which extends throughout the Borborema mesoregion, and part of the Sertão (Francisco *et al*., 2015; Alvares *et al.*, 2013).

The climatic data were obtained from conventional meteorological stations of the National Institute of Meteorology (Inmet) of the federal government, and the data are available in the Meteorological Database for Teaching and Research (Bdmep), with its variables including monthly temperature (T, ºC) and relative humidity (RH, %) varying from 1961 to 2015 to perform THI calculations. The stations are located in the municipalities of Areia, Campina Grande, João Pessoa, Monteiro, Patos and São Gonçalo.

The dry season was determined by averaging the four driest months of the rainfall series for each station. Thus, Table 1 shows the size of the series and the months which constitute a dry period.

The dew point temperature (Dpo) was calculated from the collected climatic data Eq. 1.

$$Dpo = \frac{237.3\left(logR_H + \frac{7.5\,t}{237.3 + t}\right)}{7.5 - \left(logR_H - \frac{7.5\,t}{237.3 + t}\right)} \quad \text{(Eq.1)}$$

For $t \geq 0$ *and the RH fraction.*

The THI was calculated using the equation proposed by Thom Thom (1958) (Eq. 2):

$$THI = T + (0{,}36 \times Dpo) + 41.5 \quad \text{(Eq. 2)}$$

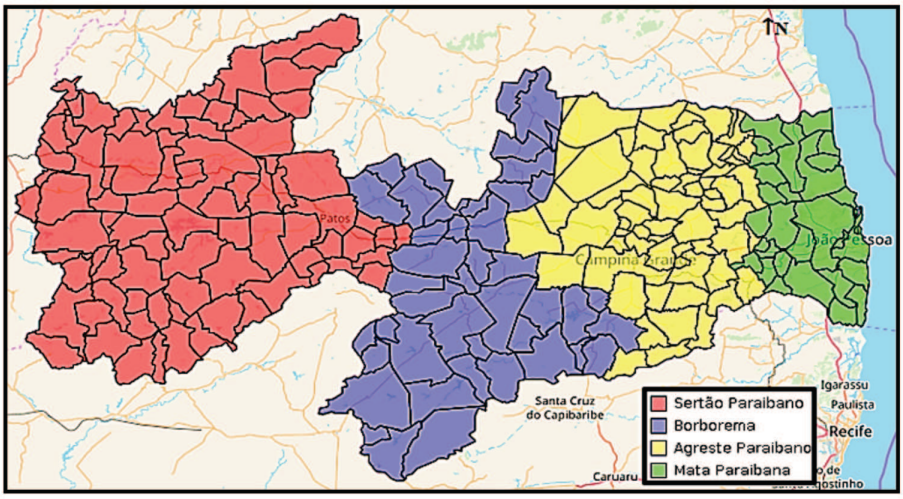
Where THI is a dimensionless dimension. Maps with spatial distribution were then prepared from the index values using the Surfer® demo version 13.6 software program for the state of Paraíba in the dry period, with the interpolation of the data done by the Kriging method.

The climatological data obtained were compared with the ideal thermal comfort conditions for quails in the literature in order to find the comfortable bioclimate for the production of these animals within the state. The recommendations of temperature and relative air humidity cited by Sousa *et al.* (2014a) were used to evaluate these conditions for quails in the third week, who performed the determination of thermal comfort ranges for cutting quails of different ages (Table 2).

Sousa *et al.* (2014b) determined the upper limits of the thermal comfort zone (TCZ) for cutting quails acclimatized

Table 1: Drier months for the seasons under study

Season	Period	Dry
João Pessoa	1961 – 2015	September - December
Areia	1974 – 2015	September - December
Campina Grande	1961 – 2015	September - December
Monteiro	1962 – 2015	August - November
Patos	1976 – 2015	August - November
São Gonçalo	1961 – 2015	August - November



Source: Aesa, 2018.

Figure 1: Mesoregions of the State of Paraíba.

in Brazil from 22 to 35 days old. Thus, these variables were used for the fourth and fifth weeks to find the ideal comfort range for quails up to the fifth week of life in relation to the THI, with the calculation procedure being the same as that used previously.

The mappings by means of the temperature and humidity index during the dry season were used to verify the areas which would present lower, ideal and higher values of ITU's than those recommended for quails in the third, fourth and fifth week of life.

RESULTS AND DISCUSSION

There was a variation of THI in the state of Paraíba in the dry period from 71 to 75. When analyzing the state's mesoregions, it is possible to observe THI ranging from 73 to 75 in Zona da Mata, 71 to 73 in Agreste, 71 to 74 in Borborema and 74 to 75 in Sertão, as shown in Figure 2.

For raising quails in the third week of life in the dry period, 89.5% of the territory of Agreste would be within the ideal range of THI (71 - 72), with a variation in T between 23 - 24 ºC and RH of 64 - 76% according to the historical series. In turn, Borborema has T and RH of 23 - 27 ºC and 52 - 72%, respectively, comprising only 32.9% of its territory within the TCZ for breeding these animals based on the index. Heat stress would predominate in 10.5% of the Agreste territorial area and 67.1% of Borborema, in addition to 100% of the mesoregions of Zona da Mata (73 - 75) and Sertão (74 -75) (Figure 3).

Sertão is the mesoregion with the state's highest temperatures and lowest humidity, while Zona da Mata is characterized by high temperature and relative humidity. In proving the effect of high temperatures for the performance of quails, El-Kholy *et al*. (2017) observed a decline in feed consumption and weight gain ranging from 0.9 to 1.4 g bird^{-1} day^{-1} and 7 to 8 g bird^{-1} day^{-1}, respectively, when there was a temperature variation between 23 and 33 ºC. However, corrective measures are necessary in order to provide greater comfort to the animals in these locations considering that birds are sensitive animals to high temperatures, which may cause increased mortality and consequently economic losses in addition to productive losses (Silva *et al*., 2015).

For raising quails in the fourth week of life, the THI in the mesoregions of Zona da Mata (73 - 75) and Sertão (74 - 75) would be within the recommended TCZ in 100% of the territories, therefore being able to raise these animals without the need to apply mitigating measures (Figure 4).

It is observed that 67.1% of the territory of the Borborema mesoregion would be comfortable according to the THI, which varies from 73 to 74, while the same conditions would only be observed in 10.5% of the territory in Agreste (71 - 73).

However, the Borborema and Agreste mesoregions would also register cold stress (71 - 72) for these animals in 32.9 and 89.5%, respectively, making it necessary to apply corrective measures given that situations in which temperatures are found below the lower critical zone bring losses to the performance of quails.

Table 2: Thermal comfort range in relation to temperature, relative humidity and temperature and humidity index for quails from the third to the fifth week of life

Weeks	Variables		
	T (ºC)	RH (%)	THI – Calculated
3rd	24.6 - 23	52.6 - 64.4	69 – 72
4th	26.1 - 27.3	53.8 - 66.6	73 – 76
5th	25 - 26.1	56.2 - 65.2	71 – 75

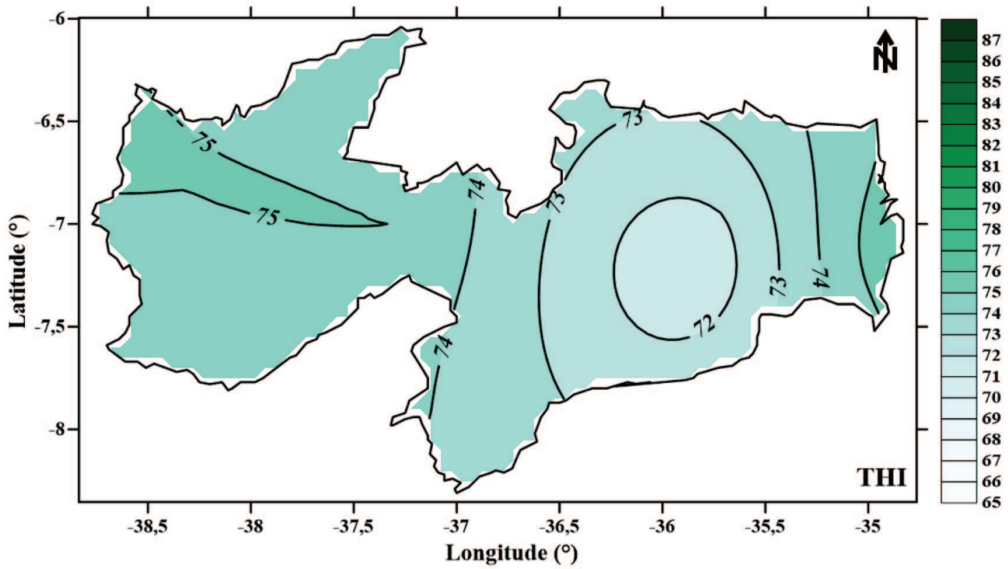


Figure 2: Spatial distribution of the ITU during the dry season.

In evaluating the behavior of quails subjected to different temperatures, Castro *et al.* (2017) observed an increase in food consumption of the animals in 2 g bird^{-1} day^{-1} when there was a reduction from 24 ºC to 20 ºC. According to Ribeiro *et al.* (2016), animals tend to increase food consumption in order to maximize heat production to maintain constant body temperature.

All the mesoregions of the state of Paraíba would be able to raise quails in the fifth week of life according to the TCZ in relation to the THI (71 - 75), with no need for any corrective measures in the facilities, given that 100% of its territorial areas are within the recommended comfort (Figure 5).

Both temperature and relative humidity in the dry period in the mesoregion of Zona da Mata would be above what is considered ideal for quails in the third week of life, and the use of corrective measures is essential, since the combination of high values of temperature and relative humidity can lead to death (Silva *et al.*, 2015).

The quails increase their water intake in order to minimize this severe heat condition, which must be supplied in adequate quantity and quality as it helps to cool the body and reduces the dehydration that occurred during the panting process (Castro *et al.*, 2017).

The most suitable types of roofing materials must be taken into account, choosing those which have good resistance, durability and thermal conductivity in order to facilitate heat loss, as in the case of ceramic tiles. This type of tile also supports more moisture, preventing the formation of fungi and mold (Gontijo, 2019).

Parallel to the roof, there is the possibility of using insulating ceilings, which act as a physical barrier to radiation, contributing to reduce heat transfer directly to birds (Lopes Neto, 2017). Another strategy would be the use of lanterns, as it has the function of dissipating the mass of hot air, providing greater ventilation, expanding convective exchanges aided by the chimney effect. There

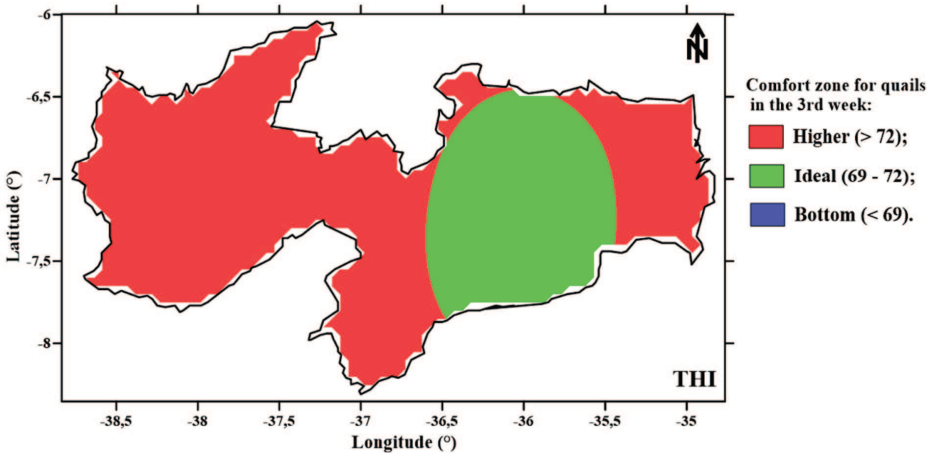


Figure 3: Spatial distribution of temperature and humidity index ranges for quails in the 3rd week in the dry season.

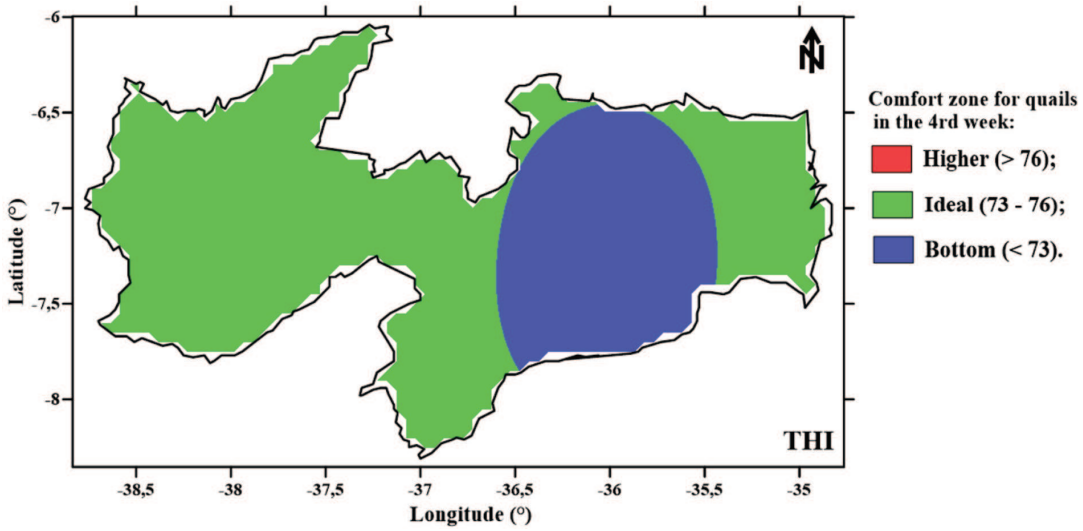


Figure 4: Spatial distribution of the temperature and humidity index ranges for quails in the 4th week in the dry period.

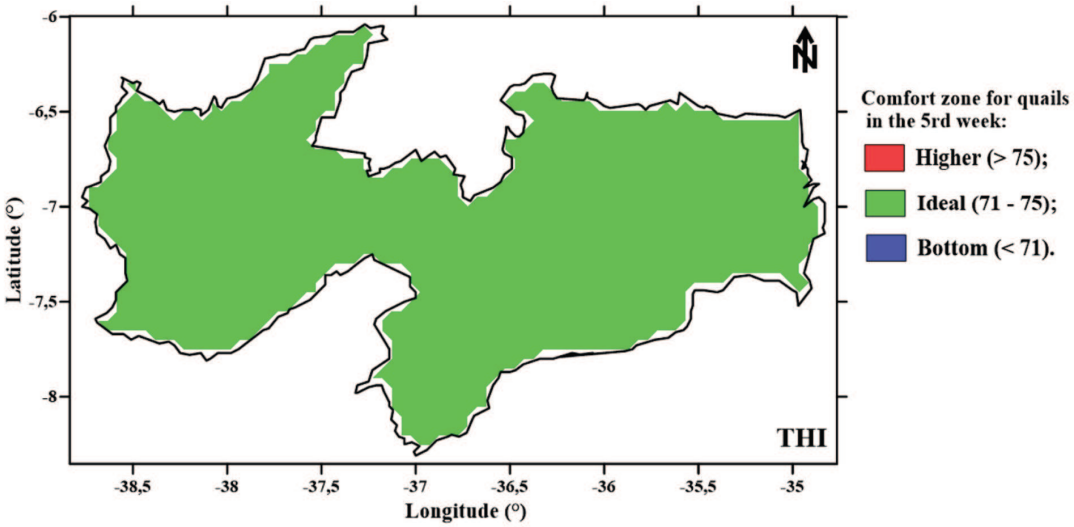


Figure 5: Spatial distribution of the temperature and humidity index ranges for quails in the 5th week in the dry period.

is a need for a higher right foot for better efficiency of the lanterns (Lopes Neto, 2017).

Regarding artificial thermal packaging, we can mention the use of fans being used in order to facilitate dissipation of excess heat, improving the thermal sensation of the microenvironment of the installations (Silva *et al.*, 2015).

The T would be below the TCZ of the birds, while the RH above in the dry period in the Agreste Paraiba mesoregion for the fourth week of life of the quails. Curtains can be kept in semi-open installations at times when the temperature is milder as a corrective measure for both variables in order to increase the internal temperature, which would allow the air to be renewed inside through natural ventilation, and consequently reduce the relative air humidity (Santos *et al*. 2017).

CONCLUSION

The T and RH were elevated in Borborema in the dry period for quails in the third week of life, as well as in the mesoregion of the Zona da Mata in the same period and age, thus being able to adopt the same previous mitigating measures. The T would be below the recommended and the RH above the comfort in the fourth week of life of the quails, and this same situation can be observed in the mesoregions of the Agreste in the same period and for birds with the same age, being able to adopt the same corrective measures.

The T and RH would be above the TCZ for the third week of life of the quails in the dry period in the Sertão mesoregion, and this same situation occurs in the mesoregions of Zona da Mata and Borborema for the same week of life of these animals, and therefore the same corrective measures previously mentioned can be adopted in these mesoregions.

For quails in the third week, the Agreste mesoregion would provide the best situation in the dry period, not requiring any corrective measures to maintain the animals' comfort while in the Zona da Mata, Borborema and Sertão stress would occur, due to the elevation of the T variables and RH, used to calculate the THI.

In the fourth week of life of the quails, the mesoregions that would provide THI values within the TCZ in the dry period would be the Zona da Mata and Sertão, with no need for any corrective measures. In Agreste and Borborema, cold stress would be observed, due to the decrease in T and increase in RH in this period. The TCZ for quails in the fifth week of life could be found throughout the state of Paraíba, not requiring mitigating measures at this stage.

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