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CHARACTERIZATION OF HEAT WAVES WITH IMPACT OVER BROILER MORTALITY

MARCOS MARTINEZ DO VALE[1]; DANIELLA JORGE DE MOURA[2]; IRENILZA DE ALENCAR NÄÄS[2]

[1] Researcher, post graduate student, FEAGRI/UNICAMP/Campinas – Brazil. e-mail: mmdovale@hotmail.com
[2] Professor, PhD, FEAGRI/UNICAMP/Campinas – Brazil.

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ABSTRACT: Climatic issues may affect broiler production, especially under the occurrence of heat waves (HW) which may trigger high mortality rates due to the heat stress. The HW prediction and characterization allows some early mitigation actions to be taken. Data Mining is one of the tools that allow such a characterization, mainly when there are a great number of variables involved. The objective of this research was to classify heat waves that promote high broiler chicken mortality in poultry houses equipped with minimum acclimatization. For poultry houses equipped with fans and evaporative cooling, the characterization of HW with an impact over the mortality of broilers aged between 29 days and the slaughter age showed a model accuracy of 89.34%, as well as a class precision for high mortality of 0.73. There was no impact over the high mortality (HM) for birds aged between 29 and 31 days old. The HM of broilers aged between 31 and 40 days occurred when the maximum THI (temperature and humidity index) was beyond 30.6ºC and the maximum temperature of the day was beyond 34.4ºC. For those broilers aged more than 40 days there were two main causes of HM: 1) the maximum THI was beyond 30.6ºC and the minimum THI reached 15.5ºC or less; 2) the maximum THI was beyond 30.6ºC, the minimum THI was lower than 15.5ºC and the time of the maximum temperature was later than 3 pm. The HW with an impact over the broiler mortality lasted an average of 2.7 days.
KEYWORDS: Mortality, heat wave, productivity losses.

INTRODUCTION: Climatic factors may trigger broiler productive losses. A great deal of such losses is due to a heat waves that increase broiler mortality and reduces the productive performance (ST-PIERRE et al., 2003). Moreover, in tropical environments as in Brazil, the impact might be even worse. Heat stress affects mainly older birds, 29 days old or beyond, leading to a significant mortality rate. The possibility to forecast climatic events allows early mitigation actions to be taken which may neutralize or decrease the heat waves effects. Distinct acclimatization systems show different degree of mitigation and reduction potentials in terms of broiler mortality. However, in some Brazilian regions, the poultry houses with minimum acclimatization outweigh and they are equipped with forced ventilation, evaporative cooling by misting or fogging and the isolation with PVC ceiling TINOCO et al., 2004).

One of the main challenges for Heat Waves prediction is to define the climatic features that have an impact over the broiler production. The mortality, which is a parameter registered daily in all of the poultry houses, might be an important factor to model heat waves. The large amount of variables involved in the forecast justifies the use of Data Mining in order to classify days with an impact over the broiler mortality rate. The objective of this research was to classify heat waves that promote high broiler chicken mortality in poultry houses equipped with minimum acclimatization.

METHODOLOGY: The data was collected at a poultry farm located in Tuiuti, SP State, Brazil (22º 48’ 056” S; 46º 42’ 046” W, altitude of 807 meters). The poultry farm had 14 poultry houses east –

west oriented, with dimensions ranging from 72 to 150 m length and 10 m width. They were built in masonry, covered with clay tiles and paved with concrete. All of the poultry houses were equipped with axial fans, fogging, side curtains and PVC ceiling. The data regarding 20 mixed male and female flocks' broilers were recorded between October and February – period of incidence of heat waves in the region. The mean stocking density was 13 (±1) birds per m^2. The feeding and care received by the lots followed specific schedule and certain rules by the integrator company without interference of this research.

The meteorological data collected were the atmospheric pressure, air temperature, air relative humidity, wind speed and direction, and the global sun radiation; all of them collected by a meteorological station (Hobo Onset®) located at the poultry farm's geographical center. The data were stored in the meteorological station's own data logger in an hourly basis measurement.

The broilers' mortality rate in birds 29 days old or beyond was daily recorded. The mortality rate beyond the mean heat occurrence determined the classification in High Mortality (HM). The HM was classified by considering a minimum mortality of 0.2% (twice as big as the mortality in normal days) and related with the occurrence of minimal climatic conditions for heat wave, according to the findings by VALE et al. (2008), such as: 1) maximum temperature reaching 32º C or beyond; 2) average temperature reaching 24º C or beyond and 3) mean temperature and humidity index (THI) reaching 23ºC or beyond. The rest of the days were classified as having normal mortality rate (NM).

A new data base was build by associating the HM or NM mortality classification with the daily means data of the meteorological station, according to the respective days of occurrence.

The data mining techniques were applied to the data according to the CRISP-DM methodology comprising the following steps: domain understanding, data acquisition, data understanding, data preparation, data modeling and evaluation according to the knowledge from the domain experts (CHAPMAN et al., 2000). The software used for the analysis was Weka® 3-4 (WITTEN & FRANK, 2005) which is composed by a collection of machine learning algorithms for data mining tasks (e.g., classification). In particular, the classification algorithm chosen was J48, an implementation of the C4.5 (QUILAN, 1996), which generates a decision tree for classifying broilers' mortality as normal or high. The data base for the analysis encompassed 39 attributes. The model accuracy was calculated by a confusion matrix (Table 2), and it is expressed as the percentage of correctly classified test instances over all test instances, including True positives and True negatives. On the other hand, the class precision was also calculated by the confusion matrix (Table 2), and it is expressed as a rate raging from 0 to 1, representing the instances that were correctly classified as True positives or True negatives.

Table 2 – Confusion matrix.

Class	Predict as C+	Predict as C-	Class precision	Model Accuracy[1]
C+	True positives (Tp)	False negatives (Fn)	Tp/(Tp+Fn)	[(Tp+Tn)/N]x100
C-	False positives (Fp)	True negatives (Tn)	Tn/(Fp+Tn)	

[1]N is equal to the number of instances in the test set.

RESULTS AND DISCUSSION: During the researched period six heat waves (HW) were observed. The HW had showed duration between one and five continuing days and the mean duration was 2.7 days. The data mining allowed us to obtain a decision tree model to classify the HW that have an impact over the high mortality among broilers with 89.34% of accuracy and a class precision of the 0.73 (Figure 1).

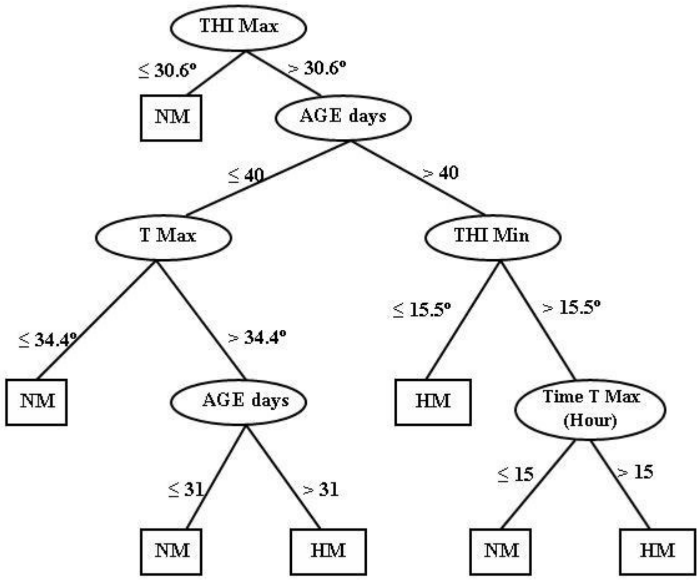

Figure 1 – Decision Tree for high broiler's mortality due to heat waves.

In days whose maximum Temperature and Humidity Index (THI Max; CHEPETE at al., 2005) was below 30.6º C there was no high mortality (HM) among broilers living in poultry houses that was equipped with minimum acclimatization (Figure 1). The construction of the decision tree on Figure 1, making use of the THI and the bird's age, agrees with literature (RYDER et al., 2004; VALE et al., 2008; ABU-DIEYEH, 2006), were temperatures were beyond 30º C, may trigger high mortality and the stress index for broilers and the bird's age were the major causes of production losses.

No parameter in the model directly considered the Relative Humidity (RH) that is another important factor for bird's thermal comfort (MACARI & FURLAN, 2001; CONY & ZOCCHE, 2004; CHEPETE et al., 2005; ABU-DIEYEH, 2006). However, the minimum THI (THI Min) 15.5º C or lower used in the model on Figure 1, when the THI Max is beyond 30.6º C, which causes the HM in birds aged older than 40 days, indicates a relation with days of low RH. Those days show larger and faster raise in temperature along the day.

The use of the age in the Figure 1 model is according to the alterations on the birds' thermal tolerance as they grow. Management guides (COBB, 2003) and several authors (MACARI & FURLAN, 2001; CONY & ZOCCHE, 2004) show those variations on the birds' thermoneutral zone between 32º C on the first growth week to 20º C on the 6th growth week.

The last attribute applied in the construction of the model is the time to maximum temperature (T Max) and it may indicate weather conditions in which the temperatures importantly raise along the day and that temperature keeps raising until after 3 pm. Under this condition, the number of hours in which the birds are under an unfavorable environmental condition could be decisive mainly for those birds aged beyond 40 days.

The model has generated three major rules, obtained from Figure 1 in order to classify the HW. Among broilers aged between 31 and 40 days, the Max THI beyond 30.6º C and the Max Temperature beyond 34.4º C cause high broiler mortality (Rule 1).

Rule 1 - **IF** THI Max > 30.6º C **AND** age ≤ 40 days **AND** T Max > 34.4º C **AND** age > 31 days **THEN** Class = HM

For broilers aged beyond 40 days the THI Max beyond 30.6º C and the THI Min 15.5º C or lower was enough to cause high broiler mortality (Rule 2).

Rule 2 - **IF** THI Max > 30.6º C **AND** age > 40 days **AND** THI Min ≤ 15.5º C **THEN** Class = HM

The high mortality for broilers aged beyond 40 days, occurred also when the THI Min was beyond 15.5º C and the time of the maximum temperature was later than 3 pm (Rule 3).

Rule 3 - **IF** THI Max > 30.6º C **AND** age > 40 days **AND** THI Min > 15.5º C **AND** time to T Max > 15 hors **THEN** Class = HM

CONCLUSION: For broilers aged between 29 and 42 days in poultry houses with minimum acclimatization, the classification of the high mortality due to heat waves showed a model accuracy of 89.34% and a high mortality class precision of 0.73.

Heat waves affect differently birds of different ages. There was no impact over the mortality rate among birds aged between 29 and 31 days old.

The maximum THI beyond 30.6º C was the main feature of those days with a heat wave causing impact over the mortality of broilers older than 31 days. Broilers between 31 and 40 days old showed high mortality when the maximum temperature of the day was beyond 34.4º C.

For those broilers beyond 40 days old, there were two critical conditions for high mortality: 1) maximum THI beyond 30.6º C and minimum THI of 15.5º C or lower; 2) Maximum THI beyond 30.6º C, minimum THI beyond 15.5º C and the time of the maximum temperature was later than 3 pm.

The heat waves with an impact over broilers' mortality lasted an average of 2.7 days.

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