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Climate Change in Layer Poultry Farming: Impact of Heat Waves in Region of Bastos, Brazil

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ABSTRACT

The region around the municipality of Bastos, state of São Paulo, accounted for about 7% of Brazilian egg production in 2015. In 2012, it experienced a heat wave that resulted in the death of approximately 500,000 hens, according to information released at the time. Considering the impact of heat waves on layer mortality, the objective of this study was to analyze how heat waves impact the layer farming in the region of Bastos, considering the climate change scenarios forecasted by the IPCC for the next years. This study was conducted in three stages: i) analysis of the IPCC reports to understand climate change scenarios; ii) analysis of historical temperature data in the region of Bastos; iii) analysis of how climate change, through heat waves, may impact layer mortality in this region. All the IPCC scenarios indicate that both average temperature and the number of extreme events, such as heat waves, are expected to increase. Historical data showed that since the mid-1980s, maximum temperature has increased, as well as the frequency, intensity and duration of heat waves. The association of layer mortality due to heat waves with the IPCC climate change forecasts for that region indicates a trend of increasing layer mortality in egg production operations which sheds are not equipped with air conditioning.

INTRODUCTION

Climate change may affect poultry production in several ways. It may have indirect impacts, influencing production inputs (corn, soy, electricity, etc.), as well as direct impacts, generated by the constant increase in environmental temperature over the years (productivity and egg quality losses) or by the incidence of extreme temperature events (mortality). It should be noted that the present study analyzed egg production systems which layer shed do not have full environmental control, as those equipped with air-conditioning suffer different impacts.

According to most scientists, the temperature of the planet's surface has increased over the years, causing changes in the climate. The World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) to study this issue. The IPCC gathers researchers from different countries and areas of activity with the objective of generating and organizing information to forecast future scenarios of temperature and rainfallvariation. Based on these scenarios, the possible socioeconomic and environmental impacts generated by climate change may be predicted (IPCC, 2018a).

Climate changes also produce extreme events, such as heat waves, cold waves, droughts, frosts, floods, cyclones, tec. According to the IPCC (2014a), extreme events indicate, with a high level of confidence, great vulnerability and exposure of diverse ecosystems, which may have strong impacts on food production. The IPCC (2014a) also points out, with a medium level of confidence, that the duration and frequency of heat waves have globally increased since 1950 and their numbers, duration and intensity will most likely continue to grow.

According to the National Institute of Meteorology of Brazil (INMET, 2017a), a heat wave "is an uncomfortable and excessively hot period. "Heat waves can also be characterized as periods of a sudden increase of environmental temperature, which intensity and duration may vary (Zuo *et al*., 2015). In egg production, Pereira *et al*. (2015) reported that environmental temperature affects hen behavior. In the study of Riquena (2017), layer mortality during heat waves characterized and predicted.

The region around municipality of Bastos, state of São Paulo, accounted for 7% of the Brazilian egg production in 2015 (IBGE, 2018). That region experienced a heat wave in 2012 that resulted in the death of approximately 500,000hens, according to information released at the time (AVICULTURA INDUSTRIAL, 2012). In addition, Salgado and Nääs (2010) determined that the municipalities of Tupã, Osvaldo Cruz, and Rancharia, which are located in the region of Bastos, present higher risk of occurrence of heat wave events compared with other municipalities of the state of São Paulo.

The objective of this study was to analyze how the heat waves may impact layer farming in the region of Bastos, state of São Paulo, Brazil, considering the climate changes scenarios forecasted by the IPCC for the next few years.

MATERIALS AND METHODS

This study was divided into three phases. In the first phase, the IPCC's reportsAR5 of the work group2 (IPCC, 2014a; IPCC, 2014b) and Special Report on Extreme and Disaster Risk Management to Advance on Climate Change Adaptations (IPCC, 2012) were used to analyze the IPCC's temperature and heat wave forecasts for the coming years.

In the second stage, the historical maximum daily temperature (°C) data published by BDMEP (Banco de Dados Meteorológicos para Ensino e Pesquisa - Meteorological Data Bank for Teaching and Research) of INMET (Instituto Nacional de Meteorologia - National Meteorological Institute) were analyzed for the period between January 1st, 1961 and May 31st, 2012. The data refer to temperatures recorded at Station No. 83716, located in the municipality of Presidente Prudente, SP, distant 72 km from the municipality of Bastos, SP. Figure 1 shows the location of the municipality of Bastos.

Figure1 – Location of the municipality of Bastos in the State of São Paulo.

In the third stage, literature reports on the environmental effects on layer farming was reviewed to discuss the estimated impacts of the expected extreme climate events (heat waves) in the region of Bastos on layer mortality in the next few years. Figure 2 illustrates the diagram of the steps described.

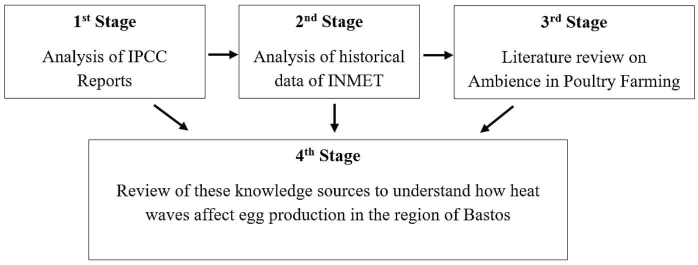


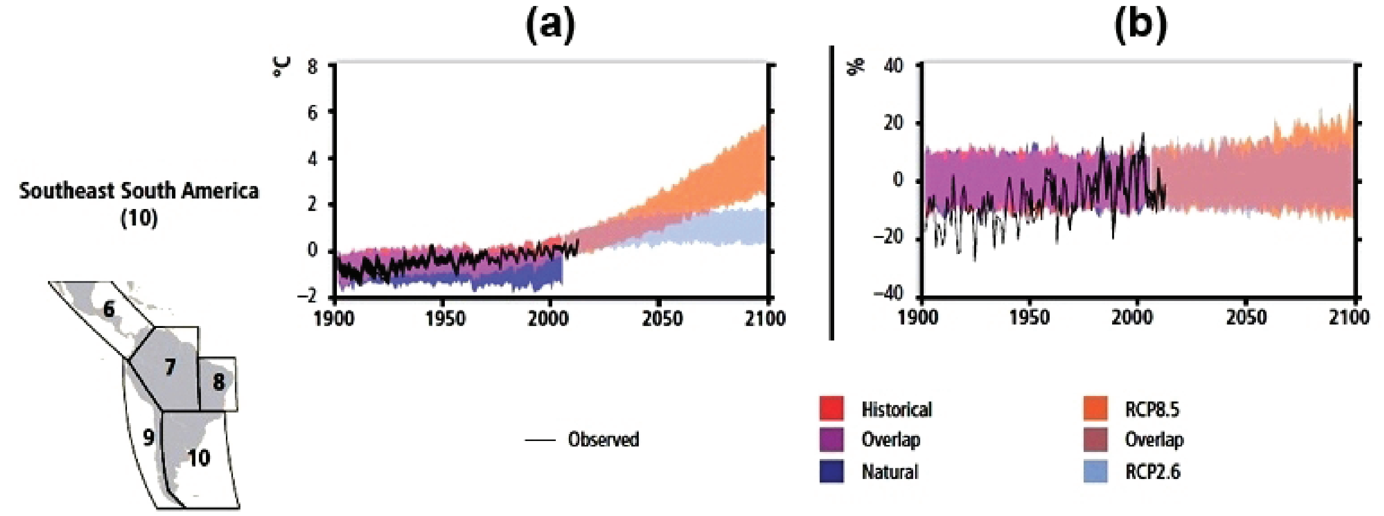
Figure 2 – Study Development Diagram

RESULTS AND DISCUSSION

In 1988, in search of new discoveries and also seeking to solve future problems, the World Meteorological Organization (WMO) and the United Nations Environmental Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC), which aims at generating and organizing information on climate change by researchers around the world (IPCC, 2018a).

The IPCC regularly publishes reports generated by three research groups, which try to describe the effects of climate change under different approaches. These reports include "The basis of physical science" (Working Group 1); "Impacts, Adaptations and Vulnerability" (Working Group 2) and "Mitigation of Climate Change" (Working Group 3). In addition, special reports on specific issues have also been issued, and have the same structure as the main reports (IPCC, 2018b).

Those reports include data, information, graphs, and maps that forecast future temperatures and precipitation levels for different regions of the world. Figure 3 shows the historical and forecasted temperature (Graph a) and precipitation (Graph b) variations for the southeast of South America.



Source: Adapted from IPCC (2014b).

Figure 3 – Average temperature and precipitation level in Southeastern of South America.

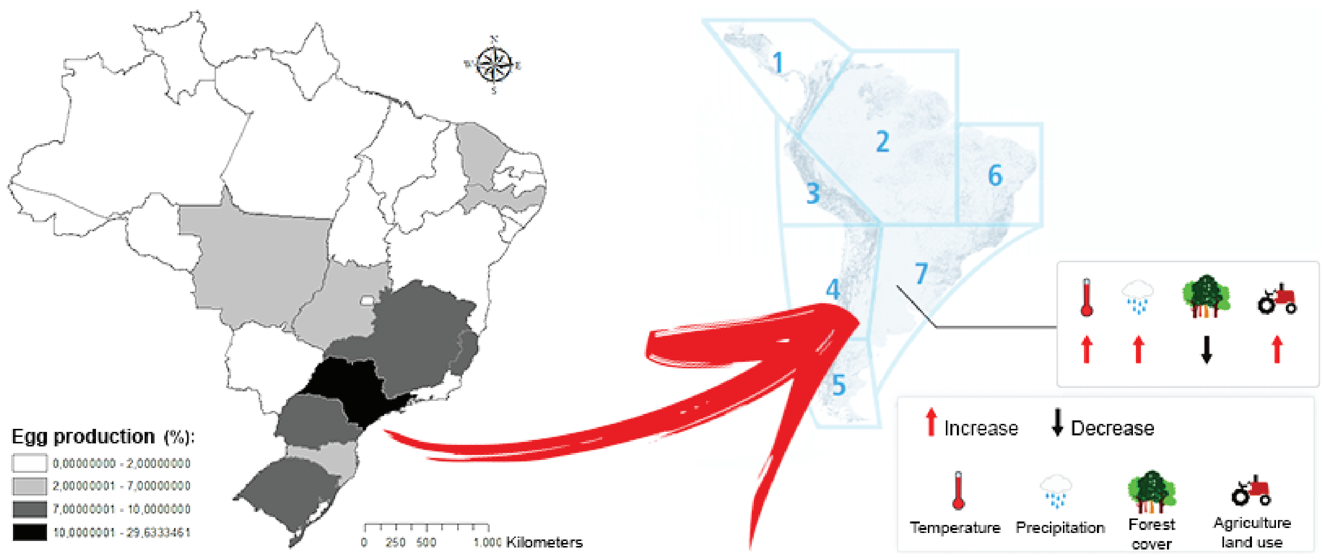
The black line shows the variations observed between 1900 and 2012. The blue band indicates "optimistic" forecasts (RCP2.6) and the orange strip, "pessimistic" forecasts (RCP8.5). Temperature forecast values (in °C) for the Southeast region of South America until the end of this century are presented in Table 1.

Table 1 – Average temperature projections for the IPCC scenarios for Southeast region of South America.

SCENARIO	2030	2050	2100
RCP2.6	Approximately between+0.2°C and+1.2°C	Approximately between +0.3°C and +1.8°C	Approximately between +0.4°C and +1.9°C
RCP8.5	Approximately between +0.4°C and +1.6°C	Approximately between +1.0°C and +2.6°C	Approximately between +2.4°C and +5.2°C

Source: Adapted from the information shown in Figure 3.

Figure 4 shows the map of egg production distribution in Brazil, and IPCC climatic changes forecasts for the southeast of South America, where the municipality of Bastos, analyzed in the present study, is located.



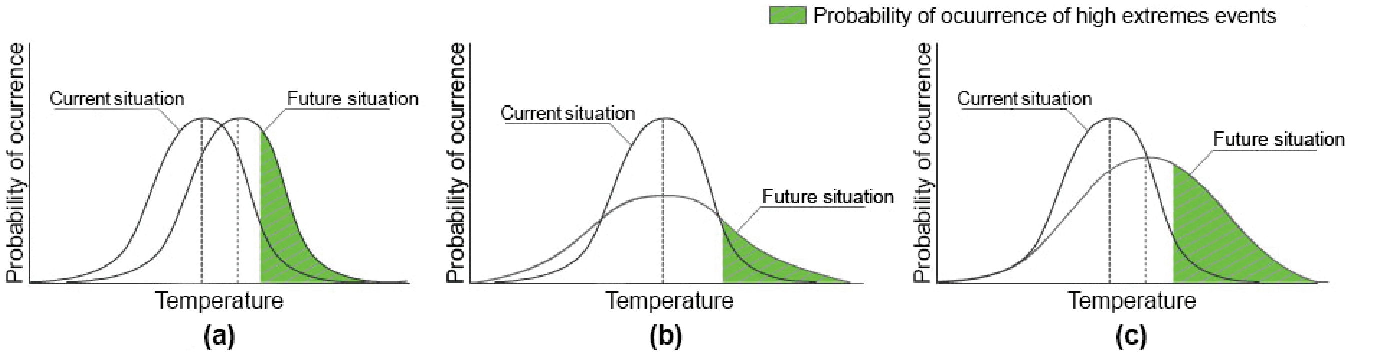
Source: Based on IBGE (2018) and IPCC (2014b).

Figure 4 – Map of egg production distribution of in Brazil by state and climate change and land use forecasts in the Southeastern of South America.

According to the IPCC's forecasts, temperature, precipitation and land use for agriculture and a decrease in forest cover are expected in this region. For purposes of the present study, we highlight the increase in temperature, which may impact the egg production system.

These forecasts are based on new scenarios, called *Representative Concentration Pathways* (RCPs), generated by the *Special Report Emissions Scenarios* (SRES), which analyze the greenhouse gas emissions including a more restrictive analysis of ozone emissions, precursor aerosols, and associated pollutants (IPCC, 2014a).

In addition, the IPCC emphasizes that extreme events, especially heat waves and droughts, are likely to increase, causing impact on average temperature (IPCC 2014a). Figure 5 illustrates possible projections for extreme events.



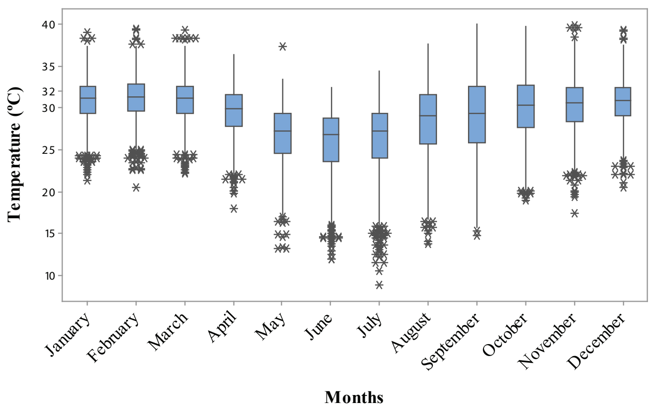
Source: Adapted from IPCC (2013).

Figure 5 – Forecasts of the occurrence of extreme events.

Three possible projections are shown in Figure 5. The first projection (Figure 5a) indicates a possible increase of minimum, maximum and average temperatures (displacement of the distribution to the right), followed by the second projection (Figure 5b), which points to a higher variation of cold and hot temperatures, resulting in a general temperature decrease (flattening of the distribution). Finally, the third projection (Figure 5c) shows a shift of the curve to the right and a slight flattening due to an increase in average and maximum temperatures.

Maximum temperature (ºC) during extreme events may further increase in the presence of the El Niño phenomenon. This event can be described as an oceanic-atmospheric phenomenon during which there is an abnormal temperature increase in the Equatorial Pacific Ocean. This may lead to a change in the regional and global climate (INPE, 2018).

It should be emphasized that the presence of El Niño can strongly increase the incidence of heat waves. According to the definition of INMET (2017a), heat waves occur when daily temperature is higher than 32ºC, at least five degrees above the normal historical for the region, and for at least two days. In addition, this climatic anomaly causes significant changes, such as unexpected higher temperatures during some months of the year. In this context, the maximum temperatures recorded between 1961 and 2012 in the municipality of Presidente Prudente, SP, were analyzed through the analysis of a boxplot chart, as shown in Figure 6, below.

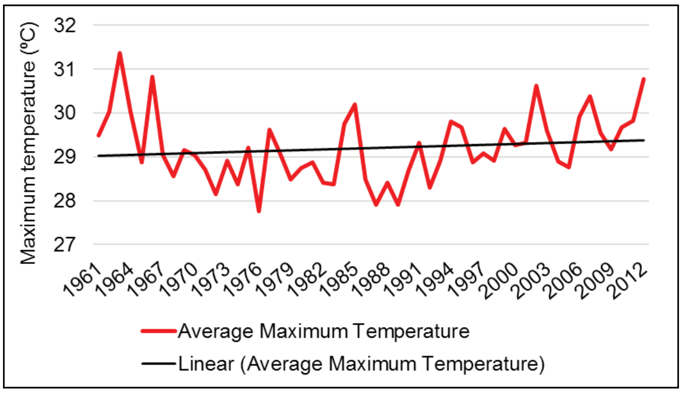


Source: INMET (2017b).

Figure 6 – Maximum monthly temperature (ºC) recorded in the municipality of Presidente Prudente, SP, between 1961 and 2012.

Figure 6 shows that, from November until March, there is a greater incidence of extreme temperatures, which may have a negative impact on egg production. During these months, followed by September and October, the third temperature quartile is above 32ºC, indicating that, during seven months of the year, only over 25% of the temperature data is higher than 32ºC. These temperature ranges include the incidence of heat waves, which, obviously, are more likely to occur during the hottest months of the year. During August (8) and September (9), there is a greater temperature amplitude and variation. This may be explained by the season change, when temperatures start to increase.

In addition to the monthly data analysis, the average annual maximum temperature is shown in Figure 7.



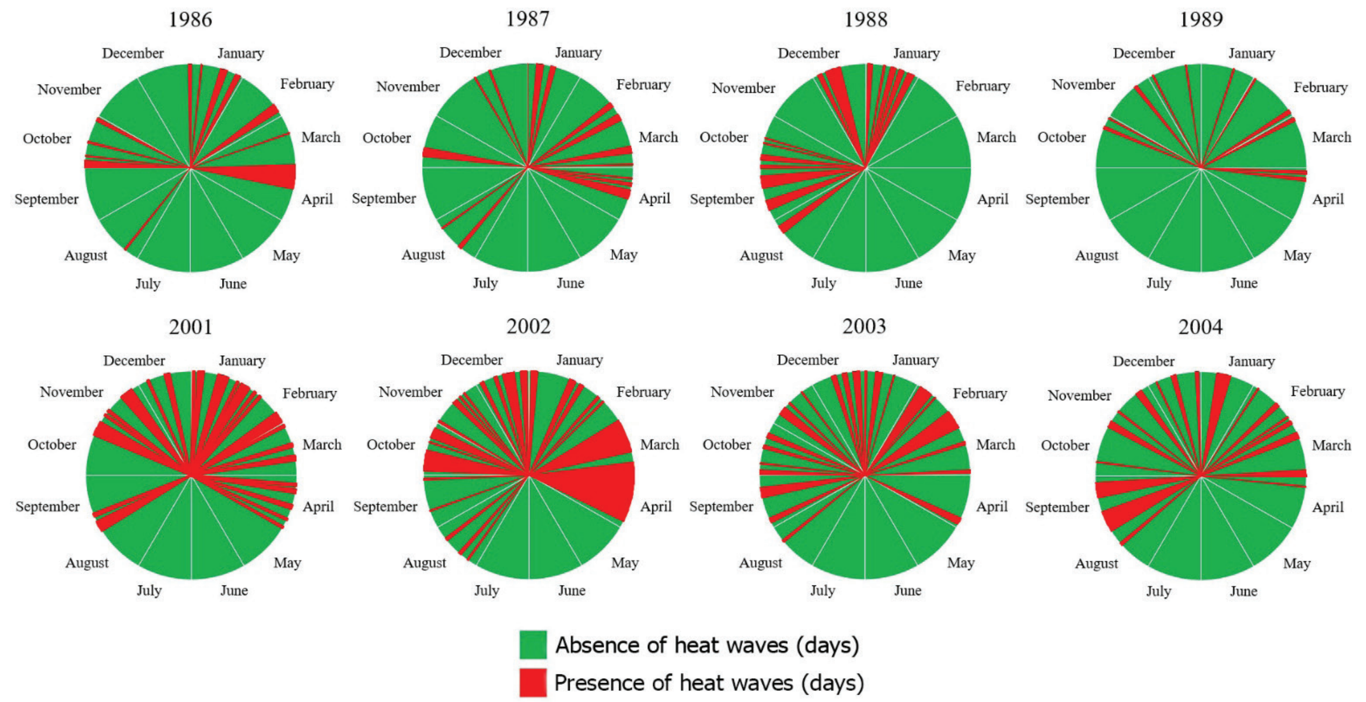
Source: INMET (2017b).

Figure 7 – Annual average maximum temperature (°C) recorded in the municipality of Presidente Prudente, SP, between 1961 and 2012

Average annual maximum temperature has annually changed. In particular, it should be noted that it has linearly increased from the mid-1980s, indicating a rise in the temperature range in the region. An increase in the incidence of heat waves was also observed during this period (Figure 8).

In Figure 9, the red bands represent the days characterized as heat wave. When the period of 1986-1989 are compared with the period of 2001-2004, a clear increase in the frequency, number, duration and temperature (intensity) of this climatic anomaly is observed, as shown in Table 2.

The data presented in Table 2 show an increase in the annual number of events, from 13 days in 1986 to about 21 days in 2003. The duration of the event



Source: INMET (2017b).

Figure 8 – Heat waves recorded in the municipality of Presidente Prudente, SP.

Table 2 – Heat Wave numbers, average duration and maximum average temperature recorded in themunicipality of Presidente Prudente, SP.

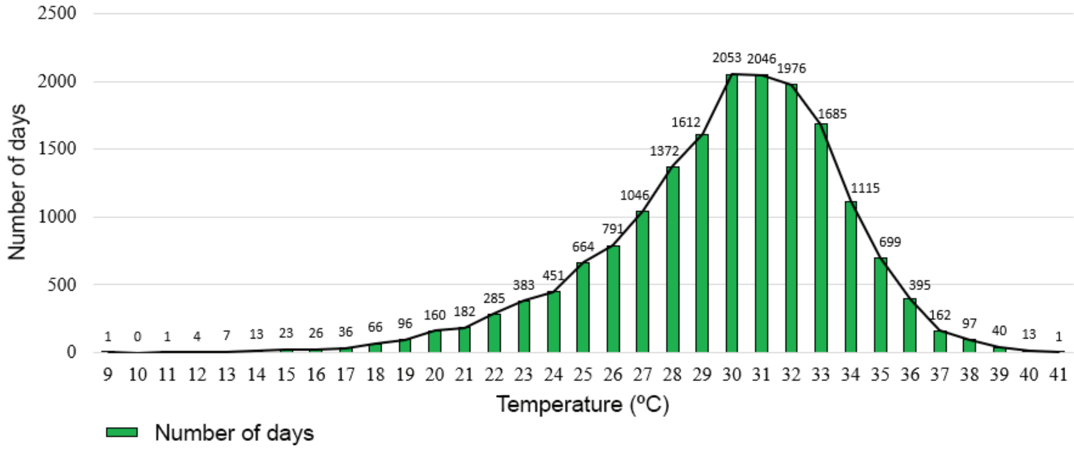
	Number of Heat Waves	Average Duration of Heat Waves	Maximum Average Heat Wave Temperature
1986	13	4	33.15
1987	14	3.64	32.98
1988	14	4.64	34.31
1989	11	2.55	32.77
2001	24	3.75	33.19
2002	23	6.04	34.06
2003	21	4.33	33.84
2004	18	4.5	33.93

Source: INMET (2017b).

was approximately 3 to 4 days in 1986-1989, and increased to around 5-6 days in 2001-1004. Finally, the average temperature (intensity) of these waves varied between 32ºC and 34ºC in the first period and between 33ºC and 34ºC, showing a 1ºC increase in temperature during heat waves. These results clearly show that all the variables involved in heat wave events are increasing over the years.

Figure 9 shows the frequency distribution of daily temperature averages for the period of 1961 to 2012, recorded at the Presidente Prudente meteorological station. It is observed that the data distribution is concentrated between 27ºC and 34ºC, with 35.32% of the recorded temperatures above 32ºC.

Several studies show that the egg production and behavior of layers affected by the thermal environment



Source: INMET (2017b).

Figure 9 – Distribution of the number of days with maximum temperature recorded in municipality of Presidente Prudente, SP, between 1961 and 2012.

of the shed (Silva *et al.* 2013; Castilho *et al.* 2015; Nayak *et al.* 2015; Pereira *et al.* 2015). The upper limit of the thermoneutrality and thermal comfort zones of chickens (both broilers and layers) was established as below 30ºC (Freeman, 1988; Costa, 1994; Alves, 2006; Pereira & Nääs, 2008; Baeta & Souza, 2010).

Amendola *et al.* (2004) and Oliveira *et al.* (2005), in studies with layers and broilers, respectively, determined temperatures of 29ºC (broilers) and 30ºC (layers) are detrimental to the birds, independently of relative humidity level. According to the criteria established by INMET, heat waves are characterized by 32ºC minimum temperature, which is higher than the critical upper temperature for layers.

Mack *et al*. (2013), in a study on genetic differences in layers, observed that hens submitted to heat stress (32.6ºC) presented reduced egg production and presented behavioral changes compared to those maintained under thermal comfort (24.3ºC). Using data mining to develop a model to estimate layer mortality caused by heat wave as a function of shed typology, Riquena (2017) found that layer typology may influence the mortality of the hens.

Comparing the analyzes of the different data bases, it is observed that the months of January, February, March, October, November and December correspond to the periods of the spring and summer seasons, with an average temperature of the maximum average temperature above 30ºC, being outside the thermal comfort zones and thermoneutrality zone suggested for poultry commercial operations (Freeman, 1988; Costa, 1994; Alves, 2006; Pereira & Nääs, 2008; Baeta & Souza, 2010).

Yet, in relation to the annual production period, considerable increases in temperature values have been recorded in August and September, during the winter. Pereira *et al.* (2010) observed that the mortality rate of broiler breeders during this period was significantly higher compared with the other months. It is very likely that the hens will be strongly affected by these higher temperatures, as they have not yet acclimated to higher temperatures of the hottest months of spring and summer (Sykes & Fataftah, 1986; Yahav & McMurtry, 2001; Pereira *et al.* 2010).

There has been a considerable increase in the frequency, number, duration and average temperature of the heat waves over the years, as observed in Figure 8 and Table 2. All these variables significantly affect poultry production, and, in particular, the high temperature (intensity) of these events is emphasized, when the upper limit of the thermal comfort and thermoneutral zone of layers is exceeded, as previously mentioned.

Considering the linear tendency of increase in maximum temperatures since the mid-1980s indicated in Figure 7, the increase in the number of heat waves and the data reported by the IPCC (Figure 3, Figure 4 and Figure 5), it is believed that in the next few years, egg producers of the region of Bastos that do not have air-conditioned layer houses are likely to experience higher mortality rate in their flocks as a result of heat waves.

CONCLUSION

The historical temperature series recorded in the region of Bastos show a linear increase of the maximum temperatures, as well as a greater frequency, quantity, duration and intensity of heat waves.

Considering the future scenarios forecasted in the IPCC reports, an increase in average temperature between 0.4°C and 1.9°C for the optimistic scenario and between 2.4°C and 5.2°C for the pessimist are expected to occur in the studied region by the end of the century. In both scenarios, heat waves are expected to be more frequent, longer and more intense, which will inevitably result in higher hen mortality in non-climatized egg production systems.

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