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Time series evaluation of ascitic syndrome condemnation at poultry abattoirs under Federal Inspection Service of Brazil (2010-2019)[1]

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ABSTRACT.- Souza M.C.C., Borges L.F.N.M., Nascimento Y.F., Costa L.R.M., Dias S.C., Ventura N.K.O., Freire I.S. & Cossi M.V.C. 2021. **Time series evaluation of ascitic syndrome condemnation at poultry abattoirs under Federal Inspection Service of Brazil (2010-2019).** *Pesquisa Veterinária Brasileira 41:e06806, 2021.* Universidade Federal de Uberlândia, Rua Ceará, Bloco 2D, Sala 29, Campus Umuarama, MG 38405-315, Brazil. E-mail: marcuscossi@yahoo.com.br

Over the last decade, Brazil registered a 10.56% increase in the number of poultry slaughtered in establishments registered under the "Serviço de Inspeção Federal" (SIF - Federal Inspection Service), as a result of technological advances in management, health and genetics applied to national aviculture. At slaughter, during post-mortem inspection, carcasses can be totally or partially condemned for various reasons, including ascitic syndrome. This syndrome has economic implications for the industry, in addition to being a problem for the health and welfare of poultry. The objective of this work was to evaluate the historical series (2010-2019) of partial and total condemnations of poultry carcasses due to ascitic syndrome in slaughterhouses registered under the SIF and located in the main poultry-producing states. Through official data, the condemnation occurrence index (COI) and the adjusted seasonal index (ASI) were calculated. The condemnation rate was 1,140 carcasses condemned, totally or partially, for ascitic syndrome for every 1,000,000 poultry slaughtered. The smallest and largest COIs were found in São Paulo (February 2010) and in Goiás (January 2017), respectively. The occurrence of condemnations for this syndrome was cyclical throughout the historical series, showing peaks of condemnation in all years evaluated, with the highest ASIs in July, August and September, and with rates varying between 1.24 and 1.54 in these months. Considering the period of pre-slaughter housing, the highest ASIs coincide with the coldest period of the year (May to August) for all analyzed states. The results show that ascitic syndrome is a growing problem in Brazil, with greater occurrence during the coldest months of the year, having a negative impact on animal health and the profitability of producers and industries in the poultry production chain.

INDEX TERMS: Ascitic syndrome, poultry slaughter, Federal Inspection Service, Brazil, condemnations.

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RESUMO.- [Avaliação de um período histórico de condenações por síndrome ascítica em abatedouros de aves sob Serviço de Inspeção Federal do Brasil (2010-2019).] O objetivo deste trabalho foi avaliar a série histórica (2010-2019) de condenações parciais e totais de carcaças de aves por síndrome ascítica em abatedouros registrados no SIF localizados nos principais estados produtores de carne de frango. Através de dados oficiais, foram calculados o índice de ocorrência de condenações (IOC) e o índice de sazonalidade ajustado (ISA). A taxa de condenação foi de 1.140 carcaças condenadas total ou parcialmente por síndrome ascítica a cada 1.000.000 de aves abatidas. O menor e maior IOCs foram encontrados em São Paulo (fevereiro/2010) e em Goiás

(janeiro/2017), respectivamente. A ocorrência de condenações por esta síndrome teve comportamento cíclico ao longo da série histórica, apresentando picos de condenação em todos os anos avaliados, sendo os maiores ISAs encontrados nos meses de julho, agosto e setembro, com índices variando entre 1,24 e 1,54 nestes meses. Considerando o período de alojamento pré-abate, os maiores valores de ISAs coincidiram com o período mais frio do ano (Maio a Agosto) para todos os estados analisados. Os resultados mostram que síndrome ascítica é um problema crescente no Brasil, com maior ocorrência durante os meses frios do ano, impactando negativamente a saúde dos animais e a lucratividade dos produtores e indústrias da cadeia produtiva de frango de corte.

TERMOS DE INDEXAÇÃO: Síndrome ascítica, abatedouro de aves, Serviço de Inspeção Federal, Brasil, condenações.

INTRODUCTION

In the last decade, Brazil has recorded a 10.56% increase in the number of poultry (broiler, turkey and quail) slaughtered in establishments registered under the "Serviço de Inspeção Federal" (SIF - Federal Inspection Service), increasing from 4,795,965,464 birds in 2010 to 5,302,510,470 birds in 2019 (MAPA 2020). This growth is the result of the competitive strength of poultry farming in the country, based on low production costs, high product quality, good zootechnical indexes and high health status (Vogado et al. 2016). These characteristics of the sector are the result of technological advances in management, health and genetics applied to poultry, especially broilers (Goscinscki 2016).

Modern breeds of broilers are able to reach their slaughter weight faster than the broilers of 40 years ago (Parveen et al. 2020), but their lung and cardiac capacities are similar to those of the past decades. This combination causes an overload in the chicken's cardiorespiratory system, forcing it to work close to the physiological limit (Lorenzoni & Ruiz-Feria 2006) and resulting in losses in its ability to regulate its energy balance in extreme situations, such as low temperature environments or high altitudes (Luger et al. 2003). The insufficient supply of oxygen to the tissues stimulates the development of several compensatory mechanisms in the cardiorespiratory system, which lead to ascitic syndrome.

Ascites (pulmonary hypertension syndrome) is a multifactorial problem mediated by environmental, nutritional and genetic factors, and is the main non-infectious cause of death in broilers (Hassanzadeh et al. 2014). It is characterized by hypoxemia, increased workload of the cardiorespiratory system, central venous congestion, accumulation of fluids in the celomatic cavity, hypertrophy of the right ventricle and death (Parveen et al. 2020).

During post-mortem inspection in the slaughterhouse, carcasses of poultry with ascitic syndrome can be entirely or in part condemned, depending on the degree of involvement (MAPA 2017). Ascitic syndrome harms the health and well-being of poultry, in addition to having economic implications for the industry, due to mortality at the end of the period of poultry housing and condemnation in the slaughterhouse (Kalmar et al. 2013). Even considering the development on the selection of more adapted strains and more appropriate management practices, it is estimated that the ascitic syndrome is still responsible for losses around US$100 million per year worldwide (Tarrant et al. 2017).

Carcass condemnation records have been recognized as an important source of information on animal diseases in several countries and are valuable for demonstrating trends in occurrence, indicating economic losses under different conditions and identifying areas where more research may be needed (Oliveira et al. 2016). Condemnation patterns can lead to the identification and control of production factors that may be related to increases in causes of condemnation at certain times of the year (Moretti et al. 2010).

Considering that Brazil is the second largest producer of chicken meat and the largest exporter, responsible for 32.81% of world exports in 2018, the analysis of condemnation data is highly relevant and necessary for the sector's profitability (USDA 2019). Thus, the aim of this work was to evaluate the historical series (January 2010 to December 2019) of partial and total condemnation of poultry carcasses due to ascitic syndrome in slaughterhouses registered under the SIF and located in the main broiler-producing states in Brazil.

MATERIALS AND METHODS

A cross-sectional study was carried out using data obtained through the website of the "Ministério da Agricultura, Pecuária e Abastecimento" (MAPA - Ministry of Agriculture, Livestock and Supply), on the number of poultry slaughtered and number of carcasses condemned due to ascitic syndrome from January 1, 2010 to December 31, 2019 in slaughterhouses registered under the SIF of Brazil. Individual data were obtained from the six main poultry-producing states (Paraná, Santa Catarina, Rio Grande do Sul, São Paulo, Minas Gerais and Goiás), which are responsible for 87.7% of the volume of poultry slaughtered in Brazil. Information from the other Brazilian states was combined for analysis. On the official condemnation records, it was not possible to differentiate the slaughtered species (chicken, turkey, duck, quail, etc.) regarding the number of daily slaughtered and condemned animals, therefore, all data were included and analyzed together. Furthermore, all collected data for analysis went through individual verification to identify and exclude inconsistent information. In addition, in order to include all possible forms of recording condemnation due to ascitic syndrome, we used the following search terms: ascitic syndrome, ascites, ascitic syndrome (poultry). Finally, considering that there are variations in the way of describing the destination of the carcass, we also used the following options as a filter in the research: total condemnation, partial condemnation, cuts and rendering area.

The relative contribution of the number of carcass condemnations for ascitic syndrome in relation to the total number of slaughtered animals was assessed using the condemnation occurrence index (COI). COI was defined by the ratio between the monthly condemnation value due to ascitic syndrome and the total number of animals slaughtered in the period (Moretti et al. 2010). This calculation allowed us to assess the behavior of the condemnation due to ascitic syndrome without the influence of the size of the slaughtered population in each month. With these results, the standard COI range for each year and state was also calculated, according to the average COI of the year in each state plus the standard deviation for that period. Using this data, it was possible to identify which months had COI above the standard range for the year and state. To facilitate data visualization, the calculated COI was multiplied by 10^6 (condemnation occurrence index per million slaughtered animals).

The adjusted seasonal index (ASI) related to the ascitic syndrome for each state was also calculated (Moretti et al. 2010). First, values of monthly COI were used in the numerator and the annual COI mean in the denominator to identify the specific contribution of each month in the condemnation rates of the year (JAN2010 = COI January 2010/COI 2010 average; FEB2010 = COI February 2010/COI 2010 average ... DEC2019 = COI December 2019/COI 2019 average). Later, the ASI was obtained by calculating the average for each month using the 10-year historical series ((JAN2010 + JAN2011 + ... JAN2019)/10; ... (DEC2010 + DEC2011 + ... DEC2019)/10). Through the calculation of ASI, it was possible to minimize random variations that may have occurred in the data on ascitic syndrome condemnation. This procedure was repeated for all states included in this study.

Finally, the average temperature data of each state was obtained from the website of the "Instituto Nacional de Meteorologia" (INMET - National Institute of Meteorology) (INMET 2020) in order to calculate the annual thermal amplitude. To obtain the monthly average temperature and monthly average temperature amplitude (Δ = highest average temperature in the month -lowest average temperature in the month) of each state, daily temperature data of the main broiler production regions of the states were selected: for Rio Grande do Sul, east and northeast regions; for Santa Catarina, western region; for Paraná, west, center and north regions; for São Paulo western region; for Minas Gerais, western region; and for Goiás, center and southwest regions.

RESULTS

The importance of each state regarding the volume of poultry slaughtered in establishments under federal sanitary inspection in the years 2010 to 2019 is shown in Table 1. Together, the six largest states were responsible for 87.7% of the poultry slaughtered in Brazil. The southern region has been responsible for approximately 63% of the poultry slaughtered in the last decade, with Paraná being responsible for the largest volume, equivalent to almost 32% of the national slaughter.

In Brazil, 1,140 carcasses were totally or partially condemned for ascitic syndrome for every 1,000,000 poultry slaughtered, with three states having individual rates lower than the national rate (Paraná, Rio Grande do Sul and São Paulo) (Table 1). From 2010 to 2019, Goiás had the highest rate of carcass condemnation for ascitic syndrome and the lowest rate was found in São Paulo.

When performing a monthly evaluation of the studied time series, a similar behavior is observed between the minimum and maximum values obtained in each month (Fig.1-6). The lowest rate of condemnation occurrence index (COI) for ascitic syndrome was found in February 2010 in the state of São Paulo (301 carcasses condemned for every 1,000,000 poultry slaughtered) (Fig.2) and the largest COI was found in January 2017 in the state of Goiás (6,927 carcasses condemned for every 1,000,000 birds slaughtered) (Fig.6).

The states of São Paulo and Rio Grande do Sul were the states that most often presented the lowest monthly COI values among the evaluated states, with the former having the lowest COI in 69 out of the 120 months evaluated (57.5%) (Fig.2) and the latter having the lowest COI in 34 months (28.3%) (Fig.4). The states of Goiás, Santa Catarina and Minas Gerais were responsible for the highest COI in 36 (30.0%), 41 (34.2%) and 41 (34.2%) of the evaluated months, respectively (Fig.3, 5 and 6). In addition to an upward trend over time, except at Rio Grande do Sul state (Fig.1), it can be seen in Figure 1-6 that the occurrence of condemnation for this syndrome had an apparently cyclical behavior, with peaks in all the evaluated years.

Given that each state has its own production characteristics, the standard value (average + standard deviation) of condemnation for each year and state was calculated (Fig.7). Despite the wide variety of regions analyzed, out of the 129 months with an above-standard condemnation rate, 108 (83.7%) occurred in three months: July (28.7%), August (34.9%) and September (20.1%). This result helps us to identify which months proportionally contributed the most to the peaks observed in Figure 1-6.

In order to assess the real impact of each month and minimize random variations that may have occurred throughout the historical series, the adjusted seasonal index (ASI) was calculated (Fig.8-13). With the results of the ASI, we identified the months that were historically responsible for a lower than the expected average (values less than 1.0) condemnation due to ascitic syndrome and the months responsible for a higher than the expected average (values greater than 1.0) condemnation values. Thus, as observed in Figures 1-6 and 7, months of July, August and September were those with the highest ASI values in all states. The values varied between 1.29 (Fig.13) and 1.38 (Fig.8) for July (an average increase in condemnation between 29 and 38%), 1.36 (Fig.10) and 1.54 (Fig.11) for August (increase between 36 and 54%) and 1.24 (Fig.10) and 1.39 (Fig.9) for September (increase between 24 and 39%). It was also observed that even the state of Goiás, presenting the highest COI value in January 2017 (Fig.6), the analysis of the historical period, represented by ASI, showed that January is responsible for a lower number

Table 1. Condemnation rate (total + partial) of poultry carcasses caused by ascitic syndrome in Brazil in slaughterhouses under Federal Inspection Service (2010-2019)

State	Number of slaughtered animals (%)	Number of condemnation for ascitic syndrome	Condemnation rate (%)
Paraná	16,633,662,860 (31.9%)	15,875,954	0.095
Santa Catarina	8,672,133,498 (16.7%)	13,220,048	0.152
Rio Grande do Sul	7,473,942,362 (14.4%)	7,230,792	0.097
São Paulo	5,613,858,419 (10.8%)	4,307,193	0.077
Goiás	3,502,161,998 (6.7%)	5,998,431	0.171
Minas Gerais	3,776,218,240 (7.2%)	5,632,218	0.149
Others*	6,421,278,702 (12.3%)	6,993,994	0.109
TOTAL	52,093,256,079	59,258,630	0.114

* Other states, except Rio de Janeiro, due to the absence of records of slaughter of chickens under federal inspection in the state in the evaluated period.

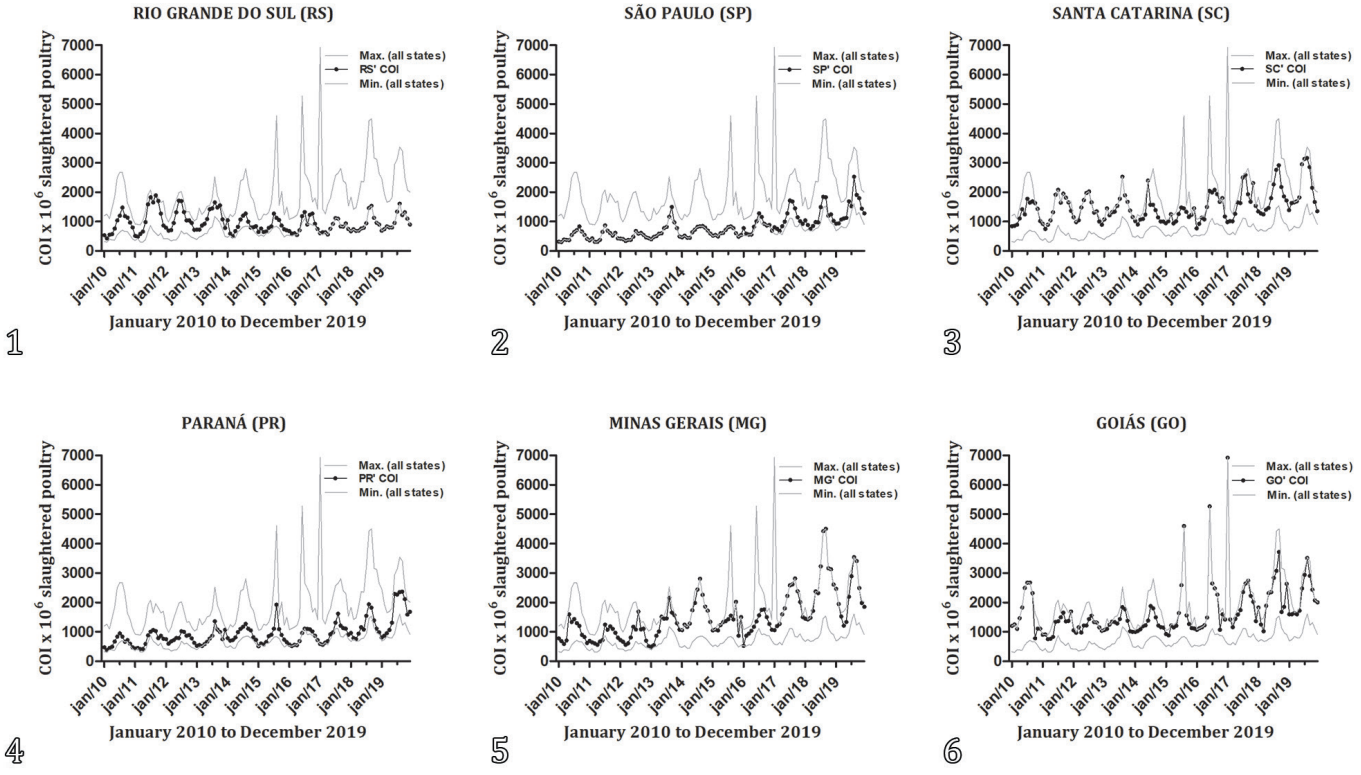

Fig.1-6. Condemnation occurrence index (COI) for ascitic syndrome in poultry slaughterhouses registered under "Serviço de Inspeção Federal" (SIF - Federal Inspection Service), located in the six main states in production of chicken meat in Brazil (2010-2019).

of condemnations when compared to the annual average (ASI = 0.96), as seen in Figure 13.

Considering that the months with the highest ASI values could be related to the coldest months of the year, it was carried out an evaluation of the average monthly temperature of each state (Fig.8-13). It was observed that all states had the months of May, June, July and August with the lowest temperature averages, showing a possible relation between low temperatures and an increase of ASI (40 to 45 days of pre-slaughter housing). The only exception was observed at the state of Goiás, for which the coldest months are May, June and July, only. The lowest temperature averages were observed in July and June at Rio Grande do Sul (13.13°C and 13.43°C, respectively). In addition, the highest monthly temperature amplitude averages were observed in July, August and September, for all states (Fig.14). The highest temperature amplitudes occurred in August at Rio Grande do Sul (Δ = 31°C) and São Paulo (Δ = 30.9°C). Based on these results, it was possible to recognize that even in the states with higher annual temperature averages (Goiás and São Paulo), a greater temperature amplitude was observed during the months with the lowest temperatures (Fig.8-13 and Fig.14).

DISCUSSION

Previous studies have evaluated ascitic syndrome condemnation in broilers in different regions of Brazil and using different time series than those of the present study. Oliveira et al. (2016) found a lower rate of condemnation for ascitic syndrome compared to the present study, at 900 for every

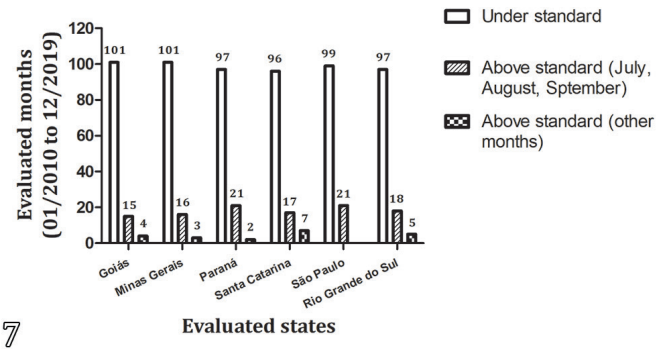

Fig.7. Number of months with condemnation occurrence index (COI) above the standard value (Mean + SD) for ascitic syndrome condemnation of poultry carcasses (2010-2019).

1,000,000 broilers slaughtered from 2006 to 2011 in Brazil. Almeida et al. (2017) evaluated the condemnation of broilers carcasses in the Brazilian Northeast in 2016, and obtained an even lower rate, with 700 carcasses condemned for every 1,000,000 birds slaughtered. It should be noted that a single year of condemnation data does not necessarily represent the pattern in that region, as we observed at Goiás condemnation rates in 2017 compared to the rest of the time series period (Fig.6 and 13).

The same upward trend that we observed was observed by Jacobsen & Flôres (2008) in Rio Grande do Sul (South of Brazil), with a 50% increase in total condemnations for ascitic syndrome from 2002 to 2006. This increase in the occurrence

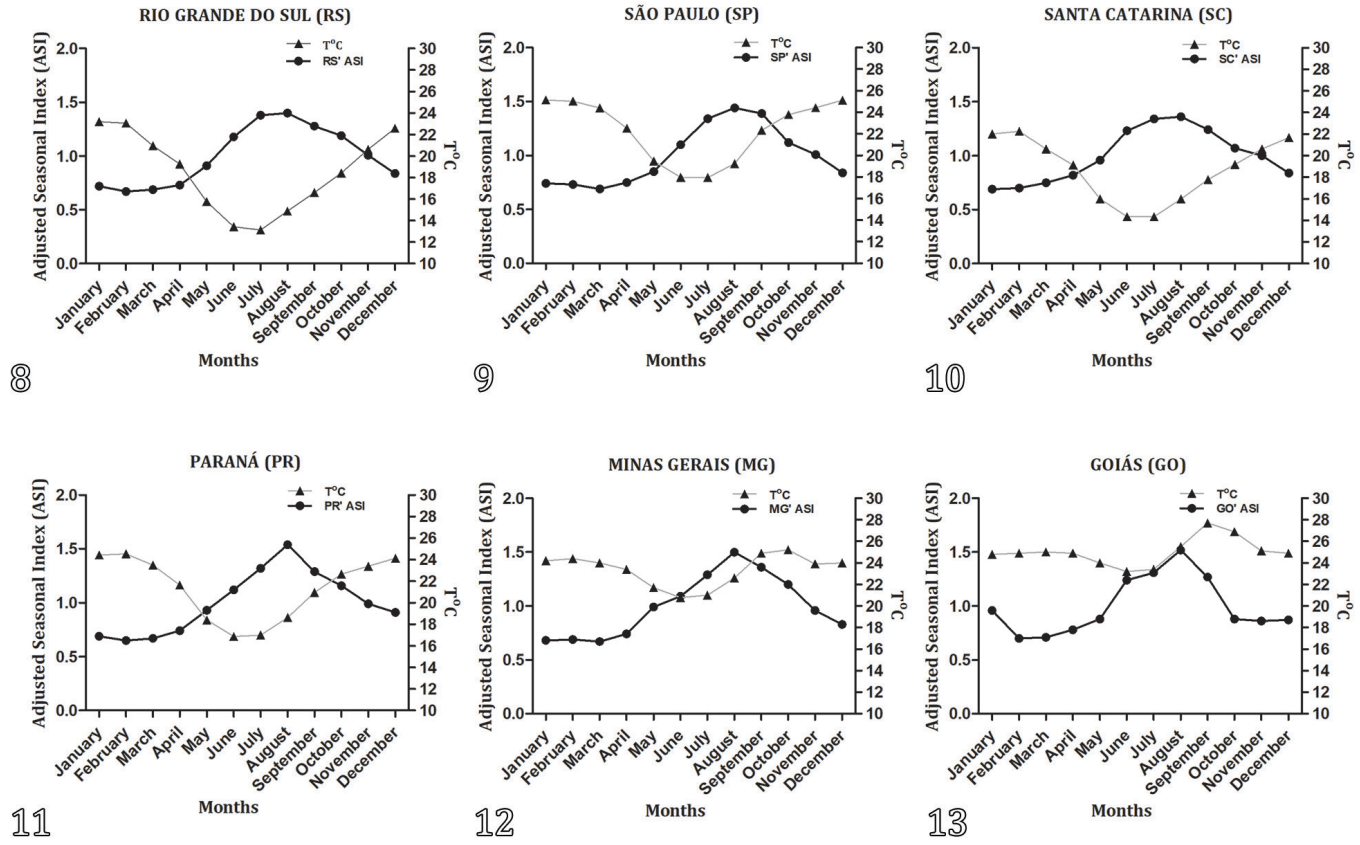

Fig.8-13. Adjusted seasonal index (ASI) for ascites syndrome condemnation in poultry slaughterhouses registered under "Serviço de Inspeção Federal" (SIF - Federal Inspection Service), and monthly average temperature of the six main states of poultry meat production in Brazil (2010-2019).

of ascitic syndrome carcass condemnation suggests that this syndrome is not being properly controlled. This may reflects the concern of the productive sector in guaranteeing a zootechnical performance excellency, even if financial losses caused by ascitic syndrome are a side effect. This hypothesis agrees with the findings of Rosário et al. (2004) and Jacobsen & Flôres (2008). In addition, in order not to underestimate the losses caused by ascitic syndrome, it should be noted that in addition to carcass condemnation, it is also an important cause of poultry mortality on farms (Qureshi et al. 2018).

The occurrence of ascitic syndrome has been related to genetic, environmental and nutritional factors, for example: genetic selection for lower feed conversion and higher growth rate; diet composition and feed supply system; high altitudes; low temperatures; lighting systems; and air quality and ventilation in broiler breeding systems (Deaton et al. 1996, Julian 2000, Rosário et al. 2004, Baghbanzadeh & Decuypere 2008). Thus, variations observed between the states may have their explanation based on these characteristics. Rio Grande do Sul (RS), for example, was the only state that did not show a tendency to increase COI over the historical series analyzed (Fig.1). In this case, characteristics of the state's poultry production in the organizational and technological scope (Lazaretti et al. 2018) may have contributed to this maintenance of the index. In addition, RS presented the lowest temperatures within the historical series and this may have

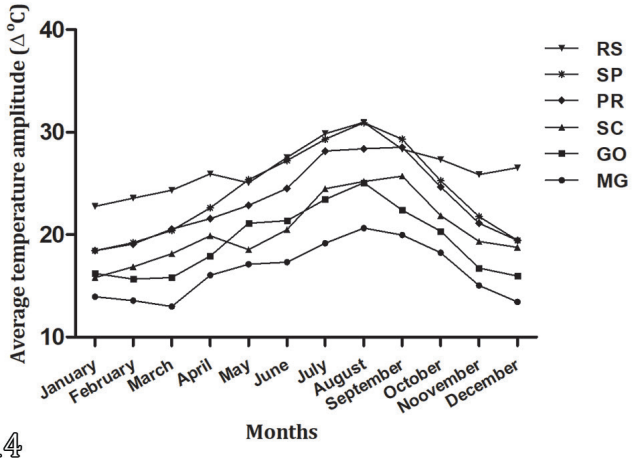

Fig.14. Monthly average temperature amplitude (Δ = highest average temperature in the month -lowest average temperature in the month) of the six main states of poultry meat production in Brazil (2010-2019).

contributed to the chicken' adaptation, as observed by Qureshi et al. (2018), and these conditions have resulted in a greater control over COI values (Fig.1). The chicken' adaptation to the cold temperatures, added to genetic variations and broiler

breeding systems in each state, can help explain the lower COI values in states with more severe winters, such as RS and PR, compared to milder climate states, such as GO and MG (Fig.1-6 and 8-13). Considering the historical analysis presented by this study and the variations observed in each state, subsequent prospective studies can help to understand specific characteristics of each region in search of solutions for the occurrence of ascitic syndrome.

In addition, ascitic syndrome is a problem related to several species of poultry as chickens, turkeys and ducks. Some studies, however, point out that there is a variation in frequency between species, with the syndrome being more common in chickens than in turkeys, for example (Vecerek et al. 2019). Thus, whereas turkey is the second most slaughtered bird in Brazil and it represents less than 2.5% of the volume of chicken slaughtered in the country, it must be understood that chicken has a greater influence on our data, justifying our discussions focused on this species (ABPA 2020). Inferences about species that proportionally represent a smaller slaughter volume, must be made with caution and specific studies may be necessary.

The findings of this study regarding the seasonality of condemnation due to ascitic syndrome, especially during coldest months of the year, are consistent with other results in the literature (Jacobsen & Flôres 2008, Part et al. 2016, Nemati et al. 2017). Cold stress increases the energy needed for thermoregulation, deflecting the energy available from production to maintenance (Ruiz-Castañeda et al. 2015). The increase in cardiac output induced by cold leads to pulmonary hypertension, which, associated with the increment in the metabolic demand for oxygen, can increase the occurrence of ascites. Broiler chickens that develop ascites due to exposure to low temperatures exhibit the same clinical signs as those that develop it under conditions of low oxygen pressure, including increased hematocrit, hemoglobin, heart weight and right ventricle:total ventricle ratio (Druyan 2012).

Biswas (2019) reported that the duration of cold stress is more critical than the minimum temperature reached. According to Deaton et al. (1996), low temperatures in broiler chickens (26.7ºC, 24.4ºC and 21.1ºC in the 1st, 2nd and 3rd weeks of life, respectively) significantly increased mortality from ascites in the 6th week of life, when compared to higher temperatures. A study carried out by Embrapa (Brazilian Agriculture Research Corporation) concluded that the use of supplementary polyethylene curtain in broiler barns during the first 21 days of life is a practical device that is easy to assemble and economically viable, and reduces mortality due to ascitic syndrome (Jaenisch et al. 2001).

The seasonal occurrence of condemnation due to ascites syndrome found in the present study demonstrates that harmful management procedures were repeated every year. The improvement of animal health and welfare and the consequent reduction of losses can be achieved through epidemiological evaluation of the factors associated with the occurrence of ascitic syndrome, for example, through case-control studies, as suggested by Moretti et al. (2010). Considering our results, Goiás, Santa Catarina and Minas Gerais were responsible for the highest COI among the evaluated months, and for this reason, specific studies are needed to identify characteristics that differ them from other states in order to identify possible actions to reduce the rates of condemnation due to ascites syndrome.

Several studies have been carried out in order to reduce the negative impacts of ascitic syndrome in the production of broilers. McGovern et al. (2000) studied the effect of temperature variation, which resulted in a 1.4% increase in mortality from ascites in relation to the control treatment. In a study by Sato et al. (2002), production at a controlled temperature of 20ºC±5ºC reduced the clinical and pathological signs of ascitic syndrome in 80% of the evaluated animals. Lorenzoni & Ruiz-Feria (2006) studied the effect of supplementation with L-arginine in the feed of broilers raised at temperatures below normal, and found improvements in the relaxation of the arteries of the lungs. According to this study, the gain occurred as a consequence of the extra availability of L-arginine substrate for the enzyme nitric oxide synthase (NOS). This enzyme synthesizes nitric oxide (NO), which is a potent endogenous pulmonary vasodilator. By reducing pulmonary vascular resistance, it is possible to reduce the pulmonary arterial pressure necessary to boost the cardiac output required to meet the metabolic demand, and delay the pathophysiological progression that leads to the occurrence of ascitic syndrome.

Nemati et al. (2017) studied the effect of supplementation with vitamin C and coenzyme Q-10 individually and combined to mitigate the negative effects of cold stress in broilers. They found improvements in production parameters such as decreased feed conversion and increased body weight, and in parameters related to ascites (lower red blood cell count, lower hematocrit, lower heart weight). There was no additional benefit from the combination of vitamin C and coenzyme Q-10. The results found by Lorenzoni & Ruiz-Feria (2006) and Nemati et al. (2017) suggest that the interventions proposed would not need to be used throughout the year, but only in the coldest season in each region, which possibly would reduce the seasonality of the occurrence of ascitic syndrome. Results presented by Qureshi et al. (2018) also show that specific and, sometimes, small actions to combat the harm caused by the cold stress are always advantageous in decreasing the losses caused by ascitic syndrome.

The genetic improvement of broilers for certain metabolic and behavioral characteristics has led to the unwanted appearance of locomotor problems, ascites and sudden death syndrome (Crespo 2019). Thus, in chicken breeding one aim is to develop genotypes with greater genetic resistance to anomalies and conformation disorders. In addition, there is growing concern among consumers about well-being and metabolic diseases in animal production, putting pressure on breeders to select more physiologically balanced birds (Embrapa 2020).

CONCLUSIONS

The results show that ascitic syndrome remains a problem for the chicken meat production chain in Brazil, having a negative impact on the animals` health and on the profitability of producers, industries and others involved in this supply chain. In addition, it was observed that the months of July, August and September were those with the highest number of condemnations by this syndrome, corresponding to the coldest period of the year in all the analyzed states.

Before definitive solutions are put into practice, it will be necessary to carry out complementary studies to assess in each region the factors that cause ascitic syndrome and its variation in occurrence, thus facilitating the mitigation of losses through the adoption of specific preventive measures.

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