SPATIAL VARIABILITY OF AIR DRY BULB TEMPERATURE AND BLACK GLOBE HUMIDITY INDEX IN A BROILER HOUSE DURING THE HEATING PHASE

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ABSTRACT: The air dry-bulb temperature (t_{db}),as well as the black globe humidity index (BGHI), exert great influence on the development of broiler chickens during their heating phase. Therefore, the aim of this study was to analyze the structure and the magnitude of the t_{db} and BGHI spatial variability, using geostatistics tools such as semivariogram analysis and also producing kriging maps. The experiment was conducted in the west mesoregion of the states of Minas Gerais in 2010, in a commercial broiler house with heating system consisting of two furnaces that heat the air indirectly, in the firsts 14 days of the birds' life. The data were registered at intervals of five minutes in the period from 8 a.m. to 10 a.m. The variables were evaluated by variograms fitted by residual maximum likelihood (REML) testing the Spherical and Exponential models. Kriging maps were generated based on the best model used to fit the variogram. It was possible to characterize the variability of the t_{db} and BGHI, which allowed observing the spatial dependence by using geostatistics techniques. In addition, the use of geostatistics and distribution maps made possible to identify problems in the heating system in regions inside the broiler house that may harm the development of chicks.

KEYWORDS: broiler chickens, kriging, chick, semivariogram, thermal stress.

VARIABILIDADE ESPACIAL DE VARIÁVEIS AMBIENTAIS EM UM GALPÃO AVÍCOLA DURANTE A FASE DE AQUECIMENTO

RESUMO: A temperatura de bulbo seco do ar (t_{bs}) bem como o índice de temperatura do globo negro e umidade (ITGU) exercem grande influência no desenvolvimento de frangos de corte durante a fase de aquecimento. Sendo assim, o objetivo deste trabalho foi analisar a estrutura e a magnitude da variabilidade espacial da t_{bs} e ITGU, utilizando ferramentas da geoestatística por meio de análise de semivariograma e, ainda, a produção de mapas de isolinhas por meio de interpolação por krigagem. O experimento foi conduzido na mesorregião oeste de Minas Gerais, na primavera de 2010, em um galpão comercial com sistema de aquecimento constituído de duas fornalhas de aquecimento indireto do ar, durante os primeiros 14 dias de vida das aves. Os dados foram registrados em intervalos de cinco minutos, no período das 8 às 10 horas. As variáveis foram avaliadas por semivariograma ajustado pelo método da máxima verossimilhança restrita (REML), testando-se os modelos esférico e exponencial. Os mapas de krigagem foram produzidos baseados no melhor método de ajuste do semivariograma. As técnicas da geoestatística possibilitaram caracterizar a variabilidade da t_{bs} e ITGU, permitindo a observação da dependência espacial. Além disso, com a utilização da geoestatística e dos mapas de distribuição, pode-se identificar falhas no sistema de aquecimento, em regiões do galpão que poderiam vir a prejudicar o desenvolvimento dos pintinhos.

PALAVRAS-CHAVE: frangos de corte, krigagem, pintinho, semivariograma, estresse térmico.

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INTRODUCTION

Data of thermal comfort for chicks shows that both heat and cold stress during the first weeks of life can cause weight loss and other damages to the animal's health (MOURA et al., 2008). The initial development of the chick is critical to the performance of the broiler until the end of the production cycle (TEIXEIRA et al., 2009).

In the first few days after hatching, the chick is considered a poikilotherm animal, i.e., their body temperature undergoes variations according to air temperature. This is because these birds have neither mature thermoregulatory systems, nor enough energy reserves to be able to adapt to adverse environmental conditions.

Thus, in order to meet the thermal comfort requirements for the birds, heating is essential in early life and the animal's proper development depends on it. It is known that intensive farming systems has a direct influence on the animal's comfort and welfare, and on the expression of natural behaviors, affecting the productive performance of birds (VIGODERIS et al., 2010). Hence, it is important to adept the environmental settings to ideal conditions for the welfare of young birds.

Homogeneity of variances is expected in a production environment, within the facility, and according to YANAGI JR. et al. (2011), these variables can be evaluated through spatialization. Among the ways of analyzing the spatial variables, the geostatistics modeling is highlighted, because it allows a quantitative description of the spatial variability of microclimatic attributes in broiler houses and an unbiased estimate with minimum variance of values for these attributes in non-sampled locations (ISAAKS & SRIVASTAVA, 1989). This tool also allows seeing through contour maps, the distribution of variables within a broiler house. Thus, the objective of this study was to analyze the structure and magnitude of spatial variability for dry-bulb temperature (t_{db}) and black-globe humidity index (BGHI) in a broiler house during the heating phase of chicks, using geostatistics tools through semivariogram analysis and also the production of contour map through interpolation by kriging.

MATERIAL E METHODS

The study was carried out in a commercial broiler house in the west mesoregion of Minas Gerais State (20°12'02" south latitude and 45°02'08" longitude west of Greenwich), from September 28^{th} to October 11^{th}, during the spring season of 2010.

The broiler house was northeast-southwest oriented (approximately 13 m x 160 m x 3 m high), with roofing of 6 mm thick cement fiber, concrete floor and bed of rice husk. Double yellow side curtains were used on the broiler house (one internal and one external) and in the ceilling, the curtain was positioned at the high of 2.45 m from the floor. The internal curtains were drawn on the fifth day of life and the external were managed according to the weather conditions throughout the experimental period. The area inside the broiler house was limited by the plywood boards so the chicks would stay as close to the heating systems as possible. As the animals grew, these plywood boards were removed so the area available to animals increased. At the beginning of the experiment, in the first day of life, the birds were distributed at a lodging density of 54 birds per m². Subsequently, the area was increased in order to reduce the lodging density, gradually, until 13 birds per m² at the end of the heating phase.

The heating system installed in the broiler house consisted of two furnaces for indirect heating of the air using biomass (wood) as fuel, built by hand with bricks, mud and dung on iron structure (Figure 1). The furnaces were located 40 m away from each other. Each furnace was 1.88 m long, 1.27 m wide and 1.58 m high. A three-phase motor (2206 W or 3 CV, and 1725 rpm) was used for this operation, which sent the heated air through a tube with 10 cm in diameter.

Twenty eight thousand Cobb male chicks 1-14 days old were housed in the broiler house and the birds had *ad libitum* access to water throughout the experimental period. The diets provided to the animals were formulated to meet nutrient requirements for different stages of growth.

(a) (b) (c)

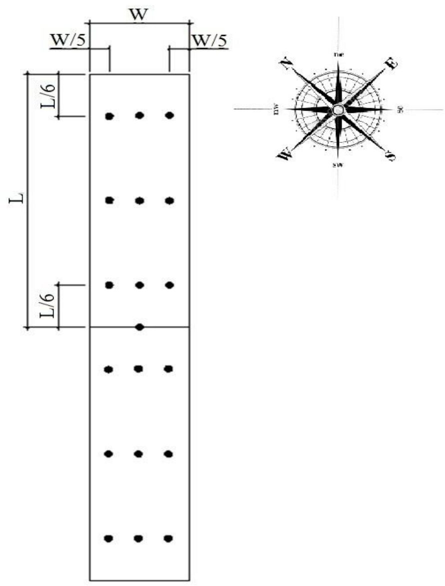
FIGURE 1. Furnace for indirect air heating (a) side view, (b) front view, (c) rear view.

To characterize the thermal environment, t_{db}, dew-point temperature (t_{dp}), relative humidity and black globe temperature (t_{bg}), measurements were taken. After, the BGHI was calculated through the equation developed by Buffington et al. (1981).

For the spatial distribution of dataloggers and to perform the t_{db} and BGHI mapping, a geographic coordinate was refereed (in meters) for the broiler house, taking as starting point the coordinates (0;0) located at the western end and as end point the coordinate (13;160) positioned at the east end. The indirect heating furnaces were located at coordinates (6.5;60) and (6.5; 100).

Measurements were taken at a height compatible with the birds size, 10.0 cm over the bed (CORDEIRO et al., 2010), at five minutes interval from 8 a.m. to 10 a.m. t_{db} dataloggers, model Hobo Pro Series, from the manufacturer Onset®, were used, with an accuracy of ± 3% of reading, kept in cages of wire mesh so the animals would not damage them.

The position of the dataloggers changed as the placement of the plywood changed so that when the dataloggers registered the condition in which the birds were submitted, as illustrated in Figure 2. Considering W is the width of the available area for birds and L is the length. W was 8 m and L was 62 m to the 1st until the 5th day of birds life. To the day 6 and 7, W was 11.06 m and L was 62 m. From the day 8 to the day 13, W was 11.06 m and L was 74.4 m. The day 14th presented W equal to 13 m and L equal to 74.4 m. The positioning of containment plates was established on the first day of the chicks' life, and was changed in the sixth, the eighth and the fourteenth day.



• Sensors/datalloggers

FIGURE 2. Positioning scheme of sensors/dataloggers in broiler house.

The spatial dependence of the t_{db} and BGHI in the broiler house during the heating phase of chicks was examined by semivariogram adjustments, and interpolation by ordinary kriging. The classical semivariogram was estimated by equation 1 (BACHMAIER & BACKERS, 2008).

$$\hat{\gamma}\,(h) = \frac{1}{2N(h)}\sum_{i=1}^{N(h)}[Z(x_i) - Z(x_i + h)]^2 \tag{1}$$

where N (h) is the number of experimental pairs of observations Z (x_i) and Z (x_i + h) separated by a distance h. The semivariogram is represented by the graph $\hat{\gamma}(h)$ *versus* h. From the adjustment of a mathematical model to the calculated values of $\hat{\gamma}(h)$, the coefficients of the theoretical model for semivariogram called the nugget variance, C_0; sill variance, $C_0 + C_1$, and the range "a", as described by BACHMAIER & BACKERS (2008).

The spatial dependence index of the studied attributes was calculated by dividing the nugget variance (C0) by the sill (C0 + C1) and multiplying them by 100, as follows, (C0/Co+C1)*100. It was analyzed by the classification suggested by CAMBARDELLA et al. (1994) which considers as strong spatial dependence the semivariograms that have a nugget effect when <25% from the sill, moderate when between 25 and 75% and low when >75%.

The semivariogram adjustment method used was the Residual Maximum Likelihood (REML) that has been suggested for small data sets. According to DIGGLE & RIBEIRO JR. (2007) and KERRY & OLIVER (2007), for small samples, this estimator generally results in less biased estimates. The REML method uses combinations of data rather than working with the original data and according to MARCHANT & LARK (2007), this method estimates the random and deterministic components of variation, with lower tendency.

The spherical and exponential models were tested for the empirical semivariogram adjustment. To choose the best model, the cross-validation data was taken into account (FARACO et al. 2008, JOHANN et al. 2010 and FERRAZ et al., 2012). According ISAAKS & SRIVASTAVA (1989), the cross-validation is the technique for errors evaluation of estimates to compare predicted values to the sampled. One can draw some useful values for the choice of method such as mean error (ME), standard deviation of the mean errors (SD_{ME}), standardized error (SE), and standard deviation of standardized error (SD_{SE}).

The selection criteria based on cross-validation must find the value for ME and SE closer to zero, the value SD_{ME} must be the smallest, and the value of SD_{SE} should be the closest to one (ISAAKS & SRIVASTAVA, 1989).

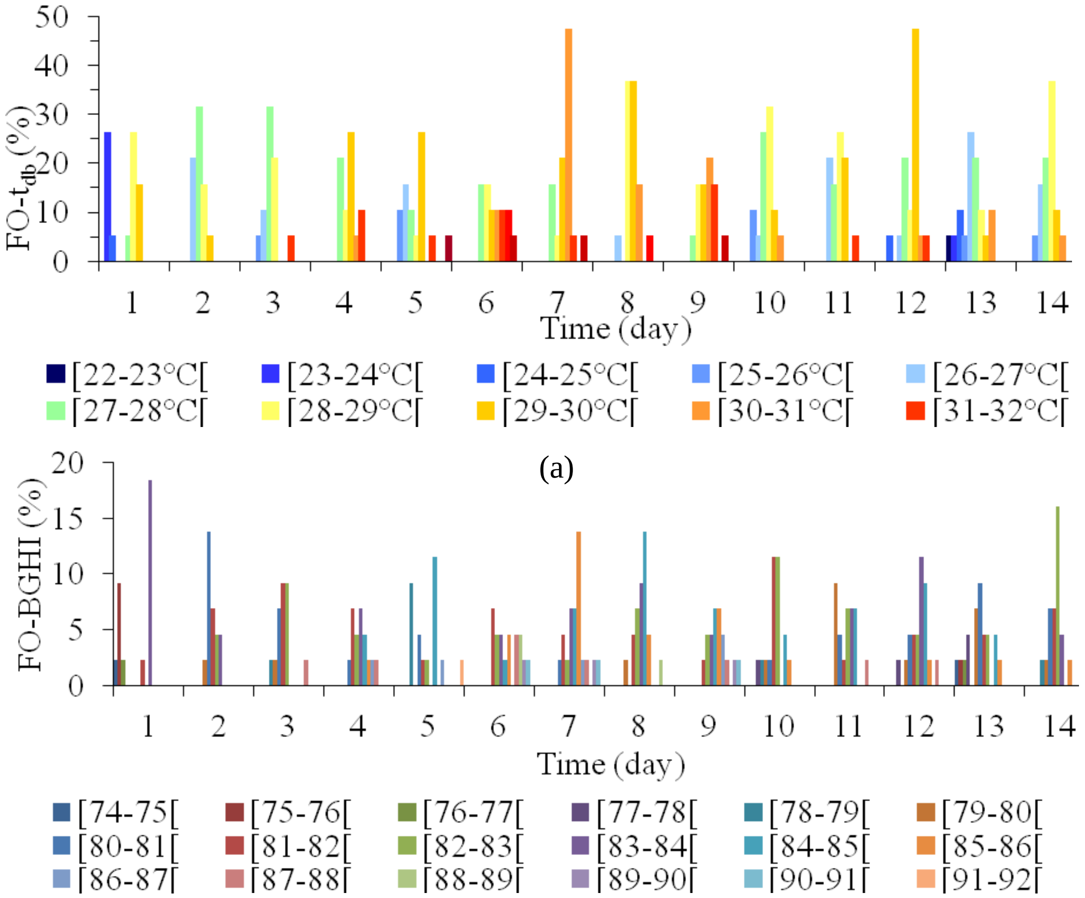
After adjusting the semivariogram, the interpolation was carried out by ordinary kriging of data in order to enable the visualization of spatial distribution of t_{db} and BGHI in the broiler house. The kriging interpolation method is used in geostatistics to predict the value of a variable to a location not sampled through information obtained from sampled data and spatial dependence expressed by the semivariogram between neighboring samples (ISAAKS & SRIVASTAVA, 1989).

For the geostatistics analysis and for the plotting of contour maps the R statistical computing system (R DEVELOPMENT CORE TEAM, 2011) was used, through the geoR package (RIBEIRO JUNIOR & DIGGLE, 2001).

RESULTS AND DISCUSSION

To characterize the thermal environment during the data sampling stage, the graphs of the frequency of occurrence (%) for each t_{db} (°C) and BGHI that occurred during the fourteen evaluated days were produced (Figure 3). It was observed t_{db} ranging from 23.20°C to 34.85°C in the first week and 22.90°C to 33.59°C in the second week of life. BGHI ranged from 74.90 to 91.95 in the first week, and from 74.46 to 90.11 in the second week (Figure 3, Table 1). OLIVEIRA et al. (2006) claimed that in the first week of life, the t_{db} should be between 32 and 34°C and in the second week, 30 to 32°C. The same authors considered comfortable BGHI values from 77 to 81.3 on the first week and from 74.5 to 77.0 for the second week. It is observed that both the first and the second week, at times, the t_{db} and BGHI were considered outside of the recommended for this age group.

According to MOURA et al. (2010) when the values of the environmental variables are above or below the ranges considered ideal for broilers it might affect negatively the performance and poultry production.



(a)

(b)

FIGURE 3. Frequency of occurrence of dry-bulb temperature (FO-t_{db}) (%) (a) and black-globe humidity index (FO-BGHI) (%) (b) occurred in the broiler house during the 14 experimental days.

According to TEIXEIRA et al. (2009) and CORDEIRO et al. (2010), the first weeks of bird's life are the most critical and mistakes made at this stage will not be corrected to the satisfaction in the future and this will affect the final performance of birds. Hence the importance of adapting the environment to the ideal conditions for the welfare of young bird as well as of ensuring a uniform distribution of t_{db} and BGHI along the broiler house where the animals are housed.

From the minimum and maximum analysis, and also the mean of the attributes presented on Table 1 it is possible to observe the existence of a variation in the data.

TABLE 1. Descriptive statistics for dry bulb temperature (t_{db}) (^oC) and the black globe humidity index (BGHI) in the first 14 days of the bird's life.

Day	Min	Max	Mean	Medium	Standard deviation	Variance	CV
				Dry-bulb temperature (t_{db})			
1	23.20	29.00	26.73	28.80	2.64	6.98	9.88
2	26.34	29.10	27.58	27.40	0.88	0.78	3.20
3	25.95	31.52	27.91	27.91	1.30	1.69	4.65
4	27.30	31.93	29.11	29.05	1.35	1.84	4.65
5	25.40	34.85	28.50	28.10	2.54	6.48	8.93
6	27.40	33.59	29.98	29.60	2.00	3.99	6.66
7	27.10	33.59	29.83	30.00	1.46	2.14	4.90
8	26.30	32.76	29.23	29.20	1.30	1.68	4.43
9	27.80	33.59	30.09	30.00	1.51	2.29	5.03
10	25.20	30.71	27.91	28.00	1.36	1.86	4.88
11	26.30	31.52	28.29	28.60	1.49	2.21	5.26
12	24.90	31.52	28.61	29.10	1.55	2.41	5.43
13	22.90	30.71	26.86	26.90	2.12	4.50	7.90
14	25.60	30.31	27.91	28.25	1.13	1.29	4.06
				Black globe humidity index (BGHI)			
1	74.90	83.39	80.07	83.09	3.87	14.97	4.83
2	79.49	83.53	81.30	81.05	1.29	1.67	1.59
3	78.92	87.08	81.79	81.78	1.90	3.62	2.33
4	80.90	87.68	83.55	83.46	1.98	3.94	2.37
5	78.12	91.95	82.65	82.07	3.73	13.88	4.51
6	81.05	90.11	84.83	84.27	2.92	8.55	3.45
7	80.61	90.11	84.61	84.85	2.14	4.58	2.53
8	79.43	88.89	83.73	83.68	1.90	3.60	2.27
9	81.63	90.11	84.98	84.85	2.21	4.91	2.61
10	77.82	85.89	81.80	81.92	2.00	3.98	2.44
11	79.43	87.08	82.35	82.80	2.18	4.75	2.65
12	77.38	87.08	82.81	83.53	2.28	5.18	2.75
13	74.46	85.89	80.25	80.31	3.11	9.65	3.87
14	78.41	85.31	81.80	82.29	1.66	2.76	2.03

However, only knowledge of this amplitude is not sufficient to identify the locations where the high and low values of t_{db} and BGHI occur. In this case the use of geostatistics tools is necessary so the identification of the spatial variability of the data, as well as to perform the making of the map in order to enable precise management of the necessary interventions (FERRAZ et al., 2012).

When performing geostatistics analysis, only on day 2, 3, 8, 11 and 14 there were spatial variability for t_{db} inside the broiler house expressed by the semivariogram (Table 2 and Figure 4).

TABLE 2. Days of life of the chicks, methods, models and estimated parameters of experimental semivariogram for broiler house dry bulb temperature and the black globe humidity index.

Day	Method	Model	C0	C1	C0 + C1	a	SDI	ME	SD_{EM}	SE	SD_{SE}
Drybulb temperature (t_{db})											
2	REML	Spherical	0.455	0.401	0.856	22.324	53.13	0.0017	0.8867	0.0009	1.0457
3	REML	Spherical	1.488	0.208	1.695	10.496	87.76	-0.0060	1.3825	-0.0022	1.0341
8	REML	Spherical	1.264	0.434	1.698	9.753	74.44	-0.0076	1.3341	-0.0029	1.0247
11	REML	Spherical	1.289	0.934	2.223	4.225	57.98	-0.0062	1.5631	-0.0021	1.0288
14	REML	Spherical	0.288	1.014	1.302	4.789	22.11	-0.0162	1.1353	-0.0073	1.0225
Black Globe Humidity Index (BGHI)											
2	REML	Spherical	0.975	0.860	1.835	22.325	53.13	0.0025	1.2983	0.0009	1.0457
3	REML	Spherical	3.189	0.445	3.634	10.496	87.76	-0.0087	2.0241	-0.0022	1.0341
8	REML	Spherical	2.710	0.930	3.640	9.753	74.45	-0.0111	1.9533	-0.0029	1.0247
10	REML	Spherical	2.260	1.731	3.991	4.341	56.63	-0.0019	2.0868	-0.0005	1.0277
11	REML	Spherical	3.436	1.839	5.275	29.554	65.14	-0.0371	2.1713	-0.0087	1.0266
12	REML	Spherical	3.683	2.916	6.599	43.377	55.81	-0.0336	2.2812	-0.0076	1.0336
13	REML	Spherical	6.524	5.097	11.621	41.811	56.14	-0.0328	3.0041	-0.0056	1.0280
14	REML	Spherical	0.623	2.169	2.792	4.796	22.32	-0.0237	1.6623	-0.0073	1.0225

C_0 – Nugget variance; C_1 – Spatially dependent component; C_0+C_1 – Fill variance; a - Range; SDI – Spatial Dependence Index; ME – Mean Error; SD_{ME} – Standard Deviation of the Mean Error; SE – Standardized Error; SD_{SE} – Standard Deviation of Standardized Error

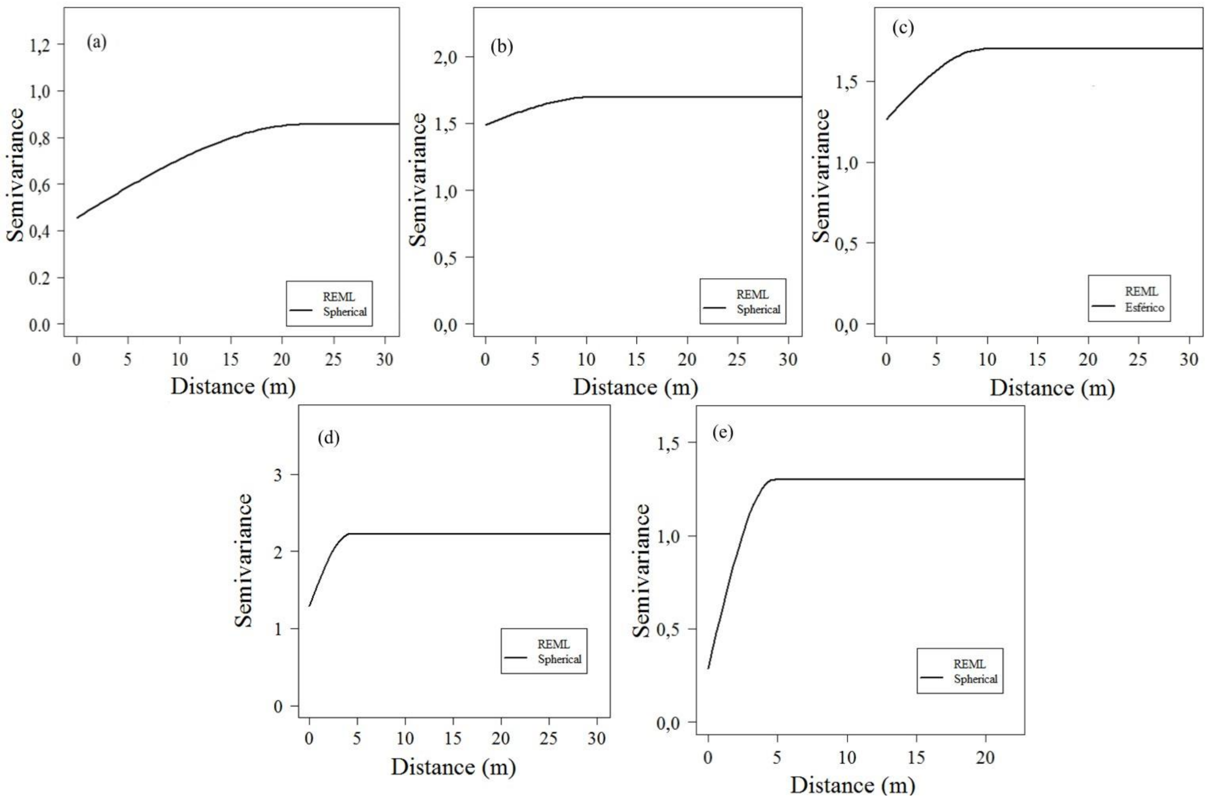


FIGURE 4. Dry-bulb temperature´s semivariograms on day 2 (a), 3 (b), 8 (c), 11 (d) and 14 (e) adjusted based on the residual maximum likelihood (REML) and by the spherical model.

For the remaining days of the chick’s life, it was not possible to find spatial variability of t_{db}, which may indicate that in these days the system was working to ensure the homogeneity of the spatial distribution of this variable, although it does not guarantee values of t_{db} within the comfort limit.

To choose the best adjustment of the semivariogram the cross-validation criteria was used. Thus, for both of variables the days that presented spatial variability the semivariograms were adjusted by spherical model, and according to WEBSTER & OLIVER (2007), the spherical model is one of the most frequently used in geostatistics.

On the Table 2 and Figure 5, it is observed that on the days 2, 3, 8, 10, 11, 12, 13 and 14 occurred a spatial variability in BGHI distribution. For the remaining days 1, 4, 5, 6, 7 and 9, it was not possible to find spatial variability of BGHI.

The nugget variance (C_0) is an important parameter in the semivariogram, and indicates unexplained variability (McBRATNEY & WEBSTER. 1986), considering the distance of sample used, as local variations, analysis errors, sampling errors and other errors. The nugget variance found for the variable t_{db} on day 2 was 0.4548, on day 3 it was 1.4877, on day 8 it was 1.264, on day 11 it was 1.229 and on day 14 it was 0.2879. The nugget variance to BGHI varied from 0,623 on day 14 to 6.524 on day 13. As it is impossible to quantify the individual contribution of these errors, the nugget variance can be expressed as a percentage of the sill variance, thus facilitating the comparison of the spatial dependence level of the variables under study (TRANGMAR et al., 1985).

According to the classification suggested by CAMBARDELLA et al. (1994) the spatial dependence index (SDI), it was observed to the t_{db} that only on day 14 there was a strong dependence, and the moderate dependence presented on day 2, day 8 and day 11 and only day 3 showed a low spatial dependence. To the BGHI the strong dependence was presented on day 14, the day 2, 8, 10, 11, 12 and 13 presented moderate dependence while the day 3 and day 8 presented low spatial dependence.

According to CRESSIE (1993), the range determines the spatial extent over which the variable is correlated. In this study, on day 2, the t_{db} of a given point sampled was correlated in points located up to 22.32 m close to it. On day 3, 8 and 14, the range was 10.49 m, 4.79 m and 9.75 m, respectively. To the BGHI the range values varied from 4.341 m on day 10 to 43.377 m on day 12.

Figure 6 represents the spatial distribution of t_{db} (°C) on day 2 (a), 3 (b), 8 (c), 11 (d) and 14 (e). On the five represented days, it is possible to observe great variability of t_{db} inside the broiler house illustrating regions with very low t_{db}, characterized by bluer colors, and higher t_{db}, illustrated by redder colors, indicating the high inefficiency of the heating system adopted, both in heating and in keeping this heat evenly.

In Figure 6 (a) and (b) it is possible to observe that day 2 and 3 were the most critical regarding t_{db}. On day 2 (Figure 6a) there was great variability and the higher dry bulb temperature was observed in the region between 80 to 100 m (considering length) in the broiler house, with 29°C.

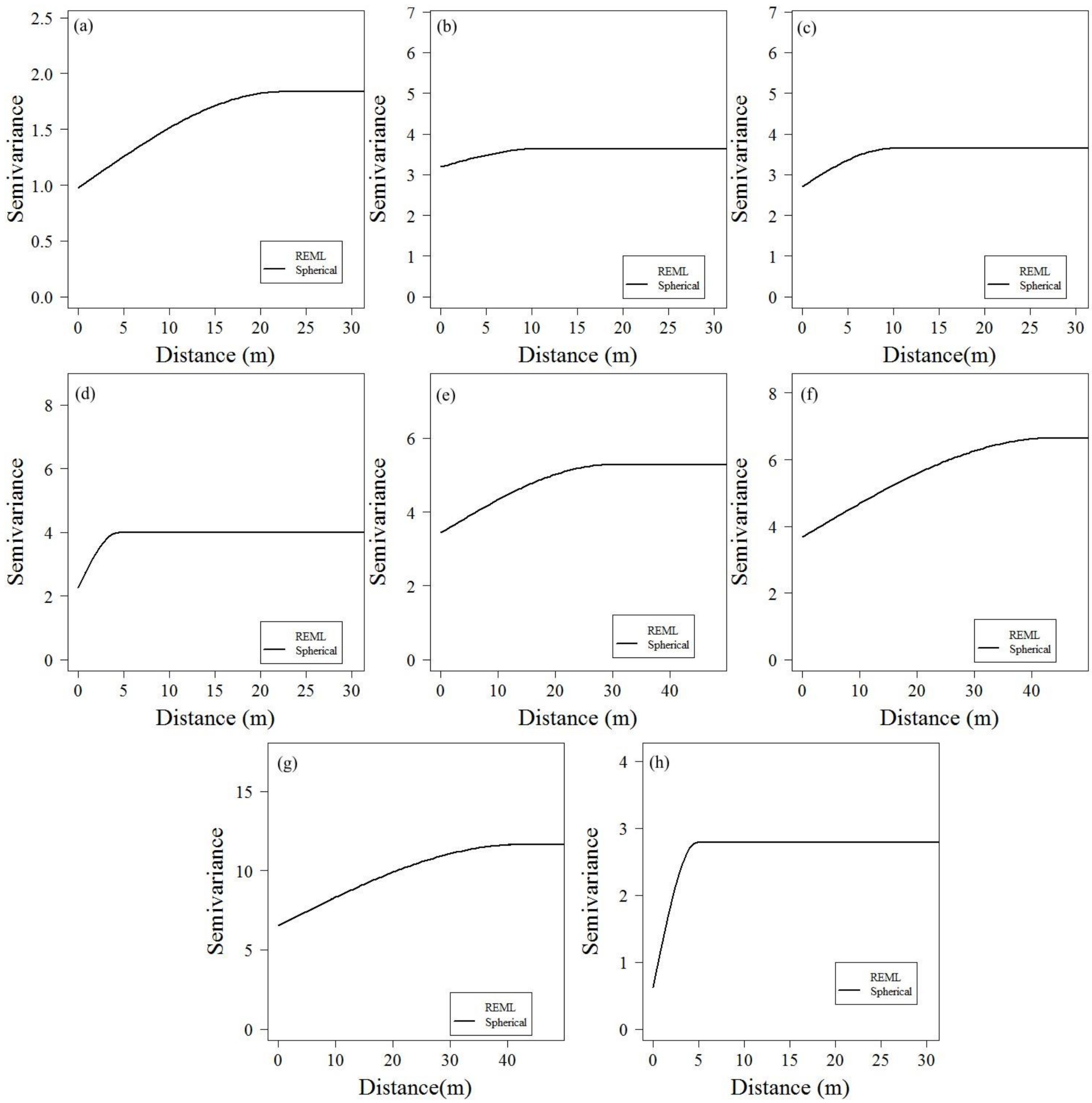


FIGURE 5. BGHI´s semivariograms on day 2 (a), 3 (b), 8 (c), 10 (d), 11 (e), 12 (f), 13 (g) and 14 (h) adjusted based on the residual maximum likelihood (REML) and by the spherical model.

According to OLIVEIRA et al. (2006), the t_{db} is still far below the ideal dry bulb temperature for poultry at this age. The same variability was observed in the t_{db} of day 3 (Figure 6b), but the higher dry bulb temperature was found in the region at 65 m of length in the broiler house, with values close to 31°C. This value is still below the recommended for the birds. In other regions in the broiler house, the t_{db} was found to be much lower than those found close to 65 m in length, indicating that the heater was not heating properly the broiler house to ensure the comfort and homeothermy for the birds.

Looking at the Figures 6 (c) and (d) related to the heating of the broiler house on the 8^{th} and 11^{th} day of life of the bird, respectively, it is possible to note that although uneven, the heating system was able to keep the t_{db} in most of the broiler house within the limits recommended by OLIVEIRA et al. (2006) for the second week of life of the bird, which is between 28 and 32°C.

Figure 6 (e) illustrates the spatial variability of t_{db} on the 14^{th} day. It is observed that most of the broiler house was within the range of t_{db} recommended for birds in the second week of life

(OLIVEIRA et al., 2006). However, at various locations within the broiler house, the t_{db} was suboptimal.

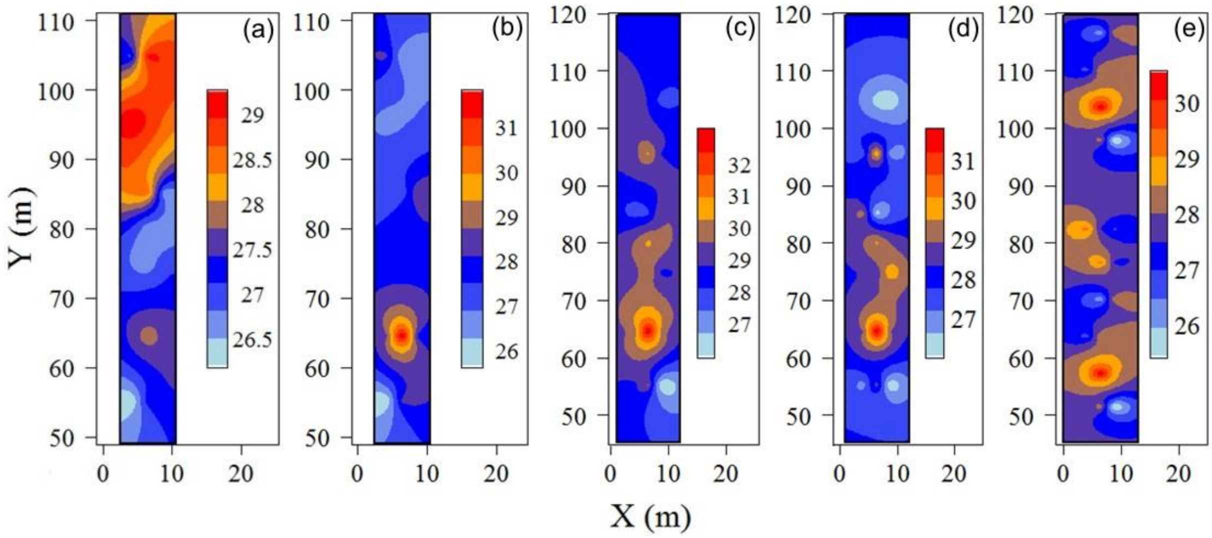


FIGURE 6. Spatial distribution of t_{db} on day 2 (a), 3 (b), 8 (c), 11 (d) and 14 (e) (°C).

When performing a general analysis of the five observed days, regions where the t_{db} was consistently higher can be seen, and they are indicated by roughly circular redder regions at the bottom of Figure 5 (a), (b), (c) and (d), with about 60 m in length. The heating system used in this broiler house consisted of two furnaces for indirect heating fueled by wood, located at the coordinates (6.5; 60) and (6.5; 100). The furnace of coordinates (6.5; 60) was located exactly where these circles occurred.

When the spatial distribution of BGHI is analyzed, it is observed that there were more days with spatial variability than the distribution of t_{db} (Figure 7). That is because BGHI is not only a variable; it is an index that incorporates the t_{db}, relative humidity, wind speed and radiation in the form of black globe temperature into a single value. So, BGHI is currently the most widely used index for predicting thermal comfort in hot regions and it can explain better the real comfort condition that chicks are submitted.

In Figure 7 it is possible to see the spatial variability of BGHI in the days 2 (a), 3 (b), 8 (c), 10 (d), 11 (e), 12 (f), 13 (g) and 14 (h). Regions with higher values of BGHI are characterized by yellow colors and low BGHI values are illustrated by redder colors.

In the 2^{nd} and 3^{th} days of chicks' live at Figure 7 (a) and (b), in the most part of the broiler house, the values of BGHI were very higher than the recommended for the comfort of chicks in this period, that is between 77,0 and 81,3 (OLIVEIRA et al., 2006). High values of BGHI might cause stress and discomfort to the chicks.

The days 8, 10, 11, 12, 13 and 14 (Figure 7 c, d, e, f, g and h) represents the second week, which according to OLIVEIRA et al. (2006) the recommended BGHI ranges from 74,5 to 77,0 to broiler. In all of these days the broiler house environment was always above the ideal. It was observed that in these days the higher values of BGHI (81,0 to 86,0) is concentrated between the coordinates 60 to 100. In the broiler house edges, the values of BGHI were lower. In the days 10, 11, 12, 13, and 14, in some parts of these edge regions the values of BGHI were closer of the values recommended by the literature.

SALGADO et al. (2007) claim that when the chicks are in an environment different from the comfort, excessive cooling or excess of heating, it results in lower productivity, also affecting the growth and health of birds, which, in the extremely cases, it can cause an increase in mortality of the lots. So it is very important to maintain a comfort environment to the animals.

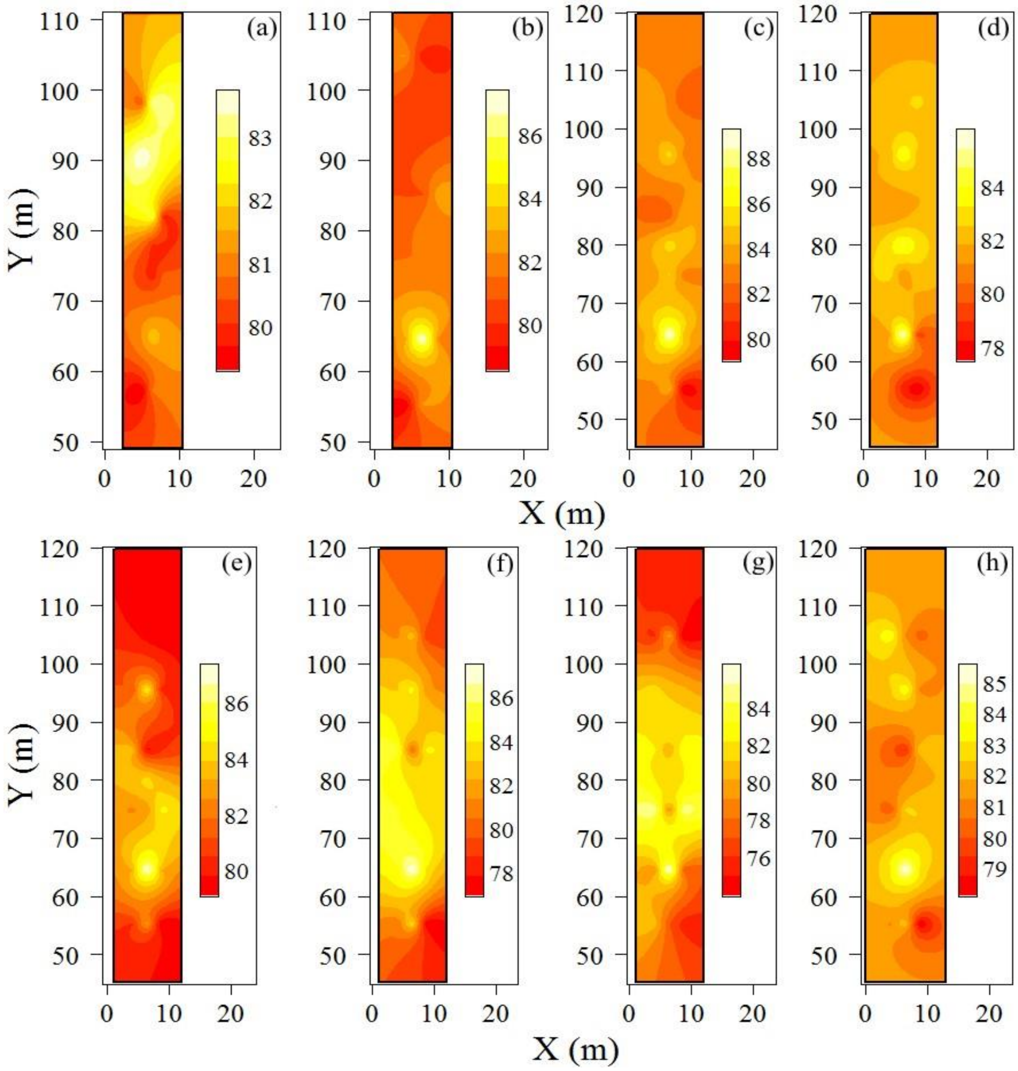


FIGURE 7. Spatial distribution of BGHI on day 2 (a), 3 **(**b**),** 8 (c), 10 (d), 11 (e), 12 (f), 13 (g) and 14 (h).

CONCLUSION

The semivariograms allowed the characterization of the magnitude of spatial variability of the internal dry bulb temperature and of the black globe humidity index of a broiler house. The kriging interpolation allowed the preparation of contour maps that allowed the observation of spatial variability, where it was possible to identify the uneven distribution of dry bulb temperature and the black globe humidity index inside the broiler house. These maps also allowed the visualization of the faults in the heating system in areas of the broiler house that may impair the development of chicks and consequently the final performance of these animals.

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