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One day-old chicks transport: Assessment of thermal profile in a tropical region

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poultry production
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ABSTRACT
The aim of this study was to assess the thermal profile of truck with different levels of box placement during one day-old chicks transport. An experiment was conducted through monitoring of 11 transport loads. A acclimatized truck was used in this research, with maximum capacity of 630 one day-old chicks boxes, totalizing 63,000 animals. The assessment of thermal environment was performed in 5 min intervals, through the following variables: temperature, relative humidity and specific enthalpy. The treatments were registered at two levels of the load (first rack and floor) where 17 data loggers were distributed throughout the truck. The experiment used a completely randomized design and geostatistics was used for spatial dependency and Kriging interpolation. The microclimatic conditions of the truck were not as per recommended values, which confirm a heterogeneous distribution of heat and moisture in environment. Regarding the box positioning, the mean values of thermal variables associated with thermal comfort of one day-old chicks was found in the floor area. The most stressful environment for birds inside the truck was located in front and at the center of the truck.

Palavras-chave:
avicultura de corte
conforto térmico
carga viva
pintos de um dia
transporte animal

Transporte de pintos de um dia: Avaliação do perfil térmico em região tropical

RESUMO
Objetivou-se, com esta pesquisa, avaliar o perfil térmico do caminhão conteiner com diferentes níveis de posicionamento de caixas durante o transporte de pintos de um dia. A pesquisa foi realizada no Brasil, por meio do acompanhamento de 11 cargas de transporte. Foi utilizado um caminhão climatizado com capacidade para 630 caixas de pintos, totalizando uma carga de 63.000 pintos de um dia. A avaliação térmica do ambiente da carga foi realizada em intervalos de 5 min por meio do registro das variáveis térmicas temperatura, umidade relativa e entalpia específica. Os tratamentos foram registrados em dois níveis de carga (primeira prateleira e piso) em que foram utilizados 17 dataloggers distribuídos ao longo da carroceria. O delineamento experimental utilizado foi inteiramente aleatorizado enquanto a análise da estatística foi realizada por meio de modelagem geoestatística Krigagem. Por meio dos resultados observou-se que as condições microclimáticas do caminhão estiveram abaixo das faixas ideais comprovando desuniformidade térmica no ambiente. O nível de posicionamento das caixas do piso obteve os valores médios mais próximos das faixas ideais para as condições de transporte. As piores regiões para o transporte de pintos foram localizadas na frente e no centro da carga.

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Introduction

The preparation of one day-old chicks for transportation is an activity of poultry industry with same importance as poultry raising and handling, due to microclimatic effect on first-week development, mainly in hot regions. The combining factors during initial handling might affect the broiler growth during the last week (Tzschentke, 2007; Vale et al., 2008; Teixeira et al., 2009).

An improvement in thermal control during one day-old chicks transport is necessary in the tropics, where the absence of standards about this issue is observed. The environmentally controlled trucks have great thermal heterogeneity throughout the load profile. Density of birds per box varies according the hatchery supply and demand, which reach beyond 60,000 one day-old chicks transported in the same container. This increases the thermal loads in different load regions. Other factors might be considered, such as: fasting time, distance between hatchery and farm, vibration level, road quality, travel time, type of boxes and controlling environment inside the lorry (Quinn & Baker, 1997; Nazareno et al., 2013; 2015). These variables might contribute with non-uniform load distribution, which promotes quantitative and qualitative losses, before and after housing of one day-old chicks on farms.

However, the effect of logistics and different thermal environment during transportation is complex and has not been studied in tropical and subtropical regions. Thus, in this study the thermal profile of environmentally controlled trucks with different box placement was assessed during transport of one day-old chicks.

Material and Methods

This study was carried out in a broiler hatchery in the State of São Paulo, Brazil (22º 25' 55" S, 46º 57' 28" W; atmospheric pressure of 762 mmHg at 632 m above sea level and). From November to December 2010 and February 2011, the information related to 11 one day-old chicks loads was recorded.

The day-old chicken transport truck (approximately 8 × 2.50 m, 2.50 m high) was environmentally controlled, with three box stacks (left, right and center) spaced 0.7 m. Each stack has two racks, each one vertically spaced 0.8 m. Air temperature, wind speed and humidity were controlled by sensors and electronic panel located in the truck cab. The set points for thermal conditions were: temperature between 23 and 25 °C and relative humidity between 60 and 70%. The HVAC (heating, ventilation, and air conditioning system) of the truck was located in front of the lorry. Air circulation (ventilation) was distributed through the openings of the floor and the air vents were located in the openings of the roof (truck louver). It is noteworthy that the HVAC system was only triggered when the truck was moving. The boxes (0.42 × 0.57 × 0.15 m) were made of plastic material which have perforated walls and floor for ventilation. Each truck had a maximum stocking density of 480 boxes in racks and 150 boxes in center, totalizing 630 boxes with 100 chicks each.

To characterize the environmental condition during transport, the following thermal variables were used: dry-bulb temperature (T; °C) and relative humidity (RH; %), through data loggers (Onset, HOBO) programmed to record data at 10 min intervals. The treatments were recorded at two load racks (first rack and floor) that were distributed 14 boxes of chicks along the profile of the back of the truck. Three loggers were distributed in the hallway, totaling 17 loggers.

To assess discomfort conditions for one day-old chicks, the psychrometric measure specific enthalpy (h, kJ kg^{-1} dry air) was used as a thermal index. This expresses the thermal energy amount per unit mass of dry air, as described by Rodrigues et al. (2011).

The experiment used a completely randomized design with two treatments levels of box placement (floor and first rack) and 11 repetitions (one day-old chicks loads). The statistical analysis of thermal environment was the linear mixed model, assuming a first-order autoregressive covariance structure. The F-test was used to test the equality of variances (SAS, 2010).

Geostatistics was used for modeling spatial dependency and Kriging interpolation of temperature, relative humidity and specific enthalpy. In each data set, the samples were divided into two levels of box placement (floor and first rack). The software GS^+ 7.0 was used for estimation (Robertson, 2000).

For analysis of geostatistics, the data were subjected to descriptive statistical analysis and exploratory, as proposed by Nazareno et al. (2013; 2015), to verify the presence of outliers. In geostatistical modeling, these values lead to a strong impact, especially in the early part of the semivariogram. This might lead to wrong conclusions about the noise variance (nugget effect) and/or existence of spatial correlation.

The fit of theoretical models (spherical, exponential and Gaussian) is given by calculating the semivariogram, according to the equation proposed by Vieira (2000).

The following coefficients were estimated: nugget effect (C_0), level ($C_0 + C_1$), structural component (C_1) and spatial dependence (a) for the semivariogram. The choice of model was based on the smallest sum of squared residuals (SSR) and determination coefficient (R^2). Furthermore, the cross-validation R^2 (R^2 - VC) (observed versus estimated) was used. For analysis of spatial dependence index (SDI), the relationship defined by the software GS^+ ($C_1/C_0 + C_1$) was used, as well as the intervals proposed by Zimback (2001), which considers the spatial dependence as weak (SDI ≤ 25%), moderate (25% < SDI < 75%) or strong (SDI ≥ 75%).

With the adjustment of the theoretical models and the definition of the coefficients for the semivariogram, an ordinary kriging was used to estimate the values of attributes distributed in space from adjacent values. This is estimated by the method of moving averages (Landim, 1998).

Results and Discussion

Differences ($p < 0.05$) between the levels of box placement (first rack and floor) was observed for temperature (Table 1). Highest values of mean temperature were found on the floor (around 33 °C). No interactions were observed specifically between box placement and average values of relative humidity and specific enthalpy ($p < 0.05$).

Table 1. Average values of variables: temperature (T), relative humidity (RH) and specific enthalpy (h) compared to the levels of box positioning of day-old chick transport

Levels of chick box positioning	T (°C)	RH (%)	h (kJ kg^{-1} dry air)
First shelf	31,5 B	51,5 A	68,0 A
Floor	33,0 A	49,0 A	70,5 A
Test F	8,41*	0,69NM	2,46NM

In the same column, means followed by the same capital letter do not differ among themselves at the probability level of 0,05 using Test F. NM - not meaningful, * – meaningful 0,05 ($p < 0,05$)

Based on thermal variables (Table 1), the box positioning (floor and first rack) were recommended by the literature, which reports that broiler chicks during the first week should be under the condition of temperature in the range of 32 to 35 °C (Lin et al., 2005; Nascimento et al., 2013). However, with the existence of spatial dependence in this case, the geostatistical analysis can better detail the lack of spatial component, i.e., variation factors (temperature, relative humidity and specific enthalpy) along which the truck can increase the difference positioning between the levels of the boxes (Barbosa Filho et al., 2009).

The need to keep the temperature of the transportation environment of one day-old chicks in the optimal range is related to the precociousness in the thermoregulatory system because these birds have a high tolerance to elevated temperature when compared to low temperature, thus showing a widespread need to maintain a high temperature during the first weeks of life (Dunnington & Siegel, 1984). Also, the acceptable zootechnical performance of the broiler, in adult phase, is related to the one day-old chicks capacity on regulating its own body temperature efficiently. Therefore, the performance of the birds in the creation of pre-slaughter phase allocated in sheds depend on the development of physiological mechanisms standards stimulated by the thermal environment during the one day-old chicks phase (Tzschentke, 2007).

In regard of semivariogram (Table 2), the limit value of distance from which spatial dependence of temperature is not observed was 1.06, 1.88 and 2 m for overall box placement, floor and first rack, respectively. Similar values were found for relative humidity, for which limit values of distance was 1.12, 1.10 and 2.82 m for different box placements. However, in an overall average of box placement, specific enthalpy was higher (3.97 m).

These results of geostatistical analysis in Table 2 indicated that the variables temperature and humidity showed strong spatial dependence in different levels of box placement, according to Zimback (2001) where in the spatial dependency index was ≥ 75%. However, only specific enthalpy showed a moderate spatial dependence (25% < SDI < 75%).

The thermal profiles of floor and first rack of the truck are shown in Figure 1. Mean values of temperature and relative humidity was out of recommended ranges (32 to 35 °C and 50-60%), as proposed by Mujahid & Furuse (2009) and Nascimento et al. (2013) for one day-old chicks. Also, there is a strong spatial distribution of temperature and humidity throughout the truck, with temperature ranging 11–12 °C and relative humidity around 60%. However, the mean values of specific enthalpy were under recommended range (69.4-88.2 kJ kg^{-1} of dry air). In general, the heat load inside the container was acceptable, with mean values of specific enthalpy varying between 40 and 50 kg kg^{-1} of dry air (Figure 1).

Table 2. Estimated model and parameter of experimental semivariograms for the microclimate attributes temperature (T), relative humidity (RH) and specific enthalpy (h) in different levels of box positioning (general, floor and shelf) for day-old chick transport

	T (°C)	RH (%)	h (kJ kg^{-1} dry air)
General			
R^2	0,30	0,50	0,62
C_0	0,14	25,08	37,3
(C_0+C_1)	5,75	394,17	145,6
C_1	5,61	369,09	108,3
SDI (%)	97,00	93,60	74,4
Reach (m)	1,06	1,12	3,97
Model	Spheric	Spheric	Exponential
Floor			
R^2	0,40	0,50	0,30
C_0	1,14	82	100
(C_0+C_1)	14,35	410,20	201
C_1	13,21	328,2	101
SDI (%)	92,10	80,00	50,00
Reach (m)	1,88	1,10	1,01
Model	Spheric	Spheric	Spheric
First shelf			
R^2	0,76	0,50	0,50
C_0	5,70	31,33	25,9
(C_0+C_1)	22,8	335,8	118,25
C_1	17,1	304,47	92,35
SDI (%)	75,10	90,70	78,10
Reach (m)	7,00	2,82	1,01
Model	Gaussiano	Gaussiano	Gaussiano

C_0 – pepita effect, (C_0+C_1) – tyer, C_1 – structural component, SDI – spatial dependency index, R^2 – coefficient of determination

The reason for this heterogeneity along the thermal load is the influence of air circulation (inefficient ventilation system) inside the container truck chicks, causing a wide range in temperature, relative humidity and specific enthalpy (AT, ARH and Ah) (Figure 1). It is known that the reduction of the air flow over the load possibly entails a greater heterogeneity along the thermal load (Quinn & Baker, 1997).

Regarding the overall thermal profile of the container, it was observed that there are several nuclei in thermal load profile of one-day chicks, and that the regions located in the center and rear cargo container conditioned showed the smallest average overall temperature (27-30 °C). These results showed that the biggest problem in the transport of these birds is the presence of thermal core that were responsible to cause a cold stress in one day-old chicks. The chicks have greater tolerance to high temperatures in relation to low temperatures (Dunnington & Siegel, 1984; Lin et al., 2005). This fact is related to the immaturity of body thermoregulation of the day-old chicks that need to maintain a high body temperature (Dunnington & Siegel, 1984; Tzschentke, 2007).

Regarding the tread profile, it was observed that in most of the cases the chicks showed a profile with lower temperatures. This event can be justified due to the cold air which tends to move downwards, being denser than the warm air masses (Çengel & Boles, 2001). Quinn & Baker (1997) also observed that the floor of the vehicle one day-old chicks was the coldest

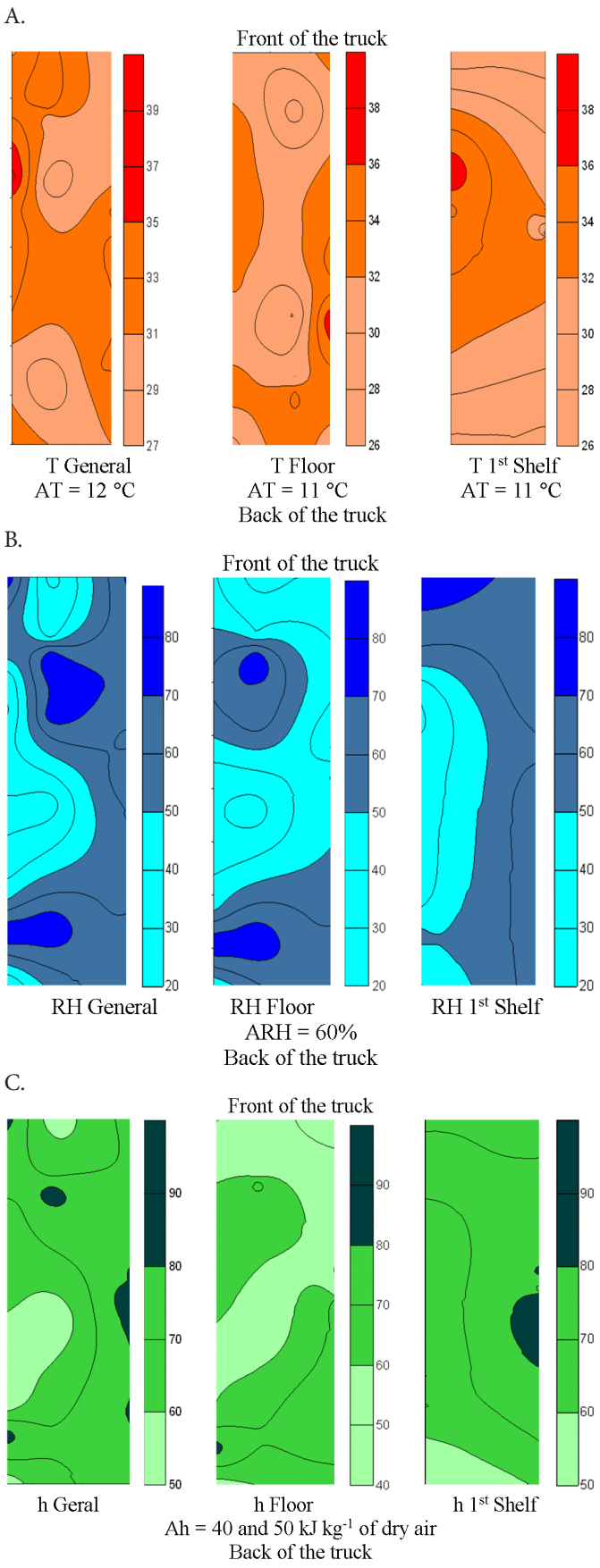

Figure 1. Profile of the variables: temperature (T), relative humidity (RH) and specific enthalpy (h) in acclimatized container in different levels of box positioning (general, floor and first shelf), with their respective amplitude temperature (AT), relative humidity (ARH) and specific enthalpy (Ah)

place to load the configuration adopted for all the boxes. Similar results were observed in the fertile eggs and one day-old chicks transport (Nazareno et al., 2013; 2015).

As for the relative humidity inside the container, analysing the thermal profiles, it was observed that there is some nuclei relative humidity, and the average values found in the center and rear parts of the air-conditioned container were around 20-50% and 70-80%, respectively. These results corroborate with the authors Damron et al. (1994); Gast & Holt (2000); Anderson et al. (2008) which evaluated the transport of eggs and Nazareno et al. (2015) who investigated the transport of one day-old chicks.

The relative humidity plays an important role in heat transfer (sensible and latent) of broiler chicks (Schmidt et al., 2009). The evaporative heat loss (latent) increases with temperature, but decreases with increasing relative humidity, and the effect of thermoregulation of the bird will depend on the air temperature as well as on the age of the bird (Lin et al., 2005). Values of relative humidity above 60% reduce heat transfer from inside the body to the periphery, which reduces the heat exchange with the environment. However, when the relative humidity is below 50% range, the heat exchanges between the animal and the environment by imaging are increased, which may lead to ascites, also known as pulmonary hypertension syndrome (Mujahid & Furuse, 2009).

Conclusions

1. Microclimatic conditions of the air-conditioned truck chicks were below the tracks ideal for one day-old chicks.

2. The level of placement of boxes on the first shelf showed the best thermal comfort during transport.

3. The worst regions of the air-conditioned container for the transport of chicks were located in front and at the center of the container.

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