Poultry Transport Microclimate Analysis through Enthalpy Comfort Index (ECI): A Seasonal Assessment

J. A. D. Barbosa Filho[1], F. M. C. Vieira[1], B. H. F. Fonseca[2], I. J. O. Silva[1], D. B. Garcia[3], and A. Hildebrand[3]

[1] Ambience Research Nucleus (NUPEA), Piracicaba, SP, Brazil

[2] Department of Statistics (ESALQ/USP), Piracicaba, SP, Brazil

[3] Agronomy, University of São Paulo (USP), Piracicaba, SP, Brazil

Abstract. *The transport of poultry is carried out under different conditions of distance, time and travel periods during the day. Depending of the thermal daily variability and seasonal effect, it is known that one of the mainly causes of animal stress during this pre-slaughter operation is the microclimate of the load, which can cause great losses. A method to evaluate the lorry thermal conditions during transport is the Enthalpy Comfort Index (ECI), which combines environmental temperature and relative humidity for an assessment the amount of heat in this environment and how much the birds are affected in their welfare. Thus, the aim of this study was to evaluate the microclimate of the load, for winter and summer, using the ECI as index of thermal comfort. The trial was conducted in a commercial abattoir, in the State of Sao Paulo, Brazil, during 2006 and 2007, where were accompanied transports in the winter and summer, during the afternoon. The load of trucks was tracked by 47 data loggers, in order to draw a thermal profile. After obtaining this profile, the ECI (kJ/kg of dry air) was calculated. The data analysis was made using geostatistics for the prediction of the other points in lorry, through ordinary kriging. The profile of the IEC, during the afternoon and in summer, was ranked as critical and lethal in most parts of the load, classifying the microclimate of the load as harmful to birds.*

Keywords. *Poultry, Transport, Thermal stress, Enthalpy*

Introduction

The pre-slaughter operation of poultry transport is basically the action of getting the birds from the farm to the slaughterhouse and this operation can be performed in different conditions and combinations of distances and periods of the day. These combinations will have a direct reflection on the quality of the final product (meat), and in most cases will be responsible for the losses (deaths) during the travel.

During transport, the birds are subjected to a lot of stressful factors. According to Mitchell et al. (1992) and Mitchell and Kettlewell (1998), these factors compromise their welfare and could result in great losses due to the high mortality and drop in meat quality.

The main stressful factor on pre-slaughter operations, especially on transport to the slaughterhouse, is the microclimate of the load. Expositing of birds to extremes of temperature during transport is most responsible for DOA´S (“Deaths on arrival”) as discussed by Hunter et al. (1997) and Mitchell and Kettlewell (1998). Studies carried by Bayliss and Hinton (1990) summarized that 40% of DOA´s during pre-slaughter are due to the poultry transport to the abattoir.

It is already known that the distribution of dead birds along the load of the truck is not random, but reflects the variation of ventilation and regions of comfort through the load. Kettewell and Mitchell (1993) held a three-dimensional characterization of environmental conditions within some commercial trucks for transport of chickens and could confirm a great heterogeneity of environmental variables within the load.

The metabolic heat production by poultry during the transport will create thermal gradients among crates and the external environment, which will be affected by wind effect in each point. Therefore, it will result in a heterogenic thermal distribution within the load (Mitchell and Kettlewell, 1994).

Studies conducted by Mitchell et al. (1992) and Kettlewell and Mitchell (1993) indicate the existence of a "thermal core" in the load of trucks caused by the low ventilation and in some regions where the thermal load and humidity are higher.

Thus, the objective of this research was to characterize the microclimate profile of the loads of poultry transport trucks, through the Enthalpy Comfort Index (ECI), during the seasons of winter and summer and relate this information to the losses occurred during transport to slaughter.

Material and Methods

A trial was conducted on a commercial poultry abattoir, located in State of São Paulo, Brazil. The birds used in the experiment were about 6 to 7 weeks old. A total of 16 transports have been monitored since the exit of birds from the farm until the arrival at the slaughterhouse, and the conditions of transport evaluated based on factors such as distance and the period of travel.

The operation of transport of birds had the following characteristics: all the tracked trucks had a load comprising 486 boxes of transport arranged in three rows (two sides and a central), with each row being 9 boxes high and 18 boxes long.

To distribute loggers and cover the entire length of the load a fixed and standardized configuration of loggers was used for all transports (Figure 1). As seen in Figure 1, this configuration used 47 loggers, and the number of loggers placed in the center of the load was greater than in other parts, this was done since this row was expected to be the region with the most frequent occurrence of heat stress in birds.

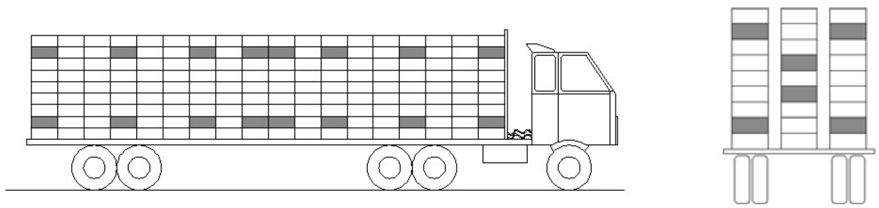


Figure 1. Distribution of loggers (dark boxes) within the load.

To obtain a profile of environmental variables along the loading of trucks, data loggers were installed throughout the load, which allowed to identifying the microclimate for the birds, as well as the profile of the Enthalpy Comfort Index (ECI). This allowed the classification of the regions of the load in accordance with the limits of thermal comfort for broiler chickens in the sixth week of age, Barbosa Filho (2008).

Enthalpy (H) is an index of thermal comfort which expresses the amount of heat in kcal, contained in 1 kg of dry air through the empirical formula in Eq. 1, according Villa Nova (personal communication) cited by Barbosa Filho (2005) :

$$H = 6.7 + 0.243 \times Tdb + \left\{ \frac{RH}{100} \times 10^{\frac{7.5 \times Tdb}{237.3 + Tdb}} \right\} \quad (1)$$

where H: enthalpy (kJ/kg dry air); Tdb: dry bulb temperature (°C); RH: relative humidity (%).

Data for ECI along the load were analyzed using geostatistics (ordinary kriging) to predict the other points of the load. The aim of this analysis was to determinate the spatial dependence of Enthalpy Comfort Index (ECI), considering the interior of the load as the region of study. In each set of data, the samples were divided into three groups, with L1 - side 1, M - center and L2 - Side 2 of the load of the truck. At all stages of this analysis, the statistical software R (R Development Core Team, 2006) was used.

Results and Discussion

Table 1 shows the main characteristics encountered during the pre-slaughter transport of birds in this research. According to Table 1, the transport distance of the birds from the farm to the slaughterhouse ranged from 12 to 120 km, and the overall average for both the phases (winter and summer), was below 50 km. The mean distance recorded in this research, as well as the percentages of deaths on arrival (DOA), which were around 0.23 to 0.33%, were below the values as observed by Voslarova et al. (2007), who found in their studies DOA values of 0.592% for travel distances less than 50 km. Freeman et al. (1984) evaluated the effects of transportation for periods of 2 to 4 hours for travel distances up to 200 km and could conclude that the stress suffered by the birds increased significantly the farther the distance of transport. For this study the percentage of deaths rise as the distance of transport increased (Table 1), which also could be verified by Warriss et al. (1990).

Regarding the period of transport, a correlation existed as described by Bayliss (1986), in which higher values of average percentage of deaths were in the afternoon for the summer season. However, for winter season, death losses were greatest during the afternoon, which reinforces that this period is the most harmful from the point of view for thermal conditions of tropical climate.

Table 1. Characteristics of transport of poultry.

Transport								
Phase	Day	Period	Dist (Km)	Time	Speed (km/h)	Bird/crate	DOA (%)	Wetting
Winter	1	Morning	15	0:15	60	9	0,10	Yes
	2	Morning	50	0:55	55	8	0,23	No
	3	Afternoon	20	0:20	60	7	0,35	No
	4	Afternoon	50	0:45	67	6	0,24	Yes
	5	Afternoon	30	0:20	90	6	0,18	Yes
	6	Night	120	2:25	50	7	0,27	No
	7	Night	70	1:43	41	7	0,26	Yes
	8	Night	20	0:35	34	8	0,22	No
	Mean		47	0:54	57	7	0,23	
Summer	1	Morning	25	0:50	30	7	0,12	No
	2	Morning	100	1:50	55	7	0,35	No
	3	Afternoon	50	1:10	43	8	0,51	No
	4	Afternoon	12	0:35	21	6	0,32	Yes
	5	Night	100	2:25	41	7	0,57	Yes
	6	Night	15	0:25	36	8	0,15	Yes
	7	Night	30	0:53	41	7	0,41	No
	8	Night	60	1:50	33	7	0,20	No
	Mean		49	1:14	38	7	0,33	

The time of transport also showed great variation, being directly linked to the distance and the speed of transport. However, characteristics such the conditions of roads and the occurrence of rains may have influenced this. In this study, the lowest travel time was 15 min (winter) and the highest of 2 hours and 25 min (summer).

According Warriss et al. (1992), there is a positive correlation between the length of the travel and the incidence of Deaths on Arrival (DOA), with a significant elevation of deaths for travels longer than 4 hours, which did not occur in this research.

The column with information about the speed of trucks for each period analyzed in this research also represents important information, since the higher the speed of the trucks during transport, the more circulation of air within the load. This had a direct positive effect on the microclimate for the birds.

High values of density of birds per crate influenced, as mentioned by Mitchell and Kettlewell (1994), the mechanisms of thermal exchanges of birds, reducing the dissipation of heat and increasing humidity of the microclimate in the load, due to the effects caused by increased panting and the reduced ventilation in the region.

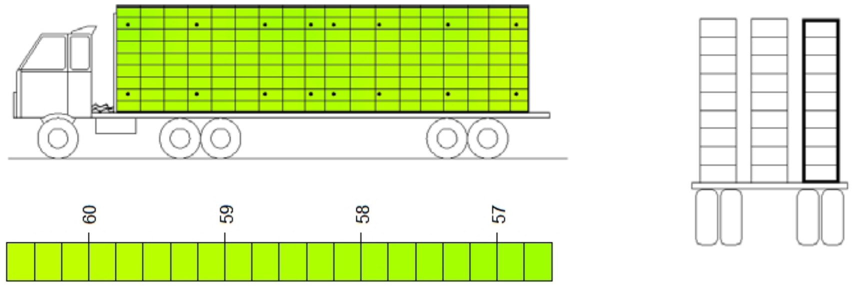
According to Bayliss and Hinton (1990), the percentage of Deaths on Arrival represents the number of birds dead by truck on arrival in the slaughterhouse (DOA). These values will have a direct link with all pre-slaughter operations carried out previously. However, as the conditions in which the birds are transported, these values could present some important variations. These variations can be noted in the values of the general averages for each phase of this research, which showed a difference of 0.10% between winter (0.23%) and summer (0.33%). This difference indicates how environmental conditions influence in losses during the stages of the pre-slaughter operations, Tabbaa and Alshawabkeh (2000); Warris, et al. (2005); Vecerek, et al. (2006); Voslarova, et al. (2007).

Microclimate Analysis.

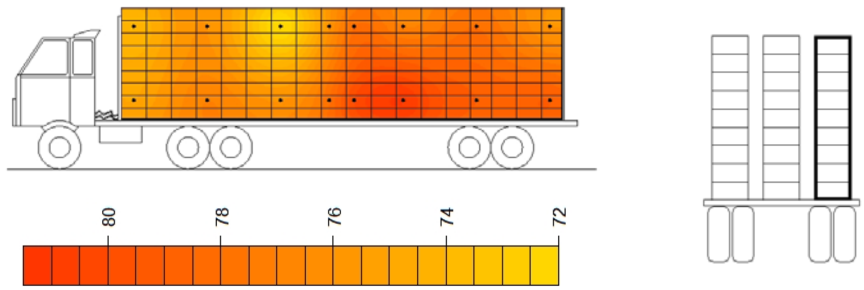
According to Mitchell and Kettlewell (1994); Hunter et al. (1997); Mitchell and Kettlewell (1998) and Mitchell et al. (2001), the potential stressor agents and the most important stimuli imposed on birds during transport are directly related to the microclimate of the load, and the environment is a major responsible factor for the deaths on arrival (DOA’s).

Therefore, an analysis was made from the microclimate of the load, using the geostatistical inference, in the two seasons evaluated (winter and summer).

Figure 2 presents the geostatistical profiles of Enthalpy Comfort Index of side 2 of the load (L2) for the afternoon period. As can be seen, for the winter season and afternoon period, the whole profile of the ECI can be classified as a region of microclimate of comfort to birds (green), according to Barbosa Filho (2008). Moreover, for the summer season and afternoon period too, almost all regions can be classified as critical (orange) and lethal (red) to birds.



L2H (kJ/kg dry air) - Day 3 - Winter - Afternoon



L2H (kJ/kg dry air) - Day 3 - Summer - Afternoon

Figure 2. Geostatistical profile of Enthalpy Comfort Index along Side 2 (L2H), in the days evaluated in this study.

The results presented in this study shows that the summer season had the worst microclimate thermal conditions for the birds. The morning and night periods, were less harmful to birds, from the environmental point of view, which allows an indication of how dangerous are conduct the pre-slaughter operations in the afternoon period, mainly the transport. So the recommendation should be avoided handle or transport birds in periods of high temperatures.

During the winter, the side 2 of the load (L2) presented a better condition of microclimate for the birds. This result suggests that for this season the afternoon period is not so dangerous in terms of DOAs as compared to the summer season.

For the percentage of birds dead on arrival (DOA), during the summer, as expected, the values of DOA tend to increase (Table 1), mainly in the afternoon periods (Barbosa Filho, 2008), it suggest that the morning and night periods, except for some situations of long travel times and distances, were the most indicated for the transport operation of birds.

In summer, a “thermal core” existed in the center and back part of the load, probably due to inadequate ventilation and heterogeneous air flow distribution, as describe for Kettlewell et al. (1993).

Conclusion

Analyzing of the results presented in this study, it was concluded that, on the environmental aspect and the microclimate of the load, the summer phase and afternoon period presented the most unfavorable conditions for thermal comfort of the birds.

References

Barbosa filho, J. A. D. 2005. Welfare evaluation by image analysis of laying hens in different houses systems and environmental conditions. 2005. 123 p. Dissertation (MSc in Phisics of Agricultural Environment) - Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo, Piracicaba.

Barbosa filho, J. A. D. 2008. Quantiqualitative characterization of bioclimatic and productive conditions on poultry preslaughter operations. 2008. 174 p. Thesis (PhD in Phisics of Agricultural Environment) - Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de São Paulo, Piracicaba.

Bayliss, P. A. 1986. A study of factors influencing mortality of broilers during transit to the processing plant. Dissertation (M.S.) – 185 p. University of Bristol.

Bayliss, P. A., and M. H. Hinton. 1990. Transportation of broilers with special reference to mortality rates. *Applied Animal Behaviour Science*, Amsterdan, 28: 93-118.

Freeman, B. M., P. J. Kettlewell, A. C. C. Manning, and P. S. Berry. 1984. Stress of transportation for broilers. *Veterinary Record*. London, 144: 286-287.

Hunter, R. R., M. A. Mitchell, and C. Matheu. 1997. Distribution of “dead on arrivals” within the bio-load on commercial broiler transporters: correlation with climatic conditions and ventilation regimen. *British Poultry Science*, London, 38: 7-9.

Kettlewell, P. J., M. A. Mitchell, and A. Meehan. 1993. The distribution of thermal loads within poultry transport vehicles. *Agricultural Engineer*. London, 48: 26-30.

Mitchell, M. A., P. J. Kettlewell, and M. H. Maxwell. 1992. Indicators of physiological stress in broiler chickens during road transportation. *Animal Welfare*, London, 1: 91-103.

Mitchell, M. A., and P. J. Kettlewell. 1994. Road transportation of broiler-chickens – induction of physiological stress. *World’s Poultry Science Journal*, London, 50: 57–59.

Mitchell, M. A., and P. J. Kettlewell. 1998. Physiological stress and welfare of broiler chickens in transit: Solutions not problems! *Poultry Science*, Stanford, 77: 1803-1814.

Mitchell, M. A., P. J. Kettlewell, R. R. Hunter, and A. J. Carlisle. 2001. Physiological stress response modeling – application to the broiler transport thermal environment. In: *Livestock Environment 6.* International Symposium, 6., Louisville, Proceedings... 21-23 May 2001, Louisville. p. 550-555,

Tabbaa, M. J., and K. Alshawabkeh. 2000. Some factors affecting preslaughtering mortality and damage to broilers and interaction during transportation to processing plants. Dirasat, *Agriculture Science*, 27: 375-384.

Vecerek, V., S. Grbalova, E. Voslarova, B. Janackova, and M. Malena. 2006. Effects of Travel Distance end the season of the year on death rates of broilers transported to poultry processing plants. *Poultry Science*, Stanford, 85: 1881-1884.

Voslarova, E., B. Janackova, F. Vitula, A. Kozak, and V. Vecerek. 2007. Effects of transport distance and the season of the year on death rates among hens and roosters in transport to poultry processing plants in the Czech Republic in the period from 1997 to 2004. *Veterinarni Medicina*, Czech Republic, 52:(6): 262–266.

Warriss, P. D., E.A. Bevis, and S. N. Brown. 1990. Time Spent by broiler chickens in transit to processing plants. *Veterinary Record*, London, v. 127, p. 617-619.

Warriss, P. D., E. A. Bevis, S. N. Brown, and J. E. Edwards. 1992. Longer Journeys to processing plants are associated with higher mortality in broiler chickens. *British Poultry Science*, London, 33: 201-206.

Warriss, P. D., A. Pagazaurtunda, and S. N. Brwon. 2005. Relationship between maximum daily temperature and mortatily of broiler chickens during transport and lairage. *British Poultry Science*, London, 46: 647-651.