

AIR VELOCITY AND EXPOSURE TIME TO VENTILATION AFFECT BODY SURFACE AND RECTAL TEMPERATURE OF BROILER CHICKENS

R. L. FURLAN¹, M. MACARI, E. R. SECATO, and J. R. GUERREIRO

Departamento de Morfologia e Fisiologia Animal, Faculdade de Ciências Agrárias e Veterinárias UNESP, Rodovia Carlos Tonanni, km5, CEP 14.870-000,

Jaboticabal, São Paulo, Brazil

Phone: 55 (016) 323-2500

FAX: 55 (016) 322-4275

E-mail: rfurlan@fcav.unesp.br

E. B. MALHEIROS

Departamento de Ciências Exatas, Faculdade de Ciências Agrárias e Veterinárias UNESP, Jaboticabal, São Paulo, Brazil

Primary Audience: Broiler Supervisors, Broiler Growers, Extension Agents, Researchers

SUMMARY

Increasing air movement over poultry by using fans (ventilation) has become an accepted means of reducing environmental heat stress over the last several years. The purpose of this study was to evaluate the effect of air velocity and exposure time to ventilation on body surface and rectal temperature of broiler chickens. Male broiler chickens aged 36–42 days were placed in individual wire cages and exposed to five different air velocities (5.7, 4.2, 3.1, 2.4, or 1.8 m/sec). Throughout the experiment head, back, leg, and rectal temperatures were monitored every 10 min during a 30-min period for each air velocity. The data showed that exposure time to the wind affected ($P < .05$) leg and body temperature, with a rapid reduction being observed during the first 10 min. There was a reduction in leg temperature with air velocity of 2 m/sec; however, air velocity lower than 4.5 m/sec was not effective in decreasing head and back temperature. The results suggest that air velocity of 2 m/sec, in air temperature of 29°C, improves heat loss in the birds. The data also indicate that exposure time to ventilation seems to be a critical point in the maintenance of bird thermal homeostasis.

Key words: Air velocity, body temperature, broiler chicken, heat stress, surface temperature

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¹ To whom correspondence should be addressed

DESCRIPTION OF PROBLEM

Heat stress during the summer has caused significant losses in world poultry production. According to Xin *et al.* [1], the economic loss attributable to heat prostration is a source of concern since broilers are most susceptible to heat during the last 3 wk of the growing period, with males being affected more than females. As a consequence, heat will have a negative impact on animal production by reducing feed consumption, increasing the feed conversion ratio, and thus decreasing the growth rate [2]. Since broiler productivity is influenced by heat stress, some techniques such as feed restriction [3], drinking water management [4], broiler acclimatization [5], and ventilation [6] have been proposed to alleviate the effects of heat on the birds.

Studies have shown that environmental control should be the last point of importance in broiler production at low cost [7]. Improvements in poultry house quality offer the broiler producer a means of establishing an environment where broiler chickens can express all their genetic potential. In this respect, poultry house ventilation with mixing fans or tunnel ventilation, for instance, has attracted the attention of producers as a means of reducing heat stress for the birds [8]. The concept underlying use of a ventilation system is that increased the air velocity maximizes the birds' utilization of convective heat loss. Siegel and Drury [9] observed that the body temperature of chickens maintained at an ambient temperature of 40°C with an air speed of approximately 150 m/min was 1–2°C lower than that of birds maintained at an air speed of 30 m/min. Lott *et al.* [10] showed that broilers raised in a tunnel ventilation system (higher air velocity on the birds) presented better weight gain and feed conversion ratio than the animals raised in a conventional system. Bottcher *et al.* [11], using fans at night during the summer in a naturally ventilated poultry house, observed better weight gain, improved feed conversion ratio, and reduced mortality.

Several studies have been conducted to verify how the ventilation systems affect poultry house environment as a physical condition [12, 13, 14]. Among the more studied parameters are air velocity, air direction, fogging system, and humidity. However,

considering that the thermal homeostasis of broilers can be affected by environmental conditions, the objective of the present investigation was to study the effect of ventilation on body surface and rectal temperatures of broiler chickens maintained under conditions of different air velocities and different exposure time to ventilation.

MATERIALS AND METHODS

The experiment was conducted on male broiler chickens aged 36–42 days and housed in individual wire cages (0.4 × 0.4 × 0.5 m) that were submitted to a ventilation test using a commercial fan for poultry houses. Cages were placed at 2, 4, 6, 8, and 10 m from the central axis of the fan, with air velocities of 5.7, 4.2, 3.1, 2.4, or 1.8 m/sec, respectively, as shown in Figure 1. Head, back, leg, and rectal temperatures were measured every 10 min, during a 30-min period, for each velocity. A different bird was used for each air velocity. The temperatures of the head (behind the comb), back (between the wings), and legs (area without feathers) were obtained using an infrared thermometer (Horiba IT-330). The rectal temperature was measured by inserting a thermistor probe connected to a digital thermometer (Haenni tH 1200 C) into the colon-rectum (6 cm) of the bird. The relative humidity and environmental temperature were monitored every 10 min using a thermohygrometer (Hanna Instruments HI 9065) and were used as co-variables in the analysis of variance. The average temperature during the experiment was 29°C (temperatures range from 26 to 32°C), and average relative air humidity was 66% (60 to 72%).

The motor-fan kit used was fixed in a vertical position 1.5 m above the floor and placed in a 30 × 15 × 3 m room. The fan had four blades (10 cm wide × 45.5 cm long) directly connected to the central axis of a ½ hp motor. The frontal air velocity (m/sec) was determined using an anemometer (model 3010 Campbell Scientific Instruments, USA) connected to a data logger (CR10 Central Measurement System, Campbell Scientific Instruments, USA).

A split-plot design with 12 replications per air speed was used, in which the main plot was air velocity (5.7, 4.2, 3.1, 2.4, or 1.8 m/sec) and the sub-plot, exposure time to ventilation

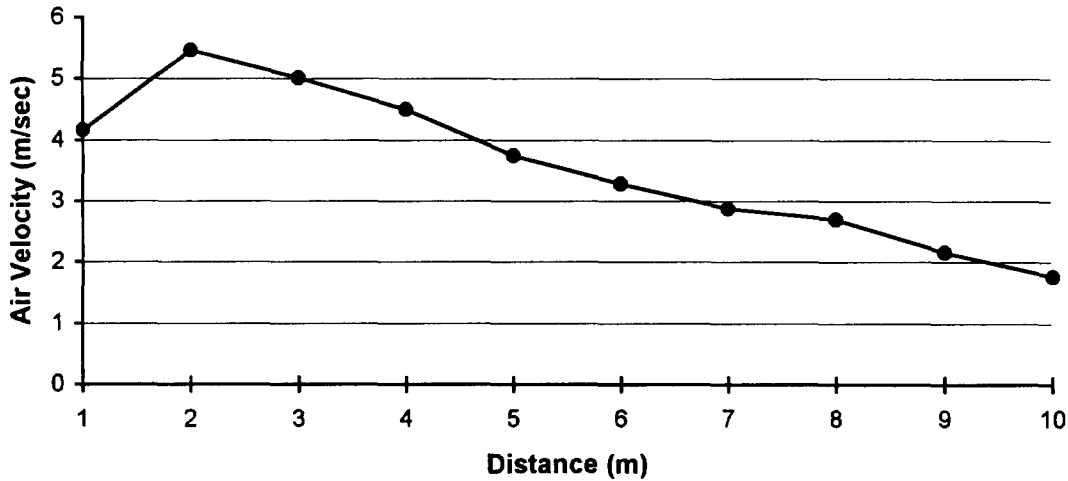


FIGURE 1. Frontal air velocity measured at linear distances from the fan

(0, 10, 20, or 30 min). The data were analyzed using the General Linear Model procedure of SAS [15].

RESULTS AND DISCUSSION

The present findings showed that the rectal temperature of broilers was significantly ($P < .05$) affected by exposure time to ventilation (Table 1) at an air temperature of 29°C. At all air velocities studied, rectal temperature was reduced after 10 and 20 min of exposure; however, only ventilation of 5.7 m/sec was able to reduce rectal temperature after 30 min of exposure. The reduction in body temperature must be due to an increase in convective heat loss, which produces a heat flow from the center to the periphery of the broiler chicken's body. Since surface temperature is affected by ventilation, many investigators have reported

the effect of air velocity over different body areas of the birds. Mitchell [16] reported that increasing air speed over broiler chickens from 0.3 to 1.05 m/sec did not produce a significant reduction in body surface temperature when ambient temperature was 20°C, but at an environmental temperature of 30°C, a 0.6°C reduction in surface temperature was obtained. Timmons and Hillman [8] showed that at an ambient temperature of 37.7°C, increasing air velocity over the birds did not reduce heat stress, and suggested that 35°C is the highest practical air temperature at which increasing air velocity can reduce heat stress by convective heat loss. Recent data reported by Simmons *et al.* [17] demonstrated that increasing air velocity causes a shift from latent to sensible heat loss when ambient temperature is between 29.5°C and 35°C. Thus, the

TABLE 1. Effect of air velocity and exposure time to ventilation on rectal temperature (°C) of broiler chickens

AIR VELOCITY (m/sec)	TIME (min)			
	0	10	20	30
	RECTAL TEMPERATURE (°C)			
5.7	41.70 ^{axy}	41.21 ^{bx}	41.03 ^{xy}	40.88 ^{dy}
4.2	41.91 ^{ax}	41.47 ^{bx}	41.28 ^{cx}	41.17 ^{cx}
3.1	41.51 ^{xy}	41.27 ^{bx}	41.19 ^{baxy}	41.07 ^{cxy}
2.4	41.60 ^{axy}	41.35 ^{bx}	41.21 ^{cxy}	41.20 ^{cx}
1.8	41.61 ^{axy}	41.38 ^{bx}	41.16 ^{cx}	41.09 ^{cx}

^{a-d}Means within a line with no common superscript are significantly different ($P < .05$).

^{xy}Means within a column with no common superscript are significantly different ($P < .05$).

magnitude of heat loss from feathered and unfeathered areas of the birds will be relevant in establishing the thermal equilibrium during ventilation.

Table 2 shows the interaction ($P < .05$) between air velocity and exposure time for head and leg temperatures at 29°C. There was a reduction in head temperature when the bird was submitted to ventilation of 5.7 m/sec and 4.2 m/sec; however, head surface temperature was not affected ($P > .05$) at an air velocity equal to or lower than 3.1 m/sec. For each air velocity, exposure time to ventilation showed that head thermal equilibrium was reached during the first 10 min, since after this period head temperature did not change. The reduction in head temperature during the first 10 min of ventilation was 0.96°C (mean value), and only 0.24°C thereafter. Back temperature (feathered area) was not affected by air velocity or exposure time, possibly due to postural changes of the bird during ventilation (data not shown). The surface temperature of unfeathered areas, such as the legs, was significantly ($P < .05$) affected by air speed and exposure time (Table 2). During the first 10 min of ventilation, the reduction in leg surface temperature was 3.7°C at an air velocity 5.7 m/sec and 1.94°C when the air speed was reduced to 1.8 m/sec. However, after 20 min ventilation the maximum decrease obtained

in the leg surface temperature was 0.8°C at an air velocity of 5.7 m/sec, suggesting that thermal equilibrium was also reached in the unfeathered area after 10 min of ventilation. Bottcher *et al.* [18] also found that an air velocity of 2 m/sec would be enough to cool birds in hot weather, apparently because of convective heat loss in unfeathered areas. Richards [19] pointed out that the body surface temperature of feathered areas increased 2–5°C compared to an increase of 11–20°C in unfeathered areas when the environmental temperature increased from 20 to 40°C. Several researchers have also demonstrated the importance of feathering for sensible heat loss [20, 21]; Yahav *et al.* [22] showed that naked-necked birds exposed to a low environmental temperature underwent hemodynamic changes that reduced heat loss to the environment. Thus, the variation in surface leg temperature found in this study provides evidence that autonomous outlying adjustment is induced within 10 min of ventilation by reducing blood flow and decreasing heat loss. Wolfenson [23] reported that arteriovenous anastomoses appeared mostly in unfeathered skin, and contributed 17% and 83% of the total blood flow under cold and hot conditions, respectively.

The present study gives evidence that at elevated ambient temperature, even though

TABLE 2. Effect of air velocity and exposure time to ventilation on head and leg temperatures (°C) of broiler chickens

	TIME (min)			
	0	10	20	30
AIR VELOCITY	HEAD SURFACE TEMPERATURE (°C)			
5.7	32.63 ^{ax}	31.78 ^{by}	31.37 ^{by}	31.52 ^{by}
4.2	33.60 ^{ax}	32.52 ^{bxy}	32.44 ^{bx}	32.95 ^{bx}
3.1	33.28 ^{ax}	32.82 ^{ax}	32.97 ^{ax}	33.00 ^{ax}
2.4	32.78 ^{ax}	32.88 ^{ax}	32.58 ^{ax}	32.91 ^{ax}
1.8	32.96 ^{ax}	32.74 ^{ax}	32.66 ^{ax}	32.63 ^{ax}
	LEG SURFACE TEMPERATURE (°C)			
5.7	37.68 ^{ax}	33.98 ^{by}	33.18 ^{by}	33.46 ^{bz}
4.2	37.73 ^{ax}	35.28 ^{bx}	35.08 ^{bx}	34.77 ^{by}
3.1	37.67 ^{ax}	35.23 ^{bx}	35.21 ^{bx}	35.24 ^{bxy}
2.4	37.82 ^{ax}	35.56 ^{bx}	35.46 ^{bx}	35.41 ^{bxy}
1.8	37.75 ^{ax}	35.81 ^{bx}	35.68 ^{bx}	35.66 ^{bx}

^{a,b} Means within a line with no common superscript are significantly different ($P < .05$).
^{x-z} Means within a column with no common superscript are significantly different ($P < .05$).

broiler chickens stay sitting most of the time, better broiler performance can be achieved by increasing ventilation, regardless of ventilation method, if the incoming air temperature is lower than the bird surface temperature, since there will be a thermal gradient between environment and the bird. Once the thermal gradient is established,

sensible heat loss will be enhanced, especially from unfeathered areas.

The data of this study also revealed that thermal equilibrium seems to be established during the first 10 min of ventilation with incoming air temperature of 29°C and that unfeathered areas play an important role in this mechanism.

CONCLUSIONS AND APPLICATIONS

1. An increase in air velocity over the birds decreases skin temperature in broiler chickens, mainly in unfeathered areas such as the legs.
2. Broiler chickens seem to reach thermal equilibrium during ventilation within the first 10 min with incoming air temperature of 29°C.

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