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Turkey Wattle Temperature Response to Distinct Environmental Factors

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Wind speed, thermal comfort, relative humidity, environmental exposure.

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ABSTRACT

Rearing environmental conditions are important for turkey production, because this bird is particularly sensitive to heat stress. This study aimed at measuring the wattle temperature response of turkeys of three different ages (61, 96, and 131 days old) exposed to different combinations of dry bulb temperature, relative humidity, and wind speed ranges, as an indication of their physiological responses. The experiment was conducted with 42 male birds housed in a controlled environment chamber and exposed to different combinations of two air speed (WS) ranges (WS_1 = 0.3-0.6 ms^{-1}, considered low, and WS_2 = 1.2-1.6 ms^{-1}, considered high), dry bulb temperature (DBT) between 22 and 34 °C, and relative humidity (RH) between 40 to 90 %. The statistical analysis showed that WS, DBT, and RH significantly influenced wattle temperature of 61-d-old turkeys, while only WS and DBT influenced this response when turkeys were 96 days old. Furthermore, DBT was highly correlated with both low and high WS. In 131-day-old turkeys, WT response was virtually the same at both wind speed ranges when high DBT was applied. Turkey wattle temperature was influenced by wind speed, and was dependent on both environmental dry bulb temperature and relative humidity, as well as bird age.

INTRODUCTION

The Brazilian turkey production has expanded in the last 25 years. In 2013, turkey meat production totaled 364,000 tons (79 % fresh and 21 % processed meat), out of each 161,000 tons were exported. Brazil is currently the third producer (following the USA and the EU) and the second exporter (after the USA) of turkey meat (UBABEF, 2014).

In the last decades, fast-growing meat-type turkey shave shown significant improvements in growth performance, feed conversion ratio, and livability (Havenstein *et al*., 2007), mainly due to intensive genetic selection. These improvements, however, have also resulted in a significant increase in heat production by these birds, which have shown difficulties in coping with extreme environmental conditions, consequently impacting their productivity. Birds dissipate heat through respiratory/evaporative mechanisms, acutaneous evaporative mechanism, and sensible heat loss (SHL) via radiation, convection, and conduction (Yahav *et al*., 2011). Wattle temperature may be used as an indication of thermal comfort, and environmental conditions influence wattle temperature (Morello *et al.,* 2007). For many years, research has focused on the effects of air temperature (Ta) (Hurwitz & Bengal, 1982; Yahavand Plavnik, 1999; Yahav *et al.,* 2000a) and, to a lesser extent, of relative humidity (RH) (Yahav *et al*., 1995, 1998; Yahav, 2000b) on the performance and thermoregulation of young and mature turkeys. Only recently the interest shifted towards the effects of ventilation rate (VR) on the thermoregulation and performance of turkeys. This shift was driven by the availability of thermal-imaging equipment, which allows measuring body surface temperature and it is the main source of data for developing models to calculate SHL under various combinations of environmental conditions (Yahav *et al.*, 2005).

Birds housed in artificial habitats face a wide range of potentially harmful environmental challenges, such as temperature, relative humidity, air quality, and wind speed (Hurwitz *et al.*, 1980; Yahav *et al.*, 1995; Teeter & Belay, 1996; Martrenchar, 1999; Morgan & Tromborg, 2007). Turkeys, like most birds, need high environmental temperature immediately after hatching, while optimal temperature ranges are 25-35 °C and 15-21 °C for 8-wk-old and 12-24-wk-old turkeys, respectively (Yahav *et al.,* 2011). On the other hand, mature turkeys present high tolerance to cold environments, including temperatures around freezing point (Hellickson *et al.*, 1967). Environmental temperatures above 27°C increase both respiratory rate and body temperature, as well as water consumption, consequently decreasing growth rate and performance (Cavalchini, 1985; Yahav *et al.*, 1995; Martrenchar, 1999).

Environmental relative humidity dramatically impacts poultry over all ambient temperatures, especially during heat stress. The ability of air to hold water vapor is not constant and significantly increases with temperature. As environmental relative humidity rises, the bird's ability to evaporate water declines, and consequently, its body temperature increases (Nääs, 1994; Teeter & Belay, 1996). In order to achieve optimal temperature inside turkey houses under tropical climate conditions, adequate ventilation and fogging systems are required. The use of cooling and ventilation systems affects the thermal environment of poultry houses, and the balance between sensible and latent losses obtained with the use of this equipment is well documented in literature (Sasseville *et al.*, 1988; Nixey & Grey, 1989; Timmons & Hillman, 1993; Aradas *et al.*, 2005). However, there is a lack of scientific information on the response of turkeys exposed to different combinations of temperature and relative humidity.

The objective of this study was to determine the effect of wind speed on the wattle temperature response of turkeys of different ages/rearing phases exposed to different combinations of environmental temperature and relative humidity.

MATERIALS AND METHODS

The experiment was carried out in an environmentally controlled chamber located at the Agricultural Engineering College (FEAGRI), UNICAMP, Campinas, SP, Brazil, located at 2°2 54' S latitude, 47° 05' W longitude, and 674 m altitude.

Forty-two male turkeys (14 birds with 61 days old, 14 birds with 96 days old, and 14 birds with 131 days old) were submitted to the experimental treatments shown in Table 1.The birds derived from a commercial turkey farm located in Uberlândia, state of Minas Gerais, Brazil. Upon arrival to the experimental facilities, with 54, 89 and 124 days of age, birds were housed under thermoneutral temperature for a week in order to minimize the stress, after which they were placed inside the environmental chamber at a stocking density of 2.8 birds m^{-2}. All birds of each age group were exposed to the 14 different combinations of dry bulb temperature (DBT) and relative humidity (RH) shown in Table 1. Birds were submitted to each treatment (DBT + RH combination) for 90 minutes, with an interval of 10 min between treatments, during which the thermoneutral conditions were re-established. Each bird was counted as a separate event

Table 1 – Combinations of dry bulb temperature and relative humidity ranges applied both at wind speeds used in the present experiment (WS_1: 0.3-0.6 m s^{-1} and WS_2: 1.2-1.6 m s^{-1}).

DBT limit range (°C)	RH limit range (%)
[22-25]	[40-50]; [60-70]; [70-80]; [80-90]
[25-28]	[40-50]; [60-70]; [70-80]; [80-90]
[28-31]	[50-60]; [60-70]; [70-80]; [80-90]
[31-34]	[70-80]; [80-90]

The environmental temperature was maintained constant during each assay by the use of a cooler and a heater with a thermal resistance, which enabled a 5 to 40 °C temperature range (Figure 1a). A humidifier fixed on the ceiling was used to increase relative humidity, and a dehumidifier to decrease it (Figure1b). Two wind speed (WS) ranges were applied: WS_1 = 0.3-0.6 ms^{-1}, which was considered as low, and WS_2 = 1.2-1.6 ms^{-1}, which was considered as high. Wind speed was changed using two positive pressure fans (140 W, 127 V, 1.1 A) (Figure 1c). All equipment was connected to a computer and controlled by a software (Figure 1d).

Data relative to DBT and WS were recorded manually using a thermo-anemometer with hot wire (model9555, VelociCalc®, TSI_{TM}, Shoreview, USA),and RH data using a hygrometer (model THDL 400, Instrument®, Sao Paulo, Brazil). Wattle temperature (WT) was measured during the last 10 minutes for each treatment. Therefore, the treatment effects were measured directly on the birds, using an infrared thermometer (OS530 model,

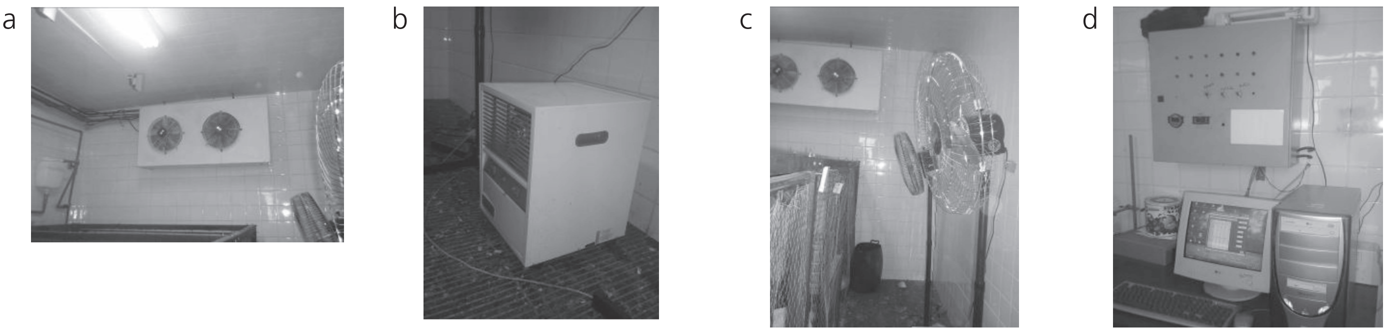

Figure 1. Equipment used to control the environmental conditions inside the chamber: (a) cooler; (b)dehumidifier; (c) fan; (d) controlsoftware.

Omega® OS530, Stamford, USA; Figure 2). There were 14 replicates per treatment per age.

Figure.2..Infrared temperature reading of the turkeys' wattle during the trial.

Data were submitted dummy-variable regression analysis to verify the influence and the correlation between wind speed and turkey wattle temperature as a function of the applied DBT and RH combinations (Table 1). The software used for statistical analysis was MINITAB (2005).

RESULTS AND DISCUSSION

The results of the interactions between DBT, RH, and WS are presented according to turkeys' age (61, 96 and 131 days old, respectively).

61-day-old turkeys: The statistical analysis showed that the variables WS, DBT, and RH significantly affected ($p \leq 0.000$) the wattle temperature of 61-d-old turkeys (WT_{61}). The following equation describes the variation of wattle temperature as function of WS, DBT, and RH (Eq. 1).

$$WT_{61} = 19.06 + 7.01_{(WS1)} + 0.33 * DBT + 0.08 * RH – 0.12 * DBT_{(WS1)} – 0.05 * RH_{(WS1)} (R^2 = 0.68) \quad \text{Eq. 1}$$

The model shows an interaction between WS and both DBT and RH. Figures 3 and 4 show the influence of RH and DBT on wattle temperature according to two different WS ranges: 0.3 to 0.6 (WS_1) and 1.20 to 1.60 ms^{-1} (WS_2). The results indicated that only RH significantly interacted with WS_1, suggesting that increasing wind speed does affect the thermal response of 61-day-old turkeys reared in a closed environment. Although the use of evaporative cooling is often used by turkey producers in Brazil and other tropical regions, the obtained results indicate that low ventilation rates may be sufficient to reduce internal RH values, in agreement with the recommendations of Bottcher & Czarick (1997) and Gates *et al*. (1998) for broiler houses.

Although wattle temperature dispersion was similar between the two applied WS (Figure 3), the slope of the lines indicates that RH had a stronger influence on WT at the range of high wind speed (1.2 to 1.6 ms^{-1}). Figure 4 shows that there was an interaction between the variables DBT and WT ($p < 0.05$), according to the line slope of WS_1. The line slope shows that both DBT and RH influenced turkey wattle temperature at both WS ranges. Czarick (2006) reported that head surface and body temperatures of broilers increased proportionally to the increase in internal broiler house temperature, as also shown in the present study, where it was found that WT temperature increased with DBT ($p < 0.05$), DBT influenced the increase in WT for this specific experiment.

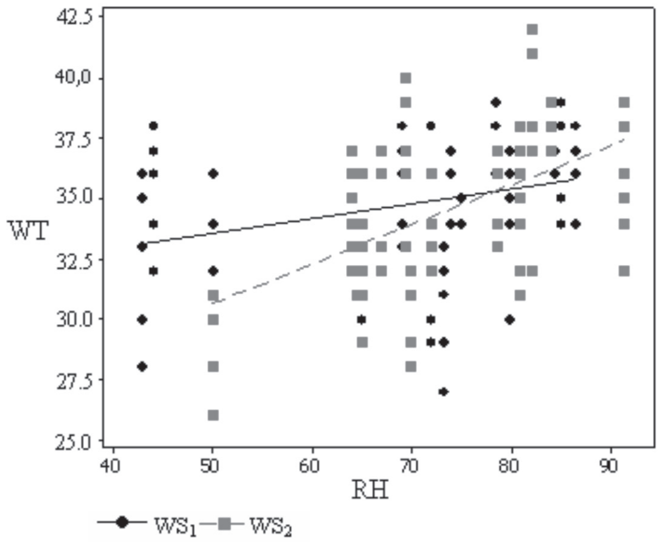

Figure 3. Influence of relative humidity on the wattle temperature of 61-day-old turkeys at two wind speed ranges (WS_1=0.3 to 0.6 m s^{-1} and WS_2= 1.2 to 1.6 m s^{-1}).

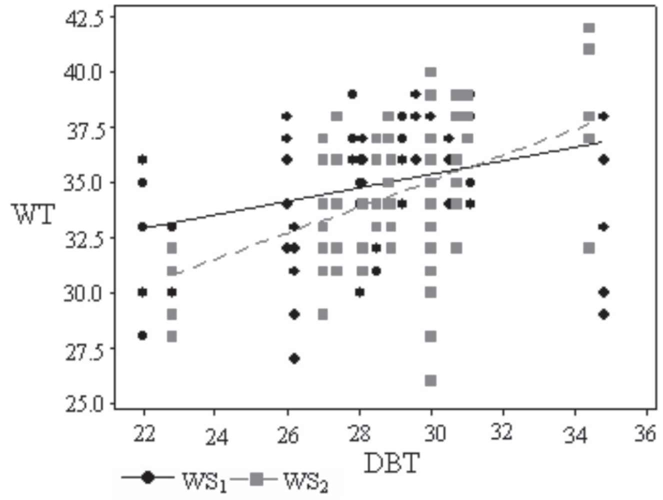

Figure 4. Influence dry bulb environmental temperature on the wattle temperature of 61-day-old turkeys at two wind speed ranges (WS_1=0.3 to 0.6 m s^{-1} and WS_2= 1.2 to 1.6 m s^{-1}).

Turkeys are known to be less sensitive than broilers to changes in environmental conditions (Yahav, 2000a) and their body temperature (40.6 to 41.5 °C) is at the lowest end of the range determined for domestic fowl (Prinzinger *et al*., 1991). The fact that the body temperature of turkeys was not affected by the highest DBT (35 °C) may be explained by their better thermoregulation capability compared with broiler chickens, which showed significantly higher body temperature when exposed to the same environmental temperatures (42.8 to 43.9 °C; Yahav *et al*., 2004).

96-days-turkeys: The statistical analysis showed that both WS and DBT influenced turkey wattle temperature response ($p \leq 0.000$). Relative humidity did not affect WT. Equation 2 describes the model that associates turkey wattle temperature with the evaluated environmental factors.

$WT_{96} = 21.57+5.54_{(WS1)}+0.499*DBT - 0,17 *DBT_{(WS1)}$ ($R^2 = 0.63$) Eq.2

The variables WS and DBT were highly and positively correlated with WT ($p \leq 0.000$), but not RH. Figure 5 presents an interaction between WS_1 and RH. Fig. 5 and 6 show the influence of RH and DBT on WT at both wind speed ranges. Ventilation moves the air around the birds increasing their critical effective temperature upper limit and resistance to thermal stress (Bottcher & Czarick, 1997; Aradas *et al*., 2005), and has a positive effect on their physiological parameters, particularly when environmental temperature reaches levels above the thermoneutral zone (> 25 °C).

In Figure 5, the line that represents the WT response to RH at both wind speed ranges presents a horizontal profile, indicating that RH did not influence the WT of 96-day-oldturkeys. Furthermore, both lines have the same slope, which indicates that there was no significant interaction between RH and WT at WS_1 or WS_2.

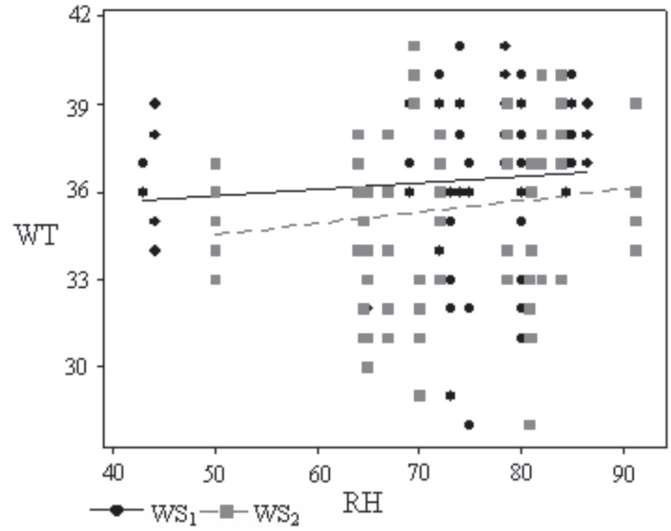

Figure 5. Influence of relative humidity on the wattle temperature of 96-day-old turkeys at two wind speed ranges (WS_1=0.3 to 0.6 m s^{-1} and WS_2= 1.2 to 1.6 m s^{-1}).

Figure 6 shows that DBT was highly correlated with WT at both low and high wind speeds, as the slopes of the lines are steeper. There was also an interaction between DBT and WS, as shown by the significantly different slopes for similar data dispersion, which is in agreement with previous studies(Czarick, 2006; Aradas *et al.,* 2005).

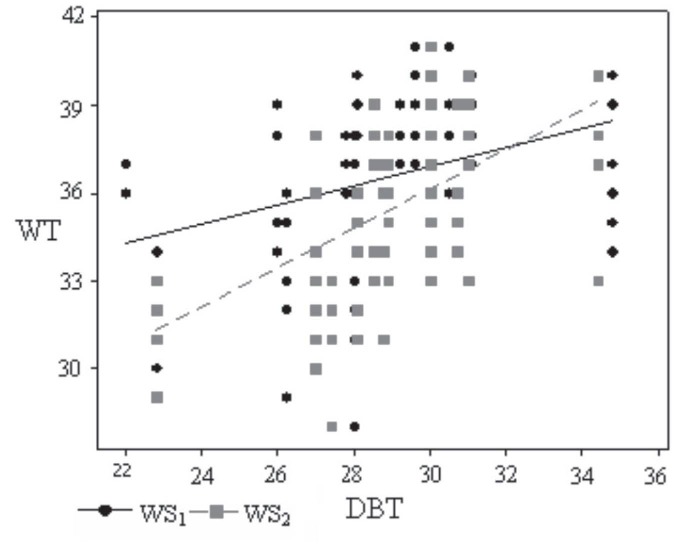

Figure 6. Influence dry bulb environmental temperature on the wattle temperature of 96-day-old turkeys at two wind speed ranges (WS_1=0.3 to 0.6 m s^{-1} and WS_2= 1.2 to 1.6 m s^{-1}).

According Lin *et al.* (2005), the effect of relative humidity on the ratio between peripheral and core temperatures of broiler chickens is related to age and depends on air temperature. Thermal balance modification cannot be as certained merely by changes in rectal or peripheral temperatures at one time point; it is necessary to determine constant average body temperature within a certain period of time.

131-day-old turkeys: The regression equation indicated correlations between turkey wattle temperature and environmental variables (Equation 3).

$$WT_{131} = 24.29 + 5.76_{(WS1)} + 0.46 * RH + 0.34 * DBT - 0.09 * DBT_{(WS1)} - 0.032 * RH_{(WS1)} \quad (R^2 = 0,72) \qquad \text{Eq. 3}$$

Results showed that all environmental variables were positively correlated with turkeys' wattle temperature ($p \leq 0.000$; Fig. 7 and 8). The line slope indicates there was a higher correlation of RH with WS than DBT at the WS_2 range ($p = 0.10$).

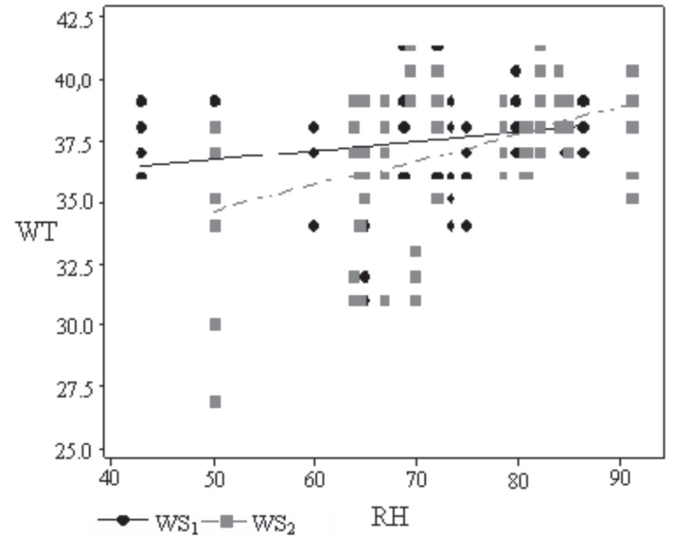

Figure 7. Influence of relative humidity on the wattle temperature of 131-day-old turkeys at two wind speed ranges (WS_1=0.3 to 0.6 m s^{-1} and WS_2= 1.2 to 1.6 m s^{-1})

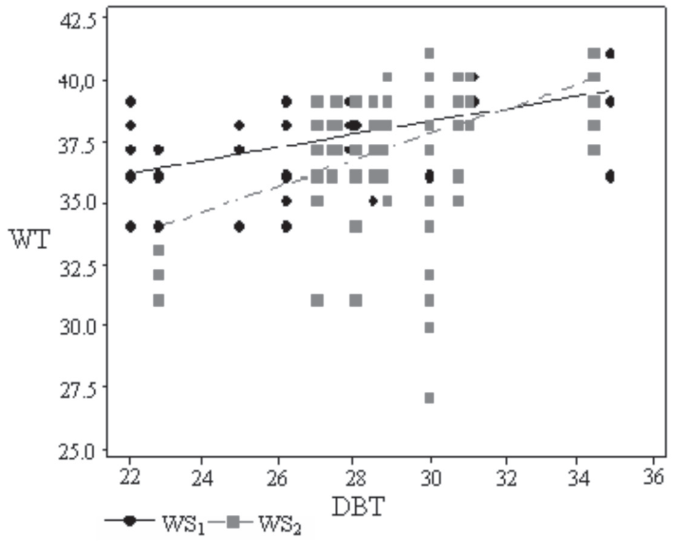

Figure 7. Influence of relative humidity on the wattle temperature of 131-day-old turkeys at two wind speed ranges (WS_1=0.3 to 0.6 m s^{-1} and WS_2= 1.2 to 1.6 m s^{-1})

Even though WT data dispersion at both WS ranges were similar when RH was analyzed (Figure 7), the slope of the adjusted lines shows the effect of the interaction of RH with WS_2 on WT. Moreover, WT responses were practically the same at both wind speed ranges when DBT was higher (Figure 8), but the analysis revealed a correlation between DBT and WS_2. The steep slope of both lines indicates that both RH and DBT are correlated with WT at both wind speed ranges.

In the present study, results were different according to turkey age. The WT response atall ages (61, 96, and 131 days) depended on positive forced wind speed (WS_1 and WS_2), according to the different DBT and RH combinations. There was a higher effect of interaction of RH with WS on the WT both at61 and 131 days. The interaction between DBT and WS affected the WT response of 96- and 131-old male turkeys. Brown-Brandl (1997) evaluated the physiological responses of male tom turkeys of five different ages (5 to 20 weeks) exposed to five ambient dry bulb temperatures (25-40 °C) and relative humidity values (40-80 %), and found that RH had higher overall impact than DBT on both turkey's respiratory rate and body temperature, differently from the results of the present experiment. However, that author also found highly positive correlation between RH and DBT in 20-week-old turkeys, in agreement with the findings of the present study.

The results show that the use of forced ventilation in turkeys' rearing environment may is a good strategy to reduce heat stress, as previously suggested for broiler chickens in literature (Mitchell & Kelley, 1983; Timmons andHillman,1993; Bottcher & Czarick,1997; Czarick & Lacy, 1999; Aradas *et al.*, 2005; Hurwitz *et al.*, 1980; Cavalchini, 1985; Yahav *et al.*, 1995; Martrenchar, 1999; Teeter & Belay, 1996).

The impact of the wind speed on wattle temperature depended on turkeys' age and was correlated with rearing environment variables (DBT and RH), as also found by Brown-Brandl & Beck (1998). In addition, Veldkamp *et al*. (2000) reported that environmental temperature have a marked effect on feed intake, body weight gain, feed conversion ratio, and carcass yield of turkeys.

CONCLUSIONS

Wind speed influenced turkey wattle temperature as a function of environmental dry bulb temperature and relative humidity, as well as of turkeys' age.

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