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Variable Velocity System for Evaluating Effects of Air Velocity on Japanese Quail

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In view of the importance of air velocity influence on birds welfare and performance, and considering the practical difficulties often encountered in implementing this type of experiment under field conditions, it was determined to be helpful to develop an air velocity control prototype for use in Japanese quail experiments in controlled environments. A system that provides high air velocity in a controlled fashion over the entire face of a birdcage, especially in the feeder zone, similar to exterior rows of cages in open-sided housing, is not readily available. No similar device could be found in the literature, prompting the design and fabrication. The objectives of this study were to: (1) evaluate the performance of the system to provide nominal air velocity setpoints, (2) to evaluate the uniformity of air velocity at common lines and heights where birds approach the feeder, and (3) to evaluate the repeatability of system performance between prototypes.

Materials and Methods

The velocity control system was fabricated from a simple length of 25cm diameter PVC tubing, with axial fans (Micro Motor Elgin 1⁄25 MM – 20B, 60 Hz, 11.93 W) mounted on each end, each capable of producing 950 m³ h-¹. A 10 x 100 cm (w x l) long opening was cut along one side of each PVC tube for air to discharge toward the cage. Aluminum angles, 2 x 2 x 110 cm were fastened to the edges of the opening. This facilitated establishment of an air jet to smooth outflow of air toward the cage. A simple solid-state rheostat was used to adjust the fan motor speeds, hence volumetric flow rate and resultant discharge velocity from the tube. A total of six prototypes were fabricated for use in a series of research trials designed to evaluate the effect of velocity, temperature and humidity on Japanese quail behavior. A typical setup in one of the climate chambers used is illustrated in Fig. 1. Four climate chambers were used, one for each nominal velocity level: 0, 1, 2, and 3 m s^{-1}. Individual dimensions are 3.2 m wide x 2.44 m deep x 2.38 m high, and each climate chamber includes equipment for heating, cooling and humidification as highlighted in Fig. 1. The test facilities are located in the Ambiagro group (Research Center of Environment and Agroindustry Systems Engineering) at the Department of Agricultural Engineering at the Federal University of Viçosa (Minas Gerais, Brazil). A three-dimensional abstraction of the cage system was created, with the origin located at the right rear side of each cage (Fig. 2) with coordinates (x,y,z) referring to lateral, depth and height, respectively. A grid was established, consisting of 275 points/cage within this grid, spaced equidistantly (Fig. 2). Resolution for locating these points was estimated to be ±10 mm. Air velocity was measured using a hot wire anemometer (Testo 425, TESTO INC., Germany) within the entire cage were useful in order to characterize the distribution of air velocity. However, the main focus was on the velocity in the feeder zone, as is highlighted in Fig. 2. This zone comprises the points located in Lines 3, 4 and 5, measured at 7 points located at the most central portion of the cage (Figure 2A). Two heights, denoted Z0 and Z1, were established for the Line measurements. Z0 is located at the feeder top surface, and Z1 is approximately at the height of the birds when at the feeder.

Figure 1. Inside view of the climatic chambers, where 1: air conditioning; 2: air humidifier; 3: electronic temperature and relative humidity controller (MT-531R plus); 4 and 5: ventilation tubes; 6: air heater; 7 and 8: cages; 9 and 10: feeders; 11 and 12: water tanks.

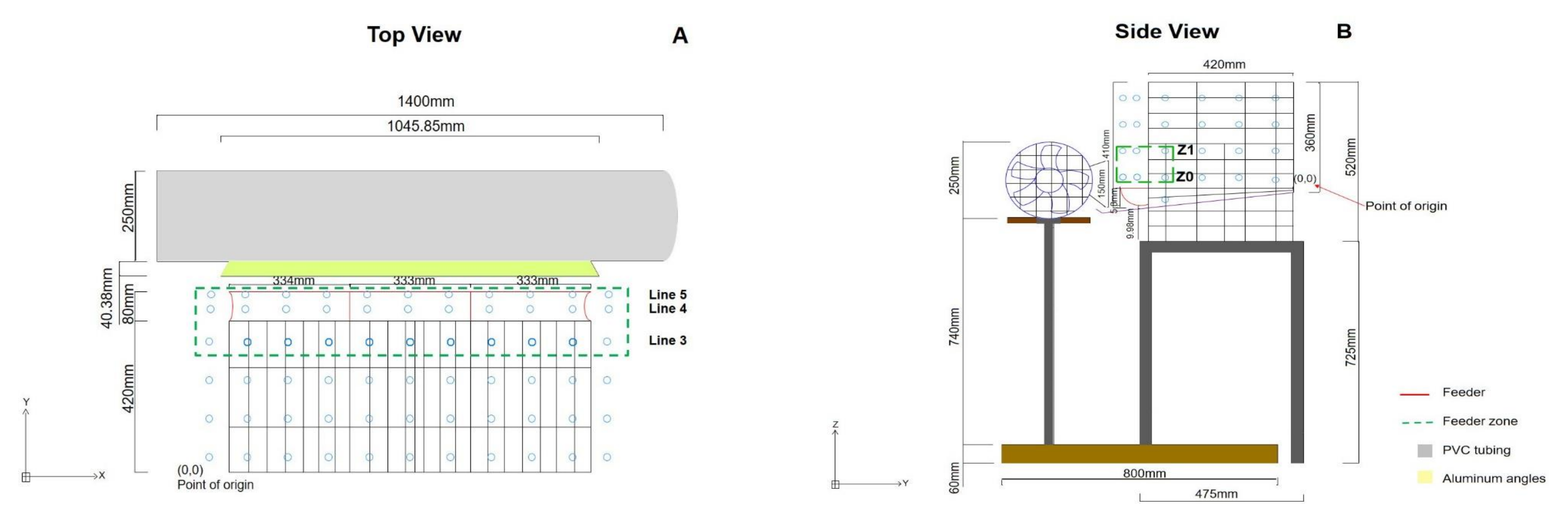

Figure 2. Schematic of cage and ventilation control system, with sampling points (275 per cage), Lines (3, 4 and 5) located at different distances from the feeder zone, and heights (Z0, Z1) of primary interest for assessing actual velocities experienced by birds at the feeder. A) Top view. Note the grid includes points located at the exterior of each side of the cage. Line 5 was at the feeder, Line 4 was spaced 40 mm further into the cage, and Line 3 was spaced 115 mm from Line 4. B) Side view, illustrating the location for heights Z0 and Z1 that are used to quantify system performance.

Results

The two nearest lines to the feeder (Lines 4 and 5 at Z1 height), in combination, best represent the condition in which the birds were exposed due to the fact that they correspond to the zone effectively occupied by the birds during the feeding. Thus, it is possible to observe in Table 1 the actual air velocity to which the animals were submitted when approaching the feeder.

Table 1. Relationship between air velocity set point and mean observed data (±standard deviation) for the combination of values obtained in lines 4 and 5.

Air velocity set point (m s^{-1})	Mean observed in lines 4 and 5 (in combination) (m s^{-1})
1 (Low)	1.1 ± 0.09
2 (Medium)	2.0 ± 0.22
3 (High)	2.3 ± 0.10

Strong positive correlations were found in velocity at similar points in these replicate cages, as illustrated in Table 2. The overall correlation results for all points in the replicate cages (n=275), by velocity setpoint, demonstrate excellent correlation with the Pearson correlation coefficients exceeding 0.9 for all three velocity set points. Similarly, restricting the analysis to the feeding zone produced similarly high correlation coefficients (0.9 to 0.98). Consequently, it was concluded that replicate cages are adequately similar for experimental purposes, if adjusted carefully at the outset.

Table 2. Mean and standard deviation of difference in velocity measurements between replicate prototypes, Pearson's correlation coefficient, and significance of correlation test.

Nominal Air Velocity Setpoint (m s^{-1})	Mean Difference (m s^{-1})	Standard Deviation (m s^{-1})	Correlation Coefficient, r	P
Results for all sample points (n=275)				
low	0.01	0.24	0.893	<0.001
medium	0.05	0.28	0.905	<0.001
high	0.02	0.19	0.976	0.001
Results for all feeding zone sample points (n=66)				
low	0.02	0.32	0.899	<0.001
medium	0.10	0.39	0.900	<0.001
high	0.01	0.23	0.982	<0.001

Conclusions

The system provided mean air velocity that was greatest in the zone where birds are housed (Z0 and Z1), as designed. Replicate cages, using different air velocity control systems, demonstrated similar velocity magnitude and distribution. Measured air velocity variation within a cage was substantial, because of the open nature of the cages; however, desired velocity at the feeder zone was achieved, except for the mean air velocity measured in the feeder zone for the 3 m s^{-1}, where velocity nominal set point was 2.3 (±0.10) m s^{-1}. Comparing the mean value of the measured and predetermined air velocity for each treatment, there is a need for greater attention for adjusting the air outlets at higher velocities (e.g. at or above 3 m s^{-1}).

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