Effect of stocking density on air quality and health and performance of heavy tom turkeys

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Perkins, S.L., Zuidhof, M.J., Feddes J.J.R., and Robinson, F.E. 1995. **Effect of stocking density on air quality and health and performance of heavy tom turkeys.** Can. Agric. Eng. 37:109-112. Four environmental chambers housing either 75 (5.5 birds/m^2) or 37 turkeys (2.8 birds/m^2) were used to study the impact of stocking density on air quality, bird health, and performance under similar per bird ventilation rates (3 L/s per bird). Stocking density had little effect on air quality or liveweight gain. The following observations were made for the high and low density stocked chambers, respectively: respirable dust concentrations were 26 and 24 particles/mL, mean ammonia concentrations were 4 and 4 ppm, mean carbon dioxide levels were 1830 and 1890 ppm, ammonia production was 0.05 and 0.06 L/h per bird, and carbon dioxide production was 9.3 and 8.8 L/h per bird. Lung lesion incidence and severity was not significantly different between stocking densities, although lesion severity tended to increase with increased density. A greater percentage of birds in the high density treatment gasped when the ambient temperature was temporarily elevated (31% high density, 6% low density). Eight, 12 and 16 week body masses and feed:gain were not influenced by density or lesion score.

Keywords: stocking density, air quality, dust, ammonia, lesions

Quatre chambres de contole, dont deux logeant 37 dindons (5.5 dindons/m^2) et deux autres longeant 75 dindons (2.8 dindons/m^2) furent utilisées pour étudier l'impact de la densité animale sur la croissance de la population et sur la qualité de l'air. Un taux de ventilation de 3L/s per dindon était maintenu dans les quatre chambres. Le densité animale avait peu d'effet sur la qualité de l'air et sur de leux de croissance des dindons. Les données suivantes furent relevées des quatre chambres de contrôle, sous une densité animale faible et élevée, respectivement : la concentration de poussière dans l'air était de 26 et 2,4 particules/mL; la concentration moyenne d'ammoniac étai de 4 et 4 ppm alors que la production d'ammoniac étai de 0,05 et 0,06 L/h per dindon, respectivement; le taux de gaz carbonique était de 1830 et 1980 ppm alors que la production de gaz carbonique étai de 9,3 et 8,8 L/h per dindon, respectivement. La densité animale n'avait pas d'effet significatif sur l'incidence et al sévérité des lésions de poumons, sauf lors de températures temporairement élevées, ou la sévérité des lésions augmentait de 131% sous une population élevée et par rapport a la population basse. La croissance des dindons sur une période de 12 à 16 semaines n'était pas affectée par la densité animale et le nombre de lésions.

INTRODUCTION

With increased use of total confinement as a means of raising livestock, concerns have been expressed regarding the health and well being of animals reared in these environments. As a result, the impact of air quality on animal welfare and performance is becoming an issue. Turkeys are often raised in total confinement up to 20 weeks of age. Aerial contaminants such as ammonia (NH_3) and dust are present in poultry barns, often in concentrations higher than recommended levels (Morrison et al. 1993). Hauser and Folsch (1988) stated that dust and ammonia are associated with respiratory disease in poultry. Impaired respiratory function may also adversely affect bird productivity and lead to higher mortality.

Chronic exposure to aerial contaminants can also result in decreased lung function and impaired respiratory health in poultry labourers (Perkins and Morrison 1991). Work by Schlenker et al. (1987) reported that the majority of respiratory complaints were from labourers working with pigs, turkeys, or chickens. Respiratory symptoms were more prevalent during winter months when air quality is poorest. Low winter ventilation rates result in higher aerial contaminant levels as contaminated air is not as frequently replaced with outside air. Decreasing stocking density may be an alternative to increasing ventilation rates to ensure better air quality in turkey barns.

Zuidhof et al. (1993) studied the impact of ventilation rate and stocking density on air quality and bird health and performance. Birds were housed at high density (5.5 birds/m^2) - low ventilation rate (3 L/s per bird), high density-high ventilation rate (7 L/s per bird), low density (2.8 birds/m^2)-low ventilation rate (6 L/s per bird) or low density-high ventilation rate (13.8 L/s per bird). The authors reported a trend that both respirable and non-respirable dust concentrations were affected more by housing density than by ventilation rate. In addition, the gaseous environment in their study tended to be poorest in chambers with low ventilation. Significantly higher NH_3 and CO_2 were reported in chambers with low ventilation rate. As well, lung lesions tended to be more severe in high density rooms.

This study was a follow up to their work and examined the impact of decreasing industry recommended stocking density on air quality and health and performance of heavy tom turkeys. Birds in each density were housed under similar ventilation rates on a per bird basis.

EXPERIMENTAL METHOD

Facility

Four identical environmental chambers located at the Edmonton Research Station, Edmonton, AB were used in this study. Each room measured 3.4 x 4.0 x 2.4 m with a floor area of 13.6 m^2. Rooms had a counter balance continuous slot air inlet and a recirculation duct to ensure complete mixing between resident and incoming air. Each chamber had a

250-mm two-speed and a 350-mm variable speed exhaust fan. A mean ventilation rate of 2.9 L/s per bird was maintained in each chamber. Supplemental heat was provided in each of the low density rooms by a thermostatically controlled 1 kW electric baseboard heater. A lighting schedule of 23 L: 1 D was provided by a 60 W incandescent bulb. Feed and water were available ad libitum.

Equipment

Air quality was measured during the 8 to 16 week growth period. Sampling was done over a 24 h period once a week. Environmental parameters measured included respirable (<5 µm) and non-respirable (>5 µm) dust, ammonia (NH_3), carbon dioxide (CO_2) and oxygen (O_2) concentrations, dry bulb temperature, dewpoint, and chamber ventilation rate. Sampling equipment was housed in the plenum directly above the chambers as described by Zuidhof et al. (1993).

Dust concentrations were measured by an aerodynamic particle sizer (TSI, St. Paul, MN). The particle sizer was connected to a ball valve assembly that was controlled by an I/O board connected to an IBM PC. Sampling tubes from the centre of each chamber and one from the fresh air plenum were connected to the ball valve assembly. Each chamber was sampled for 4 minutes each hour. Before switching valves, data were recorded and stored on the computer.

Ammonia and CO_2 were measured using non-dispersive infrared analyzers (Beckman Industrial, Model 880 and 870, respectively, La Habra, CA). Oxygen concentrations were measured with a paramagnetic oxygen analyzer (Servomex, Model 540 A, Sussex, England). Each instrument was spanned with a certified gas mixture specific to the instrument and zeroed with nitrogen gas.

Dry-bulb temperatures were measured using thermistors (Fenwal Electronics, Framingham, MA) and dewpoints by a dewpoint hygrometer (General Eastern, Watertown, MA). Gas concentrations and dewpoints from each chamber and the plenum were measured once an hour. Samples were drawn from each chamber to the instruments via tubes connected to solenoid activated valves controlled by a datalogger. Prior to switching valves, the datalogger scanned the outputs from the analyzers and thermistors. Records from the datalogger were stored on a second computer.

Air velocity was measured in a discharge duct downstream from each exhaust fan. Measurements were taken with a constant temperature thermal anemometer (Velocicalc, TSI, St. Paul, MN).

Turkey Stock

Male heavy turkeys (Hybrid strain) were raised to 8 wks of age at the Edmonton Research Station. At 8 wks of age, birds were individually weighed and wing banded. Turkeys closest to the mean mass were ranked and randomly assigned to the 4 chambers. Thirty seven birds were placed in each of the two low density rooms (2.8 birds/m^2) and seventy-five birds (5.5 birds/m^2) were placed in each of the two high density rooms. Feed consumption was recorded over the 8-12 wk and 12-16 wk intervals. Birds were individually weighed at 12 wks and again at 16 wks of age. At 12 wks, 25 turkeys from each of the high density rooms and 12 birds from each of the low density rooms were removed to accommodate their increased size. All mortality was recorded and taken into consideration when analyzing feed consumption and weight gains/pen.

Lung function

One day prior to slaughter, room temperature was elevated to 30°C for one hour. The number of birds gasping was recorded as an indirect measure of lung function.

Lung scoring

The turkeys were slaughtered and processed in a commercial abattoir at 16 wks of age. Lungs were removed at slaughter and observed for the presence of lesions. Both lungs from each bird were examined. A cross section of each lobe was evaluated and the most severe score recorded. Lesion scores were as follows:

0 - No visible lesions
1 - Lesions < 1 mm diameter
2 - Lesions 1 - 2 mm diameter
3 - Lesions 2 - 5 mm diameter
4 - Lesions > 5 mm diameter

Lesion diameter was estimated across the longest cross section of lesion.

Statistical analysis

Data obtained were analyzed using the General Linear Model for analysis of variance on the SAS software package (SAS Institute 1989). Significant means were separated using Duncan's Multiple Range Test. Lesion data were transformed using the arcsine of the square root of the percentage prior to analysis (Steel and Torrie 1980). Significance was evaluated at the 0.05 level.

RESULTS

Dust

Dust was analyzed as respirable and non-respirable dust. There was no significant difference in either respirable or non respirable dust as a result of density ($P = 0.99$, both respirable and non-respirable dust) (Table I). This effect may be explained by a difference in ventilation rate. Although ventilation rate per bird is similar (Table I), mean ventilation rate of the low density rooms was half that of the high density rooms. As well, respirable particle production rates (particles/s per bird) were not significantly different between densities ($P = 0.87$), but were somewhat higher in the low density chambers (Table I). In addition, subjective evaluation of litter conditions showed the litter in the low density chambers was drier than that in the high density chambers.

Ambient gas levels

Data for CO_2 and NH_3 concentrations are only available for weeks 10 - 16 as a result of instrumentation problems. There were no significant differences in NH_3 ($P = 0.45$) or CO_2 ($P = 0.58$) concentrations between the two densities (Table I). There was a trend towards higher CO_2 concentrations in the reduced density rooms. Again this may be the effect of reduced ventilation rate. Average production rates (L/h per bird) for NH_3 and CO_2 are presented in Table I. There was no significant difference in production rates of either gas be-

Table I. Mean aerial contaminant concentrations, gas production rates, and ventilation rates for high and low stocking densities

Parameter	High density	Low density
R.D. (particles/ mL)[1]	26	24
N.R.D. (particles/ mL)[2]	9	8
R.P.P. (particles/ s per bird)[3]	76280	79120
NH_3 (ppm)	4 (0.2)	4 (0.2)
CO_2 (ppm)[4]	1830 (66)	1890 (66)
O_2 consumed (ppm)	1466 (133)	1571 (133)
NH_3 production (L/h per bird)	0.05 (0.007)	0.06 (0.006)
CO_2 production (L/h per bird)	9.4 (1.9)	8.8 (1.3)
O_2 consumptin (L/h per bird)	9.21 (1.9)	9.39 (1.4)
Respiratory quotient	1.02 (0.05)	0.94 (0.05)
Ventilation rate (L/h per bird)	3.00 (0.18)	2.93 (0.18)

[1] Respirable dust (< 5 μm)
[2] Non-respirable (> 5 μm)
[3] Respirable particle production
[4] Includes outside concentration (350 ppm)
SD in parentheses

tween the high and low stocking densities.

Similar results were found with O_2 concentrations. There was no significant difference in O_2 levels, consumption rates or respiratory quotient between the densities. Results are presented in Table I.

Lung lesions

Figure 1 illustrates the distribution of lung scores. No significant difference was found in either the incidence or severity of lung lesions. However, there is a trend towards more severe lesions with increased stocking density.

Using degree of gasping as an indicator of lung function, a similar trend was seen. A higher percentage of birds were observed gasping at elevated temperatures in the higher density rooms (Fig. 2). This may indicate a higher degree of respiratory impairment with increased bird density.

Table II. Summary of turkey performance

		Rm 1	Rm 2	Rm 3	Rm 4
# Birds/pen	start	75	75	37	37
	end	541	48	24	24
Body mass (kg)	8 wk	3.47 (0.028)	3.48 (0.028)	3.46 (0.040)	3.46 (0.040)
	12 wk (	7.31 0.068)	7.51 (0.068)	7.24 (0.096)	7.68 (0.095)
	16 wk	11.62 (0.084)	11.73 (0.086)	11.30 (0.121)	11.83 (0.123)
Gain (kg)	8 - 16 wk	8.15	8.25	7.84	8.37
Feed : Gain	8 - 16 wk	2.28	2.44	2.50	2.72

SD in parentheses

Bird performance

Table II shows 8, 12, and 16 wk body massess and feed:gain ratios for the four rooms. Mean body masses for 8, 12, or 16 wks were not significantly different between densities or between chambers. Bird performance was slightly lower in room 3. During the first 2 weeks of the experiment, room temperature was slightly lower in this chamber, resulting in higher feed:gain and lower mass gains. Body massess were not significantly affected by lesion severity (P = 0.81, 0.49, and 0.28 for 8, 12, and 16 wks, respectively). This is in agreement with Zuidhof et al. (1993).

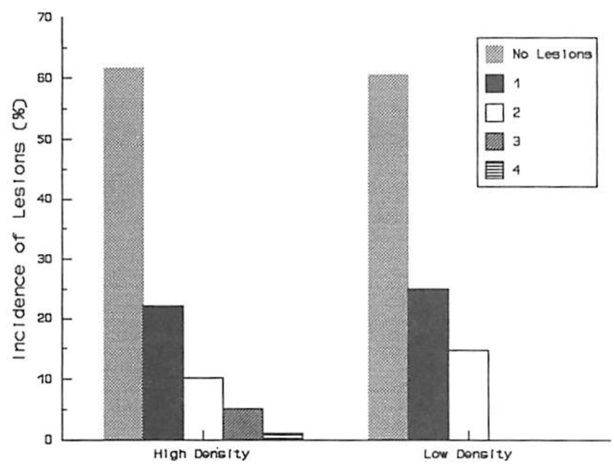

Fig. 1. Lesion severity for turkeys at high or low stocking densities.

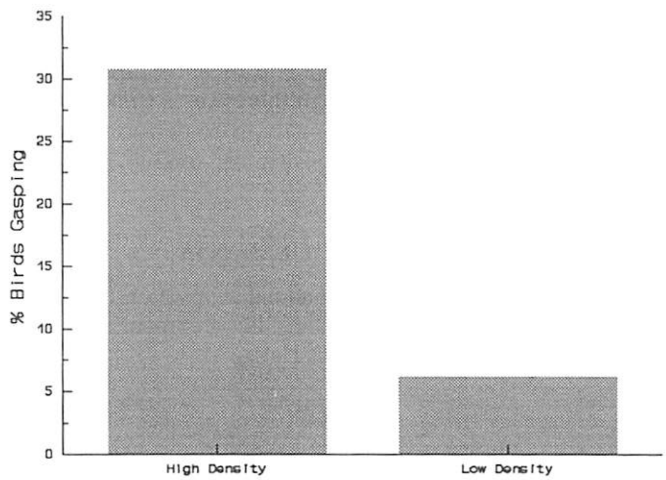

Fig. 2. Mean percent of birds gasping at elevated temperatures ranging (25 - 30°C).

DISCUSSION

Aerial contaminants such as respirable dust and NH_3 may lead to respiratory disease in poultry (Perkins and Morrison 1991). Anderson et al. (1968) reported that high dust concentrations led to increased incidence of airsac lesions in turkeys. An increased incidence of air sacculitis was found in turkeys housed at densities of 0.21 m^2 per bird when compared to those housed at 0.46 m^2 per bird (Noll et al. 1991). Cravener et al. (1992) reported that male broiler chickens were more affected by population density than females.

Although lesion incidence and severity were not significantly affected by stocking density in this study, a trend towards more severe lesions with increasing density exists. A similar trend was reported by Zuidhof et al. (1993). Lung function also appeared to be compromised in high density housing as well, indicated by the degree of gasping. The reason for these trends is unclear, as air quality is similar between the densities. As well, there is no difference in gas or particle production rates between high and low densities. Although not monitored in this study, birds housed under increased density may experience a higher level of stress, rendering them more susceptible to respiratory impairment.

Bird performance was not influenced by stocking density. Body massess were similar across treatments. This is consistent with other findings (Zuidhof et al. 1993). However, Noll et al. (1991) reported decreased performance in turkeys housed under increased density. Lower body massess, feed conversion, and decreased gains were observed after 12 wks of age in broiler chickens housed at 0.05 m^2/bird (Cravener et al. 1992).

Although dust levels were not different in this study due to ventilation rate, there is evidence to suggest that reducing density may decrease dust levels. Webster (1990) stated that decreasing stocking density by 50% appears to be more effective than a 10 fold increase in ventilation rate in reducing aerosol concentrations.

CONCLUSIONS

Air quality was not affected by stocking density when birds were housed under a similar per bird ventilation rate. As well, mean gas and particle production rates were not affected by density. Stocking density did not significantly influence the severity of lung lesions, although there was a trend to more severe lesions with increased density. Bird performance was not influenced by stocking density, air quality, or lesion severity.

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