Influence of the Stocking Density and Rearing Season on Incidence of Sudden Death Syndrome in Broiler Chickens

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ABSTRACT
Influences of the stocking density and rearing season on the incidence of sudden death syndrome (SDS) were investigated in commercial broiler chickens, which were reared until 63 d after birth. The SDS mortality and total mortality were measured at three different stocking densities of 12, 15, and 18 birds/m² in rearing seasons of summer, autumn, and winter. At stocking densities of 15 and 12 birds/m², neither SDS mortality nor total mortality was significantly different throughout the rearing season. However, at 18 birds/m², SDS mortality significantly increased in summer and winter. The increased SDS mortality was accompanied by a significant increase in total mortality in summer but not in winter. Irrespective of the stocking density, body weight gain and feed intake were lower in summer with no significant change in feed efficiency. The data suggest that stocking density can act as a factor affecting the incidence of SDS in summer and winter, independent of feed efficiency.

(Key words: broiler, sudden death syndrome, mortality, stocking density, rearing season)

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INTRODUCTION

Sudden death syndrome (SDS) is a disease characterized by an acute death of well-nourished and seemingly healthy broiler chickens after abrupt and brief flapping of their wings (Ononiwu et al., 1979a; Hulan et al., 1980; Steele et al., 1982). This disease represents a major economic loss to the broiler industry.

Factors that have been implicated in the incidence of SDS include growth rate (Bowes et al., 1988), B vitamins (Hulan et al., 1980), fats in the diet (Rotter et al., 1985), pelleting of feed (Proudfood and Hulan, 1982; Proudfood et al., 1982), and lighting (Ononiwu et al., 1979b). However, the etiology of SDS is still unknown. Pathological studies revealed that SDS is frequently, but not extensively, accompanied by some failure of the cardiovascular system, myocardial degeneration (Volk et al., 1974; Ononiwu et al., 1979a), and atherosclerotic changes of the coronary arteries as well as myocardial necrosis (Kawada et al., 1994). Therefore, SDS has been suggested to be a cardiac disease. A recent study (Imaeda, 1999) to characterize SDS from the viewpoint of blood chemistry demonstrated that the serum level of enzymes utilized as indicators for clinical diagnosis of human circulatory disturbance are elevated in association with SDS.

Broiler chickens are generally reared at a considerably high stocking density. Such rearing conditions may act on the birds as a stress that causes functional disorders in their organs, including the heart. Indeed, in the mature hen, the reduction of the floor space per bird results in a significant decrease in laying rate, perhaps because of increased stress (Feldkamp and Adams, 1973). The purpose of the present study was to investigate the effect of stocking density on the incidence of SDS in broiler chickens, taking into account variations in rearing season.

MATERIALS AND METHODS

A 50:50 mixture of male and female broiler chickens (Arbor acres × Arbor acres; 6,903 in total) was used for the present study. The research was executed in three different seasons, namely, June to August (summer), October to December (autumn), and January to March (winter). In the respective seasons, one-third of the total birds (2,301) was divided into four flocks, and the flocks were reared for 9 wk at different stocking densities in a windowless chicken house with four pens, each with a floor area of 39.4 m². Two of the four flocks (484 and 483) were raised at a stocking density of 12 birds/m², and the remaining two (607 and 727) were at 15 birds/m² and 18 birds/m², respectively. The ventilation rate in the chicken house was adjusted depending on the age of birds and rearing season, as presented in Table 1. The photoperiod was fixed at 23 h/d.

Commercial feed (CP = 22.0% and ME = 3,100 kcal/kg) was used as a starter for feeding from 1 to 3 wk of

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Abbreviation Key: SDS = sudden death syndrome.
TABLE 1. Varied ventilation rates in a windowless chicken house, depending on the age of broilers and rearing season

<table>
<thead>
<tr>
<th>Season</th>
<th>1 to 21 d</th>
<th>22 to 42 d</th>
<th>43 to 63 d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(m³/min·bird)</td>
<td>(m³/min·bird)</td>
<td>(m³/min·bird)</td>
</tr>
<tr>
<td>Summer</td>
<td>0.0394 to 0.0577</td>
<td>0.1183 to 0.1373</td>
<td>0.2433 to 0.2707</td>
</tr>
<tr>
<td>Autumn</td>
<td>0.0203 to 0.0330</td>
<td>0.0337 to 0.0813</td>
<td>0.0387 to 0.0747</td>
</tr>
<tr>
<td>Winter</td>
<td>0.0027 to 0.0047</td>
<td>0.0143 to 0.0183</td>
<td>0.0303 to 0.0443</td>
</tr>
</tbody>
</table>

age and another feed (CP = 18.0% and ME = 3,200 kcal/kg) as a finisher from 4 to 9 wk of age. Feed and water were consumed *ad libitum*.

The average individual body weight for each flock was determined by weighing a random 25 to 30% of the chickens at 1, 21, 42, and 63 d of age. With these pooled data, a final body weight gain per bird was estimated. Feed intake per bird over the entire rearing period was calculated from amounts of provided and uneaten feed, which was determined daily.

Dead chickens found by daily visits to the pens were necropsied. If they had a well-grown body, crop fully filled with feed, empty gall bladder, and no clinical sign of other disease, their death was recognized as the result of SDS (Ononiwu *et al.*, 1979a; Hulan *et al.*, 1980).

**Statistical Analysis**

The total and SDS incidences were statistically analyzed using Fisher’s exact probability test, and the body weight gain and feed intake were analyzed with the chi-square test.

**RESULTS**

**Influence of Stocking Density**

A survey of total deaths from SDS was made in broiler flocks that were raised at three different stocking densities of 12, 15, and 18 birds/m² in three different rearing seasons of summer, autumn, and winter (Table 1). The SDS mortality and total mortality were calculated from the data in Table 2, and they were plotted against the stocking density separately in each of the three different seasons (Figure 1). In summer, SDS mortality and total mortality of birds housed at 18 birds/m² were significantly higher ($P < 0.01$ and $P < 0.05$, respectively) than were those of birds housed at 12 and 15 birds/m². The SDS deaths expressed as percentages of total deaths were 33, 38, and 43% at 12, 15, and 18 birds/m², respectively. In autumn, there was not a significant increase in SDS mortality as the stocking density was increased. The total mortality of birds housed at 18 birds/m² was significantly higher ($P < 0.05$) than that at 15 birds/m² but not that of birds housed at 12 birds/m². In winter, SDS mortality was significantly higher ($P < 0.05$) at densities of 18 birds/m² than at densities of 12 birds/m². However, total mortality was not significantly different between any pair of the three stocking densities. The number of deaths from SDS at 18 birds/m² was 53% of the number of total deaths, which was elevated by some 20% from 31 and 33% at densities of 12 and 15 birds/m², respectively.

**TABLE 2. A survey of total deaths from sudden death syndrome (SDS) in broiler flocks raised at different stocking densities in different seasons**

<table>
<thead>
<tr>
<th>Stocking density birds per square meter</th>
<th>Birds¹ (no.)</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(no.)</td>
<td>(%)</td>
<td>(no.)</td>
<td>(%)</td>
</tr>
<tr>
<td>12</td>
<td>967</td>
<td>64/21</td>
<td>33</td>
<td>48/20</td>
<td>42</td>
</tr>
<tr>
<td>15</td>
<td>607</td>
<td>34/13</td>
<td>38</td>
<td>27/15</td>
<td>56</td>
</tr>
<tr>
<td>18</td>
<td>727</td>
<td>72/31</td>
<td>43</td>
<td>50/19</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>2,301</td>
<td>170/65</td>
<td>38</td>
<td>125/54</td>
<td>43</td>
</tr>
</tbody>
</table>

¹The number of birds in each rearing season.

²The number of total deaths, the number of SDS deaths, and the relative percentages, respectively. Data are derived from observations from day of hatch to 63 d of age.
FIGURE 2. Plots of total mortality (○) and sudden death syndrome mortality (•) against the rearing season at a stocking density of 18 birds/m². Significant difference ($P < 0.05$) exists between a and b.

**Influence of Rearing Season**

The SDS mortality and total mortality at each stocking density apparently varied from one rearing season to another. However, stocking densities of 12 and 15 birds/m² changes in mortality did not differ between any pair of the rearing seasons. As shown in Figure 2, at 18 birds/m², total and SDS mortality were significantly higher ($P < 0.05$) in summer than in autumn. Between summer and winter, the difference in the total mortality, but not SDS mortality, was significant ($P < 0.05$).

**Body Weight Gain and Feed Intake**

Table 3 represents the mean body weight gain and feed intake per bird in the flocks raised at three different stocking densities in the three seasons. Feed efficiency, which is calculated by dividing the body weight gain by the feed intake, is also presented in Table 3. Neither body weight gain nor feed intake significantly differed among the stocking densities of any one rearing season. Both values at one stocking density showed such seasonal changes that they are significantly lower ($P < 0.05$) in summer than in any other seasons. Feed efficiency ranged from 2.19 to 2.33 and was nearly constant, regardless of the stocking density and rearing season.

**DISCUSSION**

The SDS mortality of birds housed at a stocking density of 18 birds/m² was significantly higher than those at the other stocking densities in summer and winter. It seems that in summer, the higher incidence of SDS contributes to a significant increase in the total mortality, as number of SDS deaths expressed as a percentage of total number of deaths increased by some 10%. However, one can never exclude the possibility that an outbreak of some fetal disease such as heatstroke affects total mortality. In fact, some of the dead chickens had positive signs of heatstroke.

Interestingly, the higher SDS mortality in winter was not reflected in the total mortality, leading to some 20% increase in the percentage (53%) of SDS deaths to total death. One possible explanation for this is that the high stocking density exerts a concomitant effect to reduce the number of deaths from fetal diseases other than SDS. Jones (1995) reported that in broiler chickens reared in a cold chicken house, the incidence of ascites due to a cardiac disorder similar to SDS increased. As heat production of broiler chickens increases with increasing the stocking density, the ventilation rate used in winter may prevent the birds from being exposed to a room temperature cold enough to cause birds to die from such ascites.

In the present study, at stocking densities of 12 and 15 birds/m², SDS incidence showed no seasonal difference. However, Gardiner *et al.* (1988) demonstrated in large-scale field research that SDS incidence was highest in January and lowest in July. If these results are carefully analyzed, it may be observed that the changes in SDS incidence with rearing season are rather complicated and presuppose that a stocking density, which is above a critical level, has a role for SDS incidence at least in summer as well as in winter.

Growth rate and feed intake have been suggested to act as important factors for the incidence of SDS (Bowes...
et al., 1988), but these were not supported by the present finding that there was no significant difference in body weight gain and feed intake between the stocking densities in any rearing season. The observed high incidence of SDS in flocks at 18 birds/m² is independent of these factors. This view is also supported by no change in the SDS mortality at 12 or 15 birds/m² through the three rearing seasons, among which there was a significant difference in body weight gain and feed intake.

Broiler chickens that died of SDS have signs cardiovascular failure (Ononiwu et al., 1979a; Kawada et al., 1994; Imaeda, 1999), a high content of calcium ions in cardiac muscle (Rotter et al., 1985), and a decreased calcium regulation in cardiac muscle (Chung et al., 1993). In general, as a stress response, a surge of catecholamines occurs mainly from the adrenomedullary system, and serum levels at catecholamine are elevated (Beuving and Vonder, 1978). Because catecholamines increase the intracellular calcium level in cardiac muscle, stress may overcome membrane calcium transport, leading to calcium overloading within the cardiac muscle. This phenomenon might account, at least in part, for the incidence of SDS at such a stocking density that it could produce the stress response. Further study needs to clarify the relationship between stocking density and serum catecholamine levels and to investigate whether elevation of circulating catecholamines can precipitate broiler chickens into SDS.

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REFERENCES