Influence of male–male competition on reproductive performance and mortality of broiler breeders following intra-spiking

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ABSTRACT The study was conducted to determine the influence of male–male competition on reproductive performance and male mortality of Cobb 500 broiler breeder flocks following double intra-spiking. Broiler breeders were housed in 3 open-sided houses each accommodating 8,200 females and 820 males. Males of the same age on the same farm were exchanged between the houses (intra-spiking) to stimulate competition thereby changing the social hierarchy of each house. Intra-spiking was performed by replacing 25, 35, and 45% of males between the houses at 40 and 48 weeks of age (**WOA**), respectively. Eggs were collected from 36 to 55 WOA, when egg fertility and male mortality were recorded. Data was analyzed using repeated measures techniques of SAS 9.4, modeling the covariance structure of the observed data. Male–male competition (intra-spiking), age and their interaction significantly ($P < 0.05$) influenced egg fertility, hatchability, and male mortality. Average fertility and hatchability were increased in the 45% intra-spiked flocks ($P < 0.05$) (95.89 and 85.83%) compared with the 35% (95.13 and 86.30%) and 25% (94.42 and 0.23%) intra-spiked flocks. Fertility and hatchability with the 45% double intra-spiked flocks was consistently higher ($P < 0.05$) over time than the other double intra-spiked flocks. Male mortality was lower ($P < 0.05$) in the 45% intra-spiked flock (0.23%) than in the 35% (0.40%) and 25% (0.44%) intra-spiked flocks. After double intra-spiking, the male mortality in the 25 and 35% double intra-spiked flocks significantly increased ($P < 0.05$), whereas that of 45% intra-spiked flocks remained relatively low. Male mortality in the 45% intra-spiked flocks was consistently low over time than other double intra-spike levels from 45 WOA until the end of the trial. Noteworthy, egg fertility and hatchability gradually decreased, and mortality increased with increasing flock age toward the end of the productive life cycle. High level of male–male competition (45%) showed great promise as a tool to slow down the decrease in egg fertility and hatchability, and reduce male mortality in aging broiler breeder flocks.

Key words: fertility, hatchability, intra-spiking, social interaction

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INTRODUCTION

The broiler industry plays a major role worldwide (87%) in meat production (Brillard, 2001). The fast growth of human population demands more animal protein. Improvement of broiler growth rate has been brought about through genetic selection (85 to 90%), with the remaining change (10 to 15%) been attributable to nutrition (Havenstein et al., 2003). Male broiler breeders must be physically capable of mounting females to successfully inseminate upon cloacal contact, however, selection for higher body weight (Hocking and Bernard, 1997) and large musculoskeletal frame (Hocking and Duff, 1989; Duncan et al., 1990), and poor management practices (Hocking and Bernad, 2000) may result in reduced mounting ability (Bilcik et al., 2005) and greater fertility problems (McGary et al., 2003; Bilcik et al., 2005).

In the last decades, the fertility of the broiler breeder flocks has decreased to such a degree, particularly the older flocks, that it potentially threatens the economical production (Creel et al., 1998; Walsh and Brake., 1997). Flock fertility is dependent on the productive status, interest, and mating capability of the birds (Hocking, 1990; McGray et al., 2003; Bilcik et al., 2005). After 40 weeks of age (**WOA**) the breeder hen requires more frequent mating to sustain high fertility, while at the same age the rooster is less interested in mating (Ottinger et al., 1983; Joseph and Moran, 2005), moreover, the hatchability of eggs decreases with age (Tona et al., 2001; Seker et al., 2004; Zakaria et al., 2009). Therefore, it is important to manage the aging parent stock in such a manner as to maintain a relatively high reproductive performance for optimum productivity and reduced mortality.

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The contribution of the male broiler breeder to egg fertility is of greater importance than the contribution of the female (Wolc et al., 2009). Mating activity is influenced by the male fitness and female receptivity that are both influenced by sex ratio and feeding programs (Casanova, 2000). Intra-spiking can be used to compensate for the decrease in libido stimulating aging males to resume mating thereby improving overall life-long flock fertility (Casanova, 2000; Brillard, 2004; Végi et al., 2006). The best time to spike is when the flock is at 40 to 45 WOA (Jafari et al., 2015). However, spiking interferes with social interactions/pecking order within the flock, so fighting and new pecking order had to be established (Guhl, 1968). However, this might result in injuries and mortalities. Although double intra-spiking presents an opportunity to address the problem, it is debatable whether the standard 25% intra-spiking (Arbor Acres Breeder Management Guide, 2006; Cobb Breeder Management Guide, 2013) is sufficient to improve the flock's reproductive performance. There is paucity of information on effectiveness of different levels of double intra-spiking in poultry breeders. Therefore, the study was conducted to determine the effect of male–male competition on reproductive performance and male mortality of broiler breeder flocks following double intra-spiking.

MATERIALS AND METHODS

Study Site and Experimental Design

The study was carried out at Opti Chicks Boschpoort Breeding Farm situated in Ottosdal district of the North West Province, South Africa. Nine (9) units/production cycles were used for each flock, whereby 1 unit consists of 3 open-sided houses each house accommodating 8,200 females and 820 males (1:10 male to female ratio). Intra-spiking was performed by replacing 25 (industry standards according to Arbor Acres Breeder Management Guide, 2006; Cobb Breeder Management Guide, 2013), 35 and 45% of males between the houses at 40 and 48 WOA, respectively. The males were randomly selected, spray-painted and moved at 40 and 48 WOA. However, the males moved at 40 WOA were not selected at 48 WOA in order to further break the established hierarchies.

Flock Management

The Cobb 500 broiler breeders were housed in open-sided houses with concrete floors covered with wood shavings with a depth of 3 to 5 cm in summer and 6 to 7 cm in winter. The litter was stirred or turned to maintain its condition, and the wet litter spots were replaced with a fresh new litter, on daily basis. The stocking density used was 7.16 birds/m^2 following the Cobb Breeder Technical Manual. Feed and water were provided ad libitum following the Cobb Breeder Technical Manual and the restricted feeding started at day 8. When the temperature raised above 33°C, the anti-stress (vitamin C, electrolytes) was supplied. The photoperiod was set to 16L:8D during the experimental period. Birds were vaccinated against Marek's disease, Newcastle disease, avian encephalomyelitis and fowl pox. All management practices were standardized across the 3 experimental houses.

Data Collection

A total amount of 1,600 hatchable eggs per house were collected daily from the third egg collection (between 12h00 and 13h00) from 36 to 55 WOA to determine the reproductive performance (fertility and hatchability), while male mortality was also recorded. Eggs were fumigated for 30 min and stored overnight in the cold room between 18 and 20°C. Eggs were transported to the hatchery for storage at 17°C the next morning. Eggs were incubated at dry bulb temperature of 37.5°C and wet bulb temperature of 28.3°C with the broad ends pointing upwards; on day 18 of incubation they were candled.

The fertility, hatchability, and mortality rates were determined using the following equations:

$$\text{Fertility rate (\%)} = \frac{\text{Total number of fertile eggs}}{\text{Total number of eggs set}} \times 100 \quad (1)$$

$$\text{Hatchablity rate (\%)} = \frac{\text{Total number of chicks hatched}}{\text{Total number of eggs set}} \times 100 \quad (2)$$

$$\text{Male mortality rate (\%)} = \frac{\text{Total number of the male breeders died}}{\text{Total number the male breeders in a house}} \times 100 \quad (3)$$

Statistical Analysis

Data was analyzed using repeated measured techniques of the Statistical Analysis Software 9.4 (SAS, 2013) in PROC MIXED considering the covariance structure of the observed data (Littell et al., 1999). The following statistical model was used:

$$Y_{ijk} = \mu + T_i + \varepsilon_{ij} + W_k + (TW)_{ik} + \varepsilon_{ijk} \quad (4)$$

where Y_{ijk} = measurement of response (fertility, hatchability and mortality rates) on the jth flock of the ith double intra-spiking treatment (25, 35, and 45%) at the kth time (weeks), μ = overall mean, T_i = fixed effect of double intra-spiking (25, 35, and 45%), W_k = fixed effect of the kth time on measurements (k = 36,

Table 1. Least square means and their standard errors (SE) for fertility, hatchability and mortality at different double intra-spike treatments, modeling time as a classification variable.

	Least square means (±SE)		
Intra-spiking	Fertility	Hatchability	Mortality
25	94.52 ± 0.35^{c}	85.83 ± 0.36^{c}	0.44 ± 0.02^{a}
35	95.13 ± 0.35^{b}	86.30 ± 0.36^{b}	$0.40 \pm 0.02^{a,b}$
45	95.89 ± 0.35^{a}	87.06 ± 0.36^{a}	0.23 ± 0.02^{b}

[a–c]Column means with different superscripts differs significantly ($P < 0.05$)

37,. . . , 55), $(TW)_{ik}$ = interaction between ith double intra-spiking and kth time, ε_{ij} = random effect associated with the jth house on the ith double intra-spiking group, ε_{ijk} = random error associated with the kth bird in the ith double intra-spiking at the jth time.

RESULTS

The effect of double intra-spiking, time, and their interactions significantly ($P < 0.05$) influenced the fertility, hatchability, and male mortality, when time was molded as a classification variable. The least square means (**LSM**) for different double intra-spiking groups for fertility, hatchability, and male mortality when time was molded as a classification variable are presented in Table 1. Average fertility and hatchability were higher ($P < 0.05$) in 45% (95.89 and 87.06%) than the 35% (95.13 and 86.30%) and 25% (94.42 and 85.83%) double intra-spiking flocks. The male mortality was generally lower ($P < 0.05$) in the 45 (0.23%) than in 35 (0.40%) and 25% (0.45%) intra-spiked flocks.

The fertility rate of the broiler breeders following different double intra-spike treatments performed between 40 and 48 WOA is presented in Figure 1. Fertility of the 45% double intra-spiked groups was consistently higher over time when compared with the other double intra-spike treatments with higher value observed being 97.01% at 44 WOA. The fertility levels of the 45% double intra-spiked flocks increased significantly ($P < 0.05$) after 2 wk following the first intra-spiking and remain high until the end of production cycle compared to the other double intra-spike treatments. The fertility of 25% double intra-spiked flock was lower ($P < 0.05$) from 45 WOA until the end of production cycle compared to the other double intra-spike treatments. The fertility levels between 25 and 35% intra-spike were below the Cobb fertility standard (96.6% from 39 WOA) and among these two flocks, only the 35% double intra-spiked flocks showed a slight improvement after the first intra-spiking though it did not maintain the standard of 96.1% and lower from 44 WOA onwards. The 45% double intra-spike treatment maintained the standard even better throughout the trial.

The effects of double intra-spike on hatchability of eggs are presented in Figure 2. After the first intra-spike at 40 WOA, there was an increase in ($P < 0.05$) in the hatchability levels of the intra-spiked flocks for the following 3 wk. After the first intra-spike, the hatchability of the 45% intra-spiked flocks consistently became higher over time than other double intra-spike levels (25 and 35%) with the higher value observed being 88.4% at 45 WOA. The second intra-spiking at 48 WOA did not show that stimulus on the males on the mating activity as the hatchability continues to gradually decrease. There was still a downward trend on the hatchability on the 3 different double intra-spiked flocks from 46 WOA until 55 WOA. The 25% double intra-spike performed poorly ($P < 0.05$) from week 45 until the end of the production cycle compared to the 35 and 45% double intra-spikes. The fertility levels of the double intra-spiked flocks were lower than the Cobb hatchability standard (Cobb, 2013) from 37 to 43 WOA and 53 to 55 WOA. The 45% double intra-spiked flocks maintained higher hatchability than the Cobb standard between the 44 and 53 WOA, with other intra-spiked flocks being lower throughout the trial.

The male mortality rate was similar ($P > 0.05$) between 25 and 35% intra-spiked flocks (Figure 3). After

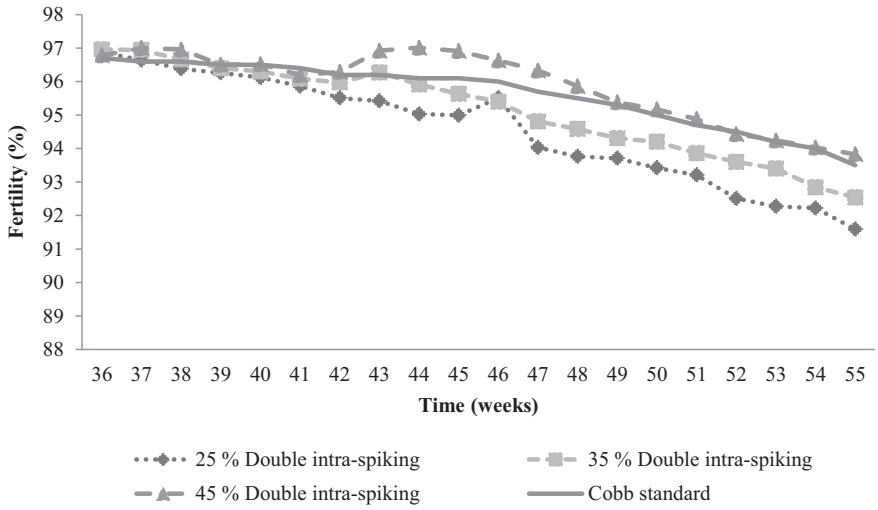

Figure 1. Fertility of breeder flocks following intra-spiking over time.

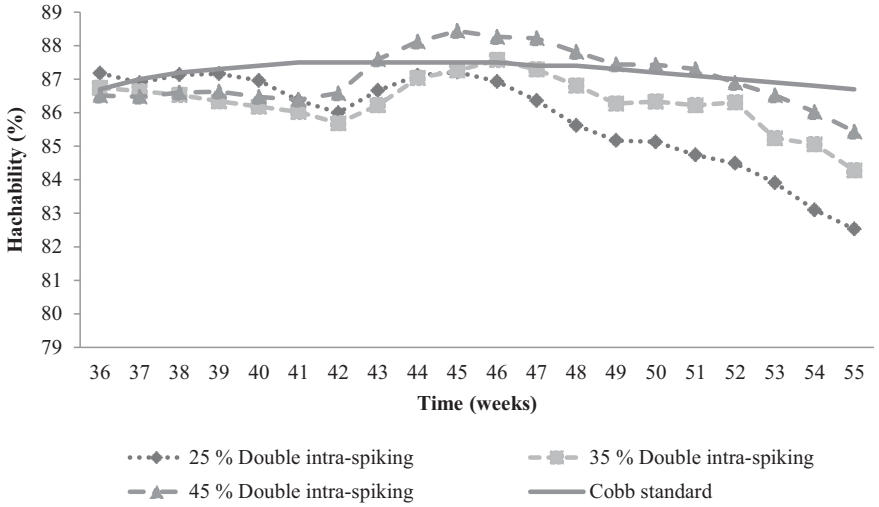

Figure 2. Hatchability of breeder flocks following intra-spiking over time.

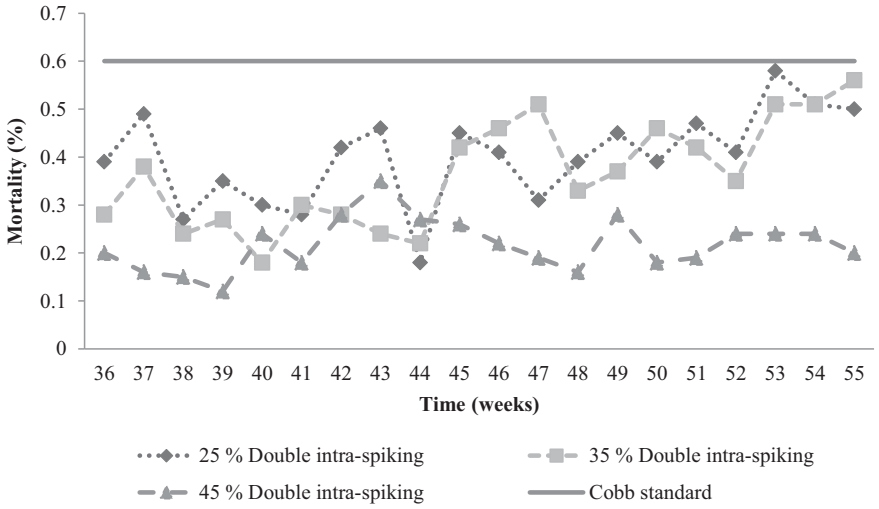

Figure 3. Mortality of breeder flocks following intra-spiking over time.

the first and second double intra-spikes, the male mortality of the 25 and 35% double intra-spiked flocks increased ($P < 0.05$), while of 45% remain relatively low. The male mortality of the 45% intra-spiked flocks was consistently low over time than other double intra-spike levels from 45 WOA until the end of the trial with the lowest value of 0.12% observed at 39 WOA. However, all the double intra-spiked flocks mortality was lower than the Cobb standard weekly mortality of 0.6%.

DISCUSSION

Egg fertility and hatchability rates can be considered as measures of the reproductive success or fitness of a breeder flock and dictates its profitability (McGovern, 2002). Infertility issues have been associated with a problem with the males, both inter-spiking and intra-spiking are used to compensate for the decreased libido in aging broiler breeder flocks, and it has become the common practice in many breeder operations worldwide (Brillard, 2004; Casanova, 2000). The double intra-spiking has a significant ($P < 0.05$) effect on egg fertility and hatchability. The results of this study depict that 45% intra-spike slowed down the decline in egg fertility and hatchability. These results are consistent with those reported by several authors (Casanova, 2000; Ordas et al., 2015) that spiking was significant ($P < 0.05$) for egg fertility and hatchability and slowed down the decline in egg fertility and hatchability. The increased egg fertility and hatchability from 42 to 55 WOA in the 45% double intra-spike treatment could be attributed to the fact that double intra-spike stimulates older males to resume mating thereby improving overall life-long flock fertility (Végi et al., 2006).

The effect of double intra-spike became evident 2 or 3 wk after the replacement, similarly to a study by (Ordas et al., 2015); however, Casanova (2002) reported that the effect of spiking became evident as soon as 1 wk after the replacement, although large effect was evident from the third week. This could be attributed to an increased aggression during the first weeks after spiking, resulted from disruption of the established pecking

order in the flock until new dominant and subordinate statuses are re-established (Chung et al., 2012), consequently leading to delay the evidence for effect of spiking.

On the contrary, several researchers reported that spiking had no significant ($P > 0.05$) effect on egg fertility (Nazarpark and Fallah-Khair, 2011) and hatchability (Nazarpark and Fallah-Khair 2011; Chung et al., 2012). Fertility decline is not a problem being solely with males/roosters; hens are also responsible for the fertility decline (Bramwell et al., 1996; Chotesangasa, 2001).

Egg fertility and hatchability decreased with increasing flock age and this is often associated with reduced mating frequency (Ottinger et al., 1983; Demmining and van Middelkoop 1999; Joseph and Moran, 2005), lower sperm mobility and reduced sperm penetration into the egg in aging broiler breeders (Fasenko et al., 2009). The decline in egg fertility and hatchability with increasing broiler was expected and consistent with common observations in the poultry industry (Sexton et al., 1989; McGary et al., 2002). Older hens experienced lower fertility levels (Bramwell et al., 1996; Wishart et al., 2004; Sarabia et al., 2013; Ordas et al., 2015) and hatchability (Joseph and Moran, 2005; Ordas et al., 2015) than younger hens. However, on contrary, fertility and hatchability were not affected ($P > 0.05$) by the flock age (Hocking and Bernard, 2000). As the male ages, there is a reduction in the number of spermatozoa in the ejaculate and also a reduction in semen volume (Casanova, 2002). Decrease in fertility was observed starting at 45 WOA (Wishart et al., 2004; Sarabia et al., 2013), 41 and 50 WOA (Ordas et al., 2015), 48 and 50 WOA (Kirk et al., 1980; Hocking, 1990). The lack of consistency between results could be due to age and strain interactions (Hocking and Bernard, 1997) or age and diet interactions (Peebles et al., 2000).

The double intra-spiking has a significant ($P < 0.05$) effect on male mortality. The average mortality was significantly ($P < 0.05$) lower in the 45% double intra-spiking treatment than in the other treatments from week 45 to 55. The difference in the male mortality observed in the present study depicts that the double intra-spike had impeded the established pecking order within the chicken flocks and, therefore, new pecking order had to be established (Guhl, 1968). The results of the present study depict that 45% double intra-spike slowed down the male mortality. On contrary, Casanova (2002) reported that intra-spiking has no significant ($P > 0.05$) effect on the birds mortality.

CONCLUSION

High level of male competition (45% intra-spiking) showed great promise as a tool to slow down the decrease in egg fertility and hatchability, and reduce male mortality in aging broiler breeder flocks. There are less biosecurity risks associated with the intra-spiking practice and no cost involved as there are no extra males required.

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