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EFFECT OF STOCKING DENSITY ON DEVIATION FROM BILATERAL SYMMETRY AND SLAUGHTER WEIGHT IN BROILERS

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ABSTRACT

The main objective of this study was to investigate the effect of two different stocking densities (11 birds / m^2 and 17 birds / m^2) on deviation from bilateral symmetry in broiler chickens. For this purpose, the weekly body weight, left and right shank length, shank width, wing length, face width and face length of the same birds were measured on from 7^{th} to 42^{nd} days of age. Repeated measurements analysis of variance was used to investigate the effect of stocking densities and ages (week) on relative asymmetry. Binary logistic regression analysis was used to determine the most important morphological character influencing the deviation from ideal slaughter weight of 1800 g. The overall relative asymmetry mean for shank width was significantly greater in control group (2.42±0.41) than in treatment group (1.87±0.43). The results of binary logistic regression analysis showed that only increase in difference of width in left and right shank caused significant change (p=0.0148) in slaughter weight. In this study, the deviation from the bilateral symmetry was mostly found in fluctuating asymmetry for the measured characters in treatment group (11 birds per m^2), and the low fluctuating asymmetry level was generally indicated higher welfare level and lower developmental instability for this group than that of the control group (17 birds per m^2). Stocking density can be stated as one of the most important environmental factors which may influence developmental stability, welfare and performance of broilers.

Key words: Stocking density and bilateral symmetry, logistic regression, morphological traits.

INTRODUCTION

In the healthy animals grown under appropriate environmental conditions, not stressed and living in a good welfare level, deviation from bilateral symmetry is expected to be small. However, deviations from bilateral symmetry due to genetic structure, selection for yield, breeding systems applied, and some other environmental factors may be so large that could not be attributed to chance (Clarke *et al*., 1986; Parsons, 1992; Campo *et al*., 2005). As deviations from bilateral symmetry increased, some abnormalities of developmental stability may appear on animals (Moller and Pomiankowski, 1993; Moller and Swaddle, 1997; Moller *et al*., 1999; Moller and Manning, 2003). This may cause negative changes in the performances of animals and thereby economic losses.

Deviations from bilateral symmetry are tried to be detected generally by taking measurements on some morphological characters such as right and left shank lengths, shank widths, wing lengths, face widths and lengths in broilers (Campo *et al*., 2000; Moller and Manning, 2003; Yalçın *et al*., 2003; Campo *et al*., 2007; Mendeş, 2008). Detecting of important characters which have significant effect on developmental instability is an important issue. Many studies have been carried out related to this topic (Yang *et al*., 1998; Nestor *et al*., 2000; Yalçın *et al*., 2003). However, there is a deficiency in these studies, namely on the effects of the deviation from bilateral symmetry on body weight changes, and of which detected morphological characters may be an important risk factor on emerging developmental instability. The magnitude of deviation from bilateral symmetry is mostly affected by breeding conditions. Lighting and stocking density are the important environmental factors affecting bilateral symmetry and thereby developmental stability (Moller *et al*., 1999; Moller and Manning, 2003). Unsuitability of these factors causes stress on the animals, moreover, animal welfare is negatively affected and results a developmental instability. This lack of stability in development, in turn, results low performance, higher susceptibility for diseases, and increased mortality for animals (Moller and Manning, 2003; Yalçın *et al*., 2003).

In this study, some important asymmetry measures (directional asymmetry (DA), fluctuating asymmetry (FA), anti-asymmetry (AS), and relative asymmetry (RA) in five characters namely, right and left shank lengths, shank widths, face widths and face lengths. Then, the relations between these symmetry measures and body weights were investigated.

MATERIALS AND METHODS

Experimental birds and morphological traits: This study was conducted on 56 male broilers by dividing them into two groups: group 1 (control) and group 2 (treatment). The birds in groups 1 and 2 were raised under 17 birds / m^2 (n_1=34) and 11 birds / m^2 (n_2=22) stocking density, respectively. Nipple drinkers and round feeders were used. Water and feed were provided *ad libitum* with 23 h light and 1 h darkness throughout the experimental trial. The birds were fed starter diet between 0-3 weeks and then grower diet between 4-5 weeks and finally finisher diet in the last week of the trial. The starter, grower and finisher diets contained 24.09, 25.32 and 22.38 percent crude protein and 2818, 2892 and 2912 kcal/ME, respectively. The weekly body weight (BW, g), left and right shank length (SHL, mm), shank width (SHW, mm), wing length (WL, mm), face width (FW, mm) and face length (FL, mm) of the same birds from each group were weekly measured from 7^{th} to 42^{th} days of age using a digital caliper. Directional asymmetry (DA, mean with non-zero normal distribution), fluctuating asymmetry (FA, $|L - R| \cong N(0, \sigma^2)$), anti-asymmetry (AS, with zero mean non-normal distribution) and relative asymmetry (RA, the ratio of the absolute value of left-right differences divided to by the value for the size of the trait) were used as measures for studying deviation from bilateral symmetry. RA was computed as: $RA = (|L - R| / ((L + R) / 2))100$ (Van Valen, 1962; Palmer, 1996; Yang and Siegel, 1998; Yalçın *et al*., 2003). Optimum slaughter weight for commercial broiler ranged between 1800-2200 g (Şenköylü, 2001), therefore the birds were divided into two groups of slaughter weights above and under 1800 g no grouping.

Statistical Analysis: Shapiro-Wilk test was used to test for normality (Winer *et al*., 1991; Mendeş and Pala, 2003). The effect of stocking densities, ages and interaction between them on relative asymmetry (RA) were tested by repeated measurement analysis of variance (Zar, 1999). In order to determine the most important morphological character that affecting deviation from the ideal slaughter weight (1800g), a binary logistic regression analysis was performed (Sharma, 1996).

RESULTS

Results of asymmetry measures: As seen in table 1, type of asymmetry measures varied based on both groups and characteristics. Two asymmetry types (AS and FA) were observed for shank length, wing length, face width and face length of control group while all three types (AS, DA and FA) of asymmetry were observed for shank width. The FA and AS asymmetry measures were observed for shank length of treatment group. On the other hand, the FA and DA observed for shank width while the FA and AS were observed for shank length, wing length, face width and face length

Results of repeated measurement for relative asymmetry (RA): There were no statistically significant differences for the calculated RA values of the shank length between the groups and ages (p>0.243). The calculated RA values for shank width were also not significant for age groups (p=0.119), whereas, the overall mean RA values (2.42±0.41) of the control group (17 birds/m^2) was observed to be higher (1.87±0.43) than that of the treatment group (11 birds/m^2) (P=0.043). The mean RA of the group consisting of more birds in m^2 is higher than that of the group consisting lesser birds in per m^2.

It was observed that the differences in RA values calculated for the wing and face length of birds in control and treatment groups changed with respect to the age (group x age interaction effect; p=0.001). For the wing length in the control and treatment groups, some differences between 2^{nd} and 5^{th} weeks were observed (Fig. 3). Difference in the face length, on the other hand, was mostly noticed between 3^{th} and 5^{th} weeks (Fig. 5). The calculated RA values for face width values differed only by age (weeks) (p=0.000) and the differences were more obvious after 2^{nd} week (Fig. 4).

The overall relative asymmetry (RA) mean for shank width was significantly larger for control group than that of the treatment group. On the other hand, RA for shank length, wing length, face width and face length were found to be similar for both groups (p>0.05). Therefore, the character yielding the largest deviation from the bilateral symmetry was shank width. The observation of the higher RA values of the shank width in control group than that of the treatment group also indicated that the control birds had higher asymmetry for the shank width character, which shows that more birds per m^2 caused larger differences in the shank width of the left and right sides of the birds.

When the L-R differences were taken into consideration, it was obvious that the right shank width was larger than the left shank width for both groups. However, this difference was higher for control group than that of the treatment group. Therefore, it can be stated that feeding more birds per m^2 can create larger differences for the left and right shank width values.

There was significant difference between two groups (stocking densities) for the mean of shank length, wing length and face length (p<0.05) when overall evaluation was made (Table 2). While the shank and face lengths of the control group were significantly longer than those of the treatment group (p<0.05), the wing lengths of the control group were significantly shorter than that of the treatment group (p<0.01). The shank and face widths of control and treatment groups were found to be similar (p>0.05) (Figures 1-5).

Table 1. Mean ± SE for measures of deviation of bilateral symmetry of various morphological traits by groups and ages.

Ages		shank length	shank width	wing length	face width	face length
1	RA	3.05±0.76	4.27±0.86	1.66±0.22	3.87±0.34	1.98±0.27
		2.85±0.27	**3.17±0.41**	**1.93±0.12**	**2.91±0.47**	**1.09±0.18**
	|L-R|	AS (**FA**)	AS (**FA**)	FA (**FA**)	AS (**FA**)	FA (**AS**)
2	RA	1.27±0.23	1.96±0.22	0.72±0.13	1.79±0.30	1.07±0.16
		1.17±0.31	**1.44±0.67**	**0.75±0.14**	**0.86±0.12**	**0.92±0.11**
	|L-R|	AS (FA)	FA (**FA**)	AS (**FA**)	FA (**FA**)	FA (**FA**)
3	RA	1.56±0.26	1.78±0.27	0.71±0.16	1.63±0.21	1.23±0.19
		1.91±0.43	**1.88±0.29**	**1.10±0.18**	**2.34±0.33**	**1.09±0.15**
	|L-R|	FA (**FA**)	DA (**FA**)	AS **(FA**)	FA (**AS**)	FA (**FA**)
4	RA	2.05±0.29	2.90±0.41	1.88±0.55	2.78±1.39	1.79±0.31
		3.41±1.52	**1.54±0.33**	**1.42±0.36**	**0.69±0.16**	**0.23±0.08**
	|L-R|	FA (**AS**)	DA (**DA**)	AS (**FA**)	AS (**AS**)	FA (**FA**)
5	RA	1.92±0.34	1.89±0.19	1.35±0.20	0.94±0.18	1.31±0.26
		2.26±0.40	**1.86±0.33**	**1.09±0.19**	**1.11±0.21**	**0.69±0.23**
	|L-R|	AS (**FA**)	DA (**DA**)	AS (**AS**)	AS (**AS**)	AS (**FA**)
6	RA	2.00±0.43	1.67±0.31	0.27±0.07	0.71±0.14	0.26±0.10
		1.39±0.27	**1.33±0.52**	**0.25±0.05**	**1.72±0.79**	**0.17±0.07**
	|L-R|	AS (**FA**)	FA (**FA**)	AS (**AS**)	AS (**AS**)	AS (**FA**)
overall	RA	1.98±0.39 a	2.42±0.41 a	1.10±0.22 a	1.95±0.43 a	1.27±0.22 a
		(2.17±0.55) a	**(1.87±0.43) b**	**(1.09±0.17) a**	**(1.61±0.35) a**	(**0.90±0.14) a**

Bolds represent treatment group

Table 2. Mean ± SE Mean for the morphological characters by groups ((L+R)/2).

	shank length	shank width	wing length	face width	face length
(R+L) / 2	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
Control	37.51±0.68 a	15.83±0.44 a	80.86±3.81 b	27.33±0.42 a	50.81±0.66 a
Treatment	34.56±0.59 b	15.04±0.48 a	101.01±3.71 a	25.93±0.42 a	48.64±0.66 b

Table3. Binary logistic regression analysis.

Predictor	Coefficient	SE coefficient	Z	P	Odds ratio
Constant	-1.1615	0.3837	-3.03	0.0025	
Shank length	-0.0838	0.1288	-0.65	0.5152	0.92
Shank width	0.2525	0.1087	2.32	0.0148	1.28
Wing length	-1.1922	0.9489	-1.25	0.3805	0.30
Face width	-0.1499	0.2517	-0.60	0.5515	0.53
Face length	0.1571	0.8000	0.20	0.8443	0.24

The results reveals that the increases in differences between left and right shank width caused significant changes in slaughter weight (p=0.0148) (Table 3). The odd ratio also indicate that the relative asymmetry (RA) values of the slaughter weight of birds below 1800 g was 1.28 times higher than that of the birds slaughter weight above 1800 g.

DISCUSSION

The endeavor to gain more economical benefits for the birds as for the other farm animal species for economical reasons has yielded some problems as well. Most of these problems are diseases, lower resistance, and increase in death rates, lower performance, and deformations in skeletal system and abnormalities in developmental stability. Higher levels of developmental instability cannot be expected in healthy animals with lower stress and higher welfare leading to better performance in these animals. The quality evaluation of the living conditions of animals is important. For these reasons, especially in recent years, some asymmetry measures like FA, DA and AS are measured for some morphological characters of the animals (Campo *et al*., 2000; Yalçın *et al*., 2003). Palmer and Strobeck (1992) reported that fluctuating asymmetry (FA) was the most suggested measure or index of developmental instability.

Since very low level of fluctuating asymmetry (FA) is an indicator of small deviation of the most of the birds in the group from perfect symmetry or lack of asymmetry in the birds (Moller and Manning, 2003).

In this study, the FA is generally observed for all characteristics of both groups. The FA level for treatment group (11 birds/m^2) is generally lower than that of the control group (17 birds/m^2) indicates that there is not significant level of asymmetry in treatment group or there are small deviations from the perfect symmetry for this group. Hence, high stocking density can cause higher differences in the right and left sides of morphological characters, and this case is more obvious especially in shank width. Moller *et al*., (1995) observed a positive correlation between stocking density and FA and it was concluded that levels of FA may be accepted as a measurement of animal welfare status. Moller and Manning (2003) have also indicated that animals kept under high stocking density had enhanced FA and lower growth rate. Similarly, Poucke *et al*., (2007) reported higher FA in animals maintained under stocking density.

Results of this study showed that the deviations from bilateral symmetry were mostly in FA type for the measured morphological characters of the treatment group of 11 birds per m^2, and the FA level was generally low that indicate higher welfare level and lower developmental instability for these animals than that of the control group of 17 birds perm^2. It can be stated that stocking density may be claimed as an important environmental factor affecting developmental stability, animal welfare and performance. Numerous studies have indicated similar findings (Sanotra, 1999; Campo *et al*., 2000; Poucke *et al*., 2007).

On the other hand, it should be kept in mind that more general predictions can be done by only one observation of asymmetrical character. The developmental instability is dependent on many different factors (Gangestad and Thornhill, 1999). The RA value of the shank width of the birds whose weighing are less than 1800 g at slaughter was found to be 1.28 times of those birds weighing more than 1800 g. This is an indicator of the negative reflection of the increase of the asymmetry on shank width. In other words, the increase in difference between right and left shank width displays as an important risk factor for the birds whose weighs are less than 1800 g. It can be discussed that weighing more or less than 1800 g which is the optimal slaughter weight as commonly accepted, may be affected by the possible deviations which occur in shank width. On the contrary, in the present study it was observed 38.2 % of the control group (13 birds), and 22.7 % of the treatment group (5 birds) were less than 1800 grams. It was further noted that increase in the stocking density increased the deviation from bilateral symmetry; and this has affected the slaughter weight in a negative way. In other words, most of the birds maintained under a high density would not reach the optimum slaughter weight (1800 g). The animals with low FA are expected to have better performance. Manning and Ockenden (1994) showed that in race horses, a good level of symmetry between front leg and head is associated with a higher performance. As known, the most important performance measure in broilers is body weight. In the birds possessing a low level of deviation from bilateral symmetry, developmental instability is rare, and the body weight in slaughter age is expected to be high. Thus, there was a statistically significant difference between the slaughter weight mean of control group (2011,9 g) and treatment group (2275,1 g) (p=0.034). These results suggest that the changes in FA level may affect developmental stability.

Based on the findings of the present study it can be stated that (a) increasing the bird number per m^2 can exert a significant level of stress which may affect shank width (b) increasing the bird number per m^2 may cause serious developmental instability in birds and this may reflect the bird performance (c) among the detected five morphological characters, only shank width may be one of the most important risk factors affecting growth performance of broilers.

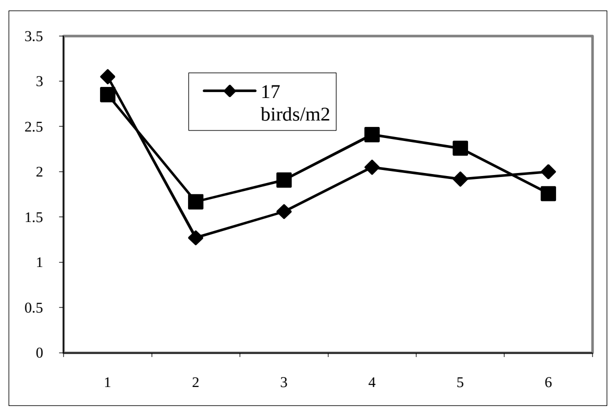

Figure 1. Weekly RA changes in shank length by groups

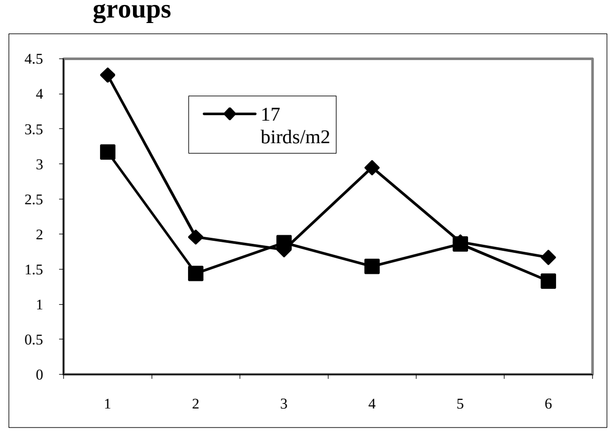

Figure 2. Weekly RA changes in shank width by groups

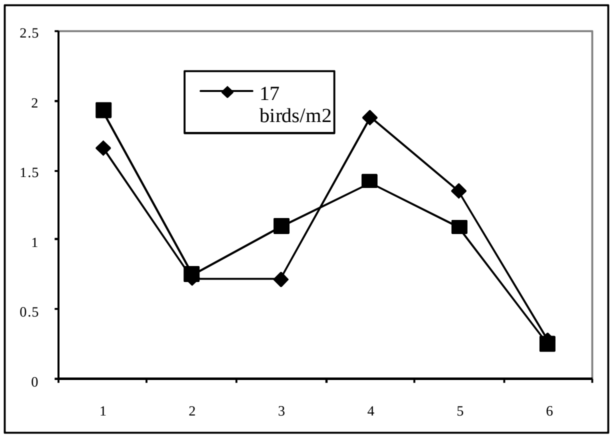

Figure 3. Weekly RA changes in wing length by groups

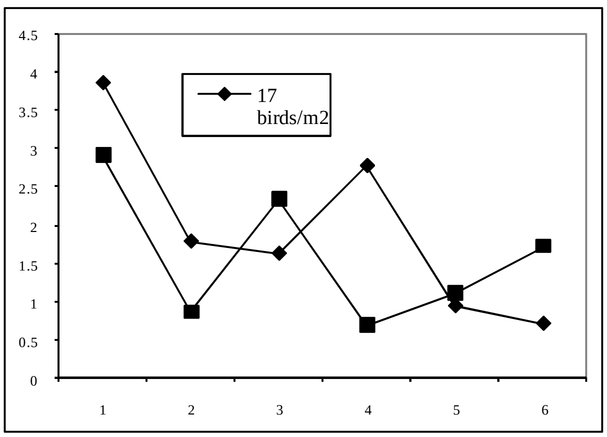

Figure 4. Weekly RA changes in face width by groups

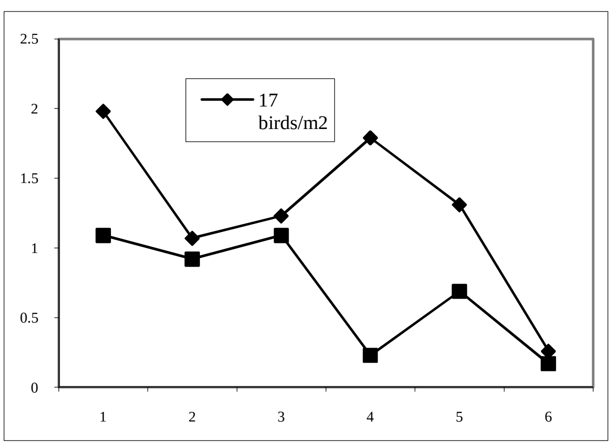

Figure 5. Weekly RA changes in face length by groups

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