ADDITIVE AND NON-ADDITIVE GENE EFFECTS ON LINEAR BODY TRAITS OF LOCAL TURKEYS REARED IN THE HUMID TROPICS OF NIGERIA

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ABSTRACT
Research reports on genetic evaluation of growth traits, general and specific combining ability effects in domestic turkeys are rare; hence the need for this study. Breeding programmes involve crossbreeding of various strains of turkey to improve the already existing breeds and to estimate specific and general combining abilities in the domestic turkey. General Combinig Ability (GCA) and Specific Combining Ability (SCA) were used to determine the influence of additive and non-additive genes effects on linear body traits, using a total of 215 1-day-old poults of three strains of local turkey crossbred in the humid tropics. A full diallel crossing experiment was conducted using three phenotypes of indigenous turkeys with the plumage colour: black, white and lavender (spotted). Randomized complete block design (RCBD) was also used to analyze the data with phenotypic class as a major factor and batch as block. Parameters measured includes: Body weight (BWT), Body length (BDL), Shank length (SL), Keel length (KL), Wing length (WL), Breast width (BW), Drumstick length (DL), Neck Length (NL). Data obtained were subjected to analysis of variance (ANOVA). The result obtained in the showed that GCA was significant for BL, WL, DS and SL and non-significant for BW, BRW, KL and NL with values ranging from – 0.34 to 0.640, respectively. SCA was also significant for BL, BW, BRW, KL and SL but non-significant for WL, DS and NL ranging from 2.981 to 8.324. It was concluded that the significance (P<0.05) differences observed for most LBMs and BW in different ages (weeks) for GCA and SCA indicates that non-additive effects of genes could be improved genetically through selection and crossbreeding of BxS, BxW and WxS genotypes to bring about genetic improvement for BW and LBMs and by improving the environment. The additive gene action governs BL, WL, DS and SL and not for the other traits which may be governed by genes with non-additive effect.

Keywords: Additive and non-additive genes, linear body traits, turkey

INTRODUCTION

Genetic gains could be due to improvement within the primary breeding lines (additive genetic variation) or exploited through heterosis (non-additive genetic variation) in the crosses used to produce the commercial turkeys. Several studies have showed increase in body weight (McCartney *et al.,* 1968; Nestor, 1977, 1984; Nestor *et al*., 1996), breast width (Nestor *et al*., 1969) and shank length (Nestor *et al*., 1985) due to genetic selection within lines of several strains. Genes could impart additive and non-additive effects on traits. While additive gene action is transmissible from parents to their offspring, non-additive gene action (dominance and epistasis) is not. Consequently, the proportion of total phenotypic variance that is additive is used as measure of heritability (Obasi and Ibe, 2008).

Genetic progress can be attained by selection and crossbreeding (Adebambo *et al*., 2011). Crossbreeding could lead to the production of birds. The test for good combining abilities is developed by generating a diallel cross, which is a set of possible combinations between several genotypes and general populations and analysis of data from such crosses (Hayman, 1954). The combining ability analyses help to identify the desirable combiners that may be utilized to exploit heterosis (Saadey *et al*., 2008). Gardner and Eberhardt (1966) defined general combining ability (GCA) as an average performance of a line in different hybrid combinations. Lin (1972) also defined GCA as a numerical value expressing the influence of one of the lines on its progeny. The estimates of general combining ability (GCA) reflect the importance of additive gene effects of breeds on body weight at different ages (Afifi *et al*., 2002). The general combining abilities (GCA) is defined as the average performance of a line (strain, breed or genotype) in hybrid combination with other lines (Gardner and Eberhardt, 1966).

The variation in GCA is owing to additive genetic variance. Specific combining ability (SCA) refers to a cross produced by a pair of lines (Adebambo *et al*., 2011). Exploitation of heterosis is a major reason for crossbreeding in farm animals (Ibe *et al*., 2005). Utilization of this phenomenon has led to the development of high quality breeds of livestock in both poultry and other farm animals. Usually characters that suffered reduction in inbred status are often restored or tend to be restored on crossing (Falconer, 1981). Commercial turkey breeders have made major improvements in growth traits of the modern turkey (Havenstein *et al*., 2004).

MATERIALS AND METHODS

Location of Study

The study was conducted in the Poultry Unit of Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State. Umudike lies between latitude 05° 29^1 N, longitude 07° 33^1 E and altitude of 122 m above sea level. The town is within the humid rain forest zone of South Eastern Nigeria and has a bimodal rainfall pattern with a total annual rainfall range of 1700 mm to 2100 mm. The minimum and maximum daily temperatures of the area ranges from 18.6^0 to 23^{0}C and from 26^0 to 36^{0}C during the rainy and dry seasons, respectively while the humidity range from 57.0% to 91.0% depending on the season of the year. The climatic data were taken from the meteorological station of the National Root Crops Research Institute, Umudike.

Mating Design

The mating design was as follows:

Pure crosses: Black male x Black female; White male x White female; Lavender male x Lavender female

Main (Direct) Crosses: Black Male x White female; Black male x Lavender female; White male x Lavender female;

Reciprocal Crosses: White male x Black female; Lavender male x Black females; Lavender male x White female;

Management of Experimental Birds

A total of 86 adult local turkeys of three phenotypic classes based on colour (Black, White and Lavender) were used as a parent population: 28 Black, 28 White and 30 Lavender phenotypes to generate the 251 F_1 poults for the study. They were brooded differently according to phenotypic group (Black, White and Lavender) from day-old to 6 weeks in a battery cage system after which they were transferred to deep litter pen at 6 weeks of age and reared till week 24. Dry wood shavings were used as litter material. Fresh clean water was given *ad libitum* to the poults during this period. Routine management operations were carried out on daily basis. Prophylactic antibiotics and anticoccidial drugs were administered to the birds every month for six months. The birds were also dewormed. Feeds were provided in adequate quantities to the poults twice daily (morning and evening) and drinking water *ad libitum*. Poults (0-6weeks) were fed starter mash containing 28% crude protein and 2800 kcal ME/kg (as labeled). Growing turkeys (7-20 weeks) were fed growers mash containing 20% crude protein and 3000 kcal ME/kg (as labeled). Laying hens (21-30 weeks) were fed layers mash containing 18% crude protein and 3200kcal ME/kg (as labeled) at 5% egg production. At 16 weeks of age, sexing was done and all the males were transferred to different pens for mating and crossing with other phenotypic groups. Massage method was used for collection of semen from the mature selected males at the farm during the mid-day hours of 12-1pm and inseminated artificially. Eggs produced by the base population turkey hens were collected on a daily basis and identified properly with markers, and incubated for 28 days in four (4) sets and hatched to generate the F1 progenies. The incubator had a relative humidity of 80%, temperature of 55^{0}C and proper ventilation.

Parameters Measured

Body weight (BWT), Body length (BDL), Shank length (SL), Keel length (KL), Wing length (WL), Breast width (BW), Drumstick length (DL) and Neck Length (NL). All parameters except BWT were measured weekly using a tailor's tape calibrated in cm while body measurement was measured with a sensitive table weighing scale.

Statistical Analysis

Randomized complete block (RCBD) with phenotypic class as factor of interest and batch as block

and data analyzed by analysis of variance (ANOVA) to test the null hypothesis that there were significant differences among the various phenotypic groups (the crosses) with respect to body weight and all the linear body measurements studied as given in expression (1).
The statistical model for analysis of variance is given as:

$$\mathbf{Y_{ijk} = \mu + H_i + P_j + e_{ijk}} \qquad \text{… (1)}$$

Where
Y_{ijk} = k^{th} observation in the i^{th} block and the j^{th} phenotypic class, i.e. single observation
μ = Overall mean
H_i = effect of the i^{th} batch (Block) (i = 1,…, 4)
P_j = effect of j^{th} phenotypic class (j = 1,…, 9)
e_{ijk} = Random error, assumed to be independently, identically and normally distributed with zero mean and constant variance [iind $(0,\sigma^2)$].
The method of Griffing (1956) was used to further examine the diallel cross using the statistical model of combining ability as described by Siewerdt and Dionello (1991). The general combining ability, specific combining ability and reciprocal effect was estimated using expression (2) as given by Obasi and Ibe (2008).

$$\mathbf{Y_{ijk} = \mu + g_i + g_j + s_{ij} + r_{ij} + 1/n \textstyle\sum e_{ijk}} \qquad \text{… (2)}$$

Where Y_{ij} = mean of ij^{th} cross between line i (as sire) and line j (as dam)
μ = overall mean
g_i/g_j = General Combing Ability (GCA) of the i^{th} / j^{th} breed
s_{ij} = Specific Combing Ability (SCA) of the ij^{th} combination
r_{ij} = Reciprocal Effect
e_{ij} = Error associated with k^{th} individual observation.
Expression (3) and (4) were used to estimate GCA and SCA, respectively.

$$\text{GCA, }_{i/j} = 1/2p\ (Y_i + Y_{.i}) - 1/p^2 Y \qquad \text{…… (3)}$$

$$\text{SCA, } s_{ij} = ½\ (Y_{ij} + Y_{ji}) – 1/2p\ (Y_{i.} + Y_{.i} + Y_{j.} + Y_{.j}) \qquad \text{…….(4)}$$

Where p = number of lines/breeds involved in the crosses.

RESULTS AND DISCUSSION

General Combining Ability

General combining ability (GCA) was significant (P<0.01) for BL, WL, DS and SL and non-significant (P>0.01) for BW, BRW, KL and NL with ranges from 0.111 to 24.218 respectively. This implies that additive gene action governs BL, WL, DS and SL and not for the other traits which may be governed by genes with non-additive effects. Hence, those characters governed by genes with additive effects are expected to respond to selection for their genetic improvement, since their heritability values are expected to be moderate to high GCA estimates were highest for drumstick length in white breed and significant in seven out of eight traits studied. White phenotypes were highest in one trait while lavender phenotypes (spotted) had the lowest estimates in all traits studied. This suggests that white breed has the highest preponderance of genes, which imparted additive effects on the growth traits. The indication is that white phenotype turkeys could possibly increase growth performance because of their higher GCA values. This result is similar to the early findings of Obasi and Ibe (2008) who reported significant GCA for body length, hearth girth, ear length and tail length in a full diallel cross involving three breeds of rabbits (New Zealand White, Dutch and Chinchilla. This result obtained in this study contradicts the works of Okoro *et al.* (2012) who reported non-significant GCA values for BWT, BRW, DS, SL, BL in full diallel crosses between three locally adapted parental turkey lines comprising of black, bronze and white plumage-coloured genotypes. McCartney and Chamberlin (1961) concluded that genetic variance was much more important than non-additive genetic variance for BWT and body conformations in turkeys using diallel crosses. Adebambo *et al.* (2011) reported best GCA values for BW from weeks 1 to 12 with Values ranging from 19.49±0.42 to 769.30±4.80 in a full diallel combination involving four breeds of chicken (Anak Titan, Alpha, Gririraja and normal indigenous chickens). Musa *et al.* (2015) reported a significant GCA, SCA and RE in a full diallel crosses involving 3 genotypes of Nigeria indigenous chickens: normal (N), frizzle (F) and naked neck (Na) with GCA values ranging from -0.03 to 8.88 from day old to week 20 indicating importance of additive gene effects on body weight.

Specific Combining Ability

The SCA estimates were significant (P<0.01) for BL, BW BRW, KL and SL but non-significant for NL, DS and NL. The significant SCA is an indication of non-additive gene action for these traits. The implication is that BW, BL, BRW, KL and SL can be improved genetically through appropriate crossing, utilizing non-additive gene effects like dominance and epistasis involving dominance. The highest and significant SCA values were observed in BW (-105.131) in WxS crosses followed by BL (-1.309) and WL (-1.106). SCA for WxS was highest for all the traits studied namely BW, BL, WL, BRW, DS, SL, KL and NL. This indicates that non-additive gene effects could be exploited to genetically improve the traits in BxS, WxS and BxW crosses since most of the traits showed significant SCA in all the crosses.

The result also suggests that BxS performed generally well in crosses with either White or Lavender (W or S). This findings is similar to the results of Okoro *et al*. (2012); and Obasi and Ibe (2008) who reported significant SCA values for BW and linear body traits in a full diallel crosses involving three turkey lines namely; black, bronze and white plumage colour genotypes and three breeds of rabbits namely; New Zealand White, Dutch and Chinchilla, respectively indicating importance of non-additive gene effects which could be exploited genetically to improve the body weight and linear body traits. Musa *et al.* (2015) also reported that FxNa (frizzle x naked neck) chickens gave significant SCA values for body weights in weeks 4 to 20. Similarly, Adembabo *et al.* (2011) reported SCA value for breast girth (BG) and Tibia length (TL) with values ranging from 7.43$\pm$0.11 to 0.86$\pm$0.30 in weeks 1 to 20.

Reciprocal effect

Reciprocal effect was significant only in BL, BRW and DS for BxW crosses. This significant estimate obtained for RE at week 20 of age implies that there was variation owing to sex-linked genes and maternal effect for the BxW crosses. Non-significant and negative RE values were observed for BxW, BxS and WxS cross on BW, BL, WL, BRW, DS, SL, KL and NL. This suggests that BxS and WxS may be used as sire and dam in planned crossbreeding programmes. The absence of significance RE indicates that there are no sex-linked or maternal effects exhibited by the BxS and WxS crosses. This result is in line with the findings of Okoro *et al.* (2012) who reported non-significant RE on BW and linear body traits in a full diallel experiment involving three lines of turkeys black, bronze and white plumage coloured genotypes. Ibe *et al.* (2005) reported no significant RE for BW and all LBMs in a full diallel experiment involving three breeds of rabbits. New Zealand White, Dutch and Chinchilla. However, Nestor *et al.* (2005) reported a significant RE for SL in male and female turkeys in a reciprocal cross of a commercial sire line and a line selected for long term increased 16 week body weight. Musa *et al.* (2015) reported significant effect of RE at hatch and 12 weeks of age in a full diallel experiment involving three genotypes of Nigeria indigenous chicken namely; normal, frizzle and naked-neck.

CONCLUSION

The study showed that there was significant General Combining Ability (GCA) for Body Length, Wing Length, Drum Stick and Shank Length and non-significant General Combining Ability (GCA) for Body Weight, Breast Weight, Keel Length and Naked Length. This implies that additive gene action governs these linear body traits which showed significant differences and not for the other traits which may be governed by genes with non-additive effect. Most of the linear body traits measured can be genetically improved through appropriate crossbreeding programmes. Consequently, improvement in the environment may also bring about improvement in the characters. The result also suggests that Black x Spotted breeds performed generally better in all crosses with eith er white or lavender breeds.

Table 1. Estimates of general combining ability, specific combining ability and reciprocal effects for growth traits of 3 Strains of Domestic Turkeys at week 20

Parameters	BW (g)	BL (cm)	WL (cm)	BRW (cm)	DS (cm)	SL (cm)	KL (cm)	NL (cm)
GCA_{Black}	24.218	0.312*	0.261*	0.238	0.155*	0.131*	0.112	0.140
GCA_{White}	24.188	0.312*	0.263**	0.237	0.158*	0.113*	0.112	0.140
$GCA_{Lavender}$	24.208	0.312*	0.264**	0.238	0.158*	0.114*	0.111	0.139
$SCA_{Black, White}$	-101.801*	-1.309**	-1.099	-0.997**	-0.654	-0.523	-0.467**	-0.555
$SCA_{Black, Lavender}$	-101.719*	-1.308**	-1.105	-0.997**	-0.661	-0.489	-0.468**	-0.584
$SCA_{White, Lavender}$	-105.131*	-1.309**	-1.106	-0.997**	-0.661	-0.488	-0.467**	-0.585
$RE_{Black, White}$	- 0.025	-0.455*	-1.015	-0.390*	-0.110*	-0.175	-0.020	-0.030
$RE_{Black, Lavender}$	- 0.030	-0.505	-1.030	-0.410	-0.120	-0.005	-0.040	-0.045
$RE_{White, Lavender}$	-0.027	-0.460	-0.015	-0.395	-0.020	-0.160	-1.820	-0.030

* = P<0.05 ** <0.01. GCA = general combining ability, SCA = specific combining ability, RE = reciprocal effects. BW= body weight, SL = shank length, NL = neck length, BRW = Breast width, BL = body length, KL = keel length, WL = wing length and DS = drumstick length

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