

INVESTIGATING LEVEL OF INBREEDING AND ITS EFFECTS ON PRODUCTIVE TRAITS FOR THREE GENERATIONS IN NAPRI X BROILER CHICKENS UNDER SELECTION

Abstract

Inbreeding refers to the mating together of individuals that are more closely related than would be the case if mating was at random. In this study, we investigate inbreeding and its effect on productive traits in NAPRI X broiler chickens. Traits measured were bodyweight and morphometric traits (Neck length, back length, keel length, breast length, thigh length and shank length). Pedigree information which consists of the base generation, 1060 (sire line) and 341 (dam line) birds; in generation 1, there were 565 (sire line selection), 859 (dam line selection), 433 (sire line control), and 592 (dam line control); and in generation 2, there were 595 (sire line selection), 764 (dam line selection), 457 (sire line control), and 654 (dam line control) were used to calculate inbreeding using J.M.P genomics software. The rate of inbreeding increased by 0.38% and ultimately approached 1.28% in 2014 for sire line selected. In dam line selected, it ranged from 0.41% to 1.06%. In the sire control line, the ranged from 0.58% to 1.27% while in the dam control line, the inbreeding ranged from 0.30% to 1.16%. Inbreeding significantly ($p < 0.05$) influenced bodyweight and morphometrics in a positive direction (0.020 -1.052) though some of the traits are tending to zero. The trend of inbreeding coefficient was quadratic with a range of 0.63-1.28/yr in SLS, 0.41-1.06/yr in DLS, 0.58-1.27/yr in SCL and 0.30-1.16/yr in DCL. It is therefore concluded that there is a gradual build-up of inbreeding in NAPRI X population thus, the use of mate allocation programs is hereby recommended to put a limit or constraint on the level of inbreeding for the future progeny of NAPRI X broiler chickens.

INTRODUCTION

The mating of people who share a common ancestor is known as inbreeding. The inbreeding coefficient (F) is defined as the likelihood that two alleles at any given locus in an individual are identical-by-descent (IBD) and hence descended from a common ancestor (Wright, 1922). Inbreeding leads to a rise in homozygosity, which indicates a loss of genetic variety, and can eventually lower the performance of economically significant traits. Inbreeding coefficients have traditionally been calculated using pedigree information (FPED), which evaluates parentage relationships (Meuwissen and Luo, 1992). Inbreeding also results in a decline in the mean phenotypic values of some traits, mainly including those related to fitness and physiological efficiency in normal outbreeding species, which is known as inbreeding depression (Niknafs *et al.*, 2013). In comparison to earlier studies, Niknafs *et al.* (2013) found a higher inbreeding coefficient in native chickens after 18 generations of selection, which could be due to the fact that the birds were part of a selection program. In commercial chicken populations, there are limited instances of inbreeding coefficients. Szwaczkowski *et al.* (2003) estimated very low levels of inbreeding in two lines of broiler and laying birds, while Muir *et al.* (2008) showed high levels of inbreeding likely due to the purebred nature of the populations studied. This method has limitations as it requires a complete and reliable pedigree, it is unable to accurately capture the Mendelian sampling that occurs during mating, and it assumes that founders are unrelated (Keller *et al.*, 2011). Consequently, inbreeding coefficients based on pedigree records (FPED) have been shown to underestimate the true level of inbreeding in an individual (Forutan *et al.*, 2018).

In a review by Leroy (2014), a meta-analysis was completed investigating inbreeding depression according to species and trait. Overall, the author observed a 0.14% decrease of the mean of a trait per 1% increase in inbreeding. Additionally, production traits were seen to be strongly affected by inbreeding depression, in comparison to other traits. The meta-analysis by Leroy (2014) concluded, however, that in livestock species, any kind of selected trait may be affected by inbreeding depression where the degree of the effect of inbreeding depression largely depends on the importance of dominance variance within the trait (Misztal *et al.*, 1997).

Inbreeding has been quantified using different methods in humans (McQuillan *et al.*, 2008; Verweij *et al.*, 2014), cattle (Mastrangelo *et al.*, 2016; Peripolli *et al.*, 2018; Makanjuola *et al.*, 2020), swine (Gomez-Raya *et al.*, 2015; Xu *et al.*, 2019), and sheep (Chitneedi *et al.*, 2017; Mastrangelo *et al.*, 2018), but limited research is available on the topic in poultry, especially in NAPRI broiler chickens undergoing genetic selection. Knowledge of inbreeding in NAPRI X broiler birds under selection will allow for more effective management and monitoring of economic traits and reduction in mortality of the birds so as to conserve the genetic resources. This will allow for the animal agriculture industry to continue to provide healthy products to consumers while meeting the rising food needs of the world's growing population in a sustainable manner. The goal of this research project was to investigate inbreeding using the pedigree methods to analyze the effect on the production traits. Within this goal, the specific objectives were to estimate yearly trend in inbreeding coefficient in sire and dam lines of NAPRI X broiler birds under genetic selection and evaluate the effect of inbreeding depression on body weight and body linear measurements traits in sire and dam lines of NAPRI X broiler birds.

MATERIALS AND METHODS

Location of the Study

The research was conducted at the Poultry Breeding Unit of Poultry Research Programme of the National Animal Production Research Institute (NAPRI) Shika, Zaria. Shika is located in the semi-arid, Northern Guinea savanna zone of Nigeria within latitude 11°8'N and 07°4'E with an elevation of 2178 feet (663.77 metres) above sea level (Ovimaps, 2014).

Description of the original stock

A total of 2,800 day old grandparent broiler chicks were imported between the years 2006 to 2008. They belonged to two strains of meat type chickens {Anak (A) and Hubbard (B)}. Both sire-line and dam-line were present within each strain. The two strains were all white in colour. For the formation of F₁ generation, the parental strains were crossed according to the monoallelic system. For this purpose mating was arranged among the surviving 831 and 742 hens of dam-line and sire-line respectively and their matching 242 and 371 cockerels to produce the F₁ generation chicks of four different genotypes each in both sire-line and dam-line.

This base population was divided into two selection lines and two control lines as follows:-

- Population I - Line selected for bodyweight male line (Sire line)
- Population II - Line selected for bodyweight female line (Dam line)
- Population III - Control line reproduced by random mating (Sire line)
- Population IV - Control line reproduced by random mating (Dam line).

Sub lines Formation and Selection Method

From the original stock, two sub-lines were developed in the following ways: The individuals in the base generation (G₀) with high 8-weeks body weight in the two lines formed the parental

stock for the two lines. Thereafter both lines were maintained separately and the selection was practiced within each line in subsequent generations following the criteria of selection described above.

A total of 1200 hens and 1000 cockerels were pedigree hatched for each line (sire line and dam line). Chicks were wing-banded at day old, brooded and reared to point of lay. A total of 1060 (sire line) and 341 birds (dam line) had complete records at the end of 8 weeks. At the end of rearing, a total of 10 cockerels and 60 hens were picked at random to constitute the control population, while 20 cockerels and 120 hens with the highest body weights were selected based on their corrected eight week body weights for each line. The birds were mated in the ratio of 1 cockerel to 6 hens to produce eggs which were hatched for generation 1. A total of 565 (sire line selection), 859 (dam line selection), 433 (sire line control) and 592 (dam line control) had complete records at the end of 8 weeks. Breeding and selection were similar to the base generation. A total of 595 (sire line selection), 764 (dam line selection), 457 (sire line control) and 654 (dam line control) had complete records at the end of 8 weeks. Breeding and selection were similar to the base generation and generation 1. A total of 585 (sire line selection), 551 (dam line selection), 461 (sire line control) and 529 (dam line control) had complete records at the end of 8 weeks. Breeding and selection were similar to the base generation, generations 1 and 2.

Bird Management

The deep litter system of management was used to rear the birds from day old to 8 weeks of age. The birds were brooded with the aid of electric bulbs, coal pots and kerosene stoves. A starter ration containing 23% crude protein (CP) and 2800kcal ME/kg was fed *ad libitum* during the

first four weeks. Thereafter, the feed was changed to broiler finisher containing 20% CP and 3000kcal ME/kg for the next four weeks of the study.

Data Collection

Live body weight

The weight of individual birds was taken first at day old using a digital weighing scale measuring to the nearest one gram and thereafter bi-weekly until 8 weeks of age.

Morphometric trait measurements

Morphometric trait measurements were taken at 8 weeks of age, using a measuring tape in centimeters.

The neck length, which was measured in centimeters, was taken on the live birds, using a tape rule. The neck being somewhat arched was straightened out with the hand and measurements were taken. The measurement covered the entire length of the straightened axial skeleton, which included the first neck bone after the skull and the last cervical vertebra at the shoulder point.

The back length was measured in centimeters from the base of the neck to the uropygial gland at the base of the tail. The measurement included the cape and saddle parts of the bird.

The shank (Tarso-Metatarsus) length was measured in centimeters using a tape-rule from the lower thigh joint to the base of the three toes.

The keel length was measured in centimeters from the anterior end to the posterior end of the keel, using a tape rule.

The thigh length was measured with a tape rule in centimeters from upper thigh joint to the lower thigh joint.

Results and discussion

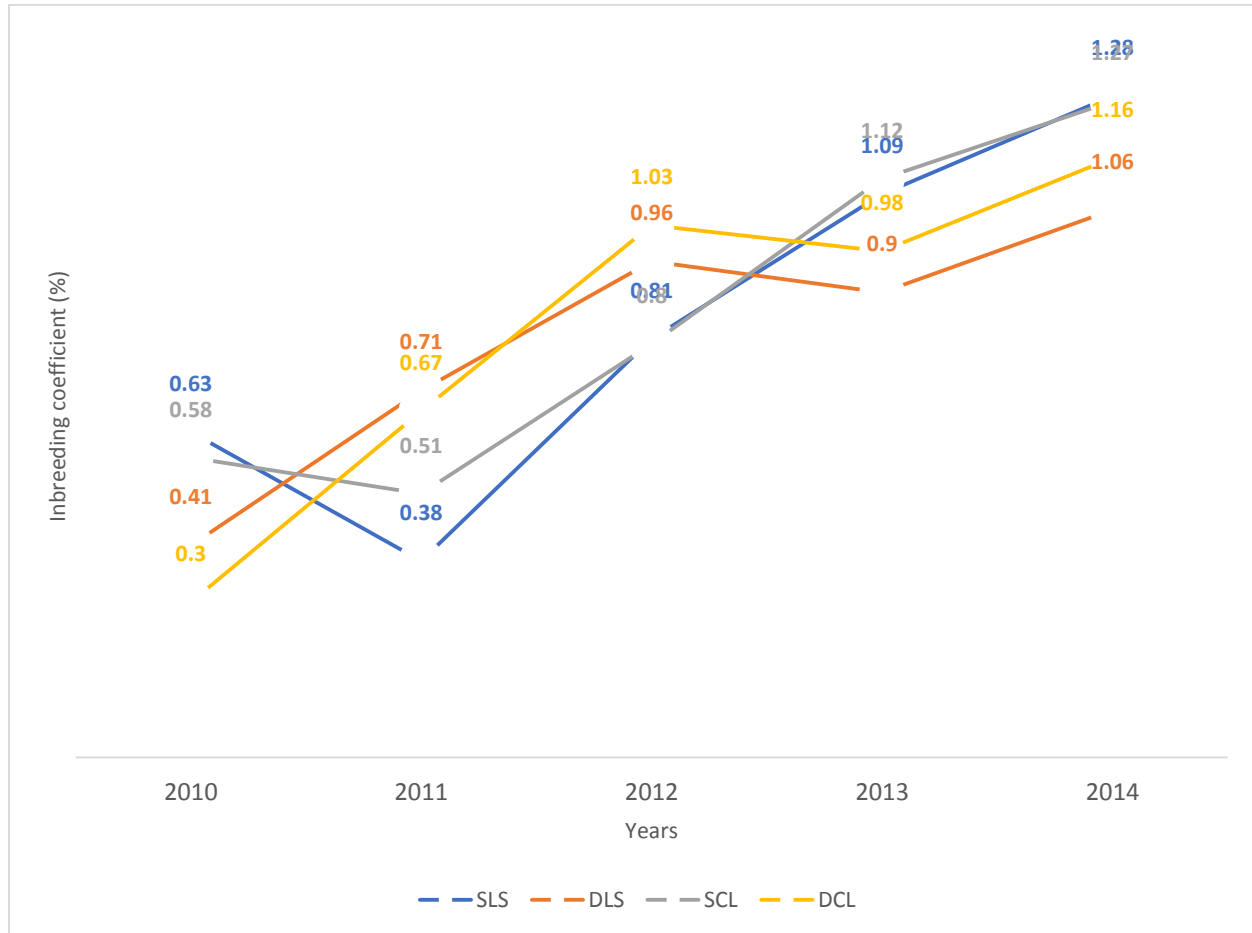


Figure 1. Average inbreeding coefficient within year of birth for sire and dam line selected and dam line in the pedigree of the reference population. SLS-Sire line selected; DLS-Dam line selected; CSL-Control sire line and CDL-Control dam line.

Average inbreeding coefficients by year of birth of all animals born between 2010 through 2014 are shown in Figure 1. The rate of inbreeding increased from 0.38% to 1.28% in 2014 for sire line selected. In dam line selected, it was 0.41% and increased to 1.06%. In the sire control line, the increased from 0.58% to 1.27% while in the dam control line, the inbreeding increased from 0.30% to 1.16%. These discrepancies are because of the use of a few proven cocks in the breeding program and may indicate the lack of an ongoing mating strategy to control inbreeding.

Estimates of inbreeding depression for bodyweight and body linear measurement in sire line selected of NAPRI X broiler birds are presented in Table 1. Inbreeding significantly increased ($P < 0.01$) bodyweight by 0.085g, neck length by 0.378cm, back length by 0.038cm, keel length by 0.358cm, breast length by 0.437cm and shank length by 1.052 with the exception of thigh length for each 1% increase in inbreeding.

Table 2 shows the estimates of inbreeding depression for bodyweight and body linear measurement in dam line selected of NAPRI X broiler birds. With the exception of breast length, inbreeding significantly ($P < 0.05$) influenced bodyweight by 0.517g, neck length by 0.330cm, back length by 0.051cm, keel length by 0.254cm, thigh length by 0.031cm, breast length by 0.019cm and shank length by 0.096cm.

Table 3 show the estimates of inbreeding depression for 1% increase of inbreeding and their corresponding P -value for production traits in random control sire line. With the exception of neck length, keel length and breast length, inbreeding significantly ($P < 0.05$) influenced bodyweight by 0.501g, back length by 0.092cm, thigh length by 0.107cm and shank length by 0.144cm.

Estimates of inbreeding depression for bodyweight and body linear measurement in randombred control dam line in NAPRI X broiler birds are presented in Table 4. Inbreeding significantly increased ($P < 0.01$) bodyweight by 0.729g, neck length by 0.062cm, keel length by 0.072cm, breast length by 0.107cm, thigh length by 0.104cm and shank length by 0.074cm for each 1% increase in inbreeding.

Table 1: Estimates of [inbreeding depression](#) for 1% increase of inbreeding and their corresponding P -value for production traits in sire line selected

Traits	Inbreeding depression	Wald p value
Bodyweight (g)	0.085	0.0002*
Neck length (cm)	0.378	<.0001*
Back length (cm)	0.038	0.0108*
Keel length (cm)	0.358	<.0001*
Thigh length (cm)	0.020	0.0663
Breast length (cm)	0.437	<.0001*
Shank length (cm)	1.052	<.0001*

Table 2: Estimates of [inbreeding depression](#) for 1% increase of inbreeding and their corresponding P -value for production traits in dam line selected

Traits	Inbreeding depression	Wald p value
Bodyweight (g)	0.517	<.0001*
Neck length (cm)	0.330	<.0001*
Back length (cm)	0.051	0.0014*
Keel length (cm)	0.254	<.0001*
Thigh length (cm)	0.031	0.0015*
Breast length (cm)	0.019	0.0709
Shank length (cm)	0.096	<.0001*

Table 3: Estimates of [inbreeding depression](#) for 1% increase of inbreeding and their corresponding P -value for production traits in control sire line

Traits	Inbreeding depression	Wald p value
Bodyweight (g)	0.501	0.0009*
Neck length (cm)	0.036	0.1035
Back length (cm)	0.092	0.0158*
Keel length (cm)	0.030	0.1140
Thigh length (cm)	0.107	0.0098*

Breast length (cm)	0.039	0.0778
Shank length (cm)	0.144	0.0081*

Table 4: Estimates of [inbreeding depression](#) for 1% increase of inbreeding and their corresponding *P*-value for production traits in control dam line

Traits	Inbreeding depression	Wald p value
Bodyweight (g)	0.729	0.0003*
Neck length (cm)	0.062	0.0157*
Back length (cm)	0.009	0.3642
Keel length (cm)	0.072	0.0106*
Thigh length (cm)	0.140	0.0026*
Breast length (cm)	0.107	0.0042*
Shank length (cm)	0.074	0.0113*

The significant, positive and small increase in inbreeding may be attributed to the high probability of controlled matings among relative NAPRI X broiler chickens. Overall, estimates of inbreeding depression obtained from the present study were consistent with the results reported in the literature. The effect of inbreeding was positive for all production traits. This is an indication that inbreeding has not shown depression on the production traits. The low inbreeding coefficient in this study was in contrast with the report of Niknafs *et al.*, (2013) who reported a greater inbreeding coefficient in native chickens, after 18 generations of selection, compared to other studies, which may relate to the fact that the birds were involved in a selection program. The variations might be link to the fact that selection was concluded in the 3rd generations in this study. Likewise, few accounts of inbreeding coefficients are known in commercial chicken populations. Szwaczkowski *et al.* (2003) estimated very low levels of inbreeding in two lines of laying hens which agrees with the trend reported in this study, while Muir *et al.* (2008) showed high levels of inbreeding likely due to the purebred nature of the populations studied. Most recent estimates of inbreeding coefficients in turkey populations consist of those completed on two purebred lines in a research thesis by Melka (2010). Estimates of the rates of inbreeding obtained in the current study are still considerably higher (0.41-1.28%/yr) than the critical level

of 0.5%/yr suggested for animal breeding programs (Nicholas, 1989). The higher rates of inbreeding coefficient might be connected to extensive use few sires in all the generation.

The positive and low inbreeding depression in this study implies that occasional intense inbreeding does occur in these populations. Woodard *et al.* (1983) demonstrated that a low negative effect of inbreeding on body weight which was in contrast to the positive effect obtained in this study. Kamali *et al.* (2007) reported that a reduction in 12-week body weight and body linear measurement is due to increased inbreeding. In this population, the low level of inbreeding may be attributed to mating policy. One male was mated to about 10 females with special attention being aid to avoid the mating between closely related individuals. Also, individuals in the base population assumed to be unrelated and non-inbred.

Conclusion

The trend of inbreeding coefficient was quadratic with a range of 0.63-1.28/yr in SLS, 0.41-1.06/yr in DLS, 0.58-1.27/yr in SCL and 0.30-1.16/yr in DCL; thus, this suggest using mate allocation programs that put a limit or constraint on the level of inbreeding for the future progeny of NAPRI X broiler chickens. The buildup of inbreeding coefficient had not depressed the bodyweight and body measurement traits though some traits are tending towards zero in control and selected sire and dam line, and mating should be carefully design to avoid inbreeding depression in the NAPRI X broiler chicken under selection.

Recommendation

Mating should be carefully design to avoid inbreeding depression in NAPRI X broiler chickens. The use of mate allocation program should encourage to effectively manage inbreeding that put a limit or constraint on the level of inbreeding of the future progeny.

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