Journal of Poultry Research 14(2): 07-11, 2017
Print ISSN:1302-3209 - Online ISSN:2147-9003
www.turkishpoultryscience.com
Research Article

Performance and Heterosis of Indigenous Chicken Crossbreed (Naked Neck x Frizzled Feather) In The Humid Tropics

Jeremiah Monday I. Nwenya[1*], Emeka P. Nwakpu[2], Roseline N. Nwose[3], Kanayo P. Ogbuagu[4]

ABSTRACT: Forty-four (44) birds (about 50 weeks old) male and female inbred naked necked and frizzle feathered chickens were crossed to generate F_1 crossbred chicken that were used to evaluate the performance and heterosis effects. Data taken on 180 chicks (97 NN and 83 FF) day-old chick weight (BWT0), body weight (BWT), daily average feed intake (AFI), feed conversion ratio (FCR), brooding and rearing mortalities, linear body measurements (LBM): body length, wing length, keel length, shank length and breast width were used to estimate heterosis and performance of F_1 progenies. Results of the experiment showed positive heterosis with significant differences among the F_1 progenies over their parents in body weight, average feed intake and feed conversion ratio. The reciprocal cross (i.e. frizzle feather rooster x naked neck hen) showed a significant improvement in their performances genetically, explaining that better results are achieved through crossbreeding of these indigenous breeds. With reference to their body linear parameters, the reciprocal cross of naked neck and frizzle feathered chickens developed higher body length, whereas the main crosses performed better in their wing length, keel length, shank length and body width respectively, mainly after 8 weeks suggesting that earlier performance was attributable to maternal influences.

Keywords: Frizzle feather, Growth performance, Heterosis, Naked neck, Reciprocal cross

Received: 02.08.2017 **Accepted:** 28.11.2017

Nemli Tropikallerde Yerli Melez Irk (Çıplak Boyun x Kıvrık Tüylü) Piliçlerde Performans ve Hetorozis Özellikleri

ÖZ: Yaklaşık 50 haftalık yaşta, 44 adet erkek ve dişi kan yakınlığı olan çıplak boyun ve kıvrık tüylü (frezzled feathered) tavukların F1 melezlemesi yapılarak performans ve heterozis etkileri incelenmiştir. F1 döllerinin performans ve heterozis özelliklerini saptamak için 1 günlük yaştaki 180 adet (97 çıplak boyun ve 83 kıvrık tüylü) civcive ait başlangıç canlı ağırlığı (BW0), canlı ağırlık (BW) ortalama günlük yem tüketimi (AFI), yem dönüşüm oranı (FCR), kuluçka ve yetiştirme döneminde ölüm oranları, linear vücut ölçüleri (LBM): vücut uzunluğu, kanat uzunluğu, göğüs kemiği uzunluğu, bacak uzunluğu ve göğüs genişliği ölçümleri değerlendirildi. Deneme sonuçları F1 melezleri arasında vücut ağırlığı, ortalama yem tüketimi ve yem dönüşüm oranı bakımından önemli derecede pozitif heterozis olduğunu göstermiştir**.** Karşılıklı çaprazlama (kıvrık tüylü horoz x çıplak boyun tavuk) ile genetik performansta önemli iyileşmenin görülmesi, bu yerli ırkların melezlemesiyle daha iyi sonuçların elde edileceğini açıklamaktadır. Vücut linear parametreleri referans alınarak çıplak boyun ve kıvrık tüylü tavukların karşılıklı çaprazlamaları ile, daha önceki haftalardaki performans anasal etkilere atfedilerek, özellikle 8 haftadan sonra daha yüksek vücut uzunluğu, bacak uzunluğu ve vücut genişliğine sahip piliçler geliştirildi.

Anahtar Kelimeler: Kıvrık tüy, Büyüme performansı, Heterozis, Çıplak boyun, Karşılıklı çaprazlama

INTRODUCTION

The genetically unimproved local chicken has remained predominant in African villages despite the introduction of exotic and cross-bred types. This is due to the fact that, local farmers have not been able to afford the high input requirements of the introduced breeds (1). This is why it has become imperative to access the heterosis evaluation of the crosses of indigenous local chicken as a way of improving their productivity.

The indigenous species represent valuable resources for livestock development because their extensive genetic diversity allows for rearing of poultry under varied environmental conditions, providing a range of products and functions. Thus, great genetic resources embedded in the indigenous poultry await full exploitation that will provide basis for genetic improvement and diversification to produce breeds that are adapted to local conditions for the benefits of farmers especially in developing countries (2, 3).

In classification, indigenous chickens in Nigeria are characterized along genetic lines of feather and plumage colour (such as normal or frizzle feathered), body structure (such as naked neck, dwarf types) and colour variants (such as black, white, brown, mottled etc.) The frequency of distribution of the normal feathered chickens was about 91.8% while that of frizzled and the naked neck were 5.2% and 3.0% respectively in Bayelsa State of Nigeria (4). Classification majorly has been on the basis of location. There are various ecotypes in the local chickens in the different agro-ecological zones in Nigeria. Most of the classifications by the different agro-ecological zones considered were mainly the normal feathered indigenous chickens because they are the most prominent whereas the naked neck and frizzle feathered are rare and almost becoming endangered and the gene pool they represent may be lost if not characterized and conserved.

[1]Federal University, Ndufu Alike, Ikwo, Ebonyi State, Nigeria
[2]Department of Animal Science, Ebonyi State University, Abakaliki, Nigeria
[3]Federal University, Ndufu Alike, Ikwo, Ebonyi State, Nigeria
[4]Department of Animal Breeding and Physiology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
*Corresponding Author: Jeremiah Monday I. Nwenya, e-mail: unclejerryforfavour@gmail.com

Heterosis, also called hybrid vigour, is therefore, the increase in such characteristics as size, growth rate, fertility and yield of a hybrid organism over those of its parents. Animal breeders exploit heterosis by mating two different pure-bred lines that have certain desirable traits. The first-generation offspring generally show in greater measures, the desired characteristics of both parents. This vigour may decrease, and lines must be maintained and crossed for such new group desired (5).

Exploitation of heterosis is a major reason for crossbreeding in farm animals (6). 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 (7). Heterosis has been exploited to genetically improve characters that are subject to little additive gene action, such as those related to fitness (8). Crossbreeding, therefore, is one of the sure ways of achieving rapid genetic improvement in non-descript and unselected indigenous stocks within the shortest time (Jagdish, 2007). However, under experimental and field breeding conditions, not every crossbreeding effort produces desirable results. It is therefore important that an animal breeder knows what mating method to employ and what breeding goals to accomplish (9). The objective of this study, therefore, was to determine the heterosis of the main cross and reciprocal effects on growth traits of indigenous naked neck (Na) chickens with the frizzle feathered (Ff) chickens. This would lead to the development of slow growing broiler production that would continue to improve as selection progresses.

MATERIALS AND METHODS

Location of study: This study was conducted at the Poultry Unit of the Teaching and Research Farm, Ebonyi State University, Abakaliki. Abakaliki is located within the tropical rainforest zone of the South-Eastern Nigeria and it is situated between latitude $06^{0}4^{1}$N and longitude $08^{0}6^{1}$E at the elevation of 71.4mm above sea level. It has a bimodal rainfall pattern and its rainfall per annum ranges from 1700 - 2000mm which is between April to July and August to November yearly. The relative humidity at dry season ranges between 60 and 80% and the soil belongs to the order Ultisols (10, 11).

Experimental birds: Forty-four indigenous breed of inbred chickens consisting of matured males and females were used to generate the F_1 progenies. The native chickens were made up of two varieties namely naked neck (Na) and Frizzle feather (Ff) genotypes. They were mated in a ratio of 1:10 for the cock and hens respectively. The breeding groups were NF = naked neck rooster × frizzle hen, FN = frizzle rooster × naked neck hen for the main and reciprocal crosses respectively, while the inbreds were; NN = naked neck rooster × naked neck hen, FF = frizzle rooster × frizzle hen respectively.

Management of experimental birds: The chicks were brooded and reared in deep litter pens according to their genetic groups. The birds were fed commercial starter mash (23% Crude Protein, 2875 Kcal ME/kg) and water was served *ad-libitum* from 0 - 4 weeks of age. Vaccination and prophylactic medications were administered to ensure optimal health of the birds. At rearing phase (5 - 16 weeks), the birds were fed grower diet (16% CP, 2675 Kcal ME/kg) and water was also provided *ad-libitum* until they attained 16 weeks of age.

Parameters measured: Hatch weight, Body weight (BWT), Daily feed intake, Body length (BL), Wing length (WL), Keel length (KL), Shank length (SL), Breast width (BW), Feed conversion ratio (FCR) and Body weight gain (BWG). Measurements of these parameters were taken at hatch, subsequently at interval of four weeks till the 16^{th} week respectively.

Statistical analysis: Data collected were subjected to analysis of variance (ANOVA) technique in a randomized complete block design (RCBD) to test for the effect of genetic group. Hatches were the blocking factor. Significant means were detected using the Duncan's new multiple range test (12). Direct and percentage heterosis was estimated using linear contrast procedure as described by Dickerson (9). The procedure is as follows:

$$PH=\frac{\text{Crossbred average - Purebred average}}{\text{Purebred average}} \times 100$$

PH : Percentage heterosis (% heterosis),

Given that Direct heterosis (DH);

DH : Crossbred average - Purebred average

RESULTS AND DISCUSSION

Table 1 above shows the performance of main and reciprocal progenies of naked neck and frizzle feathered chicken crosses. At hatch, the body weight of the reciprocal cross (FN) was the highest with 29.50g while the naked neck inbred (NN) had the lowest body weight of 22.17g. this is in line with the report by Nwachukwu (13) which stated that reciprocal crosses of normal, naked neck and frizzle chickens performed better than their main cross counterparts in growth parameters in a humid tropical environment. This also agrees with Oke (14) stating that frizzle (F) genotypes had highest day-old weight as well recorded highest mean body weight at 16 weeks. That is to say that frizzle feather genotypes generally contributed more to growth rates. There was however, no significant difference ($P>0.05$) in day-old weight between the frizzle feather (F) and naked neck (NN) inbreds and the frizzle feather main cross. This suggests that better results in body weight (BWT) is achieved by the combination of frizzle feather (F) sire and naked neck (NN) dam aligning with the report by Musa (15). They reported that the two genotypes provided the most suitable combination for an improved body weight.

At 4 weeks, the frizzle (F) reciprocal cross maintained the highest body weight, expressing its superiority over its main cross and the inbreds. This can be attributed to maternal influences.

Throughout the stages of the experiment, the performances of the reciprocal cross (FN) outweighed both the main cross and the inbreds in all the growth parameters. Meanwhile, the main cross ranked next to the reciprocal cross, followed by the frizzle (F) inbred. This implies that the reciprocal cross (FN) gave the best estimates for heterosis and specific combining abilities and that frizzle (F) genotype gave the best estimate for general combining ability in line with the report by Musa (15).

Table 1. Performance of F_1 main and reciprocal progenies of naked neck and frizzle feather chicken crosses

Parameters	Genotypes				
	NN (inbreds)	FF (inbreds)	NF (Maincross)	FN (Reciprocal)	SEM
$BWT_{0\ (g)}$	22.17^{c}	23.83^{bc}	25.50^{b}	29.50^{a}	1.55
$BWT_{4WK\ (g)}$	140.33^{b}	172.67^{ab}	187.00^{a}	194.17^{a}	17.97
$AFI_{4WK\ (g)}$	25.60^{b}	27.50^{ab}	28.80^{a}	29.40^{a}	2.05
FCR_{4WK}	4.08^{b}	4.30^{ab}	5.30^{a}	5.50^{a}	0.13
$BWG_{4WK\ (g)}$	42.12^{c}	49.99^{bc}	57.89^{ab}	62.89^{a}	4.33
$BWT_{8WK\ (g)}$	347.33^{b}	399.50^{ab}	434.50^{a}	443.00^{a}	37.67
$AFI_{8WK\ (g)}$	37.80^{b}	40.10^{ab}	43.50^{a}	44.61^{a}	3.97
FCR_{8WK}	4.31^{b}	4.81^{ab}	5.61^{a}	5.81^{a}	0.43
$BWG_{8WK\ (g)}$	53.21^{c}	$56.30b^{c}$	61.71^{ab}	64.84^{a}	5.33
$BWT_{12WK\ (g)}$	537.33^{b}	635.50^{b}	747.33^{a}	757.83^{a}	47.14
$AFI_{12WK\ (g)}$	51.82^{b}	56.30^{ab}	58.50^{a}	59.10^{a}	5.61
FCR_{12WK}	5.61^{b}	6.30^{ab}	6.70^{a}	7.10^{a}	0.90
$BWG_{12WK\ (g)}$	61.30^{c}	67.40^{bc}	71.80^{ab}	75.15^{a}	5.16
$BWT_{16WK\ (g)}$	654.00^{b}	773.67^{b}	895.96^{a}	972.83^{a}	65.23
$AFI_{16WK\ (g)}$	66.30^{b}	68.40^{ab}	70.53^{a}	72.14	6.94
FCR_{16WK}	6.34^{b}	7.3^{ab}	7.51^{a}	8.13	1.14
$BWG_{16WK\ (g)}$	73.50^{c}	76.41^{bc}	81.09^{ab}	90.31^{a}	7.50

a-c: Means on the same row with different superscripts are significantly different (P<0.05); BWT, AFI, FCR, BWG:- Body Weight (g); Average Feed Intake (g); Feed Conversion Ratio; Body Weight, Gain (g). SEM: Standard error of the means; NN: Naked Neck; FF: Frizzle Feathered; NF: Naked × Frizzle genotypes; FN: Frizzle × Naked Neck genotypes.

Table 2. Heterosis performance of F_1 main and reciprocal progenies of naked neck and frizzle feather chicken crosses

Parameters	Parental Mean ± SEM	Crosses Mean ± SEM	H%	H%NF	H%FN
BWT_0	23.00 ± 0.62^{b}	27.50 ± 0.82^{a}	19.95	10.77	29.12
$BWT_{(4WK)}$	156.50 ± 2.11^{b}	190.58 ± 11.09^{a}	21.65	24.24	19.07
$AFI_{(4WK)}$	26.55 ± 0.56^{b}	29.10 ± 0.72^{a}	9.60	36.16	32.99
$FCR_{(4WK)}$	4.19 ± 0.10^{b}	8.05 ± 0.53^{a}	9.21	19.80	14.41
$BWG_{(4WK)}$	46.06 ± 2.01^{b}	89.34 ± 3.50^{a}	9.39	20.39	10.51
$BWT_{(8WK)}$	373.42 ± 8.01^{b}	438.75 ± 32.42^{a}	17.87	18.67	17.07
$AFI_{(8WK)}$	57.85 ± 1.98^{b}	65.81 ± 1.99^{a}	13.79	23.79	20.91
$FCR_{(8WK)}$	4.56 ± 0.22^{b}	5.71 ± 0.23^{a}	25.22	53.07	41.68
$BWG_{(8WK)}$	56.10 ± 2.50^{b}	90.50 ± 4.10^{a}	11.40	57.37	45.39
$BWT_{(12WK)}$	586.67 ± 8.50^{b}	752.58 ± 47.10^{a}	28.50	27.83	29.19
$AFI_{(12WK)}$	68.61 ± 1.51^{b}	70.31 ± 1.67^{a}	16.40	27.18	23.40
$FCR_{(12WK)}$	4.80 ± 0.50^{b}	5.83 ± 0.60^{a}	28.13	61.10	45.70
$BWG_{(12WK)}$	$60\ 50 \pm 2.61^{b}$	101.04 ± 3.16^{a}	21.14	63.18	56.41

a - c: Means on the same row with different superscripts are significantly different (P<0.05). H% = Percentage heterosis; H%NF = Percentage heterosis from the main cross; H%FN = Percentage heterosis from the reciprocal cross.

Moreso, average feed intake (AFI) was highest among the reciprocal crosses (29.40g) which were closely followed by the main cross (28.80g) at week 4. There were significant differences (P<0.05) between the reciprocal cross and main cross and the naked neck chicken which had 25.60g average feed intake. Feed conversion ratio (FCR) was almost the same between the main cross (5.30) and the reciprocal cross (5.50) although not significantly different (P>0.05) with the naked neck having the lowest (4.08). In body weight gain (BWG) at Week 4, there were significant differences (p<0.05) in weight gain between the reciprocal cross with 62.89g, being the highest and the naked neck chicken (42.12g) having the least. That is to say that, the highest weight gain was recorded among reciprocal crosses (FN) followed by the main cross (NF) (57.89g), the frizzle feathered (FF) (49.99g) and the least body weight gain was from the naked neck (NN). This however, disagrees with the report by Adedeji (16), which stated that the progenies of naked neck (NN) sire were superior to other breeds in body weight.

At age 8 weeks, the body weights of the birds generally appreciated with the main and reciprocal crosses recording highest body weights. While the reciprocal cross weighed 443.0g, the main cross weighed 434.50g and frizzle feather was inbetween the two crosses with 399.50g and then naked neck which had the least body weight of 347.33g. The average feed intake (AFI) at 8 weeks also took the same pattern as in the body weight.

There were no significant differences (P>0.05) between the frizzle feathered (40.10g) and the main cross and reciprocal cross in their average feed intake values (43.50g and 44.61g respectively). The naked neck birds had the least feed intake of 37.80g. Feed conversion ratio (FCR) equally recorded the best among the reciprocal crosses (5.81). This was followed by frizzle feathered chicken (4.81) though, without a significant difference (P>0.05). Naked neck also had the least feed conversion ratio of 4.31. In the same vein, the reciprocal cross gained most in body weight (64.84g) at 8 weeks. This was also followed by the main cross with 61.71g; then the frizzle feather (56.30g) while the naked neck gained the least (53.21g). Similar trend of performances was observed at

week 12. The reciprocal crosses had 757.83g body weight, the main cross; 747.33g, frizzle feather; 635.50g and the naked neck; 537.83g. Average feed intake followed similarly as 59.10g, 58.50g, 56.30g, and 51.82g for reciprocal crosses, main cross, frizzle feather and naked neck respectively. Feed conversion ratios were also; 7.10, 6.70, 6.30 and 5.61 accordingly for the reciprocal cross, main cross, frizzle feathered and naked neck progenies. The reciprocal cross (FN) had the highest body weight gain of 75.15g followed by the main cross (NF) with 71.80g, then the frizzle feather chicken, 67.40g and the naked neck with the least body weight gain, 61.30g.

Table 2 describes heterosis performance of F_1 main and reciprocal progenies of naked neck and frizzle feather chicken crosses considering parameters like body weight (BWT), average feed intake (AFI), feed conversion ratio (FCR) and body weight gain (BWG). At day old, the mean body weight of the progenies (27.50g) was higher than the mean body weight of the parents (23.00g) with a percentage heterosis (H%) of 19.95. This aligns with the investigation by Iraqi (17) which recorded higher body weights at early ages (weight from hatch to 8 weeks) than those at later ages (from 12 - 16 weeks). Also, many other investigations confirmed the superiority of crossbreds over purebreds regarding reproductive and some economic traits (18, 19, 20, 21). The percentage heterosis in the main cross (H%NF) (10.71) was lower than the percentage heterosis in the reciprocal cross (H%FN) (29.12%). There was a significant difference ($P<0.05$) between parental mean weight at day old and the crosses mean weight. The mean weight of the parents and the crosses simultaneously increased at Week 4 with a significant difference ($P<0.05$). Mean weight of the parents was 156.50g while the crosses mean weight was 190.58g with an increased heterosis development of 21.65%. The percentage heterosis for the main cross (H%NF) and the reciprocal cross (H%FN) reversely changed; H%NF, 24.24 and H%FN, 19.07. Also, average feed intake (AFI) at week 4 in the crosses (29.00g) was higher than the parents (26.55g) with a significant difference ($P<0.05$). The heterosis in average feed intake was significantly low (9.60%) while percentage heterosis in the main cross (H%NF) (36.16%) was higher than the percentage heterosis in the reciprocal cross (H%FN) (32.99%). Feed conversion ratio (FCR) at the week 4 was equally higher in the crossbreds (8.05) than in the parents (4.19). There was also a low heterotic performance between the parents and the crossbreds in feed conversion ratio. The percentage heterosis in FCR in the main cross (19.80) was higher than it was in the reciprocal crossbred (14.41). Mean body weight gain of 89.34g in the crosses was tremendously higher than the parental mean of the body weight gain (46.06g) at week 4. Heterosis (H%) of body weight gain was lower (9.39%) than percentage heterosis in the reciprocal cross (H%FN) (10.51).

At week 8, parental mean body weight was 373.42g whereas the crossbreds mean body weight was 438g. There was an appreciable heterotic improvement of 17.87% with an almost the same percentage performance in both the main and reciprocal crosses; 18.67% and 17.07% respectively. Average feed intake (AFI) was significantly different ($P<0.05$) between the parents and the crosses. The parental mean AFI was 57.85g, and which was lower than the crosses average feed intake of 65.81g. There was a relatively low heterotic development of 13.76% in the main cross with 23.79% which was higher than the percentage heterosis in the reciprocal cross with 20.91% in the average feed intake of the birds. Higher percentage heterosis of 5.71 was recorded in the main cross than in the parents with 4.56 at week 8. This agrees with Flock (22) which indicated low heterosis as a consequence of pureline selection, as against improved heterosis in the performances of crossbreds. Heterosis of 25.22% was high but a higher percentage heterosis of 53.07% was registered in the main cross than that of the reciprocal cross with 41.68%. Mean body weight gain recorded higher in the crosses (90.50g) compared to the parents (56.10g). Heterosis (H%) for BWG (11.40%) remained low. The percentage heterosis in the main cross was 57.37% and the percentage heterosis in the reciprocal cross was 45.39%.

At 12 weeks upwards, the percentage heterosis in all the parameters maintained similar trends. Mean body weight in the parents was 586.67g and 753.58g in the crosses; with a high percent heterosis (H%) (28.50%). Percentage heterosis in the reciprocal cross (H%FN) (29.19) was higher than the main cross (H%NF) (27.83). Parental mean of the average feed intake was 68.61g and the crosses mean AFI was 70.31g. Heterosis (H%) was 16.40%. Percentage heterosis of AFI in the main cross (H%NF) was 27.18% while in the reciprocal cross, it was 23.40%. Feed conversion ratio at the same week 12 had parental mean of 4.80 and the crosses mean at 5.83. Heterosis (H%) was also high (28.13). In the main cross, percentage heterosis was 61.10% while in the reciprocal cross, it was 45.70%. Parental mean of body weight gain at week 12 was 60.50g while the crosses mean was 101.04g, with heterosis of 21.14%. Percentage heterosis was 63.18% in the main cross (NF) and 56.41% in the reciprocal cross (FN).

CONCLUSION

There was a positive heterosis of the F_1 progenies (main and reciprocal) over their parents in body weight, average feed intake and feed conversion ratio. The reciprocal cross (i.e. frizzle feather rooster x naked neck hen) showed a significant improvement in their performances genetically, explaining that better results are achieved through crossbreeding of indigenous breeds using frizzle feather (F) sire and naked neck (NN) dam. Particularly, initial body weight and body weight gain in the reciprocal cross increased significantly, from 29.50g to 90.31g against the parents whose peak of weight gain was 73.50g at 16 weeks. With reference to their body linear parameters, the reciprocal cross of naked neck and frizzle feathered chickens developed higher body length, whereas the main cross performed better in their wing length, keel length, shank length and body width respectively, mainly after 8 weeks. It is, however, hoped that in the future, further investigations will be carried out till the F_2 generation to further bring out more purified progenies that can perform better in either meat or egg production than their F_1 generation counterparts.

REFERENCES

1. **Kaiser, D.,**1990. Improvement of traditional poultry keeping in Niger. Rural poultry. CTA Wageningen, Rural Poultry production in Hot climates, 12 June 1987, Hamelin, Germany

2. **Horst P.,** 1988. Native fowl as reservoir for genomes and major genes with direct and indirect effects on production adaptability: Proceedings of the 18th World Poultry Congress, Sept. 4-9, Nagoya, Japan, pp: 105-105.
3. **Sonaiya, E.B., Branckaert, R.D.S and Gueye E.F., 1999**. Research and development options for family poultry. First INFPD/FAO Electronic Conference on Family Poultry.
4. **Ajayi, F.O. and Agaviezor, B.O.,** 2009. Phenotypic Characteristics of Indigenous Chicken in Selected Local Government Areas in Bayelsa State, Nigeria. Proceedings of the 3rd Nigeria International Poultry Summit, Feb. 22-26, Abeokuta, pp: 75-78.
5. **Encyclopaedia Britannica Inc**., 2012. Web. 12 Jun. 2012
6. **Ibe, S.N., Obasi, V.N., Ojewola, G.S. and Nwachukwu, E.N.,** 2005. Heterosis and reciprocal effects for growth traits in crosses of New Zealand White, Dutch and Chinchilla breeds of rabbit. Nig. J. Anim. Prod. 32(2): 191 - 197.
7. **Falconer, D.S.,** 1981. Introduction to Quantitative Genetics. Longman Inc. New York.
8. **Ndjon, M.N. and Nwakalor, L.N.,** 1999. Heterosis in maternal traits from crossing of exotic and local breeds of rabbits. Trop. J. Anim. Sci. 1(2): 9-15.
9. **Dickerson, G.E.,** 1992. Manual for evaluating breeds and crosses of domestic animal publications Div., FAO, Rome, Italy.
10. **FDALR.,** 1985 Federal Department of Agriculture and Lands Resources. Reconnaisace Soil Survey of Anambra State, Nigeria. Soil Report FDALR, Kaduna.
11. **Oformata, G.E.K.,** 1975. Nigeria in Maps, Eastern States; Ethiopia Publishing House, Benin City, Nigeria.
12. **Duncan, D.B.,** 1955. Multiple Range and Multiple F. Tests. Biometrics 11:1-42
13. **Nwachukwu, E.N., Ibe, S.N., Ejekwu, K. and Oke, U.K.,** 2006. Evaluation of growth parameters of main and reciprocal crossbred normal, naked necked and frizzle chickens in a humid tropical environment. J. Anim. Vet. Adv., 5(7): 542-546.
14. **Oke, U.K.,** 2011. Influence of some major genes on growth traits of local pullets in humid tropical environment. Agric. Biol. J. N. Am. 2(4): 570-576.
15. **Musa, A.A., Orunmuyi, M., Akpa, G.N., Olutunmogun, A.K., Muhammad, H. and Adedibu, I.I.,** 2015. Diallel analysis for bodyweight involving three genotypes of Nigerian indigenous chickens. S. Afr. J. of Anim. Sci. 45(2): 188-197.
16. **Adedeji, T.A., Adebambo, O.A., Peters, S.O., Ojedapo, L.O. and Ige, A.O.,** 2006. Growth performance of crossbred and purebred chickens resulting from different sire strain in a humid tropical environment. J. Anim. Vet. Adv., 5(8): 674-678.
17. **Iraqi, M.M., Hanafi, M.S., Khalil, M.H., El-Labban, A.F.M. and Ell-Sisy, M.,** 2002. Genetic evaluation of growth traits in a crossbreeding experiment involving two local strains of chickens using multi-trait animal model. Livestock Research for Rural Development 14 (5)
18. **Kosba, M.A., Mahmoud, T.H., Shawer, M.F. and Abd-Alla, G.M.,** 1981. A comparative study of four breeds of chickens and their F_1 crosses. Egg fertility and hatchability. Agric. Res. Rev., 59:83-90.
19. **Farghly, M. and Saleh, K.,** 1988. The effect of crossbreeding on egg traits in laying hens. Egypt Poult. Sc. 8:376-391.
20. **Abdou, F.H.,** 1992. A working panel to improve Menofyia chickens through developing the new strain of (Norfa) Menofyia. J. Agric. Res., Vol. 17 (2): 980-982.
21. **Nawar, M.E. and Abdou, F.H.,** 1999. Analysis of heterotic gene action and maternal effects in crossbred Fayoumi chickens. Egypt Poult. Sci., Vol. 19 (III): 671-689.
22. **Flock D.K., Ameli H. and Gloder P.,** 1991. Inbreeding and heterosis effects on quantitative traits in a White Leghorn population under long-term reciprocal recurrent selection. British Poultry Science 32(3): 451-462.