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Gene Segregation Effects on Fertility and Hatchability of Pure and Crossbred Chicken Genotypes in the Humid Tropics

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Abstract: This study was conducted to compare fertility and hatchability among pure and crossbred chicken genotypes. A total of three sires and thirty dams per genetic group were used in a study which was conducted over three months involving both direct and reciprocal crosses. A total number of 5804 eggs were set out of the total laid. Number of eggs fertile at first and second candling were significantly ($P < 0.01$) affected by both sire and dam strains. Similarly, number of eggs hatched, percentage fertility and hatchability were significantly ($P < 0.01$) affected by both sire and dam strains. There was also significant ($P < 0.05$) interaction effects between dam and sire strains on fertility and hatchability percentages. Matings involving pure strains of Naked Neck indigenous chicken resulted in lowest hatchability when compared to matings involving other pure and crossbred genotypes. Variations observed in percentage fertility and hatchability of eggs were attributed to segregation effects of genes in both pure and crossbred chicken genotypes used for the study.

Key words: Indigenous chicken, fertility, hatchability, eggs, genes

Introduction

The genetic make-up of an individual is fixed at fertilization and hence, fertility and hatchability is generally considered as a trait of the two parents. It is perhaps best defined as the interaction between male and female gametes in the production of a viable zygote. Fertility is the ability to reproduce. It determines the number of offspring that can be obtained from a given number of eggs. Fertility is expressed as the percentage of eggs fertilized and it is judged by candling or microscopy. The ultimate test of fertility can only be made by depositing semen in the oviduct of the hens and true evaluation is only possible when sufficient sperm number are inseminated with optimum frequency (Sexton and Randen, 1988). Fertility is a function of the spermatozoa. Male fertility covers aspects of quality and quantity of sperm produced. Some important parameters in measuring fertility being motility, proportion of live-dead ratio, normal and abnormal spermatozoa. The potency of the chicken semen is related to the number of matured sperm cells in an ejaculate. Significant breed differences in volume of ejaculate inmost cases are due to weight variation in favour of heavier breeds.

Hatchability on the other hand, refers to the percentage eggs hatched reported either as, percentage of fertile eggs hatched or percentage of chicks hatched from all eggs placed in the incubator. Hatchability of eggs is affected by several factors which include fertility of the egg, and the genetic constitution of parents. Hatchability is heritable and inbreeding among flocks depresses it, while crossbreeding enhances it. Sire and sire genotype thus affects hatchability by the quality of semen produce. It is however, difficult to determine the relative influence of the sire in transmitting hatchability to progeny. Nevertheless, the result of an investigation conducted by Sexton and Randen (1988) indicates quite definitely that the sire exercises an appreciable influence on the level of hatchability inherited by his daughter. Since it is known that hatchability is inherited it should be possible to demonstrate differences in transmitting ability among dams mated to the same sire.

Zygote development and thus hatchability are traits of the embryo influenced by maternal effects according to Gowe *et al.* (1993). In most previous studies, they were considered solely as female reproductive traits (Sewalem *et al.*, 1998) ignoring the male factor when estimating genetic parameters of fertility and hatchability (Gowe *et al.*, 1993; Forster, 1993). The existence of genetic variation in such reproductive traits among chicken types can be exploited through crossbreeding and out crossing. Fertility and hatchability are the most important determinant for producing more chicks from a given number of breeding stocks within a stipulated period (Islam *et al.*, 2002). Nevertheless, there is paucity of information on the effects of sire, dam and the interaction between sire and dam genotypes on fertility and hatchability of artificially inseminated chickens' eggs in the humid zone of Nigeria. This study therefore, was initiated to fill this gap and examine the segregation and combining effects of genes on the fertility and hatchability of pure and crossbred chicken genotypes in Southwest Nigeria.

Materials and Methods

The data used in this study were obtained from an experiment conducted between January and March, 2004 at the Poultry Breeding Unit of the Teaching and Research Farm, University of Agriculture, Abeokuta,

Nigeria. The University of Agriculture, Abeokuta is located on latitude 7°10' N and longitude 3°2'E in Ogun State, Nigeria. The area lies on an undulating plain in south west Nigeria and has a prevailing tropical climate with mean annual rainfall of about 1037 mm. The mean ambient temperature ranges from 28°C in December to 36°C in February with a average relative humidity of about 82%. The vegetation represents an interphase between the tropical rainforest and the derived savannah.

The population of the chickens used in this study consisted of three matured sires from seven different sire strains and thirty dams from each genetic strain except the Frizzled Feathered type. Three strains were exotic in origin (Black Nera, White Leghorn and Giriraja) and another three were indigenous (Naked Necked, Frizzle Feathered, Normal Feathered); while the last strain,(Alpha) is obtained from a cross between Shaver and the Normal feathered indigenous chicken. The Alpha was developed at the Animal Breeding and Genetics Department, University of Agriculture, Abeokuta, Nigeria. These birds were caged in an open-sided house providing a cage space of 0.4m^2/bird. They were exposed to natural daylight of 13 hours per day Insemination of bird was artificially carried out. Semen collection from the sires was accomplished by abdominal massage technique (Lake, 1960). Dams were inseminated twice weekly throughout the investigation period. 0.1 ml of undiluted semen was inseminated with the aid of a pastet. The pastet was inserted into the inverted oviduct deep enough to deposit sperm close to the sperm storage glands in the vagina. Eggs were collected twice daily from the inseminated females and pedigreed along sire and dam lines. Good shaped and sound shelled eggs were sorted and stored over a period of 5-7 days at a temperature of between 20°C and 25°C and 80% relative humidity. Proper cleaning, disinfection and fumigation were carried out before setting of eggs. Numbers of eggs set for each individual sire-dam group were recorded. The eggs were turned automatically through 90°C in the incubator. On the 10th and 18th day of incubation, the eggs were candled to identify and remove infertile eggs. The remaining eggs were transferred to the hatching tray for hatching. On the 21st day, the numbers of hatched chicks, including the normal, weak, abnormal chicks and dead chicks after hatch were recorded.

The records keep include:

(1) Total number of egg set per sire/dam strain.
(2) Total number of fertile eggs per sire/dam strain
(3) Total number of hatched eggs per sire/dam strain
(4) % Fertility per sire/dam
(5) % Hatchability per sire/dam

% Fertility is calculated as:

$$\frac{\text{Total number of fertile eggs per sire/dam}}{\text{Total number of egg set per sire/dam}} \times 100$$

% Hatchability is calculated as:

$$\frac{\text{Total chicks hatched per sire/dam}}{\text{Total number of fertile eggs per sire/dam}} \times 100$$

All percentage data were transformed to their arcsin square root of % values before analysis.

Data analysis: The response variables were analyzed by fitting a fixed effect model using the least squares procedures of the generalize linear model (GLM) of the Statistical Analysis System Institute (SAS, 1999), which was also used to pre-adjust the data for the effects of sire age, season-monthly variation and egg batch. The fixed effects included in the final analysis were sire strain, dam strains and their interactive effects. Linear contrast of least squares class means was computed using New Duncan multiple range test (Steele and Torrie, 1980) to determine the significance of specific classes.

The final Model used was

$$Y_{ijklmn} = \mu + S_i + D_j + (SD)_{ij} + E_{ijklmn}$$

Where: Y_{ujklm}= Dependent variable (Fertility or Hatchability), μ = Overall mean, S_i = Effect of the i^{th} Sire strain (I = 1, 2, ...7), D_j= Effect of the j^{th} Dam strain (j = 1, 2.....6), $(SD)_{ij}$ = Effect of the interaction between sire and dam genetic group, E_{ijklmn} = Randon residual error normally distributed with zero mean variance δ^2_e

Results and Discussion

Fertility and hatchability are the most important determinants in the production of more chicks from a given number of breeding stocks within a stipulated period of time. They also to a large extent determine the profitability of the poultry enterprise. Sire and dam genotype significantly ($P < 0.01$) affected on number of eggs set, number of eggs fertile, percentage fertility and percentage hatchability ($P < 0.05$) respectively in this study. The least square means and the significant test of the effect of sire genetic group, dam genetic group and their interactive effect on fertility and hatchability of eggs of the Nigerian local chicken types are shown in Table 1.

The significant effect of sire genotype on fertility and hatchability in this present study is consistent with the reports of Kirby *et al.* (1998), who stated that the duration of sperm fertilizing ability varied widely among individuals within specific commercial parent male lines and within the lines used for their study.

Table 1: Least square means of egg parameters as affected by Sire and Dam genotype

Variables	No. of egg set	No. fertile	No. hatch	% fertile	% hatch
Overall	5804	5104	4681	84.64	87.50
Sire genotype					
Naked Neck (Na)	409^{g}	345^{d}	292^{d}	80.62±6.1^{c}	82.63±5.7^{c}
Frizzled Feathered (FF)	620^{d}	529^{c}	452^{c}	83.61±6.8^{b}	84.62±6.1^{bc}
Normal Feathered (NF)	515^{f}	442^{d}	390^{c}	82.13±7.1^{bc}	89.75±7.5^{ab}
Alpha	545^{e}	509^{c}	548^{b}	87.65±8.0^{a}	88.52±7.0^{ab}
Nera Black (NB)	1600^{a}	1411^{a}	1289^{a}	86.79±9.1^{a}	87.47±4.9^{b}
White Leghorn (WL)	1371^{b}	1244^{b}	1167^{a}	86.82±5.9^{a}	92.05±6.5^{a}
GirirGiriraja (G)	744^{c}	624^{c}	543^{b}	84.84±7.4^{b}	87.46±4.9^{b}
Dam genotype					
Naked Neck(Na)					
	243^{e}	190^{e}	158^{e}	78.93±5.1^{c}	83.26±5.1^{b}
Normal Feathered (NF)	939^{c}	808^{c}	732^{e}	81.52±6.7^{bc}	87.93±7.6^{bc}
Alpha 879^{c}	798^{c}	703^{c}	87.26±7.0^{ab}	84.05±5.6^{b}	
Nera Black(NB)	1424^{b}	1245^{b}	1184^{b}	82.95±5.8^{b}	84.96±5.7^{b}
White Leghorn (WL)	1846^{a}	1666^{a}	1538^{a}	90.56±5.7^{a}	92.27±7.2^{a}
Giriraja(G)	473^{d}	397^{d}	366^{d}	80.43±4.7^{b}	89.56±4.9^{ab}

Values within the same column with different letters are significantly different ($P < 0.05$)

The Nera black sire group produced the highest number of fertile eggs, followed by the White leghorn sire group. However, the white leghorn sire group sired the highest percentage of fertile eggs relative to the number of eggs set as shown in the table above. Nevertheless, the Alpha sire produced the highest percentage of fertile eggs, followed closely by White Leghorn and Nera Black, Giriraja, Frizzled feathered, Normal feathered and lastly Naked neck with corresponding values of 87.65%, 86.82%, 86.79%, 84.84%, 83.61% and 80.62% respectively. On percentage egg hatchability, the White Leghorn sire had the highest value followed by the Normal feathered sire, the Alpha, the Nera Black and Giriraja, Frizzled feather, normal and Naked neck with corresponding values of 92.05%, 89.75, 88.52%, 87.47, 87.46, 84.62 and 82.63 respectively. The Alpha line had the highest mean value of 87.65% for fertility probably because it combines the productive and adaptive genes of both the

exotic and the indigenous chicken: Among the indigenous chicken groups, the Frizzled feather sire group produced the highest number of fertile eggs followed by the Normal feathered genetic group The Naked neck (Na) sire genotype sired the least fertile eggs. The better performance of the Frizzle feather (Ff) chickens among the indigenous chicken types in this study could be associated with positive adaptive genes influence of the frizzle feather trait significantly affecting thermoregulatory ability (Horst, 1989). However, the Normal feathered (Nf) genetic group produced eggs with the highest hatchability percentage. Corresponding percentage hatchability values for Nf, Ff and Na was 89.75%, 84.62 and 82.63 respectively. Percentage fertility and hatchability was consistently lower among eggs sired by the Na genetic group This result is consistent with the reports of Crawford (1977); Horst (1980); Rauen (1985) and Merat (1986), who claim that, increase in embryonic mortality (up to 10% in pure strains) found among Na/Na and to a lesser extent, among their Na/na counterpart put them at a slight disadvantage to the NF control birds. There was a 6.1% reduction in embryonic survival when compared to the NF genotype in this study. This value is less than the 13% reduction in embryonic survival reported by Horst (1988). This embryonic mortality normally occurs during the last stage of incubation (18-21 days).

Dam genotype effect was significant ($P < 0.05$), affecting percentage fertility and hatchability. This result also is consistent with the reports of Kirby *et al.* (1998). The White Leghorn dam produced the highest number of fertile eggs and Naked Necked dam produced the least with corresponding values of 90.56% and 78.93% respectively. Among the indigenous chicken types. Dam genotype effects on fertility have frequently been attributed to differences in egg production (Beaumont *et al.*, 1992) or body composition (Bilgili and Renden, 1985; Yu *et al.*, 1992; Goerzen *et al.*, 1996). The differences observed in fertility that resulted in the White leghorn dams having the highest fertile eggs might be due to possible group genotype differences in sperm storage and release (Beaumont *et al.*, 1992; Brillard, 1993; Goerzen *et al.* (1996). The mean values of hatchability as affected by dam genotype in this study suggest that hatchability may not entirely be a function of fertility because of some intrinsic factors associated with the eggs (Bramwell *et al.*, 1996).

A significant interaction between sire and dam genetic group influencing percentage fertility and hatchability was also observed (Table 2). The least squares means of the first order interaction between sire and dam genotypes showed that naked neck birds as dams produced a high rate of infertile eggs as compared to

Table 2: Least square means of egg parameters as affected by Sire X Dam genotype interaction

Variables	No. of egg set	No. fertile	No. hatch	% fertile	% hatch
Overall	5804	5104	4681	84.64	87.50
Sire x Dam Genotype					
Na x Na	99	71	17	71.71±5.4^{d}	23.94±4.7^{d}
Na x Alpha	100	82	78	82.00±5.7^{bc}	95.12±6.7^{b}
Na x NF	126	102	96	80.95±4.9^{bc}	94.11±5.8^{bc}
Na x WL	127	100	95	78.74±5.2^{c}	95.00±5.4^{b}
Na x G	190	151	148	79.47±6.2^{c}	98.01±6.2^{a}
Na x NB	108	80	75	74.07±5.9^{c}	93.75±6.0^{bc}
FF x Alpha	150	117	113	78.00±6.2^{c}	96.58±6.2^{b}
FF x Na	138	105	39	76.08±5.7^{c}	37.03±6.7^{c}
FF x NF	207	171	167	82.61±7.8^{bc}	97.66±8.0^{ab}
FF x WL	147	121	117	82.31±5.2^{bc}	96.69±5.4^{b}
FF x G	170	140	138	82.35±6.2^{bc}	98.57±6.2^{a}
FF x NB	189	142	137	75.13±5.9^{c}	96.47±6.0^{b}
NF x NF	147	131	125	89.12±5.2^{a}	95.42±5.4^{b}
NF x Na	150	130	128	86.67±6.2^{b}	98.46±6.2^{a}
NF x Alpha	168	145	142	86.31±5.9^{b}	97.93±6.0^{ab}
NF x WL	147	122	120	82.99±5.2^{bc}	98.36±5.4^{a}
NF x G	120	107	100	89.17±6.2^{a}	93.45±6.2^{bc}
NF x NB	128	105	102	82.02±5.9^{bc}	97.14±6.0^{ab}
Alpha x Alpha	201	171	162	85.07±6.2^{b}	94.73±7.8^{bc}
Alpha x Na	120	96	84	80.00±6.7^{bc}	87.50±3.7^{c}
Alpha x NF	120	107	100	89.16±6.2^{a}	93.45±6.2^{bc}
Alpha x WL	130	105	100	80.76±5.7^{bc}	95.24±6.7^{b}
Alpha x G	141	110	107	78.01±7.8^{c}	97.27±8.0^{ab}
Alpha x NB	147	121	114	82.31±5.2^{bc}	94.21±5.4^{bc}
WL x WL	180	155	150	86.11±6.2^{ab}	96.77±6.2^{b}
WL x Na	208	165	162	79.33±5.9^{c}	9818±6.0^{a}
WL x Alpha	147	115	110	78.23±5.2^{c}	95.65±5.4^{b}
WL x NF	140	127	123	90.71±6.2^{a}	96.85±6.2^{b}
WL x G	128	110	107	85.93±5.9^{b}	97.27±6.0^{ab}
WL x NB	141	111	108	78.72±5.2^{c}	97.29±5.4^{ab}
G x G	140	117	113	83.57±6.2^{b}	96.58±6.2^{b}
G x Na	140	115	110	82.14±5.9^{b}	95.65±6.0^{b}
G x Alpha	119	91	88	76.47±6.2^{c}	96.70±7.8^{b}
G x WL	120	96	90	80.00±6.7^{bc}	93.75±3.7^{bc}
G x NF	181	151	147	83.43±6.2^{b}	97.35±7.8^{ab}
G x NB	120	96	91	80.00±6.7^{bc}	94.79±3.7^{bc}
NB x NB	194	147	141	75.77±6.2^{c}	95.91±6.2^{b}
NB x Na	109	92	90	84.40±5.7^{b}	97.82±6.7^{ab}
NB x Alpha	151	128	126	84.76±7.8^{bc}	98.43±8.0^{a}
NB x WL	147	121	120	82.31±5.2^{bc}	99.17±5.4^{a}
NB x G	110	90	87	81.81±6.2^{bc}	96.67±6.2^{b}
NB x NF	181	145	140	80.11±5.9^{bc}	96.55±6.0^{b}

Talues within the same column with different letters are significantly different ($P < 0.05$), Legend, Na = Naked Neck, WL = White Leghorn, FF = Frizzled feather, NB = Nera Black, NF = Normal feather, G = Giri raja, Alpha = Alpha.

other genetic groups. Similar the percentage hatchability of eggs laid by this group was significantly lower than the values observed for the other groups. Purebred mating involving naked neck birds produced a high percentage of dead in shell corroborating the report of Peters (2005) that the naked neck gene is likely to be lethal when present in homozygote dominant form. Mating between Frizzle feathered sires and Naked neck dams resulted in relatively lower fertility and hatchability when compared to others, indirectly indicating that, there is a possibility of low combining ability between the major genes controlling these traits and also that combining the two major genes of Frizzling and Naked neck in a single genotype is not desirable.

In conclusion, the results of this study showed that the variations in the genetic groups of the strains of birds used significantly affected fertility and hatchability of eggs from these chicken types. Fertility and hatchability reduced when sires and dams carrying the Naked neck gene were involved in crossing to produce fertile eggs. Similarly, purebred mating of Naked neck bird resulted in high percentage of dead in shell confirming earlier suggestion of lethal effect of the gene controlling this trait. The Alpha genotype was well adapted and appear to compete favourable with the exotic groups in this environment.

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