

Evaluation of Sire and Dam for Genetic Improvement of Fertility, Embryonic Mortality and Hatchability in Nigerian Local Chickens Populations

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Abstract

The study was conducted at Akpehe poultry farm Makurdi. About 50 adult females and 10 males each of the Fulani and the Tiv ecotypes were used for the study. The birds were house singly in identified pens partitioned into smaller units and hand-mated in the pen. About 600 fertile eggs were used to study the effect of sire and dam on fertility, embryonic mortality and hatchability.

The eggs were incubated in different batches. Candling was carried on the 7th and 14th days to remove infertile eggs and those with dead embryos. Sire and dam had significant effect on fertility, embryonic mortality and hatchability. The effect of the dam was due to the variation in non-additive and additive genetic variances in the dam that influences its egg environment, nutrients sufficiency and delivery systems and other maternal effects that support fertility, embryo survival and hatchability, and that which affect maternal effects, egg environment and nutrients delivery systems that do not support fertility, embryo survival and hatchability due to genetic variation. The effect of the sire was due to additive genetic variance of the sire determining fertility, embryo survival and hatchability due to proper transcription and translation of genetic information. Or the additive genetic variance of the sire that determines the frequency of deleterious and lethal genes that had transition that supported improper transcription and translation of genetic information due to chromosomal aberration. Selecting superior sires and dams from the population base on high fertility, embryo survival and hatchability in a multiple traits selection may lead genetic improvement of these traits.

Keywords Dam; Embryonic-Mortality; Fertility; Hatchability; Sire

Introduction

Local breeds of poultry contribute greatly to the world's poultry genetic diversity. They are very important in developing countries where they account for 95 percent of the total poultry population. These breeds are well-adapted to the free range production systems and suitable for rural resource-poor poultry production. The local chicken are poor egg producers [1], with small body sizes for males and females [2,3]. They are however highly resistant to various diseases. The birds are highly adapted to their environment with better survival under traditional free-range management system than the commercial hybrid strains [4,5]. Local chickens need little or no management assistance from the farmer.

The challenge of improving the productivity of local chickens is to conserve their traits or attributes those appeals to the rural farmer. There is evidence to show that the local chickens can be subjected to genetic improvement as identified by the performance of their crossbred grades that showed higher productivity. The implication of genetic improvement through crossbreeding were the loss or dilution of the local chickens peculiar traits, loss of instinct for broodiness and the added management needs from the farmer [6].

Thus, a breeding programme for genetic improvement of the local chickens must identify peculiar traits and specific attributes and include these in their selection and breeding goals. While at the same

time be able to conserve the little attention from the farmer characteristics.

Fertility, embryonic mortality and hatchability determine chicks output and flock size in Nigerian local chicken populations. These traits must be studied as specific characteristics that could be utilising in breeding programme for improve production, enhance the use and conserve desired attributes. Egg fertility is affected by the ability of the hen to mate, ability to store sperm, to ovulate an egg cell and to produce a suitable egg environment to support the formation and development of the embryo [7].

Fertility also depends on the ability of the male and its efficiency of mating, the volume and viability of semen deposited [7,8]. Fertility therefore depends on genetic and non-genetic factors arising from the female and the male mate [9]. Several reports on the influence of male and female on fertility are available in literature. Szwaczkowski [10] reported maternal effects on fertility. Sapp, et al. [11,12] reported random non-genetic effect of the male. Bennowitz, et al. [13] reported on the joint effects of the male and the female. While Brommer, et al. [14] considered the effects of the male and the female genetic, environmental effects and the covariance between genetic and non-genetic effects.

Hatchability is a trait of major economic importance in the rural poultry production because it has a strong effect on chick output. Fertility and embryonic mortality are sub traits of hatchability and all work together to determine chicks output. It is also significantly

influenced by genetic factors acting directly or indirectly through the egg [15,16].

Embryonic mortality account for about 33% of fertile eggs in traditional chickens [17]. The probability of embryo survival depends on the genotype whose genes are contributed by the sire and the dam. The internal and outer egg quality traits, egg nutrients sufficiency and delivery system depends entirely on the dam. It is also significantly influenced by genetic factors acting directly or indirectly through the egg [15,16]. In their review reported that early embryo mortality may be due to chromosomal aberrations and lethal genes. Thus, the survival of the embryo is controlled by both the sire and the dam. Beaumont [18] reported that the heritability of susceptibility to embryonic death based on sire component decreases from 0.09 for early mortality to 0.05 for late mortality and from 0.25 to 0.18 based on dam component. The aim of the study is to assess the effect of sire and dam on fertility, embryonic mortality and hatchability with a view to advance a case for the selection of superior sires and dams on these traits for genetic improvement.

Materials and Methods

The study was carried out at Akpehe poultry farm, Makurdi. Akpehe poultry farm is located on latitude 7041' N and longitude 80311E [19]. Makurdi is warm with temperature range of 17.3C - 35.6C. Rainfall is between 508 mm - 1016 mm [20]. The relative humidity ranged from 47-85 percent [21]. The Tiv and the Fulani local chickens were purchased from different rural farming communities and identified. The birds were housed, in dwarf wall wire mesh screened pens and the house was roofed with corrugated roofing sheets. The birds were housed individually and reared on deep litter. They were fed a formulated diet containing 18 percent crude protein. The birds were fed in the morning and evening and water was provided ad libitum.

Data collection and analysis

A total of 600 fertile eggs were used to evaluate fertility, embryonic mortality and hatchability. The eggs were incubated in two batches. Candling was carried out on the 7th and 14th days to remove infertile eggs and those with dead embryos. Fertility, embryonic mortality and Hatchability were estimated by the following methods:

Sire	Fertility(%)+SE	Hatchability(%)+SE	Embryonic(%)+SE
1	66.68 ^a ± 2.61	54.91 ^a ± 2.97	36.66 ^a ± 2.98
2	63.94 ^b ± 2.98	54.31 ^b ± 2.51	35.98 ^b ± 2.51
3	58.35 ^c ± 2.97	55.18 ^c ± 3.40	35.00 ^c ± 3.41
4	61.99 ^d ± 3.10	50.24 ^d ± 3.43	39.83 ^b ± 3.45
5	58.57 ^e ± 2.78	55.02 ^e ± 3.18	35.25 ^d ± 3.19

a,b,c,d,e figures with different superscripts down the groups are significantly different at p < 0.05. SE = Standard error.

Table 1: Mean square values of effect of sire within the Fulani ecotype on fertility, hatchability and embryonic mortality.

Effect of sire on hatchability within the Fulani ecotype

The mean squared values due to effect of sire on hatchability within the Fulani ecotype did not vary extensively unlike fertility. Sires one and two were statistically similar but both differed significantly (p <

The eggs fertility and hatchability were estimated as follows:

$$\% \text{ Fertility} = (Te - Le / Te) \times 100$$

Where Te = Total number of eggs incubated

Le = Total number of infertile eggs.

$$\% \text{ Hatchability} = (He / Ve) \times 100$$

Where He = Total number of hatched eggs.

Ve = Total number of viable eggs.

% Embryonic

$$\text{Mortality} = (Td / Ve) \times 100$$

Where Td = Total number of eggs with dead embryo

He = Total number of viable eggs

Data were first transformed using the ARC sine transformation. These were then compared by the analysis of variance using the model.

$$Y_{ijk} = \mu + F_i + H_j + e_{ijk}$$

Where

Y_{ijkl} = Measurement on any individual in the population

μ = Population mean

F_i = Effect of Sire (i=1,2,...12)

H_j = Effect of the jth dam mated to the ith sire (j = 1,2,...560)

e_{ijk} = Residual random error.

Result

Effect of sire on fertility, embryonic mortality and hatchability

Effect of Sire within the Fulani ecotype on fertility: Mean square values varied significantly (p < 0.05) between the sires within the Fulani ecotype. The fertility values of sires one and four were higher and differed significantly (p < 0.05) from each other and from sires three and five which did not vary significantly (p < 0.05) (Table 1).

0.05) from sires three and five which were also similar (p < 0.05) (Table 2). Sire four recorded the least hatchability which differed significantly (p < 0.05) from the other sires (Table 1).

Sire	Fertility(%) +SE	Hatchability(%) +SE	Embryonic Mortality(%) +SE
6	61.5 ^a ± 2.83	61.66 ^a ± 3.23	28.31 ^a ± 3.25
7	43.63 ^b ± 5.75	64.00 ^b ± 5.68	26.00 ^b ± 6.63
8	47.26 ^c ± 3.09	39.26 ^c ± 3.53	43.79 ^c ± 3.35
9	59.72 ^d ± 3.50	54.71 ^d ± 4.02	34.20 ^d ± 4.04
10	60.23 ^d ± 3.34	51.94 ^e ± 3.81	38.10 ^e ± 3.89
11	58.35 ^d ± 5.79	49.15 ^f ± 6.60	40.85 ^e ± 6.63

a,b,c,d,e,f figures with different superscripts down the groups are significantly.

Table 2: Least square means of effect of sire within the Tiv ecotype on fertility, embryonic mortality hatchability.

Effect of sires within the Fulani ecotype on embryonic mortality

Mean squared values due to effect of sire within the Fulani ecotype did not vary extensively. Sire four recorded the highest embryonic mortality which differed significantly from all the others (Table 1). All the other values were similar ($p < 0.05$) statistically (Table 1).

Effect of Sire within the Tiv ecotype on fertility

Sires six and eleven recorded highest fertility which differed significantly ($p < 0.05$) (Table 2) between them. Sire ten did not differ significantly from sire eleven. Sires seven and eight were least and similar ($p < 0.05$) but both differed significantly from all the other sires. Sire twelve also differed significantly ($p < 0.05$) from all the others (Table 2).

Effect of Sire within the Tiv ecotype on hatchability

The effect of sire within the Tiv Ecotype varied significantly ($p < 0.05$). Sire seven recorded the highest hatchability followed by sires six and ten which differed significantly ($p < 0.05$) in that order. Sire eight

was least (39.26 ± 3.53) followed by sire twelve (49.15 ± 6.60) which also varied significantly ($p < 0.05$) (Table 2).

Effect of sire within the Tiv ecotype on embryonic mortality

Sire effect within the Tiv ecotype on embryonic mortality varied significantly ($P < 0.05$). Sire eight recorded highest embryonic mortality (43.79 ± 3.55) followed by (40.85 ± 6.63) and (38.10 ± 3.89) for sires ten and eleven respectively (Table 2). The least embryonic mortality was recorded by sire seven (26.00 ± 6.63) followed by sire six (28.31 ± 3.25) and (34.20 ± 4.04) for sire ten. All these values differed significantly ($P < 0.05$) from each other (Table 2).

Effect of sire between the Fulani and the Tiv ecotype on fertility, embryonic mortality and hatchability

The effect of sire between the ecotype varied significantly ($p < 0.05$) in all the parameters (Table 3). All the sires between the ecotype differed significantly ($p < 0.05$) in their effect on fertility, embryonic mortality and hatchability (Table 3).

Traits	Ecotype	Mean (%)	SE	SD	CV
Fertility	1	63.59 ^a	± 1.09	12.46	19.59
	2	56.62 ^b	± 2.07	16.81	29.70
Hatchability	1	58.12 ^a	± 1.35	15.44	26.56
	2	51.78 ^b	± 2.28	18.52	35.77
Embryonic	1	35.19 ^a	± 1.18	12.72	36.15
Mortality	2	36.64 ^b	± 0.25	48.12	49.46

a,b figures within different superscripts down the group are significantly ($P < 0.05$) different. SE = standard error, SD = standard deviation CV coefficient of variation

Table 3: Effect of ecotype on fertility, embryonic mortality and hatchability.

Analysis of variance result also indicated that sire had a significant effect on fertility, hatchability and embryonic mortality (Table 4).

Sources of variation		DF	SS	MS	F
Sire	Ferti.	38	392.065	196.032	1.4565*
	Hatcha.	38	2188099	10.94.050	6.283**
	Embryo.	38	629.763	314.881	1.789*
Dam	Fert.	28	5977.693	213.489	1.595*
	Hatch.	28	10226.127	3.65.219	2.095**
	Embryo.	28	9426.213	336.650	1.913*
Error	Fert.	178	18604.575	133.846	
	Hatch.	11	24202.856	174.121	
	Embryo.	11	24459.295	175.966	

*Significant at ($p < 0.05$), **significant at ($P < 0.01$), ns: not significant. Fert. = Fertility, Hatch = Hatchability, Embro mor = Embryonic mortality and SE = Standard error.

Table 4: Effect of sire and dam on fertility, embryonic mortality and hatchability of the ecotypes.

Discussion

Effect of dam on fertility, embryonic mortality and hatchability

The significant effect of dam on fertility within and between the ecotypes was due to the dam's ability to mate successfully, store the sperm, ovulate an egg cell and produced a suitable environment for the formation and development of the embryo. Bennowitz and Brommer [3, 13-14] also reported significant effect of dam on fertility of layer hens. Thus selecting superior dams within the population will improve fertility. The significant effect of dam within and between the ecotypes on hatchability was also understandable. This is because hatchability depends on genetic variance, egg environment, nutrients sufficiency and delivery systems which are dam's and sire traits. Egg quality both internal (quality of albumen, size of various internal components and integrity of shell membrane); and external (size, shape and structure, thickness and strength of shell) which are dam traits, all affect hatchability also reported significant effect of dam on hatchability. The formation of viable embryo was affected by genetic and environmental factors originating from the dam [22]. Genetic variation in hatchability of the fertile egg may partly arose from the dam which laid the egg due to quality of the laid eggs that affected successful development of the embryo to become chick during incubation and the emergence of the chick from the egg at hatching made similar observation on genetic variation in hatchability [23,24].

The ability of the mature chick to break out (chick vigour) of the egg shell at hatching was affected by genes contributed by the dam, the internal egg environment and the environment to which the egg was exposed, and also common permanent and temporal environmental effect due to the dam. Wolc [24] also reported significant effect of dam on hatchability of laying white leghorn birds. The observed significant differences between dams within and between ecotypes on fertility and hatchability were due to the additive and non-additive genetic differences that existed between the dams. There were thus dams in these populations with superior additive and non-additive genetic variances that could be selected for genetic improvement of these

traits. The observed significant differences within and between the ecotypes due to dam effect on embryonic mortality was also expected. Embryonic mortality is a function of the genotype of the embryo that depended part by the genes received from the dam; and the egg environment which depended solely on the dam. The high embryo mortalities may be due to chromosomal aberrations and lethal genes, or insufficient nutrients delivery systems [25] and this indicated that embryo mortality is also a trait of the dam.16 made similar observation. The significant variation that existed between dams within and between ecotypes was also ascribed to the differences in the genetic potentials of the dams in this trait. The significant ($P < 0.05$) effect of ecotype on fertility and hatchability was also expected. This implied that there were levels of genetic differences between the dams of these ecotypes had reported significant genetic distances between these ecotypes. It also indicated that these traits were influenced by genetic effects [26]. The influence from the dam may be due to the additive and non-additive genetic variance of the dam that determine its maternal effects, egg environment and nutrients delivery systems that support fertility, embryo survival and hatchability, and that which affect maternal effects, egg environment and nutrients delivery systems that do not support fertility, embryo survival and hatchability due to genetic variation.

Effect of sire on fertility, embryonic mortality and hatchability

The significant effect of sire on fertility was due to the ability of the sire to mate successfully, release enough quantity and quality of semen and deposit that in the female reproductive tract also reported significant effect of sire on fertility of broiler breeders [27]. Although fertility had been treated as maternal effect to include non-random genetic effect of mate; the genetic factors in both sexes determine fertility [12]. The male and female genetic, permanent environmental effects and covariance between genetic effects and non-random, non-genetic effect of mates accounted for all sources of variation. The significant ($P < 0.05$) effect of sire on hatchability is also understandable. The formation of viable embryo is a process affected by genetic and environmental factors originating from the sire and dam. The ability of the mature embryo to break out of the egg shell at

hatching was affected by its genotype in which the sire also contributed. The fertility of eggs set is a function of both the hen and her male mate. This also implied that both the sire and the dam genetic superiority or inferiority affects hatchability. Selecting superior sires and dams within local chicken populations for breeding will enhance genetic improvement of hatchability.

The significant effect of sire on embryonic mortality was because embryonic survival is a function of egg environment and its genotype. The genotype depends on genes received from the sire and dam. The significant ($P < 0.05$) differences that existed between the sires within the ecotype indicated that there were genetic differences between the sires used in the study on these traits had also reported on the distribution of embryonic mortality in broiler breeders. The influence from the sire was due to additive genetic variance of the sire determining fertility, embryo survival and hatchability due to proper messenger splicing. Or that determining the frequency of deleterious and lethal genes that had transition that disrupt proper messenger splicing due to chromosomal aberration that were contributed by the sire [28].

It is evident from this study that, fertility and embryonic mortality are sub-traits of hatchability. Breeding program designs for genetic improvement of hatchability in the local chicken must therefore, include these hatchability sub-traits. Thus a breeding program for genetic improvement of hatchability in the local chicken must combine superior sires and dam's base on high fertility, low embryonic mortality and high hatchability in a multiple traits selection for mating in order to improve these traits. This implies that independent improvement of hatchability requires selection for fertility and embryonic mortality rather than only hatchability.

It is also important to note the influence of egg environment, maternal and other non-genetic effects on these traits. These non-genetic factors must be given their desire attention to limit their restrictions on the expressions of the genes controlling these traits. It is only after these that, superior genotypes in these traits could be identified, selected and concentrated or reconstituted through breeding to improve hatchability.

Conclusion

Sire and dam had significant effect on fertility, embryonic mortality and hatchability. The influence from the dam were due to the additive and non-additive genetic variance of the dam that determine its maternal effects, egg environment and nutrients delivery systems that support fertility, embryo survival and hatchability, and that which affect maternal effects, egg environment and nutrients delivery systems that do not support fertility, embryo survival and hatchability due to genetic variation. The influence from the sire was due to additive genetic variance of the sire determining fertility, embryo survival and hatchability due to proper messenger splicing. Or the additive genetic variance of the sire that determines the frequency of deleterious and lethal genes that had transition that disrupted proper messenger splicing due to chromosomal aberration. Selecting superior sires and dams from the population base on high fertility, embryo survival and hatchability in a multiple traits selection may lead to genetic improvement of these traits.

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