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Additive Genetic Effect of Dam-sire, Dam, Common Maternal and Environmental Effect on Clutch Traits of Two Nigerian Local Chickens Populations

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ABSTRACT

The study was conducted at Akpehe poultry farm, Makurdi. The objectives of the study were to assess the additive genetic effects of dam-sire, dam and maternal effects on clutch traits with the aim to apply these to selection and breeding in order to improve these traits.120 birds were used for the study, 60 each for the Fulani and the Tiv ecotypes. The birds were housed singly in identified cages and hand mated in the pen. Data were collected on clutch size, clutch number, pause length and number, month, sire, dam and ecotype. Ecotype significantly affected clutch size and clutch number. Pause length and number were not affected by ecotype. The additive genetic effect of the sire and dam significantly affected clutch size and clutch number. Heritability estimates due to sire on pulse length and pulse number were very low, while the heritability estimates for clutch number and clutch size were moderate. Non additive genetic effect of the dam ,other maternal environment as well as month significantly affected clutch number, pause length and number. Selecting superior birds based on clutch size and number due moderate heritability estimates will lead to genetic improvement in egg number especially when dam conditions and management employed are improved.

***Keywords*:** additive-effect; clutch-traits; dam and sire

1. INTRODUCTION

Chickens lay eggs on successive days known as clutch after which they will not lay for more than one or more days (North, 1976). The number of such successive clutches in a given period is the clutch number while the number of eggs lays in a clutch is the clutch size. Otchere *et al.* (1990) reported a clutch size of 10.4 eggs for Nigeria indigenous chicken under scavenging systems. The local fowl was also reported to lay 3.1 ±0.2 eggs in a clutch under intensive management (Omeje and Nwosu, 1983). Clutch size showed negative phenotypic correlation with egg number in local chickens (Omeje and Nwosu, 1983). The interval between clutches is the pause; the number of such interval is the pause number. The pause length is the length of the interval in days. Calculations of pause number and length as well as clutch number are only possible where birds are housed singly and their individual egg production is recorded daily. Omeje and Nwosu, (1983) reported pause number and length in local chickens during short-term egg production to be 15 ±1.1 and 3 ±0.04 days respectively. Nwosu (1990) summarized that the poor egg performance of the local chicken is probably tied to poor management under extensive systems and to long pause length of 3 days as well as their low clutch number of 16 and clutch size of 3.1, all of which are found to be related to the fowls low egg number. Additive genetic effect on traits is a measure of the heritability estimates of the trait. It is a parameter that indicates the ability of an individual to pass it genetic attribute to its offspring. Heritability is not a biological constant, as it can be affected by management procedure and method of estimation. It is a property not only of the trait, but also of the population and environmental conditions surrounding the animals (Falconer, 1989) and, therefore, varies from population to population. Heritability estimates for traits are usually categorized into three classes viz, low, moderate and high with it values in all cases ranging from 0-1 or 0-100%. Low heritability -(0-0.19) moderate heritability -(0.2-0.39) and high heritability -(0.4 and above). Low heritability is an indication that variability due to additive gene action is probably small or the non-additive gene actions such as dominance, over dominance and epitasis may be important in addition to environmental factors. On the other hand, high heritability values indicate that hereditary rather than environmental factors are more important in the expression of the trait concerned. The objectives of the study were to assess the additive genetic effects of dam-sire, dam and maternal effects on clutch traits with the aim to apply these to selection and breeding in order to improve these traits.

2. MATERIALS AND METHODS

2. 1. Experimental site

The study was carried out at Akpehe poultry farm, Makurdi. Akpehe poultry farm is located on latitude 7°41’ N and longitude 8°31’ E (Microsoft Encarta, 2008). Makurdi is warm with temperature range of 17.3-35.6 °C. Rainfall is between 508-1016 mm (BSN, 1982). The relative humidity ranged from 47-85 percent (TAC, 2002).

2. 2. Experimental animals

The Tiv and the Fulani local chickens were purchased from different rural farming communities and identified. About 120 birds comprising 50 pullets and 10 males for each ecotype were purchased. The birds were bought in five groups of 12 birds per group for each ecotype and one group from each rural farming community. (Gbise, Gesa, Vingir, Utim and Senga village for the Tiv ecotype. The Fulani ecotype were purchased from Fulani settlements at Tsea village, river Benue bank, Abinsi, Kardarko and river Katsina-Ala).

2. 3. Management of Animals

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. They were reared on deep litter management system. The birds were given anti stress on arrival and also on the following day, were vaccinated against Newcastle disease (Lasota). They were deworm and dusted for ectoparasites and allowed to acclimatize for four weeks. They were fed a formulated dietcontaining 18 percent crude protein. The birds were fed in the morning and evening and water was provided *ad libitum.*

2. 4. Experimental design and procedure

The experimental design was the completely randomized design. There were a total of ten pens numbering 1to 10. Pens number 1 to 5 were allocated to Fulani ecotype while pens number 6 to 10 were for the Tiv ecotype . Each pen was partitioned into 11 units by wire mesh. This units were also numbered as p1c1, p1c2, p1c3, p1c4, p1c5, p1c6, p1c7, p1c8, p1c9, p1c10 and p1c11 for pen 1.This was done for pen 2, 3, 4, 5, 6, 7, 8, 9 and 10 respectively. The birds were also organized into 5 groups of 10 females and 1 male for each ecotype giving a total of 10 groups. These 10 groups were allocated to the pens by random permutation as well as in the partitioned units . The number on the partitioned units were used for identification of the sires, dams, eggs and their chicks. Each bird was housed singly in a cage. A mating ratio of 10:1 (female: male) was employed for all the groups by pen mating.

2. 5. Data collection and Analysis

Data were collected on clutch size, clutch number, pause number and length, sire, dam and month. Analysis of variance was used to compare these effects using the models below.

2. 6. Clutch traits

One way analysis of variance SAS (1998) was used to compare effect of ecotype and clutch traits using the model below.

$$Y_{ijklm} = \mu + E_i + Cn_j + Cs_k + Pn_l + Pl_m + e_{ijklm}$$

where:
Y_{ijklm} = Clutch number of the i^{th} individual in the $_j$th ecotype.
μ = Population mean
E_i = Effect of the i^{th} ecotype
Cn_j = Clutch number of the $_j$th individual.
Cs_k = Clutch size of the k^{th} individual.
Pn_l = Pause number of the l^{th} individual.
Pl_m = Pause length of m^{th} individual
e_{ijklm} = Residual random error

2. 7. Estimation of heritability

The intraclass correlation coefficient method was use to estimate heritability. This method is use when data of progeny but not of parents are averaged. The individuals were grouped as full sib families. By analysis of variance the total observed variance were partitioned into between ecotypes and within ecotypes variance components. The ratio of between ecotypes variance component to total variance component were the intraclass correlation coefficients and were given by

$$t = \frac{\sigma_B^2}{\sigma_B^2 + \sigma_W^2}$$

where: σ^2_B = is the between ecotype variance component
σ^2_W = is the within-ecotype variance component
t = symbol for intraclass correlation.

The between ecotypes vriance component expresses the amount of variation that was common to members of the same ecotype and it can be referred as the covariance (COV) of members of the ecotypes. The intra class correlation coefficients (t) among full sib was used to estimate h^2. Full sibs are relatives who have both parents in common. The coefficient of relationship between full sibs is 0.50. The intra class correlation coefficients (t) among fullsib was estimated by

$$\mathbf{t_{(FS)} = \tfrac{1}{2} h^2}$$

where: $t_{(FS)}$ = intra class correlation coefficients (t) among fullsib
h^2_S = Heritability estimates and heritability due sire was estimated by

$$\mathbf{h^2_S = 2t_{(FS)}}$$

where: $t_{(FS)}$ = intra class correlation coefficients (t) among fullsib
h^2_S = Heritability estimates and heritability due sire was estimated by

2. 8. Effect of sire and dam

The effect of sire and dam on clutch number and size, pause number and length, were also compared using the model.

$$Y_{ijk} = \mu + S_i + D_j + e_{ijk}$$

where: Y_{ijk} = Measurement of clutch number, clutch size, pause number and pause Length of any individual.
μ = Population mean
S_i = Effect of sire (j = 1,2…15)
D_j = Effect of Dam (k = 1,2,3….100).
e_{ijk} = Residual random error.

3. RESULTS

3. 1. Genetic effect on clutch traits

Ecotype had significant ($P < 0.05$) effect on clutch number and clutch size. Pause number and pause length were not significantly ($P > 0.05$) affected by ecotype (Table 1). Analysis of variance result also indicated significant ($P < 0.05$) effect of ecotype on clutch number and clutch size (Table 1).

Table 1. Mean values of effect of ecotype on clutch number, clutch size, pause number and pause length.

Clutch Trait	Ecotype	Mean	SE
Clutch Number	Fulani Tiv	2.80^{a} 2.02^{b}	0.19 0.08
Clutch Size	Fulani Tiv	9.63^{a} 7.21^{b}	0.40 0.44
Pause Number	Fulani Tiv	3.23^{a} 3.54^{a}	0.11 0.19
Pause length	Fulani Tiv	2.59^{a} 2.62^{a}	0.11 0.14

a,b, figures with different superscript within a clutch trait are significantly different at $P < 0.05$.
SE standard error

Table 2. Mean square values of effect of ecotype on clutch traits.

Sources of variation	Degree of freedom	SS	MS	Fcal
Ecotype				
Clutch Number	1	18.25	18.25	16.64**
Clutch Size	1	177.6	177.60	15.98**
Pause Number	1	2.84	2.84	1.96^{ns}
Pause Length	1	0.021	0.92	0.02^{ns}
Error				
Clutch Number	123	134.90	1.10	
Clutch Size	123	1367.7	11.1	
Pause Number	123	177.96	1.45	
Pause Length	123	117.98	0.96	

** Significant at $P < 0.01$
ns not significant.

3. 2. Additive genetic effect of dam-sire on clutch traits

Within the Fulani ecotype, dam-sire had a significant (P < 0.05) effect on pause number and clutch size. Whiledam-sire had no effect on pause length and clutch number significantly (P < 0.01) (Table 3). Within the Tiv ecotype dam-sire significantly (P < 0.05) affected clutch number and clutch size. Pause number and pause length were not significantly affected (Table 4).

Table 3. Mean square values of effect of sire on clutch traits of the Fulani ecotype.

Sources of variation	Degree of Freedom	SS	MS	Fcal
Sire				
Clutch Number	1	0.17	0.17	0.11^{ns}
Clutch Size	1	1739.84	1739.84	262.74**
Pause Number	1	9.38	9.38	7.36^{*}
Pause Length	1	0.68	0.68	0.57^{ns}
Error				
Clutch Number	144	224.44	1.56	
Clutch Size	144	953.53	6.62	
Pause Number	144	183.56	1.27	
Pause Length	144	1788	1.21	

** Significant at P < 0.01
*Significant at P < 0.05
ns not significant.

Table 4. Mean square values of effect of sire on the clutch traits of the Tiv ecotype.

Sources of Variation	Degree of Freedom	SS	MS	Fcal
Sire				
Clutch Number	1	1330.62	1330.62	394.06*
Clutch Size	1	100.04	100.04	12.03**
Pause Number	1	825.47	825.47	196.56^{ns}
Pause Length	1	1118.09	1118.09	301.91^{ns}
Error				
Clutch Number	102	344.42	3.38	
Clutch Size	102	848.12	8.31	
Pause Number	102	428.37	4.20	
Pause Number	102	377.75	3.70	

** Significant at P < 0.01
*Significant at P < 0.05
ns not significant

3. 3. Additive genetic effect of dam on clutch traits

Mean square values due to effect of dam was significant (P < 0.05) on all the clutch traits both within the Fulani and the Tiv ecotypes (Tables 5 and 6).

Table 5. Mean square values of effect of dam on clutch traits of the Tiv ecotype.

Sources of Variation	Degree of Freedom	SS	MS	Fcal
Dam				
Clutch Number	1	50292.20	50292.20	3380.84*
Clutch Size	1	39118.20	39118.20	945.81*
Pause Number	1	46877.50	46877.50	1258.65*
Pause Length	1	48937.80	48937.80	1331.71*
Error				
Clutch Number	102	3715.00	36.40	
Clutch Size	102	4218.70	41.40	
Pause Number	102	3978.90	37.20	
Pause Length	102	3748.30	36.70	

*Significant at P < 0.05

Table 6. Mean square values of effect of Dam on clutch traits of the Fulani ecotype.

Sources of Variation	Degree of Freedom	SS	MS	Fcal
Dam				
Clutch Number	1	4460.60	4460.60	141.01**
Clutch Size	1	649.80	649.80	17.71**
Pause Number	1	4113.90	4113.90	131.22*
Pause Length	1	4628.00	4628.00	147.93**
Error				
Clutch Number	144	4555.30	31.60	
Clutch Size	144	5284.40	36.70	
Pause Number	144	4514.40	31.30	
Pause Length	144	4505.00	31.30	

** Significant at P < 0.01
*Significant at P < 0.05

3. 4. Environmental effect on clutch traits

Among the Fulani ecotype month effects significantly (P < 0.05) affected all clutch traits (Tables 7). While within the Tiv ecotypes the effects of months were significant (P <

0.05) on clutch number, pause number and pause length, clutch size was not affected significantly (P < 0.05) by the effects of months (Table 8).

Table 7. Mean square values of month effect on clutch trait of the Fulani ecotype.

Sources of Variation	Degree of Freedom	SS	MS	Fcal
Month				
Clutch Number	1	608.62	608.62	165.14*
Clutch Size	1	242.55	242.55	26.93*
Pause Number	1	487.95	487.95	144.06*
Pause Length	1	669.78	669.78	201.82*
Error				
Clutch Number	137	504.90	3.69	
Clutch Size	137	1234.00	9.01	
Pause Number	137	464.03	3.39	
Pause Length	137	453.66	3.32	

* Significant at P < 0.05

Table 8. Mean square values of effect of month on clutch traits of the Tiv ecotype.

Sources of Variation	**Degree of Freedom**	**SS**	**MS**	**Fcal**
Month				
Clutch Size	1	553.85	553.85	165.65*
Clutch Number	1	8.65	8.65	1.04ns
Pause Number	1	249.24	249.24	59.82*
Pause Length	1	420.01	420.01	114.44*
Error				
Clutch Number	102	341.04	3.34	
Clutch Size	102	844.73	8.28	
Pause Number	102	424.98	4.17	
Pause Length	102			

*Significant at P < 0.05 ns.not significant.
SS sum of squares, MS. mean squares and Fcal. F calculated.

3. 5. Maternal effect on clutch traits

Dam had significant effect on pause number, pause length and clutch number of the ecotypes (Tables 5 and 6).

3. 6. Heritability estimates from Sire variance component of clutch traits of the ecotypes

The least heritability estimates were recorded on pause length (0.036 and 0.048) in the Fulani and Tiv ecotype populations, respectively.This was followed by the estimates for pause number (0.045 and 0.063) in the same order as above. Clutch number recorded high heritability estimates under the Fulani ecotype (0. 412) and mordrate heritability estimates under the Tiv ecotype (0.391). Clutch size recorded moderate heritability estimates for the Fulani ecotype (0.358) while that for the Tiv ecotype (0.428) was high (Table 9).

Table 9. Heritability estimates from sire variance components of clutch traits of the ecotypes.

Parameters	Ecotype	
	Fulani (h^2s)	**Tiv (h^2s)**
Clutch size	0.358	0.428
Clutch number	0.412	0.391
Pause number	0.045	0.063
Pause length	0.036	0.048

h^2_S: Heritability estimates due to sire.

4. DISCUSSION

4. 1. Genetic effect on clutch traits

The significant (P < 0.05) effect of ecotype on clutch number and size indicated that the ecotype differed genetically. The variations in the additive and non-additive genetic effects between the ecotypes were responsible for the differences in their potential and expression in clutch number and size. El-labban et al. (2011) also reported variation in clutch number and size due to different strains of local birds in Egypt. The non significant effect of ecotype on pause number and pause length could be due to higher non additive genetic effect and environmental influence on these traits.

The mean values obtained in this study on clutch traits are within the range of previous reports. The mean clutch size observed for the Fulani ecotype (9.630±0.401) was higher than the report of Akbas et al. (2002) (7.41), Luc et al. (1996) (5.30 and 6.21), but less than the estimates of (11.7 and 16.5) reported by Bednarczyk et al. (2000). The mean clutch size observed for the Tiv ecotype (7.212±0.444) was less than (7.41) reported by Akbas et al. (2002) and (11.7 and 16.5) and Bednarczyk et al. (2000). Horst, (1988) reported that the genetic resource base of the indigenous chicken in the tropics is rich and should form the basis for genetic improvement and diversification to produce a breed adapted to the tropics.

4. 2. Additive genetic effect of dam-sire on clutch traits

The significant (P < 0.05) effects of dam-sire on clutch number and clutch size within the Fulani ecotype also indicated that the additive genetic effect of the dam-sire significantly (P < 0.05) affected these traits. The dam received an X chromosome determining her offspring sex from the dam-sire, it is expected that the additive genetic variance of the dam-sire will influence clutch traits as observed in this study. Bennewitz et al. (2007) also reported significant effect of sire on clutch size and number in laying hens. Thus selecting superior sires within the population to be parent of the next generation will improve clutch number and size. The insignificant effect of dam-sire on clutch number and pause length suggested that non-additive genetic effects and other environmental factors have greater effects on these traits. Improving the environment will allow greater expression of the genetic potentials of the birds on these traits.

4. 3. Additive genetic effect of dam on clutch traits

The significant ($P < 0.05$) effect of dam on clutch size and clutch number of the ecotypes was understandable. This indicated that the additive genetic effects of the dam exert greater influence on these traits. Applying selection targeting superior dams with specific objectives at higher selection intensity on clutch size and clutch number will improve the genetic potentials of clutch traits within the ecotypes populations.

4. 4. Heritability estimates from sire variance component of clutch traits.

The heritability estimates observed in this study on pause length are in line with the report of Akbas et al. (2002), but lower than the report of Kieu et al. (1996). The differences in the value observed in the study was due to differences in breed, environment and management, as well as the fact that the the birds were not selected for these traits. The heritability estimates for pause number recorded in the study are in the range of the report of AM El-Labban et al. (2011) (0.00 to 0.07). It does appear that pause number and pause length are controlled more by non additive genetic effects and the environment than the additive genetic effects. It is however wise to mention that, the measure of additive effect on traits (heritability), is not a biological constant, as it can be affected by management procedure and method of estimation. It is a property not only of the trait, but also of the population and environmental conditions surrounding the animals (Falconer, 1981) and, therefore, varies from population to population. Giving improve conditions the values observed may improve. Family and within family selection can be applied to pulse length and pulse number for genetic improvement of these traits. However, selecting from a large population using appropriate breeding program between selected lines will yield greater genetic improvement in these traits.

The heritability estimates recorded for clutch number and clutch size were in the range reported by Kieu et al. (1996) and Akbas et al. (2002) who reported 0.43 ± 0.22 and 0.43 ± 0.23, 0.407 and 0.231 for clutch number and clutch size from commercial sire lines. The high heritability observed in the study indicated that the additive genetic effects have significant ($P < 0.05$) influence on these traits. This indicated high potentials of these ecotypes for genetic improvement through individual and or mass selection. This study also indicated genetic disimilariry in the indigenous chicken ecotypes populations of Nigeria even though they have not been characterized and are closely related to their jungle fowl (Gallus Gallus) ancestors (AACMC, 1984). There are wide variations in clutch production characteristics. These variations may have arisen mainly from geographical isolations, management practices, and selection criteria imposed by natural challenges and/or man-made depending on the differences in the Scio-cultural life-style of their keepers and their migratory pattern.

4. 5. Effect of environment on clutch traits

The significant effect of month on all the clutch traits was also expected. This showed that climatic variations affect clutch traits. The birds would eat less at very hot months; body heat regulation through evaporative cooling will be low at rainy months. The sum total of these significantly affected clutch size as noted in this study. Falconer and Mackay (1996) also reported a similar observation. The Tiv ecotype appeared to have tolerated the environmental restrictions on clutch traits more than the Fulani ecotype. It had greater expression of its genetic potential in clutch traits than the Fulani ecotype. This was because the study was conducted in an environment that the Tiv ecotype was used to compares to the Fulani ecotype that were brought from other environment and have never been reared under such conditions.

4. 6. Effect of common maternal environment on clutch traits

The significant ($P < 0.05$) effect of dam on pause number and length (which appears not to be under the influence of additive genetic effects) indicated that non additive genetic effects of the dam and common maternal environment due to the dam exert significant influence on pause number and length. Thus aside the additive genetic potential of the dam, other on additive genetic effects of the dam and common maternal effects like dam's body condition, age, nutritional needs and health status exert considerable influence on clutch traits. These factors must be considered in attempting to improve clutch traits through the dam line.

7. CONCLUSION AND RECOMMENDATION

7. 1. Conclusion

Clutch size and clutch number were strongly influenced by additive genetic effects. They thus varied from ecotype to ecotype. These traits can be improve by selecting superior sires and dams to be parents of the next generation. Common maternal environment, dam non-additive genetic effects and the production environment also exert influence on clutch traits.

7. 2. Recommendation

Egg number can be improved by selecting superior birds (dam and sire lines) using clutch size and clutch number as the selection criteria. The dam's body condition and the physical production environment must be given priority to allow maximal expression of the genes in order to achieve genetic progress.

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