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Genotype by Environmental Interaction Effects on Laying Characteristics of Lohman Brown in Sub-Humid Tropics of Nigeria

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ABSTRACT

Egg production performance of Lohman breed were collected from production record at the Livestock Teaching and Research Farm Federal University of Agriculture Makurdi, Nigeria. The records were collected from 2010 – 2015 to assess the effect of year and season on brooding mortality, age at first egg, at peak production, hen-day lay at 25 weeks and at peak production when the data were subjected to descriptive statistics. There was significant ($p < 0.05$) difference in brooding mortality between seasons and years. The study also showed that age at first egg varied significantly ($p < 0.05$) between the years. The age at first egg of 2010 and 2011 were similar but both differed significantly ($p<0.05$) from the age at first egg of the year 2014. Age at peak production were also significant at ($p < 0.05$) between the years. There was delayed age at peak production in 2010 and 2011 while that of 2014 came earlier. There were also significant differences ($p < 0.05$) in peak hen-day lay between the years. There were also significant differences ($p < 0.05$) in hen-day lay at 25 weeks between the years. The hen day-lay of 2014 had the least value. This implied that there was variation in the climatic conditions across the years and seasons that affected these parameters in varied degrees, that also elicited varied deviation and responses from the genotype. The dry seasons enhanced higher deviation and reduced response on these performance from the genotype, while the deviation from the effect of the wet seasons were less with higher responses from the genotype on these performance. This indicated that climatic conditions and their effects varied between and within years. Brooding mortality, age at first egg and at peak production were the parameters that were highly affected. A good stocking plan to enhance brooding, age at first egg and at peak production to occur in the wet season will enhance higher responses, reduce deviation from climatic impact and increase egg production performance.

Keywords: *Age-at-peak, climatic- condition, genotype, hen-day- lay, peak-production, year*

INTRODUCTION

Layers are sexually mature female birds raised for egg production. A layer is a hen in its physiological state of regularly egg production (Sastry and Thomas 2010; Damron, 2009 and Taneja et al., 2008). Egg laying starts at 20 weeks of age, progresses and rises to a peak and remained economical up to 72 to 75 weeks and begins to decline with advance in age. When the egg production goes below the economical level or the breakeven point, the birds are culled (Sastry and Thomas, 2010). According to Taneja et al. (2008), layer flocks should be transfers from grower house to layer house at 18 to 20 weeks of age. At 18 weeks of age, all under grown pullets are to be cull from the flock. Careful selection at the time of housing enables better returns and fewer cull at point of first egg production (Sastry and Thomas,2010). The stock can either be reared in the same house where it was brooded /reared or transferred to the laying house. Sastry and Thomas, (2010) stated that the laying period, also called laying cycle or biological year is when the birds reach 5% egg production on hen- day basis and continues to the end of the birds laying age. The age at which a hen begins to lay eggs affects the total egg production in its life cycle (Dafwang, 1987). According to Sastry and Thomas, (2010) selection of laying hens is normally based on partial records, improvement in egg production occurs largely in the first part of the laying cycle. Brown (2010) recommended that most profitable way for layer production is to follow "all in, all out" practice. Urban populations are rapidly growing throughout the tropics and there is need to equally increases poultry production.

The layer industries are distributed in a pattern much like that of human populations, across regions, agro-climatic zones, tropical regions and temperate regions (Damron, 2009). Most of the layer birds are developed from other regions of the world to be introduced to other regions that do not have the capacity to develop layer birds fitted to their environment. While there is no doubt that these birds have been selected to a superior point in egg production, the environmental deviation restricting the full expression of their genetic potential in the varied regions they may be introduce are completely unknown. At the locations of introduction, diverse climatic and management conditions would certainly affect the mean performance of even the most superior genotype. Breed variability and superiority at this point becomes less critical, as the covariance between the genotype and the environment as well as the interaction between the genotype and the environment becomes the determining factors dictating performance, degree of tolerance, susceptibility and fitness into that location. It is only when there is environmental correlation between the location of breed development and that of introduction that the covariance between the genotype and the environment as well as the interaction between the genotype and the environment becomes less critical for breed diversity to dictate production levels. Performance of layer breeds introduced into the tropical conditions of Nigeria may also not be affected only by their genetic potentials. The genotype enviroment covariance and interaction would no doubt determines the production levels. Commercial poultry production ranks among the highest source of animal protein in Nigeria. Leenstra and Sambeek, (2014) pointed out that worldwide, all commercial poultry are being produced by breeding companies. Gomulka et al. (2010) reported that longer sequence lengths, fewer pauses, shorter pause lengths, and uniform oviposition time indicate good laying performance. However these are affected by environmental conditions.

Lohman breed (layer breed) is used by many layer producers, cooperate farms, many research institutes and on the Livestock Teaching and Research farm University of Agriculture, Makurdi, Nigeria. This study was designed to provide information on the effect of years and season within years as a measure of the breed environmental covariance and the breed environmental interaction effects that determines its fitness and performance under Nigeria tropical conditions. The study was also intended to provide information to prospective farmers on critical enviromental factors limiting the full expression of lohman breed laying characteristics as well as how these can be managed to enhance improve performance.

MATERIALS AND METHOD

Location of study

The study was conducted at the Teaching and Research Farm, Federal University of Agriculture, Makurdi. Nigeria. Makurdi is located in the Guinea Savannah zone of Nigeria. Makurdi is located between latitude 7^{o}38'' N,7^{o}50'' N, and longitude 8^{o}24'' E and 8^{o}38'' E. It is situated in the Benue valley in the North Central region of Nigeria. The climate of Makurdi consists of the tropical wet and dry seasons. The rainy season lasts from April to October, with a five (5) month dry season (November to March). Annual rainfall in Makurdi was reported have mean value of 1173mm (Abah, 2012). Temperature in Makurdi varies from a daily minimum of 22.5^{0}C and a maximum of 40^{o}C (Ologunorisa and Tor, 2006). Temperature in Makurdi was generally high throughout the year, with February and March being the hottest months.

Experimental Birds and their Management

The experimental birds were lohman brown (commercial laying stock) reared from day-old to point of lay, peak production and to spent age. The period of brooding lasted from day-old to 8 weeks, after which the birds were transferred to the rearing/laying house on deep litter at week 9. During brooding period, the chicks were fed with chick mash, while at week 9 to 18 the birds were fed a grower mash. At 19 weeks and above. Layer mash was fed to the birds. Proper sanitation was maintained throughout in the birds' houses. Routine medication and vaccination against infectious diseases were carried out . Fresh and clean water was supplied ad libitum.

Experimental Procedures, Data Collection and Analysis

Data were collected from farm records routinely kept on brooding , brooding mortality, age at first egg, at peak production, hen-day lay at 25 weeks and at peak production from the layer section of the Teaching and Research Farm of the Federal University of Agriculture Makurdi. The data used in this study were secondary data for the period of 2010-2015 from the Livestock Teaching and Research Farm, Federal University of Agriculture, Makurdi. Meteorological report from 2010 to 2015 was also collected from the Nigeria Meteorological agency Makurdi, on temperature, rainfall and relative humidity. Data were subjected to descriptive statistics using MINITAB14 Statistical package to estimates the effects of year, seasons between years, within years and days within months and seasons on egg production traits of lohman breed in sub humid tropics of Nigeria.

Table1.*Effects of Dry Season between years on Percentage Mortality of Lohman breed during brooding*

Variables		**Mortality**			
Year	**Number of birds**	**Mean**	**Standard error**	**Minimum**	**Maximum**
2010	570.00	10.86^{b}	2.59	4.00	22.00
2011	426.00	7.75^{c}	0.85	6.00	10.00
2013	656.00	6.00^{c}	1.30	2.00	10.00
2014	791.00	31.90^{a}	16.40	5.00	124.00

a, b, c, figures with different superscripts down the column are significantly (p < 0.05) different.

Table2.*Effects of Wet Season between years on Percentage Mortality of Lohman breeds during brooding*

Variables	**Mortality**				
Year	**Number of Birds**	**Mean**	**SE**	**Min**	**Max**
2010	588	3.67^{c}	0.49	2.00	5.00
2011	453	3.29^{c}	0.47	2.00	6.00
2013	724	15.33^{a}	3.68	7.00	31.00
2014	811	11.54^{b}	4.34	1.00	57.00

SE, Standard error, Min, Minimum, Max, Maximum, a, b, c, figures with different superscripts down the column are significant (p < 0.05) different.

Results and Discussion

Effect of dry and wet seasons on brooding Mortality between years

The percentage brooding mortality for the dry season is presented in table 1. Brooding mortality of 2014 dry season was the highest and was significantly ($p < 0.05$) different from that of 2010, 2011 and 2013 years (Table 1). There was no significant ($p> 0.05$) difference between the dry season brooding mortality of 2011 and 2013 years. While the brooding mortality of 2010 dry season which was the second highest was significantly ($p < 0.05$) different from that of the other years (Table 1). In the wet season the highest percentage brooding mortality was recorded in 2013 (Table 2). The brooding mortality in the wet season of 2013 was significantly ($p < 0.05$) higher from that of the other years. This was followed by the brooding mortality of 2014 wet season that was also significant (($p < 0.05$) from that of 2010 and 2011 wet season mortalities. The brooding mortalities of the wet seasons of 2010 and 2011 were not significantly ($p < 0.05$). Generally, high percentages of brooding mortalities were recorded in dry seasons as compared to the wet seasons. This might be due to climatic factors that varied between the seasons. This is in line with the report of NAERLS, (2000) who pointed out that chick mortality was highest during the dry season because dehydration was added to the other causes of mortality. The high brooding mortality in the wet seasons of 2013 and 2014 could due to excessive rainfall of 107.30% in 2013 and 105.50% in 2014 .This would made litter management difficult while at the same favoring the proliferation of disease causing micro-organisms, there would be more disease challenges and higher incidence of brooding mortality as observed.

Effect of year on Age at First Egg

There was significant difference in the age at first egg between the different batches of Lohman breeds in 2014, 2013, 2011 and 2010 (Table 3). This may not only be attributed to effect of year as the segregation of genes to produce the commercial line is a random effect. Variation in genetic potential may occur between batches. However, deviation from the genetic mean value of age at first egg may occur due to effect of year. This is line with the findings of Williamson et al. (1984) who stated that the major factors that determine age of pullets at first laying are breed, with light breeds lying at an earlier age than heavy breeds. Also, Kekeocha, (1987) and Dafwang, (1987) both reported that age at first egg depends on the breed. Similarly, Sunil, (2008) also noted that different breeds starts laying at different ages. However, the variation in age at first egg of Lohman breed in 2014 may be due to effects of year. Other authors had also reported ranges in age at first egg as a deviation from the mean value due to non genetic effects. Cooper and Appleby, (1996) reported age at first egg for Rhode Island Reds, Delaware's' and Barred Rocks to range from 18 – 20 weeks, Amin and Hamidi, (2013) reported for modern hybrid layers 18 – 20 weeks.

Effect of year on persistency of lay at 25 Weeks

There was no significant ($p < 0.05$) difference in the hen-day lay at 25 weeks between the years (2010 and 2011). This may be due to the fitness of lohman breed to the Nigerian tropical conditions that enable it to overcome the restrictions of varied climatic changes between the years. There was however, a significantly ($p<0.05$) difference between years (2010, 2011) and 2014. This indicated that beyond certain levels of the changes in environmental stress, lohman breed environmental covariance; (a genetic value) became susceptible to the breed environment interaction, (an environmental value) of climatic conditions that affected it performance in 2014. Thus under stressful conditions, the breed environmental covariance and environmental interaction effects becomes more critical than the genetic superiority and diversity of the breed. There was no fluctuation in hen-day lay between the point of lay that at 25 weeks of age. This observation agreed with the report of Dafwang, (1987) who noted that from the first day of laying to 25 weeks of age there was no fluctuation in lay. The general performance on hen-day lay at 25 weeks in this study was in line with the report of Sharma et al., (2008) which documented that well managed flock should come to lay in time and attain 5% production by 25 weeks of age. This was also in indication of the fitness of lohman breed to the Nigerian tropical conditions.

Table 3.*Effect of year on Egg Production traits of Lohman breed*

Variables	2010	2011	2013	2014
Age at first egg (weeks)	19.00^a	19.00^a	-	22.00^b
Hen-day lay at 25 weeks (%)	61.41^a	60.54^a	-	30.85^b
Age at peak production (week)	48.00^b	45.00^b	59.00^a	35.00^c
Peak Hen-day lay (%)	83.58^a	81.99^a	74.14^b	74.88^b

a, b, c, figures with different superscripts across the rows are significant ($p <0.05$).

Effect of year on hen-day lay and age at Peak Production

The close range of age at peak production in 2010 and 2011 was an indication of the similar weather conditions for those years as well as the fitnes of the breed to moderate variation in environmental factors. Akhater and Zaman, (2003) noted that age at peak-of-lay is influenced by temperature; nutrition and lightening but that the degree of effects depended on breed adaptation. This was also an indication of the fitness of lohman breed to the Nigerian tropical conditions. There was a significant ($p<0.05$) difference of age at peak production between 2013 and 2014 years. This could be due to the variation in amount of rainfall between the years. However, Amin and Nawawi, (2013) reported 41 weeks for age at peak lay that this was maintained up to 44 weeks of age. Abduli et al. (2000) reported that age at peak production could ranged from between 30 – 39 weeks and or 40 – 49 weeks of age. The report of this study of years 2010, 2011, and 2014 agreed with ealier reports, also confirming the fitness of lohman breed to the Nigerian tropical conditions.

Effect of Year on Hen-Day Lay of Lohman brown

The significant differences in the hen-day lay between the years were due to climatic factors that causes a deviation on the mean hen-day lay of the breed. There were significant ($p < 0.05$) differences in temperature and Relative humidity between the years (table 6, 7, 8 and 9). Rainfall between the years also differed ($p< 0.05$) significantly (table 10). The variation in egg production between the years could be as a result of the variation in climatic conditions. Payne, (1966) also reported that yearly variations in climatic conditions have tremendous effect on egg production and mortality. Malau-Aduli et al. (2003), Abduli et al. (2000) , Ahmed and Islam, (1985) , Rahman et al. (1999) and Gwaza et al. (2012) all that variation in climatic conditions afected egg production of layer breeds in the tropics. The low percentage of hen-day lay in 2013 and 2014 (74.14% (3763)) and (74.88 (5074)) may be due to 107.30 mm and 105.50 mm rainfall which might have caused management of body heat dessipation difficult due to high moisture content of the air. This will inevitably affects feed intake and performance in general as observed in this study.

Table 4. *Effect of Year on Hen-day Lay of Lohman breed*

Variables	Number of Birds	Hen-day lay	Percentage lay
2010	562	3288	83.58^a
2011	335	1926	81.99^a
2013	667	3463	74.14^c
2014	968	5074	74.88^b

a, b, c, figures with different superscripts down the column are significant (p < 0.05).

Table5. *Effect of Season on hen-day lay of Lohman breeds.*

Variables	Wet Season				Dry Season		
	2010	2011	2013	2014	2010	2011	2014
Age at first egg (weeks)	19.09^a	19.04^a	$19,25^a$	20.00^a	22.65^b	22.86^b	23.28^b
Hen-day lay at 25 week(%)	61.41^a	60.54^a	59.32^a	59.85^a	56.85^b	48.67^C	36.08^d
Age at peak production (weeks)	45.35^c	46.23^c	52.00^a	45.17^c	48.00^b	45.00^c	35.00^d
Peak hen-day lay (%)	89.37^a	89.87^a	84.14^b	79.13^d	83.58^b	81.99^c	74.88^e

a, b, c, d, e figures with different superscripts across the rows are significant (p < 0.05)

Effect of Season on age at first egg, Hen-day Lay at 25 weeks, hen-day lay at peak production and age at peak production of Lohman brown

Age at first egg and hen day lay at 25 weeks in the wet season were similar. There was however significantly (p < 0.05) difference between age at first egg and hen-day lay at 25 weeks of the wet season and that of the dry season (Table 5). There were delayed age at first egg and reduced hen-day lay in the dry season compared to the wet season. This could be due to climatic factors that were involved in body temperature regulation in the dry season that reduced feed intake as an avenue to reduce heat generation in the body. Under temperature stress feed intake is reduced, energy and body reserves available to the birds are diverted to body maintenance than to production, hence the delayed age at first egg and reduced hen-day lay at 25 weeks. Peak hen- day lay percentage varied (p < 0.05) significantly between the dry and the wet seasons. This was due to the fact that peak egg production is affected by the environment. It is clear that hen-day lay fluctuated more frequent in the dry season because climatic conditions affecting egg production becomes more critical causing a deviation from the average potential of the breed. While in the wet seasons, these effects were minimized and the genotype environmental covariance becomes superior over the interaction effects causing a deviation on egg production, hence the reduction in fluctuations in egg production. This was also a credit to the fitness of Lohman brown to enhance production when environmental limiting factors were not at extreme. Dewing, (1987) AFFP (2006), Abdul et al., (1982) also made similar observations in the humid tropics of Nigeria.

Effect of Days within Months and Seasons on GGS Production Performance

There was significant (p<0. 05) variations in age at first egg, hen-day lay at 25 weeks, age at peak production and peak hen-day lay of the breed between the days within the months and the seasons (Figures 1, 2 , 3 and 4). These were so because, climatic conditions within seasons were not distributed evenly. In the wet season, there were days within months that temperature, amount of rainfall and relative humidity varied (Tables 6, 7, 8, 9, and 10). These variations in climatic factors within specific periods within seasons would also restricts or cause a deviation on the average performance of the breed. These specific breed enviromental covariance and interactions effects on production performance were responsible for the variation in egg production traits within and between seasons. The narrow margins in the variation within seasons are a mark of fitness and adaptation of the breed in the subhumid tropics of Nigeria.

Ikhimioya and Arijeniwa, (1998), Yakubu et al. (2007) and Lin et al. (2006) all reported the variation in egg production within and between the wet and the dry seasons.

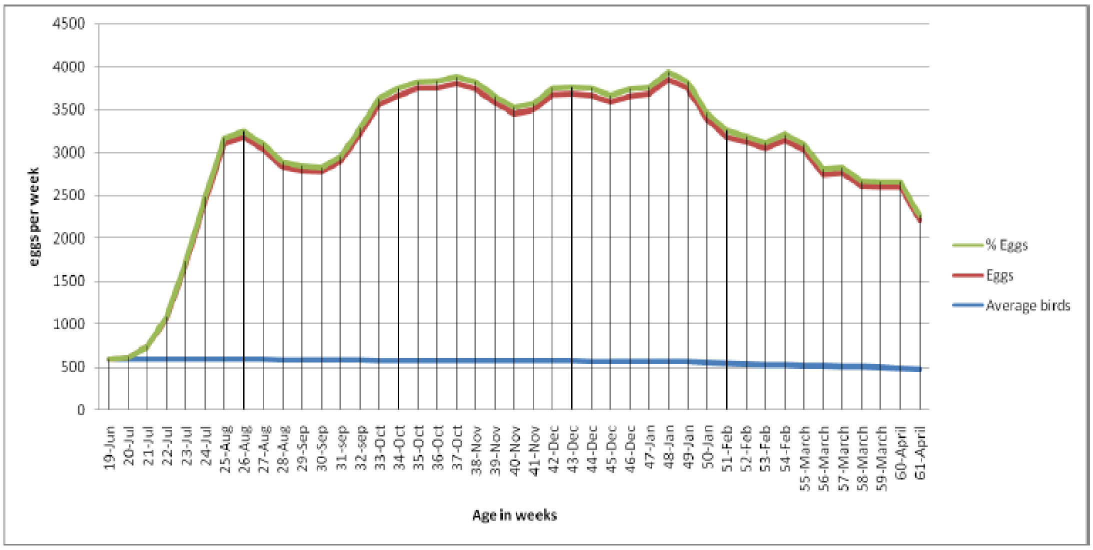

Figure1. *Effect of days within months and seasons on ggs Production*

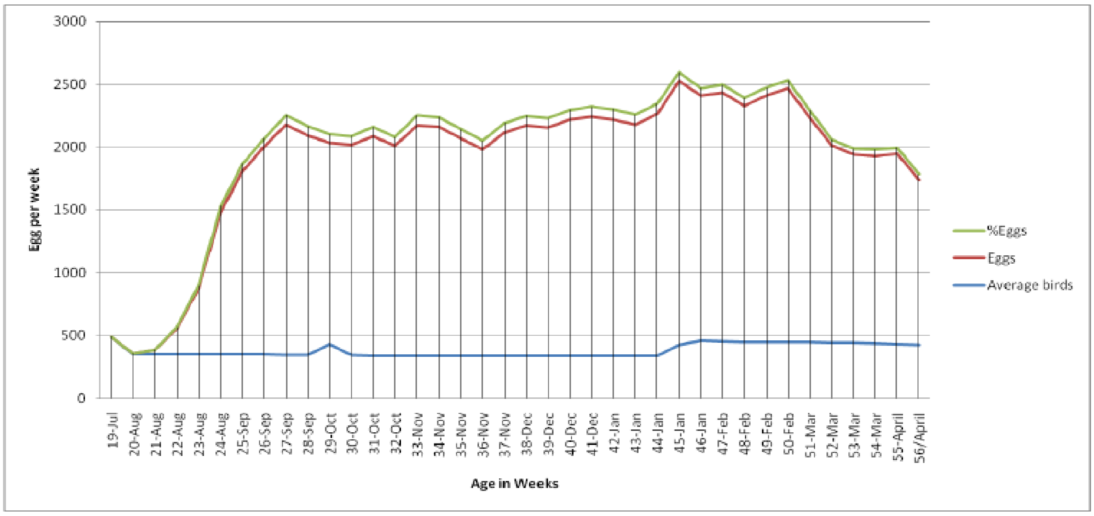

Figure2. *Effect of days within months and seasons on ggs Production Eggs Production Performance Batch 2*

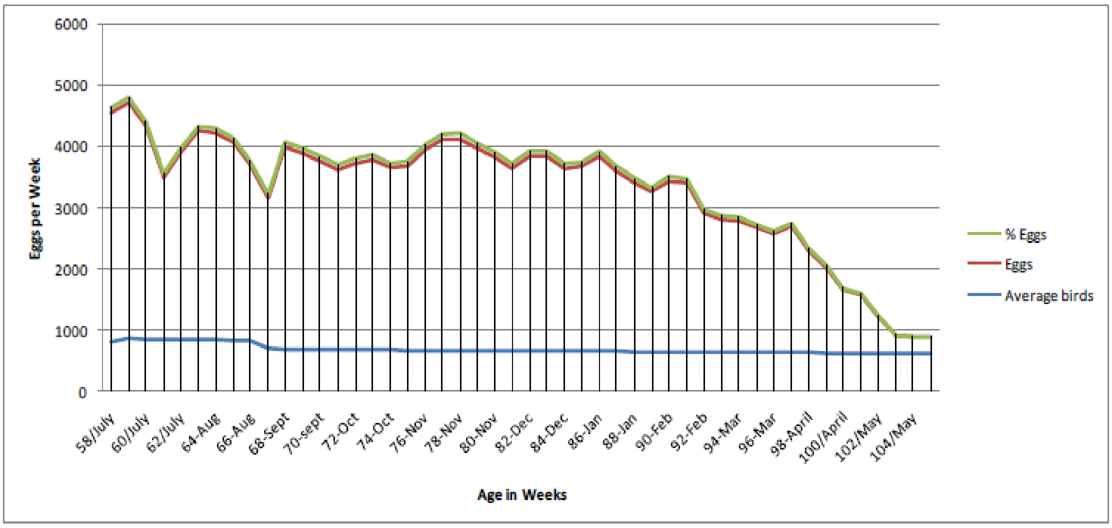

Figure3. *Effect of days within months and seasons on eggs Production*

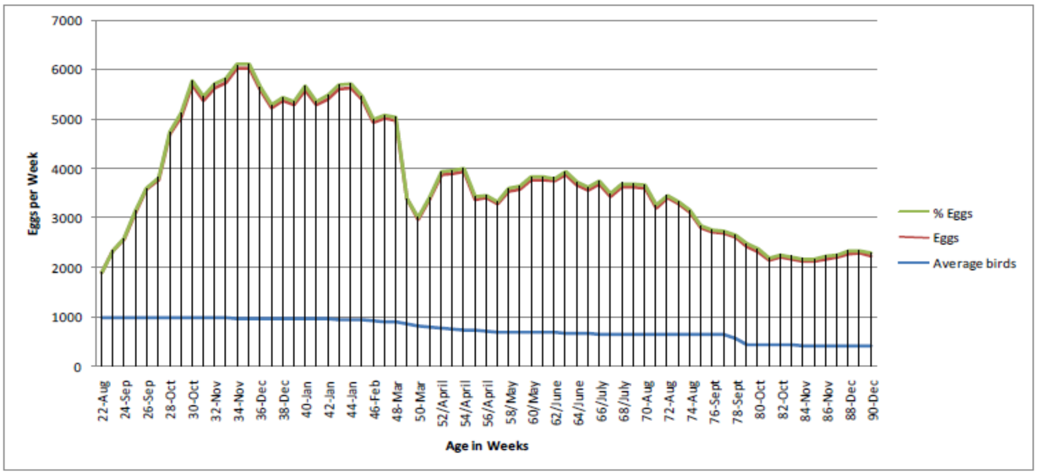

Figure4. *Effect of days within months and seasons on eggs production*

Weather

Weather report on temperature (maximum and minimum), relative humidity (maximum and minimum) and rainfall are presented in tables 6 and 7, 8, 9 and 10 respectively. Temperature, relative humidity and rainfall showed significant ($p < 0.05$) difference between the years.

Table6.*Distribution of maximum Temperature in Degree Celsius between the years*

Variables	Mean	SE	Minimum	Maximum
2010	33.93^{a}	0.91	30.10	38.60
2011	32.98^{b}	0.70	29.50	37.00
2013	33.08^{a}	0.76	29.50	37.70
2014	33.11^{a}	0.72	29.40	37.00

Source TAC, (2017)
a, b,c, figures with different superscripts down the column are significant ($p < 0.05$).

Table7. *Distribution of Minimum Temperature in Degree Celsius across the years*.

Variables	Mean	SE	Minimum	Maximum
2010	23.22^{a}	0.88	16.10	26.40
2011	21.71^{b}	0.99	14.50	26.20
2013	21.48^{b}	0.48	17.90	23.30
2014	21.50^{b}	0.52	17.90	24.20

Source TAC, (2017)
a, b, c, figures with different superscripts down the column are significant ($p < 0.05$).

Table 8.*Distribution of high Relative Humidity in Percentage (%) between the years*

Variables	Mean	SE	Minimum	Maximum
2010	72.00^{b}	3.64	54.00	86.00
2011	71.75^{b}	4.54	38.00	86.00
2013	72.50^{a}	4.27	47.00	86.00
2014	72.92^{a}	3.62	51.00	86.00

Source TAC, (2017)
a, b, c, figures with different superscripts down the column are significant ($p < 0.05$), SE, Standard error of mean.

Table 9.*Distribution of low Relative Humidity in Percentage (%) across the years*

Variables	Mean	SE	Minimum	Maximum
2010	52.00^{c}	5.55	26.00	74.00
2011	52.42^{c}	5.64	19.00	73.00
2013	55.67^{a}	5.68	26.00	74.00
2014	53.17^{b}	5.16	26.00	74.00

Source TAC, (2017)
a, b, c, figures with different superscripts down the column are significant ($p < 0.05$), SE, Standard error of mean.

Table10. *Distribution of Rainfall Amount in Millimetre (mm) across the years*

Variables	Mean	SE	Minimum	Maximum
2010	92.90^{c}	28.40	0.00	305.60
2011	95.90^{b}	31.90	0.00	293.40
2013	107.30^{a}	28.40	0.00	285.30
2014	105.50^{a}	30.30	4.00	306.90

Source TAC, (2017)

a, b, c, figures with different superscripts down the column are significant ($p < 0.05$), SE, Standard error of mean.

Conclusion

There was higher brooding mortality in the dry seasons compared to the wet seasons. Hen-day lay of Lohman breed were better in the wet seasons compared to that of the dry seasons. Brooding mortality of Lohman breed varied significantly between years that had extreme climatic conditions. Age at first egg, hen-day lay at 25weeks, and at peak production also varied between years with extreme climatic conditions. There were no significant variations in egg production performance of the breed between years that had less climatic variations. The breed environmental covariance which is a genetic factor supporting egg production performance had enable Lohman breed to overcome the effects of it,s interaction with the environmental factors limiting its potential on egg production. This was an indication of the breed fitness to the challenging environment of the Nigerian tropical conditions. However, when the environmental challenge becomes too critical, the breed environmental covariance decreases such that its interaction with the environment (environmental effects) imposed a deviation on its mean performance on egg production traits. This was while its performance was affected when the environmental challenges become too critical as in extreme climatic conditions under which there was a deviation on its mean performance. Lohman breed genetic potential has the capacity for adaptation and fitness to the Nigerian tropical conditions. Extreme climatic conditions may however limit the full expression of its potentials.

Recommendation

The use of Lohman breed is recommended for commercial layer industries in the humid tropics of Nigeria. However, under extreme climatic conditions (high relative humidity and temperature) extra management support must be provided to maintain performance. It is also important to ensure that critical phases of production (brooding, age at peak egg production) are planned to occur outside period of extreme climatic conditions to reduce management stress and ensure more economical returns,.

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