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Effects of Genotype and Housing System on the Laying Performance of Chickens in Different Seasons in the Semi-Humid Tropics

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Abstract: An experiment was designed to study the effects of genotype and housing system on the performance of two commercial layers, Bovans Brown and Lohmann Brown in the hot-dry and wet seasons in Lafia, Nasarawa State, Nigeria. Six hundred, 27 week-old layers were used. One hundred and fifty birds of each strain were randomly assigned to the battery cage system, while another one hundred and fifty birds of each strain were managed on deep litter. The observation for the hot-dry and wet seasons lasted 2 months each respectively in the year 2004. Body weight, hen-housed egg production, egg weight and mortality rate were significantly better in Lohmann Brown than Bovans Brown (1.75±0.01kg vs. 1.69±0.01kg, 74.50±0.84% vs. 68.72±0.86%, 53.70±0.24g vs. 52.43±0.26g, 0.58±0.09% vs. 1.20±0.15%; $p<0.05$). Birds in cages were superior to those on deep litter in terms of hen-housed egg production, egg weight and mortality (74.06±0.75% vs. 69.16±1.02%, 53.40±0.24g vs. 52.73±0.29g, 0.68±0.10% vs. 1.10±0.15%; $p<0.05$). Generally, birds performed better in the wet than hot-dry season in body weight, hen-housed egg production, feed intake, egg weight, egg cracks and mortality (1.76±0.01kg vs. 1.68±0.01kg, 74.92±0.74% vs. 68.30±0.86%, 98.51±0.50g vs. 90.90±0.23g, 53.92±0.18g vs. 52.22±0.27g, 1.99±0.23% vs.5.12±0.39%, 0.55±0.08% vs. 1.22±0.15%; $p<0.05$). The interactions between genotype×housing system, genotype×season and housing system×season produced significant results. Proper housing design, provision of quality and adequate feeds and proper timing of the laying period were recommended.

Key words: Exotic strains, management system, season, performance parameters, interaction

Introduction

The performance of laying hens kept in the tropics is determined to a large extent by the birds' productive adaptability. A high level performance, no doubt, is the aim of any enterprise involved in the production of eggs. Genetic variation in egg production between breeds, strains and lines has been reported (Nawar and Abdou, 1999; Suk and Park, 2001; Hocking *et al*., 2003). On the other hand, the productivity of exotic strains intensively reared is high compared with the native hens (Ershad, 2005).

The influence of housing system on productivity traits has been studied. Comparison of results of egg production rate, egg weight, feed efficiency (feed/dozen eggs) and lay house mortality of layers showed the superiority of cage over deep litter housing system (Ayorinde *et al*., 1999). Muthusamy and Viswanathan (1998) also found higher egg laying performance of hens in cages than those kept on floor. According to Suto *et al*. (1997), housing systems influenced the hen-housed egg production, correlated egg mass production and daily feed consumption. In his own findings, Awoniyi (2003) reported that the productivity of layer-chickens in the different tiers of 3-tier cages varied. Housing system significantly affected the body weights of birds, while egg production, egg weight, feed consumption and efficiency, shell thickness and livability were not significantly influenced (Akinokun and Benyi, 1985).

Environmental factors such as temperature and humidity also affect greatly the laying performance of fowls (Kassim *et al*., 1984; Hazan, 1984). The Nigerian climatic environment is characterised by high temperature and relative humidity typical of tropical regions. This tends to affect negatively the physiological functions of birds (Dauda *et al*., 2006). The temperature zone in which the performance of adult fowl is not adversely affected by temperature is 12.8-26°C (Oluyemi and Roberts, 2000). Ikhimioya and Arijeniwa (1998) observed that the average performance of layers was better in the wet season for hen-housed egg production, mean daily, weekly egg production and egg weight compared with the dry season. Similarly, low egg production and high mortality rate in the hot-dry season has been documented (Bannor and Ogunsan, 1987). According to Al-Rawi and Abou-Ashour (1983), feed intake, egg production and body weight declined with increase in temperature.

Table 1: Mean monthly values for environmental temperature, relative humidity and rainfall of Lafia during the study period

Month	Max. temp. (°C)	Min. temp. (°C)	Relative humidity (%)	Rainfall (mm)
January	36.2	18.5	46.4	0.0
February	37.6	22.1	NA	0.0
March	38.8	24.4	41.6	1.0
April	35.2	25.4	66.3	56.8
May	33.5	23.1	NA	124.3
June	31.1	22.2	NA	373.3
July	29.7	22.7	85.1	213.7

NA : Not available, Source: Nigerian Meteorological Agency (NIMET), Lafia, Nasarawa State, (2004)

Table 2: Effect of genotype on the laying performance of hens

	Genotype	
Parameters	Bovans Brown	Lohmann Brown
Average weekly body weight (kg)	$1.69{\pm}0.01^b$	$1.75{\pm}0.01^a$
Hen-housed egg production (%)	$68.72{\pm}0.86^b$	$74.50{\pm}0.84^a$
Feed intake (g/bird/day)	$95.46{\pm}0.78^a$	$93.96{\pm}0.77^b$
Egg weight (g)	$52.43{\pm}0.26^b$	$53.70{\pm}0.24^a$
Average weekly egg cracks (%)	$3.69{\pm}0.45^a$	$3.42{\pm}0.39^a$
Average weekly mortality (%)	$1.20{\pm}0.15^a$	$0.58{\pm}0.09^b$

Means within rows designated by different superscripts differ significantly ($p<0.05$)

A review of available literature revealed that studies on the laying performance of exotic strains in the semi-humid tropics are inconclusive. Therefore, the present study was conducted to investigate the influence of genotype and housing system on egg production performance of chickens in different seasons under tropical conditions of north central Nigeria.

Materials and Methods

Study location: The study was conducted in a commercial poultry farm in Lafia, the capital of Nasarawa State, which is in the Northern Guinea Savanna zone of Nigeria. It lies within latitude 8°30' N and longitude 8°34' E. It has two succinct climatic seasons; the wet season starts from May and ends in October, while the dry season starts from November to April.

Experimental birds and management: The experimental birds were 600 selected pullets of Bovans Brown and Lohmann Brown (commercial laying stock) reared from day-old. At 27 week-old, 150 birds of each strain were randomly assigned to the battery cage housing system, while another 150 birds of each strain were similarly housed on deep litter. A two-tier cage was used in an open-sided building. The dimension of each cage which housed 2 birds was 0.38m×0.33m. Each strain was divided into three groups of fifty birds each, while the dimension of the deep litter housing each group was 2.20m×2.00m. Proper sanitation was carried out in the birds' houses, while they were also routinely vaccinated against infectious diseases. All birds were fed pelletized commercial layer's feed containing 16.50% crude protein; 2550 kcal/kg metabolizable energy; 4.00% fat; 4.60% crude fibre; 3.70% calcium and 0.41% available phosphorus. Fresh and clean water was also supplied *ad libitum*. The investigation for the hot-dry season lasted from March to April, 2004 while that of the wet season lasted from June to July, 2004. The average monthly temperature, relative humidity and rainfall of Lafia during the study period are presented in Table 1.

Data collection: Data on average weekly body weight (kg), hen-housed egg production (%), feed intake (g/bird/day), egg weight (g), average weekly egg cracks (%) and average weekly mortality (%) were taken. Egg collection was done at 0800, 1100 and 1700 hours each day. Feed intake was estimated by the difference in the amount offered and the leftover collected the following day. Individual eggs were weighed.

Data analysis: Data collected were subjected to analysis of variance using the PROC MEANS procedure of SAS (1999) package.

The statistical model employed was:

$$Y_{ijk} = \mu + G_i + H_j + S_k + (GH)_{ij} + (GS)_{ik} + (HS)_{jk} + e_{ijk}$$

Where,

Y_{ijk} = individual observation

μ = population mean

G_i = effect of the ith genotype (I = Bovans Brown, Lohmann Brown)

H_j = effect of the jth housing system (j = Battery cage, Deep litter)

S_k = effect of the kth season (Hot-dry, wet)

$(GH)_{ij}$ = effect of the interaction of the ith genotype and jth housing system

$(GS)_{ik}$ = effect of the interaction of the ith genotype and kth season

$(HS)_{jk}$ = effect of the interaction of the jth housing system and kth season.

e_{ijk} = random residual error normally and independently distributed with zero mean and common variance.

Mean separation was effected using least significance difference (LSD) method and tested at $p<0.05$.

Results and Discussion

Effect of genotype: Table 2 shows the mean body weight, hen-housed egg production, feed intake, egg weight, egg cracks and mortality. Genotype had significant ($p<0.05$) effects on the performance traits

Table 3: Effect of housing system on the laying performance of hens

	Housing System	
Parameters	Battery Cage	Deep litter
Average weekly body weight (kg)	1.73±0.01[a]	1.72±0.01[a]
Hen-housed egg production (%)	74.06±0.75[a]	69.16±1.02[b]
Feed intake (g/bird/day)	93.79±0.70[b]	95.62±0.83[a]
Egg weight (g)	53.40±0.24[a]	52.73±0.29[b]
Average weekly egg cracks (%)	3.68±0.44[a]	3.43±0.40[a]
Average weekly mortality (%)	0.68±0.10[b]	1.10±0.15[a]

Means within rows designated by different superscripts differ significantly ($p<0.05$)

Table 4: Effect of season on the laying performance of hens

	Season	
Parameters	Hot-dry	Wet
Average weekly body weight (kg)	1.68±0.01[b]	1.76±0.01[a]
Hen-housed egg production	68.30±0.86[b]	74.92±0.74[a]
Feed intake (g/bird/day)	90.90±0.23[b]	98.51±0.50[a]
Egg weight (g)	52.22±0.27[b]	53.92±0.18[a]
Average weekly egg cracks (%)	5.12±0.39[a]	1.99±0.23[b]
Average weekly mortality (%)	1.22±0.15[a]	0.55±0.08[b]

Means within rows designated by different superscripts differ significantly ($p<0.05$)

studied with the exception of egg cracks. Lohmann Brown hens had significantly higher body weight, hen-housed egg production and egg weight compared with Bovans Brown. Feed intake and percentage mortality were higher in Bovans Brown than Lohmann Brown.

Variable egg production performance for various strains of chicken had been reported (Tolimir and Masic, 2000). According to Ershad (2005), brown shelled hybrid layers were better than their white shelled counterparts in terms of body weight. The findings of Akinokun and Benyi (1985) indicated that genotype had significant effects on body weight traits. A relationship was also established between the production parameters. Egg weight and feed intake were correlated with body weight as observed in Lohmann Brown. Majaro (2001) reported the superiority of Lohmann Brown over Harco layers in egg production during feed restriction. This was inconsistent with the findings of Duduyemi (2005) that there was no significant difference between Bovans Brown and Bovans Nera in egg production. It was attributed to the fact that the exotic birds were commercial hybrids that have been selected over many generations from interbreeding between specialized breeds, lines or strains. Although feed intake was higher in Bovans Brown, it did not reflect in the body weight, hen-housed egg production and egg weight. This is an indication of better feed utilization by their Lohmann Brown counterparts which impacted positively on productivity traits. The lower mortality rate of Lohmann Brown also indicated a better adaptation to the prevailing environmental conditions compared to Bovans Brown.

Effect of housing system: A summary of the means of the different performance characteristics in the battery cage and deep litter housing systems are presented in Table 3. Hen-housed egg production, feed intake, egg weight and mortality were significantly ($p<0.05$) influenced. No significant difference ($p>0.05$) was observed for body weight and egg cracks respectively. Birds in the battery cage had significantly higher hen-housed egg production and egg weight compared with those on deep litter. Feed intake was higher among birds on deep litter while mortality was lower among those in cages.

Laying hens differ in their adaptability to different husbandry systems. Results of the present study are in consonance with some of the earlier investigations that birds in cages lay more eggs than those on deep litter (Suto *et al.*, 1997; Ayorinde *et al.*, 1999; Flock *et al.*, 2005). The higher egg rate in the cage is attributable to better rearing environment. According to Tauson *et al.* (1999), caged birds performed better because they were relatively guarded against air pollution and pathogenic organisms. This may also be indicative of the fact that hens were more efficient in feed conversion; and there was lesser incidence of feed wastage. The higher egg weight in the cage system compared with the deep litter system is consistent with the findings of Suto *et al.* (1999). However, the present result obtained did not conform with that observed by Akinokun and Benyi (1985), where housing system had no significant effect on egg weight. It also disagreed with the findings of Al-Rawi and Abou-Ashour (1983) that floored hens were superior to caged birds in egg weight. Plane of nutrition is known to affect productivity traits. Birds on deep litter consumed more feed than their counterparts in cages, although there was no reflection on hen-housed egg production and egg weight. This could be attributed to greater mobility of the birds thereby resulting in more energy utilization at the expense of production. Extra energy could also be required for maintenance at low ambient temperature or when feather cover is poor (Scientific Veterinary Committee, 1996). The present result on mortality is in conformity with that reported by Ayorinde *et al.* (1999) in NAPRI commercial layers. It also corroborates the observations of Al-Rawi and Abou-Ashour (1983) that housing system exerted no significant influence on body weight. The non-significant difference in egg cracks between the housing systems disagreed with the findings of Adeyemi *et al.* (2002) and Farooq *et al.* (2002) where higher incidence of cracked eggs was recorded in floor-reared laying hens than those kept in cages. The present findings are attributable to the adequate calcium content of the experimental diet and frequent egg collection. According to Moreki *et al.* (2005), 2.5% level of dietary calcium was sufficient to sustain sound eggshell quality.

Table 5: Effect of Genotype x housing system interaction on egg production performance of layers

Genotype	Housing system (%)	Performance Parameters: Average weekly Body weight (kg)	Hen-housed egg production (%)	Feed intake (g/bird/day)	Egg weight (g)	Average weekly Egg cracks (%)	Average weekly Mortality
Bovans	Battery cage	1.70^{a}	71.63^{a}	94.87^{a}	52.76^{a}	3.56^{a}	0.89^{b}
Brown	Deep litter	1.68^{a}	65.82^{b}	96.04^{a}	52.11^{a}	3.82^{a}	1.51^{a}
Lohmann	Battery cage	1.76^{a}	76.50^{a}	92.71^{b}	54.05^{a}	3.80^{a}	0.46^{a}
Brown	Deep litter	1.75^{a}	72.51^{b}	95.20^{a}	53.35^{a}	3.04^{a}	0.69^{a}
SEM		0.01	0.58	0.24	0.29	0.44	0.13

SEM: Standard error of means, Means along the same column designated by different superscripts differ significantly (p<0.05)

Table 6: Effect of Genotype x season interaction on egg production performance of layers

Genotype	Season	Performance Parameters: Average weekly Body weight (kg)	Hen-housed egg production (%)	Feed intake (g/bird/day)	Egg weight (g)	Average weekly egg cracks (%)	Average weekly mortality (%)
Bovans	Hot-dry	1.65^{b}	65.76^{b}	91.46^{b}	51.34^{b}	5.40^{a}	1.67^{a}
Brown	Wet	1.73^{a}	71.68^{a}	99.45^{a}	53.53^{a}	1.99^{b}	0.73^{b}
Lohmann	Hot-dry	1.71^{b}	70.85^{b}	90.34^{b}	53.09^{b}	4.84^{a}	0.78^{a}
Brown	Wet	1.79^{a}	78.16^{a}	97.57^{a}	54.31^{a}	2.00^{b}	0.37^{b}
SEM		0.01	0.58	0.24	0.29	0.44	0.13

SEM: Standard error of means, Means along the same column designated by different superscripts differ significantly (p<0.05)

Effect of season: The mean body weight, hen-housed egg production, feed intake, egg weight, egg cracks and mortality in the hot-dry and wet seasons are shown in Table 4. Season significantly (p<0.05) affected all the parameters studied. Body weight, hen-housed egg production, feed intake and egg weight were higher in the wet season compared with the hot-dry season. Incidence of egg cracks and mortality was significantly higher in the hot-dry season. High temperature and humidity influence the rate and extent of growth in birds. The better performance in body weight in the wet season could be as a result of high feed consumption and utilization which are characteristic of cooler environmental conditions. Al-Rawi and Abou-Ashour (1983) reported that accelerated body weights associated with cooler temperature were related to excessive feed consumption. In a similar study-carried out by Njoya and Picard (1994), heat stress, as observed in the hot-dry season had a negative effect on growth and feed intake of laying hens. The decrease in feed consumption, one of the appetite control factors, is considered as a function of the regulation of caloric intake. Additionally, heavier body weight would require more feed for maintenance purposes. Birds laid more eggs in the wet season. The lower laying rate among birds during the hot-dry season may be due to the inability to satisfy their thermo requirement (Lin *et al*., 2006). In a hot environment, chickens grow and lay by exerting an effort to maintain their body temperature within a normal range to cope with stress response and to ensure their visceral organs function under a heavier heat burden. Alternatively, harsh temperature may result in a great reduction in the function of the oviduct (Arima *et al*., 1976). The heavier eggs laid by birds in the wet season might be due to the linear relationships among egg weight, feed intake and body weight. The influence of body weight on egg size has been reported (Leeson and Summers, 1997). A temperature higher than 26^{o}C especially during the hot season of the year usually depresses egg quality (Oluyemi and Roberts, 2000). The present findings on egg cracks corroborate this as its incidence was higher in the hot-dry season where temperatures could get to the extremes. The deleterious effect of thermal stress could be responsible for the high mortality rate recorded in the hot-dry season. This conforms with the observation of Bannor and Ogunsan (1987), but contradicts the findings of Mmereole and Omeje (2005) that mortality rates of the wet season were higher than that of the dry season.

Effect of genotype×housing system interaction: The interaction between genotype and housing system is shown in Table 5. This interaction significantly (p<0.05) affected hen-housed egg production, feed intake and mortality. Body weight, egg weight and egg cracks were not significantly (p>0.05) influenced. Bovans Brown in cages laid more eggs than those on deep litter. Similarly, Lohmann Brown in cages laid significantly more eggs than their deep litter counterparts. This is an indication that there is no change in ranking of the birds under the two housing systems. With regard to feed intake, Bovans Brown performance was equal in both

Table 7: Effect of Housing system x season interaction on egg production performance of layers

Housing System	Season	Average weekly body weight (kg)	Hen-housed egg production (%)	Feed intake (g/bird/day)	Egg weight (g)	Average weekly egg cracks (%)	Average weekly mortality (%)
		Performance Parameters					
Battery	Hot-dry	1.67^{b}	71.42^{b}	90.51^{b}	52.71^{b}	5.52^{a}	0.86^{a}
Cage	Wet	1.77^{a}	76.71^{a}	97.07^{a}	54.10^{a}	1.84^{b}	0.50^{a}
Deep litter	Hot-dry	1.68^{b}	65.19^{b}	91.29^{b}	51.73^{b}	4.71^{a}	1.59^{a}
	Wet	1.76^{a}	73.14^{a}	99.95^{a}	53.73^{a}	2.14^{b}	0.61^{b}
SEM		0.01	0.58	0.24	0.29	0.44	0.13

SEM: Standard error of means, Means along the same column designated by different superscripts differ significantly ($p<0.05$)

housing systems, while the reverse was the case in Lohmann Brown, as birds on deep litter consumed more than those in cages. Mortality was higher on deep litter for Bovans Brown while Lohmann Brown showed no difference in performance under both systems. Although body weight and egg weight were higher in the battery cages for both genotypes, these were however, not statistically significant. Egg cracks were higher in the deep litter for Bovans Brown while in the Lohmann Brown it was higher in the cage, showing a change in the ranking of the birds. The present result on egg weight disagreed with that of Akinokun and Benyi (1985), where a significant genotype x environment interaction was found.

Genotype×season interaction had significant ($p<0.05$) effects on all the performance parameters studied (Table 6). Body weight, hen-housed egg production, feed intake and egg weight were higher in the wet than the hot-dry season for both genotypes. Egg cracks and mortality were more in the hot-dry season compared with the wet season. The finding on mortality is inconsistent with what was reported by Mmereole and Omeje (2005), where genotype x season interaction had no significant effect on this trait. The great performance recorded in the wet season is associated with cooler temperature.

Shown in Table 7 is the effect of housing system×season interaction on egg production performance of birds with the exception of mortality in the battery cage system. Body weight, hen-housed egg production, feed intake and egg weight were significantly ($p<0.05$) higher in the wet than hot-dry season for both housing systems. Egg crack incidence was higher in the hot-dry season for both husbandry systems, likewise mortality on deep litter. Birds in cages were not different in mortality rate under both seasons. The implication of this is that the survivability of birds in cages is higher compared with those on deep litter.

Conclusion: The results of this study showed that Lohmann Brown was superior to Bovans Brown in body weight, hen-housed egg production, egg weight and mortality rate. Birds in cages performed better than those kept on deep litter in terms of hen-housed egg production, egg weight and mortality. Season significantly affected all the body parameters, with birds giving better results in the wet season compared with the hot-dry season.

Genotype×housing system, genotype×season and housing system×season interactions produced significant results. These revealed the equal and separate rankings of the experimental birds under the two housing systems and seasons.

Considering the deleterious effects of heat stress as observed in this investigation, poultry houses should be constructed with materials such as asbestos roofing sheets that reduce the effect of heat; while there should be room for proper aeration. Controlled feeding regime attenuates the effect of thermal stress. Wet feeding done probably once in a day would increase the dry matter intake. The dietary inclusion of some amino acids such as lysine and arginine will improve feed efficiency. Vitamins and minerals should also be adequately fed to enhance production. Improved management practices such that pullets would start laying at the beginning of the rainy (wet) season are equally advocated. More elaborate investigation involving other exotic strains should also be carried out.

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References

Adeyemi, O.A., R.A. Awosanya and O.E. Fasina, 2002. A survey of On-Farm egg cracks in Ogun State, Nigeria. The Ogun J. Agri. Sci., 11: 166-176.

Akinokun, O. and K. Benyi, 1985. The effect of genotype and housing on the laying performance of chickens in south western Nigeria. Bull. Anim. Health Product. In Africa, 33: 147-151.

Al-Rawi, B.A. and A.M. Abou-Ashour, 1983. Performance of laying hens under different housing and environmental conditions. World Rev. Anim. Product., 19: 54-60.

Arima, Y., F.B. Mather and M.M. Ahmed, 1976. Response of egg production and shell quality to increases in environmental temperature in two age groups of hens. Poult. Sci., 55: 818-820.

Ayorinde, K.L., J.K. Joseph, O.E. Adewale and I.J. Ayandibu, 1999. Growth, laying performance and egg quality traits of “NAPRI COMMERCIAL LAYERS” on deep litter and in cages. Trop. J. Anim. Sci., 1: 147-155.

Awoniyi, T.A.M., 2003. The effect of housing on layer-chicken’s productivity in the 3-tier cage. Int. J. Poult. Sci., 2: 438-441.

Bannor, T.T. and E.A. Ogunsan, 1987. The effects of environmental temperatures on intensive poultry production on Sokoto State of Nigeria. Bull. Anim. Health Product., 35: 39-45.

Dauda, T.O., A.O. Adetayo and A.K. Tiamiyu, 2006. Effects of weather on egg characteristics of Isa Brown layers in Ibadan, Nigeria. Anim. Sci. J., 77: 117-121.

Duduyemi, O.A., 2005. Evaluation of the egg-laying performance of two strains of bovan chicken (Bovan Brown and Bovan nera) in the tropics. Proc. 1st Nigeria International Poultry Summit, Feb. 20-25, 2005, Ota, Ogun State, Nigeria, pp: 35-38.

Ershad, S.M.E., 2005. Performance of hybrid layers and native hens under farmers’ management in a selected area of Bangladesh. Int. J. Poult. Sci., 4: 228-232.

Farooq, M., M.A. Mian, F.R. Durrani and M. Syed, 2002. Egg production of performance of commercial laying hens in Chakwal district, Pakistan. Livestock Research for Rural Development, 14 (2): http:// www. cipav.org.co/ lrrd/lrrd14/2/faro/42.htm.

Flock, D.K., K.F. Laughlin and J. Bentley, 2005. Minimizing losses in poultry breeding and production: how breeding companies contribute to poultry welfare. World’s Poult. Sci. J., 61: 227-237.

Hazan, A., 1984. The effect of high summer environmental temperatures on laying performance of different ages of heavy breeders. Proc. XVII World’s Poultry Congress and exhibition, Helsinki., pp: 471-472.

Hocking, P.M., M. Bain, C.E. Channing, R. Fleming and S. Wilson, 2003. Genetic variation for egg production, egg quality and bone strength in selected and traditional breeds of laying fowl. Br. Poult. Sci., 44: 365-373.

Ikhimioya, I. and A. Arijeniwa, 1998. A preliminary investigation on the effect of season on some performance characteristics of Black Harco layers in Delta State, Nigeria. The Nigerian Agri. J., 29: 170-174.

Kassim, M., P. Horse and G. Monreal, 1984. Immune response and health status of laying hens during long-term heat stress. Anim. Res. Develop., 20: 91-101.

Leeson, S. and J.D. Summers, 1997. Commercial Poultry Nutrition (Second Edition). University Books, Guelph Ontario, Canada.

Lin, H., H.C. Jiao, J. Buyse and E. Decuypere, 2006. Strategies for preventing heat stress in poultry. World’s Poult. Sci. J., 62: 71-85.

Majaro, O.M., 2001. Response of layers of two genotypes to dietary regimes for reducing egg production during glut in egg market. Trop. Vet., 19: 48-51.

Mmereole, F.U.C. and S.I. Omeje, 2005. Genotype×season interaction effects on the laying mortality rates of the Nigerian local chicken, the Barred Plymouth Rocks and the crosses. Proc. 1st Nigeria International Poultry Summit, Feb. 20-25, Ota, Ogun State, Nigeria, pp: 28-31.

Moreki, J.C., H.J. Van der Merwe, J.P. Hayes and P. Phitsane, 2005. Effect of dietary calcium level on egg weight, eggshell weight, eggshell percentage and egg production in broiler breeder hens at peak production. Proc. 1st Nigerian International Poultry Summit, Feb. 20-25, 2005, Ota, Ogun State, Nigeria, pp: 79-84.

Muthusamy, P. and K. Viswanathan, 1998. Effect of rearing systems on performance of commercial layers. Indian J. Poult. Sci., 33: 264-267.

Nawar, M.E. and F.H. Abdou, 1999. Analysis of heterotic gene action and maternal effects in crossbred Fayoumi Chickens. Egypt. Poult. Sci. J., 19: 671-689.

Njoya, J. and M. Picard, 1994. Climatic adaptation of laying hens. Trop. Anim. Health Prod., 26: 180-186.

Oluyemi, J.A. and F.A. Roberts, 2000. Poultry production in warm wet climates (2nd Edition), Spectrum Books Limited, Ibadan Nigeria, pp: 192.

SAS, 1999. Statistical Analysis System User’s guide: Statistics. SAS Institute Inc., Cary, NC 27513, USA.

Scientific Veterinary Committee, 1996. Report on the welfare of laying hens. Commission of the European communities, Directorate-General for Agriculture, Brussels, Luxembourg.

Suk, Y.O. and C. Park, 2001. Effect of breed and age of hens on the yolk to albumen ratio in two different genetic stock. Poult. Sci., 80: 855-858.

Suto, Z., P. Horn and J. Ujvari, 1997. The effect of different housing systems on production and egg quality traits of brown and leghorn type layers. Acta Agraria Kaposvariensis, 1: 29-35.

Tauson, R., A. Wahlstrom and P. Abrahamsson, 1999. Effect of two floor housing systems and cages on health, production and fear response in layers. J. Appl. Poult. Res., 8: 152-159.

Tolimir, N. and B. Masic, 2000. The results of European egg production tests in 1997-1998. Zivinarstvo, 35: 66-68.