Effects of location and season on productivity and productive adaptability of two parent stock exotic layer chicken strains in a warm-wet environment

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Abstract

Tropical commercial poultry industry is anchored on exotic strains which suffer varying degrees of productivity and adaptability problems. Adaptability is the ability to produce better or demonstrate least variation in productivity under multiple environments. The study was undertaken to examine the productivity and adaptability of Bevan Nera (IB) and Isa Brown (IB) parent stock strains under two locations and seasons. Data on weekly feed intake (FI g), cock weight (Cockwt, g), hen weight (Henwt, g), hen house production (HHP, %) and egg weight (Ewt, g) were collected from a commercial parent stock breeding farm in Ibadan, Nigeria, on the two strains. Data were subjected to general linear model analysis (GLM) procedures using SAS (1999), while mean separation was by bonferoni t-test ($P=0.05$). The statistical model was randomized complete block design (RCBD) in factorial. Factors of importance were Genotype (S), Location (L) as Fixed, and Season (S) as random. The effects of location on seasonal productivity and season on locational productivity for strains were 7.38, 4.96; and 4.99, 8.11 (%) for BN, IB respectively. GxL and GxLxS interactions were significant ($P<0.043$ and <0.013) for adaptability of strains. Locational adaptability indices were 48.59 and 51.41 while Seasonal adaptability indices were 63.32 and 36.68 (%) respectively for BN and IB strains.

Keywords: Body weight, breeding, egg weight, genotype by location by season interaction, hen house production.

Introduction

The concept of adaptability revolves around 'fitness' describing the relative ability of an individual to survive and reproduce the next generation to ensure continued survival of the population (Naskar et al., 2012). Adaptability is the ability of an animal to adjust to fit or produce better under multiple conditions or for some purposes (Webster, 2017). It is also the ability of an animal to withstand adverse and extreme climatic conditions, adjust to and produce optimally in the environment in which it lives. Adaptability, could also refer to a reduced variation in performance across locations (Roy and Kharkwal, 2004) resulting from the ability of an organism to alter its responses to changing circumstances,

environment and weather conditions. Chickens deviate from their potential in reproductive performance when challenged by environmental conditions (Clark and Amin, 1965). Adaptation to the environment in which any animal is being reared for production is very important. Genetic Slippage (Dickerson 1955) – a phenomenon where performance of the individuals reared in a specific environment degrades when forced to perform in different environment (Naskar et al., 2012) – usually results when temperate genetics are imported to the tropics. Adaptability therefore is an advantage in the harshly competitive global economy (Oxford, 2017). Adaptability can be built up in poultry flock as a genetic trait. Birds bred under suboptimal conditions could perform

better, when better environment is given (Kotiah, 2012). Unadapted poultry breeds are incapable of achieving or maintaining high respiratory rates in the order of 400 respirations/minute, high productive and fitness rates of the well-adapted breeds, without apparently suffering from heat or thermal stress in the warm wet tropics (Webster and Wilson, 1980). Temperate strains of chicken reared in tropical climates are affected directly by high environmental temperature, intense radiation, humidity and indirectly by the effect of heat on the animals' environment, including their natural feed supply (Webster and Wilson, 1980). Heat distress suffered by animals reduce rate of animal feed intake and result in poor growth performance (Rowlinson, 2008). High heat stress above the critical region of 33-35°C manifests in rapid deterioration in feed conversion efficiency in poultry. High temperature and relative humidity like those in the tropics cause about 30% drop in feed consumption and performance of poultry in the tropics. It has also been reported that at 34°C and 45% RH, light Leghorn hybrids showed a deterioration in feed conversion rate from 2.1-2.2:1, while medium-weight layer hybrids dropped from 2.8-4.0:1 under same conditions (Herz and Steinhau, 1978). Prolonged exposure to temperatures above 90°F or below 60°F results in a reduced egg yield. Eggs produced under high air temperature conditions have thinner than normal shells and as a result are particularly fragile. There is also evidence that genetic differences affect the sensitivity and adaptability of chickens to high environmental temperatures. This is true between breeds and between families (Clark and Amin, 1965). The hot-humid climatic conditions of the Tropics constitute a primary constraint to breeding which results to

depression in productivity in poultry which cannot be fully overcome by management, feeding and hygienic controls.

Stress also suppress appetite, reduce growth rate, alter digestive and rumen function, and compromise immune function (Loerch and Fluharty 1999), suggesting its role in driving the energy balance of the body potentially in different directions. Stress has been shown to negatively impact live animal performance. Climate change is also affecting survivability tactics and patterns of birds. Clutch size is an important life-history trait because it sets an upper limit on offspring production. It is also the easiest life-history trait to measure, and data on clutch size variation often are available when data on other life-history traits are not. According to the report of Winkler et al. (2002), tree swallows have advanced their mean date of clutch initiation (lay date) by 9 days over the past 30 years across North America, apparently in response to climate change. To understand the relationship between climate change and lay date, Von-Haartman (1982) suggested a dichotomy in the way that birds adjust their clutch sizes to the timing of breeding. Taking this as a precedent we can visualize the similar effects on all backyard poultry or other birds. However, intensification of poultry breeding and its industrialization has provided micro-environments for birds, which hardly get any chance to interact with macro-environment. This alludes to the fear of major impact of climate change on the poultry industry.

Horst (1981) further submitted that non-ruminants possess biologically high adaptability to different climates, production levels, and high productive ability. The depression induced by environmental temperature is characterized by reduction in feed intake, which causes an imbalance of the individual energy, protein

and mineral supply. The performance of any individual depends on its genetic makeup and the environment in which it lives. In layers, productivity is a combination of number of eggs, the size of eggs, feed consumption and the flock depletion or survivability (Kotiah, 2012). Production records and observations of chickens in the pen showed that they consumed less feed under high environmental temperatures and humidity, and these result to nutritional stress. Given the lack of significant difference in the temperate conditions of many layer hybrids imported into South-west environment, one could appropriately select between them in the tropics by using the complex-trait of 'productive adaptability' to the environment (Horst, 1981). Productive adaptability will be the ability of an animal to maintain its normal body functions, grow and produce with minimum difference in productive traits under two or more environments of defined stress situation. This complex-trait could be measured indirectly by the productivity or yield performance of animals under different conditions, whereby animals with smaller reductions in productivity levels would be regarded as possessing better genetic potential for adaptability (Horst, 1981). The trait could also be measured in terms of interaction between genotype, G and environment, E. GxE is a source of variation of phenotypic values, and in most cases, is inseparable from the environmental variance. This phenomenon raises the problem of adaptability to local environmental conditions (Falconer and Mackay, 1998). Environment could include different locations and seasons. Thus, the mean difference in productivity of a genotype under two specific environments will be a measure of adaptability of the genotype. This research studied the

productivity and adaptability of two exotic layer genotypes – namely Bovan nera and Isa brown – to the South-west environment of Nigeria, under two locations and two seasons that interacted with each other.

Materials and Methods

Information on weekly feed intake (Intake, g), cock weight (Cockwt, g), hen weight (Henwt, g), hen house production (HHP, %) and egg weight (Ewt, g) were taken on two chicken genotypes namely Bovan Nera (BN) and Isa brown (IB) from the record books of CHI farms limited, Ajanla village, Ibadan, in South-west Nigeria, located on lat. 7.2461539 and long. 3.8285759 and altitude 200m ASL. Data obtained covered 75-week life-cycle for each flock on 20 flocks for each genotype, over 10 years from 1999 to 2008, with mean flock population of 4496 chickens/pen at a hen: cock ratio of 6.5:1 at point of lay. The data were obtained from two 'CHI farms' locations of about 10 km apart, namely Ajanla and Sanusi in Oluyole Local Government Area of Oyo State, Nigeria; and were partitioned by genotype (G), and subjected to analysis for productivity and adaptability using GLM procedures of SAS® (1999) Version 8. Statistical model adopted for the study was randomized complete block design (RCBD) in factorial, using genotype (G) and location (L) as fixed factors and Season (S) as random factor. Mean separation was conducted using the Bonferonni t-test ($p=0.05$). Productive ability or productivity was measured directly by 'Means analysis' while the complex-trait of 'productive adaptability' was evaluated by Interaction study, difference between locations and seasons, and life-cycle curve analysis of traits for strains.

Mean productivity was determined by converting each trait-mean to relative

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percentage value for each strain (equations 1), and subtracting between them for the absolute difference (equation 2). Percent mean productivity Index for each strain was determined by summing-up all percent trait values and dividing by the number of traits, (equations 3). The effect of season within location, and location within season, were computed using Equations 4 and 5.

Productive adaptability index was determined in four stages. The first step involved calculating the absolute differences for each trait; calculating the % difference for each trait (equations 4), summing-up all % differences of each trait for the strain, and calculating the mean percent difference for each strain (equation 5b). The last step was the estimation of the adaptability index as in Equation 6.

Formula used for computations were:

Productivity value for a Trait (%) = (Mean value for a Trait in a strain / Sum of mean values for Trait in both strains) x 100. ----- Equation 1a.

Productivity value for a Trait (%) = $X_i / ((X_i \text{ strain1} + X_i \text{ strain2}) / 2) \times 100$ --- Equation 1b.

Absolute Difference (%) = Trait i Strain1 – Trait i Strain2 ----- Equation 2.

Mean productivity for a Strain (%) = Sum of % values of all Traits for Strain/No of Traits. ----- Equation 3a.

Mean productivity for a Strain (%) = (Intake + Cockwt + Henwt + Ewt + HHP, (%))/5. ----- Equation 3b.

= $(X_A + \dots + X_E) / 5$. ----- Equation 3c.

% Difference between Locations/Seasons for a Trait = (Absolute Difference between means for trait between two Locations/Seasons)/(Mean value for the trait between the two Locations/Seasons) x 100 ----- Equation 4a.

% Dif._i = $((X_1 - X_2) / ((X_1 + X_2) / 2)) \times 100$. ---- Equation 4b.

Mean % Difference for a Strain = Sum of % Differences for all Traits for Strain / No of Traits. ----- Equation 5a.

Mean % Difference for a Strain = $\text{Dif. } (X_A + \dots + X_E) / 5$ ----- Equation 5b.

Adaptability Index (%) = $100 - ((\text{Mean \% dif. for all trait of a Strain} / \text{Mean \% dif. for all Traits of both strains}) \times 100)$ ---- Equation 6a.

= $100 - ((\% \text{ dif. } (X_{Ai} + \dots + X_{Ei}) / 5) / \% \text{ dif. } (X_{A1} + X_{A2} + \dots + X_{E2}) / 10) \times 100$ --- Equation 6b.

Coefficient of variation (CV) = Standard deviation/Mean ----- Equation 7.

The study model was of the form:

$Y_{ijkl} = G_i + L_j + S_k + G \times L_{ij} + G \times S_{ik} + L \times S_{jk} + ?_{ijkl}$.

Y_{ijk} = Response of a trait due to genotype i, location j and season k.

G_i = Fixed effect of genotype i.

L_j = Fixed effect of location j.

S_k = Random effect of season k.

$G \times L_{ij}$ = Fixed interaction effect of genotype i and location j.

$G \times S_{ik}$ = Random interaction effect of genotype i and season k.

$S \times L_{jk}$ = Random interaction effect of season k and location j.

$?_{ijkl}$ = Radom error committed NID with 0, σ^2 .

The hypothesis for study was that there was no difference in the productivity and adaptability of both genotypes.

Results

Productive performance

Table 1 gives the mean productive performance of BN and IB strains by genotype, location and season. ANOVA and Bonferroni T-test revealed that genotype caused significant ($p < 0.05$) difference in Intake, Henwt, HHP and Ewt between strains. BN had higher values in Intake and Henwt while IB was superior in Ewt and HHP. The mean productivity of

Table 1: Mean productive performance of *Bovan nera* and *Isa brown* in South-west environment

Factor	Intake/day (g)	Cock weight (g)	Hen weight (g)	Egg weight (g)	HHP (%)	Mean Productivity Index	Mean % Difference	CV
Genotype Productivity								
BN	98.06±26.66 ^a	2240.58±786.08	1727.56±555.83 ^a	56.35±5.04 ^b	64.99±27.94 ^b	-	-	-
IB	94.60±25.66 ^b	2197.48±778.93	1576.92±759.54 ^b	57.52±5.13 ^a	70.08±23.11 ^a	-	-	-
% BN	50.90	50.49	52.28	49.49	48.12	50.26	-	0.031
% IB	49.10	49.51	47.72	50.51	51.88	49.74	-	0.031
% Ab.	1.8	0.98	4.56	1.02	3.75	-	2.42	-
Dif.								
Locational Productivity								
Ajanla	101.40±20.64 ^a	2381.34±635.17 ^a	1742.60±434.69 ^a	55.89±5.12 ^b	68.05±19.92	-	-	-
Sanusi	93.13±29.14 ^b	2109.71±856.33 ^b	1610.92±763.31 ^b	57.58±4.95 ^a	66.34±30.54	-	-	-
% Ajanla	52.13	53.02	51.96	49.26	50.64	51.40	-	0.029
% Sanusi	47.87	46.98	48.04	50.74	49.36	48.60	-	0.030
% Ab.	4.26	6.04	3.92	1.48	1.28	-	3.40	-
Dif.								
Seasonal Productivity								
Wet	92.51±29.22 ^b	2102.97±863.93 ^b	1604.20±603.01 ^b	56.96±5.20	66.39±30.68	-	-	-
Dry	102.06±20.37 ^a	2391.05±615.98 ^a	1746.38±707.31 ^a	56.56±4.97	67.99±19.76	-	-	-
% Wet	47.55	46.79	47.88	50.18	49.40	48.36	-	0.029
% Dry	52.45	53.21	52.12	49.82	50.60	51.64	-	0.027
% Ab.	4.90	6.43	4.24	0.36	1.2	-	3.43	-
Dif.								

NOTES: Values in same column with different superscripts are significantly different at 0.05; % = Percent; CV= Coefficient of variation; Ab, Dif. = Absolute difference

Table 2. Effect of location on seasonal (Location x Season) productivity of both *Bovan nera* and *Isa brown* in South-west Nigeria

Factor	Intake/day (g)	Cock weight (g)	Hen weight (g)	Egg weight (g)	HHP (%)	Mean % Difference	CV
Ajanla X Wet	97.85±24.87 ^a	2267.04±775.17 ^a	1713.06±534.00 ^a	56.45±5.37 ^b	56.72±21.51	-	-
Sanusi X Wet	89.19±31.18 ^b	1997.94±901.12 ^b	1534.82±633.71 ^b	57.34±5.04 ^a	55.34±36.13	-	-
Ab. Locational Diff.	8.66	269.10	178.24	-0.89	1.38	-	-
% Difference	9.26	12.62	10.98	1.56	2.46	7.38	0.680
Ajanla X Dry	105.27±13.69 ^a	2519.08±362.60 ^a	1778.58±263.40	55.26±4.78 ^b	57.44±18.23	-	-
Sanusi X Dry	99.23±24.46 ^b	2284.62±749.10 ^b	1721.91±909.41	57.94±7.94 ^a	58.12±0.96	-	-
Ab. Locational Diff.	6.04	234.46	56.67	-2.68	-0.68	-	-
% Difference	5.91	9.76	3.24	4.73	1.18	4.96	0.647

NOTES: Values in same column with different superscripts are significantly different at 0.05; % = Percent, CV= Coefficient of variation; Ab. Locational Dif. = Absolute locational difference

Table 3: Effect of season on locational (Season x Location) productivity of both *Bovan nera* and *Isa brown* in South-west Nigeria

Factor	Intake/day (g)	Cock weight (g)	Hen weight (g)	Egg weight (g)	HHP (%)	Mean % Difference	CV
Wet X Ajanla	97.85±24.87 ^b	2267.04±775.17 ^b	1713.16±534.00	56.45±5.37 ^a	56.73±21.51 ^b	-	-
Dry X Ajanla	105.27±13.69 ^a	2519.08±262.60 ^a	1778.58±263.40	55.26±4.78 ^b	57.44±18.23 ^a	-	-
Ab. Seasonal Diff.	7.42	252.04	65.42	-1.19	-0.71	-	-
% Difference	7.31	10.53	3.75	2.13	1.24	4.99	0.775
Wet X Sanusi	89.19±31.18 ^b	1997.94±901.12 ^b	1534.82±633.71 ^b	57.34±5.04	55.34±36.13 ^b	-	-
Dry X Sanusi	99.23±24.46 ^a	2284.62±749.10 ^a	1721.91±909.41 ^a	57.94±7.94	58.12±00.96 ^a	-	-
Ab. Seasonal Diff.	10.04	286.68	187.09	0.06	2.78	-	-
% Difference	10.66	13.39	11.49	0.10	4.90	8.11	0.676

NOTES: Values in same column with different superscripts are significantly different at 0.05; % = Percent; CV = Coefficient of variation; Ab. Seasonal Diff. = Absolute Seasonal Difference.

Table 4: Effect of location on productive adaptability (Location x Genotype) of Bovan nera and Isa brown in South-west Nigeria

Strain	Factor	Intake/day (g)	Cock weight (g)	Hen weight (g)	Egg weight (g)	HHP (%)	Mean % Difference	% Adaptability
Bovan nera	Ajanla X BN	103.92±19.83 ^a	2392.52±629.71 ^b	1813.72±439.98 ^a	55.05±4.98 ^b	66.25±18.46	-	-
	Sanusi X BN	94.65±29.24 ^b	2147.60±855.10 ^a	1676.52±608.72 ^b	57.35±4.86 ^a	64.07±33.15	-	-
	Absolute Diff.	9.27	244.92	137.20	2.3	2.18	-	-
	% Difference	9.34	10.79	7.86	4.09	3.35	7.09	48.59
Isa brown	Ajanla X IB	98.81±21.15 ^a	2368.32±641.89 ^a	1661.74±18.96 ^a	57.07±5.11	69.99±21.23	-	-
	Sanusi X IB	90.55±28.81 ^b	2045.72±855.41 ^b	1526.45±39.88 ^b	58.06±5.12	70.18±25.11	-	-
	Absolute Diff.	8.26	322.61	135.29	0.99	0.19	-	-
	% Difference	8.72	14.29	8.49	1.72	0.27	6.70	51.41

NOTES: Values in same column with different superscripts are significantly different at 0.05; % = Percent; Diff. = Difference

Table 5: Effect of season on productive adaptability (Season x Genotype) of Bovan nera and Isa brown in South-west Nigeria

Strain	Factor	Intake/day (g)	Cock weight (g)	Hen weight (g)	Egg weight (g)	HHP (%)	Mean % Difference	% Adaptability
Bovan nera	Wet X BN	94.53±28.21 ^b	2162.46±857.20 ^b	1660.19±607.01 ^b	56.31±5.16	64.85±33.99	-	-
	Dry X BN	102.66±23.46 ^a	2344.32±666.89 ^a	1816.99±465.11 ^a	56.39±4.90	65.15±18.74	-	-
	Absolute Diff.	8.13	181.86	156.80	0.08	0.30	-	-
	% Difference	8.24	8.07	9.02	0.1	0.46	5.18	63.32
Isa brown	Wet X IB	89.82±30.34 ^b	2021.78±867.17 ^b	1528.05±589.53 ^b	57.93±5.13	68.54±25.21 ^b	-	-
	Dry X IB	101.21±14.90 ^a	2463.85±519.41 ^a	1645.24±943.98 ^a	56.89±5.09	71.77±20.46 ^a	-	-
	Absolute Diff.	11.39	442.07	117.19	1.04	3.23	-	-
	% Difference	11.92	19.62	6.74	1.81	4.60	8.94	36.68

NOTES: Values in same column with different superscripts are significantly different at 0.05.; % = Percent; CV=Coefficient of variation; Diff. = Difference.

Effects of location and season on productivity and productive adaptability

BN exceeded that of IB (50.26 vs 49.74%), although there was no significant difference ($p < 0.05$) between strains. Location caused significant ($p < 0.0001$) difference in productivity of traits between strains. Ajanla recorded higher values in Intake, Cockwt and Henwt while Sanusi influenced higher values in Ewt making the mean productivity higher in Ajanla than Sanusi (51.40 vs 48.60%). Between seasons, dry season resulted in higher and significant ($p < 0.0001$) Intake, Cockwt and Henwt, which gave the superiority between seasons to dry (51.64%) over the wet season (48.36%). The CV among traits, for mean productivity of each strain by genotype, location and season were similar (0.027-0.031).

Table 2 gives the effect of location on seasonal productivity (LxS) of both strains - BN and IB - was examined. Location caused higher mean percent difference in strain productivity - 7.38 and 4.96% - due to wet and dry seasons respectively.

Table 3 reveals the effect of season on locational (SxL) productivity of BN and IB which was also investigated. The mean percent difference between wet and dry season productivity in Ajanla was lower than that of Sanusi (4.99 vs 8.11%).

Productive adaptability

Table 4 displays the effect of location on productive adaptability (LxG) of both strains. BN demonstrated higher % difference in productivity namely feed intake, Ewt and HHP (9.34 vs 8.72, 4.09 vs 1.72 and 3.35 vs 0.27). Thus, BN consumed more feed due to differences in location and laid bigger and more eggs in Sanusi than Ajanla. However, cockwt and henwt were higher (10.79 vs 14.29; 7.86 vs 8.49) for IB in Sanusi than Ajanla.

Table 5 displays the effect of season on productive adaptability (SxG) of both strains. Although ANOVA was not sensitive

enough to detect real differences ($P = 0.47$) for the interaction in both strains, BN still demonstrated smaller percent differences in mean Intake, Cockwt, Ewt and HHP (8.24 vs 11.92; 8.07 vs 19.62; 0.1 vs 1.81 and 0.46 vs 4.60) while IB showed superiority for adaptability in mean Henwt (9.02 vs 6.74). ANOVA results also revealed the significant ($P < 0.013$) effect of GxLxS interaction on productivity and adaptability of both strains.

Discussion

Reports on effect of location on chicken productivity is limiting in literature. Horst (1981) showed significant differences from data between two locations (Kuala Lumpur and Berlin) for 20-week, 40-week and 68-week body weights, feed consumption and average egg weight for brown layer (MM) chickens. The low CV implied similarity in variability among traits at each factor level. The mean percent differences due to genotype, location and season (2.42, 3.40 and 3.43) were low. These values implied that Season and location exerted higher effects on productivity than genotype in the environment. The difference in productivity of strains between locations showed that wet season caused greater difference than dry season, but the mean value for traits of strains in the dry season were higher, leading to a higher productivity of both strains in the dry season. CV estimates (0.680 vs 0.647) revealed similarity in variability among traits examined between locations. As productive activities moved from Ajanla to Sanusi. The wet season caused reductions in Cwt (-12.62%), Hwt (-10.98%) and HHP (-1.56%) while dry season caused lower feed intake (-5.91%), lower Cwt (-9.76%) and lower Hwt (-3.24%). Thus, change in location from Ajanla to Sanusi farms caused reduced Cwt and Hwt due to lower feed

intake of birds.

Results showed that season caused smaller differences in productivity in Ajanla, while it had greater differences and impact on productivity in Sanusi for both strains. Result from Sanusi was probably influenced by absence of many shade-trees since the farm was established only recently. The CV showed that there was similarity in variability (0.775 vs 0.676) among traits in each location. The lower impact of season on productivity of strains in Ajanla might be due to the presence of an impressive hill with thick tropical forest overbearing the location at the background. This produced further cooling effect in the dry season, thus moderating the environmental conditions. Hermes (2007) reported that the primary impact of seasonal change from summer into fall is a reduction in egg production and increased eating habit, as day length declines from about 16.5 hours per day to about 8 hours per day in December as season changed from wet to dry, Ajanla demonstrated a decrease in egg production (56.45 vs 55.26 or -2.13 %), while other traits appreciated in values.

The percent differences in productivity due to LxG measured the adaptability of genotypes in strains to location. These results conferred better adaptability on BN for HHP and Ewt; and better adaptability on IB for feed intake, Cockwt and Henwt. The life-time adaptability curve (not shown) also conferred better adaptability on BN for HHP and Ewt, while IB recorded better adaptability on Intake and Cockwt (from 20 weeks onward). Furthermore, ANOVA output showed that the effect of LxG was significant on productive adaptability ($P < 0.043$). The systematic effect of LxG interaction on adaptability of exotic chickens is usually manifested through depressions in productivity of traits in the humid tropical regions (Jesuyon, 2011).

The first-year production cycle (16-75 week) adaptability curves (not shown) demonstrated smaller differences between locations for HHP, Ewt, Henwt in BN; while IB had smaller differences between locations for Cockwt and Feed intake; and therefore, these two strains were conferred with better adaptability for respective traits. The conflict on adaptability for Henwt between strains under study could have arisen from the approximation procedures involved in the approaches employed.

The mean percent difference for all traits were 7.09 and 6.70% while the mean percent adaptability was 48.59 and 51.40% for BN and IB respectively in the south-west environment, conferring better overall adaptability on IB. Variations in adaptability for different traits and strains are important criteria for selection under any given set of environmental conditions in hot humid environments. Therefore, productive adaptability as a trait should be treated as very important during improvement of quality or productivity of stock, especially where harsh environmental conditions prevail and where feed is scarce. Smaller differences in productivity conferred better adaptability on strains between seasons for the concerned traits. The overall mean percent difference for all traits was 5.18 and 8.94 indicating adaptability values of 63.32 and 36.68 % for BN and IB between seasons respectively, implying that BN could cope better with seasonality and express higher genetic ability for adaptability under changing seasons in hot humid environment than IB (Jesuyon, 2014). Results obtained also implied that Henwt in IB was better adapted to Seasonality than in BN, thus IB laid bigger eggs earlier within seasons. The first-year (16-75 weeks) seasonal adaptability curves (not shown) also conferred better adaptability on BN for

Ewt, HHP, intake, Henwt and better adaptability on IB for Cockwt (from 19 weeks onward) between seasons. Studies on the effect of location and season on adaptability of chickens are sparse in literature. The phenomenon GxLxS represents a complex interplay of these interacting factors on the productivity and adaptability of strains; which is difficult to explain biologically. The breeder and farmer can enhance productivity and adaptability by sourcing for good genetic materials, offering adequate nutrition and feed quantity, providing good and ventilated housing, providing clement ambient and micro-environment by purposive management plans and interventions; skillful management and thorough timing of onset of egg-laying to commence towards the tail end of the dry season at the time when the wet and favourable season approaches. Obayelu and Adeniyi (2006) reported that climatic variables (temperature, rainfall, wind speed and relative humidity) in Ilorin contribute about 81, 96 and 43 (%) to the variance in poultry egg production, feed intake and outbreak of diseases of poultry production respectively; that temperature has an inverse relationship with poultry feed intake, and that high relative humidity in the study area encouraged outbreak of poultry diseases which reduced egg production. These conditions could reduce adaptability of exotic chicken in the south-west environment. Lamy *et al.* (2012) also submitted that climate, nutrition and health factors have effects on livestock productivity and that climate and location are most significant. The genetic mechanism influencing fitness and adaptation is not well explored, and adaptation traits are usually characterized by low heritability. Furthermore, it may be difficult to combine adaptability traits with

high production potential, as there seem to be different physiological and metabolic processes involved (Naskar *et al.* 2012). Favorable correlation suggests that if major importance is placed on performance traits in stressful environments, adaptability traits would not be compromised and thus the most productive and adapted animals for each environment would be identified for breeding purposes (Naskar *et al.* 2012).

Results showed that mean performance of strains based on genotype, locational and seasonal productivity were 50.26 and 49.74; 51.40 and 48.60; and, 48.36 and 51.64 (%) respectively for BN and IB. IB was better adapted to locational changes, while BN was better adapted to seasonal fluctuations of the environment. Adaptability should be regarded as a basic trait in tropical breeding programs because tropical environments require strains with high genetic ability for fitness and adaptability to increase productivity. Findings also reveal that Bovan Nera has potential for better productivity in the humid regions while Isa Brown has potential for higher productivity in drier environments. Adaptability should be treated as a major trait in breeding programmes. The complex-trait of 'productive adaptability' could be evaluated in chicken based on combination of multiple-traits: feed intake, body weight, growth rate, mortality/survivability, hen house production and egg weight.

Conclusion

In terms of productivity, Bovan nera genotype performed better than Isa brown, Ajanla produced better than Sanusi while Dry season produced better than Wet season. Both Ajanla and Sanusi produced better in the wet season than dry season. The effect of season on productivity was higher in Sanusi than Ajanla. Bovan nera was

better adapted to season while Isa brown was better adapted to locations. Chicken evaluation centres should certify only highly adaptable breeds for commercial poultry production in the environment.

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