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Comparative Study of Strain, Location and Seasonal Effects on Reproductive Adaptability of Two Parent-Stock Layer Flocks in Ibadan, Nigeria

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Abstract

Two exotic strains of layer chicken were evaluated for adaptability to location and season. An array of 10-year records on hatching parameters from 18 batches each of Bovan nera and Isa brown were utilized. The study design was Completely Randomized Design (CRD) in a 2 x 2 x 2 factorial treatment arrangement involving Strain, Location and Season. Measurements were taken on number of eggs set, number of eggs fertile, number of day-old chicks hatched, number of unhatched eggs and number of rejected day-old chicks. Data were analyzed for effects of single factors, and interactions of strain, location and season. Tukey's HSD test was employed for mean separation ($P<0.05$). The Statistical Analytical Software (SAS) version 9.3 was used for analysis. Results revealed significant ($P<0.05$) strain by locational effect on percent eggs set (PES), fertility of eggs set (FES) and hatchability of eggs set (HES) ($P = 0.0002$-0.0240); while strain by seasonal effect was strong ($P = 0.0001$-0.0410) on fertility of eggs set (FES), hatchability of eggs set (HES), pullet chicks hatched on eggs set (PDS) and hatching rejects on eggs set (HRJ). Adaptability index of between strain, within season, between locational differences for hatching traits, exposed Isa brown with smaller mean difference as better adapted to Sanusi than Ajanla (14.56 vs 3.92, %), while Bovan nera exposed better mean adaptability to Ajanla than Sanusi (0.71 vs 9.54, %). Also, between strain, within location, between seasonal differences revealed Bovan nera as better adapted with smaller mean difference to the wet season than dry season (0.75 vs 13.15), while Isa Brown showed better adaptability to the dry season than wet season (6.34 vs 2.47). The two-factor interaction model could be employed for quick practical selection for adaptability.

Keywords: Hatching traits, index, strain by location interaction, strain by season interaction, tropics, parent-stock layers.

Introduction

A lot of exotic poultry strains are imported to the tropical environment annually. These suffer varying degrees of low performance or performance depression due to the hot-humid climate, compared to performance of similar or same strain in the temperate environment. This phenomenon borders on adaptability of strains to tropical environment. High reproductive adaptability is important in poultry breeders to ensure a profitable venture. Environmental factors responsible for low reproductive performance and adaptability usually pass uninvestigated by farmers. Adaptability is a concept which relates to variability in performance across locations (Roy and Kharkwa, 2004). Tropical adaptability is the relative ability to survive, grow and reproduce in the presence of endemic stressors in different tropical environments (Burrow, 2012). The key factor that determines adaptability as measured through survival and reproduction is the inherent genetic variation which interacts with environmental constraints to create phenotypic variation (Naskar et. al., 2012). Thus, statistical measurement of observed interactions, help to determine the importance and magnitude of the influences of various environmental factors on adaptability of an individual. The magnitude may lead to better performance or genetic slippage (Dickerson, 1955), - a phenomenon where performance of individuals reared in a specific environment degrades when forced to perform in different environment.

Reproduction is the biological process by which organisms produce new individuals of their own kind. In avian species, reproduction takes place through the laying of internally-fertilized eggs by the female; which is also responsible for the natural brooding of these eggs. The advent of commercial egg-incubator and hybridization technology, has promoted poultry production to a worldwide industry supplying the needed daily protein requirements. Reproductive adaptability– a complex trait and a component of fitness, is the ability of an animal to adjust to different environments and reproduce with better or reduced variation in performance. Many primary poultry breeding companies (eg Hendrix genetics, BV Netherlands) have emerged mainly in the temperate climate. These conglomerates export exotic breeds and strains to tropical countries of the world. Thus, PS strains (eg. Bovans, Dekalb, Hisex, Isa, Shaver and others) are imported from these primary breeders into secondary poultry breeding companies (eg CHI, Zartech, Agrited etc.) in Nigeria, for re-distribution to local farmers who engage in commercial egg and meat production. Although the genotype generally remains constant from one environment to the other, barring mutation; but when the same genotype is subjected to different environments, it may produce a wide range of phenotypes, in numerical or quantitative values for same trait or character (Baye *et al.,* 2011). This response to different environments is termed genotype-environment (GxE) interaction (Nguyen *et al.,* 2017), and its indices could be used as determiner of adaptability to the environment.

The GxE phenomenon also brings about the well-known 'performance depression' that has been documented in literature (Horst, 1983; Jesuyon and Oseni, 2015; Jesuyon, 2018). Hatching performance of parent stock (PS) poultry strains is important for assessing reproductive adaptability in different environments such as locations and seasons. Reproductive adaptability in avian species could be influenced by genotype, viability, survivability, persistency of egg production, number of eggs laid, environmental condition etc. All loci for quantitative traits interact with the environment to give specific results in different environments. Genotype by environment (GxE) interaction becomes important in poultry breeding when its variance is significant ($P < 0.05$), so that prospective breeding stock could be evaluated and selected under the same conditions in which their offsprings shall be produced (Khan and Singh, 2002). This study was conceived to evaluate the effect of strain (genotype), location and season on reproductive adaptability of Bovan nera (BN) and Isa brown (IB) parent stock layers in a tropical environment. The research hypothesis was that there shall be differences in adaptability indices of strains due to interaction of strain, location and season.

Materials and Methods

The Location and Environment: The two locations are Ajanla farms and Sanusi farms, with different environmental features which make them differ in ecology, but under same corporate management of CHI Farms Limited. The two farms are about 10 km apart, in Oluyole Local government Area, in the derived Savannah, Ibadan, South-west, Nigeria. Ajanla farm is located on coordinates $7^0$14' 4" N and $3^0$48'16" N; on Altitude 162 metres ASL. Average annual rainfall, mean monthly temperature and relative humidity were 111.27 cm/month, 26.63^0C and 74.51% during the period of data collection. The wet and dry seasonal periods in the environment were mid-April to October and November to mid-April respectively.

Determination of Reproductive Adaptability

Three approaches were adopted in studying reproductive adaptability. The first method is the 'difference between same strain (Str) in different environments. This approach shall utilize the difference in two locations (Loc) and two seasons (Ssn) by two-factor interaction approach; that is, strain by location (Str x Loc) and strain by season (Str x Ssn) interactions. The second approach is the three-factor interaction of 'strain by location by season' (Str x Loc x Ssn) approach. The third method uses the difference between the 'mean performance of the two strains' over all environments under study (STR; Horst, 1983). In all three approaches to estimating adaptability, the stock of strain with lower mean difference in reproductive performance over the range of environments is considered better adapted to the whole environmental complex.

Experimental Materials and Data Collection: Records on Bovan nera (BN) and Isa brown (IB) parent-stock chickens were obtained from 18 batches of each strain, spanning a period of 10 years (2012-2022). Feeding method, feeding standard and nutrition were similar and consistent throughout the 10-year period. Data were collected on hatching (reproductive) traits from the farms and hatchery namely: number of eggs layed, number of eggs set, number of fertile eggs, number of hatched eggs, number of pullet day-old chicks hatched (PDOC), number of unhatched eggs and number of chicks rejected. These were used to estimate percent eggs set (PES, %), fertility on eggs set (FES, %), hatchability on eggs set (HES, %), pullet day-old chicks hatched on eggs set (PDS, %), unhatched eggs on eggs set (UNE, %), hatching rejects on eggs set (HRJ, %).

Experimental Design: The completely randomized design (CRD) was employed in a 2 x 2 x 2 factorial treatment design involving strain, location and season.

Statistical Model:

$$Y = \mu + \alpha_i + \beta_j + C_k + \alpha\beta_{ij} + \alpha C_{ik} + \beta C_{jk} + \alpha\beta C_{ijk} + \varepsilon_{ijkl}$$ **; where:**

Y = observed value of a trait in strain α, location β and season C.

μ = overall constant

α_i = effect of strain i (i = 1: Bovan nera, 2: Isa brown)

β_j = effects of location j (j = 1: Ajanla, 2: Sanusi)

C_k = effect of season k (k = 1: wet, 2: dry)

$\alpha\beta_{ij}$ = interaction effects of strain i and location j.

αC_{ik} = interaction effect of strain i and season k.

βC_{jk} = interaction effect of location j and season k.

$\alpha\beta C_{ijk}$ = interaction effect of strain i, location j and season k.

ε_{ijkl} = random error component of all factors, in levels ijkl, NID ~ (o, δ^2)

Analytical Method: Data generated were subjected to factorial analysis of variance (factorial ANOVA) for interaction of strain, location and season for adaptability, and Tukey's Honestly significant difference (HSD) test for mean separation (p <0.05). Differences between interactions of strain by location, strain by season; and strain by location by season were studied between strains in order to unearth the magnitude of adaptability of strains. The statistical Analytical Systems (SAS®) computer software version 9.3 (SAS, 2011) was used to analyze data.

Results

Table 1: Significant (*P*) values from main and interacting factors for egg hatching traits of Bovan nera and Isa brown parent stock layers (from 20 to 75 weeks) in Ibadan Nigeria

SV	PES (%)	FES %	HES (%)	PDS (%)	UNE (%)	HRJ (%)
Single Factors						
Strain	0.0001	0.0001	0.7876	0.4657	0.1230	0.4901
Location	0.0712	0.0602	0.3710	0.9369	0.5622	0.9894
Season	0.9827	0.0001	0.0140	0.4725	0.7600	0.0839
Interactions						
Str x Loc	0.0240	0.0002	0.0006	0.3359	0.9396	0.2590
Str x Ssn	0.9785	<0.0001	0.0042	0.0410	0.1994	0.0264
Str x Loc x Ssn	0.9580	0.6252	0.3221	0.2400	0.9987	0.5229

NOTES: PES = Percent eggs set, FES = fertility on eggs set, HES = hatchability on eggs set, PDS = Pullet day-old chicks hatched on eggs set, UNE = Unhatched eggs on eggs set, HRJ = hatching rejects on eggs set, % = percentage, Str x Loc = Strain by location interaction, Str x Ssn = Strain by season interaction, Str x Loc x Ssn = Strain by location by season interaction, *P-values below* 0.05 are significant, while *P*-values above 0.05 are not significant.

Table 1 gives the significant (*P*) values, based on single factor analysis of variance, for traits performance; and based on analysis of variance for interaction which determine adaptability. Strain affected PES and FES (*P* =0.0001), while season affected FES and HES (*P* =0.0001 - 0.0140). The two-way interaction of strain by location (Str x Loc) influenced PES, FES, HES (*P* =0.0002 - 0.0240); while strain by season interaction (Str x Ssn) influenced PES, FES, HES, PDC and HRJ (*P* =0.0001 - 0.0500). The three-way interaction of strain, location and season (Str x Loc x Ssn) was not statistically significant (*P* >0.0500) on trait performance in both strains.

Table 2: Effect of strain by location (Str. x Loc) on egg hatching traits of parent stock layers under commercial farming system in South-west Nigeria

Trait	Strain	Location	Value	SEM	*P-level*	Str x Loc diff	Strain diff.
Percent Eggs Set (%)	BN	Ajanla	98.75^{a}	0.60	0.0240	0.49	
		Sanusi	98.26^{a}	0.49			
	IB	Ajanla	89.65^{c}	0.68		-3.88	[4.37]
		Sanusi	93.53^{b}	0.44			
Fertility on eggs set (%)	BN	Ajanla	84.43^{b}	0.43	0.0002	2.52	[4.10]
		Sanusi	81.91^{c}	0.40			
	IB	Ajanla	85.12^{a}	0.45		-1.58	
		Sanusi	86.70^{a}	0.45			
Hatchability on eggs set (%)	BN	Ajanla	73.04^{a}	0.56	0.0071	3.37	[4.77]
		Sanusi	69.67^{b}	1.39			
	IB	Ajanla	70.27^{ab}	0.70		-1.40	
		Sanusi	71.67^{a}	0.58			
Pullet day-old chicks hatched on eggs set (%)	BN	Ajanla	34.52	0.30	0.3359	0.49	
		Sanusi	34.03	1.30			
	IB	Ajanla	33.64	0.51		-1.13	[1.62]
		Sanusi	34.77	0.29			
Unhatched eggs on eggs set (%)	BN	Ajanla	13.29	1.87	0.9396	1.05	[0.17]
		Sanusi	12.24	1.31			
	IB	Ajanla	15.92	0.62		0.88	
		Sanusi	15.04	0.39			
Hatching rejects on eggs set (%)	BN	Ajanla	0.89	0.02	0.2590	0.05	
		Sanusi	0.84	0.02			
	IB	Ajanla	0.83	0.06		-0.07	[0.12]
		Sanusi	0.90	0.04			
Strain x Location Mean	BN	Ajanla	**65.77^{a}**		0.0500	16.28	[15.07]
		Sanusi	49.49^{b}			-	
	IB	Ajanla	49.23^{b}			-	
		Sanusi	**50.44^{b}**			1.21	

NOTE: BN = Bovan nera, IB = Isa brown, SEM = standard error of the means, *p-level* = level of significance. Str. x loc. difference = Mean in Ajanla - Mean in Sanusi, Strain dif. = difference across locations between strains for trait. Strain x location Mean = Mean of all traits across locations for the strain. Means with different superscripts within trait differ significantly (p <0.05).

Table 2 reveals that interaction of strain by location was significant on PES, FES, and HES (P <0.0002 - 0.0071). A small and better difference between locations (better adaptability) was exposed for BN on PES (0.49%). The lower percent difference for IB was recorded on FES (1.58%) and HES (1.40%). The mean strain by location difference for all traits, was higher in Bovan nera than Isa brown (16.28 v 1.21%).

The highest PES and HES values (98.75 and 73.04, %) were produced by BN in Ajanla. The highest FES value (86.70 %) was recorded by IB in Sanusi. Ajanla location revealed the highest mean productivity of 65.77 % over all traits evaluated.

Table 3: Effect of strain by season (Str x Ssn) on egg hatching traits of Bovan nera and Isa brown parent stock layers under commercial farming system in South-west Nigeria

Trait	Strain	Season	Mean	SEM	*p-level*	StrxSsn dif.	Strain dif.
Percent Eggs Set (%)	BN	Wet	98.54^a	0.48	0.9787	0.08	
		Dry	98.46^a	0.60			
	IB	Wet	91.44^b	1.38		1.30	[1.22]
		Dry	90.14^b	0.57			
Fertility on eggs set (%)	BN	Wet	83.44^b	0.46	0.0001	0.57	
		Dry	82.87^b	0.37			
	IB	Wet	88.18^a	0.45		4.36	[3.79]
		Dry	83.82^b	0.44			
Hatchability on eggs set (%)	BN	Wet	70.85^b	0.60	0.0042	-0.47	
		Dry	71.32^a	1.36			
	IB	Wet	73.64^a	0.51		6.23	[6.74
		Dry	67.41^c	0.72			
Pullet day-old chicks hatched on eggs set (%)	BN	Wet	33.69^a	0.32	0.0410	-1.11	
		Dry	34.80^a	1.28			
	IB	Wet	35.68^a	0.28		2.85	[3.96]
		Dry	32.83^b	0.52			
Unhatched eggs on eggs set (%)	BN	Wet	0.94	0.02	0.1994	0.15	[0.15]
		Dry	0.79	0.02			
	IB	Wet	0.86	0.04		0.00	
		Dry	0.86	0.06			
Hatching rejects on eggs set (%)	BN	Wet	13.98^a	1.89	0.0264	2.36	[4.20]
		Dry	11.62^b	1.30			
	IB	Wet	14.54^a	0.42			
		Dry	16.38^a	0.62		-1.84	
Strain x Season mean	BN	Wet	50.24		-		
		Dry	**50.47**		-	0.23	
	IB	Wet	**50.72**		-	2.15	[1.96]
		Dry	48.57		-		

NOTE: BN = Bovan nera, IB = Isa brown, SEM = standard error of the means, *p-level* = level of significance, Str x Ssn: Strain x Season difference = Mean of strain in Wet Season - Mean of strain in Dry Season, Strain diff. = Difference across seasons between strains for trait. Strain x Season Mean = Mean of all traits across seasons for the strain, Means with different superscripts within trait differ significantly (p <0.05).

Table 3 unveils significant effect of strain by season interaction on adaptability and productivity of strains on PES, FES, HES, PDC and HRJ (P=0.0001-0.0410). Bovan nera strain, showed smaller difference (better adaptability) between wet and dry seasons on PES (0.08 vs 1.30), FES (0.57 vs 4.36), HES (0.47 vs 6.23) and PDS (1.11 vs 2.85). Isa brown strain UNE recorded 0.00 % difference while HRJ had a least difference of 1.84 %. The mean strain by seasonal difference was lower (better overall adaptability) in BN than IB (0.23 v 2.15, %).

The result of strain by season interaction revealed that BN had higher productivity of PES (98.54%) in the wet season. The IB strain recorded higher FES, HES, PDS, UNE (wet season) and HRJ (dry season) values of 88.18, 73.64, 35.68, 0.86 and 16.38, %.

There was no significant (*P* >0.05) strain by seasonal difference in mean productivity, between strains, in all traits examined.

Table 4: Effect of three-factor interaction of strain, season, locations on reproductive adaptability of Bovan nera and Isa brown parent stock hens in Ibadan, Nigeria

Interacting Factors			Layer hatching traits							
Strain	Season	Location	PES (%)	FES (%)	HES (%)	PDC (%)	UNE (%)	HRJ (%)	Mean loc. dif. within season (%)	Difference between Strains (%)
1	1	1	98.25	85.39	74.88	34.45	13.84	0.97		
1	1	2	98.89	80.98	66.83	31.47	14.15	0.90		
Locational dif. for traits			**-0.64**	4.41	8.05	2.98	-0.31	0.07	14.56	|10.64|
2	1	1	88.66	88.64	74.33	36.01	14.31	0.80		
2	1	2	93.90	88.09	73.67	35.74	14.41	0.86		
Locational dif. for traits			-5.24	**0.55**	**0.66**	**0.27**	**-0.10**	**-0.06**	**-3.92**	**-**
1	2	1	99.35	83.27	70.84	33.39	12.62	0.80		
1	2	2	97.80	82.57	71.68	35.84	10.88	0.79		
Locational dif. for traits			**1.55**	**0.70**	**-0.84**	-2.45	**1.74**	**0.01**	**0.71**	**-**
2	2	1	89.81	83.28	66.52	32.43	16.72	0.84		
2	2	2	92.65	85.56	70.79	34.51	14.77	0.86		
Locational dif. for traits			-2.84	-2.28	-4.27	**-2.08**	1.95	-0.02	-9.54	|8.83|

NOTES: Strain 1= Bovan nera; Strain 2= Isa brown; Season 1= Wet Season; Season 2= Dry Season; Location 1= Ajanla, Location 2= Sanusi, Mean loc. dif. within season = difference between locations, within season, within strain. Difference between strain = absolute strain difference between locations for all traits.

Table 4 exposes the effect of the three-factor interaction of strain, season and location on adaptability of traits in both strains. Between BN and IB strains, the wet season by locations differences showed that IB recorded the lowest locational difference (better adaptability) than BN (14.56 vs 3.92, %) for all traits in the dry season. Similarly, BN revealed lower overall dry season by locations differences than IB (0.71 vs 9.54, %) for better overall locational adaptability to the wet season. There was no consistency in the pattern of the high or low performance of traits between strains, seasons and locations.

Table 5: Effect of the three-factor interaction of strain, location, seasons on reproductive adaptability of Bovan nera and Isa brown parent stock hens in Ibadan Nigeria

Interacting Factors			**Layer hatching traits**							
Strain	Location	Season	PES (%)	FES (%)	HES (%)	PDC (%)	UNE (%)	HRJ (%)	Mean seasonal diff. within Location (%)	Difference between Strains (%)
1	1	1	98.25	85.39	74.88	34.45	13.84	0.97		
1	1	2	99.35	83.27	70.84	33.39	12.62	0.80		
Seasonal dif. for trait			**-1.10**	**2.12**	**4.04**	**1.06**	**1.22**	0.17	**7.51**	
2	1	1	88.66	88.64	74.33	36.01	14.31	0.80		
2	1	2	89.81	83.28	66.52	32.43	16.72	0.84		
Seasonal dif. for trait			-1.15	5.36	7.81	3.58	-2.41	**-0.04**	13.15	|5.64|
1	2	1	98.89	80.98	66.83	31.47	14.15	0.90		
1	2	2	97.80	82.57	71.68	35.84	10.88	0.79		
Seasonal dif. for trait			**1.09**	**-1.59**	-4.85	-4.37	3.27	0.11	-6.34	|3.87|
2	2	1	93.90	88.09	73.67	35.74	14.41	0.86		
2	2	2	92.65	85.56	70.79	34.51	14.77	0.86		
Seasonal dif. for trait			1.25	-2.53	**2.88**	**1.23**	**-0.36**	**0.00**	**2.47**	

NOTE: Strain 1= Bovan nera; Strain 2= Isa brown; Location 1= Ajanla, Location 2= Sanusi, Season 1= Wet Season; Season 2= Dry Season; Seasonal difference for trait= difference between seasons for trait, within location and within strain. Mean seasonal diff. within Location = mean difference between seasons, within location, within strain for all traits, Difference between strains = absolute strain difference between seasons for all traits.

Table 5 displays the effect of the three-factor interaction of strain, location and season on reproductive adaptability of both parent stock strains. Between strains, Ajanla location by wet seasonal differences revealed that BN had lower mean seasonal difference within location than IB (7.51 vs 13.15, %), which translated to better adaptability (5.64% difference between strains), recording better productivity in the wet season. Also, IB had lower Sanusi by dry seasonal difference than BN (6.34 vs 2.47, %) with better overall performance in the dry season. The percent difference between strains was 3.87%.

Discussion

The significant interactions obtained in the study indicate adaptability potentials of respective strains in specific traits. These values revealed important interaction effects of strain by location, strain by season, and strain by location by season on many reproductive or hatching traits in both genotypes. The two-factor interaction effect revealed a stronger effect of strain by season on FES, HES, PDS and HRJ (P<0.0001-0.0264) than the effect of strain x location on PES, FES and HES (P<0.0002-0.0240). The three-factor effect of strain by location by season was not important statistically. This could be because of the third factor which blurred the strong effects observed under the two-factor interactions, probably due to the close proximity of the two locations. This implies that strains that may show strong three-factor interaction would be truly more adapted than one that reveals a two-factor effect.

The strain by location effect revealed better average adaptability of Bovan nera to Ajanla location and Isa brown to Sanusi. This showed low differences in magnitude between locations on PES, PDS, HRJ (0.05 - 0.49, %) traits in Bovan nera. Similarly, the low differences between locations on FES, HES and UNE (0.88 - 1.58, %) in Isa brown reveal adaptability to Sanusi location. Aggregate mean adaptability to locations was better in Isa brown than Bovan nera, because Isa brown had lower mean strain by location difference over all traits examined for IB (1.21%), which confers on it better locational adaptability than BN (16.28%) over the 10-year period in the environment. In contrast, the strain by seasonal effect recorded smaller differences on PES, FES, HES and PDS (0.08, 0.57, 0.47 and 1.11, %) and lower aggregate strain difference between seasons (0.23 vs 2.15, %) in Bovan nera than Isa Brown. These lower differences for above parameters resulted in better aggregate seasonal adaptability status for Bovan nera than Isa brown strain with lower differences on UNE and HRJ (0.00, 1.84, %) between seasons. Thus, strain x seasonal influence revealed better stability on productivity of PES, FES, HES and PDS in Bovan nera between seasons, while productivity of UNE and HRJ (%) were stable in Isa Brown.

The effect of the three-factor interaction was very low and insignificant (P >0.05); but by evaluating differences between locations while keeping season constant between strains, and vice versa, we could observe a clearer picture (Tables 4 and 5). The locational adaptability of strains (comparing strains) was observed within same season (season being constant) between locations. Between the two locations, Isa brown strain was better adapted to Sanusi location with lower difference (14.56 v 3.92, %) but with higher productivity in being recorded on FES, HES and PDC in the wet season (88.64, 74.33 and 36.01, %). Bovan nera was better adapted to Ajanla location with smaller difference (0.71 v 9.54, %), while the better productivity values on PES and FES were observed in wet, HES and PDC were observed in the dry season.

Similarly, study also revealed a better adapted Bovan nera strain to the three-factor strain by location by seasonal changes than Isa brown in Ajanla (7.55 v 13.15, %). The better productivity values of BN traits were observed on FES, HES, PDC, UNE and HRJ in the wet season. By holding the second location constant (Sanusi), Isa brown revealed least difference between seasons and was better adapted to the wet season than Bovan nera (6.34 v 2.47, %). The better productivity values on PES, HES and PDC were observed in the wet while FES and UNE were observed in the dry season. The three-factor interaction thus revealed more information by indicating particular location or season in which a particular genotype was better adapted or adjusted than the other. Reproductive adaptability studies based on strain by location by season interaction on Bovan nera and Isa brown layer chickens in the tropics is sparce in literature. Strain and Johnson (1957) reported important strain by season interaction on albumen quality of strains differing in rate of sexual maturity, in the early period of the laying season.

Few interaction studies have been reported on broilers. Suarez *et. al.* (1997) reported significant effects of interactions of strain and age on incubation time, egg weight at transfer and chick weight at hatch. Akinsola and Olawumi, (2018) reported no significant strain by feed restriction interaction effect on live weight and slaughter weight of broiler chickens. Akinsola *et al.* (2019) reported significant effect of strain by feed restriction interaction on haematological parameters of broiler chickens at 8 weeks. Ikusika et. al. (2020) examined strain, sex and slaughter weight effect on performance, meat quality and yield of broiler chicken. They revealed significant strain by sex effect on growth performance of broiler chicken. Amato and Castellini (2022) reported that fast-growing broilers at older age (81 d) are heavy and possessed unbalanced body conformation due to intense genetic selection for breast muscle and body mass; which render kinetic activity more difficult and unusual. The use of slow-growing strains which do not have above welfare problems of modern commercial strains has been recommended.

However, layers do not exhibit above conditions which hamper physical conformation and adaptability. Burrow (2012) reported that in the subtropics, differences that exist between breeds in temperate environments are masked by effects of environmental stressors, and that re-ranking of breeds across environments should best be managed by use of breed type(s) that are best suited to the particular production environment. He also reported that re-ranking of sires across environments is apparent in poorly adapted breed types across extreme tropical and temperate environments or where breeding animals are selected in a temperate environment for use in the subtropics. It has been postulated that G x E interactions are unlikely to be of major importance in tropically adapted breeds grazed in either temperate or (sub)tropical environments, although re-ranking is likely to occur in temperate breeds reared in temperate and (sub)tropical environments (Burrow, 2012). Variations in adaptability are important in selecting stock for a given set of conditions. Variations in adaptability summarize important work that has been done in various parts of the world to determine the reactions of animals to their environment, and to develop animals adapted to specific conditions.

Conclusion and Recommendation

The two-factor interaction model revealed important interactions of strain x location in favour of Isa brown; and of strain x season in favour of Bovan nera. Similarly, the three-factor interaction model by difference revealed a better adapted Isa brown to locations and Bovan nera to seasons.

The two-factor interaction could be employed for practical selection for adaptability. The three-factor strain x season by location interaction by difference would reveal a better adapted strain in the tropics.

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