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Full Length Research Paper

Laying performances and egg quality characteristics of F_1 crossbred hens resulting from Label Rouge (T55XSA51) and two local ecotypes as parental lines

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The laying performances and the egg quality characteristics of hens of different genotypes were studied, namely: the; local hens of savannah ecotype (Es) , the local hens of forest ecotype (Ef), the Label Rouge (Lr or T55xSA51) and its crossbred products with local ecotypes: LrxEs, EsxLr and EfxLr. In family poultry farms, the hatching rate (HR), the fertility rate (FR), the average brood size (ABS_H) at hatching and at the weaning (ABS_W), the egg weight (EW) and the chick's body weight (BW_C) were significantly higher (P<0.05) in local hens of savannah type than those obtained in local hens of forest ecotype. The highest laying rate (RL) was obtained on station with the hens of Lr breed (41%) followed by the LsxLr crossbred (36%) and the Ls hens. The most fertile hens were those of the local ecotypes (Es, Ef) with a fertility rate (FR) "taken from 88 to 90%"followed by the hens of genotypes EsxLr and EfxLr (82 to 84%), the Lr hens (77%) and the LrxEs (68%). At the laying, the eggs of the Label Rouge were significantly heavier (P<0.001) than those of the crossbred hens. The lightest EW was obtained in the local hens of the two ecotypes. A significant (p<0.05) negative heterosis effects was found for the traits egg weight, egg yolk and egg white in the crosses involving females Lr. In crosses involving males Lr, a significant (p<0.01) heterosis was observed only for egg weight. The crossing EsxLr is the best adapted for the genetic improvement of local chickens of Benin.

Keys words: Hens, laying performance, egg quality, genotypes, ecotypes, heterosis.

INTRODUCTION

The genetic resources of poultry in West Africa are mainly represented by domestic local chickens (*Gallus gallus domesticus),* guinea fowls (*Numida meleagris*) and ducks (*Cairina* sp.). These local avian species are bred according to a traditional breeding system. The birds are bred for meat as well as for eggs. The size of the national poultry livestock of Benin was estimated in 2005 at 16,690 000 heads of which 81.29% were local chickens (Bebay, 2006) for 6,000,000 inhabitants. Despite its numerical importance, the local production of poultry meat is below the needs expressed by the consumers. This deficit has led to increased imports of poultry meat (FAO, 2008) from developed countries or to the promotion

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of crossbreeding programs involving exotic breeds.

In 10 years, the quantum of poultry meat imported moved from 19361 t in 1995 to 49634 t in 2005 in Benin (FAO, 2008). Apart from this meat dependence toward foreign countries, certain diseases, which formerly did not exist on the African continent, are met today in the majority of the West African countries in an endemic or epidemic form. Indeed, the Gumboro disease, the Marek's disease and the Newcastle disease are now met in Benin. Recently, the highly pathogenic avian influenza (HPIA) appeared in Africa in 2006 (Bebay, 2006) and 2007 in Benin (Direction de l'Elevage, 2007) after having caused significant economic losses in several countries of Asia and Europe.

In addition, the crossings between large format cockerels of exotic breeds and local hens (small size) were done in the majority of the countries of West Africa to increase body weight of progeny (FAO, 2004). These anarchistic crossings often failed most because of the lack of follow-up or the lack of adapted husbandry techniques. In the majority of cases, the females resulting from these crossings do not have, unfortunately, a good maternal ability (incubation, hatching, chicks' follow-up) (FAO, 2004).

From all that proceeds, it comes out that the local production must be encouraged to reduce imports and limit the spreading of new diseases. For more durability and food safety in animal protein, the meat production must be directed towards the indigenous chicken populations which indeed account for 80% of the local production of chicken meat. In Benin, the indigenous chicken populations of the species *Gallus gallus* of the two great climatic areas (savannah in the North and forest in the South) have a remarkable heterogeneity both for phenotypical traits (live weight, body measurement, feather colour and structure, skin colour and eyes colour) and molecular polymorphism (Youssao et al., 2010). Local chickens from the Savannah areas, in the North of Benin, exhibited a higher body weight than did local chickens from the Forest areas, in the South of Benin, either in village conditions or in experimental conditions (Youssao et al., 2009a). The effect of crossbreeding with Label Rouge chickens was then investigated in experimental conditions, on growth, carcass traits and meat quality (Youssao et al., 2009a; Youssao et al., 2009b).

The characterization of egg production and reproductive traits of local chickens and their crosses with Label Rouge chickens is needed in order to set up a breeding programme. The aims of this study were to:

1. Characterize the laying performances of local chickens of the species *G. gallus* of the two agro ecological areas of Benin in traditional breeding system, and
2. Compare the laying performances of local chicken populations to those of Label Rouge chickens and their cross in confinement experimental conditions;
3. Evaluate the egg quality of the various genetic types.

The genotype of slow-growing chickens from a Label Rouge cross (T55 X SA51) was included as a control in order to connect this comparison of savannah and forest local chickens with similar comparisons realised in other coastal countries of West Africa (Ivory Coast and Ghana) within the frame of a project supported by the DURAS programme for promoting sustainable development in agricultural research systems (Youssao, 2006).

MATERIALS AND METHODS

Areas of study

The study of laying performances and characteristics of local hen eggs was carried out in the forest and savannah areas of Benin, from October 2005 to May 2008. In the savannah areas, work was realized in the Departments of Borgou and Donga and in the forest, the Departments of Atlantic, Littoral, Mono and Couffo. In Borgou, the survey was carried out in the Commune of N'Dali. In the Department of Donga, the investigations were done in the Commune of Copargo. In the Atlantic and Littotal, the area of study was the Commune of Abomey-Calavi. In the Departments of Mono-Couffo, the area of study was the Communes of Lokossa and Aplahoue. The farmers identified for these investigations had a herd of at least 10 chickens during the survey. These communes were retained in order to have a good spatial distribution of the local chicken populations in each area. Figure 1 locates the surveyed communes.

The two departments of savannah are characterized by a climate of Sudanese type. This climate is marked by one dry season (November to May) and one rainy season (June to October) with a yearly rainfall varying from 900 to 1000 mm and an average monthly temperature which varies between 26 and 28°C (ASECNA, 2007).

The forest area of Benin has a subequatorial climate with 2 dry seasons and 2 rainy seasons. The rainfall mode is bimodal with a large and a small season of rains separated by dry seasons. The seasons of rains go from April to July and October to November. Average rainfall was 1200 mm per year, from 2000 to 2006 (ASECNA, 2007). The average monthly temperature varies between 27 and 31°C and the relative humidity fluctuates between 65% from January to March and 97% from June to July (ASECNA, 2007).

In confinement, the study on the laying performances and eggs characteristics was carried out on the Experimentation Farm of the Polytechnic School of Abomey-Calavi (EPAC) on the local chickens, the Label Rouge (T55 X SA51) and the cross chickens resulting from the crossing of those two genetics types.

Animals

The data collection was carried out on the local chickens of forest and savannah ecotypes, in the traditional chicken breeding farms. In confinement, the reproductive animals used in the present study were composed of Label Rouge hens, the local hens of Forest and were composed of Label Rouge hens, the local hens of Forest and Savannah ecotypes and the F1 crossbreeds resulting from the crossing between the local chickens and the Label Rouge. The Label Rouge chickens are heavy chickens stock with slow growth resulting from the final crossing between the stock T55 and SA51 of SASSO GROUP (Couvoir 7203, Sicamer, Route du Grand Lucé, 72440, Volnay, France). The local chickens of Forest and Savannah ecotypes are from the nucleus of reproductive chickens of the Experimentation Farm of the Polytechnic School of Abomey-Calavi. The crossings were carried out on this farm. The study of

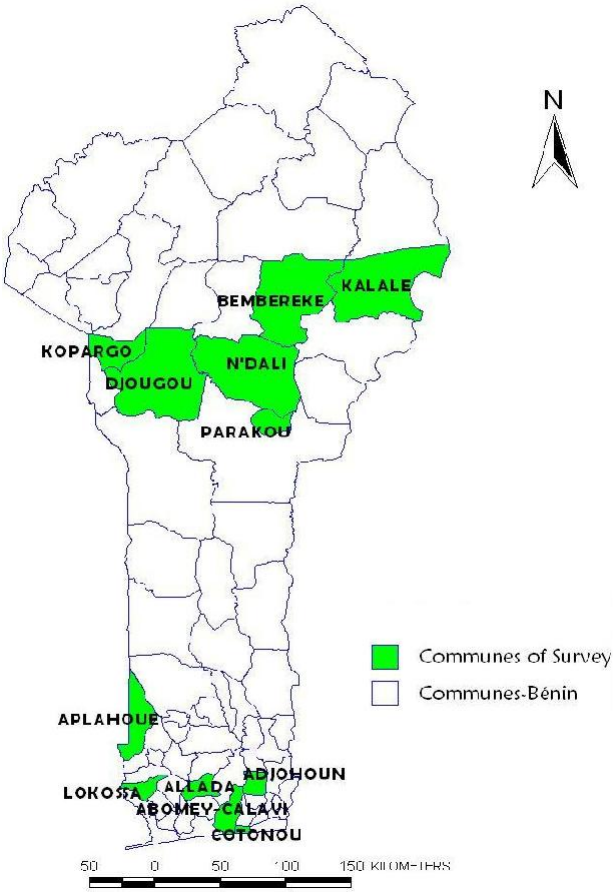

Figure 1. Areas of study.

the laying performances was made on six lots of seventy chickens of sixty hens and ten cocks. Each lot contained one genetic type:

1. Lot 1 is composed of chickens of savannah ecotype of twenty weeks old on average;
2. Lot 2 is composed of chickens of forest ecotype of twenty weeks old on average;
3. Lot 3 is composed of Label Rouge chickens of twenty two weeks old on average;
4. Lot 4 is composed of the cross chickens of 22 weeks old on average resulting from the crossing Savannah ecotype male and Label Rouge Female (EsxLr);
5. Lot 5 is composed of the cross chickens of 22 weeks old resulting from the crossing between Male Label Rouge and Savannah ecotype female (LrxEs), and
6. Lot 6 is composed of the cross chickens of 2 weeks old resulting from the crossing Forest ecotype male X Female Label Rouge (EfxLr).

The animals were fed *ad libitum* with a laying diet (2800 ME Kcal/kg of feed and 201 g/kg of crude protein). The composition of the laying diet is given in the Table 1a and b.

Data collection

Laying performances in traditional breeding system

For the survey on the laying performances in the traditional breeding system, 96 chickens belonging to 15 chicken breeders were retained in the North and 91 chickens belonging to 20 chicken breeders in the South. These chickens breeders were selected according to some criteria of accessibility to the farm (breeding) and their availability to give explanations if need be. The chickens were followed up from the laying of the hens to the weaning of chicks. The data collected were: The number of laid eggs, the number of fertile eggs (presence of the embryo), the number of hatched eggs, the number of dead embryos and the number of weaned chicks.

Laying performances in confinement (station)

For the study of the laying performances in confinement, the data collected by lot were: The number of laid eggs, the quantity of consumed feed and the weight of egg from 32th to 36th weeks of age, the number of incubated, fertile and hatched eggs, the number of dead embryos, the weight of egg and that of chicks. The eggs collection was made every day in the morning from 9 to 12 o'clock and in the evening from 15 to 17 o'clock. The eggs collected were counted and recorded by genetic type. For laying curve, eggs were collected every day for Savannah ecotype hens, Forest ecotype hens and Label Rouge hens.

Qualities of eggs

The assessment of the quality of eggs was made on the basis of composition in egg albumen, egg yolk and shell according to Monira et al. (2003) and Fotsa (2008). For that purpose, fifty eggs of each genetic type (Label Rouge, local chickens of savannah ecotype, local chickens of forest ecotype, the crosses resulting from the crossing between the male of savannah ecotype and female Label Rouge; the crosses resulting from the crossing between the female of savannah ecotype and male Label Rouge, the crosses resulting from the crossing between the male of forest ecotype and female Label Rouge) were used in the 3rd month of laying, between 32th and 36th weeks of age. Each egg was initially weighed individually using a Terraillon® scale of a precision of 1 g; the corresponding length and the height were then taken using a slide calliper instrument. Then, the egg was broken methodically to facilitate the separation of the egg albumen from the egg yolk. Thus, the egg yolk collected was weighed and the shell was cleaned and then weighed first once. The shell was then dried with sterilizer at 100°C for 60 min before been weighed again. The egg albumen weight was obtained by subtracting the weights of the egg yolk and egg shell from the weight of the egg. Percentages of yolk, albumen and shell were then calculated. The heterosis of each egg's characteristic was estimated by the following formula:

$$\text{Heterosis} = F_1 - \frac{(Parent\,1 + Parent_2)}{\frac{(Parent\,1 + Parent\,2)}{2}}$$

where F1 resulting from the crossing EsxLr, LrxEs or EfxLr, the parents were male or female of Label Rouge and local chicken ecotype of the north or South area, according to the crossing.

Statistical analysis

The FR, the HR and the embryos mortality rate (EM) , the means of the number of eggs laid by hatching, the hatching size, the eggs weight and the chicks weight were calculated and compared by ecotype in traditional breeding or genetic type in confinement (station). The feed efficiency (FE) was calculated in station

Table 1a. Composition and nutrient content of the laying diets.

Component	Value
Soy cakes (%)	15.5
Wheat bran (%)	7
Corn (%)	59
Cotton cakes (%)	6
Fish meal (%)	9
Lysine (%)	0.2
Methionine (%)	0.2
Salt (%)	0.2
Oyster shell (%)	2.5
Premix 0.25% (%)	0.25
Total (%)	100
Metabolisable energy (kcal/kg)	2800.0
Crude protein (%)	20.1
Lysine (%)	0.92
Methionine + Cystine (%)	0.72
Calcium (%)	1.35
Digestible phosphate (%)	0.35

Table 1b. Composition of the premix used in the laying diets.

Component	Proportion
Vitamin A (IU/kg)	500000
Vitamin D3 (IU/kg)	100000
Vitamin E (mg/kg)	750
Vitamin K3 (mg/kg)	50
Vitamin B1/Thiamin (mg/kg)	50
Vitamin B2/Riboflavin (mg/kg)	200
Niacin Vitamin PP (mg/kg)	1000
Vitamin B3 (mg/kg)	350
Vitamin B6 (mg/kg)	50
Vitamin B12 (mg/kg)	7500
Choline (mg/kg)	10000
Biotin (mg/kg)	1250
Folic acid (mg/kg)	50
Iron (mg/kg)	2500
Manganese (mg/kg)	3500
Copper (mg/kg)	200
Zinc (mg/kg)	2500
Iodine (mg/kg)	25
Cobalt (mg/kg)	12.5
Selenium (mg/kg)	12.5
Anti-oxydizer (mg/kg)	150
Red carophyl (mg/kg)	600
Avizant Gelb (mg/kg)	615

(confinement) by genetic type as the ratio of the total feed intake to the total egg mass between 32th and 36th weeks of age. The percentages of egg white, the egg yolk and the shell were then calculated by genetic type. For the weight data, the means were also calculated by genetic type. Software SAS (Statistical Analysis System, 1996) was used for the data analysis. The test of ^{2} was used for the percentages comparison and the test of student for the means comparison.

RESULTS

Laying performances of local chickens in traditional breeding

The laying performances of local chickens of savannah and forest ecotypes in traditional breeding system are given in Table 2. On the whole, 877 eggs were laid by hens of Savannah ecotype and 856 of the Forest ecotype. No significant difference (P = 0.15) was observed between the means of the number of eggs laid by hens of Forest ecotype (9.14) and that of hens of Savannah ecotype (9.40). The total number of incubations was of 4 in the both ecotypes. The HR, the means of number of hatched chicks, the number of weaned chicks of Savannah ecotype were significantly higher than those of the Forests ecotypes (P<0.05). The eggs of hens of the Savannah ecotype were more fertile than those of the Forest ecotype, whereas EM was more met in the Forests ecotypes (P<0.01) . The eggs and the chicks of hens of Savannah ecotype were heavier than those of Forest ecotype (P<0.001).The relation between the weight of eggs and that of chicks was 73.6% for hens of Savannah ecotype to 69.1% for the Forests ecotypes.

Laying performances in confinement (station)

The first eggs were obtained in the 18th week in the group of local hens of Savannah ecotype, 19th week in local hens of forest ecotype and the cross and 20th weeks in the group of Label Rouge. The crosses were earlier than the parental with an age of laying start of 16, 19 and 17 weeks, respectively for the three crossbreeds types: EsxLr, LrxEs and EfxLr. In station, the production of eggs was continuous in the group of local hens. From the beginning until the end of the laying season, the Label Rouge chickens had a better laying rate (P<0.01) compared to the local chickens. The curve of laying of the Label hens was classic while that of local hens of Savannah ecotype is characterized by more or less significant fluctuations (Figure 2). Instincts of incubation were noticed in the lot of the local chickens of North ecotype. Some laying stops were in particular observed at the 30th week especially in the lot of local hens of the Savannah ecotype. After 40 weeks of laying, the Label Rouge laying curve decreased.

Between the 32nd and the 36th week of age, the laying rate the more important were obtained in the lot of Label Rouge (41%), followed then by the hens resulting from

Table 2. Laying performances of Savannah and forest ecotypes of local chickens under traditional breeding conditions.

Variable	Symbol	Forest ecotype (N = 91)			Savannah ecotype (N = 96)			Significance test
		Number		Standard error	Number		Standard error	
Age at first laying	AGE1	38	26.6 [a]	1.6	42	27.8 [a]	1.2	ns
Average number of incubated eggs	E_{INC}	96	9.1 [a]	0.3	91	9.4 [a]	0.3	ns
Number of hatched eggs	E_{HA}	96	6.4 [a]	0.3	92	7.4 [b]	0.3	*
Average number of weaned chicks	NWC	96	4.6 [a]	0.4	92	5.6 [b]	0.3	*
Hatching rate (%)	HR	96	80.3 [a]	-	91	86.5 [b]	2.4	*
Fertility rate (%)	FR	96	87.8 [a]	-	91	92.4 [b]	-	-
Embryo mortality (%)	M_E	96	6.8 [a]	-	91	6.1 [b]	-	**
Egg weight (g)	EW	229	36.3 [a]	0.3	269	38.6 [b]	0.5	***
Chicks weight at hatching (g)	CW_H	131	25.1 [a]	0.6	142	28.4 [b]	0.6	***
Ratio chick weight/ egg weight (%)	-	-	69.1	-	-	73.6	-	-

ns: p>0.05; *: p<0,05; **: p<0.01; ***: p<0,001; The means of the same line followed by different letters differ significantly at p = 0 .05.

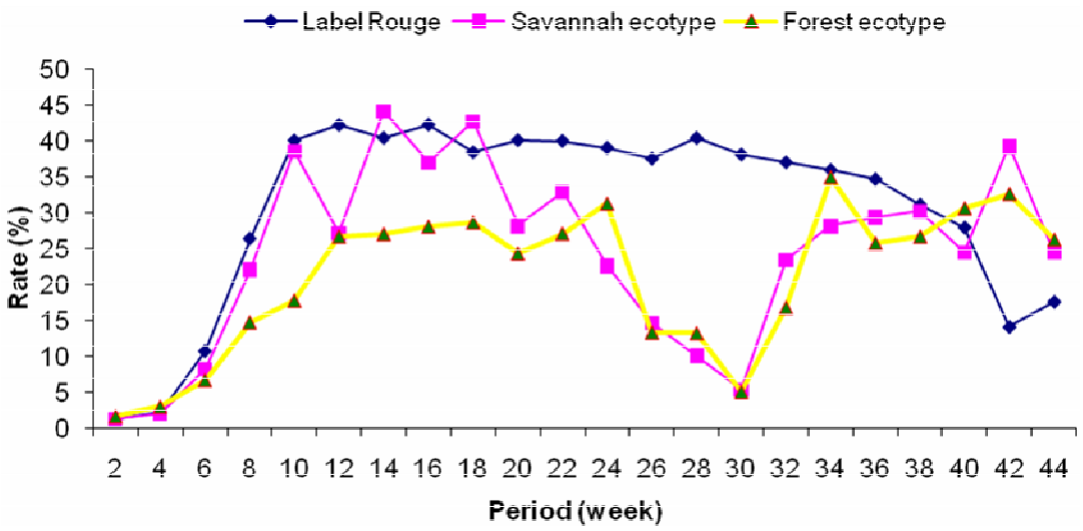

Figure 2. Laying curve of local chickens of North and South Benin and the Label Rouge.

the crossing male of Savannah ecotype × female Label Rouge and the hens of Savannah ecotype with the respective rate of 36 and 35%. During this same period, the FE had varied according to the genetic type from 3.25 to 5.11. The FE of the local chickens was weaker than the one of the crosses and whereas the Label Rouge had the highest FE.

The highest FR were obtained in the lot of local chickens (88 to 90%), followed by the cross chickens resulting from the Label rouge females and local males (82 to 84%), the Label Rouge (77%) and finally, the cross resulting from the males labels and females of the Savannah ecotype (68%). The weakest HRs and the highest embryonic death rates were obtained in cross resulting from the crossing male of forest ecotype and Label Rouge females. At the laying, the eggs of the Label Rouge were heavier than those of cross (P<0.001) and the Local chickens had the lightest eggs. The eggs of local chickens of the savannah ecotype weighed more than those of the forest ecotype (P<0.05) .The lowest HR and the highest EM were obtained in the lot of the cross EfxLr. The Hatching, the Label chicks had a weight (43.03 g) significantly more important than those of the cross ones. Among the cross, the hybrids LrxEs were heavier than the cross resulting from the Label Rouge hens and the local cock. Lastly, the chicks of savannah ecotype weighed more than those of the forest ecotype (P<0.05). The chick weight/egg weight ratio varied from 64.8 to 73.3% according to the genetic type with the highest rates observed in the group of Label Rouge and local chickens of the savannah ecotype. Table 3 presents the laying performances of local hens, the Label Rouge

Table 3. Laying performances of the studied chicken breeds under traditional husbandry system: The local chicken savannah type, the local chicken forest type, the Label Rouge (exotic breed) and its cross products with local breeds.

Parameter	Symbol	Savannah ecotype (Es)	Forest ecotype (Ef)	Label rouge (Lr)	EsxLr	LrxEs	EfxLr
Number of hens	-	60	60	60	60	60	60
Number of cocks	-	10	10	10	10	10	10
Laying rate (%) *	RL	35.2^{b}	22.9^{d}	40.8^{a}	35.9^{b}	25.0^{c}	21.3^{d}
Feed intake (g/d)*	FI	75.2 ± 2.4^{d}	96.8 ± 2.4^{c}	125.6 ± 2.6^{a}	96.05 ± 2.3^{c}	116.2 ± 2.3^{b}	93.8 ± 2.2^{c}
Feed efficiency *†	FE	3.25	3.80	5.11	4.67	4.23	4.34
Number of incubated eggs	E_{INC}	92	98	70	67	106	56
Number of hatched eggs	E_{HA}	75	77	49	49	59	32
Number of not hatched eggs	E_{NHA}	17	21	21	18	47	24
Number of infertile of eggs	E_{INF}	9	12	5	11	34	10
Number of fertile eggs	E_{FER}	83	86	54	56	72	46
Embryo mortality	M_E	8	9	5	7	4	13
Fertility rate (%)	FR	90.2^{a}	87.7^{a}	77.1^{b}	83.6^{ab}	67.9^{c}	82.1^{ab}
Hatching rate (%)	HR	90.4^{a}	89.5^{a}	90.7^{a}	87.5^{a}	81.9^{ab}	69.6^{b}
Embryo mortality (%)	M_E	9.6b	10.5^{b}	9.3^{b}	12.5^{b}	5.6^{b}	28.3^{a}
Egg weight (g)	EW	38.6 ± 1.5^{c}	36.3 ± 1.3^{d}	60.2 ± 2.98^{a}	42.5 ± 2.1^{b}	48.0 ± 3.2^{b}	43.8 ± 2.7^{b}
Chicks weight at hatching (g)	CW_H	28.3 ± 0.8^{c}	24.9 ± 0.6^{d}	43.0 ± 0.3^{a}	28.0 ± 1.5^{c}	33.3 ± 1.7^{b}	28.4 ± 3.5^{c}
Chick weight/ egg weight (%)	CE_r	73.3	68.5	71.5	65.8	69.3	64.8

*: Measurement taking place between 32 an 36 weeks of age; †The feed efficiency (FE) was calculated as the ratio of the total feed intake to the total egg weight between 32^{th} and 36^{th} weeks of age; LrxEs: Male Label Rougex × female Savannah type; EsxLr: Male Savannah type × female Label Rouge; EfxLr: Male Forest type × female Label Rouge. The means the same line followed by different letters, differ significantly at p = 0.05.

and the cross products resulting from their crossings in station.

Qualities of eggs

The eggs weight of the Label (52.6 g) was significantly higher than that of cross and the local chickens of Savannah ecotype, whereas the local chickens of forest ecotype have the weakest eggs weights (P>0.001).The length and the height of eggs of local chickens of savannah ecotype were higher than those of the local chickens of Forest ecotype. The eggs coming from the Label Rouge and the various types of crossings have similar dimensions and were significantly higher than those of the Savannah and Forest ecotypes (P<0.001).

With regard to the weight of the various components of the egg (egg yolk, egg white, and the shell), the eggs of Label Rouge chickens was the best followed by those of the cross (LrxEs, EsxLr, EfxLr), the savannah ecotype and finally eggs of chickens of the South.

In term of percentage, the egg white of the cross LrxEs, EsxLr, EfxLr was more significant than that of Label Rouge which was significantly higher than that of local chicken eggs (P<0.001) whereas the proportions of egg yolk and shell of the cross and local chickens remained high compared to those of the Label. The weight, dimensions and the composition of egg are given by genetic type in Table 4.

Table 5 presents the heterosis of the characteristics of eggs of F1 resulting from the crosses between Label Rouge and the local chickens of savannah and forest ecotypes. The heterosis effects on egg weight were negative for all types of crosses. Heterosis effects on weights of egg yolk, egg white and shell, were non significant for the cross resulting from Label Rouge males, but they were negative and significant in the crosses obtained from Label Rouge females (P<0.05). The heterosis of the egg yolk, egg white and egg shell percentage, were positive and significant, except for egg yolk percentage in the LrxEs cross and shell percentage in the EfxLr cross. For the three crossbred types, the heterosis were positive and significant for the length and the height of eggs (P<0.001).

DISCUSSION

In traditional poultry breeding, the surveys were carried out in each ecotype and it appears that the average number of chicks at the hatching, the brood size at weaning, the HR by incubation, the FR, the weight of egg and that of chicks of local chickens of Savannah ecotype, were significantly higher than those of local chickens of Forest ecotype. In station, the FR is identical to those obtained in traditional breeding. The HRs is relatively higher in station than in traditional breeding where the incubation is done by the “hen mother”. In station, the

Table 4. Egg quality characteristics of studied chicken breeds under traditional husbandry system. The breeds involved were the local chicken savannah type, the local chicken forest type, the Label Rouge (exotic breed) and its cross products with local breeds.

Egg quality traits	Lr†	Ef†	Es†	LrxEs†	EsxLr†	EfxLr†	Significance test	RSD	R2 (%)
Egg (g)	52.60a	35.4d	35.4d	42.9b	38.7b	37.8b	***	2.9	0.81
Egg yolk (g)	14.57a	10.9d	10.9d	13.1b	12.1c	12.1c	***	1.2	0.51
Egg white (g)	29.28a	17.9d	17.9d	25.3b	22.5c	21.8c	***	2.2	0.77
Egg shell (g)	4.55a	3.3e	3.3e	4.1b	3.8c	3.6d	***	0.4	0.57
Egg yolk (%)	27.73c	31.0b	35.4d	30.6b	31.3a	31.8a	***	2.1	0.32
Egg white (%)	55.61b	50.8c	10.9d	59.0a	58.2a	57.7a	***	3.0	0.59
Egg shell (%)	8.66d	9.3c	17.9d	9.7a	9.8a	9.5bc	***	0.8	0.18
Egg length (mm)	49.60a	41.6c	3.3e	48.8a	48.3a	48.4a	***	1.9	0.75
Egg height (mm)	35.60a	30.6c	35.4d	36.4a	35.1a	34.8a	***	1.1	0.82

†The number of the hen was 60 in each genotype and 50 eggs were used per genotype; RSD: Residual standard deviation; R^2: Coefficient of determination;***: p< 0.001; LrxEs: Male Label Rougex x female Savannah type; EsxLr: Male Savannah type x female Label Rouge; EfxLr: Male Forest type × female Label Rouge.

Table 5. Heterosis effect regarding egg quality characteristics of F1 cross products of Label Rouge and local chicken savannah and forest type.

Variable	LrxEs	EsxLr	EfxLr
Egg (g)	-2.75**	-7.42***	-7.01***
Egg yolk (g)	-0.58^{ns}	-4.46***	-2.76*
Egg white (g)	2.13 ^{ns}	-3.62**	-3.89**
Shell (g)	1.11 ^{ns}	-2.84*	-4.59**
Egg yolk (%)	1.60 ^{ns}	2.83**	4.10***
Egg white (%)	5.72***	4.97***	4.21***
Shell (%)	3.70*	4.92***	2.67 ^{NS}
Length (mm)	2.69***	2.19***	3.11***
Height (mm)	4.54***	2.56***	2.58***

*: p<0.05, **: p <0.01, ***: p <0.001 ; ns: p >0.05 ; LrxEs: Male Label Rougex x female savannah type; EsxLr: male savannah type x female Label Rouge; EfxLr: Male forest type× female Label Rouge.

incubation of eggs was made with an electric incubator and the infertile eggs were eliminated after mirage. However, EM was more significant in station than in traditional breeding.

In traditional breeding, the laying age was on average 27 weeks for the two ecotypes. This age is identical to that obtained in local chickens of 6 villages located in three climatic zones of Morogoro Districte in Tanzania where the age at first lay were ranged between 6 and 8 months (Mwalusanya et al., 2001). In general, the sexual maturity of female chickens is estimated to be 28 weeks in Tanzania (Katule, 1992), 24 weeks in Mali (Kassambara, 1989), Nigeria (Sonaiya and Olori, 1989) and in north-west of Ethiopia (Halima et al., 2007), 32 weeks in Sudan (Wilson, 1979), 28 to 36 weeks in Benin (Assan, 1990) and 25 weeks in Senegal (Sall, 1990). Under intensive management systems, pullets reached sexual maturity at 22 to 23 weeks of age (Halima et al., 2007). In general, artificial incubation is not practised by the owners of indigenous chickens in Benin. For hatching of chicken eggs, farmers depended on broody hens.

In station, the first eggs were obtained in the 18th week in the lot of the local hens of Savannah ecotype, 19th week in the group of local hens of forest ecotype and the cross chickens, and 20 weeks in the group of Label Rouge. These ages were early in station that in family poultry farming because of the breeding mode in general and the feed in particular. In Cameroun, the first egg age is 32, 31.5, 31.5 and 33.5 weeks, respectively for local hens of the Center, the South and North- west of Cameroun and the Label Rouge (Fotsa, 2008) . A difference in 11.5 weeks was obtained between the first egg age of the Label Rouge bred in Benin and those bred in Cameroun. The age at laying start was 18 weeks in the layers of commercial stocks (Leeson and Summers, 1991) and of stock ISA Brown raised at the experimental Farm of EPAC (Kpoglo, 2009).

The hens of forest and savannah ecotypes laid on average 9 eggs by brood in traditional breeding. In station, the production of eggs was continuous with season of fluctuation. These fluctuations can be due to the instincts of incubation because during the incubation, the local hens cease laying. In traditional breeding, a mean of 36 eggs laid per year and by hen was observed for the two ecotypes and no effect of laying season was noted on the number of eggs laid by hen. However, most of the hens had three laying cycles per year, except in the cool and wet zone, where most had only two laying cycles per year (Iqbal and Pampori, 2008). The estimated annual egg production, based on the clutch size and the number of laying cycles per year, was 35.4 (Iqbal and Pampori, 2008). The annual egg production reported in present study from the indigenous chicken was low. These results were low than the production potentials reported in the indigenous chicken of South Africa (Swatson et al., 2003), Ethiopia (Tadel et al., 2003), Pakistan (Farooq et al., 2004), Zimbabwe (Mapiye and Sibanda, 2005) and Kashmir (Iqbal and Pampori, 2008)

where, 50 to 60 eggs per year or 12 to 18 eggs per clutch were reported in scavenging system of rearing. In addition, it was reported that eggs per clutch, clutches per year, and eggs per hen per year produced were respectively 12 to 13, 3 and 36 in Tanzania (Katule, 1992), 8.8, 2.1 and 35 in Mali (Wilson et al., 1987), 10.9, 4.5 and 50 in Sudan (Wilson, 1979), and 8 to 15, 4 to 5 and 40 to 50 in Senegal (Sall, 1990). However, it is an established fact that egg production being under genetic control, is drastically reduced if hen is not fed properly, provided good housing or protected from diseases (Wethli, 2003). The egg production in this system of rearing has been recorded in the range of 75 to 90 eggs per year in backyard or subsistence system of rearing (Iqbal and Pampori, 2008). Compared to the Red Label and cross, the FR of local chickens are high in the whole in station or family poultry farming. According to Fotsa (2008), the high fertility and hatchability may be due to genetic factors but they are also probably due to the high cock to hen ratio and availability of vitamins obtained from scavenging. The male to female ratio and the mode of breeding being identical, the difference between these rates would be due to the aptitudes of the race for cockerel/young cock and the laying.

The HR, the average number of hatched chicks, the number of weaned chicks was higher at the savannas ecotypes compared to the forests ecotypes in traditional breeding while in station, the highest FR were obtained in the group of local chickens, followed by cross chickens resulting from the Label Rouge females and local male, the Label rouge chickens and finally, the cross resulting ones from the Label rouge males and females of the savannah ecotype. The HR in family poultry farming varies from 80 to 90% in the center, the south and the east of Cameroun (Fotsa et al., 2007). These rates are similar to those obtained in the present study.

The weight of eggs of the Label Rouge was significantly higher than that of the Cross and the Local chickens of savannah ecotype, whereas the Local chickens of forest ecotype have eggs whose weights were the weakest. In local hens of the wet dense forest belt with bimodal pluviometry, the weight of eggs is 44 g in the center, 43.5 g in the south and 43.2 g in the east and does not present significant differences (Fotsa et al., 2007).

At 36 weeks of age, the average weight of eggs of Label Rouge was 56.4 g and is significantly higher ($P<0.05$) than that of local chickens of the center, the south and the north-west of Cameroun with respective weights of 44,1, 45,8 and 46,9 g (Fotsa et al., 2008). The same reports were made in the present study. However, the weight of eggs of local hens of Benin is less than those of local hens of Cameroun whereas the eggs of Label Rouge raised in Benin have equal weights to those raised in Cameroun. The difference in egg weight in favour of Label Rouge compared to the local genetic types was also conforms to what was also brought back in the zone of High Plateau of the West of Cameroun between Dahlem Red (normal lines of laying with brown eggs) and local hens (Mafeni, 1995).

This report was also observed in Lesotho by Nthimo (2004) between the hens Rhode Island Red (lines of normal size of layer type with brown eggs) and the local ecotypes of Lesotho and Nigeria raised in controlled area. At the 36th week of age, the weights of eggs of the local ecotypes were less heavy than those reported by Mafeni (1995) and Aganga et al. (2003) in intensive breeding in local hen of Botswana with 44.5 g. In the same way, in Congo-Brazzaville, in local hens of negro, fawn-coloured black ermined colour and golden, the weight of eggs is identical to those of local hens of Benin with respective weights of 37.2, 39.3 and 36.9 g, obtained in family poultry farming in rural environment (Bandtaba et al., 2006) . Some eggs weighing on average 52.2 ± 2 g were met in the smallholder sector of Rushinga district of Zimbabwe (Mapiye and Sibanda, 2005).

The weight of egg was proportional to that of hen in the present study. The percentage of egg white was higher in cross chickens and occupies 58.2, 59.0 and 57.7% of the weight of egg respectively for the cross EsxLr, LrxEs and EfxLr, whereas it occupies only 55.6 and 50,28% of the weight of egg respectively in the Label and the local chickens of North and South ecotype. While considering the weight of the egg yolk, the Label come at first, followed by the three crossbreeds types and finally, the local chickens. However, the opposite was observed for the percentage of the egg yolk: The local chickens and the cross have a similar percentage of egg yolk in the order of 31% which is significantly higher than that of the Label Rouge (27.3%).

These results approach those of Amoussou (2007) which obtained percentages of egg yolk of 32, 31 and 28% respectively for chickens of North, those of the South and the Label Rouge. The egg yolk being the most significant element in the quality parameters of egg, one deduces from it that the eggs of local chickens are better qualities compared to those of the Label (Amoussou, 2007). Thus, these results show that one could improve quality of eggs of Label Rouge by crossing with local chickens even if the cross have a percentage of shell slightly higher than that of their parents. Other results on the variability of the weight were reported in the literature.

N'Dri (2006), reports that the golden Gauloises chickens (GD) have a weak weight, a height and a length larger than the Gallic Black one (GN). In the same way, the eggs of the hens GD had a proportion of egg yolk and shell higher of 2 to 8%, the difference being more significant at the age 33 to 36 weeks than at the age 50 to 52 weeks (N'Dri, 2006). Similar results on the variability of the weight and the dimension of eggs were also reported various genetic types where the egg weight was highest in White Leghon (58.4 g), intermediate in Barred Plymouth Rock (56.3 g) and Rhode Island Red (55.9 g) and lowest in White Rock (59.6 g) (Monira et al., 2003).

Likewise, egg length was highest in White Leghon (5.91 cm), intermediate in Barred Plymouth Rock (5.9 cm) and Rhode Island Red (5.7 cm) and lowest in White Rock (5.6 cm) (Monira et al*.,* 2003). At last, egg width was highest in White Leghon (4.2 cm), intermediate in Barred Plymouth Rock and White Rock (4.2 cm) and lowest in Rhode Island Red (4.1 cm) (Monira et al*.,* 2003). These tendencies were also observe in the present study.

For the heterosis effect of the characteristics of eggs, it was thus observed that the expression of the genotype of the individuals of cross EsxLr, LrxEs and EfxLr was higher than the half-sum (in other words with the average) of the values of the parental genotypes, contrary to what should occur if there were simple addition of characters. The crossing between the local chickens and the Label Rouge reduced the frequency of homozygous alleles (identical gene couples) and increased the number of heterozygous alleles (Lhoste et al*.,* 1993). So the majority of recessive characters, unfavorable, are masked by dominant, favorable characters. This is why the cross resulting from the crossings local chickens and the Label Rouge, have genetic capacities definitely higher than the average of those of their parents. The high heterosis observed in the present study is explained by the genetic distance between the local chickens and the Label Rouge. This variability of the heterosis obtained in this experimentation comes from the fact that the relative value of a crossing depends on the genes which are put in presence and not absolute value of each one of these genes (Ricard, 1990).

In general, according to Bonne et al*.* (1991), the importance of the effect of heterosis is related to several factors of variation. The genetic distance between the races, makes it possible to have a heterosis effect more significant as it was observed in the present study. The heterosis effect also depends on the type of crossing used: In the case of the crossing on double floor utilizing an even cross female, one cumulates two sources of heterosis: The heterosis due to the use of a cross female (heterosis on maternal component) and the heterosis due to the fact that the final products result from crossing (heterosis individual or heterosis direct); while In the case of simple crossing, only the direct effect intervenes. The environment conditions can also influence the heterosis. For a determined character, it is in general, all the more high as when the animals are placed under more difficult environmental conditions. The importance of the heterosis varies according to the characters, like their heritability but contrary to this one. Generally, an opposition between the importance of the additive effects, characterized by the heritability, and that of the non additive effects of genes, materialized by the heterosis are observed. This opposition makes it possible to envisage the most effective means of genetic improvement of the performances. It should not however be concluded from it that the genetic improvement from local chickens of the two ecotypes, only results, according to cases', from the "selection in pure race" or from the practice of the crossings. It is indeed often preferable, to obtain the maximum efficiency, to associate selection and crossing which are thus two complementary and non concurrent strategies.

Conclusion

In traditional breeding, the average number of chicks at hatching, the brood size at the weaning, the hatching rate by brood, the FR, the weight of egg and that of chicks of local chickens of the Savanna ecotype, were higher than those of local chickens of forest ecotype. In station, the FR is identical to those obtained in traditional breeding. The HRs is relatively higher in station than in traditional breeding where the incubation is done by the hen mother. The FR is high in the whole at the local chickens raised in station or in family poultry farming. The average number of hatched chicks, the number of weaned chicks was higher in the group of chickens of savannas ecotypes compared to the forests ecotypes in traditional breeding while in station, the highest FR were obtained in the group of local chickens, followed by the cross resulting from the crossing Label females × local males, the Label Rouge and finally, the cross resulting from the males Labels and females of the savanna ecotype. Lastly, the quality of egg of local chickens is better than that of Label Rouge; the heterosis rates obtained compared to the various variables of the crossing male of North and female Label were the highest, therefore, this direction of crossing was the best adapted for the genetic improvement of local chickens of Benin.

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Abreviations: HPIA, Highly pathogenic avian influenza; **FAO,** Food and Agriculture Organization; **ASECNA,** Agence pour la Sécurité de la Navigation Aérienne; **SAS,** statistical analysis system; **DURAS,** programme for promoting sustainable development in agricultural research systems; **EPAC,** Polytechnic School of Abomey-Calavi.

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