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HETEROSIS AND MATERNAL EFFECTS FOR CARCASS TRAITS IN THREE BREEDS OF RABBIT

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ABSTRACT

A total of 202, 272 and 256 records for purebred, crossbred and reciprocal-crossbred male and female rabbits, of three breeds Chinchilla (CHC), Californian White (CAW) and New Zealand White (NZW) were used in this study. The aim of the study was to estimate maternal, direct additive and heterotic effects for carcass characteristics in order to identify the best crossbreeding plan to use for rabbit meat production in Nigeria. Kits used for this experiment belong to 3 parities and were weaned at 35 days of age. Each rabbit was identified and weighed individually at weaning and at slaughter age (63 days). They were slaughtered after 18 hours of fasting from feed only. After dissection the dressing percentage was calculated as carcass weight x 100/live weight. Statistical analyses were performed using the General Linear Model procedure of SAS. Crossbreeding parameters were calculated from linear contrasts between breed group means. Results showed that breed differences exist for carcass weight in the purebreds, where the CHC had significantly ($P<0.05$) higher carcass weight (1214g) than the NZW (1195g) and CAW (1174). Pre-slaughter weight, carcass weight and dressing percentage were also affected by breed in the purebreds and reciprocal crossbreds. Among the reciprocal crossbreds, NZW x CHC had highest slaughter weight (1711g) while CHC x CAW had the highest carcass weight (1263g) and dressing percentage (73.9%). Heart, liver, kidneys, lungs and other visceral organs showed no significant ($P>0.05$) differences among the breed groups. Estimates of heterotic effect (%H') calculated for carcass characteristics in unit and percent (%) for slaughter weight in the CHC x NZW, NZW x CAW and CAW x CHC crosses were 27.4 and 42%, 25.1 and 29% and 23.7 and 36%, respectively. Examined carcass traits showed a general insignificant ($P>0.05$) heterosis. Maternal effects for various carcass traits also showed no differences in all the crosses except for heart, kidneys and lungs ($P<0.05$). The maternal effect herein is conceivably confounded with the reciprocal effect (ie sex linkage) since it is determined as the difference between the three reciprocal crosses (NZW x CHC, CAW x NZW and CHC x CAW). The results of this study show that the three selected populations do not seem to complement each other or aggregate the responsible genes regarding heterotic and maternal effect as well as reproductive efficiency of the studied carcass traits. Therefore, it can be assumed that the three breeds of rabbit could be used as dam line for carcass traits.

Keywords: Breed, Carcass traits, Heterosis, Rabbits

INTRODUCTION

Rabbits raised for commercial rabbit meat production are usually produced by a three-way cross involving crossbred dams mated to bucks from a sire line (Larzul and Rochambeau, 2004). The crossbred dams are obtained from mating males and females from two dam lines selected for litter size (Kabir *et al.*, 2012) while the sire lines are generally selected for growth rate, affecting carcass and meat quality (Baselga, 2003).

The New Zealand white (NZW) breed is known for its high breeding qualities which include prolificacy, maternal performance, fast growth rate and precocious body development which make it ready for slaughter at 56 days so as to obtain a light carcass (Kabir *et al*., 2014), while the Californian white (CAW) breed is possibly the second most popular meat producing rabbit. The Chinchilla (CHC) rabbit falls under both the medium and small class breeds. The Chinchilla Giganta, also called Grand Chinchilla, weighs between 4.10 and 5kg, while the small Chinchilla weighs between 2.5 and 3.4kg (Piles *et al.,* 2004).

Heterosis indicates the increase in fitness or productivity of crossbred offspring above the average of the parental breeds because of increased heterozygousity (Ndjon and Nwakalor, 1999). Apart from heterosis, reciprocal effect or deviations between the crosses of two or more breeds in which their roles as male or female parents are reversed, represent another feasible route to the economic exploitation of interbreed difference (Kabir *et al.*, 2014; Pascual *et al.,* 2004). The aim of this study was to estimate heterotic, direct and maternal additive effects on carcass traits of three breeds of rabbit in Northern Guinea Savanna Zone of Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Rabbitry Unit of the Research and Teaching Farm, Department of Animal Science, Ahmadu Bello University Zaria, Nigeria. The site falls within the Northern Guinea Savannah zone and detailed description of the location was given by Kabir *et al*. (2014).

Experimental animals and management

A total of 202, 272 and 256 records for purebred, crossbred and reciprocal-crossbred male and female rabbits belonging to Chinchilla (CHC), Californian white (CAW) and New Zealand white (NZW) were analyzed. All the experimental rabbits from which the records analyzed were derived were housed under uniform conditions of management in hutches measuring 72cm x 62cm x 52cm. Experimental diets fed to the animals and detailed mating plan was earlier reported (Kabir *et al.,* 2014).

Slaughtering and carcass analysis

At the age of 63 days (±1day), rabbits were individually weighed and again 30 minutes before slaughter. They were slaughtered within 24hours of fasting from feeds and dissected according to the method of Larzul and Rochambeau, (2004). Carcass weight (g) was determined immediately after slaughter excluding the blood, skin, tail, the gastro intestinal tract (GIT) and urogenital tract. Dressing percentage, (the ratio between hot carcass weight and live weight of the rabbit expressed as percentage), weights of heart, liver, kidney, lungs and other visceral organs were taken and expressed as percentage of carcass weight.

Data analysis

Data obtained were subjected to Analysis of Variance using the General Linear Model (GLM) Procedure of SAS (2002). For the analysis of carcass weight, the age at slaughter was taken as covariate. Maternal heterosis and reciprocal effect was calculated using the method of Linear Contrasts (Dickerson, 1992) as follows:

H'_{CHC} {CHC x NZW} = {CHC x NZW + NZW x CHC} – {CHC x CHC + NZW x NZW}

H'_{NZW} {NZW x CAW} = {NZW x CAW + CAW x NZW} – {NZW x NZW + CAW x CAW}

H'_{CAW} {CAW x CHC} = {CAW x CHC + CHC x CAW} – {CAW x CAW + CHC x CHC}

The percent heterosis was computed as follows: $\frac{H' \text{ (unit)}}{\text{mean of straightbred}} \times 100$

While the reciprocal effect was calculated thus; $\frac{R' \text{ (unit)}}{\text{mean of straightbred}} \times 100$

H′ = Estimate of maternal heterosis in unit and R′ is the estimate of reciprocal differences.

Heterosis was calculated using the general formula given below;

$$\% \text{ heterosis} = \frac{\text{crossbred average} - \text{straightbred average}}{\text{straightbred average}} \times 100$$

The statistical model used in this investigation was as follows: $Y_{ij} = \mu + B_i + E_{ij}$ where Y_{ij} is the record of j^{th} kit of the i^{th} breed group; B_i is the effect of i^{th} breed group; μ is the random mean and E_{ij} is the error residual.

RESULTS

Carcass traits analysis

The carcass traits for the pure, main and reciprocal crosses are presented in Table 1. For the pure cross, breed differences were observed for carcass weight, where the CHC had significantly ($P<0.05$) higher carcass weight (1214g) than the NZW (1195g) and CAW (1174). Initial or pre-slaughter weight, carcass weight and dressing percentage were also affected by breed in the main and reciprocal crosses. The mean values obtained were 1734g, 1062g and 61.24% in the CHC x NZW cross; 1693g, 1139g and 67% in NZW x CAW cross and 1616g, 1056g and 65.34% in the CAW x CHC cross, for pre-slaughter weight, carcass weight and dressing percentage, respectively. The corresponding values obtained in the reciprocal crosses were 1711g, 1188g and 69% in the NZW x CHC cross; 1655g, 1150g and 69% in the CAW x NZW and 1709g, 1263g and 73% in the CHC x CAW cross. From the main-cross (Table 1), the CHC x NZW gave significantly ($P<0.05$) higher slaughter weight (1734g) than NZW x CAW (1693g) and CAW x CHC (1616g), while the NZW x CAW cross had higher carcass weight (1139g) and dressing percentage (67%) than the CHC x NZW (1062g and 61.24%) and CAW x CHC (1056g and 65.34%). In the reciprocal cross on the other hand, NZW x CHC was highest for slaughter weight (1711g) while CHC x CAW had the highest carcass weight (1263g) and dressing percentage (73.9%). The heart, liver, kidneys, lungs and other visceral organs showed no significant ($P>0.05$) differences among the breed groups.

Table 1: Least square means (±SE) for carcass traits

Traits	BREED GROUP[a]								
	Purebred			Crossbred			Reciprocal		
	CHC x CHC	NZW x NZW	CAW x CAW	CHC x NZW	NZW x CAW	CAW x CHC	NZW x CHC	CAW x NZW	CHC x CAW
Live weight (g)	1696±47[a]	1674±40[a]	1638±41[a]	1734±63[a]	1693±48[b]	1616±52[c]	1711±88[a]	1655±20[b]	1709±53[a]
Carcass weight (g)	1214±42[a]	1195±66[a]	1174±53[b]	1062±34[b]	1139±71[a]	1056±18[b]	1188±50[b]	1150±38[c]	1263±49[a]
Dressing out percentage (%)	71.58[a]	71.38[a]	71.67[a]	61.24[b]	67.28[a]	65.34[a]	69.43[b]	69.48[b]	73.9[a]
Heart (%) (as % of carcass weight)	0.44	0.41	0.46	0.47	0.35	0.51	0.44	0.53	0.49
Liver (%)	5.10	5.12	5.96	5.93	4.66	5.25	5.70	4.93	5.11
Kidney (%)	0.94	0.96	0.91	1.03	0.96	0.88	0.92	0.76	0.80
Lungs (%)	1.25	1.21	1.15	1.22	1.07	1.13	1.26	1.05	1.19
Full gut (%)	23.08	24.33	22.84	27.4	19.75	15.06	22.47	19.80	24.54
Empty gut (%)	10.50	10.17	10.44	10.36	9.34	10.87	11.21	9.75	9.62
Head (%)	13.95	13.88	13.23	13.93	14.61	13.74	14.31	14.85	13.96
Thigh (%)	28.73	29.02	26.47	27.02	23.71	30.68	29.45	25.55	28.39
Skin (%)	17.77	17.69	17.46	17.64	15.42	16.92	17.36	17.94	17.25
Length of small intestine (cm)	313[a]	295[a]	305[a]	316[a]	296[a]	278[b]	310[a]	264[b]	304[a]
Length of large intestine (cm)	184[a]	177[b]	181[a]	198[a]	184[b]	179[b]	190[a]	166[c]	170[b]

[a] CHC=chinchilla; NZW=New Zealand white; CAW=California white; N=Sample size
[abc] = Means in the same row (within the same cross) having the same letter are not significantly different

Heterosis and maternal effects for carcass traits

Estimates of heterotic effect (%H') calculated for carcass characteristics are presented in Table 2. The estimates of heterosis in unit and percent (%) for slaughter weight in the CHC x NZW, NZW x CAW and CAW x CHC crosses obtained were 27.4 and 42%, 25.1 and 29% and 23.7 and 36%, respectively. The examined carcass traits showed generally insignificant (P>0.05) heterosis. Maternal effects for various carcass traits (Tables 2) showed no differences in all the crosses except for heart, kidneys and lungs (P<0.05). However, no particular trend was established for the maternal effect on carcass traits studied.

Table 2: Heterosis and Maternal effects (±SE) for carcass traits

	Direct heterosis						Maternal effect		
	CHC x NZW		NZW x CAW		CAW x CHC				
Traits	Units	%	Units	%	Units	%	CHC x NZW	NZW x CAW	CAW x CHC
Live weight (g)	27.4±34.7	42.1	25.1±11.4	29.42	23.73±30.0	36	-31.4±61.0	-28.3±45.4	-24.0±22.8
Carcass weight (g)	1.66±0.51	11.5	0.96±0.05	7.77	1.07±0.11	9.24	0.27±0.14	0.24±0.20	0.26±0.31
Dressing out percentage (%)	3.07±0.37	6.23	2.66±0.75	2.06	2.0±0.66	4.90	0.16±0.11	0.10±0.23	0.13±0.08
Heart (%) (as percentage of carcass weight)	0.05±0.04	4.61	0.13±0.06	6.22	0.08±0.08	5.32	0.29±0.17*	0.21±0.21	0.18±0.16
Liver (%) "	0.08±0.02	2.19	0.05±0.02	2.27	0.16±0.32	1.94	-0.21±0.22	-0.18±0.20	-0.13±0.17
Kidney (%) "	0.02±0.03	3.33	0.04±0.01	3.72	0.67±0.25	2.69	0.16±0.13*	0.12±0.23	0.93±0.21
Lungs (%) "	0.05±0.04	3.06	0.05±0.06	4.02	0.08±0.05	3.62	0.32±0.14*	0.27±0.24	0.23±0.23
Full gut (%) "	-0.63±0.56	-6.29	-0.54±0.43	-4.36	0.11±0.26	2.54	-0.18±0.13	-0.15±0.21	0.10±0.17
Empty gut (%) "	-0.49±0.32	-5.45	-0.35±0.28	-2.99	-0.28±0.15	-0.30	-0.08±0.06	-0.11±0.15	0.07±0.09
Head (%) "	0.58±0.24*	18.36	0.39±0.41	16.18	0.41±0.41	0.32	0.25±0.51	0.21±0.30	0.30±0.23

Thigh (%)	"	-0.01±0.21	-2.90	-0.03±0.33	-3.14	-0.06±0.21	-3.02	-0.11±0.34	-0.32±0.26	-0.28±0.18
Skin (%)	"	-0.44±0.17	-8.98	-0.27±0.17	-6.22	-0.36±0.23	-7.14	-0.07±0.22	-0.13±0.17	-0.09±0.14
Length of small intestine (cm)		6.44±3.02	16.66	3.78±3.11	19.65	3.11±3.26	18.19	11.42±6.02	7.39±4.55	5.29±4.32
Length of large intestine (cm)		3.39±3.18	21.30	4.46±3.24	19.82	3.67±3.18	17.25	8.33±6.17	6.54±4.11	5.63±3.62

CHC=Chinchilla; NZW=New Zealand white; CAW=California white

* = P<0.05

DISCUSSION

Carcass traits

Variation among rabbit breeds and crossbreeding combinations of different origin for carcass traits exist (Szendro *et al.,* 1994; Ouyed and Brun 2008; Bawa *et al.,* 2009). The variation observed in this study with respect to main-cross for slaughter weight, carcass weight and dressing percentage is in line with the reports of Oke *et al.,* (2010) where they observed higher mean values for live weight, carcass weight and dressing percentage in the CHC x NZW crossbreds. Das and Bujarbarua, (2005) had earlier noted a higher live weight of these breeds compared to the Dutch breed. The relatively low and non-significant differences observed for heart, liver, kidneys, lungs and other visceral organs in the pure, main and reciprocal crosses could be explained by the environmental circumstances, which could influence the ability of the breeds. However, values of carcass traits are difficult to be compared objectively with those reported in literature because of the different initial or pre-slaughter weights, breeds, method of slaughter and evaluations as well as the statistical model adopted (Kabir *et al.,* 2012).

Heterosis and maternal effects for carcass traits

Results obtained in this study for heterotic effects on carcass traits agree with those of Oke *et al.,* (2010) who reported that the proportions of carcass traits differed slightly between the purebreds and crossbreds. According to Ahmed (2003), crossing does not only take advantage of traits with considerable non-additive genetic variations (dominance and epistasis), but also exploits differences in additive effects (differences in mean performance between populations as a deviation from the overall mean) between populations. Maternal effect consists mainly from additive maternal and cytoplasmic-inheritance. However, the maternal effect herein is conceivably confounded with the reciprocal effect (sex linkage) since it is determined as the difference between the three reciprocal crosses (NZW x CHC, CAW x NZW and CHC x CAW). Sex linkage as an effect is due to additive effects of genes concerned with the trait and is carried on the sex chromosomes (Ahmed, 2003).

CONCLUSION

In explaining maternal effect in terms of complementarity effects, certain crosses may show much more maternal effect than others depending on the extent to which the crossed populations differ in reproductive performance and in production characters. Therefore, this type of effect, according to Kabir *et al.,* (2014) will rely on the direction of crossing, hence the negative signs obtained for some carcass traits in this study (Table 2).

The results of this study show that the three selected populations do not seem to complement each other or aggregate the responsible genes regarding heterotic and maternal effect as well as reproductive efficiency of the studied carcass traits. Therefore, it can be assumed that the three breeds of rabbit could be used as dam line for carcass traits.

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